

May, 2019

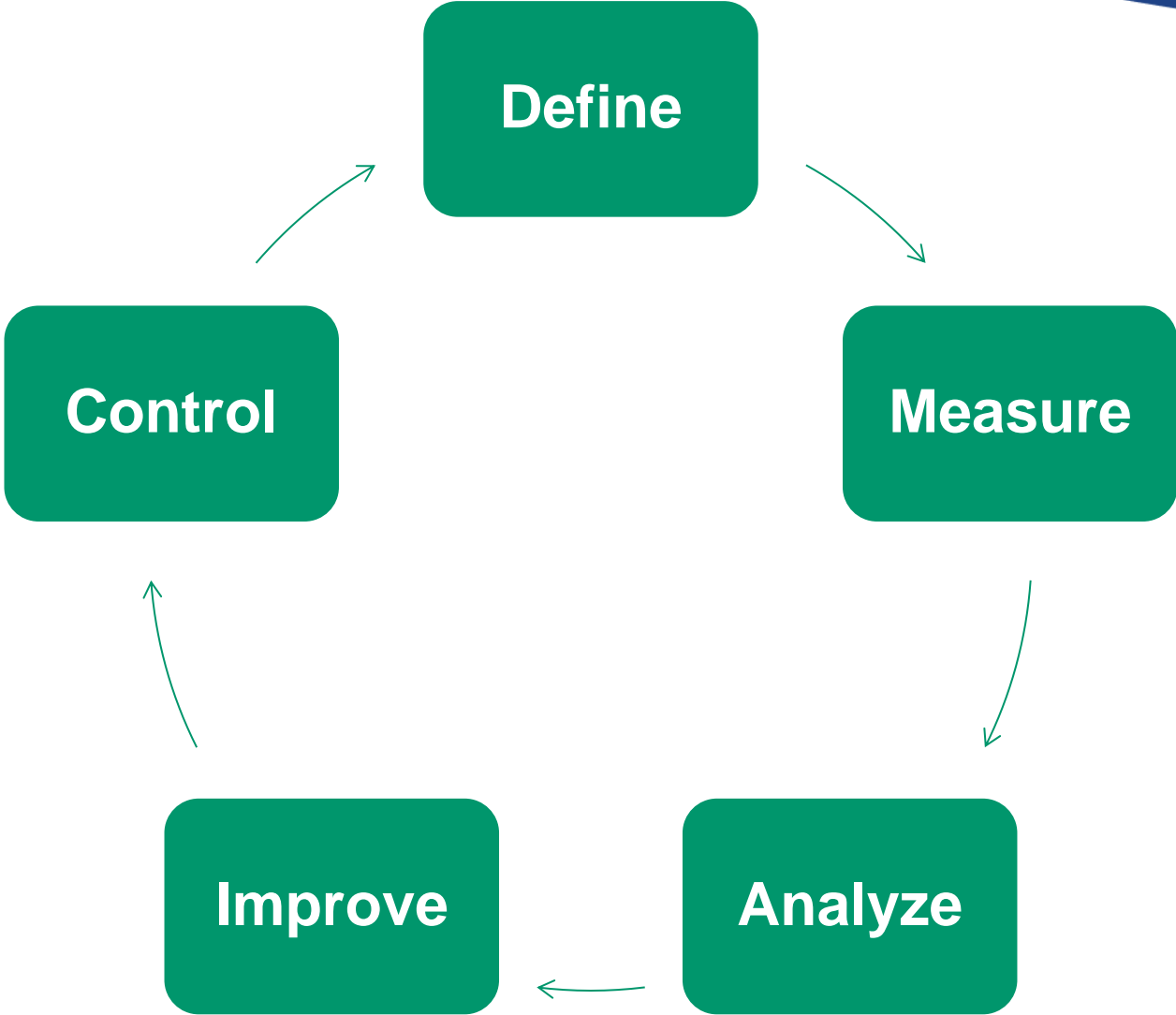


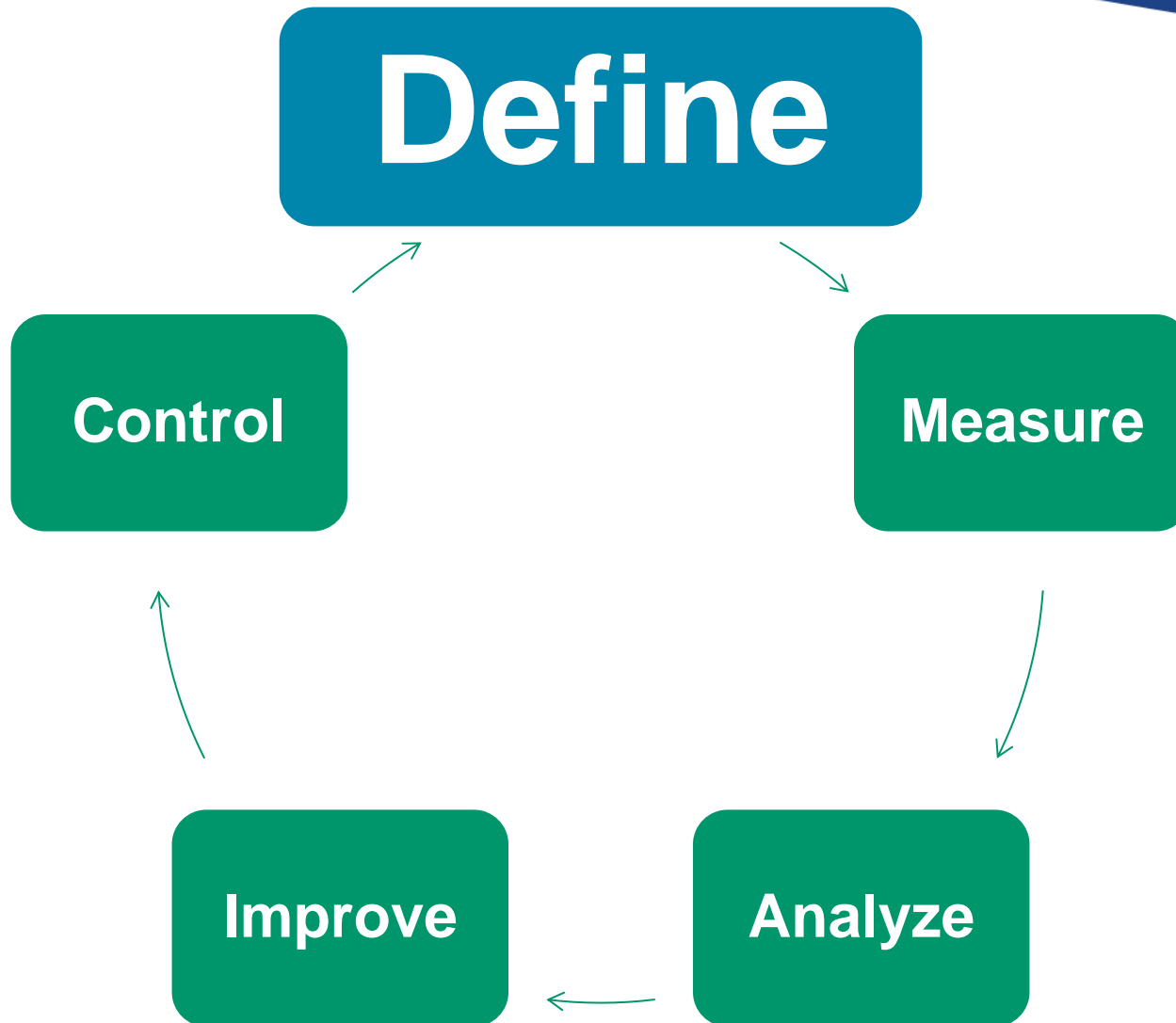
The Non Revenue Water Journey

JOSEPH DRYER
SOLUTION APPLICATION ENGINEER
SENSUS, A XYLEM BRAND



DMAIC





The Chart You've Probably Seen Before

Define

| | | | | | | |
|--|--------------------------------|---|------------------------|---------------------------------|------------------------------|------------------------------|
| | | Water Exported (corrected for known errors) | Billed Water Exported | | | Revenue Water |
| | | Water Supplied | Authorized Consumption | Billed Authorized Consumption | Billed Metered Consumption | Revenue Water |
| Water Losses | Real Losses | | | Unbilled Authorized Consumption | Billed Unmetered Consumption | |
| | | Water Imported (corrected for known errors) | System Input Volume | Water Losses | Apparent Losses | Unbilled Metered Consumption |
| Real Losses | Unbilled Unmetered Consumption | | | | | |
| | Customer Metering Inaccuracies | | | | | |
| | Real Losses | Unauthorized Consumption | | | | |
| Systematic Data Handling Errors | | | | | | |
| Leakage on Transmission and Distribution Mains | | | | | | |
| Real Losses | Real Losses | Leakage and Overflows at Utility's Storage Tanks | | | | |
| | | Leakage on Service Connections up to the Point of Customer Metering | | | | |
| | | | | | | |

NOTE: All data in volume for the period of reference, typically one year.

Source: AWWA M36

| | | | | | | |
|---|---|--|------------------------|---------------------------------|---------------------------------|-------------------|
| | | Water Exported (corrected for known errors) | Billed Water Exported | | | Revenue Water |
| Volume From Own Sources (corrected for known errors) | System Input Volume | Water Supplied | Authorized Consumption | Billed Authorized Consumption | Billed Metered Consumption | Revenue Water |
| | | | | | Billed Unmetered Consumption | |
| Water Imported (corrected for known errors) | | Water Losses | Real Losses | Unbilled Authorized Consumption | Unbilled Metered Consumption | Non-revenue Water |
| | | | | | Unbilled Unmetered Consumption | |
| | | | | Apparent Losses | Customer Metering Inaccuracies | |
| | | | | | Unauthorized Consumption | |
| | | | | | Systematic Data Handling Errors | |
| | Leakage on Transmission and Distribution Mains | | | | | |
| | Leakage and Overflows at Utility's Storage Tanks | | | | | |
| | Leakage on Service Connections up to the Point of Customer Metering | | | | | |
| <p><i>NOTE: All data in volume for the period of reference, typically one year.</i></p> | | | | | | |

Source: AWWA M36



Billed Authorized Consumption

Define

| | | | | | | |
|---|---------------------------------|--|------------------------|---------------------------------|--|---|
| Volume From Own Sources (corrected for known errors) | System Input Volume | Water Exported (corrected for known errors) | Billed Water Exported | | | Revenue Water |
