AEP Guidance Document for Managing Lead in Municipal Drinking Water Systems in Alberta:

Phase 1 tools for utilities to plan, assess and implement lead management plans for 2020-2024

2020.05.14, V1.3

Phase 1 tools for utilities to plan, assess and implement lead management plans for 2020-2024

Table of Contents

List of Tables

List of Figures

Acknowledgements

AEP acknowledges the time and efforts invested by members of the Lead Working Group for Municipal Systems, in particular its external stakeholder representatives from the City of Calgary and EPCOR Water (Edmonton) for sharing waterworks learnings from their respective lead management programs.

Version Control

Version Number	Date issued	Update information
V1.0	2019.08.28	First published version
V1.1	2019.09.23	Changed Figures 4 and 5 to indicate that providing POU filters is recommended, not required.
V1.2	2019.11.12	Section 2.2: Added second paragraph regarding collection of personal information. Section 4.1: Added content regarding lead results file in protected format and changed sample information from recommended to required (also in Appendix A). Section 4.3: Clarified that reporting lead results within 14 days is a requirement. Section 6.1: Last paragraph, clarified that 5 µg/L was from 30MS sampling result. Section 8: Added information about submitting lead sampling results in a separate electronic Excel file. Appendix A: Included informed consent and added space to record sample information. Appendix A-8: Clarified that storage at 4˚C was recommended, not required. Added information about timeframe for preservation and analysis – removed analysis as soon as possible. Clarified that list of labs in Table 7 is not exhaustive. Changed relative detection limit to reported detection limit. Appendix D: Added Case Example #8. Excel result template: Added dropdown menus for Approval/Registration number and Operation ID to ensure consistency and added instructions on how to fill in the data. Updated Figure 9 to correspond to updated report template appearance.
V1.3	2020.05.14	Added Postal Code to Table 6 sample data sheet. Updated Figure 9 to reflect changes to reporting template. Clarified that visual confirmation of service line material is an alternative to profile sampling. Updated Figures 3 and 4.

Abbreviations

30MS	30-minute stagnation sampling protocol
AEP	Alberta Environment and Parks
ANSI	American National Standards Institute
AWWARF	American Water Works Association Research Foundation
CALA	Canadian Association for Laboratory Accreditation
COP HQGW	Code of Practice for a Waterworks Systems using High Quality Groundwater
COP WDS only	Code of Practice for a Waterworks System Consisting Solely of a Water Distribution System Only
CWQA	Canadian chapter of the Water Quality Association
DWOS	Drinking water operations specialist
DWSP	Drinking Water Safety Plan
FOIP	Freedom of Information and Privacy Act
GCDWQ	Guidelines for Canadian Drinking Water Quality
ID	Internal diameter
IQ	Intelligence quotient
L	Litre
LSL	Lead service line
m	Metre
MAC	Maximum acceptable concentration
mg/L	Milligrams per litre (equivalent to parts per million)
mm	Millimetre
POE	Point-of-entry
POU	Point-of-use
RDT	Random daytime sampling
RO	Reverse osmosis
SCC	Standards Council of Canada
UL	Underwriters Laboratories
WQA	Water Quality Association
µg/L	Microgram per litre (equivalent to parts per billion)

1. Purpose and Scope

The purpose of this Alberta Environment and Parks (AEP) guidance document is to provide clear direction on behalf of AEP to waterworks systems owners and operators to support their assessment of lead hazards and development of lead management plans that address the risks of consumption of lead in drinking water at the customer's tap.

Why the need for this guidance document? In March 2019, Health Canada published a new lead limit for the Guidelines for Canadian Drinking Water Quality (GCDWQ). The new guideline for lead introduces two (2) fundamental changes from how lead has been managed in drinking water since 1992, namely: the maximum acceptable concentration (MAC) for lead was lowered to 5 µg/L; and more importantly, the point of compliance for lead is at the customer's tap and no longer in the distribution system upstream from the service connection point or property line.

This impacts waterworks systems because the change in the point of compliance will require a shift in how we think about our role and responsibility in producing and distributing drinking water. The goal of waterworks systems[1] (referred to as facilities in this document) is the protection of public health; and going forward, treatment and monitoring must consider the impacts of household plumbing. AEP recognizes the challenge of managing lead levels at the customer's tap. It is a complex issue that, for some facilities, will take many years to resolve.

AEP recommends approaching lead management in two phases:

Phase 1 - Planning, communication and assessment; and
Phase 2 - Mitigation.

The two phases are inter-dependent, with Phase 2 building on the results of Phase 1 which does not have to be fully completed before Phase 2 commences. Key outcomes for Phase 1 include:

- facilities having appropriate water quality monitoring programs;
- timely communication with customers;
- providing or incentivizing customers to have point-of-use (POU) filters for some interim period;
- initiating or continuing the physical removal of lead service lines (LSLs); and
- regulatory reporting to AEP on an annual basis.

These are measurable deliverables that meet the challenge of achieving the ultimate goal – to get the "lead out" – in order to minimize customer exposure to lead in drinking water in accordance with Health Canada's guideline. AEP will assess facility progress and performance for lead management achieved during 2020 to 2024. This assessment will be based on a facility's lead management plan development and its program implementation. The assessment is not based on numeric metrics of how many customer taps have lead concentrations exceeding the new MAC (i.e. 5 µg/L).

It is anticipated that Health Canada will update their 2009 *Guidance on Controlling Corrosion in Drinking Water Distribution Systems* in 2021 that will provide technical information to support Phase 2 by giving facilities operational guidance for managing pipe alloy metals from leaching into drinking water.

Phase 2 outcomes will include:

- characterizing common sources of lead from treatment to tap through ongoing monitoring in the distribution system and customer taps;
- ongoing LSL replacement;

[1] "Waterworks system" in the *Environmental Protection and Enhancement Act*, R.S.A. 2000, c E-12, includes water treatment plants and distribution systems.

- communication with customers;
- evaluation of water corrosivity; and
- assessment of lead control options.

This document provides guidance on the various components of a facility's lead management program, including:

- understanding factors that contribute to increased lead concentrations at the tap;
- evaluating and assessing sources of lead contamination;
- setting priorities for lead sample collection, testing and mitigation;
- strategies to evaluate the extent of the lead problem in a drinking water system and distribution zones by evaluating the corrosiveness of water through water characterization and survey of lead concentrations at residential taps, followed by a more detailed examination and response to those residences with elevated lead levels;
- information on approaches to minimize lead at the tap;
- messaging plan and examples to assist facility staff in communicating with customers regarding sources of lead, lead results, sampling plans, mitigation measures and steps the customer can take to reduce lead exposure; and
- regulatory reporting obligations to AEP.

This document does not include an evaluation of health impacts or exposure such as measuring blood lead levels. Health information for the public and drinking water facility staff can be obtained from online publications from Alberta Health [1], Alberta Health Services [2] and Health Canada [3]:

- Common Questions about Lead and Drinking Water;
- Drinking Water: What about lead? and
- Lead and drinking water from lead service lines.

Although it refers to the outdated MAC for lead (10 µg/L), *Lead and drinking water from lead service lines* published by Alberta Health has information on steps individuals can take to avoid lead exposure from drinking water at home. Alberta Health will update this latter document in the near future. Customers can also be directed to Alberta HealthLink 24/7 by telephone at 811.

For drinking water facilities, questions and guidance on developing your lead management program can be directed to your regional AEP DWOS (Drinking Water Operations Specialists). Your regional AEP Environmental Protection Officer (Inspector) can provide guidance on meeting the regulatory requirements and together with DWOS will monitor progress and completion of your lead management program.

2. Introduction and Background

Typically, lead levels in source water are very low and the finished drinking water produced at water treatment plants is virtually lead-free. However, lead can leach into drinking water from LSLs[2], tin-lead solder, brass fittings and some water meters. Lead-containing materials were more commonly used in the past, and consequently occur more frequently in older homes. However, recent construction does not eliminate the risk of lead leaching into drinking water. Newer brass fittings can potentially release more lead than older fittings because the concentration of lead is highest at the internal surface due to the molding process and movement of water or the parts against each other can release lead [4].

The National Plumbing Code allowed the use of lead pipes until 1975 and tin-lead solder until 1986. Construction before 1960 has been used as a benchmark for use of lead as a service line material [1]. However,

[2] LSL refers to service lines made of lead and other high lead materials such as "Camaloid".

poor construction practices may have resulted in installation of lead pipes after 1975 and in-fill construction may have used the existing LSL instead of installing a non-lead service line.

2.1 Health effects and lead-sensitive populations

Although the lead MAC is 5 µg/L, there is no known level of lead exposure that is considered safe [5] and efforts to reduce lead levels as low as achievable are strongly encouraged by Health Canada. Pregnant women and children under six years-of-age are the populations most vulnerable to lead. Women who have been or are exposed to lead can in turn expose their foetus or infant during pregnancy and breastfeeding [6]. Children are more affected by exposure to lead than adults are because they absorb more ingested lead than adults do. In children and foetuses, lead can cause adverse effects on neurological development and behaviour in children, including reduction of intelligence quotient (IQ). In adults, lead exposure can cause increased blood pressure or kidney problems. Exposure to lead in drinking water is a concern only if the contaminants are ingested [1]. Inhalation and dermal absorption during bathing and showering are not significant routes of exposure.

2.2 Maintaining customer confidence

Customer communication is a key component of the water facility's approach to address lead contamination and maintain customer confidence. Transparency is an important factor in effective communication; therefore, reasonable customer requests for lead sampling should be accommodated by the facility. Customers can also be directed to the labs listed in Appendix A. The public and individual homeowners need information about the risks of lead in drinking water, steps they can take to reduce exposure and what the facility owner/operator is doing to address the issue. Your customers must have enough information to make informed decisions to protect their health.

Those conducting the surveys and collecting the personal information, i.e. name, contact info and address, need to obtain informed consent directly from the individual the information is about. This can be done in the form of a FOIP or Privacy Clause which can be handed to the individual when tap water samples are collected from private residences (refer to Appendix C). It is essential that these homeowners understand that their drinking water data (lead result and address) will be shared with AEP. Individual addresses and sampling information about that address would not be provided in a FOIP request for information from AEP because it is personal data. Residential lead sampling results submitted with annual reports to AEP will be saved in a protected format. AEP is developing an online platform to publish summary statistics at the neighbourhood, postal code or community level.

Section 7 contains more information on customer communication and for examples of message content, refer to Appendix C.

3. Lead Management Program Overview

Determining appropriate actions to reduce lead concentrations at the tap is complex because of the:

- shared responsibility and ownership of lead-containing components by homeowners and waterworks facilities;
- variability of lead levels from one home to the next;
- large number of factors that can affect lead concentration (refer to Appendix E: Factors that Influence the Dissolution of Lead from Lead-containing Materials); and
- financial cost of removing sources of lead on the private-side that in turn can create a disproportionate burden on lower income families and health inequities.

Facility owners/operators need monitoring programs in place to identify elevated lead concentrations at the tap and likely sources of lead contamination. This then enables facility owners/operators to remove sources of lead such as LSLs, take suitable actions to reduce the lead concentration at the tap and communicate to customers on appropriate steps they can take to reduce their lead exposure from drinking water.

AEP will expect waterworks facilities to develop and implement a lead management program starting January 1, 2020 by undertaking the following tasks summarized in Table 1 before the end of 2024. Each task is described in more detail later in this document.

Table 1: Overview of lead management program tasks for 2020-2024

Task	Guidance document section(s)

Records management
• Develop and continually maintain a database which includes:
  o an inventory of LSLs
  o lead results for single and multi-family (fewer than 8-units) residences and large building residences
  o sampling data
	3 and 4.1

System assessment • Stratified sampling planned and mapped • Informed consent obtained from owner/occupant • Number of unique addresses sampled meets requirements in Table 2 • Select lab that meets sampling and analysis requirements • Complete sampling by September 30, 2021	4 and Appendix A
Investigative sampling and follow-up to verify lead concentrations and/or identify lead sources • Perform verification sampling • Identify lead source by profile sampling • Post-LSL replacement sampling	5
LSL replacement and exposure reduction strategy developed and implemented which includes: • establishing a resource plan for your lead management program, point-of-use (POU) filter offer program and LSL replacement; • initiating LSL replacement with post-replacement flushing and sampling; and • putting POU filter offer program in place.	6

Communication strategy and content developed and implemented to:
• recruit water sampling and LSL survey volunteers from the community (if opting for volunteer participation);
• provide information on adverse health effects and guidance to customers for reducing exposure; and
• notify owner and occupant regarding
  o presence of LSL, annually,
  o lead results, within 14 days of receipt, and
  o post-LSL replacement hazards of elevated lead and practices to prevent exposure, prior to replacement.
	7

Regulatory reporting obligations are met:
• Operations Program updated to include:
  o lead monitoring and analysis,
  o schedule and procedures for compiling a lead source inventory,
  o financial planning, and
  o removal of LSL from the distribution system;
• Lead management program strategy and progress submitted in Annual Report;
• Drinking Water Safety Plan (DWSP) updated with customer risks associated with lead; and
• Lead sampling results summarized and submitted.
	8

3.1 Records management

Information/records management tools will be essential to enable water facilities to develop, implement and adapt their lead management programs year over year. The following is a list of useful data fields:

- residential addresses, including large residential buildings;
- construction date;
- pipe lengths (private-side and public-side service lines and household plumbing);
- pipe diameters;
- public-side service line material(s);
- private-side service line material(s);
- name(s) and contact information for;
    - the occupant and owner of sampled locations (collected from billing information and/or during sampling),
    - mailing list for lead program communications,
- lead sampling results;
- lead sampling protocol used;
- records of communications with the owner/occupant including informed consent to take samples and report sample address; and
- status of service line replacement on public- and/or private-sides.

This data will be maintained and updated by facilities to respond to customer questions and concerns expected especially from households with lead-sensitive populations such as women in pregnancy and/or parents or guardians of young children. Customers may also be concerned about the presence of LSLs due to the potential impact on the perceived value of a home and desirability as a rental [7]. In cases where either the name of the owner or occupant only are known, communications can include a request to the recipient that the other party (occupant or owner) is informed (Section 7).

3.2 Inventory of Lead Service Lines (LSLs)

Lead service lines are a consistently high source of lead and contribute 50–75% of the total lead at the tap after extended stagnation times [8]. Given that most lead pipe internal diameters were 1 inch or less [9, 10], they were most commonly used for service lines to single family and multi-family residences with fewer than eight units [1, 11]. Facility owner/operators are expected to compile an inventory of LSLs, both on the private- (homeowners' responsibility) and public-side (refer to Figure 1).

Since LSLs were mostly installed over 40 years ago, lot-servicing records of LSLs on the public-side may be non-existent or incomplete. Information regarding the presence of LSLs may be available from [12]:

- data from profile (or other relevant) studies for lead at the tap;
- construction records from initial installation;
- repair and rehabilitation records;
- tax records indicating when buildings were constructed;
- plumbing permits;
- visual confirmation; and/or
- operational experience.

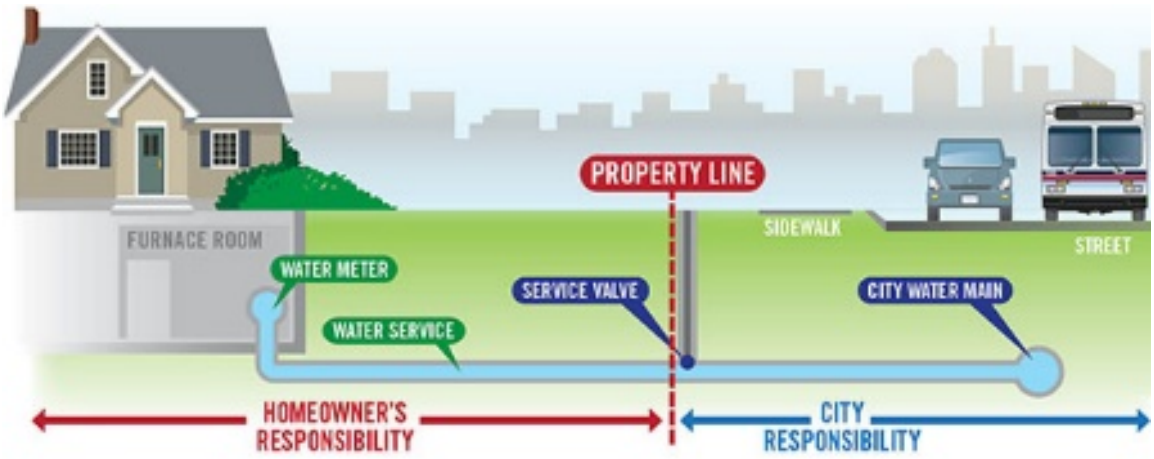


Figure 1: Responsibility for water service lines is split between the homeowner (private-side) and the city/waterworks (public-side).
Provided courtesy of the City of Calgary (2019).

Records of private-side (homeowner's side) of the service line material are even less likely to be available to the facility, however, in addition to the above sources; this data may be available from:

- The customer. Ask the homeowner or occupant to report on the pipe material they see entering the shutoff valve.
- Meter readers and installers. Include identification of pipe material entering the shutoff valve with information collected during reading and installing.
- Distribution system repair records. Excavation of the service valve might have revealed part of the private-side service line and this information may have been recorded.
- Prioritized excavation (hydrovac) of service lines around the service valve based on lead test results or construction age.

Visual confirmation of a small section of service line does not guarantee that the remainder is the same. Mixed materials are not uncommon. Based on the information gathered (records, year of construction), communication of confirmed full or partial LSLs on the public- or private-side will be provided to the owner and occupants of the affected building on an annual basis. See Appendix C for communication examples.

4. System Assessment

Over the period of 2020 to 2021, a stratified sampling system assessment of locations across the distribution system will be required to:

- estimate level of corrosivity;
- estimate lead exposure in the population;
- identify and/or verify homes and zones with elevated lead levels; and
- identify sentinel homes[3] for long term trending of lead levels and assessment of corrosion protection treatment efficacy (if applicable).

Before October 1, 2021, facilities shall collect samples from the number of unique addresses given in Table 2. The number of sites listed in Table 2 are the minimum requirement. The number of sites sampled may be

[3] Sentinel homes are usually high-risk sites (with confirmed LSL). The high drinking water lead levels at these locations allow detection of significant changes in lead concentration due to corrosion control treatment or changes in water chemistry.

accumulated over more than one year, but samples must be collected between the period of May 1 and September 30 when water temperatures are warmer. Samples must be collected from taps used for drinking water **in residences**. Recreation centres, hydrants or gas station bathrooms are not acceptable sites for the system assessment. Approximately 10% of samples should be from large residential buildings, if available.

Samples will be analyzed for total lead according to *Drinking Water Information Letter 1/2014: Analysis of drinking-water for metals* (Appendix B) by an approved laboratory (Appendix A) that is ISO/IEC 17025 accredited for this method. The facility owner/operator will cover the cost of sampling, shipping and analysis.

Table 2: System assessment minimum number of sample sites based on population. Collection period between May 1 and September 30.

Alberta Population Served By Drinking Water System	Total number of sites to be sampled between 2020 and 2021
100,000 or more	100
50,000 - 99,999	80
10,000 - 49,999	60
3,300 - 9,999	40
500 - 3,299	20
100 - 499	10
50 - 99	5
< 50	10% of number of population served

The system assessment described in this section must be completed before the end of 2021. It is a one-time sampling program, however, investigative and follow-up monitoring may be required (refer to Section 5 for more details).

The system assessment site sampling does not have to be repeated if an equivalent sampling program has already been completed. However, regulatory reporting requirements (Section 8) must be met and the historical data proposed to fulfil the requirements of the system assessment provided in the format given in Appendix F.

4.1 Sampling locations

Addresses should be sorted into groups (strata) based on evidence and estimates of the concentration of lead customers may be exposed to – from high to low. The strata may correspond geographically to neighborhoods or distribution zones defined by presence of LSLs, date of construction, or areas of greater water age (and potentially increased corrosivity).

