# Appendix D: INVESTIGATION METHODS

## Contents

## GENERAL INFORMATION AND HIERACHRY OF INVESTIGATION METHODS

On MDE's Service Line (SL) Inventory spreadsheet, the classification (i.e., "Lead", "Galvanized Requiring Replacement", "Lead Status Unknown", or "Non-Lead") of each service line portion will be automatically generated based on three specific pieces of information (i.e., characteristics) related to the current service line: **Material**, **Diameter**, and **Installation Year**. The classification of each portion of the service line will then dictate the classification of entire/overall service line (See Appendix I for more information).

When the **material** of the service line pipe is not known, the **diameter** and/or **installation year** of the service line can potentially help water systems determine the service line material.

- If the **diameter** of the service line is known, water systems could potentially narrow down possible materials of the service line pipe if they have knowledge of specific pipe diameters and their corresponding pipe materials in that local area. Furthermore, pipe diameters greater than 3 inches typically indicate "Non-Lead" SL classification. There have been very few instances of lead service lines as large as 3 inches in diameter in the US; most lead service lines were found to be 2 inches or less in diameter.

- Knowing **when the current service line was installed** can potentially help water systems determine whether the service line material is Lead or Non-Lead, especially if the pipe was installed after Lead was no longer an acceptable service line pipe material per federal, state, and/or local ordinances.

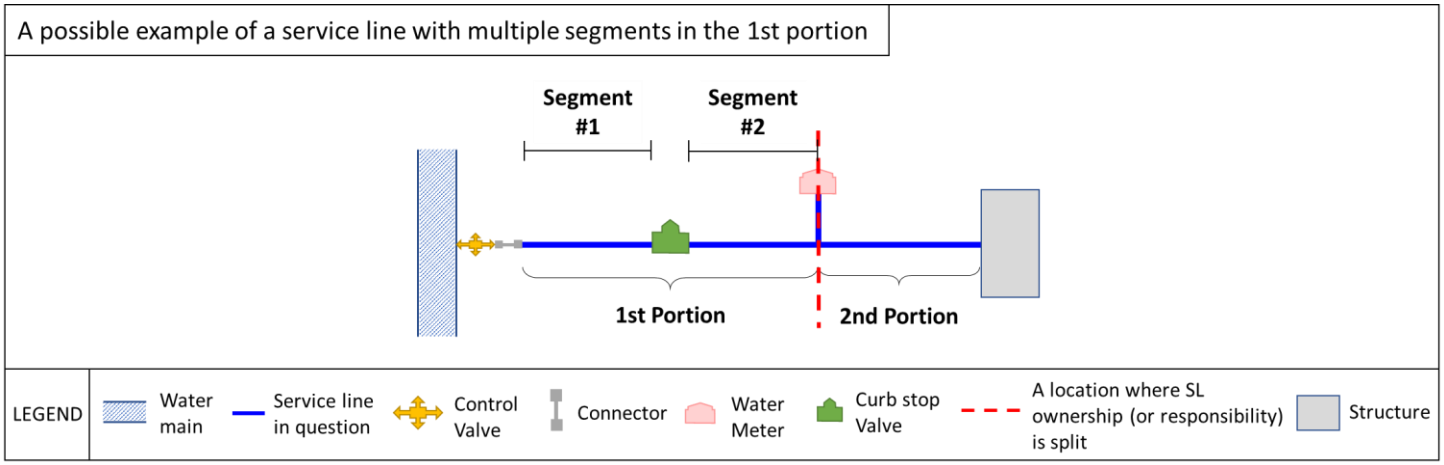
    - Based on the effective date of the federal lead ban pertaining to service lines (i.e., March 30, 1989, in Maryland), any service lines installed on or after this date are classified as a "Non-Lead" SL.

    - Additionally, Maryland regulations (COMAR 09.20.11.10, Water Supply System Materials) filed with the Clerk of the Court of Appeals of Maryland and the Maryland State Library on May 17, 1972, do not include Lead in the list of acceptable service line pipe materials. Since the regulations became effective on the date of filing (as per Article 41, Section 246(b), of the Annotated Code of Maryland (1971 Replacement Volume)), **any service lines installed on or after May 17, 1972** (i.e., the effective date), are **classified as a "Non-Lead" SL**. See Appendix E for a copy of 1972 COMAR 09.20.11.10 with relevant title/section highlighted.

    - If there was a local ordinance indicating that lead was not an acceptable service line pipe material and the local ordinance was in effect prior to May 17, 1972 (i.e., the effective date of Maryland regulations that excluded lead from the list of acceptable service line pipe materials), any service lines installed prior to May 17, 1972, are classified as a "Non-Lead" SL. A copy of the local ordinance will need to be provided to MDE.

Note that for each portion of a service line, there may be one or more segments that comprise that portion. A segment is defined as a piece of service line pipe with each end connected to a fitting, valve, and/or meter. For example, in the diagram below, if the first portion of the service line contains a valve at the midpoint, then there would be two segments for that first portion of the service line: Segment #1 is from the water main to the valve and Segment #2 is from the valve to the property line or location where ownership of service line is split. Water systems will need to determine the characteristics for each individual segment using one or more MDE-approved investigation methods (see

Table D1) in order to determine the characteristics of the entire portion of the service line that is comprised of those individual segments.




If a portion of a service line contains **multiple segments** and the individual characteristics are not the same for all segments that comprise the portion (e.g., material of segment 1 is copper and material of segment 2 is lead), then:

- For **material**:
  - If any segment is lead, then select either "Lead" or "Multiple (including Lead) Pipe Materials (Please provide details in Comments)" as the material of that portion of the service line AND provide details in comments if applicable;
  - If any segment is galvanized iron or galvanized steel (and none of the segments is "Lead"), then record "Galvanized (Iron or Steel)" or "Multiple Non-Lead (including Galvanized) Pipe Materials (Please provide details in Comments)" as the material of that portion of the service line AND provide details in comments if applicable;
  - If all segments are non-lead (and none of the segments is galvanized), then record the appropriate non-lead material option (e.g., Non-Lead Non-Galvanized, Plastic, Multiple Non-Lead Pipe Materials, etc.) as the material of that portion of the service line AND provide details in comments if applicable;
  - If any segment has unknown material (and none of the segments is "Lead"), then record "Don't Know or Unknown" as the material of that portion of the service line.
- For **diameter:**
  - If the diameters of all segments are not the same, then the smallest of the diameters should be recorded on the spreadsheet as the diameter of that portion of the service line;
  - If the diameter of any segment is not known, then record "Don't Know or Unknown" as the diameter for that portion of the service line.
- For **installation year:**
  - If the installation years of all segments are not the same, then record in the spreadsheet the earliest installation year for that portion of the service line;
  - If the installation years of any segment is not known, then record "Don't Know or Unknown" as the installation year for that portion of the service line.

