Machine Learning Modeling and Inventory Preparations

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April 12, 2024

PHILADELPHIA WATER DEPARTMENT

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Philadelphia Background and Regulatory Review

PWD Organization Structure and Customer Base

The Philadelphia Water Department ("PWD" or the "Department"), one of the City's ten operating departments that reports to the Office of the Managing Director with approval of the Mayor, operates, maintains, repairs and improves the City's water and wastewater systems.

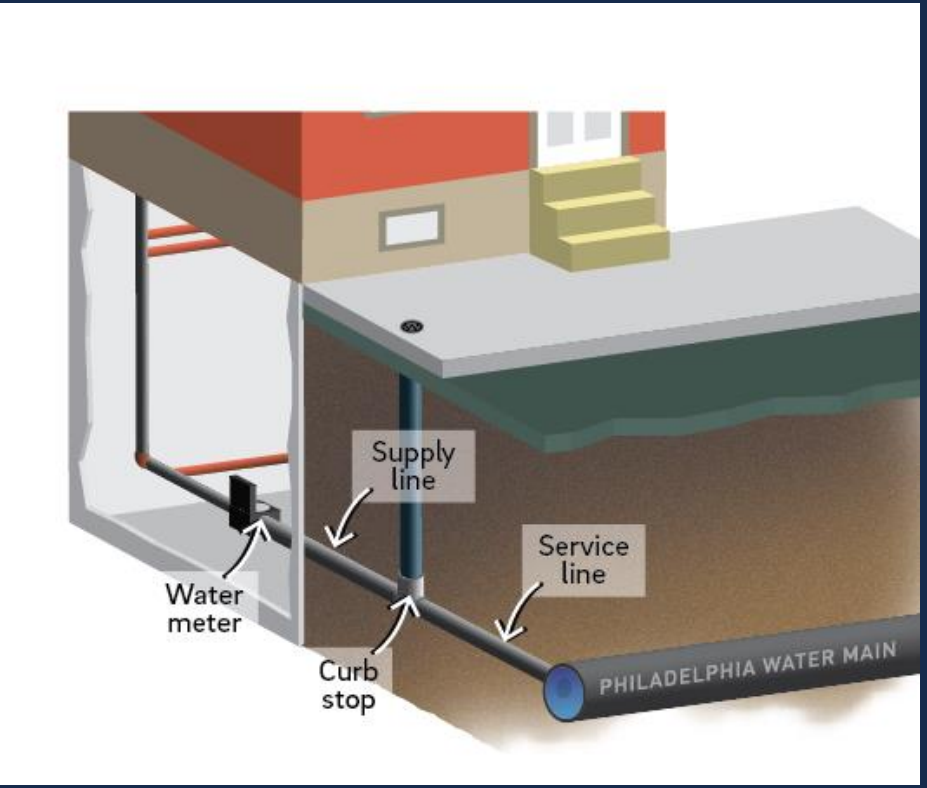
- Serves 1,603,797 individuals
- Approximately 505,000 active water accounts
- Approximately 544,000 wastewater accounts, including approximately 51,000 stormwater-only accounts

Philadelphia Service Line Background

- Philadelphia property owners are **responsible** for and **own** the entire service line from the main to the meter

- Service versus Supply:
  - Service – Main -> Curb Stop
  - Supply – Curb Stop -> Meter

- Number of service lines
  - ~511,000



USEPA Released Draft LCRI 11/30

Inventory

- Must validate the accuracy of the non-lead service line category in their inventory no later than 7 years after the compliance date (i.e., by 2034)
- Complete inventory by replacement deadline (i.e., by 2037)

2024
Anticipated Final LCRI

2027
Anticipated LCRI Compliance Date

2034

2037

Lead Service Line Replacement

Replacements must be completed within 10 years of the anticipated LCRI compliance (i.e., by 2037)

Service Line Inventory Regulatory Requirements

PADEP Guidance

"If a water system's investigation concludes that the pipe material is non-lead (e.g. copper), they are expected to show sufficient evidence through one of the *"stand-alone" verification options, or a combination of 2 or more other methods as described below."*

Option 1. "Standalone" Records

- Records showing an installation or replacement date after January 6, 1991
- Meter size >2" in diameter
- Records of a local ordinance prohibiting LSL installation and water system records indicate service line installation or replacement after the ordinance was in effect

"Standalone" records do not require additional verification

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Option 2 . “Standalone” Field Verification

a. Mechanical Excavation

Must be conducted at minimum of 3 locations:

01

Location 1

Curb stop to building – min. 18” from curb stop.

