# Units of Service for Non-Master Metered Customers of Great Lakes Water Authority and System Water Audit

29 November 2018

## November 2018 Water Charges Work Group

## Phase 2 Report Summary

GLWA
Great Lakes Water Authority

BLACK & VEATCH
Building a world of difference.

# Units of Service for Non-Master Metered Customers of Great Lakes Water Authority and System Water Audit

**Phase 1 (March 2017 – Dec 2017):**

- Desktop Analysis
- Best Available Data
- Use of benchmarks and peers

**Phase 2 (Jan 2018 – Nov 2018):**

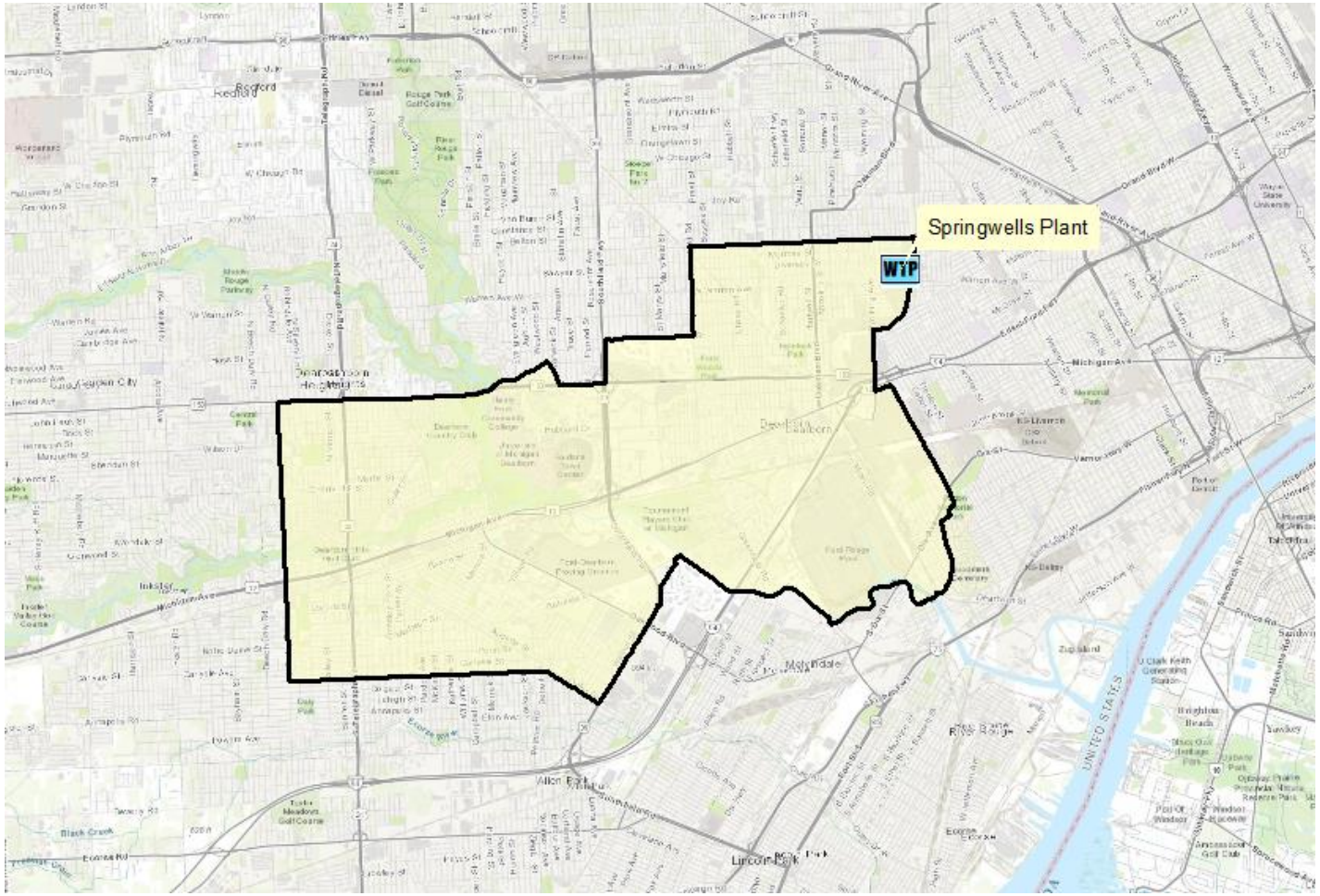
- Obtain data from the field
- Improve processes
- Collaboration

# Phase 2 Work Areas

1) Conduct District Metered Area Analyses for Dearborn and Detroit
2) Evaluate Water Treatment Plant Water Production Flow Meter Testing
3) Evaluate Water Transmission Main Blow Off Valve Assessment
4) Develop Master Metering Approaches for Dearborn and Detroit
5) Develop a Long-term Water Audit Approach for GLWA
6) Develop a Process for an Annual Wholesale Meter Audit
7) Identify and Prioritize Data Gaps
8) Preparation of Phase 2 Report (available via Outreach Portal by 11/30)

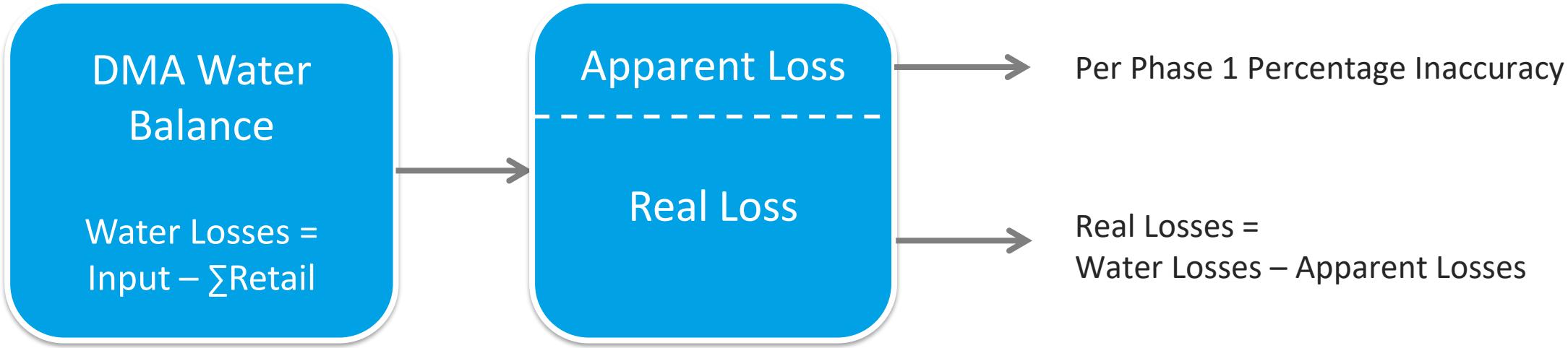
# CITY OF DEARBORN

City of Dearborn



# Using DMA Results

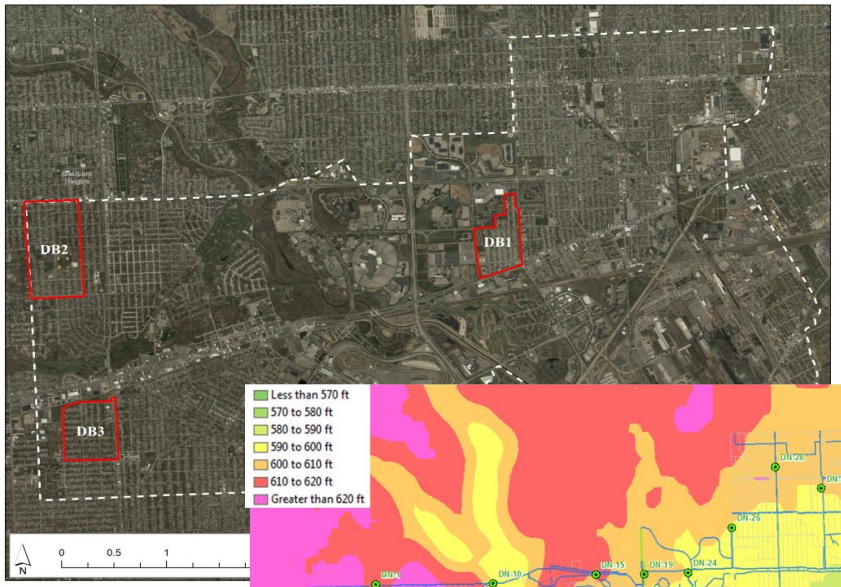
- Two to three week monitoring periods
- Flow balance yielded water losses (real and apparent)

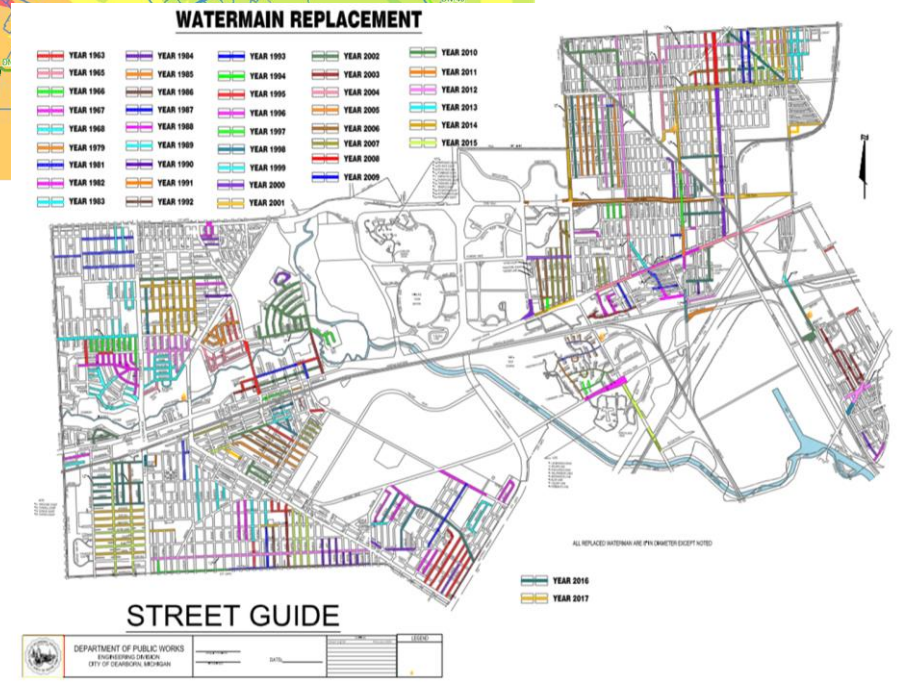



- Real and apparent Losses were calculated using Gallons/Connection/Day

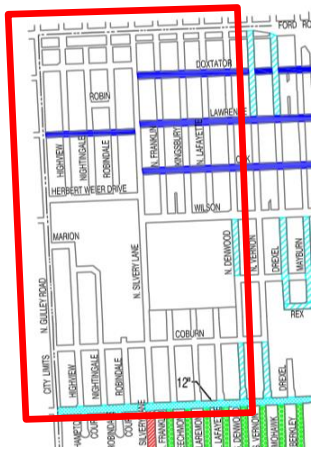
# Selection of Dearborn DMAs

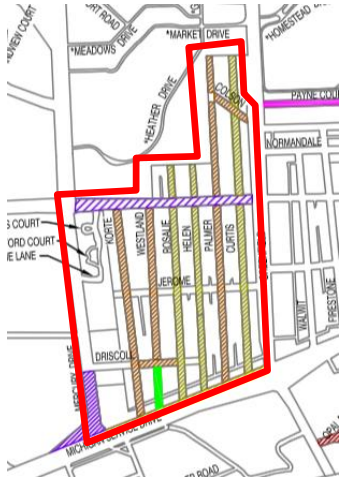
- High probability of isolation
- Areas representative of broader system
- Data available for extrapolation (e.g., pipe age, pressures)
- Minimal valve closures
- No DMA in commercial and industrial areas:
  - Impact of 24/7 operations on minimum night flow
  - Lack of redundancy in DMA for critical customers



