APPENDIX D

Galvanized Plumbing Key Questions & Answers

You may download the complete FAQ sheet on household plumbing (PDF 950 kb)

Why did DC Water decide to hire a firm to do a study on lead and old household plumbing?

DC Water wanted an independent expert to provide scientific scrutiny of its data and commissioned a study conducted by HDR Engineering Inc. to examine the relationship between lead in drinking water and galvanized plumbing.

The study was presented in October 2009 and a journal publication is being prepared that will go through a peer review process before publication.

What are galvanized pipes?

Galvanized iron pipes are actually steel pipes that are covered with a protective layer of zinc.

Galvanized pipes were installed in many homes that were built before the 1960s.

Over many years, zinc erodes from galvanized pipes. Corrosion can build-up on the inside walls of the pipes and creates the potential for lead to accumulate over time.

Corrosion in galvanized pipes can lead to lower water pressure and water quality issues.

Should I be concerned about my galvanized pipes?

Customers, who have galvanized pipes and have or had lead service lines, can potentially have lead released in tap water from these corroded pipes.

* Customers that had lead service lines replaced, but still have galvanized pipes, are still susceptible to lead in water from lead released from the galvanized pipes.

Customers that never had lead service lines, but have galvanized pipes, are not at significant risk for lead release from galvanized iron pipes.

How can customers determine if they have galvanized pipes?

Find where your piping enters your home and then scratch it. If the piping is:

- Copper —the scratched area will have the look of a copper penny.
- Galvanized steel —the scratched area will be a silver-gray color and have threads.
- Plastic —usually white in color and you will be able to see a clamp where it is joined to the water supply piping.

A plumber can advise you of the type of pipes in your home.

What is the relationship between galvanized pipes and lead?

LEAD IN DRINKING WATER

Information provided by the Environmental Protection Agency

Lead is a common metal found throughout the environment in lead-based paint, air, soil, household dust, food, certain types of pottery, porcelain, pewter, and in drinking water. Lead can pose a significant risk to your health. It can cause damage to the brain, red blood cells and kidneys. The greatest risk is to young children and pregnant women. Lead has been shown to slow down normal mental and physical development of infants and children.

Lead enters drinking water primarily as a result of the corrosion, or wearing away, of materials containing lead in the water distribution system and plumbing. These materials include lead-based solder used to join copper pipe, brass and chrome plated faucets, and in some cases, pipes made of lead.

You can evaluate various means to reduce lead levels. This may include replacing fixtures and piping that may be contributing lead to the water and/or installing chemical corrosion control treatment. The program selected should be conducted in accordance with the requirements of the EPA, the State of Connecticut, Department of Public Health (DPH) and your local health department.

Sources of Lead in Drinking Water:

Lead levels in your drinking water are likely to be highest if:

- Your home has faucets or fittings of brass which contains some lead, or
- Your home or water system has lead pipes, or
- Your home has copper pipes with solder, and
- The house is less than five years old, or
- You have naturally soft water, or
- Water often sits in the pipes for several hours.

Q: Why is lead a problem?

A: Although it has been used in numerous consumer products, lead is a toxic metal now known to be harmful to human health if inhaled or ingested. Important sources of lead exposure include: ambient air, soil and dust (both inside and outside the home), food (which can be contaminated by lead in the air or in food containers), and water (from the corrosion of plumbing). On average, it is estimated that lead in drinking water contributes between 10 and 20 percent of total exposure (from all sources). Known effects of exposure to lead range from subtle biochemical changes at low levels of exposure, to severe neurological and toxic effects or even death at extremely high levels.

Q: Does lead affect everyone equally?

A: Young children, infants and fetuses appear to be particularly vulnerable to lead poisoning. A dose of lead that would have little effect on an adult can have a big effect on a small body. Also, growing children will more rapidly absorb any lead they consume. A child's mental and physical development can be irreversibly stunted by over-exposure to lead. In infants, whose diet consists of liquids made with water makes up an even greater proportion of total lead exposure (40 to 60 percent).

Q: How could lead get into my drinking water?

A: Typically, lead gets into water after water leaves your local treatment plant or well. That is, the source of lead in your home's water is most likely pipe or solder in your home's own plumbing. The most common cause is corrosion, a reaction between the water and the lead pipes or solder. Dissolved oxygen, low pH (acidity) and low mineral content in water are common causes of corrosion. All kinds of water, however may have high levels of lead. One factor that increases corrosion is the practice of grounding electrical equipment (such as telephones) to water pipes. Any electric current traveling through the ground wire will accelerate the corrosion of lead in pipes. (Nevertheless, wires should not be removed from pipes unless a qualified electrician installs an adequate alternative grounding system.)

Q: Does my home's age make a difference?

A: Lead-contaminated drinking water is most often a problem in houses that are very old or very new. Up through the early 1990's, it was common practice, in some areas of the county, to use lead pipes for interior plumbing. Also, lead piping was often used for the service connections that join residences to public water supplies. (This practice ended only recently in some localities.) Plumbing installed before 1930 is most likely to contain lead. Copper pipes have replaced lead pipes in most residential plumbing. However, the use of lead solder with copper pipes is widespread. Experts regard this lead solder as the major cause of lead contamination of household water in U. S. homes today. New brass faucets and fittings can also leach lead, even though they are "lead-free." Scientific data indicate that the newer the home, the greater the risk of lead contamination. Lead levels decrease as a building ages. This is because, as time passes, mineral deposits form a coating on the inside of the pipes (if the water is not corrosive). This coating insulates the water from the solder. But, during the first five years (before the coating forms) water is in direct contact with the lead. More likely than not, water in buildings less than five years old has high levels of lead contamination.

Q: How can I tell if my water contains too much lead?

A: You should have your water tested for lead. Testing costs between $20 and $100. Since you cannot see, taste, or smell lead dissolved in water, testing is the only sure way of telling whether or not there are harmful quantities of lead in your drinking water. You should be particularly suspicious if your home has lead pipes (lead is a dull gray metal that is soft enough to be easily scratched with a house key), if you see signs of corrosion (frequent leaks, rust colored water, stained dishes or laundry, or if your non-plastic plumbing is less than five years old). Your water supplier may have useful information, including whether or not the service connector used in your home or area is made of lead. Testing is especially important in high-rise buildings where flushing might not work.

Q: How do I have my water tested?

A: Water samples from the tap will have to be collected and sent to a qualified laboratory for analysis. Contact your local water utility or your local health department for information and assistance. In some instances, these authorities will test your tap water for you, or they can refer you to a qualified laboratory. Contact the CTDPH Laboratory Certification Program, at 860-509-7389, to find out which laboratories have been certified for conducting lead analyses.

Q: What are the testing procedures?

A: Arrangements for sample collection will vary. A few laboratories will send a trained technician to take the samples; but in most cases, the lab will provide sample containers along with instructions as to how you should draw your own tap-water samples. If you collect the samples yourself, make sure you follow the lab's instructions exactly. Otherwise, the results might not be reliable. Make sure that the laboratory is following EPA's water sampling and analysis procedures. Be certain to take a "first draw" and a "fully flushed" sample.

Q: How much lead is too much?

A: Federal standards initially limited the amount of lead in water to 50 ppb. In light of new health and exposure data, EPA has set an action level of 15 ppb. If tests show that the level of lead in your household water is in the area of 15 ppb or higher, it is advisable, especially if there are young children in the home, to reduce the lead level in your tap water as much as possible. (EPA estimates that more than 40 million U. S. residents use water that can contain lead in excess of 15 ppb.) Note: One ppb is equal to 1.0 micrograms per liter (µg/1) or 0.001 milligrams per liter (mg/1).

Q: How can I reduce my exposure?

A: If your drinking water is contaminated with lead, or until you find out for sure, there are several things you can do to minimize your exposure. Two of these actions should be taken right away by everyone who has, or suspects, a problem. The advisability of other actions listed here will depend upon your particular circumstances.

STEPS TO REDUCE EXPOSURE TO LEAD IN DRINKING WATER

The following simple steps can be taken to reduce your exposure to lead in drinking water. This is a simple and inexpensive measure you can take to protect your health. "Flush" the tap before using the water for consumption. Flushing the tap means running the cold water faucet until the water gets noticeably colder, usually about 15-30 seconds. Do not cook with, or drink water from the hot tap. Hot water can dissolve more lead; more quickly than cold water. You can consult a variety of sources for additional information. Your family doctor or pediatrician can perform a blood test for lead and provide you with information about the health effects of lead. You can also contact:

1. Your local health department.
2. The Drinking Water Section of the DPH at (860) 509-7333
3. EPA Safe Drinking Water Hotline 1-800-426-4791

Other Actions

- If you are served by a public water system, contact your supplier and ask whether or not the supply system contains lead piping, and whether your water is corrosive. If either answer is yes, ask what steps the supplier is taking to deal with the problem of lead contamination. Drinking water can be treated at the plant to make it less corrosive. (Treatment to reduce corrosion will also save you and the water supplier money reducing damage to plumbing.) Water mains containing lead pipes can be replaced, as well as those portions of lead service connections that are under the jurisdiction of the supplier.
- If you own a well or another water source, you can treat the water to make it less corrosive. Corrosion control devices for individual households include calcite filters and other devices. Calcite filters should be installed in the line between the water source and any lead service connections or lead-soldered pipe.

Definitions:

Corrosion: A dissolving and wearing away of metal caused by a chemical reaction (in this case, between two different metals).

First Draw: The water that immediately comes out when a tap is first opened.

Flush: To open a cold-water tap to clear out all the water which may have been sitting for a long time in the pipes. In new homes, to flush a system means to send large volumes of water gushing through the unused pipes to remove loose particles of solder and flux. (Sometimes this is not done correctly or at all).

Flux: A substance applied during soldering to facilitate the flow of solder. Flux often contains lead and can, itself, be a source of contamination.

Naturally soft water: Any water with low mineral content, lacking the hardness minerals calcium and magnesium.

Public Water System: Any water company supplying water to fifteen (15) or more consumers or twenty-five (25) or more persons, based on the “Design Population” as defined in Section 16-262m-8(a)(3) of the regulations of Connecticut State Agencies, jointly administered by the DPH and the Public Utilities Regulatory Authority, daily at least sixty days (60) of the year.

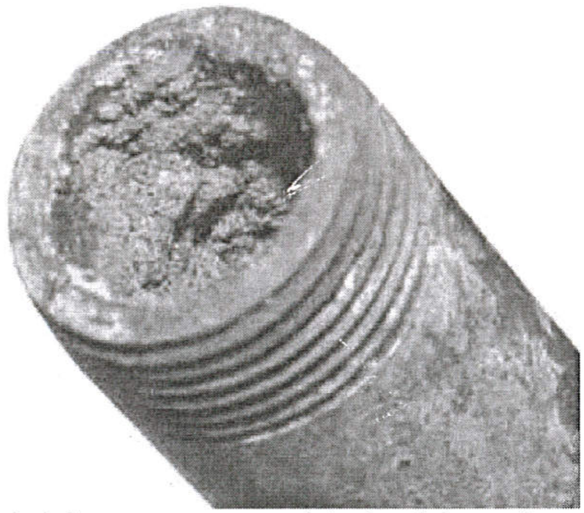
Service Connector: The pipe that carries tap water from the public water main to a building. In the past these were often made of lead.

Soft water: Any water that is not “hard.” Water is considered to be hard when it contains a large amount of dissolved minerals, such as salts containing calcium or magnesium. You may be familiar with hard water that interferes with the lathering action of soap.

Solder: A metallic compound used to seal joints in plumbing. Until recently, most solder contained 50 percent lead.

Homes that have galvanized pipes and have or had lead service lines are at risk for the release of lead in water from corroded pipes.

In-home galvanized iron pipes are found to accumulate lead that is released from lead service lines.



Galvanized piping may accumulate lead deposits over time.

As galvanized pipes corrode and form rust, lead that is accumulated over decades is likely to be found deep in the interior walls of rusty pipes.

Lead in galvanized iron home plumbing can periodically contribute to lead in drinking water.

The only way to ensure that lead is not mobilized from plumbing to tap in a given home is to fully replace the galvanized plumbing and lead service lines.

Galvanized pipes may continue to serve as a lead source in drinking water long after all other sources of lead have been removed, including lead service lines and fixtures.

How can lead be released from galvanized pipes if the lead service lines have been replaced?

Lead accumulated in corroded pipes can persist and be present in household tap water after full replacement of lead service lines, potentially for the remaining service life of the galvanized plumbing.

Although lead service lines have been replaced, the rusted areas of galvanized pipes contain deep layers of iron and lead minerals that have accumulated over decades and continue to be released in water.

Lead released immediately after lead service line replacement can increase as a result of disturbing the fragile interior surfaces of in-home corroded galvanized pipes.

Lead release following lead service replacement varies with location. Typically, a decreasing trend is found in lead release as time elapses following lead service replacement.

What factors should I look for that can increase the release of lead from galvanized pipes?

Lead release from galvanized plumbing can be increased by excessively high water flow or physical disturbances, such as water hammer (vibration of the pipes when they are suddenly turned on or off quickly).

Any modifications or improvements to the plumbing, including water heater installations or even fixture replacements, could potentially lead to short term spikes in lead release.

Does lead released from galvanized pipes vary by location?

The potential for lead release from galvanized plumbing at a given home must be assessed on an individual basis because lead released from galvanized plumbing can differ substantially in magnitude and behavior from one location to another.

Other factors, such as plumbing history, pipe layout in the home, and length of the lead service line might impact the degree to which lead is accumulated in galvanized plumbing at a given location.

Does the current corrosion control treatment effectively minimize lead release from galvanized pipes?

The Washington Aqueduct is responsible for treating the drinking water in the District of Columbia and adds the common food-grade chemical orthophosphate to reduce pipe corrosion.

Introduced in August 2004, orthophosphate has reduced lead concentrations to below EPA's action level of less than or equal to 15 parts per billion.

Orthophosphate works by creating a thin protective coating inside pipes and plumbing fixtures to minimize the corrosion of pipes.

Orthophosphate binds to galvanized pipes, but is only partially able to prevent the rust from breaking off and releasing lead and iron.

Does flushing your water for a specific time decrease the presence of lead from galvanized pipes?

If you have galvanized pipes and have or had lead service lines, lead can be released at any time, and may still be present in water after flushing your taps.

The study recommends replacing galvanized pipes or using NSF certified filters to prevent lead in drinking water.

If you have lead service lines and no galvanized pipes or if you have galvanized pipes and never had a lead service line, DC Water recommends flushing your water for at least two minutes prior to using water for cooking or drinking, when the water has not been used for several hours.

Do galvanized pipes cause discoloration in water?

Yes, in-home galvanized pipes can release iron and cause discoloration.

Based on the study results, is my water safe to drink?

Yes, the drinking water produced by the Washington Aqueduct and delivered to DC residents by DC Water meets all U.S. Environmental Protection Agency (EPA) drinking water standards.

DC Water takes exposure to lead very seriously. Since 2003, DC Water has made exceptional progress in reducing drinking water lead levels. We are far below EPA limits, in fact, our results are lower than the top five major US cities in the northeast, based on current consumer confidence reporting.

If you have or had lead service lines and still have galvanized plumbing, DC Water recommends replacing lead service lines and galvanized pipes or drinking filtered tap water.

What if I am pregnant or have young children?

We take exposure to lead very seriously. If you are pregnant; have children under the age of six; have lead service lines; and/or previously had lead service lines and still have galvanized plumbing:

1. drink filtered tap water and
2. use filtered tap water to prepare infant formula or concentrated juices until the source has been identified and removed.

Boiling water does not reduce lead levels.

The District of Columbia Department of Health's Childhood Lead Poisoning Prevention Program (DC DOH) provides information on how to get a simple blood lead test to check lead levels in young children, pregnant women, and nursing mothers. You can also learn more about how to protect you and your family from lead by contacting the DC DOH at (202) 442-9216, or by visiting its website www.dchealth.dc.gov. If you have additional concerns about a child's health, or would like the screening done by his/her own doctor, please contact his/her pediatrician.

Is it useful to have my water tested for lead?

If you have or had lead service lines and have galvanized pipes, it is likely lead is only periodically released in the water and a single lead test may not be an effective tool in identifying actual lead levels. However, if you have a concern, see our list of certified testing laboratories.

If you are interested in additional information, contact our Customer Service department at (202) 354-3600.

What types of filters does DC Water recommend for removing lead in water?

If you are purchasing a treatment device to reduce lead levels at your tap, choose a treatment device installed at the tap or use a filtration pitcher. These devices must be used, installed, operated and maintained according to manufacturer instructions.

Be sure to purchase a treatment device certified by an independent testing organization, such as NSF International. You can search the NSF International website for certified drinking water treatment devices by visiting.

Please be advised that neither the EPA nor DC Water certifies or endorses specific home drinking water treatment devices.

What do I do if I own a home that has galvanized pipes?

According to the study, the only way to fully ensure that lead is not mobilized from galvanized plumbing in a given home is to fully replace the galvanized plumbing.

What do I do if I live in a rental property that has galvanized pipes?

Contact your property manager or landlord to discuss this issue.

See the recommendations above for filter options.

How long has DC Water known about the finding of the HDR Report?

The study was presented in October 2009.

How is DC Water planning to alert stakeholders and residents of these new findings?

DC Water will be hosting a forum and will provide information and recommendations to all its customers on the website, in the customer newsletter and in a future bill.

Will the Department of Health and EPA be notified?

DC Water has shared the study results with DDOH, DDOE and EPA.

Where can I go for additional information or assistance?

DC Water and Sewer Authority —For questions relative to water quality in your home, contact the Drinking Water Division at (202)612-3440, email drinkingwater@dcwater.com.

DC Department of the Environment —You can learn more about how to protect you and your family from lead by contacting the DDOE at (202) 535-2600, or by visiting the website www.ddoe.dc.gov.

Environmental Protection Agency —For information on reducing lead exposure around your home and the health effects of lead, visit EPA's website at www.epa.gov/lead.

Mother Jones

Lead: America's Real Criminal Element

The hidden villain behind violent crime, lower IQs, and even the ADHD epidemic.

By Kevin Drum | Thu Feb 11, 2016 6 58 PM EST

When Rudy Giuliani ran for mayor of New York City in 1993, he campaigned on a platform of bringing down crime and making the city safe again. It was a comfortable position for a former federal prosecutor with a tough-guy image, but it was more than mere posturing. Since 1960, rape rates had nearly quadrupled, murder had quintupled, and robbery had grown fourteenfold. New Yorkers felt like they lived in a city under siege.

Throughout the campaign, Giuliani embraced a theory of crime fighting called "broken windows," popularized a decade earlier by James Q. Wilson and George L. Kelling in an influential article in *The Atlantic*. [1] "If a window in a building is broken and is left unrepaired," they observed, "all the rest of the windows will soon be broken." So too, tolerance of small crimes would create a vicious cycle ending with entire neighborhoods turning into war zones. But if you cracked down on small crimes, bigger crimes would drop as well.

Giuliani won the election, and he made good on his crime-fighting promises by selecting Boston police chief Bill Bratton as the NYPD's new commissioner. Bratton had made his reputation as head of the New York City Transit Police, where he aggressively applied broken-windows policing to turnstile jumpers and vagrants in subway stations. With Giuliani's eager support, he began applying the same lessons to the entire city, going after panhandlers, drunks, drug pushers, and the city's hated squeegee men. And more: He decentralized police operations and gave precinct commanders more control, keeping them accountable with a pioneering system called CompStat that tracked crime hot spots in real time.

[2]

Flint Kids Have So Much Lead in Their Blood That the Mayor Declared a State of Emergency. [2]

The results were dramatic. In 1996, the *New York Times* reported [3] that crime had plunged for the third straight year, the sharpest drop since the end of Prohibition. Since 1993, rape rates had dropped 17 percent, assault 27 percent, robbery 42 percent, and murder an astonishing 49 percent. Giuliani was on his way to becoming America's Mayor and Bratton was on the cover of *Time*. It was a remarkable public policy victory.

But even more remarkable is what happened next. Shortly after Bratton's star turn, political scientist John DiIulio warned that the echo of the baby boom would soon produce a demographic bulge of millions of young males that he famously dubbed "juvenile super-predators [5]." Other criminologists nodded along. But even though the demographic bulge came right on schedule, crime continued to drop. And drop. And drop. By 2010, violent crime rates in New York City had plunged 75 percent from their peak in the early '90s.

[4]

This Mom Helped Uncover Flint's Toxic Water Crisis [4]

All in all, it seemed to be a story with a happy ending, a triumph for Wilson and Kelling's theory and Giuliani and Bratton's practice. And yet, doubts remained. For one thing, violent crime actually peaked in New York City in 1990, four years before the Giuliani-Bratton era. By the time they took office, it had already dropped 12 percent.

Second, and far more puzzling, it's not just New York that has seen a big drop in crime. In city after city, violent crime peaked in the early '90s and then began a steady and spectacular decline. Washington, DC, didn't have either Giuliani or Bratton, but its violent crime rate has dropped 58 percent since its peak. Dallas' has fallen 70 percent. Newark: 74 percent. Los Angeles: 78 percent.

There must be more going on here than just a change in policing tactics in one city. But what?

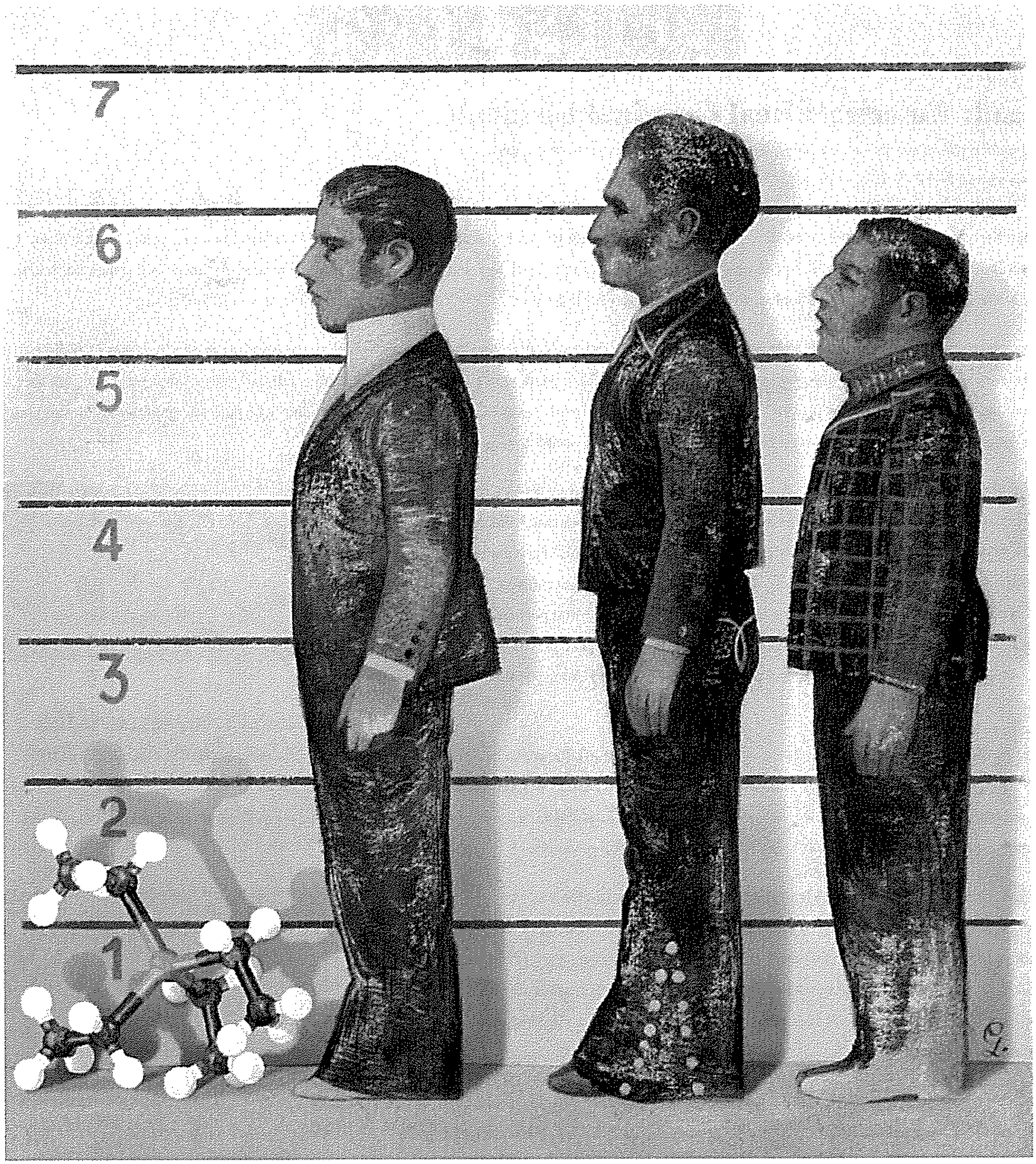


Illustration: Gérard DuBois

There are, it turns out, plenty of theories. When I started research for this story, I worked my way through a pair of thick [6] criminology tomes [7]. One chapter regaled me with the "exciting possibility" that it's mostly a matter of economics: Crime goes down when the economy is booming and goes up when it's in a slump. Unfortunately, the theory doesn't seem to hold water—for example, crime rates have continued to drop recently despite our prolonged downturn.

Another chapter suggested that crime drops in big cities were mostly a reflection of the crack epidemic of the '80s finally burning itself out. A trio of authors identified three major "drug eras" in New York City, the first dominated by heroin, which produced limited violence, and the second by crack, which generated spectacular levels of it. In the early '90s, these researchers proposed, the children of CrackGen switched to marijuana, choosing a less violent and more law-abiding lifestyle. As they did, crime rates in New York and other cities went down.

Another chapter told a story of demographics: As the number of young men increases, so does crime. Unfortunately for this theory, the number of young men increased during the '90s, but crime dropped anyway.

There were chapters in my tomes on the effect of prison expansion. On guns and gun control. On family. On race. On parole and probation. On the raw number of police officers. It seemed as if everyone had a pet theory. In 1999, economist Steven Levitt, later famous as the coauthor of *Freakonomics*, teamed up with John Donohue to suggest that crime dropped because of *Roe v. Wade* [8]; legalized abortion, they argued, led to fewer unwanted babies, which meant fewer maladjusted and violent young men two decades later.

But there's a problem common to all of these theories: It's hard to tease out actual proof. Maybe the end of the crack epidemic contributed to a decline in inner-city crime, but then again, maybe it was really the effect of increased incarceration, more cops on the beat, broken-windows policing, and a rise in abortion rates 20 years earlier. After all, they all happened at the same time.

To address this problem, the field of econometrics gives researchers an enormous toolbox of sophisticated statistical techniques. But, notes statistician and conservative commentator Jim Manzi in his recent book *Uncontrolled* [9], econometrics consistently fails to explain most of the variation in crime rates. After reviewing 122 known field tests, Manzi found that only 20 percent demonstrated positive results for specific crime-fighting strategies, and none of those positive results were replicated in follow-up studies.

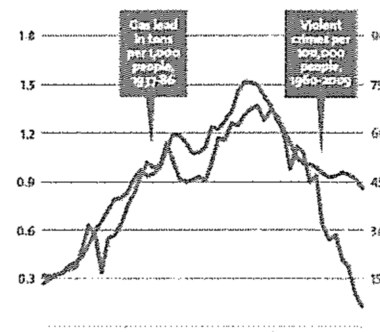
So we're back to square one. More prisons might help control crime, more cops might help, and better policing might help. But the evidence is thin for any of these as the main cause. What are we missing?

Experts often suggest that crime resembles an epidemic. But what kind? Karl Smith, a professor of public economics and government at the University of North Carolina-Chapel Hill, has a good rule of thumb for categorizing epidemics [10]: If it spreads along lines of communication, he says, the cause is information. Think Bieber Fever. If it travels along major transportation routes, the cause is microbial. Think influenza. If it spreads out like a fan, the cause is an insect. Think malaria. But if it's everywhere, all at once—as both the rise of crime in the '60s and '70s and the fall of crime in the '90s seemed to be—the cause is a molecule.

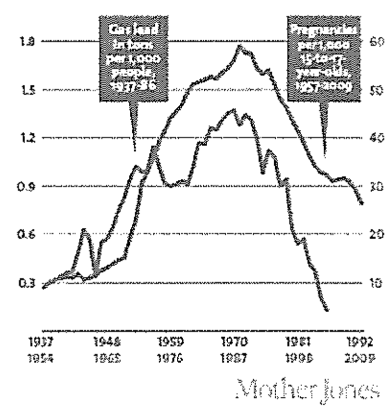
THE PB EFFECT

What happens when you expose a generation of kids to high lead levels? Crime and teen pregnancy data two decades later tell a startling story.

Gasoline lead and violent crime



Gasoline lead and teen pregnancy



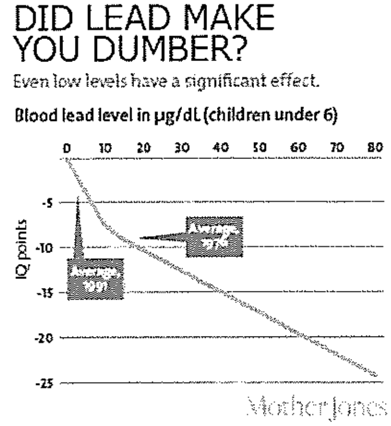
Top: Rick Nevin, USGS, DOJ; Bottom: Rick Nevin, Guttmacher Institute, CDC

A molecule? That sounds crazy. What molecule could be responsible for a steep and sudden decline in violent crime?

Well, here's one possibility: $Pb(CH_2CH_3)_4$.

In 1994, Rick Nevin was a consultant working for the US Department of Housing and Urban Development on the costs and benefits of removing lead paint from old houses. This has been a topic of intense study because of the growing body of research linking lead exposure in small children with a whole raft of complications later in life, including lower IQ, hyperactivity, behavioral problems, and learning disabilities.

But as Nevin was working on that assignment, his client suggested they might be missing something. A recent study had suggested a link between childhood lead exposure and juvenile delinquency later on. Maybe reducing lead exposure had an effect on violent crime too?



Rick Nevin/CDC

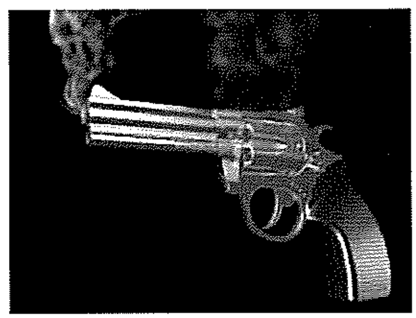
That tip took Nevin in a different direction. The biggest source of lead in the postwar era, it turns out, wasn't paint. It was leaded gasoline. And if you chart the rise and fall of atmospheric lead caused by the rise and fall of leaded gasoline consumption, you get a pretty simple upside-down U: Lead emissions from tailpipes rose steadily from the early '40s through the early '70s, nearly quadrupling over that period. Then, as unleaded gasoline began to replace leaded gasoline, emissions plummeted.

Intriguingly, violent crime rates followed the same upside-down U pattern. The only thing different was the time period: Crime rates rose dramatically in the '60s through the '80s, and then began dropping steadily starting in the early '90s. The two curves looked eerily identical, but were offset by about 20 years.

Gasoline lead may explain as much as 90 percent of the rise and fall of violent crime over the past half century.

So Nevin dove in further, digging up detailed data on lead emissions and crime rates to see if the similarity of the curves was as good as it seemed. It turned out to be even better: In a 2000 paper [11] (PDF) he concluded that if you add a lag time of 23 years, lead emissions from automobiles explain 90 percent of the variation in violent crime in America. Toddlers who ingested high levels of lead in the '40s and '50s really were more likely to become violent criminals in the '60s, '70s, and '80s.

And with that we have our molecule: tetraethyl lead, the gasoline additive invented by General Motors in the 1920s to prevent knocking and pinging in high-performance engines. As auto sales boomed after World War II, and drivers in powerful new cars increasingly asked service station attendants to "fill 'er up with ethyl," they were unwittingly creating a crime wave two decades later.



[12]

How Dangerous Is Lead in Bullets? [12]

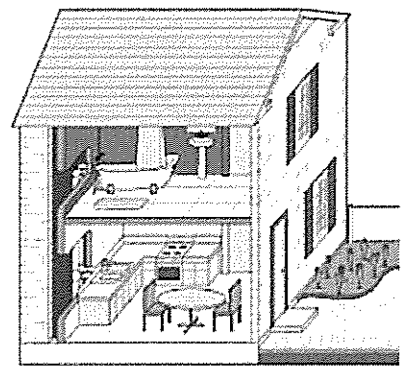
It was an exciting conjecture, and it prompted an immediate wave of...nothing. Nevin's paper was almost completely ignored, and in one sense it's easy to see why—Nevin is an economist, not a criminologist, and his paper was published in *Environmental Research*, not a journal with a big readership in the criminology community. What's more, a single correlation between two curves isn't all that impressive, econometrically speaking. Sales of vinyl LPs rose in the postwar period too, and then declined in the '80s and '90s. Lots of things follow a pattern like that. So no matter how good the fit, if you only have a single correlation it might just be a coincidence. You need to do something more to establish causality.

As it turns out, however, a few hundred miles north someone was doing just that. In the late '90s, Jessica Wolpaw Reyes was a graduate student at Harvard casting around for a dissertation topic that eventually became a study she published in 2007 as a public health policy professor at Amherst. "I learned about lead because I was pregnant and living in old housing in Harvard Square," she told me, and after attending a talk where future *Freakonomics* star Levitt outlined his abortion/crime theory, she started thinking about lead and crime. Although the association seemed plausible, she wanted to find out whether increased lead exposure *caused* increases in crime. But how?

In states where consumption of leaded gasoline declined slowly, crime declined slowly. Where it

The answer, it turned out, involved "several months of cold calling" to find lead emissions data at the state level. During the '70s and '80s, the introduction of the catalytic converter, combined with increasingly stringent Environmental Protection Agency rules, steadily reduced the amount of leaded gasoline used in America, but Reyes discovered that this reduction wasn't uniform. In fact, use of leaded gasoline varied widely among states, and this gave Reyes the opening she needed. If childhood lead exposure really did produce criminal behavior in adults, you'd expect that in states where consumption of leaded gasoline declined slowly, crime would decline slowly too. Conversely, in states where it declined quickly, crime would decline quickly. And that's exactly what she found [13].

declined quickly, crime declined quickly.



[14]

Is There Lead in Your House? [14]

Meanwhile, Nevin had kept busy as well, and in 2007 he published a new paper looking at crime trends around the world [15] (PDF). This way, he could make sure the close match he'd found between the lead curve and the crime curve wasn't just a coincidence. Sure, maybe the real culprit in the United States was something else happening at the exact same time, but what are the odds of that same something happening at several *different* times in several *different* countries?

Nevin collected lead data and crime data for Australia and found a close match. Ditto for Canada. And Great Britain and Finland and France and Italy and New Zealand and West Germany. Every time, the two curves fit each other astonishingly well. When I spoke to Nevin about this, I asked him if he had ever found a country that didn't fit the theory. "No," he replied. "Not one."

Just this year, Tulane University researcher Howard Mielke published a paper [16] with demographer Sammy Zahran on the correlation of lead and crime at the city level. They studied six US cities that had both good crime data and good lead data going back to the '50s, and they found a good fit in every single one. In fact, Mielke has even studied lead concentrations at the *neighborhood* level in New Orleans and shared his maps with the local police. "When they overlay them with crime maps," he told me, "they realize they match up."

LOCATION, LOCATION, LOCATION

In New Orleans, lead levels can vary dramatically from one neighborhood to the next—and the poorest neighborhoods tend to be the worst hit.

Put all this together and you have an astonishing body of evidence. We now have studies at the international level, the national level, the state level, the city level, and even the individual level. Groups of children have been followed from the womb to adulthood, and higher childhood blood lead levels are consistently associated with higher adult arrest rates for violent crimes [17]. All of these studies tell the same story: Gasoline lead is responsible for a good share of the rise and fall of violent crime over the past half century.

Like many good theories, the gasoline lead hypothesis helps explain some things we might not have realized even needed explaining. For example, murder rates have always been higher in big cities than in towns and small cities. We're so used to this that it seems unsurprising, but Nevin points out that it might actually have a surprising explanation—because big cities have lots of cars in a small area, they also had high densities of atmospheric lead during the postwar era. But as lead levels in gasoline decreased, the differences between big and small cities largely went away. And guess what? The difference in murder rates went away too. Today, homicide rates are similar in cities of all sizes [18]. It may be that violent crime isn't an inevitable consequence of being a big city after all.

When differences of atmospheric lead density between big and small cities largely went away, so did the difference in murder rates.

The gasoline lead story has another virtue too: It's the only hypothesis that persuasively explains both the rise of crime in the '60s and '70s and its fall beginning in the '90s. Two other theories—the baby boom demographic bulge and the drug explosion of the '60s—at least have the potential to explain both, but neither one fully fits the known data. Only gasoline lead, with its dramatic rise and fall following World War II, can explain the equally dramatic rise and fall in violent crime.

If econometric studies were all there were to the story of lead, you'd be justified in remaining skeptical no matter how good the statistics look. Even when researchers do their best—controlling for economic growth, welfare payments, race, income, education level, and everything else they can think of—it's always possible that something they haven't thought of is still lurking in the background. But there's another reason to take the lead hypothesis seriously, and it might be the most compelling one of all: Neurological research is demonstrating that lead's effects are even more appalling, more permanent, and appear at far lower levels than we ever thought. For starters, it turns out that childhood lead exposure at nearly *any* level can seriously and permanently reduce IQ. Blood lead levels are measured in micrograms per deciliter, and levels once believed safe—65 μg/dL, then 25, then 15, then 10—are now known to cause serious damage. The EPA now says [19] flatly that there is "no demonstrated safe concentration of lead in blood," and it turns out that even levels under 10 μg/dL can reduce IQ by as much as seven points. An estimated 2.5 percent of children nationwide have lead levels above 5 μg/dL.

But we now know that lead's effects go far beyond just IQ. Not only does lead promote apoptosis, or cell death, in the brain, but the element is also chemically similar to calcium. When it settles in cerebral tissue, it prevents calcium ions from doing their job, something that causes physical damage to the developing brain that persists into adulthood.

Only in the last few years have we begun to understand exactly what effects this has. A team of researchers at the University of Cincinnati has been following a group of 300 children for more than 30 years and recently performed a series of MRI scans that highlighted the neurological differences between subjects who had high and low exposure to lead during early childhood.

High childhood exposure damages a part of the brain linked to aggression control. The impact is greater among boys.

One set of scans [20] found that lead exposure is linked to production of the brain's white matter—primarily a substance called myelin, which forms an insulating sheath around the connections between neurons. Lead exposure degrades both the formation and structure of myelin, and when this happens, says Kim Dietrich, one of the leaders of the imaging studies, "neurons are not communicating effectively." Put simply, the network connections within the brain become both slower and less coordinated.

A second study [21] found that high exposure to lead during childhood was linked to a permanent loss of gray matter in the prefrontal cortex—a part of the brain associated with aggression control as well as what psychologists call "executive functions": emotional regulation, impulse control, attention, verbal reasoning, and mental flexibility. One way to understand this, says Kim Cecil, another member of the Cincinnati team, is that lead affects precisely the areas of the brain "that make us most human."

So lead is a double whammy: It impairs specific parts of the brain responsible for executive functions *and* it impairs the communication channels between these parts of the brain. For children like the ones in the Cincinnati study, who were mostly inner-city kids with plenty of strikes against them already, lead exposure was, in Cecil's words, an "additional kick in the gut." And one more thing: Although both sexes are affected by lead, the neurological impact turns out to be greater among boys than girls.

[22]
How Hidden Lead Can Sicken Your Kids
[22]Zurijeta/Shutterstock

Other recent [23] studies link [24] even minuscule blood lead levels with attention deficit/hyperactivity disorder. Even at concentrations well below those usually considered safe—levels still common today—lead increases the odds of kids developing ADHD.

In other words, as Reyes summarized the evidence in her paper, even moderately high levels of lead exposure are associated with aggressivity, impulsivity, ADHD, and lower IQ. And right there, you've practically defined the profile of a violent young offender.

Needless to say, not every child exposed to lead is destined for a life of crime. Everyone over the age of 40 was probably exposed to too much lead during childhood, and most of us suffered nothing more than a few points of IQ loss. But there were plenty of kids already on the margin, and millions of those kids were pushed over the edge from being merely slow or disruptive to becoming part of a nationwide epidemic of violent crime. Once you understand that, it all becomes blindingly obvious. *Of course* massive lead exposure among children of the postwar era led to larger numbers of violent criminals in the '60s and beyond. And *of course* when that lead was removed in the '70s and '80s, the children of that generation lost those artificially heightened violent tendencies.

Police chiefs want to think what they do on a daily basis matters. And it does. But maybe not as much as they think.

But if all of this solves one mystery, it shines a high-powered klieg light on another: Why has the lead/crime connection been almost completely ignored in the criminology community? In the two big books I mentioned earlier, one has no mention of lead at all and the other has a grand total of two passing references. Nevin calls it "exasperating" that crime researchers haven't seriously engaged with lead, and Reyes told me that although the public health community was interested in her paper, criminologists have largely been AWOL. When I asked Sammy Zahran about the reaction to his paper with Howard Mielke on correlations between lead and crime at the city level, he just sighed. "I don't think criminologists have even read it," he said. All of this jibes with my own reporting. Before he died last year, James Q. Wilson—father of the broken-windows theory, and the dean of the criminology community—had begun to accept that lead probably played a meaningful role in the crime drop of the '90s. But he was apparently an outlier. None of the criminology experts I contacted showed any interest in the lead hypothesis at all.

Why not? Mark Kleiman [25], a public policy professor at the University of California-Los Angeles who has studied promising methods of controlling crime, suggests that because criminologists are basically sociologists, they look for sociological explanations, not medical ones. My own sense is that interest groups probably play a crucial role: Political conservatives want to blame the social upheaval of the '60s for the rise in crime that followed. Police unions have reasons for crediting its decline to an increase in the number of cops. Prison guards like the idea that increased incarceration is the answer. Drug warriors want the story to be about drug policy. If the actual answer turns out to be lead poisoning, they all lose a big pillar of support for their pet issue. And while lead abatement could be big business for contractors and builders, for some reason their trade groups have never taken it seriously.

More generally, we all have a deep stake in affirming the power of deliberate human action. When Reyes once presented her results to a conference of police chiefs, it was, unsurprisingly, a tough sell. "They want to think that what they do on a daily basis matters," she says. "And it does." But it may not matter as much as they think.

So is this all just an interesting history lesson? After all, leaded gasoline has been banned since 1996, so even if it had a major impact on violent crime during the 20th century, there's nothing more to be done on that front. Right?

Wrong. As it turns out, tetraethyl lead is like a zombie that refuses to die. Our cars may be lead-free today, but they spent more than 50 years spewing lead from their tailpipes, and all that lead had to go somewhere. And it did: It settled permanently into the soil that we walk on, grow our food in, and let our kids play around.

That's especially true in the inner cores of big cities, which had the highest density of automobile traffic. Mielke has been studying lead in soil for years, focusing most of his attention on his hometown of New Orleans, and he's measured 10 separate census tracts there with lead levels over 1,000 parts per million.

To get a sense of what this means, you have to look at how soil levels of lead typically correlate with blood levels, which are what really matter. Mielke has studied this in New Orleans [26], and it turns out that the numbers go up very fast even at low levels. Children who live in neighborhoods with a soil level of 100 ppm have average blood lead concentrations of 3.8 µg/dL—a level that's only barely tolerable. At 500 ppm, blood levels go up to 5.9 µg/dL, and at 1,000 ppm they go up to 7.5 µg/dL. These levels are high enough to do serious damage.

"I know people who have move into gentrified neighborhoods and renovate everything. They create huge hazards for their kids."

Mielke's partner, Sammy Zahran, walked me through a lengthy—and hair-raising—presentation about the effect that all that old gasoline lead continues to have in New Orleans. The very first slide describes the basic problem: Lead in soil doesn't *stay* in the soil. Every summer, like clockwork, as the weather dries up, all that lead gets kicked back into the atmosphere in a process called resuspension. The zombie lead is back to haunt us.

Mark Laidlaw, a doctoral student who has worked with Mielke, explains how this works [27]: People and pets track lead dust from soil into houses, where it's ingested by small children via hand-to-mouth contact. Ditto for lead dust generated by old paint inside houses. This dust cocktail is where most lead exposure today comes from.

Paint hasn't played a big role in our story so far, but that's only because it didn't play a big role in the rise of crime in the postwar era and its subsequent fall. Unlike gasoline lead, lead paint was a fairly uniform problem during this period, producing higher overall lead levels, especially in inner cities, but not changing radically over time. (It's a different story with the first part of the 20th century, when use of lead paint did rise and then fall somewhat dramatically. Sure enough, murder rates rose and fell in tandem.)

And just like gasoline lead, a lot of that lead in old housing is still around. Lead paint chips flaking off of walls are one obvious source of lead exposure, but an even bigger one, says Rick Nevin, are old windows. Their friction surfaces generate lots of dust as they're opened and closed. (Other sources—lead pipes and solder, leaded fuel used in private aviation, and lead smelters—account for far less.)

We know that the cost of all this lead is staggering, not just in lower IQs, delayed development, and other health problems, but in increased rates of violent crime as well. So why has it been so hard to get it taken seriously?

There are several reasons. One of them was put bluntly by Herbert Needleman, one of the pioneers of research into the effect of lead on behavior. A few years ago, a reporter from the *Baltimore City Paper* asked him why so little progress had been made recently on combating the lead-poisoning problem. "Number one," he said without hesitation [28], "it's a black problem." But it turns out that this is an outdated idea. Although it's true that lead poisoning affects low-income neighborhoods disproportionately, it affects plenty of middle-class and rich neighborhoods as well. "It's not just a poor-inner-city-kid problem anymore," Nevin says. "I know people who have moved into gentrified neighborhoods and immediately renovate everything. And they create huge hazards for their kids."

Tamara Rubin, who lives in a middle-class neighborhood in Portland, Oregon, learned this the hard way when two of her children developed lead poisoning after some routine home improvement in 2005. A few years later, Rubin started the Lead Safe America Foundation [29], which advocates for lead abatement and lead testing. Her message: If you live in an old neighborhood or an old house, get tested. And if you renovate, do it safely.

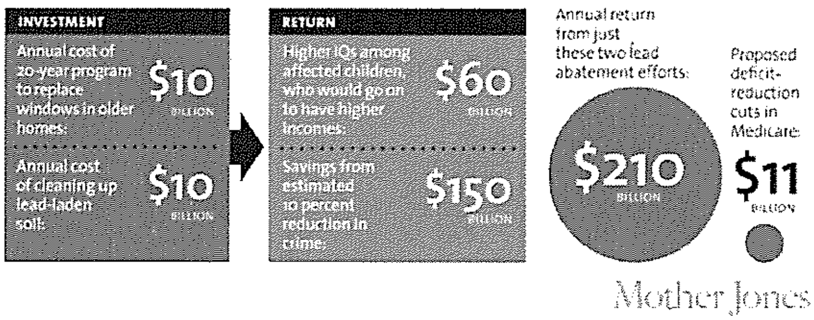
Another reason that lead doesn't get the attention it deserves is that too many people think the problem was solved years ago. They don't realize how much lead is still hanging around, and they don't understand just how much it costs us.

It's difficult to put firm numbers to the costs and benefits of lead abatement. But for a rough idea, let's start with the two biggest costs. Nevin estimates that there are perhaps 16 million pre-1960 houses with lead-painted windows, and replacing them all would cost something like $10 billion per year over 20 years. Soil cleanup in the hardest-hit urban neighborhoods is tougher to get a handle on, with estimates ranging from $2 to $36 per square foot. A rough extrapolation from Mielke's estimate to clean up New Orleans suggests that a nationwide program might cost another $10 billion per year.

So in round numbers that's about $20 billion per year for two decades. But the benefits would be huge. Let's just take a look at the two biggest ones. By Mielke and Zahran's estimates, [30] if we adopted the soil standard of a country like Norway (roughly 100 ppm or less), it would bring about $30 billion in annual returns from the cognitive benefits alone (higher IQs, and the resulting higher lifetime earnings). Cleaning up old windows might double this. And violent crime reduction would be an even bigger benefit. Estimates here are even more difficult, but Mark Kleiman suggests that a 10 percent drop in crime—a goal that seems reasonable if we get serious about cleaning up the last of our lead problem—could produce benefits as high as $150 billion per year.

Put this all together and the benefits of lead cleanup could be in the neighborhood of $200 billion per year. In other words, an annual investment of $20 billion for 20 years could produce returns of 10-to-1 *every single year* for decades to come. Those are returns that Wall Street hedge funds can only dream of.

We can either get rid of the remaining lead, or we can wait 20 years and then lock up all the kids who've turned into criminals.



There's a flip side to this too. At the same time that we should reassess the low level of attention we pay to the remaining hazards from lead, we should probably also reassess the *high* level of attention we're giving to other policies. Chief among these is the prison-building boom that started in the mid-'70s. As crime scholar William Spelman wrote a few years ago, states have "doubled their prison populations, then doubled them again, increasing their costs by more than $20 billion per year"—money that could have been usefully spent on a lot of other things. And while some scholars conclude that the prison boom had an effect on crime, recent research suggests that rising incarceration rates suffer from diminishing returns: Putting more criminals behind bars is useful up to a point, but beyond that we're just locking up more people without having any real impact on crime. What's more, if it's true that lead exposure accounts for a big part of the crime decline that we formerly credited to prison expansion and other policies, those diminishing returns might be even more dramatic than we believe. We probably overshot on prison construction years ago; one doubling might have been enough. Not only should we stop adding prison capacity, but we might be better off returning to the incarceration rates we reached in the mid-'80s.

So this is the choice before us: We can either attack crime at its root by getting rid of the remaining lead in our environment, or we can continue our current policy of waiting 20 years and then locking up all the lead-poisoned kids who have turned into criminals. There's always an excuse not to spend more money on a policy as tedious-sounding as lead abatement—budgets are tight, and research on a problem as complex as crime will never be definitive—but the association between lead and crime has, in recent years, become pretty overwhelming. If you gave me the choice, right now, of spending $20 billion less on prisons and cops and spending $20 billion more on getting rid of lead, I'd take the deal in a heartbeat. Not only would solving our lead problem do more than any prison to reduce our crime problem, it would produce smarter, better-adjusted kids in the bargain. There's nothing partisan about this, nothing that should appeal more to one group than another. It's just common sense. Cleaning up the rest of the lead that remains in our environment could turn out to be the cheapest, most effective crime prevention tool we have. And we could start doing it tomorrow.

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[30] http://www.sciencedirect.com/science/article/pii/S0048969710012672

Beyond Flint: Excessive lead levels found in almost 2,000 water systems across all 50 states

TESTS FOR CITIES, RURAL SUBDIVISIONS AND EVEN SCHOOLS AND DAY CARES SERVING WATER TO 6 MILLION PEOPLE HAVE FOUND EXCESSIVE AND HARMFUL LEVELS OF LEAD.

Alison Young and (/staff/2018/alison-young)

Mark Nichols, USA TODAY (/staff/10047818/mark-nichols)

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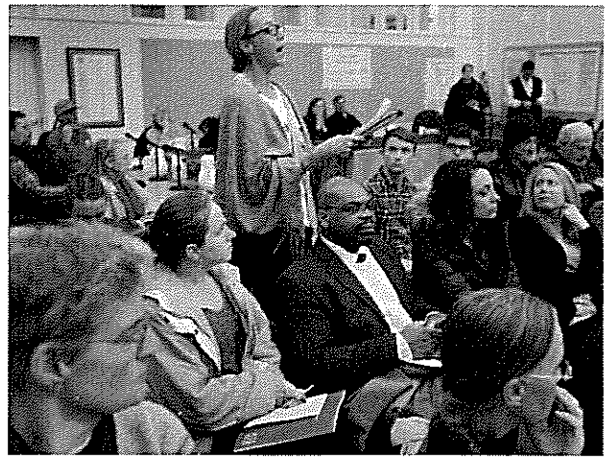
While a harsh national spotlight focuses on the drinking water crisis in Flint, Mich., a USA TODAY NETWORK investigation has identified almost 2,000 additional water systems spanning all 50 states where testing has shown excessive levels of lead contamination over the past four years.

The water systems, which reported lead levels exceeding Environmental Protection Agency standards, collectively supply water to 6 million people. About 350 of those systems provide drinking water to schools or day cares. The USA TODAY NETWORK investigation also found at least 180 of the water systems failed to notify consumers about the high lead levels as federal rules require.

Many of the highest reported lead levels were found at schools and day cares. A water sample at a Maine elementary school was 42 times higher than the EPA limit of 15 parts per billion, while a Pennsylvania preschool was 14 times higher, records show. At an elementary school in Ithaca, N.Y., one sample tested this year at a stunning 5,000 ppb of lead, the EPA's threshold for "hazardous waste."

"This is most definitely a problem that needs emergent care," Melissa Hoffman, a parent in Ithaca, forcefully pleaded with officials at a public hearing packed with upset parents demanding answers.



Melissa Hoffman, 40, expresses her concerns about the high lead levels found at her children's school, Caroline Elementary School, during a town hall meeting March 3, 2016, in Ithaca, N.Y.

(Photo: Romain Blanquart, USA TODAY NETWORK)

In all, the USA TODAY NETWORK analysis of EPA enforcement data identified 600 water systems in which tests at some taps showed lead levels topping 40 parts per billion (ppb), which is more than double the EPA's action level limit. While experts caution Flint is an extreme case of pervasive contamination, those lead levels rival the 400-plus of the worst samples in far more extensive testing of around 15,000 taps across Flint. The 40 ppb mark also stands as a threshold that the EPA once labeled on its website an "imminent" health threat for pregnant women and young children.

Even at small doses, lead poses a health threat, especially for pregnant women and young children. Lead can damage growing brains and cause reduced IQs, attention disorders and other problem behaviors. Infants fed formula made with contaminated tap water face significant risk. Adults are not immune, with evidence linking lead exposure to kidney problems, high blood pressure and increased risks of cardiovascular deaths. The EPA stresses there is no safe level of lead exposure (http://www.usatoday.com/story/news/nation/2016/03/16/what-lead-levels-in-water-mean/81534336/).

Fractured system, limited testing

Most Americans get their drinking water from a fragmented network of about 155,000 different water systems serving everything from big cities to individual businesses and school buildings. The EPA determines that a system has exceeded the lead standard when more than 10% of samples taken show lead levels above 15 parts per billion. It's called an "action level" because, at that level, water systems are required to take action to reduce contamination. But enforcement, which is implemented state by state, can be inconsistent and spotty. Some 373 systems have failed repeatedly, with tests continuing to find excessive lead in tests months or even years later, the EPA data shows. What's more, the systems have widely varying levels of financial resources and staff training.

Amid cotton fields in Lamesa, Texas, for example, tests last year showed lead contamination more than seven times the EPA limit at Klondike Independent School District, which serves 260 students in a single K-12 building. "Some things just slip by," said the school superintendent Steve McLaren when pressed about skipping a round of testing in 2014. In a tiny school system, McLaren said leaders "wear a lot of hats." At times he's served as principal and bus driver, in addition to being superintendent and in charge of the drinking water system. The school replaced drinking fountains, and plans to replace its entire water system next fall. McLaren said he's concerned about how high lead levels might affect students and understands the need for action. But he said, "Our kids are strapping and healthy, and they've been drinking this water all their lives."

The testing required by the government can include samples from as few as five or 10 taps in a year, or even over multiple years. The system is designed only to give an indication of whether homes or buildings with lead pipes and plumbing may be at higher risk of lead leaching into water. Even the biggest water systems in cities are required to test just 50 to 100 taps.

The limited and inconsistent testing means the full scope of the lead contamination problem could be even more widespread. People in thousands more communities served by water systems that have been deemed in compliance with the EPA's lead rules have no assurance their drinking water is safe from the brain-damaging toxin.

"This is just a case where we have a rule that's not been adequately protective," said Lynn Goldman, a former EPA official and dean of George Washington University's school of public health. "The entire design of the regulation doesn't tell you about your own water."

Drinking water typically isn't contaminated with lead when it leaves the treatment plant. It becomes contaminated as it travels through lead service lines on individual properties and lead plumbing fixtures inside homes. At best, the EPA's rules and testing are a sentinel system, alerting officials of the need to treat their water with anti-corrosion chemicals. Doing so reduces, but does not eliminate, the lead in water reaching the tap.

USA TODAY
How much lead in water poses an imminent threat?

(http://www.usatoday.com/story/news/nation/2016/03/16/what-lead-levels-in-water-mean/81534336/)

There are about 75 million homes across the country built before 1980, meaning they're most likely to contain some lead plumbing. That's more than half of the country's housing units, according to the Census Bureau. The heaviest concentrations are in New York, Rhode Island, Massachusetts, Connecticut and Pennsylvania.

"You would hope that the cities and the counties and the state and the federal government would be holding people's feet to the fire when it comes to providing quality water to the consumer if there is an issue," said Terry Heckman, a board member at the Arizona Water Quality Association, a group that represents water systems. "That's what the government is supposed to do, is look over the general welfare of the populace."

Flint's risk factors not rare

Experts say what happened in Flint is an extreme case and helps show how the limited testing required by the EPA provides only a crude indicator of systems where harmful levels of lead may be in water at homes with lead pipes.

The struggling city of about 100,000 people passed the government's required lead tests. But one resident's vocal complaints spurred extra tests at her home, revealing shocking levels of lead contamination: 104 to 13,200 ppb. The crisis worsened as independent researchers tested 300 samples across the city, revealing homes with high lead levels that the government-mandated tests missed. More than 10% contained at least 27 ppb of lead. Since then, regulators conducted another 15,000 tests. More than 1,000 samples show lead above the 15 ppb limit, and more than 400 show dangerous levels above 40 ppb.

One unique factor in Flint: the water department changed to a corrosive river water source, then failed to treat it with anti-corrosion chemicals. The result: a pervasive contamination problem as the insides of old lead pipes broke down and released a torrent of poison.

Yet the fundamental risk factor in Flint – old lead service lines that deliver water to homes (https://youtu.be/nQSRWovWfvo), plus interior plumbing containing lead – is a common problem for tens of millions of homes mostly built before 1986. Unlike other contaminants that can be filtered out at the water plant, lead usually gets into drinking water at the end of the system, as it comes onto individual properties and into homes.

At greatest risk, experts say, are an estimated 7.3 million homes connected to their utility's water mains by individual lead service lines -- the pipe carrying water from the main under the street onto your property and into your home. The water passes through what amounts to "a pure lead straw," said Marc Edwards, a Virginia Tech environmental engineering professor who has studied water contamination in Flint and a similar, earlier crisis in Washington, D.C.

Lead service lines were mostly installed before the 1930s, although some communities continued to lay lead pipes for decades longer.

The way tap water becomes contaminated — at or even inside individual homes — poses a vexing problem for regulators, utilities and consumers. A home with a lead service line and older internal plumbing may have high levels of lead in its tap water. But a nearby, newly constructed home may have no lead contamination. The only way to know if your house is at risk is to find out about its water line and plumbing.

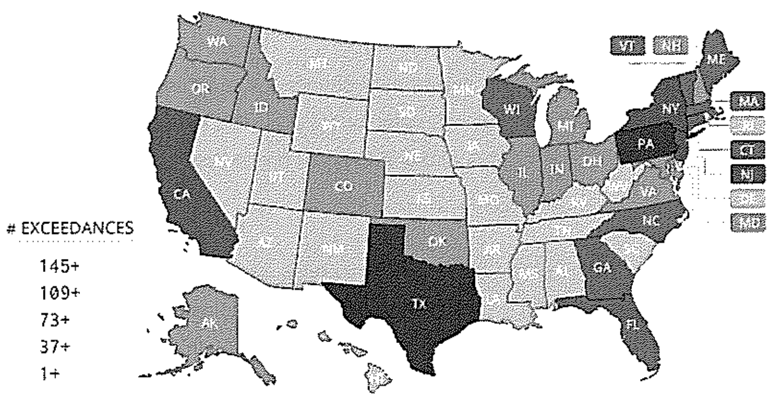
"People are legitimately concerned about what they're hearing in the wake of Flint," said Lynn Thorp, of the advocacy group Clean Water Action, who recently served on a federal work-group on lead in drinking water. "As long as we have lead in contact with drinking water, we can have exposure at the tap."

Thorp said consumers need to become educated about any risks at their individual homes.

LEAD IN THE WATER: A NATIONWIDE LOOK

Since 2012, nearly 2,000 water systems across the U.S. have found elevated lead levels in tap water samples, a public health concern that requires them to notify customers and take action. Search or click the map to find systems in your area. The map table shows the state / name of the water system; the county it serves; the range of lead levels over 15 parts per billion in samples that triggered an action status, and total action-level tests over the period.

United States



Search these results

STATE	SAMPLE MEASURE	# EXCEEDANCES
Texas	15.5ppb - 600ppb	1[illegible]3
Pennsylvania	15.5ppb - 1,273ppb	1[illegible]7
New York	15.5ppb - 2,300ppb	1[illegible]8
California	15.8ppb - 13,200ppb	11[illegible]
New Jersey	15.5ppb - 600ppb	111
Wisconsin	15.5ppb - 12,465ppb	96

SOURCE: USA TODAY analysis of EPA's Safe Drinking Water Information System (SDWIS) database.
Learn more about how we analyzed this data.

What is government doing?

Under the EPA's Lead and Copper Rule, implemented in 1991, the government's approach for protecting people from lead in drinking water has relied heavily on water systems monitoring for indications that their water has become more corrosive. The more corrosive the water, the more lead will be drawn out of pipes. Treatment of water with anti-corrosion chemicals can only reduce, not eliminate, lead from leaching into tap water in invisible and tasteless doses.

That's why the EPA's National Drinking Water Advisory Council wrote agency leaders in December calling for removing lead service lines "to the greatest degree possible." It's a daunting recommendation since in most cases, the water utility owns part of the line and the rest belongs to the homeowner. A credit ratings firm warned this month that replacing lead service lines could cost tens of billions of dollars.

"We're now dealing with a legacy issue on private property distributed throughout many communities," said Tracy Mehan, the American Water Works Association's executive director of government affairs. The cost to replace each service line can range from hundreds to thousands of dollars.

Meanwhile, the EPA advisory council, whose members include experts from water utilities and state agencies, recommended that EPA take numerous steps to strengthen the existing regulation. They include developing a "household action level" that would trigger public health actions when lead contamination reaches certain levels and ensuring the public receives more information about the risks they face.

In addition, state water regulators say, federal officials need to tell water utilities what level of lead contamination indicates an acute health risk that should trigger a "do not drink" alert to all of the systems' customers. The EPA is evaluating the recommendations and expects to propose revisions to its lead contamination regulations in 2017.

"We really recognize there's a need to strengthen the rule," Joel Beauvais, deputy assistant administrator for EPA's Office of Water, said in an interview.

While he characterized Flint as an outlier, he said, "There's no question we have challenges with lead in drinking water across the country. Millions of lead service lines in thousands of systems."

Changing the rules could take at least a year. Beauvais said the EPA is working now to make sure states fully enforce existing rules. The agency last month sent letters to governors and state regulators calling for greater attention to drinking water oversight. While federal rules are made by the EPA, they're enforced by the states.

Because of Flint, some utilities and state water regulators said they were already taking a closer look at water systems where testing identified excessive lead.

"It has caused a sort of shock wave through the drinking water industry generally," said Jim Taft, executive director of the Association of State Drinking Water Administrators. States are looking at water systems' performance and oversight, he said, "to make sure we're not missing something."

High lead in systems large, small

At a trailer home at the Maple Ridge Mobile Home Park in Corinna, Maine, Christi Woodruff recalls the notice hung on her door last year alerting her to potential lead contamination in the neighborhood.

A mom with an 8-year-old daughter, Woodruff initially planned to get her water tested. But, she shrugged it off after the park's landlord told her testing was unnecessary. "The manager said not to worry because it was only certain trailers ... He didn't think my trailer was one of them," she said.

Property manager Randy Dixon blamed tap water from a single old trailer with lead-soldered copper pipes for causing the park's water to fail the EPA's testing. He then told a USA TODAY NETWORK reporter to stop interviewing residents.

Christi Woodruff of Corinna, Maine, doesn't know whether her trailer's water has lead problems but says she's drinking bottled water anyway because of a notice delivered several weeks ago to residents of her trailer park.

(Photo: Andrew West, USA TODAY NETWORK)

The analysis of EPA's data show the Maine park is among almost 2,000 water systems flagged for having an "action level exceedance" for lead during 2012 through 2015. That generally means more than 10% of tap water samples taken during a testing period showed lead contamination above 15 ppb.

If you're living in a home with a lead service line and received a notice about possible lead contamination, "it's a good idea to get your water tested," said Beauvais, the EPA water office official.

Most of the water systems that failed the EPA's lead standard serve anywhere from a few hundred to several thousand people each, often running their lines to homes in rural communities, or managing water for individual schools or businesses in remote areas.

In Lake Mills, Wisc., about 50 miles west of Milwaukee, EPA records show the utility serving water to 5,300 people failed lead tests in 2013, 2014 and again in 2015 with some readings several times the federal limit.

Paul Hermanson, director of Public Works, said Lake Mills sent fliers with water bills since 2010 urging residents in older homes to run their water 15 to 30 seconds before using it. The idea behind not using the first water out of the tap is to avoid drinking water that's been touching the old pipes and has the greatest risk of containing lead. "I don't know that there's a good solution to it other than running the water," he said.

Some of the older homes in the growing bedroom community of Firestone, Colo., about 30 miles north of Denver, tested for excessive lead four times since 2014, records show. Town officials said they have repeatedly notified their 9,500 water customers of potentially harmful lead levels and distributed information explaining how to reduce risk. "The fact that they haven't fixed this, that's annoying," said resident Heath Gaston.

The USA TODAY NETWORK analysis showed three of every four water systems that exceeded the lead standard from 2012 to 2015 served 500 people or less. They often lack the resources and staff expertise of larger systems. "Some of these small systems don't even have a full-time operator," said Taft, of the state water regulators association. They may rely on one person, responsible for several systems, he said. In the case of schools, the same staff that does building maintenance may be managing the water system.

But nearly 70 of the systems with excessive lead findings during the past four years each provide water to at least 10,000 people. They include:

Passaic Valley Water Commission, New Jersey: More than 315,000 people are served by the water system in the industrialized area of northern New Jersey with a history of other pollution crises. It failed to meet EPA's lead standards during two testing periods last year and one in 2012. Commission officials said a $135 million construction project is underway to improve corrosion control. The utility officials also are publicly encouraging more people to participate in its lead-testing program.

New Bedford, Mass.: This municipal water system, which serves about 95,000 in a seaport city about an hour south of Boston, has been cited for excessive lead in 2014 and early 2015, EPA data show. Ron Labelle, the city's public infrastructure commissioner, said the area's housing is among the oldest in the Northeast and some still have lead service lines. A consultant has helped improve the system's anti-corrosion treatments, he said, and the city passed its most recent testing in December. Additional testing will be done this spring.

Bangor Water District, Maine: More than 28,000 people receive water from this system, which exceeded EPA's lead standards three times in 2012 and 2013. Operators tweaked chemicals used in its corrosion control program, and have been in compliance since.

Failure to notify people

When testing does reveal high lead levels, the USA TODAY NETWORK found many people were not warned as required. Of the 180 cited for failing to notify the public, almost half were cited more than once, records show.

In Ohio, in the past year, seven water systems serving a combined 8,800 customers failed to notify residents (http://www.mansfieldnewsjournal.com/story/news/local/2016/02/29/sebring-ohios-lead-problem/81099964/) of potential lead contamination within 60 days as required.

Tests found excessive lead last summer at homes in the village of Sebring. The water system didn't alert customers until January, after Flint started making national headlines. The Ohio EPA placed two employees on leave while investigating. State records show six other Ohio water systems also did not provide timely warnings to residents after failing lead tests. The systems supply water to mobile home parks, a subdivision, an arboretum and a church and its day care.

In Arizona, several water systems that found unsafe amounts of lead in drinking water samples taken several years ago failed to act until February, after the USA TODAY NETWORK began requesting data about lead levels in drinking water.

The principal at a boarding school near the Navajo Reservation was unaware until February that water from a faucet in a church at the property tested high for lead in 2013. Operators of a small water utility near the Mexico border and a small community system in eastern Arizona both had high lead test results in 2013. One said he didn't know any action was needed. The other conceded the lack of action was an oversight.

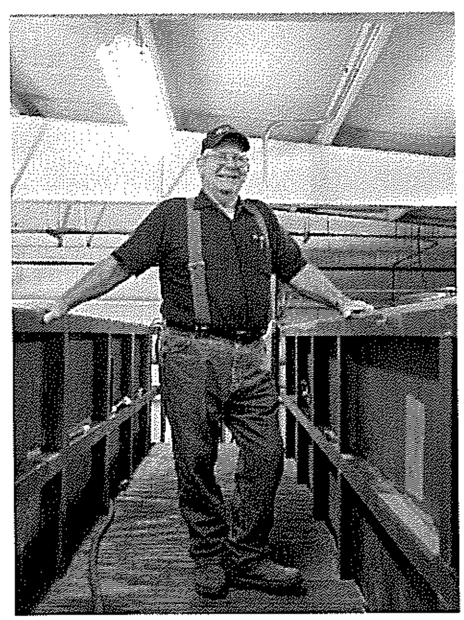
Misael Cabrera, director Arizona Department of Environmental Quality, acknowledged lapses in following up with some water systems. Cabrera said he's since asked all water providers for high lead levels to notify their customers. His department also is creating a system to better track compliance.

Without action, issues fester

Without strong action by regulators, problems can fester, especially in small systems with limited resources.

In southeastern Oklahoma's Latimer County, a rural water system serving about 1,500 people has had excessive lead levels during seven testing periods since 2013, EPA data show. The Latimer County Rural Water District #2 failed more tests in the past three years than any water system in the country.

Little has been done to fix the problem. The Latimer #2 district points its finger at its water supplier, and the supplier blames homeowners for not replacing bad plumbing.



Willie Williams, plant operator for the Sardis Lake Water Authority in Clayton, Okla., said water that comes from his plant has no detectable lead.

(Photo: Shane Bevel, USA TODAY)

"There's nothing we can do," said Linda Petty, office manager for the Latimer #2 district, which doesn't treat its own water. Latimer buys its water from the nearby Sardis Lake Water Authority. "We're at their mercy," she said.

"The water that we have coming out of the lake does not have lead in it," said Willie Williams, the Sardis Lake system's operator. "They have some houses in their system that have horrendous plumbing. There's not a single thing Latimer #2 can do about it and not a single thing I can do about it."

Customers received notices of the lead issue in their bills, the water system and residents said. County officials say they have not gotten calls from concerned residents.

"I haven't heard anybody saying anything about it," said John Medders, a county commissioner whose home is on the system. He recalled getting a notice in the fall. "Most of the time I just throw mine in the trash. I don't pay much mind to it."

Water regulators at the Oklahoma Department of Environmental Quality said they now plan to meet with both water systems and send state engineers to Latimer and 18 other water systems that don't comply with lead-contamination limits.

"The Flint, Michigan, situation has really opened our eyes to what's going on," said Patty Thompson, engineering manager for the department's public water supply group.

Contributing: Mark Alesia, The Indianapolis Star; Jessie Balmert, The (Newark, Ohio) Advocate; Patricia Borns, The (Fort Myers, Fla.) News-Press; Trevor Hughes, USA TODAY; Eric Litke, USA TODAY NETWORK-Wisconsin; Jacy Marmaduke, Fort Collins Coloradoan; Caitlin McGlade, The Arizona Republic; Marty Schladen, The El Paso Times; Todd Spangler, Detroit Free Press; Laura Ungar, USA TODAY; Jim Waymer, Florida Today; and Russell Zimmer, Asbury Park (N.J.) Press.

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Tweet (https://twitter.com/intent/tweet?url=http%3A//usat.ly/1pdGEYQ&text=Beyond%20Flint%3A%20Excessive%20lead%20levels%20found%20in%20almost%202%2C000%20water%20systems%20across%20all%2050%20states&via=usatoday)

17,938 (http://www.facebook.com/share.php?u=http%3A//www.usatoday.com/story/news/2016/03/11/nearly-2000-water-systems-fail-lead-tests/81220466/)

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FAILURE AT THE FAUCET February 1, 2016

Lead pipes, antiquated law threaten Wisconsin's drinking water quality

Madison was the first city in nation to help homeowners replace all lead service lines; Flint, Michigan, crisis dramatizes hazards

By **Silke Schmidt and Dee J. Hall**

(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/inside-flint-pipes.jpg)

Siddhartha Roy / FlintWaterStudy.org

Lead from corroded pipes in Flint, Michigan, is partially to blame for a public health crisis in the impoverished community. After the city switched its drinking water source in 2014 to the highly corrosive Flint River, there was a spike in lead poisoning among Flint's children. Residents are now drinking bottled water, and Michigan Gov. Rick Snyder and President Barack Obama have both declared a state of emergency.

Experts, and even some regulators, say existing laws are failing to protect Wisconsin and the nation from harmful exposure to lead in drinking water that leaches from aging plumbing — a danger illustrated by the public health crisis (http://www.freep.com/story/news/local/michigan/2016/01/16/president-obama-declares-emergency-flint/78898604/) in Flint, Michigan.

At least 176,000 so-called lead service lines connect older Wisconsin homes to the iron water mains that deliver municipal water, according to an estimate by the U.S. Environmental Protection Agency. Milwaukee alone, where 60 percent of the state's known lead-poisoned children live, has 70,000 lead service lines.

Regulators concede that the Lead and Copper Rule, the 25-year-old federal law that seeks to minimize the danger from these lead pipes and indoor plumbing fixtures, is failing on several fronts:

- Methods for sampling often fail to detect the highest level of lead in a consumer's home.
- Too few homes are sampled, and those that are may not be in the neighborhoods most at risk.
- The requirement that utilities replace some lead lines when they exceed federal

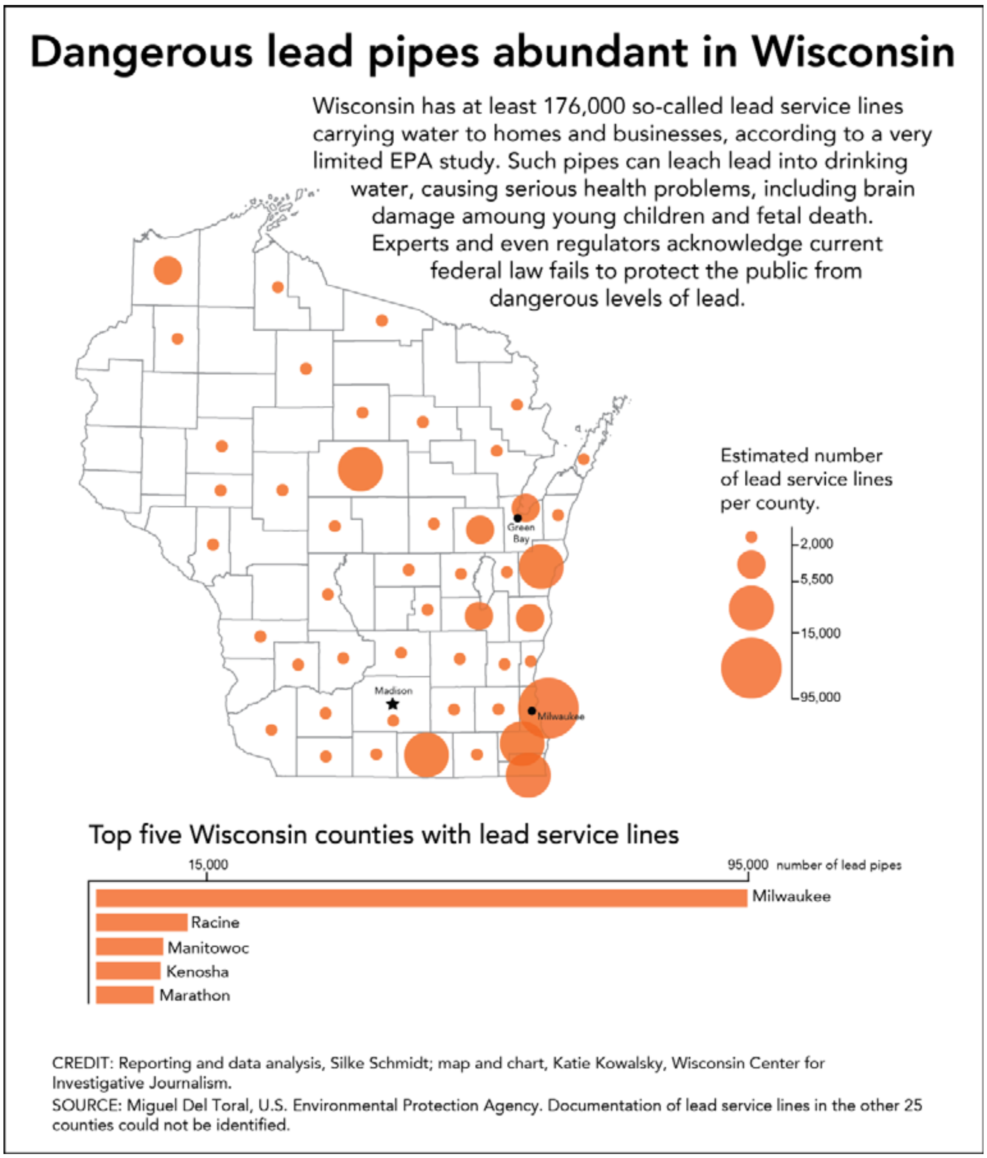
thresholds may actually cause dangerous increases of lead in drinking water.

Lead is primarily leached into Wisconsin's drinking water by the corrosion of lead pipes and indoor plumbing components.

Health effects of lead include irreversible brain damage in children under age 6 and an increased risk of miscarriage in pregnant women.

Decades ago, when it became clear that lead was one of the worst toxins for the developing brain, U.S. regulatory agencies began to eliminate the heavy metal from gasoline, paint and new plumbing. But the efforts to address the nation's existing water infrastructure were limited.

Marc Edwards, an engineering professor at Virginia Tech and one of the nation's foremost experts on lead in drinking water, helped Flint address its massive problem (http://flintwaterstudy.org/) with lead-contaminated drinking water that has poisoned a number of the city's children.



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Edwards said millions of U.S. homes have some lead components in their water delivery system, although he acknowledged "no one knows" the exact number. He agreed with some who have called the widespread risk posed by lead pipes and the astronomical cost to replace them one of the biggest environmental disasters in U.S. history.

Lead hazards underestimated

The American Water Works Association estimated in 1990 that the U.S. water infrastructure had about 3.3 million lead service lines and 6.4 million connections made of lead, many of them installed well over 100 years ago. Wisconsin is one of nine states, all in the Midwest and Northeast, where they are particularly common.

In addition to Milwaukee, several other Wisconsin communities have a high percentage of lead service lines, including Wausau (http://www.ci.wausau.wi.us/Portals/0/Departments/Water/Documents/WWaterWSummer2015.pdf) , Wauwatosa and Racine, according to the EPA.

(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/Edwards-leaking-pipe.jpeg)

Virginia Tech

Marc Edwards, a Virginia Tech engineering professor who is a national expert on lead in drinking water, collects a sample from a leaking water pipe. Edwards' research has shown that existing federal requirements can increase rather than decrease the exposure of consumers to lead.

"Although most cities in the United States were moving away from lead water pipes by the 1920s," a 2008 report (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2509614/) said, "it appears that this trend was not universal. National model plumbing codes approved lead into the 1970s and 1980s, and most water systems based their regulations on those codes."

Another 2008 study (http://www.waterrf.org/PublicReportLibrary/91229.pdf) found that these service lines account for 50 to 75 percent of lead contamination in public tap water, with most of the remainder due to indoor lead pipes and plumbing components, such as faucets and connections.

The risk of these aging pipes is so high that Madison's public water utility made the controversial decision to replace not only the portion of the lead service lines that it owned, but also the privately owned portion

from the curb stop to the house beginning in 2001. The $19 million program, partially paid for by property owners, is thought to be the first in the United States and now serves as a model for other cities.

(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/corroded-lead-pipe.jpg)

Madison Water Utility

Lead pipes, such as this one in a Madison home, are blamed for putting dangerous lead levels in drinking water. Madison replaced all of the lead service lines leading from water mains into buildings, and is thought to be the first U.S. city to do a "full" lead pipe replacement.

The problem posed by lead service lines is likely underestimated in Wisconsin, where census figures show about 27 percent of homes were built before 1950 and 63 percent before 1980.

Miguel Del Toral, a regulations manager at the EPA's Chicago office, said that after five years of effort, he could only track down written documentation of lead pipes in 113 Wisconsin communities in 47 of the state's 72 counties. The number of lead pipes outside of these communities is anybody's guess.

A nationwide EPA survey of 153 public water utilities in 1984 found that "30 percent of the respondents could not offer any estimate of the number of lead service lines remaining in their cities," according to a 2008 report (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2509614/) .

"In the smaller towns, the institutional knowledge about this is lacking," Del Toral said. "A private well connected to a home can have (lead pipes) too. They are pretty universal. But we have no access to private records."

In addition, tap water from only a fraction of the 176,000 buildings in Wisconsin on known lead service lines has to be tested regularly as part of the federal Lead and Copper Rule (http://www.epa.gov/dwreginfo/lead-and-copper-rule) . The law requires utilities to collect water samples from households known or suspected to be served by these pipes.

But, said Del Toral, "If they don't know about the lead service lines, they may not be sampling at those sites, so unless they accidentally find them, the lead levels being reported might not reflect reality."

Milwaukee Water Works is currently on a reduced monitoring schedule because of a history of compliance with the federal law; it only has to test for lead in 50 homes every three years. Even before this schedule became effective, the city only had to test 100 homes per year for lead.

Finally, some testing under the federal rule may not accurately reflect consumers' actual lead exposure, according to a study by Del Toral (http://www.ncbi.nlm.nih.gov/pubmed/23879429) and another by Edwards (http://www.ncbi.nlm.nih.gov/pubmed/22552494) . The latter study found that "slight variations from one approved protocol to another may cause lead-in-water health risks to be significantly underestimated."

(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/flint_fire_station-giveaway.jpg)

Steve Carmody / Michigan Radio

An American Red Cross volunteer stacks cases of bottled water at a Flint, Michigan, fire station in January. A state of emergency has been declared over the levels of lead in Flint's drinking water. Authorities also are providing free water filters to residents of the beleaguered city.

"We've actually documented a few cases where these instructions caused us to miss lead problems and tell people that the water was safe when it wasn't," Edwards said.

Del Toral's 2013 study (http://www.ncbi.nlm.nih.gov/pubmed/23879429) found wide swings in lead levels in Chicago households when tap samples were taken 12 or more times during a single day. He concluded that "the existing regulatory sampling protocol under the U.S. Lead and Copper Rule systematically misses high lead levels and potential human exposure."

Corrosion control can keep lead out of water

A water utility is compliant with the federal law when at least 90 percent of household samples are below the action level of 15 parts per billion (ppb) of lead. Even when utilities greatly exceed the action level, unless it involves more than 10 percent of the samples, no system-wide remediation efforts are required.

If more than 10 percent of samples exceed 15 ppb, a water utility may be required to install or improve corrosion control. This involves adding a chemical, such as orthophosphate, to the water to make it less likely to eat away at lead pipes.

Determining the water treatment method that works best requires money, ongoing maintenance and specialized knowledge about water chemistry. Systems required to use corrosion control (http://www.awwa.org/portals/0/files/legreg/documents/20140226_ndwac_occtprimer.pdf) include those serving 50,000 or more customers and those in which 10 percent or more of the water samples tested above the federal action level.

(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/flint-pipes2.jpg)

Siddhartha Roy / FlintWaterStudy.org

Blood lead levels in children increased after Flint, Michigan, began drawing its drinking water from the Flint River without adding anti-corrosive compounds. Several factors can cause lead spikes in water. One of them is the physical shaking of the lead pipes during replacement work, which can knock off lead inside the pipe.

In April 2014, when Flint began drawing its drinking water (http://www.mlive.com/news/flint/index.ssf/2015/09/new_testing_shows_flint_water.html) from the Flint River without adding anti-corrosives, blood lead levels spiked in children (http://www.npr.org/2015/09/29/444497051/high-lead-levels-in-michigan-kids-after-city-switches-water-source) , inciting a public health crisis, protests and angry finger-pointing. The city has now switched back to Detroit water (http://www.usatoday.com/story/news/nation-now/2015/10/25/lead-poisoning-flint-water/74599112/) .

"(Corrosion control) is a complicated subject that has kept water quality experts searching and even arguing for decades," said Abigail Cantor, a Madison-based chemical engineer who has worked with several Wisconsin water utilities as a technical consultant.

In addition, orthophosphate harms surface water quality. When treated water is released into lakes by the wastewater treatment plant, phosphate contributes to algal blooms, which can cause oxygen depletion and trigger the production of toxic chemicals.

That is one of the reasons that Madison, a city proud of its lakes, rejected corrosion control and instead replaced all of its lead service lines with copper pipes.

Required pipe replacements can boost danger

When a utility is not in compliance with the federal law and corrosion control is ineffective or rejected, it must replace 7 percent of the lead service lines that it owns. Additional replacements are required every year until the utility comes back into compliance.

(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/drinking-water-lead.jpg)

Bridgit Bowden / Wisconsin Public Radio

Researchers and even some regulators agree that the current sampling protocol under the federal Lead and Copper Rule can fail to detect dangerous levels of lead in water. Among the problems: The amount of lead in a home's drinking water can vary widely even within a single day.

The utility-owned portion of the service line typically runs from the water main to the curb stop, while the section between the curb stop and the house is usually privately owned.

However, replacing only the utility-owned portion of the pipe, a so-called partial replacement, can have severe unintended consequences: it may increase, rather than decrease, lead levels in consumers' tap water.

Several factors can cause these lead spikes. One of them is the physical shaking of the lead pipes during the replacement work, which can knock off lead inside the pipe.

"In Chicago, the scale that came off the service line in one event where they cut the line was 300,000 ppb lead," Del Toral said. "The sediment that came off was 125,000 ppb lead. That would pass straight through a kitchen aerator and would put an infant or child in the hospital immediately, if not worse."

Lead levels in tap water may also increase after partial replacements due to a chemical phenomenon called galvanic corrosion.

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Siddhartha Roy / FlintWaterStudy.org

This corroded pipe, taken from a building in Flint, Michigan, shows the process by which dangerous lead got into the drinking water of the impoverished city, leading to a spike in blood lead levels among children. Wisconsin has at least 176,000 lead service lines, according to a very conservative estimate by the U.S. Environmental Protection Agency.

"When old lead pipe is connected to a new copper pipe, the contact of the two metals creates a battery effect that activates lead, so that it enters the water at an accelerated rate," said Yanna Lambrinidou, one of Edwards' colleagues at Virginia Tech.

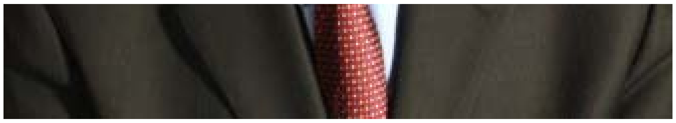
In 2012, a federal Centers for Disease Control and Prevention study (http://www.cdc.gov/mmwr/pdf/other/su6104.pdf) reported direct evidence that partial replacements may cause elevated lead levels — not just in drinking water, but also in the bodies of children under 6 years of age.

"Compared with children who had never had a lead service line," the authors found, "children having had a partial lead pipe replacement were at increased risk for increased (blood lead levels)."

They concluded that "the practice of partially replacing lead service lines as a method to comply (with the Lead and Copper Rule) should be reconsidered."

Water main repairs also can cause a physical disturbance of the lead service lines, resulting in the same risk of lead scale particles being released into the water. Milwaukee has hundreds of water main breaks a year (http://www.jsonline.com/news/milwaukee/milwaukee-avoids-water-system-crisis--but-not-main-breaks-b99584256z1-330196601.html) .

"The water main work is the primary disturbance of the lead lines. That is going on, unregulated, on a daily basis in all major water systems in the country," Del Toral said. "That's a very big concern."



(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/Paul_Biedrzycki.jpg)

Milwaukee Public Health Department

Paul Biedrzycki, head of environmental health for the city of Milwaukee, says he's concerned about the dangers of water main repairs to residents. Such repairs can disturb lead in pipes, sending high levels of the toxic substance into homes.

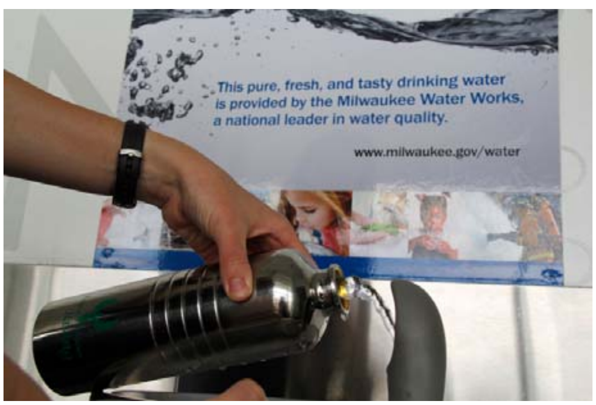
Paul Biedrzycki, director of environmental health for the city of Milwaukee, shared Del Toral's concern. Fixing water mains is "a tradeoff between replacing aging infrastructure … to ensure the continuity of drinking water service to our population … and a very real public health threat posed by this work," Biedrzycki said.

Because of the potential danger, a 2014 communications guide (http://www.awwa.org/Portals/0/files/resources/publicaffairs/pdfs/FINALeadServiceLineCommGuide.pdf) by the American Water Works Association urged utilities to notify customers of steps to protect their drinking water whenever nearby water mains are repaired or lead service lines replaced.

Milwaukee Water Works spokeswoman Sandra Rusch Walton said the city takes precautions against lead when it repairs broken water mains by flushing the line and asking homeowners to do the same.

Cantor said that may not always have the desired effect. "Flushing of building water lines is a complicated subject," she said. "Sometimes it does solve the problem. Sometimes, it riles up pipe wall debris (including lead) and makes matters worse."

Cantor also said that monitoring for lead in a building is difficult.



(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2013/05/Milwaukee-water-fountain-2500px.jpg)

Kate Golden / Wisconsin Center for Investigative Journalism

The city of Milwaukee is considered a world leader in testing for contaminants in its drinking water. But thousands of Milwaukee children are diagnosed each year with lead poisoning, which some researchers say could be at least partially due to lead-tainted drinking water. The compound, which is linked to lower IQ and behavioral issues when consumed by children, can leach from lead pipes leading into older homes.

"Every plumbing system is different, and it's hard to predict where the problems lie in the system unless studied in depth — something a property owner can't do and something a water utility can't do for a complete city," she said.

Because of concerns (http://media.jrn.com/documents/leadletter01.27.16.pdf) that water main replacement work could cause lead levels to rise, Milwaukee officials in January informed state agencies (https://www.documentcloud.org/documents/2700320-Milwaukee-Water-Works-Letter-and-Commission.html) that the city is temporarily halting planned work on five miles of water mains serving about 500 homes.

New regulations years away, public on its own

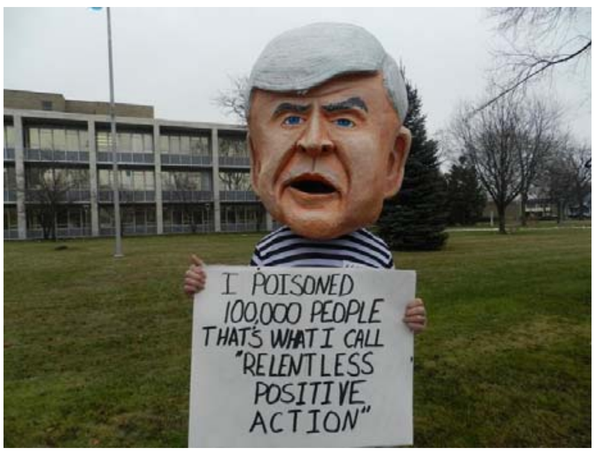
A quick fix of the nation's lead pipe problem is unlikely. Lambrinidou was part of an EPA-convened working group tasked with proposing changes to the Lead and Copper Rule. This group released its final report (http://www.awwa.org/Portals/0/files/legreg/documents/FinalLCR.pdf) in August.

One of the group's major recommendations: requiring water utilities to pursue full replacement of all lead service lines in collaboration with customers.

Lambrinidou estimates it will take at least another five to seven years before any revisions go into effect. Amy Kubly, a water supply engineer with Wisconsin's Department of Natural Resources, agrees that the EPA ought to move faster, given that the dangers of lead have been known for a very long time.

"I think (the Lead and Copper Rule) is overdue for revisions," Kubly said. "I've heard for years now that they're working on them, but haven't heard anything concrete as to what they would contain. Hopefully we'll hear something soon."

Until all lead pipes in the water infrastructure system are safely replaced, however, consumers are largely on their own when it comes to protecting their families from lead exposure, Edwards said.



(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/Flint-water-protester.jpg)

Steve Carmody / Michigan Radio

A protester parodies Michigan Gov. Rick Snyder during a Jan. 8 protest over lead in the drinking water in Flint, Michigan. Snyder and President Barack Obama have called a state of emergency over the crisis. State environmental officials initially dismissed concerns about the water. Flint switched water sources without adding anti-corrosion chemicals, causing dangerous levels of lead to leach from water pipes. The problem was discovered after the drinking water became discolored and blood lead levels among children spiked.

Specific recommendations for residents include testing their water, ideally before starting a family, installing a water filter certified to remove lead and other metals, using only cold water for cooking and never drinking or cooking with tap water that has been sitting in pipes for several hours.

Even Cantor — who has a copper water system, has tested her water and knows she has no metals issues in her house — takes precautions.

"A good rule of thumb is to never drink water that has been stagnating — in any building," she said. "I fill up a big water jug after I wash dishes at night and put the jug in the refrigerator. That way, I know that I am always drinking water that came fresh from the water main instead of water that has been sitting in the pipes in my house."

Edwards called for "complete removal of all lead service lines" across the country.

"If we don't make a decision right now to get these lead pipes out of the ground, when are they going to be removed?" Edwards asked. "They just pose an unreasonable health risk to future generations."

This story was produced as part of The Confluence, a collaborative project involving the Wisconsin Center for Investigative Journalism and University of Wisconsin-Madison School of Journalism and Mass Communication reporting classes. The nonprofit Center (www.WisconsinWatch.org) collaborates with Wisconsin Public Radio, Wisconsin Public Television, other news media and the UW-Madison School of Journalism and Mass Communication. All works created, published, posted or disseminated by the Center do not necessarily reflect the views or opinions of UW-Madison or any of its affiliates.

Overview of Lead Abatement Efforts in 2017 Proposed Budget

Steering & Rules Committee

September 29, 2016

2017 Lead Abatement Budget Summary

- $4.3 million of mainly federal funds for the abatement of lead paint in 440 housing units
- $3.4 million for the replacement of lead service lines for 300 daycares and schools
- $3.3 million for the replacement of lead service lines for 300 leaking service lines on private residential properties

Milwaukee's Lead Risk Reduction Strategy

- The City of Milwaukee Health Department (MHD) Childhood Lead Poisoning Prevention Program
  - Responds to reports of elevated blood lead levels in children from medical providers
  - Supports work of community partners in screening and outreach activities
  - Works to prevent lead poisoning through primary prevention approach including subsidizing window replacement

- Results
  - 90.3% decline in prevalence at >10 ug/dL since 1997
  - 69.7% decline in prevalence at >5 ug/dL since 2003
  - 66.2% increase in testing since 1997
  - 17,555 housing units made lead-paint safe since 1997

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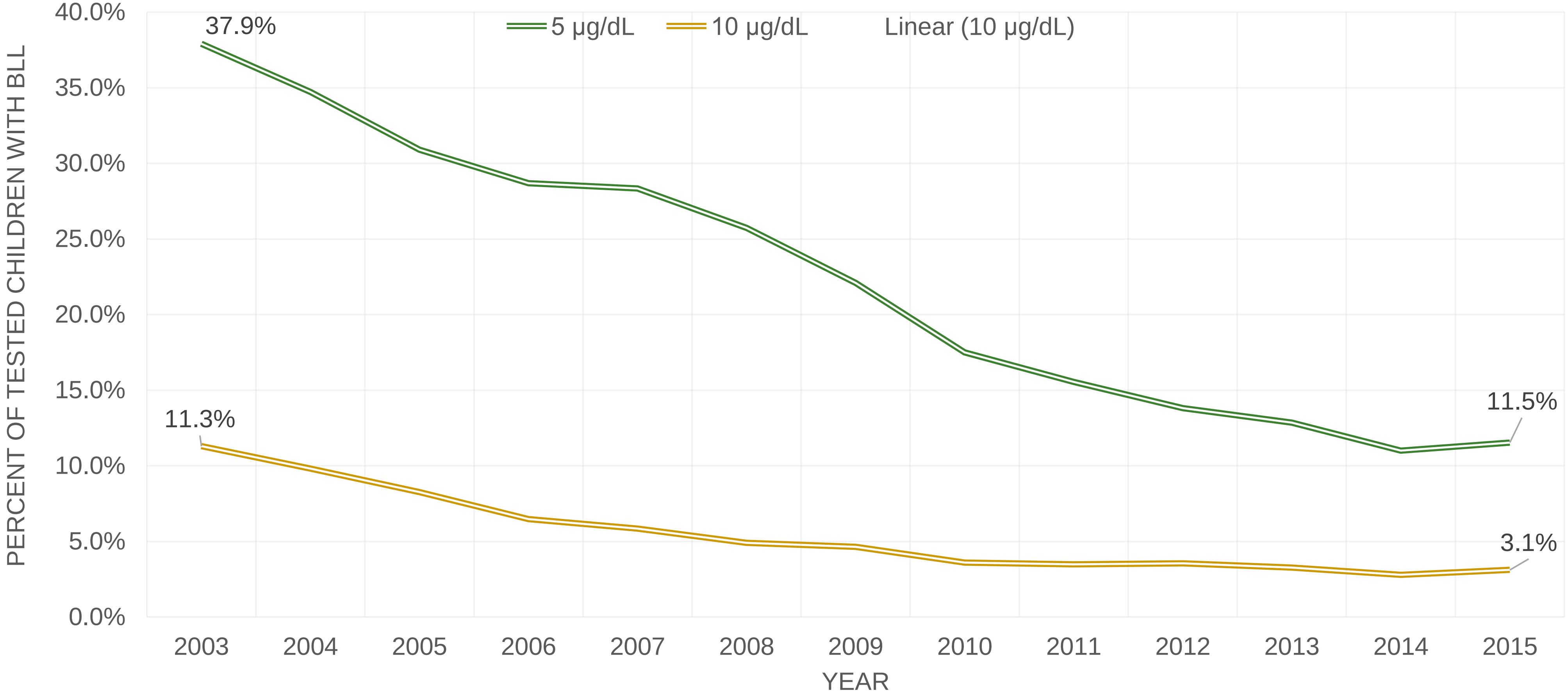
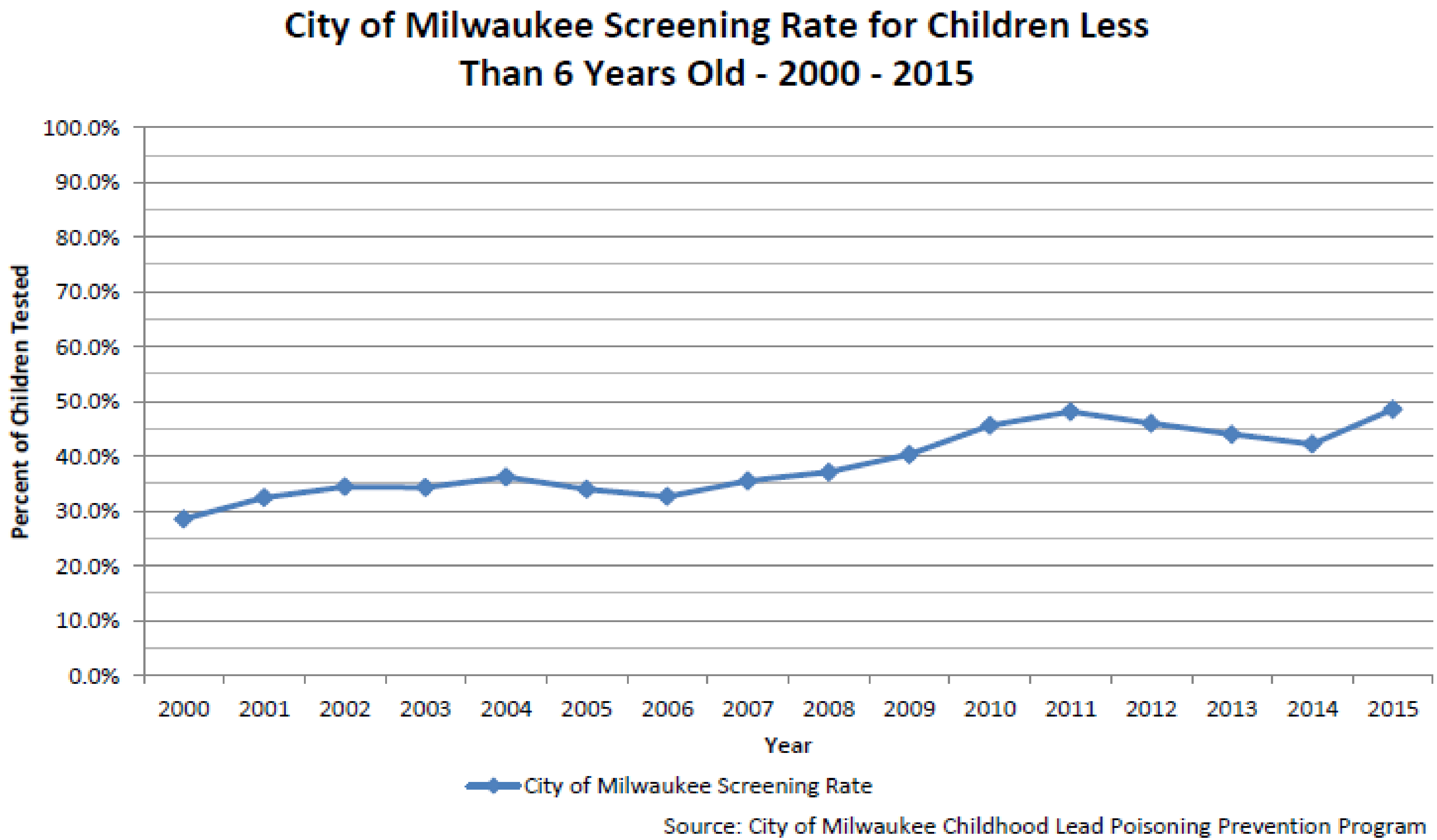
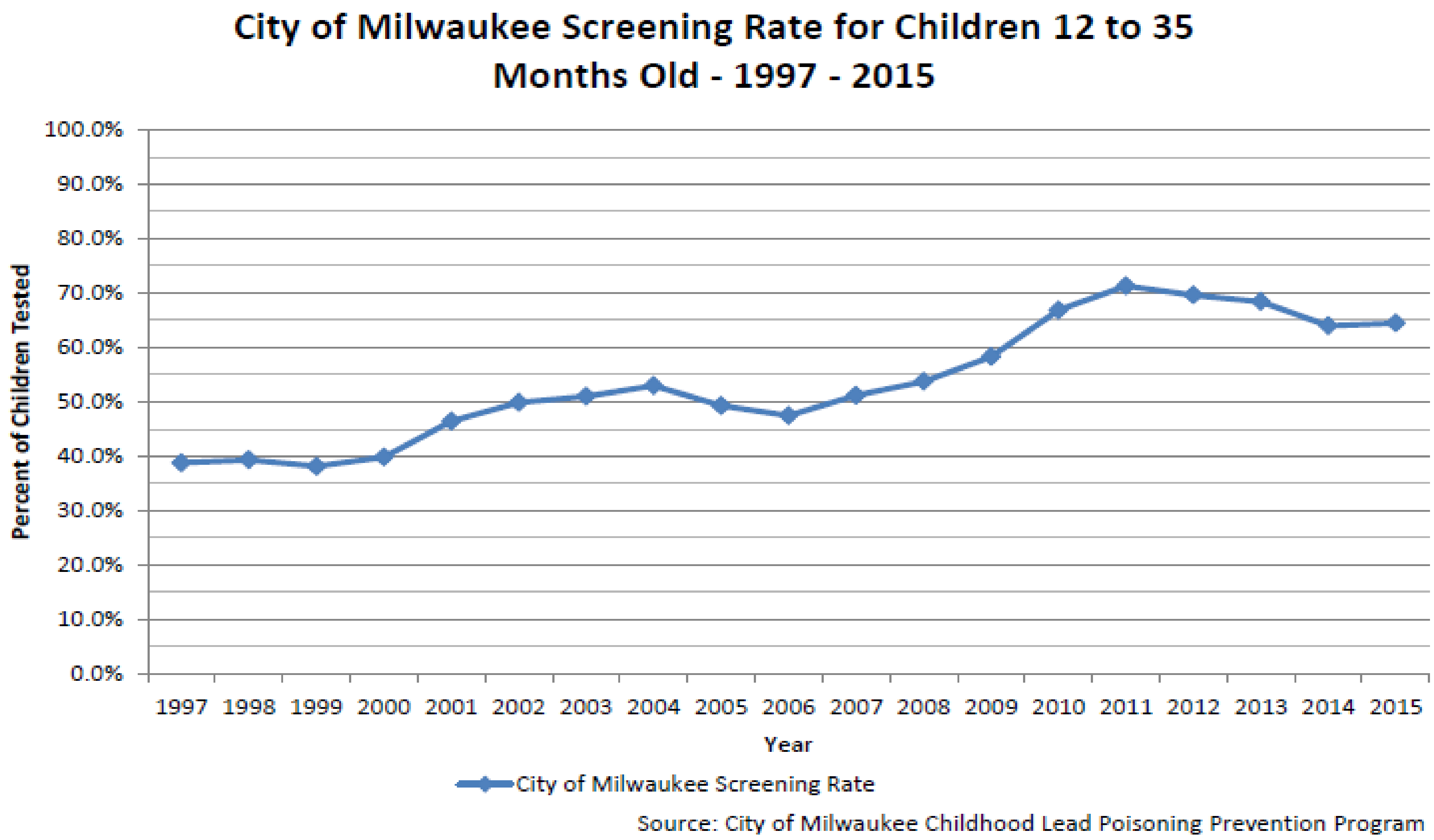


Source: City of Milwau ee Childhood Lead Poisoning Prevention Program, ST LL data as of May 201



City of Milwaukee Screening Rate for Children Less Than 6 Years Old - 2000 - 2015
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Percent of Children Tested
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
City of Milwaukee Screening Rate
Source: City of Milwaukee Childhood Lead Poisoning Prevention Program


City of Milwaukee Screening Rate for Children 12 to 35 Months Old - 1997 - 2015
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Percent of Children Tested
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
City of Milwaukee Screening Rate
Source: City of Milwaukee Childhood Lead Poisoning Prevention Program

Public Health Recommendations

1 **Continue to prioriti e mitigation of lead paint ha ards through a primary prevention approach**, because lead-based paint continues to be the most significant source of lead exposure to children in residential dwelling units

2 **Minimi e ingestion of lead from water** by assuring water treatment remains in place, continuing outreach to homes with lead service lines recommending flushing, faucet aerator change and filtration units

3 **Continue to encourage routine blood testing of children for lead** by encouraging "three tests before 3 years of age" by all health care providers.