In order for water systems to verify these three characteristics (i.e., material, diameter, and installation year) of the current service line, one or more investigation methods will need to be conducted by the water systems. Listed in Table D1 (on Page 3) are the MDE-approved investigation methods that water systems may use to verify the material, diameter, and/or installation year of the current service line pipes.

**Table D1. MDE-Approved investigation methods for the three characteristics (i.e., Material, Diameter, and Installation Year) of a service line, listed in in hierarchical order according to accuracy as viewed by MDE**

| Investigation Method - Material | Investigation Method - Diameter | Investigation Method – Installation Year |
|---|---|---|
| 1. Field Investigation – Visual Inspection of Exposed Service Line Pipe (with or without Excavation)<br>2. Field Investigation – Non-Exposed Service Line Pipe Inspection<br>3. Records Review<br>4. Analytics/Predictive Methods | 1. Field Investigation – Visual Inspection of Exposed Service Line Pipe (with or without Excavation)<br>2. Field Investigation – Non-Exposed Service Line Pipe Inspection<br>3. Records Review | 1. Records Review |

The methods above are listed in hierarchical order according to accuracy as viewed by MDE and are specific to each of the three service line pipe characteristics above. Field investigation methods and Records Review can be used to verify each of the three pipe characteristics (i.e., material, diameter, and installation year) needed for classification of the current service line. Water systems are required to conduct a records review of all service lines in their water distribution system regardless of ownership.

For the purpose of the inventory, water systems may use Analytics/Predictive methods to obtain a prediction of the service line material. Currently, Interpolation, Statistical Analysis, and Predictive Modeling using Machine Learning are all types of Analytics/Predictive methods approved by MDE; other Analytics/Predictive methods will need to be approved by MDE prior to use by water systems. Water systems may use Analytics/Predictive methods to make the prediction of service line material and/or turn these predictions into the actual material **only after** satisfying all requirements set forth by MDE (see Analytics/Predictive Methods section below for more details). For instance, in order to use Interpolation or Statistical Analysis to make predictions of material of all service lines within a homogenous neighborhood and/or within a statistical group, the water system will need to verify a certain number of the service lines within the neighborhood or the statistical group using certain MDE-approved investigation methods. For Predictive Modeling using Machine Learning, water systems may turn the prediction into the actual material only after a threshold (i.e., a point at which water systems consider service lines to be lead, non-lead, or a specific material) is set by the water systems in collaboration with their predictive modeling software providers/contractors; however, water systems must provide a justification that thoroughly explains and defends the threshold to MDE. For any of the Analytics/Predictive methods, a full report detailing the methodology will also need to be provided to MDE, including MDE's electronic form. See the "ANALYTICS/PREDICTIVE METHODS" section for more details on MDE's requirements relating to these methods.

Each of the service line's characteristics should be considered as independent pieces of information to be verified by the water systems using one (or more) investigation method(s) listed in Table D1 for that particular characteristic. For instance, a visual inspection of the exposed service line pipe (with or without excavation) can be used to verify material and diameter of the service line, but not the installation year; and, a metal detector can be used to verify only the material of the service line, but not the diameter or the installation year. In certain cases, however, the material may be determined based on diameter and/or installation year. For instance, service line pipe installation date on or after May 17, 1972, and/or pipe diameter of greater than 3 inches indicate that the service line material is non-lead.

Listed in Table D2 (on Page 4) are the MDE-approved bases of determination that water systems may use to determine the material, diameter, and/or installation year of the current service line pipes. These bases of determination are listed

in the order of the ranking of MDE-approved investigation methods (as seen Table D1) that water systems may use to verify the material, diameter, and/or installation year of the current service line pipes.

**Table D2. MDE-Approved bases of determination for the three characteristics (i.e., Material, Diameter, and Installation Year) of a service line, listed in hierarchical order according to accuracy as viewed by MDE**

| Basis of Determination - Material | Basis of Determination - Diameter | Basis of Determination - Installation Year |
|---|---|---|
| 1. Pipe material obtained directly from records AND Field Investigation via Visual Inspection of Exposed Service Line Pipe (with or without Excavation) -- *Applicable only if material from both records and field investigation matches (for a particular segment or portion)*<br>2. Pipe material obtained directly from ONLY Field Investigation via Visual Inspection of Exposed Service Line Pipe (with or without Excavation)<br>3. Pipe material obtained directly from records AND Field Investigation via Non-Exposed Service Line Pipe Inspection -- *Applicable only if material from both records and field investigation matches (for a particular segment or portion)*<br>4. Pipe material obtained directly from ONLY Field Investigation via Non-Exposed Service Line Pipe Inspection<br>5. Pipe material obtained directly from records ONLY<br>6. Pipe material obtained directly from records ONLY (but Analytics/Predictive Method also performed to obtain a prediction)<br>7. Pipe material determined based on pipe diameter greater than 3 inches<br>8. Pipe material determined based on installation date on or after May 17, 1972 (Maryland's regulations pertaining to acceptable service line materials)<br>9. Pipe material determined based on installation date on or after local ordinance in effect prior to May 17, 1972<br>10. Prediction of material from Analytics/Predictive Method ONLY (i.e., no records or field investigations)<br>11. Other Basis of Material Determination pre-approved by MDE | 1. Pipe diameter obtained directly from records AND Field Investigation via Visual Inspection of Exposed Service Line Pipe (with or without Excavation) -- *Applicable only if diameter from both records and field investigation matches (for a particular segment or portion)*<br>2. Pipe diameter obtained directly from ONLY Field Investigation via Visual Inspection of Exposed Service Line Pipe (with or without Excavation)<br>3. Pipe diameter obtained directly from records AND Field Investigation via Non-Exposed Service Line Pipe Inspection -- *Applicable only if diameter from both records and field investigation matches (for a particular segment or portion)*<br>4. Pipe diameter obtained directly from ONLY Field Investigation via Non-Exposed Service Line Pipe Inspection<br>5. Pipe diameter obtained directly from records ONLY<br>6. Pipe diameter determined to be greater than 3 inches based on pipe diameter of 2nd portion being greater than 3 inches -- *Applicable only for 1st portion of the service line pipe*<br>7. Other Basis of Diameter Determination pre-approved by MDE | 1. Installation year obtained directly from records<br>2. Installation year based on year the water system was built – This option is applicable only if (a) the water system was built on or after May 17, 1972 AND (b) if structure was built prior to May 17, 1972, no reuse of existing pipe from well to structure<br>2.1. Installation year based on year the water system was built – This option is applicable only if (a) the water system was built on or after the date on which local ordinance (prior to May 17, 1972) became effective, AND (b) if structure was built prior to the date on which local ordinance (prior to May 17, 1972) became effective, no reuse of existing pipe from well to structure<br>3. Installation year based on year the structure was built – This option is applicable only if the structure was built on or after May 17, 1972<br>3.1. Installation year based on year the structure was built – This option is applicable only if the structure was built on or after the date on which local ordinance (prior to May 17, 1972) became effective<br>4. Other Basis of Installation Year Determination pre-approved by MDE |