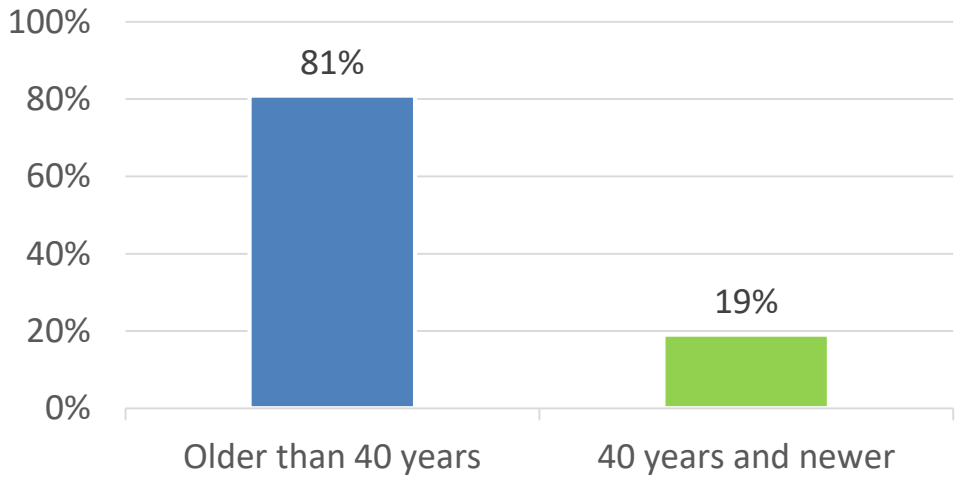



# DMA Water Main Replacement Summary

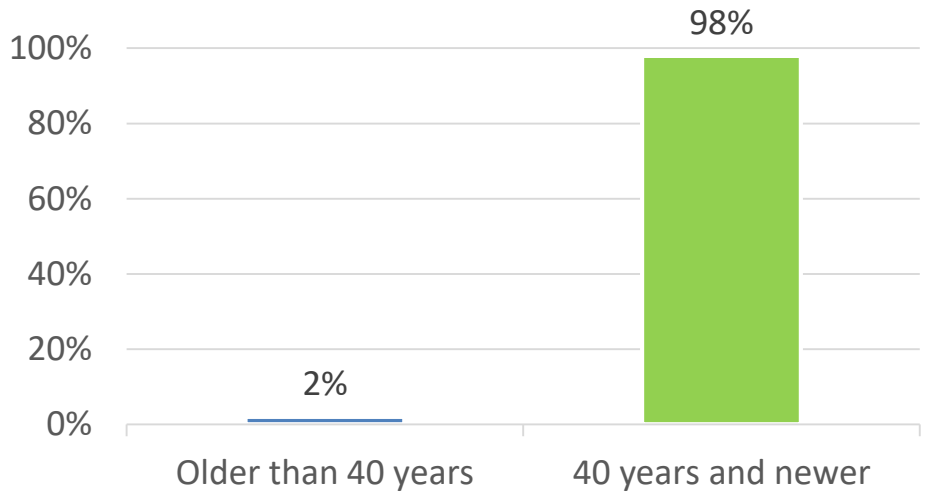


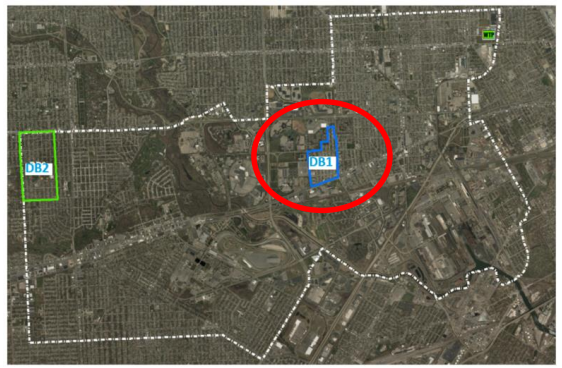




## DB2: Older / Lower Pressure




## DB1: Newer / Higher Pressure



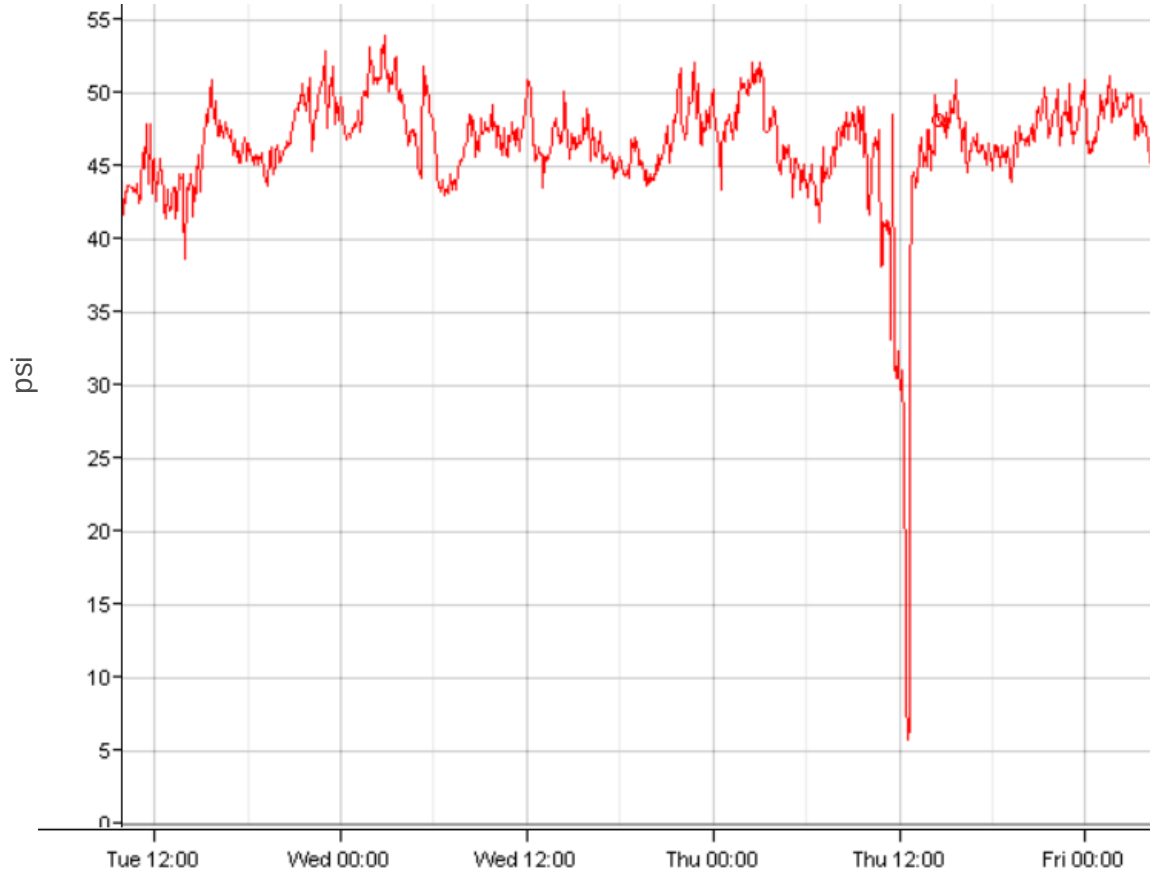



# Dearborn DMA: DB1

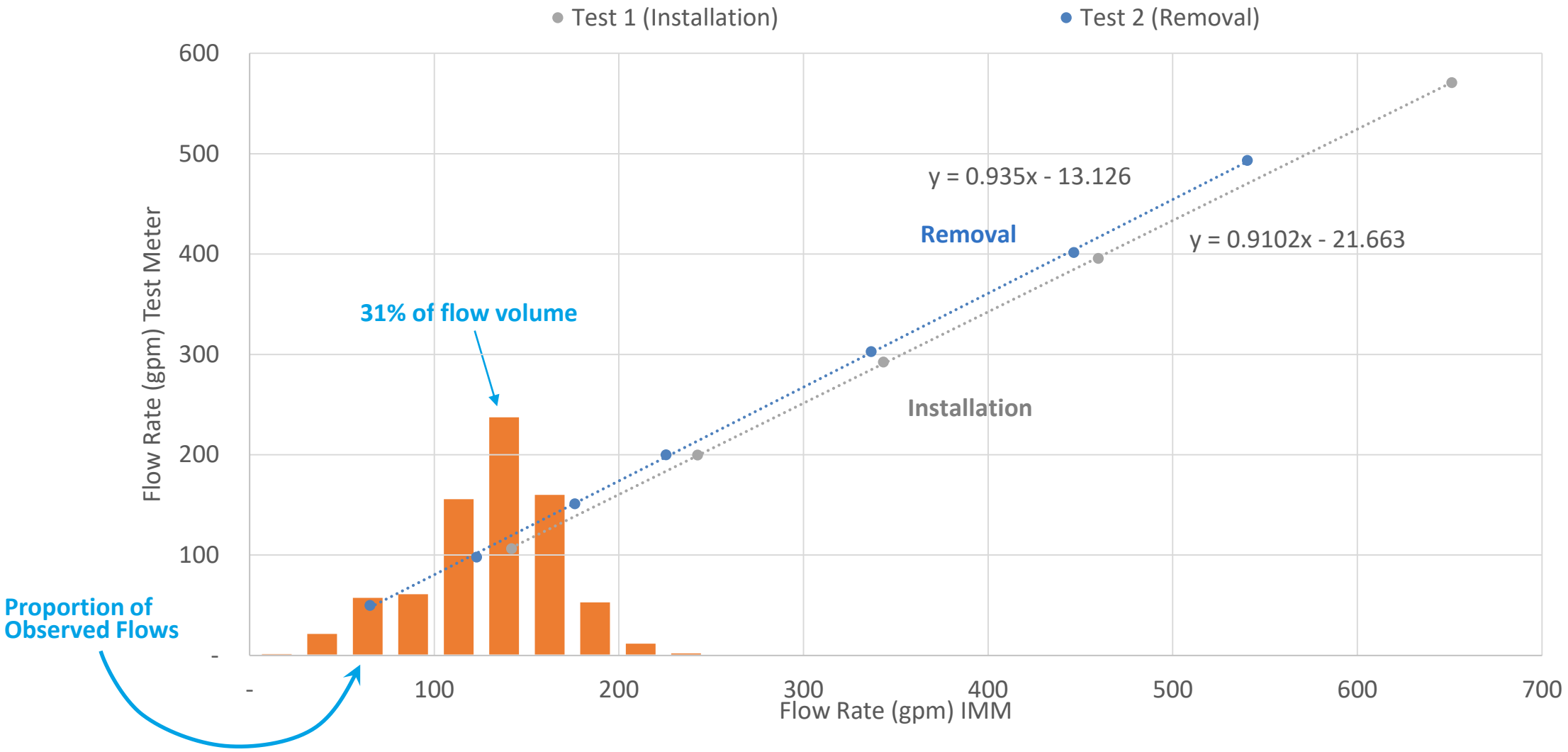
- Single insertion mag meter (IMM) installed 8/4/2018
- Dearborn installed new chamber to take advantage of newer section of pipe and ensure sufficient straight pipe up and downstream of meter
- IMM tested against a hydrant test meter to provide in-situ calibration
- Isolation achieved 8/30/2018
- Flows augmented over 3 days to build confidence in low flows
- After 14 days, second hydrant test
- Extra validation step: new meter installed for an additional 14 days

# Isolating DMAs

- Significant effort involved to isolate and confirm
- E.g., identifying valves, working valves (water quality issues), repairing valves
- Implement pressure alarms and develop emergency response protocols




# DB1: Meter 1: Hydrant Test #1 (Installation) vs Hydrant Test #2 (Removal)



# DB1: Summary Results

## Meter 1 data - typical usage period (14 days)

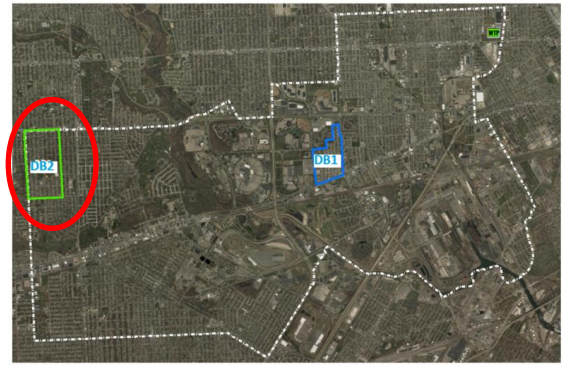
| | DB1 Meter 1 | Total Volume (Gallons) | Gallons Per Day |
|---|---|---|---|
| [1] | Raw IMM Between 10:00AM 8/30/2018 and 10:00AM 9/13/2018: | 2,323,110 | 165,936 |
| [2] | IMM Adjusted Between 10:00AM 8/30/2018 and 10:00AM 9/13/2018: | 1,926,768 | 137,626 |
| [3] | Retail Reads | 1,714,977 | 122,498 |
| [4] | Customer Metering Inaccuracies (2.01% x [3]) | 34,471 | 2,462 |
| [5] | Unauthorized Consumption (AWWA default) [0.25% x [2] | 4,817 | 344 |
| [6] | Systematic Data Handling Errors (AWWA default) [0.25% x [3] | 4,287 | 306 |
| [7] | Gallons per Connection* per Day Apparent Loss | | **4** |
| [8] | Net Real Loss | 168,216 | 12,015 |
| [9] | Gallons per Connection* per Day Real Loss | | **15** |

* 805 Total connections

## Meter 2 data - typical usage period (14 days)

| | DB1 Meter 2 | Total Volume (Gallons) | Gallons Per Day |
|---|---|---|---|
| [1] | IMM Raw Between 10:00 AM 9/19/2018 and 10:25 AM 10/3/2018 | 1,881,115 | 134,232 |
| [2] | IMM Adjusted Between 10:00 AM 9/19/2018 and 10:25 AM 10/3/2018 | 1,849,810 | 131,998 |
| [3] | Retail Reads | 1,655,327 | 118,120 |
| [4] | Customer Metering Inaccuracies (2.01% x [3]) | 33,272 | 2,374 |
| [5] | Unauthorized Consumption (AWWA default) (0.25% x [2]) | 4,625 | 330 |
| [6] | Systematic Data Handling Errors (AWWA default) (0.25% x [3]) | 4,138 | 295 |
| [7] | Gallons per Connection* per Day Apparent Loss | | **4** |
| [8] | Net Real Loss | 152,448 | 10,878 |
| [9] | Gallons per Connection* per Day Real Loss | | **14** |

* 805 Total connections

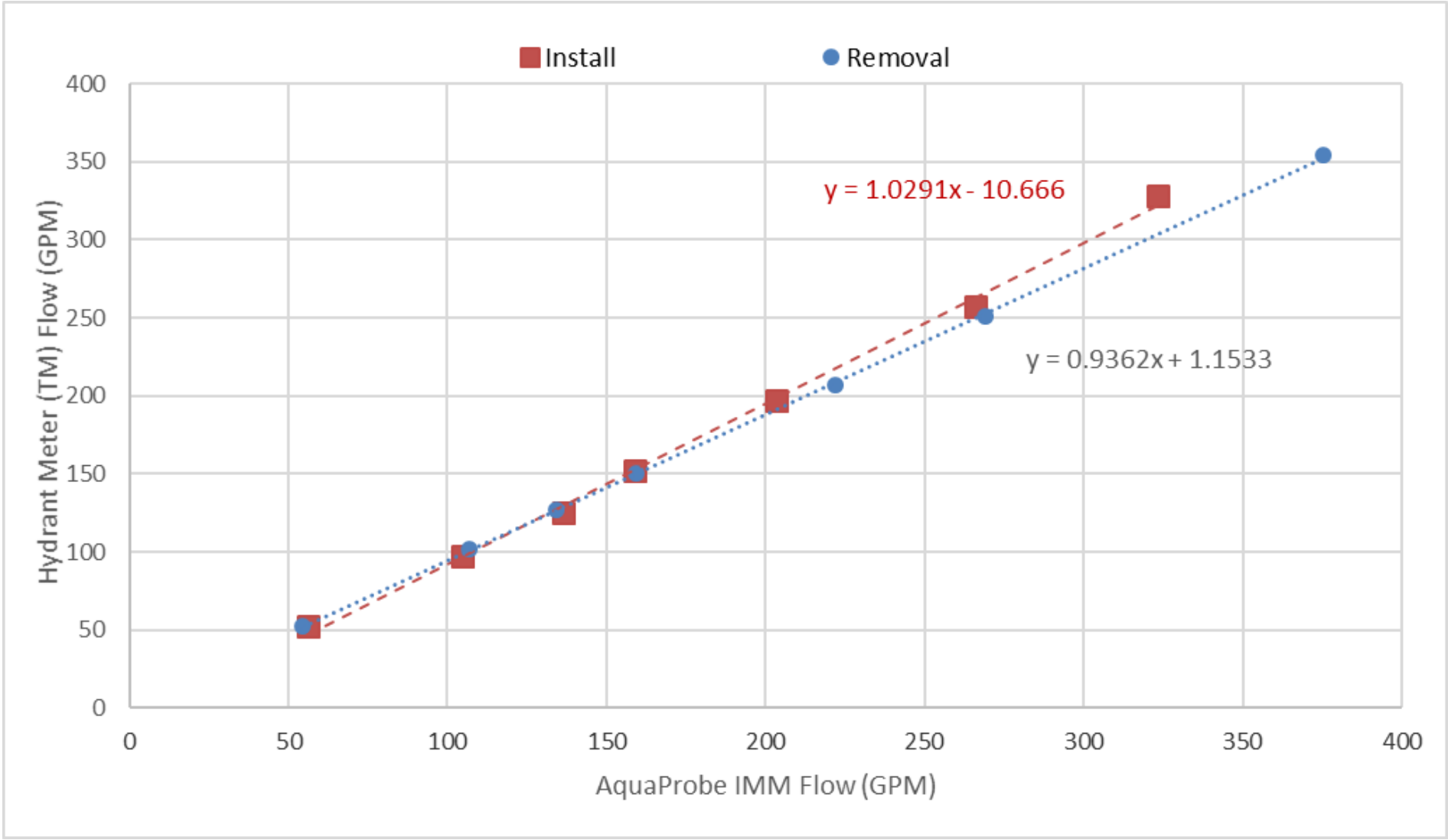



# Dearborn DMA: DB2

- DMA planned with two meters
- Dearborn installed 20ft of new pipe and temporary 8” inline mag meter in southwest corner of the DMA (concern over tuberculation in existing pipe)
- IMM installed in gate well on eastern side of the DMA
- Isolation occurred on 10/4/2018 (large effort, incl. new gate valve)
- Initial monitoring shows flows moving in and out of DMA
- Moved to one meter (IMM) feed on 10/8