| | | Water Supplied | Authorized Consumption | Billed Authorized Consumption | Billed Metered Consumption | Revenue Water |
| Water Losses | Unbilled Authorized Consumption | | | Billed Unmetered Consumption | Non-revenue Water | |
| | | Real Losses | Apparent Losses | Unbilled Metered Consumption | | Leakage on Transmission and Distribution Mains |
| Real Losses | Apparent Losses | | | Unbilled Unmetered Consumption | Leakage and Overflows at Utility's Storage Tanks | |
| | | Real Losses | Apparent Losses | Customer Metering Inaccuracies | | Leakage on Service Connections up to the Point of Customer Metering |
| Real Losses | Apparent Losses | | | Unauthorized Consumption | | |
| | | Real Losses | Apparent Losses | Systematic Data Handling Errors | | |
| Real Losses | Apparent Losses | | | | | |

NOTE: All data in volume for the period of reference, typically one year.

Source: AWWA M36

Billed Authorized Consumption

Define



Unbilled Authorized Consumption

Define

| | | | | | | |
|---|---------------------------------|--|---------------------------------|---|----------------------------|---------------|
| Volume From Own Sources (corrected for known errors) | System Input Volume | Water Exported (corrected for known errors) | Billed Water Exported | | | Revenue Water |
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| Water Losses | Unbilled Authorized Consumption | | | Unbilled Metered Consumption | Non-revenue Water | |
| | Real Losses | Apparent Losses | Unbilled Unmetered Consumption | Customer Metering Inaccuracies | | |
| Leakage on Transmission and Distribution Mains | | | Unauthorized Consumption | | | |
| | | | Systematic Data Handling Errors | | | |
| Leakage and Overflows at Utility's Storage Tanks | | | | | | |
| Water Imported (corrected for known errors) | | | | Leakage on Service Connections up to the Point of Customer Metering | | |

NOTE: All data in volume for the period of reference, typically one year.

Source: AWWA M36









NOTICE TO TENANT

owner of this building has not paid the water bill. The
turn the water off on the shut off date listed below.

SHUT OFF DATE: 11-28 - 12-5

**Do not contact the City. Direct any
questions about this notice to your landlord.**

a tenant, you may have certain rights and remedies available under MI law. If y
to get a satisfactory response from your landlord and if water was included in yo
and the landlord failed to pay, you need to

| | | | | | | |
|---|--|--|------------------------|---|------------------------------|-------------------|
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| Leakage on Transmission and Distribution Mains | Unauthorized Consumption | | | Unbilled Unmetered Consumption | | |
| | Leakage and Overflows at Utility's Storage Tanks | | | Systematic Data Handling Errors | | |
| Water Imported (corrected for known errors) | | | | Leakage on Service Connections up to the Point of Customer Metering | | |

NOTE: All data in volume for the period of reference, typically one year.

