Metropolitan Planning Council

CNT

Drinking Water 123 Academy

VILLAGE OF HAZEL CREST

Lead Service Line Inventory and Replacement Plan

December 2020

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ABOUT METROPOLITAN PLANNING COUNCIL

Since 1934, the Metropolitan Planning Council (MPC) has been dedicated to shaping a more equitable, sustainable, and prosperous greater Chicago region. As an independent, nonprofit, nonpartisan organization, MPC serves communities and residents by developing, promoting and implementing solutions for sound regional growth.

ABOUT CENTER FOR NEIGHBORHOOD TECHNOLOGY

The Center for Neighborhood Technology (CNT) is a leader in promoting more livable and sustainable communities. CNT's mission is to make cities work for everyone. CNT works at the intersection of environmental sustainability, social equity, and technology — with particular attention on creating efficient and affordable solutions for low-income communities and communities of color.

ABOUT IBM SERVICE CORPS

For more than ten years, IBM's Service Corps has given employees the opportunity to use their professional skills to help people and communities tackle complex issues. Small squads of IBMers partner for several weeks with nonprofit, government, educational and civic leaders to address high-priority issues in education, sustainability, health, and economic development. Six IBM staff from the Chicago region supported CNT during the development of Hazel Crest's lead service line inventory.

ABOUT BLUECONDUIT

BlueConduit is a water infrastructure analytics consulting company that uses data and machine learning to help cities do service line inventories and removal. BlueConduit pioneered this use of predictive modeling to help the City of Flint, Michigan, efficiently replace its pipes. These methods saved the city tens of millions of dollars and accelerated the removal of dangerous infrastructure. BlueConduit played an advisory role on this project, providing insights and support to the CNT and IBM teams during the data collection, cleaning, and analysis phases of the project.

TABLE OF CONTENTS

Executive Summary 1
Project background 3
How to use this report 3
Water Resources program 3
Drinking Water 1-2-3 initiative 4
Cnt's Great Lakes water infrastructure program 4
Planning process 5
Scope of work 5
Roles and deliverables 5
Planning context 7
Demographics 8
Existing land use 9
Water in Hazel Crest 10
Review of existing planning documents 10
Lead and water 11
The basics on lead in drinking water 11
Lead regulations 13
Lead and Copper Rule 13
Partial replacement 13
Service line material inventory 14
Developing a lead service line inventory using predictive analytics 15
Introduction 15
Methodology 16
Dependent variables 16
Independent variables 17
Results 17
Updating the inventory 19
Inventory limitations 19
Lead service line replacement plan 21
Socioeconomic factors in Hazel Crest 22
Probability-driven prioritization 24
Implementation 25
Cost estimates 25
Cost-effectiveness 25
Vulnerable populations 26
Multi-sector coordination with health and education institutions 26
Funding 27
State Revolving Fund 27
Water Infrastructure Improvements for the Nation Act 28
Water rates 28
Public education materials 29
Lead and water resolution 30
Pending legislation 31
Conclusion 32
References 33

EXECUTIVE SUMMARY

The Village of Hazel Crest applied and was selected for the Metropolitan Planning Council's (MPC) Drinking Water 1-2-3 Technical Assistance program. The challenge they posed was the need to identify the probable location of lead service lines — which bring drinking water from a utility's water main into homes and other properties — and a strategy for replacing these service lines over time. The primary deliverables in the Scope of Work are a lead service line inventory and replacement plan, which this document provides. Additional deliverables include the adoption of a lead and water municipal resolution (which passed unanimously on October 13, 2020), and the development of public education materials about the issue of lead in drinking water.

There is no safe level of lead exposure. Lead poisoning is particularly harmful to children aged 6 and under who can suffer from decreased IQ, hyperactivity, hearing problems, stunted growth, and learning disabilities. However, ingestion of any amount of lead at any point in one's life can lead to long-lasting health issues. Lake Michigan water is delivered to Hazel Crest's water customers and does not initially or naturally contain lead. Lead found in tap water usually comes from lead-based pipes, fixtures composed of an unsafe percentage of lead, or from leaded solder used to connect water pipes. According to numbers submitted by the village to the Illinois Environmental Protection Agency (IEPA), as of Reporting Year 2019, 339 service lines were reported to be lead. However, as in many communities, Hazel Crest did not have a complete inventory of its service lines and, therefore, sought to understand where additional lead service lines exist.

MPC and partners the Center for Neighborhood Technology (CNT), IBM Service Corps, and BlueConduit worked closely with the Village of Hazel Crest to develop a probability-driven inventory of lead service line locations throughout the municipality. The team collected and analyzed data from the Cook County Assessor, IEPA, and the Village of Hazel Crest to build a predictive model. Using a multiple linear regression analysis, the model showed whether the presence of a lead service line is likely or unlikely at each residential parcel.

Based on the model outputs, of the 4,221 residential parcels in the Village of Hazel Crest:

- **633 parcels (approx. 15 percent) are assumed to have non-lead service lines;**
- **347 parcels (approx. 8 percent) are assumed to have lead service lines;**
- **758 parcels (approx. 18 percent) are likely lead (66–99.99 percent probability);**
- **1,595 parcels (approx. 38 percent) may be lead (33–65.99 percent probability); and**
- **888 parcels (approx. 21 percent) parcels are unlikely lead (.001–32.99 percent probability).**

CNT created an interactive map that presents the probability for each parcel (apps.cnt.org/lsl/hazel_crest). Based on the results of the analysis, the Village of Hazel Crest should begin field testing and replacement efforts focused on Hazel Crest Proper and the Pott Hills/English Valley and Twin Creeks subdivisions. The Highlands/Apple Tree and Chateaux/Homewood Gardens subdivisions, which have a medium likelihood of having lead service lines, should be prioritized in the early phase of field testing and replacement efforts, as well. However, owing to the small number of visually confirmed service lines made of lead, copper, or another material, there are limitations to the predictiveness of the model. As the village begins field testing and replacing service lines, those data can be input back into the map database to improve the accuracy of the model.

Materials, labor, and equipment are some of the cost considerations associated with the total cost of service line replacement. Estimates range from $8,000 to $10,000 per service line replacement. Based on that, the cost for the 347 “assumed lead” parcels ranges from $2,776,000 to $6,064,000. For the 758 “likely lead” parcels, the range is $3,470,000 to $7,580,000. Combined, the total cost *for these two categories* is estimated to be between $8.8 million and $11 million. Economies of scale can be achieved by coordinating lead service line replacements with other infrastructure renewal or replacement programs. However, due to the increased risk of lead exposure or more adverse impacts, households with children, low-income households, households whose native language is not English, and other vulnerable populations should be prioritized.

Finally, among the funding options discussed, the most applicable currently available source is IEPA’s Drinking Water Loan Program for lead service line replacement. This program provides principal forgiveness loans up to $4 million per applicant, but the pool of available funds is limited and will not last long. Consult the IEPA State Revolving Fund Loan Programs webpage for more information.

PROJECT BACKGROUND

HOW TO USE THIS REPORT

The purpose of this report is to provide staff and elected officials in the Village of Hazel Crest with background information on the risk to public health posed by lead in water, the probable location of lead service lines in the village, and a strategy — including potential funding sources — for replacing lead service lines over time. This report intends to help staff and officials make informed decisions as Hazel Crest prepares to tackle this important issue.

MPC'S WATER RESOURCES PROGRAM

Northeastern Illinois' proximity to the Great Lakes and access to multiple rivers and underground aquifers mean that we generally enjoy abundant water resources. While our region's water assets are considerable, they are also finite — in the case of Lake Michigan, governed by a Supreme Court Decre — and are facing a multitude of challenges due to infrastructure age, fragmented system management, and potential contamination. As climate change advances, shorter duration but increasingly intense and more frequent storm events — much of which cannot infiltrate nor evapotranspirate because of storm intensity and urban land use decisions — overwhelm stormwater infrastructure, which is undersized and aging. The result is negative impacts for humans, aquatic ecosystems, and the ecosystem services they provide from Chicago to the Mississippi River and beyond. These realities jeopardize both public health and economic growth.

