



BlueConduit

BlueConduit Platform

Eric Schwartz

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10 November 2022

1.8+
million

Service lines
analyzed

100+
Water systems

2019
Company
founded



\$300+
million
in savings

6 years
Experience in
ML prediction,
originated in
Flint

80%+
Hit rate

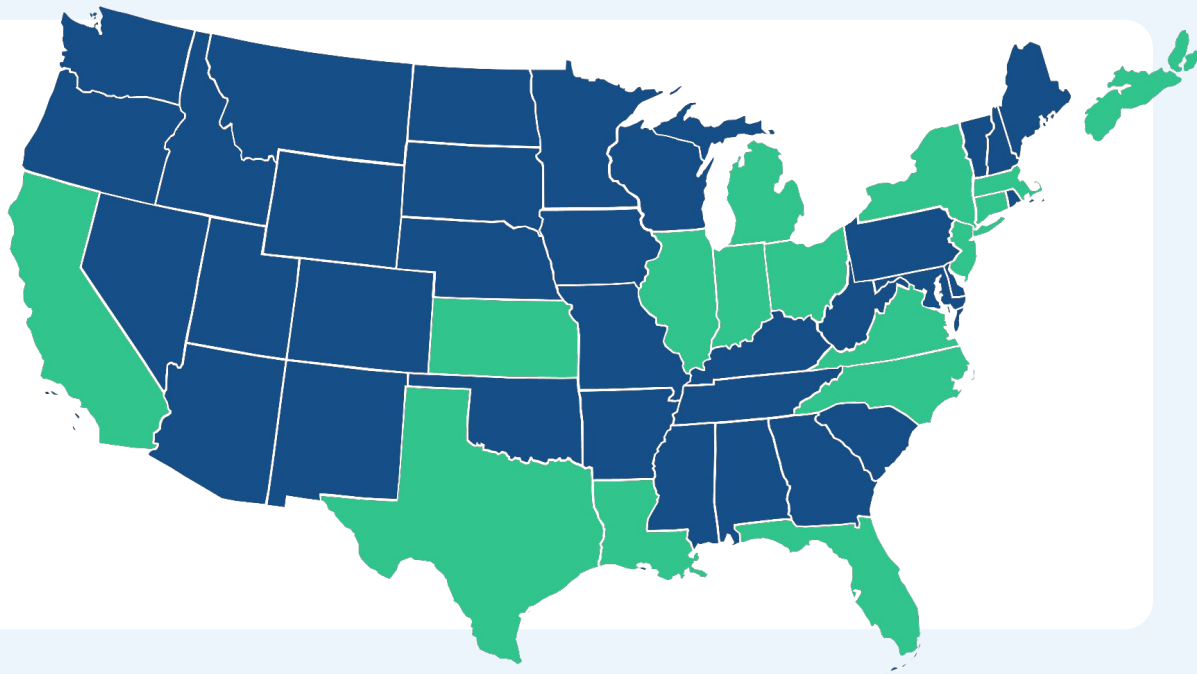


BlueConduit Strong Customer Traction

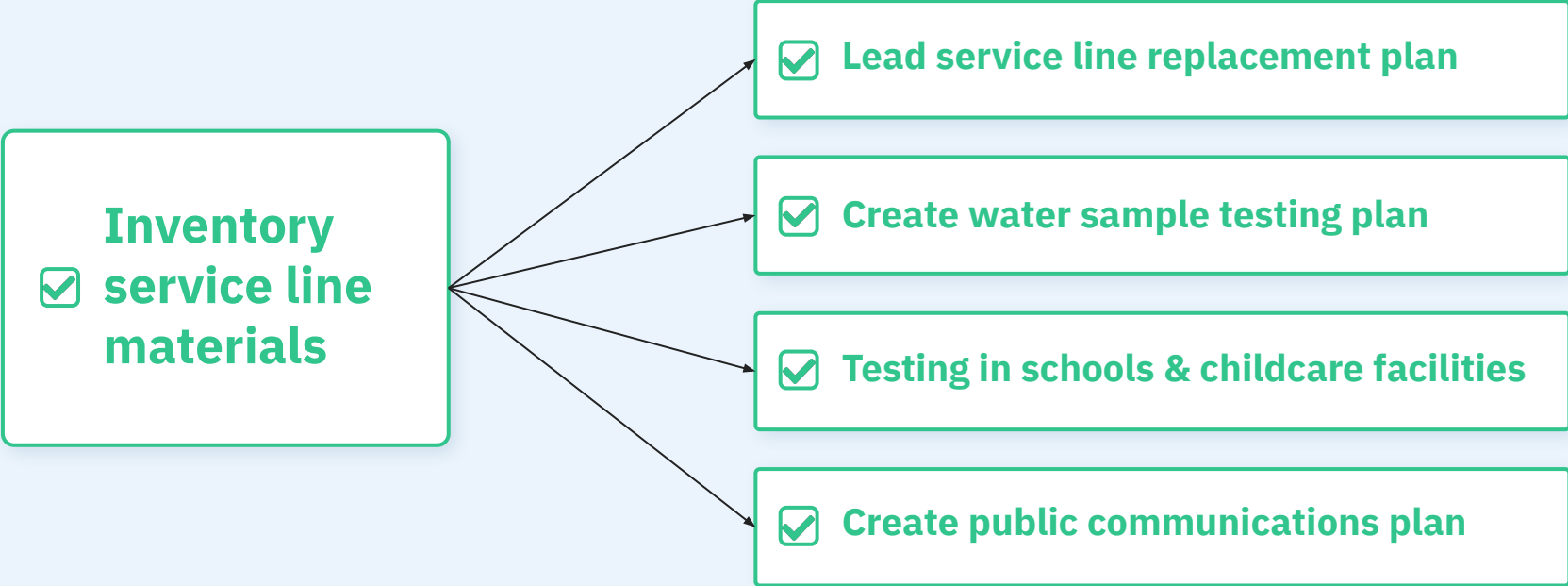
Working in

100+
cities

across US & Canada



LCR Requirements by Oct 2024



A smart SL materials inventory powers your overall LCR compliance.

