



Tuesday, June 11, 2019

## Where is the Lead?

Utilizing ArcGIS to Create a Water Service Material Inventory in the City of Muskegon

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Prein&Newhof

# Prein&Newhof

- At P&N, our goal is to serve our clients wisely with a combination of **experience, integrity, creativity, and common sense.**
- Begun by Tom Newhof and Ed Prein in **1969**, we help clients across Michigan meet infrastructure needs. We offer a wide range of **engineering, environmental consulting, surveying, GIS, and laboratory services.**
- Professional Services
  - Municipal Engineering
  - Water & Wastewater Systems
  - Stormwater Management
  - Roads & Trails
  - Airports
  - Private Development
  - Asset Management
  - Environmental Consulting
  - Laboratory Testing
  - Structural Engineering
  - Geotechnical Engineering
  - Surveying
  - GIS & Mapping
  - Landscape Architecture
- 100% employee-owned, with over 145 full-time personnel, including **engineers, surveyors, drafters, geologists, chemists, communication specialists, and support staff.**



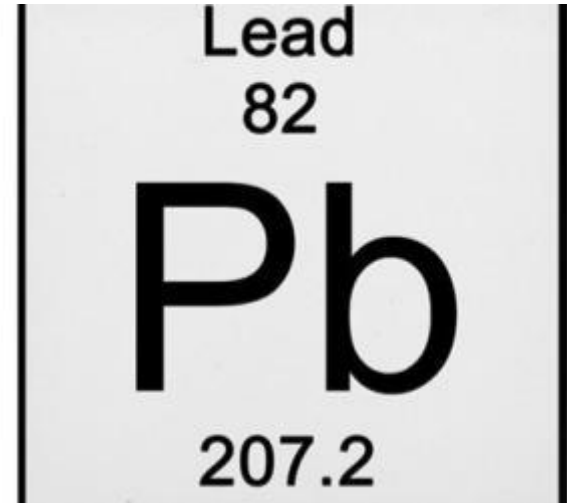
# City of Muskegon Lead Service Line (LSL) Inventory

The City of Muskegon hired Prein&Newhof to complete a material inventory of their water services, as mandated by the State.



# History of Lead

- *plumbum*
- In use by humans as early as 7000 B.C.
- Used for water pipes in Roman Empire
- White Lead Paints
- Used in lead-acid batteries
- Leaded Gasoline

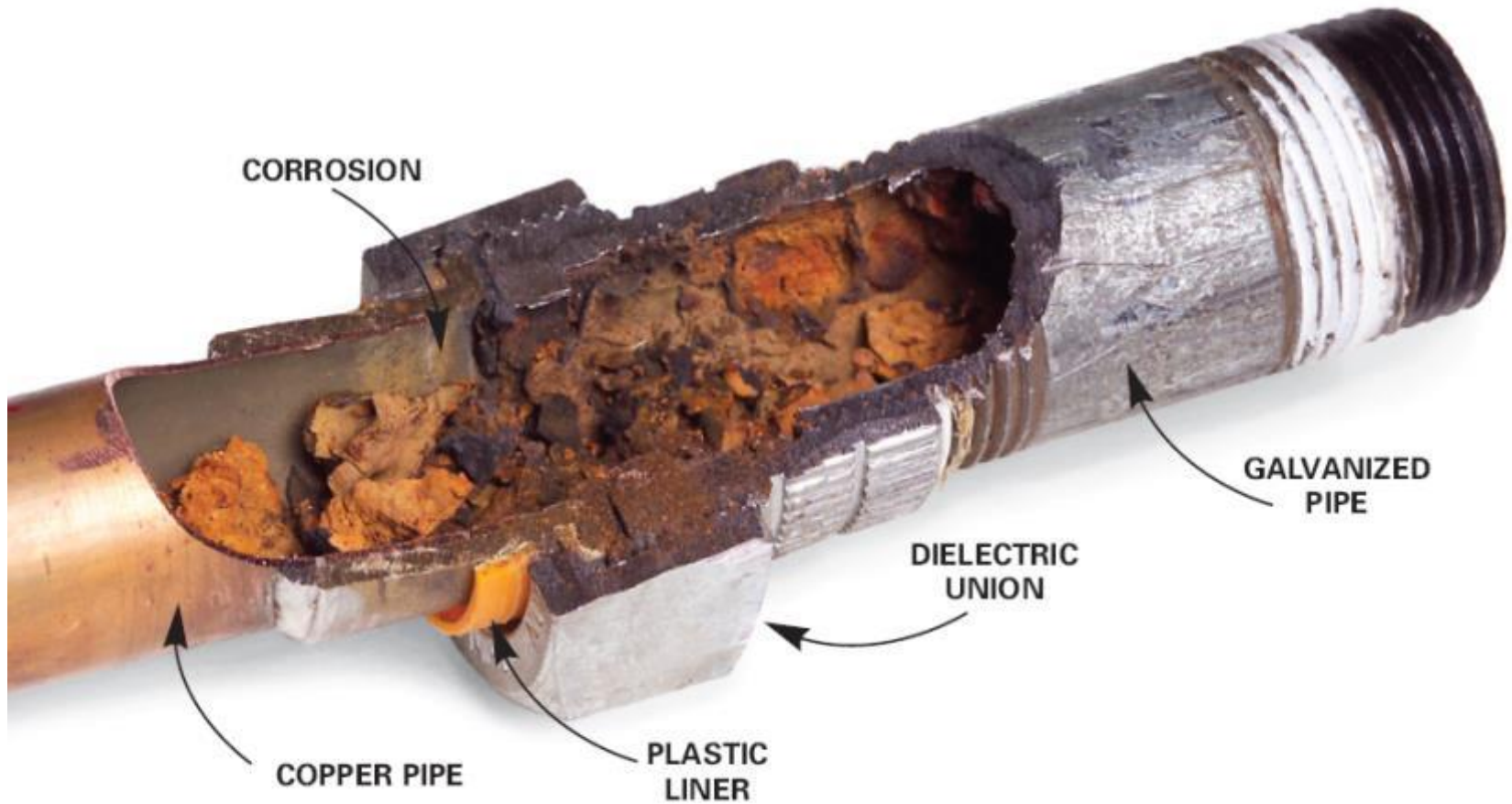


# So what is this all about?

- Lead is harmful especially to infants and children
  - ✓ Impaired Mental Development
  - ✓ IQ Deficits
  - ✓ Shorter Attention Spans
  - ✓ Low Birth Weights
  - ✓ Delinquency, Aggression
  - ✓ Inattention, Social Problems



# How does lead get into the water?



# Michigan Recent Lead History

- April 2014 – Flint changes water source
- Sept 2015 – Increased Blood Levels in Flint
- Dec 2015/Jan 2016 – Reconnection to Detroit
- April 2016 – Criminal/Civil Cases
- March 2017 – Governor Snyder wants new LCR
- 2<sup>nd</sup> Half of 2017 – Stakeholder Meetings
- Nov 2017 – Public Meeting
- Jan 2018 – 1<sup>st</sup> Draft Rule
- March 2018 – Public Hearing
- June 2018 – Rule Finalized



