MUNICIPAL STRATEGIES FOR FULL LEAD SERVICE LINE REPLACEMENT: LESSONS FROM ACROSS THE UNITED STATES

CAROLINE PAKENHAM, ROYA ALKAFAJI, AND DEBORAH PHILBRICK
ELEVATE ENERGY

This study discusses municipal approaches toward replacing lead service lines. Drawing from interviews with administrators of municipal and water utility programs, as well as published research, it identifies five novel yet replicable approaches for dealing with problems posed by lead service lines. The final section outlines effective strategies for communicating with residents about these problems, as well as potential funding mechanisms to ensure lead service line removal programs, are sustainable and supportive of safe and healthy communities. Innovative programs and policies in Cincinnati, Ohio; Lansing, Michigan; and Washington, DC, are shown to be prototypes for municipalities in Illinois grappling with lead service line problems.

INTRODUCTION

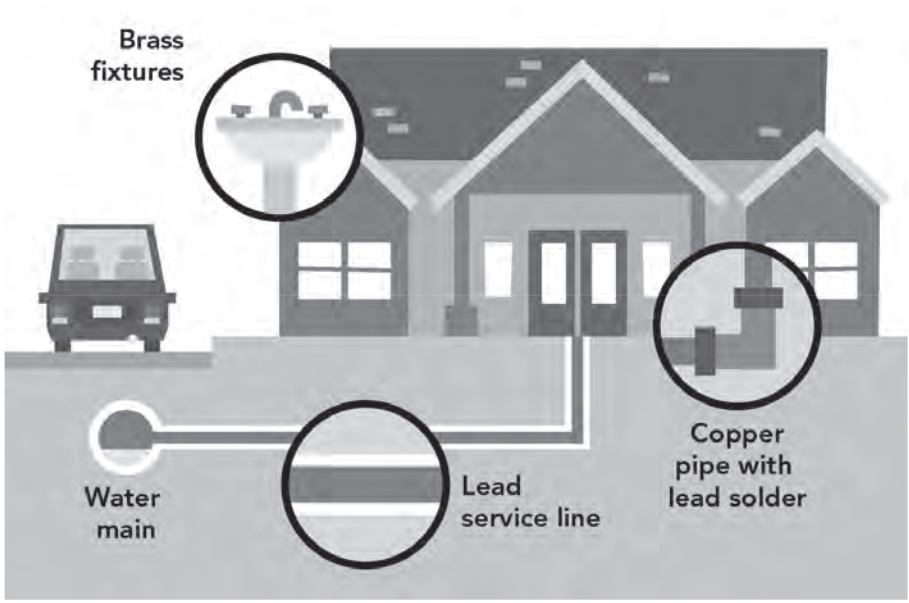
The recent drinking water crises in Flint, Michigan, and Newark, New Jersey, underscore the need for effective municipal, state, and federal strategies with which to remove sources of lead in drinking water. Elevated levels of lead recently found in drinking water in Galesburg and University Park, Illinois, and in East Chicago, Indiana, also bring this issue closer to home today. Many municipalities, in turn, are taking steps to remove and replace lead service lines to minimize the risk of lead in drinking water. While the exact number of lead service lines in the United States is unknown, recent studies estimate that six million partial or full lead service lines exist (Cornwell, Brown, & Via, 2016). An estimated 730,000 of these lines are located in Illinois, more than in any other state in the country (Cornwell et al., 2016). This issue brief highlights lead service line replacement efforts in various municipalities across the country. It also showcases strategies for communicating with residents about lead service lines and financing replacement efforts.

BACKGROUND

Lead rarely ends up in drinking water from a drinking water source such as Lake Michigan or a water-treatment plant. Typically, lead enters drinking water when lead service lines or plumbing materials like lead solder and brass fixtures corrode and leach lead into drinking water. When present, a lead service line can contribute an estimated 50% to 75% of the lead in drinking water, making it the largest potential source of the contaminant (Sandvig *et al.*, 2008). A service line is a pipe connecting the water main under the street to homes and buildings. A home or building constructed before 1987 has a greater chance of being connected to a service line made of lead because the federal Safe Drinking Water Act banned the use of lead service lines in 1986 (U.S. Environmental Protection Agency [EPA], 2013).

FIGURE 1

SOURCES OF LEAD IN DRINKING WATER



Common sources of lead in drinking water include lead service lines or brass fixtures and plumbing materials with lead solder. When present, a lead service line is the largest contributor of lead in drinking water. Image Source: Elevate Energy.

To lessen the threat that lead service lines pose to public health, community water systems use corrosion inhibitors to reduce the release of lead and copper into drinking water (EPA Office of Water, 2016). Corrosion inhibitors coat the inside of pipes to help prevent lead from leaching into water (EPA Office of Water, 2016). While corrosion control is a vital practice for protecting public health, it can fail over time or be ineffective if not implemented properly.

Lead service lines can still release lead into water even when proper corrosion control measures are in place. This can happen through changes in water quality or when the pipe is physically disturbed. One example of a physical disturbance is partial replacement of a lead service line (EPA Office of Water, 2016). Partial replacement occurs when only a portion of the lead service line is replaced, as opposed to replacing the entire line running from the water main to a person's home or business. The EPA Science Advisory Board (2011) found that partial lead service line replacement elevates lead levels in drinking water for a period of time afterward, placing public health at risk. Furthermore, the American Water Works Association (AWWA; 2017), a national association for water professionals, discourages partial lead service line replacement.

