LEAD REDUCTION PROGRAM PLAN

DRAFT FOR PUBLIC COMMENT

Version 1.0: July 11, 2019

DENVER WATER

Draft Subject to Modification

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EXECUTIVE SUMMARY

Introduction

Denver Water is committed to delivering safe water to 1.4 million people in the metro area, which is why Denver Water is working to significantly reduce lead exposure risks for customers with lead service lines and plumbing. The water we deliver to homes and businesses is lead-free, but lead can get into the water as it moves through customer-owned service lines and lead-containing plumbing.

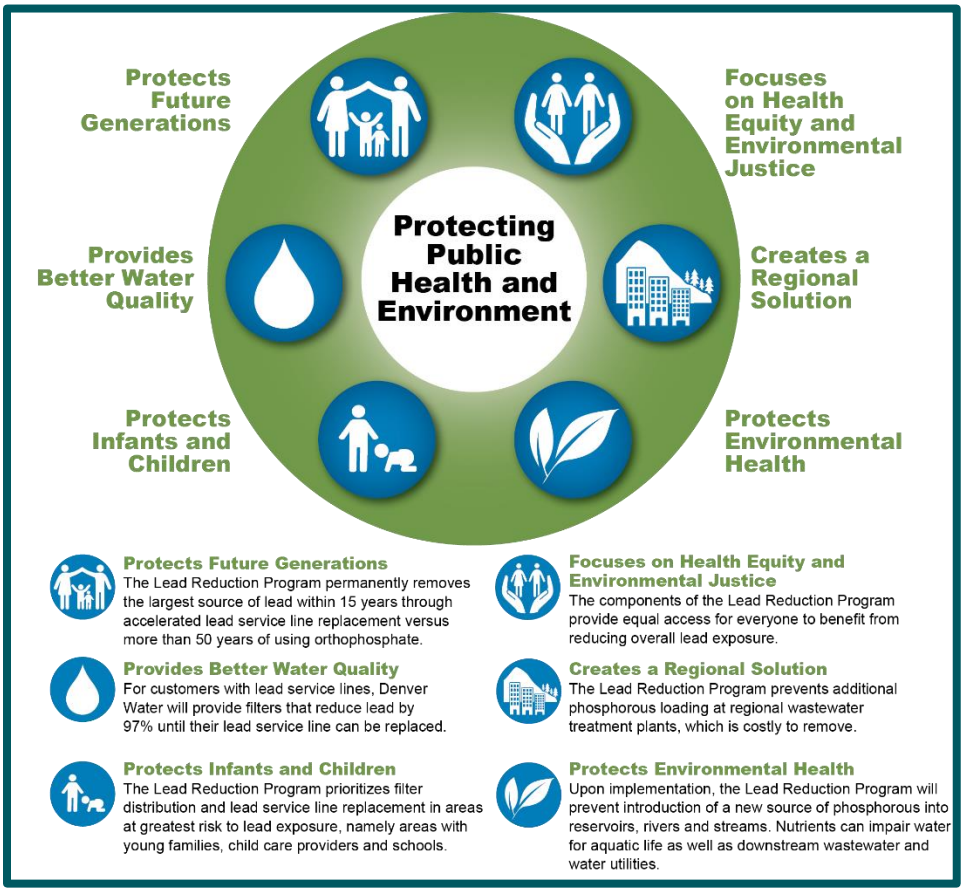
This Lead Reduction Program Plan has been prepared in support of Denver Water's request to the Environmental Protection Agency for a variance from the optimal corrosion control treatment requirements under the Safe Drinking Water Act's Lead and Copper Rule.

Currently, Denver Water maintains a pH of 7.8 to minimize corrosion of lead service lines and plumbing. Denver Water conducted a study on multiple treatment options to reduce the potential for lead to enter drinking water from lead service lines and household plumbing. Based on the results, the Colorado Department of Public Health and Environment, the state regulatory agency that oversees drinking water regulations, required Denver Water to begin adding orthophosphate by March 2020, in accordance with regulatory requirements.

Despite its benefits, orthophosphate added to drinking water can increase phosphorous levels in wastewater and storm water, resulting in adverse impacts to wastewater treatment plants and downstream reservoirs, streams and rivers. Once started, orthophosphate treatment cannot easily be discontinued without causing an increase in corrosion, making orthophosphate a potentially permanent treatment method.

Due to these concerns, Denver Water, along with the Colorado Department of Public Health and Environment and other stakeholders, convened working groups in 2018 to further evaluate the benefits and risks of orthophosphate alongside other options to reduce lead exposure. As part of this process, Denver Water investigated whether a lower dose of orthophosphate, a higher pH of 9.2 with alkalinity adjustment, or a multi-faceted approach including pH/alkalinity adjustment to 8.8 combined with the accelerated replacement of lead service lines and the provision of filters to customers could achieve the same or greater reduction in lead exposure risk. Based on this analysis, and as highlighted in Figure 1, Denver Water seeks to implement the multi-faceted Lead Reduction Program in place of adding orthophosphate to drinking water because the Lead Reduction Program provides the greatest benefit to public health and the environment.

FIGURE 1: LEAD REDUCTION PROGRAM PLAN BENEFITS



The Lead Reduction Program includes multiple elements, the most essential of which involve:

- A communication, outreach, and education plan
- Development of a lead service line inventory to identify and track lead service line replacement
- A filter program
- An accelerated lead service line replacement program
- Corrosion control treatment with pH and alkalinity adjustment

Overall, as compared to orthophosphate, the Lead Reduction Program provides a holistic and permanent lead reduction approach that is as effective at protecting public health, more efficient in reducing lead exposure, less harmful to the environment, more equitable in its public health benefits, and potentially more cost-effective with fewer regional risks.

History

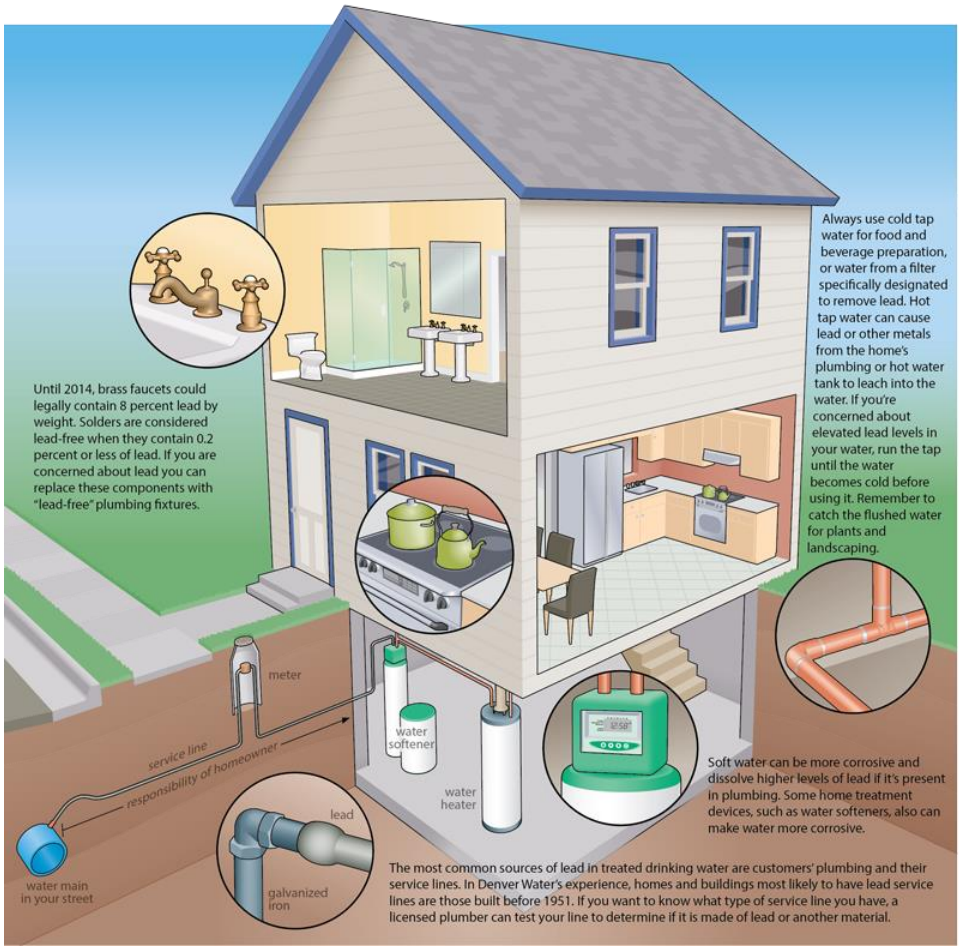
How does lead enter drinking water?

Lead exposure, whether from paint, soil, air or water, is a significant public health concern because it has the potential to adversely affect some of our most vulnerable populations, especially children. When it comes to lead in drinking water, no levels are safe. That is why Denver Water is working with the Colorado Department of Public Health and Environment, the Environmental Protection Agency and our customers to reduce the risks of lead exposure as drinking water moves through homes and businesses with lead service lines and lead plumbing.

While Denver Water delivers safe, lead-free water to customers' homes, lead can enter the water through three sources: (1) a customer's lead service line, which conveys water from the water main in the street to the customer's home, (2) a customer's household plumbing that contains lead solder; and (3) a customer's plumbing fixtures that contain lead (e.g., faucets, valves). Figure 2 highlights the sources of lead in drinking water.

Denver Water studies show that lead service lines, typically found in homes built before 1951 within the Denver Water service area, are the primary source of lead in drinking water.

FIGURE 2: SOURCES OF LEAD IN DRINKING WATER



What has Denver Water done historically to control lead and reduce lead exposure?

For decades, Denver Water has been working to reduce lead in drinking water. Figure 3 highlights the history of lead in drinking water and provides an overview of Denver Water's activities to reduce lead exposure. Since 1992, Denver Water has tested water from inside customer homes with known lead service lines or lead solder as part of the Safe Drinking Water Act's Lead and Copper Rule. Additionally, Denver Water has provided corrosion control treatment in the form of pH adjustment of the water delivered to customers' homes to minimize the corrosion of customer-owned lead service lines and plumbing.

FIGURE 3: HISTORY OF LEAD IN DRINKING WATER

Since 1994, Denver Water has been authorized to maintain a minimum pH/alkalinity of 7.5. In accordance with this authorization, in recent years, Denver Water has sought to consistently maintain a pH of 7.8. This approach has resulted in the following lead levels measured from Tier 1 homes as defined in the Lead and Copper Rule. A Tier 1 home is a sample site that is a single-family structure built between 1983 and 1987 that (1) contains copper pipes with lead solder; (2) contains lead pipes; and/or (3) is supplied by a lead service line.

Category	Lead Concentration Range (expressed in units of ppb – parts per billion)
Average lead levels for Tier 1 homes	4 to 8
90th percentile lead levels for Tier 1 homes	7 to 17*

* Lead and Copper Rule action level is 0.015 mg/L = 15 ppb; 17 ppb was reported once in 2012.

Although these treatment efforts were largely effective for many years, in 2012, the 90th percentile value for sample results of lead levels in tap water was 17 ppb, exceeding the Lead and Copper Rule action level of 15 ppb. Since the Lead and Copper Rule was adopted in 1992, the 2012 exceedance of the lead action level was Denver Water's first and only exceedance.

As a result of this one exceedance, Denver Water was required to investigate the cause and evaluate alternative treatment solutions. These studies included a lead service line pipe rack study that required the harvesting of lead service lines from homes in the distribution system. These studies, especially the pipe rack study, required a significant investment of time and resources by Denver Water and resulted in the submittal of an Optimal Corrosion Control Report in late 2017. Based on the data in the report, in March 2018, the Colorado Department of Public Health and Environment designated orthophosphate added to drinking water as the optimal corrosion control treatment and directed Denver Water to prepare to implement orthophosphate treatment by March 2020.

Corrosion Control

What is corrosion control?

When water interacts with metal, the metal can oxidize, resulting in corrosion. By adjusting the chemistry of the water, it is possible to cause a buildup or coating on pipe walls, which reduces the amount of lead released from lead-containing pipes and fixtures. This protective coating, however, requires the maintenance of a delicate chemistry in the water. To reduce corrosion and maintain the coating, the Lead and Copper Rule requires drinking water systems to maintain "optimal corrosion control treatment," which means a corrosion control treatment that minimizes the lead and copper concentrations at customers' taps. This can be done through orthophosphate added to drinking water, pH/alkalinity adjustment, or calcium hardness adjustment. Depending on the chemistry of the water, some corrosion control treatment methods can be more effective than others.

What is orthophosphate treatment?

Orthophosphate is a phosphate-based corrosion control inhibitor that changes the chemistry of water to create a protective coating on service lines and plumbing that, in turn, reduces the corrosion that causes lead releases. Although orthophosphate is effective at reducing lead exposure, it can increase phosphorous levels in wastewater and add excessive nutrients to surface water, adversely affecting rivers, streams, and lakes in our region. To remove phosphorous, wastewater treatment plants would need to invest in facility upgrades. In addition, once Denver Water begins to treat with orthophosphate, it will likely need to continue treatment indefinitely to avoid upsetting the delicate chemistry of the water that maintains the protective coating on service lines and plumbing.

Are there effective alternatives to orthophosphate?

Because of concerns about the negative impact of orthophosphate on wastewater treatment plants and the environment, Denver Water engaged stakeholders to assess alternatives to using orthophosphate that may provide even greater protection to Denver Water customers.

These studies investigated two treatment approaches: (1) the lowest effective dose of orthophosphate (3, 2 or 1 mg/L as orthophosphate) required to minimize lead at drinking water taps in Denver Water's system, and (2) the effects of a higher pH of 9.2 as a corrosion control treatment method on lead releases. Denver Water and stakeholders also analyzed the costs to remove phosphorous from the watershed as well as the costs to counter the potential effects of increasing pH. In addition, Denver Water developed a lead control model, demonstrating the efficiency of replacing lead service lines in combination with both use of lead removal filters and pH/alkalinity adjustment, as compared with orthophosphate corrosion control treatment alone.

Based upon these studies, Denver Water is proposing an alternative, holistic approach that directly tackles the biggest issue, customer-owned lead service lines, at its source by accelerating the removal of those lines through a Lead Reduction Program. The Lead Reduction Program would reduce the risk of public exposure to lead beyond what can be achieved by adding orthophosphate to the drinking water by:

- Developing a lead service line inventory so our customers can investigate the likelihood of having a lead service line
- Implementing the Filter Program, a program that would distribute filters to all homes with a known, suspected or possible lead service line, reducing lead by 97% or more
- Implementing an accelerated lead service line replacement program that would remove the major source of lead decades ahead of the current rate of replacement: approximately 75,000 lead service lines would be removed within 15 years versus 50 years or more under current practices
- Adjusting pH from 7.8 to 8.8 and maintaining alkalinity above 30 mg/L as $CaCO_3$ for corrosion control treatment to reduce corrosion of lead service lines, household plumbing and fixtures
- Enhancing the communication, outreach and education program to help customers understand the Lead Reduction Program and ways that they can reduce their exposure to lead

Variance Request and Lead Reduction Program

How does the Environmental Protection Agency determine whether an alternative treatment method is as effective as orthophosphate?

To implement the Lead Reduction Program, Denver Water must apply for a variance from the Environmental Protection Agency. Under 42 U.S.C. § 300g-4(a)(3) and 40 C.F.R. § 142.46, the

Environmental Protection Agency may grant a variance from the optimal corrosion control treatment requirements under the Safe Drinking Water Act's Lead and Copper Rule *"upon a showing from any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirements was prescribed."*

Is Denver Water proposing the Lead Reduction Program on a voluntary basis?

Denver Water is proposing the Lead Reduction Program on a voluntary basis as an alternative to orthophosphate treatment under the Lead and Copper Rule. Denver Water cares about the 1.4 million people it serves and the safety of the water at their taps. Denver Water wants to provide the best short- and long-term solution to prevent lead exposure. In addition, Denver Water is concerned about the adverse impact that orthophosphate could have on the downstream reservoirs, rivers and streams, the quality of the source of supply, and the costs wastewater treatment and storm water management providers would incur to remove phosphorous. For these reasons, Denver Water is proposing the Lead Reduction Program as a proactive measure to permanently remove lead service lines from its service area as efficiently as possible, provide additional public health protection that cannot be achieved through orthophosphate treatment alone, protect the watersheds and help reduce regional costs that would be incurred to remove phosphorous from wastewater.

What commitments is Denver Water making?

Denver Water will actively engage its customers with lead service lines within the City and County of Denver and the service areas of its distributors that collectively make up Denver Water's "integrated system." The Lead Reduction Program will aim to reduce lead levels by distributing filters to customers with known, suspected or possible lead service lines, replacing 7.0% of the lead service lines annually, and replacing all lead service lines within 15 years. The six elements necessary to accomplish this goal are described in Table ES-1.

TABLE 1: DENVER WATER'S COMMITMENTS UNDER THE PROPOSED LEAD REDUCTION PROGRAM

Communications, Outreach and Education
Denver Water is committing to: • Educate and engage with residents, customers, distributors, local public health agencies and government stakeholders about lead awareness and reduction efforts. • Educate the public on measures they can take to reduce their exposure to lead in drinking water. • Seek feedback from residents and other stakeholders to learn best practices and effective ways to implement program activities. • Strive for 100% participation in the Filter Program.
Lead Service Line Inventory
Denver Water is committing to: • Research, investigate, and document the presence of customer-owned lead service lines. • Help customers identify if they have a lead service line. • Maintain a current lead inventory and map. • Confirm materials at properties with a suspected or possible lead service line. • Use the inventory to target communications, outreach and education efforts at areas with the greatest risk.
Filter Program
Denver Water is committing to: • Provide filters and filter cartridge replacements to properties with known, suspected, and possible lead service lines for up to 15 years during the life of the Lead Reduction Program. • Educate and inform residents on the importance of using filters for drinking water.
Accelerated Lead Service Line Replacement Program
Denver Water is committing to: • Replace all known lead service lines in 15 years. • Replace 7.0% of the lead service line inventory each year, based on a cumulative annual average. • Using predictive modeling to help prioritize lead service line replacement taking into consideration the following factors: public health/toxicology concerns, child care providers, primary schools, neighborhoods with high density of young families, and socioeconomic and environmental factors. • Follow up with residents and provide filters until the service line is confirmed as non-lead or until six months after the lead service line is replaced.
Corrosion Control Treatment
Denver Water is committing to: • Maintain water quality by implementing corrosion control treatment through pH and alkalinity adjustment.
Learning by Doing
Denver Water is committing to: • Evaluate the performance of the Lead Reduction Program to improve outcomes.

How will the performance of the Lead Reduction Program be evaluated?

Denver Water will use the criteria shown in Table ES-2 to evaluate the performance of the Lead Reduction Program. An annual report will detail the program's success and provide regulators with clear criteria to determine when to require correction or take enforcement action.

TABLE 2: LEAD REDUCTION PROGRAM EVALUATION CRITERIA
(Data are provisional and subject to change)

Element	"Meets Expectation"	"Fails"	Corrective Action Upon Failure
Communication, Outreach & Education	One contact made per program year to all Denver Water households enrolled in the Filter Lead Out of Water Program	One contact made per program year to less than 40% of all Denver Water households enrolled in the Filter Lead Out of Water Program	Make contact to all Denver Water households enrolled in the Filter Lead Out of Water Program; and send a public notice to all Denver Water customers that the metric was not achieved
Lead Service Line Inventory	Investigate more than 1.4% of the total estimated number of suspected and possible lead service lines for the same program year.	Investigate less than 1.1% of the total estimated number of suspected and possible lead service lines in one program year	Increase use and types of methods to investigate service line type Send a public notice to all households enrolled in the Filter Lead Out of Water Program
Filter Lead Out of Water Program	__% annual filter adoption rate	A filter adoption rate of less than less than __% after a single program year or that remains less than __% but greater than __% for three consecutive program years.*	Implement orthophosphate Send a public notice to all Denver Water households
Accelerated Lead Service Line Replacement	7.0% cumulative annual average replacement rate	Less than 6.0% cumulative annual average replacement rate for three consecutive program years	Implement orthophosphate Send a public notice to all Denver Water households
Corrosion Control Treatment	**[Under Consideration]**		

What if the variance request is not approved or the variance criteria are not met?

Following the Colorado Department of Public Health and Environment's designation of orthophosphate for optimal corrosion control treatment, Denver Water initiated design and construction of chemical feed systems to dose orthophosphate at 3 mg/L at Denver Water's three treatment plants. If the variance request is not approved, these systems will begin introducing orthophosphate on March 20, 2020.

If the variance is granted and certain criteria in Table ES-2 are not met during the 15-year period of the Lead Reduction Program, Denver Water might also be required to implement orthophosphate using the chemical feed systems.

More details on the optimal corrosion control treatment designation of orthophosphate can be found at:

www.colorado.gov/cdphe/lead-dw-treatment

How to navigate through this Lead Reduction Program Plan

This executive summary introduces the Lead Reduction Program Plan, the variance request, and Denver Water's commitments if the variance is approved by the Environmental Protection Agency.

Section I presents the history of lead occurrence and control in the Denver Water system, from the single exceedance of the action level for lead in 2012 until the designation of orthophosphate for optimal corrosion control treatment by the Colorado Department of Public Health and Environment in March 2018.

Section II provides a summary of the investigations undertaken by Denver Water since March 2018 to demonstrate that the Lead Reduction Program is as effective as the alternative of orthophosphate at reducing lead levels in drinking water. An overview of the elements that together make up the Lead Reduction Program is presented.

Section III describes how Denver Water will implement all six elements of the Lead Reduction Program.

Section IV details how Denver Water will evaluate the performance of the Lead Reduction Program and ultimately maintain regulatory compliance with the Lead and Copper Rule.

Section V presents the implementation schedule for the Lead Reduction Program, including opportunities for public comment.

Section VI describes how Denver Water will address health equity and environmental justice needs through the Lead Reduction Program.

Section VII presents the estimated costs of the Lead Reduction Program (to be provided).

A series of technical memoranda were prepared during the development of the Lead Reduction Program and are included in the appendices to this plan.

What is Denver Water asking of the customer?

