Ontario Municipal Water Association

Executive Summary:

Lead was believed to be safe for use in water systems and hence was commonly used in the past for both water distribution systems and household plumbing components. With advancements in science, we now understand that this is not the case and in fact, that there is no known safe level for lead in drinking water. Even the smallest amount of lead in drinking water can have far-reaching and serious health consequences for many including infants, young children, expectant mothers, and older adults.

Although the use of lead components has been prohibited in Canada since 1975 and lead solder since 1986, many lead components are still in service in distribution and household plumbing systems. As such they will continue to impair water quality and pose a threat to the health of consumers until removed or eliminated from direct contact with the potable water.

Many Ontario municipal drinking water systems have implemented lead removal and control programs however there is a wide range of progress in eliminating lead from our drinking water across Ontario drinking water systems. Many municipalities are challenged by the expense and complexity of locating and eliminating lead components as well as the lack of control over eliminating private side lead components. Successfully eliminating lead from Ontario water supplies requires a coordinated, collaborative approach led by the province given the financial, resourcing, and public communication challenges.

Consequently, the Ontario Municipal Water Association is recommending that the province of Ontario undertake consultations with industry stakeholders including municipalities to develop a comprehensive plan of action to eliminate the lead issue from drinking water within specified time frames.

The OMWA recommendations delineate key elements for a lead elimination strategy that defines a logical and phased approach to deal with the lead issue - starting with enumerating lead inventories, raising the level of stakeholder and public awareness, and developing support programs designed to share the financial burden and promote equity. Further, mandatory requirements and timelines are included in the recommended strategy to promote public health equity across the province.

Introduction:

Lead is an elemental metal commonly found in the environment both naturally and from human activities. Lead has some properties such as a low melting point, relatively good flexibility and durability, and comparatively high resistance to corrosion which have resulted in its having been used in many applications including piping, as a gasoline additive, a component of lead-acid batteries, and an ingredient in house paints. It was also relatively inexpensive.

Lead was commonly used in components of drinking water and household plumbing systems for several applications including pipes, fixtures, fittings, solder, or service connection pipes to homes. The use of lead for these components became more widespread around the time of World War II as copper and other metals were diverted to the war effort.

At the time, the best science of the day indicated that lead was safe for use in potable water systems. We now know that this is not the case, thanks to scientific advancements that clearly show that lead belongs on the list of prohibited hazardous building materials that were once thought to be safe and used with the best of intentions in home construction such as asbestos, urea-formaldehyde foam insulation, and polychlorinated biphenyls.

Unfortunately, these legacy lead components in use in our drinking water and plumbing systems will continue to impair the water quality and threaten public health until they are removed or eliminated from directly contacting our drinking water.

Human exposure is typically from either inhalation of particles from burning materials containing lead or ingestion of dust, food, or water containing lead. The inorganic lead compounds found in drinking water suggest that the primary route of exposure from drinking water is ingestion. Typically lead can get introduced into the water when various internal corrosion mechanisms act on lead components and impart lead into the water. Health Canada indicates that significant reductions of lead in products such as gasoline and paints mean that food and drinking water are now the primary sources of lead exposure for the average Canadian.

Once in the body, lead is distributed to the brain, liver, kidneys, and bones. It accumulates over time and is stored in the teeth and bones. The degree of human exposure is usually assessed through the measurement of levels in the blood. Health Canada (HC), the World Health Organization (WHO), as well as the United States Environmental Protection Agency (USEPA) and Centre for Disease Control (CDC) all agree that there is no safe level of lead in blood.

Health Effects of Lead:

Lead exposure can have serious consequences for the health of children. WHO indicates that at lower levels of exposure that cause no obvious symptoms, lead is now known to produce a spectrum of injury across multiple systems in the human body. Lead can affect children's brain development, resulting in reduced intelligence quotient (IQ), cause behavioural changes such as reduced attention span and increased antisocial behaviour, and reduced educational attainment. Lead exposure also causes anaemia, hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs. The neurological and behavioural effects of lead are believed to be irreversible.

Even blood lead concentrations as low as 5 µg/dL may be associated with decreased intelligence, behavioural difficulties, and learning problems in children. As lead exposure increases, the range and severity of symptoms and effects also increase.

EPA lists health effects for adults exposed to lead including reproductive problems for both men and women, high blood pressure and hypertension, nerve disorders, memory and concentration problems, and muscle and joint pain.

EPA indicates that during pregnancy lead is released from the mother's bones along with calcium and is passed to the fetus or the breastfeeding infant. This can then result in serious health effects such as increased risk of miscarriage, premature births, lower birth weight, and damage to the baby's brain, kidneys, or nervous system.

All these health outcomes are preventable. The tool kit for reducing health risks from lead in drinking water is well understood and achievable but only if lead exposure reduction programs become a priority for government and are adequately resourced under a coordinated, comprehensive, and mandatory framework.

Sources of Lead in Drinking Water:

In Canada, lead is not usually found in natural water sources or in water from drinking water treatment plants. However, lead can enter drinking water if it is released from parts of distribution or plumbing systems that contain lead. Lead is more likely to be present in the drinking water of older homes and neighbourhoods because the National Plumbing Code of Canada considered lead an acceptable material for use in pipes, service lines, and other appurtenances that bring water to homes until 1975. Lead containing solder was considered acceptable until 1986. While the primary focus for lead removal is homes built prior to 1990, even newer homes may contain lead because fixtures such as brass faucets that contain lead are still commercially available.

Lead pipes were commonly used for the pipe that connects individual homes to the watermain called the service line. Lead service lines (LSL's) typically represent a significant proportion of the lead exposure risk for homes. Usually, the ownership of the service line is a shared one, with the municipality responsible for the portion from the watermain to the lot line and the property owner responsible for the remaining portion from the lot line into the home. This arrangement often complicates lead removal efforts because property owners are typically either unable or unwilling to cover replacement costs for the private portion. Partial replacement of LSL's does not resolve the exposure risk and in some cases has been shown to exacerbate lead contamination risks.

Lead contamination is typically related to corrosion mechanisms and so varies with many factors ranging from water chemistry to residence / stagnation time in contact with the lead. Although effective interim mitigation strategies are available, the range of factors that can result in increased lead levels makes it difficult to eliminate risk with these strategies. Unequivocally the most definite and permanent long-term approach to reduce lead exposure is removal of LSL's.

Current State in Ontario:

In March 2019, Health Canada released a revised lead guideline with a lower lead limit of 5ug/L. There has been no policy or legislation update by the Province of Ontario to improve the regulatory framework for lead in drinking water in response to Health Canada's release of those recommendations.

Existing Ontario regulations specify a lead limit of 10ug/L and require water supply providers to conduct community-based sampling at the tap for lead as well as sampling and flushing programs for schools and daycares serving particularly vulnerable populations. Regulations also require implementation of corrosion control programs for municipalities depending on whether their test results comply with existing limits.

Despite the current suite of lead control measures in place in Ontario, there remains a significant health risk to the population from lead in drinking water with no clear timeline for resolution. To gauge interest in addressing this situation from water professionals, the Ontario Municipal Water Association (OMWA) launched a 3-part webinar series in May-June of 2021 focussing on controlling lead in drinking water. The OMWA began follow-up consultation with members in Fall 2021 which ultimately led to the creation of this document.

The OMWA believes that reducing or eliminating lead from Ontario drinking water is both reasonable and achievable and the province should undertake formal consultation over the next year on the topic of eliminating lead, primarily by eliminating lead service lines (LSLs).

This document integrates input from our members and an Expert Panel established to review some of the topics that should be included in stakeholder consultations and an updated framework designed to reduce risks to consumers from lead in drinking water. The OMWA's strategic objective with respect to the lead file is to *'reduce health risks to water consumers by eliminating all LSLs in Ontario while ensuring exposures to the population are at or below Health Canada's recommended lead drinking water standard during the elimination period'*.

Program Cost Discussion:

Despite efforts made to date in many Ontario drinking water systems to eliminate lead components, the scope and costs of an Ontario-wide Lead Exposure Reduction Program are expected to be significant.

While the focus on the costs of eliminating lead is understandable, any discussion on costs should also include consideration for the costs of inaction. These costs can include long term costs for communal monitoring and corrosion control as well as the societal and health care costs to treat illnesses brought about from lead contamination. Other costs of inaction may include lead control measures, and legal and settlement costs associated with lawsuits if contamination incidents occur.

The PEW Institute in the United States published a document in 2010 that presented information from a study on the cost-benefits of lead abatement measures.

Although the study included lead contamination from sources in addition to potable water consumption (which exist in Ontario, too), they concluded that additional societal costs related to lead exposure fell into six categories including health care, IQ loss, increased special education needs, lower earnings, behaviour problems and crime.

PEW summarizes the findings of their study as: "Despite dramatic improvements over the past 30 years, lead poisoning remains a serious hazard for hundreds of thousands of young children across the country. Lead exposure can cause significant biological and neurological damage, resulting in cognitive and behavioral impairment that can affect children's lifelong success. A new study finds continuing risks, especially to low-income children who live in older housing with lead paint,1 and the potential for significant cost savings from reduced rates of lead exposure. This report concludes that returns on large-scale lead abatement efforts would yield at least $17 per dollar invested, saving billions of taxpayer dollars through a range of social benefits."