# DB2 Hydrant Tests

Required estimate of consumption for houses in isolated area



# DB2: Summary Results

## Typical usage period (14 days)

| | DMA DB2 | Total Volume Gallons | Gallons Per Day |
|---|---|---|---|
| [1] | IMM Raw Between 10/08/18 11:30 and 10/22/18 11:30 | 3,195,695 | 228,264 |
| [2] | IMM Adjusted Between 10/08/18 11:30 and 10/22/18 11:30 | 3,082,500 | 220,179 |
| [3] | Retail Reads | 2,670,994 | 190,785 |
| [4] | Customer Metering Inaccuracies (2.04% x [3]) | 54,488 | 3,892 |
| [5] | Unauthorized Consumption (AWWA default) (0.25% x [2]) | 7,706 | 550 |
| [6] | Systematic Data Handling Errors (AWWA default) (0.25% x [3]) | 6,677 | 477 |
| [7] | Gallons per Connection* per Day Apparent Loss | | **4** |
| [8] | Net Real Loss | 342,634 | 24,474 |
| [9] | Gallons per Connection* per Day Real Loss | | **18** |

* 1,349 Total connections

# Dearborn DMA Issues and Solutions

| | ISSUE | SOLUTION |
|---|---|---|
| 1 | Insertion Mag Meters did not consistently test within the expected range on the test bench or in the field. | The hydrant test provides a means of comparing the IMM flows against a calibrated test meter in the field, from which a calibration curve can be generated. This is preferred to transferring bench test results and assumptions to the field. |
| 2 | There were customer connections which could not be shut off when conducting the hydrant test. | An estimate of customer use was removed from the flow monitored at the IMM. |
| 3 | After the 14-day test period in DB1, the IMM appeared to be slightly off-center and not fully parallel to the pipe where it was set initially. | A second hydrant test was conducted and a second meter was installed to re-check the flows over a second 14-day period. |
| **4** | **The retail meters are normally read every three months.** | **Special meter recording runs were conducted on a daily basis (during weekdays).** |
| **5** | **Some meters only have a granularity of 100 cubic feet (CF).** | **Multiple days were used to calculate the retail volumes (14-days). Daily variation was typically 1-3%** |
| 6 | During initial installation, the cellular signals sending the pressure and flow data were intermittent at best. | Semi-open (grated) manhole covers were installed to allow the signal to propagate. |
| **7** | In DB1, the second IMM meter measured zero flow during some night time periods. | The IMMs are not as reliable at measuring low flows as billing meters. Analysis was conducted on all the logged data, and a minimum flow value was assigned as a proxy for the inconsistent readings at the very low-flows. This adjustment represented less than 1% of the total flow volume. |
| 8 | In DB2 isolation proved difficult. | A near pressure zero test was conducted to make sure that two valves (which were seen to be passing during the pressure drop test) were tight. |
| 9 | Once DB2 was isolated, it became obvious that flow conditions were altering at different times of the day. In the early morning, there was reverse flow through the IMM | The second (metered) feed to the DMA was turned off and only positive flow were observed with only one feed |

# Dearborn DMA Extrapolation

## Key Extrapolation Factors (for Real Water Loss):

- Age of Pipe
- Pressure

# Extrapolation Step: System Age

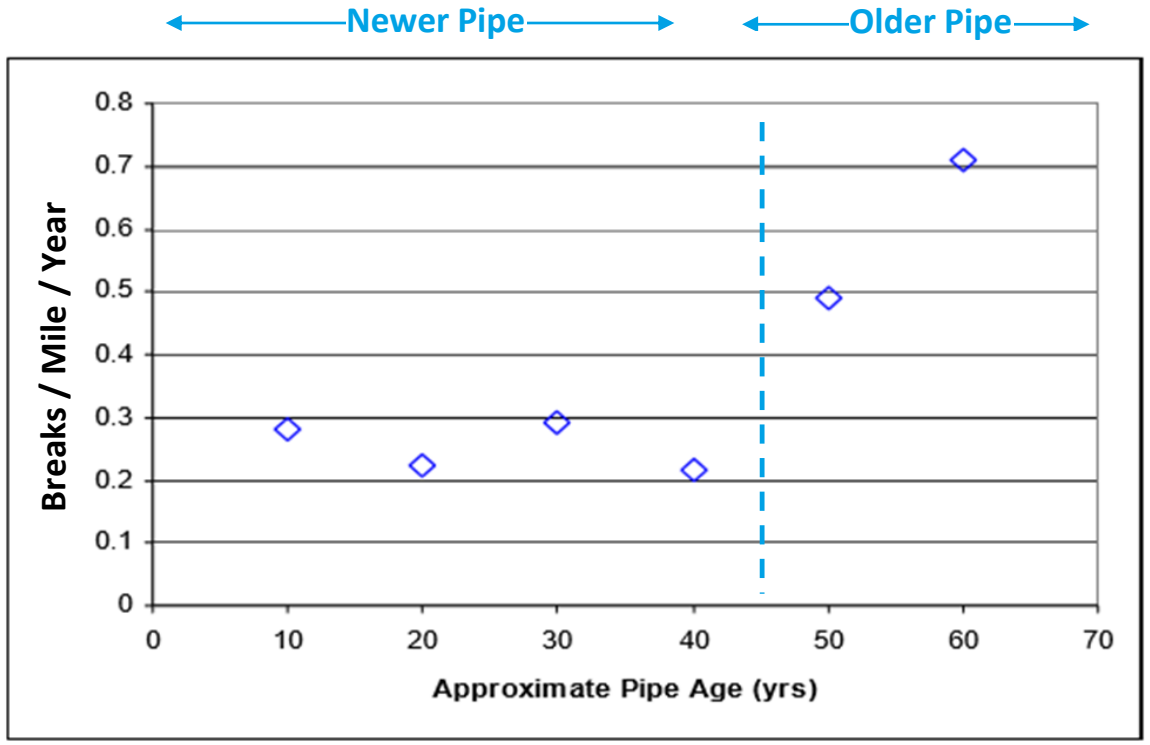
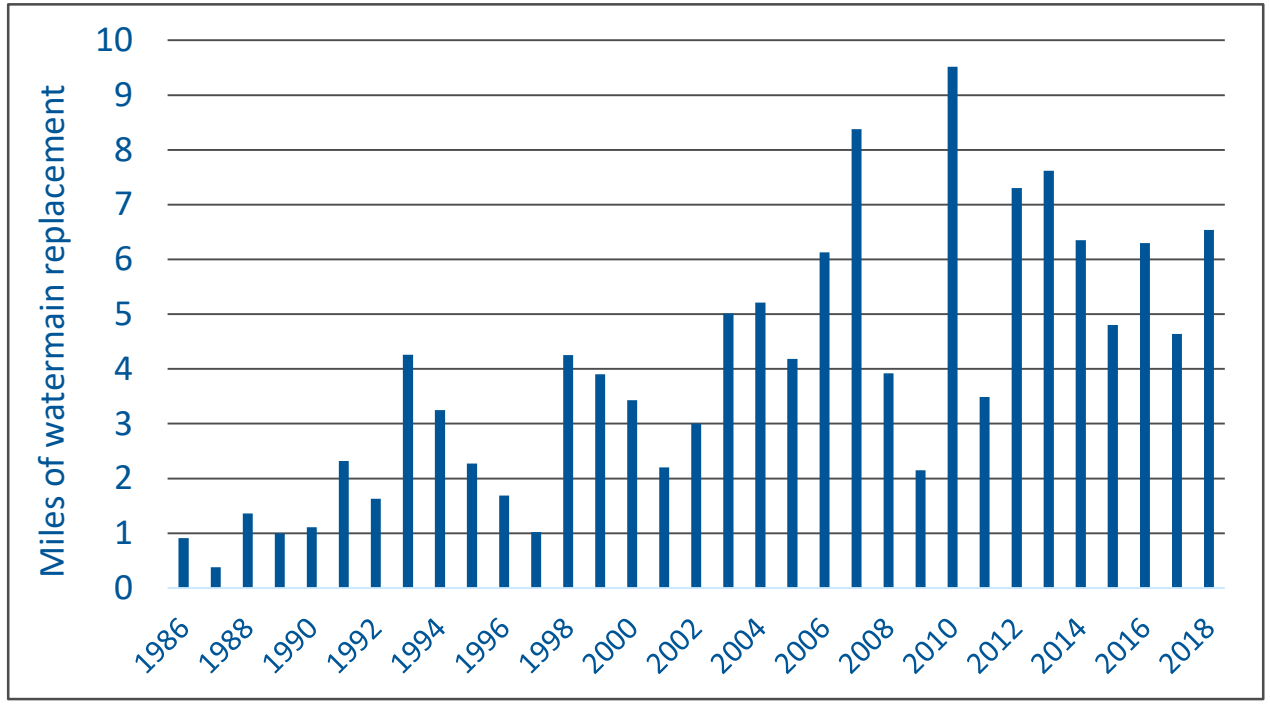