Sampling Summary through 8/1/16

Type of or	umber of welling nits Sampled	umber of Sample Sets	umber of Samples
o construction	24	36	450
ater Main eplacements Connecting Original Service to ew Main	6	18	234
Partial LSL Replacement (“city” side replaced	50	96	1,245
Sewer Main eplacement	4	20	260
ater Meter Inlet alve eplacement	5	13	169
oad econstruction	6	12	167
Total	95	195	2,525

LSLs: Findings and Recommendations

	Findings to ate	ecommendations ctions
No construction and all scenarios listed below	Detectable lead is common when water has been unused for several hours	*All:* Flush plumbing, use cold water tap for drinking and cooking, clean aerator regularly *Infants, children, pregnant breastfeeding:* Use filter or bottled water
Water main replacements	Increase in lead at tap after work	Suspend projects with LSLs
LSL leak	Increase in lead at tap after work	Inform of best practices, encourage replacement of private side, offer filter, thoroughly flush plumbing after work
Sewer main replacement where LSLs exposed	Some properties show increase, some do not	Same as LSL leak, above
Road reconstruction	Four homes no impact, two homes possible impact. More homes being sampled	Provide information on best practices

Lead Service Line Replacement Program: Key Elements

- Require replacement of private portion of lead service line when:
  - Privately owned or utility owned portion of a lead service lines leak; or
  - The utility owned portion of a lead service line is replaced
- Subsidy and special assessment financing for eligible property owners
- Moratorium on partial lead service line replacement
  - When leaks are encountered on utility owned or privately owned portion of lead service line, the entire service line will be replaced
- Prioritize replacement of lead service lines serving daycares and schools

Lead Service Line Replacement Program: Financing

- Average cost to replace lead service line - $11,000
  - Estimated cost to replace utility portion: $6,000
    - Funded through revenues from water sales
    - Will require significant rate increases
  - Estimated cost to replace portion owned by property owner: $5,000
    - Eligible property owners will receive a City subsidy and special assessment financing

Lead Service Line Replacement Program: Financing

- 1-4 unit residential properties eligible for subsidy and special assessment financing

- For City subsidy and special assessment financing the property owner must:
  - Sign “Hold Harmless” agreement
  - Grant temporary construction easement
  - Agree to have private side work performed by MWW contractor
  - Allow access into home to connect new service to meter

- When these conditions are met:
  - The City will subsidize 2/3 of the cost of replacing the private portion (approx. $3,400)
  - Property owner pays for the lesser of $1,600 or 1/3 of the cost of replacing the private portion
  - Property owner’s special assessment would be approx. $167 annually for 10 years which is less than $14 per month

Lead Service Line Replacement Program: 2017 Plan and Budget

- Replace lead service lines serving 300 daycares and schools
  - $1.8 million Water Works ratepayer funds (utility side)
  - $1.6 million Safe Drinking Water funding (private side)

- Replace lead service lines that experience leaks- approx. 300
  - $1.8 million Water Works ratepayer funds (utility side)
  - $1 million Safe Drinking Water funding (private side)
  - $500,000 Special Assessment from property owners (private side)

Lead Service Line Replacement Program: Long-term Outlook

- Estimated cost to replace the utility and privately owned portions of 70,000 lead service lines: **770 million** (in 2016 dollars)
- $1 million annual Safe Drinking Water funding uncertain beyond 2018
- City is aggressively pursuing State and Federal funds
- City subsidy funded through levy-supported borrowing in the absence of State/Federal funding

Lead Service Line Replacement Program: Long-term Outlook

- In 2018 and beyond, program will be scaled up to include proactive replacement of lead service lines in conjunction with water main replacement or other infrastructure projects

- In order to achieve replacement of all 70,000 lead service lines in 50 years, replacements need to be scaled up to approx. 1,400 per year

- Factors that will affect how quickly the City can scale up the program:
  - Approval of water rate increases
  - Pressure on levy-supported capital budget
  - Private sector capacity to perform the work

Lead Service Line Replacement Program: Employment Opportunities

- Insufficient private resources to meet the demand for service line replacement

- Long-term nature of program will create need for permanent employment

- Opportunity to employ City residents
  - RPP
  - Plumbers

MAYOR BARRETT'S GOALS:

- Continue our work on <u>all</u> sources of lead poisoning, including the primary source - lead paint
- Preserve public health and our high quality, affordable drinking water
- FULL replacement of lead service lines, public and private side
- Empower the public for action through information and resource referrals
- Get Milwaukee businesses and residents working on this long-term effort
- Advocate for State and Federal support to buy down City costs and timeline

2017 BUDGET…

Funds $4.275 million for lead paint abatement to deal with the primary source of lead in children

Funds $6.2 million ($3.6 via Water Works, plus $2.6M in State funds) to:

1) Pay for full replacement on 300+ licensed day cares (work starts in 2016)
2) Pay for full replacement on approx. 300 service line failures/leaks

Funds $428,000 for coordination between Water and Health, expanded testing capacity

Continues the 2016 suspension of replacement work on mains with lead services until ordinances supporting FULL replacement are enacted

	2017 Budget ($M)	Fund Sources	FTE	Units/ Properties
MHD Lead Paint Abatement	$4.275 ($448K City)	MHD HUD Lead Grant CDBG State DHS	22.0	440
MHD-MWW Coordination	$0.428 ($428K City)	MHD DPW-Water	3.0	-
MWW Licensed Day Care LSLs	$3.4 ($1.8 City)	DPW-Water State DNR	-	300+
MWW Failed & Leaking LSLs	$2.8 ($1.8 City)	DPW-Water State DNR	-	300
TOTAL	**$10.903 M ($4.476 City)**		**25.0**	**1,040+**

Coordination between Water and Health includes:

- 2 FTE in Water and Health to coordinate LSL activity between customers, contractors, and city agencies
- 1 FTE in Water for additional disruption testing, and expanded MHD water testing capacity
- $100,000 in Water for filter and bottled water provision to disrupted customers and outreach

MAYOR BARRETT'S PLAN - BEYOND THE BUDGET

1) Ordinances supporting FULL service line replacement should be in place by January 1, 2017:
   - **Mandate** replacement: mixed material & repair prohibition for lead service lines
   - Establish clear process for using assessments and other mechanisms to finance owner side of LSL

2) Establish contract and customer practices for full service replacement on mains projects
   - Prove process through leak and day care replacement
   - Set expectations for all property owners on access and timing for mains projects

3) With ordinances in place, include FULL LSL replacement in mains projects starting 2018

4) Work with trades and contractors to develop training/hiring/business capacity to begin accommodating full replacement on mains in 2018 and beyond

MEMORANDUM

Survey of Other Cities' Experience with LSLR

To: Priscilla Hackney, David McLaughlin
Date: 7/9/08 (update of original memo dated 10/31/07)
Author: Greg Welter
Copies: Jeff Thielker, George Rest, Kevin Williams, Mike Walsh

The purpose of this memo is to report on the results to date of our telephone survey of other cities to ask questions on their experience with Lead Service Line Replacement (LSLR) program execution and current policies and practices. We could find no definitive (or even approximate) lists of cities that have conducted LSLRs, either mandatory or voluntary, from EPA or other sources. To identify cities to contact as part of this survey, we have consulted the following sources:

- attendance list from 2004 EPA workshop on LSLR in Atlanta,
- list of respondents on AWWA survey of LSLR experience conducted in 2004,
- internet search,
- a 2004 report from EPA on Lead and Copper Rule contraventions based on EPA SIDWIS database, and
- a 2007 EPA SIDWIS search conducted at our request.

Based on these referral sources, telephone interviews have been conducted with parties from the following water systems:

Greater Cincinnati Water Works (OH)
Boston Water and Sewer Commission (MA)
Massachusetts Water Resources Authority (MA)
Saint Paul Regional Water Services (MN)
Louisville Water (KY)
Birmingham Water Works Board (AL)
Lansing Board of Water and Light (MI)
Madison Water (WI)
Providence Water Supply Board (RI)
Portland Water Bureau (OR)
San Francisco Public Utility Commission (CA)
New York City Department of Environmental Protection (NY)
Philadelphia Water Department (PA)

A synopsis of information obtained from interviews with staff of these cities follows. (In the discussions that follow, I have identified the agency staff that I spoke with to facilitate follow-up inquiry if needed. However, any misstatement or misinterpretation of the information received is the responsibility of this writer.)

Greater Cincinnati Water Works

Informants: David Hartman and Renea Lohmann of GCWW water quality office

GCWW has never exceeded the LCR action levels and so it has never been required to conduct a mandatory LSLR program. However, it did conduct a specific LSLR program (i.e. LSLR conducted independent of other infrastructure or street renewal or service line repairs) in the late 1990s. Their current practice is to conduct LSLR in conjunction with street or infrastructure renewal. Both in their earlier targeted program and in their more recent work they have collected data on the lead concentrations following LSLR (both partial and complete), and the data have been reported in a presentation at the 2006 AWWA national conference. In their current work they have a program of customer outreach to encourage private side participation.

7/9/08: Update - *Lohmann reports that they do about 100 LSLRs annually, at a unit cost of about $2000 to $2500. This work is incidental to other capital work, or in lieu of repair.*

Boston Water and Sewer Commission

Informants: Jim Steinkrauss (legal office), Charles Jewell (planning office), and Steve Shea (engineering and design).

BWSC is a somewhat similar organization to WASA as it was formerly a city department, but was later chartered as a public agency independent of the city government. It is also similar in that it is responsible for distribution of water that is supplied and treated by another agency, the Massachusetts Water Resources Authority, which also provides supply (or backup supply) to 47 other systems. BWSC and two other MWRA supplied distribution systems have had lead exceedance problems under the LCR, and BWSC is in the third year of a mandatory LSLR program. In last semester's LCR monitoring, lead levels were in compliance and they are optimistic that this semester's will also be compliant.

Under the mandatory LSLR program BWSC has been required to remove 107 LSLs annually, based on an inventory of a little over 1500 public LSLs. Actual removals in the first two years were 297 and over 500. In conjunction with the LSLR program BWSC has had an energetic private side Lead Replacement Incentive Program. Under this Program, BWSC offers to replace the private side service with the cost to be handled by

- a cost credit of up to $1000 to be handled by BWSC, and
- the balance to be paid for by the customer either as a lump sum or in installments over 24 months as part of the water bill.

This program is available to residential properties containing one, two or three family units. Of the approximately 4500 residences with private lead services (as identified in an earlier automatic meter reading project), approximately 1300 have responded with requests for replacement, and between 700 and 800 have been accomplished.

Our informants were asked what BWSC's intentions with regard to the program were if the next semester LCR sampling was compliant and LSLR was no longer mandatory. They indicated that a decision had not been made, but in view of the aggressive nature of the program that had been authorized, they expected that it would be continued.

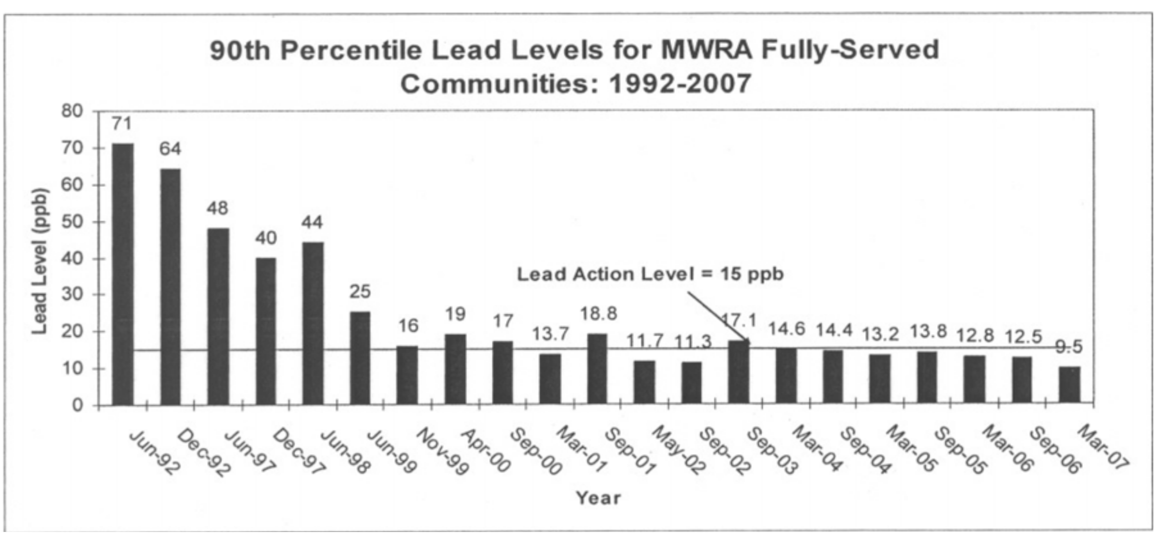
Update: 7/9/08 *- Boston became non-compliant with LCR in 2004 and started mandatory LSR program. The second semester 2007 sampling was again under the 15 ppb action level, so Boston's program was no longer mandatory beginning in early 2008; however, it is continuing LCR on a voluntary basis. The system was estimated to have approximately 1500 public lead services at the beginning of the mandatory program in 2004, and at the end of 2007 there were an estimated 1074 remaining. There is no established formal target date for complete removal. Their estimated unit cost per public LSLR has been approximately $2300. The typical cost for private side replacement is similar, but varies considerably because of varying lengths of private side services.*

Massachusetts Water Resources Authority

Informants: Stephen Estes-Smargiassi (Dir. of Planning), Joshua Das (water quality)

BWSC is the largest of 31 retail water systems that receive their water supply from the Massachusetts Water Resources Authority (MWRA). (There are additional water systems that receive water from MWRA as either a backup supply or as one of multiple water sources.) MWRA's experience with the Lead and Copper Rule and with LSLR projects is quite interesting, and in recent years, the Authority has been significantly impacted by the national attention that developed following the District of Columbia situation.

MWRA conducted treatability studies for optimal corrosion control and implemented a plan in the early 1990s based on control of pH and alkalinity. The parameters of this treatment plan have been refined over the years, resulting in a gradual reduction of its system-wide 90th percentile lead levels, as shown below (from MWRA "Staff Summary" report, dated 6/6/07). (MWRA's LCR compliance sampling program has been based on 25 residential sample locations in its largest subsystem (BWSC) and 15 each in all of the smaller systems.)



In the immediate aftermath of the publicity occasioned by the District of Columbia lead excursions in 2004, the Massachusetts Department of Environmental Protection (MADEP), the state regulatory agency, started implementing different regulatory and enforcement principles relative to MWRA.

First, MADEP began reviewing the L&C (lead and copper) compliance data for each individual water system, in addition to MWRA in aggregate.

Second, MADEP began enforcing the requirement of 7% annual replacement lead service lines for those systems failing the 15 ppb level in L&C compliance sampling.

Since that time the MWRA aggregate system has always passed; however, several of the client systems have failed. The number of systems over the 15 ppb level has varied by sampling period, typically in the range of 7 to 10 systems. The most recent sampling concluding in March 07 has been the most successful, with only 4 systems exceeding the Action Level. Some systems have fairly consistently failed, while others have never failed or have failed only occasionally. Some systems have failed, come back into compliance, and then failed again. The systems that have been most frequently above the Action Level have included Boston (pop. 589,141), Malden (pop. 58690), Medford (pop. 56,203), and Somerville (pop. 77,478). Estes-Smargiassi said for most of the systems it takes only two failing samples for the system to fail the 90th percentile Action Level, and he noted that it is often the same individual sampling locations that exceed 15 ppb on successive sampling rounds.

Estes-Smargiassi reported that the individual systems have operated their own individual Lead Service Line Replacement programs, each with somewhat different characteristics. He indicated that MWRA has been active in assisting the communities, particularly in terms of sample analysis and reporting, and in the development and dissemination of public education materials. He noted that Boston's program (described above), has been the most aggressive in its inducements for private side participation.

Estes-Smargiassi indicated that the local systems have tended to maintain their LSLR programs after coming into compliance, which has been a good thing as some then subsequently failed the Action Level and would have had to restart the program. He indicated that generally they would maintain the LSLR program, but without many of the regulation required sampling and reporting elements of a mandatory program. He indicated that he was not aware of any permanent decisions that any of the systems may have made on whether to continue or curtail their LSLR programs should they arrive at a point of consistent compliance.

Estes-Smargiassi noted that MWRA had participated in the recent AwwaRF studies on lead service line replacement, and that the experiments done in their system were consistent with the interpretation that complete, integrated LSLR is more effective at reducing lead concentrations than partial LSLR.

In an informal conversation on what kind of LSLR practice he would recommend, he indicated that he would probably recommend the following elements:

1) Lead service line replacement in conjunction with other major infrastructure or repaving work, with a coordinated program to solicit private side participation;
2) Lead service line replacement whenever repair work on the service line is done by the utility.
3) Replacement of individual lead service lines if requested by the individual property owner, and if the property owner also replaces the private portion, so that a complete LSLR would result.

7/9/08: Update - *Currently there are four wholesale customers of MWRA that are out of compliance with the LCR.*

Saint Paul Regional Water Services

Informant: Steve Gleason, up until recently the director of the LSLR program

St. Paul conducted a mandatory LSLR program in the late 1990s due to LCR sampling noncompliance. (St. Paul has since addressed the corrosivity issue through the addition of a proprietary stannous chloride compound in treatment. Their experience with phosphate based corrosion inhibitors was negative due to bacterial growth problems.) Gleason indicated that they estimate that they have approximately 15,000 to 20,000 public LSLs, which they are removing at a rate of about 500 to 1000 annually. These removals are accomplished during infrastructure renewals coordinated with street repavings. The infrastructure (and LSL) considerations are factored in to the priorities of the street repaving program.

Gleason said that St. Paul encourages private side participation when the utility pays for the private side replacement and is then reimbursed by the customer when the utility bill is paid. He estimated that they got about 20% private side replacement, although he has seen participation rates up to 50% in some areas.

Louisville Water

Informant - Keith Combs

As taken from its web site, the Louisville Water Company has an interesting charter. "*The city of Louisville is the sole stockholder. LWC is not a city agency – it is publicly owned and privately operated as a for-profit agency with an appointed board of directors.*"

Louisville has had a specific LSLR program for the last ten years, and a goal of removal of all public side lead services by 2017. Their program has not been required due to LCR sampling issues. Combs indicated that they attempt to do most work incidental to other infrastructure or street work; however, some is specifically targeted. He indicated that they do notify customers of planned work to encourage participation, but most private side services are already non-lead. Their practice has been to extend their excavations a few feet beyond the property line to that they can make sure that they don't leave a short stub of lead between the new non-lead public service and a largely non-lead private service. They conduct a one-hour post flushing operation following an LSLR.

7/9/08: Update - *Louisville has budgeted approximately $1.5 million annually for the LSLR capital program, which is being conducted on a neighborhood-by-neighborhood basis, mostly in conjunction with other capital infrastructure or repaving projects. In addition, they have maintenance funds set aside for replacement of lead service that are found to be leaking. The lead services are replaced rather than being repaired. The number of services replaced annually under the maintenance program varies significantly from year to year, but Mr. Combs guessed that this might push annual expenditures to about $2 million.*

Birmingham Water Works Board

Informant: Parry Barron, principal engineer.

Birmingham has not had to conduct a mandatory LSLR program under the Lead and Copper rule; however, it did conduct a lot of LSLRs during the late 1980s. Barron reports that they feel that they probably have about 2000 LSLs left in the system, but they are at unknown locations. She indicated that it is their practice to replace lead service lines that are encountered. They also check the services on adjacent properties and replace those as well if found to be lead. They notify the owner of the properties, but they offer no particular incentives for private side participation.

Barron indicated that Birmingham had been considering a disinfectant switch to chloramines, but held off in the light of DC experience. They have now resumed consideration of a chloramine switch for disinfection by-product (DBP) control.

Lansing Board of Water and Light

Informant: Kevin Webber

According to its web site, *"the Lansing Board of Water & Light is a municipally owned utility, providing drinking water, electricity, steam and related services to the Greater Lansing area in Mid-Michigan."*

Webber reports that Lansing has a very aggressive LSLR program that has very strong local political support, particularly from the Lansing mayor. He said that about ten years ago the Board made the decision that the entire water service line was the responsibility of the Board, from the main into the building. They initiated their LSLR program in response to the national concern that was prompted by the District of Columbia situation in 2004, and it is not a mandatory program. According to their web site, so far they have replaced a total of 4,859 lines out of 12,904 as of the end of September 2007. They intend to complete the program by 2013.

Webber indicated that there is considerable local support for the program, and that they expect future federal regulation will require that utilities replace all LSLs.

Webber indicated that in keeping with their prior ownership decision, their practice has been to replace the service line all the way into the house, unless they find that it is non-lead beyond the property line. He indicated that they do have an extensive program to coordinate with home owners, and for the most part the service line replacement is welcome. They do have some customers who choose not to participate, in which case the utility does NOT do a partial replacement. There are some instances in which there are coordination and scheduling problems with customer access, but the street side replacement is started anyway. In these cases, a temporary connection is made to the building, but the permanent replacement is installed at a later date.

7/9/08: Update - *As of May 2008, Bill Maier of Lansing Water reported that they have completed approximately 6000 lead service line replacements, with about 8000 remaining. Webber reports that they have been spending approximately $4.5 million annually on the program, and this year it has been boosted to $6 million. Also, in the recent contracts that they just bid they have found that the unit costs have been substantially reduced by the bidders, so they expect to be able to increase the numbers of LSLRs to be accomplished significantly.*

Madison Water

Informant: Doug Demaster

Madison Water is somewhat unusual in that it chose lead service line replacement as its optimized corrosion control technique. This was done out of concerns that a phosphate based corrosion inhibitor would ultimately increase the phosphorus in its wastewater discharge and be detrimental to the highly prized lakes that surround the city. As of 2001 the city had already accomplished significant LSLRs and the inventory was at approximately 6000, and at this time there are approximately 800 remaining. As part of its program a municipal ordinance was enacted requiring that private owners replace their portion of the services. The City also has financial assistance program in which 50% of the private side cost is reimbursed, up to a limit of $1000. The city web site has the additional details as follows:

"In February, 2000, Madison's lead water service line replacement Ordinance (MGO Section 13.18) went into effect. The Ordinance requires that all lead water service lines in the city be replaced by January, 2011. The requirement applies to both the Utility-owned service line extending from the water main in the street to the curb stop box, and the customer-owned service line extending from the curb box to the customer's water meter. Water Utility crews, in coordination with customers and their plumbers, are systematically replacing Utility-owned water service lines made of lead that remain part of the water system. When the Utility replaces its lead service line from the water main to the curb box, property owners are required to replace the lead service line on their private property. Property owners are notified by mail when lead service replacement is scheduled for their area.

Where the property-side part of the water service is lead and the Utility's side is copper, property owners are required to replace the lead service line. Property owners are notified by mail when they must arrange with a licensed plumber to have the work done. The Utility will work with customers who know they have a lead service line to get the work done in advance of the notification.

Madison must minimize the lead level in tap water in order to meet mandated federal water quality standards. Lead concentrations at customers' taps must be reduced to below 5 parts per billion to meet the federal standard. The U. S. Environmental Protection Agency, Wisconsin Department of Natural Resources, and the City of Madison require implementation of Madison's Lead Service Replacement Program as a means of attaining the federal water quality standard for lead in drinking water.

Property owners are eligible for partial reimbursement for the cost of replacing their lead service line. Fifty percent of the cost of the replacement, up to a maximum reimbursement of $1,000, will be reimbursed to the property owner by the Water Utility following completion of the work and submittal of a completed application form and payment receipt from the plumber. Two weeks after the plumbing contractor has applied for an Application for Water Service, the Water Utility will send out an application form to the property owner to begin the cost reimbursement process."

7/9/07: Update - *Updated information from Dennis Cawley indicates that Madison is nearly completed with its LSLR program, now less than 200 lead services left. He reported that during the program they have been removing about 500 to 600 lead services annually, at a annual cost between $500,000 and $1,000,000.*

Providence Water Supply Board (RI)

Informant: John Phillips (O'Brien & Gere)

PWSB is in its first year of a mandatory LSLR program as required due to sampling levels exceeding the LCR Action Level of 15 ppb. The system, which supplies water to multiple municipal jurisdictions, is estimated to have an inventory of 25,600 LSLs, thus requiring an annual removal rate of 1800 per year to meet the 7% requirement. They are very early in the implementation of the program so don't have much experience on private side participation. The preliminary customer notifications have resulted in 25% of the customers requesting a cost estimate for the private side replacement.

7/9/08: Update - *Providence has replaced approximately 3000 public side LSLs and 25 private side LSLs in the first year of the mandatory replacement program. Cost in this initial year were approximately $15 million.*

Portland Water Bureau (OR)

Informant: Yone Akagi

Portland has had a rather interesting experience under the Lead and Copper Rule. According to the Portland Water Bureau website, that system does not have nor has it historically had any lead services. There were lead "pigtails", short pieces of pipe connecting the water main to the service line; however, these were all removed between 1985 and 1998. Accordingly, Portland Water contends that all sources of lead in water in their system is derived from internal customer premise plumbing.

In response to the Lead and Copper Rule, Portland conducted a study to determine the required Optimal Corrosion Control Technique (OCCT). The recommended technique from the study was to maintain a pH of 9.0 and an alkalinity of 20. However, Portland entered into an negotiation with its state regulatory agency, and they came to an agreement that in lieu of full implementation of the OCCT, Portland would enter into a joint project with city health and housing agencies to fund a more general Lead Hazard Reduction Program. This was done under the assessment that other sources of lead exposure were more significant than the water exposure.

At this time, the partial implementation of the OCCT (pH target of 7.8-8.0, and no alkalinity target) has been largely successful in controlling lead in water; although, the most recent round of LCR testing yielded a 90^{th} percentile value of 17 ppb (i.e. above the 15 ppb Action Level). However, this is largely without regulatory consequence, as Portland Water already participates in enhanced public education under the original OCCT agreement, and reportedly has no lead service lines remaining.

San Francisco Public Utilities Commission

Informant: Andrzej Wilczak, Ph.D., PE; Senior Sanitary Engineer

Dr. Wilczak advised that San Francisco also has no lead service lines, having replaced them all in the 1980s. They have found that pH adjustment is the only corrosion treatment technique they have needed. However, they have a number of programs that are targeted at reducing lead exposure. One is replacement of water meters with more recent nonlead models. The other is a customer outreach effort in which the SFPUC will sell customers nonlead kitchen faucet kits for a reduced price of $10.

New York City Department of Environmental Protection

Informant: David Lipsky, DEP Chief of Water Quality

In the aftermath of the publicity over the District of Columbia lead excursion, the New York State regulatory agency gave a more rigorous review of the city's reporting under the Lead and Copper Rule, and then gave a Notice of Violation for technical errors in the calculation of the 90^{th} percentile concentrations over several years. This was purely a technical violation, as even with re-calculation the levels did not exceed the Action Level.

The assigned penalty was that the city was required to replace 7% of the lead services that it owned for each of the previous years that its calculations had been deemed to be faulty. However, then the determination was made, based on city code, that the customer owned the entire service line from the water main into the building. Thus the city's liability under the penalty has been for about 52 service lines to city owned buildings, plus one service line to a juvenile detention facility owned by the state. In an emergency contract the city has replaced about 26 lead service lines, mostly to police substations. The contracting for the remaining 26 has been delayed for a number of contracting issues.

Philadelphia Water Department

Informant: Matthew G. Smith; Manager, Planning and Research

Philadelphia's water system is served by two river sources (Delaware and Schuykill) with disparate alkalinities, and multiple water treatment facilities. The treatability studies for the plants have yielded a treatment strategy based on pH control and zinc-orthophosphate addition. Smith indicated that at times LCR sampling compliance has been close, but their most recent sampling has been about 9 ppb, compared to the 15 ppb Action Level.

PWD did not have a good record of the service line materials. In the immediate aftermath of the DC event they estimated the number of lead service lines at approximately 120,000. However, subsequent review of data sources now suggests that the number is closer to 32,000.

PWD does not have a lead service line replacement program. Similar to New York City, the Philadelphia city code specifies that service lines are privately owned from the water main to the building.

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Appendix: EPA SIDWIS data on systems in contravention of Lead and Copper Rule

2007 SIDWIS Query: For this benchmarking survey, we requested from EPA a query of the SIDWIS database of water systems that have undertaken mandatory LSLR programs due to LCR contravention. The EPA analyst noted that they do not consider the SIDWIS database reliable due to vagaries in state reporting; however, it was thought to be useful in identifying a pool of benchmarking targets. There were 69 systems identified as listed below.

2007 P SI IS uery on Lead and Copper ule LSL Milestones and iolations

Public ater System ame	State	Pop Served	Public ater System ame	State	Pop Served
UTL INC-FERSON CREEK UTILITIES CORP	IL	1,134	WEYMOUTH WATER DEPARTMENT	MA	52,632
BANNOCKBURN	IL	1,429	BAKER CITY OF	MT	1,948
WESTBORO STATE HOSPITAL	MA	1,650	GIBRALTAR	MI	4,600
BELMONT WATER DEPT. (MWRA)	MA	27,000	COUNTRY CLUB ESTATES CONDO	PA	41
SALEM BEVERLY WATER SUPPLY BOARD	MA	82,072	JIM THORPE BOROUGH WATER WEST	PA	2,274
NEW BEDFORD DEPT. OF PUB. INFRASTRUCTURE	MA	93,768	HOLY CROSS DAY CARE	PA	99
NORWOOD WATER DEPT. (MWRA)	MA	28,192	MINERSVILLE MUNICIPAL WATER AU	PA	6,547
BOSTON WATER & SEWER COMMISSION (MWRA)	MA	589,141	PATTON BORO WATER DEPT	PA	2,250
BAY CITY, CITY OF	MI	36,817	SAINT FRANCIS UNIVERSITY	PA	2,072
EVERETT WATER DEPT. (MWRA)	MA	36,000	RICHFIELD AREA JOINT AUTH	PA	1,000
RIVERVIEW	MI	13,189	SUSQUEHANNA TWP ELEM SCH	PA	72
WAYNE	MI	19,093	NORTH STAR EAST MID SCH	PA	620
Ada	MN	1,657	UTL INC-DEL-MAR WATER COMPANY	IL	290
FRAMINGHAM WATER DEPT. (MWRA)	MA	67,610	KNOUSE FOODS INC GARDNERS	PA	150
STORY CITY WATER DEPT	IA	3,228	LANCHESTER LANDFILL	PA	35
LEXINGTON WATER DEPT. (MWRA)	MA	31,507	HOLIDAY TRAV-L-PARK	VA	2,195
LYNNFIELD WATER DIST. (MWRA)	MA	3,000	Saint Paul Regional Water Services	MN	414,735
MALDEN DPW WATER DEPT. (MWRA)	MA	58,690	BAKER CITY OF	MT	1,948
MEDFORD WATER DEPT. (MWRA)	MA	56,203	NEWTOWN ARTESIAN WATER CO	PA	30,000
MELROSE WATER DEPT. (MWRA)	MA	27,244	TOWNSHIP OF BUCKINGHAM-FS	PA	333
MILTON WATER DEPT. (MWRA)	MA	26,825	NEW HOPE SOLEBURY ELEM. SCHOOL	PA	300
NEWTON WATER DEPT. (MWRA)	MA	83,829	RIVER VALLEY SCHOOL	PA	90
GALESBURG	IL	33,706	WESTTOWN-THORNBURY ELEM SCHOOL	PA	500
SOMERVILLE WATER DEPT. (MWRA)	MA	77,478	S BRANDYWINE MIDDLE SCHOOL	PA	680
STONEHAM WATER DEPT. (MWRA)	MA	22,914	HORSHAM CLINIC	PA	488
WATERTOWN WATER DEPT. (MWRA)	MA	32,986	ROCKLAND ELEM SCH	PA	300
D.C. WATER AND SEWER AUTHORITY	DC	581,530	TILDEN ELEM SCH	PA	150
DENTON TOWN OF	MT	301	BEAVER MEADOWS BOROUGH	PA	968
WYANET	IL	1,100	MADISON WATER UTILITY	WI	200,814
WESTON WATER DEPT. (MWRA)	MA	10,983	GENOA CITY WATERWORKS	WI	2,060
CONYNGHAM WATER CO	PA	1,932	ELKHORN WATERWORKS	WI	8,820
MANSFIELD UNIVERSITY	PA	3,000	STRATFORD WATERWORKS	WI	1,651
WINTHROP WATER DIVISION, (MWRA)	MA	19,249	DIXFIELD WATER & SEWER DEPT.	ME	1,485
BARRINGTON	IL	10,168	TOULON	IL	1,400
FALL RIVER WATER DEPARTMENT	MA	94,000			

2004 SIDWIS Query: In 2004, during its investigations prompted by the District of Columbia situation, EPA made a vigorous query of the state primacy agencies to collect data on LCR compliance. This is reported on in the report "**Summary Lead action level exceedances for medium (3,300-50,000) and large (>50,000) public water systems** (Updated as of June 1, 2004)." In this report EPA stated that there were 27 systems serving populations greater than 50,000 that had contraventions of the LCR in the previous four years, and 237 systems serving populations between 3300 and 50,000. The excerpted tables on the next two pages give the contravention data from the report for the 27 systems serving greater than 50,000.

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Table 3 - SDWIS/Fed data for active public water systems serving more than 50,000 people which have exceeded the lead action level of 15 parts per billion (ppb) since January 2000

(Italicized data reflect additional data received from state/system that has not yet been loaded to SDWIS/FED)

In 2003	PWSName	State	Population	Monitoring Period Start Date	Monitoring Period End Date	Lead 90th Percentile Measure (ppb)
X	district of columbia water and sewer aut	DC	595,000	7/1/2003	12/31/2003	63
				1/1/2003	6/30/2003	40
				1/1/2002	12/31/2002	75
				1/1/2001	12/31/2001	8
				1/1/2000	12/31/2000	12
	city of port st lucie utilities	FL	61,275	1/1/2003	12/31/2003	6
				1/1/2002	12/31/2002	5
				7/1/2001	12/31/2001	7
				1/1/2001	6/30/2001	7
				7/1/2000	12/31/2000	8
				1/1/2000	6/30/2000	60
X	pompano beach, city of	FL	75,000	1/1/2003	12/31/2003	59
				1/1/2000	12/31/2000	11
	forsyth co. water & sewer	GA	75,192	1/1/2003	12/31/2003	5
				1/1/2002	6/30/2002	5
				7/1/2001	12/31/2001	3
				1/1/2000	12/31/2000	27
	fall river water department	MA	94,000	7/1/2002	12/31/2002	26
				1/1/2002	6/30/2002	43
				7/1/2001	12/31/2001	33
				1/1/2001	6/30/2001	19
	falmouth water dept	MA	77,500	7/1/2001	12/31/2001	23
X	massachusetts water resources authority	MA	2,000,000	*9/1/2003*	*9/30/2003*	*17*
	(service for 28 communities)			*9/1/2002*	*9/30/2002*	*11*
				5/1/2002	5/31/2002	12
				9/1/2001	*9/30/2001*	*19*
				3/1/2001	*3/31/2001*	*14*
				9/1/2000	*9/30/2000*	*17*
				4/1/2000	*4/30/2000*	*19*
	new bedford water/wastewater department	MA	100,000	7/1/2002	6/30/2003	6
				7/1/2001	6/30/2002	15
				7/1/2000	6/30/2001	16
				7/1/1999	6/30/2000	28
X	salem beverly water supply board	MA	82,123	1/1/2000	12/31/2003	29
	weymouth water department	MA	53,988	1/1/2001	6/30/2001	15
				7/1/2000	12/31/2000	23
				1/1/2000	6/30/2000	43
	portland water dist /greater	ME	113,560	1/1/2003	12/31/2003	6
				1/1/2002	6/30/2002	15
				7/1/2001	12/31/2001	11
				1/1/2001	6/30/2001	10
				7/1/2000	12/31/2000	16
				1/1/2000	6/30/2000	20
	saint paul regional water services	MN	414,735	1/1/2003	12/31/2003	11
				1/1/2002	6/30/2002	12
				7/1/2001	12/31/2001	14
				1/1/2001	6/30/2001	14
				7/1/2000	12/31/2000	15
				1/1/2000	6/30/2000	19
X	hendersonville, city of	NC	52,840	7/1/2003	12/31/2003	16
				1/1/2002	6/30/2002	8
				7/1/2001	12/31/2001	8
				1/1/2001	6/30/2001	7
				7/1/2000	12/31/2000	37
	onslow county water system	NC	79,632	7/1/2002	12/31/2002	16
	bayonne mua	NJ	61,000	*1/1/2002*	*6/30/2002*	*21*
				7/1/2001	12/31/2001	18
	ridgewood water dept	NJ	60,000	7/1/2000	12/31/2000	17
				1/1/2000	6/30/2000	17
X	syracuse city	NY	192,000	7/1/2003	12/31/2003	17
				1/1/2003	6/30/2003	25
				7/1/2002	12/31/2002	15
				1/1/2002	12/31/2002	23
				1/1/2001	12/31/2001	28
				7/1/2001	12/31/2001	20
				7/1/2000	12/31/2000	22

In 2003	PWSName	State	Population	Monitoring Period Start Date	Monitoring Period End Date	Lead 90th Percentile Measure (ppb)
X	yonkers city	NY	196,086	7/1/2003	12/31/2003	13
				1/1/2003	6/30/2003	18
				7/1/2002	12/31/2002	33
	portland bureau of water works	OR	456,000	7/1/2003	6/30/2006	8
				1/1/2003	12/31/2005	10
				7/1/2002	6/30/2005	17
				1/1/2002	12/31/2004	13
	rockwood water district	OR	53,250	7/1/2003	6/30/2006	8
	(purchases water from portland bureau of water works)			1/1/2003	12/31/2005	10
				7/1/2002	6/30/2005	17
				1/1/2002	12/31/2004	13
	salem public works	OR	170,000	1/1/2004	12/31/2006	10
				1/1/2003	12/31/2005	23
X	tualatin valley wd	OR	158,000	7/1/2003	6/30/2006	8
				1/1/2003	12/31/2005	10
				7/1/2002	6/30/2005	17
				1/1/2002	12/31/2004	13
X	el yunque	PR	138,512	7/1/2003	12/31/2003	35
				1/1/2003	6/30/2003	7
X	fajardo ceiba	PR	70,348	7/1/2003	12/31/2003	8
				1/1/2003	6/30/2003	21
				7/1/2002	12/31/2002	7
				1/1/2002	6/30/2002	6
				7/1/2001	12/31/2001	16
				1/1/2001	6/30/2001	14
	juncos - ceiba sur	PR	59,708	7/1/2003	12/31/2003	4
				1/1/2003	6/30/2003	5
				7/1/2002	12/31/2002	2
				1/1/2002	6/30/2002	27
				7/1/2001	12/31/2001	16
				1/1/2001	6/30/2001	188
X	metropolitano	PR	1,536,172	7/1/2003	12/31/2003	21
				1/1/2003	6/30/2003	4
				7/1/2002	12/31/2002	5
				1/1/2002	6/30/2002	9
				7/1/2001	12/31/2001	4
X	rio blanco,vieques,culedra	PR	127,880	7/1/2003	12/31/2003	18
				1/1/2003	6/30/2003	11
				7/1/2002	12/31/2002	8
				1/1/2002	6/30/2002	11
				7/1/2001	12/31/2001	14
				1/1/2001	6/30/2001	6
	From 2000-2004	27 systems	7,153,801	in 2003	12 systems	5,235,961

January 2016

Lead and Copper Corrosion: An Overview of WRF Research

Jonathan Cuppett, Water Research Foundation

This summary of relevant Water Research Foundation (WRF) research projects, both completed and ongoing, provides a basic understanding of the issues surrounding lead and copper corrosion and the Lead and Copper Rule (LCR).

BACKGROUND

In 1991, the U.S. Environmental Protection Agency (EPA) published the LCR, which established that all community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) would be subject to the rule requirements. The primary purpose of the LCR is to protect public health by minimizing lead (Pb) and copper (Cu) levels in drinking water. Pb and Cu enter drinking water mainly from corrosion of Pb- and Cu-containing plumbing materials. A unique aspect of the LCR is that lead and copper have action levels (AL) of 0.015 mg/L for lead and 1.3 mg/L for copper, and therefore do not have Maximum Contaminant Levels (MCLs). The action level for lead is a screening technique for optimal corrosion control based on treatment feasibility, and is not a health-based threshold. The action level for copper does have a health reference based on the prevention of nausea. Copper also has a secondary MCL (SMCL) of 1.0 mg/L, which is based on aesthetics or taste and staining. Table 1 highlights the different regulatory levels of Pb and Cu.

Table 1. Lead and copper regulatory framework

	Copper	Lead
AL (mg/L)	1.3	0.015
Health Based Action Level	Yes	No
MCL	N/A	N/A
MCLG (mg/L)	1.3	0
SMCL (mg/L)	1.0	N/A

The LCR requires a one-liter first draw sample to be taken after a minimum six-hour stagnation time, and homeowners are allowed to take this sample at the customer tap. The LCR has a sample site tiering system for prioritizing the selection of sampling sites based on the likelihood of the sites to release lead and copper. If an action level is exceeded in more than ten percent of samples collected at customers' taps, then further action is required. These additional actions can include source water monitoring and treatment, public education, and lead service line replacement. The EPA provides more information on the Lead and Copper Rule here.

Since the late 1980s, the Water Research Foundation (WRF) has funded over 45 research projects related to Lead and Copper corrosion valued at more than $14 million. All projects with Pb and Cu corrosion implications are described below. This paper is updated annually and includes brief summaries of each project. The last three pages of this paper contain a list of all of the projects with links to the project pages where project reports and executive summaries can be viewed and downloaded.

PAPER ORGANIZATION

Section 1) WRF Project Summaries

This section summarizes the objectives, general research approach, and major findings of WRF projects that have examined various aspects of lead and copper corrosion. The project report summaries are organized under the following topic areas:

- General overview
- Corrosion control effects on water quality and corrosion
- Treatment process effects on lead and copper corrosion
- Specific water chemistry effects on lead and copper corrosion
- Material effects on lead and copper release

Section 2) Summary of Common Themes

This section summarizes common themes and lessons learned from the results of relevant WRF research reports. The results are organized under the following general topic areas:

- General overview
- Corrosion control effects on water quality and corrosion
- Treatment process effects on lead and copper corrosion
- Specific water chemistry effects on lead and copper corrosion
- Material effects on lead and copper release

Section 3) Ongoing WRF Projects

This section lists ongoing research projects that are not yet completed. The objectives, approach, and expected completion year are listed for each.

Section 4) List of published and ongoing research projects

This section provides a list of published and ongoing research projects. The title of each report is hyperlinked to the project page of the WRF website. From this page, you can view general project information and download reports for completed projects. If available, you can also view project updates, the scope of work, webcasts, and other project-related information.

SECTION 1) WRF PROJECT SUMMARIES

General Overview

4286 - Distribution System Water Quality Control Demonstration (2012)

This project demonstrates the use of three tools for process control in water systems. One is a simple data management tool for making sense of complicated systems: Shewhart control charts used in industrial quality control. Another tool is a relatively simple means of tracking water quality at consumers' taps: standardized monitoring stations that are abstractions of consumers' plumbing systems. The third tool is a monitoring strategy that identifies key information linking components of a water system together. This study demonstrates the use of three tools for process control in water systems.

For lead, the monitoring station data were shown to be equivalent to residential water samples taken directly from lead service lines. In lead service lines, the lead-surface-area-to-water-volume ratio is similar to that in a monitoring station. However, this ratio is lower in a first-draw residential sample where plumbing materials other than lead exist. Therefore, the monitoring station lead concentration data are higher than first-draw residential sample data. The same similarity applies to the copper concentrations found in the monitoring stations. However, there are typically more copper components associated with a first-draw residential sample. Therefore, it is expected that monitoring station copper concentration data and first-draw residential sample copper concentration data will be closer in magnitude than the comparative lead data.

3115 - Decision Tools to Help Utilities Develop Simultaneous Compliance Strategies (2005)

Utility managers and staff are required to make decisions about competing water quality objectives in the context of rapidly changing regulations and increasingly rigorous customer expectations. Without careful planning and proper implementation, utility actions originally intended to improve compliance can instead produce adverse unintended consequences.

The research focus of this project was to develop a web-deployed decision-making assistance tool, which allows utilities to more simply identify and assess potential simultaneous compliance conflicts and other negative unintended consequences. The Simultaneous Compliance Tool (SCTool) developed under this project, is intended to assist utilities in evaluating appropriate technology choices to comply with multiple and/or conflicting water quality goals. Potential compliance issues with the Lead and Copper Rule were evaluated as part of this research.

The SCTool is intended to be usable by utility personnel who are not "water quality experts." The SCTool is not a design tool and it will not generate final solutions or recommendations. Rather, the interface prompts the user to enter water quality data and system attributes sufficient to identify when conflicts and consequences are in play.

A webcast for this project is available for download on the WRF website.

725 - Internal Corrosion of Water Distribution Systems, Second Edition (1996)

This report is a guidance manual on corrosion control for drinking water systems that covers corrosion principles, corrosion of materials, mitigation of corrosion impacts, assessment technologies, and approaches to corrosion control studies. Various chapters address lead and copper related corrosion issues.

813 - Innovative Techniques for Lead Service Line Location (1995)

This report evaluated lead water service line location techniques. This objective was met through the following:

- Identification and evaluation of any emerging techniques or technologies available through a thorough search of literature
- Development of potential direct methods through the use of emerging or existing techniques, and conduct of bench scale and field tests for performance evaluation
- Development of indirect methodologies to determine probability of lead service lines by analyzing utility records and databases, and using statistical methods

406 - Lead Control Strategies (1990)

This report was published during the time that the LCR was first being introduced in the Unite States. At the time, EPA guidance on LCR treatment plans (i.e., pipe loop studies, analysis of data, start-up, and monitoring of treatment) had not yet been developed or published. Despite the premature timing of this study with respect to the LCR, the manual does provide a body of knowledge to help utilities develop lead control strategies.

This project identified potential sources of lead coming from customer plumbing as being goosenecks, lead service lines, lead plumbing, lead lined iron piping, lead tin solder, and brass faucets. Many variables control the rate of leaching and lead in water samples, including the age and type of material, workmanship, size of pipe, water quality, size of the water sample, standing time, and whether a water sample has been running or standing.

As a part of this project, the research team contacted utilities that had conducted lead studies to improve water quality for their customers. The studies included water quality tap sampling, pipe loop studies, lead materials investigations and replacement programs, and lead treatment programs. The case studies provided a good basis for developing viable lead control strategies at the time.

The manual also provided the theory and practical considerations for controlling lead leaching from chemical treatment processes. The researchers determined the most important water quality parameters for lead solubility to be pH, alkalinity, dissolved inorganic carbonate, and orthophosphate levels. The manual recommended controlling lead with pH adjustment, carbonate adjustment, orthophosphate addition, silicate addition, and calcium carbonate deposition.

Corrosion Control Effects On Water Quality and Corrosion

4103 - Comparison of Zinc vs. Non-zinc Corrosion Control for Lead and Copper (2011)

This project evaluated if there are corrosion control and metal release performance advantages between "zinc orthophosphate" (ZOP) and non-zinc orthophosphate corrosion inhibitor formulations under realistic distribution system and domestic plumbing conditions. While many communities nationwide use ZOP, it is expensive and the zinc becomes concentrated in wastewater sludge, which can be an environmental concern. An alternative to ZOP is orthophosphoric acid (non-zinc orthophosphate), which has been successfully used for corrosion control at a number of utilities nationwide. However, there is a lack of scientifically valid data comparing the performance of ZOP and non-zinc corrosion inhibiting compounds (CICs) for controlling the rate of corrosion and levels of metal release from iron, lead, brass, and copper piping and plumbing devices.

The project team utilized a multiphase approach to address these issues. The first phase was a series of bench-scale experiments performed to examine the impact of corrosion variables including pH, orthophosphate dose, and chloride to sulfate mass ratio (CSMR) on lead and copper release. Experiments were also performed to examine the impact of corrosion variables on cement. The second phase of the research consisted of pilot testing at five systems that currently use orthophosphate. The third phase of the research involved the collection of historical and operational data from utilities that use ZOP along with analysis of samples from distribution systems to examine the fate of zinc and orthophosphate in the distribution system.

The results from the statistical approach suggest that, for general corrosion of lead and copper in most locations, there does not appear to be a significant difference in performance between ZOP and non-zinc orthophosphate. This conclusion is based on analyses of electrochemical measurements, dissolved metal release, and particulate metal release. Bench studies have shown that zinc may be beneficial for preventing some types of copper pitting corrosion. Furthermore, results of this study suggest that addition of a zinc containing CIC is beneficial in reducing cement degradation and aluminum release to water when treated water is low in calcium and alkalinity. There appears to be little advantage in adding zinc to treated water high in calcium and alkalinity as non-zinc orthophosphate alone can inhibit calcium carbonate scaling of cement. If zinc dosing is discontinued, calcium leaching from cement can return to levels that correspond to those present when no zinc protective scale is present in as little as five weeks.

Based upon calcium and aluminum leaching results, it appears that a 0.1 mg/L zinc dose is sufficient to provide continued corrosion protection once a protective zinc-containing scale layer has been formed. The results of these studies should be interpreted with caution however, and bench-scale and/or pilot studies should be conducted to determine if zinc addition is beneficial for a specific water quality condition. Additionally, a cost/benefit analysis should be conducted concerning the benefit of adding zinc (to increase the life of concrete infrastructure) versus the cost of zinc treatment and disposal. Non-cost factors, such as the environmental impact of zinc, should also be included in the evaluation.

3174 - Investigation of the Mode of Action of Stannous Chloride as an Inhibitor of Lead Corrosion (2010)

This project evaluated the mechanism by which stannous chloride ($SnCl_2$) decreases the corrosion of lead and the corresponding release of Pb into the water supply. The specific objectives of the research were to improve the understanding of tin chemistry in drinking water, investigate the toxicity of tin to both planktonic and biofilm bacteria, and determine the mode of action of $SnCl_2$. Batch experiments were performed to investigate the reactivity of stannous ion with drinking water oxidants followed by determining the toxicity of stannous and stannic chloride to planktonic and biofilm bacteria. Finally, batch experiments with lead coupons were performed to investigate the effects of tin on lead corrosion.

Results showed that measured chlorine consumption coupled with the low recommended dose for water treatment indicates that use of stannous chloride will result in a minor chlorine demand. Stannous chloride was highly toxic to laboratory strains of heterotrophic bacteria but not as toxic to a laboratory strain of nitrifiers. Compared to the lab strains, environmental bacteria were significantly more resistant to Sn toxicity. Depending on the dose, stannous chloride can inhibit P. aeruginosa biofilm formation and remove established biofilms.

Aged and new coupons were employed in semi-batch reactors to investigate the role of microbially-influenced corrosion (MIC) and the effects of stannous chloride on lead corrosion. Bacteria and biofilms were prevalent on the lead coupons at the end of the lead corrosion experiment for all conditions suggesting that MIC may be important for lead. Furthermore, stannous chloride did not decrease the accumulation of biofilm on the coupons or the concentrations of dissolved and total lead released from the coupons.

Utilities considering use of stannous chloride for lead corrosion control should proceed slowly and with caution. In previous pipe loop studies, stannous chloride showed some benefit with respect to reducing lead and bacterial levels, but the chemical did not decrease lead release or biofilm accumulation in the batch experiments with lead coupons performed in this work. Coupon and possibly pipe loop studies are recommended for utilities considering use of stannous chloride to evaluate whether the chemical might be effective for the given water quality conditions.

157 - Distribution System Water Quality Changes Following Corrosion Control Strategies (2000)

This project documented distribution system secondary water quality impacts of implementing lead and copper corrosion control strategies. The researchers also developed mitigation strategies to preclude, minimize, or eliminate problem areas that resulted from LCR treatment.

The researchers found that the interplay of the water quality of the distributed water, types of materials present in the distribution system, and the hydraulic conditions in the distribution system all lead to secondary water quality impacts. Most impacts occurred when the distribution system water quality was unstable, either because of multiple finished water quality changes over short periods of time or because of wide fluctuations in pH levels. Wide fluctuations in pH largely occurred because of inadequate buffering in the distribution system or because large changes occurred in finished water quality conditions. For systems controlling pH and/or alkalinity, few adverse secondary impacts occurred when consistent distribution pH levels and adequate buffering intensity were maintained.

The researchers recommended that utilities establish and implement procedures for corrosion control treatment, including:

- Design corrosion control facilities with appropriate pH adjustment controls. Low buffer intensity can result in pH fluctuations that can produce scales on pipe surfaces that are less adherent. Large pH fluctuations can also cause solubilization and precipitation of scales.
- Ensure that distributed water quality remains stable by maintaining adequate buffering and consistency of treatment.
- Avoid other treatment changes during the period of time when corrosion control is initiated (such as changing disinfectants, changing coagulants, or adding new treatment processes).
- Make incremental changes to finished water quality during start up to avoid exposing the distribution system to large finished water quality changes over a short period.
- Respond to localized water quality problem areas with a flushing program.
- Evaluate the potential for secondary impact based on water quality data evaluations, assessments of piping conditions and hydraulic information, and review of historical treatment information.
- For systems using orthophosphate inhibitors, maintain adequate residuals in the distribution system and apply the inhibitors at the pH range that is optimal for lead and copper control (7.3 to 7.8).
- Implement a distribution system monitoring program to provide information to assess and respond to secondary impacts that might occur. Monitoring programs should include:
    - Standing lead and copper levels (more frequently than required by the LCR)
    - Water quality parameter measurements to assess the secondary impacts of corrosion treatment and to evaluate the amount of time needed for lead, iron, copper and other materials to re-equilibrate to new water quality conditions
    - Orthophosphate and/or silicate levels
    - pH and alkalinity levels

910 - A General Framework for Corrosion Control Based on Utility Experience (1998) and Control of Pb and Cu Corrosion By-products Using CORRODE Software (1995)

This is a compilation of utility experiences with mitigation of lead and copper corrosion by-product release under provisions of the LCR. Corrosion by-products include aqueous, dissolved, and solid species associated with lead and copper ions. This project report provides a list of publications that synthesize utility experiences with corrosion control, information on how to conduct desktop corrosion control studies, corrosion control case studies, and a software program that simplifies predictions of lead and copper solubility. This manual is meant to be used at two different levels. Utility managers, staff, and regulators could review the report to gain insights into corrosion control approaches and strategies. On another level, the report provides more specific utility experiences under the LCR, providing insight for mitigation of corrosion by-products.

The software product provided with this report is a tool to simplify predictions of maximum soluble lead and copper corrosion by-product release in pipes under different water quality conditions. It also addresses the impacts of aeration on pH and lead and copper solubility as well as the effects of mixing on water quality. It should be noted that due to gaps in knowledge regarding the fundamental science of corrosion by-product release and the fact that many corrosion by-products are particulates and not soluble, the software is somewhat limited. Despite those limitations, solubility predictions are an important component of corrosion desktop studies and were considered one of the best predictive tools for utilities at the time this report was published.

Some key points presented in this manual are:

- The 1995 Water Industry Technical Action Fund (WITAF) database referenced in this report provides a comprehensive compilation of utility experiences that allows utilities to compare their own experiences with those of other water utilities with similar water qualities.
- Differences in sampling rigor can cause substantial differences in the outcome of a tap sampling program. Monitoring programs should stress that samples be acquired following the minimum standing water period and using low flow rates during the sample draw.
- Before proceeding with the implementation of a corrosion control program, it is critical to establish representative metal release rates in the distribution system.
- Pipe loop protocols are proven to provide useful information in several corrosion control assessment programs; however, they required a substantial investment of resources and time. Additionally, the data they yield are often difficult to analyze and not always predictive of distribution system performance.
- The secondary impacts of corrosion control are usually relatively minor:
    - Utilities that attempted to define whether corrosion control treatments produced noticeable change in the taste and odor profile of the distributed water were unable to demonstrate any difference relative to the unmodified baseline water.
    - The pH shifts associated with most corrosion control strategies produced only minor changes in the concentration of disinfection by-products.
- Solubility models have value in terms of predicting metal release trends and for examining mechanisms of passivation and corrosion scale accumulation. However, while the models accurately reflect equilibrium conditions, they do not take into account solubility kinetics, the heterogeneity of plumbing surfaces, or the issue of particulate shedding versus soluble metal release.
- Some electrochemical screening techniques can accurately determine the underlying rate of corrosion on lead and copper surfaces, as well as on the surfaces of their alloys.
- Copper corrosion control is easier to achieve than lead release control. Copper corrosion is almost exclusively chemical, while lead release is governed by a combination of chemical, hydraulic, and other mechanical factors.
- Stability of pH is necessary for controlling the release of lead. Distribution system pH changes that drop the pH by greater than 0.5 units, even for brief periods, appear to disrupt the effective passivation of corrosion surfaces, especially on brass and lead/tin solder surfaces.

- There is evidence that opportunistic organisms can exploit corrosion scales as colonization sites. By doing so they create a microenvironment that may influence the rate and morphology of corrosion on the underlying metal.

2587 - Role of Phosphate Inhibitors in Mitigating Lead and Copper Corrosion (2001)

This project summarizes the effects of phosphate-based corrosion inhibitor chemicals on lead and copper corrosion. Experiments were conducted to examine the complexation of copper and lead, solid dissolution rates, and solid precipitation in the presence of polyphosphate.

Fundamental Chemistry Experiments. For the polyphosphate tested in this study, every 1 mg/L of phosphate inhibitor dosed (as P) had the potential to hold 2 mg/L of lead in solution. This could be considered a maximum capacity for lead dissolution, as this high of a value would rarely be achieved in practice due to the effects of calcium, magnesium, kinetic limitations, and other factors. Lead complexation is not as strong in the presence of calcium (40 mg/L) but is still relatively important. These experiments also indicated that hexametaphosphate increases the rate of dissolution from lead scales [including $PbCO_3$ and $Pb_3(CO_3)_2(OH)_2$]. Precipitation of lead from solutions containing $NaHCO_3$ was inhibited by sodium metaphosphate. The final dissolved lead concentration was roughly equal to the metaphosphate complexing capacity. Higher metaphosphate concentrations resulted in higher dissolved lead concentrations. This led to the conclusion that polyphosphate can influence the kinetics of scale formation in pipes.

Copper Corrosion. With a few exceptions, dosing of orthophosphate and hexametaphosphate inhibitors had beneficial effects on copper release. The exceptions are for very new pipes at pH 7.2, in which hexametaphosphate had very significant adverse short-term effects, and for well-aged pipes at pH 7.2 and alkalinity 300 mg/L as $CaCO_3$. In the latter case, although the orthophosphate had dramatic short-term benefits, a few years of aging caused marked decreases in release when inhibitors were absent.

Lead Corrosion. Orthophosphate dosing often produced significant benefits for lead. This was true for every stagnation time and water quality tested at 6 months' pipe age. The project also examined the role of phosphate inhibitors in controlling soluble lead release, as opposed to total lead. In every instance, soluble lead concentrations were lower in the presence of orthophosphate than in an equivalent system without inhibitor. Conversely, with few exceptions, soluble lead concentrations were higher in systems dosed with hexametaphosphate than without inhibitor. Orthophosphate has an enormous advantage over hexametaphophate when comparing soluble lead release. Hexametaphosphate demonstrated an increase in soluble lead in every instance when compared to an equivalent dose of orthophosphate. This lead to the conclusion that hexametaphosphate substantially increases problems with soluble lead.

Lead and Copper Corrosion By-Products. Significant fractions of particulate and colloidal lead and copper were found in participating utilities' tap water samples. Copper was mostly soluble when total copper levels were high. In contrast, most of the lead found in the tap samples was in the particulate form.

Zinc Orthophosphate. The addition of zinc did not enhance the performance of orthophosphate. In all cases zinc tended to detract from the benefits of orthophosphate. This lead the researchers to conclude that zinc orthophosphate cannot be recommended for copper or lead corrosion control when compared to orthophosphate alone.

4033 - Impact of Phosphate Corrosion Inhibitors on Cement-Based Pipes and Linings (2009)

This project investigated the interactions between water chemistry, temperature, cavitation, and phosphate corrosion inhibitors with cement-based pipes and linings in order to understand scale formation, lime leaching, and bulk water quality implications in the distribution system. The research team used field data from 19 water utilities in combination with bench-scale testing in order to understand the relationship between water quality factors and cement-based pipe failures.

The case studies from the 19 participating utilities demonstrate the diversity and complexity of corrosion control issues. The bench scale test results generally correlate with utility experience and demonstrate the effectiveness of corrosion inhibitors in the protection of concrete and cement-based pipes. It is important to note that it is unlikely for a utility to have one type and material of pipe in their distribution system, which further complicates a utility's corrosion control program.

General trends were observed from the water quality conditions that were tested at bench scale:

- Low alkalinity (~20 mg/L as $CaCO_3$) and low pH (~7.0) can be extremely aggressive to concrete and can cause rapid degradation of concrete by lime leaching into the bulk water.
- High alkalinity (~200 mg/L as $CaCO_3$) and high pH (~8.3) are non-aggressive to concrete, but scaling of pipes by calcite precipitation can be a major concern to utilities due to the potential impacts on the hydraulic capacity of the distribution system.
- Higher concentrations of magnesium and silicon can be effective at preventing concrete corrosion, but only at higher bulk water pH of about 9.5.
- The kinetics of concrete corrosion degradation reactions increase at higher temperatures, but this effect is countered by reduced calcite solubility in waters with higher pH/higher alkalinity (with no inhibitor added).
- Gaseous cavitation did not increase concrete corrosion, but vaporous cavitation can be extremely detrimental to concrete.
- Both zinc and non-zinc phosphate inhibitors (orthophosphate and polyphosphate) were effective at reducing concrete corrosion at near neutral pH. At a pH of 8.3, neither orthophosphate nor polyphosphate were effective at reducing corrosion.

Prior to making any changes to corrosion control programs, utilities should consider undertaking bench scale or pipe loop tests for baseline (control) in comparison to different corrosion inhibitors and pH/alkalinity adjustment conditions to confirm the results and develop a corrosion control strategy that meets the utility's goals. Utilities should also continuously monitor water quality changes in the distribution system to ascertain if changes may be due to corrosion of concrete or cement-lined pipes. Continuously monitoring hydraulic changes in the distribution system to assess changes in hydraulic capacity caused by lower than expected C-values can help a utility determine if those changes are due to deposition or scaling forming on distribution system pipe walls. Utilities should also evaluate surge conditions in the distribution system to avoid vaporous cavitation conditions that could be detrimental to concrete or cement-lined pipes. Based on the results of bench or pipe loop testing and all of the monitoring data, a utility can assess its current corrosion control practices and whether they are effective for protection of distribution system infrastructure and LCR compliance.

4029 - Assessment of Secondary Impacts of Corrosion Control on Distribution System Equipment (2010)

This project used a literature review, technical workshop, utility and regulator survey, and interviews with utility engineers, operators, regulators and researchers to assess distribution system and treatment plant equipment failures or problems that occur from water quality changes made for corrosion control. The focus is specifically on the secondary effects on valves, meters, impellers, and pumps.

While corrosion, scaling, and precipitation occur on a widespread basis, most utilities do not focus on these issues until problems occur. It is difficult to find utility employees with knowledge of these effects and the responsible managers are likely to be treatment and water quality staff or operations managers for both treatment and distribution systems. Most utilities are concerned with their ability to meet demands and are aware of clogging and the need to flush and renew pipes, but are not aware of the qualitative reasons behind impeded flow conditions. The general assumption is that scaling and impeded flow are inevitable and utilities use maintenance and renewal to avoid these issues. Utilities that use pH control to create calcium scales to passivate pipe surfaces seem to have a better handle on secondary effects from corrosion control.

Secondary effects are clustered around dominating distribution system material metal species—calcium, aluminum, iron and manganese—and include pipe scaling and clogging; inoperable valves, pumps and meters; water quality changes causing red, yellow, or black water; and release of constituents and transport of release materials. Calcium effects are most common in corrosion control treatment, but aluminum effects can also occur from changes in pH and from the use of inhibitors. While iron and manganese effects do not always result directly from corrosion control treatment, they are interrelated with other effects on corrosion and deposition.

The ability of calcium compounds to remain in solution is very sensitive to pH changes and the few serious calcium problems that were identified occurred suddenly due to pH shifts. Aluminum scaling can also occur from water quality adjustments used in corrosion control programs and can cause significant loss of capacity in water pipes.

Recommendations for utilities to detect and remediate the secondary effects of corrosion control include:

- Implement effective condition assessment programs as part of utility asset management systems.
- Designate a single manager at a utility to be in charge of and evaluate scaling problems.
- Conduct a study to evaluate corrosion effects, loss of pipe capacity, valve problems, pump seizures, impaired hydrant function, colored water, hot water problems, plugged injectors and other symptoms. This can be done with pilot or full-scale studies of treatment changes using pipe loops with pipe coupons.
- Use multiple approaches including uni-directional flushing, pH adjustment, change in chemical additives, re-plumbing of systems, cleaning and lining, and pipe replacement. Of course, selecting among these options requires careful consideration of the benefits

and costs of each in terms of utility objectives—including water quality, hydraulics, customer service, and workforce utilization.

2679 - Post-Optimization Lead and Copper Monitoring Strategies (2004)

This project developed a monitoring program for drinking water utilities that have already achieved optimized corrosion control. Alternative monitoring methods were developed to demonstrate to regulatory primacy agencies that corrosion control is being maintained when treatment techniques and/or source waters are altered.

Utilities have been struggling with variability in monitoring data, shrinking sample pools (due to home remodeling or lack of customer interest), increasing costs associated with monitoring programs, and the differing needs of utilities verifying optimization and corrosion control versus those trying to achieve optimization in the first place. The monitoring protocol recommended in this report simultaneously addresses the control of data variability and attrition of sample pools by recommending the sampling of fewer sites more often. It also provides utilities and regulators with tools to continue to collect statistically sound data in the face of fewer qualified sample locations.

The research team conducted regulator and utility surveys to develop both an in-home tap and an on-line corrosion monitoring protocol that were then field tested by four participating utilities. From this research, the team developed a proposed alternative lead and copper corrosion control monitoring strategies. Included are proposed in-home tap sampling protocol and statistical evaluation methodologies and an evaluation of the applicability of on-line corrosion cell predictive technologies.

Alternative In-Home Tap Monitoring Protocol. A detailed summary of the alternative tap monitoring protocol can be found in the published report. It outlines, for both lead and copper, the number of sites recommended for sampling, the number of samples per site, a quarterly evaluation period, site selection criteria, and data collection and analysis criteria.

On-line Corrosion Monitoring Protocol. The development of the on-line corrosion cell (OLCC) addressed many of the challenges associated with the initial design of a functioning corrosion cell. After several attempts, the Narrow Rectangular Cell (NRC) design showed that the Corrosion Potential-Stagnation/Flow (CPSF) theory could be verified in the laboratory and in the field. In its current level of development, the NRC OLCC is not widely applicable to utility use and data interpretation can be difficult for a typical utility operator. However, the OLCC design and findings reported are a significant first step to future investigation into this type of corrosion cell.

An automated sampling device was developed to a prototype stage and tested in the field. Data collected using the devices was comparable to manually collected samples. Future investigation will require design revision and more extensive field-testing.

Finally, the investigation of lead and copper pipe loops as a tool for tracking corrosion control changes demonstrated that the potential for their use did exist. However, due to the time required for pipe loops to stabilize, the feasibility of their use is limited to utilities that have an operable pipe loop rack in inventory or under operation. The data provided by the pipe loop racks evaluated did not justify the time and associated financial commitment required for the development of such a tool for an already optimized utility.

2648 - Optimizing Corrosion Control in Water Distribution Systems (2004)

This project developed and tested an online, real-time electrochemical sensor to screen corrosion inhibitors for drinking water treatment. It also demonstrated the use of electrochemical noise (EN) in development for corrosion control applications.

The results of this study were successful in demonstrating the use of a multi-element sensor, electrochemical technique for instantaneously monitoring corrosion and optimizing corrosion in water distribution systems. Additional findings from the study include:

- The EN technique was shown to be a sensitive tool for identifying electrochemical corrosion phenomena and allowed low rates of pitting to be accurately detected and monitored.
- EN corrosion rate calculations appeared to follow changes in process parameters such as use of inhibitors, water flow past electrodes, and water temperatures.
- Electrochemical noise measurements in the field detected corrosion rates over a wide range, and characterized the degree of localization.
- EN monitoring can be implemented with informed but minimal effort. New monitoring techniques can be effective if process is kept fairly simple.
- Although EN signals could not be directly correlated to water quality concentrations, the value of using EN is having the ability to monitor changes in corrosion environments and having the ability to identify pitting and crevice corrosion regimes.

Treatment Process Effects On Lead and Copper Corrosion

4164 - Lead and Copper Corrosion Control in New Construction (2008)

New plumbing systems can contribute to lead and copper corrosion and cause aesthetic problems. This purpose of this project was to develop guidance to install and commission new building plumbing systems and specifically answer the following questions:

1) What flushing recommendations would remove ammonia, zinc, and high chloride due to flux from plumbing lines, along with metallic debris and solvents?
2) Can more frequent flushing assist in passivation of lead leaching from new brass?
3) To what extent do residual PVC solvents and flux contribute to initiation of nitrification in premise plumbing?
4) Do current shock chlorination practices damage plastic and/or copper plumbing systems?

The following are conclusions from the project:

- If lead leaching is an issue in a newly commissioned plumbing system, a multi-faceted approach that includes comprehensive testing may be necessary to remediate problems since the root cause may be a result of installation procedures, plumbing system design, lead leaching propensity of the installed brass devices, corrosivity of the water relative to new brass, or commissioning procedures. Factors that contribute to lead problems include high lead content of brass valves, relatively high corrosivity of water towards leaded brass valves or solder, trapped lead-bearing particulates on strainers, aerators, or in the plumbing system, or nitrification because the resulting lower pH might result in excessive metal leaching or reduced rates of passivation.

- The improper use of petroleum-based flux in plumbing systems, or failure to promptly flush flux from the plumbing lines, can cause a variety of problems with drinking water affecting aesthetics, health, and corrosivity due to high metal leaching and possible promotion of microbial growth.
- Flushing of ASTM B813 compliant flux and metallic debris can be accomplished using water at or above 3.6 fps; however, petroleum-based flux cannot be flushed from plumbing systems with ambient temperature water, which can create long-term problems.
- The inadequate flushing of flux from a plumbing system can lead to the proliferation of nitrifying bacteria. Nitrification can create higher levels of lead and copper at the tap and allow higher levels of microbial growth within the plumbing system.
- One time 50 to 200 mg/L shock chlorination does not seriously damage plastic piping or copper tube; however, repeated shock chlorination events are not recommended because significant deterioration may occur.
- Pipe material has a strong influence on the level of chlorine demand and associated ability to meet required levels of disinfectant residual after shock chlorination. In a comparison of copper, brass, cross-linked polyethylene (PEX), and chlorinated polyvinyl chloride (CPVC), copper exerts the highest chlorine demand while CPVC exerts the lowest. Copper exerts a higher demand because chlorine is a strong oxidizer and the copper is subject to some oxidation whereas the CPVC is not. Chlorine is consumed as it is reduced.
- When shock chlorination is employed to disinfect plumbing waters with pH levels 9 and above, chlorine residuals tend to be held better than with waters at lower pH levels. Orthophosphate addition significantly reduced the rate at which chlorine disappears from some waters.

A brochure was produced as part of this project. This brochure provides guidance to plumbers, building managers, regulatory agencies, and code administrators on installation of premise plumbing for new construction. A strategy is outlined to test, remediate, and mitigate plumbing issues in new buildings. A webcast for this project is available for download on the WRF website.

3107 - Effect of Changing Disinfectants on Distribution System Lead and Copper Release (2010)[1]

Part 1 – Literature Review. The literature review identified many of the key issues with regard to predicting effects of disinfectant change on lead and copper corrosion and metals release into drinking water supplies. This literature provides information related to the following questions:

- How does a change in disinfectant impact lead release?
- How does a change in disinfectant affect copper release?

[1] Projects #3107 and #4088b produced conflicting results on lead release. A later WRF project, #4349, *Galvanic Corrosion Following Partial Lead Service Line Replacement*, examined these results. Please refer to page 30 of this document for details on project #4349.

- Does galvanic coupling affect metals release with the change in disinfectant?
- How does the change in disinfectant affect the nature of protective scales formed on plumbing materials?
- Historically, what have been the effects of various forms of treatment on galvanic coupling corrosion and metals release after disinfectant changes in the distribution system?
- What effect does background water chemistry have on metals release and galvanic coupling?
- What effect does a change in disinfectant have on redox?

The findings of the literature review indicated the importance of chemical and electrochemical properties that are fundamental to our understanding of the response of corroding metals and alloys to transitions from free chlorine to chloramines, and vice versa.

Part 2 – Research Results. The objective of this research was to determine effects of changing disinfectants from free chlorine to chloramines and vice versa on metals leaching rates and leaching levels from lead, brass, and copper components in the distribution system. This project also studied the effects of galvanic coupling on metals release. This investigation produced a body of data regarding metal release and passivation under a variety of conditions that provides valuable guidance for engineers and utility operators seeking to make disinfectant conversions without endangering public health. While the results of this project are especially applicable to distribution systems with lead components, the implications of this research extends to newer distribution systems containing other lead-bearing materials.

The researchers made the following conclusions:

- For lead plumbing materials that do not have extensive accumulation of surface scales containing PbO_2, changes in disinfectant are not likely to significantly impact lead leaching.
- For lead plumbing materials that are passivated and likely to have developed scales that are rich in PbO_2, changes in disinfectant—that is, conversion to chloramines or some other low ORP conditions—are likely to cause a notable increase of lead leaching when conversion to chloramines is implemented.
- Copper leaching can be temporarily increased due to chlorine/chloramines transition (or vice versa). However, in most cases the increase in copper leaching is followed by a sustained decrease in leaching rates.
- Because the sensitivity of copper leaching to the presence of a disinfectant does not appear to be disinfectant-specific, disinfectant conversions in distribution systems probably do not run the risk of substantial increases in copper concentrations at household taps.
- Lead leaching from bronze appears to exhibit trends similar to those seen from lead. Lead corrosion products appear to rapidly form on lead phase existing on the alloy surface, ultimately suppressing lead release.
- Copper leaching from bronze can be promoted by the presence of a disinfectant. However, like copper leaching from copper materials, this effect is transient and tends to be followed by a decreasing leaching.
- Effects of changing disinfectants on metal leaching from bronze plumbing materials are minimal.

- Galvanic effects appear to be very sensitive to initial chlorine/chloramines (or vice versa) transitions. However, the effect is highly transient. Under steady state conditions, the shock of initial exposure quickly wanes.
- In general, disinfectant conversion does not appear to have long-term significant impact on galvanic effects. However, background water quality conditions or particular mineral passivating scales that were not explored in this investigation may produce different results.

Additionally, based on the findings of this research, guidelines for before and after the disinfectant change were developed for utilities faced with potential consequences of lead and copper release.

4088 Part 1 - Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water (2010)

This project investigated the potential effects of coagulant changeover on lead release from plumbing components, with emphasis on changeover from aluminum sulfate to ferric chloride, ferric sulfate, polyaluminum chloride, and various polymer coagulants. Additional project goals were to investigate the finished water chemistry resulting from coagulant changeover, how distribution system scales are affected and how this affects lead release, and the magnitude of lead release after different stagnation times.

The work was performed in three phases. In Phase 1, the fundamental chemistry of galvanic corrosion attack on lead-copper joints was evaluated, and experiments examined impacts of high Chloride: Sulfate Mass Ratio (CSMR) on the integrity of soldered joints. Utility case studies were evaluated in the second phase of work to examine effects of CSMR on galvanic corrosion in a number of potable waters. Specifically, questions regarding the effects of coagulant changeover, desalination, and anion exchange treatment on lead solder and leaded brass corrosion were evaluated. The roles of alkalinity, pH, and corrosion inhibitors to potentially mitigate corrosion in high CSMR waters were also examined. Finally, in a third phase of work, re-circulating loops were used to evaluate the impacts of chloride, sulfate, and flow rate on corrosion of lead plumbing.

Some of the key conclusions that came out of this study are listed below:

- The corrosion rate of and the release of lead and/or tin from solder alloys was greater in high CSMR water. The pH at the solder surfaces was measured to be as low as pH 3.0.
- Generally, increasing the CSMR of the water results in higher lead levels in water when copper:lead solder or copper:lead pipe galvanic couples are present. There could be higher chloride and lower sulfate in the water due to road salt entering the water supply from runoff, coagulant type (chloride-based vs. sulfate-based), desalination, chloride-based anion exchange treatment, brine leak from hypochlorite generation system.
- For the utilities evaluated in this project, leaded brass leached relatively low levels of lead to the water, even in situations with high CSMR. In contrast, corrosion of lead solder in simulated copper joints contributed to very high amounts of lead in test waters. Thus, while leaded brass is impacted somewhat by CSMR, the issues associated with lead solder can occasionally achieve hazardous waste levels (>5,000 ppb) of lead in water

under worst-case scenarios. As a result, lead solder and lead pipe galvanically connected to copper are the primary concern when effects of higher CSMR are considered.

- The galvanic connection of copper to the lead materials evaluated in the study significantly increased lead leaching when compared to the situation when there was no electrical connection to copper pipe. In some waters, however, galvanic connections had little effect on lead leaching.
- Problems that occur in coagulant changeovers could usually be mitigated by controlling the type of coagulant and keeping CSMR below about 0.5. However, this is not always an option when CSMR was increased via arsenic treatment, anion exchange or desalination. For these case studies, adding orthophosphate when the CSMR was high did not reduce lead leaching or the extent of the problem.

A second phase of this project was conducted to examine effects of CSMR and galvanic corrosion on lead leaching to potable water after partial lead service line replacements.

4088B - Contribution of Galvanic Corrosion to Lead in Water After Partial Lead Service Line Replacements (2010).[2]

Due to property ownership issues, partial lead service line replacements (and not full replacements) are widely implemented in the United States, with a primary goal of reducing lead exposure at the tap. During a partial-pipe replacement, a portion of the lead service line is typically replaced with copper pipe. These dissimilar metallic pipe materials are then connected to restore drinking water service. This process creates an electrochemical or galvanic cell, which can accelerate corrosion of the lead pipe. In this work, the adverse effects of such connections in the context of lead leaching were confirmed in experiments of simulated lead service line replacements.

The results of this research found that under stagnant water conditions, galvanic connections between lead pipe (either new or old) and copper pipe increased lead release into the water, compared to a full length of lead pipe alone. The extent of galvanic corrosion observed was dependent on drinking water quality. Exposure to synthetic water of high CSMR (i.e., CSMR of 16) increased lead release from the Pb:Cu test rigs by 3–12 times, compared to low CSMR water (i.e., CSMR of 0.2). Higher galvanic currents between lead and copper were measured when the CSMR was high, mechanistically explaining the trends in lead release. Even Under stagnant water conditions, galvanic connections between lead pipe (either new or old) and copper pipe increased lead release into the water, compared to a full length of lead pipe alone. The extent of galvanic corrosion observed was dependent on drinking water quality. Key aspects of this study are also available in the March 16, 2010 Webcast.

604 - Development of a Pipe Loop Protocol for Lead Control (1994)

This project provides drinking water utilities with a standard protocol for use of the AwwaRF pipe rack to evaluate the effectiveness of various treatment options in controlling lead and copper levels at the tap. The protocol provided is a practical, hands-on approach with

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[2] Projects #3107 and #4088b produced conflicting results on lead release. A later WRF project, #4349, *Galvanic Corrosion Following Partial Lead Service Line Replacement*, examined these results. Please refer to page 30 of this document for details on project #4349.

construction, operation, and data evaluation recommendations based on results from several utilities that tested the AwwaRF pipe rack in their plants.

The AwwaRF pipe rack is designed to evaluate lead and copper leaching characteristics in a flow-through system that simulates household plumbing. Each rack is designed to contain several individual pipe loops for which various metal levels could be evaluated for specific water qualities. The pipe rack is designed to help utilities perform corrosion rate studies and metals leaching determinations for compliance with the LCR.

The LCR requires that all utilities serving over 50,000 customers conduct corrosion control optimization studies and demonstrate optimal treatment for lead and copper. The 1992 USEPA guidance manual for the LCR specifies a framework for conducting corrosion studies. The AwwaRF pipe rack can be used as a demonstration testing device for comparing the effect of corrosion treatments on metals levels and for testing secondary impacts of treatment changes on water quality and regulatory compliance.

Proper planning and operation of pipe rack studies are crucial for a successful pipe rack study: proper fabrication, adequate mixing of chemical feed solutions, adequate preconditioning, proper disinfection of sample ports (to prevent high heterotrophic bacteria counts), and monitoring of pipe rack operations. The operation can be divided into three phases: startup, preconditioning, and corrosion testing operations. With startup, a standard protocol for flushing is recommended in the manual. The manual also recommends a four-week preconditioning phase before chemical treatments are started. This allows verification that the pipe loops are constructed in a similar fashion and yield similar results with a common starting point for evaluating treatment effects on leaching. For the actual corrosion testing, the manual recommends a daily on-off cycle to simulate flow in a typical home, collection of standing samples for measuring corrosion-related parameters, and collection of running samples for determining influent water quality characteristics and operational consistency. At a minimum, lead, copper, temperature, alkalinity, total and free chlorine, and pH are recommended for analysis on first flush, standing water quality samples. The manual recommends frequency of collection of standing samples based on the expected variability of the results and the length of time over which samples will be collected.

The manual recommends that utilities run pipe rack studies for three distinct periods: a conditioning period, a transition period, and a stability period. The conditioning period consists of a rapid drop in metals levels, followed by a transition period where metals levels decrease at a slower rate. In the stability period, metals levels stabilize. Utilities must run the pipe rack studies long enough to ensure data represent the stabilization period. The utilities that tested the pipe rack for this study found that it took six to nine months for lead to stabilize in lead loops; three to eight months for lead to stabilized in lead-soldered copper loops. Copper levels stabilized in two to eight months. The manual recommends utilities operate the pipe rack long enough for the metals levels to stabilize. Longer periods may be required if data collected are highly variable or a greater degree of statistical confidence is required.

In 1994, when this study was published, an AwwaRF pipe rack cost $10,000 to $13,000 in materials and labor to build. For several water quality conditions to be tested, one rack would be needed for each treated water condition. Operation costs may require up to one full-time operator for a two to four week period, with routine operations up to 20 hours/week.

Noted drawbacks with the AwwaRF pipe rack study include:

- For statistically meaningful and valid results, the study may have to be run for as long as 18 months to obtain adequate data.
- Metals levels measured are impacted by the nature and consistency of source water quality.
- The stability of metals may not be observed if seasonal source water quality changes happen during the course of a pipe rack study.
- The cost of building a pipe rack system may be cost prohibitive for small utilities.
- Variability measured in the lead and copper data from the pipe racks used in the study was high. However, nonparametric methods are available with which to evaluate the variable data in a statistically valid manner.

Although the results from the AwwaRF pipe rack must be considered a relative evaluation of treatment impacts on metal levels, the data can be used for demonstrating optimization.

508 - Chloramine Effects on Distribution System Materials (1994)

The purpose of this project was to investigate corrosion and degradation of elastomers and some metals with chlorine and chloramine disinfection.

For elastomers, the results pointed to accelerated elastomer failure after changeover to chloramination. Accelerated life cycle testing of tension mounted thermoplastic coupons showed that with few exceptions solutions of chloramines produced greater material swelling, deeper and dense surface cracking, a rapid loss of elasticity, and loss of tensile strength than equivalent concentrations of free chlorine. Elastomers more susceptible to degradation are those formulated with natural or synthetic isoprenes. Newly engineered synthetic polymers performed well in the chloramines exposure tests.

For metals, the researchers exposed seven metals (copper, brass, bronze, three types of solders, and mild steel) to varying levels of pH (6–8), chlorine (0.5 and 5.0 mg/L), chloramines (0.5 and 5.0 mg/L) and ammonia (<10 mg/L). Corrosivity was measured using weight methods, electrochemical analysis, and galvanic current on coupons or pipe segments exposed to disinfectants. The researchers made the following conclusions:

- Both chlorine and chloramines accelerate the corrosion of copper and its alloys at pH 6 but cause minimal corrosion at pH 8.
- An increase in disinfectant concentration can increase corrosion of copper and its alloys at pH 6.
- Corrosion of copper and copper alloys by free or combined chlorine was greatest for brass, followed by copper, and then bronze.
- The presence of free or combined chlorine did not lead to pitting type corrosion on copper or copper alloy surfaces under the conditions tested in this project.
- The presence of ammonium ions produced no discernible increase in corrosion on copper or copper alloy surfaces.
- Neither leaded nor lead-free solders are substantially influenced by the presence of free or combined chlorine at pH levels common to distribution systems.
- In equal concentrations, free chlorine is slightly more corrosive than chloramines on copper and its alloys. However, residual concentrations are higher in systems that disinfect with combined chlorine, compared to free chlorine. As a result, systems that

convert to chloramine disinfection may experience higher rates of corrosion depending on pH levels.

2760 - Optimizing Chloramine Treatment, Second Edition (2004)

In 1993, WRF funded the first edition of this report, which is a manual on the use of chloramines and the role they play in water quality improvements for drinking water utilities. This second edition of the report provides updated information gathered from 68 utilities by documenting their experience with chloramination use. Using the information from the utility survey, the researchers identified critical parameters for controlling chloramination and formulated a chloramination optimization strategy.

The report provides key evaluation criteria when evaluating a switch to chloramines, a process for determining if chloramines are the right choice for a utility, a process and operating procedures for optimizing chloramines treatment, ammonia storage and feed facility considerations, chloramination start up considerations, distribution system issues, parameters to monitor, and customer relations issues to consider.

The researchers did not find that the utilities surveyed had experienced any general trends of lead and copper corrosion issues with chloramine use. Through the literature review for this project, the researchers found that many corrosion studies conducted on chlorinated and chloraminated water systems included evaluations of copper; however, very few rigorous studies exist that make a direct comparison of the corrosive effects of chlorine and chloramines.

One case-study utility conducted a comprehensive corrosion study on their soft, slightly buffered water sources. The utility evaluated the corrosivity of chlorine and chloramines using flow through pipe loops for a 12-month period. According to the results, copper thinning rates decreased as the pH was increased. At each of the different levels, chloramines caused more copper thinning than chlorine, with the exception of three control loops. It is important to note that the utility did not compare equivalent levels of chlorine and chloramines. As such, the utility results, which indicate that chloramine was more corrosive to copper than chlorine, are not direct comparisons of corrosivity between the two disinfectants.

2687 - Impacts of Enhanced Coagulation on Corrosion of Water Treatment Plant Infrastructure (2004)

This project examined the effects of enhanced coagulation (lower coagulation pH and higher coagulant doses) on water treatment plant infrastructure. This project focused specifically on corrosion of treatment plant infrastructure to include concrete, internal plant piping, pumps, and valves.

The research team conducted a utility survey and case studies to determine the effects of enhanced coagulation on water treatment plant infrastructure. Additionally, the team conducted experiments on inhibitor compatibility with enhanced coagulation and a comparison of alum, ferric, and PACl coagulants in the degradation of concrete.

Some key findings of this research are:

- Free chlorine is highly corrosive to plant infrastructure. However, few utilities anticipate increased problems from free chlorine when coagulation pH is lowered, even though such changes are known to enhance release of Cl_2 gas from water. Painting plant infrastructure provides a simple means of slowing the rate of attack.

- Metallic plant infrastructure, such as pumps and pipes, bear close monitoring for pinhole or pitting-type corrosion.
- Coagulation at the treatment plant can cause discoloration and change corrosion of materials in the distribution system. Whenever a change in coagulant type or pH is implemented, the corrosivity of the water is fundamentally changed. Even small changes in the pH of distributed water can have noticeable impacts on corrosion of distribution system materials.
- If inhibitors are used to protect components in the treatment plant, they need to be compatible with coagulation goals. Since phosphate or polyphosphate inhibitors are removed by, and likely interfere with, coagulation, they do not appear to be a good option for protecting plant infrastructure.

831 - Role of Inorganic Anions, NOM, and Water Treatment Processes in Copper Corrosion (1996)

This project studied the effects of water quality on copper corrosion using both conventional and electrochemical aging methods. In addition to natural organic matter (NOM), the researchers focused on the effects of five common anions: sulfate, chloride, bicarbonate, perchlorate, and nitrate.

Some general implications for water treatment practices were discovered. Utilities delivering high-alkalinity (> 100 mg/L as $CaCO_3$) and low pH (<7.7) waters can expect a high likelihood of problems with copper corrosion. A small pH increase to about 8.0 may alleviate or eliminate copper corrosion problems. The research team recommends on-site corrosion studies to accurately define the pH increase necessary to gain the desired benefits.

In waters with NOM in the range of 1–4 mg/L (typical for surface source waters), NOM removal by coagulation or adsorption, or both, cause little change in copper corrosion and release.

With enhanced coagulation, waters treated with alum were more aggressive towards copper than those treated with ferric chloride. Alum also caused longer-term corrosion rates. The choice between using aluminum sulfate and ferric chloride as coagulants is very important for copper corrosion control. Although chloride has beneficial effects and sulfate has adverse effects, it is not known whether these effects are magnified at increased concentrations, nor are the combined interactions understood. Once again, corrosion studies are imperative to determine whether the benefits, if any, would be worth the cost of changing coagulants.

Adsorption with GAC had a negative impact on copper corrosion while ozonation had no significant effects on copper corrosion.

Specific Water Chemistry Effects on Lead and Copper Corrosion

4409 – Controlling Lead in Drinking Water (2015)

This project provides recommendations for controlling lead in drinking water. In order to accomplish this, it is important to understand why lead is present at the tap and how lead release can be prevented. The chemistry of the water that determines both of these factors is described in this report. Control strategies used by water utilities are described, including a detailed discussion of lead service line replacement. In addition, case studies showing how six utilities have approached lead and copper corrosion control are listed under project resources.

Chapter 1 focuses on the important characteristics of lead chemistry in water. Lead in drinking water at the customer tap is almost exclusively the result of water contact with lead containing components in the distribution system or household plumbing. If these lead-containing materials are present in the system, and the water causes corrosion through contact, lead can be released in a soluble or insoluble form, depending on the water chemistry.

Chapter 2 describes how these water quality characteristics can be manipulated or accounted for in drinking water systems to control lead levels at the customer tap. The most common methods to minimize lead in drinking water are:

- Adjusting the water chemistry to produce stable water quality conditions that inhibit lead release
- High velocity flushing (especially inside the home) to remove particulate lead
- Removing service lines and plumbing materials that contain lead

Chapter 3 describes an example of a lead service line replacement strategy.

4317 - Non-Intrusive Methodology for Assessing Lead and Copper Corrosion (2014)

This project developed a corrosion test rig (CER) to gauge the effectiveness of corrosion control efforts. The test rig is designed to provide reproducible lead and copper readings to discern trends in lead and copper release. Data from the test rig allows analysis of lead pipe connected to copper pipe, leaded solder, and leaded brass in isolation, thereby assisting interpretation of lead leaching problems.

The test rig contained nine lengths of parallel pipe. These lengths are divided into three duplicate lengths of (1) copper pipe with lead solder (copper-solder), (2) PVC with brass rod inserts (brass), and (3) lead pipe galvanically connected to copper tube (lead-copper).The project was conducted over three phases. Phase I and II consisted of rig design and testing. Phase III consisted of full-scale field testing at the five participating utilities. Each of the participating utilities had one CER installed at their water treatment plant and one CER at a more distant point in their distribution system where the water quality may be different.

The following conclusions were reached:

- The highest lead leaching propensity was for lead-copper pipe, relative to copper solder and to leaded brass. The leaded brass consistently leached low levels of lead across all five utilities. Lead leaching from the copper-solder changed depending on the utility
- Particulate lead was a large component of the measured lead levels. Between 49 and 99% of measured lead was in particulate form.
- Particulate copper had less of an influence on the copper measurements compared to lead. Particulate copper accounted for 2 to 34% of measured copper levels.
- For copper leaching, the copper-solder always leached the most copper, followed by the lead-copper pipe. The brass always leached the least copper.

- CERs may provide a more consistent measure of a water's corrosivity and a utility's corrosion control effectiveness.
- Two participating utilities, which shared the same source, water but had different water processes had different results for lead and copper leaching, reinforcing the significance of treatment differences and water chemistry in corrosion control.

4211 - Lead (IV) Oxide Formation and Stability in Drinking Water Distribution Systems: Rates and Mechanisms of Processes at the Solid-Water Interface (2012)

PbO_2 solids form at the high oxidation reduction potential induced by residual free chlorine, and such solids have been observed as constituents of scales of lead corrosion products that develop on lead pipes. The PbO_2 solids have low solubility. As long as a sufficiently high oxidation-reduction potential is maintained, dissolved lead concentrations remain at low levels. However, when the oxidation reduction potential is lowered the PbO_2 is no longer stable and its reduction releases lead to the water. Even when oxidizing conditions are present, the actual solubility of PbO_2 phases is imprecisely known. Information on the dissolution rates of PbO_2 is particularly valuable as water suppliers consider process changes that affect water chemistry such as switching disinfectant type or dose, adjusting pH, or adding a corrosion inhibitor.

The project was divided into three integrated research objectives. The tasks progressed from (1) the formation of PbO_2, to (2) the stability of PbO_2 in equilibrated systems, and finally to (3) the rates of dissolution of PbO_2.

Key findings with respect to formation, equilibrium dissolved lead concentrations, and PbO_2 dissolution rates are provided in the report. Findings of particular interest include:

- PbO_2 can only form in the presence of free chlorine, and the threshold free chlorine concentration for producing PbO_2 is less than 4 mg Cl_2/L.
- The formation of PbO_2 is accelerated by the presence of dissolved inorganic carbon.
- Dissolved lead concentrations from equilibration of PbO_2 in water with free chlorine were orders of magnitude higher than predicted from published thermodynamic data.
- The dissolution rate and not the equilibrium solubility of PbO_2 will control dissolved lead concentrations in waters that are in contact with PbO_2 as a corrosion product for most relevant stagnation times.
- The rate of PbO_2 dissolution rate decreased with increasing pH. This is in contrast to the dissolved lead concentrations after multi-day equilibration that increased with increasing pH.
- Orthophosphate inhibited PbO_2 dissolution with its effects limited to near-neutral pH.

Lead(IV) oxides (PbO_2) can be an important component of corrosion products on pipe scales for utilities that have lead service lines in their distribution systems and that currently use or have used free chlorine as the secondary disinfectant. PbO_2 can only form in systems with free chlorine present; however, because of the low solubility of this phase and the complexity of pipe scales, PbO_2 may persist well after a switch from free chlorine to chloramine. The rate of PbO_2 formation and consequently the likely extent of PbO_2 formation on lead service lines is strongly affected by the water chemistry of the distribution system. The dissolution rate of PbO_2 is a very strong function of the water chemistry, and orders of magnitude differences can occur in the rates depending on the composition. Utilities should be aware of conditions that could accelerate the dissolution of PbO_2 and the release of lead from this potential reservoir of unstable lead in scales on lead service lines. This is particularly important for systems that have recently switched from using free chlorine to chloramine as the secondary disinfectant. The most significant parameter affecting PbO_2 dissolution rates is the concentration and identity of species that can act as chemical reductants to accelerate PbO_2 dissolution. These species include natural organic matter, dissolved iron(II) and manganese(II), and iodide.

4243 - Is NSF 61 Relevant for Chloraminating Utilities? (2012)

The NSF International and the American National Standard Institute (NSF/ANSI), Drinking Water System Components—Health Effects, was developed to establish minimum requirements for the control of potential adverse human health effects from products that contact drinking water or drinking water treatment chemicals. NSF/ANSI Standard 61 is concerned about the potential extraction of any chemical, including lead and copper. Release of lead and copper from these testing protocols currently uses exposure waters containing free chlorine as the disinfectant

The main objectives of this project were to directly compare the leaching characteristics of typical utility service connection and premise plumbing devices under relevant NSF 61 Section 8 and 9 protocols (both chlorinated and chloraminated conditions) in order to assess whether the standard predicts lead and copper release with sufficient accuracy to meet the public health and regulatory needs of utilities that use chloramines. A second objective was to develop a knowledge base of utility experience using NSF 61 certified appurtenances with chloramines disinfection.

Laboratory results of this study indicated that for lead release for Section 9 devices, there was very little difference seen between the chlorinated and chloraminated versions of the Section 9 test water. Evaluation of all test water conditions and all Section 9 products indicated that the current Section 9 test water was found to be the most appropriate condition for certification of Section 9 products for lead release. However, for certification of Section 8 products for lead release, the current NSF Standard 61 Section 8 test waters were not the most aggressive. When comparing lead release from all the test water conditions and devices evaluated, the chloraminated version of the current Section 9 test water yielded the highest normalized lead release for Section 8 devices. The difference in lead release from Section 8 products between the current chlorinated Section 9 test water and the chloraminated version was minimal however, and may have been due to variability in products tested versus differences in the extraction water. Therefore, for utilities that chloraminate, instituting testing protocols that incorporate chloramines, or incorporate dual evaluation of chlorinated and chloraminated exposure waters, will likely not be more predictive of extraction of lead from Section 8 products than testing with a chlorinated extraction water alone. Based on the variable laboratory results seen through the Section 8 analyses, the standard for Section 8 products would be improved by the addition of a requirement mandating a sample size greater than 1, and the exposure water for lead release for Section 8 brass or bronze containing devices should be re-assessed.