The system assessment sampling program should include unique addresses randomly located in each strata. However, since LSL are the largest contributing factor to lead, areas known or likely to have LSLs should have the highest priority for sampling. Health Canada [10] recommends that waterworks systems in which lead service lines are present, a minimum of 50% of the sampling sites should target lead service line residences. Next priority should be homes without/or unlikely to have LSL but with/likely to have lead-containing solder. Then distribution zones of stagnant or high water age are the third priority. GIS mapping of this spatial data is often useful to aid in designing sampling programs and identifying the likely lead risk for neighborhoods. Figure 2 outlines the steps to follow.

Those conducting the surveys and collecting the personal information, i.e. name, contact info and address, need to obtain informed consent directly from the individual the information is about. This can be done in the form of a FOIP or Privacy Clause which can be handed to the individual when tap water samples are collected from private residences (refer to Appendix C). It is essential that these homeowners understand that their drinking water data (lead result and address) will be shared with AEP. Individual addresses and sampling information about that address would not be provided in a FOIP request for information from AEP because it is personal data. Residential lead sampling results submitted with annual reports to AEP will be saved in a protected format.

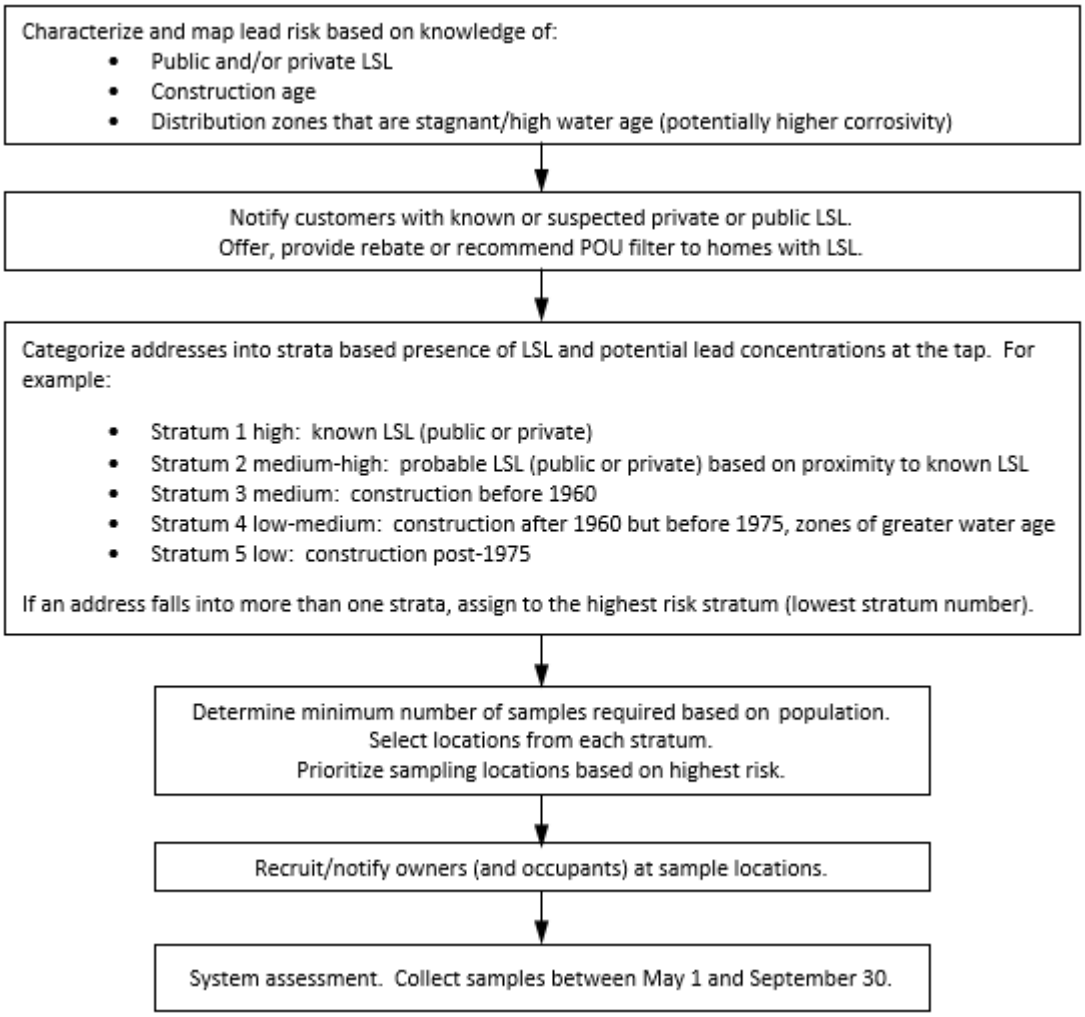


Figure 2: Action sequence for system assessment. Strata assignments are suggestions.

4.2 System assessment sampling protocols

For sampling instructions, sample information, an explanation of the sampling protocols and lab analysis requirements, refer to Appendix A. The system assessment sampling protocols are contained in Table 3.

Facilities can use voluntary customer-initiated tap sampling and seek participation using targeted outreach to customers at risk of having LSLs for assistance in sampling (refer to Appendix C for an example).

Either random daytime (RDT) or 30-minute stagnation (30MS) sampling protocols can be used for single- or multi-family (fewer than eight units) residential sites. These protocols capture typical exposures and are considered appropriate for identifying priority areas for actions to reduce lead concentrations.

For large residential buildings such as apartment buildings or seniors' residences, an RDT sampling protocol is recommended for these sites to capture typical exposures [8]. A smaller sample volume is collected in large building residences because the objective is to detect lead sources within the unit plumbing [16].

Table 3: System assessment sampling protocols

Location	Sampling type	Protocol
Single- and multiple-family (less than 8 units) residences	30MS-2L	2 – 5 minute flush. 30-minute stagnation. Collect first two litres in two 1-L bottles.
	RDT-1L	Samples collected randomly during the day (random stagnation and flushed conditions) without prior flushing. Collect 1 L.
Large residential buildings	RDT-2x125mL	Samples collected randomly during the day (random stagnation and flushed conditions) without prior flushing. Collect two 125-mL samples.

- Monitoring will be conducted at the customer's cold water tap which is used most often for drinking and food preparation, usually the kitchen tap. If there is a kitchen faucet POU filter, a second non-filtered sample point which is also used for drinking water in the residence can be sampled, or the POU filter can be removed. Residences with point-of-entry treatment devices that treat all of the water entering a house or large building should not be sampled.
- All samples will be collected in wide-mouth sample bottles, without removing the aerator or screen [8] or disinfecting the tap. An uninterrupted moderate flow rate (4 to 6 L/minute, where possible) should be used while filling sample bottles.
- Appendix A provides detailed sampling information, sampling instructions and lab analysis requirements.
- For the residential 30MS and large residential building RDT sampling protocols only, the cost of testing may be reduced by analyzing a composite of the two bottles collected from the same tap and sampling event (2 x 1 L for residences or 2 x 125 mL for large residential buildings). Preservation must have taken place at least 16 hours before a proportionate composite of the two well-mixed preserved samples is made. For example, 50-mL aliquots can be taken from each bottle to form a 100-mL composite. All steps in preparing a composite must be done by an approved laboratory because all materials that touch the sample must be acid-washed and lead-free. If the total lead concentration in the composite is ≥ 5 µg/L, the individual bottles should be tested and lead results from both bottles reported to AEP and the customer. Otherwise, results from the composite sample will be reported.

4.3 Reporting results to the customer

The occupant and owner must be provided with all lead sampling results within 14 days of receiving the result from the lab regardless of the lead concentration - This applies for all lead sampling at the tap, not just system assessment. Efforts to reduce lead levels as low as achievable are strongly encouraged and the customer can use the result, low or high, to make informed health decisions.

Communications should include relevant aspects of your lead management program as described in Section 7.

5. Investigative Sampling and Follow-up

As the system assessment portion of testing is being rolled out, the next stage of investigative sampling and follow-up will depend on the type of residence, sample results and presence of LSLs. Where the results of sampling indicate that the lead MAC (5 µg/L) has been exceeded, investigative/verification sampling will be conducted within one month after the initial sample results are received, given best efforts of the facility staff and cooperation from the home owner/occupant. The sampling procedure chosen for follow-up sampling must be appropriate to meet the desired objective [16] whether that is identifying the source of lead contamination, verifying results or monitoring water quality after LSL replacement.

5.1 Large residential buildings

Exceedance of the lead MAC (5 µg/L) should be followed up by the facility to confirm the result using the same large building RDT protocol given in Table 3. For large residential buildings, the building owner is responsible to plan and implement short-term (provide POU filters) and long-term protective and corrective measures.

5.2 Single and multi-family residences with fewer than eight units

Exceedance of the lead MAC (5 µg/L) at single- and multi-family (fewer than eight units) residences will be followed by investigative sampling using 30MS or profile sampling (Table 4 and Figure 3) depending on:

- if the presence of a LSL is unlikely, 30MS-2L sampling method can be used for verification;
- if the service line materials on both the private-side and public-side are known, and an LSL is present, investigative sampling is not required, however 30MS-XL would be an appropriate sampling protocol for verification or customer-requested sampling;
- visual confirmation of the pipe material entering the shut-off valve or hydrovac excavation around the service valve, are a couple of options for determining the service line material -otherwise, profile sampling should be done.

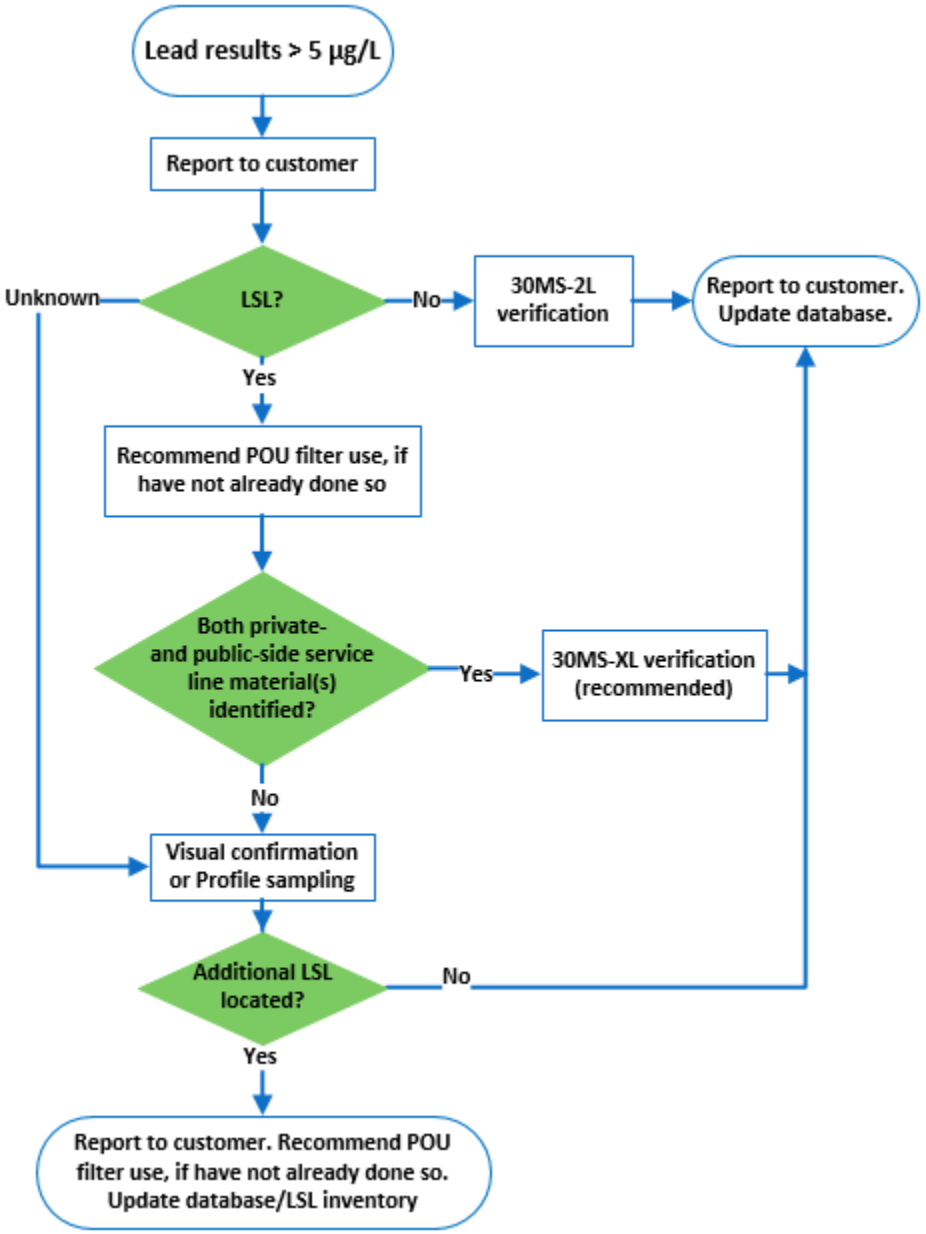


Figure 3: Action sequence for investigative sampling when system assessment sample result is greater than MAC (5 µg/L). LSL refers to full or partial LSL on the private- or public-side.

Where the results of the sampling are less than the lead MAC (5 µg/L) and there is lead service pipe on either the public- or private-side, but the remaining service line material is unknown, the investigative/verification sampling should take place in a timely manner, but no later than 2024 (Table 4 and Figure 4).

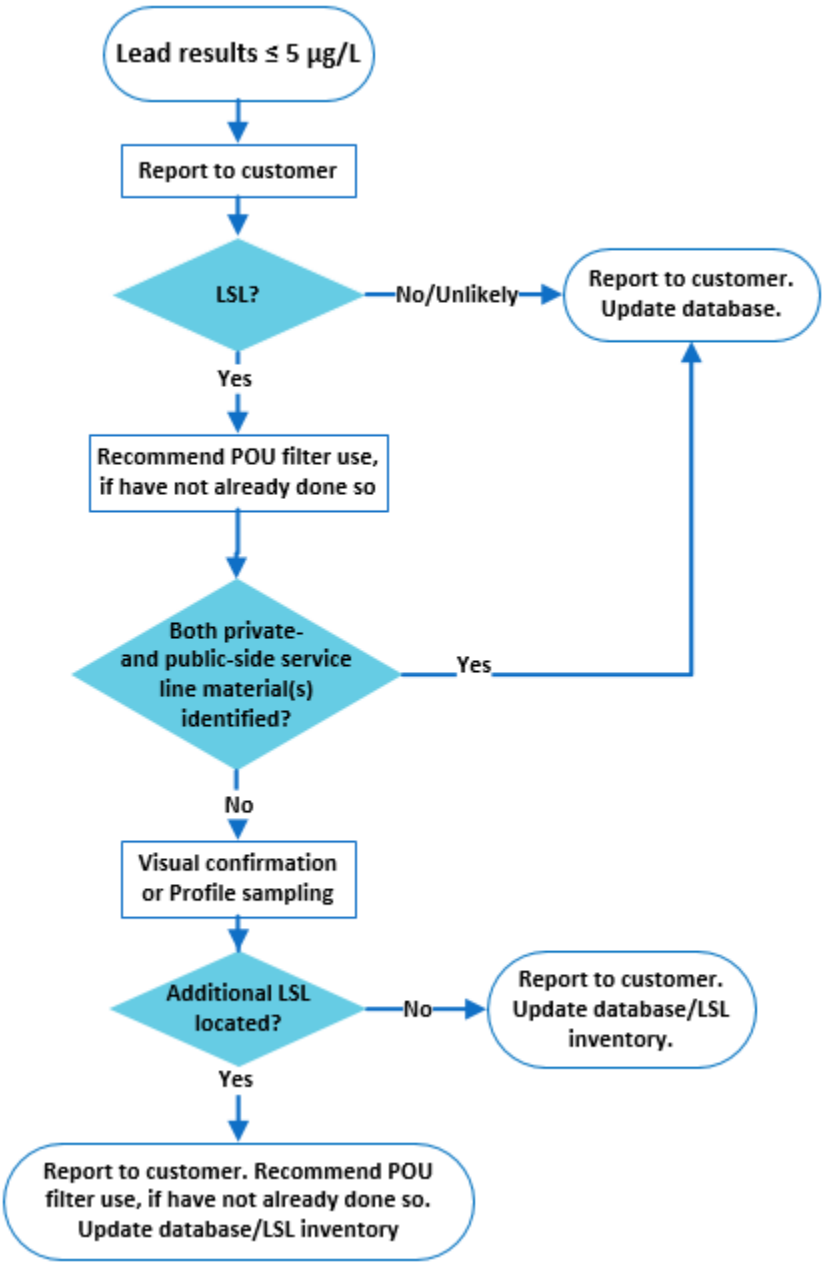


Figure 4: Action sequence for investigative sampling when system assessment sample result is equal to or less than MAC (5 µg/L). LSL refers to full or partial LSL on the private- or public-side.

In the case of multi-family residences, it may be difficult to monitor and confirm the stagnation period and water usage by other units during sampling. For profile sampling, water usage at other taps will interfere with the correlation of volume with peak lead levels and therefore identification of the location of lead sources. The

sampler will need to use their best judgement in choosing the most effective investigative sampling protocol for multi-family residences.

Table 4: Investigative and follow-up sampling protocols for single- and multi-family (fewer than eight units) residences

Objective	Location	Sampling type	Protocol
Verification and post-replacement monitoring as described in Section 6.1	MAC exceedance in non-LSL residences or post-replacement monitoring	30MS-2L	2 – 5 minute flush. 30-minute stagnation. Collect first two litres in two 1-L bottles.
Verification	MAC exceedance in LSL residences where service line material on both private- and public-sides is known. (not required for system assessment follow-up for these locations, but appropriate for verification or customer requests)	30MS-XL	2 – 5 minute flush. 30-minute stagnation. Estimate total volume (X) in household plumbing + private + public service lines to reach main. Multiple bottles can be used. Use 1-, 2- or 4-L bottles. Collect X litres.
Determination of lead sources (plumbing/LSL)	Regardless of system assessment results, residences where the presence of an LSL on either the public- or private-side is unknown but likely.	Profile sampling	Defined stagnation time of at least 30 minutes and up to 8 hours (do not flush before stagnation) Sequential samples of 1 L for a total volume to cover the piping volume (public-side + private-side + household plumbing) from main to the tap (see Table 5).
• For profile sampling, 6 to 8 hour (overnight) stagnation is optimal for identifying peak lead levels. • Monitoring will be conducted at the customer's cold water tap which is used most often for drinking and food preparation, usually the kitchen tap. If there is a kitchen faucet POU filter, a second non-filtered sample point which is also used for drinking water in the residence can be sampled, or the POU filter can be removed. Residences with point-of-entry treatment devices that treat all of the water entering a house or building should not be sampled. • All samples will be collected in wide-mouth sample bottles, and without removing the aerator or screen [8] or disinfecting the tap. An uninterrupted moderate flow rate (4 to 6 L/minute, where possible) should be used during flushing and filling sample bottles. • Appendix A provides more detailed sampling information, sampling instructions and lab analysis requirements. • For the residential 30MS sampling protocols only, the cost of testing may be reduced by analyzing a composite of the sample bottles from the same tap and sampling event. Preservation must have taken place at least 16 hours before a **proportionate** composite of the well-mixed preserved samples is made. For example, 50-mL aliquots can be taken from each bottle (each bottle containing the same volume) to form a composite. All steps in preparing a composite must be done by an approved laboratory because all materials that touch the sample must be acid-washed and lead-free. If the total lead concentration in the composite is ≥ 5 µg/L, the individual bottles should be tested and lead results from all bottles reported to AEP and the customer. Otherwise, results from the composite sample will be reported.			

When performing profile sampling:

- the volume collected (number of sequential 1-L samples) needs to cover the piping volume (public-side + private-side + household plumbing) from the main to the tap (see Table 5);
- each bottle must be analyzed;

- the bottle(s) with peak lead concentration will indicate the possible location of the lead source(s); and
- results from each bottle will be reported to the customer.