Please refer to Appendix 3 below for additional reference information on the cost impacts of lead contamination.

The PEW document can be found at the following link: (https://www.pewtrusts.org/~/media/assets/2010/02/22/063_10_paes-costs-of-lead-poisoning-brief_web.pdf)

Even with the expected substantial financial costs for abatement measures, other jurisdictions are pressing forward with Lead Reduction Programs. After several recent notable and well-publicized incidents of significant lead exposure to residents in New Jersey (Newark), Pennsylvania (Philadelphia), and Michigan (Flint & Benton Harbour), the United States Environmental Protection Agency has earmarked over 20 billion dollars to address issues including lead contamination.

Denver Water is an example of a Lead Reduction Program success story In the United States. The program is already underway with Denver implementing their program over the next 15 years to eliminate an estimated 64,000 – 84,000 Lead Service Lines with an estimated cost of $304M - $556M USD. https://www.denverwater.org/your-water/water-quality/lead)

Denver's multi-faceted program has 5 core elements:

- pH adjustment: Increasing the pH level of the water to reduce the risk of lead and other metals getting into drinking water from lead service lines or household plumbing.
- Inventory: Developing and maintaining a publicly accessible inventory of all customer-owned lead service lines in Denver Water's service area.
- Lead Service Line Replacement: Replacing all lead service lines with copper lines at no direct charge to the customer.
- Filter Program: Providing a free water pitcher, filter and replacement filters, certified to remove lead, to all customers suspected of having lead services lines until six months after their line is replaced.
- Ongoing: Communication, outreach and education programs.

Denver's commitment to the public health of their community is evident by the scope of this program.

Background on the Ontario Municipal Water Association:

The Ontario Municipal Water Association (OMWA) represents more than 140 Municipalities and Public Drinking Water Authorities in Ontario, serving more than seven million customers, and our board includes elected, appointed and management representatives. Additionally, the OMWA's Water, Wastewater, and Stormwater Equipment & Technology Advisory Council (W^3ETAC) is comprised of manufacturers, suppliers, and consultants who provide goods and services to the $water^3$ sector in Ontario.

The OMWA brings together this wide cross-section of expertise to provide direction and leadership on policy, legislative and regulatory issues related to public drinking water, wastewater, and stormwater systems. The OMWA is oriented towards actions aimed at ensuring the best possible safety, quality, reliability, and viability of public $water^3$ systems in Ontario.

OMWA's stated mission is:

"To act as the voice of Ontario's public water authorities through actions which sustain and protect the Life Cycle of Water".

<u>OMWA's Position on Lead:</u>

Given the importance of providing lead-free drinking water to our membership, the OMWA hosted a complimentary 3-part webinar series during May and June of 2021 featuring Ontario municipalities and service providers with innovative, collaborative, and best practice approaches to control communal exposure to lead from public water supplies and protect vulnerable consumers.

This sampling of current lead control practices and approaches illustrated exemplary work from several municipalities – successfully functioning practices that could be leveraged to form part of a toolkit for lead elimination and control for others.

With this starting point, the OMWA supports further provincial action on reducing lead in drinking water including aligning Ontario standards with the 2019 Health Canada recommendations for maximum acceptable concentration and developing interim strategies to control the exposure to vulnerable water consumers until LSLs can be removed from service.

To leverage the real-world experience and subject-matter expertise of members and other attendees, the OMWA then developed and published a questionnaire in October of 2021 on Ontario lead policies and controls to solicit input from the waterworks Sector. Respondents provided many valuable insights that have been integrated into the OMWA's recommendations in this submission.

The OMWA then convened a volunteer 'Lead Expert Panel' representing a geographically diverse group of 10 Ontario municipalities as well as a member representing the Canadian Environmental Law Association (CELA). Sessions were conducted with the Expert Panel to develop and calibrate the following recommendations through their lens of operational expertise and field experience.

<u>Recommendations:</u>

OMWA recommends that the province take a leadership role in collaborating with local water authorities, internal provincial counterparts, and industry stakeholders to develop a comprehensive program to eliminate lead from Ontario's drinking water and determine a clearly identified and mandatory time frame.

OMWA believes this objective can be achieved by eliminating all LSLs in Ontario while ensuring exposures to the population from drinking water are at or below the Health Canada guideline for lead in drinking water during the elimination period.

OMWA recommends that the Province of Ontario introduce a Lead Exposure Reduction strategy for drinking water that blends regulatory changes, funding mechanisms, public education and outreach and other program improvements to accelerate the replacement of LSL's with defined reasonable targets and prescribed time frames. Elements of this suite of measures should include a combination of updated regulations, increased funding, improvements to lead sampling requirements and protocols, and detailed guidance and technical support. The program development and stakeholder consultation should be undertaken by July 1, 2023.

In support of this objective, the province should also develop policies and guidance materials to improve the public's understanding of the issue and outline the steps and timelines that drinking water systems must take to achieve 100% LSL removal/replacement. This information and guidance should include a standard methodology for identifying service line materials and in particular, variations of LSLs and component configurations data that feed municipal system LSL inventories as well as a framework for mapping service line materials, and also include policy templates, best practices, and case studies. This guidance should include acceptable alternatives (e.g. service lining) that comply with the province's definition for LSL 'removal'.

The province should also encourage the use of smart technologies such as data analytics and machine learning techniques that use statistical methods and algorithms to improve the reliability of data-based classifications or predictions. These technologies can yield improved interpretations for projects involving data mining and other methods to deliver predictive analytics. Such approaches could facilitate faster and less expensive ways to identify, map, and display service line material inventory and highlight LSLs.

The OMWA further recommends that as a minimum, specific elements of a prescribed approach for each drinking water system should include:

1) A new regulation under the Safe Drinking Water Act that shall require all owners of drinking water systems to develop and implement a **Lead Exposure Reduction Plan (LERP)**, approved by local municipal Councils, and submitted and approved by the MECP, by December 31, 2023. The terms of reference and requirements should produce a planned, measured, and transparent approach to the identification and elimination of all LSL's.

2) The new regulation shall outline mandatory requirements for all "LERPs" including:
    a) Complete an inventory/registry of all service line material, including private side, within the service area by December 31, 2024.
    b) Complete a publicly available inter-active map of service line materials showing known lead, unknown materials, and non-lead material service lines.
    c) Formal notification to property owners and tenants upon discovery of an LSL supplying their property including:
        (i) Potential health impacts from lead in drinking water
        (ii) Information on how to mitigate potential health impacts, including provincial standard methods for flushing an LSL for daily usage or if the service is disturbed
        (iii) Information on flushing lead contamination from plumbing following replacement of an LSL or lead containing appurtenance
        (iv) Information on locally available financial assistance programs for removal
    d) Publicly report (at least annually) progress on LSL removals and all other lead control measures.

e) Develop a framework for inter-agency collaboration for program referrals, including public health, and other community groups and agencies whose clientele meets the definition of high-risk as it relates to lead, such as expectant mothers, children under six years of age, preschools, and daycares
f) Provide interim control measures (such as NSF-053 filters) to protect vulnerable populations and general consumers until LSLs are removed
g) Elimination (removal or lining) of all LSLs by December 31, 2035.

3) The province should undertake necessary regulatory and/or policy updates to facilitate additional measures including:
   a) Enabling mandatory requirements to eliminate all lead material service lines whether lead is found to be present on the private or public portion.
   b) Improving risk communication through the development of guidance for public water systems to inventory and eliminate LSLs, and public education and communication tools and materials.
   c) Developing a disclosure toolkit for real estate transactions requiring mandatory disclosure of LSLs for any changes in tenancy or ownership.
   d) Developing educational materials, requirements, funding incentives and other mechanisms specifically designed to encourage private LSL replacement and strongly discourage partial LSL replacements. (e.g. Building code: mandatory removal before sale, or before any building permit is issued)

4) Developing special interim lead exposure control requirements, policies, and programs aimed at protecting vulnerable populations such as found in schools, daycares, unlicensed daycares, public housing and senior living residences.

5) Developing funding mechanisms to share responsibility for the financial burden of lead elimination and control measures between the province and water system owners by:
   a) Structuring financial support programs proportionally according to system needs; establish and link metrics recognizing the capital burden for LSL replacement as a fraction of total capital budget to ensure support is effectively and equitably targeted.
   b) Recognizing the importance of equity, and the social and ecological determinants of health, establishing financial assistance programs to facilitate access to lead control measures for vulnerable populations requiring financial assistance, including grants for low-income people and a ban on passing along the cost of LSL removal or interim measures to tenants
   c) Committing to providing oversight, financial, and technical support for all communities requiring assistance and, in particular smaller or more remote systems where there may be additional challenges to implementation of the Lead Exposure Reduction Plan.

6) The OMWA recommends amending Ontario regulations to include a Drinking Water Standard for Lead of 5 µg/L while requiring system owners to continue to work towards the goal of obtaining an *As Low As Reasonably Achievable* (ALARA) based lead exposure future.

