

APPENDIX III.B.2 - PRELIMINARY IDENTIFICATION OF LEAD SERVICE LINES

DRAFT FOR PUBLIC COMMENTS

Version 1.0: July 11, 2019

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DRAFT 2- Preliminary Identification of Lead Service Lines

Date: June 28, 2019
March 21, 2019

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Background

The purpose of this Technical Memorandum is to present how the estimate of lead service lines (LSLs) was generated. An inventory of LSLs is needed to determine how many and where to deploy point-of-use filters as well as determine how many LSLs must be replaced each year. The inventory is also used in the Lead Exposure Model to compare the effectiveness of the variance versus OCCT of orthophosphate for public health protection.

This estimate of LSLs in Denver Water’s integrated system is based on data available from several sources available at each tap. No fieldwork has been performed to verify this effort to date. While the logic has been substantiated, and the mapping results appear to match our expectations, the estimate is only as good as the underlying data. No warranty is expressed or implied that these data are correct. These data represent the best available information.

Data Sources

Data used in this effort were aggregated from multiple sources. Data used are summarized in the following table:

Data	Use	Source
OM Current	Data from the field recorded in CCB, reported to O&M. Includes >=2018. Current service line material	CCB
OM Previous	Data from the field recorded in CCB, reported to O&M. Includes >=2018. Previous service line material	CCB
PBCU SERVICE	Service line material from LCR Sample Sites materials survey	Water Quality
ARG Full/Partial	ARG historical data. Goes up to 2018. Records of full and partial service line replacements.	ARG
Year Built	The year the parcel was developed.	Counties
Year Tapped	Year the tap was made to the main.	CCB
Main Install Date	Year the main was constructed.	ARG
Tap Size	Tap size.	CCB
Service Line Size	Service line size. Lead was rarely used for large diameters.	CCB
Distributor Name	Distributor name.	CCB
Service Area	Service area.	CCB
WQ Count	Number of lead samples at the tap.	Water Quality
WQ Max	Highest concentration of lead at the tap.	Water Quality
WQ Avg	Average concentration of lead at the tap.	Water Quality
Tap Cut Date	Full date of the tap cut.	CCB
Aban Install Date	Date the first time a water main was available to tap.	ARG

Data Preparation and Clean-up

1. File contains 335,457 records of taps that are for active, treated water. Provided by Denver Water GIS on 6/17/2019.
2. Created three new fields:
 - “p-value” the probability that the service has some lead materials. For example, a p-value of 0 indicates that tap does not contain lead, and a p-value of 1 indicates that a tap does contain lead. A for the p-values of 0.5, half of them would be expected to contain lead. The p-value will be used to produce a numeric estimate of the total number of LSLs in the Denver Water service area.
 - “Category” the categorical classification of the likelihood of an LSL. This should be used for communicating the results.
 - “Basis” which reports what data was used in the p-value and categorical determination. This is used to supplement our knowledge of the estimate.

3. Populate new “CCB.Service.Line.Type” column with “OM_Current” information. Service line material reflected in this field did not always reflect the material from the main to the house, depending on the main install year.
 - a. Populate column with abbreviated service line material. For example: “Copper meter to main, Lead meter to house” becomes “COPPLEAD”
 - b. For records with Main Install Date before 2010, change to UNKUNK unless they are lead or galvanized. Complete service line replacement during main installs and replacements was not standard practice at this time.
 - c. For records from 2010 to 2016, change to COPPUNK unless they are lead or galvanized. Lines were typically replaced only to the property line during this time period.
 - d. For records 2016 and later, change any COPPUNK and UNKCOPP to COPPCOPP. Service lines were replaced entirely beginning in 2016.
4. Prioritize distributor provided tap dates when possible. These records are presumed to be more accurate than Denver Water records.
 - a. Rename “TappedYear” column “DW_TappedYear”
 - b. Create new “TappedYear” column that populates first with “D_ISA_Tapped_Date” then with “DW_TappedYear”
5. Clean up City of Littleton data. 1971 was the year Littleton became part of the integrated system and some data reflects that rather than the actual tap or main install dates. The dates being removed were selected based on large peaks in the number of records on a specific date close to 1971.
 - a. Filtered by “DistributorName” for “City of Littleton”. Deleted all “TappedYear” and “TappedDate” with “TappedDate” = 01-01-1971. 4,727 records.
 - b. Filtered by “DistributorName” for “City of Littleton”. Deleted all “GISMainInstallYear” and “GISMainInstallDate” with “GISMainInstallDate” = 05-12-1970. 1,821 records.
 - c. Filtered by “DistributorName” for “City of Littleton”. Deleted all “GISAbanMainInstallYear” and “GISAbanMainInstallDate” with “GISAbanMainInstallDate” = 05-12-1970. 48 records.