In response to these challenges, the Metropolitan Planning Council's (MPC) Water Resources program uses research, advocacy, education, and technical assistance to: 1) ensure clean, equitable, and abundant drinking water; 2) prevent flooding and improve water quality; 3) facilitate and encourage stewardship of our natural assets; and 4) foster social, economic, and environmental benefits within communities.

DRINKING WATER 1-2-3

Drinking Water 1-2-3 is a collection of initiatives that assist communities in the Chicago metropolitan area with water-related issues. MPC released the *Drinking Water 1-2-3* guide (drinkingwater123.metroplanning.org), designed for elected officials and local leaders to help communities take the necessary steps to ensure livability through quality drinking water service.

In 2019, MPC launched the Drinking Water 1-2-3 Academy to assist with continued education and training for community officials and establish a peer network where learning and coordination can take place. To assist with on-the-ground technical assistance projects, which implement many of the best practices featured in the guide, MPC administers the Drinking Water 1-2-3 Technical Assistance program. Throughout 2020, MPC has coordinated expert services to help communities, including the Village of Hazel Crest, tackle their most pressing drinking water needs.

CNT'S GREAT LAKES WATER INFRASTRUCTURE PROGRAM

It could cost Great Lakes states $200 billion over the next 20 years to bring drinking and wastewater infrastructure to a state of good repair. One of the primary drivers of sky-rocketing infrastructure investment needs is a history of low investment. The vast majority of water supply and wastewater infrastructure was installed in the early 20th century and is over 100 years old. To add fuel to the fire, increased federal regulations, climatic stressors, and rising construction costs all exacerbate the level of infrastructure investment needed.

Cities that have faced industrial disinvestment are particularly vulnerable given infrastructure that may be overbuilt for current needs, economically disadvantaged residents struggling to afford bills, and little new growth-based revenue. These factors conspire to create an untenable cost burden on low- and fixed-income ratepayers and prevent utilities from proactively addressing infrastructure needs, increasing the risk of system failure.

The Center for Neighborhood Technology's Great Lakes Water Infrastructure Program, generously supported by the Charles Stewart Mott Foundation, provides technical support, research, and data analytics to communities throughout the Great Lakes Basin. Through this work, we hope to see advancements in the Great Lakes region towards improved water infrastructure decision-making that value affordability, equity, and environmental sustainability.

PLANNING PROCESS

The Village of Hazel Crest applied to the Drinking Water 1-2-3 Technical Assistance program and was selected to fulfill the following scope.

SCOPE OF WORK

1. **Conduct a robust desktop inventory of lead service lines**
2. **Develop public education materials and potentially conduct one meeting for residents**
3. **Explore the development and adoption of an ordinance or resolution by the Village Board**
4. **Create a lead service line replacement plan for the village**

ROLES AND DELIVERABLES

1. **Conduct a robust desktop inventory of lead service lines**

   Purpose: Identify where lead service lines most likely exist within the village to understand the number and location for future removal.

   Task: MPC will work with village staff to understand what has been done previously to identify lead service lines. Then MPC and village staff will work together to conduct a desktop audit using various data points — such as historical records, age of construction, building inspections, etc., plus potentially some site verifications — to provide a clearer inventory and understanding of existing lead service lines.

   Deliverable: Completion of an electronic, desktop inventory of lead service lines

2. **Develop public education materials and potentially conduct one meeting for residents**

   Purpose: Provide useful and timely educational materials and information to residents to empower their partnership and action on mitigating lead in drinking water in their homes.

   Task: MPC will conduct a search of nationwide best practices in educational materials, and work with village staff to determine existing, applicable materials, as well as materials that can be repurposed or developed for the village. If deemed appropriate, MPC will conduct one public meeting for residents on steps they can take to mitigate exposure to lead in drinking water.

   Deliverable: Completion of a printed educational piece and a possible public meeting

3. **Explore the development and adoption of an ordinance or resolution by Village Board**

   Purpose: Explore the benefits and usefulness of an adopted ordinance or resolution by the Village Board that promotes a proactive approach to building trust and protecting residents from lead in drinking water.

   Task: MPC will work with village staff to discuss and develop a draft ordinance or resolution that would be feasible for the Village Board to consider for adoption.

   Deliverable: Completion of a draft ordinance or resolution

4. **Create a lead service line replacement plan for the village**

   Purpose: To proactively create a plan and develop a pathway for the village to replace lead service lines over time to remove the risk of lead in drinking water exposure caused by the use of lead service lines and to better position the village to capitalize on state or federal funding when it becomes available.

   Task: MPC (and its contractor) will work with village staff to create a lead service line replacement plan for the village. This will include exploring how to prioritize the most vulnerable populations for lead service line replacement, and what federal, state, and/or local revenue options could be used to help replace lead service lines over time.

   Deliverable: Completion of a lead service line replacement plan.

PLANNING CONTEXT

The Village of Hazel Crest is located in south suburban Cook County at the intersection of Interstate 80 and the Tri-State Tollway (I-294), approximately 22 miles south of Chicago's Loop. The village is bordered by Markham to the north, Harvey and East Hazel Crest to the east, Country Club Hills to the west, and Homewood and Flossmoor to the south (Fig. 1).

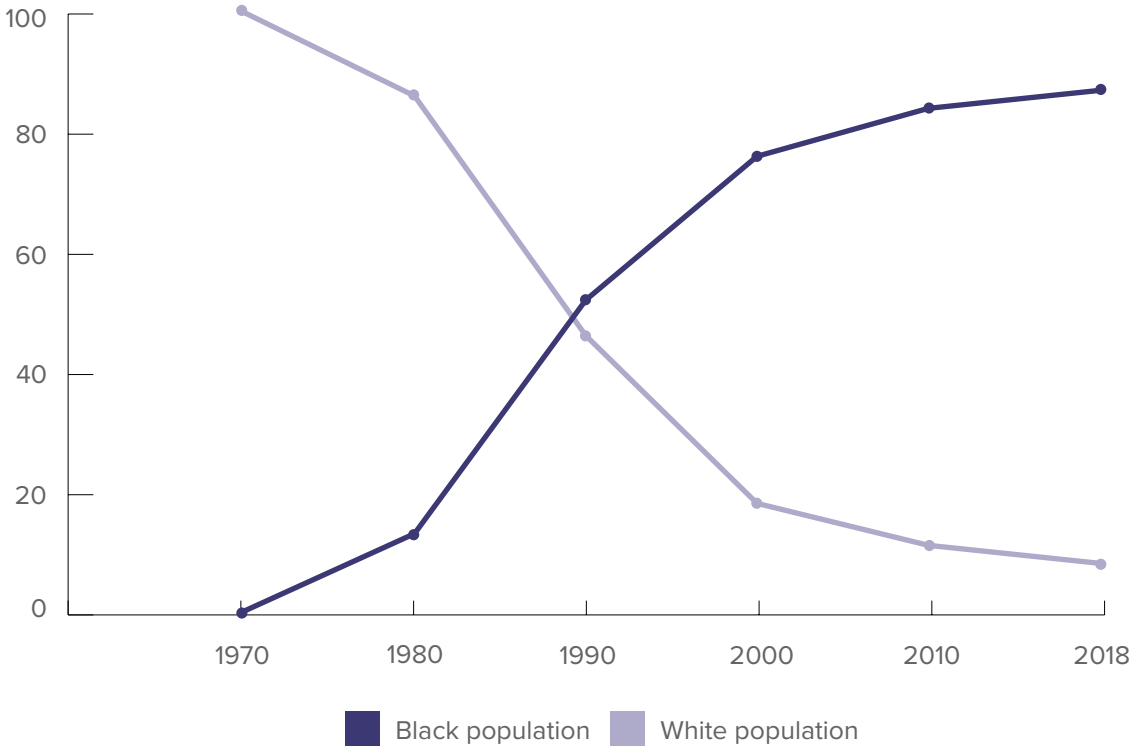
Fig. 1. Regional map of south Cook County with the Village of Hazel Crest center left[1]

Hazel Crest, like much of the Chicago area, was initially settled by the Kickapoo, Miami, Potawatomi, Peoria, and Sioux people.[2] These tribes were typically involved in the fur trade, and some of the native population remained for a time after new settlement in the 1870s.[3] The village was incorporated in 1912. Initially called South Harvey, the name was changed to Hazel Crest in 1900 to reflect the large groves of hazelnut bushes that grew on a hillside south of town. Early development was spurred by the railroads, primarily around 170th Street. This area ultimately became the historic town center, which is known today as Hazel Crest Proper.