- Understand your risks related to lead exposure and what you can do to reduce lead sources
- If you have a lead service line:
  - Allow Denver Water to replace the lead service line at no cost to the property owner
  - Use a filter until the lead service line can be replaced
- If you have sources of lead in premise plumbing inside the home:
  - Replace faucets and indoor plumbing with lead-free components

To minimize exposure to lead when using water for drinking, cooking, and making beverages, ice, and infant formula:

- Use a filter certified by the National Safety Foundation to remove lead for drinking and cooking. Replace the filter cartridge according to the manufacturer's instructions.
- Use only cold water for drinking, cooking and making baby formula. Remember, boiling water does not remove lead from water and hot water often contains higher levels of lead than cold water.
- If water has not been used in the home for a few hours, such as first thing in the morning or when getting home from work, run the kitchen or any bathroom faucet for five minutes (remember to capture the water and reuse it!). You can also run the dishwasher, take a shower, or do a load of laundry to help flush water in your internal plumbing before drinking or cooking.
- Regularly clean your faucet's screen (also known as an aerator). View step-by-step instructions.
- Consider replacing faucets and indoor plumbing with lead-free components

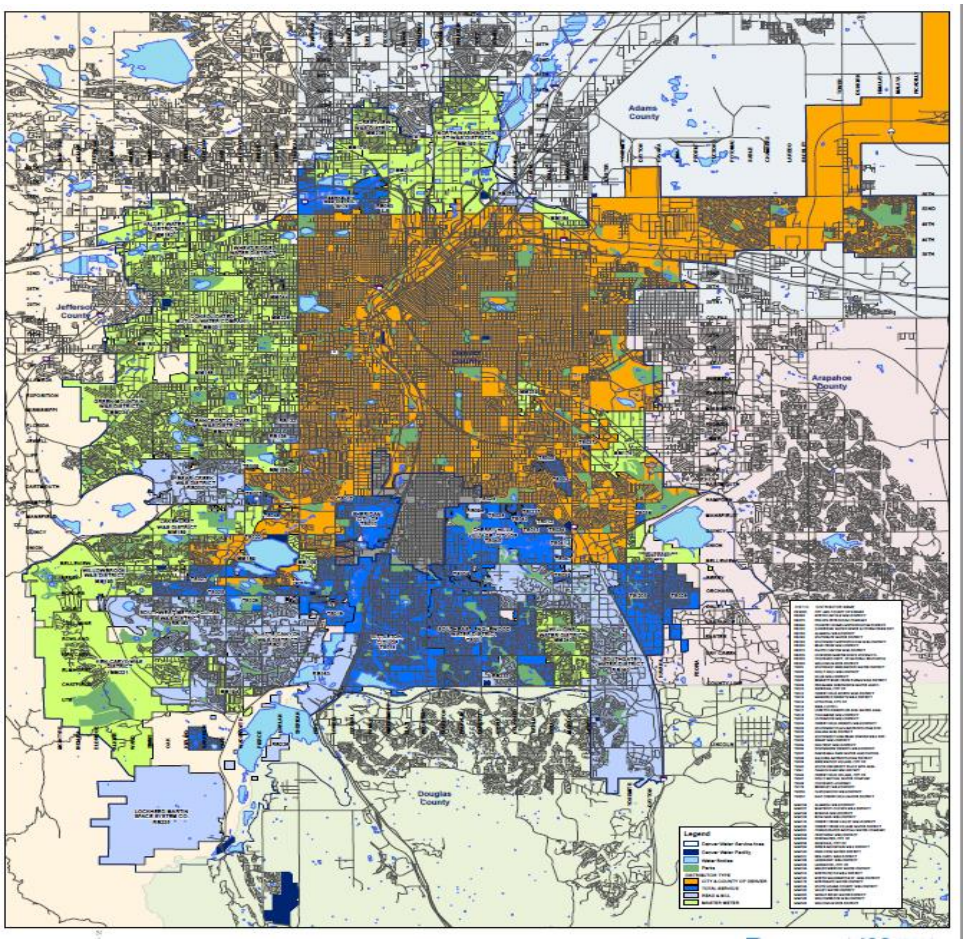
I. DENVER WATER'S HISTORY OF LEAD OCCURRENCE AND CONTROL

From the late 1800s to the mid 1900s, lead service lines were installed in Denver to deliver water from the main into customers' homes. This was a common practice in the industry across North America as lead service lines offered significant durability and protection from leaks and subsequent contamination of household water supplies. In 1949, Denver Water's engineering standards were amended to allow the use of other materials, such as copper, for service line installations. By 1986, the state of Colorado had banned lead in pipes, solder and other plumbing materials

Lead in Denver Water's Service area

Denver Water's service area consists of the City and County of Denver and its outlying suburban distributors as depicted in the map in Figure 4. The service area shown in the map includes adjacent distribution systems that are physically connected to and provided with water from Denver Water's system. See Rule 11.42(1), 5 CCR 1002-11.

FIGURE 4: DENVER WATER SERVICE AREA INCLUDING INTEGRATED SYSTEMS



Lead service lines are known to exist in Denver and in approximately half of the service areas of Denver Water's distributors.

Within Denver, customers own and have historically been responsible for their service lines. Since Denver Water did not install and does not own service lines, it has few records about the location or type of material (copper, lead or other). However, the year of service line installation provides some indication of whether the service line is likely to be made of lead.

In 1949, the Denver Water Board added copper to its list of approved materials for service lines. Although Denver Water's engineering standards did not eliminate lead as an acceptable material for service lines until 1971, data collected during construction and repair work and from water quality tests for homes built after 1950 indicate that the use of lead as a service line material sharply decreased after 1950.

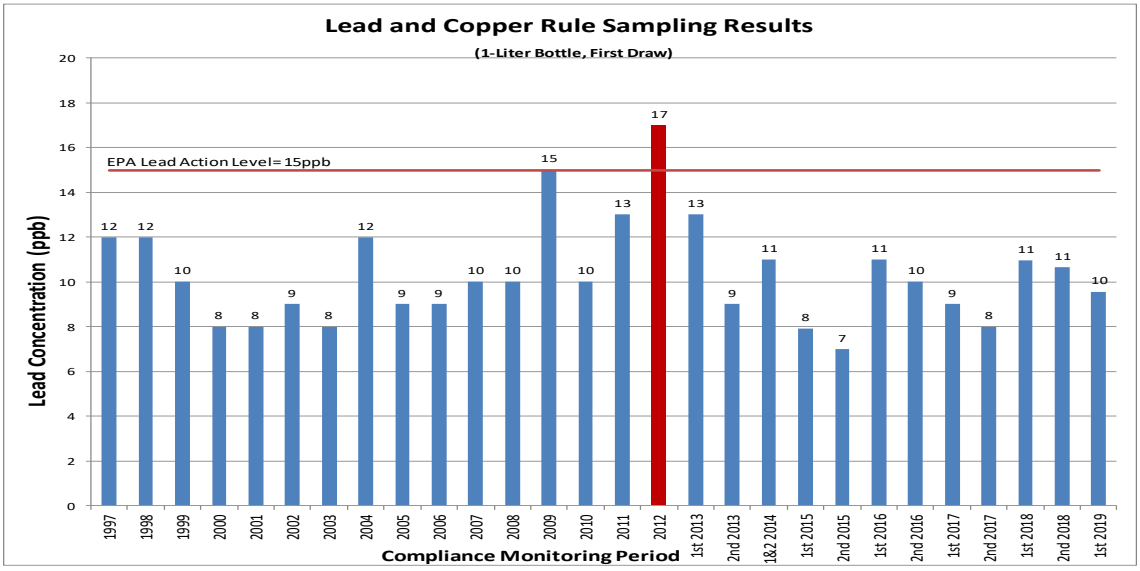
Actions taken by Denver Water to protect customers from lead in drinking water

Since 1992, Denver Water has tested water from customers' faucets per the Environmental Protection Agency's (EPA) Lead and Copper Rule (LCR) and the Colorado Department of Public Health and Environment's (CDPHE) Primary Drinking Water Regulations. The results from the last twenty years are shown in Figure 5. Additionally, Denver Water has studied corrosion control and modified treatment processes to improve corrosion control.

A corrosion control study completed in 1994 recommended that Denver Water adjust the pH of the water produced from its treatment plants to a range of 7.5 to 8.3 standard units. CDPHE issued a letter following the study indicating that to comply with the LCR, Denver Water must produce water with a minimum pH of 7.5 and minimum total alkalinity of 15 mg/L as CaCO3 before the water enters the distribution system. In 1994, Denver Water implemented the changes to meet these regulatory requirements.

Through 2011, Denver Water's LCR sample results for Tier 1 lead service lines and Tier 1 copper service lines with lead solder were under the lead action level of 15 parts per billion (ppb). In 2012, Denver Water's LCR sample results exceeded the lead action level. As seen in Figure 5, sample results from homes indicated a monitoring value of 17 ppb for the 90th percentile (meaning that the concentrations of lead were above 15 ppb in more than 10 percent of the homes tested). This exceedance prompted Denver Water to implement its largest public health education campaign and study options for improving corrosion control treatment. (Note that water testing has demonstrated corrosion of copper has always been well under the action level for copper, which is 1.3 parts per million.)

FIGURE 5: 90TH PERCENTILE LEAD LEVELS BETWEEN 1997 AND 2019
(Data are provisional and subject to change)



What steps did Denver Water take after exceeding the lead action level in 2012?

After the 2012 samples exceeded the lead action level, Denver Water implemented a multi-faceted approach to create awareness and protect customers from lead in drinking water, which included:

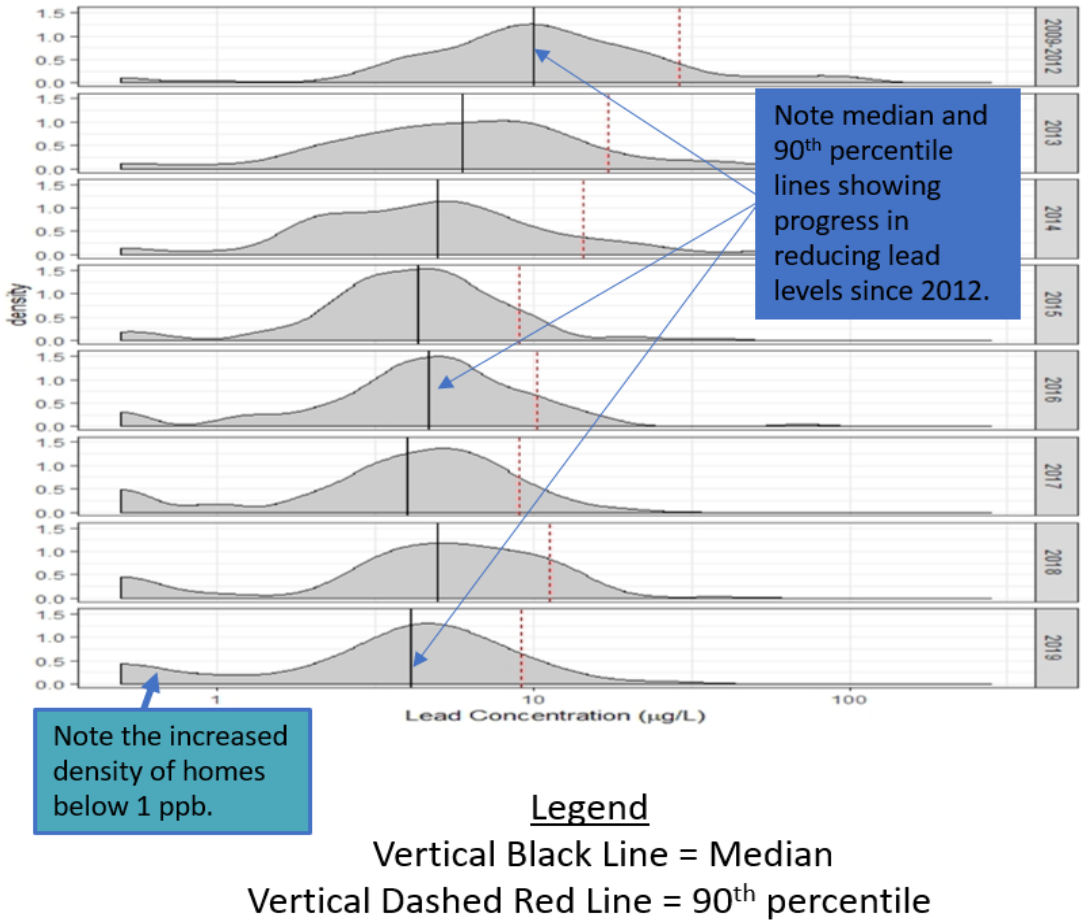
- Adopting proactive and ever-adapting communications strategies that included direct customer mailings, bill inserts, sharing information at community gatherings, working with traditional media on coverage of lead issues, and social media, including educational and call-to-action posts on Denver Water's Facebook page and messages via Twitter
- Offering free lead water quality testing kits to customers
- Replacing customer-owned lead service lines when encountered during water main or major road construction work
- Implementing policies to enforce the replacement of lead service lines during building redevelopment
- Helping homeowners remove their lead service lines by partnering with the Denver Urban Renewal Authority on a pilot program to make low- or no-interest financing available to homeowners who want to replace their lead service lines

These changes resulted in the removal of approximately 1,200 lead service lines per year as compared to the previous rate of approximately 500 per year between 2000 and 2012.

Additionally, as seen in Figure 6, Denver Water has continued to optimize its current pH/alkalinity corrosion control system through improved pH and alkalinity monitoring and control at the

treatment plants. Denver Water has also made chemical adjustments in the last year to maintain alkalinity levels above 40 mg/L as CaCO3 at all plants and decrease the chloride-to-sulfate mass ratio to further improve corrosion control.

FIGURE 6: LEAD LEVEL DISTRIBUTIONS 2009–2019 FOR HOMES WITH LEAD SERVICE LINES
(Data are provisional and subject to change)



Denver Water studied ways to improve corrosion control treatment

In 2013, Denver Water proceeded to examine all possible causes of the 2012 exceedance and undertook a desktop study to identify potential corrosion control changes to plant operations including increasing pH and alkalinity or adding corrosion control inhibitors orthophosphate and silica. The optimal corrosion control treatment (OCCT) from the study concluded that a pH/alkalinity adjustment could result in lead reductions of between 40% and 53%, while orthophosphate would likely reduce lead levels between 67% and 76%, depending on water source and temperature. However, the report suggested further studies were necessary to confirm that theoretical calculations could be replicated in a real-life scenario. The report also recommended additional studies to determine the best way to make a water quality change without causing a period of poor water quality and identify the time required for the scales to adapt to the new water quality.

The 2013 desktop study also concluded that:

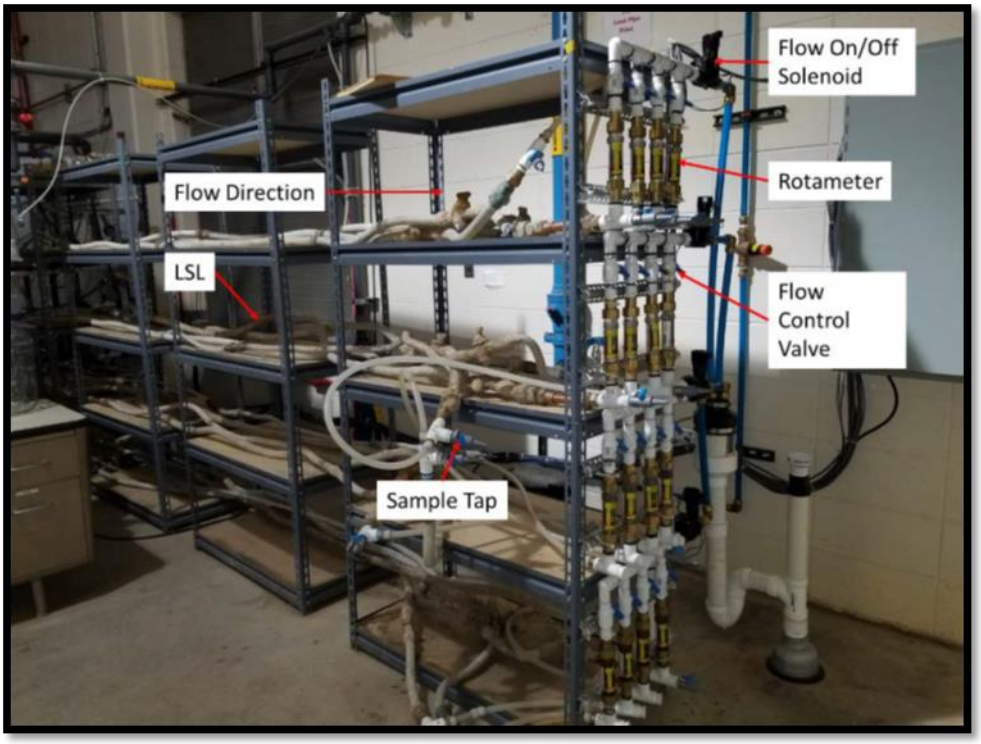
- Adjusting pH/alkalinity would require higher pH levels, which might impact disinfection byproduct formation in the distribution system and cause copper pitting
- Adding orthophosphate might contribute to increased biological growth in the distribution system and result in the precipitation of phosphate compounds that show up as turbidity in water heaters. Orthophosphate would increase the amount of phosphorous at regional wastewater treatment facilities (loading), which are tasked with removing residual phosphorous prior to discharge. Operating costs would increase not only for Denver Water but also for regional wastewater treatment plants

As a result of the 2013 desktop study, Denver Water chose to embark on a lead service line pipe rack study and began to collect lead service line piping from customers' homes. Figure 7 shows the lead pipe rack pilot plant at Marston Treatment Plant. The study included:

- Developing a CDPHE-approved pilot testing protocol
- Carefully excavating and selecting viable lead service lines from customer's homes
- Constructing and operating two lead pipe rack pilot skids in 2015 and 2016 to accommodate the two different sources of supply that provide water to Denver Water customers
- Testing three forms of corrosion control additives: silicates, pH/alkalinity and orthophosphate

Dosing for corrosion control began mid-2016 and continued through late 2017 to gather enough data to produce statistically meaningful results. Early in the study, silica was dropped as an alternative because it failed to demonstrate significant reductions in lead levels. Variability in the results for individual lead pipe racks would suggest that changes in corrosion control may disturb existing scales for either orthophosphate or pH/alkalinity adjustment; however, in both cases lead levels did decrease with time.

FIGURE 7: LEAD PIPE RACK AT MARSTON TREATMENT PLANT



The OCCT report was submitted to CDPHE in September 2017, and while the study found that orthophosphate provided greater lead reduction than pH/alkalinity adjustment as seen in Table 3, Denver Water recommended pH/alkalinity corrosion control treatment over orthophosphate due to concerns that orthophosphate would require improvements at downstream wastewater treatment plants to remove the additional phosphorous to meet discharge permit requirements. Furthermore, orthophosphate changes the scale composition on all pipelines in the distribution system, including service lines and household plumbing. Once the phosphate-based scales are formed, Denver Water would likely be committed to adding orthophosphate in perpetuity or until another treatment technique is proven to be as effective as orthophosphate at minimizing lead releases. Discontinuing orthophosphate would cause the pipe scales to dissolve, releasing lead, iron and other metals that are both aesthetic and public health issues.

TABLE 3: SUMMARY OF RESULTS FROM LEAD PIPE RACK STUDY

(Data are provisional and subject to change)

Pilot Plant Location	pH 8.8	Orthophosphate
Marston Treatment Plant (representing 80% of Denver Water's supply)	Median Reduction: 35% to 51%*	Median Reduction: 66% to 72%*
Moffat Treatment Plant (representing 20% of Denver Water's supply)	Median Reduction: 57% to 72%*	Median Reduction: 64% to 81%*

*Three pipes were dedicated to each treatment type at each pilot plant. The range here represents the low and high results from the three pipes.

CDPHE designated orthophosphate for OCCT in March 2018

On March 20, 2018, CDPHE designated orthophosphate as the OCCT based on evidence that orthophosphate would reduce lead concentrations at customers' faucets by up to 74%, as compared to 50% using pH/alkalinity adjustment. Per the LCR as set forth in Regulation 11 of Colorado's Primary Drinking Water Regulations, Denver Water treatment plants must be equipped with and ready to implement orthophosphate by March 20, 2020.

Denver Water proceeded with the design and construction of additional chemical feed systems at each treatment plant to support corrosion control treatment using orthophosphate by March 2020. These systems will also support improved pH and alkalinity adjustment for corrosion control.

Denver Water pursues an alternative to corrosion control with orthophosphate

In response to concerns about introducing a new source of phosphorous into the watershed and the downstream impacts, an alternative approach was sought by Denver Water to reduce the risk of lead exposure of its customers. The development of the alternative lead reduction strategy is discussed in Section II.

II. LEAD REDUCTION ALTERNATIVES ANALYSIS

While Denver Water's 2017 study, along with results at other water utilities, demonstrated the effectiveness of orthophosphate in reducing lead exposure, Denver Water and other stakeholders raised concerns about relying on orthophosphate as a long-term treatment strategy. Those concerns included:

(1) Detrimental Impacts to the Watershed: orthophosphate would increase phosphorous loading in wastewater, storm water and regional waterbodies. Phosphorous is a key food source for algae, especially blue-green algae, and these microorganisms compete for the same oxygen in water that other aquatic life, like fish, need to survive. Additionally, algae in large numbers release compounds that cause taste and odor problems in raw water that are very difficult and expensive to remove, often making potable drinking water unpalatable. On occasion, blue-green algae can grow quickly and release toxins in what are known as "harmful algal blooms," as seen in Salem, Toledo, the Great Lakes and the Gulf. These toxins are detrimental to aquatic life and humans, impacting recreation and drinking water supplies if local potable water treatment plants are not equipped to remove them.

(**2) Long Term Impacts to the Watershed:** orthophosphate dosing would continue until all known lead service lines were removed and Denver Water could prove that corrosion control was no longer needed, estimated to take 50 years or more at the current replacement rate of 1,200 per year. The protective coatings formed by orthophosphate begin to dissolve when orthophosphate is discontinued.

(3) Potential Impacts in Drinking Water: As noted above, the protective coatings begin to dissolve when orthophosphate is turned off. Long-term disruptions (a month or longer) in the supply chain for orthophosphate could result in significant lead releases into the drinking water of homes with lead service lines. Orthophosphate can also increase the likelihood of nitrification occurring in the distribution system, which can lead to an increased formation of disinfection by-products.

Because of these concerns and a sincere desire to protect public health, Denver Water, along with CDPHE, EPA and other stakeholders, embarked on a process to explore whether alternative approaches might be as or more effective at reducing lead exposure while also reducing the potential adverse impacts associated with orthophosphate.

This Section describes the stakeholder process, the alternatives studies specific to reducing lead in drinking water, and the conclusions derived therefrom. Studies related to the impact of orthophosphate on the environment are described in a collaborative white paper released by CDPHE.[1]

[1] See https://www.colorado.gov/pacific/cdphe/OCCT-Stakeholder-Information

The regulatory framework for alternative treatment approaches

The LCR is based on a treatment technique consisting of four key pillars: public education, source water treatment, lead service line replacement, and corrosion control - *Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper*, 56 F4 26460-01, P. 26477 (June 7, 1991). These pillars are highly prescriptive in the sense that the LCR defines specifically when each pillar is triggered and exactly what must be done to fulfill each pillar of the treatment technique. For example, once the lead action level is exceeded, a drinking water provider is required to engage in public education efforts and lead service line replacement, but only as long as the lead action level is exceeded. In addition, with regard to corrosion control treatment, specific treatment requirements must be studied and the optimal form of treatment must be implemented, with little opportunity to pursue alternative approaches.

For EPA to approve any "alternative treatment technique" under 42 U.S.C. § 300g-4(a)(3), the alternative approach must be "at least as efficient in lowering" lead levels:

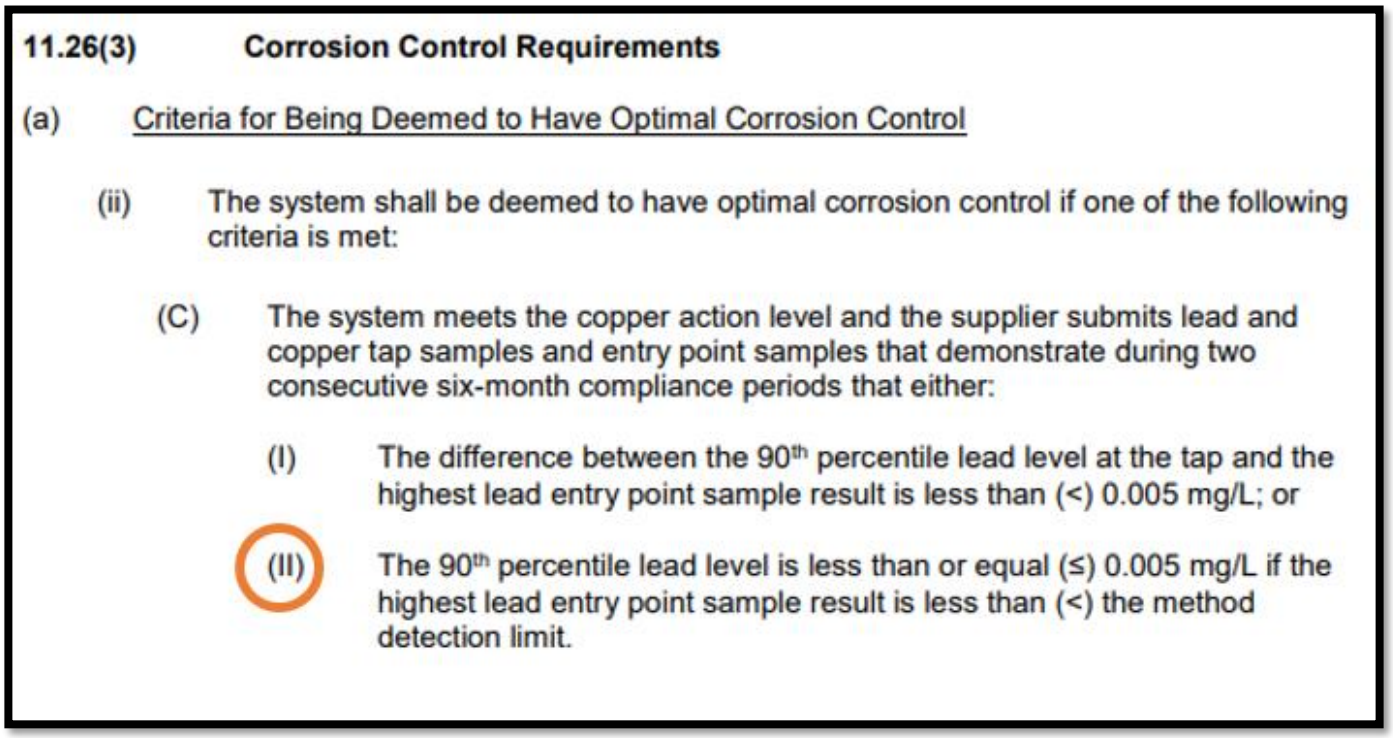
> The [EPA] Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement *is at least as efficient in lowering the level of the contaminant* with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis of the variance.