Many municipalities are independently acting to fully remove and replace lead service lines because of lead exposure's detrimental effects on public health. In adults, lead exposure can contribute to kidney, reproductive, and cardiovascular issues (EPA, n.d.-a). The effects of lead exposure are especially concerning among infants and children under the age of six because children's developing bodies absorb more of the lead to which they are exposed than their adult counterparts do (EPA, n.d.-a). Exposure to lead—even at low levels—can damage a child's developing brain and nervous system, contributing to lower IQ, hearing loss, and learning and behavior problems in and out of the classroom. An estimated 20% of a person's exposure to lead can come from drinking water. For infants who drink mostly mixed formula, this exposure rises to between 40% and 60% (EPA, n.d.-a).

Beyond the health considerations associated with full lead service line replacement, economic benefits can also result from full replacement. A recent study by the Pew Charitable Trusts and the Robert Wood Johnson Foundation found that replacing lead service lines "in the homes of children born in 2018 would protect more than 350,000 children and yield $2.7 billion in future benefits, or about $1.33 per dollar invested" (Urahn *et al.*, 2017, p. 2). The future benefits include improved health outcomes and economic benefits for impacted children (Urahn *et al.*, 2017). Additionally, major investment into

water infrastructure improvements can result in increased economic activity and jobs. A recent study found that investing $82 billion in water infrastructure annually over the next decade would result in 1.3 million jobs and $220 billion in economic activity (Value of Water Campaign, 2017).

LESSONS FROM FLINT, MICHIGAN: A CAUTIONARY TALE

The series of policymaker failures that led to the Flint water crisis piqued public awareness about the problem of lead exposure from drinking water. Public officials throughout the United States who interact with citizenry about water quality risks would benefit from understanding the basics of the crisis.

Flint was experiencing severe municipal financial instability when the crisis began. At the time, the city of approximately 102,000 was operating under a state-appointed emergency manager, Ed Kurtz, who bore the responsibility of dealing with the city's mounting deficit. In early 2014, Kurtz authorized a plan to switch from purchasing the city's water from the Detroit Water and Sewage Department to using water taken directly from Flint River and treated at the city's water treatment plant. Aware of the need to shore up the city's ailing finances, officials at the Michigan Department of Environmental Quality opted not to require that the river water be treated with the anti-corrosion chemicals required by the federal Lead and Copper Rule. Such chemicals, while adding to costs, are necessary to prevent contamination due to the presence of lead pipes. Instead, officials opted to monitor the water to determine whether additional treatment was necessary.

By April of that year, citizens began complaining about the water's color, taste, and odor. Some even expressed fears that their health was at risk. Public concerns notwithstanding, state officials downplayed the situation and even at times intentionally misinformed other stakeholders. Throughout 2014 and well into 2015, email records show, the Michigan Department of Environmental Quality misled other state agencies and the U.S. Environmental Protection Agency. The Michigan department's assertions went largely unchallenged and apparently contributed to a lengthy delay in a much-needed emergency response (Flint Water Advisory Task Force, 2016).

Frustrated with governmental inaction, residents took matters into their own hands. Flint resident LeeAnn Walters contacted the Midwest branch of the EPA's water division, and, following his communication with Walters, EPA employee Miguel Del Toral released a report in June 2015 revealing that the city had both failed to use the corrosion-control chemicals and was conducting sample tests using improper techniques likely to underestimate the extent of the corrosion. State officials nonetheless remained adamant that corrosion was not a major concern.

Walters also reached out to Virginia Tech professor and environmental engineer Marc Edwards, who brought a team of researchers to Flint to conduct independent tests. His published findings, released August–September 2015, demonstrated the severity of the lead problem. In line with Del Toral's concerns, the extent of the issue had previously been underreported due to the flawed methodology of state tests (Flint

Water Task Force, 2016). At this point, attention to the issue was growing even as the state continued to stall.

Among those concerned was Dr. Hanna-Attisha, director of the pediatric residency program at Hurley Medical Center in Flint. After an unsuccessful attempt to obtain data from the state, Hanna-Attisha carried out her own analysis. She found a link between increased lead levels in children's blood and the switch in the water supply. The state health department eventually accepted her findings, which it had strongly contested at first (Flint Water Advisory Task Force, 2016).

In July 2015, an epidemiologist with the Michigan Department of Health and Human Services released a report confirming heightened levels of lead in children observed in tests run the previous summer. News outlets nationwide publicized the growing scale of the crisis, intensifying pressure on public officials. At this point, the evidence became great enough to break the inertia. In October 2015, Flint ceased using river water and reverted to purchasing water from the Detroit water department (Flint Water Advisory Task Force, 2016).

In its official report, the Flint Water Advisory Task Force (2016)—an independent investigative body appointed by the governor—found that "the Flint water crisis is a story of government failure, intransigence, unpreparedness, delay, inaction, and environmental injustice" (p. 1). The legacy of the crisis has been profound. Concerns persist that prolonged exposure to unsafe water could have long-term impacts on local residents' health. Confidence in state and municipal bodies has suffered (Jaeger, 2017) and the crisis appears to have been a factor in the resignation of several public officials.