02

Location 2

Curb stop to water main – min. 18" from curb stop.

03

Location 3

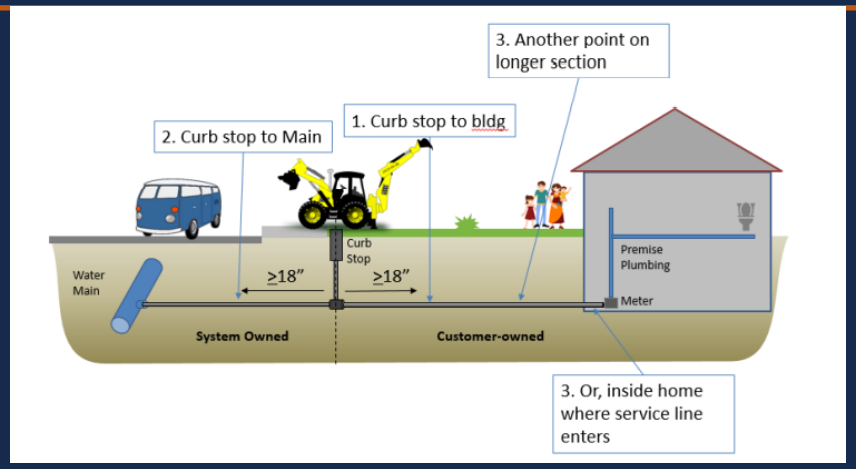
Inside home (inspected by water personnel) or at a **second excavation point**.

b. Internal CCTV of full service

Feasibility

Emerging methods are being developed by several vendors, but no reliable, proven method for verification of material for < 1-inch service lines is readily available

01



Option 3. Combination of Methods

Need two or more investigation methods listed below:

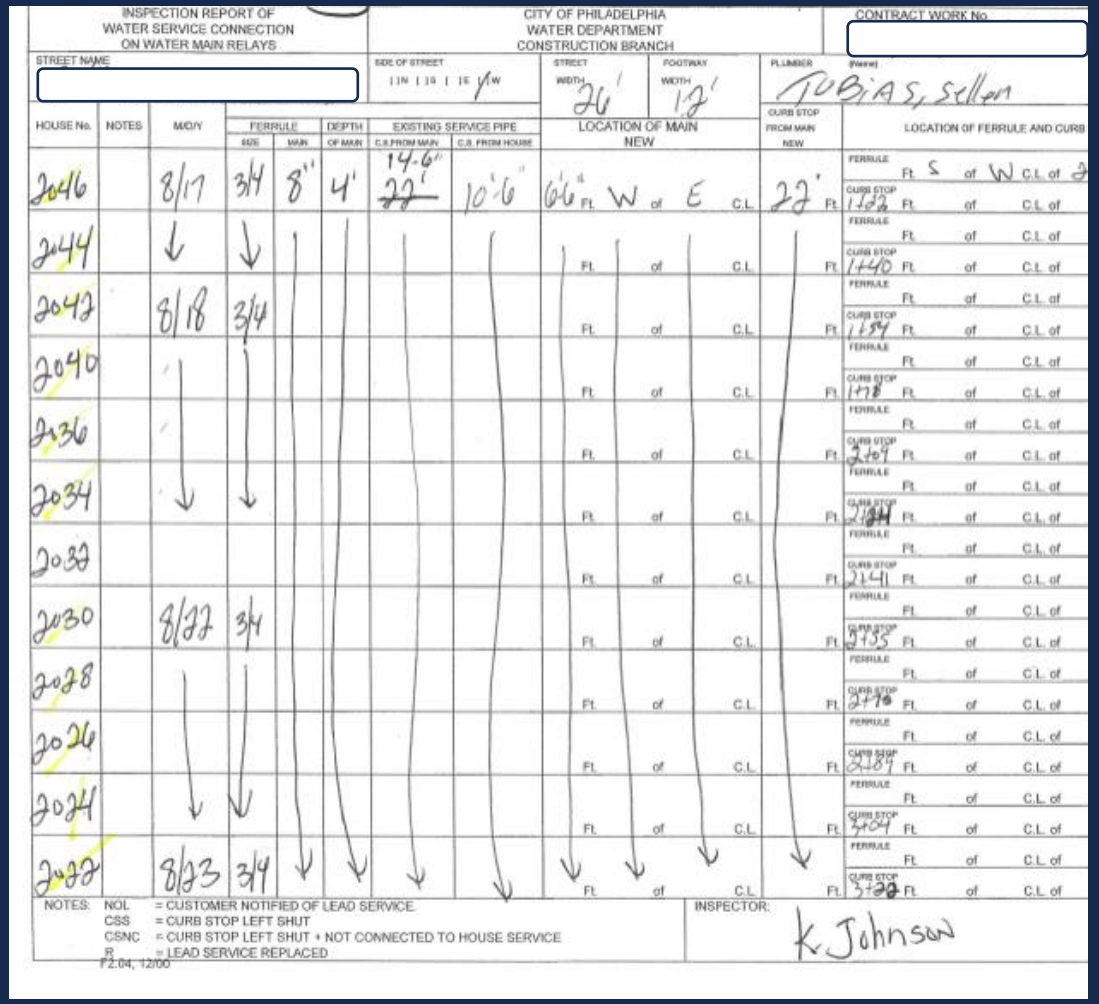
- Records review
- Modeling/statistical analysis
- Water sampling (no CCT)
- Visual inspection at exiting access point (i.e., meter pit or SL entry in customer's basement)
- Field verification
- CCTV inspection at curb box
- Mechanical excavation at two locations (for systems with joint ownership of SL)
- Other methods reviewed by DEP