Source: AWWA M36

- Under registration
- Meter Sizing

| | |
|---------------------------------|-------------|
| GAL / DAY | 50,000.00 |
| Retail Rate per 1000 GAL | \$ 4.00 |
| Accuracy | 91% |
| Loss per day (GAL) | 4,500.00 |
| Loss per day (\$) | \$ 18.00 |
| Loss per week (\$) | \$ 126.00 |
| Loss per month (\$) | \$ 504.00 |
| Loss per year (\$) | \$ 6,570.00 |



Unauthorized Consumption

Define



04/15/2019 14:42

| ERT Code | ERT Type | Trunc. Factor | Dials | Read Type | Multiplier |
|----------|----------|---------------|-------|-----------|------------|
| 03 | 50 +3 | 0 | 7 | 04 | 1000.00000 |
| 11 | 100w +1 | 0 | 7 | 07 | 10.00000 |
| 11 | 100w +1 | 0 | 7 | 01 | 10.00000 |
| 11 | 100w +2 | 0 | 5 | 06 | 100.00000 |
| 11 | 100w +3 | 0 | 5 | 10 | 1000.00000 |
| 11 | 100w -2 | 2 | 5 | 08 | 1.00000 |
| 11 | 100w -2 | 2 | 5 | 09 | 1.00000 |
| 13 | 60w +1 | 0 | 5 | 07 | 10.00000 |
| 13 | 60W +1 | 0 | 7 | 01 | 10.00000 |
| 13 | 60w +3 | 2 | 5 | 10 | 1000.00000 |
| 13 | 60W +3 | 0 | 6 | 05 | 1000.00000 |

| SmartPoint Reads | |
|------------------------------|----------------|
| Meter Units | Gallons |
| Read Resolution | 10s of Gallons |
| History Resolution | 10s of Gallons |
| Enhanced History Compression | Disabled |
| Dials | 6 |

```

CUS01000001001A/R:000002                                000N
MTR01000001001000000000000000RA                57704042    000000000020000000200000000000NN  NNW 000  MTR:000002
0001=#FAMN
RDG01000001WATR 000000000R00000100001095420002703152019095050N000000000000N123456  000020700R 00000010070001095420
RFF0100000157704042      ERT      0000  956.43125000070000003152019095050000010954260w +1  0000N
    
```

| | | | | | | |
|---|---------------------|--|------------------------|---------------------------------|------------------------------|---|
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| | | | | Real Losses | Real Losses | |
| | | Real Losses | Real Losses | | | Systematic Data Handling Errors |
| Real Losses | Real Losses | | | | | Leakage on Transmission and Distribution Mains |
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NOTE: All data in volume for the period of reference, typically one year.

Source: AWWA M36

Leakage on Mains

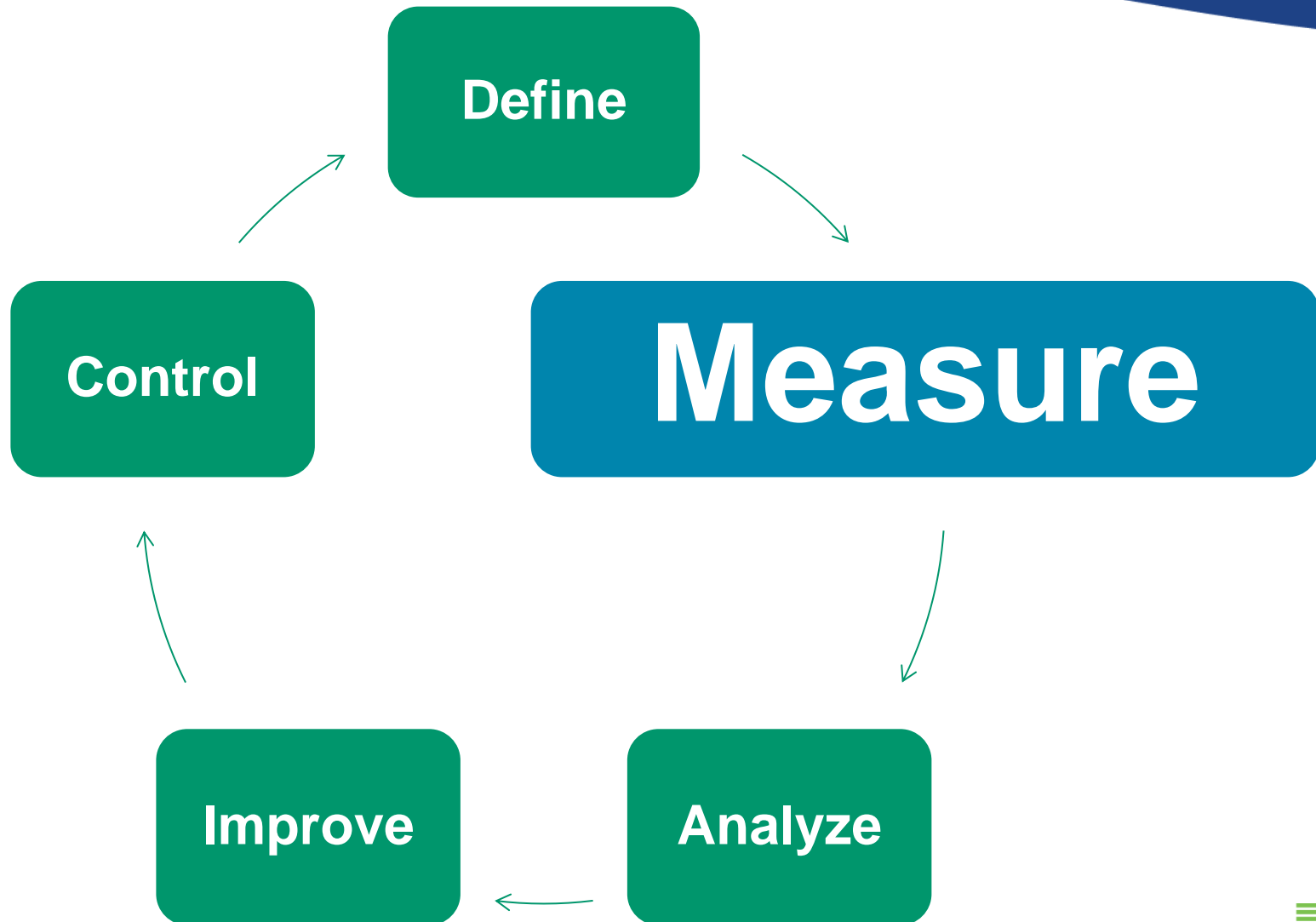
Define



- “Up to point of customer metering”
- Older poly material plastic pipe







What do we measure?

Measure

Flow

Production

Consumption

Pressure

Production

Distribution

Service
connection

Level

Elevated
tank

Ground tank

Well

- Two governing principles that dictate how a water system behaves:
 - Conservation of mass**

$$\sum \dot{m}_{in} - \sum \dot{m}_{out} = \dot{m}_{CV}$$

System Input Consumption + NRW System Storage

- Conservation of energy**

$$\frac{p_1}{\rho} + \frac{V_1^2}{2g} + Z_1 = \frac{p_3}{\rho} + \frac{V_3^2}{2g} + Z_3$$

Pressure Head Velocity Head Elevation Head

How do we measure?