On a more positive note, Flint has since emerged as a leader in lead exposure reduction. The Flint Registry, a voluntary registry to link those affected by the water crisis to support services, is a national prototype for effective public action. A working group of the registry, Flint Lead Free, has prepared a widely circulated lead eradication report that has become something of a manifesto for change while also proposing specific public policy interventions. Flint Lead Free focuses on primary prevention, eliminating exposure before it occurs. Through its efforts and intergovernmental collaboration, the group aspires to help Flint become the country's first city to eliminate lead exposure entirely. The city seeks to accomplish this goal by 2022 (Hanna-Attisha, LaChance, & Starrs, 2017).

Public agencies' accountability for the crisis has been mixed. Then-Michigan Attorney General Bill Shuette brought criminal charges against 15 current and former state and local officials (Jaeger, 2017). Seven of the charged officials pleaded guilty to misdemeanor charges, although their records will eventually be cleared (White, 2019). In June 2019, Michigan's new attorney general, Dana Nessel, dropped the remaining criminal charges, citing a flawed initial investigation. She signaled that under an expanded investigation, her office may refile charges that were previously dropped (Gonzales, 2019).

By Stephen Beavis and Nora Beamish-Lannon, DePaul University

MUNICIPAL APPROACHES TO ADDRESSING LEAD SERVICE LINES

This paper highlights different approaches that municipalities and water utilities are taking to replace lead service lines. These approaches include: i) utility-scale full lead service line replacement programs; ii) full lead service line replacement incentives; iii) coordination of lead service line replacement with water infrastructure improvement projects; iv) prioritization of high-risk areas for lead service line replacement; and v) affordability programs for lead service line replacement for lower-income households. This paper also discusses effective strategies for communicating with residents about lead service line replacement and examines a range of potential funding mechanisms.

UTILITY-SCALE FULL LEAD SERVICE LINE REPLACEMENT

One effective approach for addressing lead service lines is for municipalities or water utilities to design, implement, and fund a utility-scale replacement program for residents. A utility-led and financed program would fully replace lead service lines from the water main to the home, over a set period of time.

In the early 2000s, the City of Lansing, Michigan, implemented a 10-year plan to fully remove and replace all 14,000 of its lead service lines (Clark, 2016). To fund the project, Lansing's Board of Water and Light built the costs of replacement into its budget and increased rates across its entire customer base. Residents were not charged for any portion of the lead service line replacement outside of scheduled rate increases (Clark, 2016).

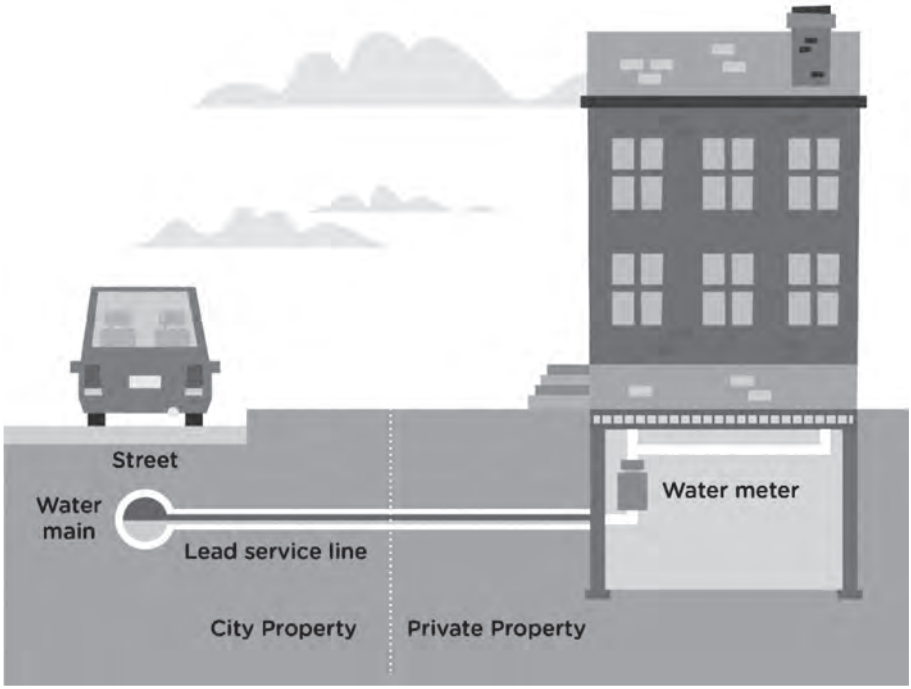
In the years after Lansing finished removing and replacing its lead service lines, the State of Michigan updated its lead and copper rule to require water utilities in the state to fully remove and replace lead service lines (Michigan Department of Environment, Great Lakes, and Energy, 2018). In the summer of 2019, Denver Water also proposed to implement a full lead service line replacement program that would leverage an increase in water rates across its customer base over a period of time to fund replacement (Kenney, 2019). The proposal also encompasses cost-sharing measures to increase affordability for low-income populations. Before moving forward, however, the final proposal must receive approval from the EPA and the Colorado Department of Public Health and Environment.

