State Recovery Now

Policy Playbook

Building Sustainable Infrastructure for the Future: Data-Driven Approach to Replacing Lead Service Lines

A guide to helping communities locate their lead service lines to support efficient replacement efforts

Executive Summary

Existing lead pipes and service lines in our drinking water infrastructure have serious economic, public health, and environmental consequences. Replacing them is a one-time public health investment that delivers job growth and long-term health benefits to communities by ensuring safe drinking water.

Efforts to remove and replace lead service lines (LSLs) have widespread support, but are hampered by a lack of necessary data. Data science and statistical modeling are powerful tools that can help communities overcome this barrier — they can help identify LSLs with much higher accuracy, thus improving efficiency and costs associated with removal efforts.

A one-time investment of American Rescue Plan (ARP) funds presents a compelling opportunity to improve LSL removal efforts, implemented through two steps:

1. An initial project planning grant that allows communities to more efficiently gather data and create smart maps showing the likely number and location of LSLs, and
2. A second grant that would fund the full replacement of the community's service lines.

ARP funds are well-suited for this use because (1) there is no need for ongoing maintenance costs; (2) it will generate information necessary to scale up LSL replacement programs; (3) it aligns with new regulatory requirements for water utilities, and (4) it benefits the public health of future generations in our communities.

This policy model is proven to be cost-effective for local governments; with an average cost of $200,000 to $500,000, each dollar spent on service line replacement leads to two dollars in economic benefit. This is in addition to savings from avoiding future infrastructure or health related costs associated with lead pipes.

Expedited lead removal also mitigates negative public health impacts and reduces dollars spent on health services. Crucially, this investment would particularly benefit communities that have historically lacked infrastructure investment, and where LSLs tend to be most highly-concentrated.

Background

The World Health Organization, Centers for Disease Control and Prevention, and the Environmental Protection Agency all state that there is no known "safe" concentration for lead in blood. Even low levels of lead exposure have been linked to severe and damaging physical and behavioral impacts, particularly for children. Yet today, there are an estimated 6-10 million lead service lines (LSLs) still in use in the U.S., impacting millions of households.

One of the greatest barriers to LSL replacement is the lack of data around the number and location of LSLs in a community; unfortunately, the majority of U.S. cities do not have complete records on their service lines. This data gap delays pipe replacement, increases costs, and extends the amount of time that residents must live with LSLs, increasing the likelihood of negative health impacts. Excavating every unconfirmed water service line would eliminate all uncertainty for inventories, but would be extremely cost- and time-intensive. Using data science and statistical modeling, however, is a more efficient and cost-effective alternative that can allow us to identify LSLs with much higher statistical accuracy.

Data-Driven Approach to Lead Abatement

By adopting a lead abatement policy that leverages data science and statistical analysis, state and local governments are able to create smart maps that identify the location of their LSLs, helping to support efficient replacement efforts and eliminate environmental contaminants. Using a statistical model helps jurisdictions accurately estimate the number and location of LSLs, enabling them to plan and execute service line replacement in the most efficient manner, thus reducing the amount of time that residents live with lead service lines.

Policy Overview

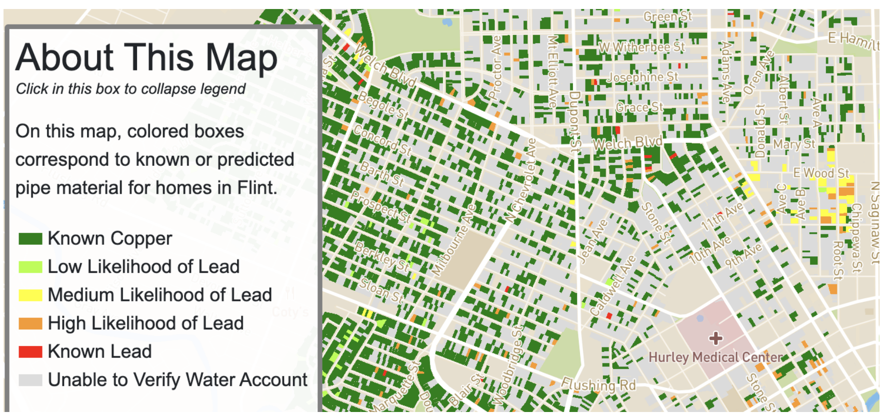
To overcome challenges associated with lead removal, state and local governments should consider allocating a portion of American Rescue Plan Act (ARP) funds to a data-gathering and statistical analysis program to create a database that estimates the number and location of LSLs in a community's water system. Through good data management and data science techniques, water utilities can build home-by-home predictions of service line material to guide decision-making for inventory and replacement programs in a time-efficient and cost-effective manner. This will meet a critical and often missing piece of an effective service line replacement program, allowing jurisdictions to accurately scope and implement programs.