Table 5: Linear-feet of pipe corresponding to 1-L of water [14]

Material	Length of pipe equivalent to 1-L of water	
	3/4” (20 mm) nominal ID	1/2” (12 mm) nominal ID
Polyvinyl chloride (PVC)	12’ (3.7 m)	22’ (6.7 m)
Lead	12’ (3.7 m)	26’ (7.9 m)
Galvanized steel	9.5’ (3 m)	17’ (5.2 m)
Copper	10.5’ (3.2 m)	22’ (6.7 m)

Figure 5 [15] is an example of the relationship between sample volume, lead concentration and location of lead source in profile sampling. This is a model of how the lead concentrations in the sequential sample bottles might vary based on the service line configuration in the example. In this figure, the first two litres represent water from within the house and is equivalent to 13 m (88 feet) of ½”-ID copper tubing from the kitchen sink to the private-side service line. Real world conformation of lead and non-lead pipes will be unique at each address. It is important that the plumbing configuration (length and internal diameter) at each residence be estimated and recorded to correlate the sample volumes to the plumbing sections including service lines. If desired, the first one or two bottles filled can be less than one litre, 125 mL or 250 mL for example, to capture the contributions from the faucet and immediate plumbing. The relationship between the lead location and bottle sequence is based on plug flow. Mixing (bends, changes in pipe diameter or material) can blur the contrast (difference) between the lead concentrations in each bottle. Longer stagnation times (up to 8 hours) will maximize the peak value(s).

Additional resampling at a specific location will be at the discretion of the facility owner/operator or as directed by AEP or AHS.

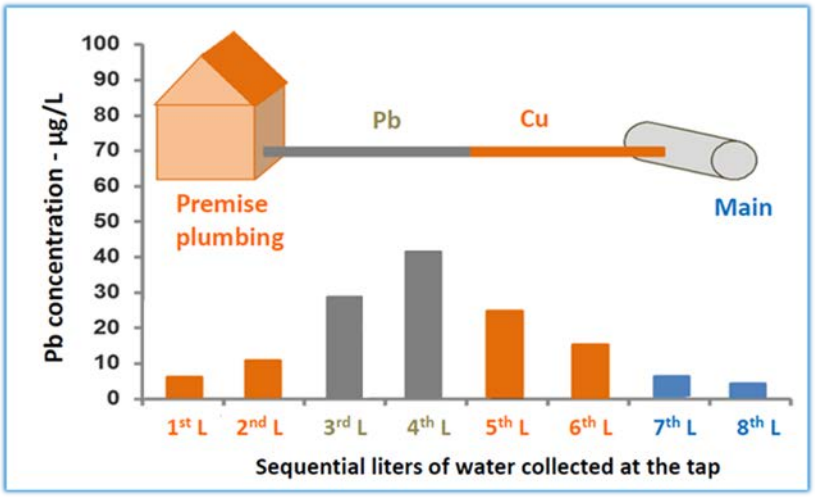


Figure 5: Profile sampling relationship between sample volume, lead concentration and location of lead source
Adapted from Canadian Water Network (2016).

5.3 Broadening scope

The number of samples listed in Table 2 are the minimum required to fulfil the system assessment sampling requirements before the end of 2021. Additional sampling may be required to:

- complete the investigative sampling as described in this section;

- ongoing assessment and investigation of high lead clusters revealed by system assessment sampling and the strata classification process; and
- post LSL-replacement (Section 6.1).

6. Exposure Reduction

In 2016, the AWWA announced its support for replacing all LSL over time. Removing all LSLs is the ultimate goal since lead-containing materials must be removed to resolve the lead in drinking water issue.

Even with effective corrosion control, LSLs can contribute to unpredictable and variable sources of exposure. Temporary increases in lead concentration in the water can be caused by LSL disturbances [19] caused by:

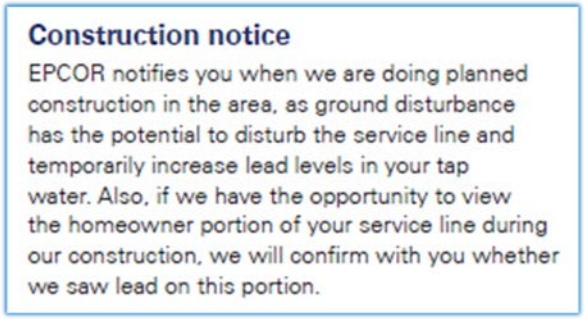


Figure 6: Construction notice - excerpt from an EPCOR letter to Edmonton homeowners regarding their LSL. Provided courtesy of EPCOR (2019).

- meter installation or replacement;
- service line leaks;
- external service valve repair;
- service repair or other water distribution system work;
- depressurization or unidirectional flushing in the area;
- significant street excavation in proximity to the home; or
- partial LSL replacement (Section 6.1).

It is recommended that occupants of residences with an LSL flush internal plumbing and clean the aerator or screen if the LSL is disturbed.

To ensure that LSLs are not reused for infill construction, it is recommended that the community implement construction standards that prohibit reuse of LSLs.

Water meters may have components that are a source of lead. As the owner of the water meter, the facility has a responsibility to replace them with low lead meters.

6.1 LSL replacement and post-replacement flushing and monitoring

LSL replacement initiatives must be designed to ensure residents are protected during and after replacement and that the work is done in a cost effective manner. LSL replacement should be prioritized based on:

- LSL on the public-side only and
- lead concentration at the tap.

Replacing the LSL can disturb or dislodge existing lead scales or sediments containing lead, resulting in a significant increase in lead levels at the tap. The owner/occupant must be advised of the risk of elevated lead levels after replacement and possible mitigation to reduce exposure such as POU filtration, removing debris from screens and aerators, and flushing (see Appendix C for communication examples). Tap aerators and screens should be cleaned immediately after LSL replacement and at least monthly for six (6) months after LSL replacement.

Flushing needs to be conducted immediately after full- or partial-LSL replacement to dislodge and remove particulate lead before the customer starts to use the tap again [20]. It is recommended that screens and aerators are removed from indoor faucets and all cold water taps opened at full velocity for 20 to 30 minutes to remove particulates from the service line and indoor plumbing.

The water quality at the customer's tap should be monitored closely following both full and partial LSL replacement [16, 21]. Increased lead concentration has been shown to continue for three or more months after

the LSL replacement [16] and may continue to cause increased variability in lead levels for two years after replacement [22]. It is recommended that sampling (30MS protocol) take place at least twice after replacement – once within one month after replacement and a second time three months after that, but within six months of replacement. The customer should be advised to continue using a POU filter until the lead levels are below the MAC (5 µg/L) from 30MS sampling.

6.2 Partial LSL replacement

In most cases, partial-LSL replacement refers to replacing the LSL on the public-side while all or part the private-side remains lead. Although partial LSL replacement can reduce lead concentrations, it does not result in a proportional decrease in lead levels when compared with full service line replacement [8]. For this reason, replacements of the public-side only leaving lead service line material on the private-side should not be performed unless necessary (e.g. service line leak). The goal of reducing lead concentration may not be achieved by partial replacements and may increase lead concentrations and variability over the short term.

Every effort should be made to replace the public-side LSL as soon as possible after private-side replacement.

6.3 Barriers to LSL replacement

It is recommended that LSL replacement initiatives address barriers to participation so that customers served by LSLs can benefit equitably, regardless of income. The cost of service line replacement is very site-specific. Actual cost of replacement reflects a number of factors including the length of the service line, the technique used to install the new service line, and the built environment where the service line is located [23]. Property owners may be reluctant to replace private-side LSL because of cost, concerns about service or property disruption or lack of concern regarding the health impacts of lead in drinking water. The potential implications are:

- it is a roadblock to replacement of the public-side LSL and extends the duration of the LSL replacement and annual notification program; and
- continued risk of exposure for the occupants.

One financial strategy for LSL replacement capital programs is to aggregate the cost of full LSL replacement – for both the public- and private-side service lines – and build this cost into the overall cost for operations and maintenance as a water provider. This approach will facilitate LSL replacement and avoid the difficulties of partial LSL replacement that can result in ongoing elevated lead concentrations at the tap. As well, facilities can build in the capital and operating costs of providing homeowners with POU filters for kitchen faucets for example. Financial assistance programs for low-income customers may otherwise be necessary to enable lead mitigation strategies to be effective at the community scale.

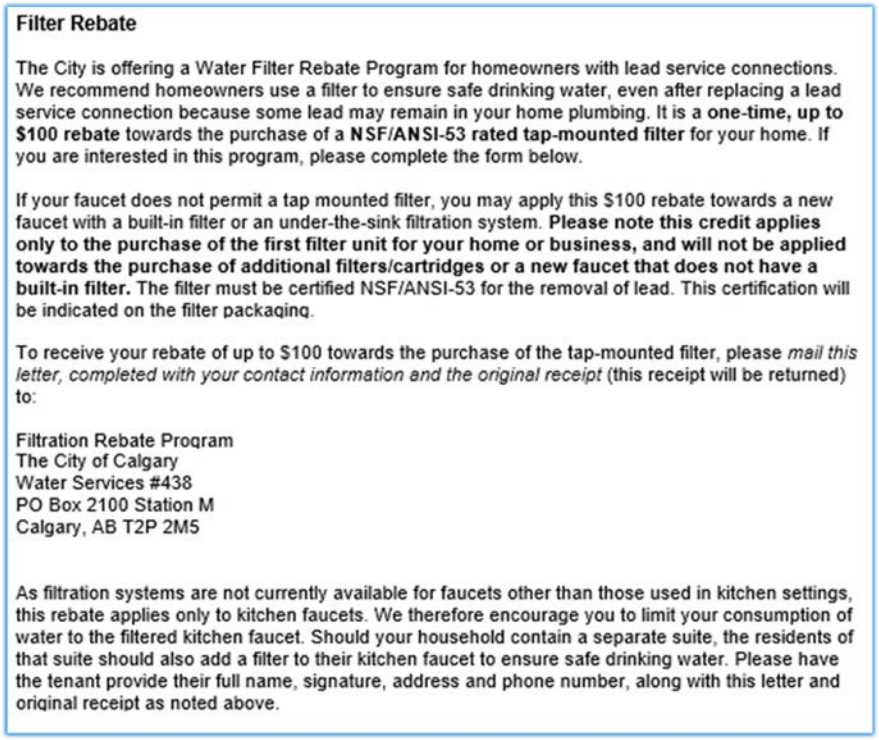
6.4 Point-of-use devices

As the primary source of lead in drinking water is the leaching from plumbing and distribution system components, drinking water treatment devices offer an effective option at the residential level [8] for the short-term – they are no substitute for LSL replacement. POU treatment devices installed at individual drinking water taps reduce concentrations to safe levels immediately before consumption or for preparation of food or beverages and where lead reduction is especially important for baby formula reconstituted with tap water [16]. Types of POU devices available are [24]:

- pour-through pitcher/carafe;
- faucet mount;
- counter-top connected to sink faucet through hose/tubing;
- plumbed-in and usually installed under a sink and filtered water dispensed through a separate faucet directly to the kitchen sink;
- refrigerator filter installed in the refrigerator and typically dispenses filtered water through the refrigerator door; and
- reverse osmosis (RO) that connects to plumbing under the sink and uses a membrane filter to reduce lead (also can reduce minerals/total dissolved solids).

POU devices are recommended over point-of-entry (POE) devices which treat all the water entering a house or a building because point-of-entry treated water may still increase in lead concentration post-treatment by leaching lead from the household plumbing before it gets to the tap [16]. Exposure to lead from drinking water is a concern only if the contaminants are ingested (i.e., inhalation and dermal absorption are not significant routes of exposure).

Facilities can provide information about POU devices to customers when results show elevated lead at the tap or, when practical, provide the device itself. One time offer of a POU filter or rebate by the facility for occupants of single and multi-family residences with LSL (not large building) is recommended. **Installation and maintenance of POU devices according to the manufacturer's instructions should be stressed to ensure that they are functioning effectively.** After LSL replacement, the replacement filters may need to be changed more frequently due to the temporary increase in particulate lead. Customers should be instructed to choose devices, including pitcher filters, which have been certified by an accredited certification body as meeting the appropriate NSF/ANSI 53 drinking water treatment standard to remove lead [23, 16]. Certification organizations provide assurance that a product conforms to applicable standards and they must be accredited by the Standards Council of Canada (SCC). In Canada, the following organizations have been accredited by the SCC to certify drinking water devices and materials as meeting NSF/ANSI standards [25]:



Filter Rebate

The City is offering a Water Filter Rebate Program for homeowners with lead service connections. We recommend homeowners use a filter to ensure safe drinking water, even after replacing a lead service connection because some lead may remain in your home plumbing. It is **a one-time, up to $100 rebate** towards the purchase of a **NSF/ANSI-53 rated tap-mounted filter** for your home. If you are interested in this program, please complete the form below.

If your faucet does not permit a tap mounted filter, you may apply this $100 rebate towards a new faucet with a built-in filter or an under-the-sink filtration system. **Please note this credit applies only to the purchase of the first filter unit for your home or business, and will not be applied towards the purchase of additional filters/cartridges or a new faucet that does not have a built-in filter.** The filter must be certified NSF/ANSI-53 for the removal of lead. This certification will be indicated on the filter packaging.

To receive your rebate of up to $100 towards the purchase of the tap-mounted filter, please *mail this letter, completed with your contact information and the original receipt* (this receipt will be returned) to:

Filtration Rebate Program
The City of Calgary
Water Services #438
PO Box 2100 Station M
Calgary, AB T2P 2M5

As filtration systems are not currently available for faucets other than those used in kitchen settings, this rebate applies only to kitchen faucets. We therefore encourage you to limit your consumption of water to the filtered kitchen faucet. Should your household contain a separate suite, the residents of that suite should also add a filter to their kitchen faucet to ensure safe drinking water. Please have the tenant provide their full name, signature, address and phone number, along with this letter and original receipt as noted above.

Figure 7: City of Calgary filter rebate program.
Provided courtesy of the City of Calgary (2019).

- CSA Group (csagroup.org);
- NSF International (nsf.org);
- Water Quality Association (wqa.org);
- Bureau de normalisation du Québec (bnq.qc.ca);
- International Association of Plumbing & Mechanical Officials (iapmo.org); and
- Truesdail Laboratories Inc. (truesdail.com).

An up-to-date list of accredited certification organizations can be obtained directly from the SCC [25]. For more information on NSF standards for lead reduction, search the NSF website for:

- Residential Water Treatment; and
- Certified Product Listings for Lead Reduction.

6.5 Corrosion control

Water chemistry affects the type and proportions of lead corrosion products, galvanic corrosion, and microbial corrosion and thus the dissolution rate and steady state concentrations of lead [26]. In general, increasing pH, alkalinity and orthophosphate decrease lead concentrations. Changes in water chemistry such as changing the source water (Flint, Michigan), disinfectant (Washington, DC) or coagulant (Durham, NC) can affect the lead contamination problem [27] and need to be considered in your Operations Program and Drinking Water Safety Plan. Corrosion can cause elevated levels of metals in addition to lead, deterioration and damage to household plumbing and aesthetic problems. Appendix E provides a list of water quality factors that can affect corrosion.

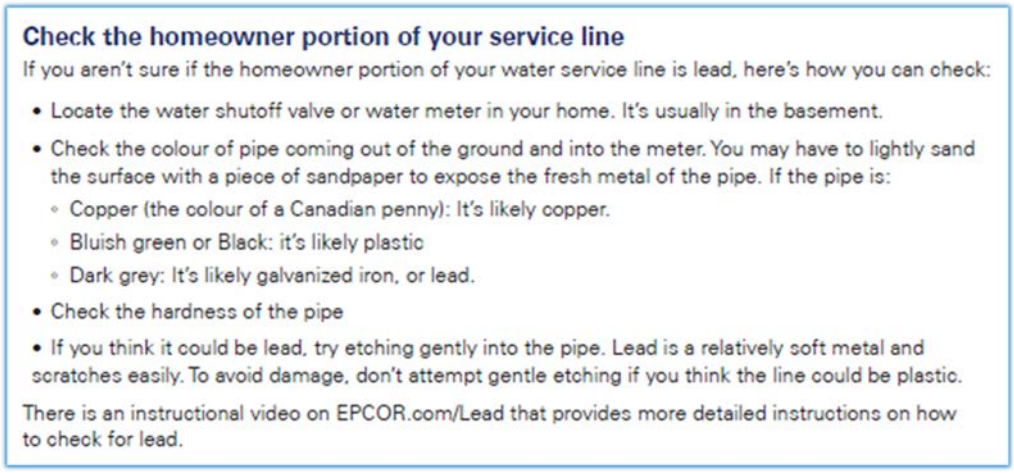
The chemistry of corrosivity is complex and makes it difficult to predict the amount of lead that is leaching from service lines or plumbing components. Indices such as the Langelier Saturation Index for controlling corrosivity are not recommended for making presumptions on sources of lead at the tap [28]. The American Water Works Association Research Foundation (AWWARF) recommends that the use of indices for corrosion control practices be abandoned [10]. The most effective method of predicting the degree of lead contamination is through a field-sampling program that measures the extent of public exposure to lead from drinking water.

Common corrosion control treatment mechanisms are pH and/or alkalinity adjustment and the use of corrosion control additives such as orthophosphate and silicate-based inhibitors. Polyphosphates, used mainly for sequestering iron and manganese, may increase risk of lead exposure [29]. Some systems will have more than one source of raw water which may make system-wide corrosion control difficult. If water treatment for corrosion control is considered, engineering studies should be conducted. Efficacy of corrosion control treatment should be determined based on 30MS sampling from sentinel sites.

7. Communication with the Public

Facilities are responsible for communicating with their customers. Communication materials can be in the form of letters, bill stuffers, website content, door hangers and/or fact sheets. Refer to “Water service lines in Calgary” website [14], and EPCOR’s “Lead in Drinking Water” website [15] for online messaging examples. Provide information on:

- purpose of your lead management program;
- purpose and usage of data collected for informed consent;
- ownership of service lines;
- how to recognize if they have an LSL at the shut off valve (Figure 8);
- LSL replacement program;
- hazards of lead in drinking water;
- how to avoid exposure (good water quality practices);
- POU filter offer program; and
- links to health information such as the Health Canada infographic and AHS resources.



Check the homeowner portion of your service line

If you aren't sure if the homeowner portion of your water service line is lead, here's how you can check:

- Locate the water shutoff valve or water meter in your home. It's usually in the basement.
- Check the colour of pipe coming out of the ground and into the meter. You may have to lightly sand the surface with a piece of sandpaper to expose the fresh metal of the pipe. If the pipe is:
  - Copper (the colour of a Canadian penny): It's likely copper.
  - Bluish green or Black: it's likely plastic
  - Dark grey: It's likely galvanized iron, or lead.
- Check the hardness of the pipe
- If you think it could be lead, try etching gently into the pipe. Lead is a relatively soft metal and scratches easily. To avoid damage, don't attempt gentle etching if you think the line could be plastic.

There is an instructional video on EPCOR.com/Lead that provides more detailed instructions on how to check for lead.

Figure 8: Identification of LSL - excerpt from an EPCOR letter to Edmonton homeowners regarding their LSL. Provided courtesy of EPCOR (2019). EPCOR [30] has a *How to Check for a Lead Service Line* YouTube video showing the differences between service line materials and the U.S. National Public Radio [13] has an interactive tool *Do you have lead pipes in your home?* [13].

Information on health impacts of lead in drinking water including steps individuals can take to avoid lead exposure from drinking water at home can be found at:

- Lead and Drinking Water from Lead Service Lines published by Alberta Health [1].
- Common Questions about Lead and Drinking Water published by Alberta Health Services [2]; and
- Drinking Water: What about lead? published by Health Canada [3].

Directed communication to residences regarding lead results or LSLs should include both the home or building owner and the occupant when this information is available (collected from billing information, customer calls and/or during sampling). Communications can include a request to forward the information to the occupant or owner. Example messages can be found in Appendix C.

Each property with a known (or suspected) private- or public-side LSL should be provided information on an annual basis about the presence of an LSL, lead hazards, steps that can be taken to reduce risk including POU filter offer, and facility contact information for scheduling sampling and testing for lead. Consider providing a contact list of reputable licensed plumbers that can replace private-side LSL to encourage replacement. In cases where the resident or owner is opposed to tap sampling, homeowners should still be provided with the above information on an annual basis. Transparency is important in effective communication. Be clear, consistent, and accurate when describing ownership and responsibility of service lines [23] (refer to Figure 1). Coordinating public-side with private-side LSL replacement can minimize the disruptions for the occupants.

8. Regulatory Reporting Obligations to AEP

Waterworks are required to provide a section in their Operations Program specific to lead management that provides information on the development of their programs to monitor for lead in the distribution system and at customer taps, identify LSLs, financial planning to fund LSL replacement and overall program results. The Operations Program document requires annual updating – including this new mandatory lead section.