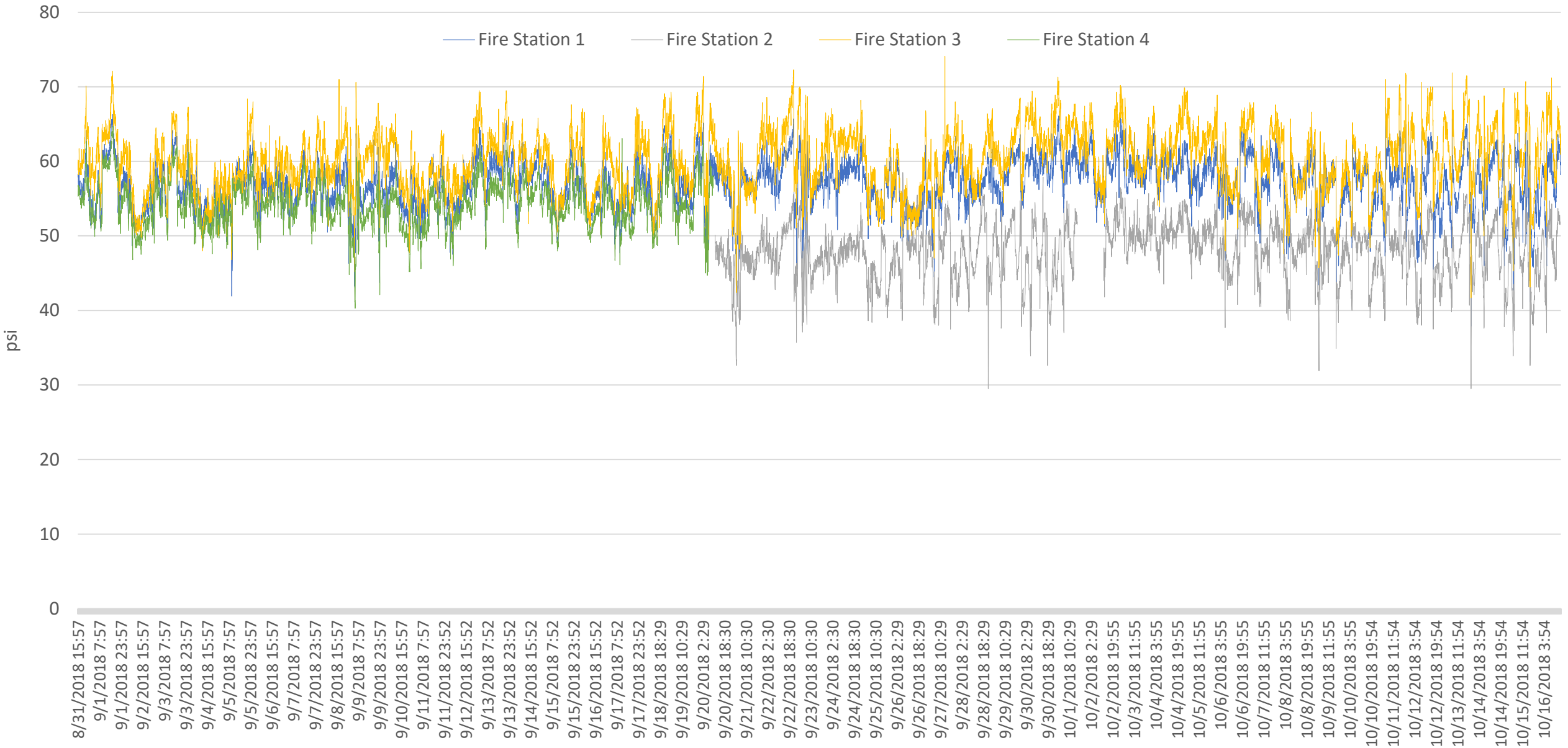

**Figure 4: Variation of Number of Breaks with Pipe Age**

**Source: 2008 Master Plan (OHM)**




Approximately 40% of Dearborn's system is less than 40 years old

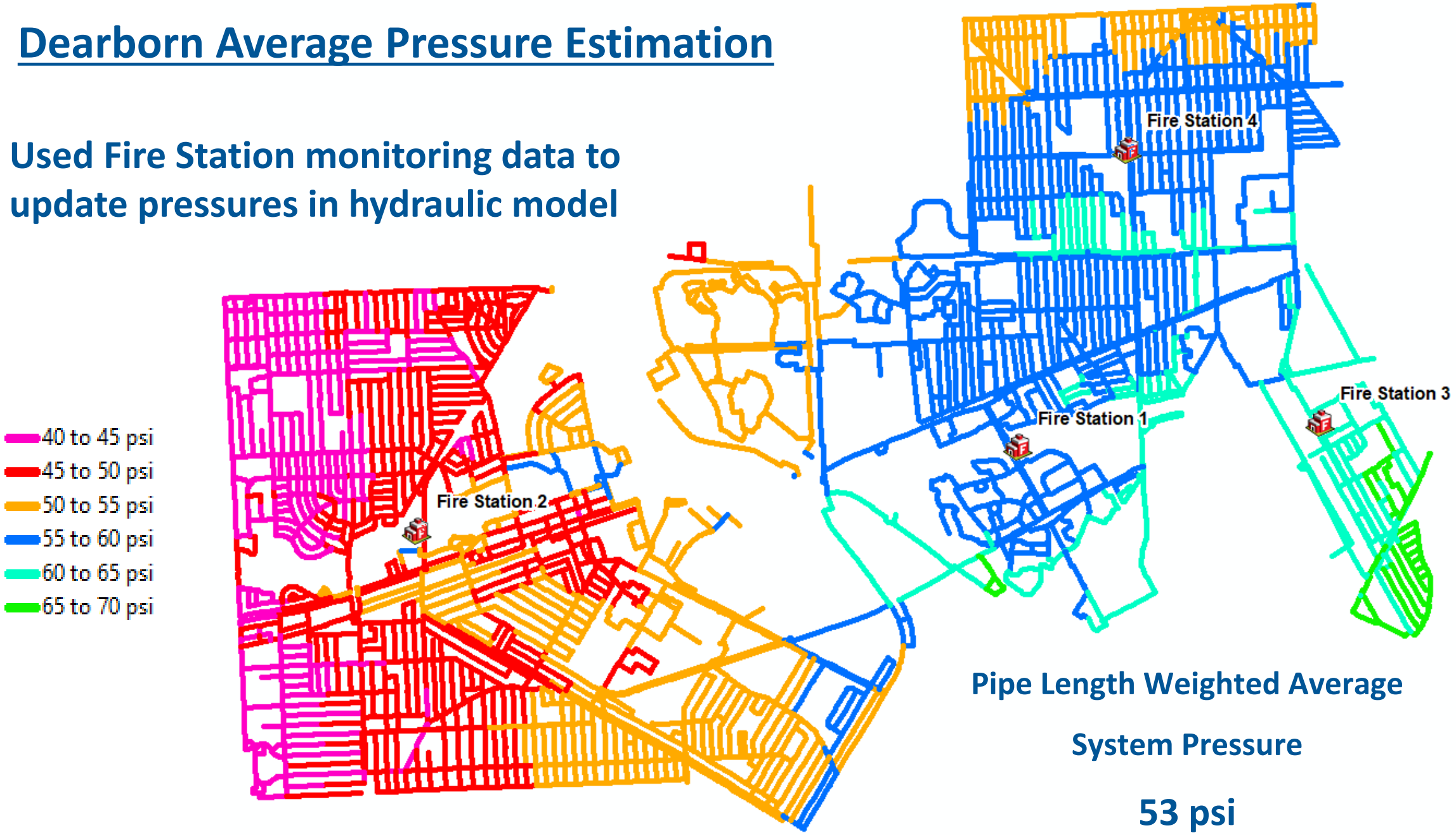
# System wide pressure monitoring




Fire Station Data Provided by Benesch

# Dearborn Average Pressure Estimation

## Used Fire Station monitoring data to update pressures in hydraulic model

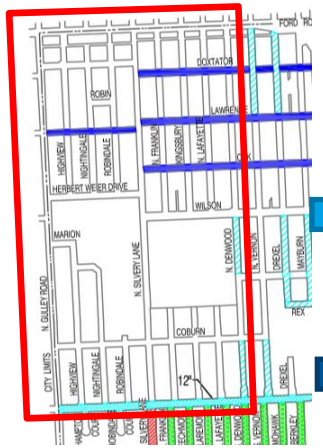



**Pipe Length Weighted Average System Pressure**

**53 psi**

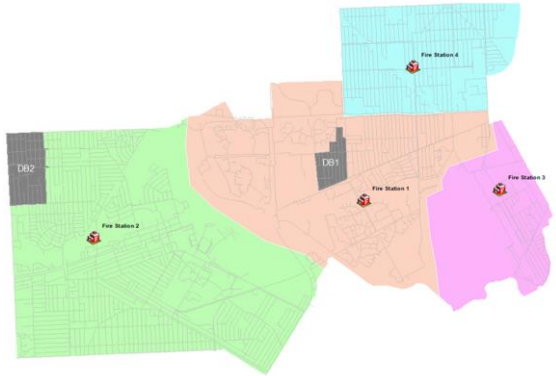
# Extrapolation Step 1:
# DMA Pressure Adjustment

DB2




18 gpcd

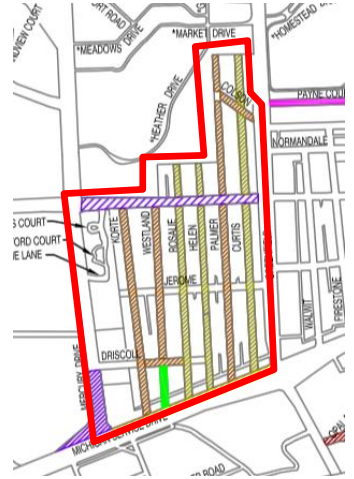
44 psi




14 gpcd

57 psi

DB1




## Pipe Length Weighted

## Average System Pressure

## 53 psi

Real Loss in DB2 =

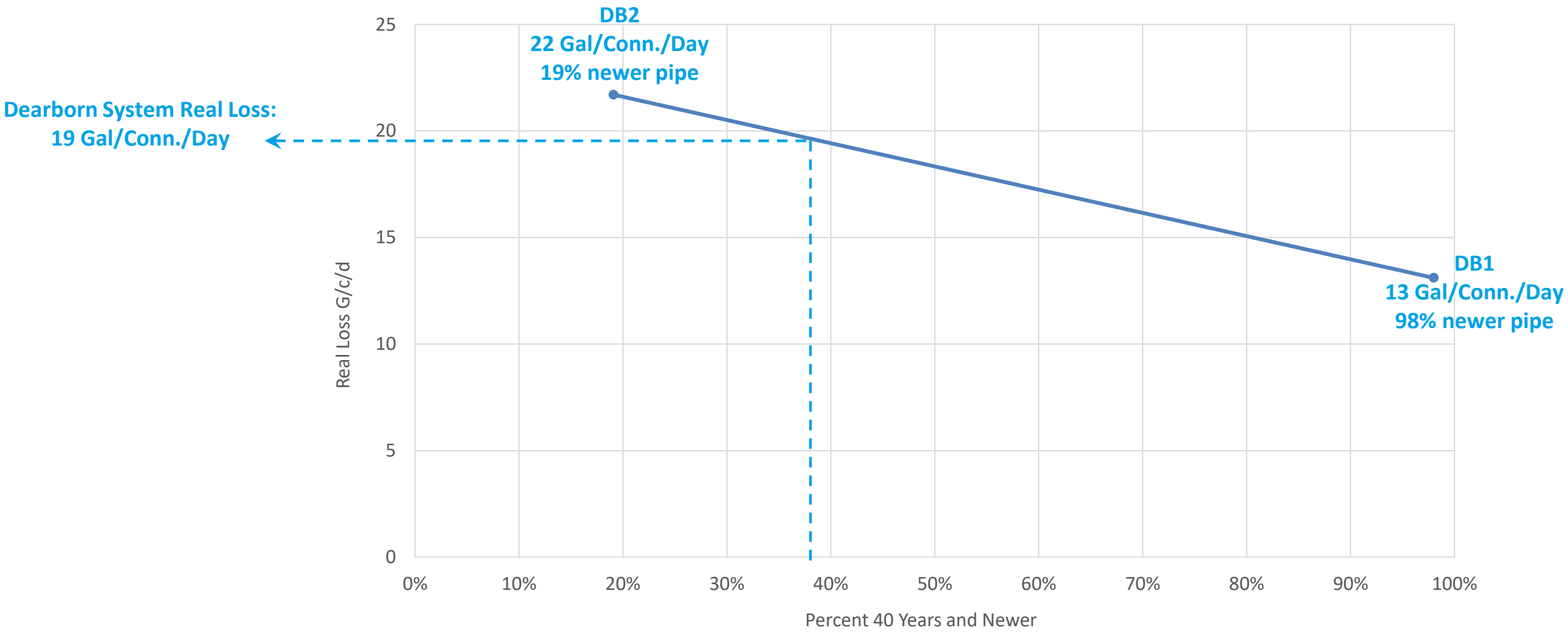
22 gallons / connection / day

Real Loss in DB1 =

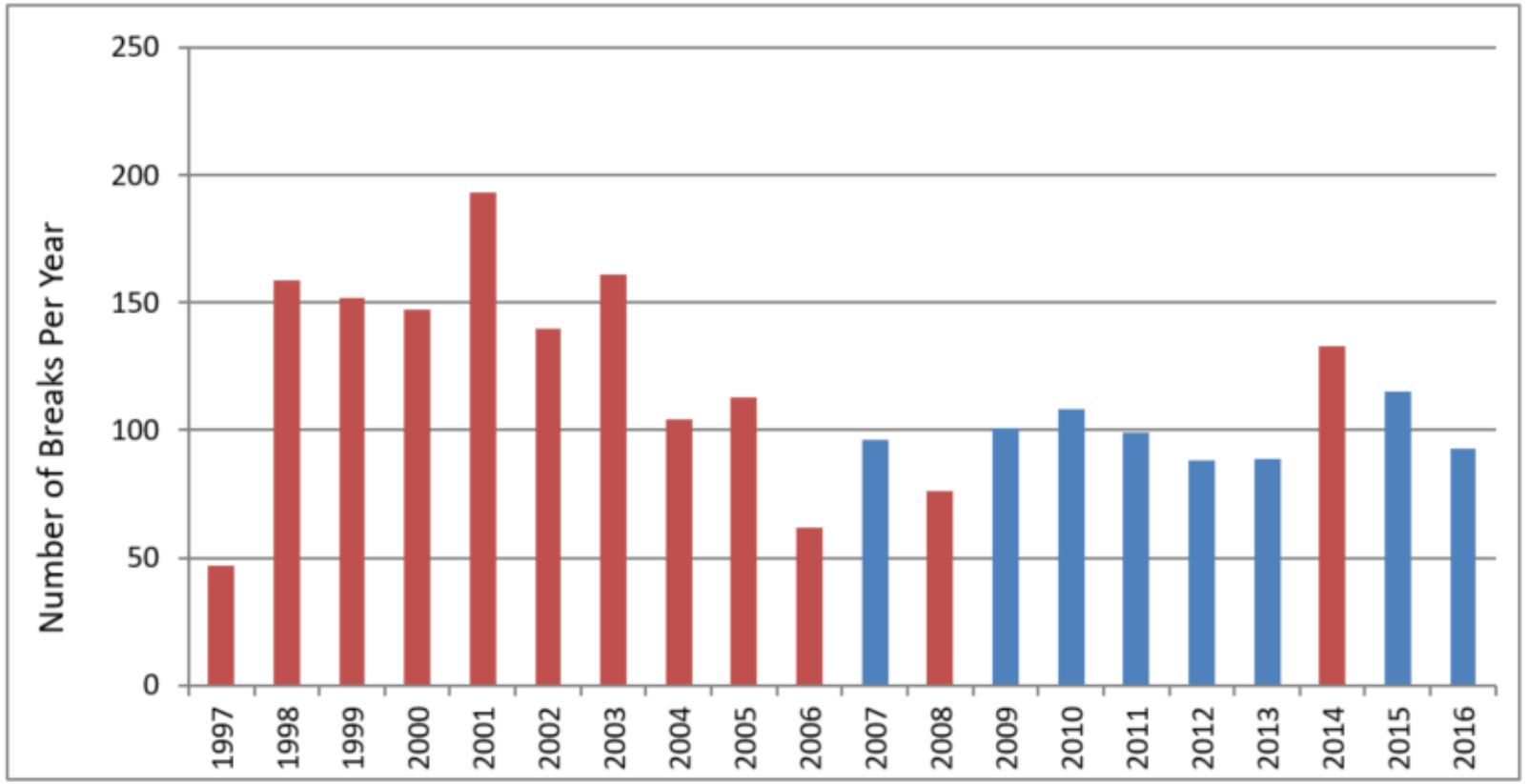
13 gallons / connection / day

**Results in DMA real loss values normalized to average system pressure**

# Interpolate Pressure Adjusted Real Loss



| Value | Component | Source |
|---|---|---|
| 99 | Breaks / year | Dearborn Break Data - 10 year avg. (excluding highest and lowest) |
| 24 | Hours to respond and fix | |
| 78 | gpm leak rate | Water Research Foundation 4372a pressure adjsuted failure flow rates.<br>Dearborn Breaks: 1% on <4", 89% on 6-10", 10% on 12" and above |
| 11,077,560 | Gallons / year | Calculated |
| 30,349 | Gallons /day | Calculated |
| 32,566 | Connections | Dearborn |
| 0.9 | Gallon / connection / day | Calculated |