States and local governments can consider using ARP funds for service line replacement through two steps:

1. An initial project planning grant that allows communities to gather data and maps showing the likely number and location of LSLs, and

2. A second grant that would fund the full replacement of the community's service lines.

This intervention builds on research from the University of Michigan and subsequent implementation by BlueConduit in more than 50 cities in the U.S. and Canada, including Toledo, Ohio and Flint, Michigan.



This image shows a portion of the map of the known or likely LSLs in Flint, based on this statistical modeling.

In Flint, the use of predictive modeling to create smart maps locating LSLs substantially [reduced the cost of successfully replacing an individual service line as compared to alternative approaches]. In 2016-2017, the city's pipe replacement program used this model with a 70% accuracy rate in excavating and replacing lead pipes, as compared to an accuracy rate of less than 15% with the standard model.

Outcomes

Marginalized communities and neighborhoods have long lacked modern water distribution systems and are most likely to still be impacted by the adverse long-term health and economic consequences of LSLs. Through this policy intervention, utilities will be able to map and target pipe replacements based on areas with the highest concentration of LSLs. Using this data to drive decisions will ensure cities can allocate resources in a more equitable way.

Because previous work indicates that lower socioeconomic status can be an indicator for higher likelihood of LSLs, our recommended statistical modeling also considers this as a data point for determining LSL location. A city-wide application of this proposed statistical modeling will therefore highlight those geographic areas that may have been ignored or under-served, by factoring in all necessary data points.

This policy proposal has the added benefit of supporting cities in their efforts to meet the Environmental Protection Agency's new service line inventory requirements under the Lead and Copper Rule.

Risks of using Statistical Models

A common issue with statistical models is the risk that the model is based on datasets that are not representative of the population they are being used to predict — biased inputs lead to biased outputs.

A good example of this risk can be found in the use of crash test dummies. If all vehicle safety information is based on the impacts to crash test dummies that are the size of the average male, it would not capture the safety risks posed to people of all shapes and sizes.

In the case of LSL data, cities might be inclined to use existing data on verified service lines from normal operations and extrapolate across the population to generate city-wide or home-by-home predictions. The verified data that cities already have, however, typically comes from water main replacements, pipe failures, or recent home construction. Because these investments are more prevalent in certain neighborhoods, verified datasets do not reflect the entire service area. Socioeconomic factors may also contribute to a city having more data on one part of the city than another. Predictions based on biased data inputs will not correct for those biases in their outputs, continuing to reinforce and entrench existing biases.

Our proposed data-gathering approach will correct for these biases in the data and ensure that the predictions are not weighed by any factor other than a well-calibrated likelihood of having an LSL, thereby mitigating the risk of inequitable outcomes in decision-making for service line replacement.

These data collection methods model a best practice that can be applied across policy areas: data should be gathered from a representative population set in order to generate accurate estimates across the entire population. This type of baseline data allows governments to measure progress and performance against their goals.