4289 - Influences of Water Chemistry and Other Physical Factors on Copper Pitting and Brass Dezincification Corrosion in Premise Plumbing (2009)

Copper pitting and brass dezincification are types of localized, or non-uniform, corrosion, which can impact the service life of premise plumbing systems. Only a few studies have succeeded in replicating either copper pitting or brass dezincification in the laboratory as it occurs in practice. This project conducted a comprehensive literature review on brass dezincification in potable water systems. Experimental work was conducted to meet three objectives:

1) Evaluate the effects of water quality parameters and common chemical constituents, and physical factors on rates of copper pitting
2) Evaluate the effects of water quality parameters and common chemical constituents on severity and selectivity of brass dezincification
3) Evaluate the effects of physical factors on type, severity, and selectivity of brass corrosion

The first and third objectives were met by conducting long-term, large-scale tests in pipe loops. Tests to meet the second objective were carried out in stagnant, bench-scale apparatuses constructed of copper tubes and brass rods, which were filled with various test waters.

A wide range of chemical and physical factors was indeed found to influence copper pitting and brass dezincification. Temperature and physical exposure conditions were also found to affect other types of brass corrosion (i.e., lead leaching and pitting). Specific results can be found in the final report.

A decision tree was developed to assist utilities in determining how to avoid or mitigate copper pitting problems associated with aggressive water (see Figure ES.1 in the report). For utilities concerned with avoiding copper pitting problems, it is recommended that proactive efforts be made to maintain non-aggressive water qualities. Thus, proposed changes to water treatment should be carefully considered and tested to evaluate if finished water quality will be rendered aggressive. For utilities with known copper pitting problems, dosing phosphate or silica corrosion inhibitors are the only recommended strategies for mitigation of significant "outbreaks" or widespread problems. If pinhole leak failures are isolated to systems known to have high flow velocities or galvanic connections between copper and other metals, problems could be mitigated by repairing or re-plumbing affected systems to remediate the contributing factors. In such cases, utilities should closely monitor failure reports to make certain that more pervasive problems do not exist.

At this time, a mitigation strategy for brass dezincification based on modifications to water quality cannot be recommended. Although it is clear that higher alkalinity and lower chloride may reduce dezincification tendencies, threshold values for inhibiting dezincification have not been determined. Furthermore, conventional corrosion inhibitors like phosphates or silica do not appear to have long-lasting effects. Thus, avoiding and mitigating dezincification failures in aggressive water is probably best accomplished by use of dezincification resistant (DZR) brass alloys. To this end, it is recommended that utilities determine if their finished water quality is, in fact, aggressive, and relay this information to consumers and developers. For utilities concerned about lead contamination, it is also recommended that brasses installed in hot water lines be considered as a lead source.

4064 - Influence of Water Chemistry on the Dissolution and Transformation Rates of Lead Corrosion Products (2006)

The internal corrosion of lead-containing pipe, fittings, and solder in premise plumbing is the most significant source of lead to drinking water. The primary objective of this project was to provide new information to the water supply community that advances understanding of lead corrosion product dissolution and transformation rates. The research approach was divided into three corresponding research tasks. Task 1 was a literature review evaluating the dissolution rates of lead(II) carbonate, lead(II) phosphate, and lead(IV) oxide precipitates. Task 2 was a systematic experimental investigation of the dissolution rates of three important lead corrosion products. Task 3 extended the study of dissolution rates of pure solids to release rates from pipe scales. Tasks 2 and 3 involved bench-scale laboratory experiments with integrated analysis of the aqueous solutions and the solid phases.

Information on the specific water chemistry and corrosion products is valuable in predicting and controlling lead release from scales on lead service lines. When collecting samples for compliance with the LCR, utilities could gain insights into processes controlling lead concentrations by measuring pH, dissolved inorganic carbon concentrations or alkalinity, free and/or combined chlorine concentrations, and orthophosphate concentrations. Information on the identity of the corrosion products can be gained by sampling and analyzing portions of pipe scales when lead service lines are removed from a system.

This study found that the effectiveness of corrosion control strategies will vary depending on the source water chemistry and the composition of the pipe scales. Generally, less lead is released at higher pH values and the addition of orthophosphate dramatically decreased rates of lead release from both plattnerite and hydrocerussite. A webcast on this project was presented on April 29, 2010.

3172 - Role of Free Chlorine, Chloramines, and NOM on the Release of Lead into Drinking Water (2008)

This project investigated the release of lead in the presence of NOM, free chlorine, and chloramine by means of the dissolution and passivation of lead oxide (PbO_2) in the distribution system.

The researchers found that lead oxide is relatively unstable in water. It is reduced to Pb(II) by the water itself, but only very slowly at or near neutral pH values. It is also reduced by NOM. The reductive capacity of the NOM is reduced if it is pre-oxidized by free chlorine. However, when free chlorine was present with NOM, lead oxide is not reduced because it would oxidize any released Pb(II) back to lead oxide.

Monochloramine, generally considered an oxidant, reduced lead oxide. The amount of Pb(II) formed was related to the amount of monochloramine that decomposed via auto-oxidation. This suggests that the reaction mechanism involves a reaction of intermediates produced from the auto-decomposition of monochloramine, which act as potent reductants of lead oxide. Because NOM was also slowly oxidized by monochloramine, the effect of mixtures of monochloramine and NOM led to more complex behavior as each component did not act independently.

Water treatment processes that can alter the oxidation potential of the treated water need to be carefully evaluated for lead release from lead oxide or other lead bearing materials, such as brass meters or valves. Water systems that have adopted or are contemplating adoption of chloramination for secondary disinfection should conduct a more thorough lead monitoring program after switching disinfectants. Additionally, pre-oxidizing NOM or removing NOM should reduce the potential for lead release from lead oxide.

3015 - Assessment of Non-Uniform Corrosion in Copper Piping (2008)

This project investigated the extent and implications of copper pitting and pinhole leaks for residential potable water plumbing systems. The research team also investigated suspected causes of copper pitting and pinhole leaks through case studies at participating communities.

Non-uniform corrosion—also known as copper pitting—that manifests itself as a pinhole leak greatly shortens the usable lifespan of potable plumbing pipes. The resulting leaks can damage customer housing infrastructure and possibly lead to mold growth. Although customer plumbing and property is not the jurisdiction of local utilities, utilities need to be aware of the extent and possible causes of copper pitting in the communities they serve.

Through a national survey of plumbers, homeowners, businesses, and corrosion experts, as well as a review of a database of copper pitting failures covering 30 years of data, the research team determined that approximately 8.1 percent of homeowners in the U.S. have experienced at least one pinhole leak. Between 21 and 60 percent of homes in certain communities have experienced pinhole leaks. The total cost of pinhole leaks and pinhole leak prevention in the U.S. is estimated to be $967 million annually, with the largest proportion of cost ($564 million) in single-family homes (particularly devoted to repairs). About 58 percent of responding utilities reported corrosion inhibitors, and annual costs of dosing corrosion inhibitors per customer (connection) ranged from $0.10 to $5.72 with an average of $1.16.

Case studies at communities experiencing pinhole leaks were designed to confirm suspected pinhole leaks and identify mechanisms that cause those leaks. Three water chemistry and microbiological factors emerged with strong links to pinhole leaks:

- high pH and high levels of disinfectant, exacerbated by aluminum and other particles
- local production of H_2S in and around pits by sulfate reducing bacteria (SRB)
- erosion corrosion in hot water recirculation systems

Of course, there are other factors believed to influence copper pitting corrosion, and further research will need to be done to identify and confirm those.

The team developed a protocol to help utilities assess the extent of pinhole leaks in their community. The report includes a CD ROM that contains the results of the detailed case studies from the participating communities. The case studies include detailed information on the hydrological, biological, and aqueous chemical factors that led to copper pitting failures.

3109 - Non-Uniform Internal Corrosion in Copper Piping – Monitoring Techniques (2009)

This project evaluated the accuracy of several electrochemical monitoring techniques in predicting pitting propensity of copper tubing in potable water supplies. For this study, the research team tested corrosion potential (ECorr), electrochemical noise (ECN), pit wires, and coupon testing. Four water qualities of well-established pitting propensities were used to assess the four corrosion monitoring techniques—a proven pitting water, a biologically active water suspected to cause pitting, a non-pitting water, and a pitting water that also produces blue water events. Each of the corrosion monitoring techniques selected for this study had artifacts or insurmountable problems relative to tracking pitting propensity in the test waters and were found to be highly imperfect and of limited value.

This research makes it very clear that existing electrochemical tests of copper pitting propensity are largely tracking measurements of solution redox potential and oxidant levels, with some undetermined modification by surface scale or rust layers. The electrochemical tests are also influenced by and in some cases are controlled by flow phenomenon. Specifically, turning a pump on and off, or long-term continuous flow, can control the electrochemical measurements that are made. Therefore, ECorr and ECN, as applied in past research, provide very little or no direct insight to pitting phenomena without extensive prior testing and experience with the water in question.

Understandably, researchers and utilities will likely continue to use electrochemical techniques to predict pitting propensity in the future despite the major limitations discovered in this study, because it is unacceptable to do nothing and because the alternatives to electrochemical techniques have their own deficiencies. However, utilities are probably better served by conducting detailed forensic evaluations of pitting failures, and then trying to relate patterns of pitting in a given system to changes in oxidant chemistry, microbial activity, and other monitored water chemistry variables throughout the distribution system. Changes in these parameters that occur in premise plumbing including pH, dissolved oxygen, disinfectant levels, and microbial communities (including SRB and nitrifiers) may provide useful insights into factors that contribute to pitting. Utilities can then consider changes in distribution system operations such as booster chlorination, reducing pH or dosing an inhibitor—which have a strong likelihood of reducing copper pitting while also achieving other desirable water quality objectives.

182 - Corrosion and Metal Release for Lead Containing Plumbing Materials: Influence of NOM (1999)

This project investigated the effects of natural organic matter (NOM) on the corrosion of lead-containing materials (i.e., leaded brass, lead-tin solder, and lead pipe) in drinking water. The researchers found that the effects of NOM were dependent on the properties of the corroding material. The primary conclusion of this research confirmed the suspicion that the presence of NOM may be a major factor affecting lead release from lead pipe, lead-tin solder, and leaded brass or bronze. The adverse effects of NOM were exacerbated in low-pH, low-alkalinity waters. Increasing pH and alkalinity can alleviate the adverse effects of NOM. Chlorination and ozonation did not diminish the lead leaching associated with NOM on the short term, but may alleviate NOM effects associated with lead release in the end. NOM did exhibit some corrosion-inhibiting action for brass and decelerate the dezincification of the brass, but it did not stop or inhibit selective lead oxidation and leaching caused by the galvanic coupling of the lead microphase with the copper-based matrix. The researchers concluded their report with a recommendation that all lead-containing copper-based alloys be eliminated in potable water applications.

Material Effects on Lead and Copper Release

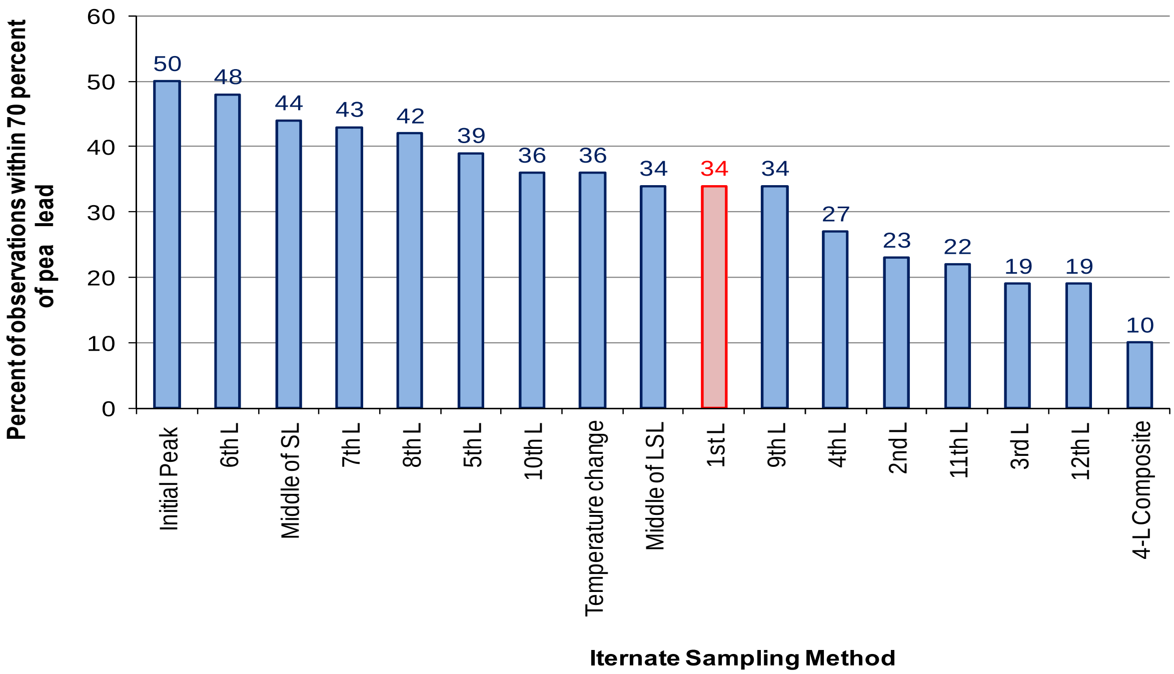
4569 - Evaluation of Lead Line Sampling Strategies (2015)

This project conducted a side-by-side comparison of five lead sampling techniques. Each strategy's effectiveness at detecting peak total lead levels was evaluated. These strategies were compared to results collected during a minimum 12-L profile on each sampling date. The five sampling strategies are listed below:

1) Run tap water until a temperature change is detected and then sample
2) Collect a full profile during a one-time sampling event at each location, determine the profile volume with the peak lead concentration, and collect future samples for lead at this peak profile volume (the "initial peak" method)
3) Sample a fixed sample volume (e.g., the 5th liter)
4) Sample the middle of the service line (SL) or lead service line (LSL) based on site specific calculations
5) Collect a composite sample (e.g., the first gallon or first ~4 liters)

Key findings of the five sampling strategies are as follows:

- No sampling method was particularly proficient at finding the peak lead level compared to doing a full profile for each sampling event.
- The figure below summarizes the sampling method results from the study, characterizing the results by the percentage of observations that produced a total lead result within 70 percent of the peak total lead value. The peak total lead value was the highest lead level found during each profile sampling event.



A webcast for this project is available for download on the WRF website.

4191 - The Performance of Non-Leaded Brass Materials (2014)

This project identifies and prioritizes key water quality characteristics and changes that might adversely impact the performance and leaching of non-leaded brass drinking water distribution system components over typical component lifetimes. This project determined the water quality impacts on short- and long-term performance of non-leaded brass components and determined the inorganic compounds (i.e., Se, Bi, Pb, Cu and Sb) likely to be released from the non-leaded brass components under a variety of water quality conditions.

This project tested four non-leaded brasses and one leaded brass (the control) for long-term performance for corrosion and leaching under the following different water quality conditions typical for North American utilities:

- Hard water, high chloride, high alkalinity
- High pH, low alkalinity, chlorinated
- High pH, low alkalinity, chloraminated
- High TOC, moderate alkalinity, groundwater
- Low alkalinity, low pH, mountain runoff

The alloys were tested for leaching of copper, zinc, lead, and nickel as well as other relevant elements such as tin, manganese, bismuth, selenium, and antimony. The materials were also tested according to NSF/ANSI Standard 61, Section 9, for lead leaching. Other performance measures tested included dezincification resistance, stress corrosion cracking, and erosion corrosion resistance.

The findings from the tests revealed, in principle, all four tested nonleaded brasses are suitable for use in drinking water. Nevertheless, in local waters with a significant dezincification potential (waters with low alkalinity, high chloride, and/or high sulfate concentrations), it is recommended to perform long-term tests to confirm the performance of the provided materials.

4349 - Impact of Galvanic Corrosion on Lead Release Following Partial Lead Service Line Replacement (2013)

This project provides an unbiased third-party review of the two previous WRF reports on lead corrosion (#3107 and #4088b). It developed guidance for water utilities on strategies for minimizing lead release from partial LSLRs on the basis of experiments conducted with commercially available transition couplings and field harvested pipes. The project also explores post replacement sampling conducted by two participating utilities as part of regularly specified sampling and special studies. The literature review comparing previous research on this topic is available in the final report as well as a stand-alone project paper. The tailored collaboration partner for the project is DC Water.

The laboratory experiments, conducted for a six-week period, indicate that galvanic corrosion can cause statistically significant increases in lead concentrations. The extended timeframe pilot experiments (16 to 57 week durations) also had elevated lead concentrations following connections of lead pipe to copper tubing, but the findings were not conclusive as to how much of this increase is attributable to galvanic mechanisms. The pilot experiments, which were conducted with sample flow rates similar to or somewhat greater than typical kitchen faucet use, exhibited Pb concentrations that declined to stable lower values after durations that ranged from about four months to ten months. Field observations from two large LSLR programs summarized in this report suggest that elevated concentrations may abate in a period of four to six months.

Non-conductive plastic couplings always released less lead than the conductive metal couplings. Consideration should be given to use of non-conductive couplings where partial LSLRs must be undertaken. If a plastic coupling is used, it is recommended that a plastic spacer be inserted in the center of the assembly to assure that there is no contact between the two pipes. If a dielectric or plastic coupling is used, consideration will have to be given to alternative means of grounding the household electrical wiring system.

4415 - Assessing Risk of Lead and Copper Consumption in Drinking Water (2013)

This project evaluated if a commercially available carbon-based filter is capable of capturing the mass of lead and copper from a faucet’s flow of drinking water, thereby creating a composite sample representing the total mass of these metals that the consumer would have been exposed to. A method to quantify the capture of lead and copper in the filter was also explored in this study. Desired characteristics of a filter to be used as a composite sampler for particulate and dissolved lead and copper were also provided.

Some point of use water filters are effective at removing dissolved and particulate metals. If the volume of flow can be determined, the filters do provide an accurate estimate of potential exposure to contaminants in drinking water. A method to calculate lead and copper in the filter was developed. Using carbon filters as composite samplers to measure the total amount of lead and copper released to the tap can be accomplished but several issues with the filters need to be better defined before this can become a practical technique.

3018 - Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues (2008)

The implementation of the LCR has resulted in significant reductions in the first liter standing lead levels measured at the tap. However, there are utilities that have implemented optimal treatment that continue to experience lead levels at or near the action level for lead. There are also utilities that would like to go a step further in reducing lead levels measured in their system by proactively replacing lead source materials. This project was initiated to help understand the contributions that various lead-based materials in premise plumbing may have on lead levels measured at the tap. Specifically, the research team investigated the contributions of premise piping, service lines, faucets and meters.

The researchers found that lead source contributions are influenced by the physical characteristics of the source (i.e., length, diameter, surface area, etc.), water quality conditions, water use and hydraulic patterns, and mixing and dilution effects as the water flows during sampling. The team hypothesized that the presence of a lead service line at an individual site may elevate the contribution of individual sources by providing an additional source of lead, either by seeding the premise plumbing system with lead, or introducing lead derived from the service line at the start of the stagnation period.

The most effective way to reduce the total mass of lead measured at the tap is to replace the entire lead service line, followed by replacing lead sources in the premise plumbing, the faucet, and then the meter. Replacement of faucets and end-use fittings may or may not improve lead levels at the tap; however, it may be appropriate at sites without lead service lines that experience elevated lead levels in first-draw samples. Elevated lead levels may occur immediately after lead source replacement and may persist for longer periods, dependent on the materials and water quality at each site, and the amount of disturbance during replacement.

Corrosion control is still the best and most cost-effective way to comply with the requirements of the LCR. However, the customer’s portion of the lead service line—which is beyond the jurisdiction of local water utilities—remains an important unresolved source of lead. Common sense tells us that, in the end, lead source removal is the most certain route to eliminating lead in drinking water. The water industry has learned a great deal about methods of minimizing the release of lead from lead surfaces exposed to water, and it has made a great deal of progress in removing lead service lines. These project results clearly demonstrate that the customer’s portion of the lead service line remains an important unresolved source of lead. This issue is beyond the jurisdiction of local water utilities and other resources will be required if it is to be resolved.

The report includes a CD ROM that contains the extensive results obtained from the national survey of lead source characteristics and jurisdictional issues, case studies, pilot and field evaluations, and scale analyses.

3112 - Performance and Metals Release of Non-Leaded Brass Meters and Fixtures (2007)

This project provides definition and structure to the issues surrounding the current state of knowledge, testing protocols, performance, regulatory environment, and research gaps pertaining to the widespread use of residential sized non-leaded brass materials in drinking water systems. Historically, leaded brasses have been used in drinking water systems; however, they were found to leach lead under certain circumstances. Because of this, alternative non-leaded brass materials were developed that have a lead content between 0.1 and 0.25 percent lead by weight. Consequently, water utilities throughout the United States have begun to specify these non-leaded materials for their systems. This project synthesized the current state of knowledge through a series of topic papers, and then convened an expert workshop to develop research needs and priorities for the drinking water industry to address.

The topic papers are included in the report by title:

- *Description of the Composition, Lead Content, and Mechanical Properties of New Non-Leaded Brasses*: Three families of non-leaded brass alloys are commercially available: Envirobrass, FederAlloy, and ECO BRASS. All three range from 0.1 to 0.25 percent lead by weight. These alternative brasses were developed to be comparable to their leaded counterparts in terms of mechanical strength.
- *Potential Health Effects of Non-Leaded Brass Alloys*: Non-leaded brasses contain a variety of metals that may be released into drinking water, including bismuth, selenium, copper, tin, nickel, antimony, zinc and lead. While there are currently no U.S. drinking water regulations for bismuth and tin, the other metals listed above are all known to cause negative health consequences and therefore have MCLGs and MCLs as regulated by the EPA.
- *Potential of Non-Leaded Brasses to Release Lead and Copper and Other Metals (Bismuth and Selenium) into Drinking Water*: The potential for non-leaded brasses to leach lead, copper and other metals has not been adequately examined. Preliminary tests studying corrosion and dezincification behavior of non-leaded brasses have been aimed more at their practical performance rather than for health effects. More work needs to be undertaken to gain a better understanding of leaching propensity of these alloys.
- *The American Society for Testing and Materials (ASTM) Specifications for New Non-Leaded Brasses*: No specifications have been developed by ASTM that focus specifically on non-leaded brass alloys. Some of the new alternative alloys have already been listed in existing ASTM standards for copper alloy applications, whereas some others are currently under evaluation for ASTM listing.
- *Summary of Current State Experience with Non-Leaded Brass Materials*: Action has been taken by a few states in order to eliminate lead use in drinking water components (e.g., California) or to promote use of components with lower lead content (e.g., Massachusetts).
- *Utility Motivations and Experience with Non-Lead Brass Components*: In 2000, Asarco commissioned a survey of U.S. water utilities to identify utility plans for replacement of leaded components with non-leaded components. They received 301 responses from utilities; 20 percent of utilities had plans to replace their lead containing brass components. Twenty one percent indicated they were not aware that non-leaded brass options were available.

- *Potential Impacts to Manufacturers*: Manufacturers who use bismuth and/or selenium in their non-leaded brasses may face competing European and Japanese demands for bismuth and selenium supplies. The new alloys may exhibit lower ductility and lower impact strength. Finally, the need to comply with NSF/ANSI Standard 61 is causing manufacturers to consider alternative strategies for production of brass water meters and other components, including: reducing the surface area available for water contact, using a different material for water contact with platings or coatings, or removing lead from the surface of the water contact component.
- *Impacts to Plumbing Industry*: Several options can be considered to facilitate the complex interaction among manufacturers, certification organizations, inspectors, and installers of brass materials. These include code revisions and code enforcement, coordination between federal, state, and local regulatory agencies, education and training of plumbers, and standardization of terminology between the various groups.
- *Impacts to Utility Operations and Maintenance Procedures*: There is little documented information on the material performance of non-leaded components that have been installed in the field; however, limited information indicates no observed differences in structural performance. Costs of non-leaded materials are currently higher than their leaded counterparts (20–30%), but when material costs are evaluated in perspective to the entire cost of installation, the overall increase in costs is significantly less (2–5%).
- *Alternative Materials for Fittings and Components*: Possible approaches to reduce human exposure to lead in brass include using alternatives to lead to fabricate the components and designing changes to existing manufacturing processes to eliminate lead leaching.

714- Evaluation of the Effects of Electrical Grounding on Water Quality (1994)

This project determined the effects of electrical grounding on water quality in residential plumbing. The objectives were to determine if electrical currents from grounding cause an increase in tap water metals concentrations and, if an effect was observed, to identify the levels of current that are problematic. The project included a literature review, an initial field survey, full-scale testing on a specially constructed model house, and field verification.

Overall, this study verified that, in the area of corrosion control, no one factor can be identified as the sole cause of elevated copper concentrations in tap water. Water quality, stray current, electrical transients (i.e., lightning), fixtures, and construction practices were all identified as possible contributors to copper concentrations.

465 - Lead Pipe Rehabilitation and Replacement Techniques (2000)

This project tested and evaluated existing and emerging technologies for rehabilitation or replacement of lead pipes distribution systems. The LCR requires that a water system that exceeds the 90th percentile action level for lead after installing optional corrosion control and source water treatment is required to replace lead service lines that contribute more than 0.015 mg/L to total standing tap water lead levels. Although replacement or rehabilitation is an efficient method to remove lead sources in the distribution system, it is usually the most costly alternative for reducing lead levels at the tap (as opposed to corrosion control and source water treatment). This manual provides utilities with a tool for assessing and selecting lead pipe rehabilitation and replacement technologies. It provides descriptions of the various techniques, where those techniques can be applied, and factors that should be considered for successful application of each technique. The manual includes cost estimates (estimated in 1998) for comparison between the various techniques.

The research team used a utility survey, case studies, and field-testing to document utility experience with several lead pipe rehabilitation and replacement techniques. Technology categories tested included:

- Open-trench replacement
- Replacement along existing route (discarded pipe is left in the ground and new pipe is installed along a different route using a trenchless method)
- Replacement along a new route (existing lead pipe is removed or displaced while simultaneously replacing it with a new pipe)
- Slip lining (existing pipe is lined with a loose or tight fitting liner made of plastic material)
- Pipe coating (existing pipe interior is coated with epoxy or other polymer material)

For each technology category, the manual describes various techniques needed to apply the technology. Twenty-eight techniques were addressed in this manual. Technology profiles are detailed in the manual and facilitate a direct comparison between the various techniques.

Comparison of technologies:

- In general, the open-trench replacement technology is the most versatile and adaptable but the costs can be very high compared to other technologies (due to the typically high costs associated with site restoration).
- Replacement-along-existing-route technology is commonly applied in the United States, but not in Canada or Europe. The technology is straightforward to apply and costs are generally lower than open trench technology, provided conditions are favorable below grade. It does tend to cause longer interruptions in water service because the water must be disconnected during replacement of the existing lead pipe.
- The replacement-on-new-route technology enables new service pipes to be installed at lower costs compared to open-trench and with minimum disruption to the environment and customers. It is commonly used in North America and Europe and is considered the most preferable technology choice for installation of replacement service pipes by many utilities surveyed for this project.
- The slip-lining technology is applied mostly in Holland and the U.K. Limited testing of this technology has been conducted in North America, but it is not applied routinely. This technology can be used to rehabilitate lead pipes where replacement-along-existing-route and replacement-on-new-route technologies are not suitable. This technology would not be suitable for lead pipes that follow a convoluted route or have significant breaks or restrictions. Costs are relatively high compared to other technologies due to the cost of the lining material and high capital cost of the equipment.
- The pipe-coating technology is not used routinely in North America or Europe to rehabilitate lead pipes. It is used in the United States to coat small diameter potable water pipes within buildings and ships. It can also be used to coat the inside of pipes around bends and through pipe restrictions. The major advantage of this technology is its

ability to complete multiple installations at a reduced cost. The major disadvantage is the extended interruption in water service due to the long time required for the resin to cure.

SECTION 2) SUMMARY OF COMMON THEMES

One of the most important lessons learned from the WRF research conducted on lead and copper corrosion is that every utility's lead and copper corrosion challenges are unique to that utility's source water quality, treatment processes, distribution system configuration, and materials. There is no standard recipe for lead and copper corrosion control that every utility can apply for corrosion control strategies or distribution system management. Below are some general lessons learned from this body of research that do apply to most or all drinking water utilities that can be helpful in addressing lead and copper corrosion issues.

General Overview

- Stand-alone monitoring stations can help predict lead and copper release trends at the tap and water quality impacts on metal release. However, the metal concentrations from pipe rigs or monitoring stations may not represent the actual concentrations at the tap due to variation in pipe materials and configurations.
- The Simultaneous Compliance Tool (SCTool) is intended to assist utilities in evaluating appropriate technology choices to comply with multiple and/or conflicting water quality goals.
- Testing results showed that indirect and direct methods can differentiate between various service line materials (lead, copper, and galvanized iron pipes).

Corrosion Control Effects on Water Quality and Corrosion

- For general corrosion of lead and copper in most locations, there does not appear to be a significant difference in performance between zinc orthophosphate and non-zinc orthophosphate. Addition of a zinc containing corrosion inhibiting compounds is beneficial in reducing cement degradation and aluminum release to water when treated water is low in calcium and alkalinity. Bench-scale and/or pilot studies should be conducted to determine if zinc addition is beneficial for a specific water quality condition and pipe material.
- Utilities considering use of stannous chloride for lead corrosion control should proceed slowly and with caution. Coupon and possibly pipe loop studies are recommended for utilities considering use of stannous chloride to evaluate whether the chemical might be effective for the given water quality conditions
- Most negative water quality impacts occur when the distribution system water quality is unstable, either because of multiple finished water quality changes over short periods of time or because of wide fluctuations in pH levels in the distribution system.
- To minimize adverse water quality impacts, maintain a consistent distribution system pH with adequate buffering intensity. Distribution system pH changes that drop the pH by greater than 0.5 units, even for brief periods, can disrupt the effective passivation of corrosion surfaces, especially on brass and lead/tin solder surfaces.
- Utilities should make incremental changes to finished water quality during start up to avoid exposing the distribution system to abrupt changes over a short period. It is also advisable to

avoid making other treatment changes during start up (i.e., changing disinfectants, changing coagulants, or adding new treatment processes).

- When using orthophosphate inhibitors, maintain adequate residuals in the distribution system and apply those inhibitors at the pH range that is optimal for lead and copper control (7.3 to 7.8).
- Look to other similar utilities' experiences concerning corrosion control. The 1995 WITAF database referenced in the report, *A General Framework for Corrosion Control Based on Utility Experience* (AwwaRF #90712B, 1997), provides a compilation of utility experiences that allows utilities to compare their own experiences with those of other water utilities with similar water qualities. The report also provides a compilation of utility experiences with mitigation of lead and copper corrosion by-product release under the LCR.
- In general, copper corrosion control is easier to achieve than lead release control. Copper corrosion is almost exclusively chemical, while lead release is governed by a combination of chemical, hydraulic, and other mechanical factors.
- *Post Optimization Lead and Copper Monitoring Strategies* (WRF #2679) provides a monitoring program for drinking water utilities that have already achieved optimized corrosion control. The program includes a proposed in-home tap sampling protocol (number of sites to sample, number of samples per site, a quarterly evaluation period, site selection criteria, and data collection/analysis criteria) and statistical evaluation methodologies.

Treatment Process Effects on Lead and Copper Corrosion

- While the WRF body of research did not specifically investigate the effect on lead release when changing from chlorine to chloramines, it did look preliminarily at copper release. It was determined that residual concentrations of free chlorine are higher in systems that disinfect with combined chlorine (chloramines), as opposed to systems that disinfect with free chlorine alone. As a result, systems that convert to chloramines may experience higher rates of copper corrosion, depending on pH levels.
- CSMR can affect lead release. CSMR can be affected by road salt entering the water supply from runoff, coagulant type (chloride-based vs. sulfate-based), desalination, chloride-based anion exchange treatment, brine leak from hypochlorite generation system.
- Problems that occur in coagulant changeovers could usually be mitigated by controlling the type of coagulant and keeping CSMR below about 0.5. However, this is not always an option.
- Changing disinfectants can affect metals leaching from lead, brass, and copper components in the distribution system. Utilities should evaluate these potential metal release changes that might occur before fully implementing a disinfectant change.
- The effectiveness of corrosion control strategies will vary depending on the source water chemistry and the composition of the pipe scales. Generally, less lead is released at higher pH values.
- Information on the specific water chemistry and corrosion products is valuable in predicting and controlling lead release from scales on lead service lines. When collecting samples for compliance with the LCR, utilities could gain insights into processes controlling lead concentrations by measuring pH, dissolved inorganic carbon concentrations or alkalinity, free and/or combined chlorine concentrations, and orthophosphate concentrations.

- Both chlorine and chloramines accelerate the corrosion of copper and its alloys at pH 6 but cause minimal corrosion at pH 8. In equal concentrations, free chlorine is slightly more corrosive than chloramines on copper and its alloys.
- In *Optimizing Chloramine Treatment, Second Edition* (AwwaRF #90993, 2004), the researchers did not find that the utilities surveyed had experienced any general trends of lead and copper corrosion issues with chloramine use. Through the literature review, they found many corrosion studies conducted on chlorinated and chloraminated water systems included evaluations of copper. However, very few rigorous studies exist that make a direct comparison of the corrosive effects of chlorine and chloramines.
- With enhanced coagulation, waters treated with alum are generally more aggressive towards copper than those treated with ferric chloride. The choice between using aluminum sulfate versus ferric chloride as coagulants is very important for corrosion control. Corrosion studies are imperative to determine whether the benefits, if any, would be worth the cost of changing coagulants.
- In waters with NOM in the typical range for surface source waters (1–4 mg/L), NOM removal by coagulation and/or adsorption, or both, cause little change in copper corrosion and release.
- Concrete corrosion can be an important concern in a utility's overall corrosion control strategy because concrete or cement-lined pipes make up over 50 percent of drinking water distribution system infrastructure in the United States. Prior to making any changes to corrosion control programs, utilities should consider undertaking bench scale or pipe loop tests for baseline (control) in comparison to different corrosion inhibitors and pH/alkalinity adjustment conditions to confirm the results and develop a corrosion control strategy that meets the utility's goals. *Impact of Phosphate Corrosion Inhibitors on Cement Based Pipes and Linings* (WRF #4033, 2009) presents a decision tree to provide utilities with a general direction of the type of inhibitors or corrosion control strategies that can be developed to avoid unintended consequences in the distribution system. This tool can also be used to evaluate the aggressiveness of a given water condition towards concrete or cement lined transmission and distribution main infrastructure.
- The AwwaRF pipe loop protocol (604) offers a practical, hands-on approach to evaluate lead and copper leaching characteristics in a flow-through system that simulates household plumbing. It is a useful tool for corrosion-rate studies and determinations of metals leaching for compliance with the LCR, but is expensive and time-consuming to use.

Specific Water Chemistry Effects on Lead and Copper Corrosion

- The most common methods to minimize lead in drinking water are adjusting the water chemistry to produce stable water quality conditions that inhibit lead release, high velocity flushing (especially inside the home) to remove particulate lead, and removing service lines and plumbing materials that contain lead.
- Pipe loop rigs can complement LCR testing results, which largely depend on nuances of home plumbing systems beyond the control of water utilities. Pipe loop rigs may provide a more consistent measure of a water's corrosivity and a utility's corrosion control effectiveness. However, it is important to remember that lead and copper release data is intrinsically highly variable.

- PbO_2 can only form in the presence of free chlorine, and the threshold free chlorine concentration for producing PbO_2 is less than 4 mg Cl_2/L.
- The formation of PbO_2 is accelerated by the presence of dissolved inorganic carbon.
- Dissolved lead concentrations from equilibration of PbO_2 in water with free chlorine can be higher than predicted from published thermodynamic data.
- The dissolution rate and not the equilibrium solubility of PbO_2 will control dissolved lead concentrations in waters that are in contact with PbO_2 as a corrosion product for most relevant stagnation times.
- NSF 61 Section 9 test water was found to be the most appropriate condition for certification of Section 9 products for lead release regardless of disinfection type (chlorine, chloramine).
- NSF 61 Section 8 testing protocols that incorporate chloramines, or incorporate dual evaluation of chlorinated and chloraminated exposure waters, will likely not be more predictive of extraction of lead from Section 8 products than testing with a chlorinated extraction water alone
- A wide range of chemical and physical factors can influence copper pitting and brass dezincification. Temperature and physical exposure conditions can affect other types of brass corrosion.
- Lead oxide is relatively unstable in water. It is reduced to Pb(II) by the water itself, but only very slowly at or near neutral pH values. It is also reduced by NOM. Pre-oxidizing NOM or removing NOM should reduce the potential for lead release from lead oxide.
- Utilities delivering water that is high alkalinity (>100 mg/L as $CaCO_3$) and low pH (<7.7) can expect a high likelihood of problems with copper corrosion. A small pH increase to about 8.0 may alleviate or eliminate copper corrosion problems. On-site corrosion studies can help to accurately define the pH increase necessary to gain the desired benefits of a pH change.
- The presence of NOM may be a major factor affecting the release of lead from lead pipe, lead-tin solder, and leaded brass or bronze. The adverse effects of NOM are exacerbated in low-pH, low-alkalinity waters.
- While customer premise plumbing is not in the jurisdiction of local utilities, utilities need to be aware of the extent and possible causes of copper pitting in the communities they serve. *Non-uniform Corrosion in Copper Piping – Assessment* (AwwaRF #91217, 2008) developed a protocol to help utilities assess the extent of pinhole leaks in their community. Three water chemistry and microbiological factors show strong links to non-uniform copper corrosion and pinhole leaks in customer premise plumbing:
    - high pH and high levels of disinfectant, exacerbated by aluminum and other particles
    - local production of H_2S in and around pits by sulfate reducing bacteria (SRB)
    - erosion corrosion in hot water recirculation systems

  Of course, there are other factors believed to influence copper pitting corrosion, and further research will need to be done to identify and confirm those.
- Utilities should not rely on electrochemical monitoring techniques (corrosion potential, electrochemical noise, etc.) to predict the pitting propensity of copper tubing in the distribution system or customer premises. Each of the corrosion monitoring techniques selected for study in *Non-uniform Corrosion in Copper Piping – Monitoring* (WRF #91251, 2009) were found to be highly imperfect and of limited value.

Material Effects on Lead and Copper Release

- When alternative (i.e. different than first liter) lead sampling strategies were analyzed no sampling method was particularly proficient at finding the peak lead level compared to doing a full profile for each sampling event.
- Many non-leaded brasses are suitable for use in drinking water. Long-term water quality tests are recommended for potentially corrosive water and to confirm the performance of the provided materials.
- Galvanic corrosion can lead to elevated lead levels at the tap. Lab, pilot, and field experiments exhibited variability in the duration and concentration of lead levels. However, lead levels typically dropped to stable lower values in approximately four to ten months.
- Non-conductive plastic couplings always released less lead than the conductive metal couplings. Consideration should be given to use of non-conductive couplings where partial LSLRs must be undertaken. If a plastic coupling is used, it is recommended that a plastic spacer be inserted in the center of the assembly to assure that there is no contact between the two pipes. If a dielectric or plastic coupling is used, consideration will have to be given to alternative means of grounding the household electrical wiring system.
- No one factor can be identified as the sole cause of elevated copper concentrations in tap water. Water quality, stray current, electrical transients (i.e., lightning), fixtures, and construction practices were all identified as possible contributors to copper concentrations.
- Some point of use water filters are effective at removing dissolved and particulate metals. If the volume of flow can be determined, the filters do provide an accurate estimate of potential exposure to contaminants in drinking water.
- Using carbon filters as composite samplers to measure the total amount of lead and copper released to the tap can be accomplished but several issues with the filters need to be better defined before this can become a practical technique.
- The most effective way to reduce the total mass of lead measured at the tap is to replace the entire lead service line, followed by replacing lead sources in the premise plumbing, the faucet, and then the meter. Replacement of faucets and end-use fittings may or may not improve lead levels at the tap; however, it may be appropriate at sites without lead service lines that experience elevated lead levels in first-draw samples. Elevated lead levels may occur immediately after lead source replacement and may persist for longer periods, dependent on the materials and water quality at each site, and the amount of disturbance during replacement.
- Corrosion control is still the best and most cost-effective way to comply with the requirements of the LCR. However, the customer's portion of the lead service line—which is beyond the jurisdiction of local water utilities—remains an important unresolved source of lead.
- New plumbing systems can contribute to lead and copper corrosion and cause aesthetic problems. Flushing of ASTM B813 compliant flux and metallic debris can be accomplished using water at or above 3.6 fps; however, petroleum-based flux cannot be flushed from plumbing systems with ambient temperature water, which can create long-term problems. One time 50 to 200 mg/L shock chlorination does not seriously damage plastic piping or copper tube; however, repeated shock chlorination events are not recommended because significant deterioration may occur.

- New non-leaded brass materials (0.1–0.25 percent lead by weight) are commercially available to help get the lead out of drinking water systems. While these materials show promise for helping utilities to comply with the LCR, these materials are relatively new and there are questions about the short- and long-term performance of these materials that need to be researched. *Performance and Metals Release of Non-Leaded Brass Meters and Fixtures* (AwwaRF #91174, 2007) includes a series of summary papers that describe what the drinking water industry currently knows about the performance of these materials, and it provides a research agenda to investigate the knowledge gaps about the use of these materials.
- The LCR requires that a water system that exceeds the 90th percentile action level for lead after installing optional corrosion control and source water treatment is required to replace lead service lines that contribute more than 0.105 mg/L to total standing tap water lead levels. *Lead Pipe Rehabilitation and Replacement Technologies* (AwwaRF #90789, 2000) is a tool for assessing and selecting lead pipe rehabilitation and replacement techniques to meet this requirement.

SECTION 3) ONGOING WRF PROJECTS

4586 - Optimization of Phosphorus-Based Corrosion Control Chemicals and Flushing for Lead and Copper Control

This project will determine if clean and biologically stable water distribution systems can optimize lead and copper corrosion control while minimizing or eliminating the use of orthophosphate and other corrosion control chemicals, thereby providing financial, water quality, and environmental benefits for both drinking water and wastewater utilities. This project is scheduled to be completed in 2016. Tailored collaboration partners: North Shore Water Utility, Green Bay Water Utility, Kenosha Water Utility, and City of Mosinee. Research partner: WERF.

4584 - Evaluation of Flushing to Reduce Lead Levels

The project will evaluate the impact of high velocity flushing on the removal of particulate lead from service lines and premise plumbing, and the subsequent impact on “at the tap” lead concentrations. The goal of the project is not only to see if high velocity flushing can successfully reduce lead levels at the tap, but also to see how frequently the flushing may need to be repeated in order to maintain any observed lead reduction. This project is scheduled to be completed in 2016. Tailored collaboration partner: DC Water.

4351 - Evaluation of Lead Service Line Lining and Coating Technologies

This project will comprehensively evaluate lead service line (LSL) lining and coating technologies as alternatives to full or partial LSL replacement, and as a means of protecting and repairing both lead and copper service lines. Another objective of this project is to provide water utilities, engineering consultants, state regulators, consumers, and other interested parties with information and supporting documentation needed to make informed decisions regarding lining and coating of both lead and copper service lines. This project is scheduled to be completed in 2016. Research partner: USEPA.

4658 - Corrosion of Nonleaded Pump Impeller Alloys in Chlorinated Potable Water

This project is intended to collect corrosion performance data for current metal alloys recommended for pump impellers. This project will also quantify the performance of several new and emerging lead-free alloys that are attempting to break into the municipal water market. This data will allow water utilities to make better-informed pump design decisions. The recommendations of this project will provide guidance to pump impeller end users and could refine existing alloy manufacturing methods to develop more lasting materials for these applications. This project is scheduled to be completed in 2017. Tailored Collaboration Partner: San Jose Water Company.

SECTION 4) LIST OF PUBLISHED AND ONGOING RESEARCH PROJECTS

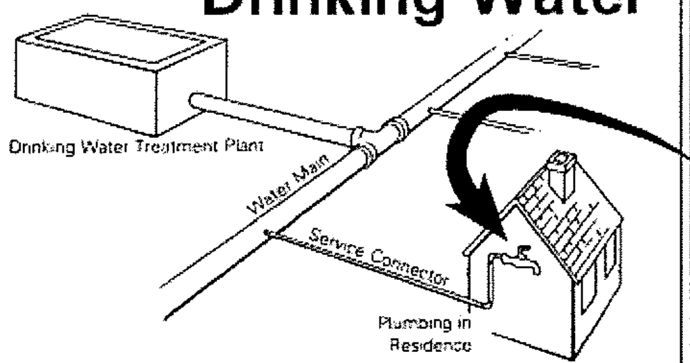
Report Title	Year Published	Project #	Principal Investigator
Corrosion of Nonleaded Pump Impeller Alloys in Chlorinated Potable Water	research ongoing	4658	Edwards (Virginia Tech)
Evaluation of Flushing to Reduce Lead Levels	research ongoing	4584	Cornwell (EET)
Optimization of Phosphorus-Based Corrosion Control Chemicals and Flushing for Lead and Copper Control	research ongoing	4586	Cantor (Process Research)
Evaluation of Lead Service Line Lining and Coating Technologies	research ongoing	4351	Randtke (University of Kansas)
Evaluation of Lead Line Sampling Strategies	2015	4569	Cornwell (EET)
Controlling Lead in Drinking Water	2015	4409	Brown (EET)
Non-Intrusive Methodology for Assessing Lead and Copper Corrosion	2014	4317	Edwards (Virginia Tech)
The Performance of Non-Leaded Brass Materials	2014	4191	Klinger (TZW)
Assessing Risk of Lead and Copper Consumption in Drinking Water	2013	4415	Cantor (Process Research Solutions)
Impact of Galvanic Corrosion on Lead Release Following Partial Lead Service Line Replacement	2013	4349	Welter (O'Brien and Gere)
Distribution System Water Quality Control Demonstration	2012	4286	Cantor (Process Research Solutions)
Is NSF 61 Relevant for Chloraminating Utilities?	2012	4243	Sandvig (The Cadmus Group)
Lead (IV) Oxide Formation and Stability in Drinking Water Distribution Systems: Rates and Mechanisms of Processes at the Solid-Water Interface	2012	4211	Giammar (Washington University in St Louis)
Comparison of Zinc vs. Non-Zinc Corrosion Control for Lead and Copper	2011	4103	Schneider (American Water)
Influences of Water Chemistry and Other Physical Factors on Copper Pitting and Brass Dezincification Corrosion in Premise Plumbing	2011	4289	Edwards (Virginia Tech)

Lead and Copper Corrosion Control in New Construction	2011	4164	Edwards (Virginia Tech)
Chloride to Sulfate Mass Ratio (CSMR): Changes from Water Treatment and its Impact on Lead Leaching in Potable Water	2010	4088	Edwards (Virginia Tech)
Influence of Water Chemistry on the Dissolution and Transformation Rates of Lead Corrosion Products	2010	4064	Giammar (Washington University)
Contribution of Galvanic Corrosion to Lead in Water After Partial Lead Service Line Replacements	2010	4088b	Edwards (Virginia Tech)
Assessment of Secondary Impacts of Corrosion Control on Distribution System Equipment	2010	4029	Grigg (Colorado State University)
Investigation of the Role of Stannous Chloride as an Inhibitor of Lead Corrosion	2010	3174	Hozalski (University of Minnesota)
The Role of Free Chlorine, Chloramines, and NOM in the Release of Lead into Drinking Water	2009	3172	Valentine (Iowa State University)
Decision Tools to Help Utilities Develop Simultaneous Compliance Strategies	2009	3115	Schendel (Malcolm Pirnie, Inc.)
Impact of Phosphate Corrosion Inhibitors on Cement Based Pipes and Linings	2008	4033	Atassi (CDM) and Edwards (Virginia Tech)
Performance and Metal Release of Non-Leaded Brass Meters, Components, and Fittings	2007	3112	Sandvig (HDR/Economic and Engineering Services, Inc.)
Impact of Change in Disinfectants on Lead, Brass, and Copper Components in the Distribution System - (2 Reports) *Part 1 (Literature Review)* *Part 2 (Lab, Pipe Loop and Field Studies)*	Part 1-2006 Part 2-2010	Part 1-91152; Part 2-3107	Boyd (HDR)
Non-uniform Corrosion in Copper Piping - Monitoring	2008	3109	Edwards (Virginia Tech)
Contribution of Service Line and Plumbing Fixtures to LCR Compliance Issues	2008	3018	Kirmeyer (HDR/Economic and Engineering Services, Inc.)
Non-uniform Corrosion in Copper Piping – Assessment	2008	3015	Edwards (Virginia Tech)
Impacts of Enhanced Coagulation on Corrosion of Water Treatment Plant Infrastructure	2004	2687	Edwards (Virginia Tech)
Optimizing Chloramine Treatment (2nd Edition)	2004	2760	Kirmeyer (Economic and Engineering Services, Inc.)
Optimizing Corrosion Control in Water Distribution Systems	2004	2648	Duranceau (Boyle Engineering Corp.)
Post-Optimization Lead and Copper Monitoring Strategies	2004	2679	Kirmeyer (Economic and Engineering Services, Inc.)
Role of Phosphate Inhibitors in Mitigating Lead and Copper Corrosion	2001	2587	Edwards (Virginia Tech)
Distribution System Water Quality Changes Following Corrosion Control Strategies	2000	157	Kirmeyer (Economic and Engineering Services, Inc.)
Lead Pipe Rehabilitation and Replacement Techniques	2000	465	Kirmeyer (Economic and Engineering Services, Inc.)

Corrosion and Metal Release for Lead Containing Plumbing Materials: Influence of NOM	1999	182	Korshin (University of Washington)
A General Framework for Corrosion Control Based on Utility Experience (includes Control of Pb and Cu Corrosion By-products Using CORRODE Software)	1997	910	Reiber (HDR Engineering)
Internal Corrosion of Water Distribution Systems	1996	725	N/A
Role of Inorganic Anions, NOM, and Water Treatment Processes in Copper Corrosion	1996	831	Edwards (University of Colorado – Boulder)
Innovative Techniques for Lead Service Line Location	1995	813	Weston Solutions, Inc.
Development of a Pipe Loop Protocol for Lead Control	1994	604	Kirmeyer (Economic and Engineering Services, Inc.)
Chloramine Effects on Distribution System Materials	1993	508	Reiber (HDR Engineering)
Evaluation of the Effects of Electrical Grounding on Water Quality	1994	714	CH2M Hill
Lead Control Strategies	1990	406	EES, Inc.

EPA United States Environmental Protection Agency | Office of Water (WH-550) | EPA/810-F-93-001 June 1993

LEAD In Your Drinking Water



Health Threats From Lead

Too much lead in the human body can cause serious damage to the brain, kidneys, nervous system, and red blood cells.

You have the greatest risk, even with short-term exposure, if:

- you are a young child, or
- you are pregnant.

Sources of Lead in Drinking Water

Lead levels in your drinking water are likely to be highest if:

- your home has faucets or fittings made of brass which contains some lead, **or**
- your home or water system has lead pipes, **or**
- your home has copper pipes with lead solder, **and**
  - the home is less than five years old, or
  - you have natually soft water, or
  - water often sits in the pipes for several hours.

Actions You Can Take To Reduce Lead In Drinking Water

- **Flush Your Pipes Before Drinking**

Anytime the water in a particular faucet has not been used for six hours or longer, "flush" your cold-water pipes by running the water until it becomes as cold as it will get. (This could take as little as five to thirty seconds if there has been recent heavy water use such as showering or toilet flushing. Otherwise, it could take two minutes or longer.) The more time water has been sitting in your home's pipes, the more lead it may contain.

- **Only Use Cold Water for Consumption**

Use *only* water from the cold-water tap for drinking, cooking, and **especially for making baby formula.** Hot water is likely to contain higher levels of lead.

The two actions recommended above are very important to the health of your family. They will probably be effective in reducing lead levels because most of the lead in household water usually comes from the plumbing in your house, not from the local water supply.

- **Have Your Water Tested**

After you have taken the two precautions above for reducing the lead in water used for drinking or cooking, **have your water tested.** The only way to be sure of the amount of lead in your household water is to have it tested by a competent laboratory. Your water supplier may be able to offer information or assistance with testing. Testing is especially important for apartment dwellers, because flushing may not be effective in high-rise buildings with lead-soldered central piping.

For more details on the problem of lead in drinking water and what you can do about it, read the questions and answers in the remainder of this booklet. *Your local or state department of health or environment might be able to provide additional information.*

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Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

Water

For information about lead in water in Flint, MI, please visit

http://www.phe.gov/emergency/events/Flint/Pages/water.aspx (http://www.phe.gov/emergency/events/Flint/Pages/water.aspx)

How does lead get into my tap water?

Measures taken during the last two decades have greatly reduced exposures to lead in tap water. These measures include actions taken under the requirements of the 1986 and 1996 amendments to the Safe Drinking Water Act (http://www.epa.gov/sdwa (http://www.epa.gov/sdwa)) and the U.S. Environmental Protection Agency's (EPA's) Lead and Copper Rule (http://www.epa.gov/dwreginfo/lead-and-copper-rule (http://www.epa.gov/dwreginfo/lead-and-copper-rule)).

Even so, lead still can be found in some metal water taps, interior water pipes, or pipes connecting a house to the main water pipe in the street. Lead found in tap water usually comes from the corrosion of older fixtures or from the solder that connects pipes. When water sits in leaded pipes for several hours, lead can leach into the water supply.

How do I know if my tap water is contaminated with lead?

The only way to know whether your tap water contains lead is to have it tested. You cannot see, taste, or smell lead in drinking water. Therefore, you must ask your water provider whether your water has lead in it. For homes served by public water systems, data on lead in tap water may be available on the Internet from your local water authority. If your water provider does not post this information, you should call and find out.

Does a high lead level in my tap water cause health effects?

High levels of lead in tap water can cause health effects if the lead in the water enters the bloodstream and causes an elevated blood lead level.

Most studies show that exposure to lead-contaminated water alone would not be likely to elevate blood lead levels in most adults, even exposure to water with a lead content close to the EPA action level for lead of 15 parts per billion (ppb). Risk will vary, however, depending on the individual, the circumstances, and the amount of water consumed. For example, infants who drink formula prepared with lead-contaminated water may be at a higher risk because of the large volume of water they consume relative to their body size.

What can I do to reduce or eliminate lead in my tap water?

If your tap water contains lead at levels exceeding EPA's action level of 15 ppb, you should take action to minimize your exposure to the lead in the water.

You should begin by asking your water authority these questions:

1. Does my water have lead in it above EPA's action level of 15 parts per billion (ppb)?

If the answer is no, no action is needed.
If the answer is yes, also ask the next question:

2. Does the service pipe at the street (header pipe) have lead in it?

This information is very important. It determines which of the next two actions (A or B) you should follow to protect your household's health.

A) If the pipe in the street (header pipe) DOES NOT have lead, the lead in your tap water may be coming from fixtures, pipes, or elsewhere inside your home.

Until you eliminate the source, you should take the following steps any time you wish to use tap water for drinking or cooking, especially when the water has been off and sitting in the pipes for **more than 6 hours**:

a. Before using any tap water for drinking or cooking, flush your water system by running the kitchen tap (or any other tap you take drinking or cooking water from) on **COLD**for **1–2 minutes;**

b. Then, fill a clean container(s) with water from this tap. This water will be suitable for drinking, cooking, preparation of baby formula, or other consumption. To conserve water, collect multiple containers of water at once (after you have fully flushed the water from the tap as described).

B) If the pipe at the street (header pipe) **DOES** contain lead, lead in the tap water may be coming from that pipe or connected pipes (it may also be coming from sources inside your home).

Until the lead source is eliminated, you should take the following steps any time you wish to use tap water for drinking or cooking, especially when the water has been off and sitting in the pipes for **more than 6 hours**. Please note that **additional flushing is necessary:**

a. Before using any tap water for drinking or cooking, run high-volume taps (such as your shower) on **COLD for** 5 minutes or more;

b. Then, run the kitchen tap on **COLD** for **1–2 additional minutes**;

c. Fill a clean container(s) with water from this tap. This water will be suitable for drinking, cooking, preparation of baby formula, or other consumption. To conserve water, collect multiple containers of water at once (after you have fully flushed the water from the tap as described).

3. In all situations, drink or cook only with water that comes out of the tap cold. Water that comes out of the tap warm or hot can contain much higher levels of lead. Boiling this water will NOT reduce the amount of lead in your water.

4. You can also reduce or eliminate your exposure to lead in drinking water by consuming only bottled water or water from a filtration system that has been certified by an independent testing organization to reduce or eliminate lead. See resources (https://www.cdc.gov/nceh/lead/tips/water.htm#Resources) below.

5. Children and pregnant women are especially vulnerable to the effects of lead exposure. Therefore, for homes with children or pregnant women and with water lead levels exceeding EPA's action level of 15 ppb, CDC recommends using bottled water or water from a filtration system that has been certified by an independent testing organization to reduce or eliminate lead for cooking, drinking, and baby formula preparation. Because most bottled water does not contain fluoride, a fluoride supplement may be necessary.

Also, some bottled waters have not been tested and may not be appropriate for consumption. Contact independent testing organizations that certify bottled water. See resources (https://www.cdc.gov/nceh/lead/tips/water.htm#Resources) below.

6. Make sure that repairs to copper pipes do not use lead solder.

Advice for lead safe water practices after plumbing work in housing with lead water lines or lead solder.

These practices include

1. Testing water after plumbing work in older housing. Please contact your state lead program (https://www.cdc.gov/nceh/lead/programs/default.htm) for information about water testing in your area.

2. Inspecting the aerator on the end of the faucet and removing any debris such as metal particles.
3. Flushing water lines before using the water for drinking or cooking.

If you own your home, you may also consider full replacement of lead water lines by removing the private lines running from the water meter into your home. This precaution has not been adequately studied, however, because the data available to CDC included too few homes having had full replacement of lead water lines. Contact your water authority for information about replacing water service lines.

If my water has high lead levels, is it safe to take a bath or shower?
Yes. Bathing and showering should be safe for you and your children, even if the water contains lead over EPA's action level. Human skin does not absorb lead in water.

This information applies to most situations and to a large majority of the population, but individual circumstances may vary. Some situations, such as cases involving highly corrosive water, may require additional recommendations or more stringent actions. Your local water authority is always your first source for testing and identifying lead contamination in your tap water. Many public water authorities have websites that include data on drinking water quality, including results of lead testing. Links to such data can be found on the EPA website: http://www.epa.gov/ccr (http://www.epa.gov/ccr) .

Resources
Please visit the following sites for more information:

General:

Blood Lead Levels in Residents of Homes with Elevated Lead in Tap Water---District of Columbia, 2004 (https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5312a6.htm). *MMWR*. April 2, 2004; 53 (12):268-270.

> **Addendum:** After release of the *MMWR* article titled "Blood Lead Levels in Residents of Homes with Elevated Lead in Tap Water -- District of Columbia, 2004," some reports have suggested erroneously that CDC determined that lead in residential tap water at concentrations as high as 300 parts per billion is 'safe.' CDC reiterates the key message from the 2004 article: because no safe blood level has been identified for young children, all sources of lead exposure for children should be controlled or eliminated. Lead concentrations in drinking water should be below the EPA action level of 15 parts per billion.

EPA - Drinking Water Requirements for States and Public Water Systems (http://www.epa.gov/dwreginfo) and information on chemical and microbial contaminants. Safe Drinking Water Hotline: 1-800-426-4791.

Water Fluoridation: CDC - Community Water Fluoridation (https://www.cdc.gov/fluoridation/) fact sheets, frequently asked questions, and publications.

Bottled Water and Water Filters:

- NSF International (http://www.nsf.org/) , a nonprofit organization that certifies bottled water (http://info.nsf.org/certified/bwpi/) and water filters (http://info.nsf.org/Certified/DWTU/) . Consumer Affairs Office toll-free hotline: 1-800-673-8010.
- International Bottled Water Association (http://www.bottledwater.org/) , the trade association that represents the bottled water industry. Information Hotline: 1-800-WATER-11.

Page last reviewed: June 15, 2013

Page last updated: February 18, 2016

Content source: National Center for Environmental Health (https://www.cdc.gov/nceh), Division of Emergency and Environmental Health Services (https://www.cdc.gov/nceh/eehs/default.htm)

ORDINANCE NO. 569-15

AN ORDINANCE REGULATING LEAD WATER SERVICE LINE REPLACEMENT IN THE CITY OF KEWAUNEE

The Common Council of the City of Kewaunee, Wisconsin, do ordain as follows:

SECTION 1. Section 14-180 of the Municipal Code of Kewaunee, Wisconsin, is hereby created as follows:

"Sec. 14-180. - Lead water service line replacement.

(1) *Intent and purpose.* The Common Council of the city finds that it is in the public interest to establish a comprehensive program for the removal and replacement of lead pipe water service lines in use within both the city utilities water system and in private systems and, to that end, declares the purposes of this section to be as follows:

(a) To ensure that the water quality at every tap of utility customers meets the water quality standards specified under the federal law;

(b) To reduce the lead in city drinking water to meet the Environmental Protection Agency (EPA) standards and ideally to a lead contaminant level of zero in city drinking water for the health of city residents;

(c) To eliminate the constriction of water flow caused by mineral rich groundwater flowing through lead water service pipes and the consequent buildup of mineral deposits inside lead pipes; and

(d) To meet the Wisconsin Department of Natural Resource (WDNR) requirements for local compliance with the Lead and Copper Rule (see 56 CFR 6460, 40 CFR parts 141.80—141.90 and Wis. Admin. Code §§ NR 809.541—809.55).

(2) *Water system reconstruction.*

(a) *Inspection required.* The public works director or his designee shall inspect all private connections to the public water mains at the time that the utility system is to be reconstructed:

1. Any existing private lead water lateral shall be considered illegal.

2. Prior to the actual reconstruction of the water main and lateral system, each property owner shall be given written notice of the project. Such notice shall be made not less than 30 days prior to commencement of the actual work.

3. As the reconstruction progresses, the public works director or his designee shall inspect each private water lateral connection for the presence of lead or, in the event inspection had been made previously, determine the condition of the private water connection from inspection records.

4. In the event that the private water lateral does not contain lead, the city shall reconnect the same to the utility system at an appropriate point near the right-of-way line.

5. In the event that the private water lateral is found to contain lead, the public works director or his designee shall immediately notify the owner in writing of that fact.

(b) *Owner to replace lead service*. The owner shall, at the owner's expense, replace the lead service. In all cases, the city shall supply an appropriate connection point as part of its work. The owner may elect to:

1. Contract with licensed contractor to complete the repair. All work needed to accomplish the repair shall be done at the expense of the owner. Within 30 days of the giving of notice of deficiency under subsection (2)(a)5 of this section, proof of arrangements for repair shall be provided to the public works director or his designee and the owner shall have up to eighteen (18) months from the date of giving notice for the repairs to be completed.

2. Have the city contractors, if available, complete the repair.

   a. The city may, as part of any project, request unit bid prices for the calculation of the cost of making appropriate repair to the private building water laterals.

   b. If available, and should the owner select this option, the owner shall make arrangements with the contractor to pay the entire cost of making the repair.

(3) *Authority to discontinue service*. As an alternative to any other methods provided for obtaining compliance with the requirements of this Code regarding replacement of illegal private water laterals, the utility may, no sooner than 30 days after the giving of notice, discontinue water service to such property served by illegal private water lateral after reasonable opportunity has been given to make the appropriate repairs."

SECTION 2. All ordinances or parts of ordinances in conflict with the provisions of this ordinance are hereby repealed.

SECTION 3. This ordinance shall take effect upon passage and publication.

Introduced by Alderman Griffith

Vote: For 8 Against 0

Adopted this 8TH day of June, 2015.

CITY OF KEWAUNEE

John Blaha, Jr., Mayor

ATTEST:

Kyle L. Ellefson, City Administrator

Published: 06/10/2015

Madison Water Utility

(https://www.cityofmadison.com/water)

Tom ei inen, eneral Manager

City of Madison (/) / Water Utility (/water) /

Water Quality (/water/water-quality) /

Information for utilities on lead service replacement (/water/water-quality/information-for-utilities-on-lead-service-replacement)

Share

Information for utilities on lead service replacement

Madison Water Utility has gotten inquiries from utilities all over the country about our Lead Service Replacement Program. In 2000, Madison was the first major city in the country to adopt a full lead service replacement initiative. Below, you'll find information about how the program was funded, average replacement costs, homeowner reimbursements, and more. If you have any further questions about lead service replacements, please contact water@madisonwater.org (mailto:water@madisonwater.org).

Water Quality (/water/water-quality)

Water Quality at My Address (http://www.cityofmadison.com/water/waterquality/mywells.cfm)

Annual Drinking Water Quality Report (/water/water-quality/annual-drinking-water-quality-report)

Water Main Flushing Program (/water/water-quality/water-main-flushing-program)

Water Quality Testing (/water/water-quality/water-quality-testing)

Private Wells (/water/water-quality/private-wells)

Cross-Connection Control Program (/water/water-quality/cross-connection-control-program)

Wellhead Protection Program

In 2000, Madison's Common Council passed an ordinance (Madison General Ordinance 13.18) PDF that requires property owners to replace their side of a water service if it's lead. The penalty for non-compliance is a fine of $50-$1000 per day. We did have a handful of property owners who refused to comply with the city's lead service replacement ordinance. Those cases were turned over to the city attorney's office. We also discover 1-2 properties a year during main work, street replacements, etc. that have lead services. Customers who discover a lead service can still receive reimbursement for half the cost of replacement up to $1,000. They can also apply for financing through the city to help pay for the remainder of the cost.

For each property where a private-side lead lateral will be replaced, a licensed plumber is required to fill out an Application for Lead Replacement Contract PDF before work begins. When work is completed, the property owner fills out an Application for Reimbursement Form PDF.

Prior to our Lead Service Replacement Program, we did not generally keep records of the material used on the property owners' side of the lateral. But we did often have records noting the material used on our side, so we had a good idea which properties were likely to be impacted by the ordinance. (Madison stopped using lead for water pipes in the late 1920s.) We sent surveys to thousands of property owners which they were required to fill out, sign and return to us stating what material was used for their water service. We held community meetings across the city where we showed people how to locate their service and do a scratch test (http://www.cityofmadison.com/water/water-quality/lead-copper-in-water/lead-in-water-what-you-should-know)to check for lead.

In addition, the utility has exhaustively documented the composition of water service lines through staff inspections (meter shop and construction inspectors), and observations by contractors and inspectors during water main replacement projects. Efforts to identify additional lead water service lines continue today albeit with less urgency since, based on the available information, it is assumed that the remaining service lines are not lead.

Here is more information about our program that may be helpful:

(/water/water-quality/wellhead-protection-program)

Frequently Asked Questions (/water/faq/water-quality)

Chromium Testing (/water/water-quality/chromium-in-water)

Lead Service Replacement Program (/water/water-quality/water-quality-testing/lead-copper-in-water)

Sections ▲

Information for Utilities on Lead Service Replacement (/water/water-quality/information-for-utilities-on-lead-service-replacement)

Well 8 (/water/water-quality/whats-next-for-well-8)

- Our program replaced more than 8,000 lead service pipes, but only about 5,600 of those included the property owner's side (many people had already head their portion of the service replaced in the decades since 1930).

- The entire cost of the program was about $15.5 million over 11 years.

- Wisconsin's Public Service Commission did not allow us to use rate-payer dollars to fund customer reimbursements, but we were able to use revenue generated by renting space on top of our water towers to cell phone companies for their antennas.

- While our crews handled the utility-side replacements, private plumbers handled the private side. We often worked closely with plumbing companies, leaving trenches open after replacing our side to lower the cost for homeowners. Plumbers would then follow us down the street replacing the private side immediately after our work was done.

- During the program, our average reimbursement for half the cost of the private-side lateral was $670. So the entire cost to replace the private-side portion was $1340 on average.

- The average cost to replace our side during the program was $1997.

- Between 2001 and 2006, our annual capital budget was about $7-9 million. During those years, we spent about $1-1.5M on utility-side lead service replacements annually. After 2006, the amount we spent on lead service replacements dropped off to less than $100K a year.

- Properties that had tested high for lead, as well as places like schools and apartment buildings, were prioritized during the program, so their services were replaced right away.

- 80% of replacements were completed between 2001 and 2006. The rest were completed during already planned street and main replacement projects between 2007 and 2012.
- Before our Lead Service Replacement Program was enacted, our 90th percentile lead result was 16 µg/L. However, it was not uncommon to find results of 40, 50, even greater than 100 µg/L at some homes.
- We continue to monitor for lead at the customer tap. Each time (twice in 2011 and once in 2014) the 90th percentile level has been around 3 µg/L. Lead testing will occur again in 2017 and then every three years after that.

ater tility

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dministrative Office
119 East Olin Avenue
Madison, WI 53713

- Report Emergency After Hours: (608) 266-4665
- Office: (608) 266-4651
- Fax: (608) 266-4426
- Office Hours: 7:30am - 4:00pm, M-F
- Drinking Water Concerns/Questions (https://www.cityofmadison.com

/reportaproblem
/water.cfm)

- Email Us
(mailto:water@cityofmadison.com)
- WI Relay Service
(/dcr/WIRelayService.cfm)

(https://mywater.cityofmadison.com)

Sign up for electronic bills
(https://mywater.cityofmadison.com)

(http://my.cityofmadison.com)

Well 31
(http://my.cityofmadison.com)

All Social Media » (/outreach)

Utility Profile

Source water	Groundwater (100%) – 24 wells
Treatment	Chlorine and fluoride addition at each well
Corrosion Control Treatment	None. Full Lead Service Line Replacement Program Implemented to meet requirements of the LCR
Daily demand	32 MGD average day demand
Service line ownership	Customer-owned from curb-stop to building Utility owns from main to curb-stop
Lead Service Lines	1574 utility owned lead service lines 1358 customer owned lead service lines
Type of replacement program	Full Lead Service Line Replacement: Full lead service lines replaced as part of on-going program to meet requirements of the LCR

INTRODUCTION

Madison Water Utility provides groundwater from a deep sandstone aquifer to over 60,000 service locations. Average water use is about 32 million gallons per day (Madison Water Utility, 2006a). The water is pumped from 24 wells that range from 500 to 1130 feet deep. It is stored in 31 reservoirs and flows through about 810 miles of water main. Water treatment consists of chlorine addition to achieve 0.2 mg/L free chlorine and fluoride addition to achieve 1.1 mg/L. This chemical addition is performed at each well house.

Lead was commonly used for water service lines from 1882, the inception of Madison Water Utility, through 1927. Eleven thousand lead water service lines were installed during this time period. From the 1930s to 1960s, the Utility began replacing lead services on a small scale. Some lead services were replaced with copper when they leaked or when customers reported a low flow problem. During the 1970s, the Utility began replacing lead services when streets were reconstructed. In the late 1980s, Utility crews began replacing lead services during street resurfacing jobs. (Madison Water Utility, 2006b)

Hersey water meters, some of which used lead weights, were used from about the 1940s through the 1960s. The last of the lead-weight Hersey meters were replaced sometime in the 1990s. In about 2004, Madison Water Utility switched to non-leaded "EnviroBrass®" meters from Badger Meter, Inc. Older meters are still refurbished and reused, but when a meter is replaced after a lead service replacement the new meter is always non-leaded. Brass Mueller corps and curb stops used in the Madison Water Utility distribution system contain about 5% lead (Madison Water Utility, 2006b).

HISTORY OF LEAD CORROSION CONTROL IN MADISON

Corrosion control investigations were initiated after Lead and Copper Rule sampling in 1992 indicated a ninetieth percentile lead concentration of 16 μg/L. The recommendations from the corrosion control studies were to skip the chemical alteration of the water as prescribed by the Lead and Copper Rule and move directly to a control step allowed in the Rule only if chemical treatment fails. That control step is the replacement of lead water service lines. The arguments for making this bold step were:

- Because of the water's potential for precipitating calcium, pH adjustment was not chemically viable.
- Because the water comes from twenty-four distinct sources with no common treatment or storage facilities, alkalinity adjustment was not economically viable.
- Sodium silicate did not show any benefit in jar tests. Plus, there was little information on the use of sodium silicates.
- Polyphosphates increased the lead concentration in the water.
- Orthophosphates successfully lowered the lead levels. (Cantor, et. al., 2000), however, the Madison Metropolitan Sewage District had recently completed the installation of a biological phosphorus removal system that depended on a particular ratio of organic matter to phosphorus. If phosphorus was to be added to the drinking water, the removal system would not work properly and a chemical phosphorus removal system would need to be added. In addition, the water that would runoff directly to the lakes would carry phosphorus with it.

The Wisconsin Department of Natural Resources (WDNR) agreed that removing lead water service lines as a means of corrosion control was the only reasonable option available and further required that Madison achieve "optimal corrosion control" where the ninetieth percentile lead concentration is to be 5 μg/L.

ESTABLISHING COMPLETE LEAD SERVICE LINE REPLACEMENT

In order to achieve the goal of 5 μg/L ninetieth percentile lead concentration, however, the WDNR required the utility to remove the complete lead service line. This presented a problem in that the water utility owns the water service line up to the curb stop at a private building and the property owner owns the service line from the curb stop to the building. Property owners would have to be encouraged to replace their portion of the service line and the cost of doing so would need to be addressed.

These were the considerations taken into account by the Madison Water Utility and the Madison Common Council. They concluded that replacement of the customer side of lead service lines in the City was of benefit not only to each individual customer, but to the utility and community as a whole in meeting state and federal drinking water standards and avoiding the cost to all customers of adding corrosion control chemicals to the water system indefinitely. The lead service line replacements would also avoid the cost and environmental impact of adding phosphorus to wastewater streams. Consequently, the City established a requirement for customers to replace their lead water service lines and a program whereby they would be reimbursed for half the cost of replacing those lines up to $1000 reimbursement per property.

Source: *Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues* by Sandvig et al.

The utility, for which rates are regulated by the Public Service Commission of Wisconsin (PSCW), requested that the PSCW include half the cost of replacing customer lead service lines in its rate base. The PSCW denied the request, rejecting the utility's arguments about the benefits to the utility and community and expressing the opinion that all water customers should not be burdened with any cost for replacing customer-owned service lines. Subsequently, the Common Council approved a plan to place half the cost of replacing customer lead service lines on sewer rates, for which the PSCW did not have regulatory jurisdiction. The City justified this by showing a substantial avoided cost to sewer customers by implementing a complete lead service replacement program as opposed to adding corrosion control chemicals to drinking water, which would need to be removed at the wastewater treatment plant. Madison approved a complete lead service replacement program in February 2000, with a goal of replacing all lead water service lines in the City by 2011.

On January 1, 2001, the initiation of the complete lead service line replacement program, there were approximately 6,000 existing Water Utility side services and 5,000 customer-side services. As of December 31, 2005, the Utility has replaced or cut off about 4,307 Utility-side lead services or 72%, while customers have replaced 3,633 lead services or 73%. There are 1574 utility-owned lines and 1358 customer-owned lines remaining in the distribution system. All services are now scheduled to be removed by the end of 2009, two years ahead of the original schedule (Madison Water Utility, 2006b).

COSTS OF LEAD SERVICE LINE REPLACEMENT

Madison Water Utility tracks lead service line replacement costs for those services replaced by Utility crews through the lead service replacement work order. Any replacements done by city contract during water main replacement jobs are not included in these numbers. Because of this, the total number of lead service line replacements reported here will not equal the number actually replaced. Nevertheless, the costs do reflect the unit cost to replace a lead service line. As shown in the Table B.6.1, the costs to replace the Utility-side services have averaged $2212 per service line over the past eleven years. The replacement cost per line has ranged from $1798 in 1995 to $2751 in 2005. (Madison Water Utility, 2006b)

On the Property Owner-side service, the property owner is reimbursed for 50% of the replacement costs up to $1000. The average reimbursement to property owners has been $663.88. This implies that the average property owner-side replacement cost is $1327.76. However, this number does not account for replacements that are over $2000 since amounts over $2000 are not reported to the Utility for reimbursement. Reimbursements made since December 2000 are calculated in Table B.6.1 and Table B.6.2 lists the customer side replacement costs.

Table B.6.1
Madison Water Utility: Utility-side Lead Service Line Replacement Costs

Year	Number of Lead Service Line Replacements	Total Cost	Unit Cost
1995	226	$406,276	$1,798
1996	202	$341,633	$1,691
1997	239	$445,960	$1,866
1998	234	$459,946	$1,966
1999	352	$679,842	$1,931
2000	309	$601,995	$1,948
2001	570	$1,128,827	$1,980
2002	528	$1,266,050	$2,398
2003	553	$1,304,975	$2,360
2004	547	$1,399,144	$2,558
2005	528	$1,452,498	$2,751
Total	4,288	$9,487,146	$2,212

Table B.6.2
Madison Water Utility: Customer-side Lead Service Line Replacement Costs

Total Dollars Reimbursed	$2,754,420.93
Number of Reimbursements	4,149
Average Reimbursement Paid	$663.88
Average Total cost for Customer-side Lead Service Line Replacement	*$1327.76

*Note: This number does not account for replacements that are over $2000 since amounts over $2000 are not reported to the Utility

Source: *Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues* by Sandvig et al.

FOLLOW-UP MONITORING ON LEAD SERVICE LINE REPLACEMENT

In 2003, Madison Water Utility initiated a special project to assess the success of the lead line replacement program in terms of achieving optimal corrosion control. The study found that total lead concentration at a residence with a lead service line in Madison is typically seen to be erratic (Figure B.6.1). After lead line replacement, the erratic behavior continues (Figure B.6.2). By comparing Figures B.6.2 and B.6.3, it is seen that the erratic lead concentration is from lead particulate matter dislodging from pipe walls and arbitrarily becoming entrained in water samples. At the same time, dissolved lead concentration, which represents uniform corrosion, is lowered with lead service line replacement. At this time in Madison, the ninetieth percentile dissolved lead sampling results are at the desired goal of 5 µg/L (Figure B.6.3). The data suggest that the lead laden particulate matter is flushed out over several years after lead materials are removed from the plumbing system and a total lead concentration of 5 µg/L is eventually achieved (Figure B.6.2). (Cantor, 2006)

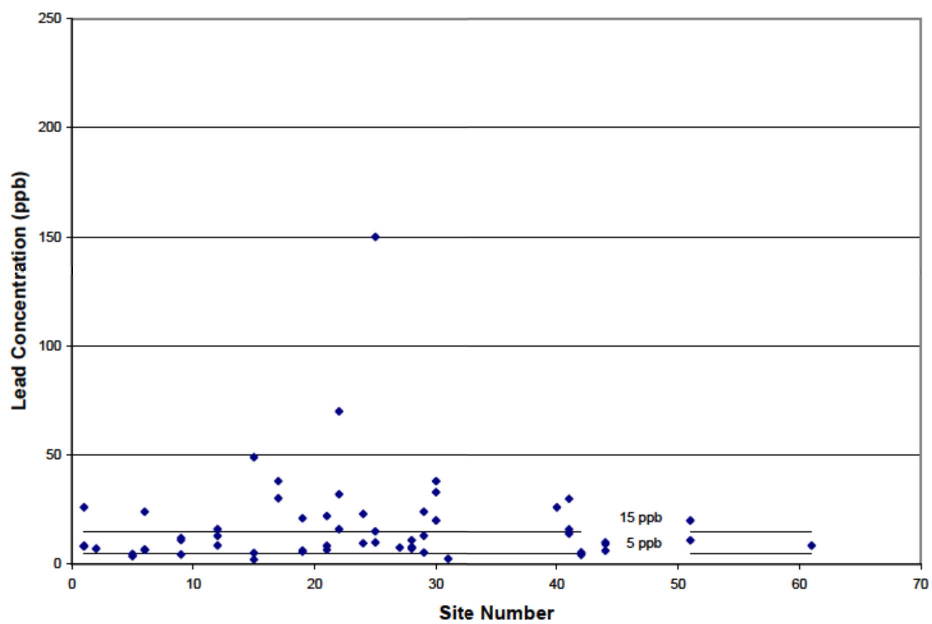

Figure B.6.1 Total (Particulate + Dissolved) Lead Concentration at Sites Before Full Lead Service Line Replacement

Source: *Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues* by Sandvig et al.

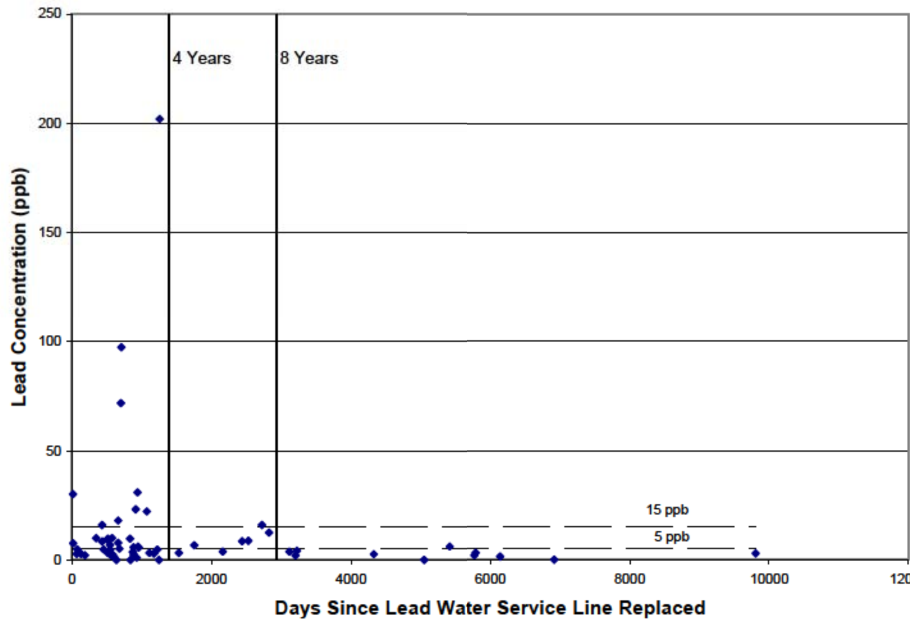

Figure B.6.2 Total (Particulate + Dissolved) Lead Concentration vs. Time Since Full Lead Service Line Replacement

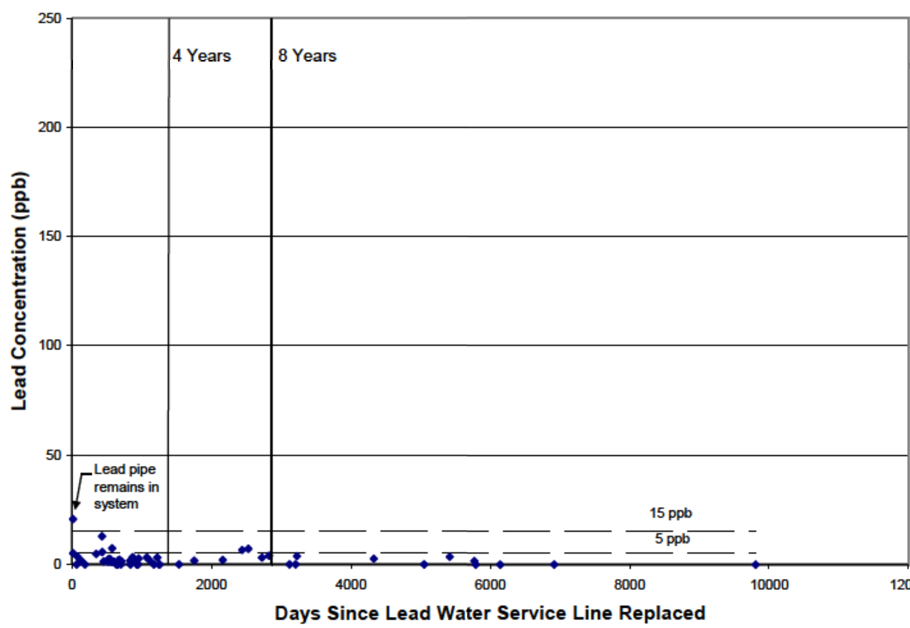

Figure B.6.3 Dissolved Lead Concentration vs. Time Since Full Lead Service Line Replacement

LEAD SERVICE PIPE SCALE EVALUATIONS

As models of lead solubility show, the DIC and pH of water determine what lead compounds will predominate, and the solubility of the predominant lead compound determines

Source: *Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues* by Sandvig et al.

the concentration of lead in the water (Schock, 1980). At a high DIC concentration such as in Madison's water, there is ambiguity in the solubility model as to how corrosive the water is. One research study reported that in high DIC water, a more soluble compound of lead (hydrocerussite) is often found where a less soluble compound (cerussite) is predicted (Sheiham and Jackson, 1981).

With that ambiguity in mind, a lead water service pipe excavated in Madison was sent to Michael Schock, US Environmental Protection Agency Research Chemist, for examination in 2001. He reported that on top of a familiar lead carbonate compound (cerussite), on the pipe wall, there was a predominance of yet another lead compound, lead dioxide (plattnerite), which was not included in the existing solubility model. He explained that this relatively insoluble lead compound would signify water with very low aggressiveness. Mr. Schock published this and similar findings noting that lead concentrations found in Madison are more than a factor of 10 below the expected lead concentrations from the DIC-based solubility model (Lytle and Schock, 2005).

Three more lead pipes were sent to Michael Schock for analysis in May and September 2005. These three pipes also had cerussite overlaid by plattnerite on the pipe wall, but there was an additional factor. A scale layer of manganese and iron compounds was observed on the pipe wall. Mr. Schock reported (Schock, et. al., 2006): "Since lead compounds are intermingled with the manganese and iron scale layers, and it is probable that lead ions are sorbed to the oxyhydroxide surfaces, destabilization of these Mn/Fe deposits could release microparticles intermittently." Indeed, past lead monitoring studies in Madison have shown lead in the drinking water to be mostly in particulate form.

FUTURE MONITORING

The results of the lead line replacement monitoring study were discussed with WDNR. Madison Water Utility proposed that more monitoring be done to substantiate the premise that particulate lead decreases over time after a complete lead service line is replaced and a concentration of 5 μg/L of total lead or below is ultimately achieved. The WDNR stated that Madison Water Utility compliance with the Lead and Copper Rule would be based on the results of the continued monitoring along with the standard Lead and Copper Rule sampling results presented at the end of the lead water service line replacement program in 2011. If the ninetieth percentile lead level for total lead concentration is over 15 μg/L at that time but the monitoring data shows that particulate lead decreases over time, then Madison Water Utility will be deemed in compliance.

SUMMARY

The Madison Water Utility has undertaken a full lead service line replacement program to meet the requirements of the Lead and Copper Rule, with a goal of replacing all lead service lines in the City by 2011. Since the customer has authority of the service line from the curb-stop to the building, the Madison Common Council approved a plan to place half the cost of replacing customer lead service lines on sewer rates. This decision was justified by showing a substantial avoided cost to sewer customers by implementing a complete lead service replacement program as opposed to adding corrosion control chemicals to drinking water, which would need to be removed at the wastewater treatment plant.

Source: *Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues* by Sandvig et al.

Water quality data collected to assess the success of the lead line replacement program suggests that dissolved lead concentrations are lower after full lead service line replacement, but total lead concentration are erratic, and continue to be erratic for several years. Evaluation of the scale present on Madison lead service pipes indicates the presence of lead compounds intermingled with manganese and iron scale layers, resulting in destabilization of these Mn/Fe deposits and intermittent release of microparticles.

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- Doug De Master, Engineering Systems and Mapping Engineer
- Dan Rodefeld, Field Supervisor
- Robin Piper, Accountant
- Tony Mazzara, Water Meter Mechanic Leadworker
- Ken Key, Customer Service Manager

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By Professor Deal 12/27/2012

"Lead levels in town water have decreased significantly since town officials stopped adding fluoride, commissioners reported at Wednesday's meeting. They also voted to officially ban fluoridation.

Fluoride itself does not produce high lead levels, but fluoride must be introduced along with fluorosilicic acid, and town officials believe that the acid washes lead from pipe soldering, said Mayor Terrence Best.

When commissioners first had water tested in 1992, some houses had 50 times the accepted limit established by the U.S. EPA, and the average amount measured twice the limit, he said. Commissioners then stopped using fluoride.

The suggested lead limit in water is 15 parts per billion. A May 1993 test showed decreasing levels of lead in water. The high was 136.25 ppb, and the average was 9.25 ppb.

A third test, conducted in November, found the high at 31.95 ppb and the average at 7.11 ppb."

Myrick

TACOMA PUBLIC UTILITIES

E. E. COATES, DIRECTOR
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P.O. Box 11007
Tacoma, Washington 98411
(206) 383-2471

DIVISIONS
Light
Water
Belt Line

December 2, 1992

Mr. Michael Heath
Department of Health
Division of Drinking Water
Box 47822
Olympia, Washington 98504-7822

Dear Mr. Heath:

Enclosed is a partially completed EPA Form 141-A, which reports the results of our second round of copper and lead testing. We will forward the 25 water quality parameter samples as soon as they are received. For our entry point samples, pH and water temperature is measured daily at our Headworks' Control Station. I understand you will provide this information to Bob James, our District Engineer, and the EPA by the required reporting date.

It is interesting to note the 90th percentile lead concentration was 17 ppb this time compared to 32 ppb last time. We have not been using fluoride since the drought this summer. This latest testing gives us some limited insight as to the amount of chemical adjustment that may be necessary. The percentage of homes that **failed** the "action level" was 9.8 percent.

Your efforts with regard to this program are appreciated. If you should have any questions with regard to this submittal or other matters, please feel free to call me or Ken Merry at 206-593-8212.

Very truly yours,

C. R. Myrick
Water Quality Coordinator

CRM/smc

Enclosure
cc: Ken Merry

Committed to Service

200 E. Wells Street
Milwaukee, Wisconsin
53202

Introduced: 9/26/2016 **File Number:** 160742

Status: Held In Council **Version:** 1

Sponsors: Ald. Hamilton and Ald. Bohl

..Number
160742
..Version
SUBSTITUTE 1
..Reference

..Sponsor
ALD. HAMILTON AND BOHL
..Title
A substitute ordinance mandating the replacement of lead water service lines and establishing a special assessment for lead water service lines on private property.
..Sections
225-22-1-f cr
225-22.5 cr
..Analysis
This ordinance:

1. Requires that the privately-owned portion of a lead water service line be replaced whenever any of the following occurs:

a. A leak or failure has been discovered on either the privately-owned or utility-owned portion of the service line.

b. The utility-owned portion of the line is replaced on either a planned or emergency basis.

2. Prohibits the repair of a privately-owned lead water service line, or reconnection of a privately-owned lead water service line to a utility-owned water service line, under any of the circumstances described in #1.

3. Authorizes the commissioner of public works or the commissioner's designee to grant temporary exceptions to these regulations.

4. Requires the commissioner of public works or the commissioner's designee to provide written notice to the property owner of the replacement requirement described in #1. Upon receipt of this notice, the property owner shall, within 10 business days, either replace the privately-owned portion of the lead service line at the owner's expense by contracting with a

licensed contractor or elect to have a city contractor replace the privately-owned portion of the lead service line. If the owner elects to have a city contractor complete the replacement, the owner shall be responsible for the average current cost of replacement of the privately-owned portion of the line. The cost shall be assessed as a special assessment, payable over a 10-year period.

5. Provides that, subject to availability of public funds, a property owner who meets certain criteria shall be eligible to receive the following subsidy of the cost of replacing the privately-owned portion of the lead water service line:

a. The property owner's share of the cost shall be the lesser of one-third of the average current cost to replace the privately-owned portion of the lead service line or $1,600.

b. The city shall pay the balance of the cost of the line replacement.

6. Stipulates that a property owner is eligible for the city subsidy only if all of the following are true:

a. The property is a one- to 4-unit residential property.

b. The owner agrees to have the work performed by a city contractor.

c. The owner signs a hold-harmless agreement holding the city harmless and free from any claim or liability for damage done in performance of the water service line replacement work.

d. The owner executes a temporary right of entry and
construction easement authorizing the city and its contractor access into the dwelling as needed in order to complete the connection.

e. The owner waives in writing the 10-day notice provision noted in #4.

7. Authorizes the commissioner of public works or the commissioner's designee to have required lead water service line replacement work performed if the owner fails to comply with the replacement requirement. The cost of this work shall be assessed and collected as a special assessment on the property.

8. Authorizes the commissioner of neighborhood services to issue a citation in the amount of $100 to the property owner upon determination that a violation of these regulations exists. Each day of violation shall constitute a separate offense, up to a maximum of 16 days.

9. Provides that, as an alternative to any other methods provided for obtaining compliance with these lead service line replacement requirements, if the commissioner of public works or the commissioner's designee determines that the owner's failure to comply will create an imminent threat to the health, safety or welfare of the public, the commissioner or the commissioner's designee may discontinue water service to the property upon notice to the owner and reasonable opportunity to attain compliance.

This ordinance takes effect January 1, 2017.
..Body
The Mayor and Common Council of the City of Milwaukee do ordain as follows:

Part 1. The title of subchapter 2 of chapter 225 of the code is amended to read:

SUBCHAPTER 2
SEWAGE DISPOSAL >>AND WATER<< SYSTEMS

Part 2. Section 225-22-1-f of the code is created to read:

225-22. Municipal Service.

1.

f. All property shall be connected to the public water main in a manner consistent with the provisions of s. 225-22.5, to the extent that the provisions of that section apply to the property's water connection.

Part 3. Section 225-22.5 of the code is created to read:

225-22.5. Lead Service Line Replacement. 1. FINDINGS. a. The common council finds that:

a-1. Disturbance of lead water service lines, particularly partial lead service line replacement, has been shown to increase lead levels in drinking water.

a-2. Reconnection of existing lead water service lines to new copper water service lines has been shown to increase lead levels in drinking water.

a-3. Full replacement of lead service lines, as opposed to partial replacement, can reduce exposure to lead in drinking water.

a-4. Because of the significant risks to public health and safety posed by disturbance of lead water service lines and reconnection of lead to copper service lines, the city has a strong public interest in remediating privately-owned lead water service lines under certain circumstances.

a-5. Residential properties containing 5 or more dwelling units are typically investment properties operated for a profit and better able to bear the costs of water service line replacement than residential properties containing one to 4 dwelling units.

b. For the reasons stated in par. a, and under the authority granted to the city to regulate connections to public water mains by ss. 66.0911 and 281.45, Wis. Stats., to act for the health, safety and welfare of the public by s. 62.11(5), Wis. Stats., and consistent with the purpose of this code set forth in s. 200-002, the common council finds that it is necessary and appropriate to establish and enforce requirements for the full replacement of lead water service lines under certain conditions and to provide a funding mechanism to assist affected property owners in complying with those requirements.

2. DEFINITIONS. In this section:

a. “Lead water service line” means a service made of lead which connects the water main to the building inlet and any lead pigtail, gooseneck or other fitting which is connected to such lead line.

b. “Privately-owned portion of a lead water service line” means the section of water service piping from the outlet joint of the curb stop to the outlet of the water meter outlet valve with the exception of the water meter itself, regardless of the ownership of the property upon which the piping is located.

c. “Utility-owned portion of a lead water service line” means the section of water service piping from the main to, but not including, the outlet joint of the curb stop.

3. REPLACEMENT REQUIREMENT. The privately-owned portion of a lead water service line shall be replaced whenever any of the following occurs:

a. A leak or failure has been discovered on either the privately-owned or utility-owned portion of the service line.

b. The utility-owned portion of the line is replaced on either a planned or emergency basis.

4. REPAIR OR RECONNECTION PROHIBITED. No repair of a privately-owned lead water service line, or reconnection of a privately-owned lead water service line to a utility-owned water service line, shall be permitted under any of the circumstances specified in sub. 3.

5. EXCEPTION. The commissioner of public works or commissioner’s designee may, at his or her discretion, grant a temporary exception to the requirement of sub. 3 and the prohibition of sub. 4 if the commissioner or commissioner’s designee determines that doing so will not create an imminent threat to the health, safety or welfare of the public.

6. NOTICE. a. Leak or Emergency Replacement. In the event of a service line leak or failure under sub. 3-a or emergency replacement of the utility-owned portion of the service line under sub. 3-b, the commissioner of public works or commissioner’s designee shall provide written notice of the replacement requirement to the owner upon the commissioner’s or designee’s determination that replacement of the utility-owned portion of the line is required.

b. Planned Replacement. In the event of a planned replacement under sub. 3-b, the commissioner of public works or commissioner’s designee shall provide written notice of the replacement requirement to the owner at least 45 days prior to the commencement of the planned replacement of the utility-owned portion of the service line.

7. OWNER ELECTION. Upon receipt of the notice in sub. 6, the owner shall, within 10 business days, do one of the following:

a. Replace the privately-owned portion of the lead service line at the owner's expense by contracting with a licensed contractor. The work shall be performed in accordance with all applicable state, local and utility regulations.

b. Elect to have a city contractor replace the privately-owned portion of the lead service line.

8. FINANCING OF REPLACEMENT BY CITY CONTRACTOR. If the owner elects to have a city contractor complete the replacement under sub. 7-b, the cost of replacing the privately-owned portion of the lead service line shall be paid in the following manner:

a. The owner shall be responsible for the average current cost of replacing the privately-owned portion of the lead water service line. The average current cost shall be established each year by the commissioner of public works, subject to adoption by common council resolution. The owner may be eligible for a city subsidy under sub. 9.

b. The owner's share of the cost shall be assessed to the property as a special assessment. Upon receipt of an invoice for this special assessment from the commissioner of public works or the commissioner's designee, the owner may pay the invoice, without interest, by remitting payment to the city treasurer within 45 days of the date of the invoice. If such invoices are not paid in full within the specified time, they shall be placed upon the tax roll under the following terms and conditions and in the following manner:

b-1. If the total amount of the principal of the invoice remaining unpaid equals or exceeds $125, it shall be spread equally over the first available and next succeeding 9 tax rolls.

b-2. If the total amount of the principal of the invoice remaining unpaid is less than $125, the amount shall be placed on the first available tax roll.

b-3. In addition to the principal remaining, interest shall be added commencing after the billing date of the invoice. A 45-day grace period for payment shall be granted from the date of billing, and if not paid within the period, interest shall be charged on a restorative basis to the date of the billing. The interest rate charged shall be set annually as of the last business day in June as an approximation of the prime rate plus 1%. For the purpose of this subdivision, the prime rate shall be defined as the Wall Street Journal prime rate published in the Wall Street Journal. The monthly rate of interest shall be computed by dividing the average prime rate plus 1% by 12 rounded to the nearest 100th of one percent. The comptroller shall review the interest rate annually and shall notify the commissioner of public works of the interest rate. The interest rate shall become effective as of the public hearing date in September at which annual assessment rate changes are submitted to the appropriate committee of the common council as provided in s. 115-43. The interest rate in effect at the time the special assessment is levied shall be fixed for the 10-year duration of the installment payments.

b-4. After being placed on the tax roll in annual installments or otherwise, the amounts of special assessments shall be paid within the time allowed for the payment of general property taxes. If the property owner fails to pay a special assessment within the time allowed for payment, it shall become delinquent and shall be treated in the same manner and subject to the same laws as a delinquent general property tax.

9. CITY SUBSIDY. a. Payment Method. Subject to availability of public funds, a property owner who meets the criteria in par. b shall be eligible to receive a subsidy of the cost of replacing the privately-owned portion of the lead water service line required by sub. 3 in the following manner:

a-1. The property owner's share of the cost shall be the lesser of one-third of the average current cost to replace the privately-owned portion of the lead service line or $1,600.

a-2. The city shall pay the balance of the cost to replace the privately-owned portion of the lead service line.

b. Eligibility Criteria. A property owner shall be eligible for the city subsidy provided in par. a if the property owner submits to the commissioner of public works or commissioner's designee documentation, on a form furnished by the commissioner or designee, attesting that all of the following conditions are met:

b-1. The property is a one-, 2-, 3- or 4-family dwelling.

b-2. The owner agrees to have the work performed by a city contractor.

b-3. The owner signs a hold-harmless agreement holding the city harmless and free from any claim or liability for damage done in performance of the water service line replacement work.

b-4. The owner executes a temporary right of entry and construction easement authorizing the city and its contractor access into the dwelling as needed in order to complete the connection.

b-5. The owner waives in writing the 10-day notice provision in sub. 6-a.

10. REQUIREMENTS FOR OWNERS INELIGIBLE FOR SUBSIDY. Any owner who elects to have a city contractor perform water service line replacement required by sub. 3 and is not eligible for city subsidy under sub. 9 shall, prior to the commencement of this work:

a. Execute a hold-harmless agreement holding the city harmless and free from any claim or liability for damage done in performance of the water service line replacement work.

b. Execute a temporary right of entry and construction easement authorizing the city and its contractor access into the dwelling as needed in order to complete the connection.

11. ENFORCEMENT. a. Performance of Work by City. If the owner fails to comply with sub. 3 within the time specified in sub. 7, the commissioner of public works or the commissioner's designee may apply for and obtain an appropriate court-issued warrant pursuant to ss. 66.0119 and 196.171, Wis. Stats., to gain access to the property and have the required work performed pursuant to s. 281.45, Wis. Stats. The cost of this work shall

be assessed and collected as a special assessment on the property.

b. Penalty. Upon determination that a violation of this section exists, the commissioner of neighborhood services is authorized to issue a citation in the amount of $100 to the property owner. Each day of violation shall constitute a separate offense, up to a maximum of 16 days.

c. Discontinuation of Service. As an alternative to any other methods provided for obtaining compliance with this section, if the commissioner of public works or the commissioner's designee determines that the owner's failure to comply with sub. 3 will create an imminent threat to the health, safety or welfare of the public, the commissioner or the commissioner's designee may discontinue water service to the property upon notice to the owner and reasonable opportunity to comply with the requirements of this section.

Part 4. This ordinance is effective January 1, 2017.
..LRB
APPROVED AS TO FORM

____
Legislative Reference Bureau
Date:______________________
..Attorney
IT IS OUR OPINION THAT THE ORDINANCE
IS LEGAL AND ENFORCEABLE

____
Office of the City Attorney
Date:______________________
..Requestor
DOA - Budget and Management Division
..Drafter
LRB166601-1
Jeff Osterman
11/01/2016

The 2017 Proposed City Budget: Improved Sustainability Continues but Structural Challenges Persist

"… we find that the City of Milwaukee's financial condition and outlook have improved significantly since our last examination in 2009. Credit is due to city leaders for their responsible approach to financing their pension obligations, restructuring their health care offerings, and downsizing the city's workforce in the face of some enormous fiscal challenges. Also, the fact that those challenges were accommodated without depleting reserves or substantially deferring capital repair needs is further evidence of effective financial management."