The inventory spreadsheet should be used by water systems to document their basis of determination, investigation methods, and findings. Since the information related to the service line may change over time, the inventory should be updated accordingly. For instance, since water systems must complete a records review of all their service lines by the initial inventory deadline (i.e., October 16, 2024), the spreadsheet should be initially filled out with findings from the records review (as applicable). If records do not exist or existing records are not useful in the determination of the current service line's characteristics (i.e., material, diameter, and installation year), then other investigation method(s) must be conducted in order to determine unknown characteristics of the service lines. The basis of determination should then be updated based on the investigation methods used and the corresponding findings.

To determine the material and/or diameter of a service line, water systems may need to conduct more than one investigation method, which may or may not occur at the same time. The inventory spreadsheet should be used by water systems to document and track the investigation methods and their findings. In other words, water systems should continually update the inventory spreadsheet to reflect the information found at that time.

The general guidelines described below should be followed when completing the inventory spreadsheet.

- The water system should record the following information on the inventory spreadsheet for a service line:
    - The characteristics (i.e., material, diameter, and/or installation year) based on the 'Basis of Determination' that is **ranked the highest** in MDE's basis of determination hierarchy (see Table D2)
    - The basis of determination for each of the characteristics (as applicable).
    - Details associated with the selected basis of determination.

- When new information is discovered and/or plumbing changes occur for a service line, the inventory spreadsheet should be updated accordingly based on the information that has changed. This may include, but not limited to:
    - Updating the characteristics (i.e., material, diameter, and/or installation year).
    - Updating the basis of determination.
    - Deleting/removing the details/information that is/are no longer relevant and/or associated with the updated basis of determination.
    - Adding and/or updating the details/information that is/are relevant and/or associated with the updated basis of determination.

**Additional important notes when more than one investigation method is conducted:**

1. When **an Analytics/Predictive method** is conducted **in addition to Records Review** to obtain the **material** of a service line, on the inventory spreadsheet for that service line, the water system should:
    - Select the material obtained from the Records Review.
    - Select "Pipe material obtained directly from records ONLY (but Analytics/Predictive Method also performed to obtain a prediction)" as the basis of material determination.
    - Under the "Records Review" section, select the type of records used to obtain pipe material.
    - Under the "Analytics/Predictive method" section, select the specific analytics/predictive method used and the prediction made, and, when applicable, provide the percentage likelihood of service line material being Lead. This information should be provided regardless of whether the material prediction aligns with the material found from records.

    In a situation where an Analytics/Predictive method provides a material prediction that does **not** align with the pipe material found through Records Review, the water system should perform the following:

- Conduct a **field investigation of the service line to confirm the material of the service line pipe**
  - Water systems should prioritize the field investigation of service lines that Records Review indicate "Lead" as the pipe material or if Analytics/Predictive method predicts "Likely Lead" as the pipe material.
- Once the field investigation is complete, update the inventory spreadsheet accordingly based on the findings of the field investigation as this method **ranked higher** than both Records Review and Analytics/Predictive method in the method hierarchy. This update to the inventory spreadsheet will include, but is not limited to, updating the basis of material determination and its associated details/information.

2. When **a Non-Exposed Service Line Pipe Inspection** is conducted to obtain a **diameter** of a service line **in addition to Records Review** and the diameter found from the Non-Exposed Service Line Pipe Inspection does **not** match the diameter from Records Review (e.g., Records Review (performed initially) indicated that the diameter of the service line is 1 ½ inches, but a Non-Exposed Service Line Pipe Inspection using Ground-Penetrating Radar (GPR) (performed later) revealed the diameter to be 2 ½ inches), the water system should perform the following:
   - Update the inventory spreadsheet with the diameter found through the Non-Exposed Service Line Pipe Inspection since it is ranked higher than Records Review.
   - Conduct a **field investigation of the service line to confirm the material of the service line pipe** only if Non-Exposed Service Line Pipe Inspection indicates diameter of greater than 3 inches and Records Review indicates diameter of less than or equal to 3 inches.
     - Note: This is because there is a discrepancy in the diameter of the same service line, the material of the service line needs to be confirmed through a field investigation to ensure accuracy.
   - Once the field investigation to verify pipe material is complete, update the inventory spreadsheet accordingly based on the findings of the field investigation as this method ranked the **highest** in MDE's method hierarchy.

3. In a situation where **both** "Field Investigation - Non-Exposed Service Line Pipe Inspection" (e.g., metal detector, GPR, etc.) **and** "Field Investigation - Visual Inspection of Exposed Service Line Pipe (with or without Excavation)" were conducted on the same service line, and the material and/or diameter is/are not matching between the two methods, then, on the inventory spreadsheet for that service line, the water system should:
   - Select the material (and/or diameter) obtained from the visual inspection of exposed pipe.
   - Select "Pipe material obtained directly from ONLY Field Investigation via Visual Inspection of Exposed Service Line Pipe (with or without Excavation)" as the basis of material determination.

   The water system should also:
   - Re-evaluate the instrument used for non-exposed pipe inspection (e.g., metal detector, GPR, etc.).

   Note that MDE may not accept the findings of the pipe characteristics for any service lines that were inspected using that particular instrument used for non-exposed pipe inspection (e.g., metal detector, GPR, etc.) that resulted in the discrepancies.

**It is important to note that the inventory spreadsheet should be kept up-to-date as new information is discovered and/or plumbing changes occur.** One such example of the latter situation is **when a service line is replaced with a new service line pipe**. The inventory spreadsheet should be updated to reflect information related to the new service line pipe including the three characteristics (i.e., material, diameter, and/or installation year). Any other related information impacted by this plumbing change should be updated and/or documented on the inventory spreadsheet as well. Furthermore, information related to investigation methods from the previous service line pipe should be deleted/removed from the inventory spreadsheet since this information would no longer be relevant to the new service line pipe.