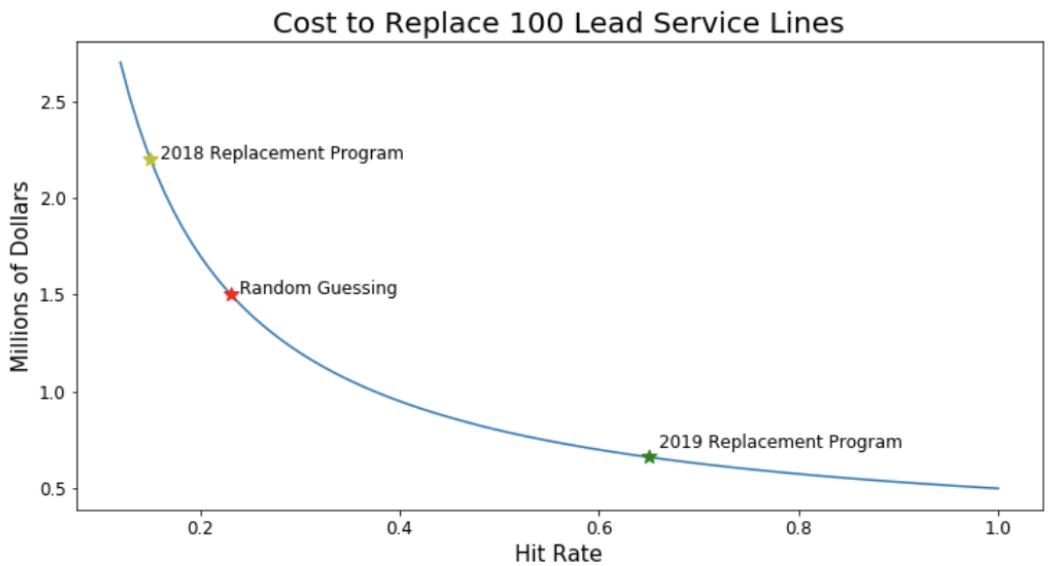
Associated Costs

The average cost of this intervention will vary slightly based on the community and the amount of existing information about service line materials. The total cost would likely be between $200,000 to $500,000, including the costs below for physical inspection and data analysis:

- $75,000 to $150,000 for estimated digging costs. For each community, the intervention would involve 150-350 inspections of service line material, costing $500 per use of a hydrovac truck.
- $50,000 for the work of a data scientist to support the analysis. This is an essential step to generate actionable data to budget, plan, and execute a successful service line replacement program.

Assessing the Return on Investment

In Flint, the use of predictive modeling to locate LSLs substantially reduced the cost of successfully replacing an individual service line as compared to alternative approaches. The use of predictive modeling translated into saved time and money for water utilities by allowing them to prioritize homes with the highest likelihood of having an LSL.



Source: Webb, T., Schwartz, Z., Abernethy, J., 2020. Getting the lead out: data science and water service lines in Flint, pg 5

More efficient LSL replacement allows communities to receive the long-term benefits of service line replacement quicker. Furthermore, part of the long-term ROI is that more efficient replacement avoids potential future costs associated with lead pipes, whether those savings be infrastructure- or health-related costs.

For instance, an analysis done by the State of Minnesota found that each dollar spent on service line replacement leads to two dollars in economic benefit. They estimate that it will cost $4 billion to replace Minnesota's LSLs, leading to $8 billion in health benefits and increased lifetime productivity.

A study by the Environmental Defense Fund estimates that removing a single LSL yields $22,000 in savings from reduced cardiovascular disease deaths. Removing the country's 6-10 million lead service lines could therefore lead to $205 billion in medical and public health savings based on that benefit alone.

Evidence of Action

The University of Michigan has published award-winning research demonstrating the effectiveness of using statistical modeling for service line replacement. Best practices based on this research, compiled by the Association of State Drinking Water Administrators, have now been applied in over 50 cities, serving a combined one million residents. Across geographies, this intervention is proven to be effective at estimating the number and location of LSLs.

During the Flint Water Crisis, faculty from University of Michigan collaborated with the city's pipe replacement program to use statistical modeling to create smart maps showing the location of lead pipes. This work supported budgeting for the program and prioritization of homes to target for replacement. Previously, estimates of the proportion of the city's pipes that contained lead ranged from 3% to 20%. Through statistical analysis based on a representative data set of homes in the city, researchers were able to estimate that approximately 38% of the city's pipes would need to be replaced. Five years and 25,000 excavations later, the true proportion of pipes requiring replacement was determined to be 37%.