The Drinking Water Safety Plan requires annual updates. Consequences and likelihood need to be considered for risk scoring in relation to lead contamination, assessment, management and mitigation given the lower MAC and change in point of compliance. Action plans may need to be updated related to Customer and Network Risks. This section should be included as an addendum in the annual performance report submitted to AEP for years 2020 through 2024.

The Annual Performance Report for the waterworks facility needs to include a section on the lead mitigation plan including program successes for the reporting year and next steps expected for the following year.

All addresses sampled and lead results will be reported annually as a separate electronic Excel file along with the annual performance report. To assist AEP in evaluating the provincial lead exposure, risk assessment, sampling protocols and possible recommended mitigation actions, the results must be complete and reported in the Excel format (not PDF) attached to this document and shown in Appendix F: Report Template. This is in addition to electronic reporting since the electronic report submissions to AEP cannot capture all of the relevant details associated with lead sampling at the tap such as address and sampling protocol.

9. Looking Ahead to Phase 2

Since lead-containing materials must be removed to resolve the lead in drinking water issue permanently, replacement of lead-containing plumbing fittings and solder is an expensive and onerous task that homeowners and large residential building owners will be reluctant to undertake to completion. Alberta has not yet set a threshold for water corrosivity – a trigger for when corrosion control treatments be considered by the facility. Trigger criteria examples include: the EU *Guidance on Sampling and Monitoring for Lead in Drinking Water* [31] that recommends system-wide control measures when a percentage of houses exceed the 10 µg/L value for lead; and Ontario that has a target of less than 10% of samples exceeding 5 µg/L and no samples exceeding 10 µg/L [32].

Before the end of 2022, AEP plans to release an additional lead guidance document (Phase 2) to support facilities in implementing their Phase 2 mitigation plans. Phase 2 guidance will cover the issue of water corrosivity and corrosion control treatment options to achieve community-wide control for lead at customer taps.

10. References

[1] Office of the Chief Medical Officer of Health of Alberta, "Lead and Drinking Water from Lead Service Lines - Guidance package for Water Utility Companies, Residents, Alberta Health Services, Healthcare Providers, and Laboratories," 2013. [Online]. Available: https://open.alberta.ca/dataset/7c5b7cd6-c734-43d8-be5d-5850cefb2daa/resource/f9b0a62d-d33b-4640-998f-62be47142bd9/download/2013-lead-and-drinking-water-from-lead-service-lines-2013.pdf.

[2] Alberta Health Services, "Common Questions about Lead and Drinking Water," 2019. [Online]. Available: https://myhealth.alberta.ca/Alberta/Pages/Common-questions-about-lead-and-drinking-water.aspx. [Accessed 8 August 2019].

[3] Health Canada, "Drinking water: what about lead?," 2018. [Online]. Available: https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/pubs/what-about-lead/drinking-water-lead-eng.pdf. [Accessed 06 May 2019].

[4] C. Cartier, S. Nour, B. Richer, E. Deshommes and M. Prévost, "Impact of water treatment on the contribution of faucets to dissolved and particulate lead release at the tap," *Water Research*, vol. 46, pp. 5205-5216, 2012.

[5] WHO, "Lead poisoning and health," 2019. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health. [Accessed 08 August 2019].

[6] U.S. Centers for Disease Control and Prevention, "Breastfeeding and Special Circumstances, Environmental Exposures to Lead," 24 January 2018. [Online]. Available: https://www.cdc.gov/breastfeeding/breastfeeding-special-circumstances/environmental-exposures/lead.html. [Accessed 27 May 2019].

[7] H. Lu, R. Romero-Canyas, S. Hiltner, T. Neltner, L. McCormick and J. Niederdeppe, "Research to Move Toward Evidence-Based Recommendations for Lead Service Line Disclosure Policies in Home Buying and Home Renting Scenarios," *International Journal of Environmental Research and Public Health*, vol. 16, no. 6, p. E963, 2019.

[8] Health Canada, "Lead in Drinking Water: Document for Public Consultation," Health Canada, Ottawa, Ontario, 2017.

[9] LSLR Collaborative, "Preparing a Lead Service Line Inventory," [Online]. Available: https://www.lslr-collaborative.org/preparing-an-inventory.html.

[10] Health Canada, "Guidance on Controlling Corrosion in Drinking Water Distribution Systems," Health Canada, Ottawa, 2009.

[11] D. Ellis and A. Bolduc, "Assessment and Action Guide for Monitoring Lead and Copper in Drinking Water," Quebec Municipal Water Directorate, 2014.

[12] California Water Boards, "Preparing a Service Line Inventory: How to Get Started and Where to Find Information," September 2017. [Online]. Available: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/leadservicelineinvpws/lead_testing_brochure_2017_4c.pdf. [Accessed 17 May 2019].

[13] Health Canada, "Guideline Technical Document - Lead," Health Canada, Ottawa, 2019.

[14] D. Lytle, M. Schock and K. Cahalan, "Lead in Drinking Water: Research Update, Sampling Tools," in *WQTC*, Toronto, 2018.

[15] Canadian Water Network, "Challenges related to the management of lead service lines, partial lead service line replacements, and lead occurrence in the tap water of large buildings in Canada," in *Webinar with Dr. Michèle Prévost (Polytechnique Montréal)*, September 28, 2016.

[16] M. A. Del Toral, A. Porter and M. R. Schock, "Detection and Evaluation of Elevated Lead Release from Service Lines: A Field Study," vol. 47, pp. 9300-07, 2013.

[17] R. A. Brown and D. A. Cornwell, "High-Velocity Household and Service Line Flushing Following LSL Replacement," *Journal AWWA*, vol. 107, no. 3, pp. E140-51, 2015.

[18] W. Krkosek, "Utility Adopts a Complete Lead Service Line Replacement Strategy," *Opflow*, pp. 12-15, August 2016.

[19] E. Deshommes, B. Trueman, I. Douglas, D. Huggins, L. Laroche, J. Swertfeger, A. Spielmacher, G. A. Gagnon and M. Prévost, "Lead Levels at the Tap and Consumer Exposure from Legacy and Recent Lead Service Line Replacements in Six Utilities," *Environmental Science & Technology*, vol. 52, pp. 9451-59, 2018.

[20] AWWA, "Communicating About Lead Service Lines: A Guide for Water Systems addressing Service LIne Repair and Replacement," American Water Works Association, 2014.

[21] NSF, "Certified Product Listings for Lead Reduction," 2016. [Online]. Available: http://info.nsf.org/Certified/DWTU/listings_leadreduction.asp. [Accessed 08 August 2019].

[22] Standards Council of Canada, "Directory of Accredited Product, Process and Service Certification Bodies," 2019. [Online]. Available: http://www.scc.ca/en/accreditation/product-process-and-service-certification/directory-of-accredited-clients. [Accessed 21 August 2019].

[23] C. Nguyen, K. Stone, M. Edwards, G. Gagnon and A. Knowles, "Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water," Water Research Foundation, Denver, 2010.

[24] R. Renner, "Out of Plumb: When Water Treatment Causes Lead Contamination," *Environmental Health Perspectives*, vol. 117, no. 12, p. A542–A547, 2009.

[25] Newfoundland Dept. of Environment and Conservation, "Pilot Study to Develop an Action Plan on Indicators for Monitoring Corrosion Control in Drinking Water," Newfoundland and Labrador, 2009.

[26] USEPA, "Optimal Corrosion Control Treatment Evaluation Technical Recommendations," March 2016. [Online]. Available: https://www.epa.gov/dwreginfo/optimal-corrosion-control-treatment-evaluation-technical-recommendations. [Accessed 16 May 2019].

[27] City of Calgary, "Water service lines in Calgary," [Online]. Available: https://www.calgary.ca/UEP/Water/Pages/Water-and-wastewater-systems/Water-Service-Lines-Calgary.aspx. [Accessed 11 07 2019].

[28] EPCOR, "Lead in Drinking Water," [Online]. Available: https://www.epcor.com/products-services/water/delivering-water-to-you/Pages/replacing-lead-pipes.aspx. [Accessed 11 07 2019].

[29] EPCOR, "How to Check for a Lead Service Line," 18 Mar 2019. [Online]. Available: https://www.epcor.com/products-services/water/delivering-water-to-you/Pages/replacing-lead-pipes.aspx. [Accessed 17 May 2019].

[30] National Public Radio, "Do you have lead pipes in your home?," 24 June 2016. [Online]. Available: https://apps.npr.org/find-lead-pipes-in-your-home/en/#intro. [Accessed 17 May 2019].

[31] E. Hoekstra, C. Hayes, R. Aertgeerts, A. Becker, M. Jung, A. Postawa, L. Russell and S. Witczak, "Guidance on sampling and monitoring for lead in drinking water," European Commission, Ispra, Italy, 2009.

[32] ON Ministry of the Environment, Conservation and Parks, "Community Sampling and Testing for Lead: Standard and Reduced Sampling and Eligibility for Exemption," 4 May 2016. [Online]. Available: https://www.ontario.ca/page/community-sampling-and-testing-lead-standard-and-reduced-sampling-and-eligibility-exemption#section-1.

[33] Directorate-General for Research and Innovation, "Developing a new protocol for the monitoring of lead in drinking water," European Commission, Brussels, 1999.

[34] D. Cornwell and D. Brown, "Evaluation of Lead Sampling Strategies," Water Research Foundation, Denver, 2015.

[35] APHA, "3010 B. Sampling and Sample Preservation," in *Standard Methods for the Examination of Water and Wastewater*, 23rd ed., Washington, DC, 2017, pp. 3-1 - 3-2.

[36] Alberta Environment and Parks, "Drinking Water Information Letters," 2014. [Online]. Available: https://open.alberta.ca/publications/drinking-water-information-letter. [Accessed 20 August 2018].

[37] USEPA, "Memo Clarifying Recommended Tap Sampling Procedures for the Lead and Copper Rule," 26 February 2016a. [Online]. Available: https://www.epa.gov/sites/production/files/2016-02/documents/epa_lcr_sampling_memorandum_dated_february_29_2016_508.pdf. [Accessed 16 May 2019].

[38] California Water Service, "Implementing The Lead Public Education Provision of the LCR: A Guide for Community Water Systems," June 2008. [Online]. Available: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/leadandcopperrule/implementing_lead_education_provisions_lcr.pdf. [Accessed 17 May 2019].

[39] NZ MoH, "Guidelines for Drinking-water Quality Management for New Zealand," 2017. [Online]. Available: https://www.health.govt.nz/publication/guidelines-drinking-water-quality-management-new-zealand.

[40] J. D. Noel, Y. Wang and D. E. Giammar, "Effect of water chemistry on the dissolution rate of the lead corrosion product hydrocerussite," *Water Research*, vol. 54, pp. 237-246, 2014.

Appendix A Sample Information, Protocols, Instructions and Analysis

A-1. Sample information

When collecting a water sample, the information (when applicable) as shown in Table 6 below is required.

Table 6: Sample records

Sample Location Address:	Phone: Email:
Contact Name:	
Owner Name (if different than occupant:	Phone: Email:
Mailing address:	
Private-side service line material at shut-off valve:	With homeowner's permission, identify the pipe material entering the shutoff valve if visible.
Name of Sampler:	Sample date and time:
Sample location: (e.g. kitchen or bathroom)	Postal code:
Informed Consent	☐ Confirmed
Sampling method Check one. Cold water only.	☐ RDT-1L No flushing, no stagnation, collect 1 L cold water at moderate flow between 4 and 6 L/minute. ☐ 30MS-2L Flush at moderate flow between 4 and 6 L/minute for 2 to 5 minutes. 30-minute stagnation. Collect two 1-L samples at moderate flow. Label bottles to identify which was filled first. Flush time = _____ minutes. Stagnation time = _____ minutes ☐ 30MS-XL Estimate total volume (X) in household plumbing + private + public service lines to reach main. 1-, 2- or 4-L bottles can be used. Label bottles in sequence if more than one will be filled. Flush at moderate flow between 4 and 6 L/minute for 2 to 5 minutes. 30-minute stagnation. Fill bottles at moderate flow, minimizing the time to switch out a full bottle with the next empty one (if applicable). Flush time = _____ minutes. Stagnation time = _____ minutes. Volume = _____ L ☐ Profile No flushing. Estimate total volume (X) in household plumbing + private + public service lines to reach main. Label bottles in sequence (1 = first L, 2 = second L, 3 = third L, … , X = X L to reach main). Allow water to stagnate at least 30 minutes and up to 8 hours (do not flush before stagnation). Collect X number of 1-L samples sequentially, minimizing the time to switch out a full bottle with the next empty one. Stagnation time = _____ minutes. Vol. #1 = ____ L, Vol. #2 = ____ L, Vol. #3 = ____ L, Vol. #4 = ____ L, Vol. #5 = ____ L, Vol. #6 = ____ L, Vol. #7 = ____ L, Vol. #8 = ____ L,… ☐ Large residential building-2x125mL No flushing. No stagnation. Collect two 125-mL samples at moderate flow. Label bottles to identify which one was filled first.

A-2. Sampling protocol overview

It is important that the selected protocol be appropriate to meet the desired objective such as:

- monitoring lead in the distribution system by sampling water entering or in the distribution system (typical monitoring in the past to establish background lead levels only, not sufficient for system assessment or investigative sampling);
- providing general exposure information and an indication of corrosivity by a **system assessment** compiled from samples collected from residential taps that is based on the Random Daytime sampling protocol (RDT or 30MS) as endorsed by Health Canada; and
- verifying MAC exceedances and identifying lead sources through a rigorous **investigative sampling** protocol that uses stagnation and flushing steps to ensure reproducibility (Section 5).

Sampling protocols vary based on:

- length of stagnation - the amount of time that no water is used in the residence (even for toilet flushing) so that water is exposed to the service line and household plumbing;
- flushing – amount of time that the sample tap is opened and given uninterrupted moderate flow before sampling or stagnation; and
- volume collected.

Stagnation, flushing and sample volume are all critical factors and following the protocols exactly ensures the results are reproducible and provides the appropriate information.

A-3. Random daytime sampling (RDT)

A 1-L sample is collected randomly during the day in each of the locations chosen to be surveyed. Samples are collected without prior flushing; no stagnation period is prescribed in order to better reflect customer use [8]. This sampling protocol enables detection of the proportion of problem properties, is practical and relatively inexpensive. The disadvantage is poor reproducibility because of variable sampling conditions, an increased number of samples required to be representative and possible overestimation of the average weekly intake [33]. Although RDT sampling is relatively inexpensive, more practical to implement and generally more acceptable to the customer, 30MS can be used for system assessment, investigating the cause of exceedances and identifying appropriate mitigation measures [8].

Sampling instructions – RDT (single and multi-family with less than 8-units)

1. Record sample information. Label 1-L bottle and remove the cap. Do not flush the tap. Stagnation time is not required (irrelevant).
2. Place the bottle under the tap and using cold water only, fill the bottle using moderate flow and cap. Follow lab preservation instructions, if any.

A-4. 30-minute stagnation (30MS)

This method enables detection of the proportion of problem properties, is representative of household installation and water properties and provides an accurate repeatable value for average weekly lead concentration. However, it underestimates the highest levels of lead at the tap [10] and is inconvenient due to the length of time the sampler spends in the residence and does not represent customer behaviour [33, 8].

Sampling instructions – 30MS-2L

1. Record sample information.
2. Using cold water only, run the water at moderate flow for 2 to 5 minutes. Turn off the water.
3. For 30 minutes, no water may be used in the residence, not even for toilet flushing.
4. Label 1-L bottles 1 and 2 (filled first and second respectively) and remove the caps.

5. At the end of the 30-minute stagnation period, place the first bottle under the tap and using cold water only at a moderate flow (4 to 6 L per minute), fill the first bottle, then immediately fill the second bottle. Cap both.
6. Follow lab preservation instructions, if any. Ensure the bottle numbers are included in the lab requisition form so that the results can be traced back to first and second bottle (or composite).

Sampling instructions – 30MS-XL

1. Estimate total volume (X) in household plumbing + private + public service lines to reach main. Multiple bottles can be used. Use 1-, 2- or 4-L bottles.
2. Record sample information.
3. Using cold water only, run the water at moderate flow for 2 to 5 minutes. Turn off the water.
4. For 30 minutes, no water may be used in the residence, not even for toilet flushing.
5. Label bottles in sequence if more than one will be filled.
6. Fill bottle(s) at moderate flow, minimizing the time to switch out a full bottle with the next empty one (if applicable). Cap.
7. Follow lab preservation instructions, if any. If filling more than one bottle, ensure the bottle numbers are included in the lab requisition form so that the results can be traced back to first, second, etc. bottle (or composite).

A-5. Large residential buildings

When sampling large or multi-dwelling buildings, priority should be given to sites suspected or known to have LSLs or internal lead plumbing. An RDT sampling protocol collecting two 125-mL samples [16] is recommended for these sites to capture typical exposures [8]. Stagnation is nearly impossible to coordinate because of the number of occupants in the building.

Sampling instructions – large residential buildings

1. Record sample information. Using 125 mL bottles, label bottles 1 and 2 (filled first and second respectively) and remove the caps.
2. Place the first bottle under the tap and using cold water only, fill the first bottle, then immediately fill the second bottle. Cap both.
3. Follow lab preservation instructions, if any. Ensure the bottle numbers are included in the lab requisition form so that the results can be traced back to first and second bottle (or composite).

A-6. Profile (sequential) sampling

Profile sampling consists of collecting consecutive samples (typically four or more 1-L samples) at the tap after stagnation. The volume collected (number of consecutive 1-L samples) needs to cover the piping volume from the tap to the main (see Table 5: Linear-feet of pipe corresponding to 1-L of water). Optionally, sample volumes of 125 mL or 250 mL may be used at the beginning of the sequence (filled first) to indicate lead contribution from the faucet and immediate plumbing, followed by 1-L volumes. For example,

Estimated volume to main = 5 L

Bottle filling sequence	Bottle volume	Cumulative volume
1 (first)	125 mL	125 mL
2	125 mL	250 mL
3	1 L	1.25 L
4	1 L	2.25 L
5	1 L	3.25 L
6	1 L	4.25 L
7 (last)	1 L	5.25 L

This protocol is used to assess responsibility (source of lead contamination). If a LSL is present, the cumulative volume to collect water that was stagnant in the household plumbing and service lines is site dependent. Collection of sequential samples is operationally difficult (more bottles, more labelling, more forms, more results to track) and therefore more prone to error. The EU Directorate-General for Research and Innovation [33] report recommends profile sampling after 30-minute stagnation to assess responsibility. Cornwell and Brown [34] found that profile sampling after 6-hour stagnation was better at finding the peak lead level than collecting a sample when the running water turns cold, collecting the 5th litre, analyzing the sample corresponding to the middle of the service line or analyzing a composite sample of the first 4 litres.

Sampling instructions - profile

1. Record the volumes for each portion (volume of the household plumbing plus private- and public-side service lines) of pipe from the tap to the main and calculate the number of bottles needed. Do not flush before stagnation.
2. For at least 30 minutes no water may be used in the residence, not even toilet flushing (stagnation period may be longer; a 6-hour or overnight stagnation is also commonly used). At the end of the stagnation period, record sample information including length of stagnation period, label bottles and remove the caps. Arrange the bottles so that they are accessed easily in the correct order.
3. Place the first bottle under the tap and using cold water only at a moderate flow, immediately start filling the first bottle and continue filling the next bottle in sequence minimizing the time and water loss between bottles. Do not interrupt or adjust the flow during the sampling period. Cap bottles.
4. Follow lab preservation instructions, if any. Ensure the bottle numbers are included in the lab requisition form so that the results can be traced back to the bottle number and therefore location in the household plumbing and/or service lines.

A-7. Flushed sampling

This protocol is used to determine the lead content in water in the main (source water characterization). A 1-L sample is taken after the supply has been run for a period long enough to ensure that water from the main is being sampled. The duration of flushing dependent on plumbing configuration (see Table 5) but 5 minutes of flushing at a moderate flow rate is commonly used.