7) The OMWA recommends that the province undertake a review and update of the existing regulations governing drinking water lead sampling protocols to build a sampling regime that is more representative of actual risks to consumers from their drinking water.
    a) Updated sampling requirements should require a linkage for sites of mandatory testing at the tap to the inventory of either known or likely LSLs

<u>Acknowledgements:</u>

OMWA Co-Chairs:
Kathy Vassilakos, OMWA Director & Stratford City Councillor
Cheryl Beam, OMWA Director & Program Lead, Water and Wastewater Task Force, City of Greater Sudbury

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The Ontario Municipal Water Association wishes to recognize and acknowledge the following volunteer members and their respective communities of our Lead Expert Panel and thank them for their commitment to providing safe drinking water and specifically for their interest in, and contributions to, the development of this document:

Lead Expert Panel:
Andy Campbell – City of Ottawa
Stephen Gendron – City of Orillia
Tony Santos – City of Thunder Bay
Amie Rutherford – City of Brantford
Patrick Halévy – City of Brantford
Sarah Cooke – Town of Smiths Falls
Heather Roberts – Utilities Kingston
Natasha Glauser – City of Waterloo
Sault Ste Marie Public Utilities Corporation
Jaqueline Wilson – Canadian Environmental Law Association (CELA)

Appendices:

Appendix 1: Case Studies

This Appendix features case studies from Ontario municipalities and public water service providers with innovative, collaborative, and/or best practice approaches to eliminating LSL's and/or controlling communal exposure to lead from public water supplies and protecting vulnerable consumers during the elimination period.

1. Case Study: City of Ottawa

The City of Ottawa is located in Eastern Ontario with a total population of 1.18 million; approximately 950 thousand of which are on the city's central drinking water system. The source water is the Ottawa River which is a near pristine source that is very soft, low in alkalinity but high in natural organics. Ottawa's central drinking water system consists of two water treatment facilities, fourteen pumping stations, four elevated tanks, five reservoirs and approximately 3400 Km of watermains. The following chart compares the source water to the treated effluent for selected parameters.

Chart 1: Source and Treated Water Characteristics:

Parameter	Source	Treated
pH	7.5	9.2 - 9.4
Alkalinity (mg/L)	27.7	32.9
Hardness (mg/L)	32.1	31.8
Turbidity (NTU)	4.5 (2-38)	0.06
Temperature (°C)	0 - 28	0 - 28
Dissolved Inorganic Carbon (mg/L)	12 - 13	7 - 8
Dissolved Organic Carbon (mg/L)	6 - 9	2 - 3
UV254 (abs/cm)	0.28	0.06
Colour (TCU)	29 - 61	2 - 4
Monochloramine (mg/L)	-	1.5 - 2.2

a. Description of Lead Issue

- Lead service lines were phased out of use in Ottawa starting in 1948 and completely phased out by 1956. Despite this early phase out, as of the end of 2021, Ottawa still has approximately 28,000 lead service lines of which approximately 11,400 are on public land i.e., the city owned portion of the LSL. The remaining approximately 16,500 LSLs are privately owned. Despite on-going measures to convince homeowners to replace their portion of the LSL, including grants and loans, only a very small percentage have taken up the offer.
- Ottawa's current corrosion control program using elevated pH has been greatly optimized over the years and has been very successful at reducing corrosion in the distribution system, including lead levels in homes with LSLs. It cannot, however, achieve ALARA, or even meet the reduced Health Canada Drinking Water Guideline for lead of 5 µg/L in 90% of samples taken in warm water conditions.

b. Our Action Plan to Address Lead

- The City of Ottawa currently cannot replace all of the LSLs in its distribution system and under the current corrosion control program, cannot meet the reduced Health Canada Guideline for lead. As a result, Ottawa has decided to upgrade and optimize its corrosion control plan to reduce the lead levels in homes with LSL's to below the Health Canada Drinking Water Guideline of 5µg/L.
- The plan is to gradually, over the course of a few months, switch from an elevated pH of 9.2-9.4 to 0.3 mg/L as elemental P at a pH of 9.0. Initially, phosphates will be added to the treated water while still maintaining the distribution pH at 9.2-9.4. Over the next few months, this pH target will slowly be lowered to the final target of pH 9.0.

c. How we got there

- From years of in-home lead testing in homes with full and partial LSLs, Ottawa has a good understanding of the successes and limitations of its corrosion control program. This coupled with an understanding that Health Canada would lower its drinking water guideline for lead, the city began to investigate other treatment alternatives using actual lead service lines collected from Ottawa's distribution system. In 2012, city staff collected six LSLs from customers who were having their entire LSL replaced and who donated their portion of the LSL to the city. The LSLs were harvested in a manner to minimize any disturbances to the lead scale contained within the LSLs and to ensure the pipes remained filled with water. The LSLs were reconnected with treated water, flowing in the same direction as when in use within an hour of being cut, capped, and transported. The LSLs were installed in the pilot facility with treated water flowing continuously at 4 L/min to ensure any disturbances to the lead scale on the inside walls of the pipe were re-stabilised. Samples were collected from the individual LSLs weekly to determine when each had reached a steady state. The data collected was later used as "control" baseline conditions.
- Over the next four years in both warm and cold-water conditions, various treatment options were studied including: no corrosion control, various pH's (9.2, 9.4, 9.6 and 9.8) and phosphates at various dosages and pH's. Samples were collected for all trials using a modified version of the ministry's mandatory lead sampling program. A free-flowing sample was collected followed by a 30-minute stagnation. The LSLs were only approximately 4.6 m in length with a total volume of just under 1L, collecting the first 2x 1L samples would miss the water that had stagnated within the LSL itself. To this end, a 400mL sample was slowly collected from the center portion of the LSL. This represented the "worst case" scenario for a 30-minute stagnation time which is significantly higher than either litre 1 or 2 used to meet regulations in residential settings. Below is a photo of the LSL set up including the chemical feed pumps.

d. Results

- The "no corrosion control" option was studied merely as a baseline to see how high lead levels would be in homes with LSLs if there was no corrosion prevention program. Plant effluent was pH corrected to pH 7.5 to align with the incoming Ottawa River pH. The results were not only very high levels of lead, but also highly variable results including frequent solid lead particulates in samples. Samples with lead particulates were as high as several thousand µg/L of lead!
- The various pH options were studied in an attempt to further optimize the elevated pH corrosion control program that originally started in Ottawa in 1932 and had been refined in the late 1990's. In the end, it was confirmed Ottawa's current elevated pH target of 9.2 (winter) and pH 9.4 (summer) is optimized as much as possible using elevated pH.
- Phosphates are extensively used around North America as a preferred corrosion control option with the typical dosage at 1.0 mg/L as P at a pH of 7.5.
- To clarify, some utilities measure the phosphate dose in terms of PO_4, other as elemental P; a dose of 3.2 mg/L as PO_4 = 1.0 mg/L as P.
- Phosphates at a dose of 1.0 mg/L as P at a pH of 7.5 was found to significantly reduce the lead levels in both flowing and 30-minute stagnation samples. However, the neutral pH was found to interfere

with the chloramination process Ottawa uses as a secondary disinfectant. A final pH at 7.5 was found to destabilize the monochloramines resulting in large amounts of free chlorine in the water which would significantly increase the concentration of disinfection by-products in Ottawa.

- At this time, it was suggested by Mike Schock of the USEPA, that due to Ottawa's water chemistry (soft, low alkalinity, low DIC), a lower dose of 0.3 mg/L as P could not only be as effective as the higher dose but may also work at a higher pH.
- After piloting the lower phosphate dose for several years in all relevant water temperatures, it was found the lower 0.3 mg/L as P was actually a slight improvement over the higher phosphate dose regardless of if the final pH was 7.5, 8.0, 8.5 or 9.0. The higher pH's also had the added bonus of being favourable to chloramination chemistry.

The following two charts illustrate the results of phosphates compared to all options tested in warm water:

<u>Chart 2: Comparison of Phosphate Dosage and pH</u>

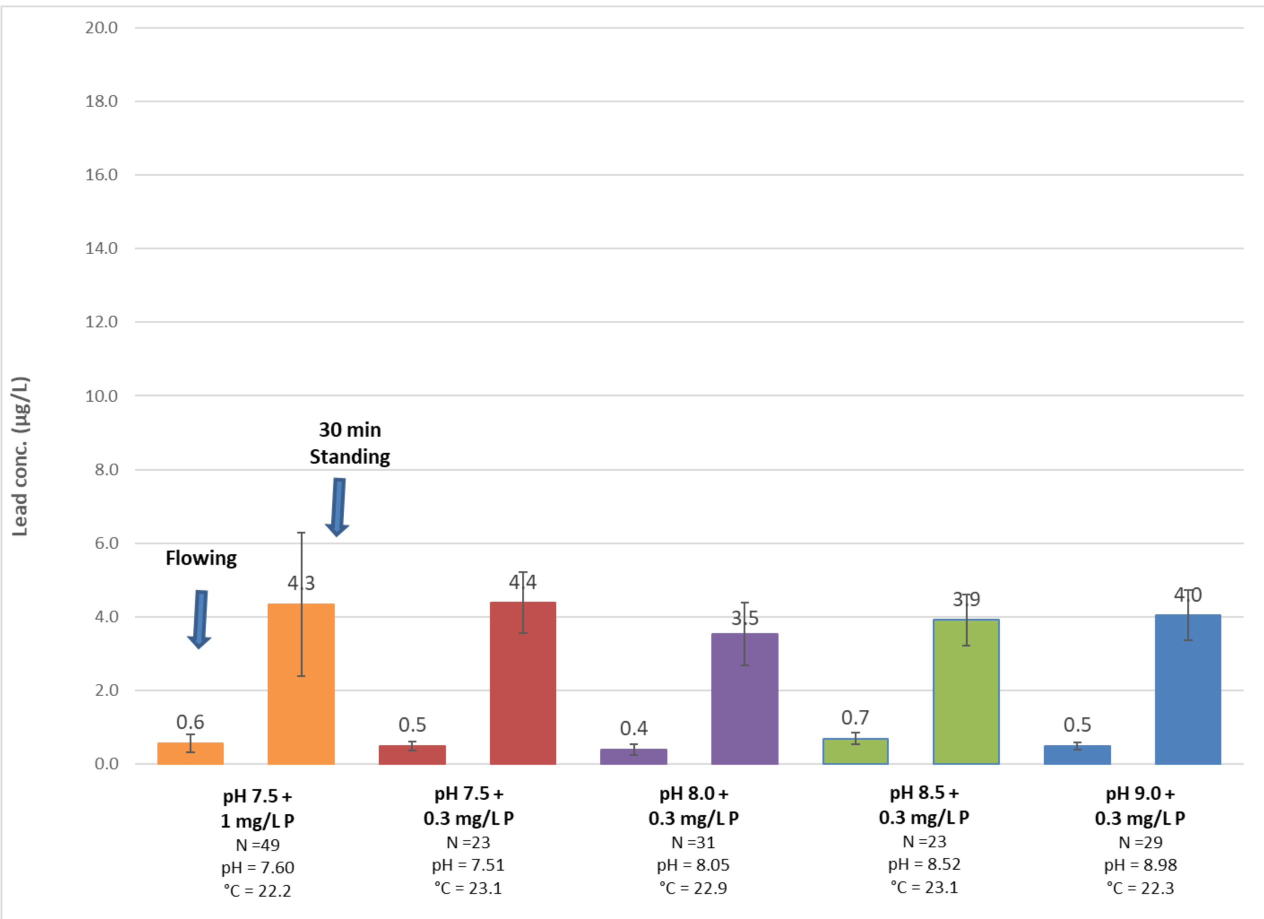
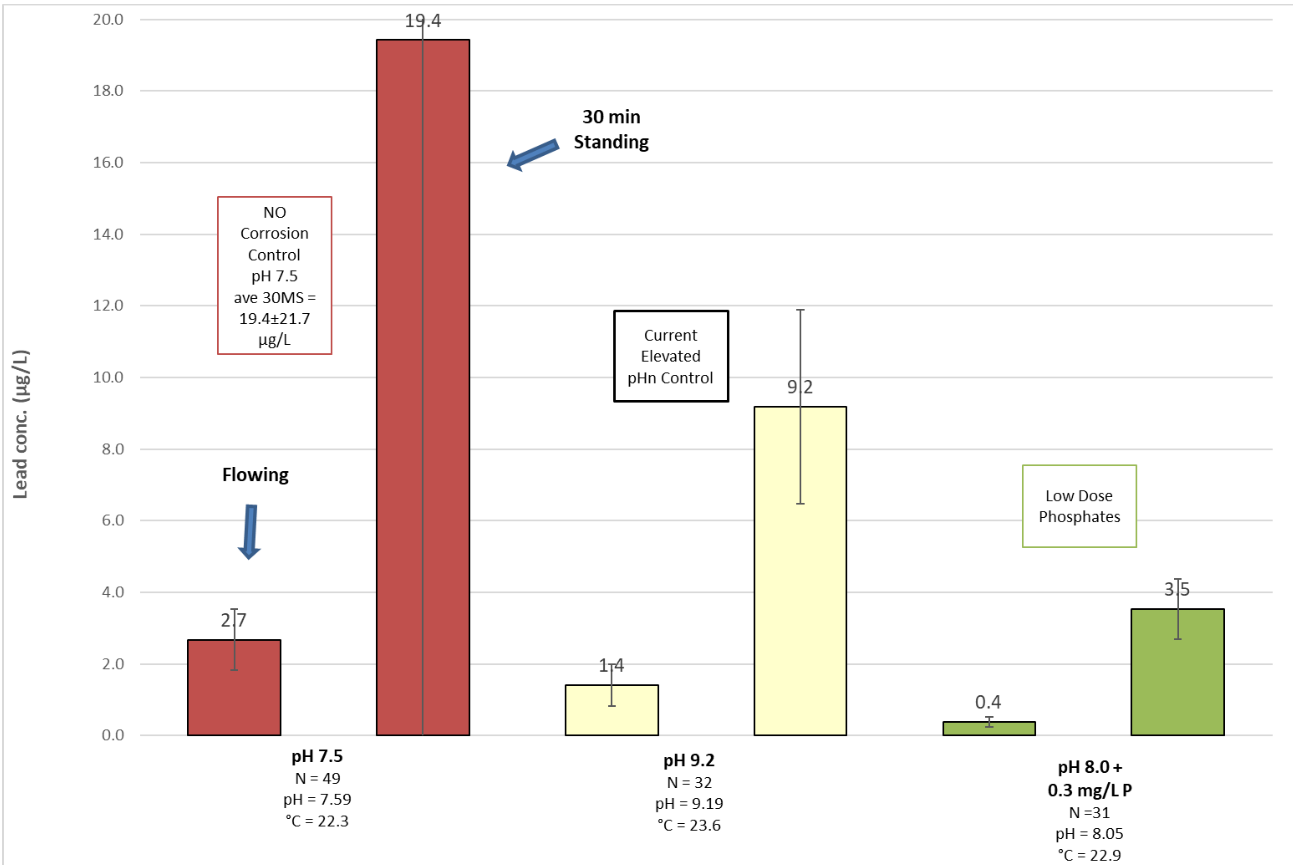


Chart 3: Comparison of All Corrosion Options



2.

e. Concerns:

- The addition of phosphate to Ottawa's drinking water does raise a few concerns, primarily the addition of a nutrient to a water system that already contains low amounts of dissolved organic carbon and nitrogen. The concern was a potential increase in biofilm and opportunistic pathogen growth (Legionella & Mycobacteria) in the distribution system and premise plumbing especially in hospitals and Long-Term Care facilities. There was also the concern of potential impacts due to an environmental release to stormwater or streams as well as the need to eventually remove the added phosphates at the waste-water treatment facility before discharge back to the environment. To better understand these risks the city consulted with leading industry experts plus other utilities who have already made the transition to phosphates. Based on these discussions, Ottawa expects negligible risk associated with opportunistic pathogens. Environmental releases will be monitored and will meet all regulatory discharge requirements.

f. Conclusions:

- Low dose phosphates will result in Ottawa being in 100% compliance with the Health Canada guideline of 5 µg/L for lead, with minimal risk of increased biofilm or pathogen growth. A higher pH with phosphates favours chloramine as a secondary disinfectant; chloramines are also very effective at inhibiting Legionella in building and residential plumbing. The low dose of 0.3 mg/L as P meets the criteria for release to stormwater and river bodies of 0.4 mg/L P and will require only a minimal increase in treatment chemicals at waste-water treatment.

g. Where are we now?

- Currently, as of April 2022, the City of Ottawa is in the final design phase of the required chemical storage tanks, pumps, pipes, control system etc. plus the external structures needed to house all of the above. The expected start-up date to transition to phosphates is late 2025.

Ontario Municipal Water Association

2. Case Study: Lead Service Line Identification – City of Thunder Bay

The City of Thunder Bay is located in Northwestern Ontario in the Thunder Bay District, Ontario, Canada. It is the most populous municipality in Northwestern Ontario and the second most populous (after Greater Sudbury) municipality in Northern Ontario.**

The Bare Point Road Drinking Water System is owned and operated by the City of Thunder Bay. The water system provides drinking water to approximately 110,000 residents covering a geographical area of approximately 328 square kilometers.**

The Bare Point Water Treatment Plant treats raw water obtained from Lake Superior and discharges the finished water into the north end of the City's distribution system. The plant rated capacity is 113.5 ML/d. Raw water is conveyed from Lake Superior via two existing intake systems, a 1350 mm diameter 733 m long HDPE/CPP pipe installed in 1995 and two 600 mm diameter steel pipes installed in the 1950's. Once the water has passed through the treatment process the finished potable water is then distributed City wide via eight pumping stations, five potable water storage facilities and 722km of linear distribution piping. The City's water distribution piping dates back to 1909, with the average pipe age being approximately 50 years old

Generally, Lake Superior water is low in turbidity with an annual average below 2 NTU. The lake water colour readings average annually below 2 TCU's with some higher values recorded during abnormal driven events such as floods, storms or other weather related instances. Temperatures of the raw lake water can fluctuate seasonally between less than 1°C and 18°C with pH ranging from 7.6 to 8.1. The treated water is described as being soft (alkalinity avg. 40 mg/L as CaC03) and the treated water pH averages 7.90. Bacteriological samples from the raw water indicate low results for E.coli and for Total Coliform.