The initial data gathering also allowed the research team to create a statistical model for the likelihood of finding a lead service line at every address in the city, used in 2016-2017 to direct the city's pipe replacement program. Of the 8,833 homes dug up for replacement based on the predictions, 6,228 had hazardous pipes that were replaced, demonstrating a 70% accuracy rate. In 2018, a national engineering firm took over the replacement project and had an accuracy rate of less than 15% in more than 10,000 excavations. As part of a federal court settlement in 2019, the city was required to return to using the predictive model. Since then, the replacement program's accuracy at prioritized addresses has returned to 65%. For an example of how these practices are helping cities be proactive about their service line replacement program, this article from WIRED describes how Toledo is integrating statistical modeling and community perspectives in its service line replacement program

How is this a compelling use of one-time funding that can drive long term-impact and avoid unsustainable funding?

One-time ARP funds are well-suited for LSL replacement projects because: (1) There is no need for ongoing maintenance costs; (2) it generates the information required to implement a full-scale LSL replacement program; (3) it aligns with new regulatory requirements for water utilities, and (4) it benefits the public health and wellbeing of future generations.

There are an estimated 6-10 million LSLs still in use in the USA. Replacing them is a one-time public health investment that delivers job growth and long-term health benefits to communities by ensuring safe drinking water. Investing in a data-gathering component will allow cities to both understand the scope of the problem and invest resources equitably and efficiently.

Authority for ARP Spending: States and Local Governments may implement this policy using funds under EC3 Services to Disproportionately Impacted Communities (i.e. 3.15 Social Determinants of Health: Lead Remediation) and EC5 Water, Sewer, and Broadband Infrastructure (i.e. 5.12 Drinking Water: Transmission & Distribution: Lead Remediation)

Implementation

To ensure effective implementation, state and local governments should assess readiness and engage relevant partners early on.

Assessing Readiness

State and local governments already have experience managing grant programs to improve drinking water systems and subject matter expertise on Lead and Copper Rule compliance. Policymakers at all levels, however, are encouraged to use the guiding questions below to reflect on whether they have the capacity necessary to implement this program successfully.

Legal Framework Requirements

ARP funds must be able to replace both the public and private side of the service line. Previous Federal funding for service line replacement has been used for private side replacements.

Much of the necessary legal framework already exists for compliance of the Federal Lead and Copper Rule. The promulgation of administrative rules to assure implementation may be necessary for state administrative oversight of the grant opportunities to be made available by the ARP grant funding.

States

- How confident is the state primacy agency with the accuracy of service line inventories?
- What kind of technical capacity does the agency have to meet the upcoming demands of the Lead and Copper Rule revisions?

Local Governments:

- Does the city have adequate expertise in infrastructure planning, grant fund appraisals, data science, and public health surveys areas?

Essential partners for successful implementation

The state's primacy agency with SDWA authority and the city (or other owner of the water system) will be the primary actors leading planning, approval, and implementation. In addition to core leadership commitment, jurisdictions should explore partnering with relevant agencies, organizations, community partners, and state or local government counterparts for successful program implementation. For lead abatement, this includes 5 critical stakeholders:

- **State legislature:** The state legislature is responsible for approving and allocating funds.
- **State primacy executive agency with Safe Drinking Water Act (SDWA) authority:** The primacy agency is responsible for managing the grant process and ensuring alignment with SDWA laws. The state agency should endorse and encourage the use of statistical modeling for service line inventory in order to align activities and incentives between service line replacement and the creation of service line inventories. The State of Michigan's Department of Environment, Great Lakes, and Energy recently published guidance that can serve as an example for how other states can implement these methodologies.
- **Water utility (city or other owner of water system):** The water utility is responsible for planning and implementing service line replacement programs, in addition to complying with the Lead and Copper Rule. Preliminary planning will include the evaluation of existing data on service line materials, identifying inspection points to ensure representativeness in data, and the analysis of those inspection results to estimate the number and location of lead service lines in a water system.
- **EPA:** As the main regulator for the Lead and Copper Rule, a subject-matter expert on drinking water, and an administrator of other service line replacement funding sources, EPA can plan an important role in using ARP funds for generating actionable service line inventories.