Measure

Measurement

Communications

Storage

Meters

Transmitters

SCADA

Head End System

AMR

Billing System

Sensors

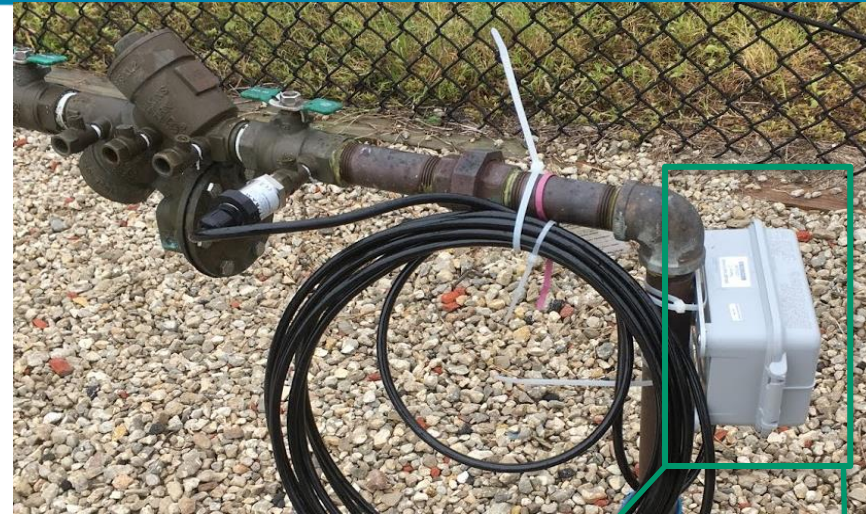
AMI

Database
Data-lake
Data-mart

Flow Measurement

Measure





- AMR
- AMI
- SCADA
- Cellular



Where

- PRV
- Booster pump
- Interconnect
- Blow off valve
- Sampling point
- Backflow
- Meter test port
- Service connection