# RECORDS REVIEW

## *TYPES OF RECORDS*

### *Plumbing Permits*

**Service line verification:** Material, Diameter, and/or Installation Year

Permits may be found in county building departments or municipal clerks' offices. Permit files/pre-1940 documents are especially important. (The use of LSLs in many communities was discontinued after approximately 1940). Permits may exist for replacing lead service lines.

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### *Local Building and Plumbing Codes, Local Ordinances, Public Works Standard*

**Service line verification:** Material

Local plumbing codes and/or local ordinances indicating the material(s) of the service line based on the installation date and/or year. Possible locations for construction and plumbing codes include:

- Municipal building permit/code enforcement department
- Agency overseeing state plumbing codes
- Local governing body (e.g., city or town council)

**This method is sufficient if relevant section(s) of the plumbing codes, local ordinances, or public works standard is provided to MDE.**

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### *Federal/State Plumbing Codes*

**Service line verification:** Material

Federal/State plumbing codes indicating the material(s) of the service line based on the installation date and/or year.

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### *Construction Contracts*

**Service line verification:** Material, Diameter, and/or Installation Year

Construction contracts indicating the material(s) and/or size(s) of the service line and when the service line was installed.

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### *Property Records on File with County – Not SDAT*

**Service line verification:** Material, Diameter, and/or Installation Year

Property records on file with the county showing service line material, diameter, and/or installation date and/or year. Note that records obtained from the Maryland State Department of Assessments & Taxation (SDAT) are not included under this type of record. While SDAT records contain the year built of a structure (e.g., home, water system facility,

etc.), they do not contain the year a service line was installed. However, SDAT records can still be used in a situation where the year built of the structure was used as the installation year of the service line. In other words, the installation year of the service line was not obtained directly from the list of allowable records listed in this Appendix, but was instead based on the year that the structure was built. When this is the case, the water system will need to select an appropriate Basis of Installation Year Determination (i.e., "Installation year based on the year the water system was built" or "Installation year based on the year the structure was built") on the inventory spreadsheet. The water system will also need to provide the description of source(s) from which the year built was obtained, which can include SDAT records.

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## *Distribution System Maps and Drawings*

**Service line verification:** Material, Diameter, and/or Installation Year

Maps and drawings of the water distribution system that indicate service line and connection information including materials, line sizes (length and/or diameter), and installation dates.

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## *Capital Improvement Plans and/or Master Water & Sewer Plans*

**Service line verification:** Material, Diameter, and/or Installation Year

Information regarding planned or executed improvements to portions of the water distribution system may be provided by existing and/or historical capital improvements or master plans.

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## *Tap/Tie/Drill/Service Cards*

**Service line verification:** Material, Diameter, and/or Installation Year

Historical records on service connection installation may be in the form of tap/tie/service cards (also called drill records), which are recorded when a service line is tapped into the water main and connected to an individual home or building/structure. They are often handwritten index cards that may contain the installation date, pipe diameter, and pipe material.

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## *Records of Maintenance/Inspection Performed by Water System Personnel or Contractors*

**Service line verification:** Material, Diameter, and/or Installation Year

Maintenance records (excluding meter-related maintenance) that document former/current/replacement materials and/or replacement materials of the service line that were identified during maintenance activities, such as water main repair/work or service line repair/work. Maintenance records include repair/replacement work orders. These activities may include both routine and non-routine maintenance such as cross-connection inspections, responses/investigation to customer complaints, or inspections to locate leaks, etc. Water systems may store this information electronically, for example, using a computerized maintenance management system (CMMS).

Maintenance records often identify such information as 1) existing materials; 2) replacement materials; 3) date of event; and 4) particular site conditions of note. Lead Service Lines may specifically be identified and encountered during maintenance activities.

## *Meter Installation/Maintenance/Inspection and/or Reading Records Performed by Water System Personnel or Contractors*

**Service line verification:** Material, Diameter, and/or Installation Year

Meter installation, maintenance and/or reading records that indicate materials and/or diameters of the service lines. These records could also provide information on the type and age of construction.

Sources of information include inspections to investigate meter issues. Water systems may store this information electronically, for example, using a computerized maintenance management system (CMMS).

Meter size is also an important element as it may be used as the basis for differentiating among structure types, i.e. single-family residences, multi-family residences, and non-residential buildings/structures.

Service line pipe may be visible from meter pit/vault.

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## *Utility Standard Operating Procedures (SOPs)*

**Service line verification:** Material and Diameter

Current and historical standard operating procedures (SOPs), including Operation and Maintenance Manuals (O&M), of the water system/utility indicating allowable materials to be used during construction and/or repair of distribution system service lines as well as material installed, method for replacement, and replacement materials to be used. These SOPs could also provide information on the water mains and connections.

When reviewing historical SOPs, water systems should review past procedures for connecting a new building/structure and if connection to an old service line was allowed. If it was allowed, this could indicate that some newer construction could be potentially connected to an LSL.

**This method is sufficient if a copy of SOPs manual is provided to MDE with the relevant section(s) of the SOPs clearly indicated.**

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## *Statements from Water System Senior Personnel and Retirees*

**Service line verification:** Not Considered for Verification Purposes (i.e., it is for information gathering purposes only)

Water system personnel or other agency staff experienced in the operation, maintenance, or material usages within the water distribution system and/or home plumbing environments. These personnel will often have first-hand knowledge regarding distribution system materials which can supplement incomplete records or provide basic data when information is otherwise lacking.

This method is currently not considered for service line verification purposes (i.e., it is for information gathering purposes only) by MDE.

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### *Interviews with Plumbers, Building Inspectors, Pipe Suppliers, Local Contractors, and/or Developers who have Specific Knowledge of the Site/Area*

**Service line verification:** Not Considered for Verification Purposes (i.e., it is for information gathering purposes only)

These individuals may have first-hand knowledge of materials of construction for sections of the distribution system and/or service area, of materials supplied during a specific time period or to a specific development, and/or of materials used for original and remodeled homes.

This information can be used to supplement incomplete records or provide basic data for water systems lacking records.

This method is currently not considered for service line verification purposes (i.e., it is for information gathering purposes only) by MDE.

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### *Community Survey*

*Applicable only to Customer-owned portion of the service line*

**Service line verification:** Not Considered for Verification Purposes (i.e., it is for information gathering purposes only)

A community survey may be helpful in identifying service line materials. A water system/utility could perform this survey using a standard questionnaire.

This method is currently not considered for service line verification purposes (i.e., it is for information gathering purposes only) by MDE.