Service Line Inventory Requirements

Classify all SLs

- All SLs must have a known material, a likelihood, or be “unknown”
- Include both private AND public sides

Customer Notification

- Must provide notification to all with Lead or Unknown material

Publicly Accessible

- Include each LSL with a location identifier

Oct 2024

All systems must submit SL inventory by Oct 16, 2024



Relying on Incomplete Data is Costly

- Material Cost \$1-3K/SL
- Labor \$5-25K/SL
- Lead Exposure Risk
- Public Relations Risk

EPA Guidance Section 1.1 "Benefits of a Comprehensive and Accurate Inventory"

**Cities do not
know where their
lead service lines
are located**



Guidance for Developing and Maintaining a Service Line Inventory

August 4, 2022 **** NEW ****



Organizing Data for Inventory

US EPA Guidance for Developing and Maintaining a Service Line Inventory
August, 2022 (PDF)



Guidance for Developing and Maintaining a Service Line Inventory

Electronic spreadsheets and databases have an added advantage over lists for tracking additional information fields. Spreadsheets and databases can be organized in a way that information can be searched, filtered, sorted, and updated. They can be configured to include photos of service line

systems with large numbers of LSLs. General recommendations for preparing a spreadsheet inventory from a white paper by the Association of State Drinking Water Administrators (ASDWA) and BlueConduit (2020) include the following:

and BlueConduit (2020) include the following:

- Each home/service line is a row in the spreadsheet.
- Each column refers to different data points available for each service line (e.g., address, installation date, service line materials classification, and source of information).
- System-owned and customer-owned portions, if applicable, are tracked separately.
- Information regarding goosenecks, pigtails, and connectors is tracked separately.
- Labeling is consistent across the data, and the spreadsheet has a data dictionary to define the column headers.
- Previous information is not lost when new information is found, which will help the utility evaluate the accuracy of historical records.

EPA developed a spreadsheet template that systems may consider using to organize their inventory. The template contains color-coded worksheets for documenting system information, inventory methods, and how the system is making the inventory publicly accessible. The template also includes a detailed worksheet that systems can use to track the materials and other relevant information for each individual service line. This detailed inventory worksheet is designed for

EPA Guidance: Organizing Data for Inventory

US EPA Guidance for Developing
and Maintaining a
Service Line Inventory
August, 2022 ([PDF](#))

3.3.1 List, Spreadsheet, or Database

Systems may be able to create a simple list of all addresses with a service line material designation for each. While a location identifier is sufficient for a publicly accessible inventory, some states may require systems to include the source of information used to classify each line to ensure the requirements in 40 CFR §141.84(a)(3) are met. See Section 2.4 for other recommended inventory elements to include.

systems with large numbers of LSLs. General recommendations for preparing a spreadsheet inventory from a white paper by the Association of State Drinking Water Administrators (ASDWA) and BlueConduit (2020) include the following:

location makes electronic spreadsheets and databases a useful inventory method, particularly for systems with large numbers of LSLs. General recommendations for preparing a spreadsheet inventory from a white paper by the Association of State Drinking Water Administrators (ASDWA) and BlueConduit (2020) include the following:

Recommended Subclassifications

A Lead Status Unknown's "LSL Likelihood." Some water systems have incorporated additional information that indicates the probable material of an unknown service line, such as an "LSL Likelihood." For example, Flint, Michigan, categorized unknowns as low likelihood of lead, medium likelihood of lead, and high likelihood of lead (see their online map showing these subclassifications⁵). Systems using predictive models may also assign numerical probabilities to unknowns representing the probability they are LSLs.

EPA developed a spreadsheet template that systems may consider using to organize their inventory. The template contains color-coded worksheets for documenting system information, inventory methods, and how the system is making the inventory publicly accessible. The template

⁵ <https://flintpipemap.org/map>. Accessed December 8, 2021.

Predictive Modeling and LCR

Predictive Modeling is an acceptable Service Line Investigation Method

US EPA Guidance for Developing and Maintaining a Service Line Inventory August, 2022 ([PDF](#))

5.5 Predictive Modeling

Predictive models look for patterns in a dataset to develop rules or algorithms. Geostatistical models use attributes from known locations to make inferences about areas of unknown condition. Examples of model inputs may include water system or community data, such as the distribution of known materials, along with other factors, such as building age and location. These models are typically built using an initial dataset and can be continually “trained” or improved as more data are added (Muylywyk, 2020).

Geostatistical models have been used by water utilities to predict areas where a service line is lead, prioritizing areas for service line replacement (Abernathy et al., 2018; Muylywyk, 2020; Bukhari et al., 2020; Hines et al., 2020). These models can be enhanced by incorporating machine learning algorithms in which the model improves itself as new data are added. Information on sensitive subpopulations and socioeconomic factors can be added as layers to enhance planning and prioritization of LSLR (Muylywyk, 2020).

The literature provides examples of geostatistical and machine learning modeling in Flint, Michigan (Abernathy et al., 2018; Walker 2020). In Denver, Colorado, systems and states can refer to the 2020 ASDWA webinar, “Predictive Tools for Lead Service Line Investigation and LSLR” (Muylywyk, 2020). These models to inform their service line investigation and LSLR programs. Using a representative set of known data on service line material is important in maximizing accuracy and reliability and minimizing bias.

For more information and examples of how predictive modeling has been used in Flint, Michigan, and Denver, Colorado, systems and states can refer to the 2020 ASDWA webinar, “Predictive Tools for Lead Service Line Investigation and LSLR” (Muylywyk, 2020).

Great Lakes, and Energy
▶ Eric Schwartz, BlueConduit

Predictive Modeling and LCR

Predictive Modeling is an acceptable Service Line Investigation Method

US EPA Service Line Inventory Guidance and Template July 27, 2022 ([XLS](#))

Part 3: Service Line Investigations

1. Identify the service line investigation methods your system used to prepare the inventory (check all that apply). If a water system chooses an investigation method not specified by the state under 40 CFR §141.84(a)(3)(iv), state approval is required. **Note that investigations are not required by the LCRR but can be used by systems to assess accuracy of historical records and gather information when service line material is unknown.**

- | | |
|---|---|
| <input type="checkbox"/> Visual Inspection at the Meter Pit | <input type="checkbox"/> Water Quality Sampling |
| <input type="checkbox"/> Customer Self-Identification | <input type="checkbox"/> Mechanical Excavation |
| <input type="checkbox"/> CCTV Inspection at Curb Box - External | <input type="checkbox"/> Vacuum Excavation |
| <input type="checkbox"/> CCTV Inspection at Curb Box - Internal | <input type="checkbox"/> Predictive Modeling |
| <input type="checkbox"/> Water Quality Sampling - Targeted | <input type="checkbox"/> Other |
| <input type="checkbox"/> Water Quality Sampling - Flushed | |
| <input type="checkbox"/> Water Quality sampling - Sequential | |