When

- One time
- Once per minute
- Once per 15 minutes
- Once per hour

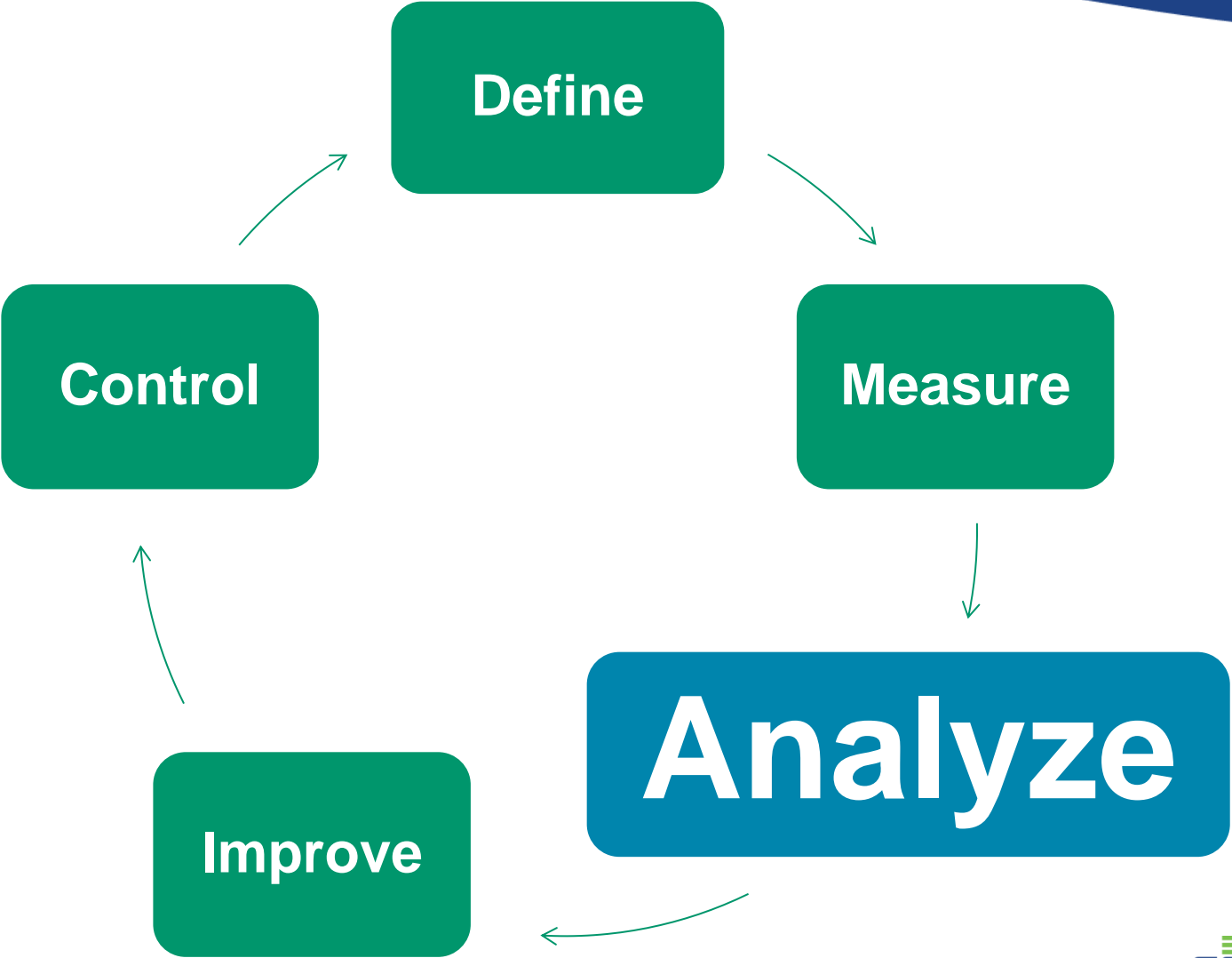
How

- Logger
- AMI
- Cellular
- SCADA



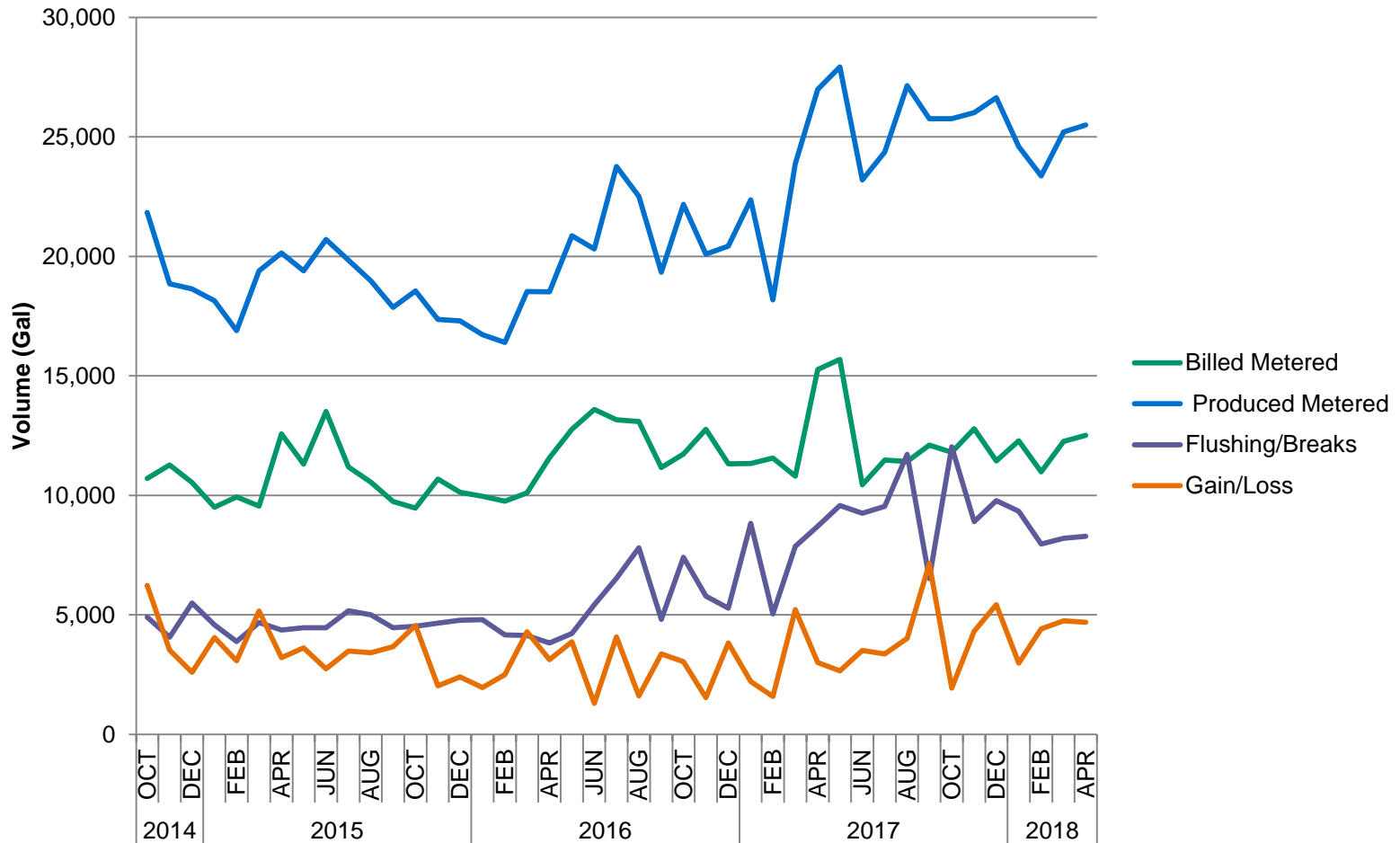


DMAIC



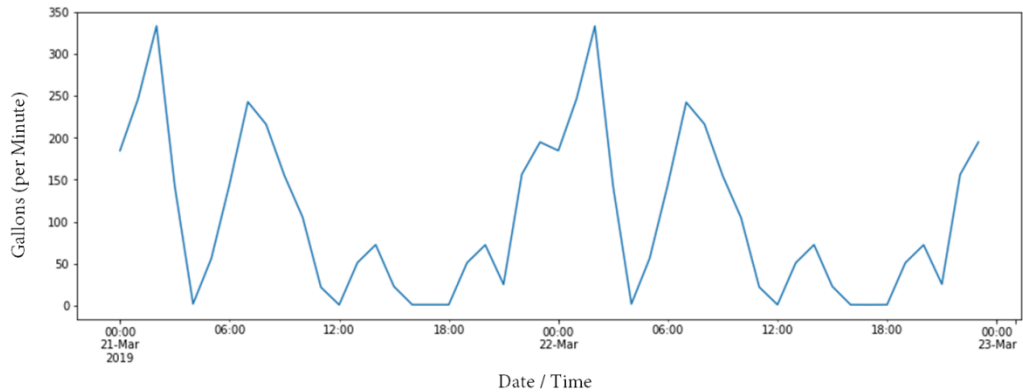
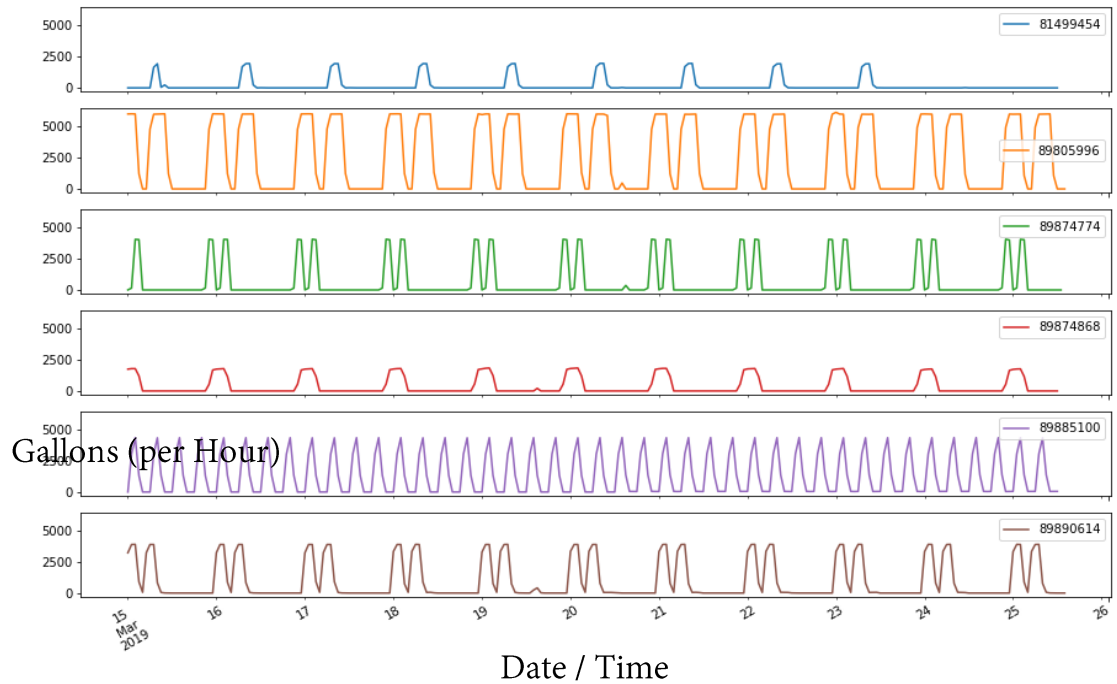
Water Balance: Monthly Trending