**However**, photographs provided by customers as part of a community survey can also be used as a visual inspection technique performed at one of the locations required under "Visual Inspection of Exposed Service Line Pipe (with or without Excavation)" of the field investigation method. See "Visual Inspection of Exposed Service Line Pipe (with or without Excavation)" under Field Investigation Methods for more details.

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### *Other Record(s)*

**Service line verification:** Not Considered for Verification Purposes (i.e., it is for information gathering purposes only), unless pre-approved by MDE.

Any other data/records/sources (historic or current) not captured in other types of records listed above.

These data/records/sources must be pre-approved by MDE on a case-by-case basis; otherwise, they will not be considered for service line verification purposes (i.e., it is for information gathering purposes only).

## ANALYTICS/PREDICTIVE METHODS

### *Interpolation*

**Service line verification:** Material (Prediction)

Interpolation is a method of using verified service lines located in a neighborhood within the service area of a water system to assume/predict that other service lines in that neighborhood are the same material based on similar characteristics/attributes within that neighborhood.

The water system service area/distribution system may be characterized by the age of various areas/regions. Housing developments within identifiable areas/regions may be assumed to have been constructed using plumbing codes and typical practices of that time. These areas and neighborhoods having common characteristics are referred to as homogeneous neighborhoods. Homogeneous neighborhoods typically have two or more common characteristics, including date of installation of service lines, contractor used, structures served (e.g., houses), or some other characteristics.

For the purpose of the service line inventory, the following are parameters for a homogeneous neighborhood as required by MDE:

- Constructed prior to May 17, 1972*, with all service lines installed prior to this date.
  ** May 17, 1972, is the effective date on which lead pipe was not included as one of the acceptable materials to be used for water service pipes under Maryland law (COMAR 09.20.11.10A). The date of a local ordinance that did not include lead as an acceptable material for water service lines may be used in substitution for this date.*
- Fewer than 1,500 service connections.
- Low expectation of lead service lines.
- Multiple* common or similar factors and/or characteristics, including construction year(s) and/or installation year(s) of service lines, location, structures served (e.g., houses), contractor/developer, etc.
  ** MDE will evaluate, on a case-by-case basis, the factors/characteristics selected by a water system to define a homogeneous neighborhood; however, <u>two or more</u> similar factors are typically required.*
- If construction contracts are used:
  - The same contractor(s)/developer(s) for the entire homogeneous neighborhood.
  - No information on the specific service line material(s)* in the contract.
    ** Interpolation is <u>not</u> needed when the material of the service line(s) can be directly obtained from the construction contracts/documents (The material(s) of service lines indicated on such contracts/documents can be entered directly on the MDE LCRR Service Line Inventory Spreadsheet).*
  - If there are records of individual service lines, the material of any originally installed service lines must be of the same material*.
    **If records indicate multiple non-lead materials for originally installed service lines, this may be acceptable on a case-by-case basis if there is an indication of multiple non-lead materials in a homogeneous neighborhood. Water systems may request an evaluation by MDE for consideration.*

*Important Note: The use of this method to predict the material of the service lines requires MDE pre-approval and is acceptable on a case-by-case basis.*

Once a homogeneous neighborhood is defined by a water system and pre-approved by MDE, the water system may use the interpolation method by meeting the following requirements:

- The interpolation method may be performed on both/either the utility-owned portions of the service lines (i.e., 1st portions, e.g., from water main to property line, etc.) and the customer-owned portions of the service lines (i.e., 2nd portions, e.g., from property line to building inlet)
- Service lines are grouped* according to ownership:
  - All utility-owned portions of the service lines will be in one group; and
  - All customer-owned portions of the service line will be in another group.
    ** NOTE: Splitting the service lines into two groups may provide water systems with a potential benefit of common locations for field investigations of the randomly select service lines (since some randomly*

*selected service lines may be at the same location) if interpolation of the two groups is performed at the same time.*

- The interpolation method will need to be performed on the two groups separately.
- Water systems will need to identify all service lines with unknown material(s) (i.e., "Lead Status Unknown" *) within each group (i.e., pool of "Lead Status Unknown" service lines).

  **"Lead Status Unknown" service lines are those service lines without records and/or previous field investigation indicating materials. Service lines with records and/or previous field investigations indicating material(s) of those service lines should not be included in the pool of "Lead Status Unknown" service lines, because the material of the service line is already known.*
- A minimum of 20%* of the pool of "Lead Status Unknown" service lines will need to be randomly selected** for field investigation within each group.

  **If the calculated number of service lines to be field investigated (i.e., 20% of "Lead Status Unknown" service lines) is not a whole number, round up to the nearest whole number.*

  ***To randomly select service lines and minimize bias in the selection, water systems can use tools, such as a random number generator, to randomly assign every service line a number and then randomly select from the numbers. See "Instructions on Generating a Uniformly Random Set of Service Lines for Field Verification using Microsoft Excel" for more details.*
- All (i.e., 100%) of the findings from the randomly selected "Lead Status Unknown" service lines in that group must be the same* material (e.g., copper, PVC, etc.) in order to interpolate the material for the remaining service lines with unknown material(s) within that group.

  **If there is an indication of multiple non-lead materials in a homogeneous neighborhood prior to the required field investigations, water systems may request an evaluation by MDE on a case-by-case basis for consideration.*
- If any lead or galvanized requiring replacement (GRR)* service lines are found in a group within a homogeneous neighborhood, the group cannot be interpolated, and:
  - All (100%) "Lead Status Unknown" service lines in that group will need to be field verified or verified by another MDE-approved method; and
  - The MDE service line inventory spreadsheet must be updated with those service lines as "Lead Status Unknown" until such field verification is completed.

  **GRR is the 2nd portion service line pipe made of galvanized iron or steel that is downstream of a lead service line in the 1st portion*
- If, in the future, any lead or GRR service lines are found in a group within a homogeneous neighborhood that was previously investigated using interpolation:
  - All (100%) materials of the service lines in that particular group in that particular homogeneous neighborhood will need to be changed to "Lead Status Unknown" in the MDE service line inventory form; and
  - A different investigation method (other than interpolation) will need to be conducted to determine the material of these service lines in that group.

To assure the quality of the prediction, water systems will need to provide documentation of the methodology used for interpolation, including the criteria used to determine homogeneous neighborhood to MDE. In addition, water systems will need to submit a report to MDE and complete an electronic form provided by MDE. On this electronic form, water systems must indicate which service lines are included in each homogeneous neighborhood, as well as which service lines were randomly selected for field investigations.