Sampling instructions – flushed

Record sample information. Calculate the volume of the household plumbing plus private- and public-side service lines. Using cold water only, run the water at moderate flow (4 to 6 L per minute) for the time required to replace the household plumbing and service lines with fresh water from the main (5 minutes is commonly used). Label 1-L bottle and remove the cap. Without interrupting or changing the flow, fill the bottle. Place the bottle under the tap and using cold water only, fill the bottle using moderate flow. Follow lab preservation instructions.

A-8. Analysis: Approved labs and method

Samples will be preserved and analyzed for <u>total lead</u> according to *Drinking Water Information Letter 1/2014: Analysis of drinking-water for metals* by an approved laboratory. The facility owner/operator will cover the cost of testing.

Sample bottles are available from the approved laboratory providing analysis services and must be lead (metals)-free. The sample volume is critical, so insist on the correct bottle size. Samples should be well sealed to prevent change in volume due to evaporation. It is recommended that samples are stored in a refrigerator at approximately 4˚C. Addition of preservative (1:1 nitric acid) should be performed by lab or waterworks personnel who are trained and competent in the appropriate safe work practices - not by home sampling volunteers. Preservation must take place within 7 days of collection. Analysis must be performed no sooner than after 16 h after preservation but within six months of sampling.

Table 7: List of Alberta labs that are ISO/IEC 17025 accredited for lead in water is not an exhaustive list, but at the time of writing, contained those ISO/IEC 17025 accredited for lead in water and does not represent an

endorsement by AEP. Other laboratories may be used if they meet the requirements. The list of tests and measurement capabilities for which a laboratory is accredited can change at any time due to circumstances such as scope extensions, voluntary withdrawal of tests by the laboratory and suspension. The facility owner/operator is responsible for checking the laboratory's accreditation status with the Canadian Association for Laboratory Accreditation (CALA) (http://www.caladirectory.ca/search.php?wId=s) or Standards Council of Canada (SCC) (http://www.scc.ca/en/search/laboratories) for the methods required in the Information Letter (Appendix B). The method detection limit or reported detection limit must be ≤ 0.5 µg/L for total lead.

Table 7: List of Alberta labs that are ISO/IEC 17025 accredited for lead in water

Lab Name	Location	Contact information
Access Analytical Laboratories Inc.	Calgary	Bob Corbet (403) 291-4682 BCorbet@accesslabs.ca
AGAT Laboratories	Calgary and Edmonton	Duncan Unrau (403) 299-2197 unrau@agatlabs.com
ALS Canada	Calgary, Edmonton and Grande Prairie	Erin Perez-Nafarrate (780) 413-5227 erin.perez@alsglobal.com Blair Easton Blair.Easton@ALSGlobal.com
Bureau Veritas (formerly Maxxam Analytics)	Calgary, Edmonton	Leanne Cameron (780) 577-7103 customersolutionswest@bvlabs.com
Element Materials Technology (formerly Exova)	Edmonton	Anthony Neumann Benjamin Morris (780) 485 7342 anthony.neumann@element.com benjamin.morris@element.com
InnoTech Alberta Inc.	Vegreville	Graham Knox 780-632-8403 Graham.Knox@InnotechAlberta.ca
Kaizen Lab Inc.	Calgary	Dr. Koshy Malayil kmalayil@kaizenlab.ca (403) 297-0412
QAS Ltd	Okotoks	Steve Gardner (403) 973 5316 steve@qasltd.ca
WSH Labs (1992) Ltd.	Calgary	Bill Wong (800) 449-6544 (403) 250-9164 support@wshlabs.com

Appendix B Drinking Water Information Letter 1/2014 [36]

Alberta Environment and Sustainable Resource Development

Drinking Water Information Letter 1/2014

Analysis of drinking-water for metals

Purpose

This letter sets out the requirements for the analysis of drinking-water samples for total metals that will come into force on April 1, 2014. These requirements supersede guidance provided in Drinking Water Information Letter 1/2012.

Scope

The scope of this letter is confined to those parameters classified as metals for which analysis is required in accordance with the terms and conditions attached to an Approval; a Code of Practice; or the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems (2012) dealing with a drinking-water facility. This letter does not pertain to any other water-related analysis e.g. as set out in Groundwater Information Letter 1/2012 "Analysis of Groundwater Samples for Metals".

This letter sets out the requirements under the authority provided in sections 17(2)(f) and (h) of the Potable Water Regulation for the handling of samples and analysis for metal parameters that may be present in drinking water samples. Authority for Directors to issue a notice is given in section 17(2).

Approval holders (including registration holders) who are responsible for procuring laboratory services are required to ensure that the requirements set out in this letter are met for all drinking-water samples analysed for any metal parameter where the sample has been taken **on or after April 1, 2014**.

Background

Drinking-water parameters classified as metals in the Guidelines for Canadian Drinking Water Quality (GCDWQ) must be analysed for the presence of total metals.

This letter sets out the analytical requirements for the analysis of total metals in drinking-water samples and the requirements to be followed in preserving drinking-water samples that will subsequently be analysed for total metals.

Detail

(i) Total Metals Analysis

Total metals are defined as "the concentration of analyte determined either by "direct analysis" of an unfiltered acid preserved drinking-water sample with turbidity of <1 NTU, or by analysis of an unfiltered aqueous sample following digestion with hot dilute mineral acid(s)" (US EPA 200.8).

Digestion of drinking-water samples prior to analysis of total metals is to be conducted using US EPA Method 200.2, or an equivalent digestion procedure approved by the Drinking Water Specialist, Alberta Environment and Sustainable Resource Development that employs hot dilute nitric and hydrochloric acids.

Digestion of drinking-water samples prior to analysis of total mercury may alternatively be conducted using US EPA Method 1631 Revision E, or an equivalent digestion procedure approved by the Drinking Water Specialist, Alberta Environment and Sustainable Resource Development that employs bromine monochloride oxidation or US EPA Method 245.7.

Drinking-water samples that have been confirmed by measurement to have turbidity levels less than 1 NTU may be analyzed directly, without prior digestion, provided that samples have been preserved in accordance with the requirements below, and provided that turbidity results are recorded and maintained for audit purposes. Turbidity measurements in support of this option may be conducted using either a preserved or raw sample aliquot. Mercury-specific test methods utilizing cold vapour atomic absorption or atomic fluorescence still require digestion/oxidation, since this is a necessary component of these test procedures.

(ii) Sample Preservation Requirements

Drinking-water samples requiring analysis for total metals (excluding mercury) are to be collected in containers constructed of plastic (e.g. high density polyethylene), or fluoropolymer. Samples should be preserved in the field with nitric acid to pH < 2. If field preservation is not possible, samples may be preserved with nitric acid to pH < 2 within 7 days of collection, provided the sample is allowed to equilibrate in its original container for at least 16 hours prior to sub-sampling or analysis. Analysis must be completed within 6 months of sampling.

Drinking-water samples requiring analysis for total mercury are to be collected in containers constructed only of glass or fluoropolymer. Samples must be preserved in the field with hydrochloric acid to pH < 2. If field preservation is not possible, samples may be preserved with bromine monochloride within 48 hours of collection, provided the sample is allowed to equilibrate in its original container for at least 24 hours prior to sub-sampling or analysis. Samples for mercury analysis must be completed within 28 days of sampling.

References:

US EPA Method 200.2, Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Elements, National Exposure Research Laboratory, Office of Water, US EPA, Cincinnati, OH, October 1999.

US EPA Method 200.8, Rev 5.5, Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry, Office of Water, US EPA, Washington, DC, October 1999.

US EPA Method 245.7, Mercury in Water by Cold Vapor Atomic Fluorescence Spectrometry, Revision 2.0, Office of Science and Technology, Office of Water, US EPA, Washington, DC, February 2005.

US EPA Method 1631 Rev E, Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry, Office of Water, US EPA, Washington, DC, August 2002.

Appendix C Example Messaging

How to reduce exposure to lead from drinking water (adapted from Health Canada [3])

Flush out your pipes before consuming the water

- Has water been sitting in your pipes for several hours? – Run the tap until it's cold (about one minute) before drinking or cooking with the water from that tap
- Only use cold tap water for drinking or cooking, since hot water increases the leaching of lead and other metals from your plumbing

Clean your taps monthly

- Every month, inspect the aerators or screens at the tap
- If you find debris, clean it out – this will remove any particles that may contain lead, and inspect more frequently
- If you do not find debris, continue to inspect monthly

Replace Brass fittings

- Brass faucets and valves can contain some lead – These can be replaced with fittings that are certified to the standard on low lead content

A household water filter at the tap can effectively remove lead from your water

- Recommended as a temporary solution
- The filter must be installed and maintained properly or it could become ineffective
- Test your water for lead before installation and during use to confirm the filter is working
- Make sure that any device you purchase is certified to the NSF International standard for removal of lead.

FOIP or privacy clause

The following is a sample FOIP/Privacy Clause and should be reviewed and authorized by each municipality's or facility owner's privacy office or equivalent and can be amended by them for any correction of the program name or other information:

To the customer:

> The personal information you provide is being collected under the authority of the *Environmental Protection and Enhancement Act*, *Potable Water Regulation* 16(1) for the sole purpose of conducting the waterworks system lead survey of tap water. Please note that your tap water sample results and your address will be disclosed to Alberta Environment and Parks as part of required reporting under this program. Your personal information will not be shared further unless you provide additional consent to do so. By providing your tap water sample and personal information, you are consenting to this collection, use and disclosure. If you have any questions about this program or the collection, use and disclosure of your personal information, please contact: _____ (NOTE: each municipality or private developer is to provide a contact name and/or title and phone number/email address, not AEP).

RDT sampling volunteers

Example message to RDT sampling volunteers (adapted from USEPA [37])

Dear (Customer's Name),

[*Insert name of your water facility*] appreciates your participation in the lead monitoring program. These samples are being collected to determine the lead levels in your tap water. This sampling effort is required by the Government of Alberta, Environment & Parks, and is being accomplished through a collaboration between your water utility and our customers (e.g. residents).

Prior arrangements will be made with you, the customer, to coordinate the sample collection. Dates will be set for sample kit delivery and pick-up by water utility staff.

Sampling instruction:

- Use a kitchen cold-water faucet for sampling. Do not remove the aerator (screen) prior to sampling.
- If you have a whole-home water treatment device such as a water softener, collect your sample from a faucet tap that is not fed from the treatment device, if possible. If the kitchen faucet has a faucet-mounted filter, use another faucet that is also used for drinking water, or remove the filter.
- Place the opened sample bottle below the faucet and open the cold-water tap as you would do to fill a glass of water. Fill the sample bottle and turn off the water.
- Tightly cap the sample bottle and place in the sample kit provided. Please review the sample kit label at this time to ensure that all information contained on the label is correct.
- If your sample was collected from a tap with a water softener or filter, note this as well.
- Place the sample kit at [*location*} so that water utility staff may pick up the sample kit.

Results from this monitoring effort and information about lead will be provided to you as soon as practicable but no later than 14 days after the system learns of the tap monitoring results.

Call _____ at _____ if you have any questions regarding these instructions.

TO BE COMPLETED BY RESIDENT
Sample was collected: Time ___ ___ ___ Date _____ _____
Sample location & faucet (e.g. Kitchen sink): _____
Is water filtered or treated by an in-home device (circle answer)? Yes No
I have read the above directions and have taken a tap sample in accordance with these directions.

Signature _____ Date _____

Location with lead results > MAC, LSL status unknown

Adapted from California Water Service [38].

Dear (Customer's Name),

[*Insert name of your water facility*] appreciates your participation in the lead monitoring program. This letter is to report the lead result from the sample collected at your residence, *[insert address of customer]* on *[date]*. The reported lead result for your residence was _____ micrograms per litre (µg/L).

This customer notification information is for the occupants of the residence where the lead samples were collected. These individual high levels may be due to conditions unique to the individual home, such as the presence of tin-lead solder, brass and chrome plated brass faucets, and lead pipes that connect your house to the water main (service lines). If your reported lead result exceeds the Health Canada maximum acceptable concentration of 5 µg/L, we strongly urge you to review the enclosed information and take the steps listed to reduce your exposure to lead in drinking water.

What Does This Mean?

Health Canada publishes health-based limits for parameters that may be found in drinking water. In 2019, they published a maximum acceptable concentration (MAC) for total lead in drinking water of 5 µg/L, based on a sample of water taken at the tap. If your water has more than 5 µg/L of lead, Alberta Health Services recommends that pregnant women and children under six-years of age do not drink your tap water without a filtration device.

Recommended actions
Install and maintain a water filtration device that meets the NSF International 053 guideline (NSF-053) as certified by the American National Standards Institute (ANSI), CSA Group, Water Quality Association (Canadian chapter CWQA), Bureau de normalisation du Québec, International Association of Plumbing & Mechanical Officials or Truesdail Laboratories Inc. to remove lead. Reverse osmosis and distillation systems work to remove lead when installed at the tap. When using POU systems, it is very important to follow the manufacturer's installation, maintenance and operation instructions carefully to ensure that the filter is effective.

Run your taps for the freshest water. The longer water has been sitting in your home's pipes, the more lead it may contain. Running cold water from the faucets you use for drinking can improve water quality by drawing fresh water into the home, particularly after long periods of time when water has not been used. The most important time to flush is after long periods of no use (more than 6 hours), such as first thing in the morning, after work, or upon returning from vacation. Run the water for at least one minute. When purchasing replacement plumbing products, make sure the products have been tested and certified to "lead-free" standards. To conserve water, other household water usage activities such as showering, washing clothes, flushing the toilet and running the dishwasher, are effective methods for flushing pipes and allowing water from the distribution system to enter household pipes. Never use hot water from the tap for drinking and food preparation. Only use cold water for drinking and food preparation – then heat it. Hot water leaches more metals than cold water.

If you have any questions, please contact us at *[Phone Number]*.

Sincerely

(Facility Info Signature Block)

Letter to a homeowner where lead concentration < MAC, public-side service line is lead

Provided courtesy of EPCOR (2019).

<Name>
<Address>
<Date>

OUR RECORDS SHOW YOUR UTILITY WATER SERVICE LINE IS MADE FROM LEAD

Please review this information, and if you are not the property owner, please share with the property owner as well.

LEAD WATER SERVICE LINES

As part of EPCOR's Lead Management Program, we send an annual notification to customers when our records show that the EPCOR portion of your water service line is made from lead.

The pipe that connects your property's plumbing to the water main in the street is called a service line.

The EPCOR portion of the service line runs from the water main under the street or alley to the property line, and the homeowner portion of the service line runs from the property line to the water meter in the home or building.

EPCOR does not have records for the homeowner portion of the lead service line but when EPCOR's portion of the water service line is lead, it is often a good indication that the homeowner portion could be lead as well.

NEW LEAD GUIDELINE FROM HEALTH CANADA

On March 8, 2019, Health Canada announced a **reduction to its maximum acceptable concentration for lead in drinking water from 10 µg/L (micrograms per litre) to 5 µg/L**. In addition to reducing the maximum acceptable concentration of lead, Health Canada is also recommending that water sample testing for lead now be taken at the tap. Previously, the sample was taken and tested as the water was leaving the treatment plant or in the distribution system.

Through our Lead Management Program, for properties with lead service lines like yours, EPCOR has been testing water at the tap and offers free sampling and testing of drinking water.

Our past records indicate that, at this address, **lead levels in your tap water were below 5 µg/L, meaning lead levels were lower than the new maximum acceptable concentration set by Health Canada.**

IMPACTS OF THE NEW HEALTH CANADA LEAD GUIDELINE FOR YOUR HOME

As a customer with a lead service line, regardless of the previous samples taken at your property, the new guideline from Health Canada underlines the importance of taking steps to reduce lead levels in your tap water.

As the utility, EPCOR supports the new guideline as it aligns with our efforts to reduce lead exposure from drinking water to as low as reasonably achievable. We are enhancing our lead management efforts, including exploring ways to accelerate the removal of lead service lines (where feasible) as well as looking at solutions to minimize lead release from home plumbing and fixtures.

IMMEDIATE ACTIONS TO TAKE AS THE TENANT AND/OR PROPERTY OWNER

Since lead levels previously taken at your tap were below the new maximum acceptable concentration set by Health Canada, there are no immediate actions for you to take, other than to continue to follow good water quality practices.

Good water quality practices include:

- Running your cold water tap for at least three minutes, or until cold, any time you haven't used the water for six or more hours, if you will be drinking or cooking with it. This flushing time can be reduced if combined with other water use like flushing toilets, showering or running household appliances like the dishwasher or washing machine.
- Do not use water from your hot taps for drinking, eating, cooking or baking. Only consume water from your cold taps, then heat it up if needed.

ADDITIONAL ACTIONS TO TAKE AS THE TENANT AND/OR PROPERTY OWNER

1. Call EPCOR and request a filter

- If you're concerned about lead levels in your tap water, consider using a water filter.
- EPCOR provides complimentary water filters for homes with a lead service line.
- You can also purchase your own filter or replacement filters – just ensure the filter you choose is certified to the NSF/ANSI standard 53 for the removal of lead.
- If you are using a water filter of any kind, properly condition new filters before their first use, and replace used filter cartridges as required according to the manufacturer's guidelines.

2. Contact us to confirm lead levels at your tap

- While previous samples taken from this address showed your lead levels as being below the maximum acceptable concentration from Health Canada, results can change
- Please contact EPCOR's Lead Management Program Representative at **780-412-6858** or **leadprogram@epcor.com** to arrange for us to visit your home and obtain a tap water sample.
- We will test your sample in our laboratory and contact you with the results within 15 business days. There is no cost to you for this water sampling.

MORE INFORMATION

Stay tuned, in the coming months, EPCOR will be sharing more of our plan on how we will be enhancing our lead management efforts. As always, we are seeking to minimize health risks from lead in drinking water and meet the requirements of the new Health Canada guideline.

As a customer with a lead service line, we will be contacting you directly by mail in the future to outline these plans and how they will impact your home.

In the meantime, for more information about your lead service line or lead in tap water:

- Refer to the detailed brochure we enclosed with this notice.
- Contact our Lead Management Program Representative at **780-412-6858** or **leadprogram@epcor.com**.
- Visit **epcor.com/lead.**

Letter to a homeowner where lead concentration > MAC, public-side service line is lead

Provided courtesy of EPCOR (2019).

EPCOR

<Name>
<Address>
<Date>

OUR RECORDS SHOW YOUR UTILITY WATER SERVICE LINE IS MADE FROM LEAD

Please review this information, and if you are not the property owner, please share with the property owner as well.

LEAD WATER SERVICE LINES

As part of EPCOR's Lead Management Program, we send an annual notification to customers when our records show that the EPCOR portion of your water service line is made from lead.

The pipe that connects your property's plumbing to the water main in the street is called a service line.

The EPCOR portion of the service line runs from the water main under the street or alley to the property line, and the homeowner portion of the service line runs from the property line to the water meter in the home or building.

EPCOR does not have records for the homeowner portion of the lead service line but when EPCOR's portion of the water service line is lead, it is often a good indication that the homeowner portion could be lead as well.

NEW LEAD GUIDELINE FROM HEALTH CANADA

On March 8, 2019, Health Canada announced a **reduction to its maximum acceptable concentration for lead in drinking water from 10 µg/L (micrograms per litre) to 5 µg/L**. In addition to reducing the maximum acceptable concentration of lead, Health Canada is also recommending that water sample testing for lead now be taken at the tap. Previously, the sample was taken and tested as the water was leaving the treatment plant or in the distribution system.

Through our Lead Management Program, for properties with lead service lines like yours, EPCOR has been testing water at the tap and offers free sampling and testing of drinking water.

Our past records indicate that, at this address, **lead levels in your tap water were above 5 µg/L, meaning lead levels were higher than the new maximum acceptable concentration set by Health Canada.**

IMPACTS OF THE NEW HEALTH CANADA LEAD GUIDELINE FOR YOUR HOME

As a customer with a lead service line, regardless of the previous samples taken at your property, the new guideline from Health Canada underlines the importance of taking steps to reduce lead levels in your tap water.

EPCOR supports the new guideline as it aligns with our efforts to reduce lead exposure from drinking water to as low as reasonably achievable. We are enhancing our lead management efforts, including exploring ways to accelerate the removal of lead service lines (where feasible) as well as looking at solutions to minimize lead release from home plumbing and fixtures.