In the 1960s, construction of nearby highways and toll road systems further contributed to the development of Hazel Crest and greatly improved interregional accessibility. The 1960s and 1970s saw rapid growth in population — 55 percent of the current housing stock dates to this period — and the village annexed new land to the west and south.

DEMOGRAPHICS

Fig. 2. Racial demographic shift in the Village of Hazel Crest[4,5,6,7,8]



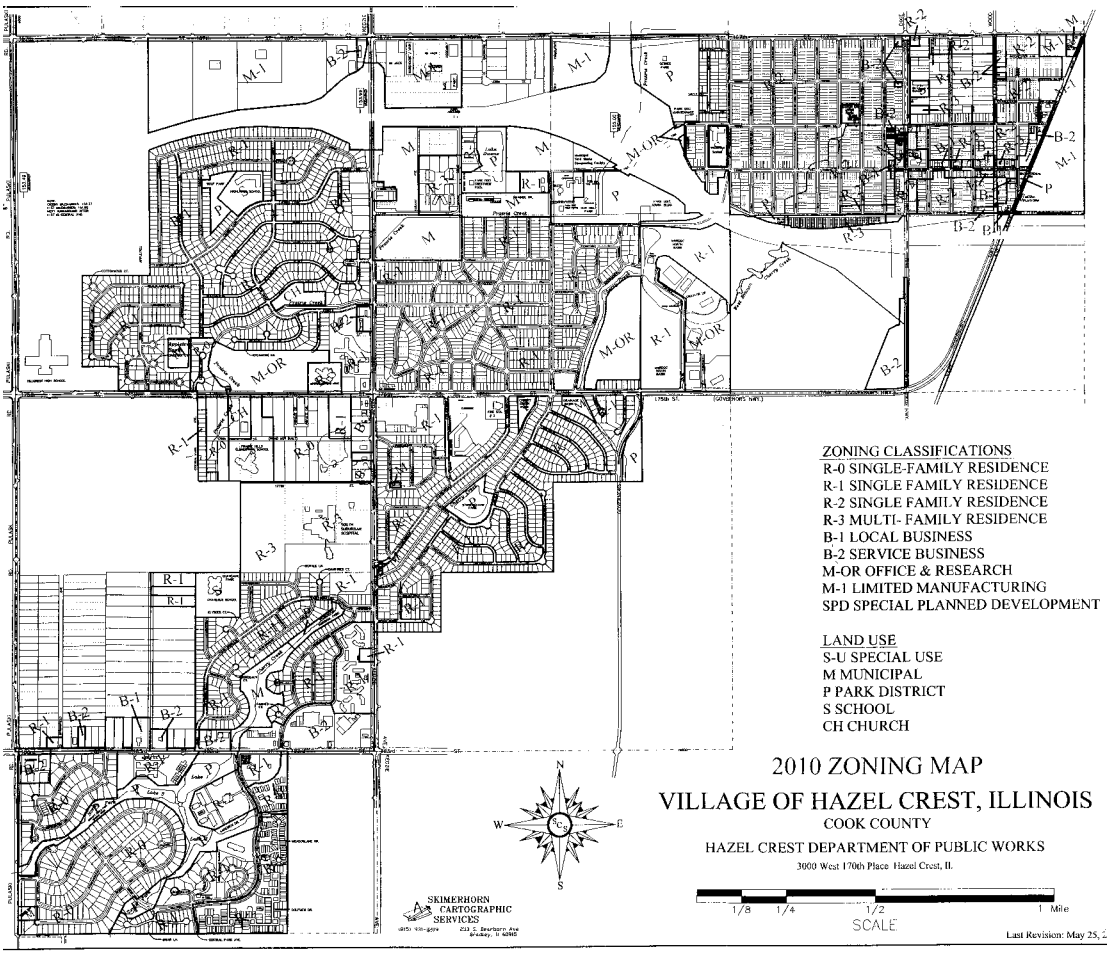
Since 1970, the population has grown from 10,329 to 13,729 individuals in 2018. During the same period, the village has undergone a demographic shift from majority-White to majority-Black, (see Fig. 2). Educational attainment has also shifted over time, with more residents graduating high school and going on to pursue a degree in higher education. In 2018, 20 percent of residents had graduated with a bachelor's degree — up from 14 percent in 2000.[9] In the same period, the median household income dropped by almost $10,000 over the

past 10 years, from $60,941 in 2010 to $51,083 in 2018 (both in 2018 dollars). The 2014-2018 American Community Survey Five-Year estimates reported Hazel Crest's population as 13,729, and, as referenced above, is predominantly Black (87.1 percent). As of 2018, 57 percent of residents own their homes.[10]

In terms of employment, the average Hazel Crest resident works in Chicago, and commutes via automobile. The largest share of the labor force works in healthcare. Within the village, healthcare is also the largest industry.[11]

EXISTING LAND USE

Fig. 3. Zoning map of the Village of Hazel Crest[12]



As of 2013, the predominant land use is Single-Family Residential (41.8 percent), followed by Transportation and Other (28.9 percent). This is followed in a distant third by Institutional (7 percent), much of which is related to Advocate South Suburban Hospital. More than 90 percent of the land area is developed — there is very little room for new development. The community is also landlocked with limited options for annexation.[13]

WATER IN HAZEL CREST

Hazel Crest purchases drinking water from the City of Harvey, which purchases filtered and chlorinated Lake Michigan water from the City of Chicago.[14] The water is re-chlorinated at Harvey and again re-chlorinated by the Sewer and Water Division of Hazel Crest's Public Works Department. This process kills dangerous germs and helps reduce nuisance tastes and odors. No water quality violations were reported in the 2018 Water Quality Report, which is the most recent publicly available information.

In addition to one elevated storage tower (approx. 1,000,000 gallons), Hazel Crest has several ground reservoirs and pumping stations, and more than 60 miles of water mains.[15]

REVIEW OF EXISTING PLANNING DOCUMENTS

The Village of Hazel Crest 2007 Comprehensive Plan provides solid support for implementing a lead service line replacement plan and safeguarding water quality for residents.[16] This project would contribute to one of the plan's goals, i.e., "municipal infrastructure will be well maintained and public services will be efficiently delivered ensuring the health, safety, and welfare of all residents." Within the plan, there is a recognition of the need to improve and update older housing, which correlates with the presence of lead service lines.

Another planning document, "Strategic Planning Process and Roadmaps for the Village of Hazel Crest," produced in 2017, lists one definition of success as, "Older buildings and homes have been tested for lead, and piping is proactively replaced."[17] In the priority area of Water, "Plan lead testing for village water" and "Old piping, underground piping has to be replaced" are listed as mid-term goals (1 to 3 years). Additionally, the report states, "Citizens are engaged through commissions, public board meetings, small citizen forums, and other circles formed to discuss various issues and topics, and are kept well informed by Village communication vehicles about events, services, and other Village initiatives." These are consistent with the producing a lead service line replacement plan and a focus on producing a variety of public education materials in the present planning process.