See also 40 C.F.R. § 142.46.[2]

Per the Colorado Primary Drinking Water Regulation (see Figure 8 below), a system can be considered optimized when lead levels are at or below 5 ppb. The water leaving Denver Water treatment plants is lead-free, and Denver Water has never exceeded the action level for lead in copper service lines with lead solder, nor has it ever exceeded the action level for copper in either lead or copper service lines. The reference value of 5 ppb carries some relevance in evaluating the predicted performance of corrosion control alternatives to orthophosphate.

[2] Under 40 C.F.R. § 142.46, EPA may approve the variance "whether or not the public water system for which the variance is requested is located in a State which has primary enforcement responsibility…."

FIGURE 8: EXCERPT FROM COLORADO PRIMARY DRINKING WATER REGULATION



11.26(3) Corrosion Control Requirements

(a) Criteria for Being Deemed to Have Optimal Corrosion Control

(ii) The system shall be deemed to have optimal corrosion control if one of the following criteria is met:

(C) The system meets the copper action level and the supplier submits lead and copper tap samples and entry point samples that demonstrate during two consecutive six-month compliance periods that either:

(I) The difference between the 90th percentile lead level at the tap and the highest lead entry point sample result is less than (<) 0.005 mg/L; or

(II) The 90th percentile lead level is less than or equal (≤) 0.005 mg/L if the highest lead entry point sample result is less than (<) the method detection limit.

Because Denver Water does not own any part of customers' lead service lines, historically, it has focused on education and optimal corrosion control efforts. The analyses described in the following sections explored alternatives to this approach.

Denver Water's part in the alternatives analysis

In July 2018, Denver Water, CDPHE and regional stakeholders entered into a memorandum of understanding to study alternative approaches to orthophosphate (at 3 mg/L) for lead reduction while assessing impacts to downstream watersheds and utilities. Stakeholders included representatives from federal and state agencies, member municipalities, utilities, environmental and watershed advocacy groups, and Denver Water distributors.

Stakeholders were tasked by executive leaders from CDPHE, Denver Water, Metro Wastewater, Aurora and the Greenway Foundation to "*work collaboratively to seek long-range regional solutions that maintain public trust and protect public health and the environment per the Safe Drinking Water Act and the Clean Water Act, while additionally minimizing impacts to water supplies, wastewater treatment plants, and watersheds, while minimizing impacts to water supplies, wastewater treatment plants and watersheds.*" Specific areas of interest included:

- Reducing impacts to downstream wastewater treatment plants. Sixty percent of Denver Water's supply is reclaimed at Metro Wastewater, Broomfield, South Adams County, South Platte Water Renewal Partners (Littleton/Englewood) and eventually participants in the WISE program. The addition of orthophosphate increases the amount of phosphorous

that must be removed during treatment and requires an investment in new infrastructure and/or increased chemical dosing to meet the low discharge limits for phosphorous.

- Reducing impacts to the watershed, storm water and nearby waterbodies. Forty percent of Denver Water's supply reaches irrigated areas from as far south as Littleton to as far north as Broomfield. Orthophosphate may require investment in new treatment infrastructure and/or increases in the number and types of management practices needed to reduce the additional phosphorous loading. Alternatives would also include phosphorous offsets, such as banning phosphorous fertilizers, to further reduce the amount of phosphorous in the watershed.
- Mitigating water quality impacts in the distribution system (specifically disinfection byproduct formation or nitrification) of both Denver Water and surrounding water utilities (Broomfield, South Adams County and East Cherry Creek Valley) that blend Denver Water's treated water with their water supplies.
- Minimizing lead releases resulting from transitions between corrosion control treatment techniques, orthophosphate to pH/alkalinity and vice versa, in part to establish whether Denver Water can ever stop using orthophosphate.

For its part in the alternatives analysis, Denver Water investigated the following alternative corrosion control strategies:

(1) the effects of a lower dose of orthophosphate;

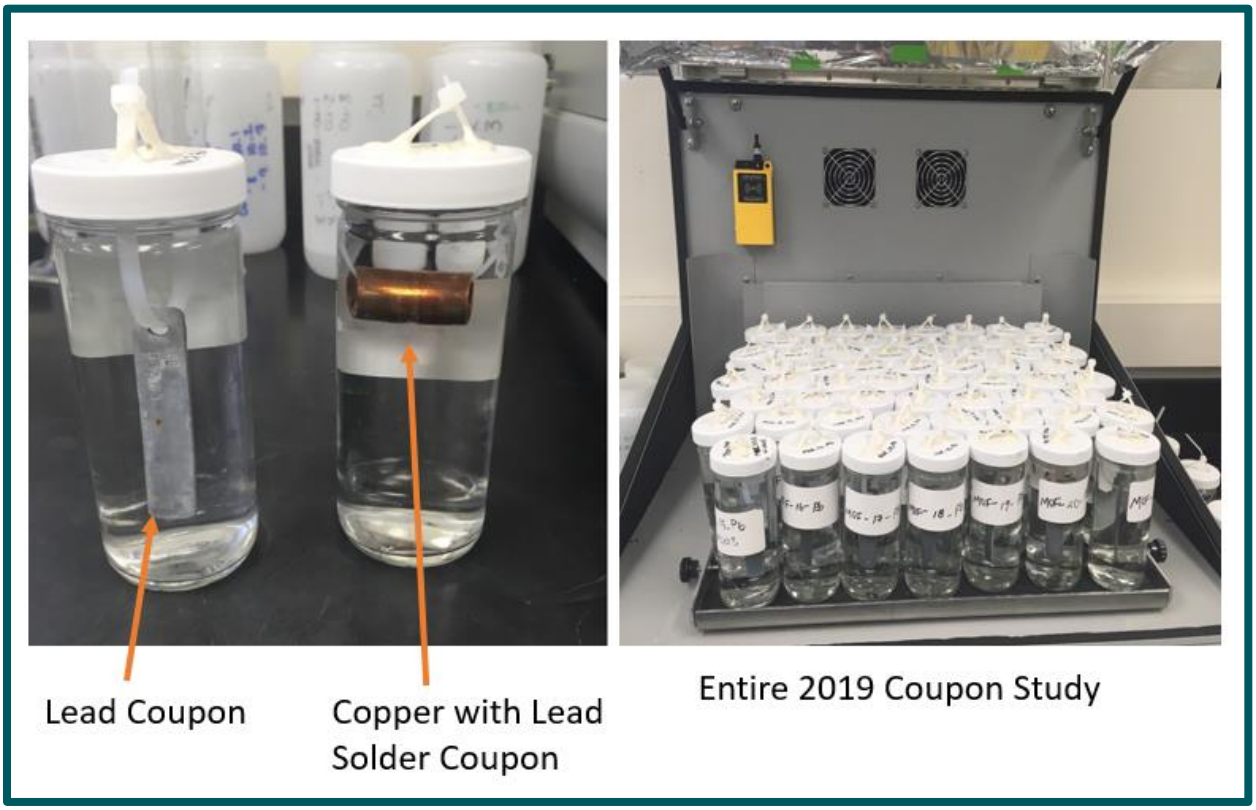
(2) the effects of a higher pH adjustment; and

(3) the effects of combined alternatives including accelerating lead service line replacement, a filter program, and pH adjustment.

The effects of lower doses of orthophosphate or higher targets for pH adjustment on lead release from lead service lines

As part of the alternatives analysis, Denver Water evaluated whether lower doses of orthophosphate, higher levels of pH, or a combination of high pH and very low doses of orthophosphate could achieve an equivalent reduction in lead levels as the designated optimal corrosion control treatment (studied at 3 mg/L). To test effectiveness, Denver Water conducted additional pipe rack studies with harvested lead service lines and initiated coupon studies to measure effectiveness of different corrosion control strategies on lead release. The coupon study is shown in Figure 9.

FIGURE 9: LEAD COUPON AND COPPER WITH LEAD SOLDER COUPON CORROSION CONTROL STUDY



Denver Water tested lower doses of orthophosphate (2 mg/L, 1 mg/L and 0.5 mg/L) to determine if a lower dose could achieve the same level of lead reduction as the 3 mg/L dose used in the 2017 study. Both the lead pipe rack studies and lead coupon studies concluded that 2 mg/L was the lowest effective dose for orthophosphate, reducing lead levels by 74% over the current corrosion control treatment method using a pH of 7.8 standard units. The 2 mg/L dose equates to a one-third reduction in the amount of phosphorous that would otherwise be contributed to the watershed under a 3 mg/L orthophosphate condition.

Denver Water also evaluated increasing pH to 9.2 standard units as an alternative corrosion control approach. The 2017 lead pipe rack study examined the effect of increasing pH to 8.8 standard units: lead levels were reduced 50% more than the current corrosion control treatment

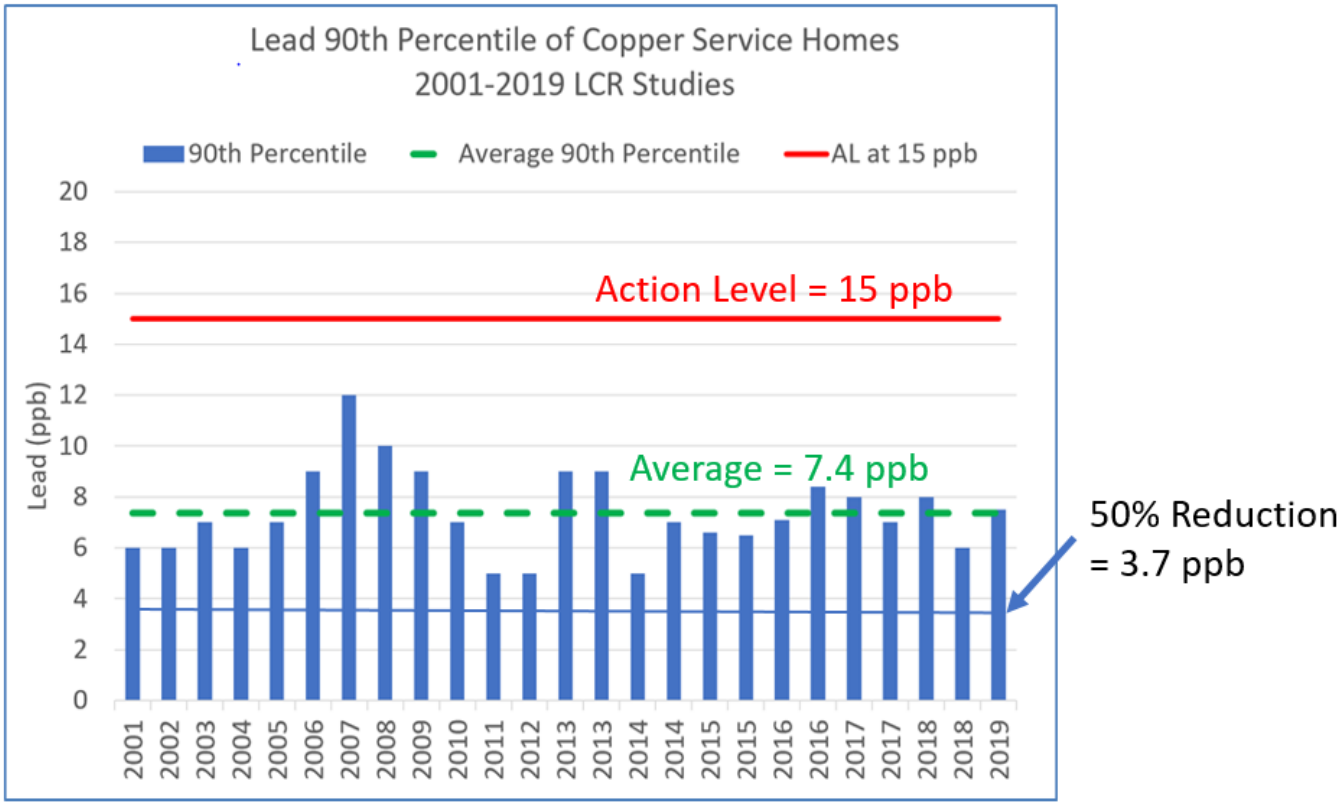
using a pH of 7.8 standard units. At pH 9.2, lead levels increased and hard water deposition was observed on plumbing fixtures. Data from downstream utilities and storm water entities suggested that a pH adjustment of 8.8 was significantly less impactful than orthophosphate at doses of 1 mg/L or higher.

The results from a combined approach, using a high pH (8.8) and low dose of orthophosphate (0.5 mg/L) also proved to be less effective than orthophosphate alone and was dropped from further study. Of all the pH and orthophosphate doses tested, only the 2 mg/L dose proved to be as effective as the 3 mg/L dose.

The effects of 2 mg/L orthophosphate or pH of 8.8 standard units on copper service lines with lead solder

Prior to January 2019, staff members from Denver Water and CDPHE were working under the assumption that the 50% lead reduction identified in the March 2018 OCCT designation for pH 8.8 and as seen in the results from the lead pipe rack pilot (Table 3) could also be applied to lead levels for Tier 1 sites with copper service lines with lead solder. As shown in Figure 10, lead concentrations of 3.7 ppb will result, if the 50% lead reduction is applied to the average 90th percentile lead concentrations of 7.4 ppb (based on data from 2001 to 2019). The projected reduction is lower than the test of 5 ppb used to evaluate performance.

FIGURE 10: DENVER WATER'S 90TH PERCENTILE LEAD LEVELS FOR TIER 1 HOMES (BUILT 1983-1988) WITH COPPER SERVICE LINES WITH LEAD SOLDER
(Data Provisional and Subject to Change)



In January 2019, CDPHE asked Denver Water to demonstrate the effectiveness of both pH/alkalinity adjustment and orthophosphate in reducing lead release from copper service lines with lead solder using water from both Marston Treatment Plant and Moffat Treatment Plant. Denver Water initiated coupon testing in March 2019 using copper coupons with lead solder. Table 4 shows the results from the coupon testing.[3]

TABLE 4: PERCENT REDUCTION IN LEAD AS OBSERVED THROUGH TESTING COPPER COUPONS WITH LEAD SOLDER
(Data are provisional and subject to change)

Corrosion Control Treatment Type	% Reduction Marston Water	% Reduction Moffat Water
Orthophosphate	67%	64%
pH/alkalinity Adjustment	44%	46%

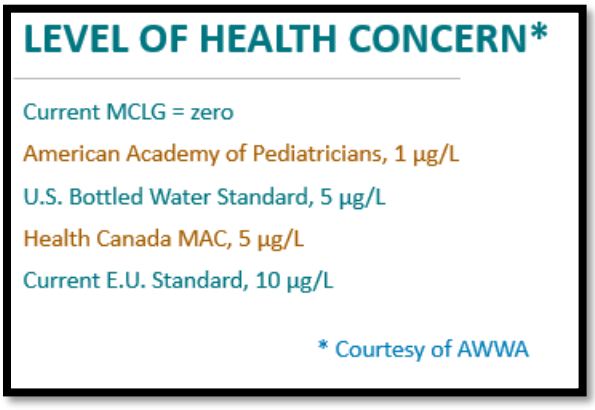
*Based on median removal through Week 14 of the study.

Applying the results to the average 90th percentile for lead levels to Tier 1 samples from copper service lines with lead solder (7.4 ppb) results in the following range of lead levels:

- Using Orthophosphate: 2.4 - 2.7
- Using pH/alkalinity adjustment: 4.0 - 4.1

Although orthophosphate demonstrated better lead reduction than pH/alkalinity adjustment, the relative difference in reduction was small. Both treatments reduced lead levels to below 5 ppb, while neither treatment minimized lead release enough to meet EPA's Maximum Contaminant Level Goal of zero or the American Academy of Pediatricians' level of 1 ug/L, as seen in Figure 11, Lead Level Standards.

FIGURE 11: LEAD LEVEL STANDARDS*



[3] A detailed overview of the coupon testing, including results for lead coupons, is presented in Appendix III.E.2.

Additionally, Denver Water profiled several properties with copper service lines with lead solder in three rounds between the last quarter of 2018 and the end of the second quarter in 2019. Per these results, lead levels decline significantly after the first liter of water. Customers can reduce this lead exposure through a simple flush of the water from their faucet after a long period of stagnation.

Effects of a combined approach (accelerated lead service line replacement, a Filter Program, and pH adjustment)

Because neither alternative corrosion control approach (high pH or lower orthophosphate) achieved the requisite equivalency for reduction in lead levels while also reducing adverse impacts to downstream wastewater treatment plants and watersheds, Denver Water evaluated other strategies to achieve an equivalent or better reduction in lead exposure as the designated optimal corrosion control treatment.

This evaluation was guided by challenges from CDPHE and EPA to provide a comprehensive solution that was as or more effective at protecting individual customers as well as the population as a whole. Denver Water evaluated coupling a pH adjustment with lead service line replacement and later added filter distribution to meet this challenge. Below are the individual studies that supported the final recommendation and request for variance.

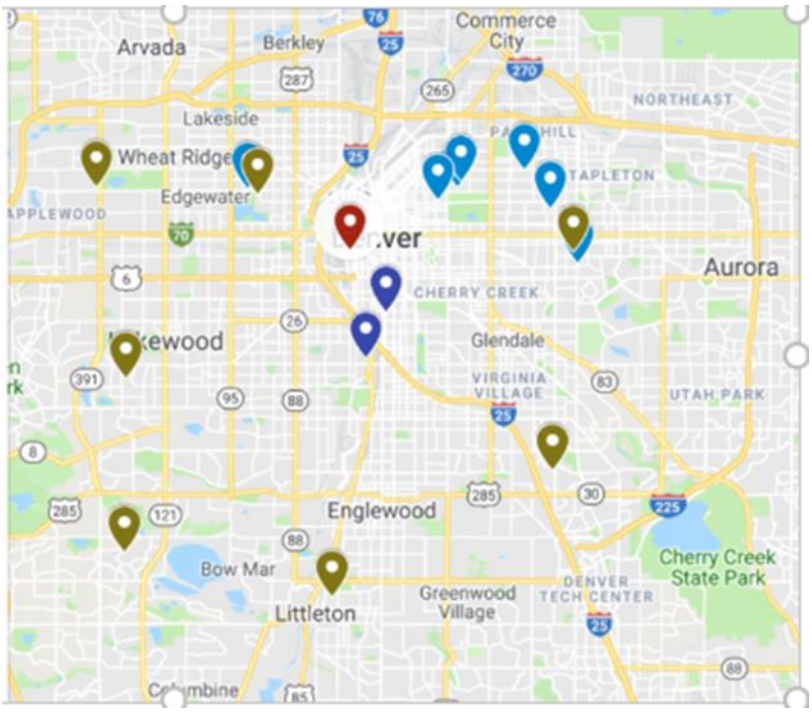
Sources of lead

In conducting the studies, Denver Water had to determine the relative contributions of lead from lead service lines as compared with other sources, such as copper service lines with lead solder and premise plumbing. In 2018 and 2019, Denver Water sampled water from volunteer Denver Water employee households to generate lead concentration profiles extending from the sink out to the water main in the street. Following EPA protocols, more than 20 sequential sample bottles of different sizes (from 125 mL to 1 L) were used in the sampling protocol.

In the initial round of sampling, Denver Water collected data from ten homes with known lead service lines; seven of these were sampled in subsequent rounds (see Figure 12). For comparison, lead profiles were also generated for eight homes with known copper service lines with lead solder, with six homes being included in subsequent rounds of profiling. Customers self-selected whether to remain in the study for each subsequent sampling event. The water samples from these homes are representative of different neighborhoods within Denver Water's service area.

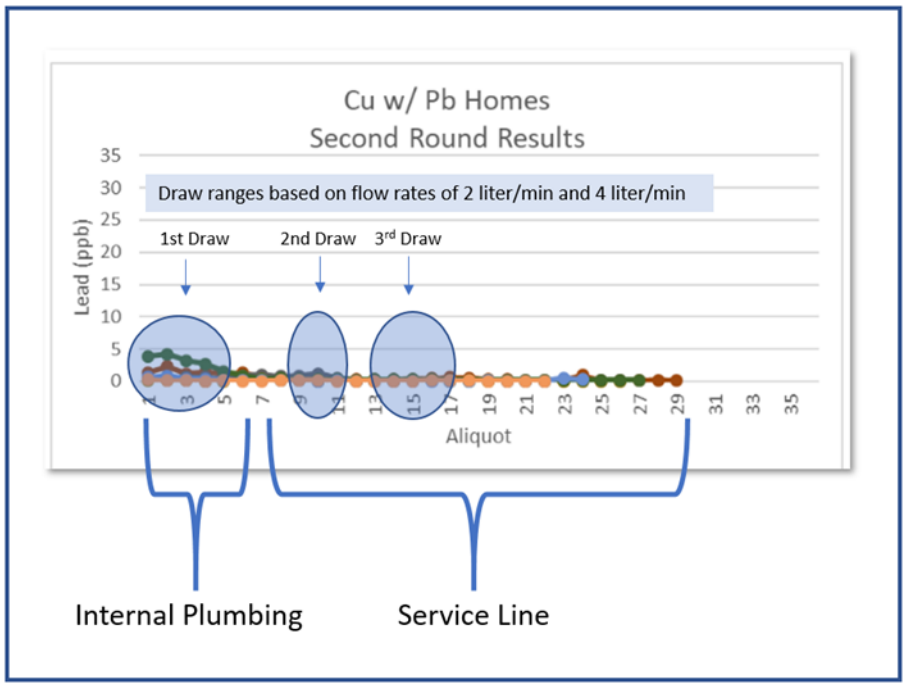
FIGURE 12: HOUSEHOLDS FROM ACROSS THE DENVER WATER SYSTEM INCLUDED IN PROFILE SAMPLING

(Blue denotes households with a known lead service line, and green denotes households with a known copper service line with lead solder as included in the first round of sampling in 2019)



Results of this analysis show a higher concentration of lead in homes with lead service lines across the length of the profile (sink to water main). At households with a known copper service line and lead in premise plumbing, lead release is typically characterized by a small increase in lead concentrations near the sink faucet, followed by a drop down to non-detect lead levels shortly thereafter, as shown in Figure 13.