Records review can include:

- Previous materials evaluation
- Construction and plumbing codes/records
- Distribution inspection and records
- Information obtained through normal operations

PWD Challenge: Developing a Service Line Inventory

- PWD does not own any portion of the service line
  - Limited records containing service line information
  - Records are scattered among numerous "databases" that need to be aggregated



INSPECTION REPORT OF WATER SERVICE CONNECTION ON WATER MAIN RELAYS

CITY OF PHILADELPHIA WATER DEPARTMENT CONSTRUCTION BRANCH

CONTRACT WORK No.

STREET NAME

SIDE OF STREET | IN | IS | IE | I/W

STREET WIDTH 26'

FOOTWAY WIDTH 12'

PLUMBER TUBIAS, Sellon

HOUSE No.	NOTES	M/D/Y	FERRULE SIZE	FERRULE MAIN	DEPTH OF MAIN	EXISTING SERVICE PIPE C.S. FROM MAIN	EXISTING SERVICE PIPE C.S. FROM HOUSE	LOCATION OF MAIN NEW	CURB STOP FROM MAIN NEW	LOCATION OF FERRULE AND CURB
2046		8/17	3/4	8"	4'	14-6" 22'	10'6"	6'6" Ft. W of E C.L.	22' Ft.	FERRULE Ft. S of W C.L. of 2 CURB STOP 1122 Ft. of C.L. of
2044		↓	↓					Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 1140 Ft. of C.L. of
2042		8/18	3/4					Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 1154 Ft. of C.L. of
2040								Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 1178 Ft. of C.L. of
2036								Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2209 Ft. of C.L. of
2034								Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2234 Ft. of C.L. of
2032								Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2241 Ft. of C.L. of
2030		8/22	3/4					Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2255 Ft. of C.L. of
2028								Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2276 Ft. of C.L. of
2026								Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2289 Ft. of C.L. of
2024								Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2304 Ft. of C.L. of
2022		8/23	3/4					Ft. of C.L.	Ft.	FERRULE Ft. of C.L. of CURB STOP 2322 Ft. of C.L. of

NOTES: NOL = CUSTOMER NOTIFIED OF LEAD SERVICE
CSS = CURB STOP LEFT SHUT
CSNC = CURB STOP LEFT SHUT + NOT CONNECTED TO HOUSE SERVICE
R = LEAD SERVICE REPLACED