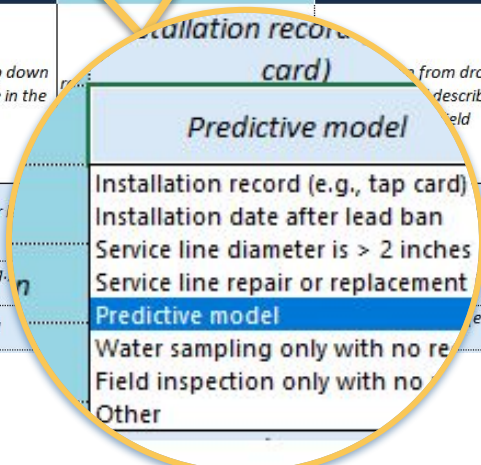
EPA Guidance: Organizing Data for Inventory



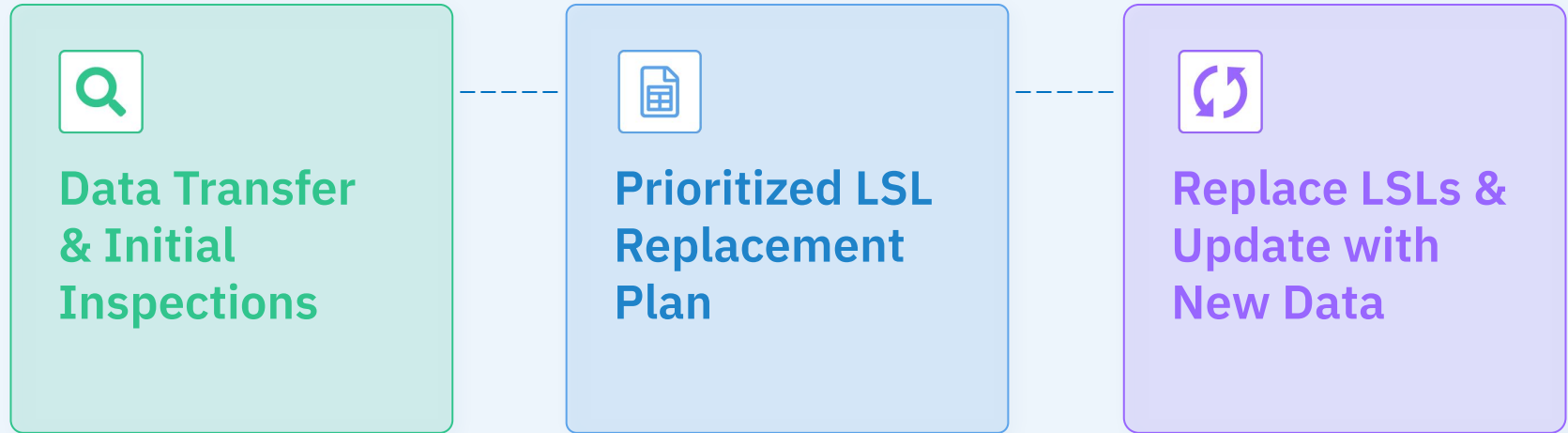
Service Line Inventory Template

Date last updated: July 27, 2022

Location Information			System-Owned Portion		Customer-Owned Portion		Entire Service Line Material Classification
Unique Service Line ID	Location Identifier		System-Owned Portion Service Line Material Classification	Basis of Material Classification	Customer-Owned Portion Service Line Material Classification	Basis of Material Classification	
	Street Address	Other Location Identifier					
A Unique ID is recommended for each service line.	Water systems must track addresses of all service lines in their internal inventory. For the publicly accessible version, location identifiers are required for lead and galvanized requiring replacement. If the system does not use addresses for their location identifier, other options could include GPS coordinates, landmark, intersection, block, or other details to specify service line locations.		Dropdown list includes recommended subclassifications. If "Non-Lead Other", describe in Notes field	Select option from drop down list. If "Other," describe in the Notes field	Installation record (e.g., tap card)	Select option from drop down list. If "Other," describe in the Notes field	Dropdown list includes four required service line classifications of Lead, Non-lead, Galvanized Requiring Replacement, or Unknown
Example 1	1234 Test St., City, State, Zip Code	Intersection of Test and Elm St.	Non-Lead - Plastic	Installation date after lead ban	Predictive model	Installation record (e.g., tap card) Installation date after lead ban Service line diameter is > 2 inches	Non-Lead
Example 2	4321 Test St., City, State, Zip Code	Intersection of Test and Main St.	Non-Lead - Plastic	Installation record (e.g., tap card)	Predictive model	Service line repair or replacement	Non-Lead
Example 3	16 Capital St., City, State, Zip Code		Non-Lead - Copper	Predictive model	Predictive model	Water sampling only with no re... Field inspection only with no... Other	Galvanized Requiring Replacement