FULL LEAD SERVICE LINE REPLACEMENT INCENTIVES

Outside of a utility led and financed effort to fully remove and replace all lead service lines, some municipalities and utilities are using incentives to ease the burden of full lead service line replacement for home and business owners. These incentives include a rebate or credit for replacement, reduced or waived permit fees, the option to pay for replacement through property assessments or water bills, and access to zero-interest loans for replacement.

FIGURE 2

COMPONENTS OF FULL SERVICE LINE REPLACEMENT



A water service line delivers water from the main in the street to a home or building. These lines may be made of lead if the home or building was constructed prior to 1987. It is important to replace the full lead service line—from the water main to the home—because partial lead service line replacement can increase levels of lead in drinking water. Image Source: Elevate Energy.

The City of Boston's Lead Replacement Incentive Program encourages full lead service line replacement by offering customers a credit of up to $2,000 to replace the portion of the lead pipe running underneath private property

(Boston Water and Sewer Commission [BWSC], n.d.). The Boston Water and Sewer Commission also secures an annual low-bid construction contract for replacements and then coordinates cost estimates and full replacement with that contractor (Massachusetts Water Resources Authority, n.d.). Boston customers can pay for replacement costs in a lump sum or over a 48-month, interest-free period through their water and sewer bill (BWSC, n.d.).

Greater Cincinnati Water Works (GCWW) offers a similar program. In Cincinnati, customers are eligible for 40% cost-sharing (up to a $1,500) to replace the line on private property (GCWW, 2017). The cost-sharing only applies if a property owner participates in the GCWW Lead Service Line Replacement Program (LSLRP). If the public portion of the service line is lead, GCWW will replace it at the same time the private portion is replaced through LSLRP (GCWW, 2017). Customers can pay for replacement with their final bill or have the option to assess the charges to their property taxes as a semiannual payment over a 5- to 10-year period (GCWW, 2017).

In the nation's capital, DC Water incentivizes full replacement by providing financial assistance for replacing the portion of the lead pipe running underneath private property if DC Water previously replaced the portion of lead pipe running underneath public property (DC Water, n.d.). In these cases, every customer regardless of income can receive a 50% discount. Customers with lower income can receive discounts that cover 80% to 100% of the replacement cost. DC Water will also replace full lead service lines during capital-improvement projects at no cost to the homeowner (DC Water, n.d.). If a customer does not fall into either of these categories but volunteers to have a lead service line replaced, DC Water will replace the portion of the lead pipe in public space at no cost to the customer if the customer simultaneously replaces the portion running underneath private property (DC Water, n.d.). DC Water also waives all permit fees associated with replacement. Funding for the first two programs has been provided by the DC government and the programs went into full effect October 1, 2019 (DC Water, n.d.).

Closer to home, Naperville, Illinois, offers rebates between $2,550 and $4,250 for lead service line replacement (Hegarty, 2018). The rebate amount hinges on the length of the lead service line (Hegarty, 2018). In Elgin, Illinois, homeowners interested in replacing the portion of lead pipe running underneath private property can apply for a zero-interest loan from the city (up to $4,800) if they use a pre-qualified plumber for the work (City of Elgin, n.d.).

LEAD SERVICE LINE REPLACEMENT WITH WATER INFRASTRUCTURE IMPROVEMENT PROJECTS

General water and infrastructure improvement projects present a key opportunity for municipalities and water utilities to fully remove and replace lead pipes. For example, water utilities can incorporate lead service line replacements into planned infrastructure improvement projects such as water main replacements, combined sewer separation projects, and street resurfacing. Full lead service lines can also be replaced during emergency repair work to water infrastructure. Incorporating replacements into other projects reduces the time and cost of independent removal efforts. Water infrastructure and maintenance projects, such as water meter upgrades, can also allow utilities to identify the material of water service lines.

Lansing, Michigan; Philadelphia, Pennsylvania; and Washington, DC, are a few examples of municipalities performing lead service line removal in coordination with infrastructure improvement projects. Both Philadelphia and Washington, DC, fully replace lead service lines at no cost to customers during water main replacement projects (City of Philadelphia, n.d.; DC Water, n.d.). Lansing also prioritized full lead pipe replacement during water infrastructure projects, including a combined sewer overflow replacement project, during street restorations, and when service lines were disturbed (Hamelink, n.d.).

PRIORITIZATION OF HIGH-RISK LOCATIONS FOR LEAD SERVICE LINE REPLACEMENT

While lead exposure is damaging to both adults and children, the effects are particularly detrimental to infants, fetuses, and young children, whose brains and nervous systems are still developing. Because of the increased risk for children, some municipalities and water utilities prioritize lead service line replacement at schools and child care facilities, or in homes with pregnant women and young children.

Milwaukee and Green Bay, Wisconsin; Lansing, Michigan; and Pittsburgh, Pennsylvania, are a few cities taking strides to address the populations most at risk of lead exposure's detrimental impacts. The City of Milwaukee mandates full replacement for lead lines that service licensed and certified child care facilities (Gonda & Beversdorf, 2018). In Green Bay, child care facilities were prioritized first for full lead service line replacement before replacement efforts moved to other parts of the city (Quirk, 2018). In addition to child care facilities, Lansing's replacement efforts also prioritized schools and "other

identified sensitive populations as identified by the U.S. EPA" (Hamelink, n.d.). Finally, Pittsburgh's replacement efforts prioritize neighborhoods with high concentrations of "at-risk populations like young children and pregnant mothers" (Pittsburgh Water and Sewer Authority, 2018).