INSPECTOR: K. Johnson

F2.04, 12/00

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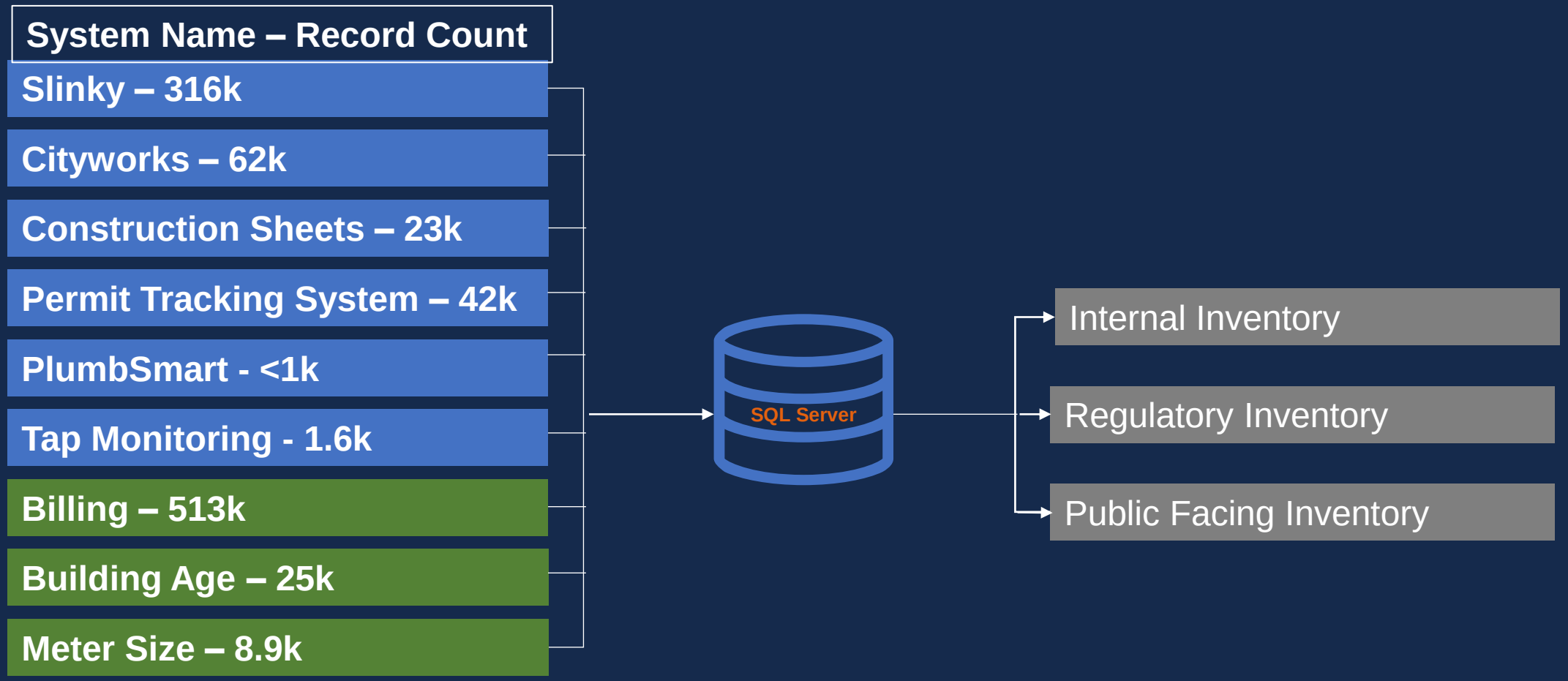
Inventory Compilation



These numbers change daily as data are reviewed and are only accurate as of April 4, 2024.

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Inventory Classification

Pennsylvania DEP Classification	
Overall Service Line Material Categorization	
Overall Material Category	**Total**
Lead	13,819
Galvanized Requiring Replacement (GRR)	998
Non-lead	54,041
Unknown	444,527

These numbers change daily as data are reviewed and are only accurate as of April 4, 2024.