Public Policy Forum, *City of Milwaukee's Fiscal Condition*; September, 2016.

Overview: The City's Budget Sustainability Strategy

Structural balance refers to a government's capacity to fund existing expenditures over time with its projected ongoing revenues. A shortfall between existing expenditures and ongoing revenues is typically referred to as a "structural imbalance".

Changes in State Shared Revenue policy and the growing costs of employee health care benefits have challenged the city's structural budget balance dating to the mid-1990's. Recent events, most notably the need to reinitiate employer pension contributions in 2010 after a 15 year hiatus, have resulted in a persistent challenge to structural balance. In addition, a $13.7 million reduction to state intergovernmental aid in 2012, on top of an $11 million decrease in 2004, have contributed to what the Public Policy Forum has termed a "broken revenue system" which makes a sustainable budget structure exceedingly difficult to achieve.

The city's strategy to achieve structural balance has been multi-faceted. The strategy can be summarized as follows:

- **Resizing**: City government will need to operate on a smaller overall scale. Between 2008 and 2016, the city budget experienced a net reduction of approximately 430 Full Time Equivalents (FTEs) positions for a decrease of approximately $35 million to the annual "budget base". The city has used enhanced technology and equipment, improved deployment, and staff development to improve productivity to avoid declines in service quality.

- **Restructuring:** Opportunities exist to increase productivity while reducing staffing levels through technology, automation, and functional consolidations. For example, investments in library circulation automation, municipal court electronic case processing, and worker's compensation administration have enabled annual operating cost reductions of $1.5 million. Substantial consolidation of information technology functions, combined with staff realignments within the Department of Administration saves approximately $700,000 annually.

  Restructuring has also extended to financial matters, with an emphasis on stabilizing annual pension funding, reducing the employer share of employee health benefit costs, diversifying revenues through user charges, and decreasing the reliance on levy supported debt to finance capital improvements. An actuarially approved modification to the employer pension contribution method has stabilized funding as a percentage of payroll over five years, avoiding potentially destabilizing annual volatility. In addition, accelerated payment of required plan year contributions is estimated to save approximately $4.3 million a year in avoided interest charges. Restructuring of employee health benefit cost sharing, the decision to self-fund all health benefit costs, incentives for utilization of quality providers, and the return on investment in wellness have enabled a 2017 appropriation that is $23.4 million lower than 2011 actual expenditures. User charges for solid waste services, snow and ice operations, and storm water management in the Department of Public Works offsets the cost of approximately 520 FTE positions, while making available more than $65 million in property tax revenue for services, such as public safety, libraries, and public health. Most of the forestry capital program is now funded via cash from the storm water charge, avoiding levy supported debt of $3.6 million in 2017.

- **Reinvesting:** In many cases effective resizing and restructuring require investments in equipment, data applications, process improvements, and people. For example, investments in technology, training, and planning have stabilized the budget for workers' compensation expense. These investments have essentially flattened out the program budget, saving at least $4 million annually compared to continuation of the 2011 baseline trend.

In addition, economic development investments will improve the city's capacity to grow and spread the cost of city services over a larger tax base. During 2015, the city added $440 million of real estate value to its tax base due to development, redevelopment, and other construction investments in real property. This 1.72% increase in "net new construction" was the third highest rate of increase among the 19 Milwaukee County communities. Milwaukee's net new construction increase was also 15% higher than the rate of change in the state of Wisconsin as a whole. This performance is expected to continue in future years as a result of the city's investment in tax increment finance projects such as the Brewery, Park East, Reed Street Yards, Northwestern Mutual Life, and Century City, among others. Over the last three years, the city has experienced over $1 billion of equalized value property growth due to net new construction. This performance demonstrates the confidence that property owners and investors have in Milwaukee's future.

Progress on Sustainability

During 2013, the Department of Administration's Budget and Management Division (BMD) projected the need to achieve $65 million to $75 million of structural improvement in order to achieve ongoing budget sustainability by the end of 2016. The projection was based on the combined amount of revenue increases and expense reductions needed by 2016 for structural balance.

Since that time, the following changes from a 2013 baseline contributed to achieving structural balance to the city's 2016 budget:

- Property tax revenues: $6.4 million;
- Other general fund revenues: $17 million;
- Departmental expense reductions from 2013 baseline: $18 million;
- Employee health care benefit and workers compensation cost reductions: $6.7 million, plus approximately $40 million in trend line decreases; and
- Pension cost reductions due to contribution pre-payment: $4.3 million annually.

This improvement over the last four years incorporated sustainable approaches that will continue to yield future benefits. This is crucial given the emerging challenges to structural budget balance.

Financial Performance Measures

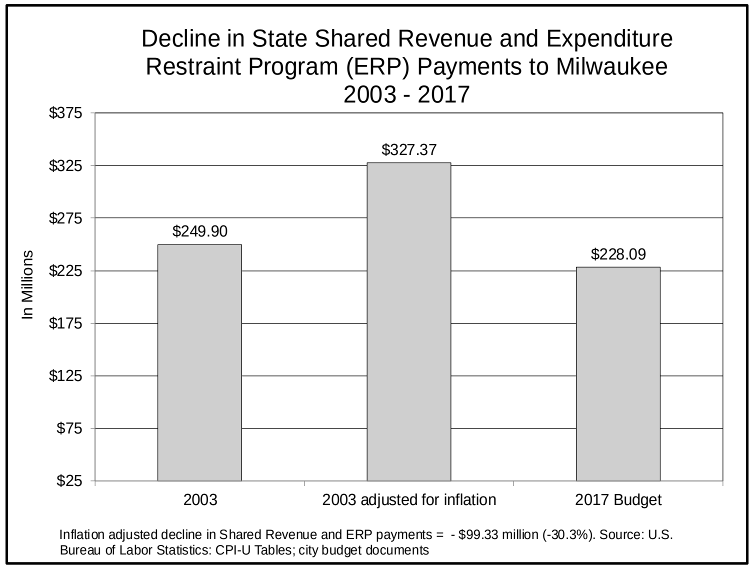
Effective financial planning begins with objectives and identifies factors that pose challenges and opportunities to structural budget balance. The Administration's two primary financial objectives are:

- Provide mission critical city services through annual budgets that limit the impact of tax levy and municipal service charge changes on the average valued residential property to 3% or less a year.
- Manage long term obligations such as core infrastructure, debt, and pension benefits in a manner that stabilizes ongoing funding requirements and minimizes transfer to future generations.

BMD has identified the following primary challenges to the city's ability to meet these objectives on an ongoing basis:

1. State intergovernmental aid funding reductions have reduced the city's fiscal capacity significantly. As Figure 1 illustrates, shared revenue (including expenditure restraint program aid) has declined $99.3 million in inflation adjusted terms since 2003 ($21.8 million in nominal terms). This decline has resulted in an increased proportion of the city's operating budget to be financed from local sources. For example, in 2003, state aids were essentially equal to the combined operating budgets of the Police and Fire departments. By 2017, these aids are expected to be $195 million less than these same two budgets. The city's state aid reductions stand in stark contrast to the 59% increase ($6.32 billion) in state general purpose revenues (GPR) during this same period.

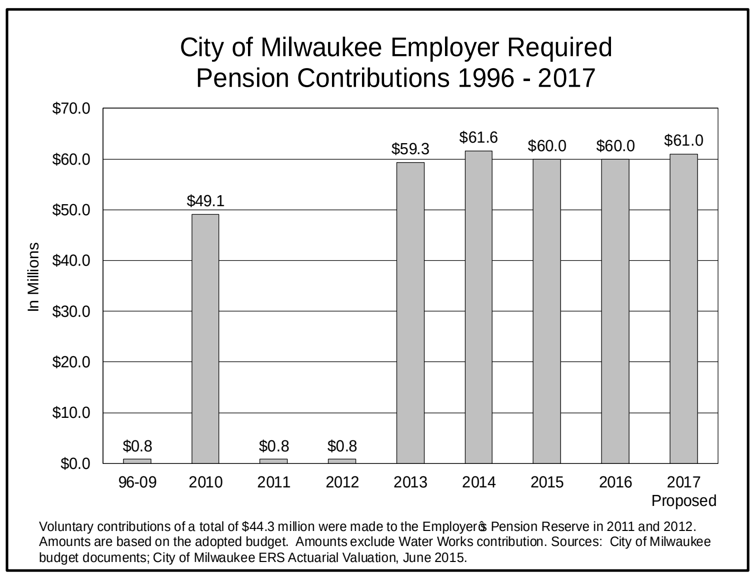
Figure 1



Inflation adjusted decline in Shared Revenue and ERP payments = - $99.33 million (-30.3%). Source: U.S. Bureau of Labor Statistics: CPI-U Tables; city budget documents

2. The city's budget has entered a "new normal" era for employer contributions to the City of Milwaukee Employes' Retirement System (CMERS). Between 1996 and 2009 the plan's funded status allowed the discontinuation of employer pension contributions. However, the 2007-2008 Global Financial Crisis (GFC) altered CMERS finance for the foreseeable future. Beginning in 2010, the city resumed making an employer contribution for pensions. This places considerable pressure on structural balance, especially given the aforementioned impacts of the state's shared revenue policy.

Figure 2



Voluntary contributions of a total of $44.3 million were made to the Employer's Pension Reserve in 2011 and 2012. Amounts are based on the adopted budget. Amounts exclude Water Works contribution. Sources: City of Milwaukee budget documents; City of Milwaukee ERS Actuarial Valuation, June 2015.

Currently, tax levy contributions equivalent to approximately 17.3% of covered payroll ($61 million in 2017) are required under the stable contribution policy and will continue at this level through the 2017 plan year. This equates to approximately 23% of the 2017 total tax levy.

Recent developments in the financial markets may have a significant bearing on employer contributions beginning with the 2018 plan year. A major factor in the calculation of the employer contribution is the assumed rate of investment return. This rate is used to discount the amount of future benefit obligations into the present. A relatively higher rate results in relatively lower annual contributions, compared to a relatively lower discount rate. Currently, the CMERS deploys an 8.25% discount rate, which is scheduled to return to the previously established rate of 8.5% in 2018. The average discount rate used in 2015 by 150 large Public Employee Retirement Systems (PERS) is 7.6%.

Some financial market analysts have questioned the feasibility of PERS achieving their assumed rates of return over the next ten years. The Annuity and Pension Board determines the various actuarial assumptions, including the assumed rate of investment return, for CMERS. The board will reset these assumptions for the 2018 plan year. A modest modification of 25 basis points could add at least $6 to $8 million to the city's annual employer contribution. This amount is equal to the amount of tax levy increase proposed for 2017. The impact of larger discount rate decreases would be very destabilizing, and similar in effect to the post-2003 decline in state intergovernmental aids.

In addition, the CMERS plan assets have a high risk exposure, given the 55% allocation to public equities. Since 1900, 32 "bear markets" have occurred in the United States. This condition is defined as a situation in which securities prices fall and widespread pessimism causes the stock market's downward spiral to be self-sustaining. A rather "garden variety" bear market loss of 20% would generate a $1 billion loss on a mark-to-market basis. Although asset gains and losses are smoothed over a five year period to avoid destabilizing the city budget, such a loss could cause an annual contribution increase approaching $10 million initially, with the potential to grow considerably higher until a positive rebound occurred. The city's primary response to such an event would of necessity be severe budget reductions.

Figure 3

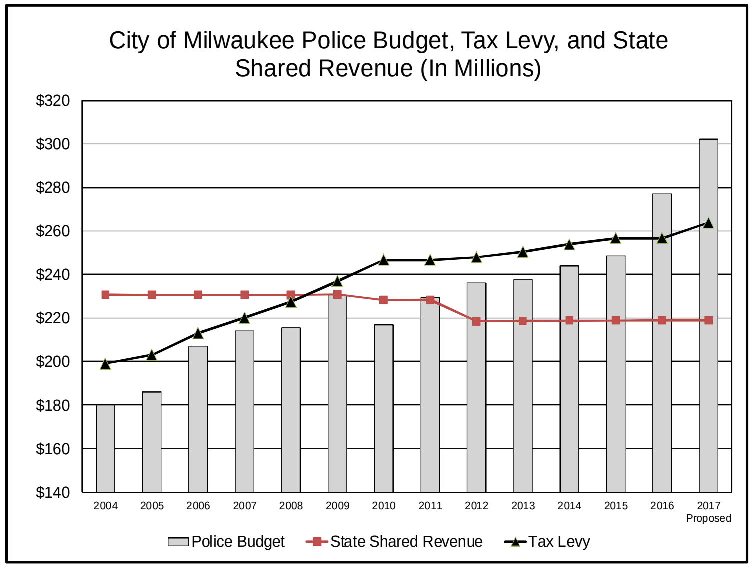
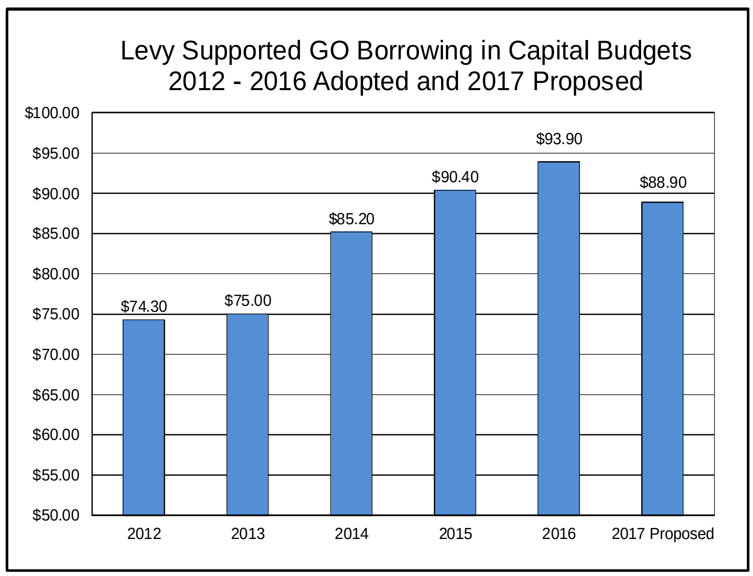


Figure 4



1. Between 2005 and 2012, the amount of annual new budget authorizations for levy supported debt remained at an essentially stable level of between $72 and $74 million. However, the need to finance two large facilities projects (City Hall foundation and the Police Administration Building), combined with the Strong Neighborhoods Plan and the continuing commitment to improved infrastructure and neighborhood libraries, resulted in a $93.9 million level in 2016. The 2017 debt service levy of $65.3 million consumes 25% of the total proposed 2017 levy. There is a need to manage the level of new authorizations so that the tax levy for debt service remains manageable.

The 2017 proposed budget reduces new levy supported authorization to $88.9 million. The administration's Capital Improvements Plan gradually lowers these annual amounts until the city hall and police facilities projects are completed. The Budget and Management Division projects that resetting the recurring "new authority" level to approximately $75 million by 2022 is sustainable given current revenue estimates. This will require difficult choices among competing priorities.

4. Milwaukee's drinking water is clean and safe to drink. But lead can dissolve from lead plumbing. Lead is not found in Milwaukee's source water, Lake Michigan, and it is not found in water as it leaves the drinking water treatment plants. Milwaukee's water meets all Environmental Protection Agency standards for water quality.

   Years ago, lead was used in paint, plumbing, and other products. The most common source of lead is from paint in older homes. Guidance from the United States Environmental Protection Agency (EPA) indicates that it is likely that the federal lead and copper safety rule will develop more prescriptive mandates requiring the removal of lead plumbing lines that serve drinking water customers.

While lead is not found in Milwaukee's treated water, lead may be introduced into the water from lead service lines and plumbing fixtures owned by our customers, especially when water stands unused for several hours. To control lead dissolving into the water, Milwaukee Water Works (MWW) treats the water with a compound that forms a protective coating inside pipes.

The EPA rule revision is expected to provide for a timeline for the removal of lead service lines. The 2017 proposed budget includes approximately $3.9 million for the lead service line replacement program. This includes $3.6 million for replacement of the utility owned portion of approximately 600 service lines. The remaining $300,000 will fund one new position to coordinate programming for service line replacement, one chemist position for additional sampling, and will cover costs of filters and bottled water for properties experiencing service disruption as a result of work related to lead service lines.

Future years will involve a significantly greater budget commitment. Combined with the need to continue an ambitious water mains replacement program, lead service line removal will have a substantial impact on the MWW capital budgets for decades. In addition, city subsidies to assist property owners with the cost of replacing the privately owned service lines represent a new financial commitment. In total, the implications of capital investments in MWW, and assistance to their customers, will generate significant pressure on both water rates and city tax levies.

BMD has also identified positive factors that it will use to manage these challenges in a fiscally responsible manner.

1. A number of initiatives have improved significantly the current baseline for employee health care benefit (EHCB) expenditures, as well as projections for annual growth. Premium cost sharing changes, migrating insured member benefits to self-funding, utilization changes, and the initial return from investments in the city's wellness program have reduced 2017 projected expenditures that are $23.4 million lower than the 2011 actual expenditures. Annual increases going forward are projected to be 3% to 4%, compared to 9% prior to 2012.

2. Recent collective bargaining agreements have resulted in all police and fire sworn employees becoming responsible for their entire 7% member contribution for pensions. Previously the city made these payments on behalf of the affected employees. This change will result in an annual $14 million reduced tax levy for retirement provisions. While the collective bargaining agreements included partial wage offsets associated with this change, the resulting arrangement makes ongoing pension financing somewhat less imposing.

3. The city's reserves are in sound condition and will assist in making the transition to more challenging budget conditions. The proposed reserve use in 2017 is less than that of 2016, and preserves the entire existing balance of the Employer's Pension Reserve for future budgets.

2017 Budget Bottom Line

The 2017 proposed budget provides for a tax levy increase of 2.7%, $7 million over 2016. The proposed tax rate will increase seven cents, or about 7/10 of 1%. Under the proposed budget, the owner of an average valued residential property will experience an estimated city government tax levy increase of $26.40, compared with 2016. The proposed tax levy increase is needed primarily to fund the ongoing costs of maintaining police strength, financing the city's increased capital budget commitments, and funding pension costs (the fundamental driver of which is police) responsibly.

The 2017 municipal service fees will increase by $10.86 for the typical residential owner. On a combined basis, the 2017 levy and municipal service charge combined changes result in an estimated increased cost of approximately $37.26, or 2.5%, to the typical residential property owner with one garbage cart, compared with 2016. This cost for the typical homeowner is within the parameters of the administration's financial objective.

Conclusion

The 2017 proposed budget capitalizes on the city's improved structural budget balance while delivering on key priorities to taxpayers. The restructuring of health care benefits and pension finance has generated a stabilizing influence on the annual budget. Moderate reserve use will assist in resolving future years' budget challenges.

Overview of Lead Service Line Replacement Program

Water Quality Task Force

December 9, 2016

Program Goals

- Full replacement of lead service lines

- Make replacement simple, equitable and affordable for property owners

- Manage full replacements within the City’s financial and legal constraints

Lead Service Line Replacement Program: Key Elements of File 160742

- Require replacement of private portion of lead service line when:
  - Privately owned or utility owned portion of a lead service lines leak; or
  - The utility owned portion of a lead service line is replaced
- City-funded cost share and special assessment financing for eligible property owners
- Prohibition on partial lead service line replacement
  - When leaks are encountered on utility owned or privately owned portion of lead service line, the entire service line will be replaced
- Prioritize replacement of lead service lines serving daycares and schools in 2016-2018

Lead Service Line Replacement Program: Financing

- Estimated average cost to replace lead service line - $10,000 to $12,000

  - Estimated cost to replace utility portion: $5,500 to $6,500
    - Funded through revenues from water sales
    - Significant rate increases required due to declining consumption, accelerated water main replacement program, and lead service line replacement

  - Estimated cost to replace portion owned by property owner: $4,500 to $5,500
    - Majority of properties with lead service lines eligible for City cost share and special assessment financing

Lead Service Line Replacement Program: Financing

- 1-4 unit residential properties eligible for cost share and special assessment financing

- For City cost share and special assessment financing the property owner must:
  - Sign “Hold Harmless” agreement
  - Grant temporary construction easement
  - Agree to have private side work performed by City approved contractor
  - Allow access into home to connect new service to meter

- When these conditions are met:
  - The City will fund 2/3 of the cost of replacing the private portion (approximately $3,400)
  - Property owner pays for the lesser of $1,600 or 1/3 of the average annual cost of replacing the private portion
  - Property owner’s special assessment would be approximately $167 annually for 10 years, or ten installments of less than $17 each year
  - No penalty for early payment of special assessment

Lead Service Line Replacement Program: 2017 Plan and Revenue Sources

- Replace lead service lines serving 300 daycares and schools
  - $1.8 million Water Works ratepayer funds (utility side)
  - $1.6 million Safe Drinking Water funding (private side)

- Replace lead service lines that experience leaks- approximately 300
  - $1.8 million Water Works ratepayer funds (utility side)
  - $1 million Safe Drinking Water funding (private side)
  - $600,000 Special Assessment from property owners (private side)

Lead Service Line Replacement Program: Long-term Outlook

- Estimated cost to replace the utility and privately owned portions of 70,000 lead service lines: **00 million to 770 million** (2016 dollars)
- $1 million annual Safe Drinking Water funding uncertain beyond 2018
- City is pursuing State and Federal funds
- City cost share funded through property tax levy-supported borrowing in the absence of State/Federal funding

Lead Service Line Replacement Program: Long-term Outlook

- In 2018 and beyond, program will be scaled up to include proactive replacement of lead service lines in conjunction with water main replacement or other infrastructure projects

- Replacing all 70,000 lead service lines in 50 years would require replacements to be scaled up to 1,400 per year, resulting in a City cost of ~$4.5 million per year

- Factors that will affect how quickly the City can scale up the program:
  - Approval of water rate increases
  - Availability of City funding
  - Private sector capacity to perform the work

..Number
161073
..Version
ORIGINAL
..Reference

..Sponsor
ALD. BOHL
..Title
Resolution directing the Department of Administration-Intergovernmental Relations Division and the Common Council's Legislative Coordinator to seek introduction and passage of state legislation relating to Wisconsin’s expenditure restraint program.
..Analysis
This resolution directs the Department of Administration-Intergovernmental Relations Division and the Common Council's Legislative Coordinator to seek introduction and passage of state legislation exempting City of Milwaukee expenditures associated with replacing the City’s 70,000 lead water service lines from calculations used for Wisconsin’s expenditure restraint program.
..Body
Whereas, An estimated 70,000 properties in the City of Milwaukee are believed to have lead water service lines; and

Whereas, Lead water service lines pose some level of health risk to City residents; and

Whereas, The National Drinking Water Advisory Council (NDWAC) recommended in August, 2015, that the U.S. Environmental Protection Agency revise the Lead and Copper Rule to require water utilities to proactively locate and replace all lead water service lines; and

Whereas, The NDWAC further recommended water utilities be required under the Lead and Copper Rule to increase public education and outreach efforts to consumers with lead service lines and other vulnerable populations (pregnant women and families with infants and young children), and increase the information available to the public; and

Whereas, The Board of the American Water Works Association voted unanimously in March, 2016, to support recommendations of the NDWAC to strengthen the Lead and Copper Rule, and ultimately remove all lead water service lines; and

Whereas, An ad hoc work group consisting of the Milwaukee Water Works, the Milwaukee Health Department, the Wisconsin Health Department, the U.S. Environmental Protection Agency and the Wisconsin Department of Natural Resources unanimously concluded the best, most responsible way to eliminate the health risk of lead in drinking water is the complete elimination of all lead water service lines; and

Whereas, The costs of replacing the City's 70,000 lead water service lines and maintaining a robust public education and outreach program for vulnerable residents have been estimated between $350 and $750 million; and

Whereas, The costs associated with replacing the City's 70,000 lead water service lines are extraordinary expenditures beyond the City's usual and customary costs for providing services to residents; and

Whereas, The expenditures to replace the City's 70,000 lead water service lines are made to promote for the public good, and are beyond the City's usual and customary costs for providing services to residents; and

Whereas, Extraordinary expenditures incurred by the City during declared emergencies as well as public-good expenditures incurred for recycling, are currently exempted from calculations used for Wisconsin's expenditure restraint program; and

Whereas, Changes in Wisconsin law are necessary to give the City of Milwaukee the latitude to incur the extraordinary and public good expenditures associated with replacing the City's lead water service lines without being penalized under the provisions of Wisconsin's expenditure restraint program; now, therefore, be it

Resolved, By the Common Council of the City of Milwaukee, that the Department of Administration-Intergovernmental Relations Division and the Common Council's Legislative Coordinator are directed to seek introduction and passage of state legislation exempting City of Milwaukee expenditures associated with replacing the City's lead water service lines from calculations used for Wisconsin's expenditure restraint program; and be it

Further Resolved, That the City Clerk shall send copies of this resolution to all members of Milwaukee's delegation to the State Legislature.

..Requestor

..Drafter
LRB #167004-1
Aaron Cadle
November 21, 2016

Reply to Common Council File No. 160742
From DOA-Budget and Management Division

November 11, 2016

Ref:

File 160742 contains a substitute ordinance mandating the replacement of lead water service lines and establishing a special assessment for lead water service lines on private property.

Milwaukee's drinking water is clean and safe to drink. But lead can dissolve from lead plumbing. Lead is not found in Milwaukee's source water, Lake Michigan, and it is not found in water as it leaves the drinking water treatment plants. Milwaukee's water meets all Environmental Protection Agency standards for water quality.

Years ago, lead was used in paint, plumbing, and other products. The most common source of lead is from paint in older homes. Guidance from the United States Environmental Protection Agency (EPA) indicates that it is likely that the federal lead and copper safety rule will develop more prescriptive mandates requiring the removal of lead plumbing lines that serve drinking water customers.

While lead is not found in Milwaukee's treated water, lead may be introduced into the water from lead service lines and plumbing fixtures owned by our customers, especially when water stands unused for several hours. To control lead dissolving into the water, Milwaukee Water Works (MWW) treats the water with a compound that forms a protective coating inside pipes. Ground disturbance can also result in lead particles entering a property's water supply.

The EPA rule revision is expected to provide for a timeline for the removal of lead service lines. The 2017 budget includes approximately $3.9 million for the lead service line replacement program. This includes $3.6 million for replacement of the utility owned portion of approximately 600 service lines. The remaining $300,000 will fund one new position to coordinate programming for service line replacement, one chemist position for additional sampling, and will cover costs of filters and bottled water for properties experiencing service disruption as a result of work related to lead service lines. $1.6 million of Safe Drinking Water Program funding is expected to be sufficient to cover the cost of replacing lead service lines at 300 schools and daycares in 2017. An additional $1 million of Safe Drinking Water Program funding will also partially fund the cost of replacing approximately 300 lead service lines that experience leaks in 2017.

The proposed substitute ordinance mandates the complete replacement of both the utility owned and the privately owned portions of a lead service line when a leak is discovered or when an emergency or planned infrastructure project affects a lead service line. The proposed substitute ordinance creates a cost-sharing program for eligible property owners to limit costs incurred by the property owner to the lesser of $1,600 or the average current cost to replace the privately owned portion of a lead service line. The proposed substitute ordinance also permits eligible property owners to use special assessment financing to pay their portion of the cost over a maximum of 10 years. The proposed substitute ordinance includes penalties for non-compliance with the full replacement mandate. These penalties may include fines of $100 per day for a maximum of 16 days, and the discontinuation of water service to non-compliant properties.

The fiscal impact for Milwaukee Water Works in 2017 is expected to be approximately $3.6 million. This will be funded through ratepayer funds from sale of water. Since grant funding was obtained to for the city's portion of the costs of lead service line replacement in 2017, there is no immediate fiscal impact to the city. However, future grant funding is uncertain at this point. As the lead service line replacement program is scaled up over coming years, it will be necessary for the city to borrow in order to subsidize replacement of the privately owned portion of lead service lines. When the program is fully scaled up to replacing 1,400 properties per year, based on current estimates approximately $5 million per year will be necessary to fund the program. The city will continue to aggressively seek State and Federal grant funding opportunities, but in the absence of State or Federal funding the city would fund the estimated $5 million per year in the city's capital budget.

RECOMMENDATION: ADOPT FILE 160742.

Bill Christianson
Fiscal Planning Specialist Senior

BJC:dmr

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The proposed substitute ordinance mandates the complete replacement of both the utility owned and the privately owned portions of a lead service line when a leak is discovered or when an emergency or planned infrastructure project affects a lead service line. The proposed substitute ordinance creates a cost-sharing program for eligible property owners to limit costs incurred by the property owner to the lesser of $1,600 or the average current cost to replace the privately owned portion of a lead service line. The proposed substitute ordinance also permits eligible property owners to use special assessment financing to pay their portion of the cost over a maximum of 10 years. The proposed substitute ordinance includes penalties for non-compliance with the full replacement mandate. These penalties may include fines of $100 per day for a maximum of 16 days, and the discontinuation of water service to non-compliant properties.

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Bill Christianson

Bill Christianson
Fiscal Planning Specialist Senior

BJC:dmr

LEAD SERVICE LINE REPLACEMENT
Proposed mandate and cost-share structure
CCFN 160742

CCFN 160742 will create two tools to begin the systematic removal of lead service lines in Milwaukee: a mandate for full service line replacement in certain situations, and partial coverage of owner costs by the city.

Goals of mandate and cost-share

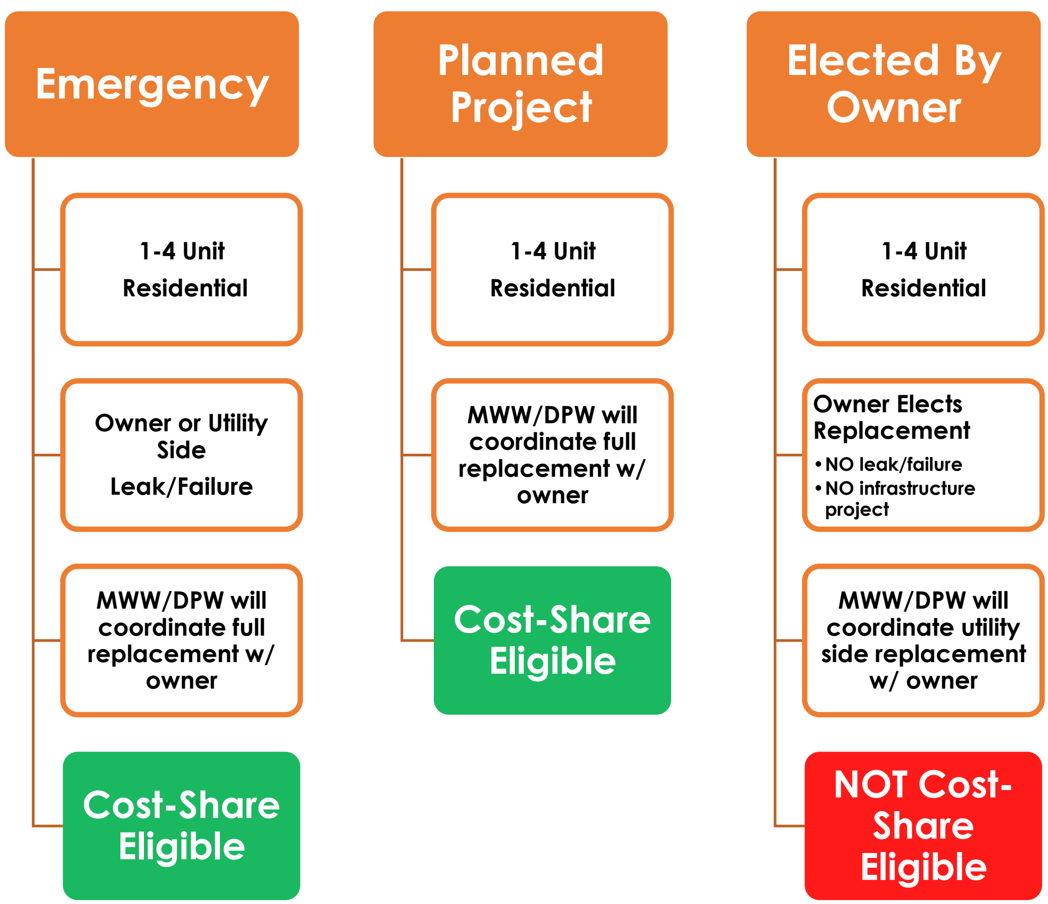
- Combine public health principles and infrastructure planning
- Create a system for full removal of all lead service lines
- Maximize value and effectiveness of limited funding
- Manage cost and make contracting simple for owners
- Set clear and simple expectations with owners and residents

Lead service line replacement will be mandatory for **ALL** owners, but **only** when:

- LSL fails, leaks, or is otherwise damaged
- A planned infrastructure project affects the property

Milwaukee Water Works will pay 100% of the cost for the "utility side".

Residential (1-4 unit) property owners can access a cost-share for the "private side" of the LSL in both of those situations, if they coordinate with the city.



LEAD SERVICE LINE REPLACEMENT
Proposed mandate and cost-share structure
CCFN 160742

CCFN 160742 Ordinance Changes for Lead Service Line Replacement Program

Key Elements

- Ordinance addresses both "utility" AND "private" side
- Builds on existing city policies and experience working with owners and residents:
  - Assessable public works (sidewalks, alleys, sewers)
  - Lead abatement orders
  - Automated water meter replacement
- Gives owners options for replacement
- Mandate for full replacement of lead service lines **only** when:
  - leaks or failures are discovered, or
  - when Water Works replaces utility-owned portion of lead service line for any reason
- For those properties, city will cover 2/3 cost of replacing privately owned portion of LSL for owners of 1-4 unit residential properties if:
  - Owner elects to have city contractors perform work
  - Owner signs waiver/hold harmless agreement, allows temporary easement
- Delayed billing will be available, assessments set by resolution annually

Full Replacement Is Required

- Repair or partial replacement of lead service lines is prohibited
- If Water Works replaces the utility owned portion of a lead service line, the property owner must replace the privately owned portion of the lead service line - and vice versa
- When a leak is discovered in a lead service line, or a water infrastructure project is planned, upon receipt of the written notice the property owner has 45 days (10 days for leaks) to:
  - Replace privately owned portion of LSL at property owners expense by contracting with a licensed contractor; or
  - Elect to have city contractor replace privately owned portion of LSL, with property owners meeting certain criteria eligible for city cost-share

Making Compliance Easy

- Cost-sharing ensures affordability when replacement is required
- Complex underground work and permitting makes evasion difficult
- Tenants should never be "stuck" between owner and city
- Goal of the mandate is full replacement, **not** fines or penalties
- DNS commissioner **may** use citations or orders to incentivize compliance, where appropriate:
  - Citations issued daily: $100/day, capped at $1,600 or equivalent to owner cost
  - Discontinuation of water service

City Cost-Share

- MWW pays 100% utility side cost, financed via water rates (estimated +$40/yr by 2018)
- City pays 2/3 of owner cost using Federal funds via DNR (2017-18)
- Owner, under mandate, pays remaining 1/3 via assessment

LEAD SERVICE LINE REPLACEMENT
Proposed mandate and cost-share structure
CCFN 160742

<u>**Eligibility Criteria**</u>

- Property is a 1-4 unit residential property, AND
    - Property owner agrees to have work performed by a city contractor
    - Property owner signs a hold harmless agreement
    - Property owner executes temporary construction easement and allows access into residence as needed
    - Property owner waives 10-day notice
- Eligible property owners shall pay the lesser of $1,600 or 1/3 of the cost to replace the privately owned portion of the lead service line
    - Property owners may finance their financial obligation with special assessment financing payable over 10 years
    - Assessable cost based on "pooled" average cost to give owners uniformity. DPW/Water Works will set the assessed cost and owner share by resolution each year

COMMON SCENARIOS FOR REPLACEMENT

Scenario #1

- Owner of a single family residential property with a lead service line notices low water pressure and calls MWW. MWW utility investigators determine that there is a leak in the utility owned portion of the service line. The utility investigator provides the property owner notice of the full replacement requirement and informs the property owner how to qualify for the city cost-share. The property owner signs the hold harmless agreement, grants the temporary construction easement, agrees to have city contractors perform the work, and waives the 10 day notice. The privately owned and utility owned portions of the lead service line are replaced by city contractors. The property owner is assessed over 10 years for the lesser of $1,600 or 1/3 the cost of replacing the privately owned portion of the service line.

Scenario #2

- Owner of a single family residential property is notified that in 3 months a water main replacement project is occurring in front of the property, and is informed about the full replacement mandate. The property owner chooses to select their own contractor to replace the privately owned portion of the lead service line, with the understanding that they will not be eligible for the city cost-share or special assessment financing. Work is coordinated between city contractors and the private contractor hired by the property owner, so that water service can be restored as soon as practicable. The property owner and their contractor handle payment terms.

Scenario #3

- Owner of a 6-unit apartment building is notified that in 3 months a water main replacement project is occurring in front of the property, and is informed about the full replacement mandate. The property owner may elect to have the city contractor replace the privately owned portion of the lead service line with special assessment financing but no city cost-share, or may choose a licensed contractor to perform the work.

Scenario #4

- Owner of a single family home elects to replace their lead service line proactively, without indications of a leak on their side or the utility side. The Water Works will coordinate replacement for their side of the line with the homeowner to ensure full replacement. The homeowner will NOT receive a cost-share NOR use of assessments for this cost, and is responsible for their own contractor's work and compliance with the ordinance and MWW rules.

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December 8, 2016

Alderman James A. Bohl, Jr.
Fifth Aldermanic District
City Hall, Room 205

Re: Remediation Fee for Lead Water Service Lines

Dear Alderman Bohl:

By letter dated November 22, 2016, you requested an opinion of this office regarding the above-referenced matter. Specifically, you asked whether the City of Milwaukee may impose a "lead remediation fee" on all properties in the city or whether it may impose such a fee on only those properties that have lead service lines. If the latter, then you wish to know whether a fee could continue to be imposed on a property after the lead service line is replaced. Finally, you requested a summary of the legal and policy impacts of creating such a fee, for example, the impacts a lead service line replacement fee would have on the City's levy limit.

As you summarize in your letter, we explained in our January 29, 2016 and March 21, 2016 opinions that under current law, the property owner is responsible for the costs of replacing the customer or private property side of the lead service line. In the March 21, 2016 opinion (copy enclosed), we advised that a good faith argument can be made that Wis. Stat. §§ 66.0911 and 281.45 permit the City to contract for lead service line replacement work and assess the costs to the property, which would allow property owners to pay the costs over the allowable special assessment payment period (currently proposed in proposed Ordinance 160742 to be 10 years). We also advised that any proposal to use water utility ratepayer funds would require approval of the Public Service Commission ("PSC") through a rate case and discussed potential arguments that could be used in advocating for a distinction between Milwaukee and the City of Madison rate case or reconsideration of the determination that use of ratepayer funds to subsidize customer-side lead service line replacements is a prohibited discriminatory rate practice. Finally, we have assisted with drafting a proposed statutory change that would permit use of ratepayer funds for such work, which is part of the 2017-2018 City of Milwaukee State Legislative Package (Resolution 160538).

In the context of your letter, we understand the "lead remediation fee" to be a fee on properties to generate revenue to help pay for the costs of having a contractor replace the

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portion of the lead service line that is owned by the private property owner. In this opinion we will refer to the fee as a "LSL replacement fee."

For the reasons explained below, it is our opinion that under current law, the City could not impose a LSL replacement fee on properties, whether applied to all properties in the city or limited to properties with lead service lines, for the purpose of generating revenue for a LSL replacement program. In order to impose such a fee, the City would need express statutory authority through adoption of an enabling statute.

I. LSL Replacement Fee Would Not Be a Valid Special Charge.

The proposed LSL replacement fee discussed in your letter would be imposed against real property (either on all properties in the city or on only those properties with lead service lines). Yet, there is no statutory provision expressly granting the City the authority to impose such a fee on real property. Therefore, we must first evaluate the threshold question whether the LSL replacement fee would constitute a valid special charge under Wis. Stat. § 66.0627 and therefore ultimately be collectible through the tax roll.

Wis. Stat. § 66.0627 authorizes a municipality to impose on real property a special charge "for current services rendered by allocating all or part of the cost of the service to the property served." A special charge is not payable in installments and the special charge is delinquent if not paid within the time determined by the municipal governing body. § 66.0627(4). A delinquent special charge becomes a lien on the property as of the date of delinquency and the delinquent special charge shall be included in the current or next tax roll for collection under Wis. Stat. ch. 74. Once the delinquent special charge is certified to the tax roll, the special charge may be paid in 10 equal monthly installments. Wis. Stat. § 74.87(3); City Charter § 19-15-1; City Attorney Opinion, dated March 19, 1999.

Pursuant to Wis. Stat. § 66.0627, we could defend in good faith the imposition of a special charge of "all or part of the cost" of having a contractor replace the private property's lead service line. But, the special charge could be imposed only on the individual property that received the service, i.e., replacement of the lead service line. The owner could not pay the special charge in installments until the special charge becomes delinquent and is placed on the tax roll; and in that case, the owner would only be able to pay in 10 monthly installments. We do not understand that to be the "lead remediation fee" discussed in your request.

In contrast to a special charge on individual properties for lead service line replacement on the individual property, a LSL replacement fee to generate revenue for replacement costs, whether imposed on all properties within the city or only on properties with lead service lines, would not be a charge "for current services rendered" and would therefore not constitute a special charge under Wis. Stat. § 66.0627. To impose a special charge, a city "must establish that *current* services of the type described in the statute are rendered to the property or properties sought to be charged." *Grace Episcopal Church v. City of Madison*, 129 Wis. 2d 331, 337-38 (1986) (emphasis added). A fee charged monthly or annually for a service not rendered for possibly many years would not be a charge for "current services rendered." The vast majority of properties with lead services paying this fee would not receive a service for several years when their lead service is replaced. If applied to properties with copper service lines, then it would not be a charge for "current services rendered" because there would be no services rendered to those properties (presumably ever).

The conclusion that the proposed LSL replacement fee would not be a special charge is important. Without the authority to impose the proposed LSL replacement fee as a special charge under § 66.0627, the City would appear to lack any statutory authority to impose the fee against real property, depriving the City of a fundamental collection method. We contrast that with the statutory grant of authority to impose against real property, the following charges for example: water rates (Wis. Stat. §62.69(2)(f)); and local sewer and storm water management charges (Wis. Stat. § 66.0821(4)). As a result, throughout the remainder of this opinion, when we discuss the City's authority to impose a LSL replacement fee on "properties," whether all properties or only those with lead service lines, we are referring to the City's ability to impose the fee on the owners of such properties.

II. <u>Fee vs. Unauthorized Tax</u>

The legality of a municipal fee, and who may be required to pay the fee, depends on whether it is truly a fee or an unauthorized tax. "A tax is an enforcement of proportional contributions from persons and property, imposed by a state or municipality in its governmental capacity for the support of its government and its public needs." *City of River Falls v. St. Bridget's Catholic Church of River Falls*, 182 Wis. 2d 436 (Ct. App. 1994) (citation omitted).

Labeling a particular charge as a "fee" is not dispositive of the "fee versus tax" question. *Bentivenga v. City of Delavan*, 2014 WI App 118, ¶ 6, 358 Wis. 2d 610, 856 N.W.2d 546. Rather, the test is: what is the primary purpose of the charge? *Id.* "A tax is one whose primary purpose is to obtain revenue, while a license fee is one made primarily for regulation and whatever fee is provided is to cover the cost and the expense of supervision and regulation." *State v. Jackman*, 60 Wis. 2d 700, 707 (1973). "[I]f the primary purpose of a charge is to cover the expense of providing services, supervision or regulation, the charge is a fee and not a tax." *St. Bridget's Catholic Church*, 182 Wis. 2d at 442. If the charge is truly a tax, then it is invalid unless state statutes give the municipality the authority to impose the tax. *Bentivenga*, ¶ 6.

III. Legality of LSL Replacement Fee on All Properties

It is our opinion that a LSL replacement fee on all properties, regardless of whether they have copper or lead service pipes, would be an unauthorized tax rather than a fee. Imposing a LSL replacement fee on all residential properties regardless of whether the property has a lead or copper service line shows that the primary purpose of the charge is to generate revenue to pay for lead service line replacements and is therefore a tax. Properties with copper service lines would by definition receive no services in return for paying a LSL replacement fee. Further, it could not be argued that the charge is to offset the costs of regulation because a regulatory program to replace lead service lines would involve no regulation of properties with copper service lines.

Even if the charge were somehow determined to be a fee, it would likely violate Wis. Stat. § 66.0628(2), which provides that "[a]ny fee that is imposed by a political subdivision shall bear a reasonable relationship to the service for which the fee is imposed." A charge on properties without lead services bears no relation to the police power objective of replacing lead services to protect the public health.

IV. Legality of LSL Replacement Fee on Properties with Lead Service Lines

A LSL replacement fee only on those with lead service lines would not be defensible as a service fee because the service (i.e. LSL replacement) would, in most cases, not be provided for many years. Likewise, the fee could not be justified as a user fee as the "use" is the consumption of water, for which the customer pays water rates.

The only potential justification for a LSL replacement fee on properties with lead service lines would be that the fee is a regulatory fee. For example, a potential argument could be made that the proposed Common Council File No. 160742 ("A substitute ordinance mandating the replacement of lead water service lines and establishing a special assessment for lead water service lines on private property") ("LSL Replacement Ordinance") establishes a regulatory program (e.g. regulating the manner in which properties are connected to the public water supply) and that a LSL replacement fee intended to cover the City's cost-share is a regulatory fee reasonably related to the expense of the regulatory program. *See, e.g., Rusk v. City of Milwaukee*, 2007 WI App 7, 298 Wis. 2d 407 (reinspection fees for building code noncompliance were valid regulatory fees and not a tax). Factors that could influence the "regulatory fee vs. tax" determination may include factors that are not clear at this stage, for example: how the revenue raised compares with the overall regulatory program expenditures; whether fee revenues are expended every year on the LSL replacement work or whether they build up over the years; and the amount or frequency of the fee.

Nonetheless, we do not believe that the "regulatory fee" label would withstand scrutiny. The primary purpose of the fee would be to generate revenue for LSL replacements rather than to regulate connections to the public water supply. The costs of regulation and supervision would undoubtedly be insignificant compared to the cost to pay the contractors to replace lead service lines. The fact that the vast majority of properties with lead services paying this charge would not receive a service in return for the fee for several years would further support a determination that the fee is truly a revenue tax rather than a regulatory fee. Even if a LSL replacement fee could be defended as a regulatory fee rather than a tax, the City's inability to impose the LSL replacement fee against real property and place delinquent fees on the tax roll would present significant enforcement and collection problems.

You also asked whether a LSL replacement fee on properties with lead service lines could continue to be imposed after the replacement of the lead service line. Because the City lacks authority to impose a LSL replacement fee against real property it is difficult to envision any legal and enforceable way to require a property owner to pay the LSL replacement fee after the lead service line is replaced, particularly in the event of a change of ownership. This underscores the need for state enabling legislation if the City wishes to pursue the LSL replacement fee.

V. Effect on Tax Levy Limit

If a defensible LSL replacement fee imposed on properties with lead service lines were found to be legal and enforceable, we do not believe that there would be any negative impact on the City tax levy limit under § 66.0602(2m). That statute requires that a local government reduce its tax levy limit as a dollar-for-dollar offset of fee revenue collected for providing a "covered service," which is defined as "garbage collection, fire protection, snow plowing, street sweeping, or storm water management…" Under that definition, a fee to cover the cost of privately-owned LSL would not require a reduction in the tax levy limit. Obviously, the legislature could amend the statute at any time to require the offsetting reduction in the City's tax levy limit.

If you have any questions, please do not hesitate to contact the undersigned.

Very truly yours,

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March 21, 2016

Carrie Lewis, Superintendent
Milwaukee Water Works
Zeidler Building, Room 409

Re: Lead Water Services on Private Property

Dear Ms. Lewis:

By letter dated January 21, 2015, you asked several questions regarding replacement of lead water service piping, or laterals, on private property, which we answer in turn. As we explained in our January 29, 2016 opinion to you, the customer is responsible for maintaining, repairing, and replacing the section of lateral that runs from the meter at the house to, and including, the outlet joint of the curb stop ("customer-side lateral"). The customer-side lateral is private property and is located on private property.

The City/MWW has long been in compliance with the U.S. Environmental Protection Agency's ("EPA") Lead and Copper Rule, 40 CFR § 141.80-91, which regulates the level of lead and copper metals in drinking water. MWW has treated water with phosphorous since 1996 to comply with the Lead and Copper Rule by reducing lead corrosion in pipes. The concern posed by lead laterals instead relates to the potential effects of water main replacement, and possibly other street construction, on lead laterals as summarized in a January 20, 2016 letter from the Commissioner of Public Works ("Commissioner") and you to the Public Service Commission of Wisconsin ("PSC").

I. ***What options are available to replace lead water services on private property? For instance, does the City have authority to require replacement of the private lead water lateral? If so, under what circumstances? If not, what authority is needed?***

To address the issue raised in your letter to the PSC, the City could adopt an ordinance requiring the property owner to replace the customer-side lead lateral when the City replaces the water main and the segment of lateral from the water main to the curb stop ("utility-side lateral"). This requirement could also be extended to situations where the City conducts other construction in the street (e.g. replaces the City sewer main and the utility-side water lateral; major street repairs) if the Common Council determines that there is a health, safety, and welfare justification for doing so. The ordinance would not require PSC approval.

The City has authority to require replacement of the customer-side lateral pursuant to its police power to act for the health, safety, and general welfare of the public. Wis. Stat. § 62.11(5); *Froncek v. City of Milwaukee*, 269 Wis. 276, 69 N.W.2d 242 (1955) (City's resolution providing for fluoridation of water supply is a reasonable and valid exercise of the police power). To survive scrutiny under a substantive due process challenge, the ordinance must be reasonably related to any legitimate municipal objective, i.e., the protection of the health and safety of the City's residents. *Metropolitan Milwaukee Assoc. of Commerce v. City of Milwaukee*, 2011 WI App 45, ¶ 51, 332 Wis. 2d 459, 798 N.W.2d 287.

In response to your general questions, the following are some options that could potentially be incorporated in a lead lateral replacement ordinance:

1. Require each property owner to replace the customer-side lead lateral in conjunction with water main replacement (and other infrastructure work in the right-of-way that the Common Council determines contributes to the disturbance of lead laterals and the elevation of lead levels at the customer's tap, e.g., sewer replacement, major street construction);

2. Require each property owner to contract with a licensed plumber to complete the replacement at the owner's expense;

3. Authorize City rebates or MWW rebates (only if approved by the PSC) for the owner's cost of replacing the lead lateral, discussed in Section III below;

4. In the event of noncompliance with the replacement requirement:

   a. Impose forfeitures;

   b. At the option of the property owner and in lieu of forfeiture, authorize the DPW Commissioner to "have the work performed"[1] and assess the costs of the replacement as a special assessment against the property under Wis. Stat. § 66.0911 or § 281.45, discussed in Section II below.

[1] As we explained in an opinion dated March 4, 2016, which we enclose for your convenience, the City and MWW are prohibited by state law from performing the replacement of the customer-side lateral with City or utility employees. Wis. Stat. §§ 145.06; 66.0901(11).

> (i) Require the owner to execute a temporary construction easement to permit City contractor to work on the owner's private property;
>
> (ii) Require the owner to execute a hold harmless agreement releasing the City from any liability resulting from the work on private property.

II. Does the City have the authority to place the cost of replacement of private water laterals on property owners? If not, what authority is needed?

Yes, the cost to replace the customer-side lateral is the responsibility of the property owner. As we explained in the January 29, 2016 opinion, the customer is responsible for maintaining, including repair and eventual replacement, the customer-side lateral at the customer's expense.

There has been public discussion whether customer-side lead lateral replacements could be funded through the special assessment process, which while still at private property owner expense, would allow the customer to pay the costs over multiple tax years. For the reasons explained below, it is not at all clear that the replacement work can be funded through the general special assessment statute, Wis. Stat. § 66.0703. Alternatively, a good faith argument can be made that Wis. Stat. §§ 66.0911 and 281.45 provide independent authority for the City to procure the replacement of customer-side lead laterals and impose the costs as a special assessment.

> A special assessment, to be valid, must be levied pursuant to and in strict compliance with the statutory powers of the municipality. "The power of a municipality to levy an assessment against a private owner is one which exists by right of statute, and the restrictions of the statute must be met if the assessment is to be deemed valid."

Dewey v. Demos, 48 Wis. 2d 161, 167, 179 N.W.2d 897 (1970) (citation omitted).

A. Cost Recovery through General Special Assessment Process

It is not clear that the general special assessment statute for "municipal work or improvements," Wis. Stat. § 66.0703, authorizes the City to perform the replacement of customer-side lead laterals and to assess the property for the replacement costs. There is no Wisconsin case law directly on point. However, it is generally accepted that "private property cannot be improved at the expense of abutting property owners, even if done for the purpose of permitting the public to use it." 70C Am. Jur. 2d, Special or Local Assessments, § 23. "Generally, speaking, the term 'public improvements,' as applied to municipal corporations in the legal context, means improvements *upon the property of the municipality* which serve to further the operation of the municipal government and the interests and welfare of the public." 13 McQuillin, *The Law of Municipal Corporations*, § 37:1, (3d ed. 2007, updated July 2015) (emphasis added).

Nonetheless, it could be argued that replacement of lead laterals incidental to water main and utility-side lateral replacements does constitute "municipal work or improvements" under § 66.0703. We have found a League of Wisconsin Municipalities Legal Opinion, in which the League attorney opined that, in addition to Wis. Stat § 66.0911, a municipality could also follow the special assessment procedure set forth in § 66.60 (now § 66.0703) to construct and charge the property for water lateral construction. *Special Assessments* #631 (May 7, 1987) ("League Opinion"). The League Opinion did not specify that that conclusion applied to construction of customer-side laterals on private property as opposed to utility-side laterals and provided no analysis that would support that interpretation. In any case, though an argument can be made, it is not at all clear that the § 66.0703 special assessment procedure applies to the replacement of customer-side laterals where a municipality, such as Milwaukee, does not own or maintain the customer-side lateral.

B. <u>Cost Recovery through Special Assessments under §§ 66.0911 and 281.45</u>

In the event that a property owner does not comply with an ordinance requiring lead lateral replacement, the City has a good faith argument that Wis. Stat. §§ 66.0911 and 281.45 authorize the City to contract for the work and impose a special assessment for the replacement work.

The City clearly has the statutory authority to impose a special assessment for: (a) *construction* of a lateral from the house to the lot line (Wis. Stat. § 66.0911); and (b) *connection* of the customer-side lateral to the main (Wis. Stat. § 281.45). While it is not entirely clear that these statutes authorize the City to procure *replacement* of the customer-side lateral and to impose a special assessment to recover the cost, a good faith argument can be made that the City has that authority.

Wis. Stat. § 66.0911 provides, in pertinent part:

> **Laterals and service pipes.** If the governing body by resolution requires water, heat, sewer and gas laterals or service pipes to be constructed from the lot line or near the lot line to the main or *from the lot line to the building to be serviced*, or both, it may provide that when the work is done...under a city, village or town contract, a record of the cost of constructing the laterals or service pipes shall be kept and the cost, or the average current cost of laying the

> laterals or service pipes, shall be charged and be a lien against the lot or parcel served. (italics added)

In *Dewey*, the court held that the charge authorized by § 66.0911 (then § 66.625) is a special assessment although it is not denominated as such. 48 Wis. 2d at 168; *see also* League Opinion (§ 66.625, now § 66.0911, is an independent method of assessing costs for utility lateral construction).

Wis. Stat. § 281.45 separately provides that a municipality may, by ordinance, require buildings used for human habitation to be connected with a water main[2] and, if the owner fails to comply after written notice, the municipality may impose a penalty or cause the connection to be made and assess the costs to the property as a special assessment.

A good faith argument can be made that these authorities apply to replacement of laterals and not just to installation or initial construction. In an unpublished, *per curiam* decision, the court of appeals recently interpreted § 66.0911 to authorize a municipality to require an owner to repair a sewer lateral. *Flores v. City of Waukesha*, No. 2015AP1185 (Wis. Ct. App. March 2, 2016) (unpublished, *per curiam* decision). The court held and reasoned as follows:

> Under Wis. Stat. § 66.0911, if a municipality requires a property owner to connect a building on its property to the main, it also may require the owner to be responsible for the cost of connecting or servicing the lateral..."[C]onnection of the [lateral]" reasonably contemplates reestablishing service between the property owner's building and the main after making necessary repairs.

Id. at ¶ 12. Using the court's logic, the same could be said of lateral connections to reestablish service after necessary *replacements*, particularly in conjunction with water main replacements. Because the *Flores* court issued a *per curiam* decision, the City cannot cite this unpublished decision to a court, even for persuasive effect. Nonetheless, the decision demonstrates that a good faith argument can be made that §§ 66.0911 and 281.45 provide authority for the City to recover the cost of mandatory lead lateral replacement through a special assessment against the property.

We do need to point out that there are significant liability risks associated with the City procuring the replacement of customer-side laterals on private property. The laterals are, and will remain, private property and are located on private property. If the policy makers wish to make this option available to property owners in lieu of forfeiture, then we recommend, at a minimum, requiring the owners to execute hold harmless agreements

[2] The City has adopted such an ordinance, MCO § 225-22.

and temporary easements for construction purposes to mitigate the potential liability risk to the City.

III. Would using utility funds to replace lead water services on private property be acceptable under PSC rules? Can City funds be used for this purpose?

A. Utility Funds

Any proposal to use ratepayer funds would require approval of the PSC.[3] In 2000, the PSC rejected the City of Madison Water Utility's ("MWU") application to partially fund customer-side lead lateral replacements with a surcharge on all ratepayers, both retail and wholesale. *Application of the City of Madison, Dane County, as a Water Public Utility, for Authority to Increase Water Rates*, Final Decision, Docket 3280-WR-106, 2000 Wisc. PUC LEXIS 47, 205 PUR4th 461 (Wis. PSC October 18, 2000) ("Madison Rate Case").

MWU exceeded the lead action levels set forth in the Lead and Copper Rule and therefore was required to gain compliance through either chemical treatment or replacement of all lead laterals. 2000 Wisc. PUC LEXIS at *3-4. The City of Madison enacted an ordinance requiring the replacement of all customer-side lead laterals and providing for a 50 percent reimbursement of the replacement costs up to $1,000. *Id.* at *5. The lead laterals were concentrated primarily in one part of the MWU service area: the Capitol/Isthmus. *Id.* at *3. MWU applied to the PSC for a rate increase in the form of a 5.5 cent surcharge per hundred cubic feet on all water sales, including retail and wholesale, to fund the replacement of both the customer-side and utility-side lead laterals. *Id.* at *5.

The PSC denied the application, determining that such ratepayer funding would constitute unreasonable and discriminatory rate practices in violation of Wis. Stat. § 196.37[4]. The PSC reasoned as follows:

> ...the Commission believes that it would be unreasonable and unjustly discriminatory if public program dollars generated through utility rates were to be authorized as a subsidy to furnish a direct benefit to an exclusive group of private property owners.

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[3] We understand that the question's use of "utility funds" refers to revenues from water rates and not other utility revenue such as grants, loans, or lease revenues, e.g. We cannot rule out the possibility of using utility revenues obtained from sources other than rates. For example, it is our understanding that Madison ultimately funded its program with utility revenues from water antenna leases.

[4] The PSC decision was vacated by the Dane County Circuit Court but upheld by the Court of Appeals in *City of Madison v. PSC*, 2002 WI App 102, 253 Wis. 2d 846, 644 N.W.2d 293 (Wis. Ct. App. Feb. 28, 2002) (unpublished).

> The Commission generally sustains the policy that where benefits accrue to the public at large from a municipal program elected by local government that all associated funding needs should properly be the responsibility of that unit of local government. In this case it would be inappropriate for a funding mechanism to be hidden in a public utility rate, *especially where the proceeds go to aiding a select few and are not generally available to widely qualifying customers of the public utility*. The City passed the ordinance requiring property owners to replace their lead laterals. It therefore is the appropriate body with the necessary authority to provide any subsidy to assure the success of the replacement program...

Id. at *8-9 (emphasis added). The PSC also emphasized the fact that the lead laterals, installed before 1927, were fully depreciated and could be in need of replacement soon anyway. *Id.* at *9.

> In Madison, as in most if not all other Wisconsin municipalities, it is the property owner who is responsible for the repair and ultimate replacement of the customer portion of the lateral. It is reasonable to assume that the owners of the properties in the Isthmus/Capitol area knew or should have known of the lead lateral liability and of the potential need for lateral replacement on their properties.

Id. at *10.

The Madison Rate Case would seem to foreclose the possibility of using ratepayer funds to pay for a customer-side lead lateral replacement program. Nonetheless, if City policy makers so desire, it may be appropriate to initiate a discussion with PSC staff regarding development of a proposal to fund a lead lateral replacement program with utility rates with the ultimate goal of petitioning the Commission to distinguish Milwaukee's situation from the facts in the Madison Rate Case or to revisit the Madison ruling.

The number of Milwaukee customers with lead laterals is far greater than the "exclusive group of private property owners" who would have benefited in the Madison Rate Case. In Madison, there were 9,000 customer-side lead laterals. *Id.* at *4. In Milwaukee, approximately 70,000 properties, or 44% of the retail customer properties, have lead laterals; arguably justifying a retail area or service area-wide solution.

Further, several factors may justify revisiting the Commission's decision. The concern over lead laterals, both statewide and nationally, is now even greater, particularly with the EPA's attention to the evolving science on the negative effects of partial lateral replacement. This heightened concern has occurred at the same time that the PSC has required MWW to perform significant levels of main replacements and the availability of utility rate funding could prevent delays in replacement of water mains connected to lead laterals.

We are also aware of a recent decision in which the PSC, through a delegated decision issued by the Administrator of the Water, Compliance and Consumer Affairs, approved utility financing of the cost of customer-side water lateral installations and private well abandonments. *Application of the City of Pewaukee Water Utility, Waukesha County, Wisconsin, to Construct a New Water Pumping Station and Associated Facilities*, Certificate of Authority and Order, Docket 4625-CW-115 (Wis. P.S.C., January 17, 2013). The utility identified 85 customers whose private wells would be significantly impacted by groundwater drawdown from operation of a new public well. The PSC approved the utility's proposal to procure, at the utility's expense, the installment of the customer-side lateral and the abandonment of the customer's private well, at an estimated cost of $5,000 per customer. Citing the "unique circumstances in this case," the PSC permitted the utility to recover its costs, budgeted at $425,000 through rates. *Id.* at 4. While the decision was not made by the full Commission and could be limited to the facts in the case, it does also show that the Commission has been able to reconcile private infrastructure subsidies with the prohibitions on discriminatory rates.

Alternatively, there may be ways to work within the confines of the Madison Rate Case and craft a proposal that would not violate the proscription against discriminatory rates. For example, MWW could explore creating a sub-classification of residential retail customers: one with lead laterals and one with copper laterals. MWW could then propose to apply a surcharge on customers in the lead lateral sub-class only to pay for lateral replacements during main replacement projects.

While we cannot predict how the PSC would view such a proposal, it could potentially serve as a way to avoid a discriminatory rate practice finding. Unlike the MWU proposal, the above proposal would be funded solely by the customers who would receive the benefit of the program.

B. <u>City Funds</u>

The use of City taxpayer dollars to fund or finance, in whole or in part, the costs of replacing customer-side lead laterals must comply with the public purpose doctrine, which requires that public funds be used only for public purposes. *Town of Beloit v. County of Rock*, 2003 WI 8, ¶ 27, 259 Wis. 2d 37, 657 N.W.2d 344. Because the City's primary objective in funding customer-side lead lateral replacements would be the preservation of public health through timely and coordinated replacement of the entire lead lateral at the same time that the water main is replaced, it is our opinion that the public purpose doctrine would not likely preclude the use of City taxpayer funds to fund replacement of customer-side lead laterals.

"[T]he public purpose doctrine has been broadly interpreted" and liberally applied. *Id.* at ¶ 30. A reviewing court must determine whether any public purpose "can be conceived" to reasonably justify the expenditure, giving great weight to the legislature's declarations. *Id.* at ¶ 28. "A court will conclude that there is no public purpose only if it is 'clear and palpable' that there can be no benefit to the public." *Id.* (citations omitted).

In *Town of Beloit*, the Wisconsin Supreme Court declared:

> In determining whether a public purpose exists, courts have considered whether the subject matter or commodity of the expenditure is one of "public necessity, convenience or welfare," as well as the difficulty private individuals have in providing the benefit for themselves...Courts also look to see if the benefit to the public is direct or remote...Additionally, provided that the primary purpose of the expenditure is designed for a public purpose, any direct or incidental private benefit does not destroy the public purpose and render the expenditure unconstitutional...

Id. at ¶ 29 (citations omitted).

Property owners would derive a benefit from replacement of their portion of the lead lateral in coordination with replacement of the main and the utility-side lateral. However, that private benefit would not necessarily eliminate the public purpose, provided that the private benefits are incidental to the public purpose of preserving the public health. *Hopper v. City of Madison*, 79 Wis. 2d 120, 256 N.W.2d 139 (1977).

Similarly, the fact that the dangers posed by lead laterals exist on private land does not eliminate the public purpose involved in countering these dangers to protect the public health and safety. In a 1981 opinion, the Wisconsin Attorney General concluded that state grants to municipalities for the costs to drill wells and fence cave-ins on private property as a result of mine closings had as their primary objective the promotion of public health and safety, respectively, and were therefore consistent with the public purpose doctrine. 70 Wis. Op. Att'y Gen. 48 (1981). The Attorney General opined that the primary reason for the well-drilling grants "would be to assure a pure water supply to the municipality's citizens." *Id.* at 50 (citing *State ex rel. La Follette v. Reuter*, 33 Wis. 2d 394, 147 N.W.2d 304 (1967) ("The primary reason in constructing [water] pollution abatement facilities is to protect the health of all citizens of the state whose need for pure water is essential to life itself.")). Noting that the private benefits were incidental, the Attorney General reasoned: "The fact that these problems [contamination of water supplies and mine shaft cave-ins caused by mine closings] have manifested themselves on private land does not abrogate the underlying public scope of the problem and public purpose in providing a remedy for them." 70 Wis. Op. Att'y Gen. at 51.

There are, however, some factors that may render public subsidy of customer-side lateral replacement costs vulnerable to challenge under the public purpose doctrine. Repair and replacement of the customer-side lateral has always been the responsibility of the property owner. Customer-side laterals are commonly in need of repair or replacement and property owners, not the City or MWW, are responsible for those costs. Roughly 55% of the properties within the City have copper laterals; those owners would continue to bear the cost of repairing and replacing their customer-side laterals.

Therefore, if the City wishes to expend public funds, it may wish to explore development of a funding program that would take into account the property owner's income level. *Town of Beloit*, at ¶ 29 (courts have considered "the difficulty private individuals have in providing the benefit for themselves."). For example, the City's deferred special assessment ordinance, MCO § 115-44, authorizes the City Treasurer to pay all or any part of special assessments placed upon the current or next tax roll against property owned and inhabited by indigent persons who meet certain eligibility requirements.

Finally, if the City wishes to expend City funds, the ordinance creating any customer-side lateral replacement program should contain a record of legislative findings concerning the public health dangers posed by lead laterals when impacted by water main or other street construction as well as declarations that the City's objective in funding the customer-side lead lateral replacements is to preserve the public health by eliminating a potential source of lead from the customer's tap in a timely and coordinated manner.

If you have any questions, please do not hesitate to contact the undersigned.

Very truly yours,

GRANT F. LANGLEY
City Attorney

THOMAS D. MILLER
Assistant City Attorney

c: Common Council President, Michael J. Murphy
Alderman James A. Bohl, Jr.
James R. Owczarski, City Clerk

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Assistant City Attorneys

March 4, 2016

Alderman James A. Bohl, Jr.
City Hall, Room 205

Re: Proposal for Replacement of Customer-Side Lead Laterals

Dear Alderman Bohl:

By email dated January 29, 2016, you asked our office to analyze the legality of a proposal to use City employees to replace privately-owned, customer-side lead laterals. The customer side-lateral is the section of water service piping located on private property. As we explained in the enclosed opinion dated January 29, 2016, the property owner/customer owns and is responsible for maintaining the customer-side lateral.

Under the proposal, the City, through the Department of Public Works (DPW) or Milwaukee Water Works (MWW), would hire two to four crews of trained, licensed plumbers to replace customer-side lead laterals. The City would then offer to replace the laterals for the cost of materials used on the job. We conclude that the proposal would not be legal without changes in state law.

Wis. Stat. § 145.06(1)(b) prohibits a public utility from performing plumbing unless the work falls under one of the exceptions in § 145.06(4). A "public utility" is separately defined, in pertinent part, as "every...city that may own, operate, manage or control...any part of a plant or equipment...for the production of...water...either directly or indirectly to or for the public." Wis. Stat. § 196.01(5)(a). Therefore, the prohibition on plumbing work applies to City employees, whether they work in DPW or MWW.

Wis. Stat § 145.06(4)(f), provides the following exception to this general prohibition:

> This section shall not apply to:....
>
> (f) Installation, repair or *replacement of water service piping, from the property line to the meter*...when such installation, repair or replacement is accomplished by employees of a public municipal water utility, providing such utility regularly has engaged in such installation, repair or replacement for at least 5 years prior to January 1, 1964. (emphasis added).

Consistent with previous City Attorney opinions applying this statute, it is our understanding that MWW did not regularly engage in such "installation, repair or replacement" on customer-side laterals as of January 1, 1959. Therefore, the exception in (4)(f) does not apply and City or utility forces could not be used to perform replacement of customer-side lead laterals.

Separately, Wis. Stat. § 66.0901(11) prohibits a political subdivision from using its own workforce "to perform a [water] construction project for which a private person is financially responsible." This relatively recent legislation, which was adopted in the 2011-13 state budget, likely serves as a separate bar precluding City employees, whether working in DPW or MWW, from performing replacement of customer-side lead laterals.

We are preparing a legal opinion to MWW which addresses the City's and MWW's authority to require replacement of customer-side lead laterals as well as the legality of using City or utility funds to pay for the replacement work. We will provide you with a copy of that opinion upon completion.

Alderman James A. Bohl, Jr.
March 4, 2016
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If you have any questions, please do not hesitate to contact the undersigned.

Very truly yours,

GRANT F. LANGLEY
City Attorney

THOMAS D. MILLER
Assistant City Attorney

c: James R. Owczarski, City Clerk
Enc.
TDM:tdm
1033-2016-235:226312

Chapter PSC 185

STANDARDS FOR WATER PUBLIC UTILITY SERVICE

Note: Chapter PSC 185 as it was in effect on May 31, 1972 was repealed, and a new chapter PSC 185 was created, Register, May, 1972, No. 197, effective June 1, 1972. Chapter PSC 185 as it was in effect on January 31, 1997 was repealed and a new chapter PSC 185 was created effective February 1, 1997.

Subchapter I — General

PSC 185.11 Authorization for and application of rules. (1) Chapter PSC 185 is part of the Wisconsin administrative code and constitutes a general order of the public service commission, the issuance of which is authorized by ss. 227.11 (2), 196.02, 196.06, 196.12, 196.15, 196.16, 196.19, and 196.37, Stats.

(2) Chapter PSC 185 is designed to effectuate and implement ss. 196.02, 196.03, 196.06, 196.12, 196.15, 196.16, and 196.17, Stats.

(3) The requirements of ch. PSC 185 shall be observed by all water public utilities, both privately and publicly owned, engaged in the pumping, purchasing, transmission, or distribution of water except that an exemption may be given by the public service commission.

(4) Nothing in this chapter shall preclude special and individual consideration being given to exceptional or unusual situations and, upon due investigation of the facts and circumstances involved, the adoption of requirements as to individual utilities or services which shall be lesser, greater, other, or different than those provided in this chapter.

(5) The manner of enforcing this chapter is prescribed in s. 196.66, Stats., and such other means as provided in statutory sections administered by the public service commission.

(6) In case of emergency, where public interest requires immediate action without waiting for compliance with the specific terms of this chapter, immediate corrective action shall be taken by the utility, which action, however, shall be subject to review by the public service commission.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.12 Definitions. The following terms as used in this chapter mean:

(1) "Ability to pay" means a customer's financial capacity to meet the customer's utility service obligation;

(2) "Actual meter read" means a reading obtained by the utility or other party upon physical inspection of the meter or remote outside meter (ROM);

(3) "Automatic meter reading" (AMR) system means a system which provides digitally encoded information from an encoded meter register. The encoded information is transferred to the utility by means of remote receptacles, telephone lines, cable TV lines, power lines, or radio transmission;

(3e) "Class AB utility" means a public utility that has more than 4,000 service connections.

(3m) "Class C utility" means a public utility that has not fewer than 1,000 nor more than 4,000 service connections.

(3s) "Class D utility" means a public utility that has less than 1,000 service connections.

(3u) "Commercial customer" means a business, not−for−profit organization, or other institution that provides goods or services and that takes service for non−residential purposes.

Note: Churches, private schools, private colleges and universities, co−ops, and associations are non−governmental entities and are considered commercial customers.

(4) "Commission" means public service commission of Wisconsin;

(5) "Complaint" means a statement or question by any person, whether a utility customer or not, concerning a wrong, grievance, injury, dissatisfaction, illegal action or procedure, dangerous condition or action committed or created by a utility, or failure of a utility to meet a utility obligation;

(6) "Customer" means any person, owner, occupant, firm, partnership, corporation, municipality, cooperative organization, governmental agency, political entity, etc., provided with water service by any water public utility and is the party billed for payment of bills issued for use of utility service at a given premises. This definition is intended to create billing and payment responsibilities, but does not limit the need to afford occupants other protection under this chapter (e.g., evictions, emergency);

(7) "Customer−requested termination" is cessation of service at the request of the customer;

(8) "Deferred payment agreement" means an arrangement between a utility and a customer for payment of a delinquent amount or deposit in installments;

(9) "Denied or refused service" means service that a utility has refused to provide to a present or future customer, occupant, or premises;

(10) "Disconnection" means an event or action taken by the utility to terminate or discontinue the provision of service, but does not include a customer−requested termination of service;

(10e) "Industrial customer" means a customer who is engaged in the manufacture or production of goods.

(10m) "Irrigation" means the use of water to sustain crops, lawns, or landscapes, including water used on athletic fields, parks, and golf courses.

(10s) "Irrigation customer" means a customer who has water service provided primarily for irrigation and other outdoor uses.

(11) "Meter" means an instrument installed to measure the volume and/or rate of flow of water delivered through it;

(11m) "Multi−family residential customer" means a customer taking service for a building that is intended primarily for residential purposes, has three or more dwelling units, and is served by a single water meter.

Note: For accounting purposes, sales to multi−family residential customers are recorded as commercial sales under to the Commission's Uniform System of Accounts for Municipal Water Utilities (January 2008).

(12) "New residential customer," for purpose of deposit, means a customer who has not received utility service in his or her name during the previous 6 months from the utility from which service is requested;

(12m) "Non−residential customer" means any commercial, industrial, or public authority customer.

(13) "Occupant" means the resident or residents of a premises to which utility service is provided;

(14) "Percent registration" means the ratio of the meter registration divided by the actual volume or rate of flow, stated in percent. Stated more simply for domestic (volumetric) meters, this is the percent of the water delivered through a meter which the meter actually registers;

(15) "Private hydrant" means any hydrant whose lead is connected to a private water main, private lateral, or public main where the hydrant lead is owned by the customer;

(16) "Prompt payment" means payment prior to the time when a utility could issue a notice of disconnection for nonpayment of an amount not in dispute;

(17) "Protective service emergency" means a threat to the health or safety of a resident because of the infirmities of aging, mental retardation, other developmental or mental disabilities, or like infirmities incurred at any age, or the frailties associated with being very young;

(17m) "Public authority customer" means a customer that is a department, agency, or entity of the local, state, or federal government, including a public school, college, or university.

(18) "Public hydrant" means any hydrant and lead owned by the utility and connected to a utility−owned main, whether that main is in the public right−of−way or owned by the utility on an easement through private property;

Note: The hydrant and related fixtures would be recorded on the books of the utility.

(19) "Public utility" means an entity or individual included in s. 196.01 (5), Stats., which provides water for the public and an entity authorized by s. 66.0819, Stats., which provides water and sewer service for the public;

(20) "Remote outside meter" (ROM) means an analog device attached to a building structure which displays the reading of the base meter through electronic pulses sent from the base meter. Remote outside meters are considered part of the utility's metering configuration.

(20g) "Residential customer" means a customer taking service for residential or domestic purposes but does not include a multi−family residential customer.

(20r) "Station meter" means a meter used to measure the volume or flow of water within a utility's distribution system and not used to measure customer use. Station meter includes any meter used to measure water pumped from groundwater wells, surface water intakes, storage facilities, treatment facilities, or booster pumps.

(21) "Voucher agreement" means a payment agreement guaranteed by a third party who has access to or control over the benefits and finances of a public assistance recipient.

(22) "Water conservation" means practices, techniques, and technologies that reduce the demand for water, reduce water loss or waste, or improve water use efficiency.

Note: Examples of some public assistance are:

(a) Aid to families with dependent children (AFDC) restrictive payment arrangements;

(b) Social security representative payee;

(c) General relief voucher payment systems;

(d) Legal guardian.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; correction in (19) made under s. 13.93 (2m) (b) 7., Stats., Register October 2001 No. 550; CR 11−039: cr. (3e), (3m), (3s), (4m), (10e), (10m), (10s), (11m), (12m), (17m), (20g), (20r), (22) Register July 2012 No. 679, eff. 8−1−12; (4m) renum. to (3s) under s. 13.92 (4) (b) 1., Stats., Register July 2012 No. 679.

PSC 185.13 General requirement. Every utility shall furnish reasonably adequate service and facilities at the rates filed with the commission and subject to this chapter and the rules of the utility that are on file with the commission.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.15 Free or discriminatory service prohibited. No utility shall provide water service free or at a rate different than provided for in its rates. (See ss. 196.22 and 196.60, Stats.) This section applies to, but is not limited to, water service for all nonutility municipal purposes such as street and sewer flushing, and service to nonutility public buildings.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.16 Protection of water utility facilities. (1) A water public utility upon receipt of written notice as required by s. 66.0831, Stats., from the property owner or from a contractor of work which may affect its facilities used for serving the public:

(a) Shall investigate and decide what action, if any, may reasonably be taken to protect or alter utility facilities in order to protect service to the public and to avoid unnecessary damage, such as identifying in a suitable manner the location of any underground utility facilities which may be affected by the work.

(b) Shall take such action as is reasonably and legally necessary to protect, remove, alter, or reconstruct its facilities, and shall perform this work with reasonable dispatch taking into account the conditions to be met, provided that nothing in this section shall be deemed to affect any right which the utility may have to require advance payment or adequate assurance of payment of the reasonable cost to the utility by the property owner or contractor.

(c) May, in order to protect its interests, require that the owner or contractor perform certain work upon or removal of that part of the service piping from the property upon which the excavating, building, or wrecking operations are being performed.

(2) This section is not intended to affect the responsibility of the contractor or owner, or the liability or legal rights of any party.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; correction in (1) (intro.) made under s. 13.93 (2m) (b) 7., Stats., Register October 2001 No. 550.

PSC 185.17 Interference with public service structures. (1) No utility having any work upon, over, along, or under any public street or highway or upon, over, along, or under any private property shall interfere with, destroy, or disturb the structures of any other public service corporation or railroad encountered in the performance of such work so as to interrupt, impair, or affect the public service for which such structures may be used, without first reaching an agreement concerning the location and the nature of the proposed work.

(2) A utility shall exercise care when working in close proximity to existing facilities. When the facilities are underground and are to be exposed or possibly may be exposed, hand digging shall be employed. In these cases, such support as may be reasonably necessary for protection of the facilities shall be provided in and near the construction area. When backfilling an excavation, such procedures and materials shall be employed to provide reliable support for existing underground facilities in and near the construction area.

(3) A utility shall, in the absence of working arrangements, give at least a 3−day written notice (not counting Saturdays, Sundays, and legal holidays) to all utilities or railroads and to those who may have facilities in and near the construction area which may be affected by the proposed work. The utility proposing to work shall obtain from the affected party the location of the existing facilities determined to be affected or to be in and near the construction area. Contacting a one−call system, such as the diggers' hot line system established under s. 182.0175 (1m), Stats., shall constitute compliance with this subsection.

(4) A utility upon receiving a notice of proposed construction shall furnish in 3 days detailed information relative to location and type of facilities that are present in the proposed construction area. Where practical in those cases where the facilities are underground, they shall be marked physically in the field relative to location.

(5) Nothing in this section shall prevent a utility from proceeding as quickly as possible with any emergency construction work which might interfere with existing facilities. However, all reasonable precautions shall be taken to avoid or minimize damage or interference to the other facilities and notification shall be given as soon as possible to the utilities which have facilities in the construction area.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; correction in (3) made under s. 13.93 (2m) (b) 7., Stats., Register April 2007 No. 616.

PSC 185.18 Location of records. All records required or necessary for the administration of this chapter shall be kept within this state unless otherwise authorized by the commission. These records shall be available for examination by the commission or its authorized representative at all reasonable hours. (See s. 196.06 (6), Stats.)

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.19 Retention of records. (1) A utility shall preserve the following records in a readable format and keep them available for inspection by the commission for the period indicated. The list is not to be taken as comprehending all types of utility records.

Description of Record	Period to be Retained
(a) Maps showing the location and physical characteristics of the utility plant	Until maps are superseded or 6 years after plant is retired, provided mortality data are retained
(b) Engineering and original cost records in connection with construction projects	Until records are superseded or 6 years after plant is retired, provided mortality data are retained. An exception is allowed when a utility maintains approved continuing property records; then, engineering and original cost records need only be preserved for a period of 6 years after construction is completed.
(c) Operating records	
1. Station pumpage records	15 years or 3 years after the source is abandoned, whichever is shorter
2. Interruption records	6 years
3. Meter test records	Until the information in the meter test record is entered in the meter history record and the meter is tested again
4. Meter history record	Life of meter plus 6 years
5. Annual meter accuracy summary	6 years
6. Pressure records	6 years
(d) Customer records:	
1. Complaint records	3 years after the complaint is resolved
2. Customer deposit	6 years after refund
3. Meter reading records used for billing	6 years
4. Billing record	6 years
(e) Filed rates and rules	Permanently

Note: See also "Investigation to Consider Proposed Changes to Records Retention Requirements for Electric, Gas and Water Utilities" adopted by the commission in docket 5−US−114, December 12, 2006, for a more comprehensive listing of retention periods of specific records.

(2) A utility may apply for a waiver from any portion of pars. (a) through (e) of this section. Such application shall include a list of the paragraphs to which the waiver would apply. Also, include the reasons the utility believes it cannot or shall not have to comply with pars. (a) through (e) and the impacts such a waiver would have on the utility's ability to maintain usable continuing property records, if any.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; **CR 13−033: am. (1) Register July 2015 No. 715, eff. 8−1−15.**

Subchapter II — Rate Schedules and Rules

PSC 185.21 Schedules to be filed with the commission. (1) INCLUDED IN SCHEDULES. The schedules of rates and rules shall be filed with the commission by the utility and shall be classified, designated, arranged, and submitted so as to conform to the requirements of the current tariff or rate schedules and the special instructions which have been and may from time to time be issued by the commission. Provisions of the schedules shall be definite and so stated as to minimize ambiguity or the possibility of misinterpretation, and shall include, together with such other information as may be deemed pertinent, the following:

(a) All rates for service with indication for each rate of the class of customers to which it applies. There shall also be shown any limitations on the service furnished under such rate, the prices per unit of service, and the number of units per billing period to which the prices apply, the period of billing, the minimum bill, method of measuring demands (where applicable) and consumptions, and any special terms and conditions applicable. The charge for late payment, if any, and the period during which the bill may be paid without late payment charge shall be specified;

(b) At commission discretion a copy of each contract or the standard contract form with a summary of the provisions of each signed contract may be required if service to other utilities or municipalities for resale is furnished at a standard filed rate;

(c) Extension rules for extending service to new customers indicating what portion of the extension or cost shall be furnished by the utility, and if the rule is based on cost, the items of cost included;

(d) Designation of such portion of the service facilities as the utility furnishes, owns, and maintains;

(e) Rules with which prospective customers shall comply as a condition of receiving service and the terms of any contracts required;

(f) Rules governing the establishing of credit by customers for payment of service bills;

(g) Rules governing the procedures followed in disconnecting and reconnecting service;

(h) Notice required from customer for having service disconnected;

(i) Rules governing temporary, emergency, auxiliary, and standby service;

(j) Rules governing any limitations on the type of equipment which may or may not be connected;

(k) A list of the municipalities in which service is rendered and the rates under which service shall be provided.

(2) RATES FOR WATER SERVICE. (a) A public utility shall adopt general service water rates that reflect the cost of service for each class of customer and include a volume charge based on actual customer consumption.

(b) A public utility may not adopt a rate under par. (a) if the commission finds that the rate is discriminatory or otherwise not in the public interest.

(c) The commission may approve rates that promote efficient water use.

(d) A utility may adopt rates that treat multi−family residential customers as a separate customer class.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 11−039: renum. (intro.) to (1) (intro.), cr. (1) (title), (2) Register July 2012 No. 679, eff. 8−1−12.

PSC 185.22 Information available to customers. (1) A utility shall have copies of its rates and rules applicable to the locality available in its office where payments are received and at area libraries. A utility shall give reasonable notice to customers as to where the information is available to them.

(2) Each water utility, for every municipality in which it serves, shall provide in the respective telephone directories a telephone listing by which the utility shall be notified during a 24−hour day of any utility service deficiency or emergency which may exist.

(3) Where a second language is common in a particular area served by the utility and so identified by the commission, all rules pertaining to billing and credit shall be available upon customer request for distribution in English and that second language in every business office of the utility in that area accessible to the public and where customer payments are received.

(4) Each utility shall have available and provide upon request written notice to its existing residential customers, and a written notice to all new residential customers, at a minimum, of the rules on deposits, payment options including deferred payment agreements and budget billing, disconnection, and dispute procedures. Such notice shall contain a reply procedure to allow customers an opportunity to advise the utility of any special circumstances, such as the presence of infants or elderly persons or the use of human life−sustaining equipment, and to advise the utility to contact a specific third−party agency or individual prior to any disconnection action being taken.

(5) (a) A utility shall provide customer usage and billing history on request to current or prospective customers, tenants, or property owners. This information shall include either the average consumption for the prior 12−month period or figures reflecting the highest and lowest consumption amounts for the previous 12 months. Provision of this information is neither a breach of customer confidentiality nor a guarantee or contract by the utility as to future consumption levels for the premises in question.

(b) Upon a residential customer request, the public utility shall provide consumption information by billing periods for at least the last year and information and instructions needed by the customer to make consumption comparisons to similar residential customers in the same class and to evaluate water conservation efforts.

Note: The information in subs. (1) − (5) is contained in the commission's residential customer bill of rights.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: am. (1), Register October 2001 No. 550, eff. 11−1−01; CR 11−039: renum. (5) to (5) (a), (5) (b) renum. from 185.33 (2) Register July 2012 No. 679, eff. 8−1−12.

Subchapter III — Service and Billing

PSC 185.30 Application for residential and multifamily service. (1) For purposes of this section, "written" or "in writing" means legibly printed on paper or, with the intended recipient's permission, legibly printed in an electronic form that the recipient can electronically store and retrieve for future reference.

(2) (a) If a utility requires an application, a residential or multifamily user of water service shall apply for service.

(b) A utility may require a verbal or written application for residential service. The utility shall establish a written policy for when a written application is required. A utility may accept an application for service from a person other than the user or potential user of service.

(c) 1. Except as provided in par. (d) and sub. (3), a utility may only require that an applicant provide the following information in an application:

a. Legal name and birthdate of the user of service and the person responsible for bill payment, if different than the user.

b. If the user of service has telephone service, the telephone number of the user of service. If the person responsible for bill payment is different than the user and the person responsible for bill payment has telephone service, the utility may also require the telephone number of the person responsible for bill payment. Lack of telephone service is not grounds for service refusal.

c. Address where service is to be provided.

d. Mailing address if different from service address.

e. Date requested for service to begin.

f. The most recent previous address of the person responsible for bill payment.

g. Initial identification data under subd. 2.

2. A utility shall accept any of the following items as adequate initial identification data, although it may accept other forms of identification:

a. Driver's license number.

b. State identification card number.

c. Passport number.

d. Social security number or the last 4 digits of the social security number.

3. If a utility requests the initial identification data under subd. 2., it shall inform the applicant of all acceptable forms of

initial identification data and allow the applicant to choose which the applicant wishes to provide.

(d) If a utility determines that an applicant's response under par. (c) 1. a. to f. indicates that additional information is necessary to further evaluate the applicant's credit history or identity, the utility may require the applicant's addresses for the past 6 years as part of its application for service. Each utility shall establish a written policy for requesting the application information under this paragraph.

Note: Also see s. PSC 185.36, which allows a request for a deposit if an applicant has an outstanding account balance that accrued within the last 6 years.

(e) A utility may request information other than that listed in pars. (c) and (d), but before requesting it the utility shall inform the applicant that providing that information is optional.

(f) A utility may refuse or disconnect service for failure to provide any information specified in par. (c) 1. a., c., e., and f. or par. (d).

Note: See sub. (3) (a) about what can be required if an applicant refuses to provide the initial identification data under s. PSC 185.30 (2) (c) 1. g.

(3) IDENTITY AND RESIDENCY VERIFICATION. (a) A utility may require verification of the initial identification data or the residency, or both, of the person responsible for bill payment under any of the following circumstances:

1. The application is for service at a premises where a bill remains unpaid for service provided within the previous 24 months.

2. The person responsible for bill payment has an outstanding bill with the utility but claims that the bill was accrued in the person's name as a result of identity theft.

3. The applicant fails to provide the initial identification data under sub. (2) (c) 1. g. or the utility finds, with reasonable certainty, that the initial identification information is inaccurate.

(b) A utility shall establish a written policy for when it will require verification of identity or residency under par. (a).

(c) A utility shall accept any of the following items as adequate verification of identity, although it may accept other forms of verification:

1. Any one of the following items:

a. Valid driver's license or other photo identification issued by a state, U.S., or tribal governmental entity.

b. Valid U.S. military or military dependent identification card.

c. Valid passport.

2. Any two of the following items:

a. Social security card.

b. Certified copy of a marriage certificate.

c. Certified copy of a judgment of divorce or legal separation.

d. Military discharge papers, including federal form DD−214.

e. Valid student identification card with the applicant's photo.

f. Current employee photo identification card that includes information, such as the employer's telephone number or address, which can be used for verification purposes.

g. Letter of identification from a social service agency or employer that includes information, such as the agency or employer's telephone number or address, which can be used for verification purposes.

(d) 1. A utility shall accept any one of the following items as adequate verification of an applicant's residency, although it may accept other forms of verification:

a. Current utility bill.

b. Current financial institution statement.

c. Rental agreement.

d. Documents indicating home purchase.

e. Current paycheck or pay stub showing the applicant's name and address, and the employer's name.

f. Verification of address provided by a social service or government agency.

2. A utility may require an applicant to provide information that may be used for verification purposes, such as a telephone number or address, if the applicant submits one of the items in subd. 1. b., c., e., or f. to the utility.

(e) If a request for verification of identity or residency is based on par. (a) 2., the utility may require that the applicant provide the information in s. 196.23 (1), Stats.

(f) If a utility requests information under this subsection, it shall inform the applicant of all items that are acceptable for verification of identity or residency, and allow the applicant to choose which items the applicant wishes to provide.

(g) If an applicant refuses to provide the information under pars. (c) or (d) or a utility finds, with reasonable certainty, that the verification is falsified, the utility may request an additional item, refuse service or disconnect service.

(4) PROCESSING APPLICATIONS AND PROVIDING NOTICE. (a) Except under exceptional circumstances, a utility shall approve or deny an application for service no later than 10 calendar days after receipt of the information required under this section. An unexpectedly high volume of requests for service shall not constitute exceptional circumstances.

(b) A utility shall notify the applicant in writing within 5 days of its denial. A utility may notify an applicant verbally before written notification is sent. An application shall be considered denied when a service refusal has been finalized and no immediate conditions that could change that refusal remain. The notification shall include all of the following:

1. An explanation of why service is being refused.

2. The applicant's right to ask commission staff to review the refusal.

3. The commission's address, telephone number and web site.

Note: For example, if a utility has told a customer that it would supply service if the customer makes a payment, enters a deferred payment agreement or provides additional identity or residency information under sub. (3), the refusal is still conditional and has not been finalized.

(c) If a third party applies for service, a utility shall send written notification of the application to the most recent previous address of the person responsible for payment and the address for which service has been requested.

(d) If an applicant indicates that a third party is responsible for payment, a utility shall send written notification of the approval or denial of an application to both the third party and the applicant within 5 days of the application's approval or denial, although a utility may notify the third party and applicant before written confirmation is sent. If service is refused, the written notification shall include the information in par. (b) 1. to 3.

History: CR 13−048: cr. Register July 2014 No. 703, eff. 8−1−14.

PSC 185.305 Application for nonresidential service. (1) For purposes of this section, "written" or "in writing" means legibly printed on paper or, with the intended recipient's permission, legibly printed in an electronic form that the recipient can electronically store and retrieve for future reference.

(2) (a) If a utility requires an application, a user of water service shall apply for service in a form specified by the utility.

(b) A utility may require a verbal or written application for nonresidential service. The utility shall establish a written policy for when a written application is required. A utility may accept an application for service from a person other than the user or potential user of service

(c) The utility may only require that an applicant provide the following information in an application:

1. Legal name of the user of service and the person responsible for bill payment, if different than the user.

2. Telephone number of the user of service and the person responsible for bill payment, if different than the user.

3. Address where service is to be provided.

4. Mailing address if different from service address.

5. Date requested for service to begin.

6. The most recent previous address of the person responsible for bill payment.

7. Credit information under par. (e).

8. Initial identification data under par. (f).

(d) A utility may request information other than that listed in par. (c), but before requesting it the utility shall inform the applicant that providing that information is optional.

(e) A utility may request reasonable credit information from a nonresidential applicant as part of its application for service. A utility shall establish a written policy about when it will request credit information and what credit information it will request.

(f) A utility shall accept any of the following items as adequate initial identification data, although it may accept other forms of identification:

1. Federal employer identification number or proof that it has been applied for but not yet granted.

2. Wisconsin department of financial institutions identification number.

3. Wisconsin seller's permit identification number.

(g) A utility may refuse or disconnect service for failure to provide any information specified in pars. (c) 1. to 7. or (f).

Note: See sub. (3) (a) about what can be required if an applicant refuses to provide the initial identification data under par. (c) 8.

(3) IDENTITY VERIFICATION. (a) A utility may require verification of the initial identification data of an applicant for nonresidential service under any of the following circumstances:

1. An applicant refuses to provide the information under sub. (2) (c), (e), or (f).

2. The utility finds, with reasonable certainty, that the information provided under sub. (2) (c), (e) or (f) is falsified.

(b) A utility shall establish a written policy for when it will require verification of identity under this subsection.

(c) A utility shall accept any of the following items as adequate verification of identity, although it may accept other forms of verification:

1. State or federal income tax returns.

2. Internal Revenue Service letter assigning federal employer identification number.

3. Wisconsin seller's permit or department of revenue letter assigning a Wisconsin seller's permit identification number.

4. Business articles of incorporation, partnership agreement, limited liability company articles of organization, or similar organizational documents.

(d) A utility may refuse or disconnect service if it does not obtain adequate verification of identity.

(4) PROCESSING APPLICATIONS AND PROVIDING NOTICE. (a) Except under exceptional circumstances, a utility shall approve or deny an application for service no later than 10 calendar days after receipt of the information required under this section. An expected high volume of requests for service shall not constitute exceptional circumstances.

(b) A utility shall notify the applicant in writing within 5 days of the denial of application. A utility may notify an applicant verbally before written notification is sent. An application shall be considered denied when a service refusal has been finalized and no immediate conditions that could change that refusal remain. The notification shall include all of the following:

1. An explanation of why service is being refused.

2. The applicant's right to ask commission staff to review the refusal.

3. The commission's address, telephone number and web site.

Note: For example, if a utility has told a customer that it would supply service if the customer makes a payment, enters a deferred payment agreement or provides additional identity information under sub. (3), the refusal is still conditional and has not been finalized.

(c) If a third party applies for service, a utility shall send written notification of the application to the potential user's mailing address and the address for which service has been requested.

(d) If an applicant indicates that a third party is responsible for payment, a utility shall send written notification of the approval or denial of an application to both the third party and the applicant within 5 days of the application's approval or denial, although a utility may notify the third party and applicant before written confirmation is sent. If service is refused, the written notification shall include the information in par. (b) 1. to 3.

History: CR 13−048: cr. Register July 2014 No. 703, eff. 8−1−14.

PSC 185.31 Metered service. (1) Except where otherwise authorized by the commission, all water sold by a utility shall be on the basis of meter measurement except that the volume of water used for fire protection, street or sewer flushing, construction, or similar purposes where metering is not practicable may be estimated. (See s. PSC 185.15.)

(2) Wherever practicable, consumption of water within the utility itself, or by administrative units associated with it or with the municipality shall be metered.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.32 Meter readings and billing periods. Readings of all meters used for determining charges to customers shall be taken by the utility monthly, bimonthly, quarterly, or for such other period or in such other manner as may be authorized by law. An effort shall be made to read meters on corresponding days of each meter−reading period. The meter−reading date may be advanced or postponed not more than 10 days without adjustment of the billing period. Bills for service shall be rendered within 50 days from the reading of the meter except as may be otherwise specifically authorized by the commission. The utility may permit the customer to supply the meter readings. Meter readings supplied by the customer or third party, acceptable to the utility, shall be considered the actual reading. The utility is obligated, upon request, to obtain a final read from both the base and ROM meters when there is a change of customers. The utility shall make reasonable efforts to read the meters of customers who cannot be available during normal business hours and when there is a change of customer. The utility may make a final read through AMR technology if available.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.33 Billing. (1) For each bill provided by the utility, the customer's receipt shall show for each meter the following information:

(a) The billing address, and service address, if different from the billing address;

(b) The customer's account number;

(c) The present and last preceding meter readings;

(d) The present and last preceding meter reading dates;

(e) The number of units consumed;

(f) The rate schedule under which the bill is calculated including the itemized calculations of the rate schedule component including, but not limited to, such items as customer charge, volume blocks, demand charges, minimum bills, and all other billing factors necessary for the customer to check the calculation of the bill. In lieu of including the rate schedule on the bill the utility may, whenever a rate change becomes effective and at least once a year, supply each customer with the schedule of rates at which the bills are computed and any other rates that might be applicable;

(g) Clear itemization of the amount of the bill for the present billing period and any unpaid balance from previous billing periods including any late payment charges;

(h) Clear itemization of other utility charges and credits.

(1m) A public utility that calculates its volume charges in units of cubic feet shall include customer usage in both cubic feet and gallons on the customer bill or provide a formula for converting usage in cubic feet to gallons on the customer bill. In lieu of providing the information on the customer bill, a public utility may provide the information in a document provided to each customer under sub. (1) (f).

(3) Estimated bills shall be distinctly marked as such.

(4) Any partial payments received should be applied to the customer's account in the following order:

(a) Current utility service;

(b) Current deferred payment agreement;

(c) Utility service arrears;

(d) Miscellaneous utility charges;

(e) Nonutility charges (e.g., charges for municipal fees or licenses, contracted sewer billing services, or penalties levied under municipal ordinances).

(5) Where the billings also include charges for other utility services, including sewer service billed on a volumetric basis, payment for current service or arrears should be applied on a prorata basis.

(6) Upon customer request, or at the discretion of the utility, partial payments may be allocated differently than set forth above provided that such allocation does not result in a disconnection of service or the imposition of a late payment penalty which would not have occurred under the allocation methodology set forth above.

(7) Costs or fees incurred by and awarded to the utility by a court of law, for pursuing bill collection through other agencies, such as small claims courts, or extraordinary collection charges as allowed and specified in the utility's tariffs filed with the commission, may be included on the utility service bill. Such tariffs shall be established on the basis of rate case proceedings or generic proceedings to establish the reasonableness of such charges.

(8) The commission may authorize the utility to make late payment charges to any portion of customer's utility service bill that is not paid in full based on the order of payment application as provided in sub. (4), within 20 days following issuance of the bill. The late payment charge may be either a one−time charge as provided in sub. (9) or a monthly charge as provided in sub. (10). The utility shall receive approval from the commission of the method it desires to use and shall not change methods without commission approval.

(9) If the utility is authorized to make a one−time late payment charge, such charge shall comply with the following requirements:

(a) The bill shall clearly indicate the amount of the late payment charge and the date after which the late payment charge shall be applied;

(b) Except as provided in par. (h), late payment charges shall be applied no sooner than 20 days after the date of issuance of the bill;

(c) The amount of the late payment charge shall be 3% of the unpaid bill, except a minimum charge of $0.50 shall apply. The utility need not calculate a late payment charge on unpaid amounts of less than $20.00, if allowed by utility tariff;

(d) Late payment charges shall be applied to all customer classes and rate classifications;

(e) Unless otherwise authorized by the commission the utility shall not waive any properly applied late payment charges;

(f) A late payment charge shall be applied only once to any given amount outstanding;

(g) If a customer disputes a bill for utility service and does not pay the disputed bill in full within 20 days following issuance of the bill, the late payment charge shall be applied only to that portion of the disputed bill later found to be correct and payable to the utility;

(h) Bills issued for utility service previously unbilled because of meter diversion or tampering with the proper metering of the account may include a late payment charge when issued.

(10) If the utility is authorized to make monthly late payment charges, such charges shall comply with the following requirements:

(a) The amount of the charge shall be no more than one percent per month for late charges related to service provided for the utility's residential class of customers, and shall be no more than one and one−half percent per month for late charges related to service provided for all other purposes. The amount of the charge shall be filed with and approved by the commission before it may be applied;

(b) The late payment charge shall be applied to the total unpaid balance for utility service including unpaid late payment charges;

(c) Except as provided in par. (h), the late payment charge shall be applied no sooner than 20 days after the date of issuance of the bill;

(d) The late payment charge shall be applied to all customer classes and rate classifications;

(e) If a customer disputes a bill for utility service and does not pay the disputed bill in full within 20 days following issuance of the bill, the late payment charge shall be applied only to that portion of the disputed bill later found to be correct and payable to the utility;

(f) The utility shall not waive any properly applied late payment charge;

(g) No additional late payment charge may be applied to a delinquent account for utility service after the date on which the delinquent account was written off by the utility as uncollectible;

(h) Bills issued for utility service that was previously unbilled because of meter diversion or tampering with the proper metering of the account may include a late payment charge when issued. The late payment charge may be applied from the estimated date that the diversion or tampering began.