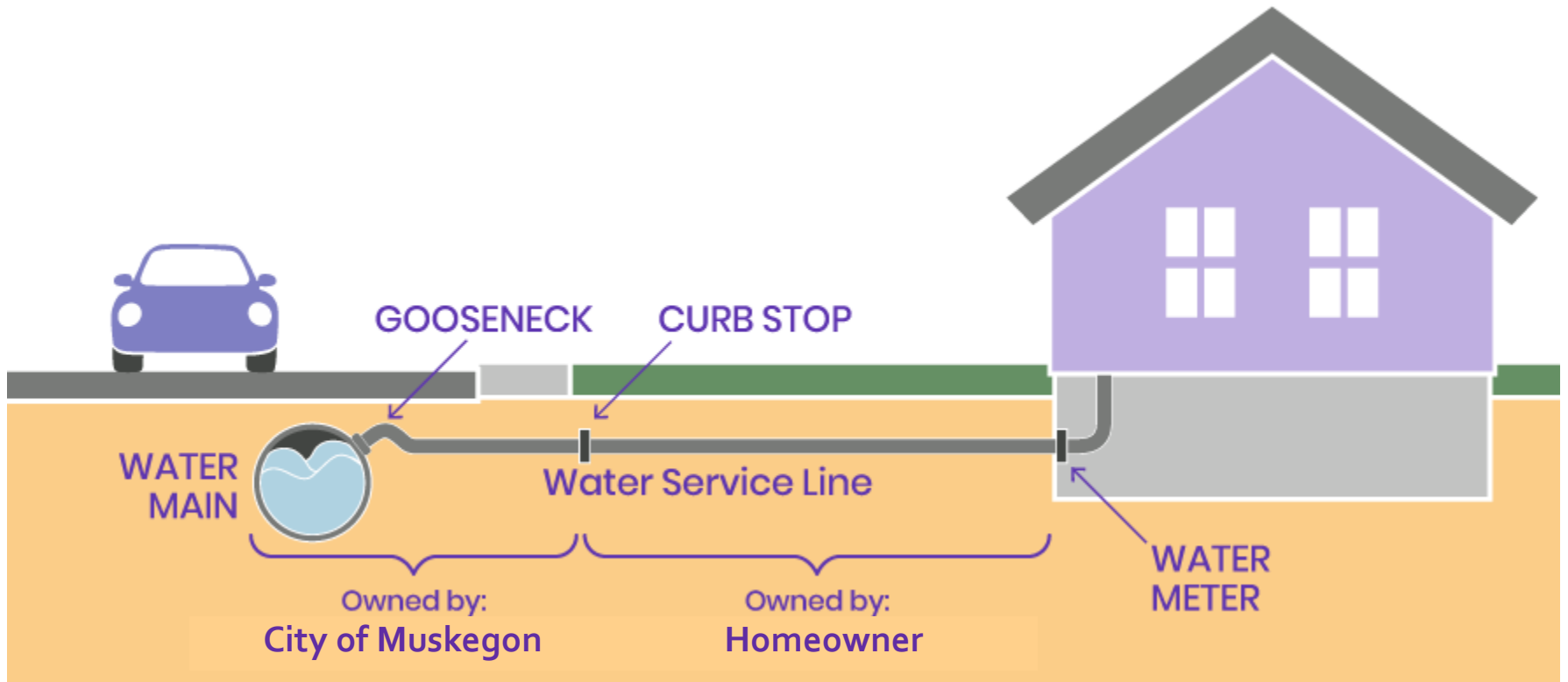
# Key Michigan Lead and Copper Rule Changes

- Stricter sampling procedures
- Allowable lead limit reduced from 15 ppb (federal limit) to 12 ppb in 2025
- Mandatory lead service line inventory by 2020
- Begin replacing lead service lines in 2021 at a rate of 5% per year over a 20-year period
- Communities are responsible to replace ENTIRE lead service line, including private portion, at the communities' expense.
- “Field verified” lead service line inventory by 2025



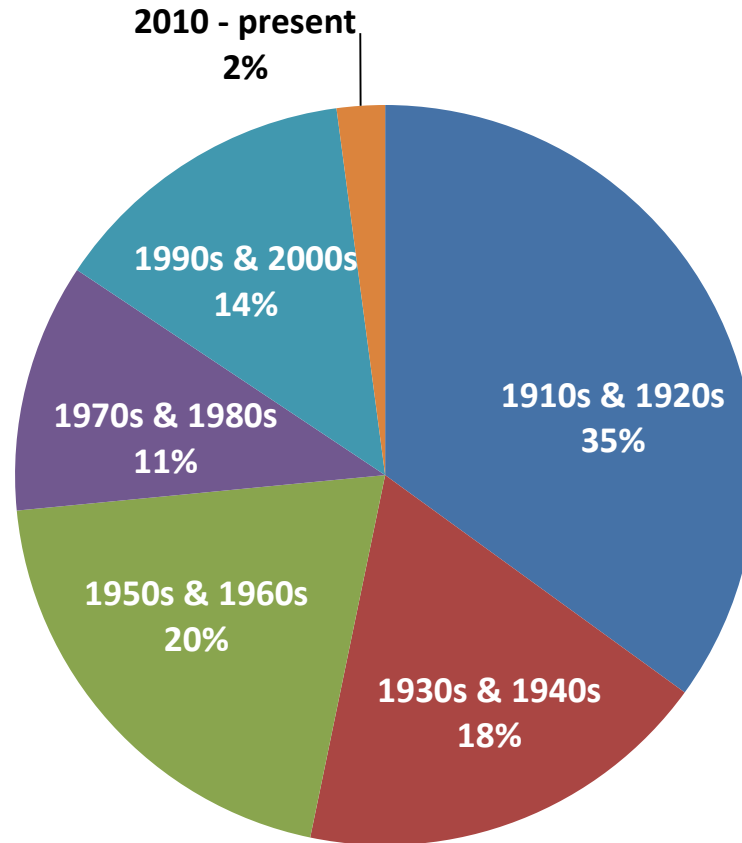


# Typical Muskegon Water Service



# The City of Muskegon is Old

## Water Main Age



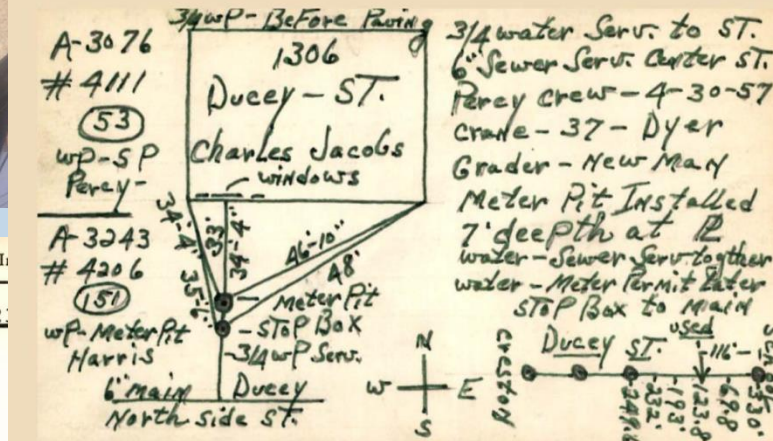
Approximately 12,800 active water services

# City of Muskegon Water Service Records

- City has a “tie card” for 90% of the water services
- Water service replacement and installation records were not always uniform and consistent
- Many data sources were used to determine materials
- All services were ASSUMED to have lead unless proven otherwise

Address		Date Installed	Water <input checked="" type="checkbox"/>
2057 MORTON			Sewer <input type="checkbox"/>
Crew	Permit #	N ↓	2057 MORTON
MRA, HU			
Size	Order #		
Mat'l.			
Main Size 6"			
Stop Box YES			
Corp. & Curb style		SIDEWALK	18.0'
Length of Service		24.6'	STOP BOX
Location	St. <input checked="" type="checkbox"/> Alley <input type="checkbox"/>	MORTON	
		6" W.M.	

# Data Source: Tie Cards



Address 2054 HARDING

Date I

8/2

Crew L.D. Permit # & M.J.

Size 3/4" Order #

Mat'l. Copper

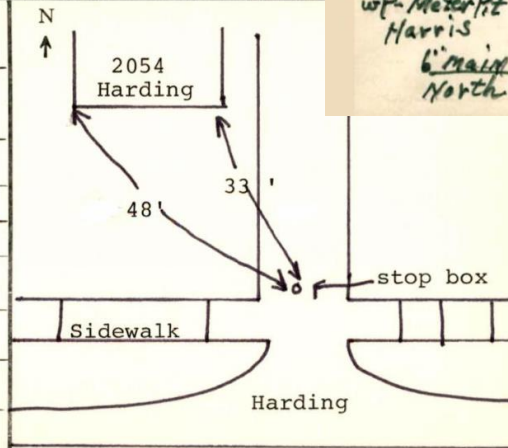
Main Size 6"

Stop Box

Corp. & Curb style

Length of Service 30'

Location St.  Alley



City's general practice since the 1950's

# Data Source: Tie Cards

Address <b>1285 5th</b>		Date Installed <b>8-1-85</b>	Water <input checked="" type="checkbox"/>
			Sewer <input type="checkbox"/>
Crew	Permit #	<p>N ↓</p> <p>1285 5th</p> <p>31'</p> <p>23'6"</p> <p>Sidewalk</p> <p>STOP BOX</p>	
Size	Order #		
Mat'l.			
Main Size			
Stop Box			
Corp. & Curb style			
Length of Service			
Location	St. <input checked="" type="checkbox"/> Alley <input type="checkbox"/>		