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Predictive Modeling

Methods to Reduce Unknowns

Need two or more investigation methods listed below:

- Records review
- **Modeling/statistical analysis**
- Water sampling (no CCT)
- Visual inspection at exiting access point (i.e., meter pit or SL entry in customer's basement)
- Field verification
- CCTV inspection at curb box
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Philadelphia W

Records review can include:

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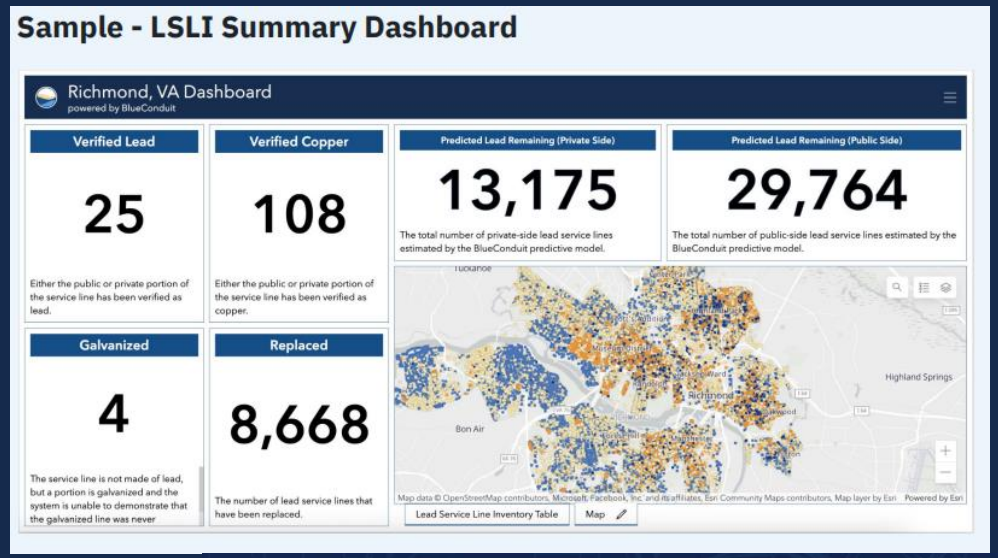
Why Model?

Use model to:

- Meet SLI requirements
- Prioritize field investigations and replacement activities
- Support funding applications and customer communications

Benefits:

- Reduces costs and staff time
- Accelerates LSL removal
- Significant decrease in inventory completion time



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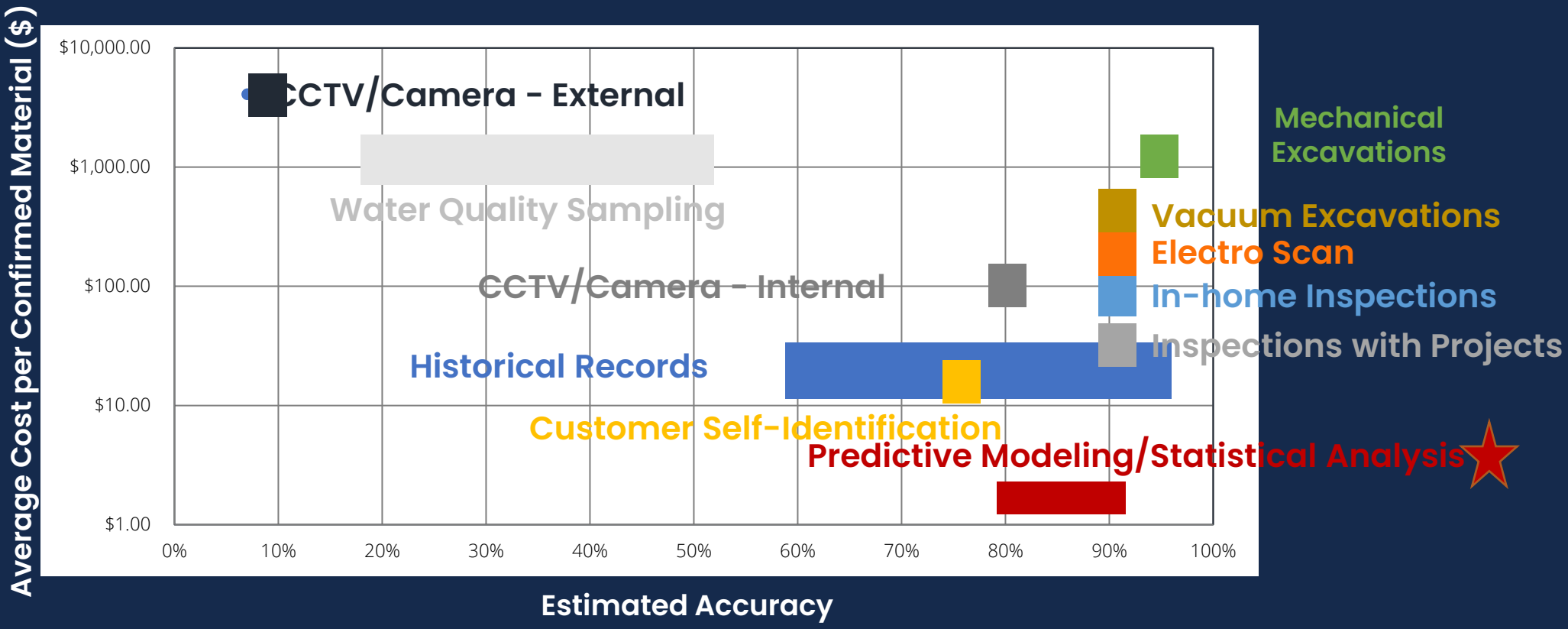
Comparison of Various SL Investigation Techniques