AFFORDABILITY PROGRAMS FOR LEAD SERVICE LINE REPLACEMENT

Water rates are on the rise across the country, and an estimated one-third of households will soon find their water bills unaffordable if rates continue rising at the expected pace (Mack & Wrase, 2017). Recognizing that many residents in low-income and vulnerable communities already struggle to pay their water bills, some municipalities are implementing targeted affordability programs for lead service line replacement.

In Washington, DC, the water utility covers lead service line replacement costs for residential customers whose household income is 80% or less of the area median income or for property owners with tenants enrolled in federal or district housing programs (DC Water, n.d.). These costs are covered in situations in which the portion of the pipe in the public space is not lead but the portion running underneath private property *is* lead.

The Help Eliminate Lead Pipes (HELP) program offered by GCWW provides additional assistance to low-income customers for replacing lead pipes on private property. In addition to the cost-sharing of 40% (up to $1,500) offered by GCWW for lead service line replacement, the HELP program provides an additional 30% off the replacement cost (GCWW, 2019). The 30% reduction is applied as a credit to the final lead service line replacement bill (GCWW, 2019).

Finally, the Pittsburgh Water and Sewer Authority (PWSA) replaces full lead service lines at no cost to low- to moderate-income customers (PWSA, 2019). To qualify for the program, customers must meet certain income qualifications and be connected to a water service line for which the portion of the line running underneath public and private property is made of lead. PWSA's Lead Help Desk provides one-on-one guidance and support to customers applying for and participating in the program (PWSA, 2019).

HOW MUNICIPALITIES COMMUNICATE WITH RESIDENTS AND STAKEHOLDERS ABOUT LEAD SERVICE LINES

Many municipalities and water utilities recognize that the public is concerned about the presence of lead service lines and the potential for lead in drinking water. To increase transparency and trust regarding the risks associated with the presence of lead in drinking water, some utilities and municipalities keep a current inventory available online of where lead service lines are located, and work with local outreach groups on a multifaceted community outreach strategy.

PUBLICLY ACCESSIBLE LEAD SERVICE LINE INVENTORIES

Identifying the number and locations of lead service lines within a community is an important first step to implementing any lead service line replacement effort or program. In 2017, Illinois passed Public Act 99-0922 and became one of only a few states that require community water systems to create a comprehensive lead service line inventory. Community water systems must submit the inventory annually to the Illinois Environmental Protection Agency (IEPA) until the inventory is complete.

Although doing so is not a component of the recent Illinois legislation, some municipalities in the state have taken the inventory requirement a step further by creating a visually mapped and address-specific public online inventory. Online inventories allow municipalities to easily share public health information with the community and update residents on the progress of lead service line replacement. By sharing this information, municipalities also help to increase transparency and trust around lead in drinking water.

In Illinois, the City of Evanston is one municipality that offers a publicly accessible lead service line inventory to its residents. Residents can search using their account number or address to view the material of the water service line running underneath public and private property. Other Illinois municipalities that have published similar online inventories include Barrington, Downers Grove, Galesburg, Moline, Naperville, Rockford, and Wheaton (Elevate Energy, 2018). While not address-specific, the IEPA also provides an online summary of the number of known lead service lines in each Illinois community based on information provided by water utilities (IEPA, 2018).

ROBUST COMMUNITY EDUCATION AND OUTREACH

Investing in robust community education and outreach can help municipalities and water utilities to ensure residents understand the importance of lead service line identification and replacement efforts. Public education efforts should provide residents with clear information about how lead gets into drinking water and its detrimental impacts on the health of children and adults. Other key components include information on how to mitigate lead in drinking water, why replacing lead service lines is important, and what actions to take before and after replacement.

Municipalities can utilize a multipronged outreach strategy to reach residents, including partnerships with local, community-based organizations; a combination of in-person and online communications; and accessible materials in multiple languages. Working with the local health and other relevant departments on messaging and communications can ensure that the public receives consistent messages about the risks of lead in drinking water.

DC Water strategically partners with trusted community advocacy groups on outreach efforts to inform residents about lead in drinking water and lead service line replacement efforts (J. Deignan, personal communications, February 7, 2019). These partnerships help the utility to better understand each neighborhood's needs and how to most effectively communicate about the risks of lead in water.

Lansing's Board of Water and Light utilized a multi-faceted outreach strategy to reach customers and garner support for replacement efforts. This included special meetings and community events, letters, meetings with the media, bill inserts, special brochures, FAQs, and Internet updates (Hamelink, 2018).

FINANCIAL MECHANISMS TO FUND LEAD SERVICE LINE REPLACEMENT

With nationwide costs for lead service line replacement averaging around $6,000 per line, municipalities and water utilities will need to access a variety of funding sources to pay for replacement efforts (Urahn *et al.*, 2017, p. 33). Utilities can combine federal, state, and local funding along with rate and fee income to fund replacement programs. While not a direct funding source, bundling replacement efforts with infrastructure improvement projects can help to drive down the replacement costs.