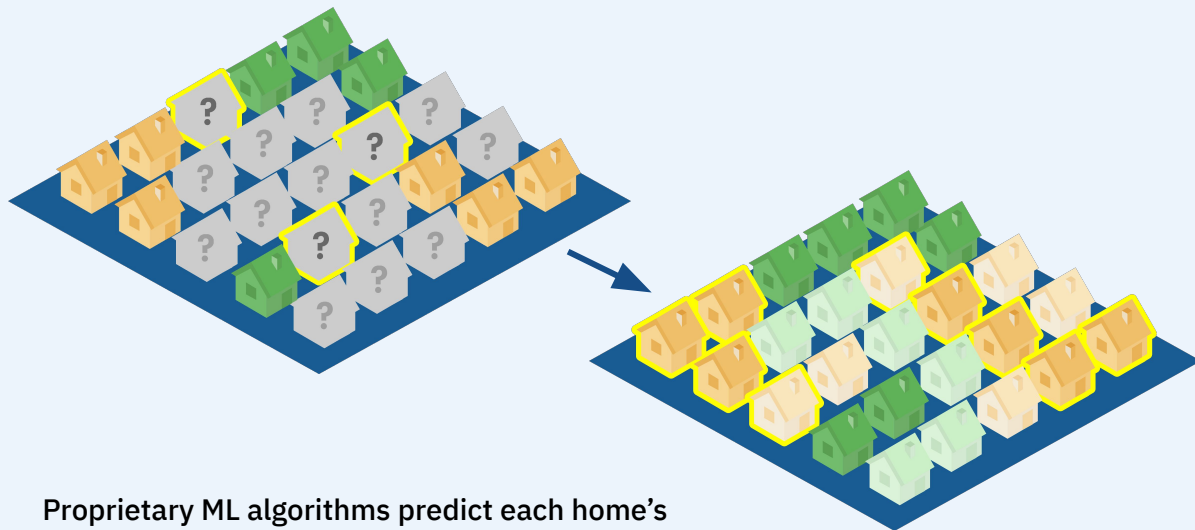


Applying ML to locate LSLs

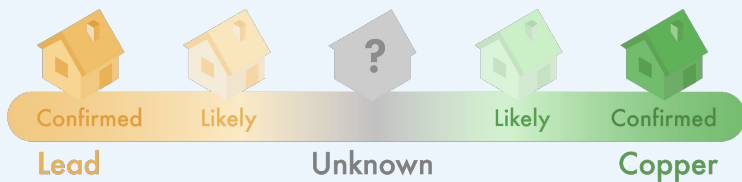


Dig where the Lead is

Following best practices in statistics allows you to better estimate the number and location of lead service lines

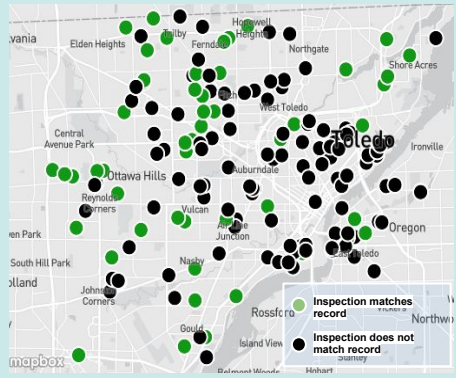


Proprietary ML algorithms predict each home's likelihood of having a lead service line





Recommended Addresses for Inspection

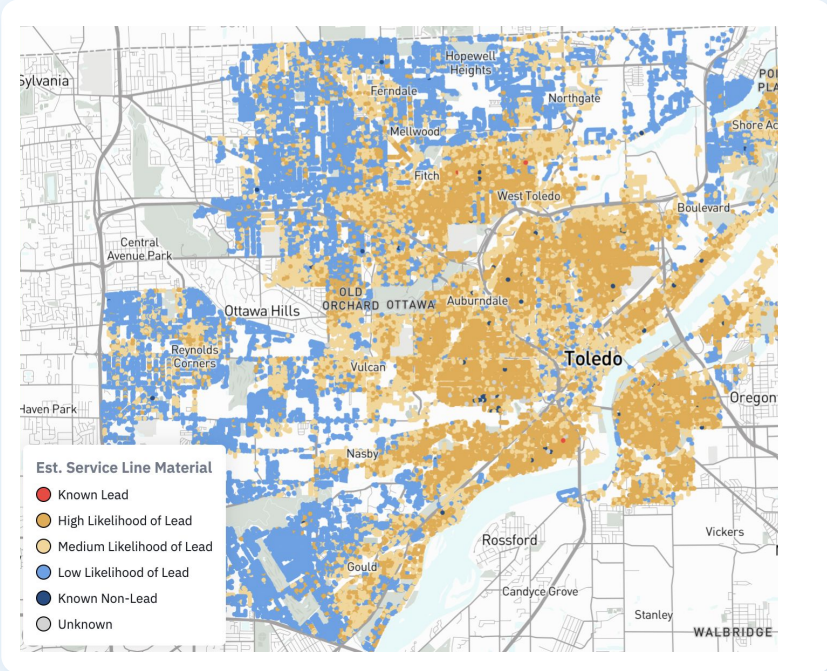
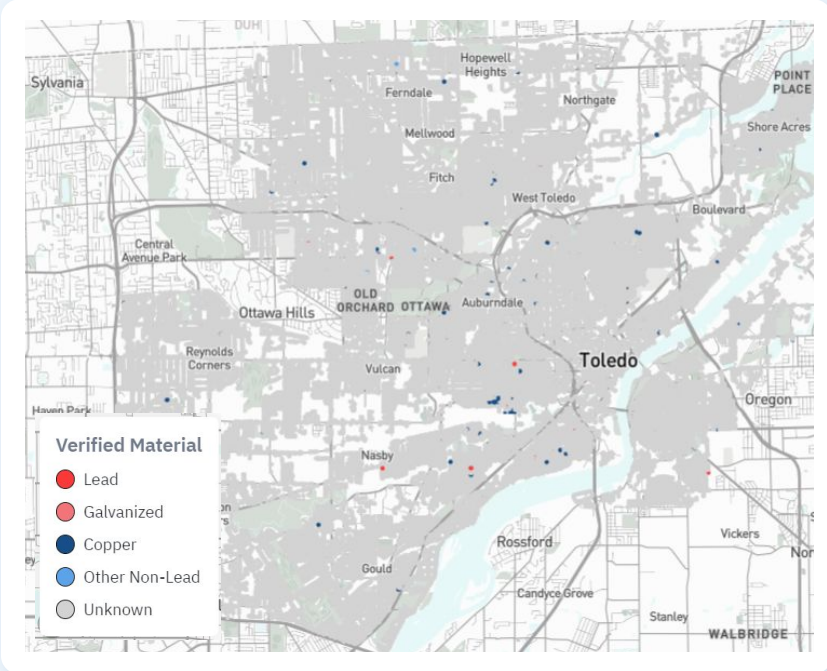


Hydrovac inspections at **180 selected representative** service lines

- Less than 48% of inspections confirmed the recorded material in GIS
- Provide accurate, representative sample of verified materials for modeling.