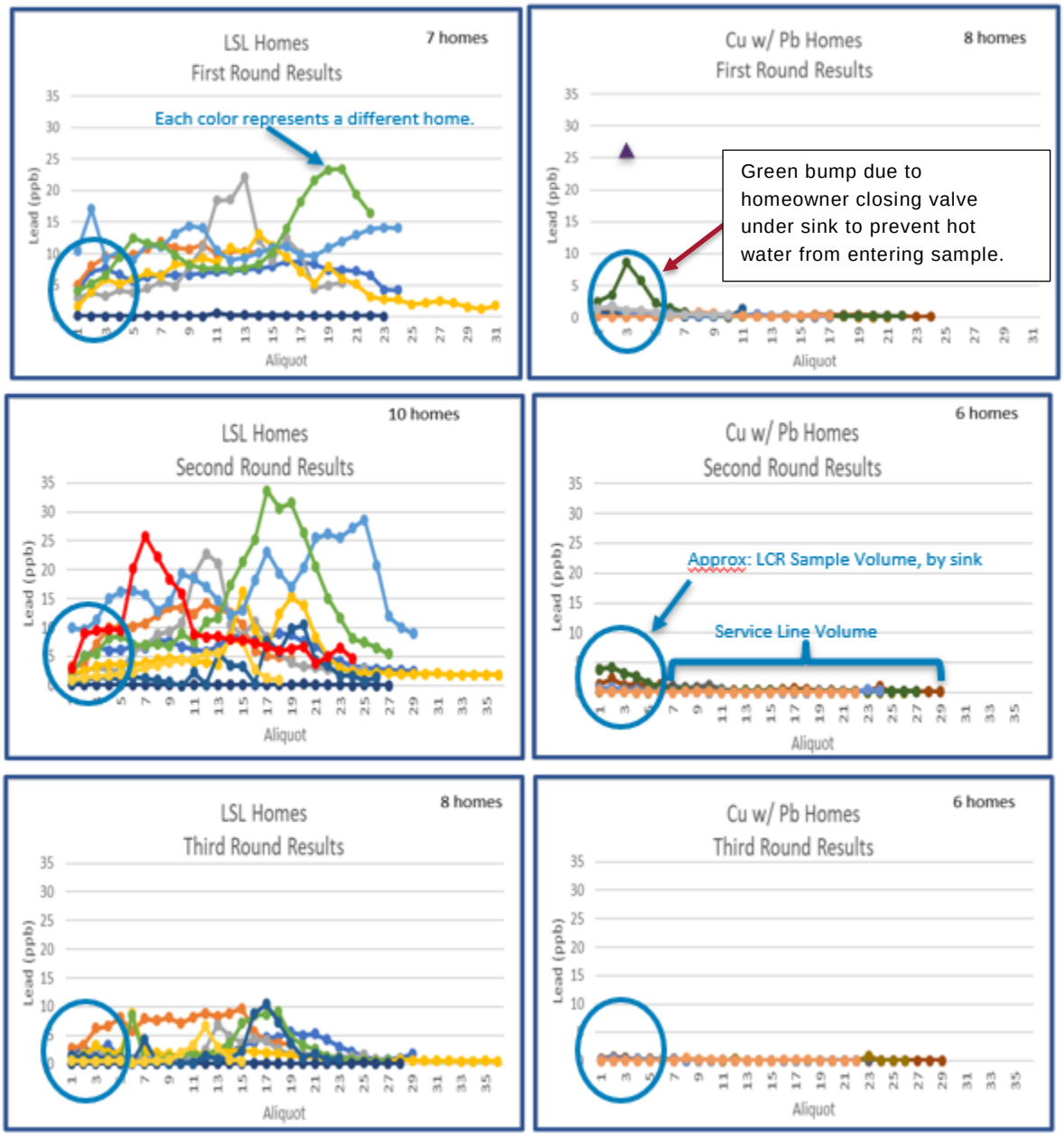
FIGURE 13: LEAD PROFILE FROM SINK FAUCET TO WATER MAIN
(Data are provisional and subject to change)



Side-by-side results from the three rounds of lead profile sampling are shown in Figure 14; the lead concentration profiles of households with lead service lines are shown in the graphs on the left and the profiles of households with copper service lines with lead solder are shown in the graphs on the right.

FIGURE 14: LEAD PROFILE RESULTS FROM VOLUNTEER DENVER WATER HOUSEHOLDS (ROUNDS 1-3) (LEAD SERVICE LINES ON THE LEFT, COPPER SERVICE LINES WITH LEAD SOLDER ON THE RIGHT)

(Data are provisional and subject to change)



Results from profile testing at homes with a copper service lines with lead solder, as shown in the right column of the figure above, demonstrate that lead levels are consistently maintained below 5 ppb and near non-detect levels with the existing corrosion control treatment (i.e., without enhanced corrosion control treatment). Simple flushing in the morning or after getting home from work would remove most of the lead captured during the sampling of water from these homes.[4]

Currently, 1,200 lead service lines are replaced annually through various activities by Denver Water, developers, and other third parties. At this rate it will take 50 years or more to remove all known and suspected lead service lines from Denver Water's service area.

Evaluation of the benefits of lead service line replacement

After the single exceedance of the action level for lead in 2012, Denver Water offered free water quality testing to all Denver Water users, and more than 3,000 samples have been returned and analyzed since then. See Figure 15 for an overview of the three-bottle sampling kit used by Denver Water.

FIGURE 15: DENVER WATER'S 3-BOTTLE SAMPLING KIT

Denver Water's 3-Bottle Sampling Protocol

Three 1 L water quality samples (i.e., 1st, 2nd and 3rd draw) were collected before and after lead service line replacement to provide insight into lead release from the faucet to the service line.

Customers receive a sample kit with three 1 L bottles and are asked to sample from a cold-water faucet in a bathroom or sink that is not connected to a home water treatment system. Customers must avoid using water for a minimum 6-hour stagnation period before collecting samples. After the stagnation period, the customer turns on the cold water faucet and fills up the first bottle, allows the water to run for 30 seconds, fills up the second bottle, allows the water to run for 30 seconds, and fills the thirds bottle. Results indicate the relative contribution to lead measured at the faucet from fixtures, in home plumbing, and the service line.

Per Figure 15, the first bottle captures water from internal plumbing and the second and third bottle capture water from the service line.

Over 3,000 households have participated in the customer requested water quality sampling program. Denver Water offers water quality sampling for lead for free to all Denver Water households, visit: denverwater.org if you would like to participate

[4] Information on the profiling study can be found in Appendix III.D.1.

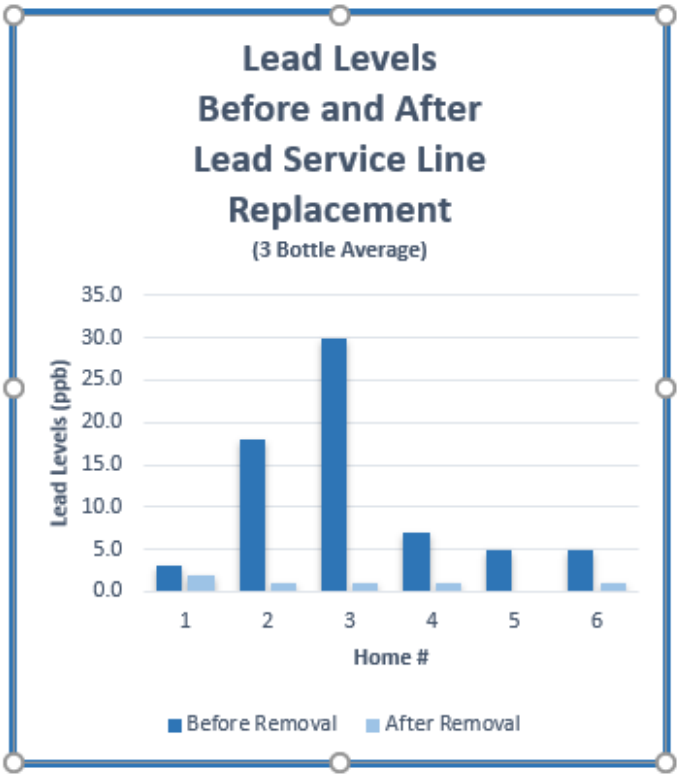
Six of the households who had previously sampled their water, subsequently replaced their lead service lines between 2016 and 2018 with non-lead lines and followed up with a recommended water sampling. A comparison of the before and after water quality results allowed Denver Water to evaluate the impact of lead service line (LSL) replacement on reducing lead levels. The results in Figure 16 demonstrate the potential public health benefit of permanently removing the dominant source of lead contributing to drinking water: lead was measured at 2.2 ppb or lower after LSL replacement, regardless of the lead levels before replacement, which were measured as high as 30 ppb. These results align with the lead profile testing results in demonstrating the benefit of replacing lead service lines.

FIGURE 16: LEAD REDUCTION AFTER LSL REPLACEMENT MEASURED AT SIX HOUSEHOLDS
(Data are provisional and subject to change)

Lead Levels Before and After Lead Service Line Removal

	Before LSL Removal			After LSL Removal		
Home #	1st Draw	2nd Draw	3rd Draw	1st Draw	2nd Draw	3rd Draw
1	5	0	5	5.1	1.3	0.2
2	9	14	30	3	0	0
3	29	31	30	1	1	1
4	8	12	2	2	0	0
5	2	2	11	1	0	0
6	3.5	5.3	5.7	2	2	0
Average	9.4	10.7	14.0	2.4	0.7	0.2

* Based on actual sample test results pre and post lead service line replacement (LSLR) between 2016 and 2018. Use of decimal points reflects data presented in lab.



Evaluation of a filter program

Although the replacement of lead service lines provides significant and permanent reductions in lead levels, it may take several years to get them all out. CDPHE was concerned about the customers who would not receive a lead service line replacement until year 10 or 15. During that time these customers would be subject to higher levels of lead using pH/alkalinity adjustment versus using orthophosphate. Hence, filters were added to the approach.

Filters can provide immediate protection from lead in drinking water when properly used and maintained. They can also provide an interim barrier to remove lead from a customer's drinking

water until the presence or absence of a lead service line can be confirmed. Pitcher filters can remove more than 97% of lead from drinking water.[5] At the same time, filters are only effective to the extent they are used. To evaluate the potential filter acceptance rate, Denver Water reviewed results from a past study of filter use by Denver Water customers as well as results from a pilot program conducted in July 2019 to gauge filter use in select neighborhoods in Denver Water's service area.

Based on a 2017 customer survey (1,432 responses) by Denver Water, the majority of customers (54%) reported that their households typically drink unfiltered tap water. Thirty-seven percent of respondents used filters (the type of filter used was not confirmed), and less than 10% drank bottled water regularly.

A filter pilot test with 300 customers with known lead service lines was initiated in July 2019.[6] Lessons learned from the filter pilot that will be implemented into the full-scale program include:

[Note: To be completed in August following pilot survey responses]

Evaluation of comprehensive approach: pH/Alkalinity adjustment combined with accelerated lead service replacement and filter program

Based on the analysis of alternative corrosion control treatments and exploration of other strategies to reduce lead exposure, a multi-faceted approach that includes corrosion control using pH/alkalinity adjustment, the accelerated replacement of customer-owned lead service lines within 15 years, and a filter program, which will provide immediate protection, will offer the highest public health benefit in both the short and long term. This approach is the foundation for the Lead Reduction Program.

As shown in Figure 17, in the long-run, replacing lead service lines and adjusting the pH/alkalinity of the water will be far more effective at reducing lead exposure compared with continued treatment with orthophosphate: lead levels are predicted to be less than 5 ppb with the variance alternative. Furthermore, when accelerated lead service line replacement (ALSLR) is combined with pH/alkalinity adjustment, the lowest 90% percentile lead levels will be achieved within 15 years, as compared with current practices, which could take over 50 years.

[5]Pitcher filters can remove more than 97% of lead from drinking water, as described in Appendix III.C.2.

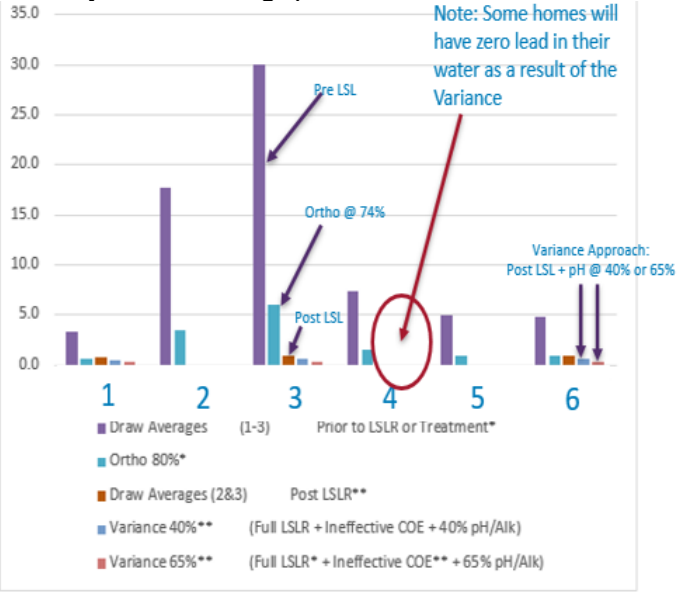
[6]The filter pilot testing with 300 customers with known lead service lines is described in Appendix III.C.2

FIGURE 17: EXPECTED LEAD CONCENTRATIONS AFTER IMPLEMENTATION OF THE LRP COMPARISON BETWEEN ORTHOPHOSPHATE AND THE VARIANCE APPROACH

(Data Provisional and Subject to Change)

Household Number	Lead (ppb) Prior to Any Treatment Pre-LSLR	Lead (ppb) After Treatment			
		Ortho 74% Reduction	Post LSLR* No Corrosion Control Treatment	Variance 40% Reduction (Full LSLR + 40% pH/Alk)	Variance 65% Reduction (Full LSLR* + 65% pH/Alk)
1	3.3	0.9	2.2	1.3	0.8
2	17.7	4.6	1.0	0.6	0.4
3	30.0	7.8	1.0	0.6	0.4
4	7.3	1,9	0.7	0.4	0.2
5	5.0	1.3	0.3	0.2	0.1
6	4.8	1.3	1.3	0.8	0.5
Average	11.4	3.0	1.1	0.7	0.4

*Based on actual sample test results pre- and post-lead service line replacement using the average of the three first draw samples from each dwelling



Evaluation of lead levels in water for households that do not adopt filters

Until the lead service line can be replaced, all customers with known, suspected or possible lead service lines will be given a filter that is NSF certified to remove lead. If a household does not use a filter to remove lead for drinking and cooking, the household will still receive the benefit of a 40% to 65% reduction in lead levels from improved pH/alkalinity adjustment (yellow columns in Table 5) but will not benefit from the 97% reduction provided by the filters (purple column in Table 5). The success of the Lead Reduction Program (LRP) depends on the cooperation of the customer, particularly during the period when all known lead service lines are being replaced. Without the interim use of filters until the lead service line can be replaced, the orthophosphate alternative will outperform the LRP for that home. The number of customers required to use filters to achieve equivalent results is discussed in Section III; however, Denver Water will strive for 100% filter adoption to reduce lead exposure for all customers with a known, suspected or possible lead service line.

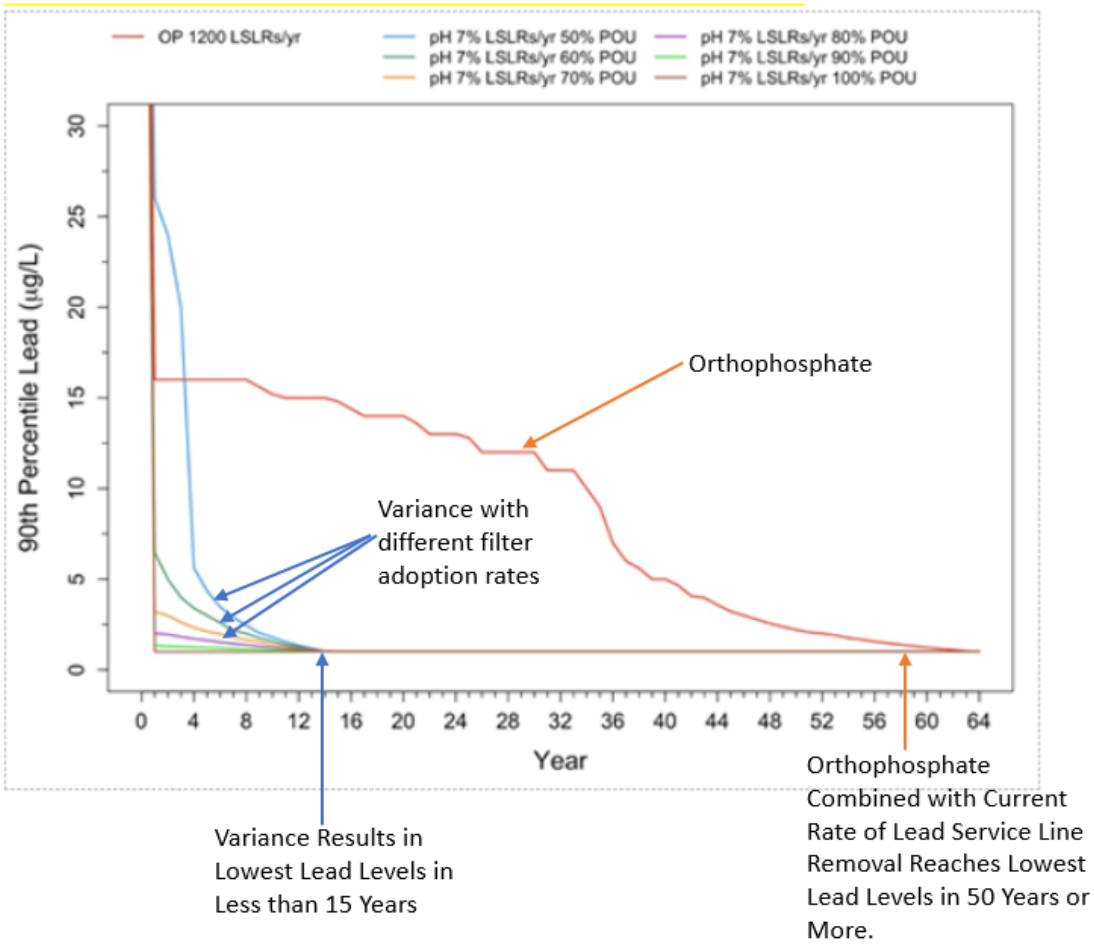
TABLE 5: EXPECTED LEAD CONCENTRATIONS 2020 TO 2034
COMPARISON BETWEEN FILTER USE AND pH/ALKALINITY ADJUSTMENT
HOMES THAT USE A FILTER (PURPLE COLUMN) AND HOMES THAT DO NOT USE FILTERS (YELLOW COLUMNS)
LEAD SERVICE LINE HAVE NOT BEEN REPLACED IN EITHER SCENARIO
(Data are provisional and subject to change)

Household Number	Lead (ppb) Prior to Any Treatment Pre-LSLR*	Lead (ppb) After pH/Alk Treatment with and without Filter prior to lead service line replacement		
		Filter** 97% Reduction	**Variance** 40% Reduction no filter/no LSLR	**Variance** 65% Reduction no filter/no LSLR
1	3.3	0.1	2.0	1.2
2	17.7	0.5	10.6	6.2
3	30.0	0.9	18.0	10.5
4	7.3	0	4.4	2.6
5	5.0	0	3.0	1.8
6	4.8	0	2.9	1.7
Average	11.4	0.3	6.8	4.0

Estimates of filter adoption were used to assess the contributing effect of voluntary filter usage on the Lead Reduction Program as a whole, as seen in Figure 18. At a minimum, Denver Water must increase filter adoption rates for customers with known, suspected and possible lead service lines from 37% (2017 survey) to at least [tbd]% to provide equivalent protection when used in combination with accelerated lead service line replacement and pH/alkalinity adjustment. Denver Water will strive for 100% adoption using lessons learned from other large lead reduction programs.[7]

[7]Denver Water will strive for 100% adoption using lessons learned from other large lead reduction programs, as documented in Appendix III.C.3.

FIGURE 18: PROJECTED LEAD LEVELS (90TH PERCENTILE) COMPARING ORTHOPHOSPHATE (RED LINE) WITH DENVER WATER'S PROPOSED VARIANCE APPROACH (ALL OTHER COLORED LINES)
(Data are provisional and subject to change)



Final evaluation of the expected results of the lead reduction program

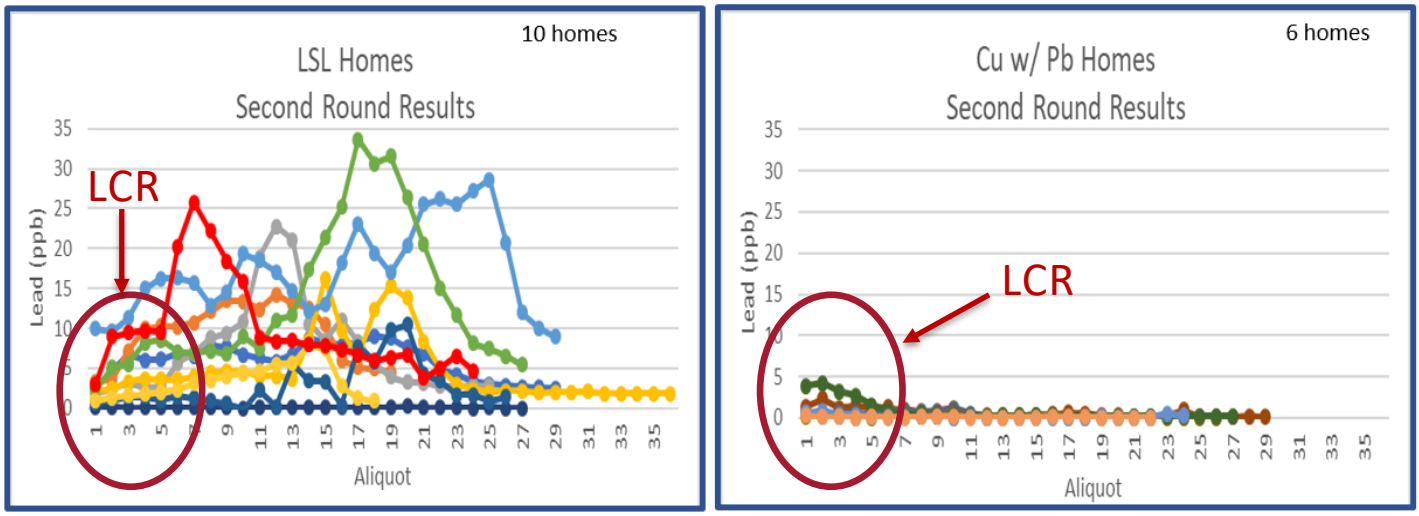
Another way to compare the performance of the Lead Reduction Program (using pH or filters) to orthophosphate is to evaluate expected 90th percentile lead levels under the four possible scenarios based on service line material and filter adoption, as shown in Table 6. Lead levels in the water, for customers who use lead filters, will drop to non-detect levels. Customers who have lead service lines and do not use filters will experience a reduction in lead levels of approximately 50%, with most but not all customers experiencing lead at 5 ppb or less. Lead levels in the first liter of water will range from 2.8 ppb to 5.9 ppb for the less than 16,000 customers who have 1983-1987 copper service lines with lead solder and do not flush. Lead levels in the subsequent liters of water will drop to near undetectable levels based on current data, as presented in Figure 18. All other service lines (~70%) will be reduced below 5 ppb to near non-detect levels under either pH/alkalinity or orthophosphate application.

TABLE 6: 90TH PERCENTILE LEAD LEVELS
(Data are provisional and subject to change)

	Expected 90th Percentile Concentration			
Scenario	**LSL + Filter**	**LSL no Filter**	**Lead Solder**	**Other**
Number of Services	74,321		15,602	229,144
Historic Lead Level	14.0		7.4	3.0
pH/Alkalinity (ppb)	< 1	7.0	2.8 - 5.9	1.1 - 2.4
orthophosphate (ppb)	3.6	3.6	1.5 - 4.0	0.6 - 1.6

While the expected lead concentration results are low in either the pH/alkalinity or orthophosphate approaches, the historic lead levels used as the beginning point for the comparison may not be the best representation of the lead exposure to Denver Water customers. Data from profiling and customer inquiries indicate that the first-draw sample underestimates the lead released from lead service lines, whereas the first-draw sample tends to overestimate the lead released from copper service lines with lead solder, as shown in Figure 19. This supports the idea that the bulk of the lead exposure comes from the approximately 75,000 lead service lines and not the approximately 16,000 copper service lines with lead solder. Lead service line replacement provides a multi-generational benefit of significantly reduced lead exposure to Denver Water customers.