Analyze

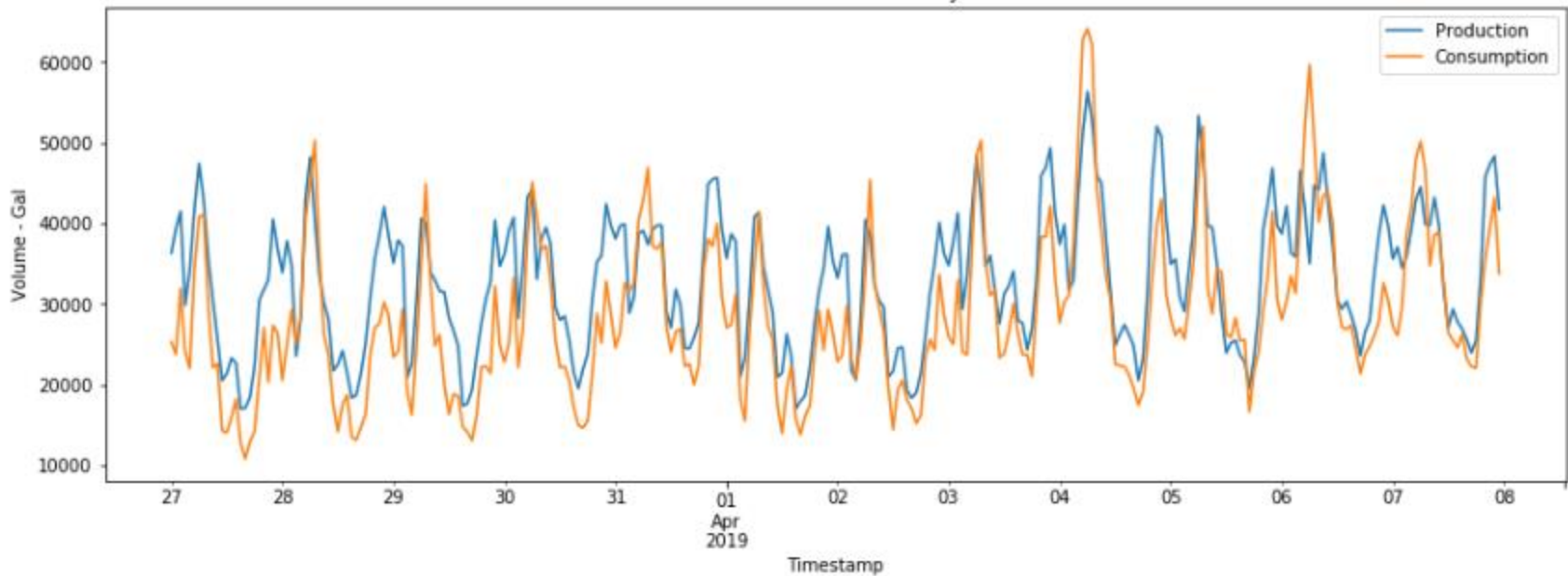


Leveraging Hourly Consumption

Analyze

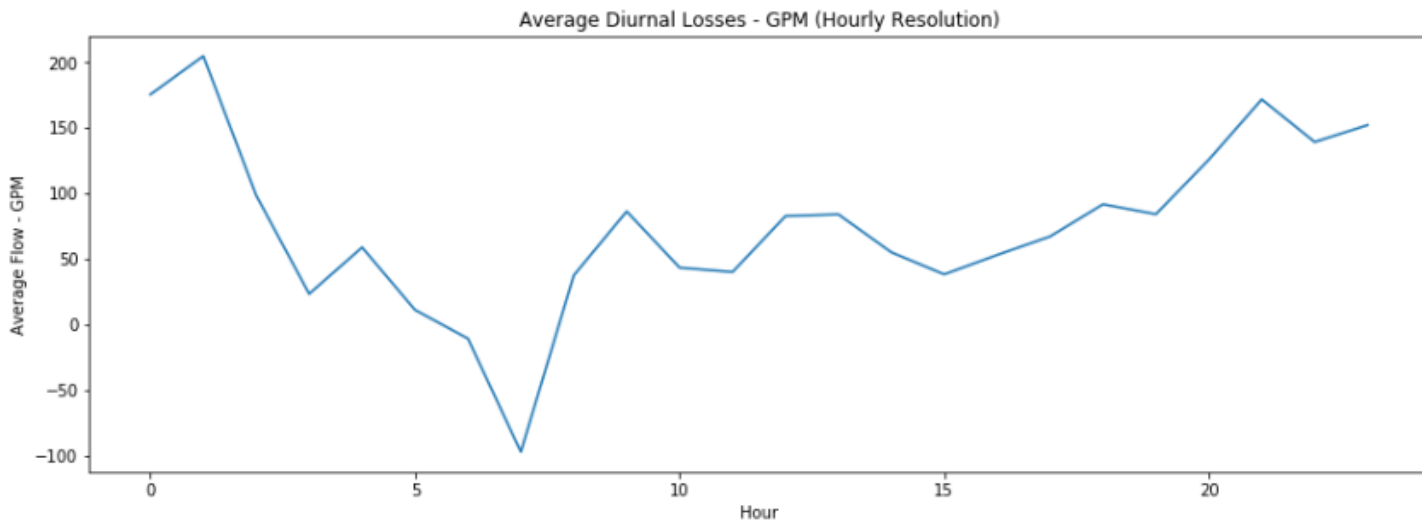
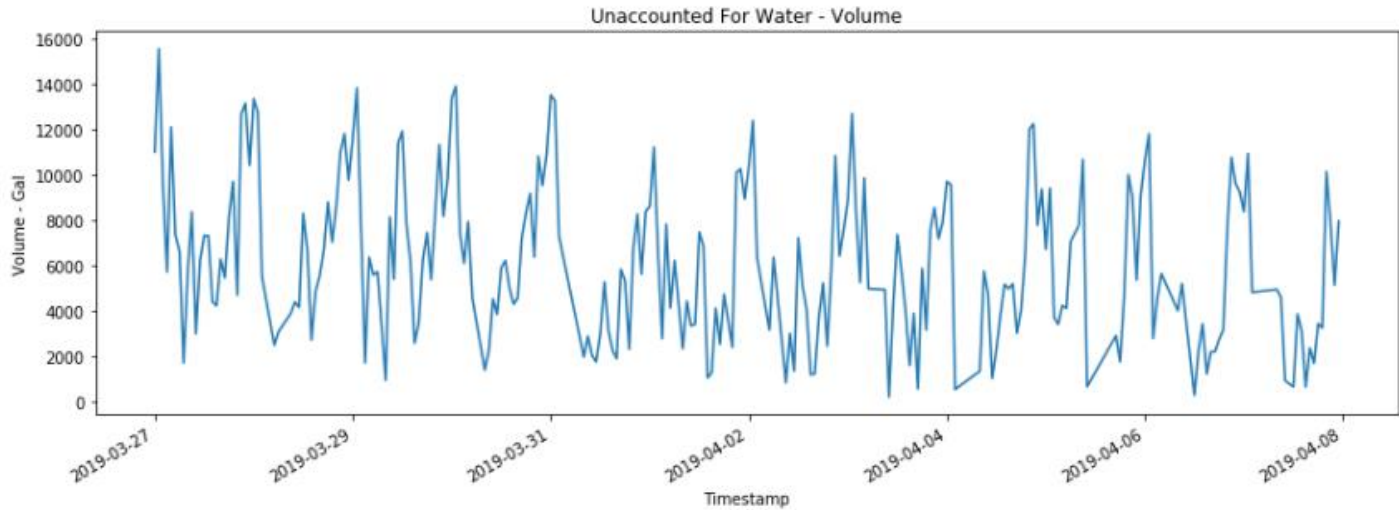