Estimation Procedure

The estimation procedure can be outlined as follows:

- Identify service lines where there is a record of observation (direct evidence) of the service line material
- Service lines installed before 1950 were required to be lead. However, a portion of those LSLs will have been replaced with non-lead materials.
- In 1971, lead was prohibited as a service line material. Services after this date are considered to not contain any lead.
- Services installed between 1950 and 1971 will have a low rate of lead occurrence. Lead had already fallen out of favor for service lines by the time Denver Water allowed use of other materials in mid-1949.
- Denver Water has some records on full and partial replacements that they have made.
- The model is further refined with data from retail areas in the integrated system and other evidence that is available (e.g. water quality tests).

The detailed procedure follows.

Use CCB OM records first because these records are considered the most accurate by Denver Water. These are completed by field workers on leak repairs and line replacements.

1. Filtered by “CCB.Service.Line.Type” for “COPPLEAD”, “LEADLEAD”, “LEADCOPP”, or “LEADUNK”.

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	29

These records were not considered further in the analysis based on other data. This data field is considered to be known when complete and contains the most reliable records.

2. Filtered by “CCB.Service.Line.Type” for “COPPGALV” and “OM_Previous” to “Lead meter to main, galvanized meter to house”. These are considered to behave as LSL.

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	5

These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

3. Filtered by “CCB.Service.Line.Type” for “COPPCOPP”.

p-value	Category	Basis	No. Records
0	Not lead	Direct Evidence	8,766

These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

Incorporate the pool of LCR monitoring sites which have had a materials survey.

4. Filtered by “PBCU_SERVICE” for “PB”.

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	146

These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

5. Filtered by “PBCU_SERVICE” for “CU”.

p-value	Category	Basis	No. Records
0	Not Lead	Direct Evidence	117

These records were not considered further in the analysis based on other data. This data field is considered to be known when complete.

Use ARG records next because they are direct evidence, but tend to be not as accurate as CCB records because the recordkeeping shifted from ARG to CCB a few years ago and may be dated.

6. Filtered by “ARG_FullPartial” for “Partial”.

p-value	Category	Basis	No. Records
1	Known LSL	Direct Evidence	300

These records were not considered further in the analysis based on other data. This data field is considered to be known when complete, but “CCB.Service.Line.Type” takes precedence. “Full” was not used because the definition of a “full replacement” has changed over time. At times in the past, “full replacement” may have referred to meter to main only.

Incorporate records from retail customers.

7. Filtered by “D_Confirmed_Copper” for “Y”. This column was added to the database to reflect results of the ISA survey conducted by Denver Water. Records were assigned “Y” when distributors verified the line was copper based on visual inspection, detailed records, or distributor policies.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	447

8. Filtered by “DistributorContractDesc” for North Washington, City of Edgewater, and Crestview. These distributors have verified that there are no LSLs in their service areas. North Washington and Crestview first installed water service lines in 1954; the lines were required to be copper. In addition, both areas have completed extensive main replacements recently and did not discover lead services. Edgewater completed potholing of all lines and replaced lead lines in 2014.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	9,898

9. Filtered by “DistributorContractDesc” for City of Glendale and “TappedYear”>1952. Glendale was incorporated in 1952 and has never allowed LSLs.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	260

10. Filtered by “DistributorContractDesc” for Cherry Creek Valley and “TappedYear”>1961. Cherry Creek Valley was formed in 1961 and has never allowed LSLs.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	2,486

11. Filtered by “DistributorContractDesc” for North Pecos and “TappedYear”>=1967. North Pecos was formed in the mid-1960s and has used only copper lines.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	463

12. Filtered by “DistributorContractDesc” for Valley Water District and “TappedYear”>1957. The District was connected in 1957 and has no known lead.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	1,842

13. Filtered by “DistributorContractDesc” for Southgate Water District and “TappedYear”>1961. Southgate formed in 1961 and all records indicate that lines are copper or poly.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	11,356

14. Filtered by “DistributorContractDesc” for Meadowbrook and Willowbrook and “TappedYear” >=1964. Neither district allowed lead from 1964 forward. DW tap dates on older homes in the area were checked against tap permit records by the Districts and found to be matching.

p-value	Category	Basis	No. Records
0	Not Lead	Distributor Evidence	5,242

Identify service lines first installed after lead was prohibited. Records in this category with a water quality sample result indicative of an LSL is considered to be a positive identification.