According to the City's records the Drinking Water System consists of:

- 1 Water Treatment Plant
- 5 Water Storage Facilities
- 8 Water Pumping Stations
- 8 Water Pressure Zones
- 722 Kilometers of Water mains consisting of approximately 47% unlined Cast Iron, 27% Ductile Iron, 10% PVC, 5% concrete, 4% lined Cast Iron, 4% steel, 2% Asbestos Cement and 1% HDPE
- 2,495 Industrial/Commercial/Institutional Service Connections
- 3,402 Fire Hydrants
- 9,212 Valves
- 36,732 Residential Water Service Connections

Ontario Municipal Water Association

Description of Lead Issue

Prior to the requirements for lead testing as set out in Ontario Regulation 170/03, Schedule 15.1, the City of Thunder Bay had participated in lead sampling and testing in conjunction with the MECP. In 1996 the city, MECP and McMaster University completed a study on lead reduction utilizing chemical addition. Sampling and testing results indicated that homes with lead service connections would benefit from chemical addition to reduce lead levels at the tap.

With the implementation of Schedule 15.1, it became apparent that the City of Thunder Bay would be required to develop and implement a Corrosion Control Plan (CCP) in accordance with the conditions set out in Schedule 15.1. Sampling and testing results indicated that approximately 25% of homes or commercial buildings with lead service lines exceeded the 10ug/L provincial limit for lead concentrations. The City of Thunder Bay's CCP was focused on lead testing at the tap, consumer education, flushing prior to consumption and removal of lead service lines. Chemical addition was to be used as a last measure to reduce lead levels at the tap.

A. Obtaining Sampling Locations

Number of Samples Required

Schedule 15.1-4 outlines the number of samples required as well as the time frames in which the samples needed to be collected. As the City of Thunder Bay had a population greater than 100,000, a minimum of 130 samples were needed in each sampling period. As a result, it was incumbent upon the City to put a strategy in place to collect the number of samples required.

TABLE
STANDARD SAMPLING — NUMBER OF SAMPLING LOCATIONS

Column 1 Item	Column 2 Population Served by Drinking Water System	Column 3 Number of Sampling Points in Plumbing that Serves Private Residences	Column 4 Number of Sampling Points in Plumbing that Does Not Serve Private Residences	Column 5 Number of Sampling Points in Distribution System
1.	1- 99	5	1	1
2.	100 - 499	10	1	2
3.	500 - 3,299	20	2	4
4.	3,300 - 9,999	40	4	8
5.	10,000 - 49,999	60	6	12
6.	50,000 - 99,999	80	8	16
7.	100,000 or more	100	10	20

Locations of Samples

Schedule 15.1-6 prescribes where lead samples should be taken as well as options in cases where sampling can be taken in the event that locations with lead service lines could not be obtained.

As the City of Thunder Bay began the residential testing program, it was identified that homes with lead solder or fixtures had lead levels detected but these results did not exceed the provincial standard except in rare cases. Large industrial or commercial buildings with numerous lead solder joints or fixtures did in some cases exceed the standard. In order to meet the sampling location requirements and the spirit of the regulation it was understood that the focus of sampling needed to be on homes with lead service lines. If sampling was focused on homes with lead solder/fixtures only (15.1-6 (2) (1.ii), it is unlikely that the City of Thunder Bay would have had to put a CCP in place.

> **15.1-6**
>
> (2) In selecting points in plumbing from which samples are to be taken under section 15.1-4 or 15.1-5, the owner of the drinking water system and the operating authority for the system shall ensure that the samples comply with the following rules:
>
> 1. Subject to paragraph 2, samples must be taken from,
>
>> i. plumbing that is **connected or is suspected of being connected to lead service pipes**, or
>>
>> ii. lead plumbing or plumbing that is suspected of being lead plumbing.

B. Our Action Plan to Address Lead

First Steps

In order to obtain the required number of sampling points historical records were reviewed to help determine where lead service lines were present. These records were stored electronically, however they were not easily searchable as information pertaining to specific homes were in the form of PDF's uploaded into the GIS system. The GIS system was primarily utilized to identify water mains and waste water collection piping which identified size, location, age, break history etc. Information on service line materials were not included in the mapping process that was searchable.

In the initial review of records a number of initiatives were undertaken in order to determine the best way to identify lead services and how to best document the findings. The initial phase included:

1- Review GIS mapping to determine age of pipes
2- Review of maintenance records uploaded into GIS System
3- Review of Engineering drawings pertaining to service connections
4- Review of Plumbing permits issued
5- Review of Building permits to determine the age of homes
6- Review of previous sampling and testing locations

Upon review of the initial phase, we found that we had accumulated a significant amount of information. However, there were numerous inconsistencies and gaps in the information. For example, age of piping was useful to hone in on areas that may have lead service connections however the age of the home proved to be the better indicator. It was found that homes built before 1950 were most likely to have a lead service connection however there were outliers. As an example, an older home was demolished and rebuilt in the 1980's but the original lead service line was reused to service the home.

C. The Hard Part

In order to get a complete understanding of the magnitude of lead service lines it was decided that all records were to be reviewed for homes built before 1950. The revenue division provided a listing of all service connections as a starting point. We found that there were approximately 15,000 homes built between 1875 and 1950, accounting for approximately 41% of all service connections in Thunder Bay. This information was transferred to an excel spreadsheet which included the following:

1- Address of home
2- Property Description
3- Year built

Over a period of two summers, students were hired to review all maintenance and plan drawings that were uploaded into our GIS system as PDF's. For each location there were anywhere from "0" to "25" PDF's that would need to be reviewed. Students were instructed to open each PDF for each address provided in the excel spread sheet and transfer the following information:

1- Service connection type – Lead, Copper, Other/Unknown
2- Lead on Private
3- Lead on Public
4- Partial Lead on Private
5- Partial Lead on Public
6- All Lead removed

In conjunction with the internal documentation review, a number of public outreach initiatives were completed in order to provide information on lead as well as help determine if records for each property were accurate. A summary of public outreach included:

1- Public information sessions
2- Radio and TV interviews
3- Publications in the Annual Report, city newspaper, My Tbay, social media
4- Lead information/Corrosion Control Plan published on City's Website
5- Public Notice pamphlet regarding corrosion control plan and facts about lead delivered to all customers with their water bill

Based on this research and public consultation, there were an estimated 7,500 municipally owned lead services and 9,463 privately owned lead services. This was an excellent starting point.

Once this initial phase was completed the information was provided to the Water and Waste Water Engineer for review and vetting of the information. A review of all capital projects, sampling and testing results, plumbing permits, engineering drawings, customer concern reports, service leaks etc. was undertaken and the resulting information added to the excel spreadsheet. As part of the information gathering process, we noted that gaps still remained in the dataset. It was found that homeowners may have removed private lead service lines without permits, so there would be no replacement record on file or they may have had small sections of a private lead service repaired/replaced making it appear that the service line was copper. For example, replacing the section of lead pipe from the home footing to the meter with copper, while leaving the rest of the service line as lead pipe. It was also noted that lead service connections replaced on the public side were sometimes only replaced to the curb stop and not necessarily up to the property line, therefore leaving a small section of lead on public property. For homes that did not have any conclusive information, they were added to the spreadsheet as a “discrepancy”. These homeowners were contacted and encouraged to have their water tested at the tap and to do a scratch test on their service line to ascertain if the connection was lead or copper.

The final review indicated that known or suspected lead service lines were as follows:

Total # of homes with some form of confirmed and/or suspected lead service line = 8,278

Break down of confirmed and/or suspected lead services:
Total # of homes with both sides having some form of lead service line = 5,875
Total # of homes with private lead ONLY (the public side is removed) = 2,129
Total # of homes with public lead ONLY (the private side is removed) = 145 (on Priority Removal List)
Total # of homes with an “Unknown” public line = 9
Total # of homes with an “Unknown” private line = 120

Once the final review of documentation was complete, the information was transferred to the City’s GIS system and is now the official record keeping mechanism. This system is updated immediately upon notification that a lead service has been repaired or replaced.

The information entered into the database is continuously evolving and the City continues to utilize a number of initiatives to determine if lead services are present which include:

1- Customer Information (photos, invoices etc.)
2- Scratch testing/visual inspection
3- Sampling and testing (as close to the meter as possible)
4- Vacuum Excavation
5- Trenching

If service line information is found to be incorrect the database is immediately updated and notes are attached to direct staff to the record keeping mechanism that justifies the change. This information is provided to the homeowner/property owner upon request.

D. Conclusion

An accurate identification of service line material is extremely challenging. However, building such a vital foundation of accurate data is the most important stage needed to develop a successful lead reduction strategy. During this data collection and review, it was estimated that there were more than 200,000 paper and electronic documents reviewed. City staff directly communicated with more than

2,000 homeowners with concerns about lead service line materials in addition to the information provided in mail outs and education initiatives. It is vital that data collection and review be staffed adequately for the size of the system being reviewed. There needs to be a plan in place to house the data once it is collected to ensure it is easily accessible and secure. It is also highly recommended that the maintenance of the system be considered to ensure that the information is relevant and as current as possible.

As a result of the service line identification process, we are confident that the service line information currently housed in the GIS system is in the 90th percentile for accuracy.

3. Case Study: Greater Sudbury

The City of Greater Sudbury is the largest municipality in Ontario geographically, with close to 1,000km of water mains and approximately 49,000 customers, the City has among the lowest population density in the province in areas serviced with municipal drinking water. Within the City of Greater Sudbury there are 6 water systems, all with different histories, construction techniques, and standards, because of the amalgamation of smaller municipalities, including several systems that were originally constructed and maintained by mining companies. The City runs a corrosion control program, which was originally introduced to address issues with metallic pipes. In annual reviews of the program, it is consistently observed that this program is also effective at controlling lead corrosion as well.