A state revolving fund (SRF) is a promising source of funding for lead service line replacement. This EPA-administered fund is allocated to states and provides low-interest loans to communities for water and sanitation infrastructure projects (EPA, n.d.-b). For example, the Drinking Water State Revolving Fund (DWSRF) can be used to fund drinking water treatment, source water protection, and pipe installation and replacement (EPA, n.d.-b). States provide a 20% match for the received funds and have a 30-year period for repayment (or longer, for disadvantaged communities). Public, private, and nonprofit community water systems are eligible to receive DWSRF funds (EPA, n.d.-b).

The Water Infrastructure and Innovation Act (WIFIA) program is another opportunity for funding lead service line replacement. This EPA-administered federal loan program funds water infrastructure development projects, as well as projects eligible for DWSRF funds (EPA, 2018). Some of the 2018 funded projects included wastewater collection and treatment projects, as well as drinking water distribution and treatment improvements (EPA, 2018). Loans are offered at low, fixed interest rates and with flexible financial terms to keep costs low for utilities and customers (EPA, 2018). Under this program, eligible borrowers include local, state, tribal, and federal government entities, as well as corporations, trusts, joint ventures, and SRF programs (EPA, 2018).

In low- to moderate-income communities, Community Development Block Grants (CDBG) can serve as an additional source of federal funding with which to assist utilities with lead service line replacement (Lead Service Line Replacement Collaborative, n.d.). The State of Illinois has $500,000 in annual CDBG funds to support public-infrastructure projects improving conditions detrimental to public health, safety, and welfare (Illinois Department of Commerce and Economic Opportunity, n.d.).

In addition to state and federal funding, innovative funding examples also exist at the local level. In Cincinnati, GCWW uses multiple funding sources to support replacement efforts throughout its community. For example, capital improvement program funds are used to replace the portions of lead pipes in the public right-of-way (GCWW, personal communication, November 29, 2018). Operating funds, along with HELP funding, are used to support replacement of lead service lines on private property. GCWW relies on a mix of revenue sources to fund its HELP Program, including voluntary donations from employees, customers, and rent collected from the use of water towers by cell phone companies (GCWW, personal communication, November 29, 2018).

The Lead Service Line Replacement Collaborative, Environmental Defense Fund, and Environmental Finance Center at the University of North Carolina have additional information on ways that municipalities can fund and support full lead service line replacement.

KEEPING RESIDENTS INFORMED: ILLINOIS MUNICIPALITIES USING SEARCHABLE ONLINE MAPS OF LEAD SERVICE LINES

Municipalities across Illinois are developing strategies to enhance public awareness about lead exposure from drinking water. Interactive maps posted online, which use sophisticated geographic information systems to inform residents about the location of lead pipes, are becoming particularly popular.

Eight municipalities (Table 1), Barrington, Downers Grove, Evanston, Greenville, Moline, Naperville, Rockford, and Wheaton, are among those that stand out for their development of interactive tools. Each community provides maps that inform residents about the presence or possible presence of lead service lines. All of the maps are searchable by address. Moline's map goes a step further by including a USPS address verification feature, and Evanston's allows users to search by either address or water account number.

All of the maps listed in Table 1 help residents better understand their options for reducing or eliminating lead exposure. Most distinguish between public and private service lines. Seven of the eight offer more detail about a pipe's material than simply noting it contains "lead" or "no lead," although the degree of specificity varies by community. Several, including Evanston and Greenville, offer construction dates of buildings and/or water service lines to help users assess the risk at properties where the pipes' composition is unknown. Naperville—which banned lead pipes in 1930, well in advance of the federal prohibition—stands out for having as part of its interactive tool the city's development boundary at 1930 so residents can better assess their risk based on a building's location and construction date. This Chicago suburb also provides inspection dates and the name of the inspecting department that has confirmed the presence or absence of lead in any location.

Half of these interactive tools feature icons or color-coding that allows users to obtain information about the location of lead pipes without navigating to a specific location. These features help give users a comprehensive perspective on overall lead problems without having to navigate to each address individually to see the information on a visual "pop-up." Evanston and Moline acknowledge the information in their maps may contain some uncertainty and include the latest modification date of their maps, and Downers Grove has a disclaimer indicating that updates to its map are ongoing.

Only a relatively small share of municipalities in Illinois have unveiled searchable interactive maps to date. Many others, including Aurora, DeKalb, and Edwardsville, use other techniques to keep their citizenry informed.

Aurora offers detailed guidance in both English and Spanish on lead pipe issues, including relevant regulations, pipe flushing procedures, exposure reduction methods, pipe material identification, and information on filters that can remove lead.

DeKalb provides a document cataloguing service line material and installation date by address when known. Although it does not offer a search feature, the list is comprehensive and clear, plainly marking properties at which the pipe material is unknown.

Edwardsville posts the sites of its lead and copper tests on a static map so residents can see where the EPA's required samples have been drawn. A separate document contains test results by address. To help users contextualize the results, they are published alongside the EPA's maximum contaminant levels.