# Data Source: Tie Cards

Address <i>1376 FRANCES</i>		Date Installed <i>9.9.13</i>	Water <input checked="" type="checkbox"/>
			Sewer <input type="checkbox"/>
Crew <i>NM</i>	Permit #		
Size <i>3/4</i>	Order #		
Material <i>COPPER to GALV.</i>			
Main Size			
Stop Box <i>SB</i>			
Corp and Curb Style		FRANCES	
Length of Service			
Location	Street <input checked="" type="checkbox"/>		
	Alley <input type="checkbox"/>		

# Data Source: Tie Cards

Address		Date Installed	Water <input checked="" type="checkbox"/>
Lake Shore Dr. ( Standard Oil Co. )		11/19/57	Sewer <input checked="" type="checkbox"/>
Crew Sims Permit # G.F.E. A-3302	<p>The diagram shows a plan view of a sewer installation. At the top, 'LAKE SHORE DR.' is written with an arrow pointing North. A thick black line represents the 'CURBING' along the street. Below the curbing is a 'SIDEWALK'. A 'BUFFALO BOX' is located on the sidewalk, with a 'VALVE IN M.H.' nearby. A 'NEW BLDG. STD. OIL BELOW HILL' is shown with a '24" SAN. PRESS.' pipe leading to it. A '24" SAN. PRESS.' pipe also runs horizontally. A '24" PRESS SAN.' pipe runs vertically, crossing 'FRIEBIE DRWAY' and 'STD. OIL DR. WAY'. A '24" OVER FLOW' pipe is shown at the bottom. Measurements include '9' FROM BUFFALO BOX TO SIDEWALK EDGE.', '23' FROM B. BOX TO (INSIDE) EDGE OF CURB.', '24' SAN. PRESS.', '12' SAN.', '24" SAN.', and '24"'. A note says 'END OF SIDEWALK'.</p>		
Size 1 1/2" Order # W.P.			
Mat'l.			
Main Size 24"			
Stop Box BUFFALO BOX			
Corp. & Curb style 1 1/2"			
Length of 3' pipe from Service B. Box to Main			
Location St. <input checked="" type="checkbox"/> Alley <input type="checkbox"/>			

# Data Source: Tie Cards

Address Fire Hydrant across from 739 Leonard		Date Installed	Water <input checked="" type="checkbox"/>
		11-1384	Sewer <input type="checkbox"/>
Crew	Permit #	<p>N ↑ Hyd 2' 10" valve 12" 150 LB Gas main 45° bend 6" main Dead end Gas main Hydrant drain is plugged</p>	
M. J. P. V.	P. V.		
Size	Order #		
Mat'l.			
Main Size			
Stop Box			
Corp. & Curb style			
Length of Service			
Location	St. <input type="checkbox"/> Alley <input type="checkbox"/>		



# Data Source: Tie Cards

Address 470 W. WESTERN		Date Installed 11-3-87	Water <input checked="" type="checkbox"/>		
			Sewer <input type="checkbox"/>		
Crew M.D. P.V.	Permit #				
Size 6"	Order #				
Mat'l. Ductile Iron					
Main Size 6"					
Value Stop Box					
Corp. & Curb style					
Length of Service					
Location T Hayer St.	St. <input checked="" type="checkbox"/> Alley <input type="checkbox"/>				
				(over)	

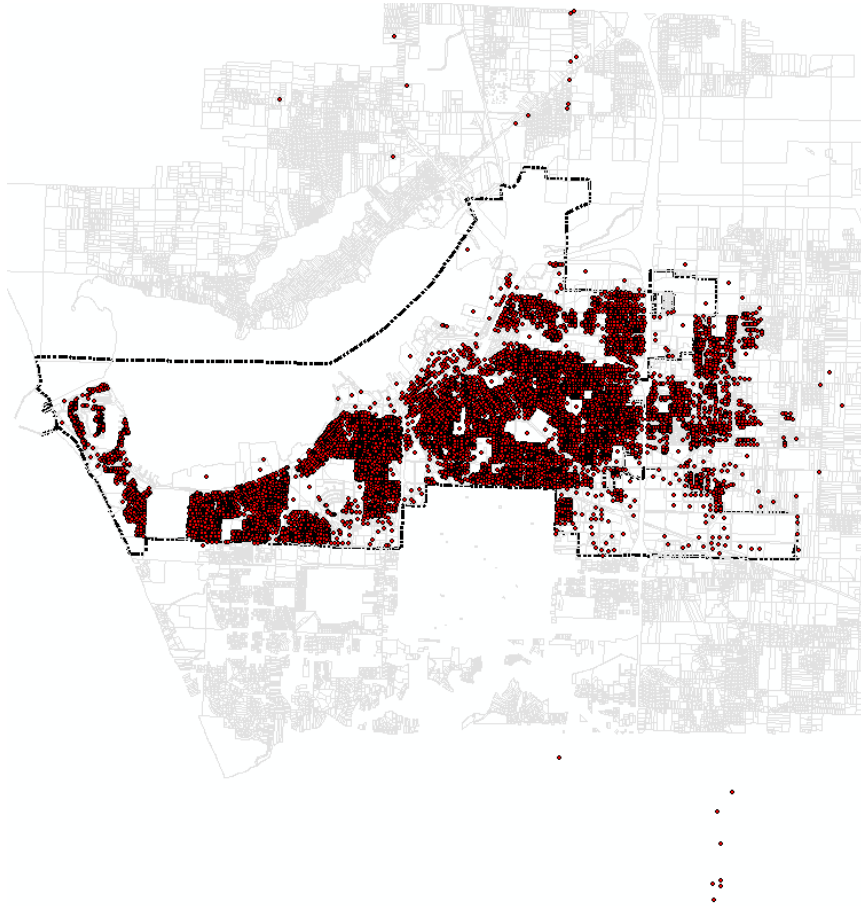
20' From 6" Tee to 12" Sam Sewer  
 4' From 12" Sam to 12" Storm  
 3' From 12" Storm to 3/4" Gas  
 7' From 3/4" Gas to 4" Water  
 3'6" From 4" Water to 1 1/4" Pipe  
 8' From 1 1/4" Pipe to 6" sewer.

# Step One: Tie Card Data Extraction

- Scanned approximately 16,000 tie cards to pdf (named by address)
- Each tie card was hyperlinked in an excel spreadsheet
- Initial fields from the tie cards were populated into the spreadsheet (searchable and sortable)

	A	B	D	E	F	G	H	I	J	K
1	Hyperlink	Address	File Name	DateInstalled	Diameter	Material	Main Size	StopBox	CorpStyle	Curb Style
135	<a href="#">\\gfiles\server\shared\2018\2180344</a>	1541 5TH ST	1541 FIFTH ST	2013-09-01	1	COP	16	LOCATION	1	1
136	<a href="#">\\gfiles\server\shared\2018\2180344</a>	1527 5TH ST	1527 FIFTH ST				6	LOCATION		
137	<a href="#">\\gfiles\server\shared\2018\2180344</a>	1505 5TH ST	1505 FIFTH ST		3/4		6	LOCATION		
138	<a href="#">\\gfiles\server\shared\2018\2180344</a>	1535 5TH ST	1535 FIFTH ST	1986-04-01	3/4	COP	6			
139	<a href="#">\\gfiles\server\shared\2018\2180344</a>	1513 5TH ST	1513 FIFTH ST				6	LOCATION		
140	<a href="#">\\gfiles\server\shared\2018\2180344</a>	1575 5TH ST	1575 FIFTH ST				6	LOCATION		
141	<a href="#">\\gfiles\server\shared\2018\2180344</a>	1569 5TH ST	1569 FIFTH ST		3/4		6	LOCATION		

## Step Two: Geocode in ArcGIS



- A “Match Address” field was created from the tie card file name and scrubbed to exactly match the Muskegon County Parcel layer
- Geocoding results: 14,230/15,700 (91%) tie cards matched with a parcel
- Created a “location assumed” field