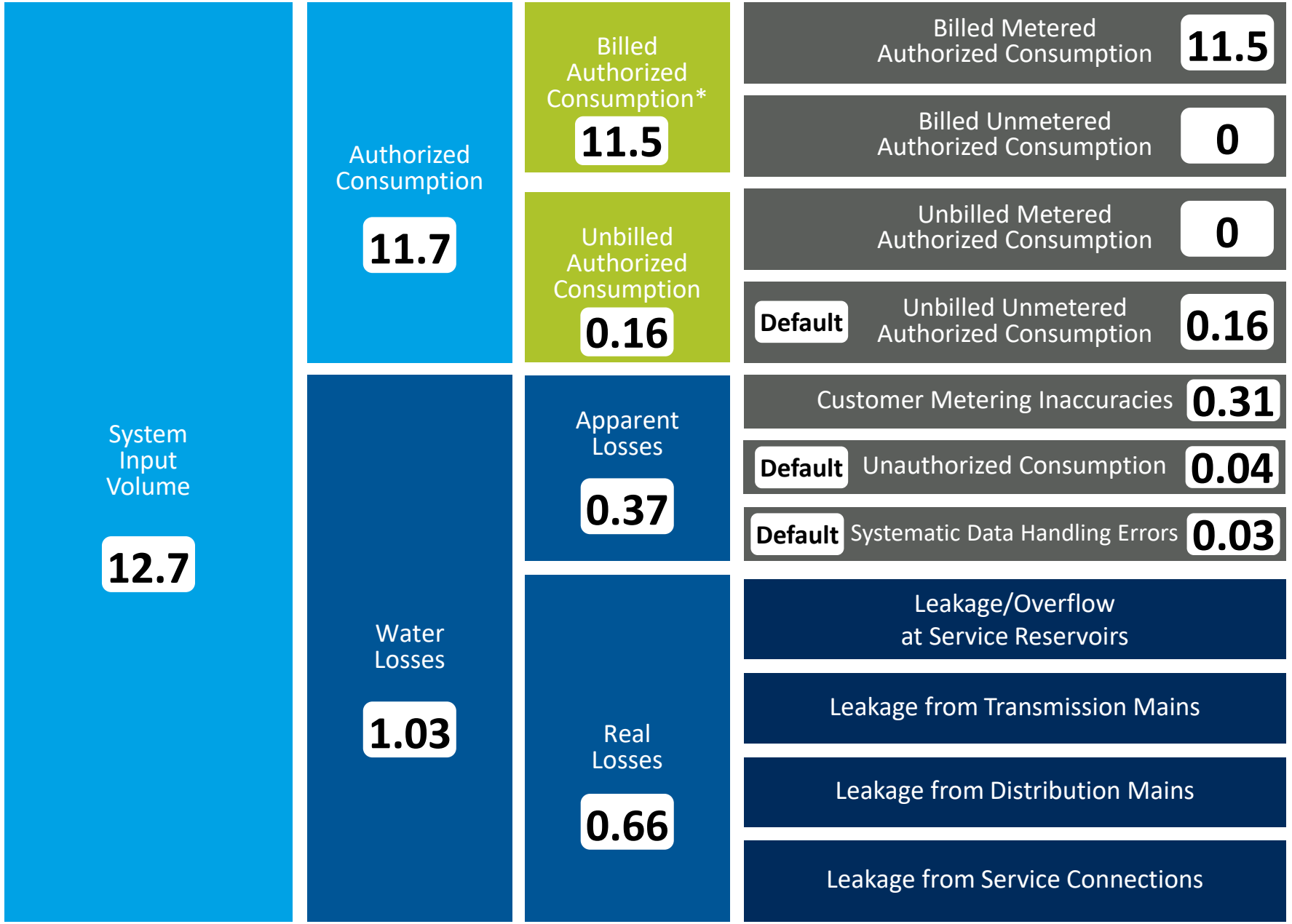


# AWWA Water Balance: Dearborn

*** Projected FY2020 Billed Authorized Consumption based on Oct 2015 – Sept 2018 including 5% reduction for base months**

## Water Balance

## Average Day Values



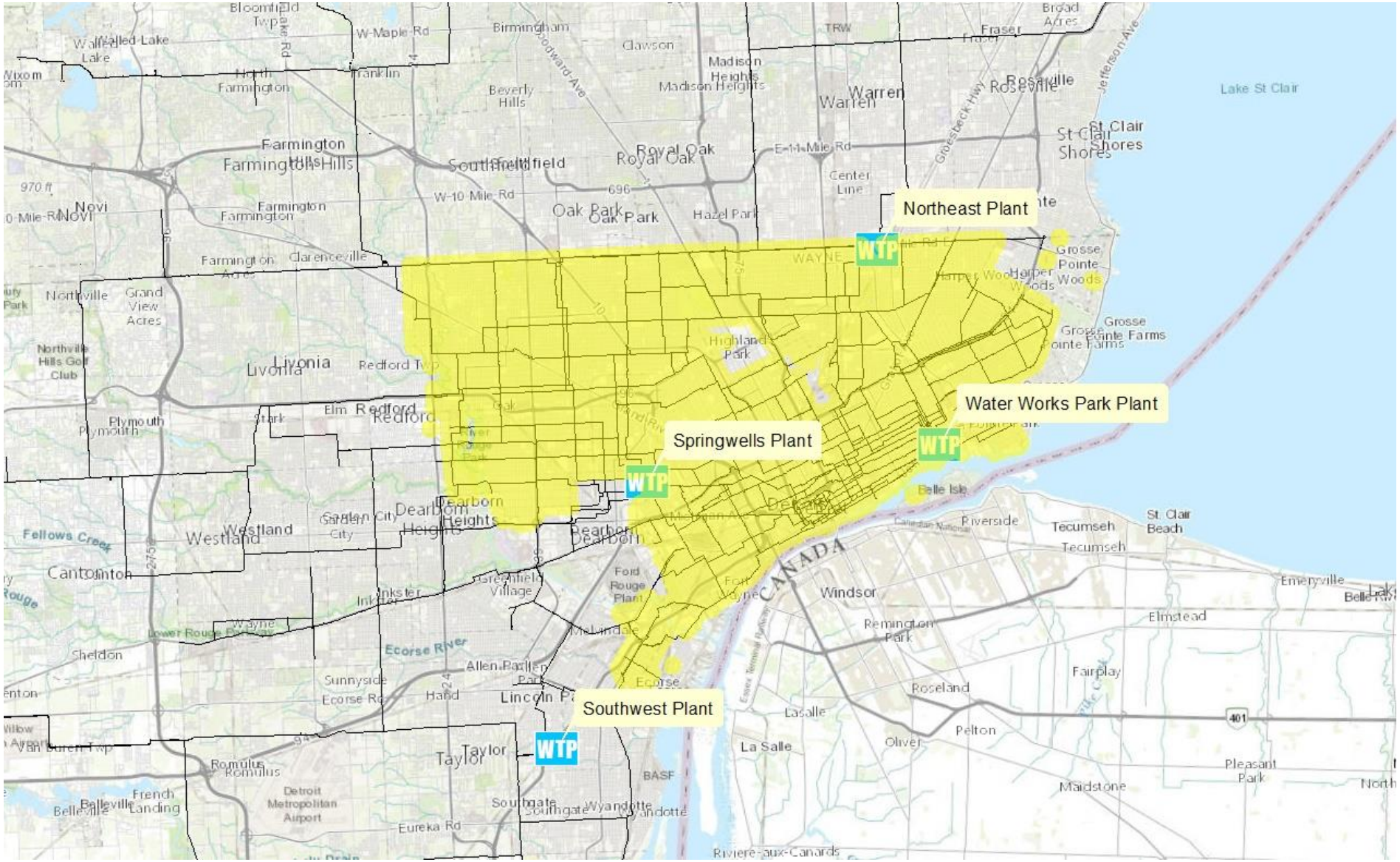
# Dearborn Peaking Factors

| METHOD | MAX DAY FACTOR | PEAK HOUR FACTOR |
|---|---|---|
| 1a) Residential Peers (weight 69.5%) | 1.65 | 2.45 |
| 1b) Non-Residential Peers (weight 30.5%) | 1.32 | 1.67 |
| **1) Peers (Weighted Avg.)** | **1.55** | **2.21** |
| **2) WAMR Monthly Peak Comparison** | **1.89** | **2.55** |
| Dearborn Peaking Factors<br>Average of Method 1 and Method 2 | **1.72** | **2.38** |

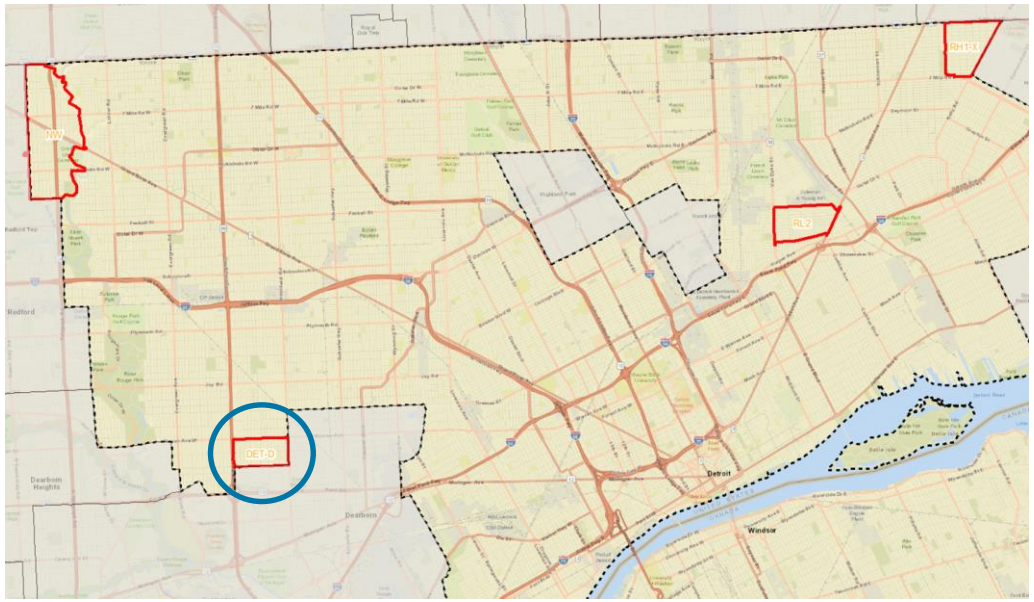
| | AVG. DAY | MAX DAY | PEAK HOUR |
|---|---|---|---|
| FY2020 MGD | 12.7 | 21.8 | 30.3 |