FIGURE 19: PROFILING DATA
(Data are provisional and subject to change)



Conclusions

In summary, Denver Water evaluated three different alternatives, separately and combined, to determine if they provide equivalent public health protection when compared with orthophosphate added to drinking water at 3 mg/L. Both alternatives will reduce lead in drinking water below 5 ppb for most but not all customers; all customers are expected to have drinking

water with lead below 5 ppb within 15 years in the case of the LRP, or in more than 50 years in the case of orthophosphate. The studies show that of these alternatives—the combined approach of accelerated lead service line replacement, filter distribution, and pH/alkalinity adjustment—will be more efficient at reducing lead releases compared with the use of orthophosphate alone while reducing impacts to wastewater treatment plants and the environment.

III. PROPOSED LEAD REDUCTION PROGRAM

The proposed LRP is a holistic and permanent lead reduction approach that will reduce lead levels to under 5 ppb and near non-detect levels in less than 15 years. The LRP is, therefore, as or more effective at reducing lead exposure as adding orthophosphate to Denver Water's drinking water and will protect public health and the environment. The essential elements of the program are:

- Execution of **communication, outreach and education program** to help customers understand the program and ways they can reduce their exposure to lead
- Creation of a **lead service line inventory** to inform the accelerated replacement of LSLs and to allow customers to investigate the likelihood of having an LSL
- Implementation of a **lead removal filter program** to all homes with known, suspected or possible LSLs, providing 97% reduction of lead
- Implementation of an **accelerated lead service line replacement program** that would remove the major source of lead decades ahead of the current rate of replacement (approximately 75,000 lead service lines within 15 years versus 50 years or more under current practices)
- Adjustment of pH and alkalinity for **corrosion control treatment** to reduce corrosion of lead service lines, household plumbing and fixtures

The following sections describe how each of these program plan elements will be implemented.

III.A Communications, Outreach and Education (COE) Plan

Communications, outreach and education is a critical foundation for successful implementation of the LRP Plan. As recognized by the EPA when adopting the LCR in 1991, "the more frequently an individual is provided with information on lead in drinking water, the more likely he or she will take some action to reduce his or her exposure." 56 FR 26460-01, 26501 (June 7, 1991).

In addition to ongoing efforts since 2012, Denver Water has been working with regional community networks to begin the communications, outreach and education program during the summer of 2019. The program informed and engaged the public on the variance process, including the broader topic of lead in drinking water, and supported the Filter Program. Lessons learned during this initial phase will be used to inform the communications, outreach and education programs that will go into effect in fall 2019 or early 2020.

Detailed communications and outreach plans for the pre-variance phase laid the foundation for the development of future communications and outreach plans. Objectives and strategies for the LRP, including for each element of the plan, are outlined below.

COE objectives and strategies:

The overarching goal for communications will be to scale up education and outreach efforts to achieve the following communications objectives:

- Inform customers and stakeholders of final EPA decision
- Raise awareness among all customers of the change and its impacts
- Emphasize the outcome of the path forward, namely improved water quality and reduced risk of exposure to lead in drinking water for those with lead service lines and plumbing and
- Provide clear and consistent messaging and branding

Upon approval of the variance, Denver Water will further aim to:

- Build a platform for community wide education and engagement regarding the LRP that includes education, engagement and participation. The platform will also include a component that allows feedback to be solicited and facilitates training for the purpose of improving contractor, employee and vendor effectiveness
- Educate and engage with the different stakeholders
- Help customers understand how to engage with and have confidence in the LRP, use of filters, and to encourage in-home plumbing updates
- Seek feedback from customers and other stakeholders about the LRP to learn best practices and effective ways to implement program activities and
- Incorporate the Learning by Doing approach to improve program outcomes during the life of the variance

Detailed communications plans will be developed for each element of the LRP: the lead service line inventory, the Filter Program, ALSLR Program and corrosion control treatment. The communications plans will include an analysis of target audiences; key messaging developed in tandem with CDPHE and EPA to inform all core communications collateral and materials; and training and resources for Denver Water employees and contractors, with an emphasis on those who are customer-facing.

Lead Service Line inventory objectives and strategies:

The goal of the LSL Inventory is to continuously update the inventory of lead service lines throughout the service area to improve the estimate of the number of lines that require replacement, and to ensure that the inventory is field-verified as replacements occur over the 15-year period of the LRP.

For the LSL Inventory, Denver Water's COE has the following objectives:

- Inform and educate customers about their service lines – ownership, material types and plumbing
- Engage suburban distributors to assess LSLs within Denver Water's integrated system and
- Work with municipalities to develop better records regarding service line material

The LSL Inventory communications plan will utilize several strategies focused on target audiences for use by Denver Water employees and contractors working, dependent upon specific roles, to educate and inform customers, assist customers with inquiries and collect LSL Inventory

data. Denver Water will utilize a variety of communications methods, including direct mail marketing and outreach, mapping tools, water quality tests, websites with links to educational information about LSL verification methods, and training resources for plumbers.

Filter Program objectives and strategies:

The goal of the Filter Program is to provide customers with known, suspected or possible lead service lines with a filter and encourage proper filter use and maintenance.

The communications plan used for the Filter Program will have the following objectives:

- Inform and educate customers about the Filter Program
- Engage with customers with known, suspected, or possible LSLs to ensure they receive a filter
- Work with property owners, where applicable, to share information and encourage filter use with tenants and residents
- Encourage filter use for drinking and cooking, and when preparing infant formula
- Encourage changing the filter cartridge according to the manufacturer's instructions;
- Verify that customers are using a filter and encourage the use of the filter as a long-term behavioral change

The Filter Program communications plan will focus on target audiences that include customers in homes with lead service lines, local governments, elected officials and public health agencies. It will also include Denver Water staff and contractors performing filter distribution work to help direct customers to appropriate resources and channels for answers to their questions. The communications plan will be implemented by notifying impacted residents of the Filter Program, and will utilize door-to-door communications, a customer tracking system, how-to videos and local opportunities to engage residents.

Accelerated Lead Service Line Replacement Program objectives and strategies:

The goal of ALSLR Program is to replace customer-owned lead service lines and provide information on post-replacement flushing procedures.

The communications plan used for ALSLR Program will have the following objectives:

- Inform and educate customers about their service lines – ownership, material types and plumbing
- Gain property-owner consent for lead service line replacement, and share information with property-owners and residents on what to expect around replacement
- Provide support and information on post-replacement filter use and flushing for both property owners and residents
- Provide customers with appropriate education and resources on water quality results following lead service line replacement

The communications plan used for the ALSLR Program will educate customers on the LSL replacement process. In addition to property owners, the communications plan will target tenants and residents to provide information on what to expect with LSL replacement. The communications plan will identify target audiences, development of messaging regarding the LSL replacement process and steps that must be taken after LSL replacement, including flushing protocols, filter use and follow-up water quality testing. The ALSLR Plan will also include a communications plan for customers who refuse to have their LSLs replaced, and strategies to gain acceptance.

Corrosion control treatment objectives and strategies:

The goal of corrosion control treatment communications is to educate and inform customers about how Denver Water treats water to help minimize the release of lead into water from lead service lines and household plumbing and fixtures that contain lead.

The communications plan used for corrosion control treatment will have the following objectives:

- Provide information on the LCR and metal corrosion for general audiences
- Inform and educate residential and commercial customers about the sources of lead in plumbing
- Raise awareness among customers of the upcoming water treatment change and its potential impacts to water aesthetics, if any
- Emphasize the outcome of increased pH — improved water quality and reduced risk of lead exposure in drinking water for customers with lead service lines and lead plumbing and
- Provide clear and consistent messaging and branding

What if the COE Plan does not generate the desired awareness and engagement?

Outreach and engagement will continue to evolve and be refined based on a review of effective engagement strategies. With each year of the LRP, Denver Water will have increased learning, understanding and awareness. Denver Water is committed to conducting ongoing assessments and annual reporting of its COE metrics to determine if corrective action needs to be taken. Additionally, Denver Water will incorporate qualitative findings from ongoing stakeholder input to determine opportunities for improvement through the Learning by Doing program element described later in this section.

How will Denver Water reach all of its customers?

Denver Water will focus much of its communication efforts on households that have known, suspected, or possible LSLs. Communication efforts are best targeted toward this group of customers because they will also be enrolled in the Filter Program. This includes single family and multi-family residences, including occupants of apartments who normally do not have a direct customer relationship with Denver Water. By working closely and frequently with this broad

group of customers, Denver Water can better foster filter adoption and use, partner with its customers in identifying and locating LSLs, and obtain valuable input from its customers.

A key focus throughout the COE and in the development of the targeted communications plans will be equity, inclusive of communications and accessibility around all elements of Denver Water's lead reduction efforts.[8]

Considerations will include health equity and environmental justice, creating systems where all customers have the opportunity to thrive.

Table 7 summarizes the strategies Denver Water will use to implement the COE:

TABLE 7: STRATEGIES USED TO IMPLEMENT COE

- **Develop and incorporate key messages and talking points for Denver Water, CDPHE, EPA and stakeholders.**
- **Develop external communication strategies and tools to include, at minimum:**
  - Digital communications (customer emails, social media, denverwater.org/lead webpage).
  - Printed collateral (fact sheets, FAQs, direct mailers).
  - Briefings with Registered Neighborhood Organization (RNO) leadership.
  - Community meetings and listening sessions.
  - Integration into existing Denver Water communications and outreach (water trailers, TAP newsroom).
  - Traditional media engagement.
  - Other tactics to be identified through discussions with neighborhood leaders and community members, and in ongoing coordination with partners.
- **Subject matter conveyed to include, at minimum:**
  - The orthophosphate designation and LRP alternative under consideration.
  - Variance process
    - Potential next steps after the decision is made.
    - Lead service line identification.
  - Corrosion control treatment.
  - Accelerated lead service line replacements and interim filter use.
  - Risks of lead to health
    - Actions people can take to protect against the risk of lead to health and the variety of sources that lead originates from.
    - Where to find more information (e.g., lead sources other than drinking water, how to test for BLL).
  - How lead can get into drinking water.
  - How to get their water tested.
- **Support staff training:**
  - Meet with internal staff to discuss communication needs
  - Develop and implement training for customer support.
  - Identify clear channels for customer inquiries, feedback and questions specific to the variance and Filter Program.

[8] For further details regarding the COE plan, see Appendix III.A.

TABLE 7: STRATEGIES USED TO IMPLEMENT COE

- **Develop initial briefings with regulators, elected officials, utility managers and local health departments.**
- **Create lists of special audiences per anticipated impacts of each potential treatment method (e.g., industrial/commercial customers).**
- **Focused and prioritized education and engagement to high risk community members (e.g., families with young children, including formula-fed infants, and pregnant women) such as:**
  - Leverage existing stakeholder relationships/communication channels established by Denver Department of Public Health and Environment and Denver Water.
  - Target messaging for various community organizations, doctor offices, etc.
  - Partner with community health clinics, daycares/child care providers, social service programs for women and families.
- **A focus on providing multiple, accessible ways for all community members to engage, with an eye toward:**
  - Providing all program materials in Spanish and other languages as needed.
  - Grassroots, on-the-ground outreach that directly engages with people in the comfort of their community (e.g., existing community events, gathering places and forums).
  - Partnering with local community leaders and non-profits with established relationships and credibility in the community.
  - Scheduling and executing public events in a manner that makes them accessible (e.g., providing child care, interpretation services, etc.).

III.B Lead Service Line Inventory

Because Denver Water does not own its customers' service lines, it has a limited database of known lead service lines compiled from historical records of observations made during water main replacements, leak repairs, and meter installations. Past water quality test results would also suggest that homes built prior to 1951 are likely to have lead service lines, but some of those service lines may have been replaced over time. Denver Water will undertake a rigorous investigative effort, especially in the early years of the LRP, to build a more accurate lead service line inventory.

Developing a comprehensive lead service line inventory to support the program

Over the last year, Denver Water has developed and continues to refine a comprehensive lead service line inventory based upon a statistically sound, comprehensive model. The inventory places service lines into five categories based on the likelihood that a service connection will be made of lead. The probability score for each property is developed using known construction practices, historical records, expert judgement, and data interpretation.

The following three categories represent service lines most likely to consist of lead:

- Known LSL – 100% direct evidence documenting lead
- Suspected LSL – 80% likelihood of lead based upon available data (i.e., homes built prior to 1951)
- Possible LSL – 50% likelihood of lead as some data may be conflicting or missing but there is not enough information to confirm a non-lead service line

The following two categories having the lowest or zero likelihood of lead:

- Unlikely LSL – 10% very low likelihood of lead
- Non-lead – 100% direct evidence or statistically defensible factors supporting categorization as a non-lead service line[9]

These categories enable Denver Water to:

1. Identify candidate properties for inclusion in the Filter Program and the ALSLR Program. Providing filters to all properties with a known, suspected or possible lead service line is fundamental to demonstrating the efficiency of the LRP when compared with the alternative of orthophosphate.
2. Pinpoint best geographic areas or individual properties for investigation of suspected or possible LSLs. Through subsequent water quality testing and/or field investigations, these properties will be moved to the "known LSL" or "non-lead" categories.
3. Quantify and prioritize the known and suspected LSLs for efficient and targeted removal during the ALSLR Program, focusing early on areas and homes with our most vulnerable populations and where economies of scale and opportunity can be achieved in conjunction with road projects and main replacements.

What factors help Denver Water identify the likelihood of a lead service?

As noted in Section I, Denver Water anticipates that most lead service lines in Denver will be found at properties built before 1951. Typical service line materials include copper, lead, galvanized, and other non-lead materials. Service lines comprised of a combination of materials that include lead, such as galvanized steel downstream of lead, or service lines that are only partially composed of lead, will also be documented and counted in the inventory as lead service lines.

Denver Water will use the following factors and activities to build and refine the inventory for use by customers, regulators, and other stakeholders:

- Historic records of observed service materials, tap sizes, water main replacements, and LCR plumbing materials surveys
- Knowledge of the materials that were used at certain periods and other likely identifiers: lead levels in Denver Water's system drop off significantly in homes built after 1950 and lead service lines were prohibited in Colorado starting in 1971
- Information from redevelopment of existing homes from City and County of Denver records and other entities that are subject to Denver Water's operating rules
- Information from the entire integrated system: Denver Water will work with its distributors to identify all addresses of known or verified lead service lines and records or information of when lead service lines were allowed or not allowed

[9] The process used to assign a given property to one of the categories of Table III.C.1 and 2 is described in Appendix III.C.3 and Appendix III.E.

Denver Water's service area has approximately 335,457 customer service lines, including schools, businesses, and multi-family units. Table 8 lists the current estimate of service lines by category:

TABLE 8: CURRENT PROBABILITY ESTIMATE OF SERVICE LINES
(Data are provisional and subject to change)

Service Line Category	Estimated Number of Services
Known LSL*	1,118
Suspected LSL	63,597
Possible LSL	36,533
Unlikely LSL	83,543
Non-Lead	150,666

*LSL = Lead Service Line

The service line categories shown in Table 9 were further refined into lead service lines and non-lead service lines on the basis of census and other data.

TABLE 9: OVERVIEW OF THE DIFFERENT CATEGORIES OF SERVICE LINES
(Data are provisional and subject to change)

	Basis	Lead Service Lines	Non-Lead	Total
Census	Direct Evidence	480	8,883	9,363
	Distributor Evidence	0	31,994	31,994
	Post 1972 Build Date and Tap Date	0	108,750	108,750
	Pre 1952 Property and Water Quality Sampling Results	638	0	638
Estimate	Build & Tap Dates	73,890	109,230	183,120
	Service Size	21	1,438	1,459
	Presumed Replacement	7	126	133
	Totals	**75,036**	**260,421**	**335,457**

Based on work to date, the total number of current estimated LSLs is 75,036 [to be finalized by August 20th final submission]. Denver Water is currently engaged in a field investigation involving potholing approximately 200 plus service lines within the City and County of Denver to confirm the material used for service lines. The results will be used to verify the logic used in the LSL Inventory and predictive model (discussed in Section III.B). Responses from the integrated systems will also be used to inform future inventory estimates.

The number of service lines categorized as suspected, possible and unlikely will diminish over time, while the number categorized as known and non-lead will increase. This is especially likely

to occur in the first five years of the LRP as further research of historical data, results from observations during the annual replacement of lead service lines, and additional field and water quality investigations inform and improve the accuracy of the numbers and factors in the inventory model.

What more will Denver Water do to improve the certainty of the LSL Inventory?

Denver Water will expand upon the previously listed factors to include additional field investigation methods to confirm the materials of construction used for the service lines and improve the accuracy of the estimated service line types. Additional field investigation methods will include:

- Water quality sampling using the 3-bottle test to identify the service line profile. Based on Denver Water research, the water quality from the second and third bottles is indicative of the service line materials, especially lead
- Public outreach and customer feedback using a variety of tactics such as
  - A geographic information system (GIS) web application [to be developed by October 20, 2019]
  - Direct mailers for various outreach efforts (i.e., water quality testing, potholing, etc.)
  - Robo-calls to customers with suspected lead service lines
- Triangulating historical data to improve the knowledge of a given property to determine the probability of a lead service line (ongoing effort)
- Viewing the service line materials where the line enters the meter box and/or home, if accessible
- Performing potholing to visually inspect for the presence of lead
- Contacting property owners to determine the history of their property

How will customers know if they have lead service lines?

To aid property owners and residents, Denver Water will maintain a map using a GIS platform to denote service line type as documented in the LSL Inventory. The goal is to provide information for each property within Denver Water's integrated system. Denver Water anticipates designing the map to be interactive and user-friendly, although it is expected to evolve over time as more information becomes available from the field. Denver Water will update the map frequently to illustrate new information gathered.

FIGURE 20: SAMPLE LEAD SERVICE LINE IDENTIFICATION MAP

[Draft Lead Service Line Map to be included at time of final submittal on August 20th.]

How can predictive modeling be used to better identify the location of lead service lines?

Denver Water is in the process of developing a predictive model based on the LSL Inventory and other factors. The application of the predictive model was designed to prioritize enrollment in the Filter Program as well as the construction sequencing of the ALSLR Program.[10] The predictive model will be used to generalize the results of investigations completed to date and to guide future investigations, without having to undertake an excavation at every property. This will improve the overall efficiency of LSL identification and the replacement process at the sites described as having a suspected or possible LSLs while fine-tuning or improving the confidence in the LSL Inventory as a whole.

The predictive model will expand the logic rules that are used to assign the likelihood of finding lead service line materials at a property by incorporating the latest information from field investigations including the ALSLR Program. The predictive model is designed to evaluate new logic rules based on the discovery of relationships between input and output variables. In addition, a decision tree approach offers the means to audit and explain the decision-making process. Finally, the predictive model can be used to identify and respond to data inconsistencies. For example, addressing a property outlier described as having no lead service line when all the neighbors on the street are confirmed for lead. Additional action can then be undertaken by Denver Water to confirm the model inputs and assessment and improve the information contained in the LSL Inventory.

How will predictive modeling be used in prioritizing replacements?

Continued refinement and utilization of the predictive model will inform Denver Water's approach to targeting communications as part of the COE plan, enrollment in the Filter Program, and prioritization of LSL replacement. Other factors that will inform the prioritization schedule will include:

- Public health considerations (i.e., relative risk–odds ratio for childhood lead poisoning per EPA and health department toxicology experts)
- Critical customers (i.e., locations of child care providers and primary schools)
- Filter adoption rates by geographic and/or demographic area
- Age-related considerations (children under the age of six, neighborhoods with a high density of young and expecting families)
- Social economic and environmental factors

The location of vulnerable populations will help inform the selection of work locations on a yearly basis. Each property associated with the LSL Inventory will be incorporated into the prioritization analysis to identify the potential risk of lead exposure.

[10] For details, please see Appendix III.B.3.

Consequence factors associated with each property are provided a set of values (consequence co-efficient) that are adjusted by a weighting factor (referred to as a criticality factor). The weighted criticality factor can be defined by analysis tools and/or stakeholder consensus agreement as shown in Figure 21.

FIGURE 21: PROCESS FOR FACTORING CONSEQUENCES INTO AN OVERALL RISK SCORE

Once the likelihood and criticality scores are generated for each property, the total risk score is calculated for a geographic area (i.e., a common spatial boundary as identified in census blocks from the American Census Records). This analysis provides both an individual and accumulated geographic risk score that can then be considered with other logistical considerations, such as planned paving schedules and water main replacement work.

The total risk scores by geographic area will be used to sequence work to address the (high) risk of lead exposure at a property and the efficiency of working through an area of properties to relative to the risk posed to a broader portion of the community. Additionally, properties that are of high risk and consequence that are not incorporated in a census area for production will be evaluated for sequence of constructions.

The updates to the predictive model will support Denver Water's annual efforts to plan the ALSLR work by allowing Denver Water to focus efforts on the properties or areas with a higher risk of lead exposure. The predictive model will be updated when field results are available from each year's LSL replacement activities (i.e., 7.0% of the total inventory of lead services) and investigations.

What happens to properties that are reclassified as part of the inventory updates?

Based on the current understanding of where LSLs may be located in the integrated system, there is the potential that properties initially classified as having a low possibility for an LSL (and therefore not enrolled in the Filter Program) may be reclassified by the predictive model as having a higher likelihood for lead. Similarly, as the predictive model is refined with results from the field, a property initially identified as having a suspected LSL may be reclassified as being unlikely to have an LSL.

Where a property is identified as having a possible or suspected LSL, the resident will be enrolled in the Filter Program. In the case of properties initially identified as having a possible or suspected lead service line that are determine by the predictive model as being unlikely to have an LSL, a letter will be mailed notifying the customer of the change, and their participation in the Filter Program will be discontinued within six months of the change in status.

What if a lead service line is found after Denver Water completes the LRP?

Any property found to have a lead service line after the end of the program will receive a filter and be scheduled for service line replacement within six months of identification.

III.C Filter Program

The Filter Program provides interim protection by removing lead from customers' drinking water.[11] As part of the Filter Program, households with known, suspected or possible LSLs whether owner-occupied or tenanted, will receive a filter and replacement cartridges until the service line is confirmed to be non-lead or six months after an LSL is replaced. Denver Water will provide filters through the duration of the LRP.

How and when will filters be distributed?

Filter distribution to all households with known, suspected, or possible LSLs will follow the multimedia public information campaign and customer notification model, in accordance with the COE Plan. Filter distribution will start within 90 days of the variance approval. Each eligible customer will receive education/outreach material, a pitcher filter, and a six-month supply of replacement filter cartridges that are NSF-certified for lead removal. A pitcher filter and six-month supply of replacement filter cartridges will be provided for each individual unit at multi-family dwellings.

Denver Water's integrated system will be divided into sub-areas for consolidated communications and distribution of the filters. Filters will be distributed to neighborhood residents in sub-areas during the same time period to reinforce filter use, consolidate outreach, and answer questions within a specific community using local community organizations and resources. The intent is to intensely target the sub-areas or neighborhoods with filter distribution using various methods:

- Primary – Direct mail to the eligible resident unit with delivery confirmation
- Secondary – Hand delivery via door-to-door canvasing (in person or drop-off)
- Exceptions – Resident preference only: pick up at Denver Water facility, mobile unit, at community meetings, or other locations and events

Vulnerable populations including expecting families, children, and those of low socioeconomic standing, will be identified, contacted, and tracked as sub-populations within the sub-areas. The vulnerable population criteria will be used to help prioritize the order of geographic sub-population distribution within a sub-area and associated community outreach.

Replacement filter cartridges will be distributed every six months using the same methodology identified for distribution of pitcher filters.

A property will be removed from the Filter Program after replacement of the lead service line, or if a non-lead service line is confirmed at the property.

[11] The Filter Program Plan is included in Appendix C.II.3.