MDE retains the authority to reject the results of this method if the method does not conform to the requirements. Water systems may also be required to, at the request of MDE, conduct additional field investigations, including possible excavation, of these service lines, particularly those that were predicted to be "Non-Lead".

See example here: Example of Using Interpolation for a Pre-Approved Homogeneous Neighborhood

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## *Predictive Modeling using Statistical Analysis ONLY (i.e., without Machine Learning)*

**Service line verification:** Material (Prediction)

Inferential Statistical Analysis is a statistical approach used to draw conclusions, make predictions, or generalize findings about a population based on a sample of data. When using this method properly, results are statistically significant.

This method can be used to assume/predict the material of all the service lines in a certain group as "Lead" or "Non-Lead" based on all the verified service lines being the same material in that group. The groups are defined based on similar characteristics/attributes within that group including date of installation, contractor used, structures served (e.g., houses), or some other characteristics.

The use of this method to predict the material of the service lines is acceptable on a case-by-case basis as long as **all** of the following conditions are met:

- Service lines are utility-owned (e.g., from water main to property line, etc.).
- Service lines are grouped into *several subgroups* based on common/relevant characteristics/attributes, such as date of installation, contractor used, type of structures served (e.g., houses), or some other characteristics/attributes.
- There is a low expectation of lead in the *subgroup* where statistical analysis will be conducted.
- A confidence level of at least 95% and a margin of error of no more than 5% are used (NOTE: Depending on how subgroups are defined, a higher confidence level and a lower margin of error may be required by MDE).
- If any lead or galvanized requiring replacement (GRR)* service lines are found within a subgroup, then statistical analysis cannot be used, and:
    - All service lines in that subgroup will need to be field verified or verified by another MDE-approved method.
    - The MDE service line inventory spreadsheet must be updated with those service lines as "Lead Status Unknown" until such field verification is completed.

  **GRR is the 2nd portion service line pipe made of galvanized iron or steel that is downstream of a lead service line in the 1st portion.*
- If, in the future, any lead or GRR service lines are found in a group within a subgroup that was previously investigated using statistical analysis:
    - All materials of the service lines in that subgroup will need to be changed to "Lead Status Unknown" in the MDE service line inventory form.
    - A different investigation method (other than statistical analysis) will need to be conducted to determine the material of these service lines in that subgroup.

Since the results from this method are dependent upon how well the subgroups/statistical populations are defined, water systems will need to provide information to MDE for review and pre-approval, including a report detailing the criteria and justification used to define the subgroups. Once water systems receive approval from MDE, they can then

proceed with this method. When the inventory spreadsheet is submitted to MDE, water systems will need to provide a final summary report to MDE with a detailed description of the subgroups/statistical populations selected, a list of service lines that had a field investigation performed, the confidence level achieved, and the margin of error used.

In addition to the final summary report mentioned above, water systems must also submit information regarding their subgroups on an electronic form provided by MDE. Water systems must indicate which service lines are included in each subgroup as well as which service lines within those subgroups were field validated.

MDE retains the authority to reject the results of this method if the method does not conform to the requirements. Water systems may also be required to, at the request of MDE, conduct additional field investigations, including possible excavation, of these service lines, particularly those that were predicted to be "Non-Lead".

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## *Predictive Modeling using Machine Learning*

**Service line verification:** Material (Prediction)

This method uses statistics to build a representation of the data and predict new output values from existing data. Predictive modeling using machine learning may include geospatial modeling, which uses spatial patterns and proximity to known lead service line(s) to make predictions for sites with unknown materials. Output quality and accuracy rely on data inputs.

When using this method, water systems should thoroughly research and carefully evaluate the products and services offered by the predictive modeling software providers/contractors before selecting one. Water systems will then need to work with their selected providers/contractors on getting predictions of service line materials based on the data inputs, which may include information from records, field investigations, and other necessary information as determined by the predictive modeling company. Once the prediction is obtained, the water system will report the data to MDE using MDE's service line inventory spreadsheet. When the spreadsheet is submitted to MDE, the water system will also need to provide a summary report with a description of the model used, process used, and data inputs specific to their water system.

This method will assign, for each service line, a numerical probability (i.e., prediction) between 0 and 1 (i.e., 0% and 100% likelihood) representing the probability that the service line is either "Lead" or "Non-Lead." Depending on how "Lead" is defined in the model, "Lead" may include both Lead and Galvanized pipe materials. The water system may turn the prediction (i.e., "Likely Non-Lead") obtained from this method into the actual material (i.e., "Non-Lead") on the inventory spreadsheet only after a threshold (i.e., a point at which water systems consider service lines to be lead, non-lead, or a specific material) is set by the water systems in collaboration with their predictive modeling software providers/contractors. However, the water system will need to provide justification of the selected threshold to MDE in addition to the summary report mentioned above. In the threshold justification, the water system must thoroughly explain and defend the threshold that was set to determine the material of the service line. It is important to note that MDE retains the authority to reject the threshold.

Water systems may also be required to, at the request of MDE, conduct additional field investigations, including possible excavation, of these service lines, particularly those that were predicted to be "Non-Lead".

In addition to the report mentioned above, water systems must also submit information regarding their prediction results on MDE's electronic form, including a list of service lines that had materials obtained through prediction as well as service lines that were field validated by visual inspection.

Note that if, by the time the initial inventory is due and/or submitted to MDE, no threshold has been set by the water system, the prediction (i.e., "Likely Lead" or "Likely Non-Lead") should be selected as the material of the service line on the inventory spreadsheet and will be considered equivalent to "Don't Know or Unknown" service line material. If the other characteristics of the service line (i.e., pipe diameter and installation year) are not known, then the service line would be automatically classified as "Lead Status Unknown" on the inventory spreadsheet. However, if water systems indicated that the pipe diameter is greater than three inches and/or the pipe was installed after the lead ban in plumbing (Local, State, or Federal), then the service line would be automatically classified as "Non-Lead" on the inventory spreadsheet as long as water systems demonstrated that the service line pipe was never downstream from a lead service line pipe.

If, in the future, any service lines that were predicted to be "Non-Lead" are found to be lead or galvanized requiring replacement (GRR):

- The material of these service lines will need to be updated on the MDE service line inventory form;
- The prediction model will need to be updated, re-run, and re-evaluated to obtain an updated prediction of service line materials for all of the service lines that had their materials previously predicted by the model; and
- The updated prediction of service line materials will need to be updated on the MDE service line inventory form.

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## *Special Water Sampling for Lead (not for compliance purposes)*

**Service line verification:** Not Considered for Verification Purposes (i.e., it is for information gathering purposes only)

Water sampling may be used to gather additional information on the possible presence of lead in the service line. These sampling techniques may include sequential sampling and flush sampling.