**All values exclude operational buffer**

# CITY OF DETROIT

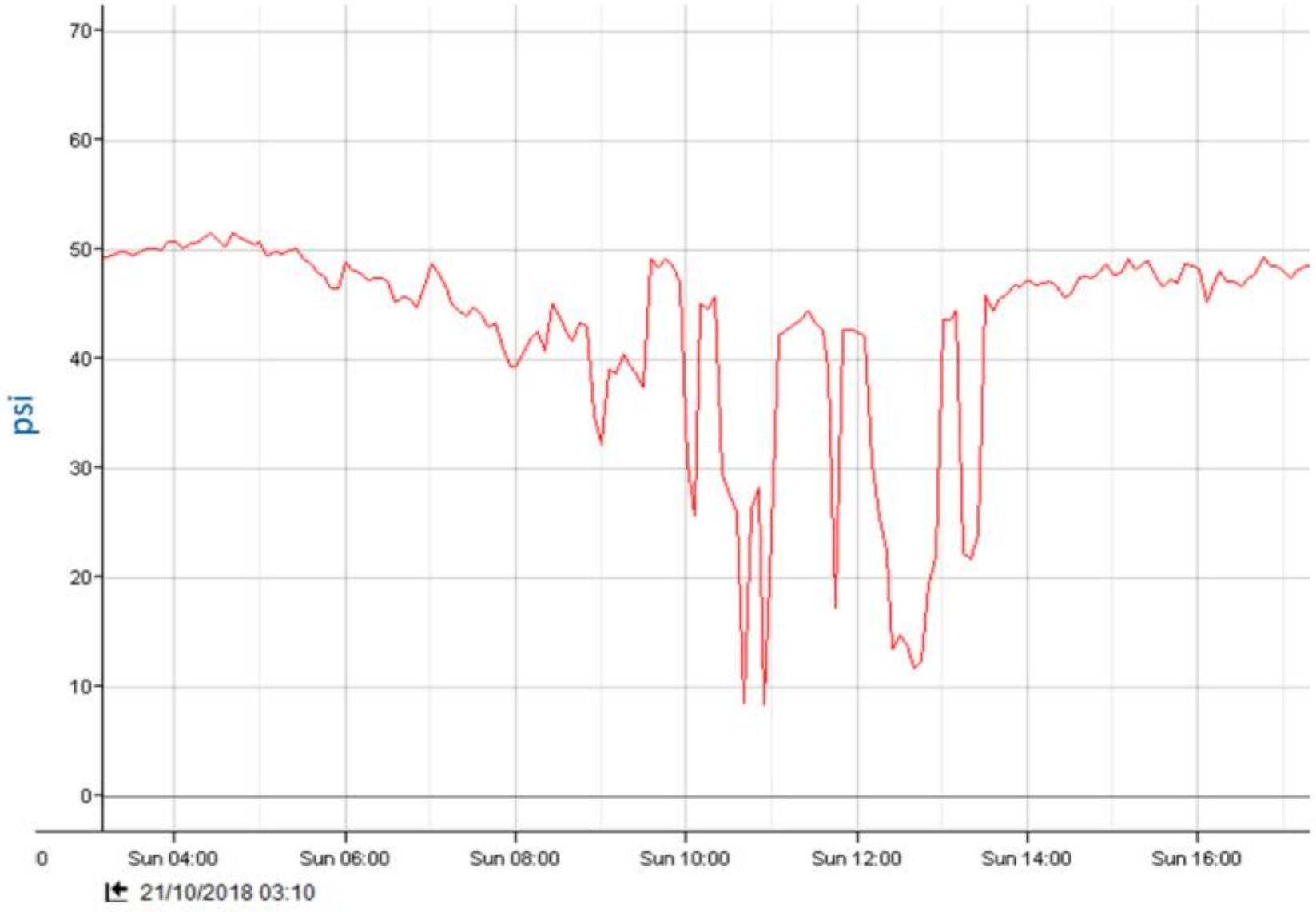


# Detroit DMA: DETD

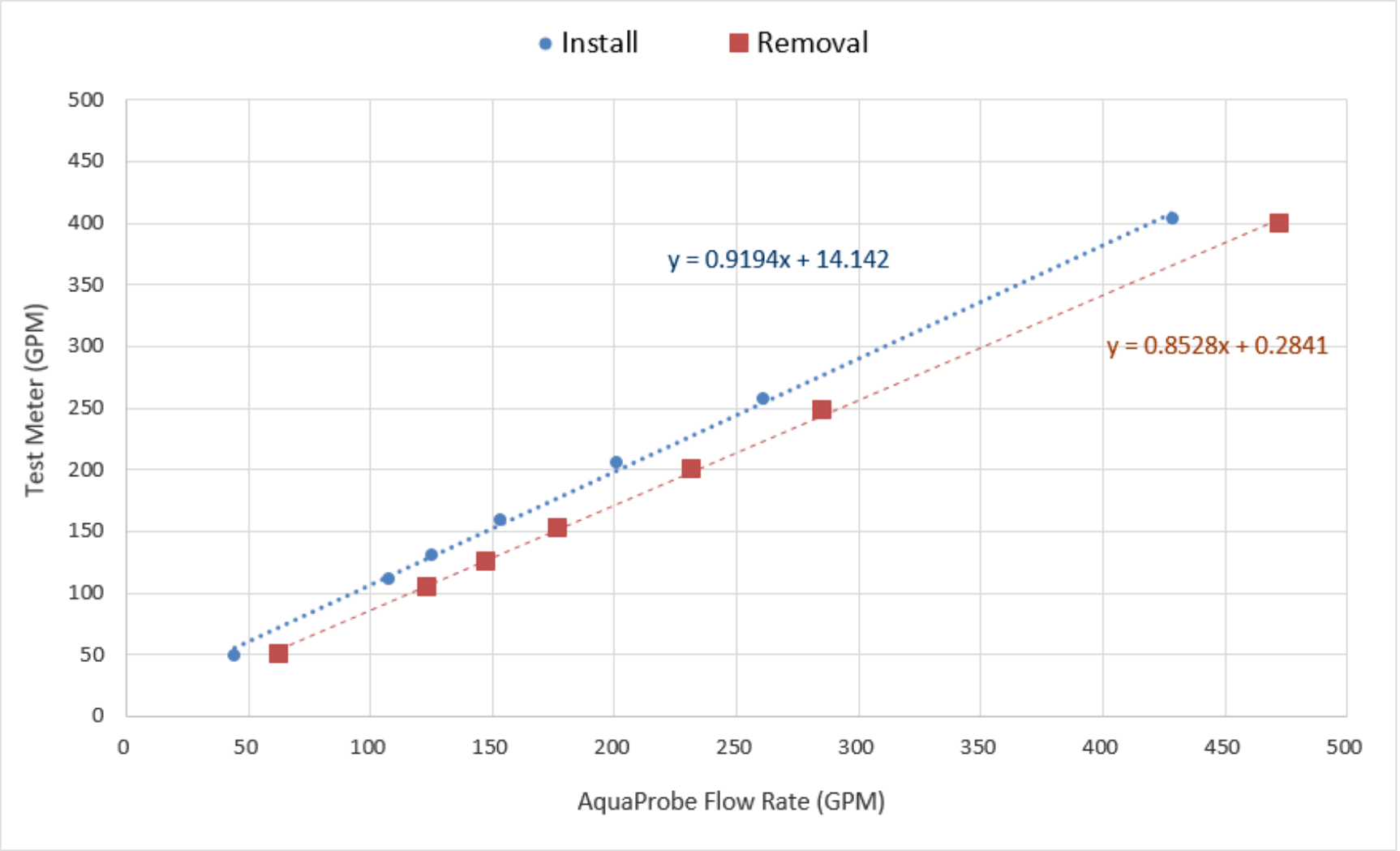



- Two meters installed
- Two pressure monitors installed
- Isolation occurred on 10/21
- Significant effort required by Detroit to achieve isolation
- Moved to one meter feed on 10/26
- DMA monitored for 11 days
- ~1,500 Retail Connections

# Pressure Drop Test: DET-D



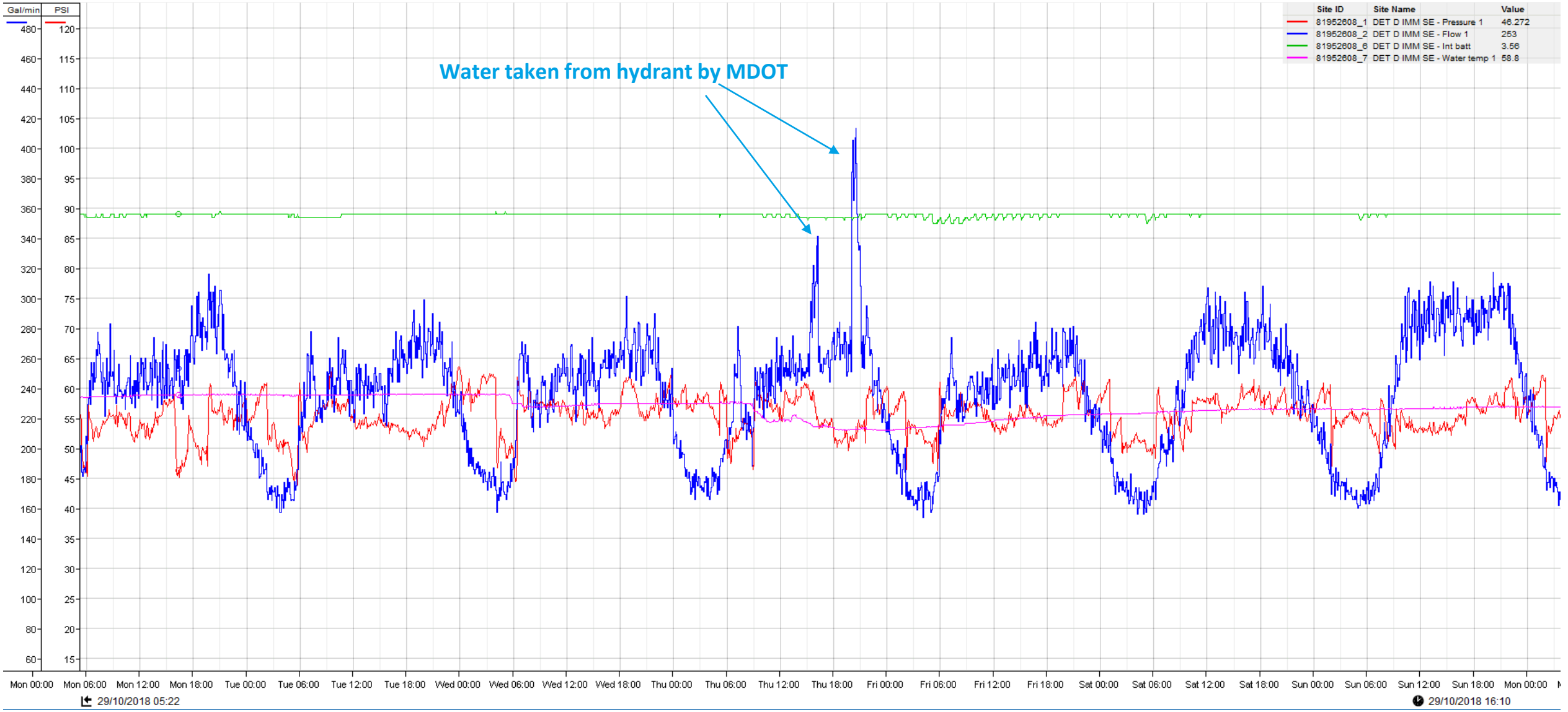
# Meter Test Comparison: DET-D




**Proposed Approach:**

Average of Install and Removal Test

# DET-D




Estimated MDOT volume removed from DMA (~2,700 gallons)

# DET-D
# 11 days of DMA monitoring

| | DET-D | Total Volume Gallons | Gallons Per Day |
|---|---|---|---|
| [1] | IMM Raw Volume Between 10/26/18 00:00 and 11/06/18 00:00 | 3,796,895 | 345,172 |
| [2] | IMM Adjusted Vol.* Between 10/26/18 00:00 and 11/06/18 00:00 | 3,481,640 | 316,513 |
| [3] | Consumption from Retail Reads** | 1,994,956 | 181,360 |
| [4] | Customer Metering Inaccuracies (2.32% x [3]) | 46,222 | 4,202 |
| [5] | Unauthorized Consumption (AWWA default) (0.25% x [2]) | 8,704 | 791 |
| [6] | Systematic Data Handling Errors (AWWA default) (0.25% x [3]) | 4,987 | 453 |
| [7] | Gallons per Connection*** per Day Apparent Loss | | **4** |
| [8] | Net Real Loss | 1,426,770 | 129,706 |
| [9] | Gallons per Connection*** per Day Real Loss | | **86** |

* Removes estimated volume from MDOT usage at hydrant (2,729 gallons)

** Includes estimated usage as provided by DWSD, and corrections to anomalies

***Total number of accounts (including estimates) = 1,506

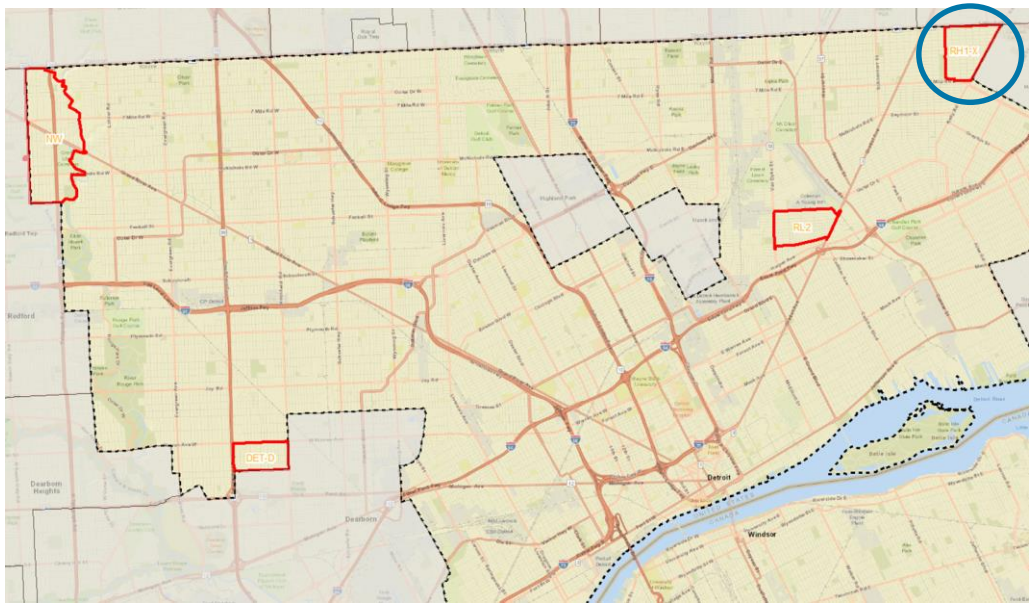
Estimated accounts with usage = 74

Estimated accounts with zero usage = 17

Average of Hydrant Test 1 and 2

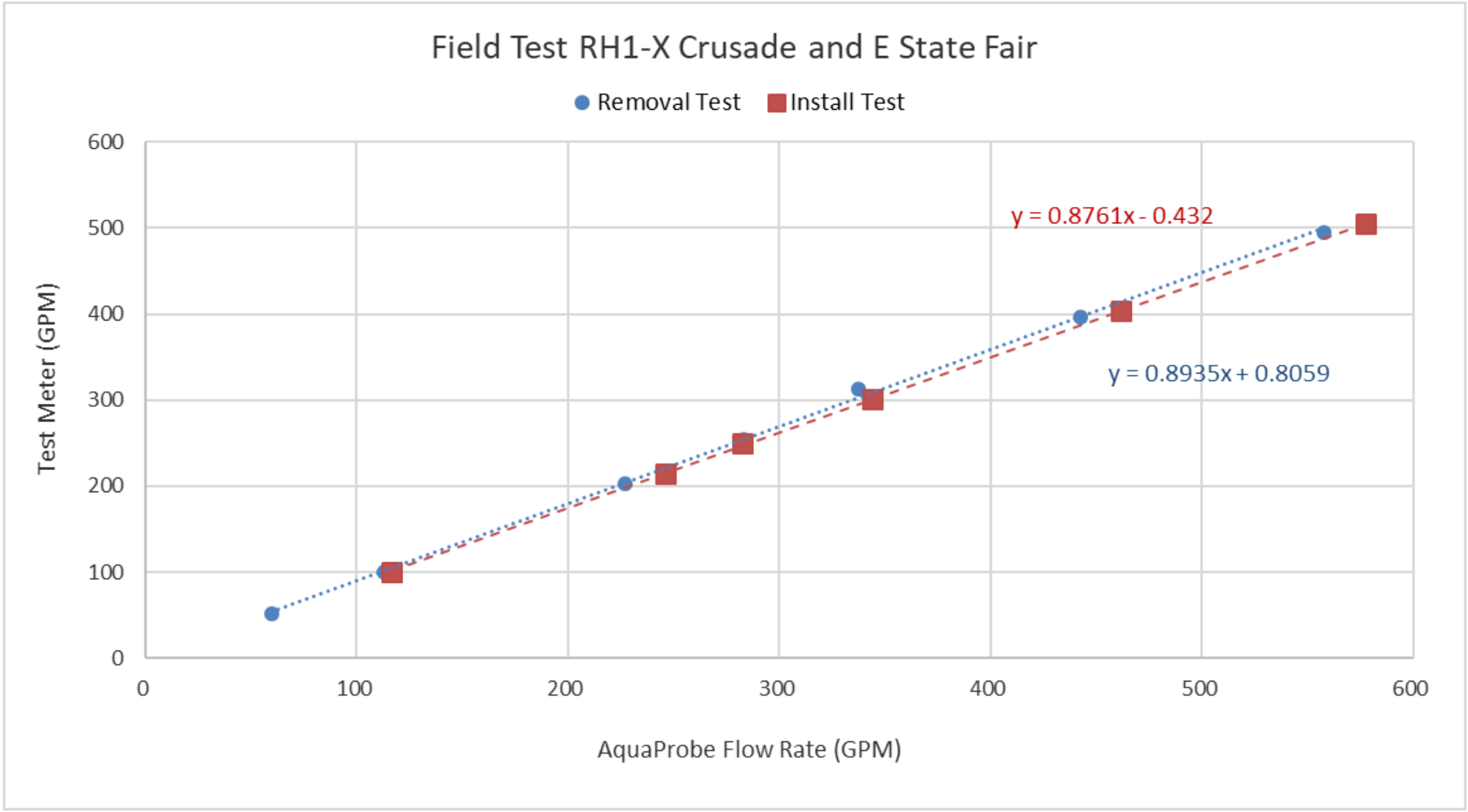
# Detroit DMA: RH1-X

- One insertion meter installed
- Two pressure monitors installed
- Isolation occurred on 10/30
- DMA monitored for 12 days
- ~1,900 Retail Connections



# Pressure Drop Test: RH1-X

# Meter Test Comparison: RH1-X




**Proposed Approach:**

Average of Install and Removal Test

# RH1-X

## Accounting of leaks found during hydrant testing

- Leaks found during hydrant testing needed to be fixed before hydrant test could be completed
- Found one vacant flooding while onsite and corrected:  8.7 gpm for vacant flooding based on observed metered leak from other account in the DMA.
- 5/8” service line maximum capacity is approximately 20 gpm
- DWSD found service line leaks on abandoned school.  Service shut off (confirm all lines found)  Leak flow rate estimated by comparing difference between two hydrant tests