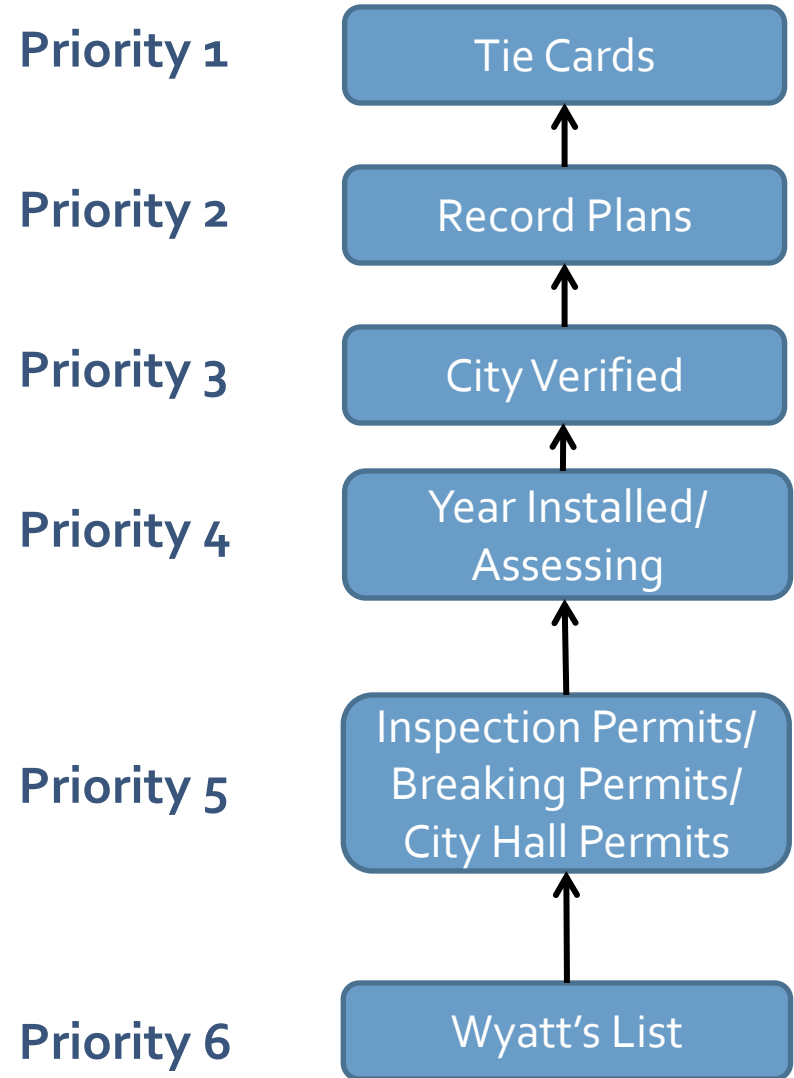
# Step 3: Create Inventory Framework

- Each water service got a point at the centroid of the parcel
- Sanitary and storm tie cards were extracted into separate shapefiles
- Created/populated major fields:
  - Lifecycle Status (active or abandoned?)
  - Ownership
  - Fire/Irrigation Flag
  - Private Side Service Attributes (diameter, install date, material... etc.)



## Step 3: Create Inventory Framework Cont.

- Added two fields to keep track of lead potential:
  - “Public Side Done”
  - “Private Side Done”
- Both fields were defaulted to “No” (signifying a potential for lead)
- Fields were populated with the data source with which the “no potential for lead” determination was made



# Step 4: Review Additional Data Sources for Material Information



Priority 1

Tie Cards

Priority 2

Record Plans

Priority 3

City Verified

Priority 4

Year Installed/  
Assessing

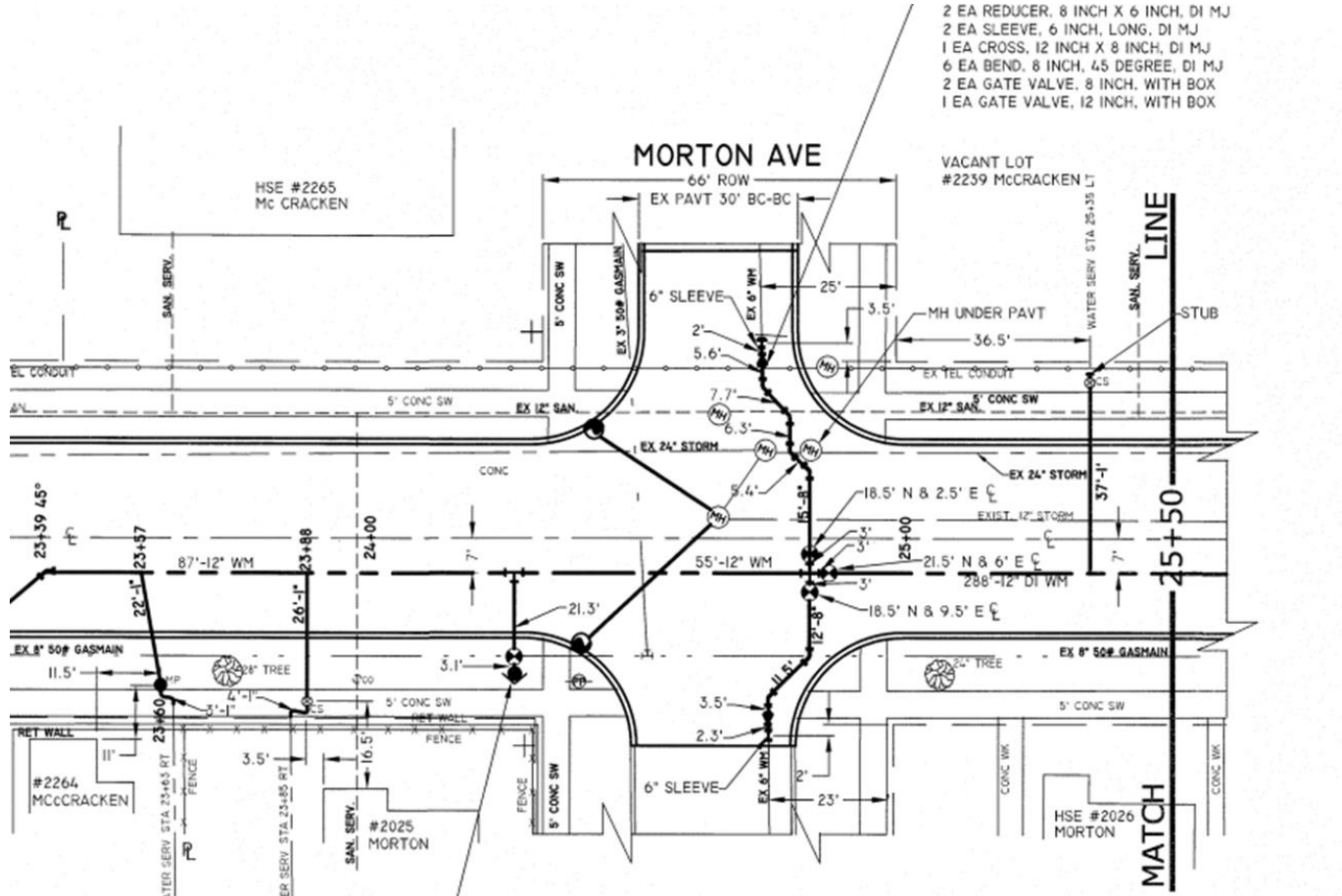
Priority 5

Inspection Permits/  
Breaking Permits/  
City Hall Permits

Priority 6

Wyatt's List

# Data Source: Record Plans



- 2 EA REDUCER, 8 INCH X 6 INCH, DI MJ
- 2 EA SLEEVE, 6 INCH, LONG, DI MJ
- 1 EA CROSS, 12 INCH X 8 INCH, DI MJ
- 6 EA BEND, 8 INCH, 45 DEGREE, DI MJ
- 2 EA GATE VALVE, 8 INCH, WITH BOX
- 1 EA GATE VALVE, 12 INCH, WITH BOX

- STA 24+27 RT
- EA TEE, 12 INCH X 6 INCH, DI MJ
- EA GATE VALVE, 6 INCH, WITH BOX
- EA HYDRANT, 6 INCH, STANDARD
- 24.2 FT WATERMAIN, DI, 6 INCH, TR DET G, MODIFIED

WATER SERVICE SCHEDULE					
STATION	1 INCH CORP	1 INCH TYPE "K" COPPER	1 INCH CURB STOP	METER PIT COMPLETE	ABANDON WATER SERVICE
21+90 RT	1 EACH	22 FT		1 EACH	
22+47 RT	1 EACH	26 FT	1 EACH		
23+63 RT	1 EACH	25 FT		1 EACH	
23+85 RT	1 EACH	30 FT	1 EACH		
22+66 LT	1 EACH	7 FT			
25+55 LT	1 EACH	37 FT	1 EACH		