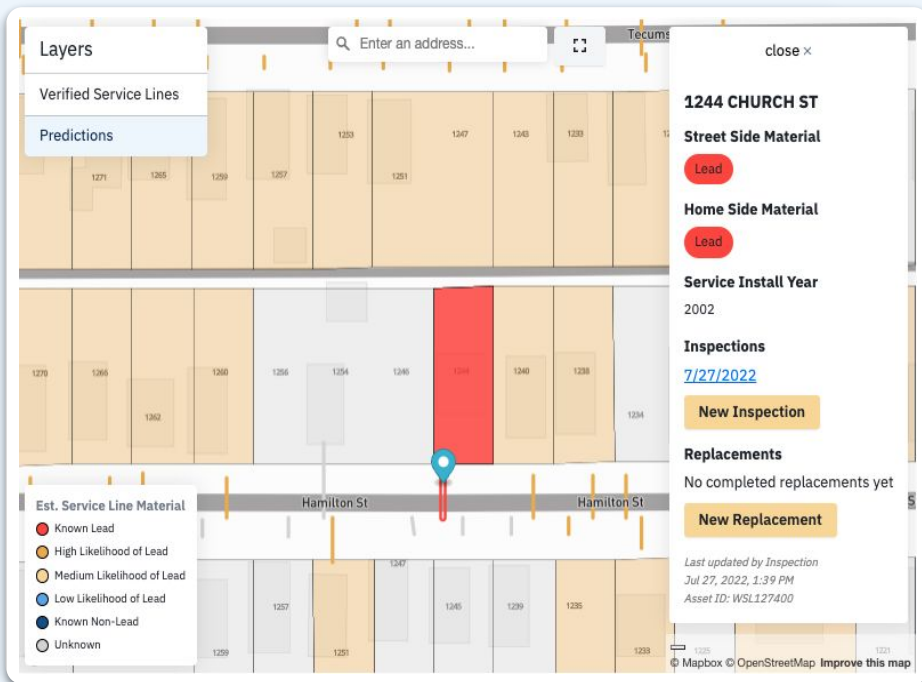
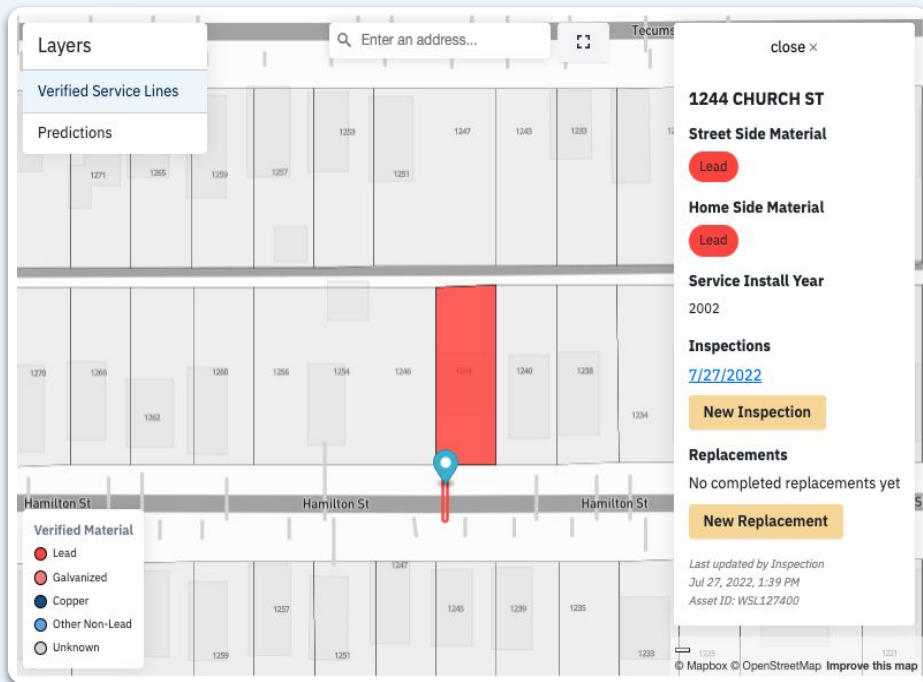


Predictions Fill in the “Unknown” Gaps in the Data



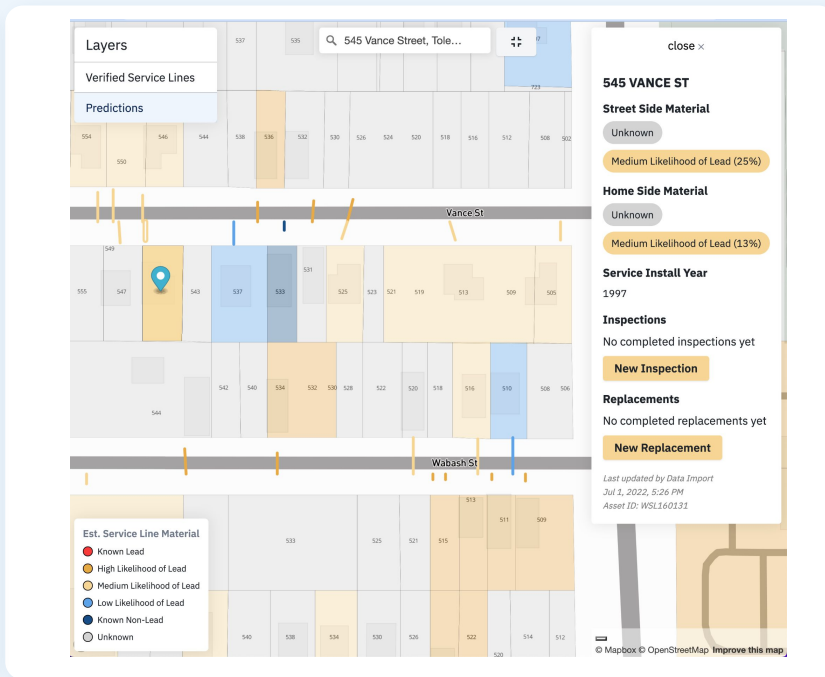
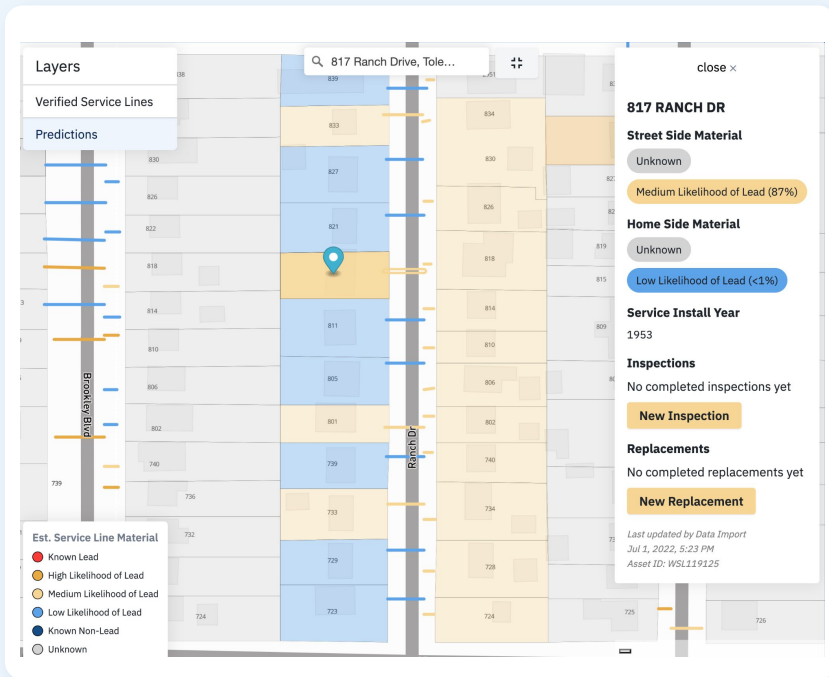
Predictions Fill in the “Unknown” Gaps in the Data