Sequential sampling (e.g., fifth liter sampling) uses series of consecutive samples (typically 500 mL to 1 L) collected from an interior tap after a stagnation period (typically 6 hours or more). The number of samples needed depends on the length and diameter of the plumbing from the tap through the length of the premise plumbing and service line.

Flush sampling uses samples collected from an interior tap after allowing the water to flow from the tap for a certain period of time to potentially capture the water from the service line.

This method is currently not considered for service line verification purposes (i.e., it is for information gathering purposes only) by MDE.

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## *Other Analytics/Predictive Method(s)*

**Service line verification:** Material (Prediction if pre-approved by MDE)

Any other analytics/predictive methods (not captured in other analytics/predictive methods listed above) that provide predictions of the materials of the service line.

These methods must be pre-approved by MDE on a case-by-case basis; otherwise, they will not be considered for service line material prediction.

Per EPA's guidance regarding service line sub-classifications (see page 2-6 of EPA's ***Guidance for Developing and Maintaining a Service Line Inventory*** (August 2022)), the prediction result from a predictive method is still considered as an "unknown" material. Therefore, the prediction result from the Analytics/Predictive method will be considered on MDE's Service Line Inventory spreadsheet as "Lead Status Unknown" classification (unless the pipe diameter is greater

than three inches and/or the pipe was installed after the lead ban in plumbing (Local, State of Federal) and/or if a physical verification/visual inspection is made).

## FIELD INVESTIGATION METHODS

### *Visual Inspection of Exposed Service Line Pipe (with or without Excavation)*

**Service line verification:** Material and Diameter

This method involves visual inspection of the service line at MDE-specified location(s). The visual inspection must be performed in-person or through videos/external CCTV and/or photographs by water system personnel and/or third-party entities (e.g., licensed plumbers). If the portion of the service line connected to the building/structure is not owned by the water system, building/structure owners or occupants may take photographs (or videos) of the service line (and any additional material tests performed) and provide them to the water system for review.

In order to visually inspect the exterior of the service line pipe, excavation may be needed to expose the exterior service line pipe. **Excavation techniques** include mechanical excavation (e.g., potholing) and vacuum/hydro excavation. For **mechanical excavation**, potholing, digging, or excavating may be used for visual inspection of the service line. Potholing is a process using high-pressurized air and vacuum (also known as soil vacuum excavation, air excavation, air knife soil excavation, or potholing). **Vacuum/hydro excavation** uses a water jet or compressed air to loosen the soil. High-pressurized water and vacuum is also known as hydrovac, hydro excavation, hydro trenching, or soft digging.

Since excavation may cause a disturbance to the pipe, the excavation technique should be carefully evaluated by the water system, including a risk assessment. Furthermore, water systems should have a plan in place to mitigate and address any disturbances that may arise from the excavation during field investigations. It is important for water systems to communicate with customers during the investigation process and maintain appropriate water quality throughout the process which may include flushing (see 40 CFR 141.85(f)). Additional information is available on MDE's Guidance.

In addition to visual inspection, additional **Material Tests** may be performed to determine service line pipe materials. These tests may include:

- **Pipe Surface Tests:** This type of testing technique is performed on the surface of the service line pipe. It is easy for residents if service line is accessible; however, these methods will only indicate the presence of lead on the surface of the pipe, and will not be able identify the presence of lead on the interior of pipe such as a lead-lined galvanized iron pipe. The pipe surface tests include:
    - **Scratch tests** are performed by scratching the pipe surface (using coin, key, etc.). The exposed outside pipe surface area will be shiny silver and flake off if the pipe surface is lead.
    - **Magnet tests** can be used on the pipe surface to determine whether the pipe surface is lead since a magnet will not stick to lead.
    - **Lead surface swab tests** can be performed using a surface swab kits approved for lead paint, which will change color after it comes in contact with a lead surface. If the pipe is painted, the surface swab test may not be accurate.
- **Electrical Conductivity (Eddy Current) or Electrical Resistance Test on the Exterior of the Pipe**: This type of testing technique is performed on the surface of the service line pipe. **Electrical Conductivity (Eddy Current)** is used to measure conductivity of materials. Different metals have varied properties and therefore act differently when electrical current is passed through them. Information on the conductivity of materials can be used to

determine the composition of the materials being tested and, therefore, the metals can be sorted depending on the conductivity properties. **Electrical Resistance Tests** are used to measure resistance of materials. It is a measure of its opposition to the flow of electric conductivity of materials.

- **Other Test(s)**: If other material test(s) was/were performed on the exposed pipe surface to determine service line pipe material (including the material on the interior surface), this category should be selected on the inventory spreadsheet. Examples of other material tests include L-Shell and K-Shell X-Ray Fluorescence (XRF) tests for lead. L-Shell XRF test is designed to detect lead at the surface, while K-Shell XRF test is designed to detect lead within the pipe including the inner lining of the pipe, such as lead-lined galvanized steel service lines.

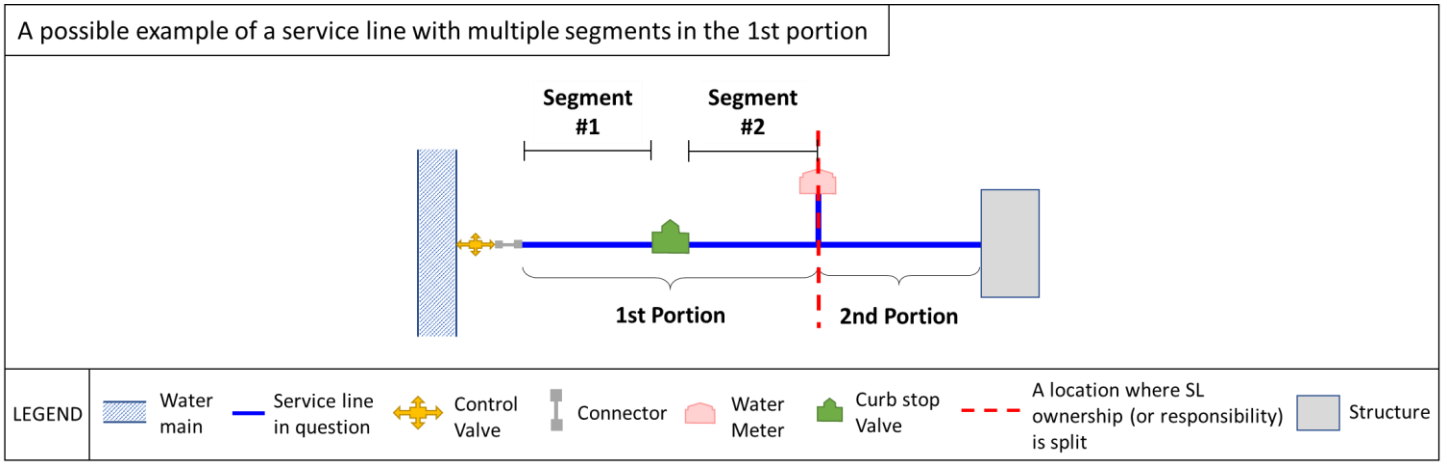
## MDE-Specified Locations for Visual Inspection