- Capture additional insights into system behavior



Water Balance: Time Resolution

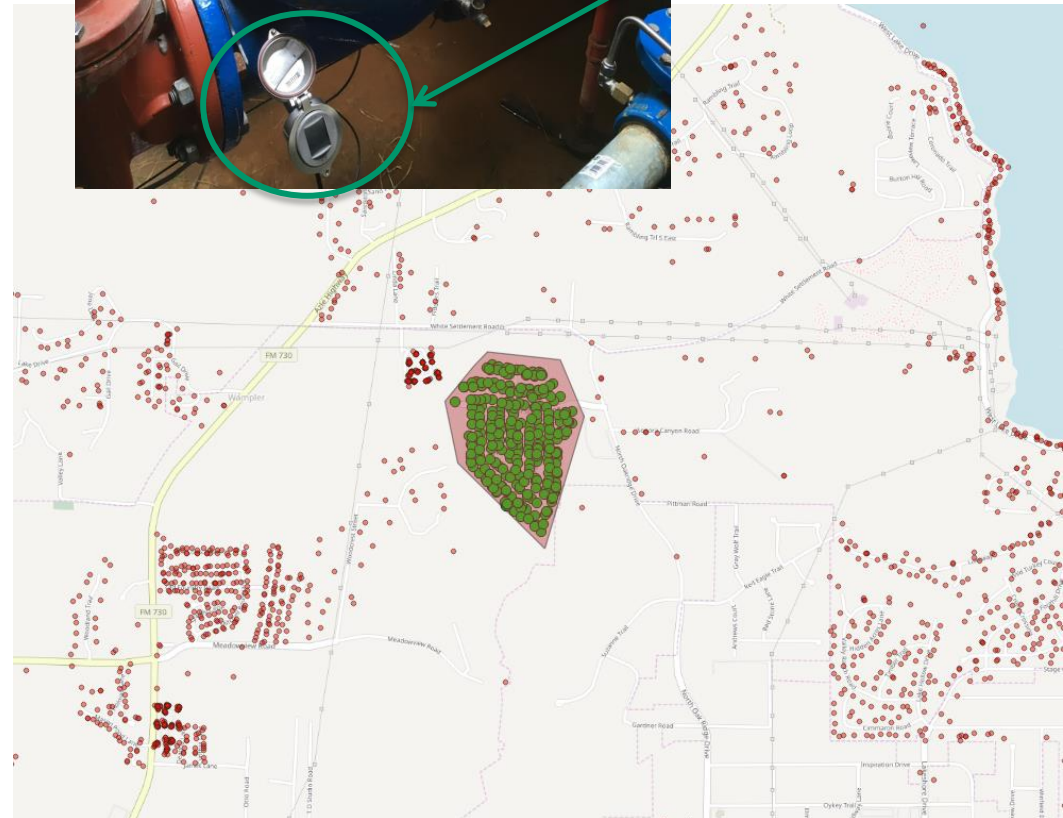
Analyze



- Create **district metered areas (DMAs)**
- Utilize **zone meters**
- Be **asset efficient**
 - Add meters to PRVs
- Use geo-fencing to sum consumption data for a zone balance
- Identify highest loss areas for more strategic action