Granular block-by-block SL-by-SL inventory guides planning, funding, communication, and sampling



Predictions Fill in the Gaps in the Data

Granular block-by-block SL-by-SL inventory guides planning, funding asks, and ongoing compliance (required communication, water testing, disclosure)





Report Progress & Update with New Data

BlueConduit Inventory Resources pwsSample | eric@blueconduit.com

Inventory x

Basic Info **Methods** Other Info Review

Inspection Info

Hydrovac

Main to Curb Material *

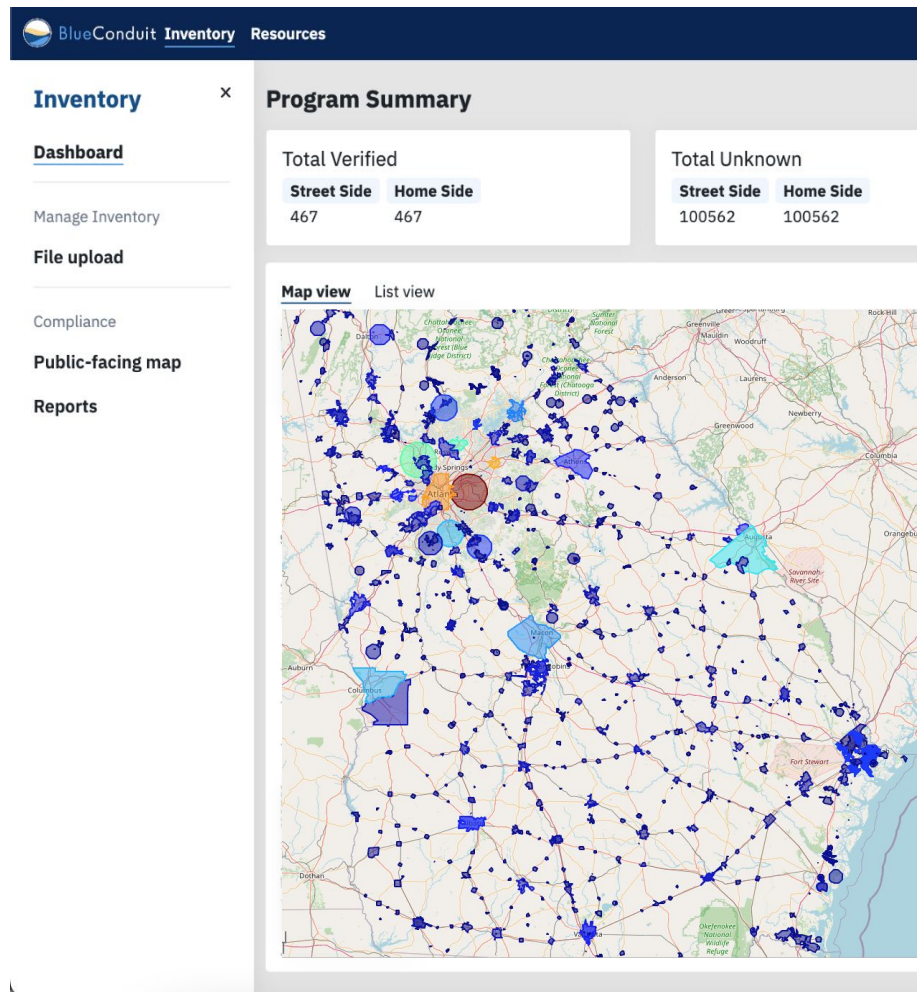
Copper

Curb to Home Material *

- ✓ Lead
- Copper
- Galvanized
- Galvanized Steel
- Galvanized Iron
- Brass
- PVC
- PEX
- Other

State-Level Dashboard and Integration

- LCRR Reporting and Compliance
- LSL inventory ingestion & standardization
- Display progress toward removing all LSLs
- Connection to SDWIS
- Integrations with Esri and other asset management software



Organizing Data for Materials Inventory

SL Verified (Private)	SL Verified (Public)	Date Verified	Method	Contractor	Parcel ID	Address	Year Built	Latitude	Longitude	Home value	SL Historical Record (Private)	SL Historical Record (Public)	Water Test Results (ppb)
Galvanized	Copper	1/2/2019	Hydrovac	Firm 1	401446	6201 MAPLE	1925	43.00802	-83.6365	7800	Copper	Copper	0
?	?				401215	1234 MAIN	-	43.07282	-83.7219	19300	Copper	-	2
?	Copper				410545	567 WALNUT	1921	43.02797	-83.7171	10900	-	Lead	8
Copper	Copper	10/2/2018	Excavation	Firm 2	401438	1486 OAK	-	43.02454	-83.6655	4000	Copper	Copper	-
?	?				4626455015	2014 CENTRAL	1953	43.02454	-83.6655	4000	Copper	Copper	1
?	?				4106453010	226 BALTIC	1945	43.05868	-83.725	17700	-	Lead	-
Copper	Copper	11/22/2016	Hydrovac	Firm 3	4108429037	556 GRANDB	1978	43.07111	-83.7222	13100	Copper	Copper	0

Organizing Data for Materials Inventory

SL Verified (Private)	SL Verified (Public)	Date Verified	Method	Contractor	Parcel ID	Address	Year Built	Latitude	Longitude	Home value	SL Historical Record (Private)	SL Historical Record (Public)	Water Test Results (ppb)
Galvanized	Copper	1/2/2019	Hydrovac	Firm 1	401446	6201 MAPLE	1925	43.00802	-83.6365	7800	Copper	Copper	0
12%					401215	1234 MAIN	-	43.07282	-83.7219	19300	Copper	-	2
54%	Copper				410545	567 WALNUT	1921	43.02797	-83.7171	10900	-	Lead	8
Copper	Copper	10/2/2018	Excavation	Firm 2	401438	1486 OAK	-	43.02454	-83.6655	4000	Copper	Copper	-
4%					4626455015	2014 CENTRAL	1953	43.02454	-83.6655	4000	Copper	Copper	1
93%					4106453010	226 BALTIC	1945	43.05868	-83.725	17700	-	Lead	-
Copper	Copper	11/22/2016	Hydrovac	Firm 3	4108429037	556 GRANDB	1978	43.07111	-83.7222	13100	Copper	Copper	0