(11) If a utility changes the type of late payment charge, or initiates a late payment charge, the new charge shall apply only to utility service provided after the effective date of the change or initiation.

(12) A delinquent amount including late payment charges covered by a deferred payment agreement shall not be subject to additional late payment charges if the customer meets the payment schedule including the current bill as required by the agreement. However, if a customer defaults on a deferred payment agreement, the amount remaining shall be subject to any applicable monthly late payment charge.

(13) (a) If the billing period is longer or shorter than allowed by s. PSC 185.32, the bill shall be prorated on a daily basis unless other provision is made in the utility's filed rules.

(b) The utility may leave a meter reading form when access to a meter cannot be gained. If requested by the customer, the utility shall provide such a form. If no form is left on the premises, or if the form is not returned in time to be processed in the billing cycle, a minimum or estimated bill may be rendered. In cases of emergency the utility may render minimum or estimated bills without reading meters or supplying meter reading forms to customers. Except in unusual cases, a meter reading by the customer or the utility shall be obtained after no more than 3 consecutive estimated or minimum bills have been rendered.

(c) When an actual meter reading indicates that a previous estimated bill was abnormally high or low, the utility shall calculate the bill for the entire period as if use of service was normally distributed throughout the period. The previous estimated charge shall be deducted from the recomputed total. If there is evidence to indicate that actual use was not uniform throughout the period, the billing shall be adjusted according to available information.

(14) (a) Credits due a customer because of meter inaccuracies, errors in billing, or misapplication of rates shall be shown separately and identified.

(b) Adjustments to past bills rendered because of meter inaccuracies, errors in billing, or misapplication of rates shall be separated from the current regular billing and the charges explained in detail.

(15) Each bill for service shall be computed at the proper filed rate.

(16) A utility may offer a budget payment plan to residential customers. Any such plan shall conform to the guidelines set forth in pars. (a) through (g).

(a) A budget payment plan tariff shall be on file with the commission, applicable only to charges for utility services under commission jurisdiction.

(b) A budget payment plan may be established at any time of the year. The budget amount shall be calculated on the basis of the estimated consumption and estimated applicable rates. If the budget period is a fixed year, then prospective and existing customers requesting a budget payment plan after the start of the fixed year shall have their initial monthly budget amount determined on the basis of the number of months remaining in the current budget year.

(c) An applicant for a budget plan shall be informed at the time of application that budget amounts shall be reviewed and changed every 12 months, if necessary, in order to reflect current circumstances. Adjustments to the budget amount shall be made with the objective that the customer's underbilled or overbilled balance at the end of the budget year shall be less than one month's budget amount.

(d) Customers on the budget payment plan shall be notified of adjustments by means of a bill insert, a message printed on the bill itself, or both. The customer shall be adequately informed of the adjustment at the same time the bill containing the adjustment is rendered.

(e) Customers who have arrearages shall be allowed to establish a budget payment plan by signing a deferred payment agreement for the arrears, according to the provisions of s. PSC 185.38.

(f) Budget payment plans shall be subject to the late payment charge provisions. In addition, if a budget payment is not paid, the customer shall be notified with the next billing that if proper payment is not received subsequent to this notification, the next regular billing may effectuate the removal of the customer from the budget plan and reflect the appropriate amount due.

(g) At the end of a budget year, if an underbilled or overbilled balance exists in the account, the balance shall be handled as follows:

1. A customer's debit balance shall be paid in full or, at the customer's option, on a deferred basis;

2. A customer's credit balance shall be applied, at the customer's option, against the customer's account credited in installments to the customer's account over the course of the next budget year, or refunded to the customer.

(17) An occupant, or other responsible party who uses utility service but does not apply for it, may be billed an estimated or actual amount at a later date for service used prior to the time of application. The utility shall have reasonable grounds to establish responsibility for the backbilling. Failure to pay charges resulting from this backbilling may result in disconnection of service. The utility shall inform the occupant of the right to dispute the billing through the dispute procedures set forth in s. PSC 185.39.

(19) (a) A utility shall pay interest on customer overpayments not refunded to the customer within 60 days of the determination by the utility or commission that refund is due, if the net amount refunded exceeds $20.00 per refund and the overpayment was made to the utility due to:

1. Meters registering fast as defined in s. PSC 185.35;

2. Billing based on a switched−meter condition where the customer was billed on the incorrect meter;

3. Misapplication of rates;

4. Other billing errors.

(b) A utility is not required to pay interest to customers for overpayments made for:

1. Financing of service extensions or other equipment;

2. Budget payment plans;

3. Estimated bills;

4. Customer overpayments or advances.

(c) The rate of interest to be paid shall be calculated in the same manner as provided for in s. PSC 185.36 (9) (b). Interest shall be paid from the date a refund is determined to be due until the date the overpayment is refunded. Interest shall be calculated on the net amount overpaid in each calendar year.

(d) Nothing in this chapter shall prevent the commission or its staff from requiring the payment of interest on amounts returned to customers in those instances where the commission or its staff finds that such payment is necessary for a fair and equitable resolution of an individual complaint.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: am. (10) (a) and (13) (b), renum. (18) (c) to be (18) (d), cr. (18) (c), Register October 2001 No. 550, eff. 11−1−01; correction in (19) (c) made under s. 13.93 (2m) (b) 7., Stats., Register October 2001 No. 550; CR 11−039: cr. (1m), renum. (2) to 185.22 (5) (b) Register July 2012 No. 679, eff. 8−1−12; CR 13−048: r. (18) Register July 2014 No. 703, eff. 8−1−14.

PSC 185.34 Adjustment of bills (ROM). (1) STOPPED ROM. A stopped ROM is defined as one that has recorded zero consumption during the last meter reading period. The consumption that was measured by the base meter and not recorded by the remote register shall be backbilled as current consumption. The usage backbilled as current consumption shall not exceed the customer's average usage per billing period based on the latest 12−months usage. Any amount greater than this usage shall be backbilled pursuant to sub. (2).

(2) STOPPED AND UNDER−REGISTERING ROM. Unrecorded ROM consumption (base meter reading less ROM reading) resulting from sub. (1) or an under−registering ROM shall be prorated from the date of the last base meter reading. Pursuant to s. 196.635, Stats., the utility may backbill for prorated amounts associated with the last 24 months.

(3) OVER−REGISTERING ROM. A ROM over registration (OM reading less base meter reading) shall be prorated from the date of the last base meter reading. The utility shall refund prorated amounts associated with the period since the meter was installed or last tested, not to exceed the last 6 years.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.35 Adjustment of bills. (1) Whenever a positive displacement meter is found upon test to have an average percent registration of more than 102 and whenever a compound or current type meter is found upon test to have an average percent registration of more than 103, a recalculation of bills for service shall be made for the period of inaccuracy assuming an inaccuracy equal to the average percent error in excess of 100.

(2) For the purposes of this rule, the average percent registration shall be the average percent registration for those normal test points which are within the normal test flow limits of the meter, except that the test point within the "change−over" range for compound meters shall be ignored. (For positive displacement meters the light flow test point would not be considered.)

(3) If the period of inaccuracy cannot be determined, it shall be assumed that the full amount of inaccuracy existed during the last half of the period since the meter was installed or last tested.

(4) Where a meter in service is found not to register or is found to have an average percent registration of less than 97, the utility may bill the customer for the amount the test indicates has been undercharged for the period of inaccuracy, which period shall not exceed the last 24 months the meter was in service unless otherwise authorized by the commission after investigation. No backbill shall be sanctioned if the customer has questioned the meter's accuracy and the utility has failed within a reasonable time to check it.

(5) If the recalculated bills indicate that more than $5.00 is due an existing customer or $10.00 is due a person no longer a customer of the utility, the full amount of the calculated difference between the amount paid and the recalculated amount shall be refunded to the customer. The refund to an existing customer may be in cash or as credit on a bill. If a refund is due a person no longer a customer of the utility, a notice shall be mailed to the last known address and the utility shall, upon request made within 6 months, refund the amount due.

(6) Subject to the utility's written rules setting forth the method of determining a reduced rate, if a leak unknown to the customer is found in an appliance or the plumbing, the utility is encouraged to estimate the water wasted and bill for it at a reduced rate not less than the utility's cost. No such adjustment shall be made for water supplied after the customer has been notified and has had an opportunity to correct the condition.

(7) Where, because of some deficiency in the utility's portion of the facilities and at the request of the utility, a customer permits a stream of water to flow to prevent freezing of the service or main, the utility shall adjust the bill for the excess consumption which results.

(8) A record shall be kept of the number of refunds and charges made because of inaccurate meters, misapplication of rates, and erroneous billing. A summary of the record for the previous calendar year shall, upon request, be submitted to the commission.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.36 Deposits for residential service. **(1)** NEW RESIDENTIAL SERVICE. (a) A utility shall not require a deposit or other guarantee as a condition of new residential service unless a customer has an outstanding account balance with any Wisconsin gas, electric, water, or sewer utility which accrued within the last 6 years and for which there is no agreement or arrangement for payment being honored by the customer, and which at the time of the request for new service remains outstanding and not in dispute. (See s. PSC 185.39.)

(b) A deposit under this section shall not be required if the customer provides the utility with information showing that the customer's gross quarterly income is at or below 200% of federal income poverty guidelines.

(c) A utility shall inform the customer of the customer's right to enter into a deferred payment agreement for payment of the deposit amount and of the customer's right to appeal any deposit request or amount required under this section to the commission.

(2) EXISTING RESIDENTIAL SERVICE. A utility may require a deposit as a condition of residential service. When the utility requests a deposit of an existing residential customer, the customer shall be informed of the customer's right to provide a cash deposit, a guarantee, or to establish a deferred payment agreement. The customer shall be given 30 days to provide the deposit, guarantee, or enter into a deferred payment agreement for the deposit amount. A deposit under this section shall not be required if the customer provides the utility with information showing that the customer's gross quarterly income is at or below 200% of the federal income poverty guidelines. The utility may require a deposit if any of the following circumstances apply:

(a) The utility has disconnected the customer's service within the last 12−month period for violation of the utility's filed rules or for nonpayment of a delinquent service account not currently in dispute;

(b) Subsequent credit information indicates that the initial application for service was falsified or incomplete to the extent that a deposit would be required under this section.

(3) GUARANTEE TERMS AND CONDITIONS. (a) A utility may accept, in lieu of a cash deposit for new or existing residential service, a contract signed by a guarantor satisfactory to the utility where payment of a specified sum not exceeding the cash deposit requirement is guaranteed, or where the guarantor accepts responsibility for payment of all future bills. If the guarantor accepts responsibility for payment of future bills, the utility shall notify the customer in writing of the agreement and of the customer's right to refuse such an agreement. The term of the contract shall be for no longer than one year, but it shall automatically terminate after the residential customer has closed the account with the utility, or on the guarantor's request upon a 30−day written notice to the utility.

(b) Upon termination of a guarantee contract, or whenever the utility deems the guarantee insufficient as to amount of surety, a cash deposit or a new or additional guarantee may be required upon a 20−day written notice to the customer. The service of any customer who fails to comply with these requirements may be disconnected upon an 8−day written notice.

(c) The utility shall mail the guarantor copies of all disconnect notices sent to the customer whose account has been guaranteed, unless the guarantor waives such notice in writing.

(4) DEFERRED PAYMENT. In lieu of cash deposit or guarantee, an applicant for new residential service who has an outstanding account balance accrued within the last 6 years with the same utility shall have the right to receive service from that utility under a deferred payment agreement, as defined in s. PSC 185.38 for the outstanding account. A customer who defaults on this deferred payment agreement may be required by the utility to furnish a deposit for the remaining balance.

(5) WRITTEN EXPLANATION. A utility shall provide a written explanation of why a deposit or guarantee is being required for a residential account. The explanation shall include notice of the customer's right to appeal any deposit request or amount required under this section to the commission.

(6) REASONABLENESS OF DEPOSIT. When requesting a deposit from a residential customer, the utility shall consider the customer's ability to pay in determining the reasonableness of its request, including the following factors:

(a) Size of the delinquent account;

(b) Customer's payment history;

(c) Time that the debt has been outstanding;

(d) Reasons why the debt has been outstanding;

(e) Any other relevant factors concerning the circumstances of the customer, such as household size, income, and reasonable expenses.

(7) AMOUNT OF DEPOSIT. The maximum deposit for a new or existing residential account shall not exceed the highest estimated gross bill for any consecutive billing period (not to exceed 4 months) selected by the utility.

(8) REFUSAL OR DISCONNECTION OF SERVICE. Residential service may be refused or disconnected for failure to pay a deposit request under the procedures in s. PSC 185.37.

(9) INTEREST. (a) Deposits for residential accounts shall bear interest payable from the date a deposit is made to the date it is applied to an account balance or is refunded.

(b) The interest rate to be paid shall be subject to change annually on a calendar year basis. The commission shall determine the rate of interest to be paid on deposits held during the following calendar year and notify the utility of that rate by December 15 of each year. The rate shall be equal to the weekly average yield of one−year United States treasury securities adjusted for constant maturity for the week ending on or after December 1 made available by the federal reserve board, rounded to the nearest tenth of one percent.

(c) The rate of interest set by the commission shall be payable on all deposits. The utility shall calculate the interest earned on each deposit at the time of refund and at the end of each calendar year. The interest rate in a calendar year shall apply to the amount of the deposit and to all interest accrued during the previous year, for the fraction of the calendar year that the deposit was held by the utility.

(10) REFUND. The utility shall refund the deposit of a residential customer after 12 consecutive months of prompt payment.

(11) REVIEW. The utility shall not continue to require a cash deposit for a residential account unless a deposit is permitted under the provisions of sub. (4) or (10).

(12) METHOD OF REFUND. Any deposit or portion refunded to a residential customer shall be refunded by check unless both the customer and the utility agree to a credit on the regular billing, or unless sub. (13) or (14) applies.

(13) REFUND AT TERMINATION OF SERVICE. On termination of residential service, the utility shall credit the deposit, with accrued interest, to the customer's final bill and return the balance within 30 days of issuing the final bill.

(14) ARREARAGES. An arrearage owed by a residential customer may be deducted from the customer's deposit under any of the following conditions:

(a) Except as provided in par. (c), a deposit may be used by the utility only to satisfy an arrearage occurring after the deposit was made;

(b) If the utility deducts an arrearage from a customer deposit, it may require the customer to bring the deposit up to its original amount. Failure of the customer to do so within 20 days of mailing a written request for payment is a ground for disconnection;

(c) When a deposit is refunded to the customer, the utility may first deduct any arrearage owed by the customer, whether the arrearage arose prior to or after the date of the deposit.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.361 Deposits for nonresidential service. **(1)** NEW NONRESIDENTIAL SERVICE. If the credit of an applicant for nonresidential service has not been established satisfactorily to the utility, the utility may require the applicant to post deposit. The utility shall notify the applicant within 10 days of the request for service as to whether a deposit shall be required. The 10−day period shall begin from the date the applicant provides all information requested under s. PSC 185.305 (2) to the utility. If no request for a deposit is made within this period, no deposit shall be required, except under the provisions of sub. (2). If a request for a deposit is made, the applicant shall be given at least 30 days to provide payment, or guarantee, or to establish a deferred payment agreement.

(2) EXISTING NONRESIDENTIAL SERVICE. The utility may require an existing nonresidential customer to furnish a deposit if any of the following apply:

(a) The customer has not made prompt payment of all bills within the last 24 months;

(b) The utility has disconnected the customer's service within the last 12−month period for violation of the utility's filed rules or for nonpayment of a delinquent service account not currently in dispute;

(c) Subsequent credit information indicates that the initial application for service was falsified or incomplete to the extent that a deposit would be required under this section;

(d) When the utility requests a deposit of an existing customer, the customer shall have 30 days to provide the deposit, guarantee, or to establish a deferred payment agreement.

(3) CONSIDERATIONS FOR DEPOSIT. In determining whether an applicant for nonresidential service has satisfactorily established credit, the utility shall inform the applicant that it shall consider any or all of the following factors, provided by the applicant, before requiring a security deposit:

(a) Credit information from a credit reporting service;

(b) Letter of credit from a financial institution or another utility;

(c) Applicant's business characteristics, including type of business, estimated size of the utility bills, previous bill payment history, and applicant's business experience;

(d) Assets of the business;

(e) The financial condition of the business, as indicated in a financial statement.

(4) GUARANTEE TERMS AND CONDITIONS. (a) The utility may accept, in lieu of a cash deposit for new or existing nonresidential service, a contract signed by a guarantor satisfactory to the utility where payment of a specified sum not exceeding the cash deposit requirement is guaranteed. The term of such contract shall be for no longer than 2 years, but it shall automatically terminate after the customer has closed its account with the utility, or at the guarantor's request, on a 30−day written notice to the utility.

(b) On termination of a guarantee contract, or whenever the utility deems the amount of surety insufficient, a cash deposit or a new or additional guarantee may be required on a 20−day written notice to the customer. The service of a customer who fails to comply with these requirements may be disconnected on a 10−day written notice, subject to the establishment of a deferred payment agreement for the deposit.

(c) The utility shall mail the guarantor copies of all disconnect notices sent to the customer whose account has been guaranteed, unless the guarantor waives such notice in writing.

(5) WRITTEN EXPLANATION. (a) A utility shall provide a written explanation of why a deposit or guarantee is being required for nonresidential service. The explanation shall include notice of the customer's right to appeal any deposit request or amount required under this section to the commission.

(b) The written explanation shall also inform the customer that if, after 12 months of utility service, the deposit amount is greater than necessary based on actual consumption, the customer may request refund of the difference between the 2 amounts.

(6) REFUSAL OR INTERRUPTION OF SERVICE. Nonresidential service may be refused or disconnected for failure to pay a deposit request, subject to the s. PSC 185.37 pertaining to disconnection and refusal of service.

(7) AMOUNT OF DEPOSIT. The maximum deposit for a new account shall not exceed the highest estimated gross bill for any consecutive billing period selected by the utility (not to exceed 4 months). If after a 12−month period the deposit amount is shown to be greater than warranted based on actual consumption, the utility shall at the customer's request refund the difference between the 2 amounts plus interest.

(8) INTEREST. (a) Deposits for nonresidential service shall bear interest from the date a deposit is made to the date it is applied to an account balance or refunded.

(b) The interest rate to be paid shall be subject to change annually on a calendar basis. The commission shall determine the rate of interest to be paid on deposits held during the following calendar year and notify the utility of the rate by December 15 of each year. The rate shall be equal to the weekly average yield of one−year United States treasury securities adjusted for constant maturity for the week ending on or after December 1 made available by the federal reserve board, rounded to the nearest tenth of one percent.

(c) The rate of interest set by the commission shall be payable on all deposits. The utility shall calculate the interest earned on each deposit at the time of the refund and at the end of each calendar year. The interest rate in a calendar year shall apply to the amount of the deposit and to all interest accrued during the previous year, for the fraction of the calendar year that the deposit was held by the utility.

(9) TIME OF REFUND. The deposit of a customer shall be refunded after 24 consecutive months of prompt payment.

(10) METHOD OF REFUND. Any deposit or portion thereof refunded to a customer shall be refunded by check unless both the customer and the utility agree to a credit on the regular billing, or unless sub. (11) or (12) applies.

(11) REFUND AT TERMINATION OF SERVICE. Upon termination of service, the deposit with accrued interest, shall be credited to the final bill, and the balance shall be returned within 30 days of issuing the final bill.

(12) ARREARAGES. An arrearage owed by a customer may be deducted from the customer's deposit under the following conditions:

(a) Except as provided in par. (c), a deposit may be used by the utility only to satisfy an arrearage occurring after the deposit was made;

(b) If the utility deducts an arrearage from a customer deposit, it may require the customer to bring the deposit up to its original amount. Failure of the customer to do so within 20 days of mailing a written request for payment is a ground for disconnection;

(c) When a deposit is refunded to the customer, the utility may first deduct any arrearage owed by the customer, whether the arrearage arose prior to or after the date of the deposit.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: am. (4) (b), Register October 2001 No. 550, eff. 11−1−01; correction in (1) made under s. 13.92 (4) (b) 7., Stats., Register July 2014 No. 703.

PSC 185.37 Disconnection and refusal of service. **(1)** (a) In no circumstances shall the cumulative time before notice of disconnection be less than 20 days after the date of issuance of the bill. An account may be deemed delinquent for the purpose of disconnection after such period has elapsed.

(b) At least 10 calendar days prior to disconnection, the utility shall give a written notice of disconnection upon a form approved by the commission and which conforms to the requirements of sub. (11) unless excepted elsewhere.

(c) When a customer, either directly or through the commission, disputes a disconnection notice, the utility shall investigate any disputed issue and shall attempt to resolve that issue. During this investigation, utility service shall not be disconnected over this matter.

(d) If a disputed issue cannot be resolved pursuant to s. PSC 185.39 (1), the utility shall inform the customer of the right to contact the commission.

(1m) Prior to disconnecting a jointly−metered property containing more than one rental dwelling unit and where service is in the property owner's or manager's name, the utility shall first make an attempt to transfer the debt to the property owner's or manager's residence or office service. If a transfer is permitted under sub. (7) (a) the utility shall pursue available collection efforts at the owner's or manager's property prior to disconnecting the jointly−metered property.

(2) Utility service may be disconnected or refused for any of the following reasons:

(a) Failure to pay a delinquent account or failure to comply with the terms of a deferred payment agreement (see s. PSC 185.38);

(am) Delinquency in payment for service received by a previous account holder or customer at the premises to be served, if an account is transferred to a new account holder or customer and the previous account holder or customer continues to be an occupant of the dwelling unit to be served.

(b) Failure to pay for an outstanding account balance with the utility owing at a previous address and for which there is no agreement or arrangement for payment and it is not in dispute but remains outstanding;

(c) Failure to comply with deposit or guarantee arrangements as specified in s. PSC 185.36 or 185.361;

(d) Diversion of service around the meter;

(e) Refusal or failure to permit authorized utility personnel to read the meter at least once every 4 months where the utility bills monthly or bimonthly, or at least once every 9 months where the utility bills quarterly or less frequently than quarterly. The 4− or 9− month period begins with the date of the last meter reading;

(f) Refusal or failure to permit authorized utility personnel access to the base meter;

(g) Violation of the utility's rules pertaining to the use of service in a manner which interferes with the service of others or to the operation of nonstandard equipment, if the customer has first been notified and provided with reasonable opportunity to remedy the situation;

(h) Failure to comply with Wisconsin statutes, commission rules, or commission orders pertaining to utility service;

(i) Failure to pay costs or fees incurred by and awarded to the utility by a court of law, for pursuit of collection of bills, or failure to pay extraordinary collection charges as allowed and specified in the utility's tariffs filed with the commission;

(j) Failure to comply with the utility's rules or if the customer uses a device that unreasonably interferes with communications or signal services used for reading meters;

(k) Failure of an applicant for utility service to provide the information or documentation required by ss. PSC 185.30 or 185.305.

(3) A utility may disconnect utility service without prior notice where a dangerous condition exists for as long as the condition exists. Upon disconnection, the utility shall provide a written explanation of the dangerous condition.

(4) Service may be discontinued with a written 24−hour notice for nonpayment of a bill covering surreptitious use of water.

(5) (a) Any one of the items under subd. 1. or any 2 of the items under subd. 2. shall constitute adequate verification of identity and residency, although a utility may accept other forms of verification:

1. Photo identification card, driver's license, or U.S. military card;

2. Social security card, birth or baptismal certificate, or letter of identification from a social service agency or employer.

(b) An applicant denied or refused service because of this subsection shall be informed in writing of the opportunity to dispute the matter through the commission, and shall be provided with the address and telephone number of the commission.

(6) A public utility may disconnect residential utility service, without notice, where it has reasonable evidence that utility service is being obtained by potentially unsafe devices or potentially unsafe methods that stop or interfere with the proper metering of the utility service.

(7) (a) Account arrears incurred by an owner or property manager for rental residential dwelling units may be transferred, without regard to class of service, to the home or office account of the owner or property manager.

(b) The utility shall send written notice of the planned transfer of the account arrears to the owner or property manager prior to making the transfer.

(c) If the transferred account arrears remain unpaid, the utility may disconnect the owner's or property manager's residence or office service, provided that the utility complies with the disconnection provisions of s. PSC 185.37.

(8) Utility service may not be disconnected or refused for any of the following reasons:

(a) Nonpayment of a delinquent account over 6 months old where collection efforts have not been made within that period of time unless the passage of additional time results from other provisions of this chapter or from good faith negotiations or arrangements made with the customer;

(b) Failure to pay for merchandise or charges for nonutility service billed by the utility, except where authorized by law as in s. PSC 185.33 (1) (h);

(c) Failure to pay for a different type or class of utility service, except as provided by sub. (7) (c);

(d) Failure to pay the account of another customer as guarantor of that account;

(e) Failure to pay charges arising from any underbilling occurring more than one year prior to the current billing;

(f) Failure to pay an estimated bill other than a bill rendered pursuant to an approved billing tariff or the customer upon request refuses to permit the reading of the meter during normal business hours;

(g) For the intentional removal or eviction of a tenant from rental property;

(h) The utility may not disconnect service in affected counties when a heat advisory, heat warning, or heat emergency issued by the national weather service is in effect. A utility shall make reasonable attempts to reconnect service to an occupied dwelling that has been disconnected when an occupant states that there is a potential threat to health or life that results from the combination of the heat and loss of service. The utility may require that an occupant produce a licensed physician's statement or notice from a public health, social services, or law enforcement official which identifies the medical emergency for the occupant. Upon expiration of the heat advisory, heat warning, or heat emergency, the utility may disconnect service to a property that was reconnected during this period without further notice if an appropriate payment arrangement has not been established.

(8m) If the utility is provided notice that there are extenuating circumstances, such as infirmities of aging, developmental, mental or physical disabilities, the use of life support systems, or like infirmities incurred at any age, or the frailties associated with being very young, the utility shall take these circumstances into consideration and ensure compliance with s. PSC 185.37 (10) prior to disconnecting service.

(9) Residential water utility service to an occupied dwelling may not be disconnected during the period November 1 to April 15 if the water service is a necessary part of a dwelling's heating system.

(10) (a) Notwithstanding any other provision of this section, a utility may not disconnect service or refuse to reconnect service to a residential customer if disconnection shall aggravate an existing medical or protective services emergency of the occupant, a member of the customer's family or other permanent resident of the premises where service is rendered and if the customer conforms to the procedures described in par. (b).

(b) A utility shall postpone the disconnection of service, or reconnect the service if disconnected, for 21 days to enable the occupant to arrange for payment, if the occupant produces a licensed Wisconsin physician's statement or notice from a public health, social services, or law enforcement official which identifies the medical or protective services emergency and specifies the period of time during which disconnection shall aggravate the circumstances. The postponement may be extended by renewal of the statement or notice. During this 21 days of service, the utility and occupant shall work together to develop resources and make reasonable payment arrangements in order to continue the service on a permanent basis. Further postponements may be granted if there is evidence of reasonable communication between the utility and occupant in attempting to make arrangements for payment.

(c) During the period service is continued under the provisions of this subsection, the customer shall be responsible for the cost of residential utility service. However, no action to disconnect that service shall be undertaken until expiration of the period of continued service. Any customer who is in this continued service category shall be admitted into appropriate and special payment plan programs the utility may offer.

(d) If there is a dispute concerning an alleged existent medical emergency, either party shall have the right to an informal review by the commission staff. Pending a decision after informal review, residential utility service shall be continued, provided that the occupant has submitted a statement or notice as set forth in par. (b).

(11) (a) A utility shall not disconnect service unless written notice by first class mail is sent to the customer or personally served upon a responsible party at least 10 calendar days prior to the first date of the proposed disconnection except as provided in subs. (3), (4), and (7). If the billing address is different from the service address, notice shall be posted at each individual dwelling unit of the service address not less than 5 days before disconnection. If access is not possible, this notice shall be posted, at a minimum, to all entrances to the building and in the lobby. The notice shall contain: 1) the date of the notice; 2) the proposed date of disconnection; and 3) that, if feasible, the occupants may apply to the utility to accept responsibility for future bills and avoid disconnection of service. Refusal or acceptance of the application for service is subject to those conditions set out in this chapter. If disconnection is not accomplished on or before the 20th day after the first notice date, a subsequent notice shall be left on the premises not less than 24 hours nor more than 48 hours prior to the disconnection unless the customer and the utility agree to extend the 20−day time period.

(b) The utility shall make a reasonable effort to have a personal or telephone contact with the residential customer prior to disconnection. If a contact is made, the utility shall review the reasons for the pending disconnection of service, and explain what actions shall be taken to avoid disconnection.

(c) The utility shall keep a record of these contacts and contact attempts.

(d) When a residential customer, either directly or through the commission, disputes a disconnection notice under s. PSC 185.37, the utility shall investigate any disputed issue and shall attempt to resolve that issue. During this investigation, utility service shall not be disconnected over this matter.

(e) If a disputed issue cannot be resolved, the utility shall inform the customer of the right to appeal to the commission.

(f) Disconnection notice shall be given on a form approved by the commission, and shall contain the following information:

1. The name and address of the customer and the address of the service, if different;

2. A statement of the reason for the proposed disconnection of service and that disconnection shall occur if the account is not paid, or if arrangement is not made to pay the account under deferred payment agreement, or if other suitable arrangements are not made, or if equipment changes are not made. If disconnection of service is to be made for default on a deferred payment agreement, the notice shall include an explanation of the acts of the customer which are considered to constitute default;

3. A statement that the customer shall communicate immediately upon receipt of the notice with the utility's designated office, listing a telephone number, if the customer disputes the notice of delinquent account, if the customer wishes to negotiate a deferred payment agreement as an alternative to disconnection, if any resident is seriously ill, or if there are other extenuating circumstances, as the presence of infants or young children in the

household, the presence of aged, or persons with disabilities in the household, the presence of residents who use life support systems or equipment or residents who have mental retardation or other developmental or mental disabilities;

4. A statement that residential utility service shall be continued for up to 21 days during serious illness if the account holder submits a statement or notice pursuant to sub. (10);

5. A statement that the customer may appeal to the commission staff in the event that the grounds for the proposed disconnection or the amount of any disagreement remains in dispute after the customer has pursued the available remedies with the utility.

(12) Service shall not be disconnected on a day, or on a day immediately preceding a day, when the business offices of the utility are not available to the public for the purpose of transacting all business matters unless the utility provides personnel which are readily available to the customer 24 hours per day to evaluate, negotiate, or otherwise consider the customer's objection to the disconnection as provided under s. PSC 185.39, and proper service personnel are readily available to restore service 24 hours per day.

(13) Notwithstanding any other provision of this chapter, utility service may not be refused because of a delinquent account if the customer or applicant provides, as a condition of future service a deposit or guarantee, as governed by s. PSC 185.36, or a voucher agreement. If the guarantor has agreed to be responsible for payment of all future bills, the customer shall be notified of the billing arrangement and of the ability to reject the proposed arrangement.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: am. (1) (b), (2) (e) and (L), (8) (h), (9) and (11) (a), cr. (1m), (2) (am) and (8m), Register October 2001 No. 550, eff. 11−1−01; CR 13−048: am. (2) (k), r. (2) (L) Register July 2014 No. 703, eff. 8−1−14.

PSC 185.38 Deferred payment agreement. (1) A utility is required to offer deferred payment agreements to residential accounts and encouraged to offer such agreements to other customers.

(2) Every deferred payment agreement entered into due to the customer's inability to pay the outstanding bill in full shall provide that service shall not be discontinued if the customer pays a reasonable amount of the outstanding bill, agrees to pay the remaining outstanding balance in installments, and agrees to pay the current bill by the due date.

(3) For purposes of determining reasonableness in sub. (2), the parties shall consider the customer's ability to pay, including the following factors:

(a) Size of the delinquent account;

(b) Customer's payment history;

(c) Time that the debt has been outstanding;

(d) Reasons why the debt has been outstanding;

(e) Any other relevant factors concerning the circumstances of the customer such as household size, income, and necessary expenses.

(4) A deferred payment agreement offered by a utility shall state immediately preceding the space provided for the customer's signature and in bold face print at least 2 sizes larger than any other print used, that:

(a) You have the right to suggest a different payment agreement;

(b) If you believe the terms of this agreement are unreasonable, DO NOT SIGN IT;

(c) If you and the utility cannot agree on terms, you may ask the commission to review the disputed issues;

(d) If you sign this agreement, you agree that you owe the amount due under the agreement;

(e) Signing this agreement does not affect your responsibility to pay for your current service. Allowing any bill for current service to become delinquent places you in default of this agreement.

(4m) A utility that does not require a written deferred payment agreement shall communicate to the customer all points listed in sub. (4) except those pertaining to a signature when making the arrangement with the customer. A utility shall send written confirmation of a deferred payment agreement upon customer request. The commission may require a utility to use written deferred payment agreements if it has evidence that the terms of the agreements are not being effectively communicated to customers.

(5) A delinquent amount, including late payment charges covered by a deferred payment agreement, shall not be subject to an additional late payment charge if the customer meets the payment schedule, including the current bill required by the agreement. A deferred payment agreement shall not include a finance charge.

(6) If an applicant for utility service or current customer has not fulfilled terms of a deferred payment agreement and there has not been a significant change in the customer's ability to pay since the agreement was negotiated, the utility shall have the right to disconnect pursuant to disconnection of service rules (s. PSC 185.37) and under such circumstances, it shall not be required to offer subsequent negotiation of a deferred payment agreement prior to disconnection.

(7) Any payments made by a customer solely in compliance with a deferred payment agreement, and not as part of a payment for other utility services, shall first be considered as payment toward the deferred payment agreement with any remainder credited to the current bill. Payments made to satisfy a current bill for utility service, which may include a portion for a deferred payment agreement, shall be credited as set forth in s. PSC 185.33 (4).

(8) If a deferred payment agreement cannot be reached because the customer's offer is unacceptable to the utility, the utility shall inform the customer in writing why the customer's offer was not acceptable.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: cr. (4m), Register October 2001 No. 550, eff. 11−1−01.

PSC 185.39 Dispute procedures. (1) Whenever the customer disputes the utility's request for a deposit or other guarantee, or advises the utility's designated office prior to the disconnection of service that all or any part of any billing as rendered is in dispute, or that any matter related to the disconnection or refusal of service is in dispute, the utility shall:

(a) Investigate the dispute promptly and completely;

(b) Advise the customer of the results of the investigation;

(c) Attempt to resolve the dispute;

(d) Provide the opportunity for residential customers, nonresidential customers at utility discretion, per s. PSC 185.38 (1) to enter into a deferred payment agreement when reasonable in order to resolve the dispute.

(2) (a) After the customer has pursued the available remedies with the utility, the customer may request that the commission staff informally review the disputed issue and recommend terms of settlement.

(b) A request for informal review may be made in any reasonable manner such as by written or telephone request directed to the commission. Either by telephone or written request, the commission staff may request the utility to investigate the dispute.

(c) The utility shall designate employees for responding to commission complaints who are readily available and have an appropriate and sufficient authority level for investigating and resolving concerns raised by the commission and its staff. Utilities shall provide the names of the designated employees to the commission and shall promptly inform the commission of any changes in these designations. A utility shall respond to the public service commission staff's request for an investigation by attempting to contact the complainant within 48 hours for most circumstances, or 4 hours in an emergency situation, and by providing a response to the commission within 10 business days. Staff may extend this time period if the utility requests more time to complete its investigation. Based on information provided by the utility and the customer, the commission staff shall make an informal determination for settlement of the dispute and communicate that determination to both parties. Either party to the dispute may request and receive the commission staff determination, and the basis for it, in writing. Commission staff shall inform any customer disputing an informal determination of the right to pursue a formal review.

(d) There shall be at least 7 calendar days between the date the commission staff telephones or mails written notice of terms of settlement after informal review and any subsequent disconnection.

(3) (a) After informal review, any party to the dispute may make a written request for a formal review by the commission. To avoid disconnection pending a formal review, the customer shall request a formal review by the commission, in writing, within 7 calendar days of the issue of the informal determination. All other requests for formal review shall be made within 30 calendar days of the date the commission staff telephones or provides written notice of terms of the settlement after informal review. If written confirmation is requested, the 30−day period begins from the date of that mailing.

(b) Within 7 calendar days of receiving a request for formal review in a dispute involving a pending disconnection of service, the commission shall make a determination whether to grant the request for formal review. The commission shall base its determination on the request for formal review and commission staff's informal complaint file. Within 35 calendar days from the time that all other requests for formal review are made, commission staff shall provide the commission with a memorandum based on the information it has received from the utility and the customer. A copy of the commission staff memorandum shall be provided to the parties 15 calendar days prior to consideration by the commission. Either party to the complaint may file a response to the commission staff's memorandum. These comments shall be filed with the commission 2 working days prior to the date scheduled for consideration by the commission. The commission shall inform both parties of its decision.

(4) Either party to the complaint may request that the commission reconsider its formal determination under this section. Such requests shall comply with s. 227.49, Stats., and shall be received by the commission within 20 days of mailing of the commission's determination. A request for reconsideration shall include any additional information or arguments that the party believes were not considered in the original complaint. The commission may review and reaffirm its original decision, issue a new decision, or decide to hold hearing on the matter for the gathering of additional information.

(5) (a) If the commission decides to conduct a formal hearing under sub. (4) on the dispute, the commission may condition the terms of its granting a formal hearing. Failure to meet these conditions before hearing shall constitute waiver of the dispute by the customer.

(b) The hearing shall conform to the procedures of ss. 196.26 to 196.34, Stats.

(c) Any such hearing shall be held not less than 10 days following a notice of hearing and a decision thereon shall be rendered following the conclusion of the hearing.

(6) Utility service shall not be disconnected or refused because of any disputed matter while the disputed matter is being pursued in accordance with the provisions of this section. The utility shall inform the customer that pursuing a disputed matter does not relieve the customer of the obligation of paying charges which are not in dispute, prevent disconnection of service for nonpayment of undisputed charges, or prevent the application of the late payment charge to amounts in dispute and later determined to be correct.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: am. (2) (c), Register October 2001 No. 550, eff. 11−1−01.

Subchapter IV — Records

PSC 185.41 Employees authorized to enter a customer's premises. The utility shall keep a record of its employees authorized pursuant to s. 196.171, Stats., to enter a customer's premises.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.42 Customer complaints. Each utility shall investigate and keep a record of complaints from its customers in regard to safety, service, or rates, and the operation of its system. The record shall show complainant's name and address, the date the complaint is filed, the nature of the complaint, its resolution, and the date resolved.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.43 Construction records. (1) Every utility shall prepare and maintain a record of its utility plant. The records shall include a description of the unit of property, the year of its construction, and its location. They shall be in the form of a map or descriptive table.

(2) Class AB utilities are required by the uniform system of accounts to institute a perpetual inventory of their assets known as continuing property records. A continuing property record system shall contain the following criteria and detail:

(a) The system shall be arranged by plant accounts as prescribed by the Uniform System of Accounts;

(b) All property units shall be described in sufficient detail to permit their identification and shall have location information to allow verification of their physical existence;

(c) All property units shall be identified with construction costs to establish their original cost for capitalization and retirement accounting;

(d) The age and service life of property units shall be calculable for depreciation studies. The original cost, description, and age of the property unit at retirement shall be converted into mortality records and permanently retained. (See s. PSC 185.19);

(e) Source documents supporting the original cost and quantities of property units shall be preserved for a period of 6 years after the plant is retired. (See s. PSC 185.19.) An exception is when a utility maintains approved continuing property records and permanent mortality records, then supporting documents need only be preserved for a period of 6 years after construction is completed. This provision meets commission requirements but may not satisfy other record−keeping needs;

(f) Maps may be part of the continuing property records if they contain the description of the unit, its location, and the year of its construction. For maps to become the Continuing Property Record, the units shall be referenced to their original cost.

(3) A utility may apply for a waiver from any portion of subs. (1) and (2). Such application shall state the paragraphs to which a waiver is requested. Also, the utility shall provide the reasons it cannot or shall not have to comply with subs. (1) through (2) (f) and the impacts such a waiver would have on the utility's ability to maintain usable continuing property records, if any.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.44 Records and reports of service interruptions. (1) Each utility shall notify the commission as soon as possible of any unusual occurrence which has caused or is expected to cause an interruption of service for one hour or longer to all of the customers or 500 (or more) customers, whichever number is the smaller. (This supplement does not preempt the requirements of ch. PSC 104.)

Note: See also s. PSC 185.88, Interruptions of service.

(2) Each utility shall maintain a record of each interruption (as defined in sub. (1)) showing the date and time it began, the duration, the cause, and the approximate number of customers affected.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.45 Pumpage records. A record shall be kept of the amount of water pumped into the distribution system each day from each station. The daily pumpage shall be summarized by months and such daily records and monthly summaries kept on file.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.46 Metering equipment records. (1) METER TEST RECORDS. (a) A utility shall create a record of a meter test whenever a meter is tested. If the meter is tested again, the utility need not retain the previous test record once the information in that record has been entered in the meter history record. The meter test record shall include all of the following:

1. Identification of the meter.
2. The service address at which the meter is installed.
3. The date of the test.
4. A statement of "as found" accuracies.
5. A statement of "as left" accuracies, when applicable.
6. The name of the person making the test.

(b) Meter test records and meter history records may be kept as separate records or one record.

(2) METER HISTORY RECORDS. (a) Each utility shall keep a history record for each meter sufficient to fulfill the requirements of s. PSC 185.19, including all of the following:

1. The date the meter was placed into service.
2. The information in all of the meter's test records under sub. (1).
3. The date the meter was retired from service.

(b) Meter test records and meter history records may be kept as separate records or one record.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; **CR 13−033: r. and recr. (1), (2) Register July 2015 No. 715, eff. 8−1−15.**

PSC 185.47 Other records. Other required records which are referred to elsewhere in this chapter include records of adjustment of customer bills (s. PSC 185.35 (8)), main flushing (s. PSC 185.86), valve and hydrant operations, pumpage and metered consumption (s. PSC 185.85 (2)), and service interruptions (s. PSC 185.88).

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

Subchapter V — Engineering

PSC 185.51 Requirement for good engineering practice. The design and construction of the utility's water plant shall conform to good standard engineering practice and shall conform to the requirements of this chapter and the requirements of appropriate federal, state, and local regulatory authorities.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.52 General construction requirements. (1) MAINS. (a) *Installed depth*. Mains shall be placed at such depth or otherwise protected as shall prevent freezing.

(b) *Dead−ends.* Where practical the utility shall design its distribution system to avoid dead−end mains. Where dead−ends are necessary, hydrants or other flushing devices shall be installed to permit flushing. (See s. PSC 185.86.)

(c) *Networked systems.* Where practical the distribution system shall be laid out to maximize service reliability.

(d) *Segmentation of system.* Valves shall be provided at reasonable intervals and at appropriate locations so that repairs to or maintenance of the mains shall minimize service interruptions.

(e) *Location of mains.* Utility−owned mains shall be located either in public right−of−way, or in a readily accessible easement. As much as possible, easements shall be free of pavement, expensive landscaping, mobile home pads, etc.

(f) *Main ownership conditions.* A utility may choose whether or not it shall accept for ownership the mains within a mobile home park. Mains may only be accepted if they meet the utility's construction standards and the requirements of ss. PSC 185.51 and 185.52.

(2) SERVICE LATERALS. (a) *Installed depth*. Laterals shall be placed at such depth or otherwise protected as will prevent freezing.

(b) *Single connections.* A customer's lateral shall be directly connected to utility−owned facilities, and there shall be no other customer connection downstream from the utility's shut−off valve. This does not apply to multi−occupancy premises, such as apartments, condominiums, and shopping centers.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.53 Metering configuration. (1) MASTER METERING. Unless a utility owns the water distribution facilities within a mobile home park, condominium association, trust, etc., the private system shall be master metered and the park owner, condominium association, trust, etc., shall be the utility's billable customer.

(2) INDIVIDUAL METERING. A utility may only provide retail service directly to individual dwellings within a mobile home park, condominium association, trust, etc., if the distribution facilities within the mobile home park, condominium association, trust, etc., are owned by the utility on easements. Such facilities may only be accepted for ownership at a utility's discretion and only if the facilities meet the utility's construction standards and the requirements of ss. PSC 185.51 and 185.52.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

Subchapter VI — Customer Meters, Accuracy Requirements

PSC 185.61 Meters. (1) All meters used for measuring the quantity of water delivered to a customer shall be in good working condition. They shall be adequate in size and design for the type of service measured and shall be accurate to the standard specified in s. PSC 185.65. Cold water meters of the turbine type shall be used for metered service only where the actual flow rates fall entirely within the normal test flow limits of the meter. Flow meters, including magnetic and ultrasonic meters, may be used for customer metering only with the specific approval of the commission.

(2) Meters and remote reading devices necessary for the billing of utility service shall be owned and maintained by the utility except where otherwise authorized by the commission.

(3) A utility may sell meters if such meters are to be used solely for nonutility purposes, such as unregulated sewer service. This section does not prohibit the sale of meters between utilities.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.65 Accuracy requirements for meters. (1) The test flow limits for positive displacement, compound, and turbine meters shall be as follows:

Meter Size (inches)	Minimum Test Flow (g.p.m.)	Normal test flow limits (g.p.m.)
5/8	1/4	1−20
3/4	1/2	2−30
1	3/4	3−50
1 1/2	1 1/2	5−100
2	2	8−160
	Compound Meters	
2	1/2	2−160
3	1	4−320
4	1 1/2	6−500
6	3	10−1,000
8	4	16−1,600
10	8	32−2,300
12	14	32−3,100
	Turbine Meters*	
2	10	16−160
3	15	24−350
4	20	40−600
6	30	80−1400
8	50	144−2,500
10	75	224−3,800
12	100	320−5,800
16	150	400−11,500

Note: See AWWA Standards C−700 (Positive Displacement Meters), C−702 (Compound Meters), and C−701 (Turbine Meters).

Note: * See s. PSC 185.61 (1).

(2) Positive displacement meters shall have a percent registration between 98.5 and 101.5 within the range of normal test flow limits before being placed in service. In addition, new meters shall have a percent registration at the minimum test flow between 90 [95] and 101.5. In all other cases, the percent registration shall be between 90 and 101.5 before being placed in service. These requirements, in addition to flow, are shown in the table below.

Note: It is the intent of the commission that new meters have an accuracy limits percent between 95 and 101.5.

Summary of Test Conditions and Accuracy Requirements for Positive Displacement Meters

Size in.	Maximum Rate: Rate of Flow	Test Quantity		Accuracy Limits	Intermediate Rate: Rate of Flow	Test Quantity		Accuracy Limits	Minimum Rate: Rate of Flow	Test Quantity*		Accuracy Limits Percent	
	gpm	Gal.	Cu. Ft.	Percent	gpm	Gal.	Cu. Ft.	Percent	gpm	Gal.	Cu. Ft.	New Meters	Repaired Meters
5/8	15	100	10	98.5−101.5	2	10	1	98.5−101.5	1/4	10	1	95−101.5	90−101.5
3/4	25	100	10	98.5−101.5	3	10	1	98.5−101.5	1/2	10	1	95−101.5	90−101.5
1	40	100	10	98.5−101.5	4	10	1	98.5−101.5	3/4	10	1	95−101.5	90−101.5
1 1/2	80	1.000	100	98.5−101.5	8	100	10	98.5−101.5	1 1/2	100	10	95−101.5	90−101.5
2	120	1.000	100	98.5−101.5	15	100	10	98.5−101.5	2	100	10	95−101.5	90−101.5

* Section PSC 185.73 (3) provides that at this flow rate the test quantity may be reduced to that equivalent to one−half revolution of the test dial. For the typical 5/8−inch meter the minimum test quantity would, therefore, be 5 gal. or 1/2 cu. ft.

(3) Compound meters shall have a percent registration between 97 and 103 throughout the range of normal test flow limits. At flows within the change−over flow range, the percent registration shall not be less than 90%.

(4) Turbine meters shall have a percent registration between 97 and 103 throughout the range of normal test flow limits and a percent registration of at least 95% at the minimum test flow.

(5) For meter installations with remote reading devices the above accuracy requirements apply to the metering accuracy of the complete installation.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

Subchapter VII — Meter Testing

PSC 185.71 Meter testing facilities and equipment. **(1)** Each utility furnishing metered water service shall own or provide, through contract or otherwise, adequate equipment and facilities to provide for testing all of its water meters in compliance with this chapter.

(2) The meter testing facility shall, to the extent practical, simulate the actual service condition of inlet pressure and outlet pressure. It shall be provided with the necessary fittings, including a quick−acting valve for controlling the starting and stopping of the test, and a device for regulating the flow of water through the meter under test within the requirements of this chapter.

(3) The overall accuracy of the test equipment and test procedures shall be sufficient to enable the testing of service meters within the requirements of this chapter and regulations. In any event, the inherent overall accuracy of the equipment shall permit tests with an overall error of not to exceed 0.5 % at normal test flows and 1.0 % at the stated minimum test flow.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.72 Calibration of meter testing equipment. **(1)** Volumetric standards shall be accompanied by a dated certificate of accuracy from an approved laboratory or agency. For any weight standard used, the scales shall be tested periodically by an approved agency and a record maintained of the results of the test.

(2) A reference meter used for testing domestic or larger meters may be used only if the referenced meter has been tested and calibrated during the preceding 6 months. A record shall be kept of the 2 latest tests of any reference meter. (See also s. PSC 185.73 (1).)

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.73 Testing of customer meters. **(1)** The test of any customer meter shall consist of a comparison of its accuracy with that of a standard of known accuracy. Where the test standard consists of a previously calibrated reference or service meter, the test results for the customer meter shall be adjusted to compensate for the inaccuracies of the reference meter at the particular flow rates.

(2) A utility shall test a meter "as found," or before repair, and, unless the meter must be retained under s. PSC 185.77 (3), "as left," or after repair.

(3) The volume of water through the meter at each test flow point shall be sufficient to produce at least one revolution of the test dial except at the "minimum test flow" point when said volume of water shall produce at least one−half revolution of the test dial.

(4) A meter not meeting the accuracy or other requirements of s. PSC 185.61 or 185.65 shall, unless the meter must be retained under s. PSC 185.77 (3), be repaired or rebuilt to meet those requirements before further use.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; **CR 13−033: am. (2), (4) Register July 2015 No. 715, eff. 8−1−15.**

PSC 185.74 Test flows. **(1)** TESTS. The minimum test flow and "normal test flow limits" as used herein refer to those listed in s. PSC 185.65. The stated test flows apply for both As Found and As Left tests.

(2) POSITIVE DISPLACEMENT METERS. (See s. PSC 185.65 (2).) For each test, the percent registration shall be determined at each of the following test flows:

(a) The minimum test flow;

(b) Two test flows within the normal test flow limits, one to be approximately at the maximum registration and the other to be at a flow as high as practicable within the normal test flow limits.

(3) COMPOUND METERS. For each test it shall be determined whether or not the by−pass unit operates at the minimum test flow and, in addition, the percent registration shall be determined at each of the following test flows as determined from accuracy curves for the particular type and size of meter:

(a) The flow for maximum registration of the by−pass unit;

(b) A flow near the point of minimum registration within the change−over range;

(c) At least 3 flows within the normal test flow limits of the current unit, one of which is to be at the flow for maximum registration, one at approximately 50 % of such flow but above the change−over range, and one at as high a flow as practicable.

(4) TURBINE METERS. For each test the percent registration shall be determined at each of the following test flows:

(a) The minimum test flow;

(b) At least 3 flows within the normal test flow limits, one of which is to be at or near the lower limit, another as near as practicable to the upper limit, and one at an intermediate flow rate.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.75 Required tests of customer meters. Meters shall be tested by the utility at the following times:

(1) Before use or sample tests in accordance with s. PSC 185.751 shall include:

(a) Rebuilt meters;

(b) New Meters which are not certified accurate by the vendor.

(2) Periodically to insure accuracy, (see s. PSC 185.76);

(3) Upon customer request or complaint, (see s. PSC 185.77);

(4) When damaged or otherwise suspected of being inaccurate;

(5) If a meter is removed while a usage dispute is pending.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: am. (5), Register October 2001 No. 550, eff. 11−1−01.

PSC 185.751 Alternate sample−testing plan for "before−use" test for 5/8−, 3/4−, and 1−inch meters. **(1)** All rebuilt meters must be tested before use.

(2) Meters as received from the supplier without a certificate of accuracy shall be divided into lots of 36 or less. Each lot shall consist of meters of the same make, type, and size.

(3) A random−selected sample of 4 meters from each lot shall be selected and tested.

(4) If any of the tested meters in a given lot fail to meet the accuracy requirements of s. PSC 185.65 (2) for new meters, either the entire lot shall be rejected, or the utility shall test all meters in the lot, rejecting or correcting those found to be inaccurate.

(5) Records shall be maintained showing the identification numbers of all meters in each lot and the test results for the meters tested per s. PSC 185.19.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.76 Periodic tests. **(1)** Customer meters ("in−use" meters) shall be tested as frequently as is necessary to maintain their accuracies within requirements set forth in s. PSC 185.65. Unless otherwise authorized by the commission, each utility shall observe a test schedule such that the intervals between tests do not exceed the following:

METER TEST INTERVALS

Meter size (in.)	Test Interval (yr.)
5/8, 3/4, 1	10
1 1/2 and 2	4
3 and 4	2
6 and over	1

(2) Where local water conditions are such that meters shall not retain the required accuracy for the periods indicated, appropriate shorter test intervals shall be observed and may be specifically required by the commission.

(3) Where local water conditions permit and with specific commission approval, the test interval for 5/8−, 3/4−, and 1−inch meters may be extended. This contemplates that the utility shall demonstrate that the accuracy of its meters shall be retained for such period.

(4) For 3− and 4−inch meters, the above test interval may be extended to 4 years where the utility shall demonstrate that the accuracy of its meters shall be retained for this period.

(5) In lieu of testing every meter as required under sub. (1), a utility may satisfy the requirements of this section by testing meters according to s. PSC 185.761.

(6) When system losses are less than the prescribed percentages under s. PSC 185.85 (4), a utility in lieu of testing every meter as required under sub. (1), may satisfy the requirements of this section for 5/8, 3/4, and 1−inch meters by adopting a new meter replacement program that results in each meter being replaced within 20 years of the original date of installation.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: cr. (6), Register October 2001 No. 550, eff. 11−1−01.

PSC 185.761 Alternative sample−testing plan for in−use meters. (1) As an alternative to testing 100% of meters that require testing under s. PSC 185.76, a utility may test a population sample equal to 25% of the total to be tested of each meter size. This test sample shall be a random selection of the total to be tested and each meter size test shall be conducted independently. If 10% or more of the test sample does not meet the accuracy requirements of s. PSC 185.35, the utility shall test all meters of that size in accordance with s. PSC 185.76.

(2) Meters testing inaccurately under sub. (1) shall be repaired prior to being returned to service. The test sample selected shall be rescheduled for testing under the intervals set forth in s. PSC 185.76 (1). The meters not selected shall be rescheduled for testing at an interval not exceeding one−half the test intervals set forth in s. PSC 185.76 (1).

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.77 Request and referee tests. (1) REQUEST TESTS. Each utility shall promptly make an accuracy test without charge of any metering installation upon request of the customer if 24 months or more have elapsed since the last customer requested test of the meter in the same location. If less than 24 months have elapsed, an amount equal to one−half the estimated cost of the meter test shall be advanced to the utility by the customer. The amount shall be refunded if the test shows the meter to be over− or under−registering by more than 2%. A report giving the results of the test shall be made to the customer and a complete original test record shall be kept on file in the office of the utility. Upon request, the test shall be made in the presence of the customer during normal business hours.

(2) REFEREE TESTS. Any customer may request to have an official test of the meter observed by the commission.

(3) METER RETENTION. (a) *Definitions.* For purposes of this subsection, "as found" means retained, filled with water and capped without any other adjustments being made since the last test was performed.

(b) *After a customer requested test.* When a utility performs a customer requested test on a customer's meter under sub. (1) or when the commission requests that a meter be tested, the utility shall keep the tested meter, in "as found" condition, at a designated location on the utility's premises for at least one full billing period plus four weeks after the test result report is issued so that the meter is available should another meter test be requested. If the meter tests as accurate, the utility may choose to keep the tested meter installed at the customer's premises for the designated time period rather than storing it at the utility's premises.

(c) *After a referee test.* When a utility or third party retests a customer's meter under sub. (2), the utility shall keep the tested meter, in "as found" condition, at a designated location on the utility's premises for at least 10 business days after the test result report is issued so that the meter is available should further testing or review be needed. If the meter tests as accurate, the utility may choose to keep the tested meter installed at the customer's premises for the designated time period rather than storing it at the utility's premises.

(d) *When a complaint or dispute occurs.* When a utility receives a complaint under s. PSC 185.42 or is notified about a dispute under s. PSC 185.39 involving a meter−related issue, the utility shall keep the meter, in "as tested" condition, at a designated location on the utility's premises for at least one full billing period plus four weeks after the complaint or dispute and any appeal of that dispute is resolved so that the meter is available should testing be requested. If the meter was tested during the complaint or dispute process, and it tested as accurate, the utility may choose to keep the tested meter installed at the customer's premises for the designated time period rather than storing it at the utility's premises.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; **CR 13−033: am. (title), renum. 185.77 to (1) and am., cr. (1) (title), renum. 185.78 to (2), cr. (3) Register July 2015 No. 715, eff. 8−1−15; correct numbering of (3) (c), (d) under s. 13.92 (4) (b) 1., Stats., Register July 2015 No. 715.**

PSC 185.79 Remote outside meter (ROM) and automatic meter reading (AMR) system tests. (1) The ROM and AMR systems shall be tested each time the associated meter is tested. If the total recorded consumption of the ROM agrees with that of the base meter or the AMR system read and the base meter read are the same, no further testing of the ROM or AMR systems is needed.

(2) The test of metering installations with remotes shall be sufficient to demonstrate that the accuracy of the meter−remote combination meets the requirements of s. PSC 185.65.

(3) As an alternative to subs. (1) and (2), a utility may receive approval and place on file with the commission a remote testing schedule which is specifically designed to meet the needs of the remote metering system used by the utility.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.795 Electrical safety. Jumpering meter settings. Under certain abnormal conditions, a dangerous voltage may appear across the meter setting when the water line is electrically opened as by removal of the meter. Before a water meter is removed (or the interior piping leading to the service otherwise opened), an appropriate electrical jumper shall be connected across the meter setting or proposed opening in the piping to maintain electrical continuity. If the water supply piping is used as a ground for the building's electrical service, the electrical jumper shall not be removed until a meter is again set or the piping closed. The utility shall inform the customer that the electrical jumper shall not be removed until a meter is again set or the piping closed.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

Subchapter VIII — Operating Requirements

PSC 185.81 Quality of water. (1) Every water public utility shall provide water of such quality that it complies with state and federal requirements for drinking water.

(2) Each water utility system shall be designed and operated so that the water supplied to all customers is reasonably free from objectionable taste, color, odor, and sand or other sediment.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.82 Pressure standards. (1) Under conditions of normal heavy system demand the residual pressure at the meter outlet shall not be less than 20 p.s.i.g. For typical residential customers, normal conditions of use shall mean a flow rate of not less than 12 gallons per minute. This standard assumes that the customer's portion of the service lateral is of normal, adequate design, and in good condition. This standard shall ordinarily require that the distribution main pressure at the corporation stop connection be at least 35 p.s.i.g. The utility is to establish minimum specifications for the service lateral to assure that excessive pressure drop does not occur in the lateral because of its length or for other cause.

(2) The maximum pressure at the meter shall not exceed 125 p.s.i.g. The maximum pressure at the meter shall not exceed 100 p.s.i.g. for new systems and, to the extent practical, major additions to existing systems.

(3) Each utility shall have at least one permanently installed pressure gauge on its system and shall have access to indicating and recording pressure gauges to check pressure levels.

(4) Each utility shall make such pressure tests or surveys as to assure that the pressure limitations of subs. (1) and (2) are being met.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.83 Station meters. (1) Each pumping station shall be provided with station metering to accurately measure the water pumped into the distribution system. (See s. PSC 185.45.)

(2) Station meters shall be maintained to ensure reasonable accuracy and shall have the accuracy checked at least once every 2 years.

(3) Station meters shall be selected so that the actual flow rates are entirely within the normal flow range for the particular meter. These meters shall ordinarily be installed in the inlet rather than outlet line of pressure tank storage reservoirs.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.85 Water audits and water loss control. (1) DEFINITIONS. In this section:

(a) "Apparent loss" means the volume of water attributable to customer and station meter inaccuracies, billing and data transfer errors, unauthorized consumption, and theft.

(b) "Authorized consumption" means the volume of water used by metered and unmetered customers and the volume of water used for other purposes that is implicitly or explicitly authorized by the utility, including water used for flushing water mains and sewers, fire protection and training, street cleaning, public fountains, freeze prevention, and other municipal purposes regardless of whether the use is metered.

(c) "Non−revenue water" means the volume of water equal to the difference between the volume of water entering the distribution system and the volume of water that is sold.

(d) "Real loss" means the volume of water attributable to leaks and losses in the pressurized distribution system up to the customer meter, including water lost due to main breaks, service breaks, and tank and reservoir overflows.

(e) "Revenue water" means the volume of water entering the distribution system that is billed and for which the utility receives revenue.

(f) "Unaccounted−for water" means the volume of water entering the distribution system for which a specific use or purpose cannot be determined.

(g) "Water loss" means the difference between the volume of water entering the distribution system and authorized consumption.

Note: Water loss equals the sum of real and apparent losses that are caused by unauthorized consumption, meter inaccuracies, accounting errors, data processing errors, leaks in transmission and distribution mains, leaks in service connections up to the customer meter, seepage, overflow, evaporation, theft, malfunctioning distribution system controls, and other unaccounted−for water, as described in the American Water Works Association M36 manual – Water Audits and Water Loss Control Programs.

(2) UTILITY PRACTICES. A public utility shall do all of the following:

(a) Meter all water uses and sales, where practicable.

(b) Maintain and verify the accuracy of customer meters.

(c) Maintain and verify the accuracy of station meters.

(d) Identify and repair leaks in its distribution system to the extent that it is reasonable for the public utility to do so.

(e) Control water usage from hydrants.

(f) Maintain a continuing record of system pumpage and metered consumption.

(g) Conduct an annual water audit under sub. (3).

(3) WATER AUDITS. (a) A public utility shall conduct an annual water audit on a calendar year basis and submit the results of the audit to the commission no later than April 1 of the subsequent year.

(b) A public utility water audit shall include the measured or estimated volume of all of the following:

1. Water purchased or pumped from all sources.
2. Water used in treatment or production processes.
3. Water entering the distribution system.
4. Water sold, including both metered and unmetered sales.
5. Water not sold but used for utility−authorized purposes, including flushing mains, fire protection, freeze prevention, and other authorized system uses.
6. Water loss.
7. Unknown or unaccounted−for water.

(c) The components of a water audit are shown in Table 1.

Table 1. Water Audit Components

<table>
<tr><td rowspan="10">System Input Volume (Finished Water + Purchased Water)</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption (including water exported, wholesale sales)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption (Bulk water sales, utility uses)</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non−revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Loss</td><td>Unauthorized Consumption (Theft, uncontrolled hydrants, etc.)</td></tr>
<tr><td>Metering Inaccuracies (Customer, station meters)</td></tr>
<tr><td>Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections (Up to point of customer meter)</td></tr>
</table>

(4) WATER LOSS CONTROL. (a) Each public utility shall calculate its annual percentage of non−revenue water and its percentage of water loss, based on the volume of water entering its distribution system.

(b) A public utility shall submit to the commission a water loss control plan if a water audit shows the public utility has any of the following:

1. A percentage of non−revenue water that exceeds 30 percent.

2. A percentage of water loss that exceeds 15 percent for a Class AB or Class C utility or 25 percent for a Class D utility.

(c) A water loss control plan under par. (b) shall include all of the following:

1. The reasons for the excessive non−revenue water or water loss.

2. A description of the measures that the utility plans to undertake to reduce water loss to acceptable levels within a reasonable time period.

3. An analysis of the costs of implementing a water loss control program, including a comparison of lost sales revenue and the costs that would be avoided by reducing leaks and losses.

4. Any additional information required by the commission.

(d) The commission may require a public utility to conduct a leak detection survey of its distribution system if for three consecutive years the public utility's percentage of water loss exceeds 15 percent for a Class AB or Class C utility or 25 percent for a Class D utility.

History: CR 11−039: r. and recr. Register July 2012 No. 679, eff. 8−1−12.

PSC 185.86 Flushing mains. (1) Dead−end mains, or other low flow portions of distribution systems, shall be flushed as needed to eliminate or minimize complaints from consumers arising from an objectionable condition of water due to lack of circulation. Hydrants or other flushing devices shall be placed to allow for flushing of the entire system.

(2) When practical, public notice of proposed flushing shall be given by radio, newspaper announcement, or other appropriate means.

(3) A record shall be kept of all flushing of mains, showing date, place, and estimated volume of water used. This record shall be used to determine the necessary frequency of flushing and to estimate unmetered use.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97.

PSC 185.88 Frozen laterals. (1) Thawing of a customer's lateral shall be at the utility's expense if:

(a) The freeze−up is a direct result of a utility disconnect and the disconnection occurs during a time when conditions are such that freeze−up could reasonably be expected to occur or;

(b) The customer's portion of lateral is electrically conductive and:

1. It is the first thaw for the customer at the location and;

2. The utility has not provided the customer with seasonal notice of the corrective actions to be taken for a known condition.

(2) Lateral thawing shall be at the customer's expense if:

(a) The customer's lateral is not electrically conductive and the freeze−up is not a direct result of a utility disconnect as set forth in sub. (1) (a) or;

(b) The customer neglected to provide or maintain proper insulation or protection for the lateral according to standard accepted practice, or specific utility instructions on, for example, the required depth of burial needed to prevent freezing, or;

(c) The utility advises the customer of the corrective measures to be taken and the customer does not follow the utility's advice. (See s. PSC 185.35 (7) for bill adjustment where a utility requests a customer to let water flow to prevent freezing), or;

(d) If the utility disconnects for a dangerous condition.

History: Cr. Register, January, 1997, No. 493, eff. 2−1−97; CR 01−033: renum. from PSC 185.89 Register October 2001 No. 550, eff. 11−1−01; republished to reinsert inadvertently deleted (2) (c) Register March 2014 No. 699.

PSC 185.89 Adequacy of Water Supply, Emergency Operations and Interruptions of Service. (1) ADEQUACY OF WATER SUPPLY. A public utility shall exercise reasonable diligence to furnish a continuous and adequate supply of water to its customers.

(2) EMERGENCY OPERATION. (a) A public utility shall make reasonable provisions to meet an emergency resulting from the failure of power supply or from fire, storm, or similar events. A public utility shall inform its employees of procedures to be followed in an emergency to prevent or mitigate the interruption or impairment of water service.

(3) INTERRUPTIONS OF SERVICE. (a) A public utility shall make all reasonable efforts to prevent interruptions of service. If an interruption occurs, the public utility shall make reasonable efforts to re−establish service with the shortest possible delay, consistent with safety to its employees, customers, and the general public.

(b) If an emergency interruption significantly affects fire−protection service, a public utility shall immediately notify the fire chief or other responsible local official.

(c) A public utility shall make reasonable efforts to schedule planned interruptions at times that minimize customer inconvenience. A public utility shall make reasonable efforts to notify customers of the time and anticipated duration of a planned interruption.

(d) A public utility shall notify the Commission of a service interruption under s. PSC 185.44 (1).

History: CR 11−039: cr. Register July 2012 No. 679, eff. 8−1−12.

PSC 185.90 Water Supply Shortage. (1) DECLARATION. A public utility may declare a water supply shortage if the public utility cannot adequately meet customer demand due to drought, insufficient source capacity, or excessive demand.

(2) PLAN. A public utility may adopt a water supply shortage curtailment plan and file the plan with the commission under s. PSC 185.21.

(3) APPLICABILITY. Unless a public utility has adopted a water supply shortage curtailment plan under sub. (2), the provisions of this section apply.

(4) TEMPORARY CURTAILMENT. Except as provided in sub. (6), a public utility may temporarily curtail water service to some or all of its customers during a water supply shortage, if the curtailment is necessary to protect public utility facilities, to prevent a dangerous condition, or to alleviate a condition that presents an imminent threat to public health, welfare, or safety.

(5) UTILITY RESPONSIBILITIES. If a public utility determines that it is necessary to curtail service under this section, the public utility shall do all of the following:

(a) Make reasonable efforts to notify customers affected by the water supply shortage.

(b) Request all customers to enact voluntary water conservation measures to reduce water consumption, including limiting irrigation and other non−essential uses.

(c) Implement any curtailment in an equitable manner that allows the public utility to maintain reasonably adequate service to the greatest number of customers, consistent with public health, welfare or safety.

(d) Promptly restore service.

(6) APPROVAL TO CURTAIL ESSENTIAL USE CUSTOMERS. A public utility may not curtail service to a customer under this section without the commission's prior approval if the customer provides essential public health, welfare, or safety functions that require consistent water service or if any of the conditions described in s. PSC 185.37 (8) (h), (8m), (9), or (10) apply.

(7) REPORT. A public utility shall report to the commission within 7 days of declaring a water supply shortage. The public utility shall include in the report the reasons for any curtailment, the number of customers affected, the duration of the curtailment, and any other information requested by the commission.

History: CR 11−039: cr. Register July 2012 No. 679, eff. 8−1−12.

Subchapter IX – Water Conservation and Efficiency

PSC 185.95 Definitions. In this subchapter:

(1) "Net cost effectiveness" means the extent to which a water conservation program or measure is cost effective, after being adjusted for all of the following:

(a) The amount of water savings that would have been achieved in the absence of the water conservation program or measure.

(b) The amount of water savings directly attributable to the influence of the water conservation program or measure but that is not specifically included in the program or measure.

History: CR 11−039: cr. Register July 2012 No. 679, eff. 8−1−12; (1) (a), (b) renum. from (1) 1., 2. under s. 13.92 (4) (b) 1., Stats., Register July 2012 No. 679.

PSC 185.96 Customer Education Requirements. Upon a residential customer's request, a public utility shall provide information to the residential customer that may assist the customer in reducing outdoor water use, repairing residential water leaks, and implementing other water conservation measures. This information may be provided on the public utility's web site.

History: CR 11−039: cr. Register July 2012 No. 679, eff. 8−1−12.

PSC 185.97 Voluntary Water Conservation Rebate or Incentive Programs. (1) DEFINITION. In this section, "voluntary program" means a water conservation program a public utility voluntarily proposes to administer or fund that provides rebates or other direct financial incentives to customers for water−efficient products or services.

(2) REQUEST TO ADMINISTER OR FUND A VOLUNTARY PROGRAM. A public utility may not administer or fund a voluntary program without commission approval. A public utility may file a request with the commission for authorization to administer or fund one or more voluntary programs within its service area. A utility requesting a voluntary program shall provide all of the following information:

(a) A description of the proposed program, including the target market, eligible measures, delivery strategy, marketing and communications strategy, incentive strategy, and potential market effects.

(b) The proposed annual program budget, including administrative costs, and source of funding.

(c) Annual and multi−year performance targets that are consistent with commission goals and policies.

(d) A portfolio and program level net cost effectiveness analysis.

(e) A description of the public utility's proposed tracking and reporting system.

(f) A description of the public utility's proposed evaluation, measurement, and verification plan.

(g) A description of how the public utility will coordinate its voluntary program with any statewide water conservation program, including any requirements contained in ch. NR 852.

(h) Any other information the commission requests.

(3) APPROVAL OF VOLUNTARY PROGRAM. (a) The commission shall consider each of the following when deciding whether to approve a voluntary program:

1. Whether the program is in the public interest.

2. The likelihood the public utility will achieve its program goals.

3. The inclusion of appropriate water conservation measures.

4. The adequacy of the proposed budget.

5. The net cost effectiveness of the program.

6. The adequacy of the public utility's evaluation, measurement, and verification plan.

7. The level of coordination with any statewide water conservation program, including any requirements contained in ch. NR 852.

(b) Unless the voluntary program is included in a general rate proceeding, the commission shall issue its decision to approve, deny, or modify a proposed voluntary program in writing within 40 working days after receiving the proposal. If the commission denies or modifies a proposed voluntary program it shall explain its reasons for the denial or modification. If the commission denies a voluntary program, the public utility may revise and resubmit a request for approval of a voluntary program at any time.

(4) MODIFYING OR DISCONTINUING A VOLUNTARY PROGRAM. A public utility may request that the commission authorize the modification or discontinuation of a voluntary program at any time. A public utility may not modify or discontinue a voluntary program without commission approval.

(5) RETURN OF FUNDS. The commission may require a public utility to return any unspent funds collected for a voluntary program approved under this section to its ratepayers.

(6) ANNUAL REPORTS. A public utility receiving commission approval for a voluntary program under this section shall submit an annual report to the commission no later than April 1 following the covered year. The report shall include all of the following:

(a) A summary of program activities in the previous calendar year.

(b) An itemized accounting of administrative and program costs.

(c) The program balance or deficit at the end of the year.

(d) Estimated water savings attributable to the program, by customer class.

(e) The number of customers receiving rebates or other incentives.

(f) Estimated non−water benefits, including energy savings.

(g) Other performance metrics identified by the public utility.

(h) Any other information requested by the commission.

(7) AUDITS AND VERIFICATION. The commission may conduct an audit, or contract with an independent third−party evaluator to conduct an audit, to verify the performance of a public utility's voluntary program. The public utility shall pay for the costs of the evaluation, as determined by the commission.

History: CR 11−039: cr. Register July 2012 No. 679, eff. 8−1−12; (7) renum. from (6) under s. 13.92 (4) (b) 1., Stats., Register July 2012 No. 679.

Lead-Safe Milwaukee
Public Awareness Campaign

Sarah DeRoo
City of Milwaukee Health Department

Sandra Rusch Walton
City of Milwaukee Department of Public Works

December 9, 2016

Campaign Objectives

1. Build upon City efforts to continue reduction in childhood lead poisoning rates
    - 90.3% decline in prevalence at >10 ug/dL since 1997
    - 69.7% decline in prevalence at >5 ug/dL since 2003
    - 66% increase in blood lead testing since 1997
    - 17,555 housing units made lead-paint safe since 1997
2. Increase awareness and understanding of lead hazards
3. Promote prevention steps to reducing lead exposure
4. Increase screening for childhood lead exposure

Campaign Identity

Lead-Safe

Milwaukee

SAFE PAINT SAFE WATER SAFE KIDS

Campaign Messages

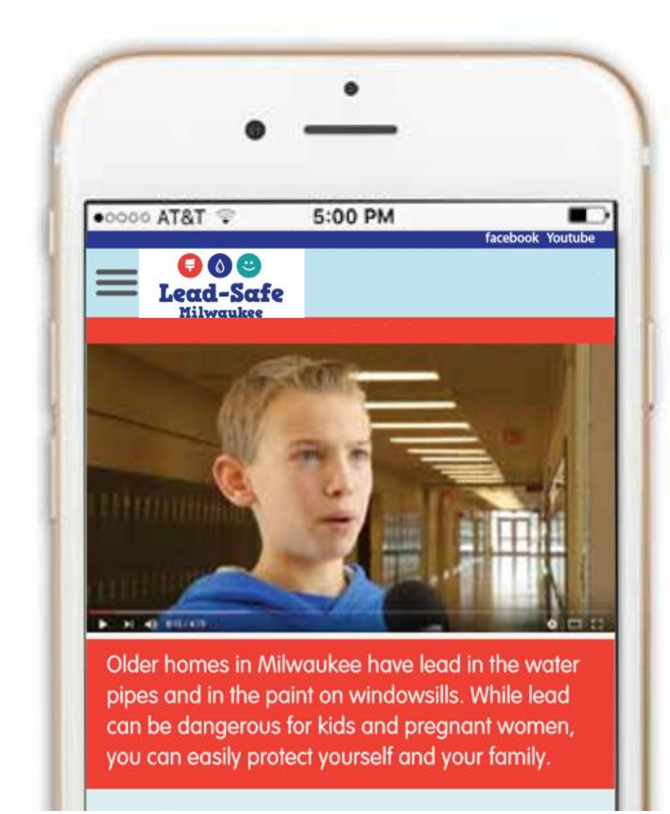
Being lead-safe at home is about three healthy habits

1. **Safe Paint:** Safely clean up & maintain lead-based paint hazards indoors and outdoors
2. **Safe Water:** Run your water when it's been sitting in your pipes
3. **Safe Kids:** Three tests before age 3

Campaign Tactics

- LeadSafeMKE.com informational site
- Outdoor and online advertising
- Print informational materials

*All materials to be developed in English & Spanish



Campaign Timeline

- Materials currently in development
- January 2017 roll-out
- Continued outreach and phases can be added

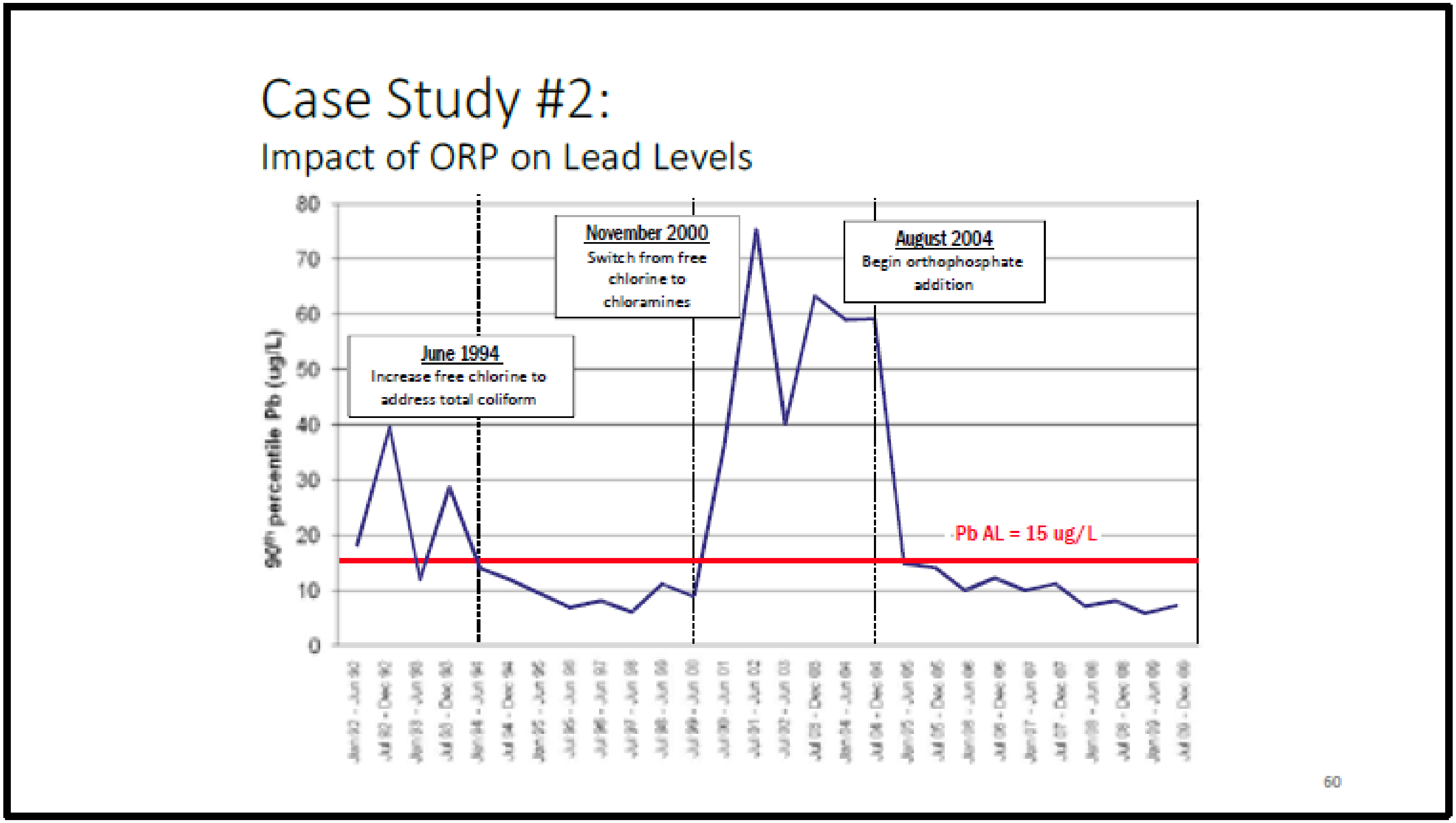
Sarah DeRoo
City of Milwaukee Health Department

Sandra Rusch-Walton
City of Milwaukee Department of Public Works

December 9, 2016

Slide from "Corrosion Control Treatment and Avoiding Unintended Consequences", presented by Christopher Hill at the Workshop on Optimizing Corrosion Control at the American Water Works Association's Water Quality Technology Conference, November 13, 2017.

These are sample results from Washington DC. Changes in ORP (oxidation reduction potential), such as those that occurred when the water system changed from free chlorine disinfection to chloramine disinfection, can cause lead release.



EPA NATIONAL DRINKING WATER ADVISORY COUNCIL

Together
We Can Protect
Drinking Water

December 15, 2015

Ms. Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington D.C. 20460

Dear Administrator McCarthy:

On behalf of the National Drinking Water Advisory Council (NDWAC or Council) and with unanimous agreement, I am pleased to provide recommendations for the long term revisions to the Lead and Copper Rule (LCR). The eventual long term revisions to the LCR will be an important opportunity for removing sources of lead in contact with drinking water and thereby reducing exposure to lead from drinking water.

Recognizing that there is no safe blood lead level, revisions to the LCR alone are not sufficient to address this critical issue. A comprehensive shared responsibility exists between federal, state and local government, public and private utilities, and customers. With other partners, such as the Housing and Urban Development (HUD), the Environmental Protection Agency (EPA or Agency) should lead a comprehensive collaborative national effort to reduce lead in drinking water.

The removal of all lead service lines will require significant financial resources and time. During this time it is essential to have in place a robust effort of consumer education and engagement to assure ongoing protection from exposure to lead in drinking water. Also, prior to adoption of the new rule the highest level of compliance with the existing rule must occur.

Please know the Council valued and considered in our deliberations and recommendations all public comments and opinions received.

The following discussion provides historical context and the Council's overarching strategic thoughts about reducing lead in drinking water. Under the Safe Drinking Water Act (SDWA) EPA sets public health goals and enforceable standards for drinking water quality.[1] The LCR is a

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1. EPA establishes National Primary Drinking Water Regulation (NPDWRs) under SDWA. NPDWRs either establish a feasible Maximum Contaminant Level (MCL) or a treatment technique, "to prevent known or anticipated adverse effects on the health of persons to the extent feasible."

treatment technique rule. Instead of setting a maximum contaminant level (MCL) for lead or copper, the rule requires public water systems (PWSs) to take certain actions to minimize lead and copper in drinking water, to reduce water corrosivity, and prevent the leaching of these metals from the premise plumbing and drinking water distribution system components and when that isn't enough, to remove lead service lines.

The current rule sets an action level, or concentration, of 0.015 mg/L for lead and 1.3 mg/L for copper. An action level is not the same as an MCL. A MCL is based on health effects; whereas an action level is a screening tool for determining when certain treatment technique actions are needed. Because the LCR is a treatment technique rule, the action level is based on the practical feasibility of reducing lead through controlling corrosion. In the LCR, if the action level is exceeded in more than ten percent of tap water samples collected during any monitoring period (i.e., if the 90th percentile level is greater than the action level), it is not a violation, but triggers other requirements that include water quality parameter monitoring, corrosion control treatment (CCT), source water monitoring/treatment, public education, and lead service line replacement (LSLR).

In early 2004, EPA commenced review of the implementation of the LCR. EPA released a Drinking Water Lead Reduction Plan in 2005, which outlined short-term and long-term goals for improving implementation. In 2007, EPA promulgated regulations that addressed the short-term revisions to the LCR that were identified in the 2005 Plan. The Agency has continued to work on long term issues that required additional data collection, research, analysis and full stakeholder involvement – with the eventual goal of promulgating long term revisions.

Seeing the need for additional stakeholder input, EPA requested that the NDWAC form a Lead and Copper Rule Working Group to consider several key questions and issues. The members of the Working Group brought diverse perspectives and expertise in preparation of the report developed and submitted for the NDWAC's consideration. The Council appreciates the extensive hard work and dedication of the Working Group members over many months and numerous face-to-face meetings. The Council recognizes the Working Group's respectful consideration of varying and detailed opinions and technical information.

With the following enhancements and considerations, the Council forwards the report to you in its entirety (attached) and unanimously agrees with its recommendations. Please note that the full economic ramifications of these possible long term revisions are not yet quantified and accordingly were not a significant part of the Council's deliberations.

The Council considers these recommendations an integrated package, rather than a menu of choices from which some options can be selected and combined with others. This package reflects a concerted attempt to strengthen public health protection, which includes utilizing the multiple approaches and resources available to PWSs to achieve the greatest public health value, including proactively engaging residents in opportunities to improve drinking water through the removal of lead in water.

The Council considers that the driving proactive principle to improve public health protection is removing full lead service lines from contact with drinking water to the greatest degree possible and minimizing the risks of exposure to the remaining sources of lead in the meantime. In framing the revisions, priority should be given to sensitive populations (pregnant women, infants and children). Additionally, environmental justice concerns including low-income populations should be considered by all levels of government. Following significant discussion, the Council emphasizes that the PWSs "control" means "ownership".

The NDWAC supports the Working Group's report with the following enhancements:

- Creating a national clearinghouse of information for the public and templates for PWSs, tailoring the Consumer Confidence Report, immediately engaging the health community to understand contribution of water to overall exposure to lead, adding targeted outreach and remedies to consumers with lead service lines;
- Improving consumer confidence in drinking water;
- Requiring corrosion control re-evaluation if changes to source water or treatment are planned;
- Clarifying the expectations for small- and medium-systems not requiring CCT under the current rule;
- Closing the science gaps and providing guidance in sampling methodologies and techniques to ensure the samples provide the desired information;
- Considering alternate ways to demonstrate steady-pace improvement in LSLR in addition to percentage targets;
- Investigating the need for a maximum number of customer-requested samples, and establishing criteria for satisfying the minimum number of samples;
- Establishing a health-based, household action level that triggers a report to the consumer and to the applicable health agency for follow up;
- Separating the requirements for copper from those for lead and focusing new requirements where water is corrosive to copper; and
- Establishing appropriate compliance and enforcement mechanisms.

Although leadership by the Agency is essential, reduction of exposure to lead in drinking water cannot be achieved by EPA regulation alone. The attached report includes recommendations for renewed commitment, cooperation and effort by government at all levels and by the general public. We urge EPA to play a leadership role not only in the revisions to the LCR but also in educating, motivating, and supporting the work of other EPA offices; federal, state and local agencies and other stakeholders.

On behalf of NDWAC, thank you for the opportunity to provide these recommendations. We look forward to providing further assistance as EPA considers these important issues.

Sincerely,

Jill D. Jonas
Chair,
National Drinking Water Advisory Council

cc: Joel Beauvais, Acting Deputy Assistant Administrator, Office of Water
Peter Grevatt, Director, Office of Ground Water and Drinking Water

Enclosure

Report of the Lead and Copper Rule Working Group
To the National Drinking Water Advisory Council

FINAL

AUGUST 24, 2015

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Appendices

Figures

Abbreviations

AL – Action Level
ALE – Action Level Exceedance
CCR – Consumer Confidence Report
CCT – Corrosion Control Treatment
DWLRP – Drinking Water Lead Reduction Plan
EPA – Environmental Protection Agency
LAL – Lead Action Level
LCR – Lead and Copper Rule
LCRWG – Lead and Copper Rule Working Group
LSL – Lead Service Line
LSLR – Lead Service Line Replacement
LTR LCR – Long Term Revisions to the Lead and Copper Rule
MCLG – Maximum Contaminant Level Goal
mg/L – Milligram per Liter
µg/L – Microgram per Liter
µg/dL – Microgram per Deciliter
NDWAC – National Drinking Water Advisory Council
OGWDW – Office of Ground Water and Drinking Water
OCCT – Optimum Corrosion Control Treatment
OWQP – Optimal Water Quality Parameter
PE – Public Education
pH – Negative log of hydrogen ion molar concentration
PLSLR – Partial Lead Service Line Replacement
POTW – Publicly Owned Treatment Works
POU – Point-of-use Treatment Device
PWS – Public Water System
SAB – Science Advisory Board
SDWA – Safe Drinking Water Act
DWSRF – Drinking Water State Revolving Fund
TT – Treatment Technique
WQP – Water Quality Parameter

Report of the Lead and Copper Rule Working Group to the National Drinking Water Advisory Council

1. Executive Summary

The Lead and Copper Rule Working Group (LCRWG) of the National Drinking Water Advisory Council (NDWAC) has completed its deliberations on issues associated with long term revisions to the Lead and Copper Rule (LCR). This report includes the group's findings and recommendations.

This executive summary provides a brief overview of the report. Details of the findings and recommendations are provided in the body of the report. A list of the members of the working group can be found in Appendix A.

1.1. Charge

The charge to the LCRWG was to provide advice to the NDWAC as it develops recommendations for the U.S. Environmental Protection Agency (EPA) on targeted issues related to long term revisions to the Lead and Copper Rule under the Safe Drinking Water Act (SDWA).

1.2. Findings and Recommendations

The anticipated Long Term Revisions to the Lead and Copper Rule (LTR LCR) is a very important opportunity for removing sources of lead in contact with drinking water and for reducing exposure to lead from drinking water in the meantime. Creative financing and robust public education also are essential.

The LCRWG took the following considerations, among others, into account in making recommendations for revisions to the LCR. A more detailed list of considerations is included in the full report.

There is no safe level of lead. Lead can pose health risks to anyone, but there are heightened risks for pregnant women, infants and young children and other vulnerable populations with both acute and chronic exposures. Effective elimination of leaded materials in contact with water and minimization of exposure to lead in drinking water is a shared responsibility; public water systems (PWSs), consumers, building owners, public health officials and others each have important roles to play. The lack of resources to reduce the sources of exposure in some communities, however, also raises important questions of disparate impact and environmental justice. Thus, creative financing mechanisms will be needed.

The LCR should remain a treatment technique rule, but it can be improved based on the scientific knowledge that has emerged since the current LCR was promulgated. Corrosion control treatment is complicated, and will vary based on specific circumstances in each public water system. Thus, regular updates to guidance by EPA based on the latest science and the creation of a national clearinghouse of information both for the public and for PWSs are needed.

The LCRWG considered but did not quantify the cost implications of its recommendations. An important factor in the group's deliberations was the principle that PWS and state resources should be focused on actions that achieve the greatest public health protection. Recognizing that lead service line (LSL) replacement programs will be costly in some locations, the LCRWG also encourages PWSs to incorporate anticipated costs into their capital improvement program as appropriate to their situation, and urges states to include the costs of LSL replacement in their criteria for allocation of Drinking Water State Revolving Funds.

The LCRWG specifically recommends that EPA revise the LCR to:

- Require proactive lead service line (LSL) replacement programs, which set replacement goals, effectively engage customers in implementing those goals, and provide improved access to information about LSLs, in place of current requirements in which LSLs must be replaced only after a lead action level (AL) exceedance;
- Establish more robust public education requirements for lead and LSLs, by updating the Consumer Confidence Report (CCR), adding targeted outreach to consumers with lead service lines and other vulnerable populations (pregnant women and families with infants and young children), and increasing the information available to the public;
- Strengthen corrosion control treatment (CCT), retaining the current rule requirements to re-assess CCT if changes to source water or treatment are planned, adding a requirement to review updates to EPA guidance to determine if new scientific information warrants changes;
- Modify monitoring requirements to provide for consumer requested tap samples for lead and to utilize results of tap samples for lead to inform consumer action to reduce the risks in their homes, to inform the appropriate public health agency when results are above a designated household action level, and to assess the effectiveness of CCT and/or other reasons for elevated lead results;
- Tailor water quality parameters (WQPs) to the specific CCT plan for each system, and increase the frequency of WQP monitoring for process control;
- Establish a health-based, household action level that triggers a report to the consumer and to the applicable health agency for follow up;
- Separate the requirements for copper from those for lead and focus new requirements where water is corrosive to copper; and
- Establish appropriate compliance and enforcement mechanisms.

Although leadership by EPA is essential, reduction of exposure to lead in drinking water cannot be achieved by EPA regulation alone. Thus, this report also includes recommendations for renewed commitment, cooperation and effort by government at all levels and by the general public. We urge EPA to play a leadership role not only in the revisions to the LCR but also in educating, motivating, and supporting the work of other EPA offices; federal state and local agencies and other stakeholders. (See Section 4: Complementary Actions Critical to the Success of the National Effort to Reduce Lead in Drinking Water.)

2. Considerations and Background Information

2.1. Considerations in Preparing this Report

The members of the LCRWG brought different perspectives and expertise to the preparation of this report. Although not all members agreed with each and every consideration listed below, the LCRWG took one another's perspectives into account and, thus, the following concepts collectively underlie the recommendations in this report. Additional detail is provided in the recommendations section below.

- There is no safe level of lead. Lead can pose health risks to anyone, but there are heightened risks for pregnant women, infants and children with both acute and chronic exposures.
- Lead-bearing plumbing materials in contact with drinking water pose a risk at all times (not just when there is a lead action level (LAL) exceedance).
- Effective elimination of leaded materials in contact with water and minimization of exposure to lead in drinking water is a shared responsibility. PWSs, consumers, building owners, public health officials and others each have important roles to play.
- The LTR LCR is an important opportunity for removing sources of lead in contact with drinking water and for reducing exposure to lead from drinking water in the meantime. However, additional action beyond the scope of the Safe Drinking Water Act is needed. Removing lead from drinking water systems also will require renewed commitment, cooperation and effort by government at all levels and by the general public. (See Section 4: Complementary Actions Critical to the Success of the National Effort to Reduce Lead in Drinking Water.)
- Proactive action is needed to remove the sources of lead, with appropriate incentives both for PWSs and their customers needed to encourage such action.
- Successful implementation of the revised LCR can only take place in the context of a more holistic effort on lead in water issues involving stakeholders other than just EPA and water systems, and resources beyond those able to be brought to bear by water systems. Partnerships at all levels are essential. Recognizing that public agency budgets are tighter than ever, greater engagement by local health agencies, those funding housing programs, and those involved in permitting and construction is particularly important.
- Creative financing mechanisms also will be needed to achieve this goal for all individuals potentially exposed to lead, regardless of race, ethnicity or income. Leaving a lead service line in place because a low-income resident does not have the means to pay raises serious questions of disparate impact and environmental justice.
- The public plays a critical role in protecting their families' health by reducing exposure to lead and copper, and informing the public enables them to be effective participants in implementing their share of the responsibility.
- The issues associated with lead and copper are very different and warrant more separate attention than has been the case in the past.
- The LCR should remain a treatment technique rule, but it can be improved.
- Corrosion control treatment (CCT) is complex, dynamic, and varies based on the circumstances in each PWS. The understanding of the challenges with CCT has improved in recent years, but questions still remain.
- Attention to unintended consequences is important generally and, in particular, with respect to CCT.
- The presence of lead-bearing materials in premise plumbing raises issues about what systems can implement in customers' homes.
- Attention to what States are able to oversee and enforce also is important.
- PWS and state resources should be focused on actions that achieve the greatest public health protection.

2.2 Regulatory Background and Formation of the NDWAC Lead and Copper Work Group

Under the Safe Drinking Water Act EPA sets public health goals and enforceable standards for drinking water quality.[1] The Lead and Copper Rule is a treatment technique rule. Instead of setting a maximum contaminant level (MCL) for lead or copper, the rule requires (PWSs) to take certain actions to minimize lead and copper in drinking water, to reduce water corrosivity and prevent the leaching of these metals from the premise plumbing and drinking water distribution system components and when that isn't enough, to replace lead service lines under their control. The current rule sets an action level (AL), or concentration, of 0.015 mg/L for lead and 1.3 mg/L for copper. An AL is not the same as an MCL. An MCL is based on health effects and feasibility; whereas an action level is a screening tool for determining when certain treatment technique actions are needed.

The LCR action level is based on the practical feasibility of reducing lead through controlling corrosion. In the LCR, if the AL is exceeded in more than ten percent of tap water samples collected during any monitoring period (i.e., if the 90^{th} percentile level is greater than the AL), it is not a violation, but triggers other requirements that include water quality parameter monitoring, corrosion control treatment (CCT), source water monitoring/treatment, public education, and lead service line replacement (LSLR). The rule also requires States to report the 90^{th} percentile for lead concentrations to EPA's Safe Drinking Water Information System (SDWIS) database for all water systems serving 3,300 or more persons, and for those systems serving fewer than 3,300 persons only when the lead action level (LAL) is exceeded. States only report the 90^{th} percentile for copper concentrations in SDWIS when the copper action level is exceeded in water systems regardless of the size of the service population. Public education requirements ensure that drinking water consumers receive meaningful, timely, and useful information that is needed to help them limit their exposure to lead in drinking water.

Copper is a common material used in household plumbing and drinking water service lines in the United States. Copper is an essential nutrient in small amounts; however, acute ingestion of excess copper in drinking water has been associated with adverse health effects, including acute gastrointestinal symptoms such as abdominal discomfort, nausea, and vomiting.

The SDWA requires EPA to set MCLGs at concentration levels at which no known or anticipated adverse effects would occur, allowing for an adequate margin of safety. EPA proposed an MCLG of 1.3 mg/l for copper in 1985, and finalized that MCLG in 1991 when the LCR was promulgated. The LCR set the action level (AL) for copper, the level at which treatment technique actions are triggered for the water system, equal to the MCLG. The AL is triggered if the 90^{th} percentile level of water samples is exceeded. All community water systems must report the 90^{th} percentile level and the number of samples that exceeded the 90^{th} percentile in their Consumer Confidence Reports.

In early 2004, EPA began a wide-ranging review of the implementation of the LCR to determine if there was a national problem related to elevated levels of lead in drinking water. As part of its national review, EPA collected and analyzed lead concentration data and other information, carried out a review of implementation in States, held four expert workshops to discuss elements of the regulations, and worked to understand local and State efforts to monitor for lead in school drinking water, including a national meeting to discuss challenges and needs. EPA released a Drinking Water Lead Reduction Plan (DWLRP) in March 2005. This plan outlined short-term and long-term goals for improving implementation of the

[1] EPA establishes national primary drinking water regulations (NPDWRs) under SDWA. NPDWRs either establish a feasible maximum contaminant level (MCL) or a treatment technique "to prevent known or anticipated adverse effects on the health of persons to the extent feasible."

LCR. The plan can be found at the following web address:
http://water.epa.gov/lawsregs/rulesregs/sdwa/lcr/lead_review.cfm

In 2007, EPA promulgated regulations, which addressed the short-term revisions to the LCR that were identified in the 2005 DWLRP. These requirements enhanced the implementation of the LCR in the areas of monitoring, treatment, LSLR, public education, and customer awareness. These revisions were intended to better ensure drinking water consumers receive meaningful, timely, and useful information needed to help them limit their exposure to lead in drinking water.

A number of Safe Drinking Water Act (SDWA) amendments aim to reduce lead in drinking water by limiting the amount of allowable lead in plumbing materials that come into contact with drinking water. In 1986, the SDWA was amended to prohibit the "use of any pipe, any pipe or plumbing fitting or fixture, any solder, or any flux, in the installation or repair of (i) any public water system; or (ii) any plumbing in a residential or non-residential facility providing water for human consumption, that is not lead free". Lead Free was defined as solder and flux with no more than 0.2% lead and pipes with no more than 8% lead.

Congress again amended the SDWA in 1996, to prohibit the introduction into commerce of any pipe, pipe or plumbing fitting or fixture that is not lead free and to also require pipes, pipe or plumbing fittings or fixtures be in compliance with 3rd party lead leaching standards. These provisions ensure that only products meeting the lead free definition are sold in the U.S. and that pipes, pipe or plumbing fittings or fixtures are certified to be lead free.

The Reduction of Lead in Drinking Water Act of 2011 revised the maximum allowable lead content from not more than 8% to not more than a weighted average of 0.25% lead and included a calculation procedure for determining the weighted average; further reducing the amount of lead in contact with drinking water. It also eliminates the federal requirement to comply with the lead leaching standard and included exemptions from the lead free definition for plumbing devices that are used exclusively for non-potable services and also for specific plumbing devices such as toilets, bidets and urinals. The Community Fire Safety Act of 2013 further amended the SDWA to add fire hydrants to the list of exempted plumbing devices.

EPA has continued to work on the long-term issues that required additional data collection, research, analysis, and full stakeholder involvement, which were identified in the 2005 DWLRP and the 2007 rule revisions. This action is referred to as the LCR Long-Term Revisions (LTR). The LCR LTR would apply to all community water systems (CWSs) and non-transient non-community water systems (NTNCWSs). In this report, the term public water system (PWS) is meant to refer to both of these categories but not to transient non-community water systems.

Seeing the need for additional input on potential revisions to the Lead and Copper Rule, EPA requested that the National Drinking Water Advisory Committee (NDWAC) form the Lead and Copper Rule Working Group (LCRWG) to consider several key questions for the LCR LTR, taking into consideration previous input. The LCRWG met seven times in 2014 and 2015 to produce this report, and sought input from the NDWAC in advance of the last meeting to understand and address questions the NDWAC might have about the working group's recommendations.

A list of members of the working group is provided in Appendix A. This report was approved by the LCRWG, with one dissent.

3. Recommendations for Revisions to the Lead and Copper Rule

The long term revisions to the LCR is an important opportunity for removing sources of lead in contact with drinking water and for reducing exposure to lead from drinking water in the meantime. Creative financing and robust public education also are essential.

The LCRWG offers the following recommendations, based on information provided to the work group and on the work group's own deliberations. The LCRWG considers these recommendations to be an integrated package, not a menu of choices from which some recommendations can be selected and combined with others. This package reflects a concerted attempt to strengthen public health protection, which includes targeting the resources available to PWSs for the greatest public health value. While individual members might differ on specific recommendations, the work group (with one dissent) agrees that this package of recommendations constitutes an improvement over the current LCR.