IMMEDIATE ACTIONS TO TAKE AS THE TENANT AND/OR PROPERTY OWNER

1. Call EPCOR and request a water filter

- Given the lead levels at your tap are higher than the new maximum acceptable concentration set by Health Canada, EPCOR recommends using a water filter (certified to the NSF/ANSI standard 53 for the removal of lead).
- EPCOR provides complimentary water filters for homes with a lead service line.
  - You can also purchase your own filter – just ensure the filter you choose is certified to the NSF/ANSI standard 53 for the removal of lead.
  - If you are using a water filter of any kind, properly condition new filters before their first use, and replace used filter cartridges as required according to the manufacturers' guidelines.
- Because our past record indicate that, at this address, lead levels in your tap water were above 5 µg/L, Alberta Health Services recommends that, **persons under six years of age, and/or pregnant women** living in, and/or regularly consuming water at your property, should not drink the tap water without a water filtration device capable of removing lead.

ADDITIONAL ACTIONS TO TAKE AS THE TENANT AND/OR PROPERTY OWNER

1. Follow good water quality practices

- Run your cold water tap for at least three minutes, or until cold, any time you haven't used the water for six or more hours, if you will be drinking or cooking with it. This flushing time can be reduced if combined with other water use like flushing toilets, showering or running household appliances like the dishwasher or washing machine.
- Do not use water from your hot taps for drinking, eating, cooking or baking. Only consume water from your cold taps, then heat it up if needed.

2. Contact us to confirm lead levels at your tap

- While previous samples taken from this address showed your lead levels as being above the maximum acceptable concentration from Health Canada, results can change.
- Please contact EPCOR's Lead Management Program Representative at **780-412-6858** or **leadprogram@epcor.com** to arrange for us to visit your home and obtain a tap water sample.
- We will test your sample in our laboratory and contact you with the results within 15 business days. There is no cost to you for this water sampling.

MORE INFORMATION

Stay tuned, in the coming months, EPCOR will be sharing more of our plan on how we will be enhancing our lead management efforts. As always, we are seeking to minimize health risks from lead in drinking water and meet the requirements of the new Health Canada guideline.

As a customer with a lead service line, we will be contacting you directly by mail in the future to outline these plans and how they will impact your home.

In the meantime, for more information about your lead service line or lead in tap water:

- Refer to the detailed brochure we enclosed with this notice.
- Contact our Lead Management Program Representative at **780-412-6858** or **leadprogram@epcor.com**.
- Visit **epcor.com/lead**.

Letter to homeowner where public-side service line may be lead

Provided courtesy of the City of Calgary (2019).

<DATE>

Attention: <<OWNER NAME>>

«OWNER ADDRESS»
«OWNER CITY», <<OWNER PROVINCE>> «OWNER POSTAL_CODE»

Re: IMPORTANT WATER QUALITY INFORMATION

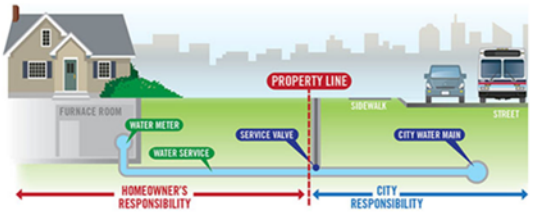
Your property at: **<<INSERT Lead Service Address>>** CALGARY, AB has been identified as possibly having a lead service pipe connecting your property plumbing to The City's water system. Lead service connections are often found in homes built between 1939 and 1949. As one of approximately 550 remaining Calgary properties with a lead service connection, the following information will be helpful in determining a course of action to resolve or mitigate the potential health impacts of a lead water service connection to your property.

You may wonder, how lead might get into tap water. First, it is important to understand that the water provided by The City of Calgary is lead free. It meets or exceeds all provincial and federal health guidelines. Lead is not found in the source water from the Bow or Elbow Rivers. The water found in The City's water treatment plants and distribution system is lead free, and 99.8 percent of service connections are also lead-free. Prior to 1950, however, lead was commonly used for water service piping, including service connections, and this kind of pipe can impact water quality. Lead may also have been used in a home's fixtures and internal plumbing.

Sampling program
The City would like to encourage your participation in our free annual tap water sampling program. If you would like to participate, **please contact 311 by June 30, 2019.** The most effective time of year to sample for lead is during the warmer months, so we will be scheduling from July to September. Participants will be scheduled in the order that we receive requests for sampling, so we encourage you to call as soon as you can to secure an appointment convenient for you and/or your tenants. The City will notify you of the sampling results. If the results indicate levels of lead higher than acceptable, The City will take steps to confirm the type of pipe on public and private property, determine what public infrastructure may need to be replaced and provide you further information on what you can do.

Replacing the water service pipe on your property
As the property owner, you are responsible for replacement of the water service on your property (Figure 1). The cost for a private service replacement can vary as it is influenced by several factors – length of service, type of construction used and contractor availability. Dependent on the sampling results, if you are interested in replacing your portion of the service connection on your property, contact us at 311 for more information.

Figure 1: Water Service Connection Diagram



Lead Service Considerations
There are ways to help minimize the impacts of having a lead water service other than replacing your service connection.

Flush the pipes: Before consuming water, flush the pipes. After long periods (more than a few hours) of non-use, let the water run for a few minutes to flush water from the plumbing. This ensures stagnant water is flushed out and fresh water is drawn directly from our water distribution system.
Conservation Tip: Capture running water for non-potable purposes such as watering plants or washing dishes.

Use cold water: For drinking, cooking or preparing baby formula use cold water. Hot water is more likely to leach minerals or metals from the plumbing. Boiling water does not remove lead.

Install a filter: A properly maintained NSF-53 certified water filter will remove most of the lead from drinking water. The City provides rebates for the installation of tap-mounted filters for customers with lead services. Details of how to apply for the rebate program are provided in this letter.

More information can be found on the following websites:

The City of Calgary:	http://www.calgary.ca/UEP/Water/Pages/Water-and-wastewater-systems/Water-Service-Lines-Calgary.aspx
Alberta Health Services:	https://myhealth.alberta.ca/Alberta/Pages/Common-questions-about-lead-and-drinking-water.aspx
Alberta Environment:	https://open.alberta.ca/publications/lead-in-drinking-water-questions-and-answers
Health Canada:	https://www.canada.ca/en/health-canada/programs/consultation-lead-drinking-water/document.html

If you have recently had your water service replaced or feel that there is an error in our information, please phone 311 so we can update our records. If you have any further questions, please contact us by calling 311. For telephone health advice, call Environmental Public Health at 403-943-2296.

Sincerely,

XXXX

Letter to homeowner where public-side may be lead

Adapted from AWWA, 2014 [23].

In our community, some of the pipes that connect older homes to the facility water main are made from lead. Records indicate that your home may have a lead service line (LSL).
The pipe that connects your household plumbing to the water main in the street is called a service line. {Facility name} maintains records of initial service line construction materials, but these records may not reflect repairs or replacements made after the original service lines were installed.

To determine if your home has a LSL, consider hiring a licensed plumber to inspect the service line. LSLs are generally a dull gray color and are very soft. They can be identified easily by carefully scratching them with a key or coin. If the pipe is made of lead, the area you have scratched will turn a bright silver color. Do not use a knife or other sharp instrument and take care not to puncture a hole in the pipe.

Lead can be harmful. It can impact normal physical and mental development in foetuses, babies and young children, cause deficits in the attention span, hearing, and learning abilities of children, and increase blood pressure in adults.

If you have a LSL, the lead from your pipe may leach into water you drink. There are steps you can take to protect yourself and your family from lead in tap water, regardless of whether you have a LSL.

Recommended actions
Install and maintain a water filtration device that meets the NSF International 053 guideline (NSF-053) as certified by the American National Standards Institute (ANSI), CSA Group, Water Quality Association (Canadian chapter CWQA), Bureau de normalisation du Québec, International Association of Plumbing & Mechanical Officials or Truesdail Laboratories Inc. to remove lead. Reverse osmosis and distillation systems work to remove lead when installed at the tap. When using POU systems, it is very important to follow the manufacturer's installation, maintenance and operation instructions carefully to ensure that the filter is effective.

Run your taps for the freshest water. The longer water has been sitting in your home's pipes, the more lead it may contain. Running cold water from the faucets you use for drinking can improve water quality by drawing fresh water into the home, particularly after long periods of time when water has not been used. The most important time to flush is after long periods of no use (more than 6 hours), such as first thing in the morning, after work, or upon returning from vacation. Run the water for at least one minute. When purchasing replacement plumbing products, make sure the products have been tested and certified to "lead-free" standards. To conserve water, other household water usage activities such as showering, washing clothes, flushing the toilet and running the dishwasher, are effective methods for flushing pipes and allowing water from the distribution system to enter household pipes.
Never use hot water from the tap for drinking and food preparation. Only use cold water for drinking and food preparation – then heat it. Hot water leaches more metals than cold water.

If you use a home treatment device to reduce your exposure to lead, make sure it is independently certified for that purpose and properly maintain it according to the manufacturer's instructions. It is important that the model you select be certified to reduce lead according to NSF/ANSI-53.
{Facility name} would like to sample the water from your home. Please contact {xxxx} at {xxx} to schedule an appointment.

Letter to homeowner where the public-side LSL has been replaced and private-side material is unverified

Provided courtesy of the City of Calgary (2019).

<Date>

Attention: HOMEOWNER OR OCCUPANT

<INSERT ADDRESS>
CALGARY, AB <INSERT POSTAL CODE>

Re: IMPORTANT WATER QUALITY INFORMATION FOR < LEAD SERVICE ADDRESS>

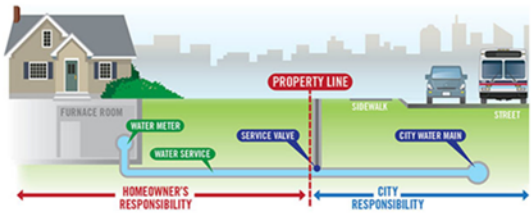
The City of Calgary has identified your home as possibly having a lead service pipe connecting your household plumbing to The City's water system. Lead service connections are often found in homes built between 1939 and 1949. In **<INSERT YEAR>**, the City removed and replaced the public side of your water service connection, which was lead (Figure 1). However, we do not have records of the private side material, which is the homeowner's responsibility. In order to determine if you are at risk for any potential health impacts of a lead water service connection, we invite you to participate in our tap water sampling program. This approach aligns with a new standard for reducing lead in communities issued by the American Water Works Association (AWWA.)

First, it is important to understand that the water provided by The City of Calgary meets and can exceed all provincial and federal health guidelines. Lead is not found in the source water from the Bow or Elbow Rivers. The water found in The City's water treatment plants and distribution system is lead free, and 99.8 percent of service connections are also lead-free. Prior to 1950, however, lead was commonly used for water service piping, including service connections, and this kind of pipe can impact water quality. Lead may also have been used in a home's fixtures and internal plumbing.

Sampling program
The City would like to encourage your participation in our annual tap water sampling program. If you would like to participate, **please contact 311 by June 30, 2019.** The most effective time of year to sample for lead is during the warmer months, so we will be scheduling from July to September. Participants will be scheduled in the order that we receive requests for sampling, so we encourage you to call as soon as you can to secure an appointment convenient for you. The City will notify you of the sampling results. If the results indicate levels of lead higher than acceptable, we provide further recommendations on steps you will need to take to confirm the type of pipe on your property and reduce your risk.

Replacing the water service pipe on your property
As the homeowner, you are responsible for replacement of the water service on your property (Figure 1). The cost for a private service replacement can vary as it is influenced by several factors – length of service, type of construction used and contractor availability. Dependent on the sampling results, if you are interested in replacing your portion of the service connection on your property, contact us at 311 for more information.

Figure 1: Water Service Connection Diagram



Lead Service Considerations
There are ways to help minimize the impacts of having a lead water service other than replacing your service connection.

Flush the pipes: Before consuming water, flush the pipes. After long periods (more than a few hours) of non-use, let the water run for a few minutes to flush water from the plumbing. This ensures stagnant water is flushed out and fresh water is drawn directly from our water distribution system.
Conservation Tip: Capture running water for non-potable purposes such as watering plants or washing dishes.

Use cold water: For drinking, cooking or preparing baby formula use cold water. Hot water is more likely to leach minerals or metals from the plumbing. Boiling water does not remove lead.

Install a filter: A properly maintained NSF-53 certified water filter will remove most of the lead from drinking water. The City provides rebates for the installation of tap-mounted filters for customers with lead services. Details of how to apply for the rebate program are provided in this letter.

More information can be found on the following websites:

The City of Calgary:	http://www.calgary.ca/UEP/Water/Pages/Water-and-wastewater-systems/Water-Service-Lines-Calgary.aspx
Alberta Health Services:	https://myhealth.alberta.ca/Alberta/Pages/Common-questions-about-lead-and-drinking-water.aspx
Alberta Environment:	https://open.alberta.ca/publications/lead-in-drinking-water-questions-and-answers
Health Canada:	https://www.canada.ca/en/health-canada/programs/consultation-lead-drinking-water/document.html

If you have recently had your water service replaced or feel that there is an error in our information, please phone 311 so we can update our records. If you have any further questions, please contact us by calling 311. For telephone health advice, call Environmental Public Health at 403-943-2296.

Sincerely,

XXXX

Letter to homeowner where the public-side LSL has been replaced and the private-side is lead

Provided courtesy of the City of Calgary (2019).

<Date>

INSERT CUSTOMER NAME
INSERTADDRESS
INSERT Calgary, AB INSERT POSTAL CODE

Dear INSERT CUSTOMER:

Re: WATER QUALITY RE-SAMPLING INFORMATION FOR <LEAD SERVICE ADDRESS>

Previously, The City of Calgary Water Services replaced the lead portion of your water service connection, located on the public side of your property line.

As part of Water Services' Tap Water Sampling Program, follow-up sampling is being performed to determine the effectiveness of the replacement and the quality of water in your home. If you would like to participate in this year's sampling program, **please contact 311 by June 30, 2019.** The most effective time of year to sample for lead is during the warmer months, so we will be scheduling from July to September. Participants will be scheduled in the order that we receive requests for sampling, so we encourage you to call early to secure an appointment that is convenient for you.

Lead Service Replacement
Replacement of any service located on private property is the responsibility of the property owner. Consider replacing your lead service if you haven't already. If you do not know the material of your service connection on private property, you may wish to contact a qualified plumber. For more information regarding private services replacement, please contact 311.

Lead Service Considerations
There are ways to help minimize the impacts of having a lead water service other than replacing your service connection.

Flush the pipes: Before consuming water, flush the pipes. After long periods (more than a few hours) of non-use, let the water run for a few minutes to flush water from the plumbing. This ensures stagnant water is flushed out and fresh water is drawn directly from our water distribution system.
Conservation Tip: Capture running water for non-potable purposes such as watering plants or washing dishes.

Use cold water: For drinking, cooking or preparing baby formula use cold water. Hot water is more likely to leach minerals or metals from the plumbing. Boiling water does not remove lead.

Install a filter: A properly maintained NSF-53 certified water filter will remove most of the lead from drinking water. The City provides rebates for the installation of these tap-mounted filters for customers with lead services. Details of how to apply for the rebate program are provided in this letter.

More information can be found on the following websites:

The City of Calgary:	http://www.calgary.ca/UEP/Water/Pages/Water-and-wastewater-systems/Water-Service-Lines-Calgary.aspx
Alberta Health Services:	https://myhealth.alberta.ca/Alberta/Pages/Common-questions-about-lead-and-drinking-water.aspx
Alberta Environment:	https://open.alberta.ca/publications/lead-in-drinking-water-questions-and-answers
Health Canada:	https://www.canada.ca/en/health-canada/programs/consultation-lead-drinking-water/document.html

If you have recently had your water service replaced or feel that there is an error in our information, please phone 311 so we can update our records. If you have any further questions, please contact us by calling 311. For telephone health advice, call Environmental Public Health at 403-943-2296.