Communications and the Filter Program

The notification methods that will be used for customers that are eligible to receive a filter include:

- Delivery of detailed instructions regarding the Filter Program, water filter cartridge use and replacement, and cartridge replacement voucher system on Denver Water's website in fall 2019
- Delivery of detailed instructions regarding the Filter Program and water filter cartridge use and replacement during door-to-door campaigns, neighborhood meetings, and additional strategic community outreach in identified areas as part of the overall Lead Reduction Program in the summer/fall 2019
- Distribution of letters informing customers and other households of the Filter Program with:
  - detailed instructions regarding the Filter Program, water filter cartridge use and replacement requirements
  - Denver Water's customer care call center phone number
  - cartridge replacement voucher system and
  - a link to Denver Water's lead website in October/November 2019
- Robocalls to impacted customers with:
  - detailed information regarding the Filter Program
  - Denver Water's customer care call center phone number and
  - a link to Denver Water's Lead Program website in October/November 2019
- Direct mail of water filters to select impacted customers, with:
  - users will be registered for a cartridge replacement voucher system based on digital, mail survey/response form
  - a mail in response survey/response form (in multiple languages)
  - a link to Denver Water's Lead Program website
  - a quick response (QR) code for access to Denver Water's digital registration page (in lieu of mail in survey/response)
  - Denver Water's customer care call center phone number
  - information regarding the manufacturer/Denver Water cartridge replacement voucher system and

- Hand deliver water filters to select impacted customers including multi-family housing, with:
  - a mail in response survey/response form (in multiple language)
  - a link to Denver Water's Lead Reduction Program website
  - a quick response (QR) code for access to Denver Water's digital registration page (in lieu of mail in survey/ response)
  - Denver Water's customer care call center phone number
  - information regarding the manufacturer/Denver Water cartridge replacement voucher system and
- Conduct follow-up communication using mail, phone, or a door-to-door survey during the first six months of filter use to determine practices and preferences

Verifying filter adoption – how will Denver Water know filters are being used?

Filter adoption assumes customers are accepting, installing (if applicable), using, and maintaining the filter properly, as well as replacing the filter and cartridges at the appropriate time.

The distribution of filters and replacement cartridges will be documented and tracked during the life of the LRP using an electronic database and GIS. A survey of randomly selected customers enrolled in the Filter Program will be conducted annually to measure the filter adoption rate. Responses from a minimum of 1,059 randomly selected customers each year will be required to estimate the filter adoption rate with at least 95% confidence and no more than 5% error, at adoption rates greater than XX%. This is referred to as the threshold for the filter adoption rate, the minimum percentage of households that use filters such that the LRP is considered equivalent to orthophosphate. Denver Water will complete the adoption survey each year using internal resources and community outreach services to generate the minimum 1,059 responses.[12]

Additionally, a customer survey will be implemented during the ALSLR Plan (approximately 5,250 surveyed based on the number of completed LSLRs each year). The results of the ongoing surveys will be evaluated and used to confirm adoption rates and make improvements to the Filter and COE Programs (Learning by Doing).

[12] Details and assumptions used to design the survey to evaluate filter adoption are provided in Appendix III.C.

What if Denver Water does not achieve the threshold filter adoption rate?

Increasing filter use at customer homes to 100% is the goal of the Filter Program. It is reasonable to expect that communication, outreach and education efforts to customers will help to increase filter adoption rates. However, if customer use falls below the threshold for filter adoption, Denver Water will:

- Increase and modify its communication, outreach and education efforts with particular attention to any sub-populations with below-average adoption rates
- Evaluate possible modifications to the ALSLR Plan

Failure to remedy persistently low filter adoption rates will trigger actions in accordance with the multi-tiered response plan as described in Section IV.

III.D Accelerated Lead Service Line Replacement Plan

Through the ALSLR Plan, Denver Water will replace all identified LSLs within 15 years. To achieve this, the Denver Water ALSLR Plan will perform the physical LSL replacement work as efficiently as possible. At the same time, Denver Water will engage with and educate customers so that they understand the benefits of LSL replacement and consent to participate.

What is Denver Water committing to as part of the accelerated lead service line replacement plan?

Denver Water is committing to replace all LSLs within 15 years at an annual average replacement rate of 7.0%. LSLs will be replaced from the main to the first fitting inside the dwelling (defined as a full lead service line). Any partial LSL or galvanized iron service line material downstream of an existing or previously existing lead service line will also be replaced up to the first fitting inside the dwelling. The ALSLR Plan describes in greater detail the process by which Denver Water will undertake the 7.0% average replacement rate over the life of the ALSLR Plan.[13]

What constitutes an LSL replacement?

The following types of LSL replacements will count as credit for an entire LSL replacement:

- Full LSL replacement of a single service line
- Replacement of an existing partial LSL that results in a lead-free service line from the main to the first fitting inside the structure
- Replacement of a galvanized service line downstream of an existing or previously existing LSL
- LSL replacements completed by property owners or third parties and verified by Denver Water

[13] The ALSLR Plan is provided in Appendix III.E

Summary of the LSL replacement process

Denver Water customers might notice a greater level of construction activity in their neighborhoods over the next 15 years, especially in neighborhoods with high concentrations of lead service lines. In addition to continuing to replace approximately 400 lead service lines per year through water main replacement projects and plus approximately 300 leaking lead service lines per year, Denver Water will also target the replacement of thousands of lead service lines per year through a systematic, prioritized replacement plan, focusing on:

- Replacing LSLs in geographic areas with cumulative opportunities to reduce lead exposure and/or provide project delivery efficiencies. This may include blocks with a high density of lead service lines or neighborhoods undergoing a municipal paving or road improvement project[14]
- Replacing LSLs at individual properties with lead levels consistently above the action level and/or at properties demonstrating a significant demographic risk (for example daycares)
- Monitoring the estimated individual LSL replacement volume from redevelopment and leaks to address potential shortfall in the overall 7.0% cumulative average goal
- Coordinating with the City and County of Denver Public Works and other area municipal, utility, and public sector agencies to ensure that a framework is in place to optimize construction and related activities

Additionally, crews will conduct investigations at homes and neighborhoods to verify the presence of suspected lead service lines and their cohorts to improve the lead service line inventory. This process will assist in future annual ALSLR planning through the predictive lead service line model developed as part of the lead service line inventory. See Table 10 and Figure 22 for a summary of this approach.

[14] The ALSLR Plan is provided in Appendix III.E

TABLE 10: EXAMPLE OF GROUPINGS FOR LEAD SERVICE LINE REPLACEMENTS OR INVESTIGATIONS

(Data are provisional and subject to change)

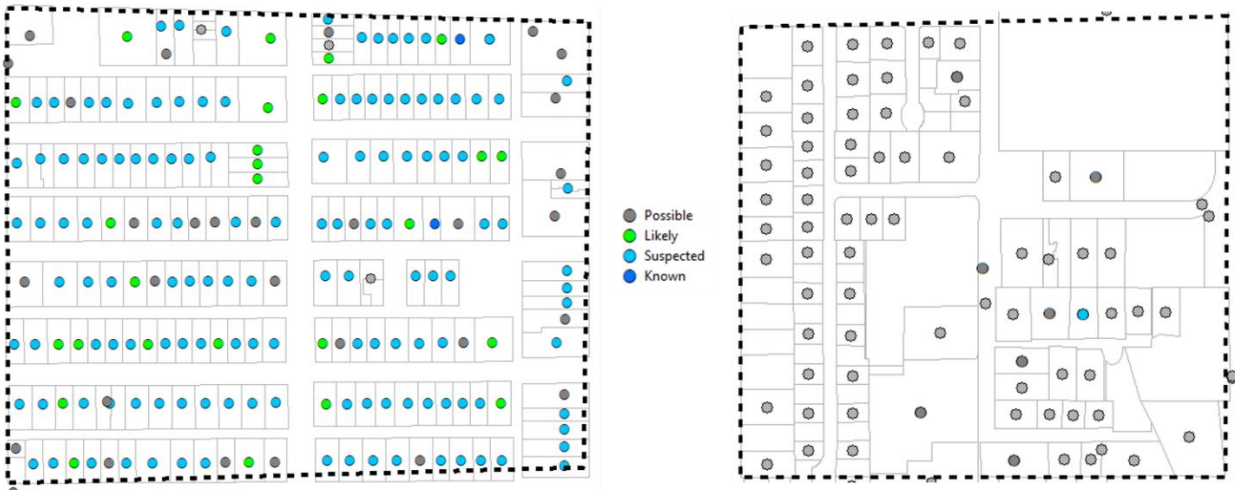
Group/Type	Est. Annual LSLR & LSL Investigation	
GROUP A – LSLR by GEOGRAPHIC AREA	Water main Replacement	400
	Block by Block or Street by Street	3,000*
	Municipal Pavement and Road Improvement Programs	450*
	Subtotal	3,850*
GROUP A – LSLR by INDIVIDUAL	Leaks	300
	Individual & High Priority LSLR	600*
	Scrape Off and Redevelopment Properties	500
	Subtotal	1,400*
	Group A Total	5,250*
GROUP B - INVESTIGATION	Investigate areas suspected and possible for LSL	500*
	Water Quality Testing of areas expected or somewhat expected to have LSL	500*
	Group B Total	1,000*

(*), Provisional numbers, subject to change

The geographic area work for Group A, defined by streets or blocks, focuses on a relatively high density of properties with lead service lines that can be removed quickly and efficiently. The geographic area is displayed on the left side of Figure 22. The properties are marked with a dark blue dot to indicate a high likelihood of having a lead service line. A property identified for an individual replacement (Group B) is represented by the right side of Figure 22. Individual

replacements will not be spatially concentrated, rather the properties (shown as dots) may be located in various areas within the overall Denver Water service area. The properties included in Group B were identified based on having lead levels consistently above the action level and/or demonstrating a significant demographic risk.[15]

FIGURE 22: GEOGRAPHIC AREA (LEFT) AND INDIVIDUAL MAP (RIGHT) VISUAL REPRESENTATION

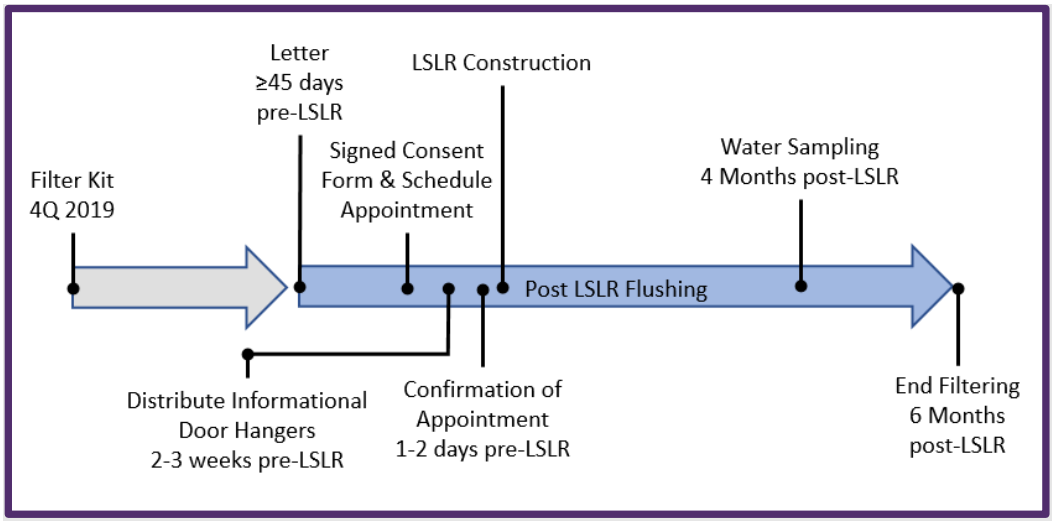


What can customers expect during a lead service line replacement?

Denver Water will contact the customer at least three times prior to the actual replacement of the LSL. As seen in Figure 23, property owners will be (1) notified via letter 45 days in advance of the construction, (2) asked to set up an appointment to discuss the construction for their property as well as sign a consent form allowing the replacement of their lead service, and (3) receive a door hanger one to two weeks in advance of construction as a reminder of the upcoming event. Also, per Denver Water policy, both owners and residents (in the case of tenanted properties) will be notified of the shutoff of service 24 hours in advance of construction.

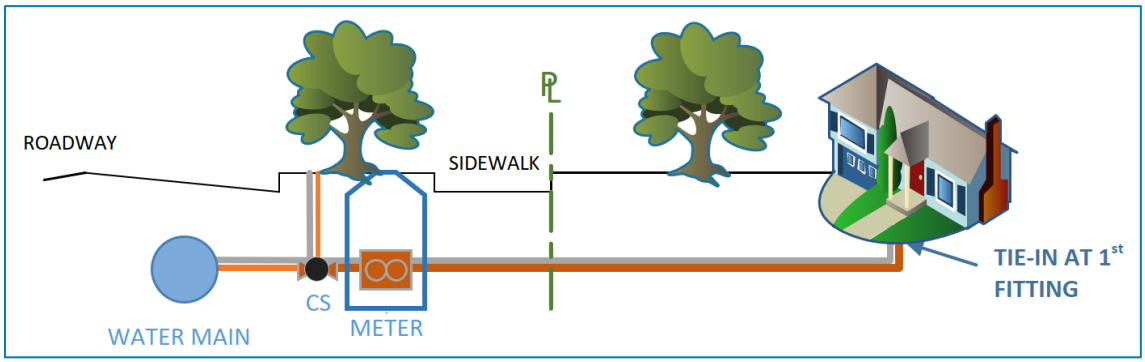
[15]How these properties are prioritized and grouped is described in Appendix III.B.3

FIGURE 23: PLANNED INTERACTION WITH PROPERTY OWNERS AND RESIDENTS DURING LSLR



During construction, Denver Water will investigate the service line material and replace the service line if the material is lead. The lead service line replacement will include the service line from the water main connection to the first fitting inside the dwelling. An example of a full lead service line replacement is illustrated below in Figure 24. The example shows an existing lead service line (grey) being replaced fully with a copper service line (orange). Additionally, all fittings, valves (curb stops (CS) and corporation stops), and meters that are not copper will be replaced.

FIGURE 24: EXAMPLE FULL LEAD SERVICE LINE REPLACEMENT



Following construction, Denver Water will provide:

a. Flushing instructions (per AWWA/ANSI Standard C810-17)

b. Educational materials on how to further reduce lead source in their premise plumbing

c. Additional filter replacement cartridges for use up to six months after replacement of the lead service to remove any lead particles that may have been dislodged as a result of replacement

d. Water quality sampling test kit, approximately four months after replacement

What happens if post-replacement water quality results are above the action level?

Property owners will be educated on how to reduce lead in their premise plumbing and will be referred to community organizations and funding programs that can assist with investigating and removing lead from their home (such as the U.S. Department of Housing and Urban Development's Lead Hazard Grant Program).

How will Denver Water achieve the 7.0% replacement rate?

A number of older cities (including Pittsburgh and Detroit) are embarking on accelerated lead service line replacement plans that aim to replace several thousand service lines per year. A review of these lead service line replacement programs revealed that it is reasonable to expect crews to replace upwards of two to four lead service lines per day, depending upon various factors with primary emphasis in lead service line inventory confirmation in advance of replacement.

The ALSLR Plan will incorporate Denver Water's internal resources to replace up to 700 (water main and leaks) lead service lines per year. Another 500 lead service line replacements are expected through redevelopment and contracting with external resources to fulfill the remaining portion (approximately 4,050) to achieve the 7.0% cumulative replacement goal. Based on typical number of replacements completed per day, it is projected that Denver Water will need upwards of 13 lead service line replacement crews based on an average of two replacements per day per crew. As the program progresses, efficiencies are expected through lessons learned. The ALSLR Plan does recognize that developers and Denver Water LSL replacement activities will require incorporation of Denver Water and City and County of Denver processes to plan and track these replacements.

Denver Water will engage and partner w/ contractors through;

- multi-year contracts to provide flexibility in targeting ALSLR crews in meeting the cumulative annual average 7.0% LSL replacement goal,
- task orders will be issued to address ALSLR inventory for Geographic and Individual groups and for LSL Investigations,
- contracts incorporate a Learn by Doing approach with bi-annual reviews on performance and to identify opportunities for improvements, and
- incentive based contracts considered for meeting performance criteria focused on safety, quality, and ALSLR rates.

To confirm local contracting capacity, Denver Water, in coordination with the communication, outreach and education plan, will conduct an Industry Day workshop. The purpose is to inform the contracting community of the LRP needs, ensure contractors know how to direct questions they may receive from external audiences on the LRP, receive feedback on contracting and procurement strategy, as well as address other comments and concerns. Denver Water conducted a review of potential contracting and procurement options and is moving towards a qualification-based approach to shortlist qualified contractors that will provide unit price bids. Denver Water will select from the lowest and most responsive qualified contractor(s) unit price bid and enter into a contract for one year with the option of two (2) one-year extensions.

What if customers do not want their lead service lines replaced?

Based on experience in Denver and elsewhere, Denver Water anticipates that property owners might occasionally refuse to allow their service lines to be replaced. Denver Water will use a three-step notification process along with continued outreach to try to obtain consent.

If property owners continue to withhold consent for the LSL replacement:

- Denver Water may choose not to replace any portion of the lead service, unless the line is in a road with high volume traffic or other hindrance that would make it difficult to replace at a later time, but may pothole in the right-of-way to determine service line material, and move to other service line replacements on that block and provide restoration of possible investigation.
- Denver Water finds that no LSL exists, the lead service line inventory will be updated and the property removed from the ALSLR list.
- Denver Water will place the property on the list of properties declining the LSL replacement. The list will be made available to CDPHE upon request.
- If consent is not provided prior to the contractor entering the area, and if the property owner (or customer) is enrolled in the Filter Program, a letter will be sent to the property owner (or customer) by registered mail providing contact information and a deadline to respond if they wish to change their minds. The registered letters will also provide clear language that the property owner (or customer) will no longer be enrolled in the Filter Program six months following the notice.
- The Denver Water COE team will be notified and additional outreach and education efforts will be provided to the property owner and the residents of the property to i) determine why consent was denied, ii) review the importance and features of the LRP and iii) drop-off a water quality sampling kit in an effort to quantify the magnitude of lead release at the property.

Next steps if consent to replace the known lead service is denied: If consent is still denied after implementing the above actions, the property will be added to a lead service line refusal list maintained by Denver Water and a note will be made in the customer account that the LSL replacement was refused.

Tracking Lead Services for Replacement in the Future: Upon a change in the name of the water account, Denver Water will reinitiate outreach and education efforts to determine if the new customers will consent to replacement of the lead service line. Timing for replacement will be determined on the basis of priority.

Exceptions for Child Care Providers: [for discussion with CDPHE, DDPHE and Denver Water legal].

Exceptions for Multi-Family Properties: Denver Water will make all reasonable effort to earn consent from property owners of single family and multi-family properties, including contacting out-of-state landlords where applicable. In the case of multi-family units, until the property owner provides consent to replace the lead service line, the residents will be notified of the known or suspected presence of a lead service line by registered mail, be provided with education materials to describe actions the residents can take to reduce their risk of lead, be provided with a sampling kit and supplied with free filter replacement cartridges.

Exceptions for Water Main Replacement: When Denver Water replaces water mains, the existing service line must be transferred from the old water main to the new water main. This gives Denver Water the opportunity to replace Property Owners' service lines if it is found to be lead. If the existing service line at the water main is identified as lead, Denver Water will request consent to investigate the service line's material up to the first fitting inside the dwelling. However, if the property owner does not consent to having their lead service line replaced, Denver Water will only replace the LSL up to the meter regardless of the service line material from the meter to the first fitting inside the dwelling. As a result of non-consent, Denver Water will take the same actions as identified earlier and place a notification on the property.

How will the predictive model be used to guide the ALSLR Plan?

The predictive model is a tool that can be used to generalize the results of explorations performed previously to guide subsequent or future explorations. This will improve the overall efficiency of identifying where LSLs are used in the water system and help plan for their replacement while fine-tuning or improving the confidence in the lead inventory.[16]

The predictive model will use the lead service line inventory and other databases to establish a road map based on a hierarchy policy to identify where to replace services to meet the 7.0% lead service line replacement goal on a cumulative average. As the details of the lead service line inventory continue to be refined and quantified, the predictive model will assist in early identification of the subsequent year's lead service line replacement plan.

Based on areas selected for replacement in a given year, Denver Water will consider field activities to conduct confirmation of lead service line inventory to increase the reliability of delivering the 7.0% cumulative average rate of replacement.

What happens if a lead service line is found after the LRP is completed in 15 years?

Lead service lines found after 15 years of the LRP will be replaced within six months of discovery. Customers will immediately receive a filter and replacement cartridges (NSF certified to remove lead) and will continue to receive shipments of replacement cartridges up to six months after the line is replaced, along with educational materials on reducing lead exposure.

[16]The development of the predictive model and its application is described in Appendix III.B.3.

How will Denver Water demonstrate a 7.0% replacement rate?

On an annual basis, Denver Water will receive credit for every lead service line replacement completed that year, including lead service line replacements completed by third-party contributors (e.g., governmental agencies, developers, homeowners, non-profits, etc.). Denver Water shall verify all third-party lead service line replacements.

The annual average shall be calculated for each calendar year by dividing the number of lead service lines replaced (X) during the calendar year by the known number of lead service lines (Y). [X and Y will be provided and agreed upon by all parties at the August 13th variance check-in]. Adjustments to X or Y can be made by the Lead Reduction Program Leadership Committee if evidence supports the adjustment and still results in a minimum 7.0% cumulative average and replacement of all known lead service lines within 15 years. Adjustments to X and Y may include:

Potential Adjustments to X (Number of Lead Service Lines Replaced during Calendar Year)	Potential Adjustments to Y (Known Number of Lead Services)
No adjustment: property owner declines replacement after multiple attempts by Denver Water to encourage replacement.	**Adjust down:** known or suspected lead service line confirmed to be non-lead during investigation phase.
Adjust up: entire lead service line replaced or existing partial lead service line replaced such that entire line is lead-free after replacement.	**Adjust up:** lead service line confirmed after customer sampling reveals high lead levels in all three bottles.
Counts as more than one: multiple lead services removed as part of a redevelopment project, even if replaced with on larger service line.	

The 7.0% cumulative annual average requirement will take effect beginning month 37 following the beginning of the ALSLR program. Although no replacement rate will apply during the first three years of the ALSLR program, as a practical matter, lead service line replacement counts cannot drop below 6.0% for the first year and 6.5% for the second year, if Denver Water is going to achieve a 7.0% cumulative annual average replacing rate beginning month 37.

Can Denver Water replace lead service lines faster than 15 years?

Protection of public health and reduction of long-term program management costs will incentivize Denver Water to replace lead service lines as quickly and responsibly as possible, which may exceed the proposed 7.0% replacement rate. Over the next 10 years, Denver Water is completing two very large water supply resiliency projects including construction of the new Northwater Treatment Plant and the expansion of Gross Reservoir. **Denver Water must balance these projects and rate increases in a manner that supports its mission without creating affordability issues for its customers.** Note: force majeure events (e.g., severe flooding or drought) may adversely impact Denver Water operations and by default, capital programs. As a result of these factors, Denver Water believes it is prudent to commit to the minimum 7.0% rate but will strive to do more when feasible.

III.E Corrosion Control Treatment

As part of the variance approach, Denver Water is proposing to use pH/alkalinity adjustment to reduce lead releases from copper service lines with lead solder and from premise plumbing containing lead. Additionally, Denver Water will submit a modification request asking CDPHE to change the 2018 optimal corrosion control treatment designation from orthophosphate to pH/alkalinity. Denver Water must have approval of both the variance and modification request to move forward with this plan.

How will pH/alkalinity adjustment protect customers with copper service lines with lead solder?

As seen in Section II, lead levels in first draw samples for homes with copper service lines with lead solder are expected to drop by 45%. Using LCR compliance data from 1997 to 2019, for Tier 1 copper lines with lead solder, the projected lead levels in first draw samples under the Lead Reduction Program are expected to decline from 7.4 ppb to below 5 ppb as shown in Table 11.