All record plans from 1960 to present were reviewed

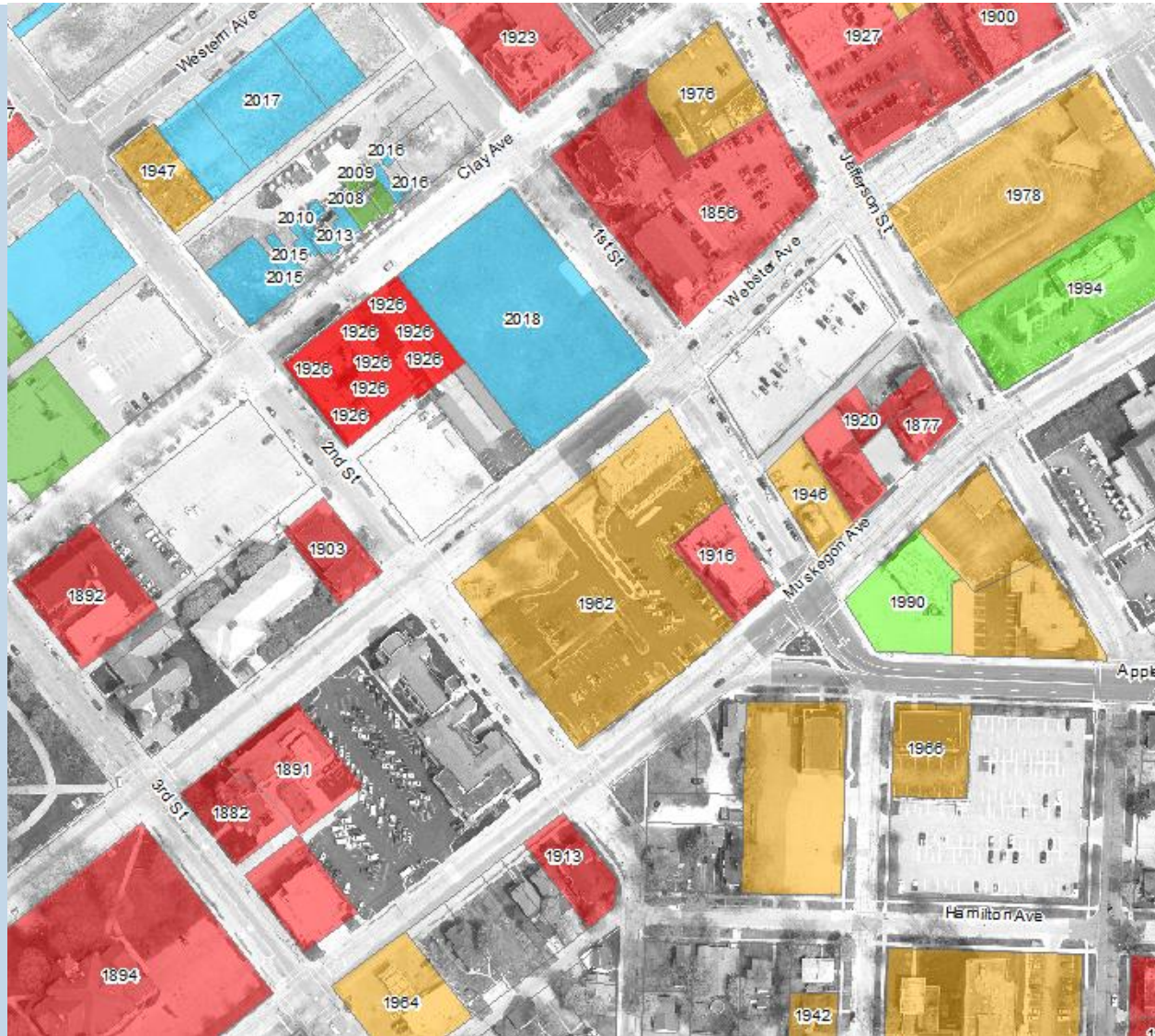
# Data Source: City Verification



City has institutional knowledge that has not been recorded anywhere



# Data Source: County Assessing Data



It was assumed that the PRIVATE side of the water service was lead free if buildings were built after 1970

# Data Source: Installation Year

2002

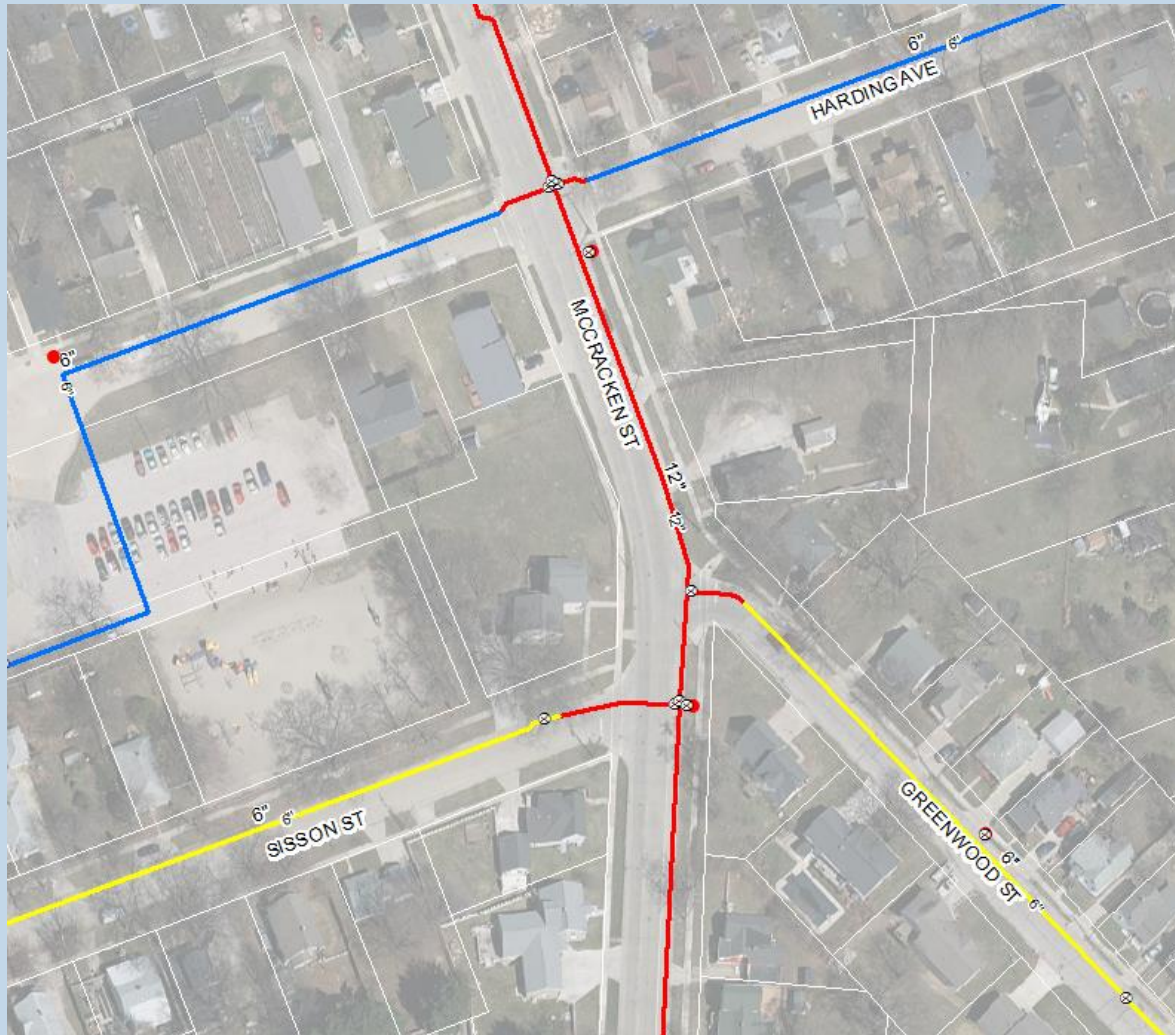


2005



Google Earth Historical Aerials were sometimes used to verify and approximate building ages where assessing data was lacking

# Data Source: Installation Year



If a NEW water main was installed after 1970, it was assumed that the services were copper