15. Filtered by “ParcelYearBuilt” for years 1972 to present and “TappedYear” for years 1972 to present.

p-value	Category	Basis	No. Records
0	Not Lead	Post No Lead	108,750

16. Filtered by “ParcelYearBuilt” & “TappedYear” for years 1951 and earlier. Filtered by for those with 3 or more lead samples. Considered an average lead concentration >=5 ppb conclusive evidence of an LSL.

p-value	Category	Basis	No. Records
1	Known LSL	pre 1952, WQ results	638

To this point, the information used is considered as an inventory. 150,745 of the 335,457 services under consideration have been assigned (45%). 1,119 LSLs, 149,627 non-LSLs.

The following steps have two recorded dates <=1951 and 1/2” or 5/8” service line sizes. Services lines in these sizes during this time period are indicative of lead; however, evidence shows that size records are less likely to be updated when lines are replaced.

17. Sort for records with “ParcelYearBuilt” and “TappedYear” <=1951 and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	28,366

18. Sort for records with no “ParcelYearBuilt” and “TappedYear” <=1951, “GISAbanMainInstallYear” <=1951 and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	13

19. Sort for records with no “ParcelYearBuilt” and “TappedYear” <=1951, “GISMainInstallYear” <=1951, no “GISAbanMainInstallYear” and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	163

20. Sort for records with no “TappedYear” and “ParcelYearBuilt” <=1951, “GISAbanMainInstallYear” <=1951 and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	0

21. Sort for records with no “TappedYear” and “ParcelYearBuilt” <=1951, “GISMainInstallYear” <=1951, no “GISAbanMainInstallYear” and “ServiceLineSize” of 1/2 or 5/8.

p-value	Category	Basis	No. Records
0.9	Suspected Lead	5/8 or 1/2 Service, pre 1952	4

The following steps have two recorded dates <=1951. Denver Water required lead service lines until 1951 but does not have records of all service line replacements.

22. Filtered by “ParcelYearBuilt” for <=1951, and “TappedYear” for <=1951.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	34,487

23. Filtered by no “ParcelYearBuilt”, “TappedYear” for <=1951, and “GISAbanMainInstallYear” <=1951. The abandoned main install likely reflects the year the service line was installed, given that it is the date of the original main install.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	12

24. Filtered by no “ParcelYearBuilt”, “TappedYear” for <=1951, “GISMainInstallYear” <=1951, and no “GISAbanMainInstallYear”. For records that do not have an abandoned main install date, the main install year is the original install date.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	138

25. Filtered by no “TappedYear”, “ParcelYearBuilt” for <=1951, and “GISAbanMainInstallYear” <=1951.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	4

26. Filtered by no “TappedYear”, “ParcelYearBuilt” for <=1951, “GISMainInstallYear” <=1951, and no “GISAbanMainInstallYear”.

p-value	Category	Basis	No. Records
0.8	Suspected Lead	Build & Tap Date	29

The following steps have two recorded dates >=1972. Unlike the subset included in the inventory, the following records are missing either “ParcelYearBuilt” or “TappedYear” data and are therefore considered to be less certain.

27. Sort for records with no “ParcelYearBuilt” and “TappedYear” >=1972 and “GISAbanMainInstallYear” >= 1972

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Tap & Main Install Date	72

28. Sort for records with no “ParcelYearBuilt” and “TappedYear” >=1972 and “GISMainInstallYear”>= 1972 with no “GISAbanMainInstallYear”

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Tap & Main Install Date	3,322

29. Sort for records with no “TappedYear” and “ParcelYearBuilt”>=1972 and “GISAbanMainInstallYear” >= 1972

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Build & Main Install Date	20

30. Sort for records with no “TappedYear” and “ParcelYearBuilt”>=1972 and “GISMainInstallYear”>= 1972 with no “GISAbanMainInstallYear”

p-value	Category	Basis	No. Records
0.01	Unlikely Lead	Build & Main Install Date	435

The following steps have either “TappedYear” or “ParcelYearBuilt” information. Since fewer data are available, less certainty is applied than in previous steps.