Description of Lead Issue

The city has conducted biennial sampling for lead in the distribution systems for the last 15 years. Results have proven that levels of lead are not a concern in most of Greater Sudbury (based on the current Provincial Lead Standard). However, based on more recent scientific understanding of the issue and levels which can cause harm there have been areas identified that require attention, which resulted in initiating various programs to reduce the risk. There is evidence from maintenance and capital programs that would suggest there are likely lead water services in some of the water systems. It has been a long-standing practice in Sudbury, that when a lead water service is discovered that the City side is replaced, and the owner is notified of the issue and encouraged to replace their side. City staff have also observed that most owners do not act on those recommendations to replace their lead service line on the private side. As there is no safe level of lead, a business case was brought forward for the 2022 budget to help reduce the risk of lead for residents, including financial assistance for replacing the private side of a water connection, and distribution of filters for high-risk populations. Council approved this business case.

Beyond Lead: Data Gaps

One of the challenges with building the business case for financial assistance for private water service replacement was that the GIS database did not have a considerable number of lead water services captured, so estimating the size of the program was difficult, and there was interest in closing the data gap.

As part of a data review to determine the scope of what this program would look like, several lead services were discovered. A considerable number of the service connections stored in the GIS system are missing material type, which would make determining how many resources would be required to replace these services difficult. Determining how to address this information gap was a part of the City's Private Lead Water Service Replacement Program, and the City continues to refine business processes and look for opportunities to gain more confidence in creating a complete inventory of water assets with a special focus on ensuring accurate material and installation dates are captured.

Our Action Plan to Address Lead

Existing program:
The addition of the Lead Service Risk Model to the other elements of the City's risk reduction strategy around lead is a welcome addition. The existing programs that are in place include:

- Removing City owned lead water services upon discovery
- Notification process to owners, encouraging them to replace their private services and providing them with information from partners at Public Health Sudbury & Districts upon discovery
- Corrosion control program
- Regulatory sampling
- Coming soon (target end of 2022): Water filter distribution, rebate and loan program for private lead water services, public education and outreach strategy with outside agency collaboration

Predictive Analysis:
After reviewing white papers and articles from others, predictive modelling was used to determine how many lead services would be expected. Based on the data that was available, several forest-based classifiers were developed that considered proximity to known lead services, pipe materials and sociodemographic information for the water systems that had enough known lead services to be included in analysis. The models were evaluated, with the best performing model used to predict lead service lines.

An index was also created to ensure that vulnerable populations who were at the highest risk of having a lead service or elevated blood lead levels would be prioritized for any lead abatement services. This index is intended to be shared with community partners including Public Health Sudbury & Districts and other organizations who work with vulnerable populations. Processes were also built to ensure the model and priority index can stay up to date as more information is collected and verified in the field and when new demographic information becomes available.

Success Story

Data-Oriented Decision Making:
The results of the predictive model are currently shared in an online web map, which has allowed many staff to see the capabilities of GIS beyond asset management. By showing sample results and known and predicted lead service lines, employees can plan for capital projects to protect the most vulnerable populations and reduce poor health outcomes. The web map also shows graphs of the relationship and distribution of indicators used in the model. This is helping staff understand the importance of the social determinants of health and how this lens can be applied to infrastructure projects.

Process Improvement:
Many opportunities to establish or streamline processes have spawned from this project to ensure that the City is able to maintain this model. The City is currently establishing digital processes to update GIS data in the field whenever a pipe is exposed because of excavation work to help maintain assets.

Greater Sudbury is also evaluating new ways of integrating lead sample data into GIS, with plans to expand this to other water sampling programs. Greater Sudbury is also leading a water meter replacement program across all water systems which is another opportunity for verification of lead service lines.

Failed Fabulously, then Succeeded

While reviewing existing datasets, broken business processes were encountered that resulted in data inaccuracies in the records and opportunities to improve data quality. The older version of the model containing flawed information was used to demonstrate the importance of data quality and the role that everyone plays in ensuring GIS data stays up to date, as well as launching a new data collection process in some of these areas.

New perspectives have come forward and new conversations started on future opportunities to collect and use data beyond this program. Operators in both water treatment and water distribution have asked to view the data, as well as people working in compliance, maintenance planning, capital planning and asset management. Capturing the data in GIS and highlighting information using the improved version of the model has made the information not only more accessible for users, but easy to understand by highlighting areas of concern and identifying trends using intuitive colours to help users focus on the highest risks or most prominent trends.

Where are we now?

Greater Sudbury is beginning to verify initial findings of the model by collecting field samples at locations with known or predicted lead service lines. Other excavations are also planned for areas with no known lead and in other systems without known lead. This information will be used to evaluate the current model and refine predictions, as well as expand to other water systems. Data will be collected from operators and contractors in the field, using ESRI apps so that the data can be easily brought back into GIS.

Beyond determining the location of lead service lines, the city is also beginning to plan the implementation of the Private Lead Water Service Program. As part of the Private Lead Water Services Program planning, the city is looking to collaborate with community partners who serve vulnerable populations that may not otherwise be informed of the negative health effects of lead or any remediation programs the City has available. Greater Sudbury is also working on a communications strategy to effectively engage members of the public, as well as internal staff on the importance of lead remediation. This tool will help to guide where best to target those initiatives, as it highlights the risk by neighbourhood.

The model is not static, and is feeding information right from the GIS SDE, so as any material and age information gets updated in GIS it is reflected in the model automatically. The city is working on changing some business processes related to water samples so that information can also be fed automatically into the model. That way whenever anyone looks at the Lead Service Replacement Program, they can view a dynamic model that has the most updated information available to anyone and does not start to become outdated the day it was initially run.

OMWA
Ontario Municipal Water Association

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Ontario Municipal Water Association

4. Case Study: City of Brantford

The City of Brantford, Ontario is home to approximately 100,000 people. The City's raw water supply is drawn from the Grand River through the Holmedale Canal. The City is responsible for the overall management of the production and distribution of Brantford's drinking water. Specifically, this includes treatment of Grand River water, maintenance of the distribution and metering systems and meeting and/or exceeding the applicable regulatory requirements. The water distribution network system consists of 508 kms of pipes, 2,801 hydrants, 8,649 valves and 35,609 water service connections; 2,450 of the water service connections are thought to be composed of lead pipes, virtually all of which are on the private side only.

Description of Lead Issue

An Education and Outreach package is mailed out twice per year to the owners and renters of properties with lead water service lines according to the City records. Following the mail out, the City would often receive a few calls from residents that recently moved in to a home supplied by a lead water service pipe and were not aware of it when they purchased or rented the home. The residents were drinking and cooking with the water for months until the letter and brochures came in the mail to inform them of the lead water service material composition.

Our Action Plan to Address Lead

In 2021, Water Compliance Staff worked with Customer Service staff to upload lead water service information into the Customer Service database. When a resident calls Customer Service to set up a new water account that is identified as lead in City records, a window pops up to notify the Customer Service Representative (CSR) to provide information to the owner or tenant about the LSL. The CSR will relay information on the financial incentives offered by the City to replace the lead water service along with the health risks of drinking water supplied by lead water service material and the City's free water filter program if eligibility criteria are met.

Success Story

City staff was able take advantage of interdepartmental cooperation to close the gap on the amount of time that a family could unknowingly drink and cook with water that is impacted by lead due to the water service pipe material.

"Notifying Owners and Tenants of LSLs": Improving Business Processes

If an owner of a rental property is paying the water bill, then the tenant would not receive an early warning notice by Customer Service because they would not call and set up an account therefore, a gap remains. Tenants are notified when the Education and Outreach package is mailed out, but if the property owner pays the water bill, there is no advance contact with the City to inform them of the lead water service material.

Where are we now?

Although some tenants will not receive early notification, the City has identified and substantially diminished a gap in notification to water users with a lead water service pipe and a simple, effective way to notify water users more quickly of the risks in drinking and cooking with water when supplied by a lead water service pipe.

5. Case Study: Sault Ste. Marie

Sault Ste. Marie is a thriving Northern Ontario community of 73,000. Situated along the St. Marys River at the outlet of Lake Superior, the city has an abundant water supply source from both groundwater and Lake Superior. Drinking water is distributed to customers through some 450 kilometers of watermains and some 25,000 service connections.

Description of Lead Issue

Occurrence of lead in tapwater at Sault Ste. Marie has been attributed to a small subset of homes with lead service lines (LSL). The use of LSLs in Sault Ste. Marie is primarily attributed to homes built between 1943 and 1948 through the Canada Wartime Housing Corporation. As a result of raw water characteristics and a blending of treated waters in the distribution system, the water utility was required to implement a corrosion control plan to reduce the uptake of lead into drinking water.

Our Action Plan to Address Lead

The corrosion control plan included modifying drinking water chemistry through pH stabilization and addition of a corrosion inhibitor. Also, part of the plan were free public side LSL replacements, free point of use filters, loans for private service replacement, and lead service pipe lining – a low cost alternative to replacement. Finally, consistent with customer-focus principles, a communications program informed public health workers of lead services at addresses where their clients included expectant and new parents.