# Data Source: Permits

Date	Numb	Street	Post	comb	Type	ID	Cost	Owner
11/29/2006	2223	MCCRACKEN	st	2223 MCCRACKEN ST	WATER & SEWER CONNECTION	2023C	\$0	SAMUEL WAKEFIELD
10/17/2000	2265	MCCRACKEN	st	2265 MCCRACKEN ST	WATER & SEWER CONNECTION	2410C	\$0	CLYDE W DURGAN
2/26/2007	2270	CROWLEY	st	2270 CROWLEY ST	WATER & SEWER CONNECTION	2041C	\$0	SAMUEL WAKEFIELD
6/17/2002	2271	MCCRACKEN	st	2271 MCCRACKEN ST	WATER & SEWER CONNECTION	2342C	\$0	SAMUEL WAKEFIELD
8/24/2001	2287	MCCRACKEN	st	2287 MCCRACKEN ST	WATER & SEWER CONNECTION	2425C	\$0	CLYDE DURGAN
3/16/2000	2301	PARK	DR	2301 PARK DR	WATER & SEWER CONNECTION	2283C	\$0	SCOTT LANGLOIS
5/13/2002	2311	MCCRACKEN	st	2311 MCCRACKEN ST	WATER & SEWER CONNECTION	2387C	\$0	CLYDE DURGAN
3/30/2006	2335	DOWD	st	2335 DOWD ST	WATER & SEWER CONNECTION	1992C	\$0	DOUGLAS GLOMB
11/22/2000	2343	GREENWOOD	st	2343 GREENWOOD ST	WATER & SEWER CONNECTION	2412C	\$0	BRENT FIELSTRA
9/10/2001	2350	HENRY	st	2350 HENRY ST	WATER & SEWER CONNECTION	2319C	\$0	KOPS CONSTRUCTION/TROPHY HOUSE
5/28/2003	2355	GREENWOOD	st	2355 GREENWOOD ST	WATER & SEWER CONNECTION	2493C	\$0	SAM WAKEFIELD
10/30/2000	2361	MILLARD	ave	2361 MILLARD AVE	WATER & SEWER CONNECTION	2305C	\$0	YOUNG & BROW BUILDERS
9/10/2002	2366	DOWD	st	2366 DOWD ST	WATER & SEWER CONNECTION	2393C	\$0	TOM FREDRICKSON
8/9/2002	2367	GREENWOOD	st	2367 GREENWOOD ST	WATER & SEWER CONNECTION	2346C	\$0	SAM WAKEFIELD

Inspection  
permits

City Hall  
permits

STR_NO	STR_E STREET	GIS_JOIN	Combined Description
1510	MORGAN	1510 MORGAN AVE	WATER AND SEWER SERVICE TO NEW HOUSE.
1694	DYSON	1694 DYSON ST	WATER SERVICE REPLACEMENT
776 W	SOUTHERN	776 W SOUTHERN AVE	WATER SERVICE FROM METER TO HOUSE
1783	HUIZENGA	1783 HUIZENGA ST	WATER SERVICE AND SEWER TO NEW HOUSE
860 W	SHERMAN	860 W SHERMAN BLVD	WATER SERVICE AND SEWER LINE
31	IONA	31 IONA AVE	WATER SERVICE AND REDIRECT SEWER FROM NEIGH
1526	FRANKLIN	1526 FRANKLIN ST	WATER SERVICE & DISTRIBUTION
1311	LAKESHORE	1311 LAKESHORE DR	WATER SERVICE
2278	STEIN	2278 STEIN ST	WATER LINE TO HOUSE AND SEWER

Three separate  
permitting  
databases were  
reviewed

9/3/2002	1137	Peck		New water service
5/26/2000	123	W. Larch		NEW WATER SERVICE
1/7/2000	507	Allen		NEW WATER SERVICE
8/25/1999	1700	APPLE AVE.		NEW WATER SERVICE
6/18/2013	790	W. Grand		New Water Service / Watermain repair
12/10/1999	2487	GREENWOOD		NEW WATER+SEWER
10/13/2003	362	W. Muskegon		Relace Water Service
4/27/2006	442	Mulder		Relocate Water & Sewer
11/16/2009	623	Catherine		Relocate Water Service

Breaking  
permits

# Data Source: "Wyatt's List"



Initial LSL  
inventory from  
Wyatt Eggleton,  
City of  
Muskegon Public  
Utilities  
Supervisor

# Additional Data Sources

- Additional data sources were used to assist with life cycle status and addressing:
  - City water billing records
  - City building demolition records
  - Google street view
  - Drive-bys



# Step 5: Put It All Together

The screenshot displays a GIS application window with a map of a residential street. The map shows several colored dots representing water service points along Ducey Ave and James Ave. A detailed data entry form is overlaid on the map, showing handwritten information for address 1435 Ducey. The form includes fields for address, date installed, water/sewer status, crew, permit, size, material, main size, stop box, curb style, length of service, and location. A diagram of the property layout is also shown, with dimensions and labels for sidewalk and driveway.

**Table Of Contents**

- SanitaryServicePoints
- Water Services
  - Water Service - Both Sides Done
  - Water Service - Customer Side Done
  - Water Service - City Side Done
  - Water Service - No Sides Done
  - Water Service - All
- WaterServicePointsGeoCode - Hardrive
- Water Service - DWRF
- Road\_RecordPlan
- Water System
  - Water Manhole - No Year Installed
  - Water Manhole - Year Installed
  - Valves - Year Installed
  - Hydrants - Year Installed
  - Valves
  - Hydrants
  - Water Main - No Year Installed
  - Water Main - No Year Installed
  - Water Main - Year Installed
  - Water Main - Abandoned
  - Water Main
  - Laterals
  - Laterals
  - Water Record Plans
- Storm Water System
- Sanitary System
  - Sanitary Manhole
  - PACP Observations
  - Sanitary Pump Station

**Identify**

Identify from: <Top-most layer>

- Water Service - City Side Done
  - 1435 DUCEY AVE

Location: 12,632,779.119 640,890.167 Feet

Field	Value
OBJECTID	8648
Shape	Point
Street	DUCEY AVE
File_Name	1435 DUCEY AVE
Material	COPPER
MainSize	6 INCH
StopBox	YES
CorpStyle	COMP
CurbStyle	COMP
Comments	<null>
NoDrawing	<null>
Hyperlink	\\gfilesserver\shared\2018\21
LinkStatus	True
MeterID	04324600
Address	1435 DUCEY AVE
Install Date	9/5/2017
Diameter	3/4
Length of Service Installed	6
Public Side Completed?	TIE CARDS
Private Side Completed?	NO
Stop Box Location	Street
Public Side Owner	CITY OF MUSKEGON
Original Address On Tie Card	<null>
Lifecycle Status	ACTIVE
Question Flag	<null>
Private Side Diameter	<null>
Private Side Material	<null>
Irrigation or Fireline	<null>
Location Assumed?	NO
Duplicate	0
Building Type	Residential
LeadFreeStatus	Public Side Completed
DWRF Replacement	<null>

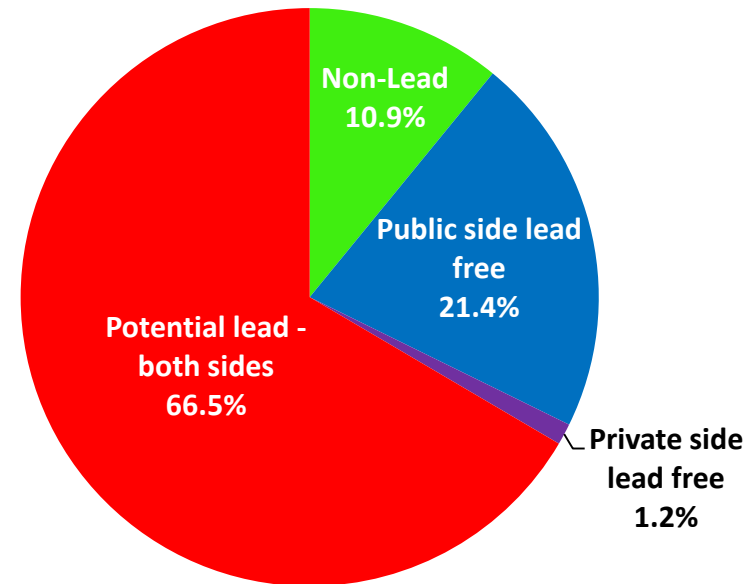
Identified 1 feature

# So Where is the Lead?

## Preliminary Results:

- 12,900 - Total active, City of Muskegon owned, potable water services
- 1,408 – Non-Lead/galvanized services (10.9%)
- 11,492 – Potential lead/galvanized services – full or partial (89.1%)
- Approximately **\$45 million** to replace all lead service lines