LEAD AND WATER

THE BASICS ON LEAD IN DRINKING WATER

There is no safe level of lead exposure. Lead poisoning is particularly harmful to children ages 6 and under who can suffer from decreased IQ, hyperactivity, hearing problems, stunted growth, and learning disabilities. Accordingly, pregnant women and nursing mothers, in particular, should also avoid exposure. However, ingestion of any amount of lead at any point in one's life can lead to long-lasting health issues. Adults exposed to lead during their lifetime have an increased risk of heart attack, high blood pressure, kidney failure, and reproductive problems.[18]

Lake Michigan water is delivered to Hazel Crest's water customers via the cities of Harvey and Chicago and does not initially or naturally contain lead. Lead found in tap water usually comes from lead-based pipes, fixtures composed of an unsafe percentage of lead, or from leaded solder used to connect water pipes (Fig. 4).

Fig. 4. Common sources of lead in drinking water[19]

Lead has been used in water supply systems since Roman times, and it was a common material for service lines until it was banned by the U.S. Congress in 1986.[20] A service line is a pipe that connects a residential, commercial, or other property to a water main. To reduce the amount of lead that is released into water from existing lead service lines, the U.S. Environmental Protection Agency (U.S. EPA) Office of Water recommends that community water systems use corrosion inhibitors.[21] Corrosion inhibitors are added by the City of Chicago during the treatment process.[22]

Despite the high cost of replacing lead service lines, healthcare costs associated with lead exposure far outweigh the costs of replacement. For example, the Environmental Defense Fund reported that $22,000 is saved for every lead service line that is removed, a dollar figure that only accounts for adult cardiovascular deaths attributed to lead exposure.[23] Because the health consequences of exposure are lifelong, the more time passes before this problem is eliminated, the more individuals become exposed, at exponential cost to society.

LEAD REGULATIONS

LEAD AND COPPER RULE

At the time of writing, the U.S. EPA's Lead and Copper Rule requires that community water systems conduct sampling to monitor lead and copper. The Lead and Copper Rule is locally administered by the Illinois Environmental Protection Agency (IEPA).[24] Water quality samples are drawn from consumer's kitchen or bathroom taps. Samples are drawn from pre-approved locations, initially every six months and reduced to every three years if concentrations remain under the Action Level of 15 parts per billion for lead or 1.3 parts per million for copper. The emphasis of sampling is to determine whether corrosion control measures are effective. Therefore, priority is placed on sampling single-family residences known to have a lead service line, lead pipes, or copper pipes with lead solder. (If more than 20 percent of the properties served by the community water system serves are multi-family residences, these structures may be included, as well.)

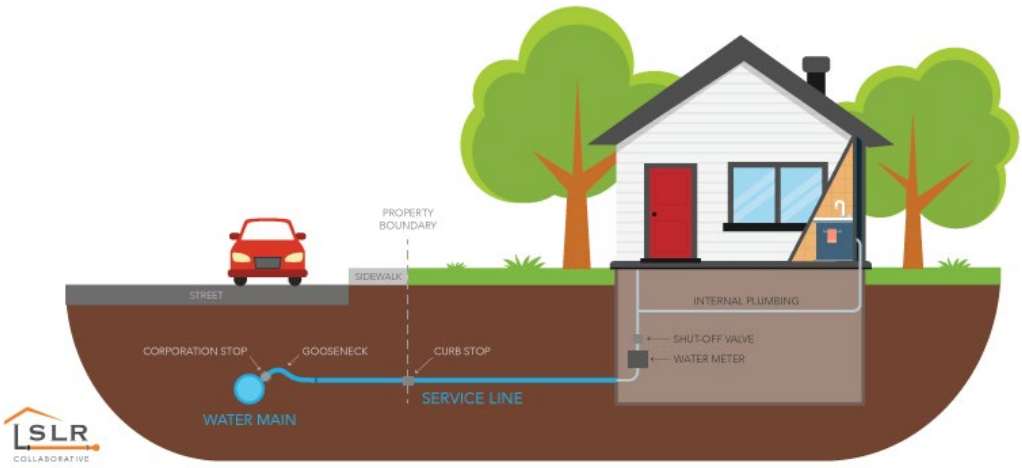
If more than 10 percent of samples exceed the Action Level, the community water system is required to take a number of actions.[19] These include additional sampling, possible source water treatment, corrosion control measures plus establishing parameters to determine if these measures are effective, and public education — such as delivering and posting printed materials, press releases, and other methods for communicating the risk. If corrosion control measures or source water treatment prove unsuccessful, the community water system must begin a lead service line replacement program, annually replacing at least 7 percent of the initial number until an Action Level is not triggered for two consecutive reporting periods.

PARTIAL REPLACEMENT

Importantly, the Lead and Copper Rule, as it currently exists, allows for partial service line replacement, meaning the community water system may replace only the portion of the service line between the water main and the curb stop (also known as a buffalo box, b-box,

or valve box; see Fig. 5). However, partial replacement should not be considered an option. Partial lead service line replacement has been shown to pose a greater risk due to higher concentrations of lead in the short term and, accordingly, is strongly discouraged.[25] Proposed revisions to the Lead and Copper Rule are currently being considered.[26] Also, in 2019, the Illinois Department of Public Health attempted to pass amendments to the Illinois Plumbing Code that would have strictly limited partial replacements, but the changes were not adopted by the Illinois General Assembly.

Fig. 5. Service line components (Image courtesy the Lead Service Line Replacement Collaborative)



SERVICE LINE MATERIAL INVENTORY

Commencing on April 15, 2018, community water systems in Illinois must develop and submit a water distribution system material inventory and are required to report updates annually. This inventory must include the total number of service lines connected to the system and the materials from which they are made, e.g., lead, copper with lead solder, galvanized steel, or unknown.

As of Reporting Year 2019, the number of service lines in Illinois totals 3,826,066, of which 677,359 have been reported as lead.[27] For the same year, the total number of retail connections in Hazel Crest was 4,594, of which 339 were reported to be lead and 252 of an unknown material.[28]

Available on the General Assembly's Illinois Administrative Code database, Section 890 of the Illinois Plumbing Code,[29] Appendix A ("Plumbing Materials, Equipment, Use Restrictions and Applicable Standards"), Table A ("Approved Materials and Standards") lists the approved materials for water service pipes. This list includes Acrylonitrite Butadiene Styrene, brass, cast iron, Polyvinyl Chloride (i.e., PVC), Poly Butylene, Polyethylene, and others. Each must meet the criteria of approved standards listed in the plumbing code. For the most up-to-date information about approved materials for water service pipes, consult the Illinois Plumbing Code.