31. Filtered by “TappedYear”<=1951 and no other dates. Later dates in other date categories indicate uncertainty as to when the current service line was installed.

p-value	Category	Basis	No. Records
0.7	Suspected Lead	Tap Date	277

32. Sort for records with “TappedYear”>=1972 and no “ParcelYearBuilt”. An early parcel build date could indicate that a new tap was installed without completely replacing the service line material.

p-value	Category	Basis	No. Records
0.03	Unlikely Lead	Date and Distributor	2,740

33. Filtered by ParcelYearBuilt<=1951 and no other dates. Later dates in other date categories indicate uncertainty as to when the current service line was installed.

p-value	Category	Basis	No. Records
0.7	Suspected Lead	Date and Distributor	323

The following steps work with the records that are between the last required lead year, 1951, and the first no lead year, 1972. During this time, lead was not commonly used. For this analysis, it is divided into two bins, surrounding the year 1958. 1958 was chosen based on the latest build date associated with a known LSL of 1956.

34. Filtered by “ParcelYearBuilt” for >1951 and <=1958, and “TappedYear” for >1951 and <=1958.

p-value	Category	Basis	No. Records
0.03	Unlikely Lead	Build & Tap Date	28,954

35. Filtered by “ParcelYearBuilt” for >1958, and “TappedYear” for >1958.

p-value	Category	Basis	No. Records
0.02	Unlikely Lead	Build & Tap Date	47,422

36. Filtered by “TappedYear” >1951 and <=1958 and no other dates

p-value	Category	Basis	No. Records
0.05	Unlikely Lead	Date and Distributor	237

37. Filtered by “TappedYear” >1958 and no other dates

p-value	Category	Basis	No. Records
0.04	Unlikely Lead	Date and Distributor	680

38. Unassigned records at this point consist of conflicting date ranges between threshold dates.

p-value	Category	Basis	No. Records
0.5	Possible Lead	Build & Tap Date	37,014

Adjust assigned values by removing the large diameters and main replacements.

39. Filter for “ServiceLineSize” & “TapSize” = 3 or 4 inches with an existing p-value > 0.05. Large diameters are rarely lead; however, LSLs up to 4 inches have been found.

p-value	Category	Basis	No. Records
0.05	Unlikely Lead	Build & Tap Date + Size	420

40. Filter for “ServiceLineSize” & “TapSize” >= 3 inches excluding records above.

p-value	Category	Basis	No. Records
0	Not Lead	Size	1,039

41. Filter for “GISMainInstallYear” after 1/1/2016 with p-value >0.5. Denver Water policy requires any LSL found during a main replacement after 1/1/2016 should be replaced to the first fitting in the building. However, Denver Water records and interviews indicate that the policy was not fully employed.

<https://www.denverwater.org/project-updates/pipe-replacement>

p-value	Category	Basis	No. Records
0.05	Unlikely Lead	Presumed replacement at scrape	133

Results

The results have been mapped by Denver Water GIS and the results are consistent with our expectations based on areas where LSLs are known to occur. The following table summarizes the number of taps in each category:

Service Type	Services
Known LSL	1,118
Suspected LSL	63,597
Possible LSL	36,533
Unlikely LSL	83,543
Not LSL	150,666

An estimate of the total number of lead service lines can be made by summing of all the p-values. This would indicate 75,036 LSLs in the Denver Water service area. However, it should be noted that the p-values assigned were based on consensus and judgment and not actual data. As the data becomes available, this estimate may be refined.

	Basis	LSLs	Non-LSLs	Total
Census	Direct Evidence	480	8,883	9,363
	Distributor Evidence	0	31,994	31,994
	Post No Lead	0	108,750	108,750
	Pre 1952 + WQ	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

Most of the probably LSLs are located in the core Denver Water service area. The Table below summarizes the occurrence of LSLs by service area.

Service Area	LSLs	Total	% LSL
Inside City	63,513	172,499	37%
Littleton	2,439	10,622	23%
SE Englewood	4,493	11,797	38%
Berkeley	382	1,336	29%
Sheridan	253	1,566	16%
Wheat Ridge	2,474	6,310	39%
South Sheridan	102	1,084	9%
Southgate	26	11,644	0.2%
Holly Hills	68	853	0.8%

Next Steps

Denver Water is currently undertaking a field verification effort of potholing as many service lines as possible. These will be used to verify the logic used in the development. This will also supplement existing data to be able to base p-values on actual occurrence data. The estimate will continue to improve as data begins to come in when the ALSLR program begins. Denver Water also continues to refine methods in being able to identify service lines from water quality sampling.

The full-scale lead service line replacement program will include an identification component consisting of a combination of replacement, water quality testing, potholing, and potentially other technologies. Also, customers will be asked to help in identifying lead services lines by providing proof of replacement, pictures of the first fitting in the house, and requesting a lead sample kit.