By Nora Beamish-Lannon and Stephen Beavis, DePaul University

TABLE 1

NOTABLE EXAMPLES OF ILLINOIS MUNICIPALITIES WITH INTERACTIVE MAPS ON LEAD SERVICE PIPES

	Barrington	Downers Grove	Evanston	Greenville	Moline	Naperville	Rockford	Wheaton
Specifies material of water service line (beyond lead/no lead)	X	X	X	X	X		X	X
Identifies construction of both public and private service lines	X	X	X		X		X	X
Editable Base Map (Users can change background for topography, street view, etc.)	X		X		X	X		
GIS map layers provided	X	X	X	X	X		X	
Date service line material identified						X		
Year pipe was installed provided		*	X	X		**		
Icons allow for at-a-glance identification of pipe material	X	X				X	X	
Information provided via a pop-up***	X	X	X	X	X	X	X	X

** No, but general information on how construction date impacts what kind of material was likely used is provided via a pop-up when the material is listed as unknown.*

***No, but identifies the extent of municipal boundaries during the time in which lead was still used.*

**** Provided either as additional information to what is captured via provided icons or as the sole source of information.*

CONCLUSION

Lead in drinking water poses serious health risks in communities across the United States, especially for infants and young children. The magnitude of the risk is not entirely known; estimates put the number of partial or full lead service lines at around six million. The path forward comprises a number of innovative approaches and funding strategies to support full lead service line removal and replacement. The primary challenges include the high costs of lead service line replacement, the inventorying and mapping of lead service lines, and developing thoughtful communication and outreach to gain the support of residents. In all cases, municipalities will be key players and partners in addressing lead in drinking water, as evidenced by a range of successful programs and approaches. The most effective programs will be those that are strategically developed with the proper funding, support, partnership, and education to best serve the local community in a clear and transparent way. There is much to be learned from one another to improve health outcomes for individuals and communities, as well as to realize economic gains, job creation, and other future benefits.

Caroline Pakenham is the *water program manager at Elevate Energy*. *Roya Alkafaji is the water program specialist and Deborah Philbrick is a senior manager of research and innovation at Elevate.*

REFERENCES

American Water Works Association. (2017). *Replacement and flushing of lead service lines*. Denver, CO: American Water Works Association.

Boston Water and Sewer Commission. (n.d.). Lead Replacement Incentive Program. Retrieved from https://www.bwsc.org/environment-education/lead-your-water/lead-replacement-incentive-program

City of Elgin. (n.d.). Lead Service Line Replacement Program FAQs. Retrieved from https://cityofelgin.org/2358/Lead-Service-Line-Replacement-Program-FA

City of Philadelphia. (n.d.). Programs for lead service line replacement. Retrieved from https://www.phila.gov/water/wu/drinkingwater/lead/Pages/programs.aspx

Clark, A. (2016, August 8). The city that unpoisoned its pipes. *Next City*. Retrieved from https://nextcity.org/

Cornwell, D., Brown, R., & Via, S. (2016). National survey of lead service line occurrence. *Journal AWWA, 108*(4), E182–E191. doi:10.5942/jawwa.2016.108.0086

DC Water. (n.d.). Lead service line assistance programs. Retrieved from https://www.dcwater.com/new-lead-service-line-replacement-assistance-programs

Del Toral, M. A. (2015, June 24). *High lead levels in Flint, Michigan—Interim Report* [Memorandum]. Chicago, IL: U.S. Environmental Protection Agency. Retrieved from http://flintwaterstudy.org/wp-content/uploads/2015/11/Miguels-Memo.pdf

Edwards, X. (2014). Fetal death and reduced birth rates associated with exposure to lead-contaminated drinking water. *Environmental Science & Technology*, *48*(1), 739–746. doi:10.1021/es4034952

Elevate Energy. (2018, December 8). Cheers to the Illinois communities that published online lead service line inventories! [Blog post]. Retrieved from https://www.elevateenergy.org/illinois-lead-service-line-inventory/

Flint Water Advisory Task Force. (2016). *Final report*. Retrieved from https://www.michigan.gov/documents/snyder/FWATF_FINAL_REPORT_21March2016_517805_7.pdf

Gonda, J., & Beversdorf, L. (2018). Lead Service Line Program semi-annual update. In *Milwaukee Steering and Rules Committee July 19, 2018 Meeting*. Retrieved from https://city.milwaukee.gov/ImageLibrary/Groups/WaterWorks/Lead-Service-Lines/LSLReporttoCommonCouncil7_19-18.pdf

Gonzales, R. (2019, June 13). Mich. prosecutors drop charges in Flint water investigation, but promise new probe. *NPR News*. Retrieved from https://www.npr.org/

Greater Cincinnati Water Works. (2017). *Lead Service Line Replacement Program*. Retrieved from https://www.cincinnati-oh.gov/water/assets/File/Lead/2017_Fall_H2Oconnection_Final.pdf

Greater Cincinnati Water Works. (2019). *Customer assistance program application: "Help Eliminate Lead Pipes" (HELP)*. Retrieved from https://la.mygcww.org/wp-content/uploads/2019/05/HELP_Application_5_14_19.pdf

Hamelink, S. (2018). Lansing Lead Service Line Replacement Program. Presentation presented at the Creating Health Communities Conference, City, ST. Retrieved from http://gettheleadoutpgh.org/lead/wp-content/uploads/2018/05/Hamelink-presentation-PDF.pdf

Hanna-Attisha, M., LaChance, J., & Starrs, L. (2017). *Flint lead free 2017 report*. Retrieved from https://www.flintregistry.org/wp-content/uploads/2019/04/Lead-Free-Report-V5.pdf

Hegarty, E. (2018, October 9). Study finds 345 properties in Naperville with lead pipes. *Chicago Tribune*.