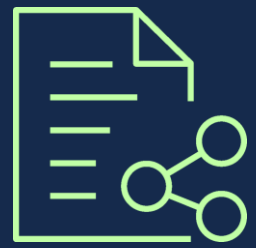
Adapted from AWWA (2022) Considerations when Costing Lead Service Line Identification and Replacement

Predictive Modeling Process

Utility Data Gathering and Review

Data Validation, Processing, and Initial Analysis

Field Investigations to Test and Train the Model



Model Development

Model Updates and Re-Runs

2-6 months

1-6 months

2-4 months

Ongoing

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Data inputs requested

- Verified service line material records
- Historic service line material records
- Any GIS records
- Real estate/parcel records
- Construction records
- Water sampling test results
- Water main size/service line size
- Water main material
- Billing account information
- Meter size records
- Census data

Ranking of confidence in data sources is very important for initial model development!

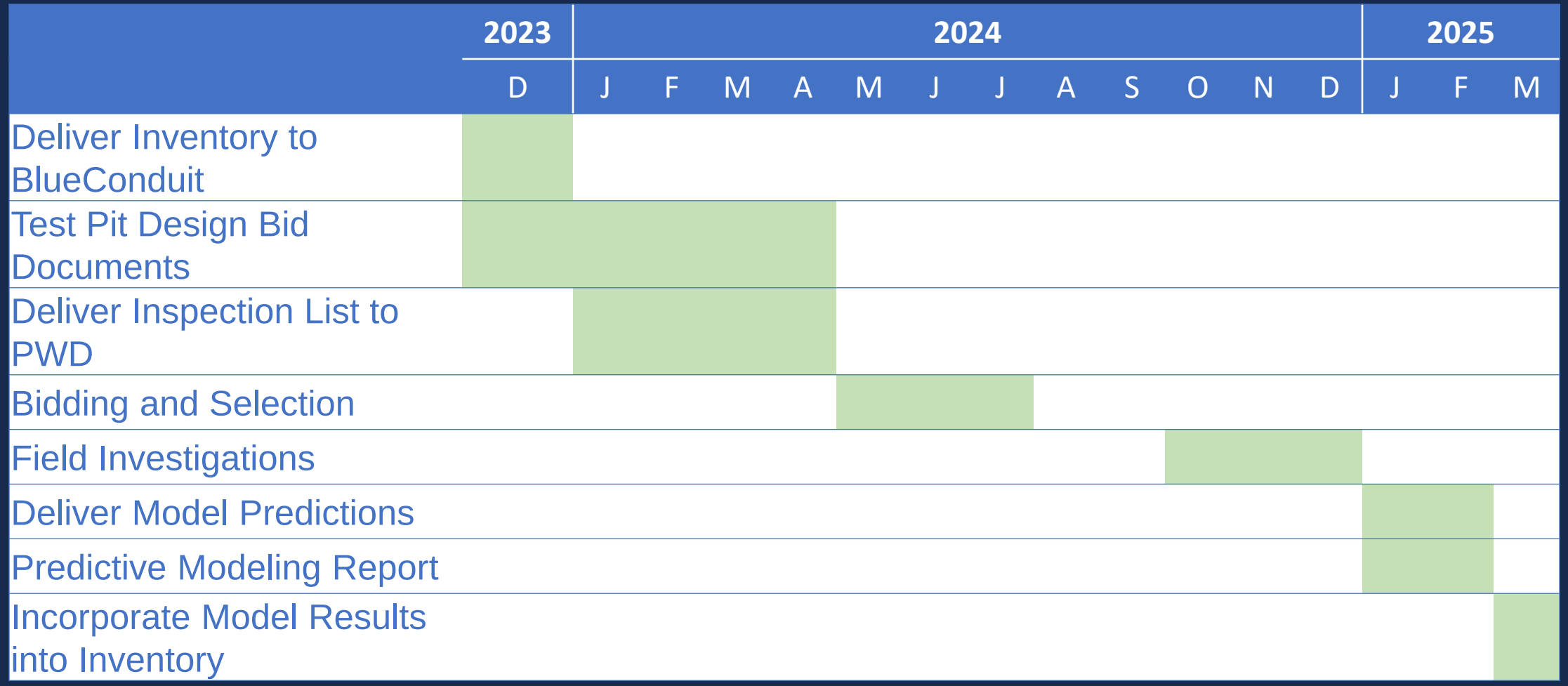
Field Testing/Validation

- Validation of model is a key component