The LCRWG carefully considered the information and questions posed by EPA in a white paper prepared for the working group. In its deliberations, the LCRWG came to the conclusion that the lessons learned from the implementation of the current LCR warranted a fresh look at the premises of the regulation. To truly solve the problem of exposure to lead in drinking water, the LCRWG concluded that lead-bearing materials should be removed from contact with drinking water to the greatest degree possible, while minimizing the risk of exposure in the meantime. That premise has led to a different paradigm for a revised LCR and, thus, to a somewhat different set of assumptions than underlay questions posed to the working group.

The diagram on page 12 illustrates the conceptual framework of the recommendations that follow.

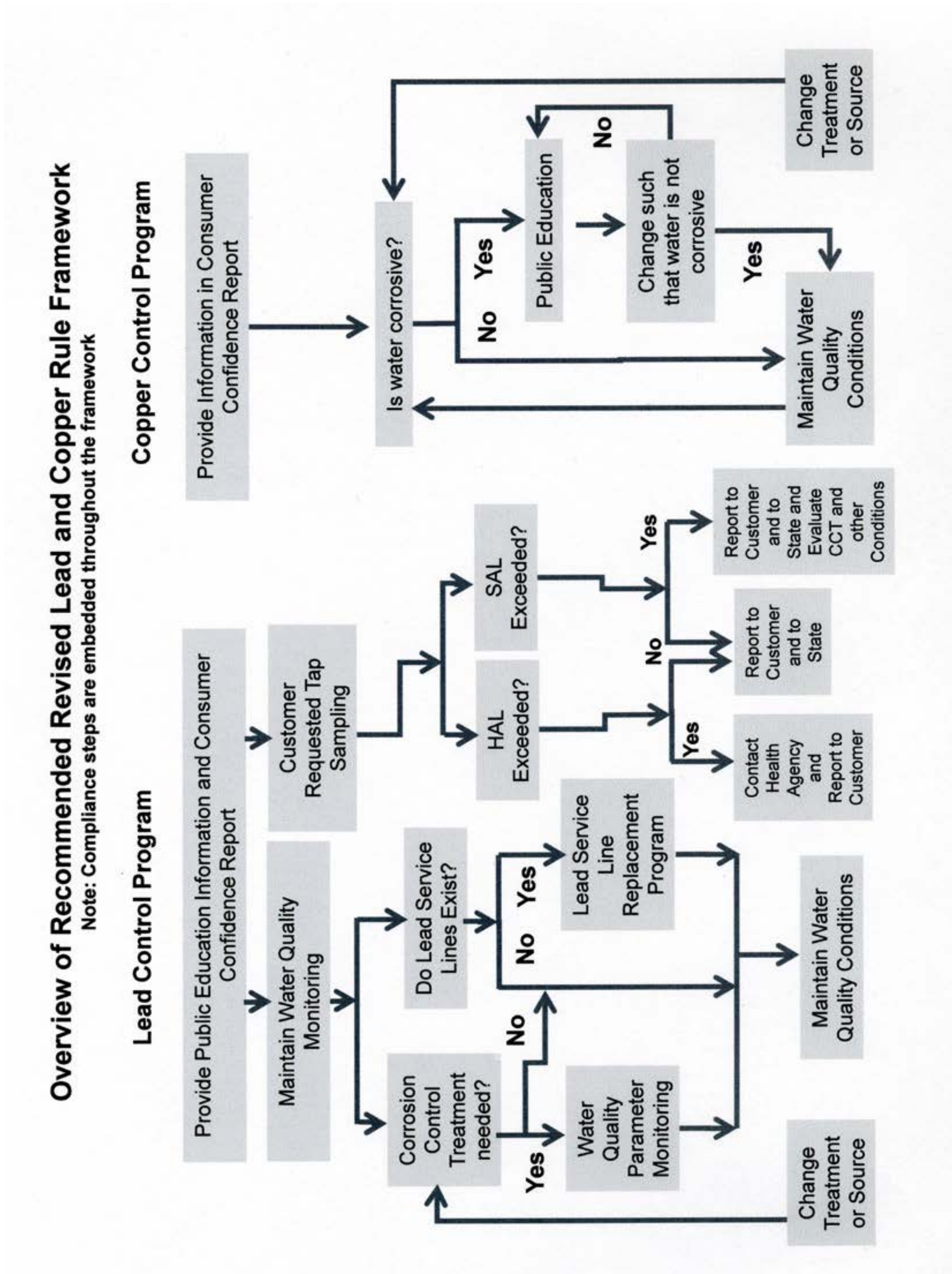
The LCRWG specifically recommends that EPA revise the LCR to:

- Require proactive LSL replacement programs, which set replacement goals, effectively engage customers in implementing those goals, and provide improved access to information about LSLs, in place of current requirements in which lead service lines (LSLs) must be replaced only after a lead action level (AL) exceedance and CCT;
- Establishes more robust public education, by creating a national clearinghouse of information for the public and templates for PWSs, by updating the Consumer Confidence Report, adding targeted outreach to consumers with lead service lines and other vulnerable populations (pregnant women and families with infants and young children), and increasing the information available to health care providers and the public;
- Strengthen corrosion control treatment (CCT), retaining the current rule requirements to re-assess CCT if changes to source water or treatment are planned, adding a requirement to review updates to EPA guidance to determine if new scientific information warrants changes;
- Modify monitoring requirements to provide for consumer requested tap samples for lead and to utilize results of tap samples for lead to inform consumer action to reduce the risks in their homes, to inform the appropriate public health agency when results are above a designated household action level, and to assess the effectiveness of CCT and/or other reasons for elevated lead results;
- Tailor water quality parameters to the specific CCT plan for each system, and increases the frequency of WQP monitoring for process control;

- Establish a health-based, household action level that triggers a report to the consumer and to the applicable health agency for follow up;
- Separate the requirements for copper from those for lead and focus new requirements where water is corrosive to copper; and
- Establish appropriate compliance and enforcement mechanisms.

Although leadership by EPA is essential, reduction of exposure to lead in drinking water cannot be achieved by EPA regulation alone. Thus, this report also includes recommendations for renewed commitment, cooperation and effort by government at all levels and by the general public. We urge EPA to play a leadership role not only in the revisions to the LCR but also in educating, motivating, and supporting the work of other EPA offices; federal, state and local agencies and other stakeholders. (See Section 4: Complementary Actions Critical to the Success of the National Effort to Reduce Lead in Drinking Water.)

Figure 1



Overview of Recommended Revised Lead and Copper Rule Framework
Note: Compliance steps are embedded throughout the framework
Lead Control Program
Provide Public Education Information and Consumer Confidence Report
Maintain Water Quality Monitoring
Customer Requested Tap Sampling
Corrosion Control Treatment needed?
Yes
No
Water Quality Parameter Monitoring
Do Lead Service Lines Exist?
No
Yes
Lead Service Line Replacement Program
Maintain Water Quality Conditions
Change Treatment or Source
HAL Exceeded?
SAL Exceeded?
Yes
No
Yes
Contact Health Agency and Report to Customer
Report to Customer and to State
Report to Customer and to State and Evaluate CCT and other Conditions
Copper Control Program
Provide Information in Consumer Confidence Report
Is water corrosive?
No
Yes
Public Education
Change such that water is not corrosive
No
Yes
Maintain Water Quality Conditions
Change Treatment or Source

3.1. Replace Lead Service Lines[2]

Removing the sources of lead in drinking water should be a national goal. More proactive action than has taken place to date is needed to achieve it.

Although success in achieving this goal will require a concerted effort by many and can not be accomplished solely through the authorities provided under the Safe Drinking Water Act, revisions to the Lead and Copper Rule are an important component to achieving this goal and should be structured accordingly. [See Section 4 for recommendations that complement revisions to the LCR.]

The existing LCR has not created sufficient incentives to fully replace LSLs and other sources of lead , because LSL replacement is only required when the lead AL has been exceeded and optimizing CCT is insufficient to bring a system back under the action level. Systems that do not exceed the lead AL will never have to implement a LSL replacement program. Further, the link to action level exceedance does not allow adequate time for a well-planned LSLR program, and a significant unintended consequence where systems have had to implement a LSL replacement program quickly has been an increase in partial LSL replacement.

EPA asked the Science Advisory Board (SAB) to evaluate the current scientific data regarding the effectiveness of PLSLR and the review centered around five issues: (1) associations between PLSLR and blood lead levels in children; (2) lead tap water sampling data before and after PLSLR; (3) comparisons between partial and full LSLR; (4) PLSLR techniques; and (5) the impact of galvanic corrosion. The SAB found that the quantity and quality of the available data are inadequate to fully determine the effectiveness of PLSLR in reducing drinking water lead concentrations. The small number of studies available had major limitations (small number of samples, limited follow-up sampling, lack of information about the sampling data, limited comparability between studies, etc.) for fully evaluating PLSLR efficacy.

While recognizing the limits to current data, the SAB concluded that PLSLRs have not been shown to reliably reduce drinking water lead levels in the short-term, ranging from days to months, and potentially even longer. Additionally, PLSLR is frequently associated with short-term elevated drinking water lead levels for some period of time after replacement, suggesting the potential for harm, rather than benefit during that time period. The available data suggest that the elevated tap water lead levels tend to increase then gradually stabilize over time following PLSLR, sometimes at levels below and sometimes at levels similar to those observed prior to PLSLR. The SAB also concluded that in studies comparing full LSLR versus PLSLR, the evaluation periods were too short to fully assess differential reductions in drinking water lead levels. However, the SAB explained that full LSLR appears generally effective in achieving long-term reductions in drinking water lead levels, unlike PLSLR. Both full LSLR and PLSLR generally result in elevated lead levels for a variable period of time after replacement. The limited evidence available suggests that the duration and magnitude of the elevations may be greater with PLSLR than full LSLR.

Taking all of these considerations into account, the LCRWG has concluded that an effective framework for replacement of LSLs would include the following and, thus, the LCR should be revised accordingly:

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[2] 40 CFR 141.2 defines: "*Lead service line* means a service made of lead which connects the water main to the building inlet and any lead pigtail, gooseneck or other fitting which is connected to such lead line."

- Requiring all PWSs to establish a LSL replacement program that effectively informs and engages customers to share appropriately in fully removing LSLs, unless they can demonstrate that LSLs are not present in their system;
- Modifying the definition of lead service lines to include any service line where any portion, including a lead pigtail, gooseneck or other fitting, is made of lead;
- Clear guidance, case studies, and templates for LSL replacement programs, including a toolkit of ideas for creative financing strategies;
- Targeted outreach to customers with LSLs, with information about the risks of lead exposure, an offer to test a tap sample, and information about and encouragement to participate in the LSL replacement program;
- Dates by which systems should have met interim goals and completed replacement of all LSLs and PLSLs, without penalty to PWSs for those homeowners who refuse to participate in the replacement program as long as the PWS has made a meaningful effort to work with such a homeowner;
- Creating incentives for understanding where LSLs and PLSLs exist, while making action on full replacement, rather than on investigation of the location of LSLs and PLSLs the priority;
- Maintaining ongoing-outreach to homeowners where LSLs or PLSLs still exist;
- Implementation of standard operating procedures (SOPs), either from EPA guidance or tailored to the system, that helps define operations that disturb LSLs and practices to minimize disturbance and consumer exposure to lead;
- Stronger programs to educate consumers, and to provide test results of tap samples at the request of consumers;
- Focus efforts on action to replace LSLs rather than on the time and expense of upfront plan approval and on using simplified reporting to the states so they would only need to intervene when problems arise; and
- Requirements that provide strong encouragement for full LSL replacements, with the understanding that there may be justifiable exceptions and that those exceptions would occur only after the efforts outlined in the recommendations below on the part of the PWS to work with customers to complete a full LSL replacement. Such exceptions might include emergency repairs where property owners have refused to participate in a full LSL replacement; during a main replacement project; or when a sufficiently high percentage of property owners participate in an area-wide LSL replacement project to justify replacing LSLs to the property lines of those who do not participate at the time. Revisions to the LCR should include options for risk management to occupants of those properties with remaining, partial lead service lines, e.g. additional sampling, filters, dielectrics to reduce the risk of galvanic corrosion, plastic piping, aggressive premise flushing, etc.

3.1.1. Update Inventories and Improve Access to Information about Lead Service Lines

Updating and improving access to information about the location of both full and partial lead service lines is both essential to ensuring LSLs are replaced and important for successful, proactive outreach to customers who are most likely to have a LSL.

The LCRWG recommends combining:

1) The presumption that a service line put in place prior to the date when lead service lines were prohibited has leaded materials unless the PWS has information to confirm that it not, with

2) Providing credit to a PWS toward its replacement goals for demonstrating that a service line presumed to include lead does not have leaded materials.

This approach is intended to create incentives for prompt action to develop an accurate inventory of LSLs and PLSLs in part by being overly conservative initially on the potential existence of LSLs, time to organize an effective replacement program, and an opportunity to take action to replace LSLs rather than devoting time and resources on planning documents that must be approved by the primacy agency.

The LCRWG recognizes that PWSs vary in the amount of information they have about the location of full and partial LSLs. EPA should take the impact on small and medium systems into account when developing the proposed rule.

The LCRWG also recognizes that the current definition of a lead service line exempts a service line that has a lead pigtail or gooseneck or other fitting but is otherwise not made of lead. We recommend that the LCR be revised to remove this exemption since a lead pipe, even if only a small portion, poses a sufficiently similar risk as a full lead service line. Because utilities may not know where these portions are and may not be able to locate them without excavating, we recommend that the presumption described above not apply to lines where the utilities do not have information or are unaware of their use. Finally, we recommend that these fittings be replaced when they are encountered during excavations and that the applicable operations and customer engagement requirements described in the next section apply.

In addition, the LCRWG recommends that all PWSs should establish a clear mechanism for customers to access information on LSL locations (at a minimum). Detailed public education recommendations for both lead and copper follow in separate sections. With respect to information about LSLs, PWSs should:

- Have outreach materials that indicate that property specific information is available.
- Inform customers who may have LSLs about the risks of partial line replacement, who is responsible for paying for replacing the service line, and the legal basis of that determination.
- Provide information it has about LSLs to existing home owners and residents on request.
- Provide information to realtors, home inspectors, and potential home buyers on request
- Communicate that this information is subject to disclaimer for accuracy based on information available to the PWS.
- Develop a system to track LSL replacement.

Where a service line serves multiple dwellings or places such as schools or child care centers that have many children, EPA should establish a formula for giving an extra weight or numerical count to these lines in the initial inventory to recognize the additional children that would be affected and effectively prioritize replacement of these LSLs.

3.1.2. Establish Active LSL Replacement Programs

Proactive LSL replacement programs by PWSs and their customers are key to moving to a future in which lead is not in contact with drinking water. To accomplish this, the LCRWG recommends replacing the current regulations, in which LSL replacement is required only if a PWS has a lead AL exceedance and after the PWS takes action to operate CCT, because this has not resulted in the complete replacement of many LSLs across the country. [3]

Instead, a revised LCR should include a requirement that all PWSs with lead service lines prepare and implement a LSL replacement program, along with a combination of changes to the regulatory approach described in this report and supportive actions by other public and private agencies, customers and other stakeholders. Taking this approach has the advantages of making replacement of LSLs something all systems do and of establishing programs that are put in place in an organized and measured way.

Supportive actions include increased funding of federal lead risk reduction programs under the Department of Housing and Urban Development (HUD) to help fund customer-owned portions of LSLs and to consider federal tax deductions for this purpose. Additionally, states should pass legislation requiring inspection, disclosure and/or replacement of LSLs on sale of property, and when lines have been disturbed as part of a renovation. Details on these and other ideas are included in Section 4 of this report.

The LCRWG recommends that EPA include the following revisions to the LCR:

1. *Goal:* PWSs will work with their customers to implement full replacement of all lead service lines in their service areas according to the milestones outlined in Table 1. Revisions to the LCR should maximize the likelihood of achieving this goal, consistent with the recommendations in this section. EPA should urges PWSs to work with their customers to replace LSLs in their service areas more quickly, while recognizing that the recommended approach of replacing LSLs in all PWSs with LSLs adds a new and potentially costly requirement for utilities and their customers with LSLs who currently are not and may not ever be triggered into a LSLR program under the current rule.

2. *Interim Milestones:* PWSs that identify LSLs in their inventory should be required to perform targeted outreach to customers on the inventory of LSLs and to work with them to replace LSLs according to a sequence of three-year milestones,[4] beginning 36 months after the effective date of a revised LCR. Milestones would be set at a faster pace in earlier years and would recognize progress may be more difficult to achieve in later years with those LSLs that remain at that time. Table 1provides an illustration of this concept. PWSs should be encouraged to contact a larger number of homeowners than needed for compliance, since some homeowners may fail to reply or may refuse to participate. If replacement goals are not met, the revised LCR should require the PWS to take additional actions intended to enhance interest in and incentives for customer participation in full LSL replacement. The details of this approach should be determined by EPA with the intent of the LCRWG being that the PWS be given the flexibility to choose among

[3] EPA estimates that there were approximately 10.5 million LSLs in 1988 before the promulgation of the LCR and approximately 7.3 million LSLs now.
[4] Three years is a standard reporting timetable for drinking water regulations.

options that are appropriate for the size and type of ownership of the system and that the number of required efforts would increase over time if replacement goals are not met. EPA should seek to add to the initial list of options suggested in Table 2 to ensure a robust menu for PWSs to choose from (again considering system size and type of ownership) to avoid a situation where a PWS is forced into specific actions; and EPA should set the number of required efforts with consideration for the number and feasibility of choices provided.

3. *Replacement Credit:* The following actions can be counted toward the cumulative replacement requirement:

    - Full LSL replacement
    - Replacement of lead pigtail where the pigtail is the only leaded material on the service line
    - Confirmation that an LSL included in the initial inventory is not lead.

    PLSLR will not be counted toward this requirement. Lack of response or refusal to participate by the customer also will not count toward replacement milestones.

4. *Targeted Outreach*: EPA should create a list of options in the rule of approved outreach methods for contacting customers with LSLs and inviting them to participate in the utility's LSLR program. Table 2 provides an initial list of options for such resident engagement, along with additional system policies and other actions if milestones aren't met. EPA also should provide guidance and/or templates for these options. For compliance purposes, the revised LCR should require that a PWS individually notify customers with known or possible LSLs describing the risks of lead in drinking water, specifically inviting them to participate in the LSLR program, and clearly describing the terms of the program, and how to follow up. If the customer does not respond or chooses not to participate, the PWS must follow up with another invitation at least every three years and always when there is a new customer at that address until the full LSL is replaced.

5. *Control and Responsibility:* The revised LCR should require PWSs to clearly state how the PWS defines ownership of LSLs, who has what financial responsibility for the replacement, what the legal basis is for that determination and any financial assistance programs that may be available.

6. *Planning and Financing Options:* EPA should provide a template and guidance for planning LSL replacement programs, including reference to options to assist customers replace their portion of lead service lines. Small systems may wish to refer to a national information source, such as one provided by EPA; large systems may wish to tailor such information to their circumstances. (See section 4 for further detail.)

7. *Operations and Customer Engagement:* EPA also should provide guidance on PWS policies and procedures for how to engage customers in full lead service line replacement and to inform them on appropriate risk reduction measures. PWSs should adopt templates provided in guidance by EPA or, for larger systems, their own standard operating procedures (SOPs) and make them available to their customers and the primacy agency for:

    a) planned capital projects by the PWS that would require:
        - Prior notification (e.g., 45 days prior to planned main replacement or repair) - Contact letter to affected households likely to have lead service lines, providing information about lead service lines, associated risk, risk reduction options, and full-lead service line replacement options.

- Reminder of flushing post LSLR (e.g., 48 hours prior to actual field work affecting structure) -- Door hanger (or alternative direct contact) with information on flushing and POU devices immediately after lead service line replacement.

b) emergency main and service line repairs by the PWS that would define how to manage potential disturbance to LSLs safely:
   - Direction to information on lead service lines, associated risk, risk reduction options, and full-lead service line replacement options.
   - Door hanger (or alternative direct contact) with information on flushing and POU devices immediately after lead service line replacement.

c) flushing of service lines after lead service line replacement:
   - Flush outside hose bib or similarly located spigot close to the meter
   - Initial flush followed by house flush by homeowner or plumber using multiple taps to maximize water velocity
   - Information on proper use of filters when lead levels might be high

d) Requiring PWSs to inform other utilities (e.g. power, cable) whose work might affect water service lines or water mains, both proactively and at "mark out" for specific projects, about how to manage potential disturbances safely and about information to provide residents of affected homes about potential risks and risk mitigation measures. Those other utilities would have the responsibility to alert residents.

8. Community and NTNC water systems (schools, hospitals, churches, jails, etc.) who own the system and control the entire distribution system should replace LSL's as soon as practical, at a timetable to be determined by EPA. This requirement would not apply to community systems where the majority of the connections are individual residential connections (such as mobile home parks and HOA's) where there may be complications due to property ownership of the residence.

The LCRWG discussed and agreed that EPA guidance should encourage PWSs to make every effort to ensure that LSL replacement provides equal protection to low income customers (or rental units with low income residents), people of color and others protected by civil rights law and policy. Environmental justice and civil rights considerations are particularly important in those jurisdictions where the PWS requires the property owner to pay a share of the costs of removing the LSL. Making environmental justice a priority can be achieved through creative financing programs for low-income customers and setting priorities for which neighborhoods are targeted first for LSLR to ensure equal treatment of low income neighborhoods.

The LCRWG also discussed but did not agree that the definition of control as ownership should be changed in the revised LCR. In the current LCR, when a system exceeds the LAL, EPA requires water systems to replace only that portion of the LSL that it owns. This is based on EPA's current interpretation of the term "control" in the definition of public water system as limited to ownership. Some members of the LCRWG urged that the current definition of control as "ownership" should be replaced with a requirement that PWSs must replace the entire LSL, where they have the authority to "replace, repair, or maintain" the line or where they have other forms of authority over the LSL. However, the LCRWG also recognized that some utilities are prevented by law from spending public funds on private property and that gaining physical access to private property poses significant legal issues when a property owner objects.

The LCRWG does agree that the revised LCR should require PWSs to inform customers about the scope of their responsibility with regard to LSL replacement and the legal basis for that decision.

3.1.3 LSL Compliance

3.1.3.a LSL Replacement Compliance

Recordkeeping:

- Inventory of LSLs
- Customer refusals to participate in full LSL replacement

Reporting: At the end of each three year period, each PWS must provide to the primacy agency:

- Certification of the outreach and other efforts implemented (see Table 2 for initial examples);
- Report on the change in the number of LSLs removed from the inventory with better information;
- Report on the number of full LSLs replaced; and
- Report on locations where the utility side LSL was replaced, but the homeowner did not replace the private portion

Violations:

- Failure to conduct required outreach;
- Failure to step up intensity of efforts if 3-year LSL replacement target has not been met;
- Failure to provide on-going outreach to new customers and to follow up (at least every 3 years) with customers at locations with full or partial LSL who do not respond or chose not to participate in the LSL replacement program;
- Outreach materials do not meet the content requirements of the rule

3.1.3.b Operations and Customer Engagement Compliance

PWS must maintain records of who was notified, when notice was given, and content of notice for each capital project. (for 7a and 7b)

Violations:

- Lack of timely notice to customer that LSL removal is scheduled
- Notice materials do not meet rule content requirements

PWS also must develop SOP, and maintain records that it was provided to all utilities conducting activities which may impact LSL (for 7d)

Violation:

- PWS has not developed an SOP (or adopted an SOP template available on the National Clearinghouse) or not provided it to other utilities

3.2 Develop Stronger Public Education Requirements and Programs for Lead and LSLs

Given the public’s role in the shared responsibility nature of the LCR, notifying and educating the public about lead in drinking water is important for risk reduction. Public education about the risks of lead in drinking water also is important regardless of whether LSLs are present, since lead can be present in other premise plumbing materials. Moreover, targeted outreach and, possibly, other efforts are a key to the success of LSL removal programs. The current LCR does not adequately focus on creating on-going opportunities to educate customers on the risks of LSLs or on opportunities to replace them, especially when action is most likely, e.g. at the sale of a home.

The objectives of public education programs should include consumer understanding of: 1) the risks of lead in drinking water; 2) the likelihood that the water in one's home may contain lead; 3) the LCR as a "shared responsibility" rule; and 4) the availability of additional resources that consumers can use to better minimize their exposure to lead.

Although the LCRWG was briefed on and has experience with public education requirements and practices, it does not include members whose specific area of expertise is consumer-centered risk communication. Thus, the LCRWG generally recommends that public education programs for lead should move away from past practices of one-way communication from "experts" to the "public" toward newer concepts of risk communication that involve sustained, multiple, two-way channels of ongoing communication and partnership with the public.[5] EPA should consult with those with such expertise about the outreach and communication recommendations in this report, and encourage and apply best practices in effective ways to communicate with the public.

Communication in languages appropriate to the demographics of the community, in clear terms understandable by the public, and with engaging, reader-friendly graphics, photos, and video all help achieve greater understanding. Outreach programs and materials can be improved by involving people with diverse, and consumer-oriented expertise and perspectives, including consumer-centered risk communication experts, community members with extensive experience with lead in water including individuals not necessarily affiliated with an organization, lead/copper corrosion experts, grassroots public-health workers, and staff of PWSs, state and federal regulatory agencies and public health agencies. This information can and should be conveyed in different ways and through different communication channels, tailored to the specific circumstances.

Thus, with these and other considerations in mind, the LCRWG recommends that EPA, in consultation with the aforementioned stakeholders and drawing on principles of consumer-centered risk communication:

- Establish an easily accessible, national clearinghouse of information about lead in drinking water to serve the needs of the public and of public water systems (section 3.2.1).
- Require information be sent to all new customers on the potential risks of lead in drinking water (section 3.2.2)
- Revise the current CCR language to address lead service lines and update the health statements (section 3.2.3).Add requirements for targeted outreach to customers with lead service lines (section 3.1.1).

[5] Resources include: 1) EPA's "Risk Communication in Action" (http://nepis.epa.gov/Adobe/PDF/60000I2U.pdf) ; 2) EPA's "7 Cardinal Rules of Risk Communication" (http://www.wvdhhr.org/bphtraining/courses/cdcynergy/content/activeinformation/resources/epa_seven_cardinal_rules.pdf); and 3) Education & Communication WG Report 2010; National Conversation on Public Health and Chemical Exposures (http://www.resolv.org/site-nationalconversation/files/2011/02/Education_and_Communication_Final_Report.pdf)

- Strengthen requirements for public access to information about lead service lines, tap monitoring results, and other relevant information (section 3.2.4).
- Expand the current requirements for outreach to caregivers/health care providers of vulnerable populations (section 3.2.5)

As part of EPA's consultation with the aforementioned communication experts and stakeholders, the LCRWG recommends that EPA include consultation about methods that would increase public awareness of and motivation to learn about the effects of lead in drinking water and the benefits of removing these materials and/or taking regular precautions when cooking or drinking, regardless of whether LSLs are present or there has been a lead AL exceedance. Consistent with this advice, EPA also should take small systems into account and consider whether such methods should be included in guidance or in revisions to the LCR.

3.2.1 National Lead in Drinking Water Clearinghouse

The LCRWG recommends that EPA take the lead, working with other partners to establish a national, accessible information clearinghouse. The LCRWG suggests that this information clearinghouse include a website, that the materials on the web site be accessible for distribution through the Safe Drinking Water Hotline for those who may not have internet access, and that EPA investigate and apply newer communication technologies and ideas for interactive or other innovative means of communication with the public about lead in drinking water (e.g. social media methods and outreach programs).

The clearinghouse should include information in multiple languages, in clear terms understandable by the public, and should include engaging, reader-friendly graphics, photos, and video. EPA is encouraged to include the design of the clearinghouse in its consultation with people with diverse, and consumer-oriented expertise and perspectives described above.

Such a clearinghouse would be intended for use by the general public, PWS's, public health agencies, and health professionals. It should include:

- information and educational materials for the public that the public could access directly and that PWSs could use to meet many of the public education requirements of the LCR.
- guidance and templates, particularly for small systems, on SOPs for compliance with the LCR (e.g. templates for communicating lead monitoring results to individual customers, templates for explaining to customers how to obtain information on whether their service line could be lead, templates for standard operating procedures related to the LSL replacement program recommendations above, etc).
- Principles and guidelines for best practices in developing the content of the public education materials.
- Case examples of how communities have been successful in lead inventory updates and removal programs, information about funding sources, model ordinances or other types of authorities PWSs have to enable them to implement full LSL replacements, and contacts to other relevant agencies.

Further, EPA should consider best practices in methods for achieving greater public awareness of the clearinghouse so that it reaches as many people as possible.

The web site should include the following information:

Health risks

- Clear and prominent statement that no level of lead in drinking water is safe for human consumption and that a short-term exposure to a young child can result in permanent harm to the brain if the levels are high enough.
- Clear and distinct language on the health risks of consuming lead in drinking water
- Identification of the most vulnerable populations
- Importance of drinking water plumbing as a lead source
- How to have blood lead levels (BLLs) checked and limitations of testing
- How to have water tested and limitations of testing
- List of labs for testing water other than the utility and what to ask for in terms of number and size of bottles, diameter of mouth of bottles, analysis that measures lead particles, etc.

Forms of lead in water and health risk implications

- Soluble
- Particulate
- Unpredictability of lead release

Sources of lead in drinking water

- LSLs
- Other lead-bearing plumbing
- Scale on internal plumbing that can be a source of lead from present or past LSLs

Identification of service line material

- How to recognize a pipe that is made of lead (and when not to check due to age of home)
- What to do about galvanized pipe and why it is a potential source of lead

For homes with LSL

- LSL ownership
- Difference between full and partial lead service line replacement (physically and in terms of health risks)
- Benefits to full LSL replacement
- Actions to take if you have a partially replaced LSL
- Available methods for LSL removal
- Opportunities for removal, approximate cost, and financing options
- Overall benefits to the community of removing LSLs fully (lower treatment costs, better community health, environmental, etc.)
- Where applicable, requirements for notification during real estate transfer or new rental

Health-protective actions

- Precautionary water-use practices
- Role of filters and proper maintenance of them if they are used
- Replacement of leaded plumbing with lead-free plumbing

Additional information

- How to contact your utility and request a LSL inspection and/or water test
- Where applicable, reference to utility-specific website with local lead-related documents and data (e.g. Consumer Confidence Reports (CCRs), sampling protocol used for LCR compliance, lead-in-water test results, etc.)

- What you need to know about lead in water in schools and day care centers (it is not regulated, and link to national website that provides more information)
- Reference to a national website that provides a video version of basic educational information, including information on how the LCR works (with minority language versions)
- Other standard operating procedures, model ordinances, or templates for compliance with the revised LCR
- Where to get more information on drinking water, on lead in water, and on lead in general

3.2.2 Outreach to New Customers

The LCRWG recommends that a revised LCR require PWSs to provide information to all[6] new customers in a letter or via other direct means on the potential risks of lead in drinking water.

The outreach materials should include information about the potential for lead from plumbing materials to contaminate drinking water even when a PWS meets the LCR LAL, to contaminate drinking water in homes with and without LSLs, and to pose chronic and acute health risks to vulnerable populations. The specific information to be covered in those materials could be included in the consultation with the diverse group of experts as described in the introduction to Section 3.2 above and in Section 4 below. Although the LCRWG defers to such a group, it suggests that at a minimum the following topics be covered:

1. Information about lead in drinking water (its sources, variable and erratic release, and wide range of lead concentrations)
2. Information about the health effects of lead in drinking water (including chronic and acute health risks)
3. Information about the LCR's shared responsibility regime
4. Actions the PWS is taking to minimize lead in drinking water
    - PWSs with LSLs would mention their proactive LSL replacement program
5. Steps consumers can take to reduce exposure to lead in drinking water
    - In addition to a list of actions like the ones mentioned in the current Rule, PWSs with LSLs would spell out how consumers in homes with a LSL can participate in their proactive LSL replacement program
6. Phone numbers and online links for additional information (including a link to EPA's online National Clearinghouse)

The outreach to new customers should be delivered within 30 days or with the first bill.

3.2.3 Revise the Current CCR Language

The CCR is a necessary but not sufficient source of information for the public. It can provide general information, but is not designed to be frequent or detailed enough for all public education purposes.

All community water systems (CWSs) should continue to include a statement about lead in their CCR. There may be circumstances (e.g. a subdivision built entirely after January 2014 when "lead-free" requirements came into effect), where a CWS can demonstrate that there are no lead-bearing materials in contact with drinking water. EPA may want to consider allowing the primacy agency to waive this CCR language requirement if an entire CWS can meet this criterion.

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[6] EPA may wish to consider circumstances under which exceptions might be applicable.

The LCRWG recommends that the CCR language should be strengthened to include:

- Public health statements updated to reflect current understandings that there is no safe level of lead and a summary of the health effects, that this risk pertains to everyone, and that some individuals are particularly vulnerable;
- A link to the national clearinghouse should be added to the CCR for all CWSs;
- Recognition that a CWS's compliance with federal regulations does not guarantee what level of lead (lower or higher) might be found at the tap in a particular home; and
- The message that customers play an important role in protecting themselves from exposure to lead.

In addition, the work group recommends that PWSs where full or partial lead service lines exist (or are presumed to exist until an inventory demonstrates otherwise) also add information about what a lead service line is and how to contact the utility for information about how to find out if you have one and why you should replace it.

Further, the LCRWG recommends that the following redraft of the CCR be considered as a starting point for incorporating the elements listed above, to be reviewed by the diverse group of experts that the LCRWG suggests EPA consult .

> ***Important Information from EPA about Lead*** *If lead is present in your drinking water, it ~~elevated levels of~~ can cause serious health problems, especially for pregnant women and young children. Lead can affect children's brains and developing nervous systems, causing reduced IQ, learning disabilities and behavioral problems. Lead is also harmful to adults. Lead in drinking water is primarily from materials and components associated with ~~service lines and~~ home plumbing <u>and service lines</u> (<u>the pipe connecting your home to the water main</u>). ~~(System name) is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components.~~ <u>Contact us for information about lead service lines, how to find out if you have one and why you should replace it</u>. [Last sentence for systems with LSLs.]*
>
> *~~When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking.~~ Protecting you against exposure to lead is a shared responsibility. <u>Your water utility is required to minimize the corrosivity of the water. However, because every home is different, the amount of lead in your tap water may be lower or higher than the monitoring results for your public water system as a whole. You can take responsibility for identifying and removing lead materials within your home plumbing and taking steps to reduce your family's risk. If you have lead service lines or lead-bearing materials in your home,</u> ~~are concerned about lead in your water,~~ you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline at 1-800-426-4791 or <u>www.epa.gov/safewater/lead</u>. [Insert new national web site link]*

3.2.4 Strengthen Requirements for Public Access to Information

The LCRWG supports the public's right to know about the quality of their water and considered various options to increase the public's access to data related to lead and copper.

Under the current rule, the PWS is only required to make publicly available through the Consumer Confidence Report (CCR) that the "90th percentile value of the most recent round of sampling and the number of sampling sites exceeding the action level." 40 CFR 141.153. In many jurisdictions, a concerned consumer may be able to obtain or view a redacted version of the complete sampling data set but this approach is time-consuming and burdensome on the PWS (or the state) and the community. EPA receives only a summary of the sampling results.

As the LCRWG evaluated different approaches, we kept in mind EPA's Office of Enforcement and Compliance Assurance (OECA) five principles for highly effective regulations and that OECA is working with regulatory programs to evaluate new and revised rules against these principles. Principle 4 calls for rules to "leverage accountability and transparency by providing the government and the public with real-time access to quality information on regulated entities" emissions, discharges and key compliance activities and outcomes." OECA identified two tools to accomplish this:

- Electronic reporting to the government.
- Public accountability via websites, paper/electronic mailings, and other ways to provide the public and stakeholders (e.g., customers, ratepayers) with compliance information.

The LCRWG encourages EPA to use the SDWIS-Prime data system[7] that is under development to meet the first provision of the above goal. Electronic reporting from utilities to a centralized data system would allow the public to access data from the State or EPA in a coordinated manner and allow for consistent access to all water quality data, not just data for lead and copper.

Until such time as the new data system is in place, though, the LCRWG believes that water systems should increase the availability of data to the public. This would include:

- The number of samples over the Household Action Level (described in Section 3.5 below) in the last monitoring period, the highest level found during the last monitoring period, the median levels, and the most recent 90th percentile level compared to the "system action level" (renamed from the current action level).
- Requiring water systems to include WQP-related information on their webpage, or in the CCR or some equally accessible manner (e.g., CCT treatment, approved WQP ranges, WQP results from the last monitoring period)
- Encouraging water systems to post additional information on their webpages such as:
    - Public education materials (and link to National Clearinghouse).
    - Sampling protocols the water system provides to customers to use when collecting lead samples and any variations from EPA recommendations.
    - Individual sampling results (with appropriate privacy provisions such as address redaction).
    - Inventory (such as a map) of confirmed and presumed lead service lines.

Where a community has lead service lines, EPA should require PWSs provide a public statement of lead service line ownership and the legal basis of said determination. (See section 3.1.2, point 5 *"Control and Responsibility."*)

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[7] SDWIS is a database for storage about drinking water systems. The federal version (SDWIS/FED) stores the information EPA needs to monitor approximately 156,000 public water systems. The state version (SDWIS/STATE) is a database designed to help states run their drinking water programs. SDWIS-Prime is an upcoming version of this program. The website for SDWIS is located here:
http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/index.cfm
SDWIS Reports:
http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/howtoaccessdata.cfm

3.2.5 Routine Outreach to Caregivers/Health Care Providers of Vulnerable Populations

The LCRWG recommends that a revised LCR encourage PWSs to cooperate in locally appropriate public education programs targeted at caregivers and health providers of the populations most vulnerable to lead in drinking water (i.e., pregnant women, infants, young children, and children with elevated BLLs). The intent of such outreach is to raise awareness among caregivers and health providers about the health risks of lead in drinking water, easy steps to prevent exposure, and the availability of EPA's online National Clearinghouse for further information. It is expected that public education messaging in service areas with LSLs will differ from public education messaging in service areas without such lines.

In conducting outreach to caregivers and health care providers it is important that the message be provided by an organization or individual that carries credibility with those audiences. The LCRWG suggests the way to best ensure that caregivers and health providers hear and respond appropriately to information about lead and drinking water is for water suppliers to participate in joint communication efforts, lead by state health departments, state lead poisoning prevention agencies, and state drinking water primacy agencies. This outreach should be targeted to individuals, organizations and facilities likely to be visited by the vulnerable populations of pregnant women, infants, and young children, such as:

1. local public health agencies;
2. public and private pre-schools, schools;
3. Women Infants and Children (WIC) and Head Start programs;
4. public and private hospitals and medical clinics;
5. pediatricians, obstetricians-gynecologists, and midwives;
6. family planning clinics;
7. local welfare agencies; or
8. licensed childcare centers.

1. The outreach efforts should make use of the information provided in the clearinghouse

Examples of communication vehicles that might be suggested in guidance materials include:

- Development and routine delivery of a joint communication from the PWS (or a group of PWSs) and the City/State to:
    - ∗ Health providers (e.g., OBGYNs, pediatricians, midwives)
    - ∗ Childhood lead poisoning prevention professionals/organizations
    - ∗ Professionals at licensed daycare centers and schools
    - ∗ Listservs/organizations for pregnant women/parents of infants (e.g., local listservs, environmental health groups, La Leche League, etc.)
- Delivery of educational materials during any water-related work at customer homes
- When lead-in-water levels at individual homes test above the HAL, delivery of information to a) the residents at the home and b) City/State health departments. These materials ought to cover information prescribed in the current LCR for public outreach during a LAL exceedance as well as:
    - ∗ The lead level detected at the specific home
    - ∗ What this level means in terms of health risk to vulnerable individuals
    - ∗ If the PWS determines that the home has a LSL, information about how to participate in the PWS's proactive, full LSL replacement program.

The LCRWG also recommends that EPA, informed by the advice of the diverse group of experts described above and working with CDC, HHS and HUD, develop guidance (and make it available through the National Clearinghouse) on how to develop and deliver effective communication efforts to caregivers and health care providers focusing on ways those individuals and groups can reach pregnant women, parents of infants and young children and those who care for them. The audience for those materials would be state primacy agencies, state or local health departments, and state or local lead poisoning prevention agencies, as well as PWSs.

To support PWSs in the development of feasible, locally appropriate, and successful public outreach programs targeting vulnerable groups on a routine basis, the LCRWG recommends the following: that the diverse group of experts EPA may convene for the development of consumer-centered public education messaging and materials (see introduction to Section 3.2), also develop guidelines and best practices that PWSs can use to create proactive risk communication programs. Echoing extant principles and understandings of effective risk communication,[8] we imagine such programs to involve robust collaboration between PWSs, many of the local public health agencies and organizations listed above, as well as local childhood lead poisoning prevention groups (State-funded and grassroots), environmental health organizations, and key community leaders (e.g., advisory neighborhood commissioners).

Education of public health and health care providers on lead and water issues

The LCRWG had extensive discussions about the frustration that members of the group had that many in the public health community minimized the risk of lead exposure from drinking water, placed a lower priority on actions to reduce that risk, and frequently provided incomplete or conflicting information to members of the public or patients. This made and continues to make the work of water professionals in motivating appropriate action by customers more difficult. Those in the health sector are highly regarded, and viewed as knowledgeable about all health related topics. Customers will look to them for advice and to validate what they hear from their water provider. Efforts by water systems to reach out to their customers must be appropriately re-enforced by those in the health sector if those efforts are to be successful.

The LCRWG recommends that EPA, CDC, HHS and HUD conduct training and outreach to local health agencies, medical professionals and local and state lead poisoning prevention agencies on:

1. Information about lead in drinking water (its sources, variable and erratic release, and wide range of lead concentrations)

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[8] Lundgren, R. E. and A. H. McMakin. 2013. *Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks*. Hoboken, NJ: John Wiley & Sons, Inc.
Risk Communication in Action, http://nepis.epa.gov/Adobe/PDF/60000I2U.pdf
Communicating about Lead Service Lines,
http://www.awwa.org/Portals/0/files/resources/publicaffairs/pdfs/FINALeadServiceLineCommGuide.pdf

Strategies to Obtain Customer Acceptance of Complete Lead Service Line Replacement, http://www.awwa.org/Portals/0/files/legreg/documents/StrategiesforLSLs.pdf

National Conversation on Public Health and Chemical Exposures: Education and Communication Work Group Report, http://www.utmb.edu/cet/downloads/Natl_Conv_Edu_Comm_WorkGroup%20Report.pdf

Advancing Collaborations for Water-Related Health Risk Communication, http://www.waterrf.org/PublicReportLibrary/91145.pdf.

2. Information about exposures routes of lead in drinking water to different vulnerable populations, including pregnant women, infants and young children
3. Information about lead service lines
4. Information about the LCR's shared responsibility regime between water system and customer
5. Actions that PWSs typically take to minimize lead in drinking water
6. Steps consumers can take to reduce exposure to lead in drinking water, including removal of LSLs
7. Phone numbers and online links for additional information (including a link to EPA's online National Clearinghouse)

The LCRWG also recommends that EPA work with CDC to incorporate in the CDC's website, educational materials, and materials used by CDC-funded childhood lead poisoning prevention programs nationwide, accurate and up-to-date information about lead in drinking water (its sources, variable and erratic release, wide range of lead concentrations, chronic and acute health risks, the LCR's shared responsibility regime, steps to prevent exposure).

3.2.6 Public Education Compliance

3.2.6.a Compliance for New Customer Outreach

Violations:

- Failure to provide information to new customers

3.2.6.b Compliance for CCR

Recordkeeping, reporting and violations: Same as in the current CCR rule, with updated content.

3.2.6.c PE Compliance for Public Access to Information

PWS must provide the public access to information about:

- Number of samples over the Household Action Level, median, 90th percentile, and highest level found in the last monitoring period
- CCT treatment, approved WQP ranges and WQP results from the last monitoring period

Violations:

- Failure to make this information available to the public

3.3 Improve Corrosion Control

Corrosion Control Treatment (CCT) involves the addition of chemicals (e.g. orthophosphates or silicate) to create a barrier between the pipes and the drinking water, or to modify drinking water chemistry (such as pH and hardness) to inhibit the potential for corrosion. The concept is to manage the treatment system to reduce corrosion (and, thus, the release of metals such as lead and copper) from the distribution system and premise plumbing.

Under the current LCR, PWSs serving more than 50,000 people were required to work with their primacy agency (typically the state) from 1994 to 1997 to designate and install optimal corrosion control treatment. Systems serving 50,000 people or less must optimize corrosion control treatment only if the results of lead and copper tap sample exceed the action levels. A PWS exceeds the lead AL if ten percent or more of the tap samples collected are greater than the 15 ppb action level.

In evaluating CCT choices, a PWS must consider list of assessment parameters; and, as part of the approval of a PWS CCT plan, the state also approves a shorter list of process control parameters applicable to that system to demonstrate that the selected treatment is being properly operated over time. For purposes of this report, the term water quality parameters (WQPs) applies to these latter process control measures. Recommendations concerning WQPs are included in Section 3.4.

Based on the experience with current LCR requirements provided to this work group and shared by work group members, the LCRWG has concluded the following:

- CCT remains an important component of the LCR, in that it is intended to achieve a water quality that minimizes dissolution of lead and copper in water.
- Effective CCT varies based on the specific conditions from system to system. Increased knowledge about CCT since promulgation of the current LCR, if applied today, could lead to improvements in CCT in some systems. Thus, PWSs and their primacy agency should apply the most current science, tailored to the unique circumstances of each system, to the choice of treatment plan and its associated water quality parameters. A variety of factors affect the dissolution of lead in water, including but not limited to pH and alkalinity. Factors other than the stability of designated WQPs can include, among others, the formation/dissolution of protective scales; the presence of manganese, iron, chlorides, sulfates, aluminum and other materials; and temperature. Variations in water quality also can occur within the distribution system. These water quality conditions vary among PWSs, which in turn affect the CCT choices a PWS must make in the context of other regulatory requirements.
- Lead also occurs in different forms in plumbing systems, from soluble to insoluble and particulate in nature. Sources of lead vary from the very common leaded solder and brass fixtures/valves, to LSLs, and to less common lead-lined iron pipe. CCT is more effective in reducing exposure to soluble lead than it is for particulate lead, although CCT that contributes to the formation of certain scales may also provide benefits in reducing exposure to particulates. Thus, while very important, CCT is not the only lead control mechanism that a PWS must have in place. In other words, CCT should not be relied upon by itself to control lead in water. Rather, it should be one of a tool box of other required mechanisms depending on a PWS's particular conditions and lead sources (e.g. LSLs, leaded solder, leaded brass, etc.). These tools are described in other sections of this report and include: LSL replacement (as well as the replacement of other less common sources of lead such as lead-lined iron pipe), current and future use of lead-free materials, stronger public education including targeted public education to vulnerable populations (pregnant women and families with infants and young children), availability of certified POU filters, instructions on how to flush plumbing systems when lead could be disturbed, etc.

3.3.1 Corrosion Control Recommendations

The LCRWG recommends that:

- EPA release a revised CCT guidance manual as soon as possible and update this manual every six years, so that PWSs and primacy agencies can take advantage of improvements in the science;
- EPA provide increased expert assistance on CCT to PWSs and primacy agencies;
- The LCR continue to require re-evaluation of CCT when a PWS makes a change in treatment or source water;

- The LCR continue to require WQP monitoring to ensure that the CCT is achieving the treatment objectives and that EPA consider requiring such monitoring on a more frequent basis with additional guidance on process control methods; and
- Large systems review their existing CCT plan in light of current science in a newly revised guidance manual with their primacy agency to determine whether the WQPs reflect the best available current science. The LCRWG suggests that this review be done every six years following EPA's six year rule review cycle, and subject to there being sufficient science change that EPA updated the guidance manual. EPA should plan to review and refresh Agency guidance every 6 years, subject to significant improvement in the state of knowledge, to allow research to inform rule implementation. In addition, regularly revised guidance would help states and systems stay current with corrosion control science as they respond to problem situations, but more importantly help them anticipate challenges as new water sources and treatments are brought on line, or they contemplate further refinement to corrosion control. Small and medium sized systems should work with their primacy agency to determine whether updates to CCT guidance is applicable to them.

3.3.2 Corrosion Control Compliance

PWS must maintain records that it reviewed new EPA guidance manuals and assessed whether and, if so, what changes to CCT are applicable, based on the current state of the science.

Violations:

- Failure to notify and consult with primacy agency on re-evaluating CCT if the PWS makes a change in treatment or source water
- Failure to review CCT when EPA updates the guidance manual (for large systems)
- Failure to act if state notifies them that they should assess CCT or make adjustments, based on state review of guidance manual (for medium and small systems)

3.4 Modify Monitoring Requirements

Under the current LCR, a PWS is required to conduct monitoring to assess the effectiveness of its corrosion control treatment (CCT) and trigger additional actions to reduce exposure when necessary. Water systems must compare sampling results to an Action Level (AL). The AL for lead is 15 µg/L and the AL for copper is 1.3 mg/L. In the Lead and Copper Rule (LCR), water systems must prioritize sample site locations (often residences) within the distribution system which are at a high-risk of elevated lead and/or copper in the water. Selection and use of these elevated lead and copper sites enables a smaller number of sample sites than random or geographic site selection procedures.

Implementation of this approach over time has revealed numerous challenges. Recruitment of customers to take in-home samples can be difficult and costly. Customers are not professional samplers and, thus, may implement the sampling protocols inconsistently. Research on sampling protocols also has shown that sampling results may vary, and not necessarily consistently, based on the configuration and length of lines from the water main to the sampling tap and whether the sample is a first draw or a subsequent sample intended to reflect water that had been in a LSL for some time.

The LCRWG recommends two types of on-going monitoring: 1) a more robust WQP monitoring program to improve process controls for CCT, and 2) voluntary customer initiated tap water sampling coupled with a more robust and targeted public education program to encourage sampling, in part to provide direct information to consumers that they can use to reduce potential exposures to lead from drinking water in their home and to provide ongoing information to the PWS to identify and correct unanticipated problems.

The LCRWG also recommends that EPA establish criteria for a PWS to transition from the current rule framework into the new rule framework. The LCRWG recommends that the transition includes a condition that a PWS must comply with the requirements of the current LCR until the PWS has achieved three rounds of monitoring results under the lead AL using the current LCR requirements. Results from past rounds of monitoring can be used or new data will be required if prior data are above the AL. At that point, the PWS can define their CCT or WQPs for the new rule as that which was used to achieve this record. The existing lead AL should be redefined as a System Action Level in the new rule wherein it will be used when determining re-optimization, e.g. for use during a review of a new source or treatment, if the state determines that additional utility tap sampling is warranted. In other words, it will provide a baseline target for confirming CCT if lead sampling is chosen as one means by which to determine CCT. PWSs must continue to demonstrate that they are maintaining the WQPs used to establish the transitions. All systems, regardless of their lead AL status, should be required to transition to the new LSL replacement program and public education program requirements of the revised LCR as of the effective date of the new rule.

3.4.1 Water Quality Parameter Monitoring

As noted above, WQP monitoring is distinguished from the more extensive list of parameters that a water system would consider as it evaluates corrosion control technology choices. WQPs for the purpose of this section involve the on-going process control monitoring that demonstrates that the selected treatment is being properly operated over time.

The WQP program recommended below builds on what is in the current rule by recommending:

1) more frequent monitoring than currently required and monitoring that is representative of the distribution system (e.g. at points currently used for DBP monitoring or at a subset of points used for TCR monitoring) to capture currently undetected variability;
2) continuing to tailor WQPs to the individual PWS CCT plan and asking EPA to review and consider adding to the list of WQPs referenced in the LCR, based on EPA's anticipated revision to the CCT guidance manual;
3) that WQP monitoring be periodically revisited based on the advancing science as documented in research reports and disseminated through periodically revised EPA guidance manuals; and
4) that a more rigorous data review process such as control charting and similar process control techniques be used to take advantage of the collected data to improve the consistency of operation, encourage fine-tuning of processes, reduce variability of water quality within the distribution system and detect and manage excursions.

In addition, these data should be reviewed whenever there is a change in source or treatment (see 4.3 above); and, when a system or state primacy agency sees significant changes in WQP data, it should initiate a "find and fix" process, looking for what changed and why, and requiring the PWS make any needed adjustments or corrections. This provides one type of reality check and correction not explicitly in the current LCR.

In addition, the LCRWG recommends that systems which are not currently practicing CCT under the LCR but have been under the lead action level by virtue of either naturally non-aggressive source water or by virtue of other aspects of treatment in use, be required to conduct a WQP monitoring program to continue to demonstrate that the characteristics which caused them to be non-corrosive are continuing to be in place.

3.4.2 Tap Sampling for Lead

The LCRWG also recommends that a voluntary customer-initiated sampling program based on the more robust and targeted public education efforts being recommended elsewhere in this report be substituted for the current LCR tap sampling requirements. .

The results of the voluntary tap sampling program will be used for three separate purposes:

- informing and empowering individual households to take action to reduce risk,
- reporting to health officials when monitoring results exceed a “household action level” (see section 3.5) and
- ongoing information to the utility to assess effectiveness of CCT.

Information for Households

Data from customer-initiated sampling will be valuable in informing and empowering individual households and thus provide greater customer service. All data provided to customers would need to include appropriate information about the variability of lead levels, that a single sample does not represent all water quality, and that levels at a particular tap at a particular time might be higher or lower. The transmittal should also provide appropriate information about the risks of lead exposure, sensitive populations, and actions the consumer can take to minimize risk.

This type of sampling is currently discouraged by the current rule because water systems are often concerned that “complaint” or “customer “ samples would be included into the required 90th percentile calculation with potential mandatory response actions if it exceeded the action level. This resulted in system not offering sampling or having the samples be analyzed through a private lab (and therefore the data would not be available for any utility management or regulatory purpose). Currently, PWSs are mandated to return to the same locations which, while it may have value for other reasons, means that many other households do not get the opportunity to understand their lead exposure. Voluntary customer-initiated sampling can also capture data from multi-family residences, which is not included in the mandatory LCR sampling in most cases. A new approach could achieve greater customer service and more data to understand and manage lead corrosion.

Outreach to encourage customers to sample will likely involve many different customer contact opportunities including the CCR, outreach related to having a LSL, outreach related to construction contracts, new customer contact, community meetings, other educational outreach efforts, and whenever a customer contacts the CWS for a water quality question or complaint.

Customers should be given the opportunity to determine the type of information they are interested in, thus should be offered a menu of sampling protocols, e,g. a random daytime sample to determine typical exposure levels, first draw to determine the effects of a brass faucet, or a timed or temperature determined sample from within a service line. The National Clearinghouse should include templates with instructions for each type of sample.

Information for Public Health Officials

Data from customer samples which exceeded the “household action level” recommended in section 3.5, would be required to be forwarded to health officials. While LCR tap water results are currently provided to the collecting household, the LCR does not require any <u>action</u> for individual high samples, and there is no mandate to refer to health authorities. While the LCR cannot guarantee actions by health departments, this recommendation provides direct health intervention in those cases where sampling indicates high lead levels.

Information for Assessing the Effectiveness of CCT

The third use of the customer tap sampling data is to provide on-going information to the utility of potential changes in the effectiveness of CCT. Under the current rule, most systems are sampling for one four-month period every three years. Any changes or variability in lead levels at the tap during the other 32 months of that period are missed. Under this proposal, it is anticipated that there would be a more regular stream of data from more locations, providing information which can be used to understand system performance. The data would be provided to the state primacy agency and presented as time series data to facilitate identifying any changes in the data over time. Small systems might report the data on something as simple as a spreadsheet chart, while larger systems might use more sophisticated analytical methods to understand and use the data.

Unexpected or unexplained changes in the tap sampling data can be used in a "find and fix" approach to identify and respond to potential problems. This could be system initiated or in response to periodic review of the system data by the primacy agency, such as during a sanitary survey. This provides a reality check on whether something unexpected is happening within the distribution system, even though consistent treatment was maintained. The more robust (in both temporal and geographic distribution) of the customer sample data set provides a more powerful check on treatment than the current episodic sampling does.

Specifically the LCRWG recommends that the revised rule require that:

- any customer sampling data be reported to the state on a routine basis and include which of the menu of sampling protocols referenced above was used;
- data be provided as soon as possible and no later than within 30 days to the customer and, if over the household action level, to the health department (as discussed above and in section 3.5);
- the PWS maintain the data set for analysis and review, taking type and location of each sample into consideration, to identify trends and changes in the data;
- the data be available for public review as described in section 3.2.4;
- the PWS and the state review the data and trend analysis during sanitary surveys;
- annually, at the discretion of the primacy agency, the PWS provide the primacy agency with a data summary report of the three most recent years of all tap sampling data, the specific details of which should be determined by EPA;
- if the three most recent years of customer sampling data show that the 90th percentile (running three-year calculation) is above the System Action Level, then the PWS must analyze any changes or trends in the data to evaluate whether they are based on system-wide, local , or household-based conditions, and provide the report and analysis to the state for their review and determination if additional analysis, re-evaluation of CCT, or other actions such as household-based actions (LSL removal, education about lead-free faucets and flushing after non-use of water, etc.) are appropriate.
- if the system makes any source or treatment changes, the PWS and state should use the customer sampling data in the consultation, review and approval by the State currently required by the LCR.

The LCRWG also recommends that EPA provide guidance to states and PWSs on additional forms and types of data analyses which can be conducted on sampling data to provide more detailed understanding of trends and to support system decision making on customer actions, treatment evaluations or development of system plans and priorities for LSL replacement programs.

It seems appropriate to include some sort of floor to the number of customer samples. Some members of the group suggested that systems should be required to collect no fewer samples in a three year period than they would under the current three-year reduced monitoring requirement.

When a system changes its source or treatment, and is required to consult with the state, the state primacy agency also may choose to require additional one-time monitoring to evaluate those changes if the degree of the change warrants.

Some members suggested that some small systems might want the opportunity to maintain the current home tap water monitoring program. The revised LCR should allow this, while not discouraging customer sampling.

3.4.3 Sample Invalidation Criteria

Under the existing regulation (141.86 (f)(1)), "The State may invalidate a lead or copper tap water sample if at least one of the following conditions is met.

(i) The laboratory establishes that improper sample analysis caused erroneous results.
(ii) The State determines that the sample was taken from a site that did not meet the site selection criteria of this section.
(iii) The sample container was damaged in transit.
(iv) There is substantial reason to believe that the sample was subject to tampering."

These are all good and necessary reasons for invalidating a sample and should be retained, but because this list is limited, samples must be accepted that are obvious "outliers" and don't represent the water that is normally consumed and should not be used as a basis for treatment changes or public education. This is especially true for small systems where the limited number of samples required means that a single, unusually high, value can cause the Action Level to be exceeded. This could lead to installation of expensive treatment when treatment is not needed or adequate corrosion control is already being provided. While probably not as frequent, non-representative samples could also cause water systems to be below the action level when treatment changes really are needed. Good invalidation criteria can help states address both problems.

The purpose of the invalidation is to make sure that decisions are based on the most representative set of samples possible and to do so through a process that provides adequate information to make good invalidation decisions and assures documentation of the reasoning behind the invalidation.

The following is a proposal from states that will serve those two functions.

States believe that the essential criteria for invalidation are already well stated in the Revised LCR Monitoring and Reporting Guidance (EPA 816-R-10-004, March 2010) or the October 2006 memorandum on Management of Aerators During Collection of Tap Samples to Comply with the Lead and Copper Rule. The LCRWG recommends that EPA take the following into account when revising the proposed rule and expand the invalidation criteria accordingly:

- Make sure the sample is taken at a tap that is used regularly, and not an abandoned or infrequently used tap."
- "If first-draw samples are collected at single-family residences, the sample must always be drawn from the cold-water kitchen tap or bathroom tap."

- "If first-draw samples are collected from buildings other than single-family homes, the sample must always be drawn from an interior tap from which water is typically taken for consumption."
- "Public water systems should not recommend that customers remove or clean aerators prior to or during the collection of tap samples for lead."

3.4.4. Monitoring Compliance

PWS must monitor and report based on water quality parameters and schedule set by state primacy agency, and use the data for on-going treatment process control (3.4.1)

Violations:

- Failure to monitor as per schedule
- Failure to maintain data, and use in process monitoring (to be evaluated by state during sanitary survey inspections or as state primacy agency requests)
- Failure to report data to state
- Monitoring results outside the WQP range established in the PWSs CCT plan along lines similar to current rule requirements

PWS also must include an offer to customers in all LCR related outreach to collect a sample, including in all LSL outreach efforts. PWS must also:

- collect sufficient number of samples, either by customer request or utility initiated sampling, i.e. no fewer samples in a three year period than under the current three-year reduced monitoring requirement, assuming the PWS qualifies for such reduced monitoring;
- promptly report the data to the customer, the state and local PH (if above health action level); and
- use the data as part of on-going evaluation of CCT performance, monitoring for changes in lead levels at the tap over time, geographic trends in levels, and interaction with distribution system water quality.

Violations:

- Failure to offer to sample
- Failure to collect minimum number of required samples within 3-year window
- Failure to report data to:
  - Household
  - State
  - Local public health agency (if above household action level) no later than 30 days after the result was received
- Failure to provide rule-required information in sampling offer materials, or in household reporting of the data
- Failure to use household tap sampling data in on-going evaluation of CCT and maintain record of having done so, (as determined by state during sanitary survey inspections or as state primacy agency requests)

3.5 Establish a Household Action Level

The current lead action level is based on the 90th percentile of the collected samples. Without a maximum limit, some users may be exposed to levels of lead in the drinking water that presents a potentially significant health threat, especially to children, without exceeding the action level.[9] If the levels are high enough and state and local authorities do not act, EPA could determine that the levels pose "an imminent and substantial endangerment to the health of persons" pursuant to section 1431 of the Safe Drinking Water Act. (40 USC 300i)

3.5.1 Household Action Level Recommendations

To avoid the possible need to invoke section 1431 of the SDWA, the LCRWG recommends that EPA establish in a revised rule a "household action level" and require the PWS to notify the local health department and state drinking water authority of sample results over that level. The requirement would be triggered by any sample results that the PWS receives from a user or from its own monitoring. However, the PWS would not be required to make the notification until it has investigated the sample in a timely manner to eliminate sampling or assay errors.

The existing rule already requires the PWS to notify residents of the results of water system conducted lead sampling. We would anticipate that the PWS would alert the resident to possibility that the health department may be notified when the sample was taken or the resident provided the PWS with the sample results. While this notice may have the unintended consequence of discouraging some customers from testing, it is important for the customer to make an informed choice.

In response to the notification, the PWS and the health department would consider the situation and take action that they deem appropriate (e.g., testing children's blood, recommending a filter, discussing lead service line replacement with the resident or landlord, advising grandparents about risk to visiting children, or continuing to monitor the situation). We anticipate that the health department be the lead agency, and that the rule would not prescribe actions other than notice as the situations are too diverse and complicated for prescription actions. The LCRWG encourages EPA to work with the Centers for Disease Control and Prevention on recommended approaches and make this information available through the clearinghouse discussed in section 4.2.

This requirement would be somewhat similar to the regulatory approach taken by the Department of Housing and Urban Development which mandates that public housing authorities notify the local health department within five days when it receives information from any source that a child of less than six years of age living in an assisted dwelling unit may have an environmental intervention blood lead level. (24 CFR 35.1225)

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[9] The LCRWG discussed the relationship between the household action level and the current lead AL (to be renamed the system action level). These levels have two distinct purposes. The LCRWG assumed during its discussions that the household action level would be significantly greater than the system action level. It recognized, therefore that, depending on what level is set, the household action level may have impacts on other recommendations in this report.

We recommend that EPA set the household action level based on the amount it would take for an infant to have a blood lead level greater than five micrograms per deciliter (µg/dL) based on consumption by an average, healthy infant of infant formula made with water. When a child's blood lead level exceeds five µg/dL, the Centers for Disease Control and Prevention (CDC) recommends that laboratories and health care providers notify local and state health departments and that action be taken to identify and prevent further exposure.[10]

3.5.2 Household Action Level Compliance

If household sample exceeds the household action level, PWS must promptly notify the household and the local public health agency; certify that this has been done, and maintain records of having done so.

Violations:

- Failure to report data no later than 30 days after the result was received, to
  - Household
  - Local public health agency
- Failure to certify to state that data was reported to the household and to the local public health agency within 30 days
- Failure to maintain records of correspondence between PWS and the local public health agency,

3.6 Establish Separate Monitoring Requirements for Copper

The current LCR does not deal effectively with copper. Generally speaking, the current rule focuses on the health benefits associated with lead risk reduction, with the result that the currently required in-home sampling is often done in locations with old copper that has passivated. Thus, the possibility may be missed that a system's water chemistry could result in copper releases. Further, the current rule does not require public education for copper, which can have broad benefits.

The LCRWG has concluded that the regulatory approach should separate lead and copper risk management, refocusing attention to where there may be a problem with copper without increasing the burden on systems where there is not a problem. This can be achieved in a cost effective manner by targeting copper monitoring requirements to those PWSs where there may be exposures.[11]

Elevated exposures to copper generally result from new copper plumbing[12] where water chemistry is aggressive to copper. It is technically possible to identify water chemistries that are aggressive versus not aggressive to copper. Thus, the LCRWG recommends that the requirements for copper monitoring focus first on sampling for basic finished water quality parameters such as pH, alkalinity, and orthophosphate in a way that is representative of the distribution system to identify waters that are aggressive to copper. Systems that can demonstrate that their finished waters are not aggressive to copper or that their

[10] http://www.cdc.gov/nceh/lead/ACCLPP/blood_lead_levels.htm

[11] The LCRWG recommends this approach, assuming EPA determines that the health benefits of regulating copper justify the costs. A full health risk assessment for copper was beyond the scope of the LCRWG's charge, however; and, thus, EPA's analysis of whether benefits justify the costs may have implications for these recommendations.

[12] New copper is generally understood to be between six months to three years of use.

distribution systems contain no copper should have no further copper monitoring requirements. This could be written into the rule, rather than require a monitoring "waiver."

3.6.1 Copper Recommendations

Further, the LCRWG recommends that the LCR be revised based on the following concepts:

1. Instead of basing action on the results of routine, in-home copper sampling, actions should be based on the aggressiveness of the water to copper. Systems can determine if their water is aggressive to copper by doing WQP monitoring in the distribution system. All PWSs should be assumed to have water that is aggressive to copper unless they demonstrate that it isn't.

2. EPA should develop criteria to define water that is not aggressive to copper for the purpose of establishing whether a system falls into that category (or "bin") for the purposes of the LCR. EPA should consider the accuracy and potential variability of pH and alkalinity monitoring as well as corrosivity to copper in establishing pH and alkalinity ranges. The criteria also should include consideration of passivation time. Examples of bins (for verification by EPA) would be:

    a. if alkalinity is < 35 pH must be > 7.0 (no upper pH limit)
    b. if alkalinity is 36 to 100, pH must be > 7.2
    c. if alkalinity is 101 to 150 , pH must be > 7.5
    d. if alkalinity is 151-250 , pH must be > 8

If orthophosphate is used, examples of bins would be:

    a. if alkalinity <150, PO4 must be >1 mg/L
    b. if alkalinity is 150 to 200, PO4 must be > 2 mg/L
    c. if alkalinity is 200 to 240, PO4 must be > 3 mg/L
    d. if alkalinity is greater than 240, PO4 must be > 3.3 mg/L

3. PWSs can choose one of several approaches to demonstrate that their water is not aggressive to copper:
    a. Conduct water quality parameter monitoring to assess whether their water meets the definition established by EPA.
    b. Conduct a one-time evaluation with copper sampling at vulnerable houses (houses < 2 years old with new copper plumbing) to demonstrate that water chemistry is non-aggressive (copper levels fall under the AL/SMCL). EPA may want to consider:
        i. Limited number of sample sites needed given copper chemistry
        ii. Provision for sample invalidation based on site-specific conditions such as biologically-induced corrosion.
    c. Conduct a pipe loop study to demonstrate the water chemistry is non-aggressive
    d. Change water chemistry to within the range established for non-aggressive water quality
4. PWSs with water **classified as non-aggressive to copper** must continue to demonstrate that the water is non-aggressive. PWS's can choose to:
    a. Maintain those WQPs that demonstrate it maintains non-aggressive water under (2) above, or

b. Conduct copper sampling at vulnerable houses (houses < 2 years old with new copper plumbing) to demonstrate that water chemistry is non-aggressive (copper levels fall under the AL/SMCL)

PWSs that are not able to maintain their WQPs must implement a public education program as described in the next section.

5. PWS's with water **classified as aggressive to copper** must initiate and maintain a public education program. The public education program must either provide:

   a. Information to all new homes (new construction or change of service) upon initiation of new service

      AND

   b.
      i. Information to newly renovated homes at time of renovation

      OR

      ii. Information to all customers on a routine basis

   In addition, in guidance, EPA should encourage PWSs to notify contractors, plumbing suppliers, and plumbers of copper corrosivity and to work with relevant officials and organizations to consider building and plumbing code changes that would prohibit copper piping in new construction if the corrosive water conditions cannot be eliminated. EPA also should provide guidance and/or templates, particularly for small systems, for public education messages and modes of delivery.

6. EPA should consider whether or under what circumstances CCT should be required for a PWS **classified as aggressive to copper** Not all systems with water aggressive to copper necessarily will have homes with new copper, so treatment might not be necessary or perhaps even advisable, particularly for small systems that can control plumbing materials used or for systems in communities that modify their plumbing codes. Passivation time of copper varies considerably, and CCT may not be necessary or advisable when passivation time is short if interim actions to protect public health other than CCT are feasible. In determining when CCT should be required and any associated monitoring requirements, EPA also should take into consideration that a PWS may not have access to information about renovations where new copper has been installed and, even when such information is available, can't control whether the customer will participate in a monitoring program. Setting the correct level and establishing a regulatory approach that triggers CCT only when necessary will require a complex assessment and is beyond the scope of this workgroup.

7. In the revised LCR, systems should continue to be required to notify the primacy agency if they are making any long-term treatment change or addition of a new source. This section of the rule should be made clear that for copper, the system may be required to demonstrate that its finished water continues to be non-aggressive to copper (per 4 above).

8. Additional information needs to be gathered on the current distribution of pH, alkalinity, and phosphate residual among systems nationally to fully understand the implications of this approach.

3.6.2 Copper Compliance

Violations:

- Failure to implement public education, for PWSs that have not demonstrated their water chemistry is not aggressive to copper.
- Failure to maintain a monitoring program representative of the distribution system that demonstrates the system has water chemistry not aggressive to copper.
- Failure to provide notice to and, if required, consultation with the primacy agency, when a PWS makes a significant change in source or treatment (as in the current LCR).
- Failure to implement CCT or other risk reduction actions prior to CCT as determined by the primacy agency.

4 Complementary Actions Critical to the Success of the National Effort to Reduce Lead in Drinking Water

The LCRWG urges EPA not only to promulgate a revised LCR, but also to play a leadership role in educating, motivating, and supporting the work of other agencies, where EPA does not have the authority to act. The LTR LCR is very important. However, removing lead from drinking water systems and reducing exposure to lead from drinking water in the meantime will require renewed commitment, cooperation and effort by government at all levels and by the general public.

Specific recommendations for action in addition to the LTR LCR include (grouped generally by who might take such actions):

<u>EPA Actions</u>

- EPA working across all offices to take an integrated approach to action and education on lead from all sources (paint, air, site clean–up, etc.), with proper emphasis on lead in drinking water, especially in relation to the populations most vulnerable to this source (pregnant women, infants and young children). For example, OGWDW should coordinate with EPA's lead-based paint program so lead hazards are communicated consistently.
- Work with other federal agencies including HUD in terms of lead programs including but not limited to expanding federal funding from those programs to include lead service line replacement; HUD/DOT in terms of efficiency in possible coordination of lead service line replacement with road projects and other construction projects; and CDC in terms of childhood lead poisoning prevention, screening, and protection programs
- Enhanced cooperation with state, county, and local health departments to promote an integrated approach to childhood lead poisoning screening, prevention, and protection that emphasizes drinking water and its potential as a primary lead source (e.g. infants dependent on reconstituted formula).
- EPA needs to work with agencies at all levels of government to support financial assistance programs for LSL removal. Building costs into a PWS's capital budget planning should also be a consideration.
- EPA should include diverse perspectives in its stakeholder engagement programs, including affected consumers (who should not be required to be members of formal organizations), lead poisoning prevention/clean water advocates, EJ advocates, lead/copper corrosion experts, and

representatives from PWSs, States, and federal agencies with Healthy Homes and childhood lead poisoning prevention programs.

<u>Other Federal Actions</u>

- A federal tax deduction to support replacement of the customer portion of LSLs.
- EPA should work with CDC and HHS to ensure that the standard protocol for investigation of any child with elevated blood lead levels or of a home with lead levels above the HAL include determination of whether there is a lead service line.
- EPA should work with HHS and HUD to modify funding guidelines for the Healthy Homes and other federal funding programs to explicitly authorize and prioritize the use of those funds for lead service line removal programs targeting the privately owned portion of any lead service line. The current situation of having tens of thousands of dollars spent by a local Healthy Home or lead poisoning prevention program to remove lead paint, and leave behind a lead service line because of arbitrary funding guidelines is unacceptable.

<u>State or Local Actions</u>

- Local or state building and plumbing codes, including possibility of prohibiting copper plumbing where water is aggressive to copper.
- State Actions to support customer lead service line replacement, e.g.
    - State legislation requiring inspection or replacement on sale of home
    - Disclosure requirements at sale of home
    - Requirements for LSL removal as part of school and day care licensing
    - Building code requirements for LSL removal upon substantial renovation (could be national action as well)
    - Priority in DWSRF funding, especially if increased funding is available. (Criteria states might wish to consider include: PWSs where there is a high incidence of elevated BLLs for children, a high percentage of homes with LSLs, a high percentage of low income families, the PWSs prior efforts to replace LSLs, etc)[13]
- States should consider including requirements for lead in drinking water in state child care licensing rules.

<u>Public Water System Actions</u>

- Options EPA may want to describe in guidance and PWSs could consider include but are not limited to:
    a. Rate design considerations:
        i. Low rates for low volumes
        ii. Household size-based rates

[13] Good examples of programs which facilitate and enable private action include a Massachusetts program which provides a state income tax credit for the replacement of failing private wastewater treatment systems (septic tanks and leaching fields) coupled with a requirement for inspection and compliance with stricter rules upon property transfer; and many local housing rehabilitations programs funded by Federal Community Development Block Grants (CDBG) which provide low or no interest loans for health and safety related improvements, payable upon property transfer, often with loan sunsets where repayment is not required or the balance is reduced over a period of continued occupancy by an income-eligible homeowner. A similar loan program could be authorized by EPA under the Drinking Water SRF program.

b. Non-rate policies
    i. Budget billing
    ii. Fixture retrofits and plumbing assistance by the PWS
    iii. Service line replacement and insurance programs not provided by PWS
    iv. Direct assistance, emergency bill payment relationships
    v. Fixture retrofits and plumbing assistance by NGO organizations providing affordable housing
    vi. Subsidies including LSL / connection replacement costs associated with street, sidewalk, and other repairs not related to drinking water infrastructure
    vii. On-bill financing provided by the PWS
c. Funding guidance
    i. EPA's Financing for Environmental Compliance – Water
    ii. Tools for Financing Water Infrastructure
d. Funding sources beyond rate revenue:
    i. EPA's Drinking Water State Revolving Fund (DWSLF)
    ii. EPA Targeted Grants to Reduce Childhood Lead Poisoning
    iii. USDA's Water and Environmental Programs, U.S. Department of Agriculture, Rural Development
    iv. HUD's Community Development Block Grant Program – U.S. Department of Housing and Urban Development
    v. HUD Healthy Homes Technical Studies
    vi. HUD Office Healthy Homes and Lead Hazard Control Lead Hazard Reduction Demonstration Program
    vii. HUD Health Homes Initiative Lead Elimination Action Program
    viii. HUD Office of Healthy Homes and Lead Hazard Control Lead Hazard Control Lead Technical Studies Grant Program

- PWSs should educate and encourage partnerships with healthcare providers and health departments even when levels are below the AL.

<u>Research</u>

- Additional technical review and/or additional study is needed on how to conduct household and service line flushing to remove particulate lead.
- Published, peer reviewed research explaining that water in plumbing systems with leaded materials and LSLs can have sufficient levels of lead in the water to be a risk to those consuming the water. This paper is important to gaining support from the public health agencies and others and to placing water in context with other sources of lead.
- Considering that lead remains a complex issue and that research and information gaps still exist, the EPA should establish a Research and Information Collection Partnership to encourage the filling of these gaps in knowledge. The RICP should be initiated once the EPA begins working on the revised rule and continue for three years or more into the promulgation of the revised rule.
- The EPA and other agencies, such as the Water Research Foundation, should conduct research (such as bench scale and limited system case studies) to confirm the bins selected to define aggressive waters for copper. The bins are based on theory and need some level of confirmation prior to promulgating an actual regulation. This work can be done within the timeframe of developing a final rule.

5 Conclusion

The LCRWG appreciates the opportunity to provide these recommendations to the NDWAC, offers our thanks to the experts and members of the public who made presentations to the work group, and wishes particularly to acknowledge EPA for the extensive commitment of staff time and expertise to this process.

ATTACHMENT A

NDWAC Lead and Copper Working Group

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Table 1: Elements of utility reports by dates in three-year cycle (*based on EPA adoption of rule in 2017)											
Action	2020*	2023	2026	2029	2032	2035	2038	2041	2044	2047	2050
Confirm broad and targeted education programs underway[1]	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.
Status of consumer sampling[2]	NA	# done & # offered	# done & # offered	# done & # offered	# done & # offered	# done & # offered	# done & # offered	# done & # offered	# done & # offered	# done & # offered	# done & # offered
Confirm communication of sampling results[3]	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.
Confirm operation policies in place[4]	Yes. If not, then explain	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.	Yes. If not, then explain.
Replacement Progress[5]	Initial Baseline	85% remaining	70% remaining	55% remaining	40% remaining	25% remaining	17% remaining	10% remaining	6% remaining	3% remaining	0% remaining
If replacement goals not met, number of checklist items confirmed completed (See Table 2)[6]	Basic requirements *[see Section 3.1.2]*	Basic requirements	TBD (by EPA)	TBD (by EPA)	TBD (by EPA)	TBD (by EPA)	TBD (by EPA)	TBD (by EPA)	TBD (by EPA)	TBD (by EPA)	TBD (by EPA)

[1] See Section 3.1.2 (item 4 "targeted outreach" EPA to provide a checklist; PWS to contact customers with LSLs individually at least every three years and when there is a new customer at that address.

[2] Number of customers offered opportunity to conduct at-tap samples and number of samples taken.

Confirmation that results were provided to the customer. Number exceeding the household action level and confirmation that the results were submitted to health department. Maintain records for review by the primacy agency.

[4] Program to ensure that emergency, maintenance and renovation operations consider risks of disruption to service line increasing lead exposure to residents. .See Section 3.1.2 item 7 (operations).

[5] A service line is presumed lead unless installed after date installation of lead service line prohibited or records or tests by utility confirm entire service line is not lead. Confirming that a service line is not lead counts toward replacement progress.

[6] This is a two-fold concept, the details of which the LCRWG suggests be determined by EPA: 1) provide the PWS the flexibility to select outreach methods and other efforts appropriate to that community and 2) increase the number of required efforts to be completed if replacement goals are not met. See Table 2 for checklist of options for additional effort (in addition to the basic outreach requirements).

Table 2 Options (in addition to the basic outreach requirements) to be accomplished by utility if replacement progress goals in Table 1 not met.[1]

Basic outreach requirements:

- Individually notify customers with known or possible LSLs describing the risks of lead in drinking water, specifically inviting them to participate in the LSLR program, offering to have the customer's tap water analyzed, and clearly describing the terms of the program and how to follow up. If the customer does not respond or chooses not to participate, the PWS must follow up with another invitation at least every three years and always when there is a new customer at that address. (see Section 3.1.2 for additional details)
- Provide a written offer to replace the LSL when work is being done on the water main in the street (with the same information above).

Resident engagement	System policies	Other
1. Notice to new customers of need	1. Plumbing code requires full replacement if service line will be disturbed.	1. Local health agency contact with resident.
2. Written offer to replace when main in street rehabbed (customer pays)	2. Grants or low-interest loan funds identified to cover customer costs sufficient to maintain progress for period.	2. Local health agency funding for removal as part of remediation
3. Written offer to volunteer (customer pays)	3. Financing options such as liens on home provided to customers or tax deductions for property owner costs.	3. Media campaign launched
4. Written refusal from customer(s)	4. MOU or other arrangement to implement notification of customers/property owners by other utilities about replacement options if LSL is disturbed	4. Homeowner association(s) send letters to members supporting replacement.
5. Certified letters sent	5. Capital improvement plans target system pipe rehab and replacement to areas with more LSLs	5. Real estate organizations notified of requirement for replacement of LSL on sale or transfer of title
6. In-person call or visit made	6. Service line insurance program revised to include replacement LSLs if damaged or leaking	6. Cooperative outreach efforts with non-profits
7.	7. More aggressive flushing in areas with LSLs to manage iron related lead particles	7. Coordinated outreach with WIC
8.	8.	8. Outreach to plumbers/contractors
9.	9.	9. Outreach to ob/gyns and pediatricians
10.	10.	10. Local ordinance requiring inspection/notification/replacement of LSLs upon sale or transfer of title
11.	11.	11. LSL identification added to home inspector standard operating procedures
12.	12.	12.

[1] EPA will provide guidance on the options and update them periodically as best practices evolve.

Milwaukee Water Works

Safe, Abundant Drinking Water.

2017 Lead Service Line Replacement Plan

The Milwaukee Water Works will begin the mandated full replacement of lead service lines with copper when they are leaking or damaged at all properties. A lead service line also would be replaced when a planned infrastructure project would disturb it. There are no such projects for 2017 known to include lead service lines but it is possible some lines could be disturbed.

The City owns the section of the water service line from the water main to the curb stop at the property line. The property owner owns the section from the curb stop to the water meter.

Mayor Tom Barrett signed an ordinance Dec. 20, 2016, approved by the Common Council, which requires replacement of the city and property owner's side of a lead service line ***when leaking or damaged.***

- To be eligible for a subsidy and financing plan, the property must be residential with 1-4 units.
- The Milwaukee Water Works will coordinate the replacement, hire a contractor and pay all costs up front.
- When the project is complete, the City will bill the owner for one-third of the cost or $1,600, whichever is less. This may be paid in full, paid over 10 years, or paid off early, but will cost no more than $16 per month.
- There is no subsidy for owners of either residential properties with more than four units or commercial properties. They are required to replace a leaking or damaged lead service line with copper at their expense.
- There are about 300 leaks on lead service lines each year in Milwaukee. That's the approximate number covered in the 2017 plan.

Child cares and private schools in 2017

In 2016, Milwaukee received $2.6 million in Safe Drinking Water Loan (SDWL) monies from the Wisconsin Department of Natural Resources. Of this, $1.6 million will be used to replace lead service lines at 385 licensed child cares and 12 private charter schools. Milwaukee Public Schools do not have lead service lines.

The remaining $1 million SDWL funds will be used to pay the city's two-third share of private side replacements for 2017.

Previously, for a lead service line leak, the Milwaukee Water Works replaced the city owned section with copper and encouraged the property owner to voluntarily pay to hire a contractor and replace their section with copper. The city plan does not include retroactive payment to property owners for previously replaced lead service lines.

If your lead service line is not leaking or damaged but you want to replace the lead with copper:

- There is no cost share with the city or special assessment financing. The property owner must pay for the replacement.
- Obtain quotes, and if you choose to hire a contractor, before you start, please call the Milwaukee Water Works, (414) 286-3710, to coordinate your work on the private side with our work to replace the city owned side of the lead service line.

12/21/16

MPS releases lead testing results

BY: Eric Ross
POSTED: 6:01 PM, Dec 16, 2016
UPDATED: 6:18 PM, Dec 16, 2016

Share Article

Friday afternoon, Milwaukee Public Schools released lead testing results taken from drinking fountains in all district schools and buildings.

Samples were taken at 3,000 water fountains. 183 had levels above EPA standards.

A spokesperson for MPS says fixtures that tested above EPA standards were immediately turned off and will be replaced.

- **Smith Family: Justice Not Yet Served In Shooting**

"The City of Milwaukee Health Department has aggressively worked to reduce children's exposure to lead hazards, and can report that we are seeing the lowest levels on record today. As we work to drive down rates even further, we applaud MPS in taking a leadership role by conducting voluntary testing and providing the results to our community," stated Commissioner of Health Bevan K. Baker. "The City of Milwaukee Health Department worked collaboratively with MPS to develop a testing protocol that can be used as a model by other schools and school districts everywhere."

According to the City of Milwaukee Health Department, the primary source of lead exposure in Milwaukee is through lead-based paint hazards found in homes. Additional sources of lead exposure can be through drinking water, soil, food, toys, and other sources.

The test results can be found here.

- **Swimmer With One Arm Chases Paralympic Dreams**

The school district began testing for lead over the summer as a precautionary measure. Currently, state and federal regulations do not require schools to test drinking water.

LOCAL NEWS STORIES

BWL removes Lansing's last lead water service line

Eric Lacy , Lansing State Journal Published 12:06 p.m. ET Dec. 14, 2016 | **Updated 7:25 a.m. ET Dec. 19, 2016**

City-owned utility says it has replaced 13,500 to 14,000 lead water service lines since 2004. With BWL's help, Flint makes progress with its lead removal plan.

(Photo: Julia Nagy / Lansing State Journal)

LANSING -- With a backhoe and much fanfare, the city's last lead water service line was removed Wednesday.

Mayor Virg Bernero and Board of Water and Light General Manager Dick Peffley celebrated the service line removal at noon near a home east of downtown. They stood at a podium with David Price, BWL's Board of Commissioners chair, with a banner that read "We got the lead out" as their backdrop. Attached to the backhoe's bucket was a GoPro camera that captured footage of the machine as it yanked the line out of the ground.

"Just because it's out of sight doesn't mean it should be out of mind," Bernero said of the city's urgency to remove lead lines over the past 12 years.

Lead water service lines received attention this year because of an ongoing crisis in Flint that involves lead-contaminated water. In Lansing, the BWL has replaced 13,500 to 14,000 lead service lines with copper lines since 2004. Of those lines, 12,150 were deemed active by BWL and replaced at a cost of $44.5 million. Money to replace BWL's lead lines with copper ones comes from a fund for capital improvements (/story/news/local/michigan/flint-water-crisis/2016/09/27/flint-detroit-water-crisis-lead/91176828/) that's main source is revenue from ratepayers. The utility has over 55,000 water customers.

Lansing's last lead service line was replaced at 619 Barnard St., just off South Larch Street, between Michigan Avenue and Interstate 496. The utility confirmed that none of its water provided to customers has detectable lead when it leaves its two water conditioning plants. It also confirmed there are no lead mains in its 800-mile distribution system.

"This is a tremendous accomplishment that shows communities across Michigan and the nation that replacing lead service lines can be successful with planning, operational expertise and the support of the community and the customers," Peffley said of Wednesday's service line removal.

Lansing BWL takes next step to help Flint water crisis
(http://www.lansingstatejournal.com/story/news/local/bwl/2016/02/17/lansing-digs-in-for-flint-help/80444724/)

During the BWL's search for lead service lines, it found that 2,695 service lines were not lead. There were also 79 inactive lead service lines found and 31 lines deemed inactive of an unknown type. Those lines were also removed and cut at properties' curb box. The BWL is unique compared to other utilities across the country because it owns service lines from the curb of a street to the meter.

All of the 110 lines were found at vacant or abandoned properties and are expected to be replaced with copper lines -- if the properties become occupied. The disconnected inactive lead and unknown service lines are not included in BWL's 12,150 lines that have been replaced since 2004.

Bernero said Lansing joins Madison, Wis. as the only two water utilities in the nation that have removed all lead service lines. The City of Madison's website confirms it was "the first major city" to launch a lead service replacement program. Madison's program started in 2001 and aimed to remove replace 8,000 lines with copper lines. The website says the program has "largely been completed." (https://www.cityofmadison.com/water/water-quality/water-quality-testing/lead-copper-in-water)

Buy Photo

Lansing Mayor irg Bernero B L eneral Manager ic Peffley, right, and B L Board of Commissioners chair avid Price celebrated ednesday removal of the city s last lead water service line *(Photo: Julia Nagy / Lansing State Journal)*

Bernero put pressure on BWL to make infrastructure improvements and remove lead lines when he was a state senator. At the time, Jennifer Granholm was governor and Bernero created a safe drinking water task force (http://flintwaterstudy.org/wp-content/uploads/2015/10/Lansing-debate-Virg-final.pdf). He also chaired the task force and appointed its members.

Bernero said Wednesday he thought, as a senator, that removal of Lansing's lead service lines would take at least 10 years. He said officials and residents in other communities need to pay attention to their water delivery systems and be proactive, especially due to Flint's ongoing water crisis.

"We take for granted that when we turn on the water good stuff comes out," Bernero said. "When we flush the toilet, bad stuff goes away. We rely on that and we have for years with confidence."

Lansing BWL's push to remove lead water lines continues (http://www.lansingstatejournal.com/story/news/local/2016/01/22/lead-water-line-removal/79108766/)

Peffley said BWL crews have learned over 12 years how to remove lead service lines more efficiently. A line can be removed in about four hours at a cost of about $3,600. When the work first started, the cost per line was about $9,000, he said.

Lead service lines that existed in Lansing before their complete removal didn't pose a hazard to customers, according to BWL officials. Steve Serkaian, a BWL spokesman, told the LSJ in January that water that passes through service lines – lead or copper – is tested "multiple times daily, seven days a week, 365 days a year."

The utility will continue to use a phosphate anti-corrosion compound to coat water pipes and prevent leaching of lead and copper into drinking water. Lead may still exist in properties' plumbing fixtures, but its the owners' responsibility to replace them.

Lansing experience helps Flint

Flint is underway with a lead service line removal program called Fast Start that's being overseen by retired Brigadier Gen. Michael McDaniel, an East Lansing resident. McDaniel said Wednesday that BWL's expertise and advice in removing lead service lines has helped Flint stay on pace to remove about 6,000 lines by the end of 2017.

“They had the foresight to say 'We’re not going to wait for an emergency, we’re going to start doing that now,'" McDaniel said of Lansing's approach.

McDaniel said three Flint area contractors, including one following BWL's removal methods, have removed about 50 lines a week in the city since October. McDaniel added that 615 lead service lines have been removed and replaced with copper ones from "most of October and all of November."

Unlike BWL, the city of Flint is only responsible for removal or replacement of service lines from the water main to the curb stop valve – not to the meter. But Flint is now removing lead service lines and replacing them with copper lines from the curb to the water meter of each property. The work done at each property requires an owner's permission. McDaniel said it's still unclear how many lead service lines are in Flint because some are paved over and others are hard to find due to a lack of records.

Flint's water crisis started when the city, under a state-appointed emergency manager, began using water from the Flint River without needed corrosion control. Doctors soon noticed a spike in lead levels among Flint children. The state helped Flint switch to another water source, but health concerns remain. Slow improvements to the water system have prompted Flint residents to still use water filters in their homes.

It is expected to take about a year before Flint switches to an improved, multi-million dollar system that will provide safer Lake Huron water.

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WHO/SDE/WSH/03.04/09/Rev/1

Lead in Drinking-water

Background document for development of
WHO *Guidelines for Drinking-water Quality*

Rev/1: Revisions indicated with a vertical line in the left margin.

Lead in Drinking-water
Background document for development of WHO *Guidelines for Drinking-water Quality*

Preface

One of the primary goals of the World Health Organization (WHO) and its Member States is that "all people, whatever their stage of development and their social and economic conditions, have the right to have access to an adequate supply of safe drinking water". A major WHO function to achieve such goals is the responsibility "to propose ... regulations, and to make recommendations with respect to international health matters ...."

The first WHO document dealing specifically with public drinking-water quality was published in 1958 as *International Standards for Drinking-water*. It was subsequently revised in 1963 and in 1971 under the same title. In 1984–1985, the first edition of the WHO *Guidelines for Drinking-water Quality* (GDWQ) was published in three volumes: Volume 1, Recommendations; Volume 2, Health criteria and other supporting information; and Volume 3, Surveillance and control of community supplies. Second editions of these volumes were published in 1993, 1996 and 1997, respectively. Addenda to Volumes 1 and 2 of the second edition were published in 1998, addressing selected chemicals. An addendum on microbiological aspects reviewing selected microorganisms was published in 2002. The third edition of the GDWQ was published in 2004, the first addendum to the third edition was published in 2006 and the second addendum to the third edition was published in 2008. The fourth edition will be published in 2011.

The GDWQ are subject to a rolling revision process. Through this process, microbial, chemical and radiological aspects of drinking-water are subject to periodic review, and documentation related to aspects of protection and control of public drinking-water quality is accordingly prepared and updated.

Since the first edition of the GDWQ, WHO has published information on health criteria and other supporting information to the GDWQ, describing the approaches used in deriving guideline values and presenting critical reviews and evaluations of the effects on human health of the substances or contaminants of potential health concern in drinking-water. In the first and second editions, these constituted Volume 2 of the GDWQ. Since publication of the third edition, they comprise a series of free-standing monographs, including this one.

For each chemical contaminant or substance considered, a lead institution prepared a background document evaluating the risks for human health from exposure to the particular chemical in drinking-water. Institutions from Canada, Japan, the United Kingdom and the United States of America (USA) prepared the documents for the fourth edition.

Under the oversight of a group of coordinators, each of whom was responsible for a group of chemicals considered in the GDWQ, the draft health criteria documents were submitted to a number of scientific institutions and selected experts for peer review. Comments were taken into consideration by the coordinators and authors. The draft documents were also released to the public domain for comment and submitted for final evaluation by expert meetings.

During the preparation of background documents and at expert meetings, careful consideration was given to information available in previous risk assessments carried out by the International Programme on Chemical Safety, in its Environmental Health Criteria monographs and Concise International Chemical Assessment Documents, the International Agency for Research on Cancer, the Joint FAO/WHO Meeting on Pesticide Residues and the Joint FAO/WHO Expert Committee on Food Additives (which evaluates contaminants such as lead, cadmium, nitrate and nitrite, in addition to food additives).

Further up-to-date information on the GDWQ and the process of their development is available on the WHO Internet site and in the current edition of the GDWQ.

Acknowledgements

The current version of Lead in Drinking-water, Background document for development of WHO *Guidelines for Drinking-water Quality*, is an update of the background document originally prepared for the second edition of the Guidelines.

The work of the following working group coordinators was crucial in the development of this document and others contributing to the fourth edition:

Dr J. Cotruvo, J. Cotruvo & Associates, USA (*Materials and chemicals*)
Mr J.K. Fawell, United Kingdom (*Naturally occurring and industrial contaminants* and *Pesticides*)
Ms M. Giddings, Health Canada (*Disinfectants and disinfection by-products*)
Mr P. Jackson, WRc-NSF, United Kingdom (*Chemicals – practical aspects*)
Professor Y. Magara, Hokkaido University, Japan (*Analytical achievability*)
Dr A.V. Festo Ngowi, Muhimbili University of Health and Allied Sciences, United Republic of Tanzania (*Pesticides*)
Dr E. Ohanian, Environmental Protection Agency, USA (*Disinfectants and disinfection by-products*)

The draft text was discussed at the Expert Consultation for the fourth edition of the GDWQ, held in December 2011. The final version of the document takes into consideration comments from both peer reviewers and the public. The input of those who provided comments and of participants at the meeting is gratefully acknowledged.

The WHO coordinators were Mr R. Bos and Mr B. Gordon, WHO Headquarters. Ms C. Vickers provided a liaison with the International Programme on Chemical Safety, WHO Headquarters. Mr M. Zaim, Public Health and the Environment Programme, WHO Headquarters, provided input on pesticides added to drinking-water for public health purposes.

Ms P. Ward provided invaluable administrative support throughout the review and publication process. Ms M. Sheffer of Ottawa, Canada, was responsible for the scientific editing of the document.

Many individuals from various countries contributed to the development of the GDWQ. The efforts of all who contributed to the preparation of this document and in particular those who provided peer or public domain review comments are greatly appreciated.

Acronyms and abbreviations used in the text

ALAD	aminolaevulinic acid dehydratase
EP	erythrocyte protoporphyrin
FAO	Food and Agriculture Organization of the United Nations
GCI	General Cognitive Index
IARC	International Agency for Research on Cancer
IQ	intelligence quotient
JECFA	Joint FAO/WHO Expert Committee on Food Additives
MDI	Mental Development Index
MNCV	motor nerve conduction velocity
MSCA	McCarthy Scales of Children's Abilities
NHANES	National Health and Nutrition Examination Survey (USA)
NOAEL	no-observed-adverse-effect level
PDI	Psychomotor Developmental Index
PTWI	provisional tolerable weekly intake
PVC	polyvinyl chloride
USA	United States of America
WHO	World Health Organization

Table of contents

1. GENERAL DESCRIPTION

1.1 Identity

Lead is the commonest of the heavy elements, accounting for 13 mg/kg of Earth's crust. Several stable isotopes of lead exist in nature, including, in order of abundance, ^{208}Pb, ^{206}Pb, ^{207}Pb and ^{204}Pb.

1.2 Physicochemical properties

Property	*Value*
Physical state	Soft metal
Melting point	327 °C

1.3 Major uses

Lead is used in the production of lead acid batteries, solder, alloys, cable sheathing, pigments, rust inhibitors, ammunition, glazes and plastic stabilizers (*1*). Tetraethyl and tetramethyl lead are important because of their extensive use as antiknock compounds in petrol, but their use for this purpose has been almost completely phased out in North America and western Europe, although not in eastern Europe or many developing countries. From a drinking-water perspective, the almost universal use of lead compounds in plumbing fittings and as solder in water distribution systems is important. Lead pipes may be used in older distribution systems and plumbing (*2*).

2. ENVIRONMENTAL LEVELS AND HUMAN EXPOSURE

2.1 Air

Concentrations of lead in air depend on a number of factors, including proximity to roads and point sources. Annual geometric mean concentrations measured at more than 100 stations across Canada declined steadily from 0.74 µg/m^3 in 1973 to 0.10 µg/m^3 in 1989 (*4,5*), reflecting the decrease in the use of lead additives in petrol. Typical quarterly averages for urban areas without significant point sources in the United States of America (USA) in 1987 were in the range 0.1–0.3 µg/m^3; in the vicinity of major point sources, such as lead smelters and battery plants, air levels typically ranged from 0.3 to 4.0 µg/m^3 (*6*). Levels at three locations in Barcelona (Spain) during the winter of 1985 ranged from 0.9 to 2.5 µg/m^3 (*7*), presumably reflecting heavy use of leaded petrol. The overall means in London and in a rural area of Suffolk in 1984–85 were 0.50 µg/m^3 (range 0.23–0.82) and 0.10 µg/m^3 (range 0.05–0.17), respectively (*8*). Levels of lead in 1983 in the Norwegian Arctic, an area remote from urban influences, varied between 0.1–0.3 and 0.3–9.0 ng/m^3 (*9*).

If an average concentration in air of 0.2 µg/m^3 is assumed, the intake of lead from air can be calculated to range from 0.5 µg/day for an infant to 4 µg/day for an adult.

2.2 Water

With the decline in atmospheric emissions of lead since the introduction of legislation restricting its use in fuels, water has assumed new importance as the largest controllable source of lead exposure in the USA (*10*).

Lead is present in tap water to some extent as a result of its dissolution from natural sources, but primarily from household plumbing systems in which the pipes, solder, fittings or service connections to homes contain lead. Polyvinyl chloride (PVC) pipes also contain lead compounds that can be leached from them and result in high lead concentrations in drinking-water. The amount of lead dissolved from the plumbing system depends on several factors, including the presence of chloride and dissolved oxygen, pH, temperature, water softness and standing time of the water, soft, acidic water being the most plumbosolvent (*11,12*). Although lead can be leached from lead piping indefinitely, it appears that the leaching of lead from soldered joints and brass taps decreases with time (*10*). Soldered connections in recently built homes fitted with copper piping can release enough lead (210–390 µg/l) to cause intoxication in children (*13*). The level of lead in drinking-water may be reduced by corrosion control measures such as the addition of lime and the adjustment of the pH in the distribution system from <7 to 8–9 (*14,15*). Lead can also be released from flaking lead carbonate deposits on lead pipe and from iron sediment from old galvanized plumbing that has accumulated lead from lead sources such as plumbing and service connections, even when the water is no longer plumbosolvent.

In 1988, it was estimated that a lead level of 5 µg/l was exceeded in only 1.1% of public water distribution systems in the USA (*16*). A more recent review of lead levels in drinking-water in the USA found the geometric mean to be 2.8 µg/l (*10*). The median level of lead in drinking-water samples collected in five Canadian cities was 2.0 µg/l (*17*). A recent study in Ontario (Canada) found that the average concentration of lead in water actually consumed over a 1-week sampling period was in the range 1.1–30.7 µg/l, with a median level of 4.8 µg/l (*18*). In the United Kingdom in 1975–1976, there was virtually no lead in the drinking-water in two thirds of households, but levels were above 50 µg/l in 10% of homes in England and 33% in Scotland (*2*). In Glasgow (Scotland), where the water was known to be plumbosolvent, the lead concentration in about 40% of the samples exceeded 100 µg/l (*19*).

If a concentration of 5 µg/l in drinking-water is assumed, the total intake of lead from this source can be calculated to range from 3.8 µg/day for an infant to 10 µg/day for an adult.

2.3 Food

Prepared food contains small but significant amounts of lead. Lead content is increased when the water used for cooking or the cooking utensils contain lead or the food, especially if acidic, has been stored in lead-ceramic pottery ware or lead-soldered cans. The intake of lead from lead-soldered cans is declining as the use of lead-free solders becomes more widespread in the food processing industry (*2,20*).

A number of estimates based on figures for per capita consumption have been made of the daily dietary lead intake—for example, 27 µg/day in Sweden (*21*); 66 µg/day in

Finland (*22*); and 23 µg/day for a 2-year-old in the USA (*23*). Estimates obtained from duplicate diet studies are in the same range and include a mean dietary intake for all food and drink of about 40 µg/day for mothers and 30 µg/day for children aged 5–7 years in England (*8*) and 53.8 µg/day (0.8 µg/kg of body weight per day) for the intake of lead from food for adolescents and adults in Canada (*17*). Lead intakes for adults were 90 µg/day in Belgium, 24 µg/day in Sweden and 177 µg/day in Mexico, based on faecal monitoring of lead (*24*). In some countries, dietary intakes as high as 500 µg/day have been reported (*20*). The regular consumption of wine can also result in a significant increase in lead intake; an average level of 73 µg/l has been reported (*25*).