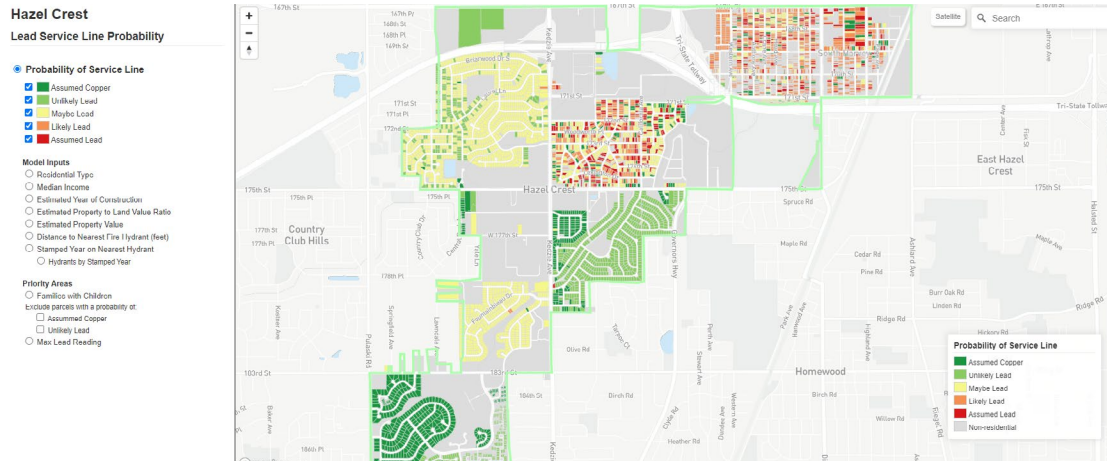
DEVELOPING A LEAD SERVICE LINE INVENTORY USING PREDICTIVE ANALYTICS

INTRODUCTION

The Center for Neighborhood Technology (CNT) worked closely with the Village of Hazel Crest, MPC, IBM Service Corps, and BlueConduit to develop a probability-driven inventory of lead service line locations throughout the municipality. The team collected and analyzed data from the Cook County Assessor, IEPA, and the Village of Hazel Crest to design and build a predictive model using a multiple linear regression analysis that determined whether the presence of a lead service line is likely or unlikely at each residential parcel.

CNT created an interactive map (available at apps.cnt.org/lsl/hazel_crest) that presents the probability for each parcel. Fig. 6 shows a screenshot of this interactive map. Checkboxes allow the user to visualize all of the model inputs or selectively turn on/off specific inputs. The map also includes replacement priority areas, e.g., parcels in block groups with a high percentage of families with children.

Fig. 6. Screenshot of Hazel Crest Lead Service Line Probability interactive map[30]



METHODOLOGY

Developing a probability-driven lead service line inventory requires an initial evaluation of available data, a designation of parcels as dependent variables, or "labels" (i.e., parcels where there is service line material data), the assignment of independent variables, and application of multiple linear regression analysis to develop probabilities for the rest of the parcels for which there is no service line material data.

DEPENDENT VARIABLES

In 2017, the Village of Hazel Crest mailed a paper survey to every residence in Hazel Crest asking residents to verify their water service line material. To guide residents' decision-making, the survey included a picture of what copper versus lead service lines look like. The village received 452 responses, which represented a response rate of approximately 10 percent. Of these, 153 respondents identified their line as copper, 286 respondents identified their line as lead, and 12 respondents were unable to confirm the material make-up of their service line.

In addition to the community administered survey, Hazel Crest's Public Works Department has a list of 85 high-risk sample sites from which they sample 30 homes every three years. This is based on IEPA's administration of the Lead and Copper Rule, which requires water utilities to identify properties that have a higher risk for elevated levels of lead and/or copper and submit the list for approval by IEPA. Upon approval, the utility is required to sample these homes every three years for lead and copper levels.

In the model, parcels with confirmed presence of lead or copper — based on the community-administered survey results and the IEPA Approved Sample Sites — were set as the dependent variables, or "labels." Age of construction was also used as a label. Properties built after 1991 are assumed to have non-lead service lines because the Lead and Copper Rule was passed in 1991.

As labels, these data were used to train the model based on the relationship between the label and independent variables of property characteristics, such as property age and property value. Once a relationship between the label and independent variables was established, a probability of presence of lead was assigned to other parcels, based on similar or divergent characteristics. In general, the more labels in a model, the more accurate the initial assigned probabilities.

INDEPENDENT VARIABLES

For this model, independent variables were property characteristics that might ultimately predict the presence of lead service lines, depending on its predictive relationship with the dependent variables. The independent variables used in this model included residence type (i.e., number of stories), median income of the census block group, the parcel's estimated year of construction, estimated property-to-land-value ratio, estimated property value, and the stamped year on the nearest fire hydrant. Table 1 lists the dependent and independent data used in the multiple linear regression model.

Table 1. Variables used in predictive model

Variable	Data source	Independent or dependent variable (Label)	Data scale (parcel, block group, etc.)
Community-administered survey	Village of Hazel Crest	Dependent	Parcel
Village of Hazel Crest selected and IEPA approved Lead and Copper Rule sample sites	IEPA	Dependent	Parcel
Estimated year of construction	Cook County Assessor's Database	Dependent and Independent	Parcel
Estimated property value	Cook County Assessor's Database	Independent	Parcel
Estimated property to land value ratio	Cook County Assessor's Database	Independent	Parcel
Residence type (i.e., number of stories)	Cook County Assessor's Database	Independent	Parcel
Fire hydrant stamp year (i.e., year of manufacture)	Village of Hazel Crest	Independent	X, Y coordinates

RESULTS

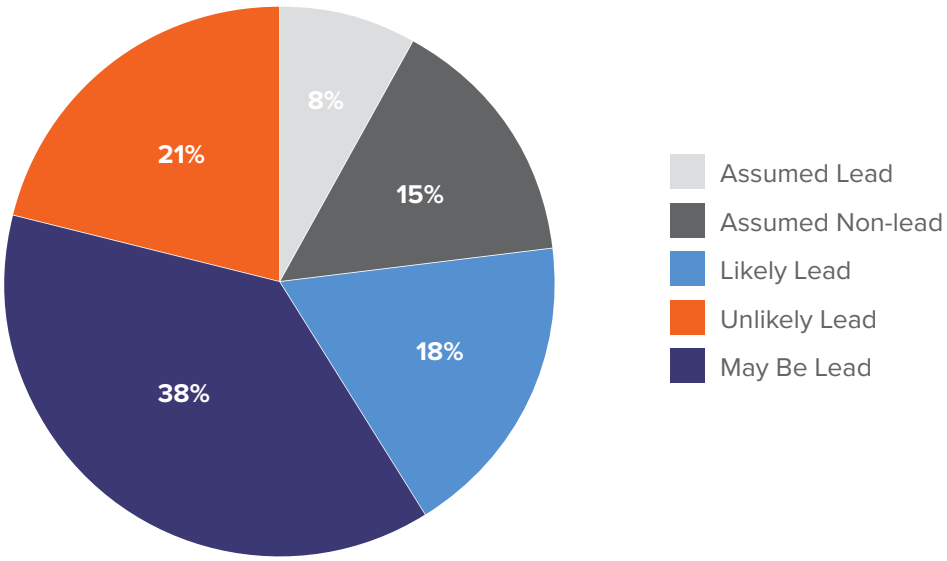
Based on community survey data, age of construction, and data from IEPA, 15 percent of Hazel Crest parcels are assumed to have non-lead service lines, and 8 percent of parcels are assumed to have lead service lines. The probability, or likelihood, of the presence of a lead service line in the remaining 77 percent of parcels was determined using a multiple linear regression. This regression analysis found that 56 percent of remaining parcels "maybe" or "likely" have a lead service line (see Fig. 7).

The vast majority of parcels in the "assumed lead" and "likely lead" categories are in Hazel Crest Proper and the Pott Hills/English Valley and Twin Creeks subdivisions. The Pacesetter/Stonebridge/Carriage Hills and Village West/Dynasty Lakes subdivisions are newer, and, therefore, service lines in those locations are classified as "assumed non-lead" or "unlikely lead."

Based on the model outputs, of the 4,221 residential parcels in the Village of Hazel Crest:

- 633 parcels (approx. 15 percent) are assumed to have non-lead service lines, either because they were built after 1991 (i.e., after the Lead and Copper Rule banned the use of lead in plumbing) or because the village-administered community survey visually confirmed the presence of a copper service line;
- 347 parcels (approx. 8 percent) are assumed to have lead service lines, either because the addresses are on the IEPA's Approved Sample Sites list or because the village-administered community survey visually confirmed the presence of a lead service line;
- 758 parcels (approx. 18 percent) are likely lead, meaning they are predicted to have a high likelihood (66 percent to 99.99 percent probability) of having a lead service line;
- 1,595 parcels (approx. 38 percent) may be lead, meaning they are predicted to have a medium likelihood (33 percent to 65.99 percent probability) of having a lead service line; and
- 888 parcels (approx. 21 percent) parcels are unlikely lead, meaning they are predicted to have a low likelihood (.001 percent to 32.99 percent probability) of having a lead service line.