Engaging Stakeholders and Beneficiaries

Transparency is essential in infrastructure, clean water, and data-driven decision-making. In any large scale infrastructure investment — including LSL replacement projects — all affected stakeholders should have an opportunity to provide input. Drinking water utilities should consult with and inform the city government, convene town hall meetings with residents, and respond to the input of community members, neighborhood organizations, churches, non-profits, and business leaders. Stakeholder buy-in is needed from 3 groups:

- Local/County/State Health Departments: Responsible for educating community members on the dangers of lead in water, particularly for at-risk populations, and on the necessity of LSL replacement.

- Neighborhood associations, churches, and other groups representing affected residents: Residents may be inconvenienced by service line replacement work, and any inspection or replacement work on a resident's property requires consent. Community members should therefore have an opportunity to provide input and feedback on inventory and replacement effort. Use of churches and neighborhood groups to expedite discussions with community members is essential.

- Wherever possible, use locally-based contractors for replacement and remediation efforts. Local contractors are invested in the community and will also provide a short-term regional economic boost.

Recommended Labor Practices

Best Practice: Flint MI contractually requires its SL replacement contractors to create an apprentice program for aspiring pipefitters.

Other implementation partners may include: the Association of State Drinking Water Administrators, local chapter of the American Water Works Association, national environmental advocacy organizations, and local environmental organizations. Each can play an important role in generating buy-in, providing expertise, and alleviating stakeholder concerns.

Risk Mitigation

What could go wrong?

- The plan is incomplete or ineffective, based on the lack of information on service line composition.

- Lead service line replacement program takes too long, disrupting neighborhoods, traffic, and water distribution to homes, creating distrust among residents, and increasing ongoing costs (e.g. personnel).

- Lead service line replacement program excavates every service line for which accurate records are lacking, resulting in unnecessary and costly replacement of copper lines.

- Every time a service line is touched, there is a small risk of lead leaching. However, utilities companies all have policies to safeguard against this risk.

- Replacement crews overlook existing lead service lines, mistaking them for copper service lines.

How can we mitigate the biggest risks?

All of the issues listed above can be avoided with statistical modeling for service line replacement. Statistical modeling will give more complete information, leading to a more effective, efficient, accurate, and cost-effective removal process.

Data and Learning Strategy

Baseline Systems: Necessary inputs to implement the policy effectively

The development of a comprehensive inventory aligns with the requirements that state agencies need to fulfil under Lead and Copper Rule revisions. The state agency charged with SDWA compliance should require data inputs from water systems owners, including:

- Inventory of existing service lines
- Inventory of known lead and unknown service lines
- Development of water system plan for LSL replacement
- Implementation of LSL replacement plan

Measuring Progress: How can progress toward the desired outcomes be measured — both to assess progress and inform improvement along the way?

The goal for this work is to replace 100% of lead service lines as efficiently as possible. This proposal allows cities to set credible estimates of the total number of LSLs in their jurisdiction, empowering them with actionable data to guide a pipe replacement program. Progress toward the goal will be measured by:

- Hit rates: The percentage of excavations that accurately result in finding an LSL versus a copper one. This percentage is crucial because higher rates of accurately identifying LSLs avoids unnecessary digs, resulting in more efficient and cost-effective replacement.

- The number of pipe replacement attempts required for successful completion.
- The total number of pipes replaced.
- The average cost of excavating and replacing a single LSL. This should be lower if LSLs are able to be identified with higher accuracy.

Additional Resources

ASDWA White Paper **-** A white paper prepared for the Association of State Drinking Water Administrators (ASDWA) by BlueConduit that outlines the Principles of Data Science for Lead Service Line Inventories and Replacement Programs. BlueConduit also provides technical assistance to utilities and cities on all aspects related to service line inventory and replacement.

Flint Pipe Map **-** The Flint Water Service Line Materials Map provides information about the residential water service lines (pipes) in the City of Flint, Michigan. The map is designed to help residents easily find out the known or likely materials of their water service lines.

Day One Project Playbook - A step-by-step guide to using statistical modeling to efficiently replace lead service lines.

Playbook Authors

Ian Robinson
BlueConduit, Managing Director
ian@blueconduit.com

Brig. Gen. Michael McDaniel
BlueConduit, Director of Government Relations and Client Services mcdanielm@cooley.edu