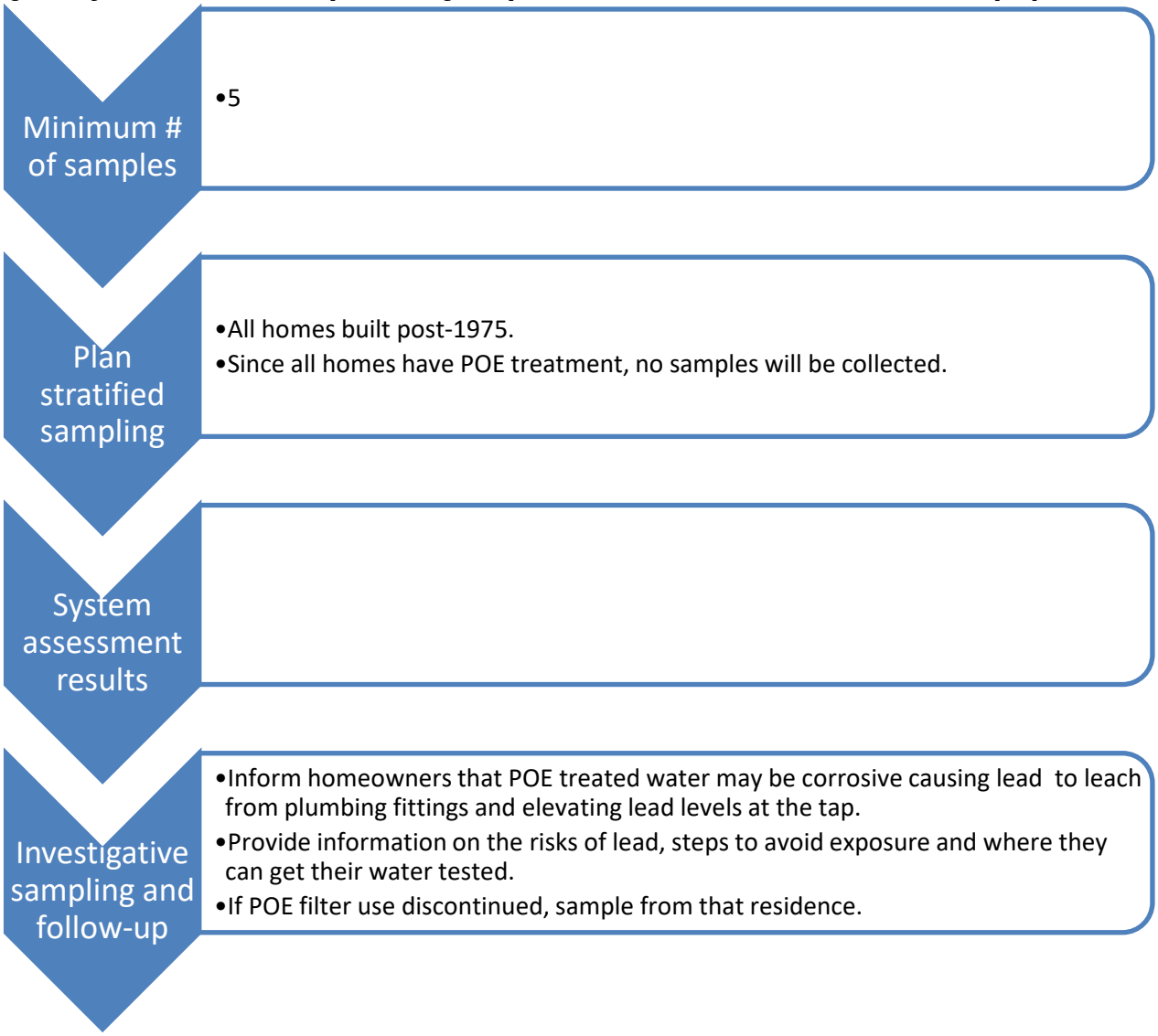
Sincerely,

XXX

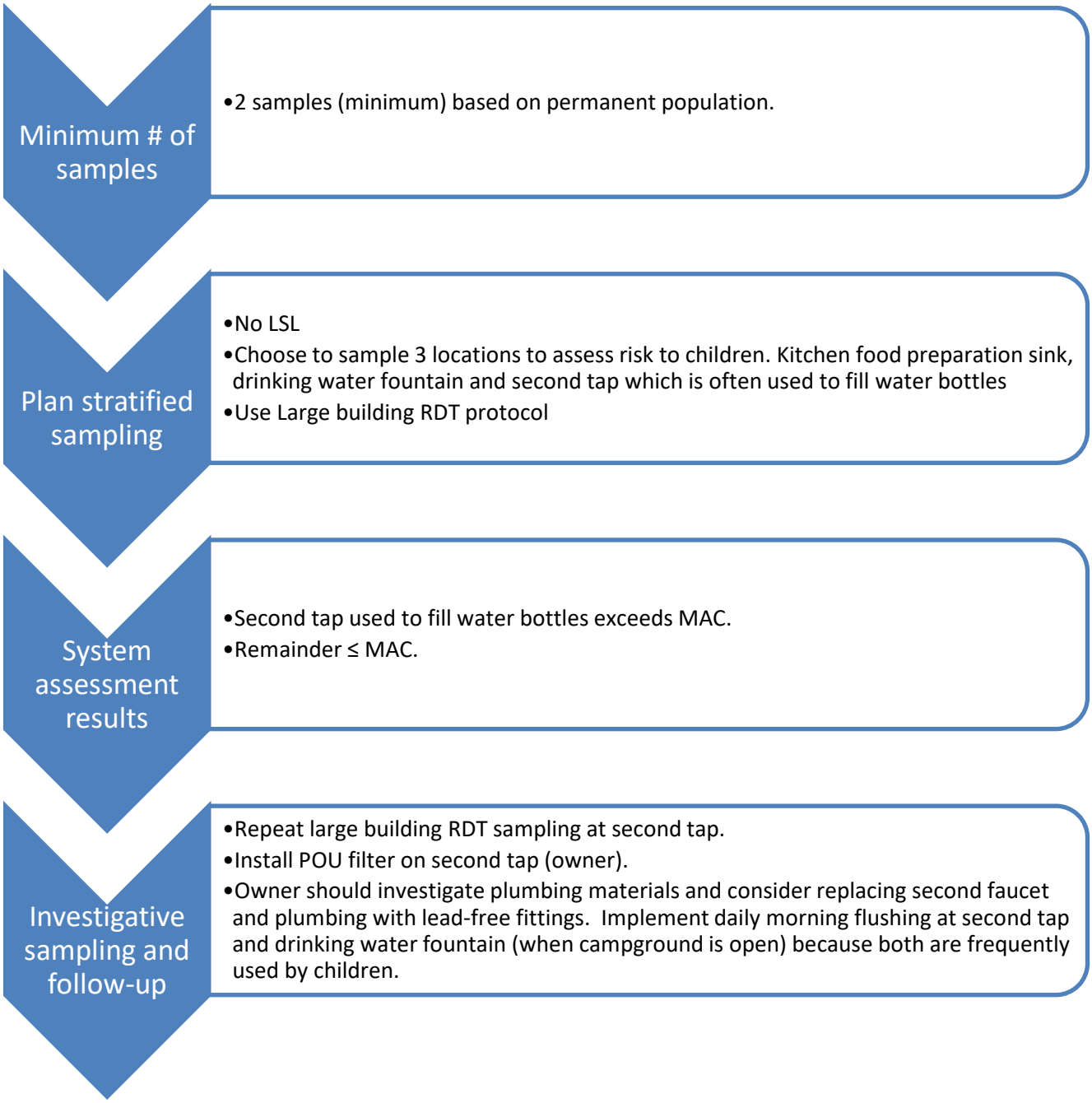
Appendix D Stratified System Assessment and Investigative Sampling Case Examples

All case examples are fictional, but designed to represent likely scenarios.

Case 1: Water co-op, Code of Practice for Waterworks Systems using High Quality Groundwater (COP HQGW), all homes have POE RO units, population 75

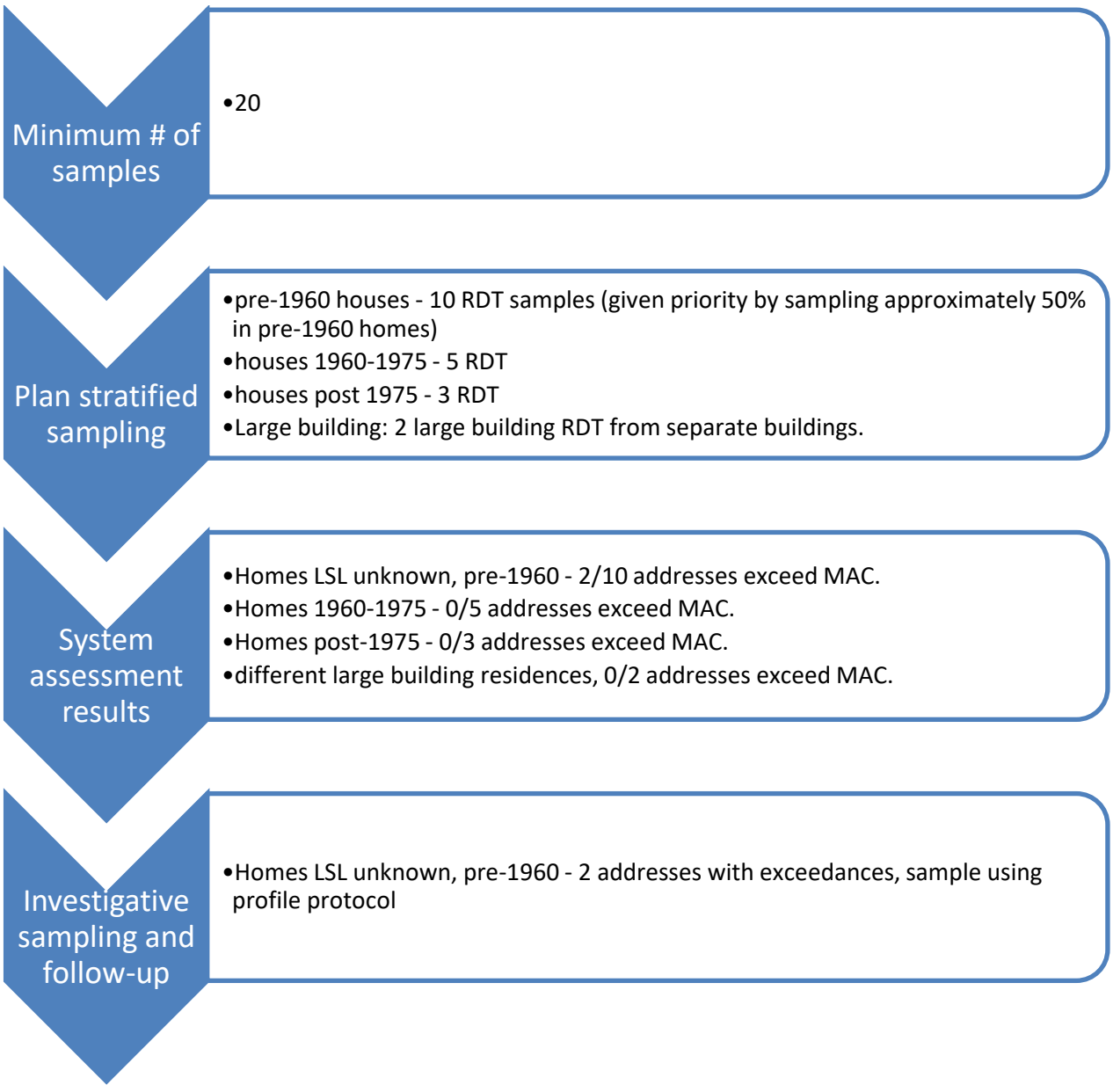


Case 2: Campground, COP HQGW, permanent population 15, seasonal population 350, food preparation and dining hall, office, and cabins constructed 1970.



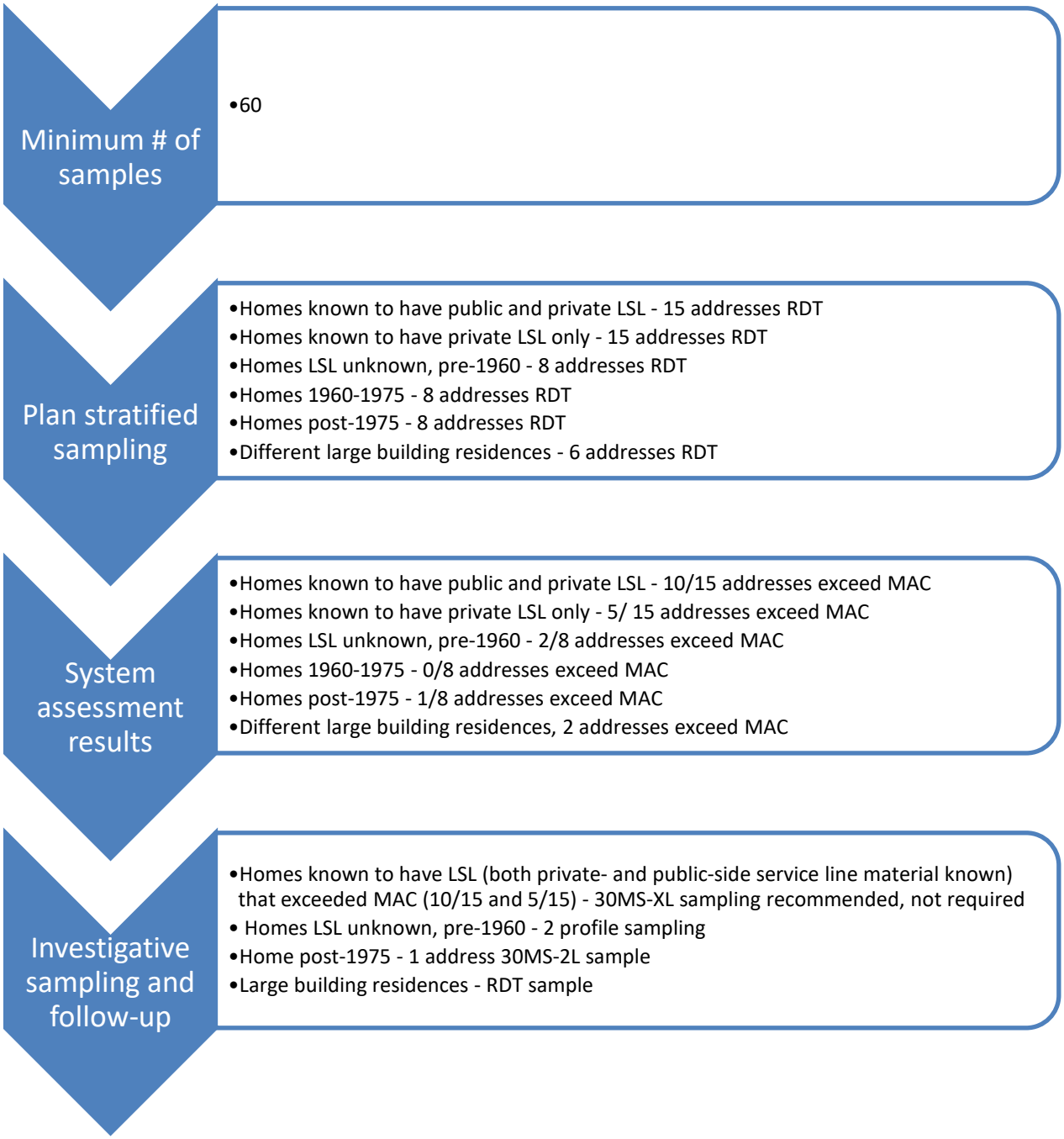
Case 3: Municipality, COP HQGW, population 2000

2019 population	2000
1948 population	1000
# of full or public-side only LSLs	No records
# of private-side only LSLs	No records
pH	7.8
Alkalinity (mg as CaCO3/L)	No data
Secondary Disinfectant	Free chlorine 0.2 to 1.6 mg/L in WDS. Average = 0.9 mg/L
# of large building residences	3



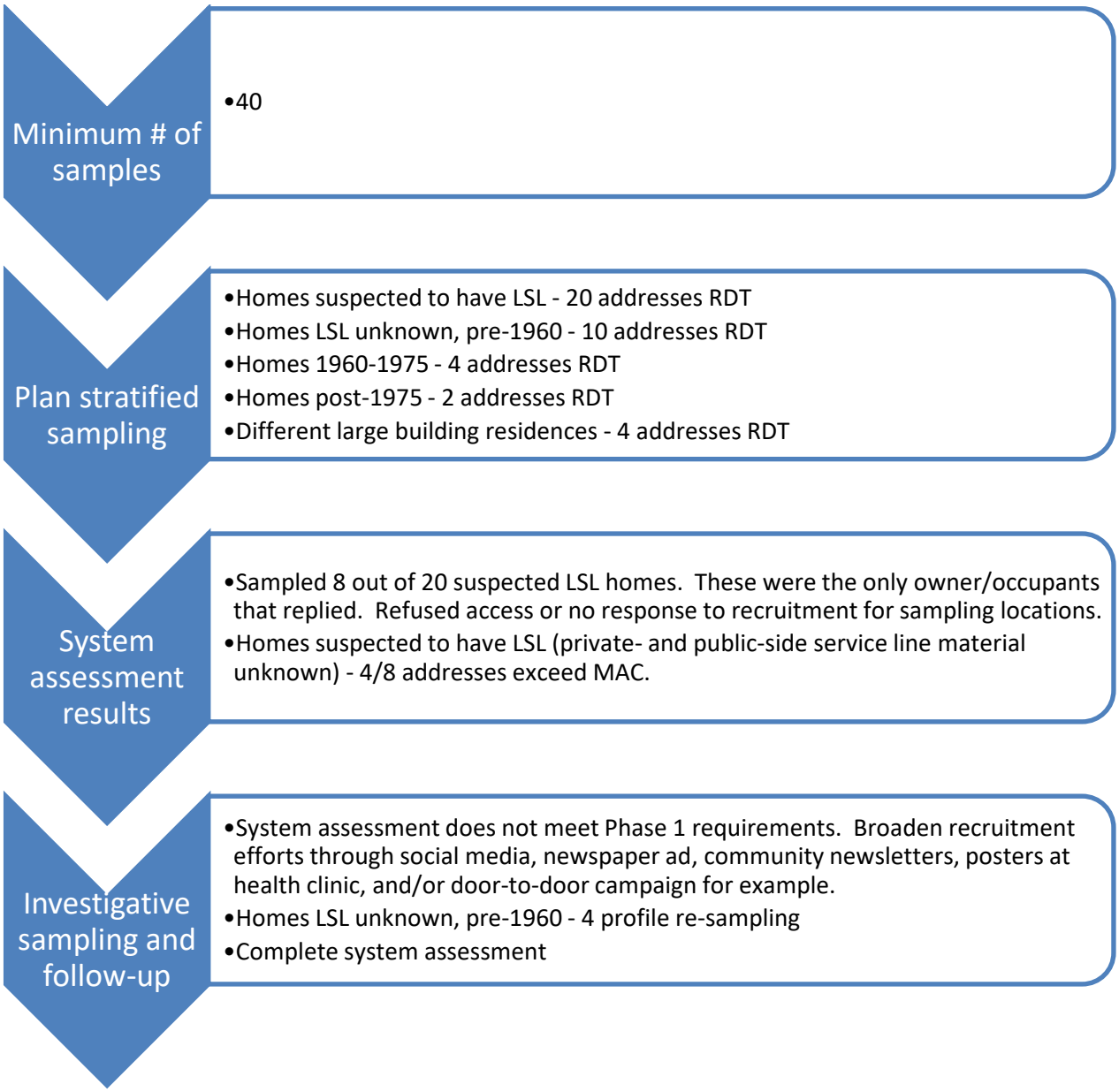
Case 4: Municipality with only private-side LSL, Approval, population 13,000

2019 population	13,000
1948 population	7400
# of full or public-side only LSLs	0
# of private-side only LSLs	370 known, more suspected
pH	7.6
Alkalinity (mg as CaCO3/L)	218
Secondary Disinfectant	Chloramine 0.2 to 2.0 mg/L in WDS. Average = 1.6 mg/L
# of large building residences	10



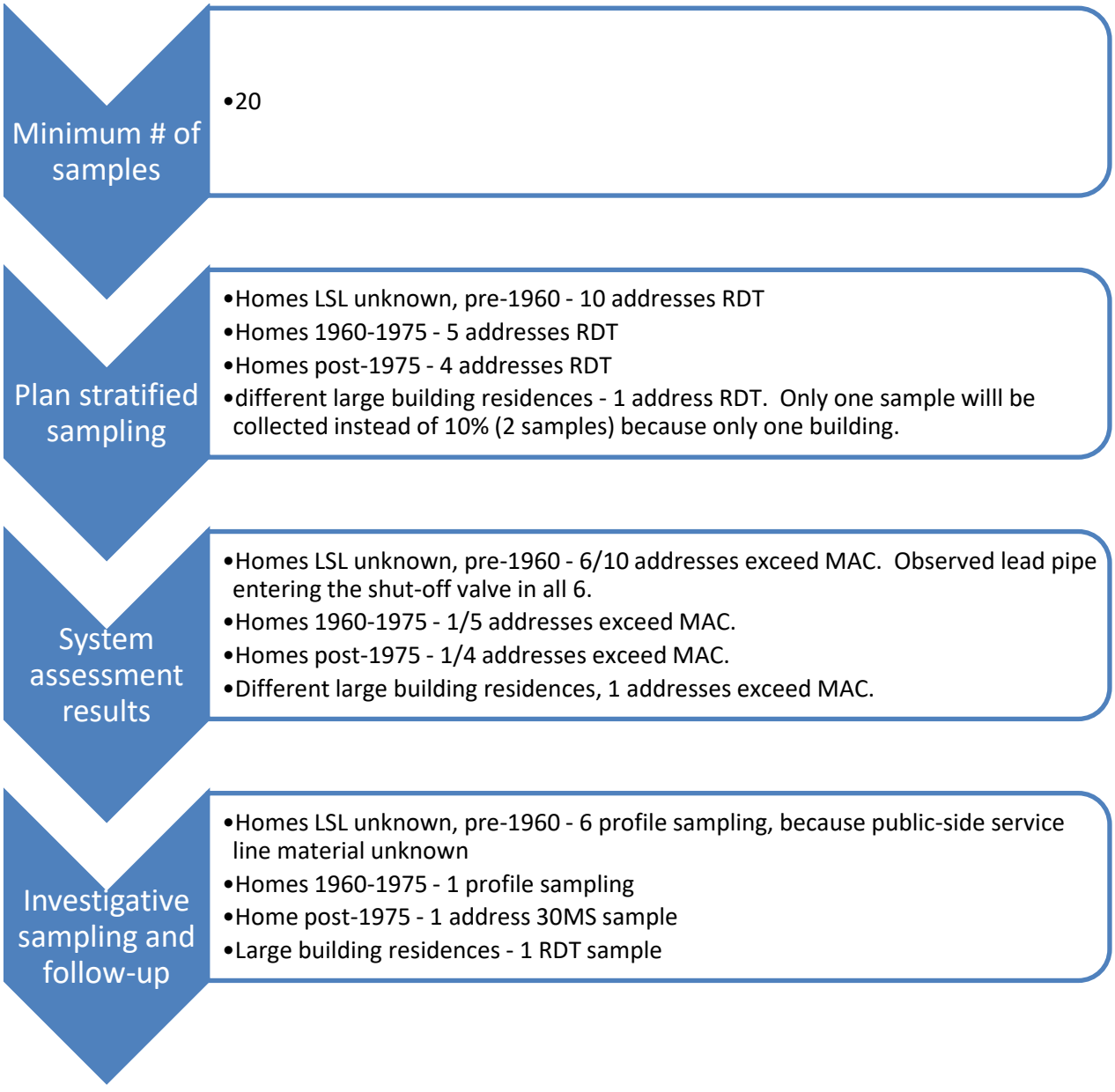
Case 5: Municipality, Code of Practice for Waterworks System Consisting Solely of a Water Distribution System Only (COP WDS only), population 8000

2019 population	8000
1948 population	600
# of full or public-side only LSLs	30 estimated
# of private-side only LSLs	No records
pH	7.4
Alkalinity (mg as CaCO3/L)	145
Secondary Disinfectant	Chloramine 0.6 to 2.0 mg/L in WDS. Average 1.3 mg/L.
# of large building residences	5