Fig. 7. Service line materials based on regression analysis



UPDATING THE INVENTORY

These initial results can help guide the village in preliminary decision-making on a lead service line replacement effort. However, owing to the small number of "labels" — or visually confirmed service lines made of lead, copper, or another material — there are limitations to the predictiveness of the model. As the village begins field testing and replacing service lines in high priority areas, those data can be input back into the map database to increase the number of known service line materials. This is important for two reasons:

1. **The village can record and visualize its replacement progress in real time, supporting its goals of compliance and transparency; and**
2. **As the village collects more "labels," these data points can be used to train and update the model used to create the initial probabilities, producing more accurate probabilities for the service lines yet to be tested/replaced.**

BlueConduit, one of the project partners, originated the use of predictive analytics with machine learning to predict lead service line locations through their work in Flint, Michigan. They followed a similar methodology as the one outlined above but also applied machine learning techniques to make their preliminary predictive model smarter. The basic principle behind machine learning is to feed the initial model a random representative sample of "ground truth," or field data, from the community, which would then correct or strengthen the preliminary predictions of where lead service lines are likely or unlikely to occur throughout the community.

Even without a random, representative sample, the Village of Hazel Crest can strengthen the predictiveness of the model by inputting data from field testing and lead service line replacement efforts.

In early 2021, CNT will work with South Suburban Mayors and Managers Association (SSMMA) to develop a map and database maintenance plan to ensure that when Hazel Crest begins collecting field data, either by on-site testing or through community surveys, there will be a straightforward process by which to update the map and train the model. CNT and SSMMA will collect feedback from Hazel Crest staff on this process.

INVENTORY LIMITATIONS

As discussed, one of the principal limitations in developing this inventory was a small number of "labels," or known service line materials. Fewer labels decrease the accuracy of predicted service line materials because there aren't as many known data correlations to inform the probabilities. This limitation can be overcome as the Village starts field testing and increasing the number of labels in the database.

Another notable limitation is the lack of data on the service line materials on either side of the curb stop, i.e., from the curb stop to the water main or to the water meter inside a residence. Regarding the inventory labels, the community survey results provide data for the residential

side of the service line, the IEPA-approved list of addresses for sampling likely provide data for the entire service line, and homes built after 1991 should be lead free.

While these distinctions have not been included in the map or database due to the level of uncertainty, a next step for the inventory database manager would be to add this distinction to the database and assign a designation based on available information. For instance, some of the community survey results for copper came from homes built well before 1991. This might indicate a home rehabilitation project, where the residential half of a lead service line was replaced with another material, but the portion from the curb stop to the water main is still lead. Again, this level of granularity can further support decision-making and efficient use of funds.

LEAD SERVICE LINE REPLACEMENT PLAN

Based on the results of the probabilistic analysis, the Village of Hazel Crest should begin field testing and replacement efforts focused on Hazel Crest Proper and the Pott Hills/English Valley and Twin Creeks subdivisions. The Highlands/Apple Tree and Chateaux/Homewood Gardens subdivisions, which have a medium likelihood of having lead service lines, should be prioritized in the early phase of field testing and replacement efforts, as well.

After determining the subdivisions in which initial replacement will be focused, the village should target parcels that are assumed to have lead service lines and consider other critical demographic and socioeconomic factors to further refine its replacement strategy (see Table 2.) Best practice suggests that, beyond households with a known lead service line, communities should prioritize replacement for households with children, low-income households (especially households below the poverty line), households whose native language is not English, and/or households of color.[31] Communities might also consider environmental justice impacts and health disparities that make some households more vulnerable than others to additional adverse health impacts. Because Hazel Crest is a largely homogeneous community, communities of color or non-native English-speaking households were not used as prioritization criteria: 87.7 percent of the Hazel Crest population is Black/African American, and, in about 94 percent of households, English is the primary language spoken.[32]

It is important to note that the analysis to determine the probability of lead service line locations was done at the parcel scale, whereas many socioeconomic data are generally only available at the census block group scale or larger. Hazel Crest's municipal boundary

intersects with 14 block groups, six of which are fully within the municipality. Therefore, it is impossible to know exactly how many parcels that are "likely" or "assumed" lead also have a child in the home. That said, of the "likely" or "assumed" lead parcels, 626 are in block groups in which more than 44 percent of households have children.

WHERE TO START

As a starting point, the Village should target the 347 parcels with an "assumed lead" designation. As noted above, the parcels assumed to have lead are those with an associated community survey result confirming lead on the private side of the service line or those that are on the list of properties that Hazel Crest submitted to IEPA in the early 1990s confirmed to have a lead service line.

Table 2. Socioeconomic data used to support replacement decision making and prioritization

Variable	Source	Data scale
Single-parent families	U.S. Census	Block group
Non-native English speakers	U.S. Census	Block group
Median household income	U.S. Census	Block group
Percent unemployment	U.S. Census	Block group
Percent of households with children	U.S. Census	Block group
Percent of households below poverty	U.S. Census	Block group
Percent households of color	U.S. Census	Block group

SOCIOECONOMIC FACTORS IN HAZEL CREST

CNT geospatially visualized the intersection between parcels with "maybe," "likely," and "assumed" lead service line designations and with families with children by block group, as well as with median income of each block group (see Figs. 8 and 9.) Of those 2,700 parcel designations, only 695 parcels, or about 25 percent, are in block groups in which 44 percent or more of the households have children; and 2,695 parcels, or 99.8 percent, are in block groups in which the median income is less than $55,000, which is less than Cook County's median household income of $62,088. Table 3 shows how Hazel Crest subdivisions align with lead service line replacement criteria.

Fig. 8. Visualization of the intersection of “maybe,” “likely,” and “assumed” lead service line parcels and families with children by block group