- Michigan EGLE guidance – max of 384 physical verification points
- Targeting no more than 5% error in the data validation pool, otherwise more physical verification is likely necessary
- Further codified in the LCRI as a requirement for validating the accuracy of all “non-lead” determinations.

TABLE 1 TO PARAGRAPH (b)(5)(ii)

Size of validation pool	Number of validations required
<1,500	20 percent of validation pool.
1,500 to 2,000	322.
2,001 to 3,000	341.
3,001 to 4,000	351.
4,001 to 6,000	361.
6,001 to 10,000	371.
10,001 to 50,000 ..	381.
>50,000	384.

PWD Model Development Schedule



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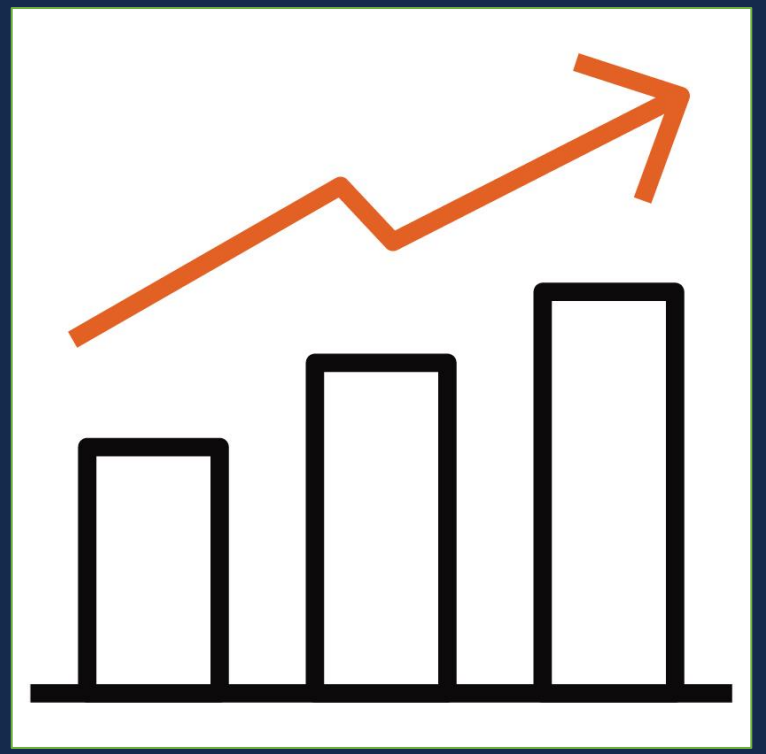
Predictive Modeling Potential

- First inventory submission will contain largely unknowns
- Expect to have a substantial increase in service lines identified as non-lead for second submission
- All unknowns have the potential to be categorized as non-lead
  - Dependent on model probability patterns
  - Reduce up to 300,000-450,000 unknowns



Questions?