2.4 Other routes of exposure

Soils and household dust are significant sources of lead exposure for small children (*6,26,27*), but the levels are highly variable, ranging from <5 µg/g to tens of milligrams per gram in contaminated areas. As lead is immobile, levels in contaminated soil will remain essentially unchanged unless action is taken to decontaminate them (*28*). The highest lead concentrations usually occur in surface soil at depths of 1–5 cm.

In a 2-year study in England during 1984 and 1985, the geometric mean concentrations of lead in road dust collected in the vicinity of two London schools and in a rural area were 1552–1881 and 83–144 µg/g, respectively. For household dusts in London and in a rural area of Suffolk for 3 consecutive years (1983–1985), the geometric mean concentrations were 857 and 333 µg/g, respectively (*8*). Household dust concentrations were 332 µg/g in an Edinburgh study (*29*) and 424 µg/g in one in Birmingham (*30*).

The amount of soil ingested by children aged 1–3 years is about 40–55 mg/day (*27,31,32*). A comprehensive study of a group of 2-year-old urban children indicated an intake of lead from dust of 42 µg/day, almost twice the dietary lead intake (*30*). Studies in inner-city areas in the USA have shown that peeling paint or dust originating from leaded paint during removal may contribute significantly to children's exposure to lead (*33*).

Lead in household dust will vary according to activities in the household, such as sanding old lead-based paint and, in some countries, recycling of industrial materials at a household level.

2.5 Estimated total exposure and relative contribution of drinking-water

More than 80% of the daily intake of lead is derived from the ingestion of food, dirt and dust. At 5 µg/l, the average daily intake of lead from water forms a relatively small proportion of the total daily intake for children and adults, but a significant one for bottle-fed infants. Such estimates have a wide margin of error, as it is not known to what extent the general public flushes the system before using tap water; in addition, the stagnation time (and hence the lead levels) is highly variable (*10*). The contribution of ingested dust and dirt to the total intake is known to vary with age, peaking around 2 years (*32*).

3. KINETICS AND METABOLISM IN LABORATORY ANIMALS AND HUMANS

Adults absorb approximately 10% of the lead contained in food (*6*), but young children absorb 4–5 times as much (*34,35*); the gastrointestinal absorption of lead from ingested soil and dust by children has been estimated to be close to 30% (*26*). Absorption is increased when the dietary intakes of iron or calcium and phosphorus are low (*36–38*). Iron status is particularly important, as children from disadvantaged homes are more likely to suffer from anaemia, further increasing their absorption of lead (*39*).

The principal vehicle for the transport of lead from the intestine to the various body tissues is the red blood cell (*40*), in which lead is bound primarily to haemoglobin and has a special affinity for the beta, delta and, in particular, fetal gamma chains (*41*). Following its absorption, lead appears both in a soft tissue pool, consisting of the blood, liver, lungs, spleen, kidneys and bone marrow, which is rapidly turned over, and in a more slowly turned over skeletal pool. The half-life of lead in blood and soft tissues is about 36–40 days for adults (*42*), so that blood lead concentrations reflect only the intake of the previous 3–5 weeks. In the skeletal pool, the half-life of lead is approximately 17–27 years (*42,43*). In adults, some 80–95% of the total body burden of lead is found in the skeleton, as compared with about 73% in children (*44,45*). The biological half-life of lead may be considerably longer in children than in adults (*46*). Under conditions of extended chronic exposure, a steady-state distribution of lead between various organs and systems usually exists (*6*), and the blood lead concentration can therefore be used as a reasonably good indicator of exposure from all sources (*47*); the relationship between them is generally thought to be curvilinear in character (*2,19*).

Placental transfer of lead occurs in humans as early as week 12 of gestation, and uptake of lead by the fetus continues throughout development (*48*). The concentration of lead in umbilical cord blood is 80–100% of the maternal blood lead level; the same applies to blood lead in the fetus (*49–52*).

Inorganic lead is not metabolized in the body. Unabsorbed dietary lead is eliminated in the faeces, and lead that is absorbed but not retained is excreted unchanged via the kidneys or through the biliary tract (*53*). Metabolic balance studies in infants and young children indicated that, at intakes greater than 5 µg/kg of body weight per day, net retention of lead averaged 32% of intake, whereas retention was negative (i.e. excretion exceeded intake) at intakes less than 4 µg/kg body weight per day (*35*). No increases in blood lead were observed in infants with low exposure to other sources of lead and mean dietary intakes of 3–4 µg/kg of body weight per day (*54*), thus confirming the metabolic data.

4. EFFECTS ON LABORATORY ANIMALS AND IN VITRO TEST SYSTEMS

4.1 Neurological effects

Research on young primates has demonstrated that exposure to lead results in significant behavioural and cognitive deficits, such as impairment of activity, attention, adaptability, learning ability and memory, as well as increased distractibility. Such effects have been observed following postnatal exposure of monkeys to lead for 29 weeks in amounts resulting in blood lead levels ranging from 10.9 to 33 µg/dl (*55*). These effects persisted into young adulthood, even after levels in the blood had returned to 11–13 µg/dl, and were maintained for the following 8–9 years (*56*). Studies on small groups of monkeys dosed continuously from birth onwards with 50 or 100 µg/kg of body weight per day showed that there were still significant deficits in both short-term memory and spatial learning at 7–8 years of age (*57*).

4.2 Reproductive toxicity, embryotoxicity, and teratogenicity

Effects on sperm counts and on the testicles (testicular atrophy) in male rats and on estrous cycles in female rats have been observed at blood lead levels above 30 µg/100 ml (*58,59*).

4.3 Mutagenicity and related end-points

Results of studies on the genotoxicity of lead are conflicting (*54,60–62*), but most suggest that some lead salts are genotoxic. Lead chloride, ethanoate, oxide and tetroxide were inactive in mutagenicity tests on a number of prokaryotes and fungi, including *Salmonella typhimurium* and *Saccharomyces cerevisiae*. In vitro tests on human cells were positive for chromosomal damage in one case and negative in two others. In vivo short-term tests on mice, rats, cattle and monkeys were positive in three cases (dominant lethal test and chromosome damage to bone marrow cells) but negative in five others (*60,61*).

4.4 Carcinogenicity

Renal tumours have been induced in rats, mice and hamsters exposed orally to high levels of lead ethanoate, subacetate or phosphate in the diet. In one study, 5, 18, 62, 141, 500, 1000 or 2000 mg of lead per kilogram of diet (about 0.3, 0.9, 3, 7, 27, 56 and 105 mg/kg of body weight per day) were fed to rats for 2 years. Renal tumours (mostly tubular epithelial adenomas) developed in male rats at 500, 1000 and 2000 mg/kg, but only at 2000 mg/kg in female rats (*53,62,63*).

5. EFFECTS ON HUMANS

Lead is a cumulative general poison, with infants, children up to 6 years of age, the fetus and pregnant women being the most susceptible to adverse health effects. Its effects on the central nervous system can be particularly serious.

5.1 Acute and long-term exposure

Overt signs of acute intoxication, including dullness, restlessness, irritability, poor attention span, headaches, muscle tremor, abdominal cramps, kidney damage, hallucinations, loss of memory and encephalopathy, occur at blood lead levels of 100–120 µg/dl in adults and 80–100 µg/dl in children. Signs of chronic lead toxicity, including tiredness, sleeplessness, irritability, headaches, joint pain and gastrointestinal symptoms, may appear in adults at blood lead levels of 50–80 µg/dl. After 1–2 years of exposure, muscle weakness, gastrointestinal symptoms, lower scores on psychometric tests, disturbances in mood and symptoms of peripheral neuropathy were observed in occupationally exposed populations at blood lead levels of 40–60 µg/dl (*6*).

Renal disease has long been associated with lead poisoning; however, chronic nephropathy in adults and children has not been detected below blood lead levels of 40 µg/dl (*64,65*). Damage to the kidneys includes acute proximal tubular dysfunction and is characterized by the appearance of prominent inclusion bodies of a lead–protein complex in the proximal tubular epithelial cells at blood lead concentrations of 40–80 µg/dl (*66*).

There are indications of increased hypertension at blood lead levels greater than 37 µg/dl (*67*). A significant association has been established, without evidence of a threshold, between blood lead levels in the range 7–34 µg/dl and high diastolic blood pressure in people aged 21–55, based on data from the second United States National Health and Nutrition Examination Survey (NHANES II) (*68,69*). The significance of these results has been questioned (*70*).

Lead interferes with the activity of several of the major enzymes involved in the biosynthesis of haem (*6*). The only clinically well-defined symptom associated with the inhibition of haem biosynthesis is anaemia (*40*), which occurs only at blood lead levels in excess of 40 µg/dl in children and 50 µg/dl in adults (*71*). Lead-induced anaemia is the result of two separate processes: the inhibition of haem synthesis and an acceleration of erythrocyte destruction (*40*). Enzymes involved in the synthesis of haem include d-aminolaevulinate synthetase (whose activity is indirectly induced by feedback inhibition, resulting in accumulation of d-aminolaevulinate, a neurotoxin) and d-aminolaevulinic acid dehydratase (d-ALAD), coproporphyrinogen oxidase and ferrochelatase, all of whose activities are inhibited (*6,40*). The activity of d-ALAD is a good predictor of exposure at both environmental and industrial levels, and inhibition of its activity in children has been noted at a blood lead level as low as 5 µg/dl (*72*); however, no adverse health effects are associated with its inhibition at this level.

Inhibition of ferrochelatase by lead results in an accumulation of erythrocyte protoporphyrin (EP), which indicates mitochondrial injury (*47*). No-observed-adverse-effect levels (NOAELs) for increases in EP levels in infants and children exist at about 15–17 µg/dl (*73–75*). In adults, the NOAEL for increases in EP levels ranged from 25 to 30 µg/dl (*76*); for females alone, the NOAEL ranged from 20 to 25 µg/dl, which is closer to that observed for children (*74,77,78*). Changes in growth patterns in infants younger than 42 months of age have been associated with increased levels of EP; persistent increases in levels led initially to a rapid gain in weight, but subsequently to a retardation of growth (*79*). An analysis of the NHANES II data showed a highly significant negative correlation between the stature of children aged 7 years and younger and blood lead levels in the range 5–35 µg/dl (*80*).

Lead has also been shown to interfere with calcium metabolism, both directly and by interfering with the haem-mediated generation of the vitamin D precursor 1,25-dihydroxycholecalciferol. A significant decrease in the level of circulating 1,25-dihydroxycholecalciferol has been demonstrated in children whose blood lead levels were in the range 12–120 µg/dl, with no evidence of a threshold (*81,82*). Tissue lead content is increased in calcium-deficient persons, a fact that assumes great importance in the light of the increased sensitivity to lead exposure that could result from the calcium-deficient status of pregnant women. It has also been demonstrated that interactions between calcium and lead were responsible for a significant portion of the variance in the scores on general intelligence ratings and that calcium influenced the deleterious effect of lead (*83*). The regulatory enzyme brain protein, kinase C, is stimulated in vitro by picomole per litre lead concentrations (an effect similar to that produced by micromole per litre calcium concentrations), levels that could be expected from environmental exposure (*84*).

Several lines of evidence demonstrate that both the central and peripheral nervous systems are the principal targets for lead toxicity. The effects include subencephalopathic neurological and behavioural effects in adults, and there is also electrophysiological evidence of effects on the nervous system of children at blood lead levels well below 30 µg/dl. Aberrant electroencephalograph readings were significantly correlated with blood levels down to 15 µg/dl (*85,86*). Significant reductions in maximal motor nerve conduction velocity (MNCV) have been observed in children aged 5–9 years living near a smelter, with a threshold occurring at a blood lead level around 20 µg/dl; a 2% decrease in the MNCV was seen for every 10 µg/dl increase in the blood lead level (*87*). The auditory nerve may be a target for lead toxicity, in view of reports of reduced hearing acuity in children (*88*). In the NHANES II survey in the USA, the association with blood lead was highly significant at all levels from 5 to 45 µg/dl for children 4–19 years old, with a 10–20% increased likelihood of an elevated hearing threshold for persons with a blood lead level of 20 µg/dl as compared with 4 µg/dl (*89*). The NHANES II data also showed that blood lead levels were significantly associated with the age at which infants first sat up, walked and started to speak. Although no threshold existed for the age at which the child first walked, thresholds existed at the 29th and 28th percentile of lead rank for the age at which the child sat up and spoke, respectively (*89*).

5.2 Reproductive effects

Gonadal dysfunction in men, including depressed sperm counts, has been associated with blood lead levels of 40–50 µg/dl (*90–93*). Reproductive dysfunction may also occur in females occupationally exposed to lead (*6,61*).

Epidemiological studies have shown that exposure of pregnant women to lead increases the risk of preterm delivery. In a study of 774 pregnant women in Port Pirie who were followed to the completion of their pregnancy, the relative risk of preterm delivery was more than 4 times higher among women with blood lead levels above 14 µg/dl than in those with 8 µg or less per decilitre (*94*).

Elevated cord blood lead levels were associated with minor malformations, such as angiomas, syndactylism and hydrocele, in about 10% of all babies. The relative risk of malformation doubled at blood lead levels of about 7–10 µg/dl, and the incidence of any defect increased with increasing cord lead levels over the range 0.7–35.1 µg/dl (*95*).

5.3 Mutagenicity

Cytogenetic studies in humans exposed to lead (blood lead levels >40 µg/dl) have given conflicting results; chromatid and chromosomal aberrations, breaks and gaps were reported in 9 of 16 studies, but not in the remainder (*60,61*).

5.4 Carcinogenicity

The carcinogenicity of lead in humans has been examined in several epidemiological studies, which either have been negative or have shown only very small excess mortalities from cancers. In most of these studies, there were either concurrent exposures to other carcinogenic agents or other confounding factors such as smoking that were not considered (*60,61*). A study on 700 smelter workers (mean blood level 79.7 µg/l) and battery factory workers (mean blood level 62.7 µg/l) indicated an excess of deaths from cancer of the digestive and respiratory systems (*96*), the significance of which has been debated (*97,98*). There was also a non-significant increase in urinary tract tumours in production workers. In a study on lead smelter workers in Australia, no significant increase in cancers was seen, but there was a substantial excess of deaths from chronic renal disease (*99*). The International Agency for Research on Cancer (IARC) considers that the overall evidence for carcinogenicity in humans is inadequate for lead (*60*), but that inorganic lead compounds are probably carcinogenic to humans (*124*).

5.5 Neurological effects in infants and children

A number of cross-sectional and longitudinal epidemiological studies have been designed to investigate the possible detrimental effects that exposure of young children to lead might have on their intellectual abilities and behaviour. These studies have been concerned with documenting effects arising from exposure to "low" levels of lead (i.e. blood lead <40 µg/dl), at which overt clinical symptoms are absent. Several factors affect the validity of the conclusions drawn from them (*100*), including the statistical power of the study, the effect of bias in the selection of study and control populations, the choice of parameter used to evaluate lead exposure, the temporal relationship between exposure measurement and psychological evaluations, the extent to which the neurological and behavioural tests used can be quantified accurately and reproducibly, which confounding covariates are included in any multiple regression analysis and the effect of various nutritional and dietary factors, such as iron and calcium intake (*39*).

5.6 Cross-sectional studies

A number of cross-sectional studies have been carried out in which many of the above factors were taken into account. In one such study in the USA, a group of 58 children aged 6–7 years with "high" dentine lead levels (corresponding to a blood lead level of approximately 30–50 µg/dl) performed significantly less well than 100 children from a "low" lead group (mean blood lead level 24 µg/dl). The children's performance was measured using the Wechsler intelligence test in addition to other visual and auditory tests and teachers' behavioural ratings (*101*). There was a significant difference of 4 points and a uniform downward shift in intelligence quotient (IQ) scores. Although this study found that a child in the group with "high" dentine lead was 3 times more likely to have an IQ of 80 or lower than one in the "low" lead group, it was claimed in a 1986 review that the effect was statistically significant only for children with the highest lead levels in dentine (blood lead >40 µg/dl) (*6*).

A similar study in which lead in dentine was used as the indicator of exposure was carried out on a cohort of 400 children in the United Kingdom (*102*). There were several consistent but non-significant differences between the high- and low-lead groups similar to those observed in the American study, including IQ decrements of about 2 points and poorer scores in behaviour indices. In the British study, mean blood lead levels in the "high" exposure group (15.1 µg/dl) were lower than the mean of the "low" group (24 µg/dl) in the American study, which may explain why the results lacked statistical significance. The results of studies on children in Germany (*103–105*) were similar to those of the British study, in that the effect of lead on behaviour was only of borderline significance.

In another study (*106*) involving 500 Edinburgh schoolchildren aged 6–9 years, a small (up to 5 points in the British Ability Scales) but significant negative relationship was found between blood lead levels and intelligence scores, reading skills and number skills. There was a dose–response relationship in the range 5.6–22.1 µg/dl. The effect of lead was small compared with that of several of the other 33 variables considered. A series of studies (*107–109*) on about 800 children in the United Kingdom with blood lead levels between 4 and 32 µg/dl failed to find any significant associations between lead and indices of intelligence and behaviour after socioeconomic and family characteristics were taken into account. It was suggested that lead might have a noticeable effect only when other factors predisposing to social disadvantage (particularly low socioeconomic status or poor home environment) are present (*108–110*).

In a cross-sectional study in Lavrion (Greece) involving 509 primary schoolchildren living near a lead smelter, blood lead levels between 7.4 and 63.9 µg/dl (mean 23.7 µg/dl) were recorded (*111*). When the IQ was measured by means of the revised Wechsler Intelligence Scale for Children and due account taken of 17 potential confounders, a significant association was found between blood lead levels and IQ, with a threshold at about 25 µg/dl. Attentional performance was also associated with blood lead levels in two different tests, but no threshold level was found. This study was part of a multicentre collaborative international study on schoolchildren sponsored by the World Health Organization (WHO) and the Commission of the European Communities (*112*). A more or less uniform protocol was used, and quality assurance procedures were applied to the exposure analyses. The most consistent associations were for visual-motor integration as measured by the Bender Gestalt test and for reaction performance as measured by the Vienna Reaction Device. The results of many of the remaining tests were inconsistent. The degree of association between lead exposure and outcome was very weak (<0.8%), even in the statistically significant cases.

The cross-sectional studies are, on balance, consistent in demonstrating statistically significant associations between blood lead levels of 30 µg/dl or more and IQ deficits of about 4 points. Although there were associations between lower blood lead levels and IQ deficits of about 2 points, these were only marginally statistically significant, except in the Edinburgh study. It is particularly difficult to determine minimum levels above which significant effects occur.

5.7 Longitudinal studies

Longitudinal studies have the advantage as compared with cross-sectional studies that more precise estimates of exposure can be made; in addition, the reversibility of the effects and the temporal sequence of causality can be investigated. However, such studies also have certain disadvantages: for example, repeated psychometric testing may lead to artefactual results, and there may also be problems of bias associated with attrition within the study population.

The possible relationship between low-level lead exposure during the fetal period and in early childhood and later effects on infant and child development has been investigated in at least six prospective studies, in the USA (Boston, Cincinnati and Cleveland), Australia (Port Pirie, Sydney) and Scotland (Glasgow). Broadly similar methodologies were used in all the studies to facilitate comparisons. The Bayley Scales of Infant Development or subsets of this test were used to evaluate early cognitive development in verbal and performance skills in infants and young children, whereas the McCarthy Scales of Children's Abilities (MSCA) were used in most studies on older children. In all the studies, except that in Glasgow, the average maternal and cord blood lead concentrations were less than 10 µg/dl (range 6.0–9.5 µg/dl).

In the Boston Lead Study, three groups of infants and young children were classified according to umbilical cord blood lead concentrations, the levels in the low-, middle- and high-lead groups being <3, 6–7 and 10–25 µg/dl (mean 14.6 µg/dl), respectively. Children were tested twice a year from age 6 months to almost 5 years (*113,114*). After controlling for 12 potential confounders, a significant inverse relationship was demonstrated between fetal exposure, measured as lead levels in cord blood, and mental development at age 2, as measured using the Bayley Mental Development Index (MDI). There was no significant correlation with the children's current blood lead levels, all of which were less than 8.8 µg/dl. However, the results of testing at almost 5 years, using the McCarthy Scales, showed an attenuation of this association. At 57 months, only the association between intelligence scores and blood lead 3 years previously, at age 2, remained significant after controlling for confounding variables (*114*).

In a longitudinal study involving 305 pregnant women in Cincinnati (*115*), an inverse relationship was found between either prenatal or neonatal blood lead levels and performance in terms both of the Bayley Psychomotor Developmental Index (PDI) and the Bayley MDI at the ages of 3 and 6 months for both male infants and infants from the poorest families. The mean blood lead levels for neonates and their mothers were 4.6 and 8.2 µg/dl, respectively, and all blood lead levels were below 30 µg/dl. Multiple regression analysis for boys only showed that, for every increment of 1 µg/dl in the prenatal blood lead level, the covariate-adjusted Bayley MDI at 6 months of age decreased by 0.84 points. The inverse relationship between MDI and prenatal blood lead disappeared at age 1, because it was accounted for, and mediated through, the effect of lead on birth weight; however, the Bayley PDI was still significantly related to maternal blood lead (*116*).

In a prospective study of design similar to that of the Boston study, undertaken at Port Pirie, a lead smelter town in Australia, 537 children were studied from birth to 4 years (*117*). The cohort was divided into four groups on the basis of maternal and umbilical blood lead, which ranged from a geometric mean of 0.21 to 0.72 µmol/l (4.3–14.9 µg/dl). The mean blood lead level varied from 9.1 µg/dl at mid-pregnancy to 21.3 and 19 µg/dl at 2 and 4 years, respectively. The integrated postnatal average blood lead level was 19.1 µg/dl. At 6, 15, 24 and 36 months, the developmental status of the child was assessed by means of the Bayley MDI; the MSCA were used at 4 years. At each age, a consistent but weak inverse relationship was found between concurrent postnatal blood lead levels and MSCA scores; no allowance was made for possible confounding factors. No such relationship was found for perinatal blood lead. After 18 covariates considered to be potential confounders were incorporated in the multivariate analysis, the integrated blood lead level showed the strongest inverse relation with the General Cognitive Index (GCI) score (a subset of the McCarthy Scales) at age 4 years, which suggests that the detrimental effect of lead on child development is cumulative during early childhood. Repeated analysis restricted to children whose blood lead levels were below 25 µg/dl showed that the inverse relationship with the GCI score was as strong for this group as for the cohort as a whole, thus demonstrating the absence of a clear threshold below which a detrimental effect of lead on child development does not occur.

A number of prospective studies have failed to show any consistent association between mental development and blood lead, either during the perinatal period or in early childhood. In a study carried out on extremely socially disadvantaged mothers and infants in Cleveland, Ohio (USA), no relationship was found between blood lead at any time and language development, MDI or the results of the Stanford-Binet IQ test at age 3 years, after confounding factors, the most important of which was the care-giving environment, were taken into account. In this cohort, half the mothers had alcohol-related problems, and the average maternal IQ was 79 (*118*). In a second Australian study carried out in Sydney on a relatively prosperous population of 318 mothers and children, no association was found between blood lead in the mother or the child at any age and mental or motor deficits at age 4 years, after account was taken of six covariates, including the HOME score (a measure of the care-giving environment) (*119*). A third negative study was that carried out in Glasgow (Scotland), where the primary exposure was to high lead levels in water that were dramatically reduced by corrosion control measures shortly after the children were born. The cohort was divided into high, medium and low groups, on the basis of maternal blood lead, with means of 33.1, 17.7 and 7.0 µg/dl, respectively. Although the expected decrements in scores in the Bayley MDI and PDI were observed at ages 1 and 2 years as lead exposure increased, they could be better accounted for by birth weight, home environment and socioeconomic status, as shown by stepwise multiple regression analysis (*120*).

The results of the prospective studies have been somewhat disappointing because of the inconsistency between studies. It appears that prenatal exposure may have early effects on mental development, but that these do not persist up to age 4, at least not as shown by the tests used so far. There are indications that these early effects may be mediated through birth weight or other factors. Several studies indicated that the generally higher exposures of children in the 18–36-month age range may be negatively associated with mental development, but this, too, has not been confirmed by other studies.

5.8 2010 Joint FAO/WHO Expert Committee on Food Additives (JECFA) evaluation[1]

There is an extensive body of literature on epidemiological studies of lead. Blood is the tissue used most frequently to estimate exposure to lead, and blood lead levels generally reflect exposure in recent months. However, if the level of exposure is relatively stable, then blood lead level is a good indicator of exposure over the longer term. Longitudinal surveys in some countries have shown substantial reductions in population blood lead levels in recent decades. Programmes such as those that have eliminated the use of leaded petrol are considered to be an important factor, resulting in an average reduction of 39% in mean blood lead level over the 5-year period following implementation. Reductions in population blood lead levels in some countries have also been associated with the discontinued use of lead solder in food cans.

Exposure to lead has been shown to be associated with a wide range of effects, including various neurological and behavioural effects, mortality (mainly due to cardiovascular diseases), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes, delayed sexual maturation and impaired dental health. IARC concluded that there is *sufficient evidence* in animals but only *limited evidence* in humans for the carcinogenicity of inorganic lead and that inorganic lead compounds are *probably carcinogenic* to humans (group 2A). More recent studies do not indicate that any revision to the IARC conclusions is required.

For children, the weight of evidence is greatest, and evidence across studies is most consistent, for an association of blood lead levels with impaired neurodevelopment, specifically reduction of IQ. Moreover, this effect has generally been associated with lower blood lead concentrations than those associated with the effects observed in other organ systems. Although the estimated IQ decrease per microgram of lead per decilitre of blood is small when viewed as the impact on an individual child (6.9 points over the range of 2.4–30 µg/dl), the decrement is considered to be important when interpreted as a reduction in population IQ. For example, if the mean IQ were reduced by 3 points, from 100 to 97, while the standard deviation and other characteristics of the distribution remained the same, there would be an 8% increase in the number of individuals with a score below 100. Moreover, there would be a 57% increase in the number of individuals with an IQ score below 70 (2 standard deviations below the expected population mean, commonly considered to be the cut-off for identifying individuals with an intellectual disability) and a 40% reduction in the number of individuals with an IQ score greater than 130 (considered to be the cut-off for identifying individuals with a “very superior” IQ). Furthermore, the Committee noted that a lead-associated reduction in IQ may be regarded as a marker for many other neurodevelopmental effects for which the evidence is not as robust but which have been observed in children at approximately the same blood lead levels (e.g. attention deficit hyperactivity disorder, reading deficit, executive dysfunction, fine motor deficit).

[1] This text has been extracted from references 122 and 123. The interested reader should refer to reference 123 for additional information and primary references.

For adults, the adverse effect for which the weight of evidence is greatest and most consistent is a lead-associated increase in blood pressure. As with the lead-associated reduction in IQ, the increase is small when viewed as the effect on an individual's blood pressure, but important when viewed as a shift in the distribution of blood pressure within a population. Increased blood pressure is associated with increased risk of cardiovascular mortality. In a meta-analysis of 61 prospective studies involving more than 1 million adults, increased blood pressure was associated with age-specific increased mortality rates for ischaemic heart disease and stroke, and the proportional difference in risk associated with a given absolute difference in blood pressure was similar at all blood pressures above 115 mmHg (15 kPa) systolic or 75 mmHg (10 kPa) diastolic.

6. PRACTICAL CONSIDERATIONS

6.1 Analytical methods

Atomic absorption spectrometry and anodic stripping voltammetry are the methods most frequently used for determining the levels of lead in environmental and biological materials. Detection limits of less than 1 µg/l can be achieved by means of atomic absorption spectrometry (*3*). Because corrosion of plumbing systems is an important source of excessive lead in drinking-water, lead levels in water should be measured at the tap, rather than at the drinking-water source, when estimating human exposure.

6.2 Prevention and control

Lead is exceptional in that most lead in drinking-water arises from plumbing in buildings, and the remedy consists principally of removing plumbing and fittings containing it, which requires both time and money. In the interim, all practical measures to reduce total exposure to lead, including corrosion control, should be implemented. It is extremely difficult to achieve a concentration below 10 µg/l by central conditioning, such as phosphate dosing.

7. PROVISIONAL GUIDELINE VALUE

The evidence for the carcinogenicity of lead in humans is inconclusive because of the limited number of studies, the small cohort sizes and the failure to take adequate account of potential confounding variables. Lead has therefore been placed in Group 2B of the IARC classification, namely possible human carcinogen (evidence inadequate in humans, sufficient in animals) (*60*). However, inorganic lead compounds have been placed in Group 2A, namely probable human carcinogen (*124*).

As there is evidence from human studies that adverse effects other than cancer may occur at very low lead levels and that a guideline thus derived would also be protective for carcinogenic effects, it is considered appropriate to derive the guideline using the TDI approach.

In 1986, JECFA established a provisional tolerable weekly intake (PTWI) of 25 µg of lead per kilogram of body weight (equivalent to 3.5 µg/kg of body weight per day) for infants and children, which took account of the fact that lead is a cumulative poison, so that any increase in the body burden of lead should be avoided (*71*). The PTWI was based on metabolic studies in infants (*35,54*) showing that a mean daily intake of 3–4 µg/kg of body weight was not associated with an increase in blood lead levels or in the body burden of lead, whereas an intake of 5 µg/kg of body weight or more resulted in lead retention. This PTWI was reconfirmed by JECFA in 1993 and extended to all age groups (*121*).

In the second and third editions of the Guidelines, a guideline value of 0.01 mg/l was derived on the assumption of a 50% allocation of the PTWI to drinking-water for a 5 kg bottle-fed infant consuming 0.75 litre of drinking-water per day. As infants were considered to be the most sensitive subgroup of the population, this guideline value was thought to also be protective for other age groups.

JECFA re-evaluated lead in 2010 (*122,123*), finding that exposure to lead is associated with a wide range of effects, including various neurodevelopmental effects, mortality (mainly due to cardiovascular diseases), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes. Impaired neurodevelopment in children is generally associated with lower blood lead concentrations than the other effects, the weight of evidence is greater for neurodevelopmental effects than for other health effects and the results across studies are more consistent than those for other effects. For adults, the adverse effect associated with lowest blood lead concentrations for which the weight of evidence is greatest and most consistent is a lead-associated increase in systolic blood pressure. JECFA concluded that the effects on neurodevelopment and systolic blood pressure provided the appropriate bases for dose–response analyses (*122,123*).

Based on the dose–response analyses, JECFA estimated that the previously established PTWI of 25 µg/kg of body weight is associated with a decrease of at least 3 IQ points in children and an increase in systolic blood pressure of approximately 3 mmHg (0.4 kPa) in adults. These changes are important when viewed as a shift in the distribution of IQ or blood pressure within a population. JECFA therefore concluded that the PTWI could no longer be considered health protective, and it was withdrawn (*122,123*).

Because the dose–response analyses do not provide any indication of a threshold for the key effects of lead, JECFA concluded that it was not possible to establish a new PTWI that would be considered to be health protective. JECFA reaffirmed that because of the neurodevelopmental effects, fetuses, infants and children are the subgroups that are most sensitive to lead (*122,123*).

There remain uncertainties associated with the epidemiology, which relate to very low blood lead levels and end-points that are affected by many factors. Nevertheless, because lead exposure arises from a range of sources, of which water is frequently a minor one, and as it is extremely difficult to achieve a concentration lower than 10 µg/l by central conditioning, such as phosphate dosing, the guideline value is maintained at 10 µg/l but is designated as provisional on the basis of treatment performance and analytical achievability.

It needs to be recognized that lead is exceptional, in that most lead in drinking-water arises from plumbing in buildings, and the remedy consists principally of removing plumbing and fittings containing lead, which requires much time and money. It is therefore emphasized that all other practical measures to reduce total exposure to lead, including corrosion control, should be implemented.

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Basic Information about Lead in Drinking Water

Have a question that's not answered on this page? Contact the Safe Drinking Water Hotline.

Información relacionada disponible en español

EPA and the Centers for Disease Control and Prevention (CDC) agree that there is no known safe level of lead in a child's blood. Lead is harmful to health, especially for children. On this page, you can find:

General Information about Lead in Drinking Water

- How lead gets into drinking water
- Health effects of being exposed to lead in drinking water
- Can I shower in lead-contaminated water?

Related Information from Other Federal Government Agencies

Centers for Disease Control and Prevention (CDC):

- About Lead in Drinking Water
- Prevention Tips for Lead in Water
- CDC main page on lead

Agency for Toxic Substances & Disease Registry (ATSDR):

- Public Health Statement for Lead
- ToxFAQs for Lead
- ATSDR main page on lead

What You Can Do

Learn how you can...

- Find out if lead is in your drinking water
- Take measures to reduce lead in drinking water at home
- Get your child tested to determine lead levels in his or her blood
- Find out if lead in drinking water is an issue in your child's school or child care facility

Drinking Water Requirements for Lead

- EPA's drinking water regulations for lead
- How EPA requires states and public water systems to protect drinking water

General Information about Lead in Drinking Water

How Lead Gets into Drinking Water

Lead can enter drinking water when service pipes that contain lead corrode, especially where the water has high acidity or low mineral content that corrodes pipes and fixtures. The most common problem is with brass or chrome-plated brass faucets and fixtures with lead solder, from which significant amounts of lead can enter into the water, especially hot water.

Homes built before 1986 are more likely to have lead pipes, fixtures and solder. The Safe Drinking Water Act (SDWA) has reduced the maximum allowable lead content -- that is, content that is considered "lead-free" -- to be a weighted average of 0.25 percent calculated across the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures and 0.2 percent for solder and flux.

- Learn more about the maximum allowable content of lead in pipes, solder, fittings and fixtures
- Learn more about EPA's regulations to prevent lead in drinking water
- Learn how to identify lead-free certification marks on drinking water system and plumbing products (PDF)

Corrosion is a dissolving or wearing away of metal caused by a chemical reaction between water and your plumbing. A number of factors are involved in the extent to which lead enters the water, including:

- the chemistry of the water (acidity and alkalinity) and the types and amounts of minerals in the water,
- the amount of lead it comes into contact with,
- the temperature of the water,
- the amount of wear in the pipes,
- how long the water stays in pipes, and
- the presence of protective scales or coatings inside the plumbing materials.

To address corrosion of lead and copper into drinking water, EPA issued the Lead and Copper Rule (LCR) under the authority of the SDWA. One requirement of the LCR is corrosion control treatment to prevent lead and copper from contaminating drinking water. Corrosion control treatment means utilities must make drinking water less corrosive to the materials it comes into contact with on its way to consumers' taps. Learn more about EPA's regulations to prevent lead in drinking water.

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*Health Effects of Exposures to Lead in Drinking Water

*The health effects information on this page is not intended to catalog all possible health effects for lead. Rather, it is intended to let you know about the most significant and probable health effects associated with lead in drinking water.

Is there a safe level of lead in drinking water?

The Safe Drinking Water Act requires EPA to determine the level of contaminants in drinking water at which no adverse health effects are likely to occur with an adequate margin of safety. These non-enforceable health goals, based solely on possible health risks, are called maximum contaminant level goals (MCLGs). EPA has set the maximum contaminant level goal for lead in drinking water at zero because lead is a toxic metal that can be harmful to human health even at low exposure levels. Lead is persistent, and it can bioaccumulate in the body over time.

Young children, infants, and fetuses 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. In children, low levels of exposure have been linked to damage to the central and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of blood cells.

The Centers for Disease Control and Prevention (CDC) recommends that public health actions be initiated when the level of lead in a child’s blood is 5 micrograms per deciliter (µg/dL) or more.

It is important to recognize all the ways a child can be exposed to lead. Children are exposed to lead in paint, dust, soil, air, and food, as well as drinking water. If the level of lead in a child's blood is at or above the CDC action level of 5 micrograms per deciliter, it may be due to lead exposures from a combination of sources. EPA estimates that drinking water can make up 20 percent or more of a person’s total exposure to lead. Infants who consume mostly mixed formula can receive 40 percent to 60 percent of their exposure to lead from drinking water.

Children

Even low levels of lead in the blood of children can result in:

- Behavior and learning problems
- Lower IQ and hyperactivity
- Slowed growth
- Hearing problems
- Anemia

In rare cases, ingestion of lead can cause seizures, coma and even death.

Pregnant Women

Lead can accumulate in our bodies over time, where it is stored in bones along with calcium. During pregnancy, lead is released from bones as maternal calcium and is used to help form the bones of the fetus. This is particularly true if a woman does not have enough dietary calcium. Lead can also cross the placental barrier exposing the fetus to lead.

This can result in serious effects to the mother and her developing fetus, including:

- Reduced growth of the fetus
- Premature birth

Find out more about lead's effects on pregnancy:

- Lead and Your Baby (March of Dimes) EXIT
- Effects of Workplace Hazards on Female Reproductive Health (National Institute for Occupational Safety and Health)

Lead can also be transmitted through breast milk. Read more on lead exposure in pregnancy and lactating women (PDF) (302 pp, 4.3 MB, About PDF) .

Adults

Lead is also harmful to adults. Adults exposed to lead can suffer from:

- Cardiovascular effects, increased blood pressure and incidence of hypertension
- Decreased kidney function
- Reproductive problems (in both men and women)

Related Information

- Learn more about lead and its health effects

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Can I shower in lead-contaminated water?

Yes. Bathing and showering should be safe for you and your children, even if the water contains lead over EPA’s action level. Human skin does not absorb lead in water.

This information applies to most situations and to a large majority of the population, but individual circumstances may vary. Some situations, such as cases involving highly corrosive water, may require additional recommendations or more stringent actions. Your local water authority is always your first source for testing and identifying lead contamination in your tap water. Many public water authorities have websites that include data on drinking water quality, including results of lead testing. Links to such data can be found on the EPA Consumer Confidence Report website.

For more information, see CDC's "Sources of Lead: Water" Web page.

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What You Can Do

Find Out if Lead is in Your Drinking Water

First, learn more about the water coming into your home

EPA requires all community water systems to prepare and deliver an annual water quality report called a ***Consumer Confidence Report (CCR)*** for their customers by July 1 of each year. Contact your water utility if you'd like to receive a copy of their latest report. If your water comes from a household well or other private water supply, check with your health department, or with any nearby water utilities that use ground water, for information on contaminants of concern in your area.

- Find your local Consumer Confidence Report
- Information about CCRs for consumers
- EPA's CCR home page
- Learn more about protecting water quality from private drinking water wells
- Printable color fact sheet: Is There Lead in My Drinking Water?

EPA's ***Public Notification Rule*** requires public water systems to alert you if there is a problem with your drinking water.

- Learn more about the Public Notification Rule

Second, you can have your water tested for lead

Homes may have internal plumbing materials containing lead. Since you cannot see, taste, or smell lead dissolved in water, testing is the only sure way of telling whether there are harmful quantities of lead in your drinking water. A list of certified laboratories are available from your state or local drinking water authority. Testing costs between $20 and $100. Contact your water supplier as they may have useful information, including whether the service connector used in your home or area is made of lead.

You can learn on our Protect Your Family from Exposures to Lead web page:

- when you may want to test your drinking water; and
- what to do if your home tests positive for lead.

You can also view and print a fact sheet on testing your home's drinking water.

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Take Measures to Reduce Lead in Drinking Water at Home

Flush your pipes before drinking: The more time water has been sitting in your home's pipes, the more lead it may contain. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking.

Only use cold water for eating and drinking: Use only water from the cold-water tap for drinking, cooking, and especially for making baby formula. Hot water is likely to contain higher levels of lead. Run cold water until it becomes as cold as it can get.

Note that boiling water will NOT get rid of lead contamination.

Use water filters or treatment devices:

Many water filters and water treatment devices are certified by independent organizations for effective lead reduction. Devices that are not designed to remove lead will not work. Verify the claims of manufacturers by checking with independent certifying organizations that provide lists of treatment devices they have certified:

- NSF International EXIT
- Water Quality Association EXIT

Underwriters Laboratories also provides drinking water product certification services for drinking water products and chemicals. EXIT

Related Information:

- Fact sheet: Actions You Can Take to Reduce Lead in Drinking Water
- How to make your home lead-safe
- What you can do to protect your drinking water
- Fact sheet: How to Identify Lead-Free Certification Marks for Drinking Water System & Plumbing Products (PDF)

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Get Your Child Tested to Determine Lead Levels in His or Her Blood

A family doctor or pediatrician can perform a blood test for lead and provide information about the health effects of lead. State, city or county departments of health can also provide information about how you can have your child's blood tested for lead. The Centers for Disease Control and Prevention recommends that public health actions be initiated when the level of lead in a child's blood is 5 micrograms per deciliter (µg/dL) or more.

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Find Out if Lead in Drinking Water is an Issue in Your Child's School or Child Care Facility

Children spend a significant part of their days at school or in a child care facility. The faucets that provide water used for consumption, including drinking, cooking lunch, and preparing juice and infant formula, should be tested.

- Protect your children from lead where they learn and play: learn how to test your child, and how to check the condition of schools and child care facilities
- How schools and child care centers can test for lead in drinking water
- EPA main page on drinking water at schools and child care facilities

Drinking Water Requirements for Lead

EPA's Drinking Water Regulations for Lead

In 1974, Congress passed the Safe Drinking Water Act. This law requires EPA to determine the level of contaminants in drinking water at which no adverse health effects are likely to occur with an adequate margin of safety. These non-enforceable health goals, based solely on possible health risks are called maximum contaminant level goals (MCLGs). The MCLG for lead is zero. EPA has set this level based on the best available science which shows there is no safe level of exposure to lead.

For most contaminants, EPA sets an enforceable regulation called a maximum contaminant level (MCL) based on the MCLG. MCLs are set as close to the MCLGs as possible, considering cost, benefits and the ability of public water systems to detect and remove contaminants using suitable treatment technologies.

However, because lead contamination of drinking water often results from corrosion of the plumbing materials belonging to water system customers, EPA established a treatment technique rather than an MCL for lead. A treatment technique is an enforceable procedure or level of technological performance which water systems must follow to ensure control of a contaminant.

The treatment technique regulation for lead (referred to as the ***Lead and Copper Rule***) requires water systems to control the corrosivity of the water. The regulation also requires systems to collect tap samples from sites served by the system that are more likely to have plumbing materials containing lead. If more than 10 percent of tap water samples exceed the lead action level of 15 parts per billion, then water systems are required to take additional actions including:

- Taking further steps optimize their corrosion control treatment (for water systems serving 50,000 people that have not fully optimized their corrosion control) .
- Educating the public about lead in drinking water and actions consumers can take to reduce their exposure to lead.
- Replacing the portions of lead service lines (lines that connect distribution mains to customers) under the water system's control.

EPA issued the Lead and Copper Rule in 1991 and revised the regulation in 2000 and 2007. States may set more stringent drinking water regulations than EPA.

In addition:

- EPA requires all community water systems to prepare and deliver an annual water quality report called a ***Consumer Confidence Report (CCR)*** for their customers.
  - Find your local Consumer Confidence Report
  - Information about CCRs for consumers
  - EPA's CCR home page
- EPA's ***Public Notification Rule*** requires public water systems to alert you if there is a problem with your drinking water.
  - Learn more about the Public Notification Rule.
- In 2011, changes to the Safe Drinking Water Act reduced the maximum allowable lead content -- that is, content that is considered "lead-free" -- to be a weighted average of 0.25 percent calculated across the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixture and 0.2 percent for solder and flux. Learn more about the maximum allowable content of lead in pipes, solder, fittings and fixtures.

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How EPA Requires States and Public Water Systems to Protect Drinking Water

The Safe Drinking Water Act (SDWA) requires EPA to establish and enforce standards that public drinking water systems must follow. EPA delegates primary enforcement responsibility (also called ***primacy***) for public water systems to states and tribes if they meet certain requirements. Learn more about:

- The SDWA and SDWA standards
- How EPA regulates drinking water contaminants
- Primacy enforcement responsibility for public water systems

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A Colloquy With Hank Paulson

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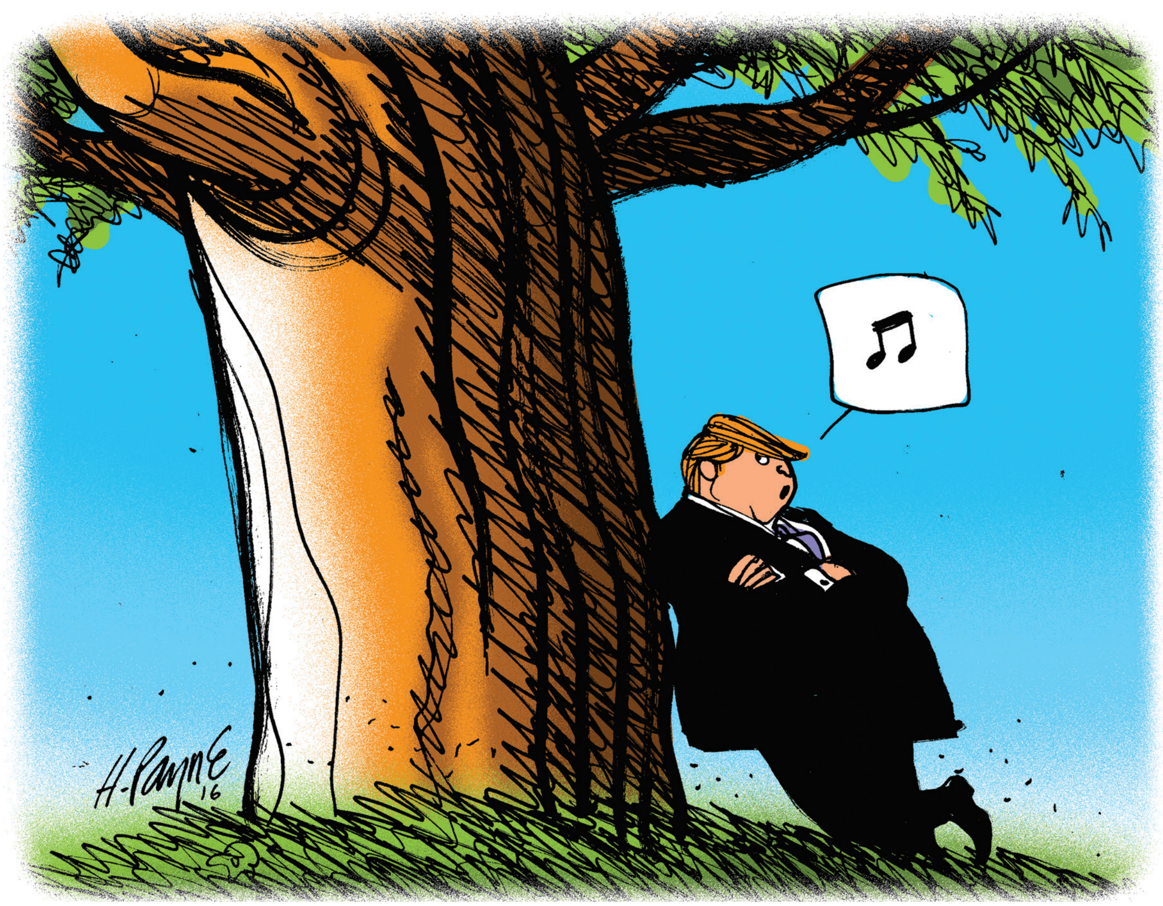

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The Path From Flint

The tragedy in this Michigan city demonstrates the need for vigilance in protecting families from lead in drinking water. There will be no better moment to develop workable solutions for getting the heavy metal out, protecting public health, and renewing faith in this basic resource

David B. LaFrance is chief executive officer of the American Water Works Association. AWWA is the world's largest and oldest association of water professionals, with more than 50,000 members worldwide.

It is difficult to imagine what it has been like to live in Flint, Michigan, for the last two years. Confidence in the city's drinking water, a critical resource for one's daily existence, was shattered, and it will likely be years before citizens will fully trust the city, state regulators, or federal policymakers. The discovery of high levels of lead in homes throughout Flint — and the series of decisions that led to it — is a reminder that the first job of every water professional is to protect the families we serve.

As the city slowly recovers, there is good news in the broad battle against lead in drinking water. Even before Flint was in national headlines, the Environmental Protection Agency was in the process of revising the national regulation that addresses lead in drinking water. The Lead and Copper Rule, first adopted in 1991, is widely considered one of the most complex regulations under the Safe Drinking Water Act. With a proposed rule revision anticipated in 2017, an advisory council representing a diverse set of stakeholders has provided EPA with recommendations that strengthen consumer protections today while working for a future where sources of lead exposure are removed altogether.

Water professionals recognize lead's health impacts and know that traces of the heavy metal in water, like lead in paint and dust, contribute to a cumulative environmental exposure that can cause severe and long-lasting harm. For decades, more than 50,000 U.S. drinking water systems have worked diligently to protect Americans from lead in the water we drink. By 2014, virtually all systems serving more than 50,000 people were actively adjusting water chemistry to control corrosion and thereby reduce the risk of lead in service lines and home plumbing from dissolving into water and ending up at the tap.

In April 2014, Flint stopped purchasing treated water from the city of Detroit that included corrosion control adjustments. At this point, Flint turned to the Flint River as its supply and cleaned that water in its own treatment plant, constructed in 1952. The city's change in water source without adequate consideration of potential changes in source-water chemistry — and without continuing corrosion control at the Flint water treatment plant — resulted in elevated lead levels at customers' taps. In December 2015, Flint declared a state of emergency. By January 2016, lead contamination in Flint dominated national headlines, sparking a demand for action to secure high-quality drinking water for all Americans.

Residential lead service lines represent a large source of lead that comes into contact with drinking water. Service lines are the pipes that connect individual homes to the water mains in the street. In the late 1800s and early to mid-1900s, lead was often used for service lines two inches in diameter or smaller. The practice fell out of favor in some communities in the early 20th century but continued in other locales until 1986, when lead pipe was banned nationally. Currently, an estimated 6.1 million lead service lines remain across the United States, serving approximately 7 percent of the population. Of the 56,000 homes and businesses in Flint, 8,000 may have lead service lines.

In most communities across America, ownership of water service lines is split between the water system and the customer. Utilities own the public portion from the street to approximately the property line, and the customer owns the remaining private portion that connects to the home or business. Removing these lines in full can therefore pose challenges to both the water system (e.g., costs and gaining access and buy-in from customers to replace the private portion of the lines) and to customers (e.g., affordability and recognition of health benefits from lead service line replacement).

It is also important to note that, in addition to lead service lines, plumbing inside a home or business can contain lead solder and brass components. These, too, can contribute to lead at the tap, particularly in the absence of appropriate corrosion control.

The Lead and Copper Rule is the federal regulation intended to protect customers from lead in drinking water. After promulgating the LCR, EPA revised it in 2000, 2004, and 2007. For most drinking water regulations, EPA identifies a Maximum Contaminant Level. The MCL represents a specific, not-to-exceed concentration of a contaminant in water. However, because lead exposure comes from service lines and home plumbing — not from water leaving the treatment plant — EPA took a different approach. The agency developed what is called a "treatment technique" instead of an MCL.

Under the Safe Drinking Water Act, a treatment technique specifies a set of practices for the water utility designed to control exposure to a contaminant of concern. The LCR treatment technique includes four elements: ongoing monitoring for all regulated systems, a requirement for corrosion control treatment at a subset of systems, public education measures when monitoring indicates lead levels are elevated, and lead service line replacement when corrosion control is not being reliably achieved.

Under the LCR, water is sampled at customer taps. To make the requirement more protective of public health, sampling occurs at locations within the utility's service area that are likely to have higher levels of lead. Using this monitoring data, utilities must determine if they have exceeded the rule's "action level." To make this determination, the water samples are placed in a progression from highest to lowest based on their lead concentrations. When the sample at the 90th percentile in the progression is above 15 parts per billion, the system has "exceeded" the action level and must take additional steps to address the issue, including public education, evaluation of corrosion control, and in some cases, replacing lead service lines.

When EPA last revised the LCR, a decade ago, the agency enhanced the implementation and public education aspects of the rule. Further enhancements that address health and policy issues related to lead in water have been, and continue to be, a focus for researchers and policymakers. The data collection, research, analysis, and other work done on these issues focus on reducing exposure to lead and will shape future revision of the LCR.

While not always the case, the term "partial lead service line replacement" generally refers to when a utility replaces only the public portion of the line. In 2011, a new evaluation by EPA's Science Advisory Board found that partial replacements might cause more harm than benefit, especially in the short term. Specifically, the study found that partial lead service line replacements "have not been shown to reliably reduce drinking water lead levels in the short term, ranging from days to months, and potentially even longer" and that they are also "associated with short-term elevated drinking water lead levels for some period of time after replacement."

The SAB finding creates a Catch-22 for EPA and for utilities needing to comply with the LCR. On the one hand, the rule requires lead service line replacement when corrosion control is not effective. In these cases, if the utility cannot gain access to the portion of the service line owned by the property owner, partial lead service line replacements are an allowable way to comply with the rule. On the other hand, the SAB found that a partial replacement can actually increase the short-term risk of higher levels of lead at the customer's tap. The utility quandary then becomes how — when a customer is unwilling to participate in the removal of the private portion of the lead service line — to comply with the LCR and at the same time protect the customer's health.

The SAB's finding also raises programmatic issues for utilities related to their ongoing routine construction and maintenance programs. For example, utilities regularly perform important maintenance and replacements of water mains buried under the street, and in the course of their work they may come across lead service lines. In light of the SAB findings, and in order to continue efficient programmatic practices, a utility must proactively develop a new series of standard operational protocols that address the discovery of a lead service line in the course of routine work. Should the utility not perform the work? Or should it replace only the portion of the lead service line in the street? Or should it add replacing the privately owned portion of the lead service line to the routine project?

In early 2012 another key issue came into focus. The Centers for Disease Control put forth a new metric for community-level intervention to prevent el-

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Sidebar

Not Through More Stringent Regulation Alone

The tragedy in Flint, Michigan, is a poignant reminder that drinking water can still be an important source of lead exposure in communities. Flint also demonstrated that without effective implementation and oversight of regulatory mandates, communities have no assurance that they are being protected from exposure to lead or other drinking water contaminants. The absence of timely, open, and honest communication also resulted in a missed opportunity to protect Flint residents through effective risk messaging. That along with the heightened anxiety that turned to outrage eroded the community's trust in its elected officials and the regulatory system.

The people of Flint were betrayed by those whose primary job is to protect the health of the public. We don't know how many more Flints there are in which government oversight and support is underfunded or just indifferent. Flint also raises important environmental justice concerns by virtue of the fact that this happened in a predominantly low-income, non-white, and economically depressed community. This crisis will hopefully serve as a wake-up call to other communities to reassess whether they are truly responsive to the needs of the citizens they serve. At the least, it will surely take extraordinary steps for the agencies and elected officials that failed the people of Flint to regain the respect and trust of the people.

Other communities have demonstrated that existing laws and rules can be effectively implemented, with the proper oversight, to ensure the protection that those mandates promise. Better planning, monitoring, oversight, and communications under the current Lead and Copper Rule would have afforded Flint a much-higher level of protection from extreme concentrations of lead than was provided. The National Drinking Water Advisory Council has made a clear case that there is a need for a more robust LCR. However, a repeat of the Flint situation will not be avoided through more stringent regulations alone.

I believe it is also important not to view Flint as representative of all cities, their water utilities, and oversight agencies across the country. Utilities are well aware of the hazards of lead and most are in full compliance with the LCR. Many are also actively working to reduce lead concentrations by optimizing water treatment and by implementing lead service line replacement strategies. Nonetheless, there is a need to revise the LCR to create a long-term plan that addresses lead service line replacement as the priority goal.


Chris J. Wiant

Prior to the public disclosure of the situation in Flint, the NDWAC recognized that there is a need to address the deficiencies of the current LCR in order to achieve a higher level of public protection. Recommendations were developed through a consensus process by its Lead and Copper Rule Working Group in 2015. With its full support, NDWAC forwarded those recommendations to EPA. While the recommendation from the working group is for the LCR to remain a treatment technique rule, there are also important enhancements.

The goal of the recommended revisions is the removal of lead service lines. The NDWAC also recognized that a shared responsibility exists among federal, state, and local governments, utilities, and customers. In recognizing the time and financial resources required to achieve the goal of lead service line removal, it is essential to have a robust effort of consumer education and engagement that enhances the protection that is currently provided through monitoring and water treatment.

The recommendation includes other important features, such as the establishment of a Household Action Level that, when exceeded, requires notification of the consumer and the applicable health agency for follow-up; additional study to address corrosion control, sampling methodologies, and monitoring; engagement of federal partners such as Housing and Urban Development and the Centers for Disease Control and Prevention; and development of the appropriate metrics that demonstrate progress with lead service line replacement.

Flint was a tragedy for the entire community. It was also a reminder for others that the problem of exposure to lead in community water supplies is real and the risk, especially to children, is not trivial. Hopefully the lessons learned from Flint will prevent a recurrence in another city. Meanwhile, the NDWAC recommendations to EPA offer a well-conceived path forward to provide enhanced protection to the public through effective implementation of a revised Lead and Copper Rule.

Chris J. Wiant, M.P.H., Ph.D., is the president and CEO of the Caring for Colorado Foundation, a health grantmaker. He has more than 40 years of experience in public health and environmental policy and programs at the state, local, and national level and with the foundation. He also served on the Colorado Water Quality Control Commission and is currently a member of the National Drinking Water Advisory Council. He was a member of the Lead and Copper Working Group.

evated blood lead levels in children. It recommended replacing the level of concern of 100 parts per billion in blood with a reference level for lead. This reference level was set at 50 ppb, which represents a blood lead level that 97.5 percent of children ages 1 to 5 fall below. CDC subsequently adopted this recommendation and urged that EPA consider it.

A 2013 study by EPA staff raised questions about how to take water samples and manage risk for homes with lead service lines. The authors collected a sequential series of samples from homes with lead service lines within a water system that was compliant with the LCR. The sequential samples were used to develop a profile of the lead levels at the tap, in the home plumbing, and in the service line. The study found higher levels of lead in samples representing water from the lead service line.

At least two possible alternative, but related, policy and operational considerations arise from these findings. One is to modify the LCR sampling process in order to target the lead concentration in water residing in the service line and to use this measurement as the indicator of the corrosion control's effectiveness. The other is community-wide planning to remove all lead service lines in their entirety and thereby eliminate this potential contribution.

In January 2014, the Reduction of Lead in Drinking Water Act took effect. This law dramatically reduced the allowable level of lead in new pipes, fittings, and fixtures installed in potable water systems, thereby further reducing the amount of lead in contact with drinking water. While the act cannot address lead in existing home plumbing and piping, it does set a very stringent standard for lead content in all plumbing materials used in current and future construction and repairs.

Against this backdrop, in February 2014 EPA asked for input from the National Drinking Water Advisory Council, a diverse group of stakeholders that includes utilities, consumer advocates, and health professionals. Twenty-three months later, the NDWAC forwarded its recommendations. The proposed work group process was to have focused on improving individual elements of the current LCR (e.g., the compliance monitoring sample pool, the compliance sampling protocol, etc.). However, as the NDWAC work group drafted its recommendations, the group took a different tack. While responding to individual LCR considerations, members also looked for the next significant opportunity for risk reduction and described a path toward that goal. They recommended that each community implement a strategy with the goal of removing all lead service lines in their entirety, engage in more proactive public education, and expand corrosion control and monitoring. They also recommended the development of a national household action level and an approach that supports customer-requested water samples.

Existing legislation significantly reduces lead in new plumbing materials, and corrosion controls address the release of lead already in contact with water. Therefore, the work group determined that the greatest remaining opportunity to further reduce lead risk in water is to remove lead-bearing materials that come into contact with water — particularly, lead service lines. When made of lead, the service line can represent as much as 75 percent of the observed lead concentration in tap water. The NDWAC recommended that every water system with lead lines in its service area develop a proactive replacement program, with a milestone of 2050 for complete removal.

Each water system will need to develop a complete inventory of lead service lines — something that many systems do not have because the private portions of service lines are not part of their system assets. Achieving full lead service line replacement (e.g., from the main to the home plumbing) will require actively engaging the customer. Replacement will take time, but it can be accelerated by local, state, and federal policies that promote lead service line replacement (e.g., replacement as a condition of property transfer, inclusion of removal in Housing and Urban Development lead-safe housing requirements, etc.). And removing lead service lines is best accomplished through an ongoing program rather than one that is sporadically initiated and stopped, as is often the case under the current LCR rule structure.

The cost of replacing the lines is substantial. Assuming the replacement of each line costs approximately $5,000, a mid-range estimate, full replacement of the estimated 6.1 million lead service lines nationally would cost roughly $30 billion. And as noted, in many, if not most communities, ownership of service lines is shared, meaning there will potentially be significant financial realities for both individual households with lead service lines and utilities.

Public education is already an element of the LCR, but the requirements for communicating about lead in drinking water apply largely after an Action Level exceedance. The NDWAC proposal makes public education on lead an ongoing activity for all water systems. It encourages EPA, CDC, HUD, and others to coordinate their lead educational materials to address the many routes of environmental exposure (e.g., paint, dust, soil, water). The proposed changes would include direct outreach to consumers with lead service lines and would speak to the potential hazards posed by lead pipes. This elevated, ongoing, and co-

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Unsafe Lead Service Lines Must Be Removed

A consensus has emerged among drinking water and public health professionals that we must replace the estimated six to ten million lead service lines still in use. LSLs deliver water from the main under the street to our homes and cannot be safely managed in place.

Corrosion control — treating the water to create a protective coating inside these pipes as well as leaded plumbing inside the house — has been our primary tool to reduce lead in drinking water. While it is important, corrosion control is not up to the task of protecting children from the unpredictable spikes of lead particulate released into drinking water when the LSLs are disturbed. Children's developing brains are vulnerable to long-term harm from even these short-term spikes. After all, there is no safe level of lead exposure.

Instead of being the last resort — as it is under the Environmental Protection Agency's Lead and Copper Rule — LSL replacement should be an essential and integral part of a revised rule. Full replacement across the nation may take decades of sustained effort to accomplish, but it needs to be done.

Three years ago, my recommendation would have been quite different. Like many who work on lead-poisoning prevention, I focused on paint and thought water was well-controlled. I routinely used the 15 parts per billion Lead Action Level in the LCR as the benchmark for safety. I had heard about the crises in Washington, D.C., in the 2000s but thought it was primarily a problem with the discredited technique of replacing only part of the lead service line. I taught classes explaining that the protective coating on the inside of lead pipes and leaded plumbing formed an effective barrier.

In 2014, my eyes were opened. EPA asked me to serve on a workgroup of its National Drinking Water Advisory Council to develop recommendations to revise the LCR. I soon realized that LSLs could release significant amounts of lead particulate into the water we drink without warning or notice. The monitoring program was not designed to detect spikes. Its purpose is to improve system-wide corrosion control, not to identify health risks.

A year later, the workgroup released a report recommending replacement of all LSLs as part of a rule overhaul and development of a health-based Household Action Level to alert public health officials and help families make decisions to protect formula-fed infants, the most vulnerable population. The report was essentially complete before Flint made the national news.

Tom Neltner

In 2015, the full advisory council recommended EPA fix the rule by implementing the workgroup's recommendations. It also suggested additional items based on the lessons from Flint and points made in a workgroup dissenting opinion. EPA committed to issuing a proposed rule revision in 2017. Its latest thinking was captured in a white paper the agency issued last October.

The path ahead will be difficult. EPA rulemaking is a slow and tedious process, especially when private homeowners are affected, costs run into the billions, and civil rights and environmental justice implications must be considered with every option. Optimistically, the rule will be finalized in 2018 and compliance would begin in 2021. Even then, the rule alone is unlikely to accomplish the goal without support from Congress and other federal agencies and programs.

Fortunately, under the leadership of the American Water Works Association, the industry has stepped up and committed to full LSL replacement. The Environmental Defense Fund has joined a broad coalition of more than 20 national utility, public health, and consumer protection groups to launch the LSL Replacement Collaborative, designed to help communities voluntarily accelerate their efforts to design and implement local programs. The collaborative will be releasing tools in early 2017 that include a roadmap for communities, best practices to replace the LSLs, and opportunities for federal, state, and private groups to support these communities.

For environmental professionals, there are important lessons to consider. First, Flint reminds us of the crucial role states play in protecting us and the implications when they fail. Second, EPA must regularly update its rules and policies to reflect the latest science. The drinking water program requires periodic reassessments, but those were insufficient. Third, the best strategy is to prevent putting a toxic compound like lead into commerce and avoid the enormous costs to clean up the legacy later.

We can fix this problem. The science is certain, the solution is clear, and stakeholders agree it needs to be done. Despite political uncertainty ahead, Americans should agree that children and their parents deserve safe drinking water.

Tom Neltner is a chemical engineer and attorney who serves as the Environmental Defense Fund's chemicals policy director.

ordinated communication program would provide the basis for public awareness needed to encourage service line replacement and bring greater attention to lead as a health concern.

While removing lead service lines reduces a major source of the metal in water, it is important to remember that there are other sources in household plumbing. Therefore, corrosion control remains a critical element in managing lead risks even after removing problematic service lines. The current LCR requires community water systems and non-transient non-community water systems serving more than 50,000 persons to maintain optimized corrosion control. Smaller systems that exceed the lead Action Level must also optimize corrosion control. The NDWAC recommendations would make optimized corrosion control a requirement for community and non-transient non-community water systems of all sizes, even smaller systems that have to-date stayed under the Action Level for lead.

The NDWAC also noted that systems already employing corrosion control should measure water quality control parameters (e.g., alkalinity, phosphate concentration, etc.) more actively and at more monitoring locations in their distribution systems. Water quality parameters are not a surrogate for observing lead concentrations, but they are variables that the water system can monitor and manage to determine the effectiveness of the utility's corrosion control program.

The NDWAC also asked EPA to propose a health-based Household Action Level for lead in water. The council recognized that even in a community where the LCR Action Level for lead in water has not been exceeded, some individual homes could have high levels at the tap. Therefore, the NDWAC recommendation was that if a water sample from a home is above a certain Household Action Level threshold, the sample results and contact information for the sample site would be provided to the local health department. This would trigger poison prevention experts from the health department to engage the household and provide the family with assistance. Additionally, having this Household Action Level would facilitate clear risk communication by helping water systems speak directly to homeowners about lead risks.

A final important public outreach element in the NDWAC's recommendations relates to challenges posed by homeowner-requested sampling. To comply with the current LCR, utility personnel must sample homes in areas that are at high-risk for lead exposure, including some homes known to have lead service lines. To obtain these samples, they must engage homeowners or tenants as willing participants to collect reliable samples using the prescribed sampling protocols.

The current sampling structure and guidance may discourage water systems from supporting customer-requested sampling. That is because under the LCR, all samples collected, whether as part of the LCR or at the request of a customer, could be used by state regulators to determine if a system is exceeding the Action Level. For example, a utility that took three samples at a home to help a customer diagnose where lead was entering the water (e.g., at the tap, indoor plumbing, or service line) could be required to include these three high values in its compliance dataset, despite the fact that the samples were taken for other reasons than LCR compliance.

The NDWAC observed that a better approach — one that would not dissuade utilities from responding to customer-requested samples — is to encourage the exchange of information between the water system and customer about actual lead levels in order to help consumers evaluate their risks, take steps to protect themselves, and understand the benefits of full lead service line replacement. To address this observation, the NDWAC recommended that water systems that are reliably compliant with the lead Action Level employ data from customer-requested sampling to inform corrosion control practices. The NDWAC feels this would encourage more dialogue with customers. With more active consumer engagement, the NDWAC anticipated there would be additional benefits, including development of a more geographically diverse and continuous dataset.

The situation in Flint has clearly demonstrated the need for vigilance in protecting families from lead in drinking water. It has also presented an opportunity. There will be no better moment to develop workable solutions for getting lead out of our water, protecting public health, and renewing consumers' faith in drinking water. The revisions to the LCR proposed by the NDWAC serve as a starting point for the newest phase of this effort, not just for Flint but for all of communities.

The future will likely see water systems being even more attentive to their corrosion control strategies, actively engaging with their customers, and ultimately, working for the complete removal of all lead service lines. While the water utilities play a significant role in fulfilling the NDWAC's vision, they cannot do it alone. It will also take collaboration among consumers, public health officials, government at all levels, philanthropy, and other partners.

The tragic events that took place in Flint have sped us down the path to solving the challenges of lead in drinking water. Addressing these concerns is complicated but also solvable if we all share the responsibility to support, fund, implement, and prioritize the action needed to assure the safety of our drinking water. **TEF**

Sidebar

Now Is the Time to Reduce Lead Exposure

Increased concern about lead in drinking water in the wake of the crisis in Flint, Michigan, offers society the opportunity to reduce lead exposure at the tap. It is time to redouble our efforts to end childhood lead poisoning, and to make drinking water source protection, treatment, and distribution true priorities that impact decisions made by government at every level and by all of us who consume water as part of daily life. Increased oversight, innovation, and investment can reduce lead at the tap and prepare us to meet other drinking water challenges.

We need to ensure that the current Lead and Copper Rule, propounded under the Safe Drinking Water Act, is being implemented properly. Last year, EPA announced increased oversight of state agencies responsible for implementing the LCR and updated protocols in a number of areas, including sampling location and methods, corrosion control treatment, and transparency between utilities and communities. EPA also directed states to work with water systems to update the inventory of lead in their distribution systems. This will result in more attention being paid to lead at the tap and to identifying treatment issues or other problems that are resulting in increased exposure.

Then EPA needs to revise the LCR, an effort in which the agency has been engaged for quite some time and which will result in a proposed revision later this year. EPA should update and provide clear requirements for monitoring programs, including where samples are taken and the protocols for taking them. A revised rule should improve how public education programs are conducted, because unlike as with most other contaminants, action in the home or building is critical to reducing lead exposure.

EPA has also committed to setting a Household Action Level, which would be an amount of lead that, if found in a sample, should prompt not only an investigation to find the source of contamination but also notification of local health officials. EPA should also require water systems to inventory sources of lead in their distribution systems, including lead service lines, and to replace them within a certain amount of time.

The best way to reduce exposure to lead at the tap is to reduce the amount of the metal in contact with water. The largest such source is the lead service line, which carries water from the main under the street to the home or commercial building. There are calls from policymakers, consumers, and others to replace them more quickly than a revised LCR could.


Lynn Thorp

Successful programs require community stakeholders to work together, and there are case studies demonstrating that it can be done. Clean Water Action is working with the Lead Service Line Replacement Collaborative, a diverse group of organizations including water systems, public health and environmental organizations, and others who plan to accelerate this process by providing tools to help communities develop programs for full lead service line replacement.

Lead exposure is most dangerous for children under the age of six, and childhood lead poisoning remains a serious issue in this country. The crisis in Flint should prompt us to ensure that lead hazard prevention programs are well-resourced and that federal, state, and local health programs prioritize childhood lead poisoning prevention while recognizing water as a prominent potential source of exposure.

Preventing future Flints is not just about preventing lead exposure at the tap. The high quality of drinking water in the United States has led Americans to undervalue the complicated tasks of protecting, treating, and distributing drinking water. For example, contaminants that pose health risks in drinking water are often the result of pollution that should be controlled where it occurs, at the groundwater or surface water source. Instead, this burden is too often passed on to treatment plants. The costs of removing contamination are thus being borne by water systems and their consumers. The Clean Water Act and other programs thus need to focus on drinking water protection and public health protection.

An overarching program for preventing lead exposure at the tap and for cleaner drinking water overall should include promoting sustainable water systems supported by a robust research program, an emphasis on innovation, and ample oversight at the federal and state levels to meet the Safe Drinking Water Act goals of reducing public health risk from drinking water. Political uncertainty in light of recent events should not distract us from these goals.

Lynn Thorp is Clean Water Action's national programs director. She served two terms on the National Drinking Water Advisory Council. She has also served on federal advisory committees and other collaborative processes around numerous Safe Drinking Water Act implementation activities, including a recent NDWAC workgroup on revisions to the Lead and Copper Rule.

..Number

..Version
ORIGINAL
..Reference

..Sponsor
ALD. PEREZ, BOHL, JOHNSON, AND HAMILTON
..Title
Resolution directing Department of Administration – Intergovernmental Relations Division to seek introduction and passage of State legislation requiring the Wisconsin State Legislature to require mandatory, periodic, and uniform testing for the presence of lead in the water of all State-licensed child care facilities and all schools (public, private, and charter).
..Analysis
This resolution directs Department of Administration – Intergovernmental Relations Division to lobby for State law to require mandatory, periodic, and uniform testing for the presence of lead in the water of all State-licensed daycare facilities and all schools (public, private, and charter).
..Body
Whereas, The State of Wisconsin licenses child care facilities; and

Whereas, The Wisconsin Department of Public Instruction regulates all schools (public, private, and charter); and

Whereas, Safe drinking water for the infants and children of Wisconsin is of utmost importance; and

Whereas, The infrastructure used for delivering drinking water in many communities throughout Wisconsin includes privately-owned lead water-service lines connecting buildings to water mains, as well as interior plumbing in buildings that may leach lead into the drinking water; and

Whereas, Some buildings are at an increased risk for lead in drinking water due to characteristics of the plumbing at individual buildings; and

Whereas, Consumption of lead poses a significant risk to public health and safety, with infants, young children, and pregnant women being at the greatest risk of complications from exposure to lead; and

Whereas, Other communities, such as Flint, Michigan, and Washington, D.C., have been placed in the national spotlight for their residents being exposed to high levels of contaminants and unsafe drinking water, putting their residents at risk of public health crises; and

Whereas, The City of Milwaukee has taken up the issue of water safety in the form of replacing lead water-service lines and mandating testing for the presence of lead in the water of its pubic and charter schools, among other measures; now, therefore, be it

Resolved, By the Common Council of the City of Milwaukee, that the City of Milwaukee urges the Wisconsin State Legislature to require mandatory, periodic, and uniform testing for the presence of lead in the water of all State-licensed child care facilities prior to licensure and all schools (public, private, and charter) prior to annual reporting; and, be it

Further Resolved, That the testing shall be conducted on all faucets used in food preparation, as well as all drinking fountains, at all State-licensed daycare facilities and all schools (public, private, and charter) annually; and, be it

Further Resolved, That the test results shall show that no drinking fountain and no faucet used in food preparation exceeds the lead levels set forth in the Lead and Copper Rule issued by the U.S. Environmental Protection Agency (EPA); and, be it

Further Resolved, That if a child care facility or school (public, private, or charter) uses an outside vendor for food preparation, such as catering of hot lunch, the outside vendor shall conduct testing of all its food-preparation faucets and submit test results showing compliance with the EPA Lead and Copper Rule annually; and, be it

Further Resolved, That if any drinking fountain or any faucet used in food preparation produces test results not in compliance with the EPA Lead and Copper Rule, that drinking fountain or that faucet used in food preparation shall be immediately decommissioned until it is brought into compliance; and, be it

Further Resolved, That if a child care facility, a school (public, private, or charter), or an outside food vendor does not meet the required standard, it shall submit documentation of work being performed to rectify the deficiency no later than 60 days after the date of unsatisfactory test results; and, be it

Further Resolved, That the Department of Administration – Intergovernmental Relations Division is directed to lobby the State Legislature to require mandatory, periodic, and uniform testing for the presence of lead in the water of all State-licensed daycare facilities and all schools (public, private, and charter);

Further Resolved, That Common Council File Number 160538 is amended by inserting the following item in the document attached to the file and identified as “2017-2018 State Legislative Package Proposals”:

Health Department	Public Health and Safety	Seek introduction and passage of State legislation that requires mandatory, periodic, and uniform testing for the presence of lead in the water of all State-licensed child care facilities and all schools (public, private, and charter).

; and, be it

Further Resolved, That the City Clerk is directed to send copies of this resolution to all members of Milwaukee's delegation to the State Legislature.
..Requestor

..Drafter
LRB167457-1
Tea Norfolk
02/06/2017

STANDING COMMITTEES:
Natural Resources & Energy, Chair
Transportation & Veterans Affairs

ROBERT L. COWLES
Wisconsin State Senator
2nd Senate District

JOINT COMMITTEES
Audit Committee, Co-Chair
Information Policy and Technology

NEWS RELEASE
FOR IMMEDIATE RELEASE
February 2, 2017

For More Information Contact:
Senator Cowles ~ 800.334.1465

Senator Cowles introduces the *Leading on Lead* Act
Giving Local Control to replace Lead Water Pipes

Green Bay- Today, in a move to help communities eliminate lead from drinking water service lines, State Senator Robert Cowles (R-Green Bay) announced the circulation of the *Leading on Lead* Act to give local governments the flexibility to do so. LRB-1934 provides the opportunity for a water utility to provide financial assistance for replacing the lead service lines to someone's home.

"Lead is harmful. Not only to children and pregnant women, but to everyone. We need to get these lead-laden drinking water service lines replaced. This legislation is a step in the right direction to give our local governments the control and flexibility they need to start replacing these lead pipes," said Senator Cowles.

Financial support may be provided only if the municipality passes an ordinance to allow financial assistance and the service line for which the utility is responsible and the water main are either lead free or will be replaced at the same time as the private laterals. Local ordinances could outline additional criteria before approving the water utility's financial assistance which may include low interest or no-interest loans, customer cost-sharing or an income threshold for qualification.

"We have this problem all over the state. Utilizing the knowledge of our local governments and water utility professionals will lend a great deal of expertise in eradicating the lead in our drinking water. I encourage my colleagues to speak with their municipal officials to discuss potential sources of lead in the drinking water of their constituents and co-sponsor this legislation for their safety and health," Cowles continued.

Currently, municipalities have very few options to assist customers to remove the lead from their water. This option can help to most cost effectively complete the lead removal process in communities all across the state. The deadline for co-sponsorship is February 10, 2017.

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State of Wisconsin
2017 - 2018 LEGISLATURE

LRB-1934/1
AJM:emw&wlj

2017 BILL

AN ACT ***to create*** 196.37 (6) of the statutes; **relating to:** lead service line replacements.

Analysis by the Legislative Reference Bureau

This bill provides that it is not unjust, unreasonable, insufficient, unfairly discriminatory, or preferential or otherwise unreasonable or unlawful for a water public utility to provide financial assistance to a customer solely for replacing service lines containing lead if the financial assistance is allowed by local ordinance. The bill also provides that the water public utility may provide financial assistance for the replacement of a service line containing lead only if the portion of the service line for which the utility is responsible and the water main that are connected to the customer's service line either do not contain lead or are replaced at the same time as the customer's service line is to be replaced.

For further information see the ***state and local*** fiscal estimate, which will be printed as an appendix to this bill.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. 196.37 (6) of the statutes is created to read:

196.37 **(6)** (a) It is not unjust, unreasonable, insufficient, unfairly discriminatory, or preferential or otherwise unreasonable or unlawful for a water public utility to provide financial assistance as specified in par. (b) to a customer solely for private infrastructure improvements with the purpose of replacing service lines containing lead if the city, town, or village in which the water public utility operates has enacted an ordinance that permits the water public utility to provide the financial assistance.

(b) A water public utility may provide financial assistance under par. (a) to replace a service line only if the portion of the service line for which the utility is responsible and the water main that are connected to the customer's service line meet one of the following conditions:

1. Do not contain lead.

2. The lead-containing portion of the service line or water main is replaced at the same time as the private infrastructure improvements under par. (a) are made.

(END)

State of Wisconsin
2017 - 2018 LEGISLATURE

LRB-0808/1
AJM:kjf

2017 BILL

AN ACT ***to create*** 704.55 of the statutes; **relating to:** lead testing and disclosures for certain rental properties.

Analysis by the Legislative Reference Bureau

This bill requires that a landlord conduct a test for lead for each water supply or plumbing system serving a premises prior to entering into a rental agreement with a prospective tenant for that premises. Under the bill, the landlord must disclose the results of the test for lead and disclose whether any water supply or plumbing system serving the premises contains lead pipes or lead service lines. If lead is detected by the test or there are lead pipes or lead service lines serving the premises, the landlord must provide the prospective tenant with the pamphlet published by the Department of Natural Resources that describes the risks of lead in drinking water. The bill provides that if a landlord fails to fulfill any of the obligations regarding testing, disclosure, or providing the pamphlet, the rental agreement for that premises is void and unenforceable in its entirety.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. 704.55 of the statutes is created to read:

704.55 Lead content testing and disclosure. **(1)** A landlord that leases a residential premises or that leases any premises to a person having the purpose of operating a school or child care center shall, prior to entering into a rental agreement with a prospective tenant, do all of the following:

(a) Conduct a test for lead content in each water supply or plumbing system serving the premises.

(b) Disclose to the prospective tenant, in writing, the results of the test for lead content under par. (a).

(c) Disclose to the prospective tenant, in writing, whether any water supply or plumbing system serving the premises contains lead pipes or lead service lines.

(d) If any lead content is detected by the test under par. (a) or the landlord discloses that a water supply or plumbing system contains lead pipes or lead service lines under par. (c), provide the prospective tenant with the pamphlet developed by the department of natural resources under s. NR 809.546, Wis. Adm. Code, that describes the risks of lead in drinking water.

(2) Notwithstanding s. 704.02, if the landlord fails to fulfill any of the requirements under sub. (1), the rental agreement for the premises is void and unenforceable in its entirety.

SECTION 2. Initial applicability.

(1) This act first applies to rental agreements entered into on the first day of the 7th month after publication.

(END)

2017-18 State Legislative Package

DOA - Intergovernmental Relations Division

Key Policy Areas

- Stabilize the City's Fiscal Capacity and Enhance Operational Efficiency
- Promote Racial, Social and Economic Equity for City residents
- Strengthen our Environment, our Mobility and our Infrastructure
- Invest in and Support Public Safety and Public Health
- Enhance our Neighborhoods and Economic Well Being
- Maintain Local Control and Flexibility

Highlights – Lead Remediation

- #32 - create a non-refundable state income tax credit of up to $200 annually for up to 10 years for private homeowner costs related to a municipally mandated replacement of their lead service line.
- #33 - allow water utility rate revenue to pay for the replacement of the privately owned portion of lead service lines, water filters and other public health measures.
- #34 - secure continued assistance for lead service line replacement using the Safe Drinking Water Loan Fund and distribute in a manner that reflects a community's proportion of statewide need and provide additional State funding for the same purpose.
- #35 - provide a dedicated state funding source to be distributed to municipalities for the removal of lead water service lines.
- #36 - allow a municipality to create a municipal fee for lead abatement and exempt the proceeds of that fee from expenditure restraint and levy limits.
- #37 - ensure daycare regulation and licensing adequately protects children from lead poisoning.

Highlights–Strong Neighborhoods

- #10 - restore authority to charge reinspection fees in a manner that reflects actual costs
- #49 - continue funding for rehab/demolition of vacant property
- #109 - require internet bidding option for Sheriff Sales and prohibit purchase by parties with tax delinquencies and unpaid building code judgments
- #110 – permit the Court to vacate judgments and dismiss the foreclosure action in no-bid situations
- #111 – create a statewide mortgage foreclosure registry
- #112 - expand powers regarding nuisance rental property
- #115 – 121 - update Housing Authority statutes to support Rental Assistance Demonstration program conversion
- #123 – align the definition of commercial property for BID assessments with the DOR's property assessment manual

Highlights – Public Safety

- #1 - secure additional Shared Revenue or another new revenue source sufficient to accommodate future growth in public safety costs
- #44 – secure a State Medicaid Plan Amendment to supplement the reimbursement for public, Medicaid-eligible ground emergency transports
- #45 - create a new regional secure detention alternative to Lincoln Hills for violent offenders
- #90 – address the health and safety of individuals suffering from overdose/misuse of opioids
- #103 –amend the prohibited possessor statute to encompass habitual offenders, straw purchasers and “human holsters”
- #107 – expedite juvenile justice timelines

Highlights - Other

- #9 – exclude local expenditure increases related to a successful referendum from budget calculations used to determine expenditure restraint payments
- #15 – allow newly constructed tax-exempt property to be included in the net new construction calculation for the purpose of determining levy limits
- #64 – allow municipalities to obtain workplace and other data that would help facilitate debt collection and allow for the use of wage attachments
- #76 – eliminate the requirement that witnesses to absentee ballots must include their address or the ballot is rejected
- #127 – restore local control over MPS real estate sales

Mayor's Independent MMSD Audit Committee

Final Report

Presented to Mayor Tom Barrett

October 1st, 2004

October 1, 2004

The Honorable Tom Barrett
Mayor of the City of Milwaukee
City Hall, Room 201
200 East Wells Street
Milwaukee, WI 53202

Regarding: Final Recommendations and Performance Review of the Milwaukee Metropolitan Sewerage District (MMSD) Conducted by the Mayor's MMSD Audit Committee

Dear Mayor Barrett:

On behalf of the Mayor's MMSD Audit Committee, we are proud to present to you the following *Final Recommendations and Performance Review of MMSD*. While running for Mayor of Milwaukee, you announced as part of The Barrett First 100 Days Action Plan that you would initiate an independent audit of MMSD.

At your directive, the Committee has conducted all of its proceedings in public and has heard extensive testimony from a variety of outstanding individuals and organizations. The Committee would like to thank the many scientists, local public officials, environmentalists, fishing organizations, national wastewater treatment experts, and staff members from the Wisconsin Department of Natural Resources (DNR) and the Southeastern Regional Planning Commission (SEWRPC) who appeared before the Committee. Their expertise, base of knowledge, commitment to clean water and unique perspectives were invaluable in producing this audit of MMSD's practices and performance.

This review has been conducted over the past three months with the assistance of nationally respected leaders in the wastewater industry including Dick Sandaas, a consultant with extensive history in the wastewater treatment industry, and Andy Lukas and staff from Brown and Caldwell. The *Final Recommendations and Performance Review of MMSD* contains new scientific information developed specifically for purposes of this audit. The review also consisted of document reviews as well as extensive discussions and testimony from MMSD executives and staff. United Water Services staff also provided input.

Clean water is a regional challenge that will take a coordinated regional response. The Committee hopes that its audit will benefit MMSD, the 28 municipalities it serves, and all those dedicated to improving water quality and moving the region forward.

On behalf of the entire Committee, we would like to thank you for the honor and privilege of serving on the Mayor's MMSD Audit Committee.

Sincerely,

Mayor's MMSD Audit Committee

Don Theiler, Committee Chair
Division Director
King County Wastewater Treatment Division

Ashanti Hamilton
Milwaukee Alderman

Tony Earl
Former Governor of Wisconsin

Wally Morics
City of Milwaukee Comptroller

Theresa M. Estness
Mayor of Wauwatosa

RoseMary Oliveira
Citizen

Nancy Frank
UW-Milwaukee, School of Architecture & Urban Planning

1. Executive Summary

In June of 2004, Mayor Tom Barrett of the City of Milwaukee formed the MMSD Audit Committee to explore the causes of the large volume of sewer overflows in May 2004. The review was to evaluate the adequacy of the sewer system and its management during this period as well as other periods of wet weather. In addition, the Mayor requested that the Audit Committee answer several questions in this regard and make recommendations for improvements. The Audit Committee conducted five day-long meetings, during which it accumulated extensive information leading to its recommendations. The Audit Committee received input from expert panels, MMSD staff presentations, and consultant presentations. This provided a wide spectrum of information covering policy, environmental, regulatory, technical, and operational matters.

The issues reviewed by the Audit Committee were complex. However, certain facts are clear to the committee as a result of its deliberations. First and foremost, there is too much storm water getting into the system during major storm events. This excess water is overwhelming the MMSD sewer system and causing an unacceptable level of overflows.

Two of the Committee's recommendations address excessive wet-weather flows into the MMSD system. The first calls for MMSD and the 28 contributing communities to reduce excessive infiltration and inflow in the separate sewer area. This could be accomplished by eliminating illegal connections, developing a cost effective infiltration and inflow (I/I) reduction program, and establishing maximum I/I levels. The second calls for development of a program to reduce excess flows into the combined sewered area, which would include partial sewer separation.

The Committee recommends that MMSD follow through on overflow reduction project implementation, minimize blending, and build treatment systems at combined sewer overflow points to minimize environmental damage. The Committee also recommends that the municipalities in the MMSD service area create a system to share the cost of I/I reduction as well the cost of treating storm water and non-point source pollution.

Complete separation of the existing combined system is not recommended at this time for a combination of reasons: the cost is prohibitive; the disruption of the downtown area would be enormous; and the impact on water quality would be negative because of the loss of the stormwater treatment, which currently occurs.

Finally, the Committee sensed a willingness on the part of regional leaders to work together on the solutions to this problem. The successful implementation of these recommendations is reliant upon regional leadership and cooperation. Assigning MMSD with sole responsibility for solutions to regional issues will not work. The committee is encouraged by the efforts of the MMSD Executive Director, Kevin Shafer, who is working regionally to improve communications and understanding of the issues. Local suburban officials who appeared before the Audit Committee testified that Mr. Shafer has been "extremely good" at sharing information and involving communities in developing regional solutions. The regional summit hosted by MMSD on September 23 of this year is an example of these efforts.

2. Recommendations

Wastewater collection systems in the Milwaukee area and the Milwaukee Metropolitan Sewer District (MMSD) have recently been overwhelmed – notably in May 2004 - by the amount of stormwater entering the system. Stormwater enters the system from both the combined sewer area and the separate sewer area. The result has been overflows and backups of untreated sewage into the area rivers, lakes, streams, and basements. MMSD has clear and specific responsibilities in this regard, including: 1) Elimination of sewer backups into homes caused by the public sewer system, 2), Elimination of Sanitary Sewer Overflows (SSOs) from the separate sewer system, and 3) Minimization and reduction of Combined Sewer Overflow (CSO) impacts. The Audit Committee recommendations are directed primarily at addressing these three areas of concern.

2.1. Reduce wet weather flow into the sewer system.

Activities must address infiltration and inflow (I/I) reduction in the separate sewer service area, and combined sewer runoff reduction in the combined sewer service area. Wet weather flows into the system have reached a level which is causing separate system overflows which must be eliminated. Flow reductions cannot occur unless both the combined sewer area and the separated sewer area undertake programs to reduce flows to an acceptable level.

a. All MMSD communities have ordinances making stormwater connections to the separate sewer illegal. MMSD must ensure that all communities enforce these ordinances.
b. MMSD should develop a continual I/I management program that provides for the cost effective reduction of I/I in existing service areas and significantly limits I/I from future development. The program must be:
    - enforceable,
    - rapidly implementable,
    - measurable,
    - fundable, and
    - supported by the communities.

    The program must include comprehensive and consistent I/I investigations in all communities to identify sources of the I/I, and the costs and benefits of controlling these sources. The program should identify I/I sources and implement activities designed to reduce I/I from identified illegal connections and from other sources which would be cost effective to control.

    The program should include a set of actions to insure that future I/I does not increase above an accepted rate. Examples are:

- Requiring the identification of possible I/I from residences and commercial establishments at time of sale;
- Developing ongoing programs to replace or repair defective or failing sanitary and storm sewers when streets, alleys, and highways are repaired;
- Providing backflow preventors in areas experiencing basement backups; and
- Testing laterals for soundness following the reconstruction of buildings.

c. MMSD should undertake a program with Milwaukee County and the cities of Milwaukee and Shorewood to analyze runoff reduction opportunities in the combined sewer area including downspout disconnection, rain barrels, rain gardens, rooftop storage and flow restrictors, catch basin storage and other techniques. These techniques should be implemented where it is determined to be reasonable and will not create other problems, such as localized flooding and building foundation problems.
d. MMSD should establish maximum acceptable I/I levels from future development.

2.2. Additional actions to reduce the impact of or eliminate overflows

a. MMSD should follow through on project commitments made in the Stipulation Agreement with WDNR.
b. MMSD should prioritize projects that will accelerate reduction of existing overflows and eliminate sewer backups into homes. MMSD should also look for opportunities to accelerate these projects. Among them, Port Washington Road and Wisconsin Avenue Relief Sewer projects provide overflow reduction and both might be accelerated, with a change in contracting policy. MMSD must, at the same time, be mindful of other organizational constraints that may limit the ability to deliver projects at an accelerated rate.
c. Using the results of the high rate treatment pilot project, MMSD should implement this type of treatment technology at appropriate CSO points to reduce impacts of untreated overflows in the combined system.
d. MMSD must make every attempt to reduce the need for blending by reducing system wet weather flows or adding treatment capacity. As a part of the blending reduction effort, MMSD should also explore the

feasibility and desirability of fast flow treatment of the flows diverted around the secondary treatment process.

e. MMSD, the cities of Milwaukee and Shorewood, and Milwaukee County should look at opportunities to reduce flows to the combined sewer area by partially separating portions of the combined sewer where the first flush pollutants could still be captured in the MMSD system. Examples of where this approach is already being pursued are the Marquette Interchange and Canal Street Reconstruction Projects. Complete separation of the existing combined system is not recommended at this time for a combination of reasons: the cost is prohibitive; the disruption of the downtown area would be enormous; and the impact on water quality would be negative because of the loss of the stormwater treatment, which currently occurs.

2.3. Financing

a. If determined to be cost-effective, MMSD should provide funding or incentives for private property owners who rehabilitate their private laterals.
b. MMSD should establish a program which creates financial incentives to control and reduce excess flows within each community's sewer system. This program could involve a surcharge for excess flows above a predetermined base flow within each community's system. The charge should reflect the cost of transporting and treating excess flows from that community including the maintenance of the overall system. Such a rate program should be designed to reward communities which control and reduce excess flows in their systems. Consideration should be given to putting at least a portion of the rates from such a charge into a fund to assist communities to control and reduce excess flows into the MMSD and local sewer systems.

2.4. Enforcement

a. Enact programs that ensure illegal contributions to sanitary system are eliminated.
b. WDNR should be aggressive and equitable in SSO enforcement actions throughout the state. Communities in Wisconsin which have experienced SSOs should be required to eliminate them.

2.5. Non-Point Source and Stormwater Pollution/ Beach Closures

Water quality problems, such as beach closures, are not caused by MMSD overflows alone. Eliminating all MMSD overflows would not prevent most beach closings. Pollution from non-point sources and pollution from municipal and county stormwater collection systems must be addressed in order to achieve the water quality levels desired by the public. There is a vacuum in assigned responsibility for and leadership in addressing non-point source and stormwater pollution.

a. MMSD should aggressively continue its efforts to assist the region in dealing with these issues.
b. All communities contribute to the water quality impacts because they generate non-point source and stormwater pollution. The Intergovernmental Cooperation Council (ICC) and MMSD contract communities should take the lead in developing a system of cost sharing for treating stormwater in the region. By virtue of the deep tunnel, all MMSD customers currently pay for treating a substantial volume of stormwater generated in the combined sewer areas of Milwaukee and Shorewood. The cost-sharing system would need to recognize this reality and include equitable ways to fund stormwater treatment in the separate sewer areas.
c. MMSD should contribute, within the limits of their authority and responsibility, to solutions that reduce non-point source and stormwater pollution to tributary lakes and rivers, for example, improving stormwater management on parking lots that discharge without treatment into receiving waters near beaches.
d. Other entities such as Milwaukee County should take actions that would have an immediate, cost-effective benefit on water quality near beaches. Such actions would include beach raking and local stormwater control on and near the beaches.

2.6. Public Communications

Public communication is needed to clarify the causes and potential solutions for regional water quality problems. It is important for everyone to understand that there is no single villain causing our water quality problems, just as there is no single cure.

a. Other organizations, working with MMSD, should communicate with the public on the respective roles and responsibilities of MMSD and other governmental entities in protecting and improving regional water quality.

b. Research public expectations on water quality and sewer overflows to assist in establishing specific water quality goals for the region taking into account public willingness to pay for the solutions.
c. Communicate with public on five key things:
    i. Nature of the regional water quality problem.
    ii. SSO and CSO goals and their impacts on water quality.
    iii. Nature of I/I and strategies for controlling I/I.
    iv. Nature of non-point source and stormwater pollution and strategies for achieving control goals.
    v. Respective responsibilities for achieving water quality goals.

2.7. United Water Services (UWS) Oversight

The Audit Committee focused its attention on the May 2004 overflows and did not identify UWS as a significant contributor to them. However, the Audit Committee has identified a number of concerns going forward.

a. To ensure that an adequate number of skilled technical staff will be available in the future to operate this highly complex system, MMSD should require any subsequent contractor to provide a Succession Plan for key human resources.
b. MMSD should follow-up on 2003 UWS Performance Evaluation recommendations related to maintenance schedules on non-critical assets.
c. On future operating contracts, MMSD should include contract incentives pertaining to overflow prevention that were recommended in the 2003 Performance Evaluation.
d. MMSD should ensure the Technical Environment Committee is fulfilling its charge of overseeing the performance of UWS in meeting its responsibilities. This should include active participation of its members, regular meetings and, at a minimum, quarterly reports to the MMSD Commission.

2.8. Regional Watershed Approach to Solutions

a. Develop and implement a mechanism for meaningful and effective suburban input to implement the recommendations in this report in an atmosphere of cooperation so that all members of the sewered community feel included in decision-making.
b. The region must develop and implement mechanisms to address all sources of pollution and also determine what the specific water quality goals are for the area. Without this information the communities

responsible for the sewer system cannot determine how to design and maintain their individual systems.

c. The WDNR should become more active in fulfilling its responsibilities and be provided with the resources to assist the region in establishing specific goals and implementation solutions.

3. Discussion of Panel Questions Regarding May 2004 Performance

Mayor Barrett commissioned the Audit Committee to answer several pressing questions regarding the environmental situation and causes surrounding the overflows in May 2004. The Mayor and his cabinet created seven categories of questions for the Audit Committee to focus on, and they are discussed as follows.

3.1. Relating to United Water Service (UWS) Performance

What impact has privatization of Milwaukee Metropolitan Sewerage District's (MMSD's) operations had on overflows?

There is no clearly identifiable impact of privatization on the major overflows which occurred in May 2004. The tunnel operating decisions are made jointly between UWS and MMSD during larger storm events. Otherwise, UWS has full authority to make operational decisions. Some isolated overflows events appear to be due to operational errors during the period UWS has been operating the system.

Weather information used by UWS and MMSD management during the May storm events for making decisions on tunnel operation, included radar and satellite imaging; current storm intensity, duration, and probability; recorded rainfall amounts for preceding events; and forecasted rainfall amounts. Resources include National Oceanic and Atmospheric Administration (NOAA) forecasts, weather-related internet websites, the Great Lakes Weather Service, and MMSD rain gages. The historic reliability of weather forecasting resources is not known at this time.

The 2003 UWS Performance Evaluation reviewed whether UWS cost-savings measures could be contributing to overflows. That review did not find that this was the case. Further, tunnel operating data would indicate that the tunnel was performing in a similar manner while MMSD was solely responsible. The review did express some concerns for reduced staffing levels, including experienced staff, and the potential for performance impacts in the future.

How has UWS performed against their contract?

UWS's performance has generally been satisfactory.

There are no contract incentives/disincentives linked to overflow prevention, as contrasted with the treatment plant operations which have incentives/disincentives. UWS has responded in a positive fashion to the incentives for treatment in their current contract. UWS follows standard operating procedures and collaborates with MMSD management while operating the system.

Is UWS making errors that are causing or contributing to the overflows?

A limited number of minor overflows might have been prevented if UWS had better technology provided to experienced operators. Also, during the first May 2004 storm, basement backups occurred, and a review is underway regarding UWS operation of overflow gates during that period.

Is UWS trying to save money at the expense of our environment?

Nothing is currently evident to suggest that UWS is making decisions that harm the environment. However, issues identified in the 2003 Performance Evaluation, such as staffing levels (reduced by one-third and lack of succession planning), and deferred maintenance of non-critical equipment, will have an impact on system performance if not addressed. The effects of cost pressures on UWS from sky-rocketing utility costs should be monitored for any future impact on their performance.

The 2003 Performance Evaluation showed the system performance since the tunnel has gone "on line" is not significantly different since UWS came under contract. Some operational protocols for the tunnel have changed as operating experience has been built, but these changes had the input of both MMSD and UWS staff and management.

The effluent quality at treatment plants has historically exceeded contract requirements, which are significantly lower than the WPDES permit for effluent. For this, UWS has received performance bonuses as provided in their contract. The following outlines the bonus, penalty, contract and permit limits for wastewater effluent.

Table 1. UWS Contract Incentives for Treatment Plant Effluent

Constituent	Bonus Limit (Less than)	Penalty Threshold (Greater than)	Contract Limit (Greater than)	Permit Limit (Greater than)
BOD	9 mg/L[2]	13 mg/L[2]	15 mg/L[1]	30 mg/L[1]
TSS	8 mg/L[2]	13 mg/L[2]	15 mg/L[1]	30 mg/L[1]
Total phosphorus	None	None	1 mg/L at South Shore 0.5 mg/L at Jones Island[1]	1.0 mg/L[1]
Fecal Coliform	None	None	100 units/100 mL[2]	400 units/100 ml[3]

[1]Monthly average
[2]Annual average
[3]Monthly geometric mean

There are no incentives/penalties in the contract for CSO's, SSO's, or other operational performance.

3.2. *Relating to Deep Tunnel*

What exactly was the deep tunnel supposed to accomplish for us?

The deep tunnel was initially designed to capture all overflows from the separate system for the largest storm of concern that was analyzed for the Water Pollution Abatement Program (WPAP). The period of record analyzed was from 1940 to 1978. Engineers then determined that a storm in June 1940 produced the largest amount of separate sewer flow that would require storage. Subsequently this storm was termed "the Storm of Record." The tunnel sizing was based on the estimated flows from the June 1940 Storm of Record assuming 12.8 percent reduction in local sewer system I/I.

Since this type of storm is rare (once in 40 years), engineers also determined that smaller storms occurring much more frequently would not use much of the tunnel volume. MMSD determined that using the excess tunnel capacity in smaller events to capture potential CSO would allow it to meet its water pollution abatement goals at significant cost savings over other alternatives. The result was a dual purpose tunnel: preventing SSOs and reducing the number of CSOs. When the decision was made to use the tunnel for dual purposes, the overall volume of the tunnel was increased to the present size. MMSD's challenge is to operate the tunnel in a manner that maximizes CSO controls while at the same time not jeopardizing its ability to prevent SSOs. The Appendix provides further information regarding tunnel design and performance history.

Unfortunately, as MMSD communicated the plans and expected performance for the tunnel, the public came away with a perception that no overflows of any kind would occur after the tunnel was operational. However, newspaper accounts from the Milwaukee Sentinel in September 1993, shortly after the tunnel became operational, clearly make a distinction between expected control performance for CSO (1.4 per year after the tunnel is operational) and SSO (elimination).