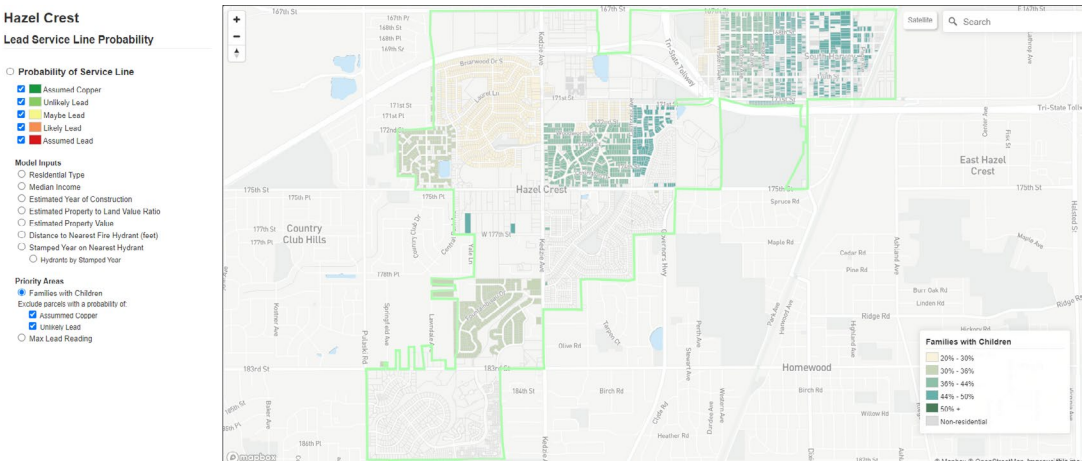


Fig. 9. Visualization of Hazel Crest’s Median Household Income by block group

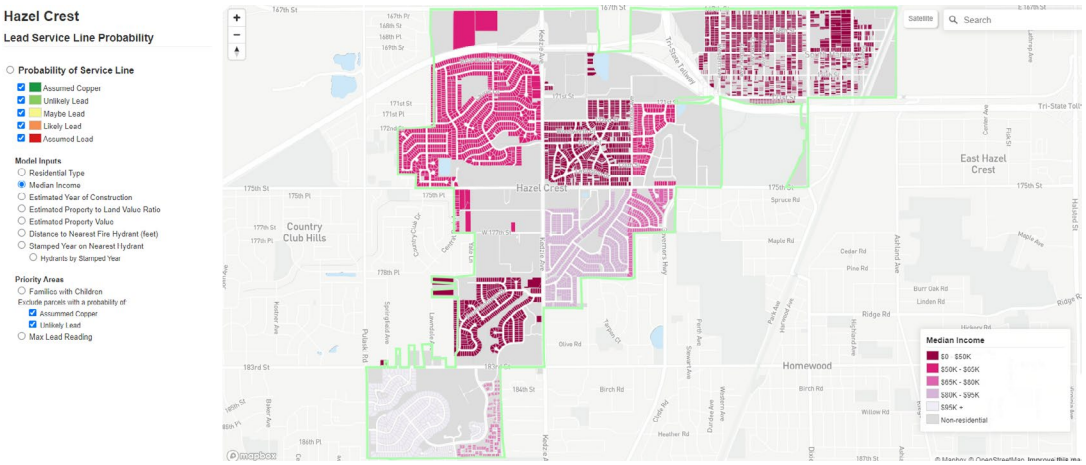


Table 3. Hazel Crest subdivision alignment with prioritization criteria

Hazel Crest subdivision name	Community location	Service line replacement priority based on probabilistic analysis	Aligned block group median income less than $55,000	Families with children make up 44%+ of households in aligned block group[1]
Hazel Crest Proper	Far Northeast	High	Yes	Yes
Twin Creeks	Northeast	Medium	Yes	Yes
Pott Hills/English Valley	North Center	High	Yes	No
Highlands/ Appletree	Northwest	Medium	Yes	No
Pacesetter/ Stonebridge/ Carriage Hills	Center-East	Medium	No	No
Chateaux/ Homewood Gardens	Center-West	Low	Yes	No
Village West/ Dynasty Cakes	South	Low	No	Yes

1 'No' does not imply that there are no families in these subdivisions, just that households with children do not make up more than 44% of the households in the block group (and aligned subdivision).

As noted above, other socioeconomic factors to consider but that are not yet visualized include households in poverty and/or areas with high unemployment. Of the 2,700 parcels designated as "assumed," "likely," and "maybe" lead, 1,031 (38 percent) are located in block groups in which more than 15 percent of households are below poverty.

PROBABILITY-DRIVEN PRIORITIZATION

Because the probability-driven lead service line inventory identified Hazel Crest Proper and the Pott Hills/English Valley and Twin Creeks subdivisions as the areas with the highest concentration of "assumed lead" and "likely lead" parcels, aligned with block group median income less than $55,000, and greater than 44 percent of these households have children (as shown in Table 3), these should be the first areas to begin a lead service line replacement program.

The Hazel Crest Lead Service Line Probability interactive map can be used to find blocks with the highest probable concentrations of lead service lines. Under "Probability of Service Line" on the interactive map, select "Exclude parcels with a probability of: Assumed Non-Lead [and] Unlikely Lead" and then select any variable below (e.g., "Families with Children" under "Priority Areas" to further refine the focus areas.

IMPLEMENTATION

COST ESTIMATES

Materials, labor, and equipment are some of the cost considerations associated with the total cost of service line replacement for a single residence. In addition, construction permits will be required, as well as temporary construction easements from homeowners.

Material considerations include, but are not limited to, the following:

- "Short replacement" vs. "long replacement," based on whether the residence is on same side as a water main
- Diameter of the pipe used for the service line
- Extent of hardscape and landscape restoration required
- Whether a valve needs to be replaced
- Whether a curb stop needs to be replaced
- Whether a water meter needs to be replaced

Accordingly, costs can vary widely. Conservative and high-end estimates range from $8,000 to $10,000[33,34] per service line replacement. The cost, then, for the 347 "assumed lead" parcels ranges from $2,776,000 to $6,064,000. For the 758 "likely lead" parcels, the range is $3,470,000 to $7,580,000. Combined, the total cost *for these two categories* is estimated to be between $8.8 million and $11 million.

According to the Lead Service Line Replacement Collaborative, "[lead service line] replacements could be prioritized based on vulnerable populations, cost-effectiveness, or a combination of both."[35]

COST-EFFECTIVENESS

To achieve greater cost-effectiveness, the best option for lead service line replacement is to coordinate with other infrastructure renewal or replacement programs. For example, because

water mains run mostly under village streets, economies of scale can be achieved by replacing water mains during a road construction project. Coordinating lead service line replacement at the same time work is being done on water mains could result in significant cost savings. Similarly, lead service line replacements can be combined with water meter installations. This, though, needs to be considered in coordination with the earlier recommendation to prioritize households with children, low-income households, and/or households whose native language is not English.

VULNERABLE POPULATIONS

Research conducted by MPC determined that Black and Latinx communities in Illinois are disproportionately at risk of exposure to lead due to lead service lines. In fact, "65 percent of the state's Black and Latinx residents, and 42 percent of Illinois' Asian-American and Native American populations, are living in communities containing 94 percent of the state's known lead service lines; meanwhile, only 30 percent of the state's White population is living in those same communities."[36] Additionally, residents of color and low-income residents are at risk of exposure to multiple sources of lead, including lead-based paint and lead-contaminated soil from lead-based paint chipping off the exterior of a home.[37]

As mentioned previously, because Hazel Crest is a predominantly Black community (87.7%), race is not a useful indicator for prioritizing lead service line replacement. Instead, the focus should be on protecting other vulnerable groups, in particular children under the age of six, and pregnant and nursing mothers, especially those who live below the federal poverty level.[38] Low-income residents should also be prioritized for replacement, e.g., residents earning at or below 150 percent of the federal poverty level.

For these groups, consider covering the full cost of lead service line replacement — including waiving all permitting and inspection fees — and providing water pitchers and replacement filters certified to remove lead to homes with "assumed lead" and "likely lead" service lines. This, of course, is contingent upon the village receiving funding to support lead service line replacement efforts.

Additionally, special consideration should be given to renters/tenants in buildings where the landlord is unwilling to share the cost of replacement.

MULTI-SECTOR COORDINATION WITH HEALTH AND EDUCATION INSTITUTIONS

Working with local and regional health and education institutions can ensure that a replacement plan is informed by a more granular understanding of where children reside and if there are households with known lead-related health impacts from paint, dust, or otherwise. Due to HIPAA protections and school enrollment confidentiality, the village may need to provide these institutions with a prioritized list of homes for replacement and allow the institutions to further refine the list based on their confidential data. Additionally, spot checks should be conducted at elementary schools, childcare facilities, and other locations where children are known to gather, particularly if those properties were constructed prior to 1991, when the use of lead pipes was outlawed.

FUNDING

Implementation of these recommendations will take time and, of course, money. The intent of this document is for the Village of Hazel Crest to be well situated to apply for grants or stimulus funding if and when it becomes available. Often, though, these funding sources require a percentage of matching funds from the applicant. Setting water rates that accurately reflect the full cost of providing water service is one step toward paying for necessary upgrades and replacement, in addition to costs related to ongoing operations and maintenance.

Funding options discussed below include the Drinking Water State Revolving Fund, Water Infrastructure Improvements for the Nation Act, and water rates.