### Water Service Material

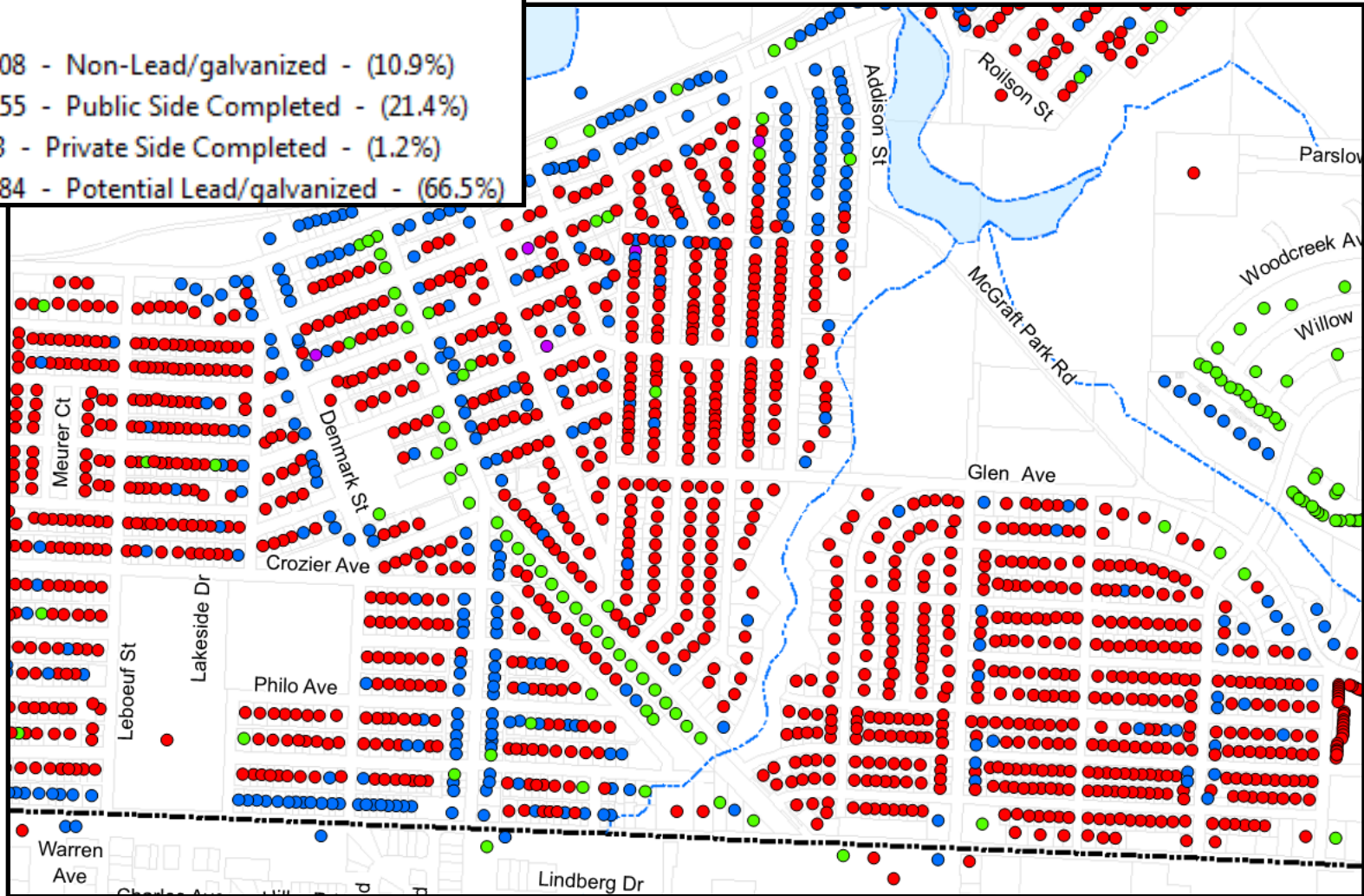




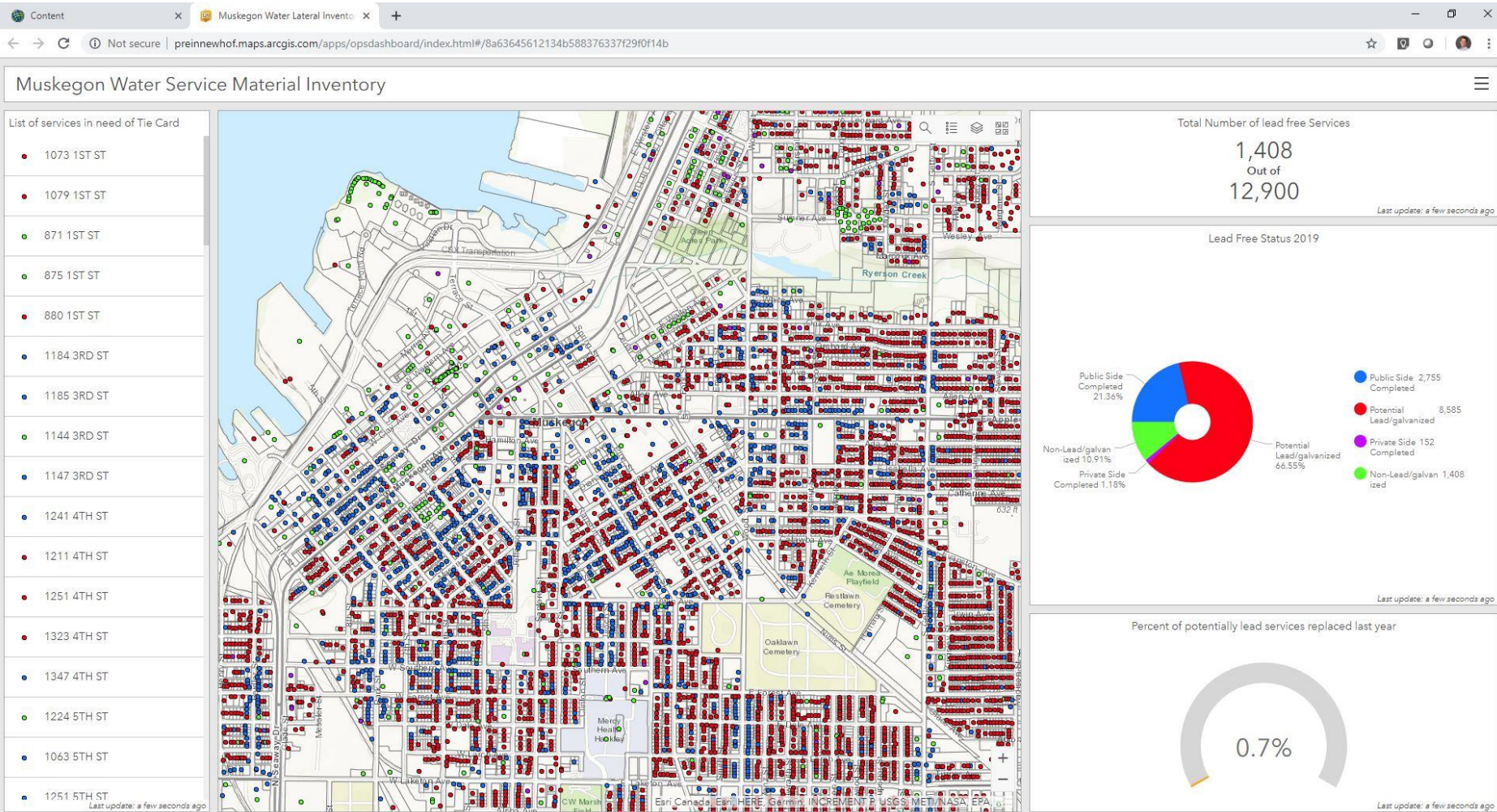
# Material Inventory: Preliminary Results

Water Service Status (12,900 total active services)