Illinois Department of Commerce and Economic Opportunity. (n.d.). Community development. Retrieved from https://www2.illinois.gov/dceo/CommunityServices/CommunityInfrastructure/Pages/default.aspx

Illinois Environmental Protection Agency. (2018, November). Lead service line information. Retrieved from https://www2.illinois.gov/epa/topics/drinking-water/public-water-users/Pages/lead-service-line-information.aspx

Jaeger, J. (2017, January 4). Ethics lessons from the Flint water crisis. *Compliance Week*. Retrieved from https://www.complianceweek.com/

Kenney, A. (2019, July 1). Denver Water proposes to replace all lead pipes in system. *The Denver Post*. Retrieved from https://www.denverpost.com/

Lead Service Line Replacement Collaborative. (n.d.). Funding. Retrieved from https://www.lslr-collaborative.org/uploads/9/2/0/2/92028126/funding.pdf

Macek, M. D., Matte, T. D., Malvitz, D. M., & Sinks, T. (2006). Blood lead concentrations in children and method of water fluoridation in the United States, 1988–1994. *Environmental Health Perspectives, 114*(1), 130–134.

Mack, E. A., & Wrase, S. (2017). A burgeoning crisis? A nationwide assessment of the geography of water affordability in the United States. *PLOS ONE, 12*(4). doi:10.1371/journal.pone.0169488

Massachusetts Water Resources Authority. (n.d.). Overview of BWSC's Lead Replacement Incentive Program. Retrieved from http://www.mwra.com/comsupport/llp/llp-examples/bwsc.pdf

Michigan Department of Environment, Great Lakes, and Energy. (2018). Lead and copper rule revision summary. Lansing, MI: Author.

Pittsburgh Water and Sewer Authority. (2018, October 26). *Mayor William Peduto, DEP Secretary Patrick McDonnell, PWSA and state officials recognize major progress addressing lead in water* [Press release]. Retrieved from http://pgh2o.com/release?id=7767

Pittsburgh Water and Sewer Authority. (2019, March 14). *Nearly $2 million remains available for free on-demand lead line replacements*. [Press release]. Retrieved from http://www.pgh2o.com/release?id=7807

Pittsburgh Water and Sewer Authority. (2019, May 21). *2019 lead service line replacement program reaches early milestones* [Press release]. Retrieved from http://lead.pgh2o.com/2019-lead-service-line-replacement-program-reaches-early-milestones/

Sandvig, A., Kwan, P., Kirmeyer, G., Maynard, B., Mast, D., & Trussell, R. R. (2008). *Contribution of service line and plumbing fixtures to lead and copper rule compliance issues*. Denver, CO: Water Research Foundation.

Quirk, N. (2018). Green Bay water utility's lead compliance plans. In *MPC roundtable—Lead in drinking water: It's time to get the lead out* [Video file]. Retrieved from https://www.youtube.com/watch?v=4T3xacjR9lg

U.S. Environmental Protection Agency Science Advisory Board. (2011). *SAB evaluation of the effectiveness of partial lead service line replacements*. Washington, DC: Author.

U.S. Environmental Protection Agency. (2013). Summary of the Reduction of Lead in Drinking Water Act and frequently asked questions. Washington, DC: Author.

U.S. Environmental Protection Agency, Office of Water. (2016). *Optimal corrosion control treatment evaluation technical recommendations for primacy agencies and public water systems*. Washington, DC: United States Environmental Protection Agency.

U.S. Environmental Protection Agency. (2018). *WIFIA program overview* [PowerPoint slides]. Retrieved from https://www.epa.gov/sites/production/files/2018-12/documents/webinarfy2019-program_overview_11.28.18.pdf

U.S. Environmental Protection Agency. (n.d.-a). Basic information about lead in drinking water. Retrieved from https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water

U.S. Environmental Protection Agency. (n.d.-b). Drinking Water State Revolving Fund (DWSRF). Retrieved from https://www.epa.gov/dwsrf

Urahn, S., Coukell, A., Mallya, G., Russo, P., Morley, R., Lenhart, A. . . . Brown, M. J. (2017). *10 policies to prevent and respond to childhood lead exposure*. Washington, DC: Health Impact Project, Robert Wood Johnson Foundation, and The Pew Charitable Trusts.

Value of Water Campaign. (2017). *The economic benefits of investing in water infrastructure*. Retrieved from http://thevalueofwater.org/sites/default/files/Economic%20Impact%20of%20Investing%20in%20Water%20Infrastructure_VOW_FINAL_pages.pdf

White, E. (2019, January 18). 3 years later, no one is in jail over Flint tainted water. *AP News*. Retrieved from https://www.apnews.com/