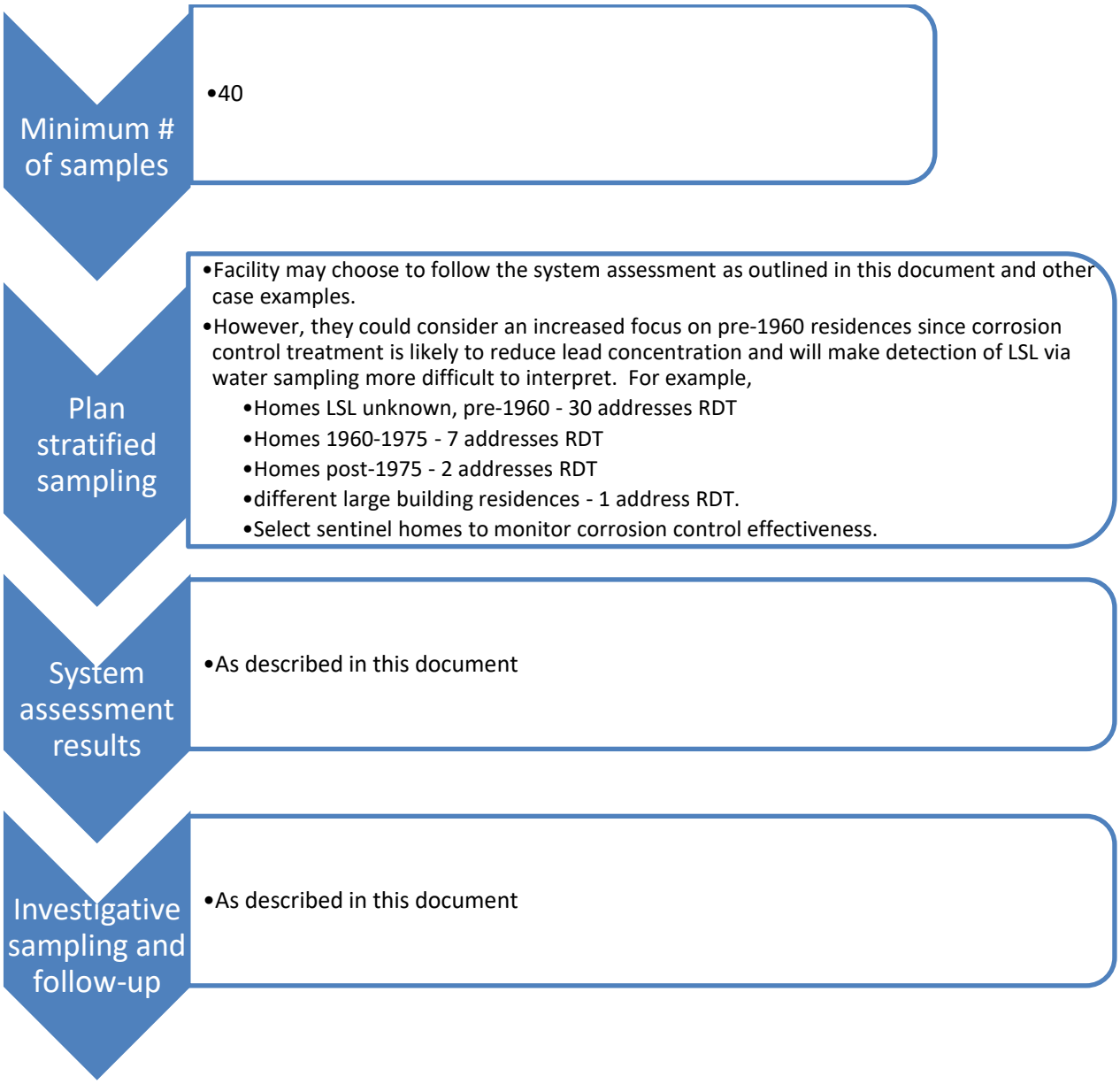
Case 6: Municipality, COP HQGW, population 500

2019 population	500
1948 population	300
# of full or public-side only LSLs	Unknown
# of private-side only LSLs	Unknown
pH	8
Alkalinity (mg as CaCO3/L)	640
Secondary Disinfectant	Free chlorine 0.2 to 0.8 mg/Lin WDS. Average = 0.4 mg/L.
# of large building residences	1



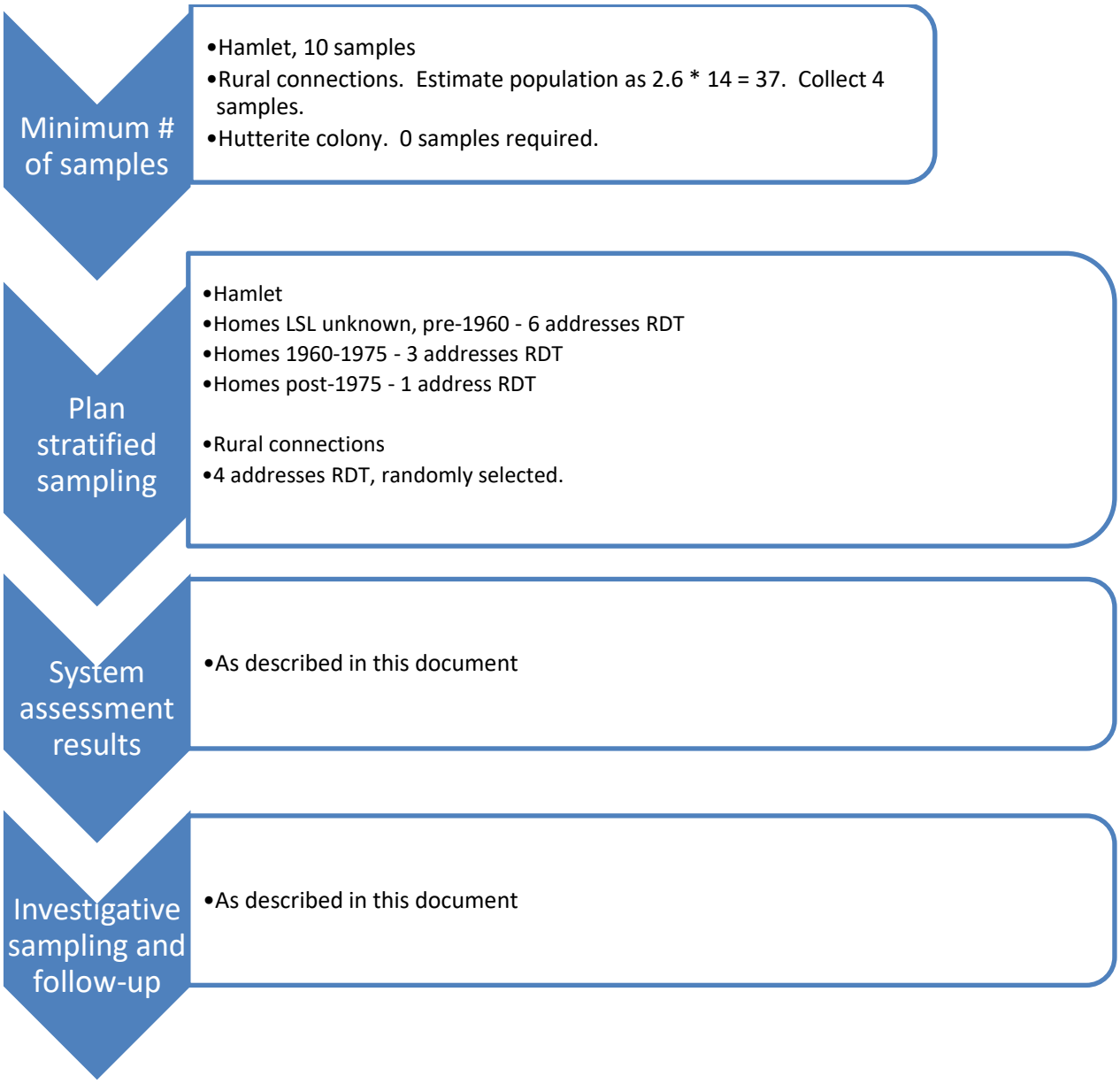
Case 7: Municipality, COP WDS only, population 6000, water supplier implementing corrosion control treatment in 2021

2019 population	6000
1948 population	2000
# of full or public-side only LSLs	Unknown
# of private-side only LSLs	Unknown
pH	Not analyzed
Alkalinity (mg as CaCO3/L)	150 (estimated)
Secondary Disinfectant	Chloramine 0.3 to 1.7 mg/Lin WDS. Average = 1.2 mg/L.
# of large building residences	1



Case 8: Amalgamated water distribution systems – multiple systems

2019 population	Hamlet with 204, 14 rural connections, Hutterite colony with 165
1948 population	Unknown
# of full or public-side only LSLs	Unknown
# of private-side only LSLs	Unknown
pH	Not analyzed
Alkalinity (mg as CaCO3/L)	150 (estimated)
Secondary Disinfectant	Chloramine 0.3 to 1.7 mg/Lin WDS. Average = 1.2 mg/L.
# of large building residences	1



Appendix E Factors that Influence the Dissolution of Lead from Lead-containing Materials

Several factors are involved in the extent to which lead enters drinking water from lead-containing materials [39, 40, 23, 4]. These include the:

- time the water has been in contact with plumbing materials;
- temperature of the water;
- composition, quality, condition and age of the plumbing materials;
- metal surface to water volume ratio;
- velocity of the water as it scoured the pipe/fittings;
- number of pipe or plumbing bends;
- use of the service line as an electrical ground;
- internal surface characteristics of the pipe (smooth versus rough);
- type of corrosion products present on the internal pipe surface; and
- chemistry of the water such as pH, conductivity, alkalinity, use of free chlorine or chloramine as disinfectants, chloride to sulphate mass ratio and concentrations of orthophosphate and inorganic carbon.

Table 8: Water quality factors affecting corrosion (adapted from BC Health Protection Branch, 2017)

Factor	Effect
pH	Low pH causes iron, lead and copper to corrode rapidly
Alkalinity and dissolved inorganic carbonate (DIC)	Neutralizes strong acids and provides buffering capacity against a pH drop. Affects many reactions in corrosion chemistry.
Disinfectant Residual	Gaseous chlorine lowers pH. Higher chlorine residuals (2 mg/L) may cause protective lead scales.
Dissolved Oxygen	Increases corrosion of copper; effect on lead less certain.
Oxidation Reduction Potential, Redox Potential (ORP, Eh)	High ORP and high pH promote protective lead scales.
Ammonia	Interferes with the formation of passivating films. Oxidation of ammonia (nitrification) lowers alkalinity and pH, increasing corrosion.
Chloride and Sulphate	Chloride (Cl^-) and sulphate (SO_4^{2-}) cause dissolved metals to remain soluble. Increases the salinity and electrical conductivity of water. High chloride-to-sulphate-mass ratios (CSMRs) increase corrosion rates for tin-lead solder connected to copper pipe.
Natural Colour and Organic Matter	May form a protective film and reduce corrosion. May react with the corrosion products to increase corrosion. Food for microorganisms growing in biofilms in the pipes.

Appendix F Report Template

An electronic copy of the report template is attached to this document. The figure below is a screenshot of the template with some example data entered.

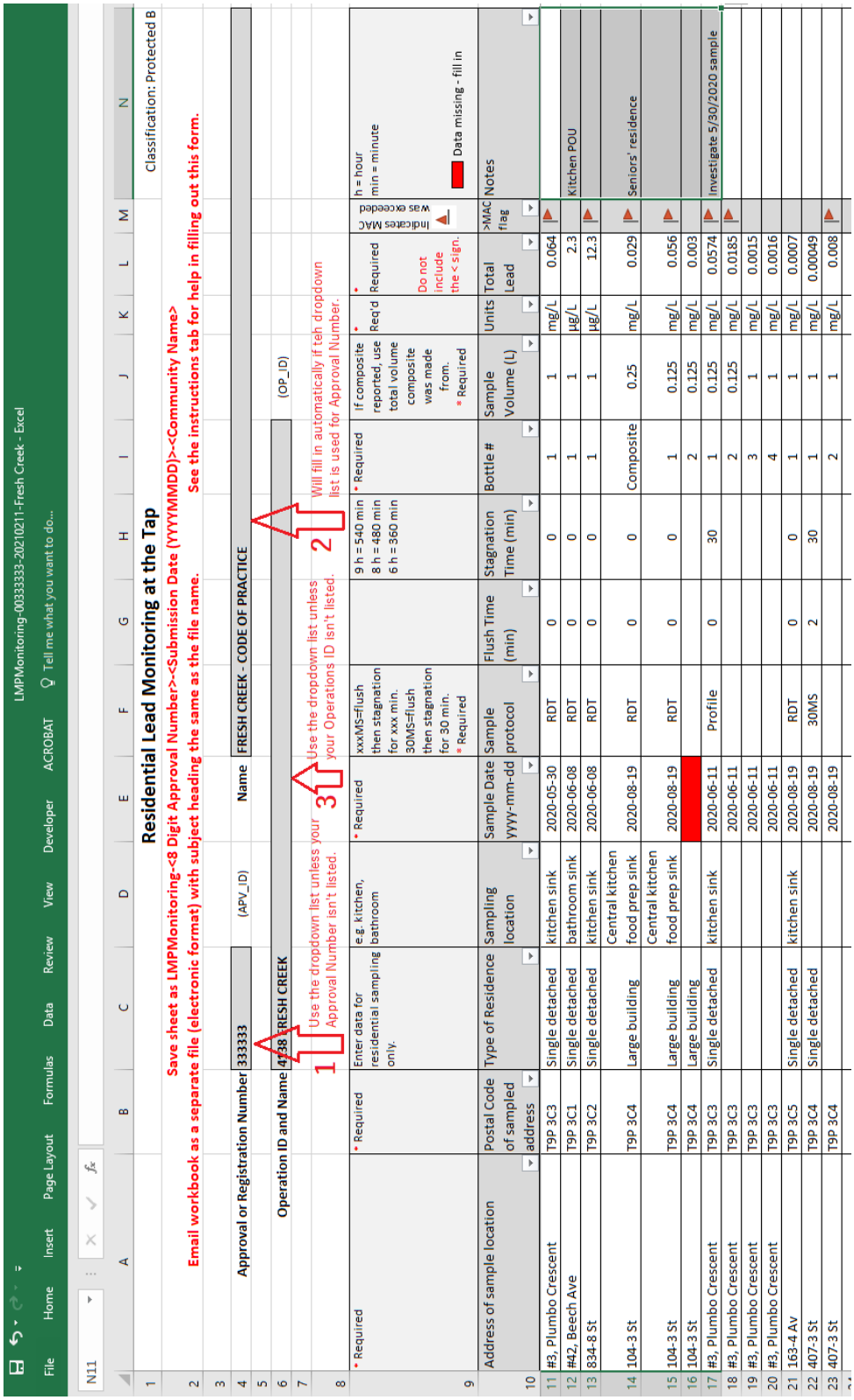


Figure 9: Sample of a completed lead result report

Appendix G Additional Sources of Information

BC Centre for Disease Control. 2014. INDICATORS OF EXPOSURE TO AND HEALTH EFFECTS OF LEAD IN BRITISH COLUMBIA, 2009-2010. http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/Health-Environment/BL_Surveillance_Report_V4_SEPT2BEtrs.pdf

Government of British Columbia. 2017. INTERIM GUIDELINES ON EVALUATING AND MITIGATING LEAD IN DRINKING WATER SUPPLIES, SCHOOLS, DAYCARES AND OTHER BUILDINGS. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/how-drinking-water-is-protected-in-bc/interim_guideline_on_reducing_exposure_to_lead_through_drinking_water_july_2017.pdf

First Nations Health Authority. 2017. LEAD AND COPPER IN DRINKING WATER. http://www.fnha.ca/Documents/FNHA-Fact-Sheet-Lead-and-Copper-In-Drinking-Water.pdf

New Brunswick Government. 2018. FACTS ON DRINKING WATER. https://www2.gnb.ca/content/dam/gnb/Departments/h-s/pdf/en/HealthyEnvironments/water/Leade.pdf

Memorial University. 2016. DRINKING WATER QUALITY GUIDE. https://www.mun.ca/health_safety/DrinkingWaterQualityGuide_2016.pdf

T Harris Environment. 2017. SUMMARY OF CHANGES TO WATER SAMPLING REGULATIONS FOR SCHOOLS, PRIVATE SCHOOLS, AND CHILD CARE CENTRES. http://tharris.ca/2017/02/10/lead-in-water-testing-regulation-schools/

Safruk, Adam M, et al. 2017. "The influence of lead content in drinking water, household dust, soil and paint on blood lead levels of children in Flin Fion, Manitoba and Creighton, Saskatchewan." SCIENCE OF THE TOTAL ENVIRONMENT. 593: 2012- https://ac.els-cdn.com/S0048969717306605/1-s2.0-S0048969717306605-main.pdf?_tid=e934e720-8005-4b32-a40e-14f1cdd3c88e&acdnat=1541779774_6dd295a99dcc7af37cdb1ca615197641

Yukon Government. 2018. WATER TESTING IN YUKON SCHOOLS. http://www.education.gov.yk.ca/water-testing.html

Dore, Evelyne, et al. 2018. "Sampling in schools and large institutional buildings: Implications for regulations, exposure and management of lead and copper." WATER RESEARCH. 140: 110-22. https://ac.els-cdn.com/S0043135418303397/1-s2.0-S0043135418303397-main.pdf?_tid=4d90e03a-31ae-4a9e-96a9-ec4bf680d131&acdnat=1541781802_9887862dd6c694b2c58c97c6c822f628

OTHER COUNTRIES

Australian Government. 2018. AUSTRALIAN DRINKING WATER GUIDELINES 6. VERSION 3.5 Updated August 2018. file:///C:/Users/mica.wickramasekara/Downloads/NHMRC%20ADWG%206%20-%20Version%203.5%20-%20Proof%203.pdf

Hayes, CR. 2009. "Is there still a problem with lead in drinking water in the European Union." JOURNAL OF WATER AND HEALTH. https://pdfs.semanticscholar.org/eea6/aac9dff315599f6272476b87a019f4b2c78f.pdf

_____. 2010. TECHNICAL DIGEST ON LEAD IN DRINKING WATER. https://ec.europa.eu/jrc/sites/jrcsh/files/Hoekstra%202010%20Technical%20Digest%20Lead.pdf

Fretman, Regina et al. 2007. "Lead exposure by drinking water: An epidemiological study in Hamburg, Germany." INTERNATIONAL JOURNAL OF HYGIENE AND ENVIRONMENTAL HEALTH. 207: 235- https://ncel.net/wp-content/uploads/2017/02/Fertman-Hamburg-Lead-Water-Women-IJHEH-2004.pdf

National Services Scotland. 2018. PUBLIC HEALTH ACTION IN RESPONSE TO DETECTING HIGH LEVELS OF LEAD IN DRINKING WATER. https://www.hps.scot.nhs.uk/resourcedocument.aspx?id=5678

Environmental Protection Agency (EPA). 2016. CLARIFICATION OF RECOMMENDED TAP SAMPLING PROCEDURES FOR PURPOSES OF THE LEAD AND COPPER RULE. https://www.epa.gov/sites/production/files/2016-02/documents/epa_lcr_sampling_memorandum_dated_february_29_2016_508.pdf

Environmental Protection Agency (EPA). 2017. PROPOSED MODELING APPROACHES FOR A HEALTH BASED BENCHMARK FOR LEAD IN DRINKING WATER. https://www.epa.gov/sites/production/files/2017-

01/documents/report_proposed_modeling_approaches_for_a_health_based_benchmark_for_lead_in_drinking_water_final_0.pdf

Morse, Dale L, et al. 1979. “Exposure of children to lead in drinking water.” AMERICAN JOURNAL OF PUBLIC HEALTH. 69(7): 711- https://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.69.7.711

U.S. EPA Flint Task Force. 2015. LEAD IN DRINKING WATER: PRELIMINARY ASSESSMENT. https://www.epa.gov/sites/production/files/2016-01/documents/ftf-3_epa_task_force_lead_in_drinking_water_-_preliminary_assessment_final_draft_december_22_2015.pdf

OTHER:

National Collaborating Centre for Environmental Health. 2018. LEAD IN DRINKING WATER: HOMES AND SCHOOLS. http://www.ncceh.ca/environmental-health-in-canada/health-agency-projects/lead-drinking-water-homes-and-schools