The water utility had previously digitized historic service records as part of a community GIS initiative making queries with other factors such as age of premises practical. Records indicated the use of lead service pipe occurred almost exclusively between 1943 and 1948, during which time the Canada Wartime Housing Corporation was active in Sault Ste. Marie. Algoma Public Health programs were also being maintained in the community GIS.
A unique aspect of a Community GIS is the ability to concurrently reference data from multiple stakeholders.

Several public health programs involved home visits to expectant parents and parents of children under 6. The public health program also had authority over some daycare facilities. Addresses for the same were part of the public health dataset in the GIS. Through overlay processes and, for example, matching postal codes, GIS queries were able to inform health workers of LSLs in client's homes where a vulnerable population existed.

Success Story

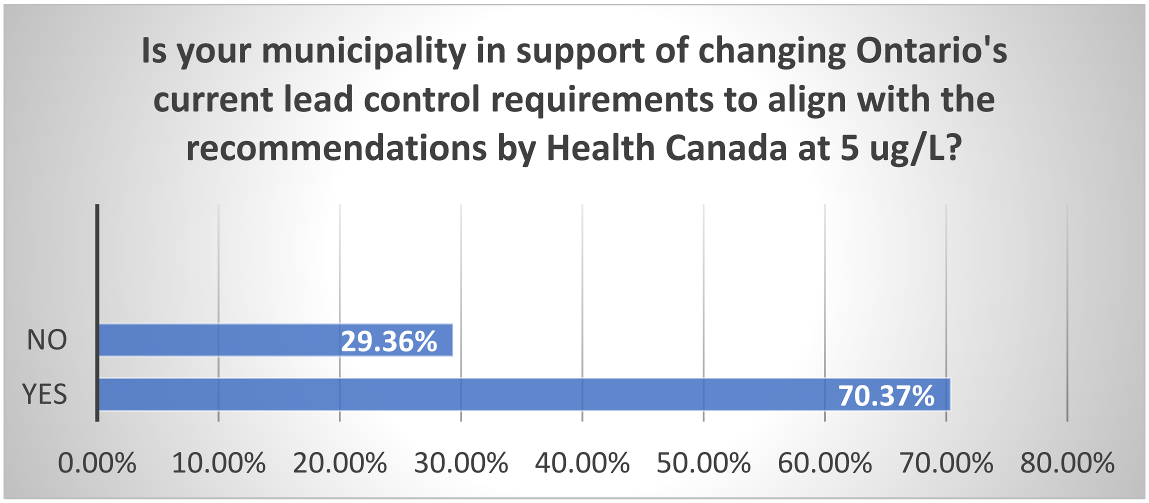
As a result of a Community GIS approach, the water utility and the public health authority were able to collaborate while maintaining confidentiality for health authority clients to deliver targeted, credible, one-on-one education for families with children under 6 years of age – the same population that could be vulnerable to lead in tap water – enabling informed decision making with respect to LSLs.

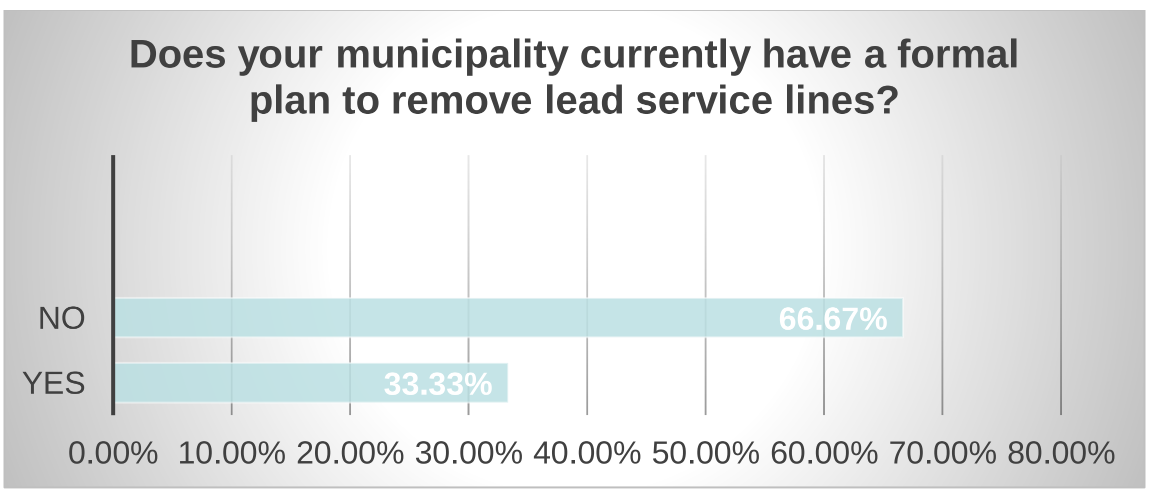
Where are we now?

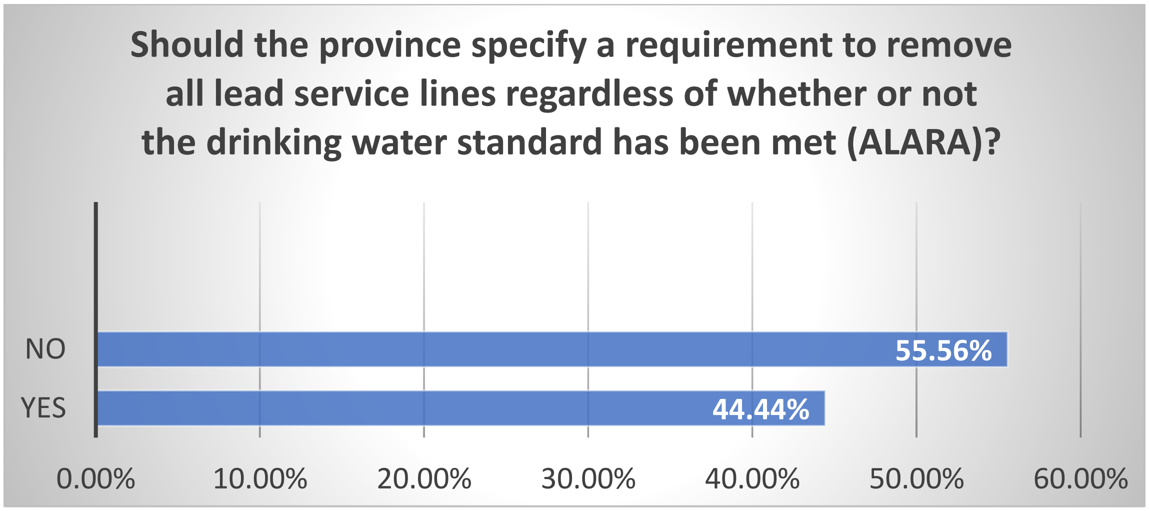
A collaborative, inter-agency approach has enabled enhanced protection of public health through targeted education while the utility continues towards its goal of eliminating lead service pipes by 2025.

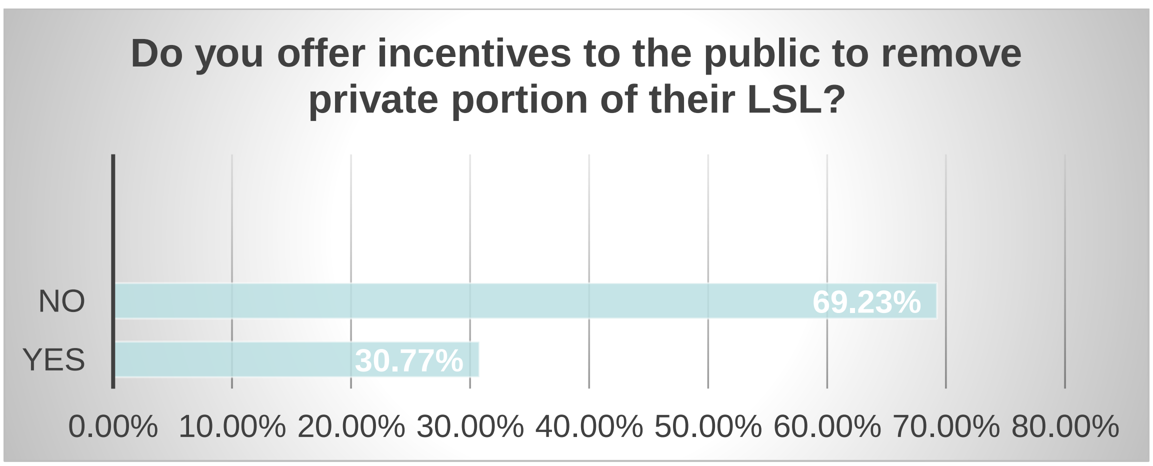
Appendix 2: Summary of Member Survey Results:

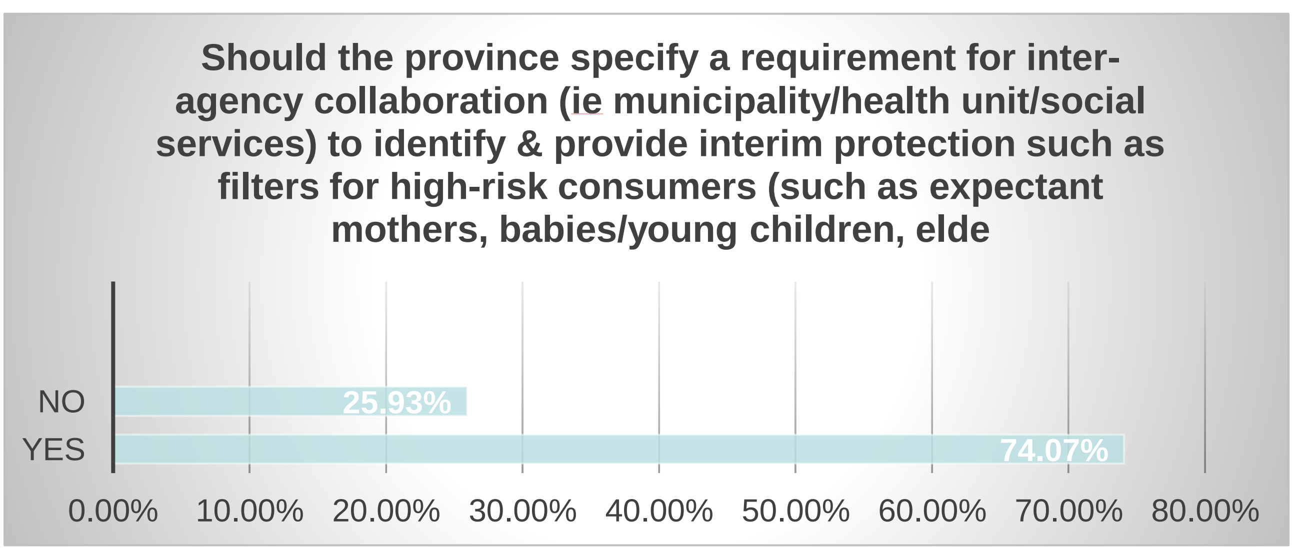
This Appendix presents a summary of the data from the responses to our questionnaire sent in October of 2021 to attendees of OMWA's 3 Part Webinar on various aspects of the issue of Lead exposure to consumers of public drinking water in Ontario.



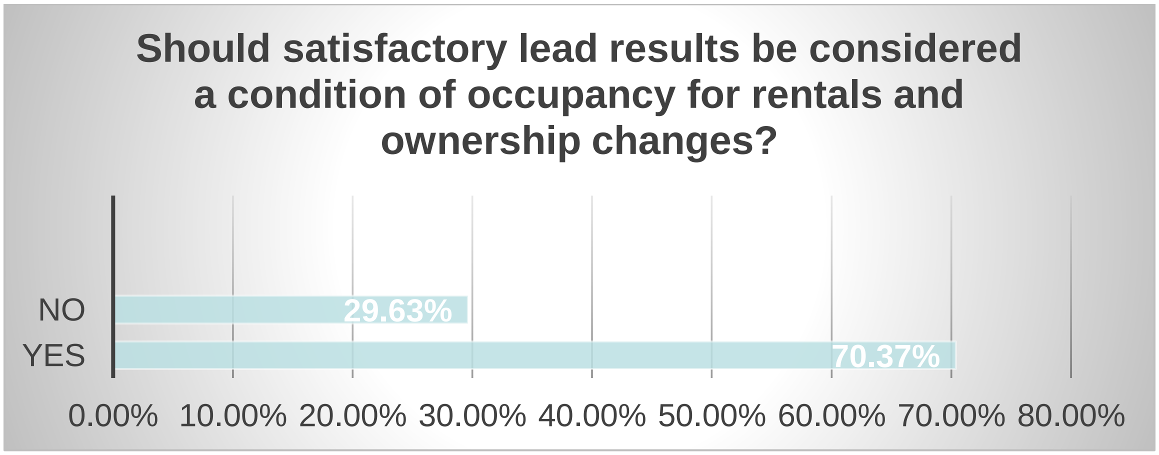


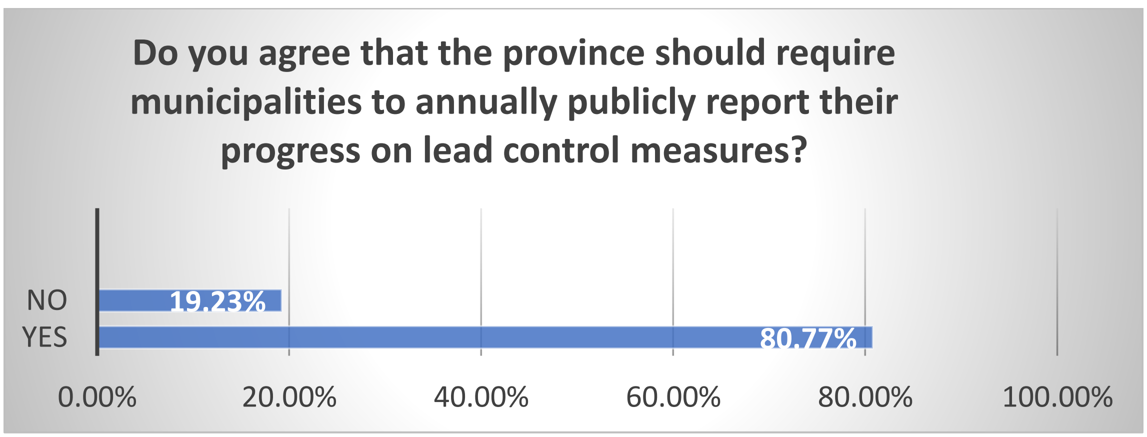

Should the province specify a requirement to remove all lead service lines regardless of whether or not the drinking water standard has been met (ALARA)?
NO
YES
55.56%
44.44%
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%

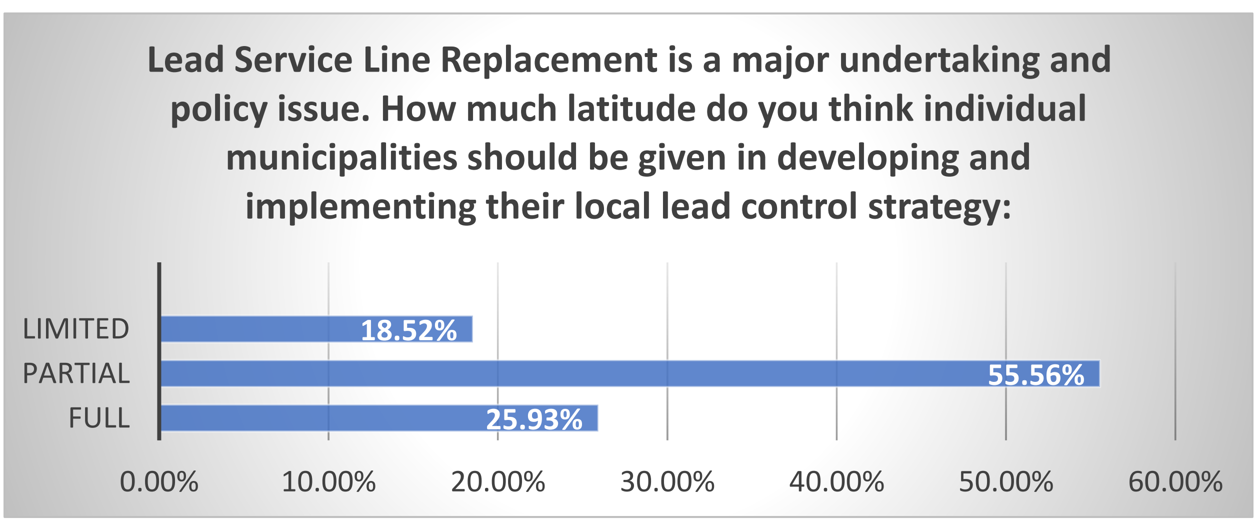

Do you offer incentives to the public to remove private portion of their LSL?
NO
YES
69.23%
30.77%
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%


Should the province specify a requirement for inter-agency collaboration (ie municipality/health unit/social services) to identify & provide interim protection such as filters for high-risk consumers (such as expectant mothers, babies/young children, elde
NO
YES
25.93%
74.07%
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%

Ontario Municipal Water Association







a. New Online Tool Calculates the Cost and Economic Benefits of Preventing Childhood Lead Exposure in the United States

> https://altarum.org/news/new-online-tool-calculates-cost-and-economic-benefits-preventing-childhood-lead-exposure-united

b. Intelligence gain and social cost savings attributable to environmental lead exposure reduction strategies since the year 2000 in Flanders, Belgium

> https://ehjournal.biomedcentral.com/articles/10.1186/s12940-019-0548-5

c. Cutting Lead Poisoning and Public Costs

> https://www.pewtrusts.org/~/media/assets/2010/02/22/063_10_paes-costs-of-lead-poisoning-brief_web.pdf

d. Lead Costs Developing Economies Nearly $1 Trillion Annually

> https://www.scientificamerican.com/article/lead-costs-developing-economies-nearly-1-trillion-dollars-annually/

e. Economic Costs of Childhood Lead Exposure in Low- & Middle-Income Countries

> https://med.nyu.edu/departments-institutes/pediatrics/divisions/environmental-pediatrics/research/policy-initiatives/economic-costs-childhood-lead-exposure-low-middle-income-countries