# RH1-X
# 12 days DMA monitoring

| | RH1-X | Total Volume Gallons | Gallons Per Day |
|---|---|---|---|
| [1] | IMM Raw Volume Between 10/31/18 00:00 and 11/12/18 00:00 | 5,507,975 | 458,998 |
| [2a] | IMM Adjusted Vol. Between 10/31/18 00:00 and 11/12/18 00:00 | 4,876,687 | 406,391 |
| [2b] | Estimated volume from leakage at 21.0 gpm | 363,364 | 30,280 |
| [2c] | Total Adjusted IMM Volume | 5,240,051 | 436,671 |
| [3] | Consumption from Retail Reads* | 2,594,751 | 216,229 |
| [4] | Customer Metering Inaccuracies (2.31% x [3]) | 59,890 | 4,991 |
| [5] | Unauthorized Consumption (AWWA default) (0.25% x [2a]) | 12,192 | 1,016 |
| [6] | Systematic Data Handling Errors (AWWA default) (0.25% x [3]) | 6,487 | 541 |
| [7] | Gallons per Connection** per Day Apparent Loss | | **3** |
| [8] | Net Real Loss | 2,566,730 | 213,894 |
| [9] | Gallons per Connection** per Day Real Loss | | **110** |

* Includes estimated usage as provided by DWSD, and corrections to anomalies

**Total number of accounts (including estimates) = 1,937

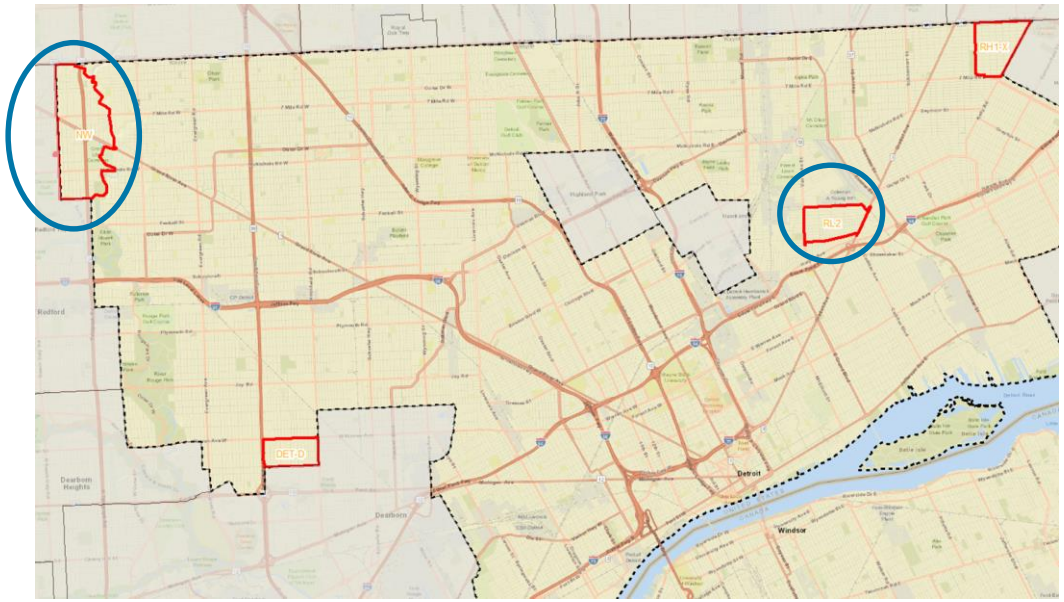
Estimated accounts with usage = 8

Estimated accounts with zero usage = 205

**Assumptions:**

Average of Hydrant Test 1 and 2 (no difference between tests)

# Detroit DMAs: RL2 and NW



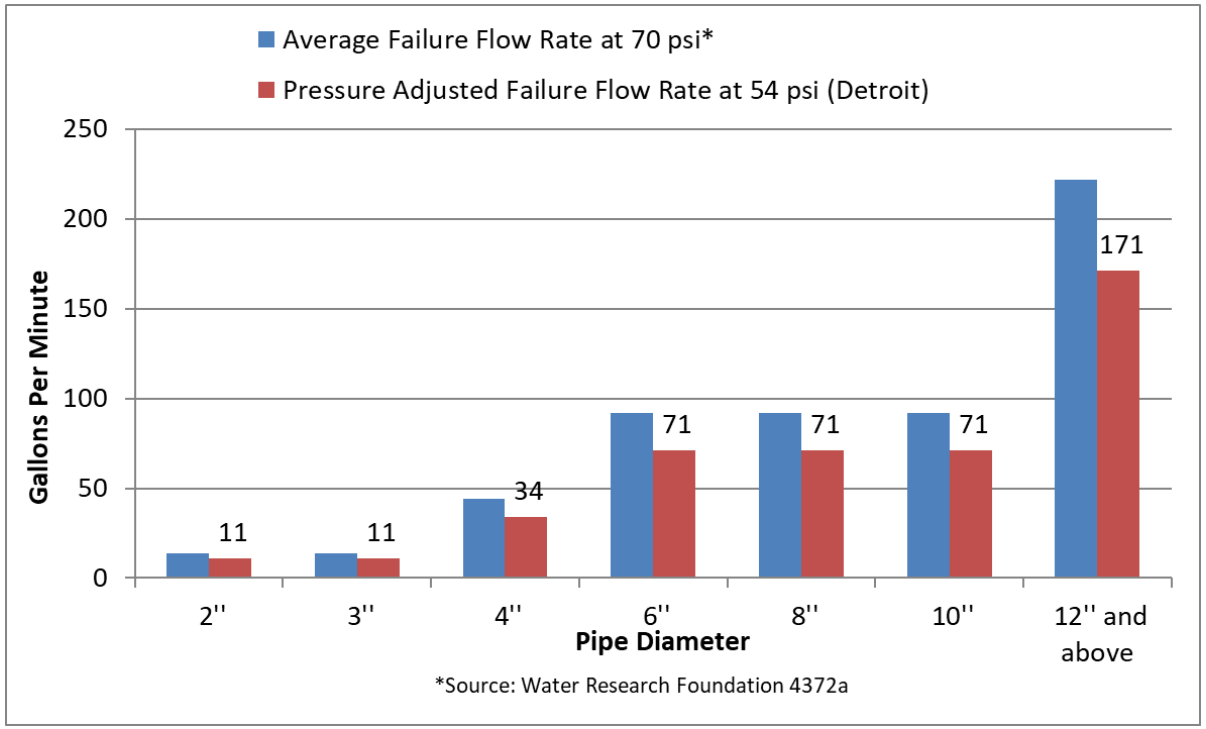

- Meters installed
- Pressure monitors installed
- Challenges in the field (RL2)
- DWSD concern over time / effort to achieve isolation in NW (3,000 retail connections)
- Currently no data available for these DMAs

# DWSD Issues / Concerns

1. Estimation of mains breaks repair time
2. Inclusion of 2015 data for NW DMA in Phase 2
3. Use of AECOM Leakage Investigation data:
    - North Rosedale Park: 6 gal./conn./day
    - Cornerstone Village: 29 gal./conn./day

# Water Loss: Mains Breaks

| Value | Component | Source |
|---|---|---|
| 1,244 | Breaks / year | DWSD Break Data - average of last three years (2014-2016) |
| 96 | Hours to respond and fix | DWSD provided KPI data, under review by B&V |
| 78.4 | gpm leak rate | Water Research Foundation 4372a pressure adjusted failure flow rates.<br>DWSD Breaks: 92% on 6-10", 8% on 12" and above |
| 561,457,133 | Gallons / year | Calculated |
| 1,538,239 | Gallons /day | Calculated |
| 309,928 | Connections | DWSD |
| 5.0 | Gallon / connection / day | Calculated |



# Real Loss Calculations for Phase 2

| DMA | DMA RL (gal.conn./day) | DMA PSI | DWSD System PSI | Pressure-adjusted RL (gal./conn./day) | Gallons / Connection / Day | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | DMA Avg. | From Mains Breaks | Phase 2 | Phase 1 |
| DETD | 86 | 46 | 54 | 101 | 97 | 5 | 102 | 106 |
| RH1X | 110 | 70 | 54 | 85 | | | | |
| NW* | 106 | 55 | 54 | 104 | | | | |
| | | | | | | Real Loss (MGD) | 31.5 | 32.9 |

*DMA results from Benesch Study 2015; utilized as best available data for Phase 1

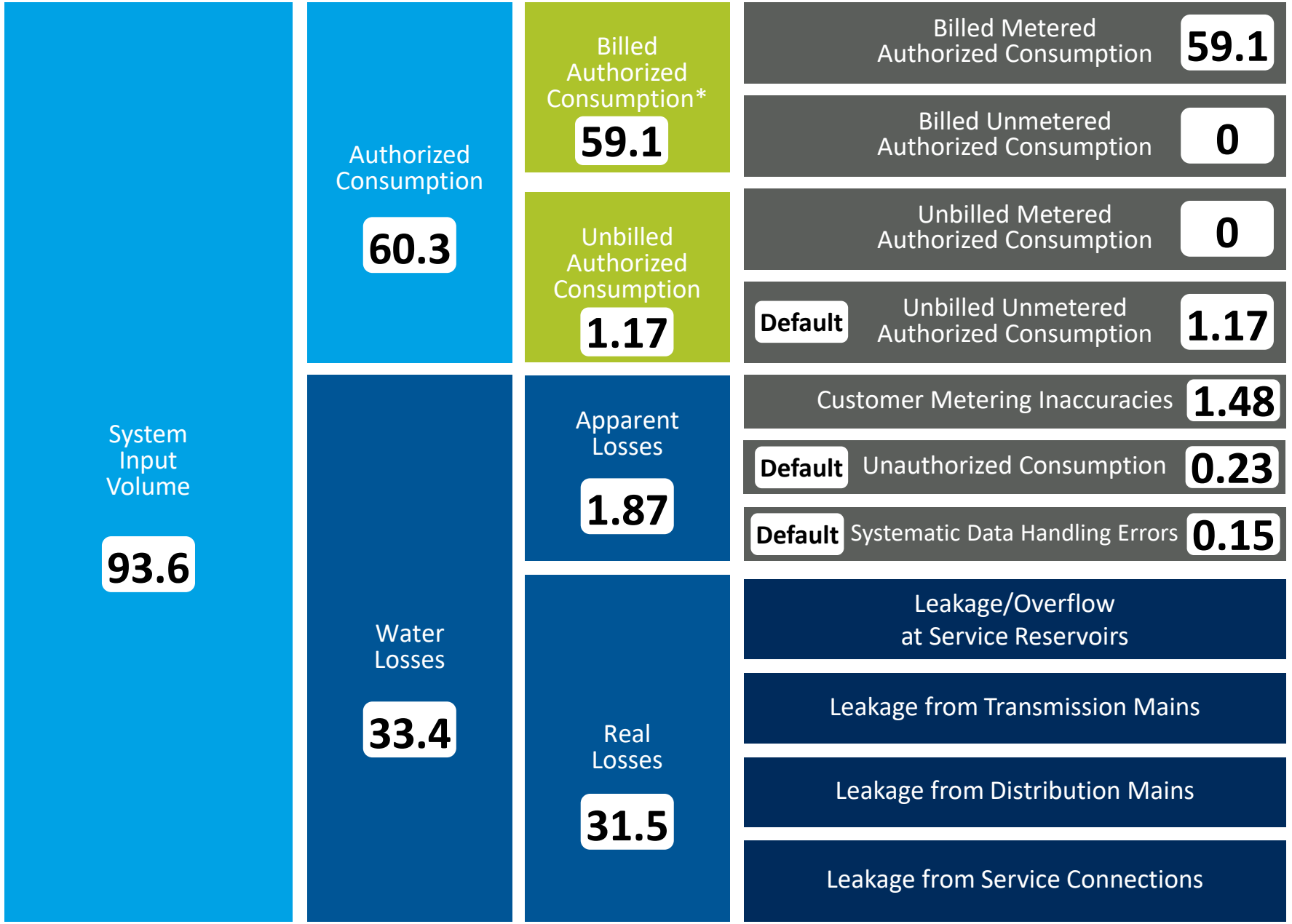
309,928 connections

# AWWA Water Balance: DWSD

*** Projected FY2020 Billed Authorized Consumption based on Oct 2015 – Sept 2018 including 5% reduction for base months**

## Water Balance

## Average Day Values



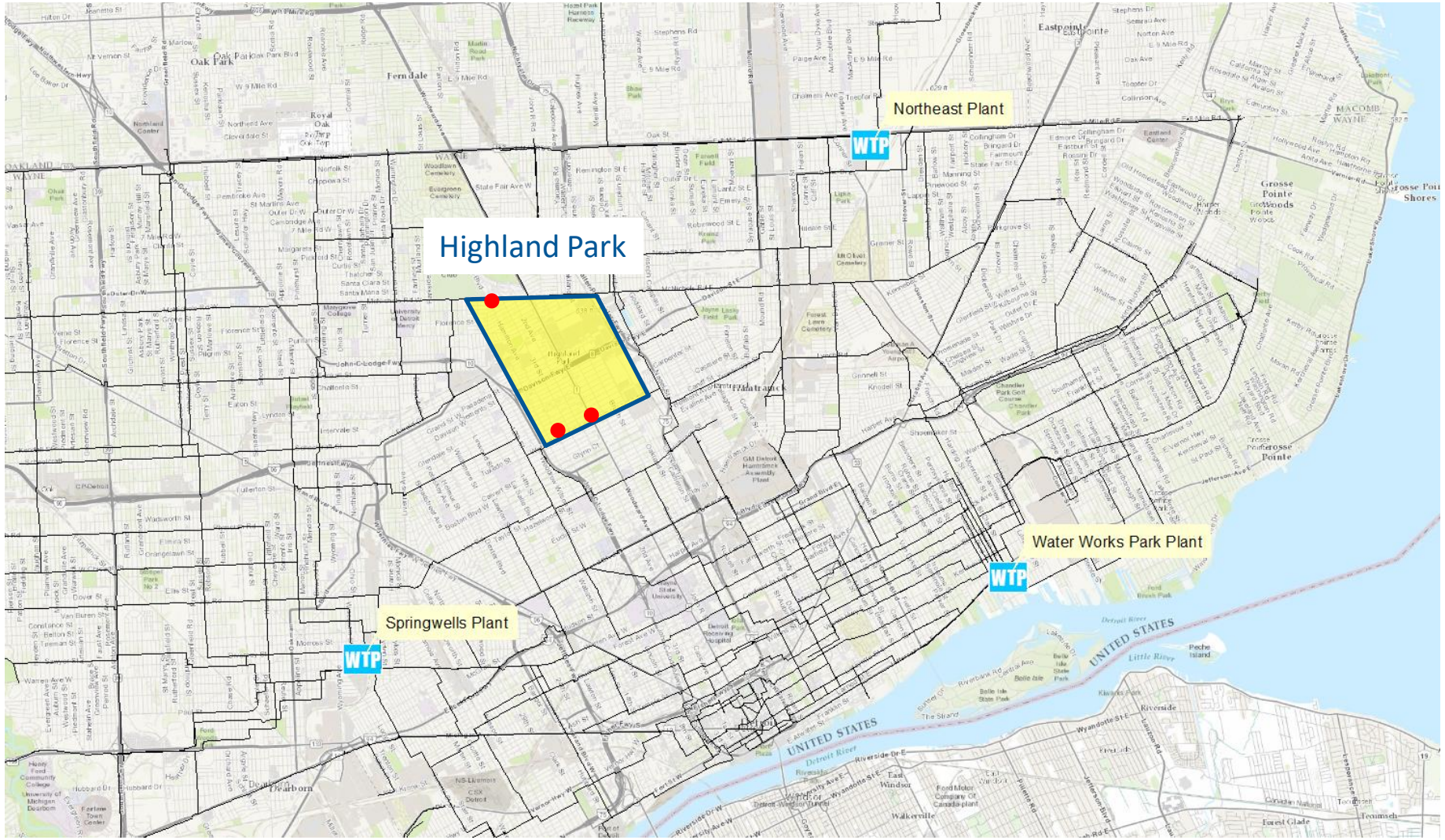
# DWSD Phase1 Demands and Peaking Factors