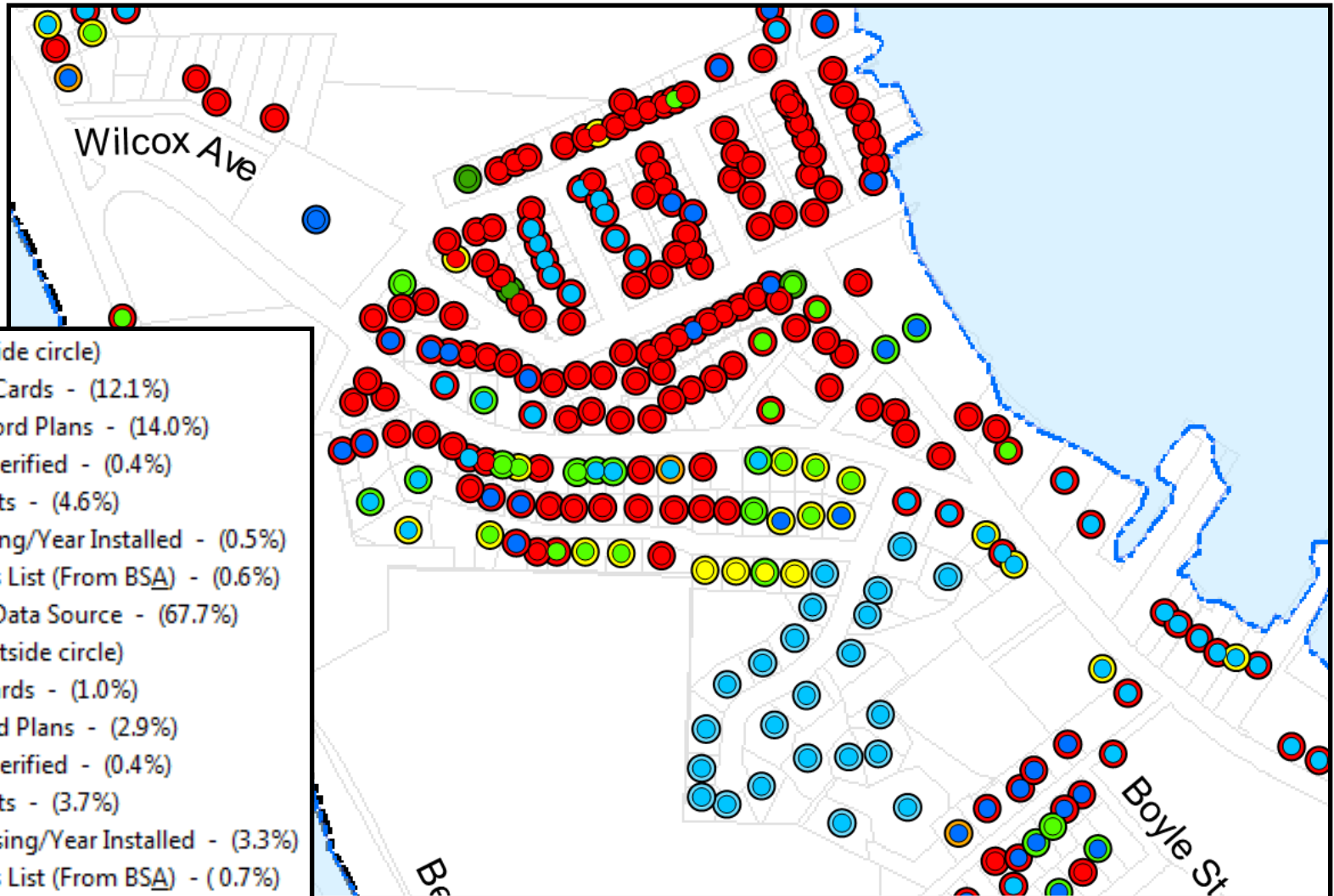
- 1,408 - Non-Lead/galvanized - (10.9%)
- 2,755 - Public Side Completed - (21.4%)
- 153 - Private Side Completed - (1.2%)
- 8,584 - Potential Lead/galvanized - (66.5%)



# Material Inventory: Dashboard



# Material Inventory: Data Source Summary



- Public side (inside circle)
  - 1,557 - Tie Cards - (12.1%)
  - 1,807 - Record Plans - (14.0%)
  - 62 - COM Verified - (0.4%)
  - 598 - Permits - (4.6%)
  - 68 - Assessing/Year Installed - (0.5%)
  - 71 - Wyatt's List (From BSA) - (0.6%)
  - 8,737 - No Data Source - (67.7%)
- Private side (outside circle)
  - 129 - Tie Cards - (1.0%)
  - 370 - Record Plans - (2.9%)
  - 58 - COM Verified - (0.4%)
  - 479 - Permits - (3.7%)
  - 431 - Assessing/Year Installed - (3.3%)
  - 94 - Wyatt's List (From BSA) - (0.7%)
  - 11,339 - No Data Source - (87.9%)

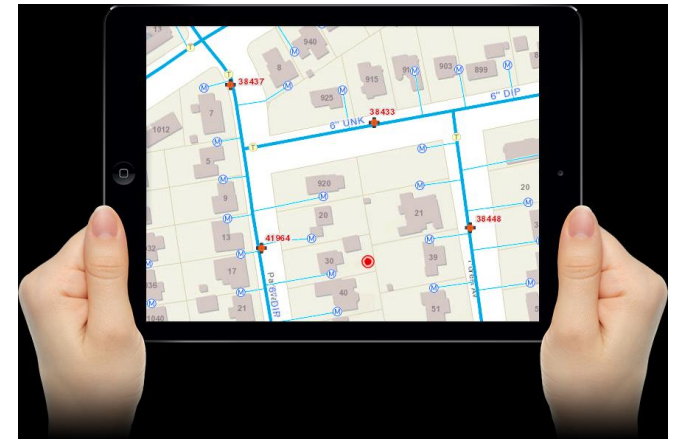
# Material Inventory: Other Results

- 1,680 active services without a tie card and 29 without a location drawn
- 133 “active” services not in City billing records (City is in process of reviewing these services)
- 111 active services on “Wyatt’s List” where no other “lead free” documentation was found



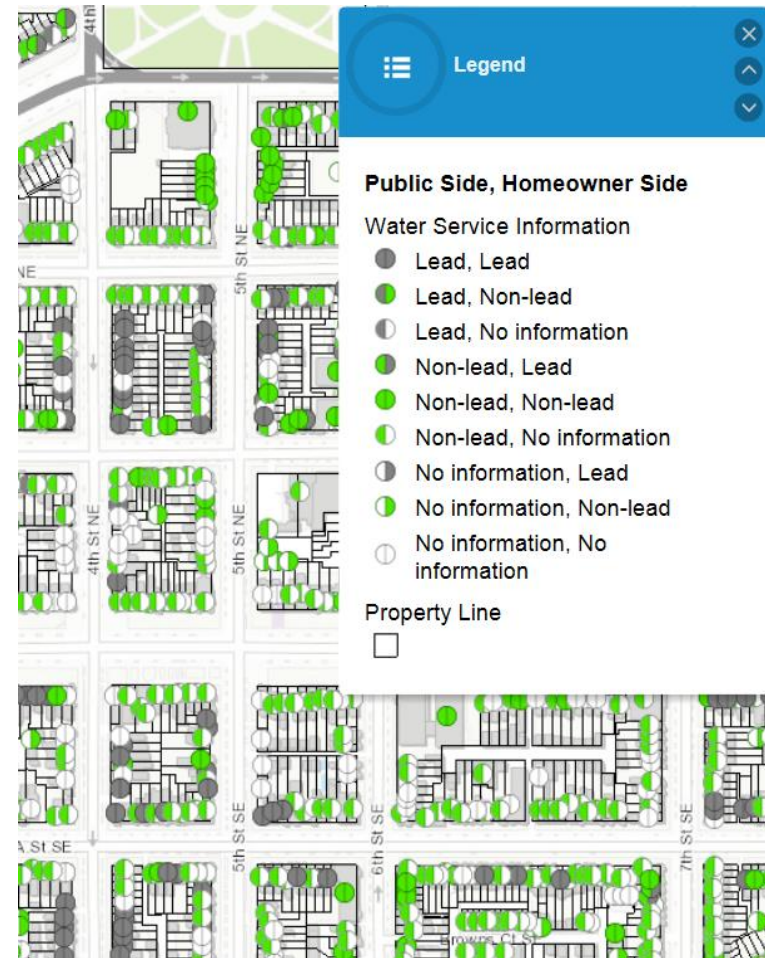
# LSL Inventory Benefits

- Access service tie cards and record plans in the field
- Data sources at your fingertips
- Potentially discover unbilled customers
- Determine which customers are missing tie cards
- GIS allows for efficient LSL replacement planning
- Public trust and transparency



# Future Possibilities

- Create field mapping for “field verified inventory”
- GPS curb stops and meter pits
- Sync BS&A updates to GIS
- Make service material inventory available to the public  
(Washington D.C. example: <https://geo.dcwater.com/Lead/>)



# Lesson's Learned

- Consider adding a “Level of Confidence” field
- Detailed, understandable, and reliable records are very important!
- Perfection is unattainable
- Each community is different
- Have a discussion on potential data sources and their accuracy/reliability early on





# Questions?

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