BlueConduit

Thank you

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Flint

12.5%

12.2%

12.2%

91.8%

14.8%

21.0%

94.4%

91.2%

17.5%

74.1%

10.3%

19.7%

10.3%

13.3%

Huron St

Huron St

Curthbertson St

Curthbertson St

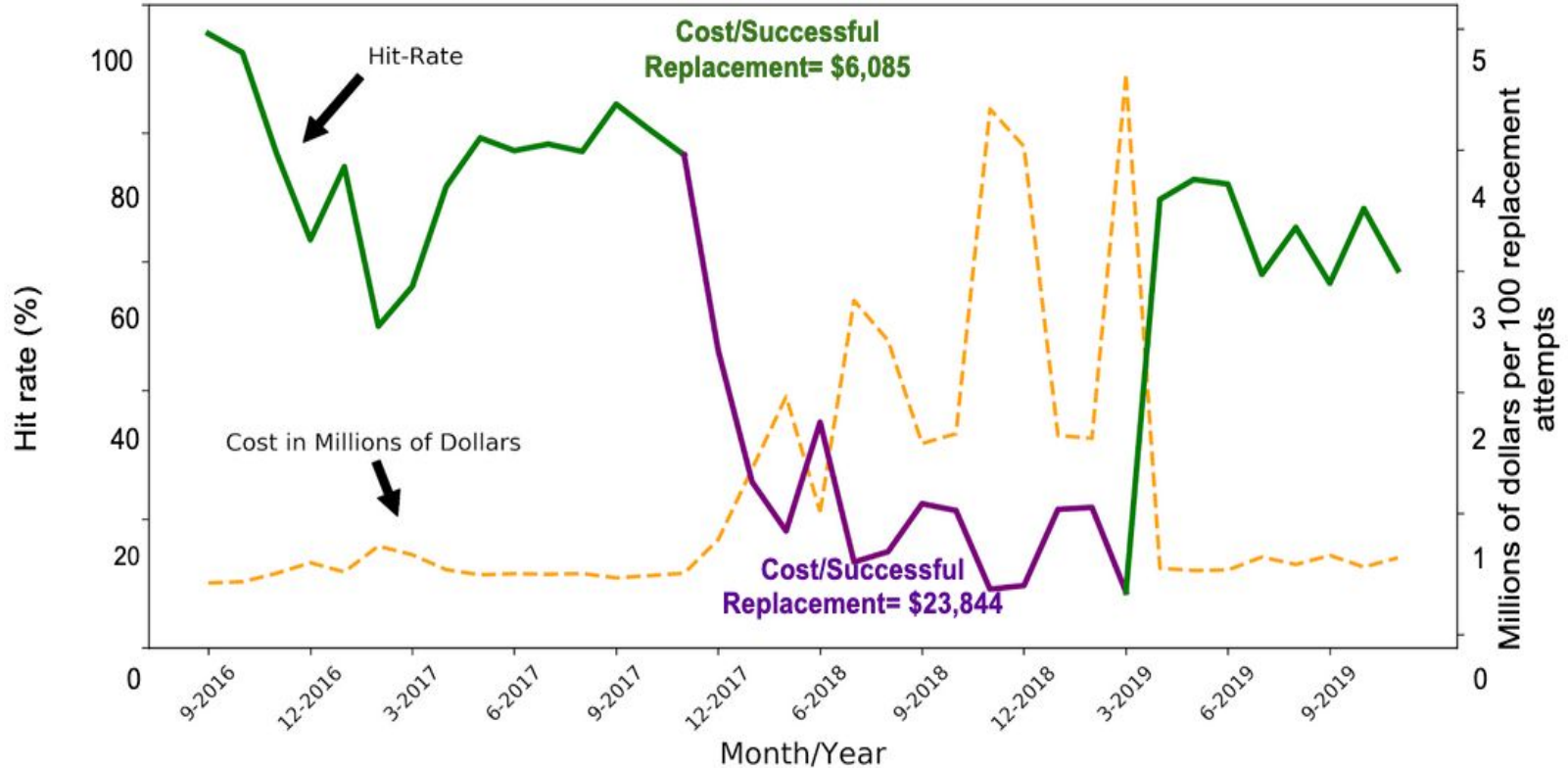
Material Predictions Drive Decision Making