- Scatter plots developed in Phase 1 to project to 900 mgd
- Update to Phase 2 Avg. Day and apply Peaking Factors

| | AVG. DAY | MAX DAY | PEAK HOUR |
|---|---|---|---|
| FY2019 MGD (Phase 1) | 98.1 | 120 | 141 |
| Peaking Factors | | 1.22 | 1.44 |
| FY2020 MGD (Phase 2) | 93.4 | 114 | 135 |

# CITY OF HIGHLAND PARK

City of Highland Park

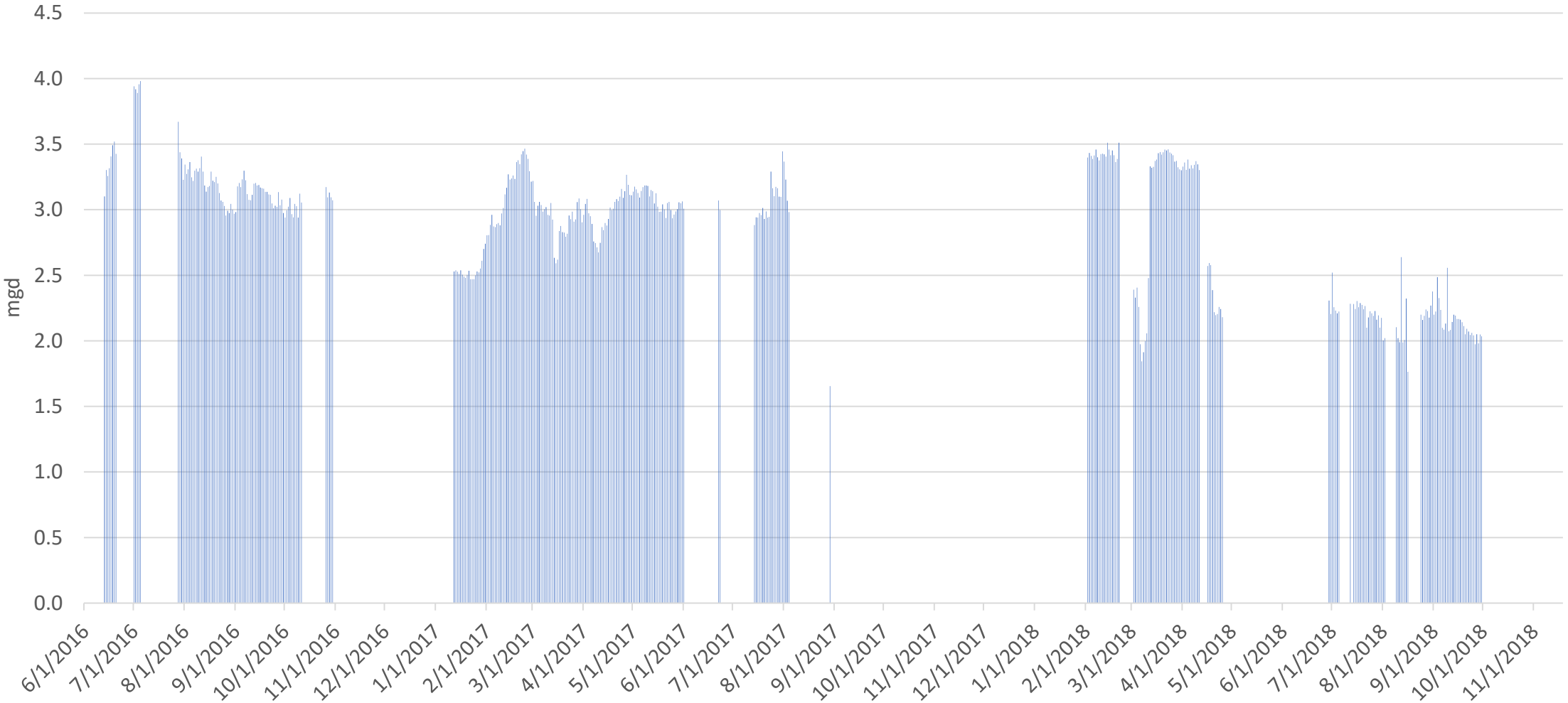


# Highland Park

- Approx. 2,700 retail connections
- System had its own source of supply until 2012
- Currently supplied from GLWA system
- Currently 3 connections open; each is measured with an insertion meter, tracked in WAMR
- Daily, hourly, and 5-min data available
- Notable change in flow patterns in April 2018

# Highland Park

Daily Data when all three meters operational



# Highland Park

- Valves checked on multiple occasions and found to be as expected
- Meters pulled, calibrated and reinstalled in August 2018
- Reported leak detection and repair activity
- Current average flow rate: 2.18 mgd
- Apply peaking factors from Phase 1 to calculated max day and peak hour

| | AVG. DAY | MAX DAY | PEAK HOUR |
|---|---|---|---|
| FY2019 MGD | 3.07 | 3.94 | 4.03 |
| Peaking Factors | | 1.28 | 1.31 |
| FY2020 MGD | 2.18 | 2.79 | 2.86 |

# Other Phase 2 Tasks

# GLWA Water Balance

# 2017 GLWA Water Balance

| TOTAL VOLUMES ASSIGNED BY ENTITY | AVG. DAY (MGD) | MAX DAY (MGD) | PEAK HOUR (MGD) |
|---|---|---|---|
| WAMR / Wholesale | 281 | 475 | 591 |
| Dearborn | 12.7 | 21.8 | 30.3 |
| Detroit | 93.6 | 114 | 135 |
| Highland Park | 2.18 | 2.79 | 2.86 |
| Transmission | 26.5 | 26.5 | 26.5 |
| GLWA / CTA | 37.4 | 39.5 | |
| Adjusted System Pumpage (Total) | 453 | 680 | 769 |

# Water Treatment Plants

# Water Treatment Plant Testing

- Plant testing underway along with planned rehab or new finished water metering
- Ultrasonic meter (Flexim) technology tested at four plants:
  - WWP – available pumps tested 10/2
  - SWP – available pumps tested 10/3
  - SPP – tested 10/15
  - LHP – tested 10/18
  - NE – pending
  - Test data shared and reviewed by BV, not all pumps tested
  - No updates to WTP accuracy at this time
  - Phase 1 reduction of 5.8% of reported volume

# Water Treatment Plant Metering

| WTP | METERING RENOVATIONS STATUS | SCHEDULED COMPLETION DATE |
|---|---|---|
| Northeast | • Venturi Meters (VM) have been rehabilitated<br>• SCADA work completed<br>• Flow data is on Ovation | Complete, pending acceptance testing (AT). |
| Southwest | VM 4 & 5<br>• Rehab is complete<br>• SCADA work underway<br>VM 1,2, & 3<br>• VM 3 complete<br>• VM 1 &2 & SCADA work | <br><br><br>1/15/2019<br><br><br>3/30/2019 |
| Springwells | Three phases of equipment shutdown and rehab planned<br>• Phase 1<br>• Phase 2<br>• Phase 3 | <br>12/03/18 + SCADA work and AT<br>1/25/19 + SCADA work and AT<br>3/25/19 + SCADA work and AT |
| Lake Huron | | 2021 |
| Water Works Park | | 2021 |

# Transmission Mains

# Transmission Blow Off Investigation

**GLWA Investigation Summary:**

- Total GLWA 990 (395 tied to sewer)
- 395 valves investigated
- Seven discharge points estimated to be minimally leaking 0 - 5 gpm
- No significant losses from open blow offs found (Phase 1: 10 mgd)
- GLWA to continue investigation

# Transmission Main Losses Evaluation

## Phase 2 Investigation:

- Researched available literature
- Utilized available data and methodology from technical paper:
  - Age
  - Pressure
  - Miles of pipe
  - Number of breaks
- Concluded similar level of transmission main losses as Phase 1 (23.5 mgd)
- Recommend maintaining estimate of 26.5 mgd based on Phase 1
- Evaluate results of condition assessment on 14 Mile transmission mains

# Master Metering

# Master Metering

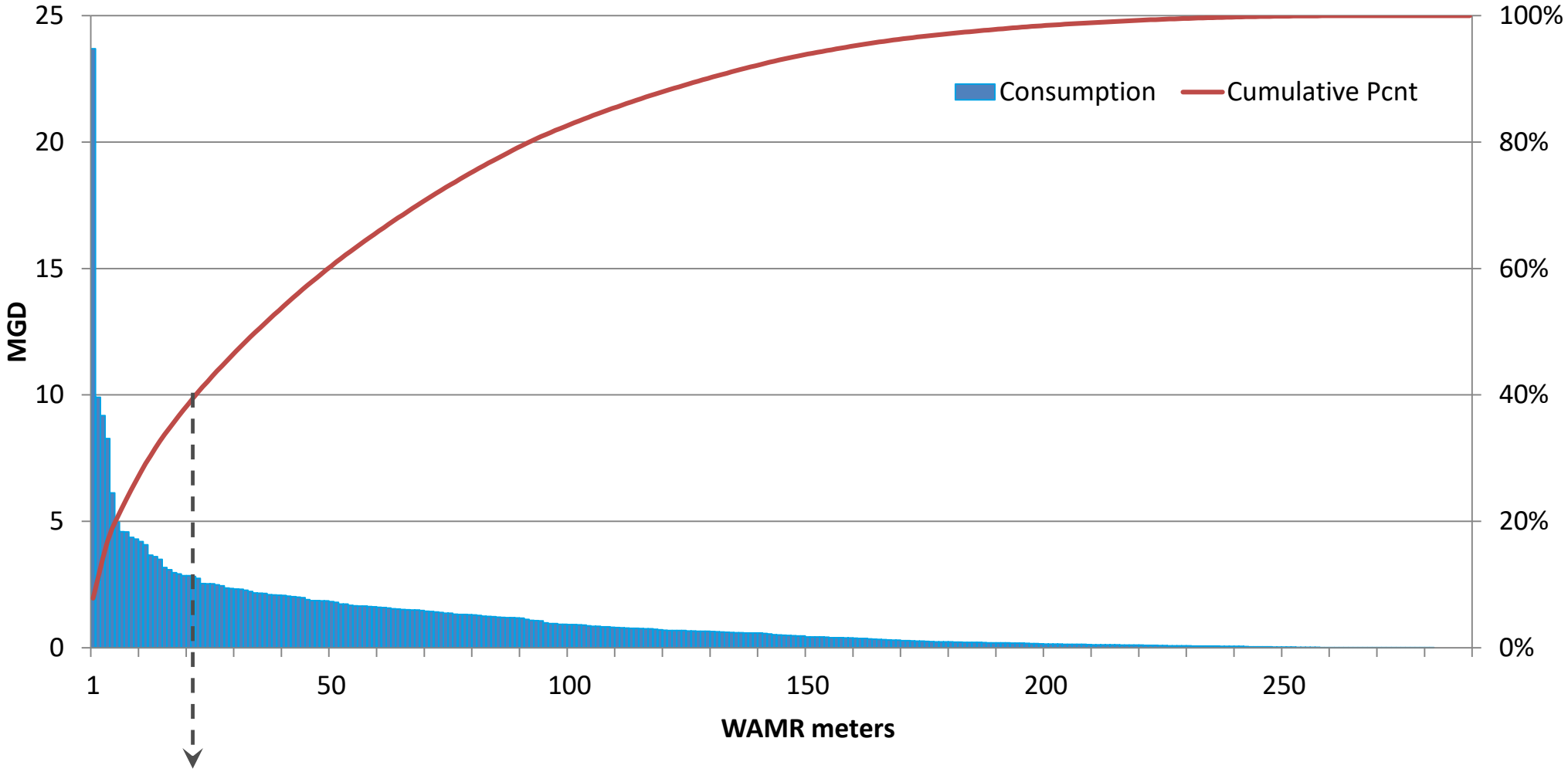
- Continued evaluation of options
- **Dearborn:**
  - Discussed master metering plan and segmentation of system
  - Redundancy discussion ongoing
- **Detroit:**
  - Master metering evaluation of complex Detroit system
  - Additional options being evaluated
- **Highland Park:**
  - Validation of existing metering ongoing

# Wholesale Water Meter Audit

# WAMR Meter Audit

- 290 WAMR meters (114 Mags, 89 Mech, 87 Differential Pressure)
- Phase 1: Reviewed testing and calibration; recommended flow verification
- GLWA is moving ahead with 50 Water Meter Upgrades (CON 285).
    - Meter sizing has been evaluated by BV and GLWA (31 downsizing)
- GLWA has replaced 23 meters since 1/1/2016
    - Three meters replaced in last three months (new mags)
- Prioritize flow testing of largest 20 volume meters (38% of volume)

# WAMR Meter Evaluation




~40% of volume from largest 20 WAMR meters

# WAMR Meter Audit

**Alternative to Flow Verification:**

- Conduct screening level water audit
- Balance wholesale volumes against retail sales
- Use AWWA Water Audit principles
- Water Audit Workshop being planned by GLWA Best Practices Workgroup

# Long Term Water Audit

# Long Term Water Audit

- Identify and prioritize Data Gaps
- Improve AWWA Data Validity Score:
  - Finished water metering
  - Wholesale meters prioritized for testing
  - Retail meter testing
- **AWWA M36 (Water Audit Manual): "It will take three to six years for most water systems to obtain a mature level of validity in their water audit approach".**

# Questions….Discussion….Feedback