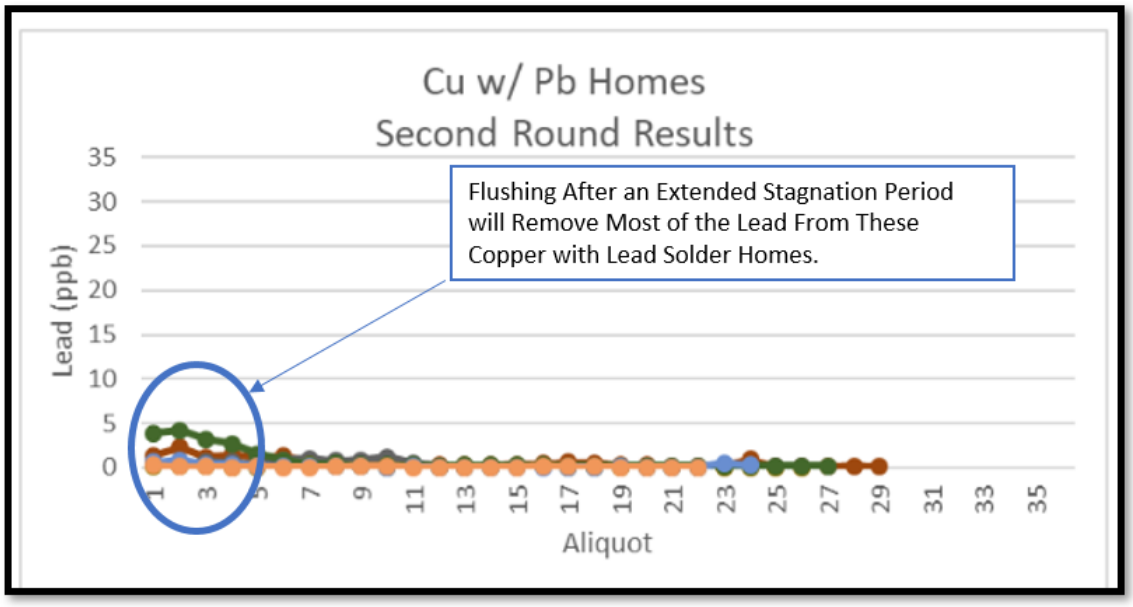
TABLE 11: PAST AND PROJECTED LEAD LEVELS IN FIRST DRAW SAMPLES FOR HOMES SERVED BY COPPER SERVICE LINES WITH LEAD SOLDER
(Data are provisional and subject to change)

Time Period	Average Lead Levels (ppb)	90th Percentile Lead Levels (ppb)
Pre-Variance: 1997 to 2019 (average)	4.6	7.4
Projected Post Variance: 2021 and Beyond	2.6	4.1

Also, as noted in Section II, lead levels in homes with copper service lines with lead solder are highest in the first draw samples, indicating the lead is coming from internal plumbing rather than the service line. As seen in Figure 25, flushing first thing after an extended stagnation period (first thing in the morning, after work or any period 6 hours or longer) will remove most of the lead. The COE program will incorporate this messaging to help customers understand how to reduce their exposure to lead.

FIGURE 25: HOW FLUSHING CAN HELP REMOVE LEAD FROM HOMES SERVED BY COPPER SERVICE LINES WITH LEAD SOLDER

(Data are provisional and subject to change)



Compliance sampling

Denver Water will continue to study corrosion control treatment to identify a final pH/alkalinity target subject to approval by EPA and CDPHE as part of the variance process. Optimization of the corrosion control treatment must be demonstrated within one year of receiving CDPHE approval to begin treatment. Non-lead Tier 1 homes (homes with copper service lines with lead solder built between 1983 and 1987) will be used for compliance monitoring and sampling, per the LCR.

Can the proposed corrosion control treatment protect customers with lead service lines who choose not to use filters?

Yes, to some extent. Customers with lead service lines who use a filter will experience a 97% reduction in lead levels. For customers with lead service lines who do not adopt filters, lead levels will decline approximately 50%. LCR, first draw, water quality sampling from 1997 to the first sampling period in 2019 showed an average lead level in homes with lead service lines to be 5.8 ppb, and the average of the 90th percentile for the same period was 11 ppb. Applying the 50% reduction to first draw lead service line LCR samples results in the lead levels shown in Table 12. Recalling the test for optimal corrosion control treatment described in Section II (difference of 5 ppb or less), the projected lead levels following implementation of improved pH and alkalinity adjustment are expected to be at or below 5 ppb for most - but not all – customers.

TABLE 12: PAST AND PROJECTED LEAD LEVELS IN FIRST DRAW SAMPLES FOR HOMES WITH LEAD SERVICE PROTECTED BY PH/ALKALINITY CORROSION CONTROL TREATMENT ONLY (NO FILTER)
(Date are provisional and subject to change)

Time Period	Average Lead Levels (ppb)	90th Percentile Lead Levels (ppb)
Pre-Variance: 1997 to 2019 (average)	5.8	11.0
Projected Post-Variance: 2021 & Beyond	2.9	5.5

How will Denver Water verify corrosion control is working?

Under the LRP, homes with lead service lines will be removed from Tier 1 sampling; however, 100 homes registered in the Filter Program will be asked to participate in the "LCR Surrogates" program. Denver Water will collect and analyze unfiltered water samples from these homes every sampling period. These results will help Denver Water continue to optimize corrosion control for homes served by lead service lines that choose not to enroll in the Filter Program.

Improving existing corrosion control performance – community wide perspective

The success of the pH/alkalinity corrosion control treatment depends on Denver Water's ability to maintain a target pH within ±0.2 standard units leaving the treatment plants and ±0.3 standard units in the distribution system. Additionally, Denver Water will maintain a minimum alkalinity level to help stabilize pH in the distribution system.

Denver Water will use its real-time monitoring system to track and trend pH, alkalinity and conductivity (where on-line instrumentation is available) at the treatment plants and in the distribution system. Figures 26 and 27 display the current monitoring screens, one for the overall distribution system and the other for one of the treatment plants, respectively.

FIGURE 26: REAL TIME SYSTEM WIDE CORROSION CONTROL MONITORING

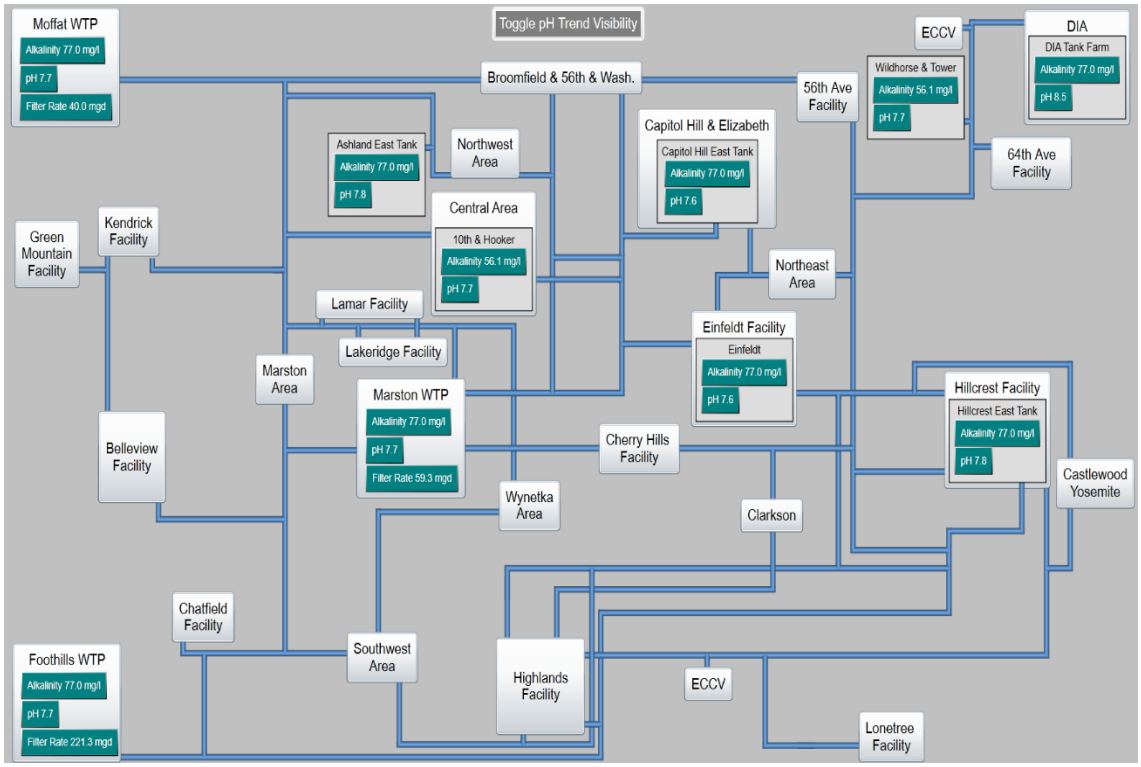


FIGURE 27: REAL TIME CORROSION CONTROL MONITORING FOR TREATMENT PLANTS

(Data are provisional and subject to change)

Corrosion Control Operating Conditions / Boundaries / Excursions

Parameter	Normal Range	Boundary	Excursion	Actual Value
Orthophosphate	2-3 mg/L	1.5 - 1.9 mg/L 3.1 - 3.5 mg/L	< 1.5 mg/L <> 3.5 mg/L	(Future) FWC
pH	7.70 - 7.80 +/- 0.2 Units - Treatment +/- 0.3 Units - Distribution	7.65 - 7.69; 7.81 - 7.85	< 7.65 > 7.85	FWC
Conductivity	TBD	TBD	TBD	Raw & FWC
Alkalinity	> 45 mg/L	< 40 mg/L	< 35 mg/L	e.RIS Dashboard
DIC	> 12 mg/L	10 - 12 mg/L	< 10 mg/L	e.RIS Dashboard
CSMR	< 0.4	0.4 - 0.6	> 0.6	e.RIS Dashboard

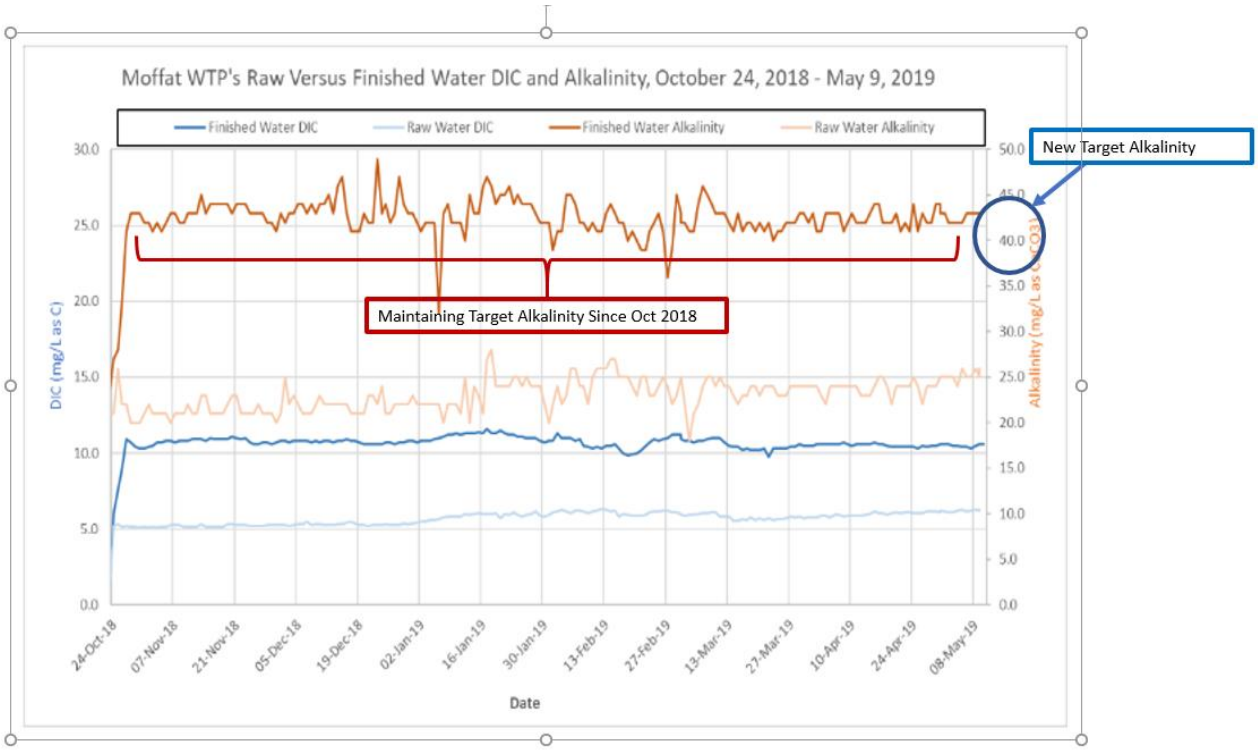
Will Denver Water have to make modifications to the treatment plants to support improved pH/alkalinity control?

As part of the 2018 CDPHE Designation, Denver Water was required to install additional corrosion control treatment systems to support orthophosphate dosing, which are currently under construction and will be ready for use in early 2020. Portions of those systems will also support an enhanced pH/alkalinity corrosion control, so no additional modifications are necessary.

Additionally, Denver Water will have to maintain a minimum monthly average alkalinity to support consistent pH levels in the distribution system. Denver Water operates three potable water treatment plants: Moffat, Foothills and Marston. Only one treatment plant requires daily alkalinity control: Moffat Treatment Plant, due to the low alkalinity Fraser River source water that feeds the plant. In 2018, the Moffat Treatment Plant's finished water target alkalinity was raised to 40 mg/L as $CaCO_3$, which it has successfully maintained since, as seen in Figure 28.

FIGURE 28: DENVER WATER'S MOFFAT TREATMENT PLANT RAW WATER VERSUS FINISHED WATER DIC AND ALKALINITY LEVELS

(Data are provisional and subject to change)



The other two treatment plants receive raw water from the South Platte River and/or Marston Reservoir, which are moderately high in alkalinity, averaging between 50 mg/L and 70 mg/L as $CaCO_3$ most of the year. The South Platte River can drop to levels between 20 mg/L and 35 mg/L as $CaCO_3$ for up to three weeks during runoff season (May to July). During the two to three weeks of low alkalinity in the South Platte, raw water intake can be shifted to Marston Reservoir to maintain a minimum monthly alkalinity in the distribution system as needed.

Table 13 shows Denver Water's proposed water treatment objectives to support enhanced pH/alkalinity corrosion control:

TABLE 13 PROPOSED TREATMENT OBJECTIVES FOR PH/ALKALINITY CORROSION CONTROL TREATMENT
(Data are provisional and subject to change)

Proposed Water Quality Standards for Treatment Plants and Distribution System	
Treatment Plants at Point of Entry	• pH = monthly average 8.8* standard units, with an operating range of 8.6 to 9.0 • Alkalinity = minimum monthly average of 30 mg/L as $CaCO_3$
Distribution System	• pH = monthly average 8.8* standard units, with an operating range of 8.5 to 9.1

*Final pH treatment objective may change as a result of additional studies in 2019.

Denver Water has also undertaken some changes in the types of chemicals it uses at the treatment plants to maintain a low chloride-to-sulfate mass ratio. Chemicals such as liquid ammonium sulfate and acidified alum (containing 5% sulfuric acid) help reduce the CSMR, which at times can peak above 0.6 in the finished water from the two treatment plants that use the South Platte River for their source. Although much higher CSMR numbers (1+) are indicative of corrosion, Denver Water is doing what it can to keep the ratio at or below 0.6.

How does Denver Water propose to maintain and optimize corrosion control using pH/alkalinity adjustment?

To ensure optimal corrosion control, Denver Water will:

- Incorporate continuous on-line corrosion control SCADA (supervisory control and data acquisition) monitoring that tracks and trends pH, alkalinity, DIC, conductivity, chlorine residual and temperature at the treatment plants and seven key locations throughout the distribution system, with clear action levels and response measures to be taken if the parameters are out of bounds (See Figure 26)
- As part of the corrosion control upgrades at the treatment plants, install automated pH dosing control loops to maintain constant feedback and adjustment of pH in the finished water leaving all treatment plants
- Monitor lead levels in LCR and customer samples on a monthly basis, looking for upward trends and adjusting treatment systems or operating practices to reverse trends, where possible
- Monitor the chloride to sulfate mass ratio and adjust treatment chemical dosing to target a ratio at or below 0.6
- Continue daily communications between treatment plants to review corrosion control targets and performance

- Capture a weekly sample from the point of entry of each treatment plant and test for pH and alkalinity
- Complete monthly sampling (pH, alkalinity) at 25 representative sites spread across the Denver Water service area. The sites are yet to be determined and will be agreed upon as part of the CDPHE modification approval
- Continue quarterly profile sampling at volunteer homes, both lead and copper service lines, to gauge corrosion control effectiveness during the first year of implementation
- Complete LCR sampling of Tier 1 (copper service line with lead solder) homes every six months; 100 sites minimum
- Complete "LCR Surrogate" sampling at 100 homes enrolled in the Filter Program with a confirmed lead service line, every six months
- Strive to consistently hit water quality goals for finished water leaving the treatment plants, as specified in Table 13

Are there other water quality considerations?

Nitrification can happen as a result of pH levels below 8.3 standard units or with the addition of orthophosphate. Nitrification can adversely affect the protective coatings in lead service lines and cause lead releases. If the variance is granted, nitrification should not be a concern if the pH target is above 8.3 standard units; to verify this, Denver Water plans to:

- Complete distribution system modeling, evaluating pH, nitrification, disinfection by-products (DBPs) and water age by January 31, 2020
- Subsequently develop and implement a "Nitrification Control Plan" by July 2020, detailing sampling, monitoring and flushing plans for nitrification control

It is important to note that Denver Water's DBPs in the distribution system (e.g., total trihalomethanes and haloacetic acids) are and have historically been less than 50% of the current regulations of 80 ppb and 60 ppb, respectively. These low levels are accomplished as a result of using chloramine as a secondary disinfectant rather than free chlorine.

What if the action level for lead is exceeded?

If the action level is exceeded in one six-month sampling period, using samples from Tier 1 homes, Denver Water will have up to six months to further optimize its corrosion control to reduce lead levels below the action level for the next round of sampling.

If the action level is exceeded during two sequential sampling periods, Denver Water will turn on the orthophosphate dosing systems within six months of the second exceedance.

Currently, Denver Water monitors reported lead levels from LCR and customer samples on a monthly basis and makes the appropriate adjustments to optimize chemical dosing or improve operational practices when lead levels appear to be trending up.

III.F Learning by Doing

The Learning by Doing approach constantly utilizes data in collaborative reoccurring cycles of collective inquiry and action to achieve improved LRP results.

The process used in the Learning by Doing approach involves the following steps:

- Gather evidence of current results and collaboratively evaluate with stakeholders.
- Develop strategies and ideas to build on strengths and improve results in challenging areas.
- Implement the strategies and ideas.
- Analyze the impact of the changes to discover what was effective and what was not.
- Apply new knowledge in the next cycle of continuous improvement.

The overall goal of the LRP Plan is to remove lead in a manner as or more efficient than adding orthophosphate to drinking water in accordance with the terms and conditions of the Lead Reduction Program. Denver Water and other stakeholders have a mutual interest in ensuring that this goal is achieved.

Through the Learning by Doing concept, Denver proposes to work collaboratively with CDPHE, EPA and other stakeholders to find new ways to efficiently implement the LRP Plan while continuously improving upon past results in accordance with the terms of the approved variance. The Learning by Doing concept is not an attempt to modify the conditions for approval of the LRP Plan, but rather, identify acceptable methods and tools to meet the goals and conditions of the LRP Plan.

To implement the Learning by Doing concept, Denver Water proposes that EPA, CDPHE, and Denver Water each appoint a representative to form an LRP Leadership Committee within 30 days of approval of Denver Water's variance request. The LRP Leadership Committee will invite other stakeholders to be members, such as representatives from watershed groups, wastewater dischargers, and public health agencies. Any decision to add other members to the LRP Leadership Committee will be made by consensus, with consideration being given to the resources and contributions other potential members may provide.

The LRP Leadership Committee will operate with the following goals:

- Achieve consensus and seek to resolve disagreements
- Provide technical input on implementation of the variance and efforts
- Identify through consensus voluntary efforts that would improve upon results achieved by the LRP Plan
- Explore methods to achieve an even greater degree of efficiency than projected in the LRP Plan

The LRP Leadership Committee will meet at least every six months starting nine months after the variance request is approved

Where the LRP Leadership Committee is unable to make a decision by consensus, and any single entity believes that the issue warrants mediation, the LRP Leadership Committee will refer the decision to CDPHE, EPA, and Denver Water management to attempt to resolve the disagreement.

In implementing the Learning by Doing concept as part of the LRP, the following principles will be used to build and promote a stable, permanent, relationship that respects the interests and legal responsibilities of the parties, while achieving the goal of the program:

- The LRP Leadership Committee will not seek a culprit for a failure to improve upon results but will provide a mechanism to identify issues of concern and focus available resources to address those issues.
- Because resources available to the LRP Leadership Committee are limited, the use of those resources will be prioritized as part of the Learning by Doing effort.
- All of the stakeholders to the Learning by Doing effort will work in good faith to implement the Learning by Doing approach in a way that complements the LRP Plan and its terms and conditions.
- If the LRP Leadership Committee desires additional resources beyond what Denver Water has made available, the Learning by Doing team will work with other stakeholders and granting agencies to identify other sources of funding to provide additional resources. If mutually defined additional resources are still desired, the team may agree to consider contributing more of their own resources on a case-by-case basis and within the context of the other principles listed herein. Each party retains its sole discretion whether or not to provide any additional resources without further judgment or prejudice by the other parties.
- Active participation in the LRP Leadership Committee will commence upon approve the LRP Plan.
- The LRP Leadership Committee acknowledges that actions inconsistent with the LRP Plan's terms and conditions will not be undertaken as part of the Learning by Doing process, unless approved in writing by EPA and CDPHE.
- LRP Leadership Committee will cease at the completion of the LRP.

IV. MONITORING AND REPORTING

Metrics will be used to allow both the public and the regulatory agencies to evaluate Denver Water's implementation of the LRP. Monitoring and reporting include the following four actions:

1. Monitoring of treatment plant performance to deliver drinking water to the distribution system of a consistent water quality that favors corrosion control; this is business-as-usual for Denver Water and not described in the LRP

2. Monitoring of the distribution system performance, including at the customer's faucet to confirm that the risk of lead exposure is reduced or if optimization or other efforts are needed to restore performance

3. Reporting to the public to describe the progress and results from the LRP and to do so with transparency while also enabling customers to know how they can help Denver Water achieve the goals of the LRP

4. Reporting to CDPHE and EPA to evaluate compliance with the LCR and the terms and conditions expected with the variance request

Introducing the Framework to Evaluate Performance

For five of the six elements that together make up the LRP (COE Program; Filter Program; LSL Inventory; ALSLR Program; and Corrosion Control Treatment), clearly defined program metrics will be used to determine whether the LRP Plan is successfully being implemented. Because Learning by Doing is a strategy, and not an outcome in itself, performance metrics are not identified for this element of the LRP.

The performance metrics are designed to incentivize and acknowledge Denver Water's proactive efforts to reduce lead exposure from drinking water. The performance metrics are also designed to communicate regulatory compliance and the overall effectiveness of the LRP.

A sliding scale, with "Meets Expectations" as the benchmark, will be used to judge expected performance. Performance beyond this metric is captured by the terms "Exceeds Expectations" and "Outstanding." Performance below "Meets Expectations" is described using "Needs Correction" and "Fails." Corrective actions are defined to restore performance to "Meets Expectations" or to begin implementation of orthophosphate within a prescribed time frame (Table 14).

TABLE 14: PROPOSED FRAMEWORK TO EVALUATE THE LRP

Metric	Fails	Needs Correction	Meets Expectations	Exceeds Expectations	Outstanding
Score	1	2	3	4	5
Metric Criteria					
Corrective Action					

Compliance Schedule

The start date of the LRP is within 90 calendar days after approval of the variance. The term "program year" is used to describe the annual period of evaluation, in case the LRP start date is not at the start of the calendar year.

In general, a single program year is used as the basis of compliance, for example for the filter adoption rate and COE Plan. The evaluation of the ALSLR Program is based on a cumulative average, starting in year three of the LRP. One or two sampling rounds (each lasting six months based on the calendar year) will be the basis of compliance to evaluate CCT, consistent with the LCR. Additional details are provided for each element later in this section.