What are the standards the deep tunnel is required to meet?

The design standards for the deep tunnel are no separate sewer overflows (SSOs) and an annual average of 1.4 combined sewer overflows (CSOs). The permit standards for the MMSD wastewater system are zero SSOs and up to 6 CSOs annually. An explanation of tunnel permit and design standards is provided in Appendix B. It is important to note that during the original planning (WPAP), engineers recognized that there would be events of significant CSO volumes. Public attention from the May 2004 events has been focused on the magnitude of the overflow volume; however, it would be more appropriate to consider the significance of the SSO events which are not allowed by permit.

Is the deep tunnel meeting these expectations and standards?

The deep tunnel falls short of public expectations for a very expensive project. It does, however, appear to be performing close to the technical objectives established during the design. To answer this question properly, it must be broken into two categories: CSO and SSO. The ability to meet CSO control objectives is largely determined by the weather, and more specifically how many large storm events occur during a given year. MMSD records indicate that the annual average for the 10 year operational history of the tunnel (1994 through 2003) is approximately 2.4 CSOs per year, which is higher than the estimated 1.4 per year. This includes a yearly high of 6 and a low of zero (shown in Figure 1). From this perspective, the tunnel has allowed MMSD to meet the permit conditions for CSO and control overflows to close to the design expectations. It is important to note that the tunnel was not sized to contain total CSO volumes during heavy rains. In fact, during the original planning (WPAP), engineers estimated that there would be events of significant CSO volume (greater than 1 billion gallons).

As for SSO events, there are two primary causes: 1) tunnel-related, and 2) pipeline bottlenecks in the system. This discussion deals with tunnel-related SSOs. Even with the changes in tunnel operation protocols that improved the capture of SSOs after 1999, SSOs have occurred. This means the zero SSO permit requirement has not been met. The remaining question is whether this is because the tunnel was originally sized with insufficient capacity or if flows from the separate sewer area are greater than what was anticipated at the time of the WPAP. Further discussion of this question is provided below.

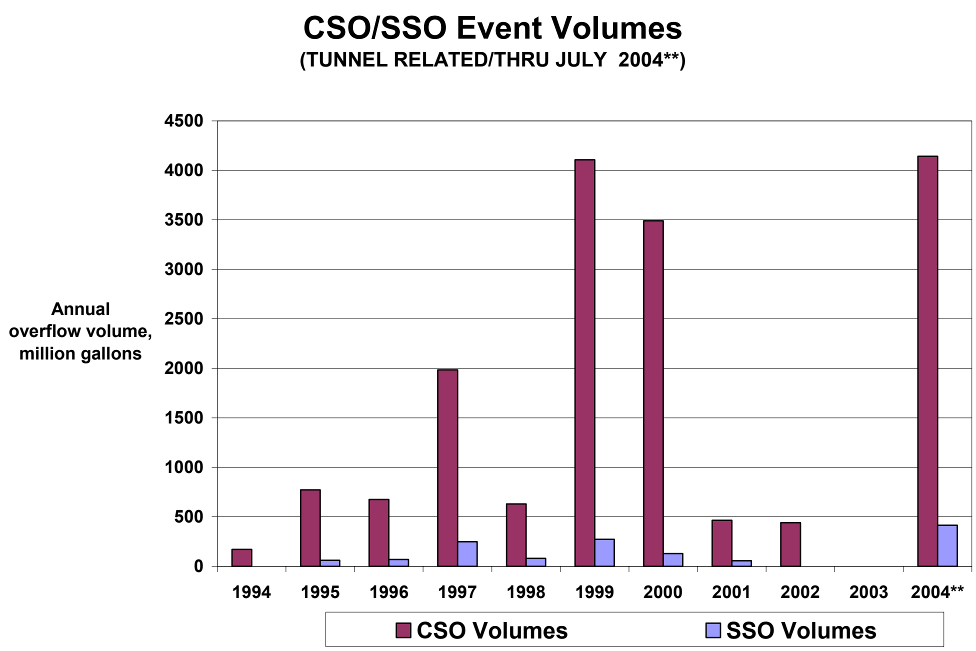


Figure 1. Tunnel-Related CSO and SSO Volumes Reported by MMSD Since 1994

If not, what are the reasons?

Excess I/I appears to be a key factor. MMSD has the authority to order I/I remediation in local systems but has not exercised it. Their current approach is to use 2020 Facility planning for dealing with I/I. The DNR is seeking legal remedies against 28 communities for excessive flows.

During the May 2004 storms, about 13 percent (equal to 7.6 billion gallons) of the rain that fell on the MMSD separate sewer service area flowed into the sewer system. This is a significant amount. Even so, it is within the range experienced in the past five years (1999 through 2003). Over that five-year period, the amount of rain flowing into the separate sewer system ranged from 7 percent to 15 percent, with an average of 9 percent. This shows the May 2004 storms were not exceptional in terms of the percentage of stormwater entering the MMSD separate sewer system; however, the volumes were extraordinary. Appendix D provides further information on these calculations.

A comparison of these I/I percentages to the Seattle, Washington area separate system shows that the MMSD system has much more I/I. An analysis of a portion of the Seattle system showed the following:

- 1 to 2 percent I/I rate for a 1 year storm event.
- 2 to 4 percent for a 20 year storm event

A broader estimate for the entire separate system in Seattle indicated the I/I is in the range of 6 to 7 percent for the 20 year storm. All of these amounts characterizing the Seattle system show significantly less I/I than in the MMSD system.

What is just as telling is the comparison of separate sewer flow to combined sewer flow that enters the MMSD system. Over the past 5 years, the separate sewer system generated, on average, 64 percent of the wet weather flow. For comparison, during May 2004 storms, 66 percent of the wet weather flow originated in the separate sewer area. This means that the majority of total sewer flow during storm events originates in the separate sewer system.

Another reason is the difficulty in predicting the amount of tunnel volume to reserve for flow from the separate sewer area. This is particularly challenging in extended rainy periods such as May 2004. A post-event analysis performed for this audit indicated that if the entire tunnel had been reserved for SSO capture, the tunnel would not have filled completely. This action would have increased CSO volumes by approximately 800 million gallons. MMSD has several projects addressing this operating constraint, including contracting with a provider of long-range precipitation forecasts.

A Monday Morning Quarterback could criticize the MMSD for not reserving all of the capacity for the separate sewer flows; however, if this had occurred, as pointed out above the increase in overflow volume would have been approximately 400 million gallons. Also, if the rainfall had ended earlier, the tunnel would not have been fully utilized. In that event, the MMSD would have certainly been rebuked for not using the tunnel to reduce combined sewer overflows.

3.3. *Relating to Other Communities with Combined Sewers*

How does Milwaukee's situation compare to other similar sized communities with similar climate? What efforts have these communities made to reduce CSO's?

The communities of Minneapolis, as well as St. Paul and South St. Paul, Minnesota, separated their combined sewers in the 1970s through the 1990s. Despite sewer separation, Minneapolis still experiences overflows in larger storm events, with the most active overflows spilling four times per year or more. A primary cause of this continued overflow activity is incomplete separation on private property that was deemed too expensive to tackle at the time. Minneapolis has recently initiated a downspout disconnection program that will require all homeowners to eventually disconnect from the system.

Chicago's system, operated by MWRDGC, includes approximately 400 square miles of combined sewer area. Chicago's most recent permit authorizes CSOs, but requires the system be able to convey and treat up to 10 times dry weather flows without a CSO occurring. This is consistent with Illinois state standards for CSO, which also requires CSOs to be treated in order to prevent sludge deposits, floating debris, and solids, and to prevent depression of dissolved oxygen levels below the applicable water quality standard. MWRDGC has no direct overflows to Lake Michigan, but in large flood events CSOs to the Chicago Sanitary and Ship Canal can discharge to the lake. The last such event was in 2002. The MMSD system performs at a higher standard than the 10 times dry weather flow standard, but would not meet the CSO treatment standard. Appendix F provides further discussion of the differing regulatory approaches to CSO and SSO discharges in the Great Lakes states.

The City of Detroit has a combined sewer area of 500 to 550 square miles, roughly 20 times the size of Milwaukee's. Detroit has implemented a $1 Billion program for downspout disconnection to reduce combined sewer flows, CSO treatment to reduce overflow impacts, and containment of stormwater in the combined sewer area to reduce the need to overflow. A sewer separation study indicated that separation was not a viable option due to the cost and the negative impact of polluted stormwater runoff on water quality if it were removed from the sewer system. Detroit plans on constructing a deep tunnel which would be designed for 1 overflow per year and 200 MG of storage for the CSO. They are also investigating I/I concurrently to quantify if it is a cost effective solution.

What has been their operational experience under similar rainfall conditions?
The City of Detroit generally experiences the same weather patterns as Milwaukee, and has historically experienced up to 50 overflows per year for the combined sewer area. Based on our understanding of the Detroit system plan, overflows will occur more frequently in Detroit than Milwaukee, but most of these overflows will receive treatment.

The State of Michigan requires treatment to consist of screening and disinfection at a minimum.

Chicago continues to implement its Tunnel and Reservoir Plan (TARP); however, overflows still occur. Records obtained from MWRDGC indicate that CSOs occurred at major discharge locations on 20 dates in 2004 thus far. MWRDGC has 145 permitted CSO discharge points. For comparison, MMSD has 117 permitted CSO outfalls.

3.4. Relating to Existing Plans at MMSD

What projects are currently developed and can/should they be accelerated?

There are a number of projects currently being undertaken by MMSD and included in the Stipulation Agreement with the Wisconsin Department of Natural Resources. Current projects that will provide additional storage are:

- Northwest Side Relief Sewer (88 MG – complete in 2005);
- Port Washington Road Relief Sewer (up to 30 MG – complete in 2008);
- West Wisconsin Avenue Relief Sewer (25 MG – complete in 2009).

The Harbor Siphons project will also add capacity from the combined sewer system into the Jones Island Wastewater Treatment Plant. This capacity will allow MMSD to delay the discharge of combined sewer flows into the deep tunnel, thus preserving storage for separate sewer flows.

Acceleration opportunities are being sought by MMSD staff for Port Washington Road and West Wisconsin Avenue. It should be noted that MMSD organizational constraints can impede these project acceleration efforts. For example, MMSD's $1.2 Billion Capital Improvement Program over the next six years exceeds the MMSD's capacity to do the work. A recent American Society of Civil Engineers (ASCE) peer review confirmed these project delivery constraints.

Current MMSD Commission policy requires a second Request for Proposals process to obtain final design services for both Port Washington Road and West Wisconsin Avenue projects. Changing this policy to allow amending the current preliminary engineering contracts to provide for final design services could save approximately six months for each project.

How would these projects have affected the May storm events if they had been in place at that time?

Based on an analysis of system operating data, it appears that these planned projects would have allowed MMSD and UWS to prevent tunnel-related SSOs during the May storm.

During the May storm period, MMSD was only able to use two of the three deep tunnel pumps due to an emergency construction project. The project was initiated to avoid a catastrophic failure of the pumping system. If full pump capacity had been available during that event, one of the tunnel-related SSOs would have been avoided. The SSOs on May 23-24 would still have occurred, but would have been substantially less. There would have been virtually no reduction in the CSO volume reported, which at a reported 4.1 billion gallons is the largest portion of the May overflows.

What additional projects would have had a substantial positive effect on the May 2004 overflows?

Based on the analysis for this Audit, it appears that additional pumping out of the tunnel, beyond what is currently designed into the system, would have allowed MMSD to greatly reduce SSOs in May. This additional pumping would take advantage of treatment plant capacity that was available at certain times during the May storms. Some SSOs would still have occurred with this additional pumping, but CSO volumes would not have been reduced. Had additional storage and pumping both been implemented before the May 2004 events, tunnel-full SSOs could have been avoided, but CSO volumes probably would have been reduced only slightly.

MMSD has provided WDNR with a list of the SSO locations during the May storms and projects that will provide local relief for SSOs. Of the sixteen reported SSO locations, five are associated with either the Port Washington or Wisconsin Avenue Relief Sewer projects. Another three would be addressed by other projects already underway. Three more locations overflowed due to the tunnel being full and could potentially be addressed with more storage. There are no planned projects for the five remaining SSO locations, and further analysis will be required to address them.

3.5. Relating to Sewer Separation

Is sewer separation a viable option?

Full separation is not a viable option for the following reasons:

- Untreated discharge of the stormwater resulting from separation would increase the level of pollution currently being experienced
- Disruption to the combined sewer area would be extensive during the extended construction period required for full separation.
- Cost of separation would be very great and not cost-effective when compared to the benefits.

Partial separation projects should be pursued where feasible when considering cost, disruption, and environmental impacts. Wherever partial separation is pursued, the first flush of stormwater pollutants should be delivered to a treatment system. The Appendix provides further details concerning the potential impacts of sewer separation.

What would full separation cost?
Estimates for full separation range from \$2.1 – \$2.7 billion (not including private property costs) in studies conducted for MMSD in 2000 and 2002. These costs did not include separation costs for private property owners' sewer improvements. In some instances these costs could be substantial and should not be overlooked when considering the full cost of sewer separation. The 2020 Facilities Plan team is performing a very thorough evaluation of separation costs and effectiveness that will include input from local construction experts.

What would be the impact on water quality and flooding?
Without proper stormwater treatment, sewer separation will cause a net increase in pollutants to area rivers and the lake. Untreated stormwater discharges would have a negative impact on water quality. The flooding impact of separation is unknown, but any further evaluations of separation should include the costs required to provide the same or better level of flood protection residents currently experience.

How does sewer separation compare to other options?
Sewer separation has not been shown as a cost effective option in many studies, especially when the cost of stormwater treatment is taken into account. Partial separation and CSO treatment should be pursued instead of full separation where shown to be viable and where it would provide significant environmental benefit.

3.6. Relating to Eliminating Overflows

Is achieving zero overflows from the entire collection system a realistic and desirable goal?
It is a realistic and necessary goal for SSOs. A reasonable goal for CSOs is to reduce them and limit their impact. Tactics could include reducing runoff to combined sewers and treating CSOs. During this Audit, the Committee received considerable scientific input indicating that CSOs are not the major contributors to beach closures and other water quality problems. If proven to be correct with further study, it would be difficult to justify the cost to achieve zero CSOs. It is quite likely that significant water quality problems will remain even if overflows were eliminated.

3.7. Relating to MMSD Management of System

How did MMSD management perform during these wet weather events?
The joint decision making process between MMSD and UWS during tunnel events seems appropriate and effective. There is a strong commitment within MMSD to achieve optimum system operation. Since the tunnel became operational in 1994, MMSD and UWS have learned how to better operate the system to reduce and in some cases avoid overflows. The key decision in this operation relates to interpreting weather forecasts to anticipate when to close off combined sewer flows to the tunnel. While this decision is hampered by the availability of reliable long term rainfall forecasts, decision-makers appear to be doing a reasonable job of managing the system.

Were there actions which MMSD should have taken which could have improved the outcome of the wet weather events and reduced overflows?

For this Audit, an analysis of system operational data was performed for the May 2004 events to determine the significance of those storms and the impact of reduced tunnel pumping on overflows. This analysis, based on recent 2020 Facilities Planning modeling, concluded that May 2004 was approximately a 10-year event from the perspective of tunnel volume required to control SSOs. MMSD has performed a separate analysis of rainfall data across the service area and determined that this 19-day window of storms had a 32-year return period.

As for the impact of reduced tunnel pumping, it was determined that the first tunnel-full SSO could have been avoided and the second greatly reduced if the full pumping capacity had been available. Pump availability would have had virtually no impact on CSO volumes, which is the largest portion of the reported overflow volume.

The Committee learned about an overflow incident at Marshall Street at the Milwaukee River on August 3, 2004. This facility, along with a number of others, has instrumentation and configuration characteristics which need remediation. There has been a lack of urgency within the MMSD organization to resolve such issues.

Strong long-term action to limit new I/I and reduce historical I/I in the separate sewer system should have been taken by MMSD in the past. If such strong action had been taken, the separate sewer overflows would have been reduced and perhaps eliminated altogether.

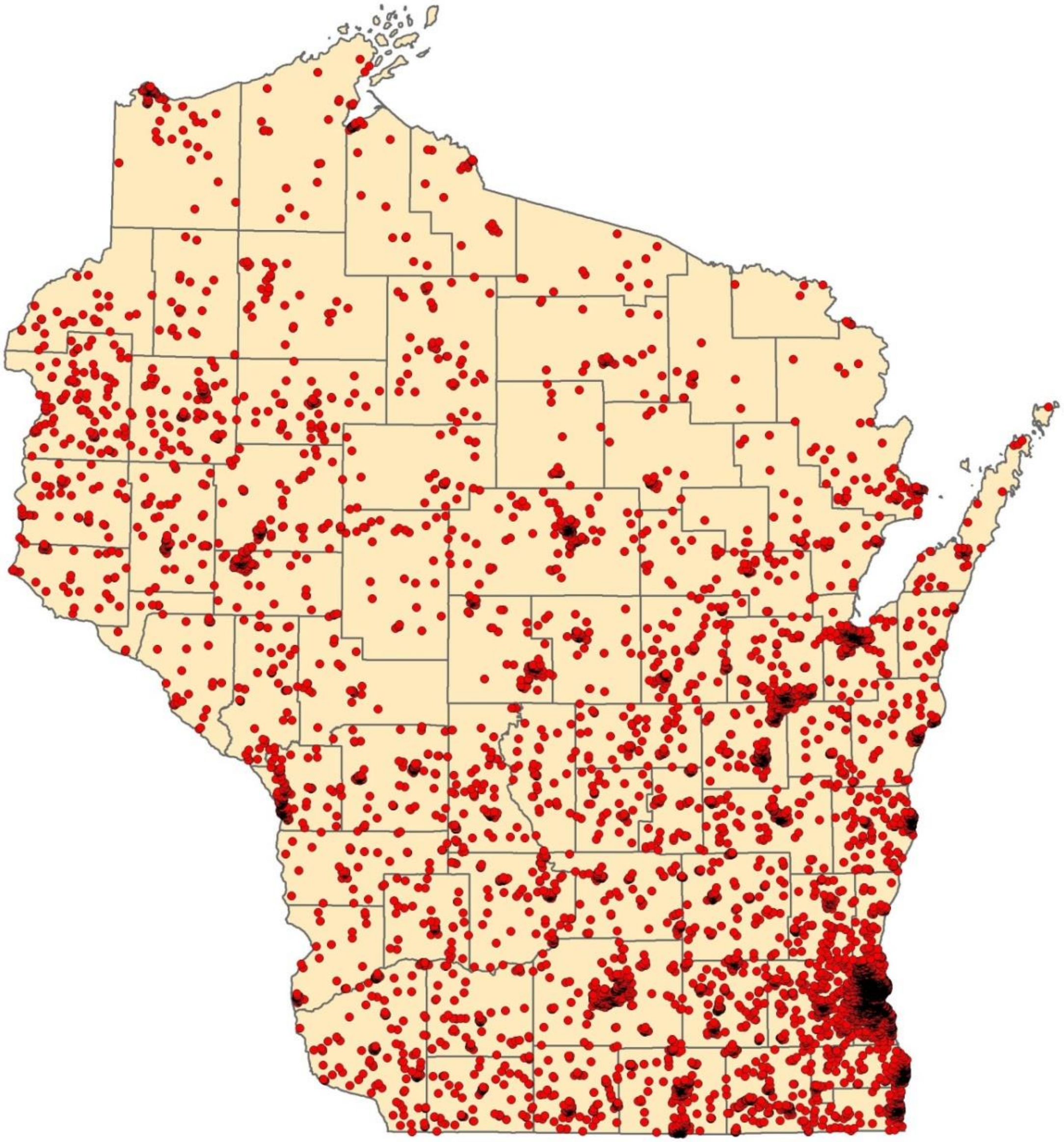
Toxicology of Exposure to Lead in Humans

Robert Thiboldeaux PhD
Senior Toxicologist
March 10, 2017

Wisconsin
Department of Health Services

Lead is widely present in the environment

- Used since ancient times due to its workability, low melting point, and resistance to corrosion.
- Past and current uses include:
  - Paint pigments
  - Water pipes, solder, fixtures
  - Fuel additives
  - Electronics
  - Lead-acid batteries
  - Projectiles
- Naturally-occurring lead in Wisconsin geology.



Lead poisoning in Wisconsin is a statewide problem.

Each red dot represents an address associated with a lead-poisoned child, 1996 to 2006.

More than 44,000 children.

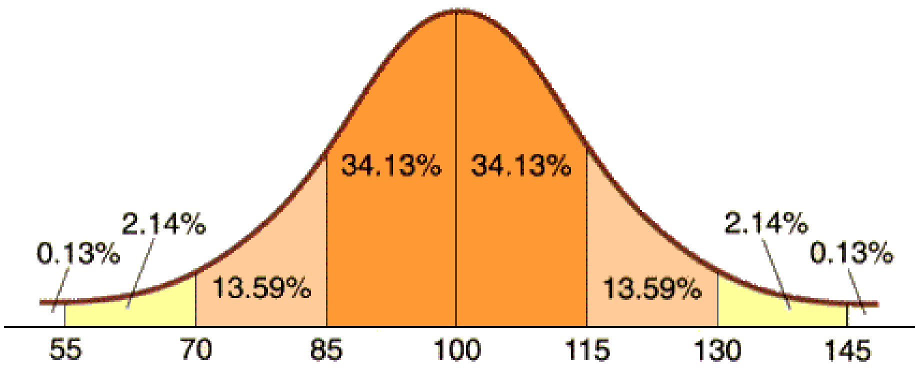
Old lead paint most important cause of exposure.

2

Lead has numerous effects on health

- Neurological effects
- Peripheral neuropathy
- Renal effects
- Blood effects
- Blood pressure
- Rate of uptake > rate of excretion, due to accumulation in bone

Lead poisoning is the most serious environmental health threat facing young children in the U.S.



"Normal" IQ distribution

- Lead poisoning interferes with the normal development of a child's brain.
- 2-4 IQ point deficit for each microgram of lead per deciliter of blood (µg/dL) increase in blood lead above 5 µg/dL

-WI Dept. Health Services. 2008. Report of Childhood Lead Poisoning in Wisconsin. PPH 45109 (5/08)
-N Engl J Med 348;16 www.nejm.org april 17, 2003

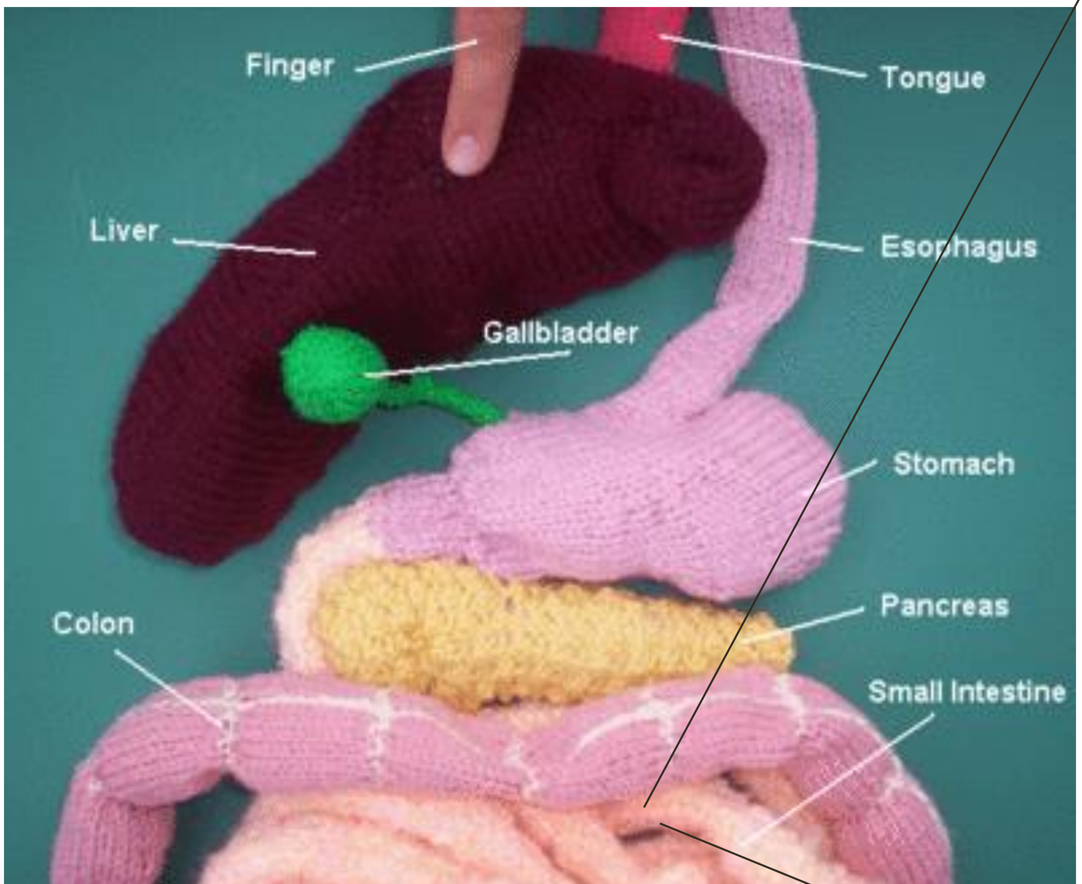
Blood Lead Concentrations Corresponding to Adverse Health Effects
From: **Agency for Toxic Substances and Disease Registry/Division of Toxicology and Environmental Medicine.** ***Toxicological Profile for Lead. 2005***

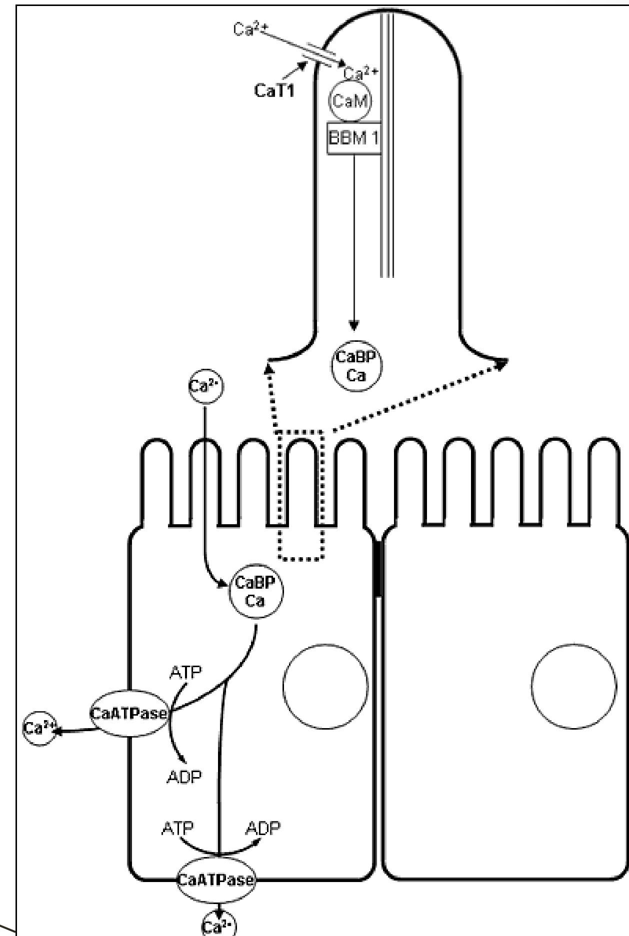
Blood Lead Concentrations Corresponding to Adverse Health Effects

Life Stage	Effect	Blood lead (µg/dL)
Children	Depressed ALAD* activity	< 5
	Neurodevelopmental effects	<10
	Sexual maturation	<10
	Depressed vitamin D	>15
	Elevated EP**	>15
	Depressed NCV***	>30
	Depressed hemoglobin	>40
	Colic	>60
Adult	Depressed ALAD*	< 5
	Depressed GFR****	<10
	Elevated blood pressure	<10
	Elevated EP (females)	>20
	Enzymuria/proteinuria	>30
	Peripheral neuropathy	>40
	Neurobehavioral effects	>40
	Altered thyroid hormone	>40
	Reduced fertility	>40
	Depressed hemoglobin	>50
Elderly Adult	Neurobehavioral effects	> 4

*aminolevulinic acid dehydratase (ALAD)
**erythrocyte porphyrin (EP)
***nerve conduction velocity (NCV)
****glomerular filtration rate (GFR)
.

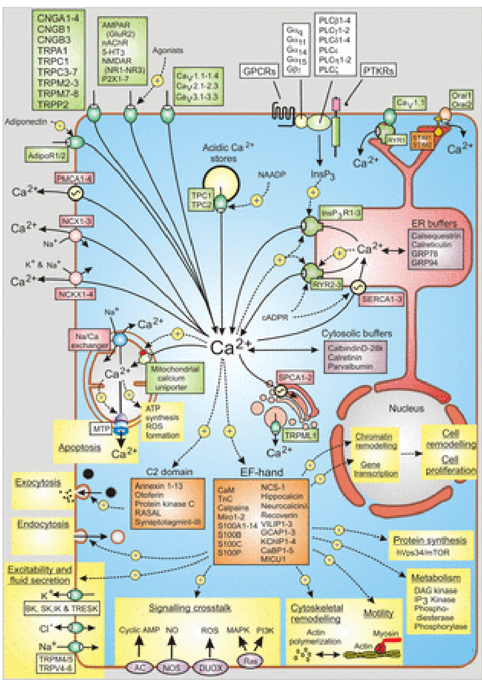
Lead (Pb) uptake primarily through calcium channels in small intestine



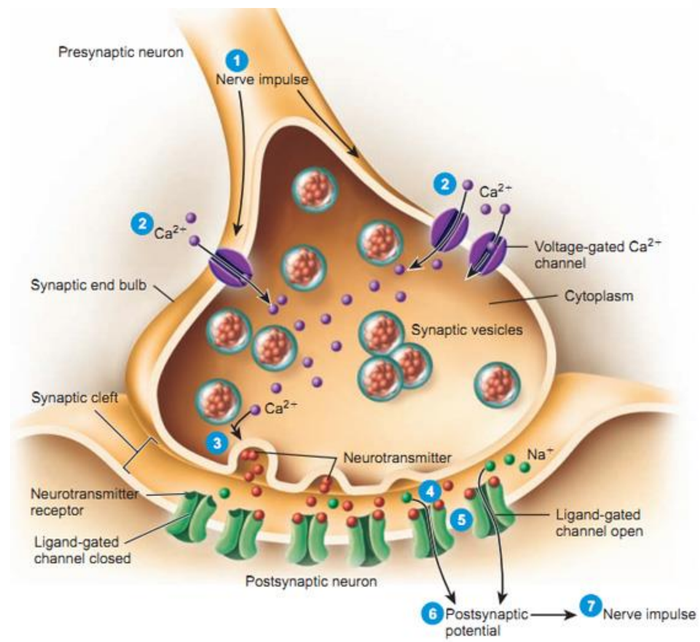


How does lead affect us at the cell and molecular level?

- Recurring theme of competition with, or inhibition of, calcium-dependent processes
  - Ca^{++} vs Pb^{++}
- *Many* molecular targets in cells and tissues



Berridge. *Biochem.Soc. Trans.* 2012



http://antranik.org/synaptic-transmission-by-somatic-motorneurons/

Public health definitions of lead poisoning

- 5 µg/dL: 5 micrograms lead per deciliter of blood: CDC policy reference value.
- No known biological role
- No "no-effect" level
- *Tolerable dose* does not equal to *no-effect dose*
- Children particularly vulnerable
  - Development
  - Uptake

The CDC blood lead Reference Value (formerly: Level of Concern) has decreased over time

	Blood lead LOC
1960s	60 µg/dL (micrograms Pb/deciliter blood)
1970s	40 µg/dL
1980	30 µg/dL
1985	25 µg/dL
1994	10 µg/dL
2012 reference value	5 µg/dL
Future reference value goals	< 5 µg/dL (to be updated every 4 years)

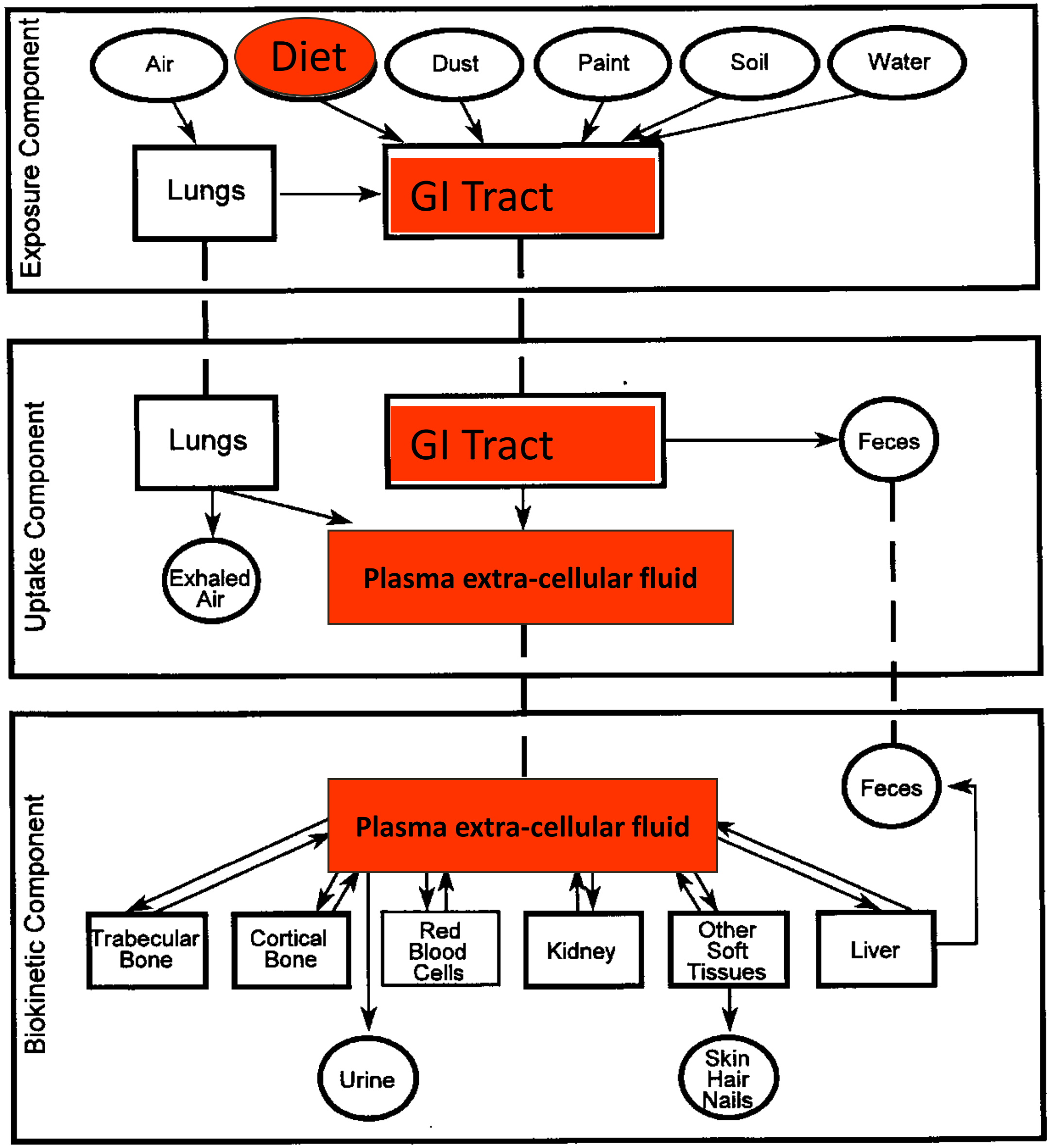
The LOC is a reference blood lead level based on the 97.5th percentile of the BLL distribution among children 1 –5 years old in the United States.

Ref. CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "*Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention*" . CDC. 2012. http://www.cdc.gov/nceh/lead/acclpp/cdc_response_lead_exposure_recs.pdf

How are decisions made about acceptable environmental concentrations of lead?

- The EPA *Integrated Exposure Uptake and BioKinetic* (IEUBK)model is used to predict blood lead resulting from environmental exposure.
- Key policy-making tool for the EPA.

IEUBK "Uptake" conceptual model



What happens when a medical test reveals a child with elevated blood lead level (BLL)?

- In Milwaukee, a tiered response from the Childhood Lead Poisoning Prevention Program:
  - BLLs 5-9 ug/dL: receive a letter and educational materials.
  - Venous BLLs 10-19: Pub Health Serv. Assoc. visits the home.
  - Venous BLLs 20+: Pub Health Nurse home visit and care coordination; risk assessor inspects the home.
  - Venous BLL 45+: Immediate poisoning response

- For more information : **Childhood Lead Poisoning Case Management Services** **http://city.milwaukee.gov/health/lead-Case-Management#.WKyrdv7rurS**

What about lead in water?

- Lead in residential and municipal water systems historically managed as a *secondary* source of exposure.
- Many communities are now paying extra attention to this source of exposure.
  - DHS is working with Milwaukee and other Wisconsin communities on this issue.
- There are several options to manage lead in water; removal is the only permanent solution.

Summary

- There are many sources of environmental lead exposure, both major and minor.
- Lead has numerous targets in the body, and affects both children and adults.
- Acceptable environmental Pb concentrations have decreased over time.
- Lead poisoning is preventable! There has been much progress in eliminating environmental lead, but still much to be done.

For more information on this topic from the Wisconsin Bureau of Environmental and Occupational Health:

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"Water, Water Everywhere — Nor Any Drop to Drink."

Alderman James Bohl, Jr., Common Council 5th District
Aaron Szopinski, Office of Mayor Tom Barrett

WHAT IS LEAD?

» A toxic, heavy metal found widely in the environment.

- Used since ancient times due to its workability, low melting point, and
  resistance to corrosion.

Past and current uses include:

- Paint pigments
- Water pipes, solder, fixtures
- Fuel additives
- Electronics
- Lead-acid batteries
- Projectiles

(PP 1-7 Referenced from Robert Thiboldeaux, PhD., Wisconsin Dept. of Health Services.)

LEAD EFFECTS ON HUMAN HEALTH

Rate of uptake > Rate of excretion, due to accumulation in bone.

» Health Impacts include:

- Neurological effects (Diminished IQ, Behavioral issues)
- Peripheral neuropathy
- Renal system
- Blood system/Increased blood pressure

LEAD POISONING:

The most serious environmental health threat to young children in the U.S.

Children are more susceptible based upon having more small intestine receptors (40% more) that absorb lead, as well as having a developing brain/body and lower body weight.

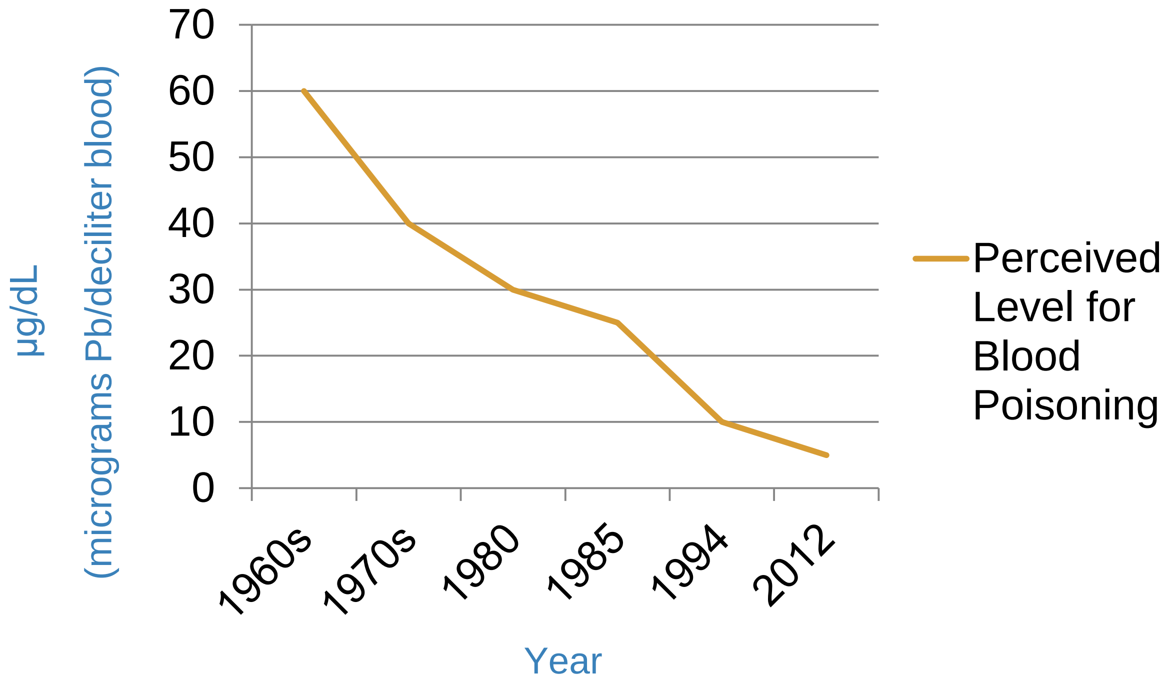
*

- » Interferes with normal brain development.
- » 2-4 IQ point deficit for each microgram of lead per deciliter of blood increase above 5 micrograms per deciliter.

*WI Dept. Health Services. 2008. Report of Childhood Lead Poisoning in Wisconsin. PPH 45109 (5/08)

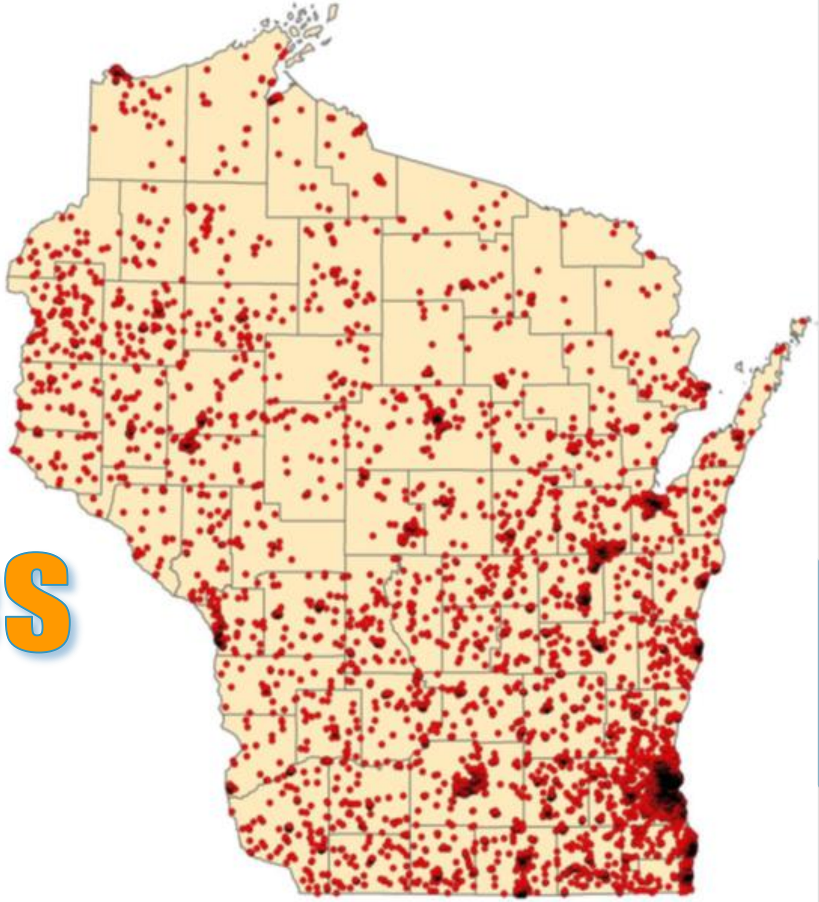
* New England Journal of Medicine. 348;16 www.nejm.org April 17, 2003

The CDC blood lead "Reference Value"… the perceived level for blood poisoning has decreased over time.



Wisconsin Reported Lead Poisoning Cases

1996 - 2006



Lead poisoning in Wisconsin is a statewide problem…but Milwaukee is most affected.

- » More than 44,000 state children reported above acceptable Reference Value from 1996-2006.
  - Old lead paint reported as the most significant cause of exposure.#
- » In 2016, 8.6% of Milwaukee children screened for lead had high blood-lead levels. This is down from 38% in 2003.*
- » By comparison, Flint, Michigan reported 5% of children screened in 2016 reported elevated blood-lead levels.*

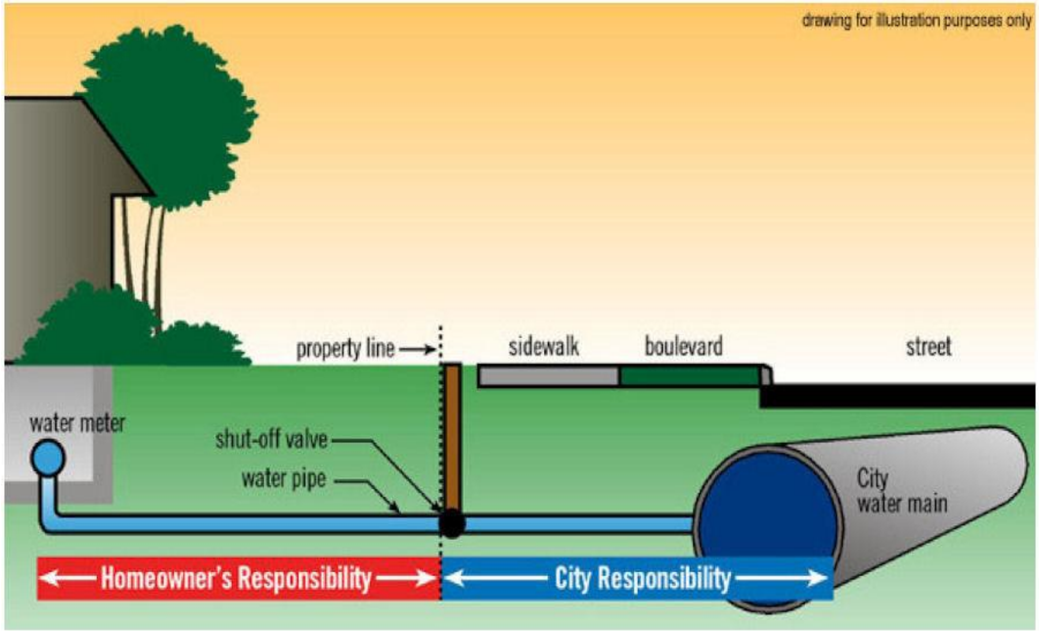
Wisconsin Dept. of Health Services
* Reuters/City of Milwaukee Legislative Reference Bureau

LEAD IN WATER?

- Historically managed as a *secondary* source of exposure.
  - CDC claims 10-20% of collective U.S. lead contamination comes from drinking water.
  - That figure reaches 40-60% for formula-fed babies. *
- Many communities are now paying extra attention to water as a source of exposure after Washington D.C. (2001) and more recently Flint, MI (2014).
  - Lake Michigan water & city water mains are lead free. Issues arise with leaded water-service laterals and/or with interior sources of lead (flux, solder, pipes, brass fixtures).
- There are several methods for managing lead in water, but **full removal** is the only permanent solution.

**Study by Monty C. Dozier/Mark L McFarland, University of Texas.*

LEAD-WATER ISSUES IN MILWAUKEE



- Roughly 70k leaded service lines in the city of Milwaukee…maybe more?
- Lead laterals represent roughly 60-70% of the lead in drinking water sources as a composite average, though this can be deceiving.
- Concerns about the city's policy of replacement of utility portion of erupted water service line disrupting lead pipes and dislodging lead flakes.

COMPLICATING ISSUES

» Interior Plumbing as a Source of Lead

Testing done in MPS schools showed 16% of the interior faucets or water sources to exceed EPA safe levels for lead, even though not one school tested had a lead service lateral (all were cast iron).

» Galvanized Steel Pipes

Rusted interior plumbing holds lead in its rust for years and provides slow release of lead for many years…even after lead service line is replaced.

» Galvanic Effect

Electrochemical process where presence of one metal increases corrosion of another in presence of an electrolyte. Issue found where copper service lines/plumbing precedes connected leaded lines/plumbing. This increases lead concentration leached into the water.

Water Quality Task Force

» Representing the City of Milwaukee

Ald. James Bohl, Jr., Chair
Common Council, 5th District

Ald. Cavalier Johnson
Common Council, 2nd District

Bevan Baker
Commissioner of Health

Ghassan Korban
Commissioner of Public Works

Carrie Lewis
Superintendent of Milwaukee Water Works

Ald. Jose Perez
Common Council, 12th District

» Representing the Private Sector

Ben Gramling
Sixteenth Street Community Health Center

Dr. Patricia McManus
Black Health Coalition of Wisconsin

- Created by Common Council File 160438, and adopted July 26, 2016.
- Major emphasis of city— replace water service laterals as the primary source of lead in water.
- WQTF has met seven times between September and March with 3 more planned meetings before April 28, 2017.

TASKED WITH:

Exploring the problem of lead in the City's drinking-water infrastructure.

Investigating and making recommendations regarding additional ways to ensure long-term health and safety to Milwaukee's drinking water.

Provide final findings and policy recommendations to the Common Council.

MAJOR FINDINGS

- Washington DC & Flint, MI crises are unrelated to Milwaukee's situation.
- Water testing mandated by EPA is merely done to test the effectiveness of corrosion control methods used by the water works.
- Historic process of replacing utility side service repairs means that many in the community could be left with copper lines before lead (Galvanic Effect).
- With limited resources…replacement of service lines should be prioritized around daycares and schools first. Water filters also prioritized for vulnerable populations (includes expecting mothers along with young children).

MAJOR FINDINGS (2)

- Adequate flushing is the single greatest mass-community "lead reduction" method other than complete replacement of exterior and interior plumbing sources.
  - EPA/CDC recommendation for flushing after 6 hours stagnancy is woefully inadequate and does not reflect the science of lead leaching. Their standard is based upon a "worst case" lead or copper exposure period.

- Policy of merely replacing service lines does not adequately address the issue of lead exposure through water.

- High attention level to lead in water complicates actual sources of lead and leads to greater confusion surrounding the issues.
  - Blessing and curse of modern day social media.
  - Resources & attention diminished regarding lead paint & other sources.

MAJOR FINDINGS (3)

- A robust media campaign addressing lead in paint as well as in water, and urging lead testing of young children is vital to stemming the severity of the lead poisoning issue.

- Wisconsin state law is extremely rigid and does not currently provide enough flexibility for local governments to fund massive capital projects in any reasonable duration of time.
  - Prohibitions on local taxing sources and state imposed levy limits.
  - State law/PSC imposition from using water revenues to fund capital or health/safety expenditures.

- Lead removal/remediation and mitigation (both for water and paint) will be a long-term effort.

MAJOR FINDINGS (4)

The City's determination of

70,000

lead service lines may **not be fully accurate**. That number could be too low.

- 1951 date for service lines reflects **only** city portion of service line and not private.
- Notch exists between 1951 and 1962 when lawful code mandate on private side of the line was enacted.

Madison's & Lansing, MI's Lead Service Line Replacement Programs Show Initial City Estimates May Be Inflated.

Madison

- 2001 to 2012.
- **8,000** water lines replaced.
- City covered ½ of cost for work up to $2,000 for private side work (max $1,000 rebate).
- Average private reimbursement of $675.85 based upon $1,350 in average private side replacement cost.

Lansing

- Work started in 2004.
- City owned entire line…no public/private side.
- PSC/State law allowed city to use water revenues to pay for replacement.
- Average cost was $9,000 when started, but reduced to $3,600 through innovated processes and economy of scale cost savings.

Legislation/Policies Enacted During WQTF's Inception

- City Budget (2017 -)
  - $3.4 million for lead service lines replacement at 385 daycares
  - $2.8 million for 300 emergency service line replacements
  - Water Quality Chemist/Construction Supervisor Positions
  - Funding for filters
- Free Community Filters/Reduced Cost Filters Through Community Partnership with A.O. Smith
- CC File 160742 from Dec. 13, 2016
  - Mandates the replacement of lead water-service lines under certain circumstances
  - Establishes a Special Assessment Policy for Private-side work
    - Reimburse 2/3 cost up to $1,600 max for property owner.
  - 10-year payment on special assessments at low interest rate

Legislation/Policies Enacted During WQTF's Inception (2)

- "Lead Safe Milwaukee" Public Service Campaign Starts (February)

- CC File 160964 - Ordinance mandating annual testing of all water fixtures in city-controlled charter schools.

- CC File 161645 - Resolution calling on state to mandate regular testing for all schools and licensed daycares statewide.

WQTF RECOMMENDATIONS

- ✓ Provide adequate City resources, supplemented by resources from foundations and corporations, to ensure vulnerable populations have access to lead-removing water filters certified to remove lead by NSF/ANSI Standard 53.
- ✓ Educate residents regarding internal plumbing as a source of lead.
- ✓ Urge the State of Wisconsin to provide greater funding to the City to eliminate sources of lead & allow greater water-utility flexibility to pay for lead water-service line replacement.
- ✓ Provide outreach to local healthcare providers on the need for lead testing of infants and toddlers.
- ✓ Use area universities as resources to address the lead-water issue.
- ✓ Support State legislative action requiring testing of water in schools and daycares; or, in its absence, explore city options for mandatory testing of water in city schools and daycares.

WQTF RECOMMENDATIONS (2)

- ✓ Explore additional financial assistance options for low-income homeowners' replacement of the privately-owned side of water-service lines, while maintaining a balanced payment program for most to ensure timely removal of service lines.

- ✓ Contract for an outside review of Milwaukee Water Works' treatment additives and corrosion-control methods.

- ✓ Seek new partners and avenues to expand public service information/announcements on managing the potential risks relating to lead-contaminated water, with a special emphasis on vulnerable populations, and ensure the City's ongoing public information campaign presents a balanced approach to all lead risks.

- ✓ Pass City legislation to provide private-side lead service line identification, removal and special assessment cost-share criteria for homes constructed between 1952 and 1962.

- ✓ Seek to balance workforce development opportunities with timeliness and cost-containment efforts on the lead service line removal program.

MENU CDC A-Z SEARCH

CDC

Fluoridation of Drinking Water and Corrosion of Pipes in Distribution Systems Fact Sheet

The concern that using fluorosilicate additives to fluoridate drinking water causes water system pipes to corrode is not supported by science. At the level recommended by the U.S. Public Health Service for fluoridation of public water supplies (0.7 to 1.2 mg/L, or parts per million), the fluoride ion has little influence on either corrosion or on the amounts of corroded metals released into the water. Fluorosilicates contribute to better water stability with less potential for corrosion, because silica stabilizes the pipe surface.

Causes of corrosion in water system pipes

Pipes used to distribute drinking water are made of plastic, concrete, or metal (e.g., steel, galvanized steel, ductile iron, copper, or aluminum). Plastic and concrete pipes tend to be resistant to corrosion. Metal pipe corrosion is a continuous and variable process of ion release from the pipe into the water. Under certain environmental conditions, metal pipes can become corroded based on the properties of the pipe, the soil surrounding the pipe, the water properties, and stray electric currents. When metal pipe corrosion occurs, it is a result of the electrochemical electron exchange resulting from the differential galvanic properties between metals, the ionic influences of solutions, aquatic buffering, or the solution pH.

For corrosion of metal water pipes to occur, an electrochemical cell must be present. An electrochemical cell can be thought of as a battery, with an electric current between a positive potential (anode) and a negative potential (cathode). The corrosive electrical potential is typically created by differences in the types of chemicals in soil or the surface of the metal pipe.

Galvanic properties between dissimilar metals

All metals have slightly different properties, and galvanic differences are the tendency of one metal to release electrons to another metal. The galvanic series of metals is the hierarchy of which metals will release their electrons to other metals. Metals lower in the galvanic series more negatively charged will sacrifice their electrons to metals higher in the series. An example that many people are familiar with is zinc galvanizing of steel, where the zinc surface coating protects the steel from rusting. The galvanic interaction of different metals has a significant role in pipe corrosion, because many commercial metals are alloys of various metals. Therefore, the interior or exterior surfaces of the pipe can provide locations for an electrochemical cell which can start the process of pipe corrosion.

Influence of ionic impurities on corrosion

Chemical additives are added to water during the water treatment process. More than 40 chemical additives can be used to treat drinking water. Many of these commonly used additives are acidic, such as ferric chloride and aluminum sulfate, which are added to remove turbidity and other particulate matter. Various chlorine disinfectants, also act as acids and have the potential to reduce pH, alkalinity, and buffer intensity. These acidic water treatment additives can interfere with corrosion protection. The amounts of each of these other additives used in water treatment typically are 5 to 10 times the amount of the fluoride additive for fluoridation of drinking water; therefore, their potential effect on the factors affecting water corrosivity is proportionately greater.

The fluoride ion interacts weakly with common metals in plumbing materials and the American Water Works Association Research Foundation has reported that fluoride ions contribute to corrosion to the same extent as at the same concentration chloride and sulfate ions. Most of the fluoride interaction will be to form a precipitate that will be incorporated into pipe scale (the deposits on the inside of pipes that are mostly calcium) or removed by routine system flushing. Therefore, the corrosive influence of fluoride in drinking water is not significant compared with other ionic influences. (*Internal Corrosion of Water Distribution Systems*, 2nd Edition, American Water Works Association Research Foundation; 1996).

Lead and copper in drinking water

Lead and copper are rarely detected in most drinking water supplies. However, these metals are a concern to consumers. Because some household plumbing fixtures may contain lead or copper, corrosive waters may leach (pick up) lead and copper from household plumbing pipes after entering a home. This is a greater issue for older houses (i.e., houses built before 1981, if the plumbing system has not been replaced) than for newer houses. The most common reason for water utilities to add corrosion inhibitors is to avoid lead and copper corrosion with older homes, and the second most common reason is to minimize corrosion of pipes in the distribution system.

When waters are naturally corrosive, many substances have a tendency to dissolve in water.

Because of this tendency, the U.S. Environmental Protection Agency (EPA) has issued a Lead and Copper Rule that requires all water systems to periodically monitor a set number of samples for lead and copper levels at different locations. This is based on population size and previous tests of lead and copper content. If a certain percentage of the samples exceeds the "action level," the utility system must take corrective actions to control the potential for corrosion in the water system. This often involves the addition of corrosion inhibitors.

Water properties influencing corrosion

Many water quality factors affect corrosion of pipes used in water distribution, including the chemistry and characteristics of the water (e.g., pH, alkalinity, biology), salts and chemicals that are dissolved in the water, and the physical properties of the water (e.g., temperature, gases, solid particles). The tendency of water to be corrosive is controlled principally by monitoring or adjusting the pH, buffer intensity, alkalinity, and concentrations of calcium, magnesium, phosphates, and silicates in the water. Actions by a water system to address these factors can lead to reduced corrosion by reducing the potential for the metal surface to be under the influence of an electrochemical potential.

Waters differ in their resistance to changes in their chemistry. All waters contain divalent metals such as calcium and magnesium that cause water to have properties characterized as hardness and softness. If a water is "hard," it is less likely to "leach" metals from plumbing pipes but often leaves a deposit on the inside of the pipe, while if a water is "soft" it has less of a tendency to leave deposits on the inside of plumbing pipes. If a water is soft, then it has low hardness. Some people in communities with hard water will use water softeners. Water systems adjust the hardness and softness of water because of these tendencies and also for taste considerations.

Alkalinity is a characteristic of water related to hardness. Waters with low hardness, or alkalinity (less than 50 mg/L as calcium carbonate), are more susceptible to the factors affecting corrosion; such systems will typically use additives that can prevent corrosion (corrosion inhibitors) to comply with federal and state regulations.

Corrosion inhibitors

Chemical additives used for corrosion control include phosphates, silicates, and those affecting the carbonate system equilibrium (amount of carbonate in the system), such as calcium hydroxide, sodium hydroxide, sodium bicarbonate, and sodium carbonate. Corrosion inhibitors are commonly used to address the corrosion influence of acidic water treatment additives. The most common forms of fluoride for approximately 92% of the drinking water that is fluoridated are fluorosilicates, as either fluorosilicic acid or sodium fluorosilicate. Using fluorosilicates to fluoridate drinking water adds silica, a corrosion inhibitor, to the water and increases the silicates available for stabilizing the pipe surface, which contributes to reduced corrosion.

Many substances with fluoride have low solubility in water

The water fluoridation additives that are used to increase the fluoride content of water are carefully chosen for their favorable solubility in water. Many divalent metals or heavy metal substances that have an ionic association with fluoride have poor solubility. These include calcium and magnesium cations, as well as many of the heavy metal ions such as nickel and lead. As the pH of the water increases to basic levels, these compounds will precipitate out of the water and be incorporated into a calcium-carbonate scale that will form on the pipe surface.

Soft waters with low buffering

A special case exists when the water source is a high-purity groundwater with little natural buffering. Buffering is the ability of a water to resist pH changes when acids or bases are added to it. Low natural buffering is not typical for community water systems. In such cases, adding acidic chemical additives, such as fluorosilicic acid or sodium fluorosilicate, could potentially result in a slight increase in corrosion because of the influence of the acid additive. However, the acidity added by such fluoride additives would be less than the acidity introduced from chlorine disinfectants. Any change in water properties is typically addressed by adding a corrosion inhibitor or adjusting the pH. This would be a standard water system practice, since water systems regularly monitor for compliance with the U.S. E.P.A. Lead and Copper Rule and take corrective action, particularly if the regulatory action levels for lead and copper are being approached.

Additional Resources

Urbansky ET, Schock MR. Can fluoridation affect lead (II) in potable water? hexafluorosilicate and fluoride equalibria in aqueous solution. *International Journal Environmental Studies* 2000;57:597–637.

The following publications provide more information on corrosion of water pipes and may be purchased from the American Water Works Association.

Internal Corrosion of Water Distribution Systems, 2nd Edition No. 90508.

Peabody's Control of Pipeline Corrosion, 2nd Edition, No. 20487.

External Corrosion-Introduction to Chemistry and Control (M27), 1st Edition No. 30027.

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Executive Summary

Evaluation of Lead Service Line Lining and Coating Technologies

Project Number: 4351 • **Date Available:** March 2017

Principal Investigators: Stephen J. Randtke, Edward F. Peltier, Craig D. Adams, Rachael F. Lane, Zachary A. Breault, and Ray E. Carter, Jr., University of Kansas; and J. Alan Roberson, American Water Works Association.

Project Advisory Committee: Clay Commons, Rhode Island Department of Health; France G Lemieux PhD, Health Canada; Michael R Schock, U.S. EPA; and Gregory J Welter PE, BCEE, O'Brien & Gere Engineers, Inc.

Quick Facts

- Lining or coating technologies can effectively reduce or eliminate the release of lead from LSLs and may be useful in reducing exposure to lead.
- PET lining, epoxy coating, and polyurea/polyurethane coating are deemed especially promising and are therefore recommended for consideration.
- Potential benefits of lining and coating include reasonably long service lives; cost savings relative to LSLR; fewer and shorter disruptions to traffic; reduced damage to landscaping and driveways; less potential for damage to other utility lines; and facilitating delay of LSL replacements until they can be more efficiently and more cost-effectively performed.
- Recommendations are provided for water utilities, consultants, property owners, regulators, and manufacturers.

Objectives

The primary objectives of this research project were: (1) to evaluate lead service line (LSL) lining and coating technologies as alternatives to full or partial LSL replacement, and as a means of protecting and repairing copper service lines (CSLs); and (2) to provide information and recommendations to water utilities, engineering consultants, consumers, property owners, state and provincial regulators, and other stakeholders to assist them in making informed decisions regarding lining and coating of both lead and copper service lines. To accomplish these primary objectives, the investigators sought, as a secondary objective, to obtain and evaluate information on many different aspects of linings and coatings, including the following:

- Effectiveness in preventing lead release from LSLs and reducing tap-water lead levels
- Advantages and disadvantages for full versus partial LSL replacement
- Commercial availability, suitability for use in small-diameter pipes, and utilization of materials certified for use in contact with potable water
- Potential, upon installation and after aging, to leach organic and inorganic chemicals of concern with respect to water quality
- Long-term effectiveness and durability
- Ability to control internal water-service-line corrosion, prevent metal release from both service lines and the scales inside them, and repair service-line leaks
- Costs to both utilities and property owners, especially relative to the cost of LSL replacement
- Engineering feasibility, commercial availability, certification, and property access issues

Background

Water service lines are the pipes extending from water mains to residential dwellings or commercial buildings. Generally, the portion of pipe from the water main to the property line is the responsibility of the public water system, while the section of pipe from the property line to the building is generally the responsibility of the property owner. However, there are exceptions. For example, customers served by Denver Water own the entire service line, and the Lansing (MI) Board of Water and Light owns their service lines from the main to the water meter inside the house. Water service lines made from lead or copper are referred to as lead service lines (LSLs) and copper service lines (CSLs), respectively; and, as they corrode, they can release lead or copper into the water supply, potentially in excess of allowable concentrations.

In the United States, the Lead and Copper Rule (LCR), promulgated by EPA under the Safe Drinking Water Act (SDWA), established an action limit (AL) of 15 µg/L for lead and an AL of 1.3 mg/L for copper. These ALs are based on the 90th percentile of first-draw tap-water samples collected, after a stagnation period of at least 6 hours, from homes with higher risk of lead exposure due to the presence of an LSL or relatively new lead solder. Public water systems exceeding the AL must take corrective action, which may include corrosion control treatment, public education, and/or lead service line replacement (LSLR). The maximum acceptable concentration (MAC) of lead in drinking water under Canadian guidelines is currently 10 µg/L, which is intended to apply to the average concentration in distributed water, typically based on samples collected after the faucet is flushed and prior to the water being taken for analysis or consumption. However, a new guideline of 5 µg/L has been proposed that would include sampling the water using a random daytime or a 30-minute stagnation sampling approach.

Older cities in some regions of the United States and Canada still have many LSLs in place. Cornwell et al. (2016) estimate there were 10.2 million LSLs in service when the LCR was promulgated in 1991, with approximately 6.1 million remaining in service and about 30% of community water systems having at least some LSLs in their system. The LCR does not require public water systems in the United States to replace the customer-owned portion of an LSL, and many public water systems are prohibited from performing work on private property at city or utility expense. Many utilities performing LSLRs, whether on a mandatory or voluntary basis, offer property owners an opportunity to sign an agreement to pay to replace their portion of the LSL at the same time, which reduces the cost. However, most property owners choose not to replace their LSLs, so the overwhelming majority of LSLRs in most cities to date has been partial LSLRs.

In recent years, it became increasingly clear that LSLs can contribute significantly to tap-water lead levels, that partial LSLRs can temporarily increase tap-water lead levels, and that lead may pose greater health risks than previously believed. For these and other reasons, a recent report by the LCR Working Group of the National Drinking Water Advisory Committee (NDWAC) in the United States recommended full replacement of LSLs, to the building wall, over a 30-year front-loaded timeframe (EPA 2015a and 2015b). This group also concluded that "[minimizing] exposure to lead in drinking water is a shared responsibility; public water systems, consumers, building owners, public health officials and others each have important roles to play."

The NDWAC report did not address linings and coatings, nor is it clear whether they will be addressed in future LCR revisions or, if they are addressed, what the relevant provisions will be. However, developing an LSLR program that ultimately replaces all LSLs all the way to the building wall, which necessarily includes LSLs on private property, will pose challenges for every public water system in the United States that has LSLs in its service area. This project provides information and recommendations intended to help all stakeholders evaluate the advantages and disadvantages of lining and coating technologies and to determine if such technologies would be helpful in planning or revising an LSLR program to meet the challenges facing their communities.

Approach

To accomplish the project objectives stated above, the investigators:

- Gathered, reviewed, and critically evaluated published and unpublished articles and reports regarding lining and coating of water service lines and the technologies and materials used
- Sought and obtained information from water utility personnel (e.g., utility and distribution system superintendents); consulting engineers; technical experts having specialized knowledge in relevant subdisciplines; state regulatory agencies and regulatory agencies outside the United States; NSF International (NSF) and other organizations involved in product certification; and manufacturers of lining and coating technologies and their representatives
- Identified issues stakeholders should consider before lining or coating LSLs, and developed a list of criteria for evaluating lining and coating technologies
- Identified lining and coating technologies potentially suitable for controlling lead release from LSLs and evaluated them with respect to their availability, effectiveness, cost, ease of installation, suitability for use in contact with potable water, estimated and warranted service life, potential impacts on water quality, and other advantages and disadvantages
- Identified three promising technologies and conducted laboratory studies on two of them – epoxy coating and polyethylene terephthalate (PET) lining – focusing primarily on their effectiveness in controlling lead and copper release and their potential to leach chemical constituents that might be of concern with respect to health or water quality (the third technology is relatively new and samples of the material used could not be obtained.)
- Based on the results of the above efforts, developed general recommendations for all stakeholders, and more specific recommendations for water utilities and their consultants, consumers and property owners, state and provincial regulators, and manufacturers and contractors.

Results and Conclusions

Three currently available lining or coating technologies can effectively reduce or eliminate release of lead from LSLs, are expected to have a long service life, and can potentially result in significant cost savings and other benefits relative to LSL replacement, depending on site-specific conditions. Other possible benefits include fewer and shorter disruptions of vehicular and pedestrian traffic; reduced damage to landscaping, trees, sidewalks, and driveways; less potential for damage to other utility lines (gas, electric, phone, cable, sewers); and facilitating delay of LSL replacements until they can be more efficiently and more cost-effectively performed in concert with future main rehabilitation or replacement projects. Thus, lining and coating technologies are potentially useful tools for reducing public exposure to lead in drinking water. Public water systems and property owners should be encouraged to evaluate their use, to the extent permitted by applicable regulations, in situations where significant cost savings and/or other benefits can be realized; and, where applicable, to incorporate their use into well organized, system-wide LSLR programs to help minimize costs and maximize benefits.

Three technologies are deemed to be especially promising and are therefore recommended for consideration by both public water systems and property owners: PET lining, epoxy coating, and polyurea/polyurethane coating. Each can effectively reduce or eliminate lead release, is commercially available, and is, or has been, certified for use in contact with potable water in the United States, Canada, and/or the UK. Each of these technologies involves materials that could potentially affect water quality by leaching certain constituents into the water; but that is true of every material that is used, or could conceivably be used, in water service lines. This issue has been effectively addressed for many years by requiring any material that may come into contact with potable water in a public water system to be certified as meeting NSF/ANSI Standard 61 (NSF 2016a).

Laboratory Experiments on Epoxy-Coated LSL and CSL Sections

The effectiveness of an epoxy coating in limiting lead release from LSLs was demonstrated in fill-and-dump experiments on 4-foor (ft.) lengths of LSLs. Lead in samples from a heavily disturbed, uncoated control LSL section ranged from 1,200 to 25,000 µg/L, whereas lead was non-detectable (≤0.5 µg/L) in 16 of 27 samples drawn from the epoxy-coated LSL sections. Only one sample (from the first extraction of one pipe section) had a lead concentration exceeding the AL, and when the same pipe section was extracted twice more, neither sample contained a detectable amount of lead. Epoxy coating also effectively limited release of copper from epoxy-coated CSL sections.

Freshly applied epoxy coatings exposed to chlorinated extraction water exerted a strong demand for free chlorine, with most of the chlorine being consumed in 6 hours (h). Similar results were observed for combined chlorine, for pipe sections stored wet or dry for 7 months, and for pipe sections repeatedly exposed to high concentrations of free chlorine. A significant chlorine demand associated with a lining or coating could potentially influence biofilm growth, disinfection byproduct formation, or other water quality parameters in a service line or downstream interior plumbing. The chlorine demand of the uncoated control pipe sections in the initial fill-and-dump experiments was similar to that observed in the epoxy-coated pipe sections, suggesting that, at least in some cases, the chlorine demand associated with an epoxy coating may have little or no net impact on water quality.

Freshly applied epoxy coatings leached an average of 0.58 mg/L of total organic carbon (TOC) into two extraction waters prepared using reagent water, but there was no significant change in average TOC concentration in dechlorinated pH 8 tap water. TOC leaching from epoxy coatings into water is expected to decrease to negligible levels over time.

Low concentrations of bisphenol A diglycidyl ether (BADGE) and two BADGE hydrolysis products were found to leach from freshly applied coatings of a BADGE-based epoxy. Two epoxy-coated pipe sections were stored wet for 7 months, with the water replaced with fresh reagent water every 7 days. When these pipe sections were again extracted, BADGE and one hydrolysis product were not detected in any of the samples, and the second BADGE hydrolysis product was detected in only a single sample, at a concentration slightly above the detection limit.

Leaching of BADGE is already addressed in NSF/ANSI Standard 61 (NSF 2016a), but additional experiments were conducted to examine: (1) how fast BADGE and bisphenol-F diglycidyl ether (BFDGE, another common epoxy ingredient) were hydrolyzing, which would affect human exposure to these compounds and their hydrolysis products;

(2) whether these compounds were reacting with free or combined chlorine to form byproducts; and (3) whether bisphenol A (BPA) was hydrolyzing or reacting with chlorine and therefore going undetected.

BADGE hydrolysis was studied as a function of pH (2–12) and temperature (15–40 °C). BADGE hydrolyzed to BADGE-H2O and then to BADGE-2H2O, the major end product under these conditions. Experimentally measured BADGE hydrolysis rates agreed well with modeled rates; thus, the model can be used to estimate BADGE concentrations remaining in water over time, facilitating exposure assessments. The half-lives of BADGE at pH 7 and 15, 25, 35, and 40 °C were found to be 11, 4.6, 2.0, and 1.4 days, respectively. At 25 °C and pH 2–12, BFDGE hydrolyzed at a rate very similar to that of BADGE, with a half-life of 5 days at pH 7 and 25 °C. No hydrolysis or decay of BPA was observed for reaction times up to 30 days for pH values of 2–12 at 25–40 °C.

Chlorination of bisphenols and BADGE was investigated using free chlorine and combined chlorine. BADGE was unreactive with free or combined chlorine at pH values of 7.6–9.0 at 25 °C, but the bisphenols reacted relatively rapidly with free chlorine at pH values of 3–12 at 10–25 °C. Estimated BPA half-lives for a free chlorine residual of 1 mg/L as Cl¬2 ranged from 3–35 minutes at pH values of 6–11 over the temperature range of 10–25 °C, but half-lives of 1–10 days were estimated for a monochloramine residual of 3.5 mg/L as Cl2 under similar conditions. These results, and a model based on them, can be used to characterize the concentrations of bisphenols and BADGE in drinking water distribution systems after leaching from epoxy coatings, thereby facilitating future risk assessments.

Laboratory Experiments on PET-Lined LSL and CSL Sections

In fill-and-dump experiments on PET-lined LSL and CSL pipe sections, very high lead and copper concentrations were found in samples drawn from the unlined (control) sections; lead increased by 1,400–21,000 µg/L, and copper by 310–910 µg/L, respectively. Only trace amounts of lead were found in the samples from PET-lined pipe sections. In one experiment, the average lead concentration in samples from PET-lined LSLs was 1.2 µg/L, and the average in samples from PET-lined CSLs was 1.3 µg/L. In a second experiment, the average lead concentration found in samples from PET-lined LSLs was 1.9 µg/L, and the average in samples from PET-lined CSLs was 1.0 µg/L. The lead levels found in both experiments were only slightly above the method detection limit (0.5 µg/L) and about an order of magnitude lower than the AL for Pb (15 µg/L). The investigators believe the traces of lead found in these samples came from the fittings used on the ends of the pipe sections (any effects of which would have been accentuated on relatively short LSL sections) and from inadvertent contamination during sample collection and handling, and not from lead permeating through the PET lining, which would not be expected to occur.

Samples from one experiment on PET-lined pipe sections were also analyzed for antimony (Sb), a common PET ingredient. Sb was detected in all but two samples, but the concentrations were very low. The average increase in Sb using dechlorinated pH 8 tap water as the extraction water was only 0.09 µg/L; the increases using chlorinated pH 8 and low pH (6.5) extraction waters were 0.09 and 0.29 µg/L, respectively; and the median increase for both LSLs and CSLs was 0.13 µg/L. The antimony concentrations in all of the samples were not only well below the MCL (6 µg/L) but also below the concentrations found in samples from the unlined LSL control section (0.42–3.94 µg/L). Thus, PET liners can actually reduce exposure to Sb if there is Sb present in the pipe being lined, as was the case in this study. PET liners and epoxy coatings can also serve as effective barriers against numerous other traces constituents found in pipe deposits.

There was no significant increase in TOC associated with the PET liners. None of the 10 phthalate esters determined using GC-MS, and none of the 3 phthalic acids determined using LC-MS/MS, were detected in any of the extraction water samples, nor were these compounds detected in solvent extracts of an unexpanded section of PET liner. The PET liners exhibited very little chlorine demand in the first set of fill-and-dump tests; only about half of the initial free chlorine residual of 2 mg/L as Cl2 was consumed after 96 hours. In subsequent tests, the chlorine demand dropped to less than 0.1 mg/L in 24 hours.

Experiences in the United States, Canada, and Elsewhere

When evaluating new technologies, or when developing or revising a program to address a complex and important challenge, it is often helpful to consider the experiences of others – what they have tried, what worked well and what did not, what could be done differently or better in the future, and what aspects or program elements are most applicable to the local situation being addressed. For this reason, brief case studies were prepared to describe the challenges faced by eight utilities in the United States and Canada in dealing with their LSLs, and to describe practices and experiences in other countries in lining, coating, and replacing lead and copper water service lines.

Over the past two decades there have been demonstration trials of PET lining and epoxy coating installations in LSLs in a number of locations in the United States, Canada, and elsewhere around the globe. More recently, a new polyurea/polyurethane coating designed for use in LSLs has been successfully demonstrated and approved for use in the UK. In the United States and Canada, few lining or coating installations in LSLs have been left in place, since most were done solely for demonstration purposes. In other locations, outside North America, larger trials have been conducted, and greater numbers of linings or coatings have been installed in LSLs that remain in service. One manufacturer reports having installed more than 100,000 PET liners in LSLs in France, and manufacturers of two different coating technologies (one using an epoxy product and the other a polyurea/polyurethane product) are reported to have recently signed contracts for tens of thousands of installations in the UK.

What is clear from these trials and installations, based on lead levels measured before and after the linings or coatings were installed, is that linings and coatings can and do effectively reduce lead leaching from LSLs. What is less clear is how many linings and coatings installed in LSLs remain in service, how long they have remained in service, and how well they have performed over time with respect to both effectiveness in controlling leads levels and physical durability. Attempts to obtain such information from utilities, manufacturers, and the literature were largely unsuccessful, apparently because retrospective studies on linings and coatings installed in LSLs are rare. However, the limited information available from studies of lined or coated LSLs, and from other studies involving related applications (e.g., epoxy coating of water mains), indicates that PET liners and epoxy coatings are durable and can be expected to remain effective for very long periods of time. These technologies are old enough that some installations have now been in place for more than 30 years, and manufacturers report that they are holding up well, although those contacted by the investigators said they were not aware of any retrospective studies on older installations of their products. The investigators have identified this as a research need that could potentially be addressed by well-designed surveys.

Applications/Recommendations

General Recommendations to All Stakeholders

It is now widely believed that no safe level of lead in drinking water can be established, that the public health goal for lead should therefore be zero, and that the health risks of lead exposure are greatest for those least able to protect themselves (i.e., those still in the womb, infants, toddlers, and young children). NDWAC (EPA 2015a) recommended removal of all lead services lines, all the way to the building wall, over a 30-year timeframe, and concluded that "[minimizing] exposure to lead in drinking water is a shared responsibility; public water systems, consumers, building owners, public health officials and others each have important roles to play." The authors agree with this assessment, recommend that all stakeholders give it careful consideration, and also recommend that manufacturers of LSL lining and coating systems be counted among the "others [having] important roles to play."

Linings and coatings can effectively reduce exposure to lead, on either a short-term or long-term basis, and should be considered by all stakeholders as viable tools that can be used for that purpose, where appropriate, taking their pros and cons into consideration on a site-specific basis. Any system-wide lead control or LSLR program is going to be full of challenges, and linings and coatings can potentially play an important role in meeting some of those challenges in a timely and cost-effective manner. Besides reducing exposure to lead, linings and coatings may also provide other water-related benefits, including:

- Corrosion control
- Leak repair
- Improved hydraulics (flow and pressure)
- Elimination of metal leaching from scale deposits
- Less favorable conditions for biological growth
- Improved aesthetic quality of water (taste and odor, clarity, color)

Other potential advantages of linings and coatings include:

- Fewer and shorter disruptions of vehicular and pedestrian traffic
- Reduced damage to landscaping, trees, sidewalks, and driveways
- Less potential for damage to other utility lines (gas, electric, phone, cable, sewers)
- Increased property value (relative to leaving an LSL in service)
- Cost savings relative to LSL replacement, especially where service lines are buried deep in the ground to avoid freezing, where the soil or subsoil is rocky, or where other factors render less expensive replacement methods impractical
- Facilitating delay of LSL replacements until they can be more efficiently and more cost-effectively performed in concert with water main rehabilitation and replacement projects

Potential disadvantages of linings and coatings include:

- Resurfacing of a lead problem in the future, if the lining or coating deteriorates, even if that happens many decades later, since the LSL remains in place
- Uncertainty regarding their service life, which though expected to be very long is likely to be known with less certainty than that of a new copper service line (though perhaps with no less certainty than the service life of alternative water service line materials, such as plastic pipe, being used or considered for use because of the high cost of copper)
- Any monitoring that may be required to verify continued performance
- Disparities between anticipated service life and warranty period
- Failure to meet future regulatory requirements
- Leaching of traces of various constituents into the water

Linings and coatings could potentially leach chemical constituents into the water, or fail to meet future regulatory requirements, but that is true of every material that is used, or potentially could be used, in water mains, service lines and interior household plumbing. The leaching concern is currently and effectively addressed by requiring materials in contact with drinking water, including plumbing materials and linings and coatings, to be certified as meeting NSF/ANSI Standard 61. The known health risks of lead exposure far exceed those associated with traces of other constituents that may leach from other plumbing materials, including linings and coatings. Thus, concerns about leaching of trace chemicals should not be used as an excuse to avoid lining or coating an LSL to reduce exposure to lead. Nevertheless, reasonable caution is recommended in selecting materials for applications involving materials that are difficult and expensive to replace, such as water service lines and household plumbing, in contrast to materials used above ground, such as exposed process piping and water treatment chemicals, which can be more readily replaced if the need arises.

Public water systems should recognize that the cost of replacing the privately-owned portion of an LSL will be very significant to most homeowners, especially those in less affluent neighborhoods. At the same time, public water systems need to recognize, and help property owners recognize, that the cost of replacing an LSL is typically modest compared to other costs of property ownership such as painting a house or building; putting new shingles on a roof; or replacing a major component of an aging heating, ventilating, and air conditioning system. Public water systems can help mitigate the impacts of LSLR expenses on property owners using creative financing arrangements, such as adding a small monthly charge to their water bill.

To minimize the cost of a full LSLR program, all stakeholders should work cooperatively to plan and implement a proactive system-wide approach, taking advantage of economies of scale and maximizing the productivity of the various work crews involved in scheduling, site preparation, traffic control, installation, and road and sidewalk repair. The approaches used by public water systems in Madison (WI), Lansing (MI), and Saskatoon (SK) are excellent examples of how to plan and implement a system-wide approach.

In planning a system-wide LSLR program, all stakeholders should evaluate using lining and coating technologies, if permitted under all applicable regulations, in locations where they have potential to generate significant cost savings or to provide other benefits. Examples include:

- Congested urban areas, where construction activities and traffic disruptions need to be minimized
- Locations where installing a new service line poses a safety risk, e.g., puncturing a gas line, cutting into an underground electrical wire, or damaging a communications cable serving a large office building
- LSLs connected to a water main, perhaps one in a congested urban area, that is not scheduled to be replaced for another 30-50 years
- Homes for which LSLR would pose a significant risk of damage to landscaping, other utility lines, or structures

Recommendations to Water Utilities and Their Consultants

Public water systems with LSLs should take the lead in working with all stakeholders to cooperatively plan and implement a proactive, system-wide LSLR program. The managers and employees of a public water system usually have a wealth of knowledge about their system and are already in communication with most, if not all, of the other stakeholders, who will be looking to the public water system to provide leadership. They will also bear primary responsibility for paying for the LSLR program and fairly allocating the costs among the rate payers.

Public outreach will be an extremely important means of informing consumers and property owners about their "shared responsibility," including financial responsibility for replacing privately owned portions of LSLs. Public water systems should provide information for consumers and property owners that emphasizes the importance of shared responsibility for minimizing exposure to lead, engages them in the planning process for the service area, clearly informs them about plans and progress to date, recommends actions they can or should take, and starts a dialog about possible financing options. Public water systems should recommend full LSLR, where reasonably possible, to consumers and building owners.

Public water systems developing (or revising) an LSLR program should involve regulatory stakeholders from the beginning of the planning process and maintain their involvement into the implementation phase. In the United States, the applicable regulations associated with the LCR are in flux, so all stakeholders, most especially public water systems with LSLs, would be well advised to keep abreast of proposed or newly promulgated regulations. Until the regulatory picture is clear, public water systems should approach with caution their use of any lining or coating system as part of their compliance strategy.

Public water systems are responsible not only for meeting the requirements of the LCR, but also for meeting state and local regulations, including building codes, that apply to their LSLR programs. State primacy agencies in the United States, and provincial regulatory agencies in Canada, may adopt policies or regulations that differ from those established or recommended at the federal level. As always, public water systems are strongly encouraged to ensure that any materials in their system, including linings and coatings, are certified to NSF/ANSI Standard 61 by an accredited certification body, and in most states and provinces this is legally required. Public water systems should also require post-installation testing of LSL linings and coatings for tap-water lead levels, adequate flow, and integrity (e.g., visual inspection using a high resolution mini-camera).

Public water systems should also engage manufacturers (or vendors) of lining and coating systems in the planning process, as well as contractors – if they plan to hire contractors to perform some or all of the work instead of doing all the work in-house using their own crews. The potential cost savings and other benefits associated with lining and coating technologies can be more effectively realized if they are evaluated ahead of time and incorporated into the program in an organized fashion, rather than considering them on a case-by-case basis, as individual situations are encountered where they might be advantageous. Both manufacturers and contractors are likely to have some excellent suggestions as to how a public water system can maximize the cost savings associated with lining and coating technologies.

For specific situations where full LSLR does not appear to be technically feasible, or economically or socially acceptable, lining or coating the customer-owned portion of the LSL should be considered as an option, if allowed under applicable regulations. During the planning process, public water systems should identify potential needs and/or opportunities for use of linings and coatings to reduce short-term and/or long-term exposure to lead, such as avoiding:

- Disturbances of historic sites or structures
- Environmental damage (e.g., to mature trees)
- Traffic disruption
- Interference with, or damage to, other utilities (gas, phone, cable, sewer, electric)

If such needs and/or opportunities exist for using linings or coatings, public water systems should take the lead in exploring them with all other stakeholders. As part of the exploration process, public water systems should assess their customers' attitudes on the following issues:

- Importance of (and willingness to pay for) minimizing exposure to lead
- Expected length of service interruptions for LSL replacements, linings, and coatings
- Disruptions to yards, trees, driveways, sidewalks, etc.
- Potential cost savings associated with linings or coatings
- Expected service life of new service lines versus lined or coated service lines
- Concerns about materials used in service lines

Epoxy coatings have been used in building plumbing systems for many years, in many countries, including the United States. However, the purpose of such coatings usually has little to do with lead. Coatings have primarily been used in building plumbing systems to control corrosion, repair leaks (especially pin-hole leaks in copper pipe), and improve the aesthetic quality of the water. Due to the growing recognition that lead can be released from interior plumbing, especially from corroded galvanized pipes, use of epoxy coatings primarily for lead control in buildings is likely to become more common in the future. While interior plumbing in buildings is not the responsibility of public water systems, building owners, public health officials, building inspectors, and others are likely to look to water utilities for information and guidance on lead control, use of epoxy coatings, potential impacts of materials on water quality, and related topics. Public water systems should strive to become more familiar with such matters to better serve their customers, and as a sign of their commitment to provide their communities with safe drinking water.

Recommendations to Consumers and Property Owners

The overwhelming majority of stakeholders are consumers and/or property owners, which could be collectively referred to as the water system's customers or the public; and they have a lot at stake. Consumers' health may be adversely affected by elevated lead levels, and property owners are usually financially responsible for replacing, lining, or coating the privately-owned portions of their LSLs. Consumers include not only bill-paying customers, but also children, tenants whose water bills are included in their rent, school teachers and students, occupants of office buildings (who may live outside the service area), visitors, and other members of the general public. The first thing consumers (especially bill-paying customers) and property owners should do is develop a general knowledge of drinking water in their communities, including lead levels in residences, schools, and office buildings. In most cases, this can be accomplished by reviewing the water system's annual Consumer Confidence Report (CCR) and other information posted on the system's website. Many water systems in communities with LSLs have posted at least some information about lead control on their websites; if not, consumers and property owners should request that they do so.

Home and building owners should determine whether or not they have LSLs. Materials developed to assist public water systems in developing LSLR programs also provide guidance for property owners to assist them in determining whether a home or other building has an LSL (AWWA 2014a). In many cases, this information will be available on the public water system's website if there are LSLs in their service area; if not, property owners should request that this information be made readily available. Property owners who have LSLs should consider full LSLR. Even though full LSLR is not currently mandated, it is a wise thing to do to protect themselves and their families, or their tenants or other occupants, as well as guests and future residents or occupants, from unnecessary exposure to lead. Property owners should recognize that although replacing their portion of an LSL is expensive, the cost is typically modest compared to other costs of home or building ownership. Full LSLR might also improve the value of the property in the long run. It would not be surprising to see, in the near future, information about LSLs included on disclosure forms for real estate transactions or included as part of property inspections. If full LSLR is not technically feasible, or economically or socially acceptable, property owners should investigate the possibility of lining or coating their portion of the LSL.

Many public water systems have already reached out to consumers and property owners, by means of billing inserts or website postings, to inform them about lead in their community, lead monitoring results, the presence or absence of LSLs in their service area, corrosion control practices, the status of any system-wide plans for lead control, any financial incentives or financing arrangements that are available to property owners wanting to replace their portion of an LSL, and recommendations for limiting exposure to lead, especially inside homes and buildings. Consumers and property owners whose water systems have not provided this information should request it, if LSLs are known to be present within the service area. Property owners with LSLs should consider taking advantage of any financial incentives their water systems offer to help property owners pay to replace their portion of an LSL.

Disturbing an LSL and/or the plumbing connected downstream from it is likely to cause temporarily increased lead levels that may persist for a month or two and perhaps as long as a year. Possible causes of disturbances include full or partial LSLR, lining or coating an LSL or a portion of it, and various other construction activities in the vicinity of an LSL, such as landscaping, foundation repair, or sprinkler installation. In the event of such a disturbance, consumers or property owners with LSLs should monitor their tap water for lead and/or filter their water (specifically the water used for drinking, cooking, and preparing beverages) using a filter designed (and certified to NSF/ANSI Standard 53 [NSF 2016b] for lead removal) to remove both particulate and dissolved lead, until the lead level is consistently within the recommended limits. Consult the public water system's website (or contact them directly if necessary) for information about lead monitoring (which they may be able to assist with, especially if they were involved in the disturbance, e.g., an LSLR) and for recommendations regarding filtration. All interior water lines should be thoroughly flushed any time a service line (whether or not it is an LSL) or other component of a plumbing system in a home or building is worked on by a plumber or contractor.

In homes and buildings having interior water lines heavily encrusted with lead-bearing deposits, especially interior plumbing made of galvanized iron pipe, the deposits may be releasing more lead into the water than an LSL, even if the LSL is the source of the lead that slowly built up inside the pipes over many years. Consumers and property owners who encounter such situations should either replace their interior plumbing with lead-free materials, coat their interior water lines to prevent lead leaching, or purchase NSF 53 certified water filters and carefully follow the operating and maintenance instructions.

Recommendations to State and Provincial Regulators

State and provincial regulators should assist public water systems in developing LSLR programs and other lead control strategies that minimize public exposure to lead in drinking water, meet all applicable regulations, and effectively utilize available tools that can contribute to this effort at a reasonable cost. Consistent with the NDWAC recommendations (EPA 2015a, b), full LSLR should be the preferred option for controlling lead associated with LSLs.

When replacing an LSL does not appear to be technically feasible, or economically or socially acceptable, lining or coating LSLs should be considered as an option, if allowed under applicable regulations. State and provincial regulators should help make both current and proposed regulations, including the aspects listed below, clear to other stakeholders with respect to both utility-owned and privately-owned segments of LSLs:

- Are linings and coatings allowed and, if so, under what conditions, and how are lined or coated LSLs treated with respect to compliance requirements?
- If full LSLR is mandated, will exceptions or exemptions be granted permitting the use of linings and coatings in situations where exposure to lead can be more rapidly controlled; where significant savings can be realized; or where damage to historic sites, landscaping, structures, or other utility lines can be avoided?
- If public water systems and/or property owners can apply for exception or exemptions, will they be permanent or temporary, and what criteria will be used to decide whether to approve exceptions or exemptions?
- What monitoring requirements apply to lined or coated LSLs?

Recommendations to Manufacturers and Contractors

Manufacturers of lining and coating technologies, and their representatives, including local contractors licensed to install their products, should familiarize other stakeholders with their technologies, the potential benefits they can provide, and the situations in which they are most likely to provide significant cost savings or other benefits. As manufacturers know, and should be prepared to help public water systems and other stakeholders recognize, LSL lining and coating costs depend heavily on the number of LSLs to be lined or coated, where they are located, and how they are scheduled. In other words, there are significant economies of scale involved, and much greater cost savings can be realized if the LSLs can be lined or coated as part of a well-organized, system-wide program that most likely will also include full and/or partial LSLRs.

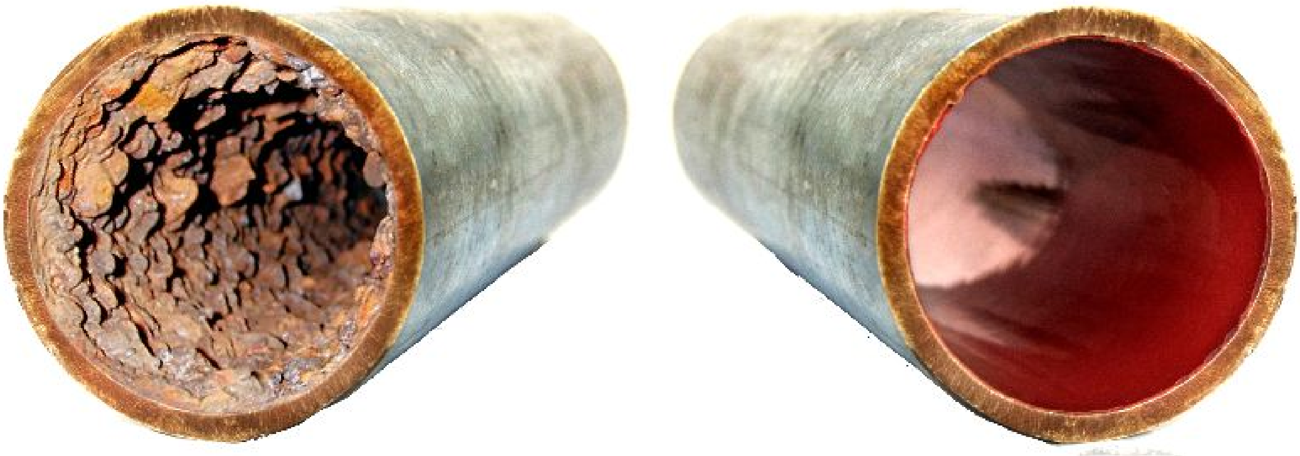
To promote their products while also helping communities minimize exposure to lead in drinking water, manufacturers of linings and coatings and their representatives are encouraged to:

- Recognize that a disparity between the expected service life of a product and the warranty period can be a stumbling block for other stakeholders
- Document and publicize supporting information regarding product service life
- Consider increasing warranty periods, when appropriate, and finding creative ways to share real or perceived financial risks in partnership with other stakeholders
- Continue to develop new or improved products and faster, better, and less disruptive installation methods
- Encourage public water systems to adopt a proactive system-wide approach for controlling lead release from LSLs, and to take advantage of the potential cost savings and other benefits of lining and coating technologies
- Consider installing sampling taps at selected locations to facilitate performance monitoring of lined or coated LSLs, since tap-water samples may be contaminated with lead from sources other than the LSLs, making it difficult to document the true effectiveness of linings or coatings

- Place a permanent tag on a lined or coated water service line to alert water utility crews, residents, and plumbers to the need to properly handle it when making repairs to the service line or other pipes, fittings, or devices connected to it

Related WRF Research

- Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues, project #3018
- Controlling Lead in Drinking Water, project #4409
- Evaluation of Lead Sampling Strategies, project #4569
- Galvanic Corrosion Following Partial Lead Service Line Replacement, project #4349



Nu Line™

Aquam's Nu Line™ pressurized pipe rehabilitation solution is used to rehabilitate pressurized pipe infrastructures including but not limited to potable water, natural gas delivery, HVAC, and fire suppression.

Nu Line epoxy barrier coating is a unique and patented process derived from the result of over 7000 research hours dedicated to finding the perfect viscosity, air temperature cure time and equipment needed to achieve optimal pipe adherence that provides a longer-lasting piping solution. Once the epoxy coating is applied to the interior of the pipe, it will seal and protect the system from further deterioration, dramatically extending the system's life. The process can be used on a variety of pipe materials, which include galvanized steel, cast/black iron, copper and lead.

The patented process begins with draining the water out of the piping system and then dry heated air is run through the pipes to ensure the removal of the moisture in the pipes. Next, pipes are sandblasted until clean removing all of the corrosion built up to create an anchor tooth for the epoxy to adhere to. Once the pipe is fully cleaned the epoxy (approved by UL to NSF 61 standards) is blown into the piping system with filter instrument quality air until the pipe is fully coated creating a barrier internal pipe coating between the water and the pipe eliminating future corrosion and lead contamination.

Learn More

Serline™

Aquam's Serline™ pressurized pipe rehabilitation solution is used to rehabilitate lead service line pipes that deliver drinking water into residential and commercial properties. This solution is fully patented. In the application process, a controlled air flow is used along with the injection of the polyurethane to evenly distribute an environmentally safe and regulatory approved polyurethane coating throughout the length of the pipe. The coating is smooth and durable, having a finish that is designed to be resistant to corrosion, mineral deposits, acids, petroleum products and alkalis. Serline™ is only lead rehabilitation solution with DWI Reg 31.4(A) approval.

Learn More

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  - Management Team
  - Divisions
  - Investor Information
- Solutions
  - Pipe Rehabilitation

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

9:23

REGISTRATIONFORM

The Water QualityTask Force meeting on April 1, 2017.
North Division High School
1011 W. Center St.
Milwaukee, WI 53206

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: SHERRIE TUSSLER

Address: 3402 W. ST. PAUL

City: MILW ZIP CODE: 53208

Organization Represented (if any): HUNGER TASK FORCE

Email address: SHERRIE@HUNGERTASKFORCE.ORG

✓ I wish to speak.

___I do not wish to speak.

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

R E G I S T R A T I O N F O R M

The Water QualityTask Force meeting on April 1, 2017.
North Division High School
1011 W. Center St.
Milwaukee, WI 53206

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Robert Miranda

Address: 2212 7th ST

City: Milw ZIP CODE: 53215

Organization Represented (if any): FLAC

Email address: VMIRANDA@WI.RR.COM

✓ I wish to speak.

___ I do not wish to speak.

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

R E G I S T R A T I O N F O R M

The Water QualityTask Force meeting on April 1, 2017.
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1011 W. Center St.
Milwaukee, WI 53206

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Dollie M. Smith

Address: 3800 block N 4Th

City: ____________________ ZIP CODE: __________

Organization Represented (if any): ____________________

Email address: ____________________

___I wish to speak.

___I do not wish to speak.

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

REGISTRATIONFORM

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North Division High School
1011 W. Center St.
Milwaukee, WI 53206

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Fred Royal

Address: 5705 W Nash Street

City: MI ZIP CODE: 5321L

Organization Represented (if any): ____________

Email address: ____________

X I wish to speak.

___I do not wish to speak.

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

REGISTRATIONFORM

The Water QualityTask Force meeting on April 1, 2017.
North Division High School
1011 W. Center St.
Milwaukee, WI 53206

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Jean E. Valentine (John Valentine)

Address: 4175 N. 69th st

City: 53216 ZIP CODE: 53216

Organization Represented (if any): ______

Email address: ______

✓ I wish to speak.

___I do not wish to speak.

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

R E G I S T R A T I O N F O R M

The Water QualityTask Force meeting on April 1, 2017.
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Milwaukee, WI 53206

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Steve Adams

Address: 1733 North 17th St

City: Milwaukee ZIP CODE: 53205

Organization Represented (if any): ____________________

Email address: sadams3276@aol.com

X I wish to speak.

___ I do not wish to speak.

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

REGISTRATION FORM

The Water QualityTask Force meeting on April 1, 2017.
North Division High School
1011 W. Center St.
Milwaukee, WI 53206

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Kimberly Thomas Britt

Address: 3859 N. 23 St.

City: Milwaukee ZIP CODE: 53206

Organization Represented (if any): ______

Email address: Kimberly [illegible]

X I wish to speak.

___I do not wish to speak.

①

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

R E G I S T R A T I O N F O R M

The Water QualityTask Force meeting on April 8, 2017.
Lynde & Harry Bradley Technology and Trade School
700 S. 4th
Milwaukee, WI 53204

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Dr. Brian

Address: ____

City: ____ ZIP CODE: 54213

Organization Represented (if any): Humanity

Email address: ____

X I wish to speak.

___I do not wish to speak.

OFFICE OF THE CITY CLERK
CITY OF MILWAUKEE

R E G I S T R A T I O N F O R M

The Water QualityTask Force meeting on April 8, 2017.
Lynde & Harry Bradley Technology and Trade School
700 S. 4th
Milwaukee, WI 53204

9:00 AM

RE: 160676 – Communication related to the activities of the Water Quality Task Force.

Please **PRINT**

Name: Terry Wiggins

Address: 224 E. Lloyd St. #2

City: Milwaukee ZIP CODE: 53212

Organization Represented (if any): ~~Milw. Water Commons~~, Interfaith Earth Network

Email address: terry.wiggins50@gmail.com

✓ I wish to speak.

___ I do not wish to speak.