STATE REVOLVING FUND

The State Revolving Fund (SRF) is a low-interest loan program designed to support water service infrastructure repair and replacement.[39] Each year, Congress appropriates funds to the SRF, and the U.S. EPA proportionally distributes these funds to each state based on a regular Needs Assessment. Illinois combines these federal dollars with required state matching funds, program repayments, bond proceeds, and interest on loans to generate a perpetual source of loan money dedicated to water supply, wastewater, and stormwater infrastructure needs.The Illinois EPA (IEPA) administers the SRF.

The SRF's Public Water Supply Loan Program, created in 1997, addresses the requirements of the State Drinking Water Act by providing funding for drinking water treatment, storage, and distribution systems. Applicants must submit a funding nomination form and obtain planning approval prior to March 31 annually. Projects are subsequently scored and ranked, and the selected projects are added to the Intended Funding List, with funds distributed on or after

July 1. More information is available at www2.illinois.gov/epa/topics/grants-loans/state-revolving-fund.

Drinking Water Loan Program for lead service line replacement — IEPA has been providing principal forgiveness loans for lead service line replacement for several years but with only limited funding available. Federal action allowed them to do a one-time transfer of approximately $100 million from their Wastewater Loan Program to their Drinking Water Loan Program. This money must be spent on lead service line replacement, and it must be spent by 2023 (though the agency expects it will be gone before then). There is a $4 million limit per applicant. Parties interested in applying should submit a Project Plan *as soon as possible*. Bill Jankousky (bill.jankousky@illinois.gov) is IEPA's on-staff expert on lead service line replacement; he is available to answer any questions about the application process. More information is available here: www2.illinois.gov/epa/topics/grants-loans/state-revolving-fund/Pages/state-revolving-fund-forms.aspx.

WATER INFRASTRUCTURE IMPROVEMENTS FOR THE NATION ACT

Adopted in 2016, the Water Infrastructure Improvements for the Nation Act (WIIN) amended the Safe Drinking Water Act, allowing the U.S. EPA to provide grants to states aimed at improving America's drinking water infrastructure. At the time of passage, $39.9 million was estimated to be annually distributed to applicants. Applicants must cost-share 20 percent of the total project cost, part of which can be waived if affordability is an issue. Applications were accepted between February and June 2020, submitted through www.grant.gov. Application dates for 2021 have yet to be announced, but Hazel Crest may be eligible for the Reduction in Lead Exposure Via Drinking Water Grant program.[40]

WATER RATES

A public utility can utilize rates to fund infrastructure projects. However, communities with predominantly low- to moderate-income residents often cannot bear rate increases sufficient to fund major infrastructure improvements. To avoid rate shock and prepare for water infrastructure replacement over the coming decades, incremental, long-term rate increases are recommended.[41]

Full-cost water pricing sets rates that are sufficient both to encourage water conservation among water users and to provide utilities with sufficient revenue to pay for long-term infrastructure needs. Determining the "full cost" of water requires that a utility have a solid understanding of their budget and capital improvement needs. As such, full-cost water pricing is part of larger initiatives to get the utility on sound financial footing. For more information, "Full-Cost Water Pricing Guidebook for Sustainable Community Water Systems" is an invaluable resource.[42]

PUBLIC EDUCATION MATERIALS

When developing and implementing a lead service line replacement plan, the municipality should take proactive steps to communicate with the public and be transparent about the process.[43,44] To that end, MPC and the village's Greenest Region Corps members conducted a search of nationwide best practices in lead-related public education and worked together to develop a suite of materials. These include:

- Web content for the village's website, explaining the sources of lead in drinking water, why lead exposure is harmful, and how residents can protect themselves. The content also provides a project overview and explains how residents can submit photos of their service lines to help make the lead service line inventory more accurate;
- Double-sided flier for residents, which essentially is a print version of the web content;
- E-newsletter content explaining the project in the village's weekly email newsletter;
- Public Service Announcement with President Alsberry for broadcasting on the village's public access channel, again explaining the project and how residents can help; and
- Template presentation for use by Hazel Crest staff when presenting to block clubs and at other meetings.

The intent was to provide the same information in various formats, in consideration of the different ways people engage with the municipality and to account for the digital divide. Because English is the primary language for 94.2 percent of village residents,[45] MPC determined that creating these materials in other languages is not a priority at this time.

LEAD AND WATER RESOLUTION

MPC worked with village staff to explore the benefits and usefulness of an adopted ordinance or resolution by the Village Board that promotes a proactive approach to building trust and protecting residents from lead in drinking water. Such an ordinance or resolution can ordain or resolve to take a range of actions, including but not limited to the following:

- resolve to take action on lead service lines
- provide for voluntary lead service line replacement (e.g., Elgin, Illinois)
- provide lead service line replacement for eligible low-income residents (e.g., Chicago, Illinois)
- mandate replacement if lead service line is found to be leaking or damaged (e.g., Fond du Lac, Wisconsin)
- prohibit the existence of lead service lines; create a mandatory replacement program (e.g., Newark, New Jersey)

Because the intent of the present technical assistance project is for the village to be ready when state or federal funding becomes available, it was determined that a simple “resolution to take action” would be appropriate. Rather than requiring immediate action, this resolution is a proactive approach to transparency and building trust with local residents, acknowledging the potential threat lead service lines pose to public health, and committing to take action via the development of a lead service line inventory and replacement plan. Resolution no. 06-2020 RESOLUTION TO TAKE DIRECT ACTION TO MITIGATE EXPOSURE TO LEAD IN DRINKING WATER passed unanimously on October 13, 2020.

The village issued a Press Release on November 10, 2020, detailing the resolution and this technical assistance project, and the Daily Southtown — a newspaper owned by the Chicago Tribune Media Group — covered the story in their November 18 issue.[46]

PENDING LEGISLATION

Illinois has the highest number of lead service lines in the U.S.[47] There was an attempt at passing state legislation requiring full lead service line replacement in 2019, but Senate Bill 1532 did not make it out of the Illinois Senate. In his 2020 State of the State address, Gov. J.B. Pritzker spoke of clean water infrastructure as a priority, but the pandemic interrupted many plans for 2020. There is good news, however, as talks have been revived. During Chicago Water Week 2020, MPC hosted a webinar to discuss state and federal solutions and national best practices to address this public health issue.[48] Priorities discussed include:

- an equitable, feasible, and fully funded plan for replacing all lead service lines in Illinois;
- targeted assistance programs to protect low-income households from potential water rate increases;
- establishment and use of best practices;
- prioritization of high-risk communities;
- ensuring Black and Brown communities share in the thousands of good jobs that would be created by a statewide lead service line replacement plan;
- increased state agency capacity to support lead service line replacement; and
- firm timelines to ensure lead service lines are replaced in a timely fashion.

CONCLUSION

Through the Drinking Water 1-2-3 Technical Assistance program, MPC and CNT partnered with the Village of Hazel Crest to: 1) Conduct a robust desktop inventory of lead service lines; 2) Develop public education materials and potentially conduct one meeting for residents; 3) Explore the development and adoption of an ordinance or resolution by the Village Board; and 4) Create a lead service line replacement plan for the village.

Probabilistic analysis was used to determine that, of the 4,221 residential parcels in the village, 18 percent are likely lead in addition to the approximately 8 percent which are assumed to be lead based on sampling and the community-administered survey. There are limitations to the modeling based on the number of known service line materials. That said, this report provides information that can help Hazel Crest's elected officials and staff make informed decisions and prepare to tackle this important risk to public health.

The location of "assumed" and "likely" lead service lines, when paired with data on vulnerable populations, provides clear guidance on where the village should focus implementation efforts. As greater certainty of the location of lead service lines is confirmed during replacement, or via resident-submitted service line pictures, the model and interactive map can be updated and, thereby, further focus the municipality's efforts to replace lead service lines over time to remove the risk of lead in drinking water exposure caused by the use of lead service lines.

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