The visual inspection must be performed on the service line pipe (i.e., not the connector/gooseneck/pigtail). For a portion of a service line pipe or a segment of a portion of a service line pipe (if the portion contains more than one segment), a visual inspection must be performed on one of the MDE-approved locations below:

- If viewing at the water main, no minimum viewing distance is required;
- If viewing at the curb box or any other valve, a minimum viewing distance of 18 inches is required;
- If viewing at a water meter pit/vault, no minimum viewing distance is required if the service line lateral is visible;
- If the service line is less than 18 inches long, a half-way point viewing distance is required;
- If viewing at a building inlet, no minimum viewing distance is required.

If using visual inspection for the entire length of a portion, all segments (see diagram below) contained within that portion must be accounted for.

A possible example of a service line with multiple segments in the 1st portion




If the service line is not owned by the water system, building/structure owners or occupants may take photographs (or videos) of the service line where it enters the building/structure (and any additional material tests performed) and provide them to the water system; otherwise, the service line must be visually inspected in-person by water system personnel and/or third-party entities contracted by the water system and/or State/local agencies.

## *Non-Exposed Service Line Pipe Inspection Methods*

### *Metal Detector*

**Service line verification:** Material

Metal detectors are electronic devices that detect the nearby presence of metal objects on the surface, underground, and under water. Metal detectors can detect both ferrous and non-ferrous metal types, although they detect ferrous metals more easily due to their magnetic properties.

Since not all metal detectors are designed to be sensitive enough to detect lead, MDE will only allow the use of metal detectors that can accurately identify the type of metals being detected, including lead. Before using this method, a field test must be conducted on service line pipes of known materials, including lead, galvanized (iron or steel), and other metals, to ensure that the chosen metal detector can effectively and accurately identify each different pipe material. Water systems may be asked by MDE to demonstrate the effectiveness of the metal detector used.

When using this method, the detection must be performed on the service line pipe (i.e., not the connector/gooseneck/pigtail) over three lengths of the service line portion (i.e., 1st portion or 2nd portion) or segment in question. These lengths are described below.

The required lengths are:

- A 5-foot length starting from where the service line portion begins;
- A 5-foot length starting from where the service line portion ends; and
- A 5-foot length of the middle of the service line portion.

If any length reveals the service line material to be lead, no further detection on other lengths is necessary (i.e., detection of only one length is required).

If the service line portion or segment is less than 15 feet long, then the detection must be performed on the entire length of the service line portion or segment in question.

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### *Electrical Resistance/Conductivity Test on the Interior of the Pipe*

**Service line verification:** Material

This method uses low-voltage conductivity on the interior surface of the pipe to identify pipe material. This equipment requires calibration (in accordance with industry/manufacturer standards) to accurately identify the different types of materials.

When using this method, the minimum detection length is required as follows:

- If the water system is able to confirm where the service line pipe begins for the portion in question (i.e., after any yokes, valves, goosenecks/pigtails/connectors, and/or any other pipes or appurtenances), then a minimum of 5 feet of detection starting from where the service line pipe begins is allowed.
- Otherwise, a minimum of 10 feet of detection is required starting from the equipment's entry point into the portion of the service line pipe in question.

Since this method can cause a disturbance to the pipe, the technique should be carefully evaluated by the water system, including a risk assessment. Furthermore, water systems should have a plan in place to mitigate and address any disturbances that may arise from using the technique during field investigations. It is important for water systems to communicate with customers during the investigation process and maintain appropriate water quality throughout the process which may include flushing (see 40 CFR 141.85(f)). Additional information is available on MDE's Guidance.

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## *Ground-Penetrating Radar (GPR)*

**Service line verification:** Diameter

Ground-penetrating radar (GPR) is a non-invasive locating tool that can detect the location and diameter of the service line; however, it lacks the ability to discern service line material.

Before using this method, a field test must be conducted on pipes with known diameters to ensure that the chosen ground-penetrating radar equipment can effectively identify each different pipe diameters. Water systems may be asked by MDE to demonstrate the effectiveness of the GPR equipment used.

When using this method, the detection must be performed on the service line pipe (i.e., not the connector/gooseneck/pigtail) over three lengths of the service line portion (i.e., 1st portion or 2nd portion) or segment in question. These lengths are described below.

The required locations for GPR are:

- Any location within a 5-foot length starting from where the service line portion begins;
- Any location within a 5-foot length starting from where the service line portion ends; and
- Any location within a 5-foot length of the middle of the service line portion.

If the method reveals the service line diameter to be different among the three locations described above, then the smallest of the diameters should be reported to MDE on the inventory spreadsheet.

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## *Internal CCTV Inspection of Inside of the Entire Portion of the Service Line Pipe*

**Service line verification:** Not Considered for Verification Purposes (i.e., it is for information gathering purposes only)

This method uses a high-resolution cameras equipped with a flexible, fiber optic scope and a light source to inspect the service line material from inside the pipe. This method is, however, ineffective when the service line is coated with corrosion scale and the method itself can cause disturbance to the pipe. It is recommended that measures be taken to reduce scale disturbances and lead release when using this method.

This method is currently not considered for verification purposes (i.e., it is for information gathering purposes only) by MDE; however, if water systems can demonstrate that the service line does not have any coating of corrosion scale, the method may be considered by MDE for verification purposes. Water systems will need to get approval from MDE prior to using this method for inventory purposes.

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## *Other Non-Exposed Service Line Pipe Inspection Method(s)*

**Service line verification:** Not Considered for Verification Purposes (i.e., it is for information gathering purposes only), unless pre-approved by MDE.

Any other tools and/or instruments (not captured in other field investigation methods listed) that provide information on materials and/or diameters of the service line.

These methods must be pre-approved by MDE on a case-by-case basis; otherwise, they will not be considered for service line verification purposes (i.e., it is for information gathering purposes only).

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