Corrective actions are expected to be started within a specified time period following the end of the previous program year. The duration used to restore performance depends on the element being evaluated. An annual report to be provided at the end of each program year will capture all metrics and corrective actions.

Consistent with the LCR, the evaluation framework gives time for Denver Water to make improvements to restore performance and get into compliance before requiring orthophosphate implementation. Denver Water will need up to six months to purchase orthophosphate and ready the treatment plants and water system to initiate orthophosphate if for select elements performance "Fails."

How Denver Water Will Evaluate Performance of the LRP

The monitoring and reporting terms and conditions, which will serve to measure performance, are summarized in this section.[17]

COE Plan

The criterion used to assess the success of the COE Plan as shown in Table 15 is the extent to which contact is made with Denver Water households enrolled in the Filter Program. "Contact" means direct mailing, water bill inserts, door hangers, in person contact, email, social media,

[17] The LRP will be subject to terms and conditions described in Appendix IV.A.

phone call or any other communication channels identified in Denver Water's COE Plan. Communications via information posted on the Denver Water website, water bills excluding water bill inserts, or public notices required as a corrective action are excluded from this definition.

TABLE 15: COMMUNICATIONS, OUTREACH AND EDUCATION PLAN PERFORMANCE EVALUATION AND CORRECTIVE ACTIONS

(Data are provisional and subject to change)

Metric	Fails	Needs Correction	Meets Expectations	Exceeds Expectations	Outstanding
Score	**1**	**2**	**3**	**4**	**5**
Metric Criteria	One contact made per program year to < 40% of all Denver Water households enrolled in the Filter Program	One contact made per program year to ≥ 40% and < 100% of Denver Water households enrolled in the Filter Program	One contact made per program year to all Denver Water households enrolled in the Filter Program	Two contacts made each program year to all Denver Water households enrolled in the Filter Program	Two contacts made per program year to all Denver Water households enrolled in the Filter Program and One contact made per program year to all Denver Water households
Corrective Action	Within six months of the end of the previous program year: • Make contact to all Denver Water households enrolled in Filter Program • Public Notice to all Denver Water households of failure to meet this metric	Within three months of the end of the previous program year: • Make contact to all Denver Water households enrolled in the Filter Program	Not Applicable	Not Applicable	Not Applicable
Outreach includes direct mailing (excluding water bills), door hangers, in person contact, email, or phone call. Mass communications via the Denver Water website is excluded.					

Lead Service Line Inventory

The intent of the LRP is to identify all lead services before the end of the 14th year of the program. The LSI is used to evaluate this element of the LRP. In addition to the investigations carried out at all properties scheduled to have a lead service line replaced, investigations will also be conducted at properties with suspected or possible lead services. Together these efforts will help Denver Water better identify the location and number of lead service lines.

Investigation refers to field methods including water quality sampling, visual inspection, and/or potholing. A completed investigation includes any combination of field and/or desk-top methods that results in a confirmed lead service line or non-lead service line at a property.

The estimated number of properties with a suspected or possible lead service line will vary over the life of the LRP, particularly in the early years of the LRP as Denver Water's understanding of the makeup of the inventory improves as a result of the investigations. The annual number of investigations performed shall be calculated for each program year by counting the number of properties where an investigation was performed in a program year and dividing it by the total estimated number of suspected and possible lead service lines [as a subset of Y; the subset of Y will be provided and agreed upon by all parties at the August 13, 2019 regulatory check-in]. Adjustments to the subset of Y can be made by the LRP Leadership Committee if evidence supports the adjustment.

TABLE 16: LEAD SERVICE LINE INVENTORY PERFORMANCE EVALUATION AND CORRECTIVE ACTIONS
(Data are provisional and subject to change)

Metric	Fails	Needs Correction	Meets Expectations	Exceeds Expectations	Outstanding
Score	**1**	**2**	**3**	**4**	**5**
Metric Criteria	Perform < 1.1% investigations per program year of total estimated number of suspected or possible lead services	Perform between 1.1% and < 1.4% investigations per program year of total estimated number of suspected or possible lead services	Perform > 1.4% investigations per program year of total estimated number of suspected or possible lead services	Perform > 1.8% investigations per program year of total estimated number of suspected or possible lead services	Perform > 2.1% investigations per program year of total estimated number of suspected or possible lead services
Corrective Action (CA)	Within six months of the end of the previous program year: • Increase use and types of methods to investigate service line type and restore performance to "meets expectations" • Public Notice to all Denver Water households enrolled in Filter Program of failure to meet this metric	Within six months of the end of the previous program year: • Increase use and types of methods to investigate lead service line type and restore performance to "meet expectations"	Not Applicable	Not Applicable	Not Applicable

The percentage of investigations per program year is based on the total estimated number of suspected or possible lead services, with all properties cleared over 14 years in the LRP (i.e., no remaining properties requiring inspection in year 15 of the LRP). As such, the potential exists for the inventory to be exhausted within 15 years.
Investigation refers to field methods including water quality sampling, visual inspection, and/or potholing.

Year one of the LRP is used as an example to provide an approximation of the number of investigations implied by the thresholds used for the LSI Inventory. Assuming there are 100,130 [update at August 13, 2019 regulator check-in] properties categorized as having a suspected or possible lead service line (see Table 16), investigations would need to be performed at 1.4% or 1400 properties for the LSI Inventory to meet the threshold of "Meets Expectations." Similarly, fewer than 1101 investigations in year one would be considered "Fails," and more than 2102 in year one would be "Outstanding." It is noted that this is in addition to the approximately 5,250 investigations that will be performed as part of the ALSLR Program when targeting a cumulative annual average replacement rate of 7.0%. Both types of investigations will inform the predictive model to help locate lead service lines in future years.

Should Denver Water underperform in this element, corrective actions include any methods used by Denver Water to increase the number of investigations performed to meet the threshold of "Meets Expectations." In the event of "Fails," a Public Notice to all Denver Water households enrolled in the Filter Program is required.

Filter Program

Measuring the annual filter adoption rate is the basis of evaluation of this element that is critical to the success of the LRP. The threshold identified for the filter adoption rate to "Meets Expectations" is based on results from Denver Water's studies and the weighted population exposure model from Section II, where by a XX% filter adoption rate [to be provided and agreed upon by all parties at the August 13, 2019 regulatory check-in] was identified as equal or more effective than the alternative of orthophosphate (Table 17).

> NOTE: Denver Water requested that the discussion on the threshold value used for the percent filter adoption used to define "Meets Expectations" be deferred until more data are available from ongoing coupon testing.]

TABLE 17: FILTER PROGRAM PERFORMANCE EVALUATION AND CORRECTIVE ACTIONS

(Data are provisional and subject to change)

Metric	Fails	Needs Correction	Meets Expectations	Fails	Needs Correction
Score	**1**	**2**	**3**	**4**	**5**
Metric Criteria	< __% annual adoption rate after a single program year or Between __ and __% for three consecutive program years	< __% annual adoption rate	≥ __% annual adoption rate	≥ __% annual adoption rate	≥ __% annual adoption rate
Corrective Action (CA)	Within six months of failure: • Implement orthophosphate • Public Notice (Tier II) to all Denver Water households of failure of this metric and introduction of orthophosphate	Before the end of the following program year, increase filter use to "meets expectation" Within three months of the end of the previous program year, Public Notice to all Denver Water households enrolled in the Filter Program	Not Applicable	Not Applicable	Not Applicable
See table for glossary for definition of LCR surrogate sample.					

If the filter adoption rate is less than "Meets Expectations," Denver Water has one year to demonstrate improvement in the filter adoption rate. Properties where a filter is not used are still provided some protection from lead in drinking water due to the community-wide use of CCT.

The success of this element is evaluated in light of the CCT performance and the reductions achieved for lead levels in drinking water. For example, if results from CCT show a higher measured reduction than expected, then a slightly lower filter adoption rate could potentially be accepted. Similarly, if survey results suggest that filter adoption is relatively lower in a geographic area or within a demographic group, COE efforts can target the area or group and annual planning efforts to support the ALSLR Program can re-prioritize replacement to address lead exposure in this area. The metric and corrective action address the interdependence of the three elements of the Filter Program, ALSLR Program, and CCT.

ALSLR Program

The proposed metric for the ALSLR Program measures the number of lead service line replacements completed each program year such that all lead service lines are replaced within 15 years.

A "completed" lead service line replacement is defined as replacement work where no portion of the lead service line is left behind at a property. Replacements completed by third parties and inspected by Denver Water will count toward the total number of replacements each year.

To account for start-up challenges and to address the potential benefits of accelerating replacements, this metric is evaluated using a cumulative annual average replacement rate. The first determination of "Meets Expectations" occurs by end of program year three. The use of the cumulative annual average also provides an opportunity for Denver Water to recover after start-up issues or an "upset" year without immediately triggering orthophosphate implementation (Table 18).

TABLE 18: ALSLR PROGRAM PERFORMANCE EVALUATION AND CORRECTIVE ACTIONS
(Data are provisional and subject to change)

Metric	Fails	Needs Correction	Meets Expectations	Exceeds Expectations	Outstanding
Score	**1**	**2**	**3**	**4**	**5**
Metric Criteria	< 7.0% cumulative annual average replacement rate for three consecutive program years*	< 7.0% cumulative annual average replacement rate*	7.0% cumulative annual average replacement rate	> 7.0% to < 9.0% cumulative annual average replacement rate	≥ 9.0% cumulative annual average replacement rate
Corrective Action (CA)	Within of six months of failure: • Implement orthophosphate • Public Notice (Tier II) to all Denver Water households of failure of this metric and introduction of orthophosphate	Before the end of the following program year, increase contractor LSL replacements and increase investigation efforts to identify service line material Within three months of the end of the previous program year, Public notice to all Denver Water households enrolled in the Filter Program	Not Applicable	Not Applicable	Not Applicable

*Does not apply to program year 1-3. Beginning program year 4, Denver Water must have achieved a 7.0% cumulative replacement rate, including for the first three years.

Implementation of orthophosphate and public notice to all Denver Water households is triggered if the cumulative annual average rate of replacement falls below 7.0% for three consecutive program years. In the case of "Needs Improvement", Denver Water will increase the number of investigations to confirm where lead is used, contract more crews to complete replacements, and release a public notice to Denver Water households enrolled in the Filter Program.

Corrosion control treatment

The performance of this element is based on measuring lead release at the customer's faucet, using the sampling protocol of the LCR and based on the 90th percentile of lead measured in 106 samples, during two sampling rounds each calendar year. LCR compliance samples will be collected from Tier 1 households known to have a copper service line with lead solder. Properties that currently have a lead service line will no longer be included in LCR compliance sampling.

To assess lead in drinking water at a property with a lead service line but that does not use a filter, Denver Water will use LCR surrogate samples. For the purposes of the LRP, an "LCR surrogate" means a water sample from 100 properties with a known lead service line enrolled in the Filter Program, where the sample is obtained from an unfiltered tap. This sample set will be used to collect data to understand potential lead levels at properties that have not adopted the use of a lead removal filter. These properties will have their lead service line replaced, and a filter will be provided until the service line can be replaced.

The threshold for "Meets Performance" is based on the action level for lead from the LCR. Reducing lead below the action level is captured in the "Exceeds Expectations" and "Outstanding" performance thresholds.

TABLE 19: CORROSION CONTROL TREATMENT PERFORMANCE EVALUATION AND CORRECTIVE ACTIONS

(Data are provisional and subject to change)

UNDER CONSIDERATION

Metric	Fails	Needs Correction	Meets Expectations	Exceeds Expectations	Outstanding
Score	1	2	3	4	5
Metric Criteria					
Corrective Action (CA)					

The performance threshold is evaluated using the sampling rounds defined in the LCR. If lead levels are above the action level for one sampling round, then Denver Water must make improvements to corrosion control treatment when using pH and alkalinity adjustment and restore performance to “Meets Expectations.”

The conditions for discontinuing the LRP and implementing orthophosphate are defined based on the performance of the corrosion control treatment and filter adoption rate. Orthophosphate implementation is triggered after two consecutive sampling rounds (i.e., one calendar year) in which the 90th percentile of LCR compliance samples are measured above the action level for lead.

Routine Reporting

Denver Water will prepare annual compliance reports for CDPHE and EPA using the performance metrics described herein. Additional parameters will be monitored and reported on, consistent with the terms and conditions for the LRP Plan.[18]

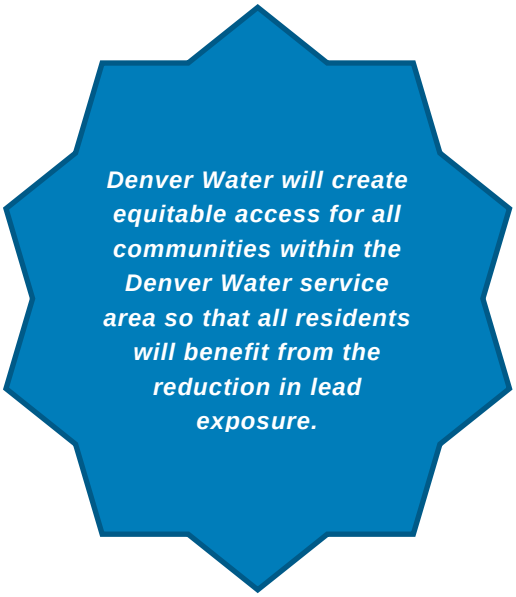
[18] The LRP will be subject to terms and conditions described in Appendix IV.A.

V. HEALTH EQUITY AND ENVIRONMENTAL JUSTICE

The incorporation of health equity and environmental justice (HE&EJ) principles is a cornerstone of the Lead Reduction Program.

Applying HE&EJ principles to infrastructure projects, including lead in drinking water, generally involves the following steps:

- Start with collating available data to understand community demographics, language and culture, health risk factors, and potential challenges to project acceptance
- Use these data to develop a targeted communication plan aimed at reaching HE&EJ community members and focused first on populations at greatest risk
- Follow with linguistically and culturally appropriate outreach and actions to reach the communities at most risk from lead exposure



Under the LRP, Denver Water will prioritize replacing lead service lines of HE&EJ residents, particularly those at greatest risk from lead exposure wherever feasible. The purpose of this section is to describe how Denver Water intends to address HE&EJ in the overall LRP and within the specific program elements.

Experience from other programs and jurisdictions informed Denver Water's approach to prioritizing HE&EJ in planning efforts for the COE Plan, Filter Program, and ALSLR Program. Understanding potential barriers that might make it less likely for someone to access the Filter Program, such as language or country of origin, allow mitigation strategies to be implemented and the benefits of lead protection provided by the LRP to be realized.

Denver Water plans to engage with HE&EJ experts, stakeholders, community representatives and customers regarding the prioritization process and logic (i.e., criteria and weighting factors) used to plan and implement the LRP with the aim of ensuring that the process is robust and understandable to all.

Planning for the ALSLR Program to address prioritization will be updated annually at a minimum, with each year's plan – and outcomes – informing the subsequent year's plan. Denver Water will use a similar strategy for the initial filter distribution as part of the Filter Program as well as in executing and updating the COE Plan.

Criteria for Prioritization to Address HE&EJ

The LRP Plan uses the predictive model to consider HE&EJ factors by applying criteria and weighting factors to convert the lead service line inventory into an annual plan. The criteria and weighting factors were established in consultation with EPA and CDPHE, and the process followed to identify and rank the criteria is presented in Section III.B. Both individual properties with a high risk of lead exposure as well as geographic groupings of households that collectively represent a high risk of lead exposure are identified in successive iterations of the predictive model. The results are then incorporated into annual planning efforts for the COE Plan, ALSLR Program, and initial Filter Program. One benefit of using the predictive model is that a sensitivity analysis can be performed on the results to test the assumptions for the criteria, their application and weighting factors on the model outputs for prioritization.

Experience from other jurisdictions suggests that median income level alone is not enough to incorporate HE&EJ priorities into annual planning efforts for the different elements of the LRP. Denver Water collaborated with the DDPHE's Office of Health Equity and the CDPHE to identify criteria, how to apply the criteria, and the relative weighting to be used in the predictive model and prioritization efforts. Data sources considered by Denver Water are listed in Table 20. [placeholder for specific data provided by DDPHE's Office of Health Equity]

TABLE 20: SOURCES OF DATA USED BY DENVER WATER TO ADDRESS HE&EJ IN THE LRP
(Data for discussion and subject to change)

Sources of data used by Denver Water to address HE&EJ in the LRP		
CHP+	Denver Public Schools	Colorado LEAP Program
Blood Lead Level data	Water quality data for lead in drinking water	

For the first year of the LRP, neighborhoods with a higher density of lead service lines will be identified and ranked, generating a list of neighborhoods for the COE teams to visit first. In subsequent years, additional criteria for HE&EJ indicators can provide overlays to the predictive model's data for lead density to determine how and to whom communications are directed. Results from the Filter Pilot Program carried out with Denver Water will help calibrate the predictive model output for the first program year (2020 planning). If in future years results from the filter adoption surveys reveal that filter use is not as effective within a given HE&EJ group, the LRP can be adjusted to better address these communities.

The following strategies and best practices for HE&EJ needs allow all Denver Water households to access the benefits of the Lead Reduction Program*

- **Soliciting feedback from impacted communities on lead reduction strategies**
  - ✓ **Denver Water is seeking comments on the Draft Lead Reduction Program Plan**
  - ✓ **EPA will launch a 30 day public comment period at the end of August 2019**
- **Prioritizing implementation in the communities most impacted**
  - ✓ **Getting to the households and geographic areas at most risk to lead exposure first, including schools and child care providers**
- **Removing economic barriers**
  - ✓ **Denver Water is allocating the necessary financial resources for the 15 year LRP**
  - ✓ **Replacement of the full lead service line at no cost to the property owner**
  - ✓ **Water filters and replacement cartridges distributed for free to households**
- **Removing communication barriers**
  - ✓ **Communication, education, and outreach materials available in the languages used by the communities impacted the most by lead exposure**
  - ✓ **Information accessible using different methods (e.g., offline municipal facilities such as the library)**
  - ✓ **Partnering with community groups to distribute filters and encourage proper use**
- **Targeting rental properties in the LRP**
  - ✓ **Water filters, replacement cartridges, and education materials to tenants in rental properties**
- **Creating opportunities for community workforce development**
  - ✓ **Partnering with local workforce development organizations in the implementation of the LRP to provide training and employment for community members**
- **Addressing all sources of lead exposure**
  - ✓ **Collaboration with other agencies and groups to holistically manage lead from paint, manufactured goods, and other sources in addition to lead in drinking water infrastructure**

*Based on Human Impact Project's "Achieving Equity in Lead Poisoning Prevention Policy Making: Proceedings from a Consensus Conference", May 2019.

Addressing HE&EJ and All Sources of Lead Exposure

Data from DDPHE indicate that in addition to drinking water, other sources of lead exposure adversely affect Denver communities, including but not limited to leaded paint, spices and household products imported from abroad, and exposure to lead in countries where regulations for lead use are less stringent than those in the United States. Denver Water views the LRP as an opportunity to raise awareness about the risks of lead exposure and to collaborate with public

health experts, medical providers, schools, and community groups to reduce lead exposure from all sources, particularly in HE&EJ households. Some of the agencies and groups that Denver Water has worked with to address lead issues are identified in Table 21.

TABLE 21: DENVER WATER HAS WORKED WITH SEVERAL AGENCIES AND GROUPS TO ADDRESS LEAD IN OUR COMMUNITIES

(Data for discussion and subject to change)

DDPHE Office of Health Equity	Colorado Department of Public Health and Environment	Colorado LEAP Program
DDPHE Office of Prevention Services	Denver Health	

VI. PROGRAM IMPLEMENTATION SCHEDULE

The schedule for the LRP as shown in Table 22 is based on a late 2019 or early 2020 variance approval. Final schedule dates will be secured upon approval of the variance.

TABLE 22: PROGRAM IMPLEMENTATION SCHEDULE
(Data are provisional and subject to change)

Phase I – Public Comment	
Date	**Activity**
July 11, 2019	**Draft Variance** and **Draft Lead Reduction Program Plan** posted by Denver Water for public review and comment
August 7, 2019	End of Denver Water initiated public review and comment period
August 20, 2019	Denver Water submits Final Variance Request, Lead Reduction Program Plan and Treatment Modification Request to EPA and CDPHE
August 21, 2019	Begin EPA public review and comment period
September 20, 2019	End of EPA public review and comment period
Fall of 2019	EPA and CDPHE issue decisions
Phase II — Implementation	

Late 2019	**Within 90 Days of EPA's approval, begin:**
	• Region wide Communication, Outreach and Education including:
	  ○ Tier II Notification to all customers with known, suspected and possible lead service lines
	  ○ Service line inventory map posted
	  ○ Community meetings
	• Distribution of filters
	• Notify 1st year LSLR customers

Early 2020	**Compliance Year Begins** 90 Days after EPA's decision, Lead Reduction Program begins accelerated lead service line replacement and the 15-year program begins.
March 20, 2020	**Begin Corrosion Control Treatment** *CDPHE reserves the right to change this date.
Phase III — Maintenance	
Bi-annually	**Bi-annual progress, compliance and leadership meetings with EPA, CDPHE and Stakeholders:** Review progress report and develop corrective actions for non-compliant element(s). Reports will be available 30 days following the sixth month meeting and the twelfth month meeting of the compliance year.
15 Year Completion Date (TBD)	All lead service lines within service area have been replaced. Replacement cartridges provided for up to six months after the line is replaced.

VII. COSTS AND REGIONAL IMPACTS

[Continuing to review costs and regional impacts with CDPHE. To be provided in next update.]

VIII. GLOSSARY OF DEFINITIONS

Abbreviations, Acronyms, or Terms	Abbreviations, Acronyms, or Terms Descriptions
90th Percentile	Per the LCR, Denver Water collects 106 samples in a sampling round. The 90th percentile refers to the concentration below which 90% of samples are measured for that sampling round. Alternatively, 10% of samples were measured with lead levels above the concentration associated with the 90th percentile.
Adoption	For the purposes of the lead removal filter survey means that the customer is using the lead removal filter for drinking water and cooking. Respondents who indicate that they use bottled water or an alternative lead removal filter verified by Denver Water will count as having adopted the use of a lead removal filter. Respondents who indicate that they do not use the lead removal filter, bottled water, or alternative lead removal filter for cooking will count as not having adopted a lead removal filter.
Alternative Lead Removal Filter	Means a refrigerator filter, faucet filter, or whole house water filtration system.
Contact	Means direct mailing, water bill inserts, door hangers, in person contact, email, social media, phone call or any other communication channels identified in Denver Water's communication, outreach, and education plan. Communications via information posted on the Denver Water website, water bills excluding water bill inserts, or public notices required as a corrective action are excluded from this definition.
Households	Refers to any single family or multi-family unit in Denver Water's service area enrolled in the Filter Program.
LCR Surrogate Sample	Means water samples from 100 properties with a known lead service line enrolled in the Filter Program, where the sample is obtained from an unfiltered tap. The 90th percentile from this sample set will be used to measure potential lead levels at properties that have not adopted the use of a lead removal filter.
LCR Regulatory Sample	Means the collection of lead and copper tap samples for all homes without lead service lines in accordance with Rule 11.26 of the Colorado Primary Drinking Water Regulations, 5 CCR 1002-11.
Lead Service Line (LSL)	Means a water service line, some portion of which contains lead, or a partial galvanized service line downstream of a portion of a service line that currently or in the past contained lead.
LSL Replacement	Lead Service Line Replacement
Non-detect	XXXXXX
Program Year	Means a 12-month period beginning on the start date for the accelerated lead service line replacement program.

Abbreviations, Acronyms, or Terms	Abbreviations, Acronyms, or Terms Descriptions
Public Notice	For the purpose of this variance means a Tier II public notice as described in Rule 11.26 of the Colorado Primary Drinking Water Regulations, 5 CCR 1002-11, with messaging approving by CDPHE.
Start Date	Means 90 calendar days following approval of the variance.
Threshold for Filter Adoption Rate	Refers to the minimum percentage of households that use filters (i.e., filter adoption rate) such that the LRP is considered equivalent to orthophosphate.