Chance of lead/galvanized service line according to predictive model**

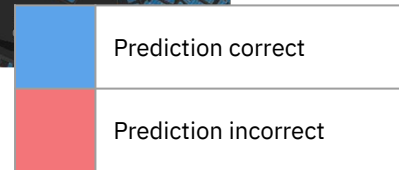
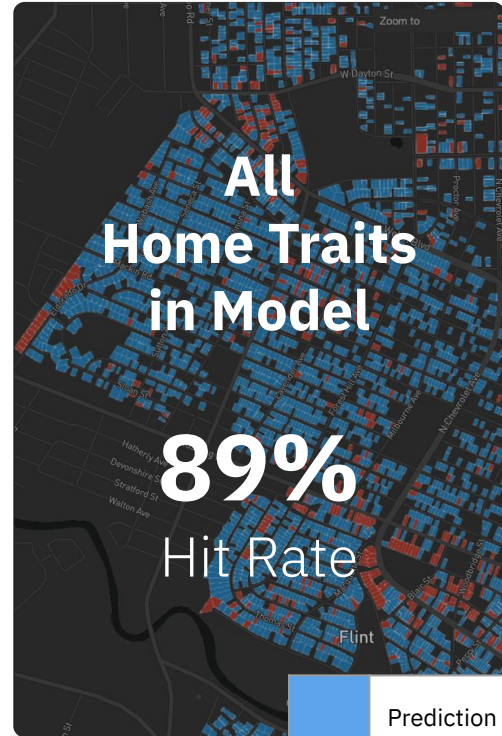
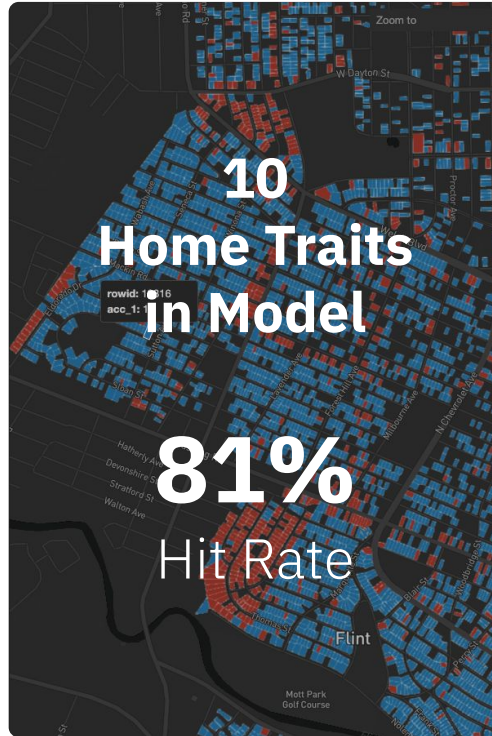
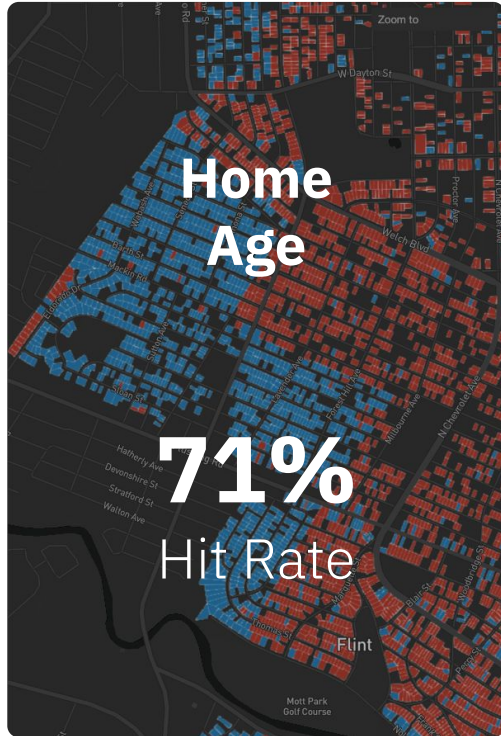
Homes with high likelihood can be next to and across the street from homes with low probability



Hit Rates and Costs Over Time in Flint



Predictive Models: Home Age is Not Enough

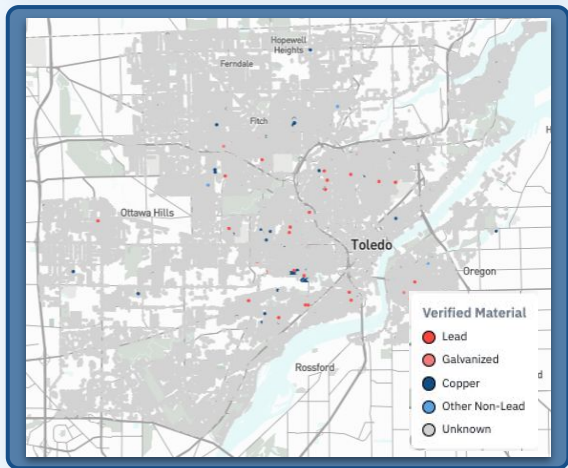




Toledo

About Toledo, OH

100,500
Total SLs



83%

Homes built before
1986 LSL ban

25%

Living below Federal
poverty line

< 1%

SL materials verified

Zero

open LCR violations

Publicly Accessible and Searchable Map

Transparency and community engagement are essential to trust

toledo.oh.gov/lead-lines

Toledo Water Service Line Map

Powered by  BlueConduit

Map FAQ

English (U.S.)

Contact BlueConduit

Search for your address

Estimated Service Line Material

- Known Lead
- High Likelihood of Lead
- Medium Likelihood of Lead
- Low Likelihood of Lead
- Known Non-Lead
- Unknown

625 ELIZABETH ST, TOLEDO OH 43602

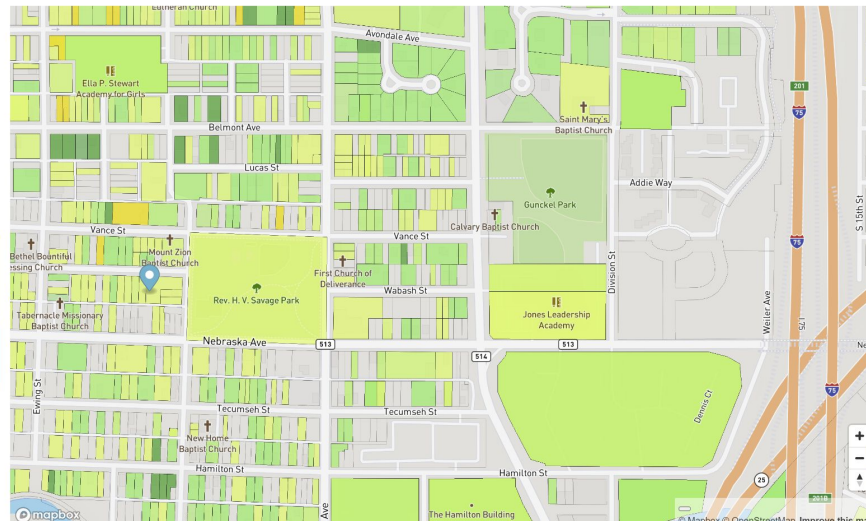
City-owned Portion

There is **HIGH LIKELIHOOD OF LEAD** in your service line. Estimated replacement in 2021-2022

Customer-owned Portion

There is **LOW LIKELIHOOD OF LEAD** in your service line.

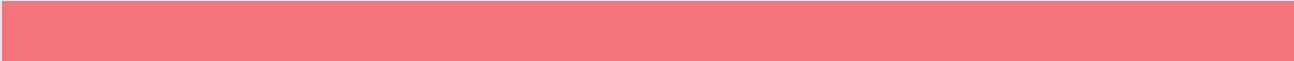
All estimates are based on the best available information. For more information, visit our FAQ page or contact your utility.



LSLR Program Completion

2020 projection

30-year program to systematically replace Toledo's 30,000+ lead service lines

 **End 2050**

2022 projection

Complete the program in 5-6 years

 **End 2027**