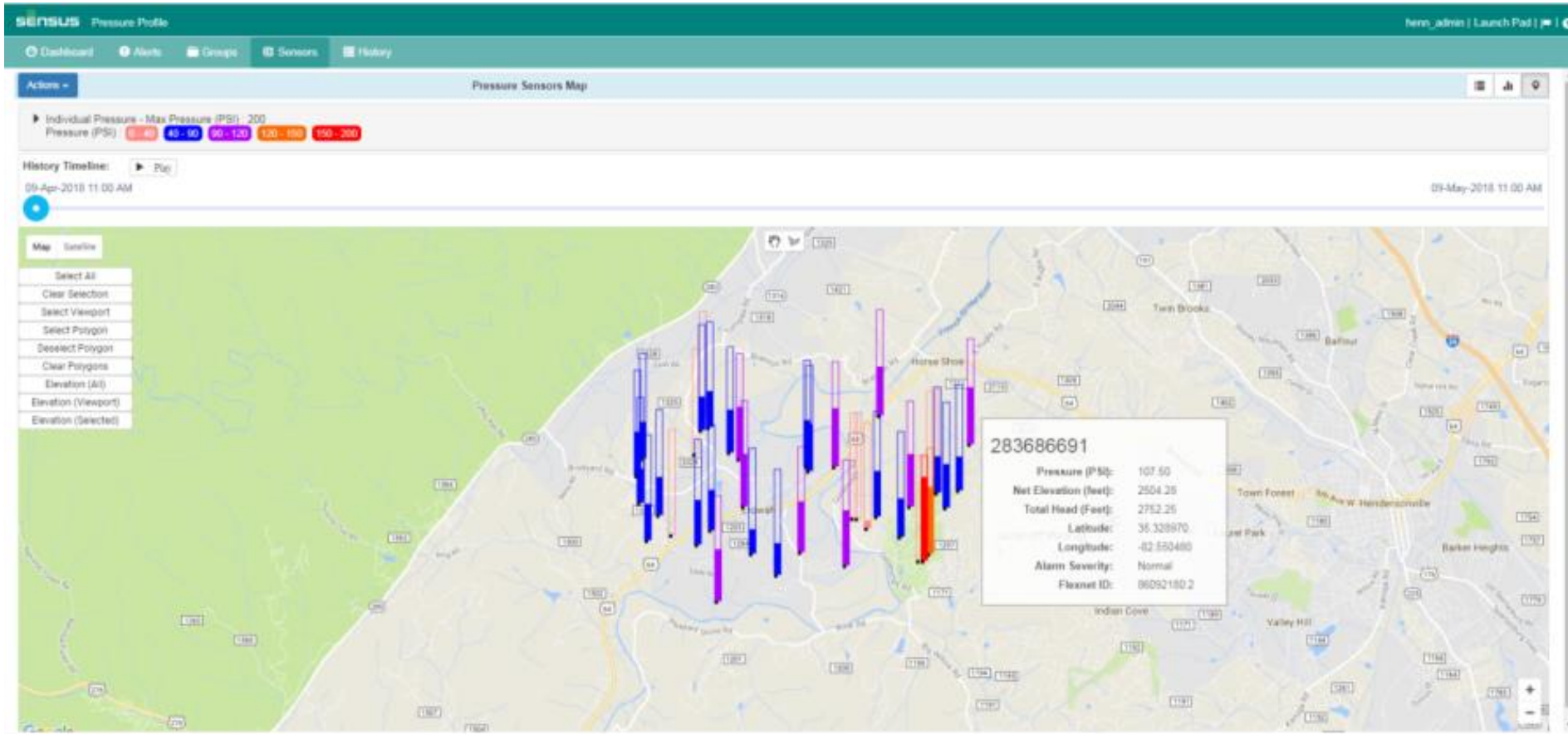


Insertion Meter

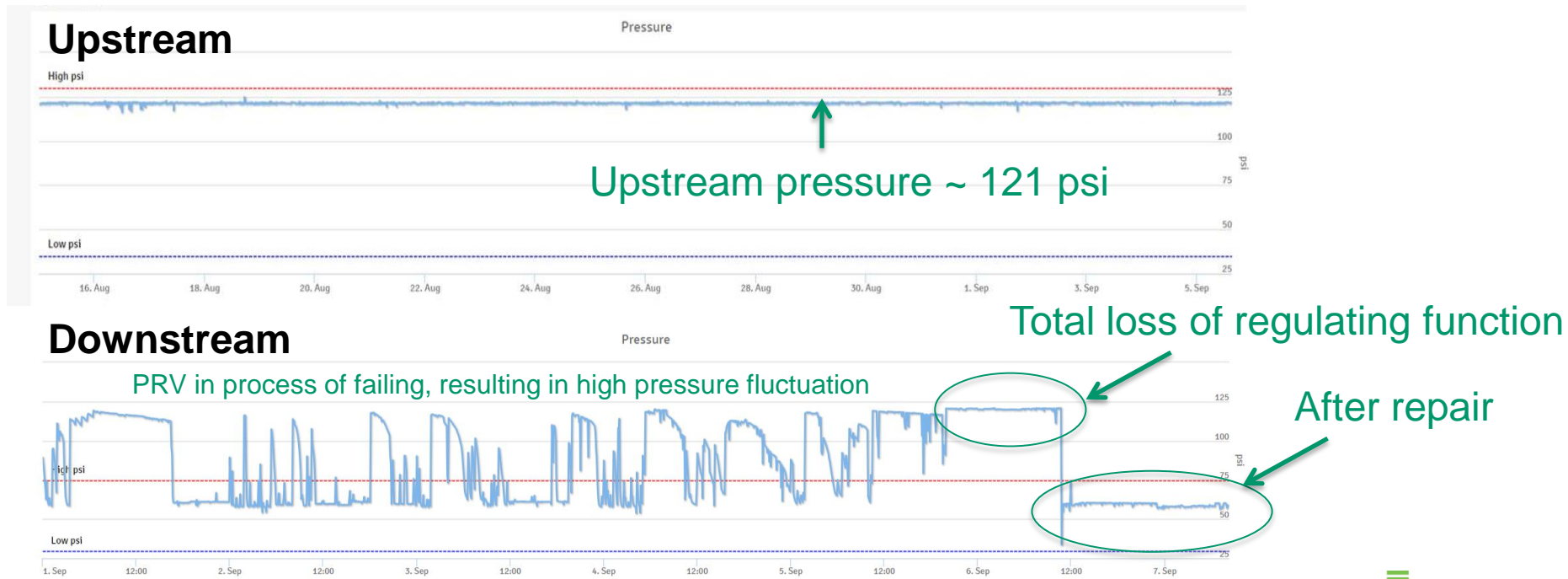


Leveraging Pressure Data

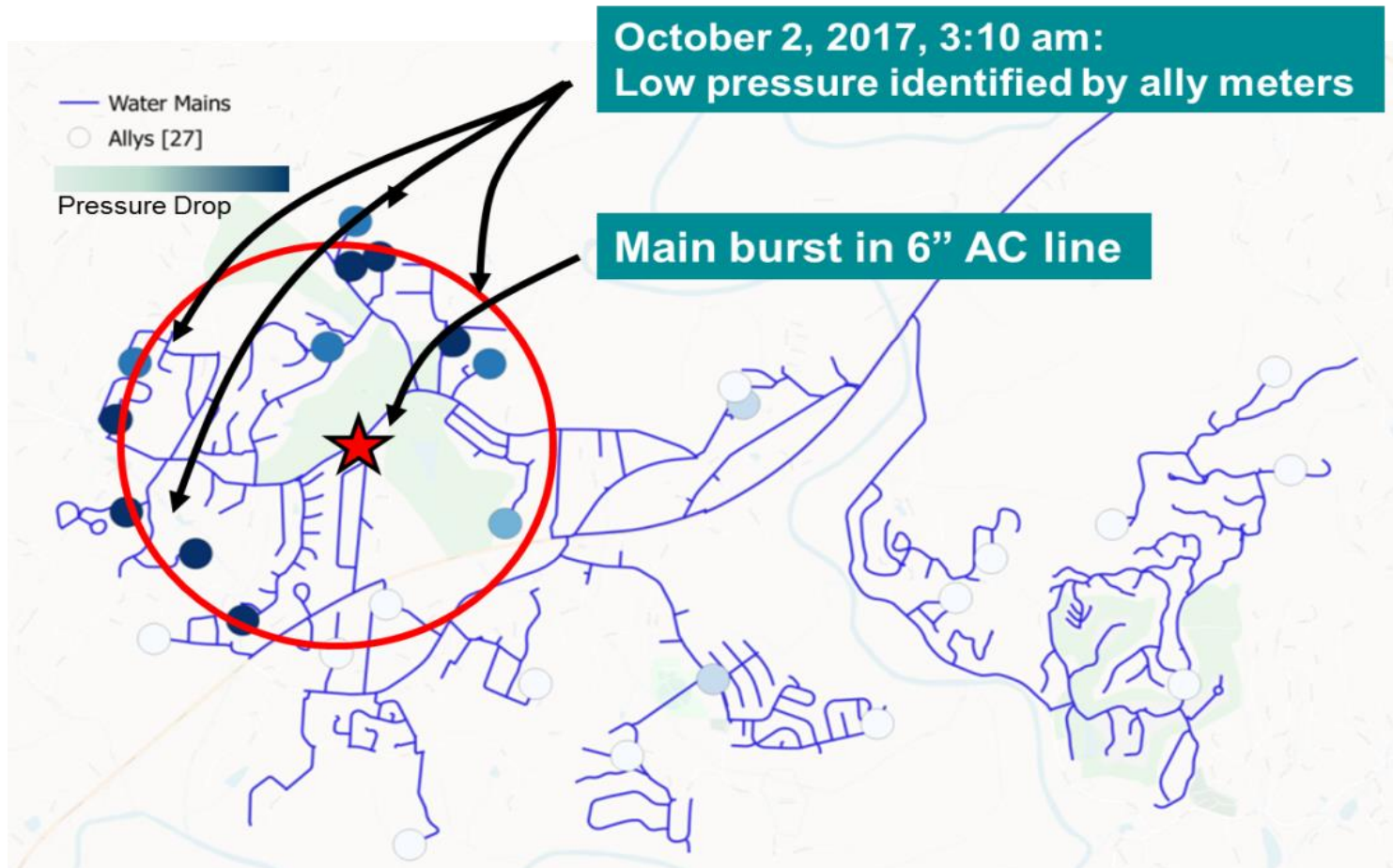
Analyze



- Set thresholds and get alerts when pressures exceed limits
- Insight into asset performance (PRV, pump station)

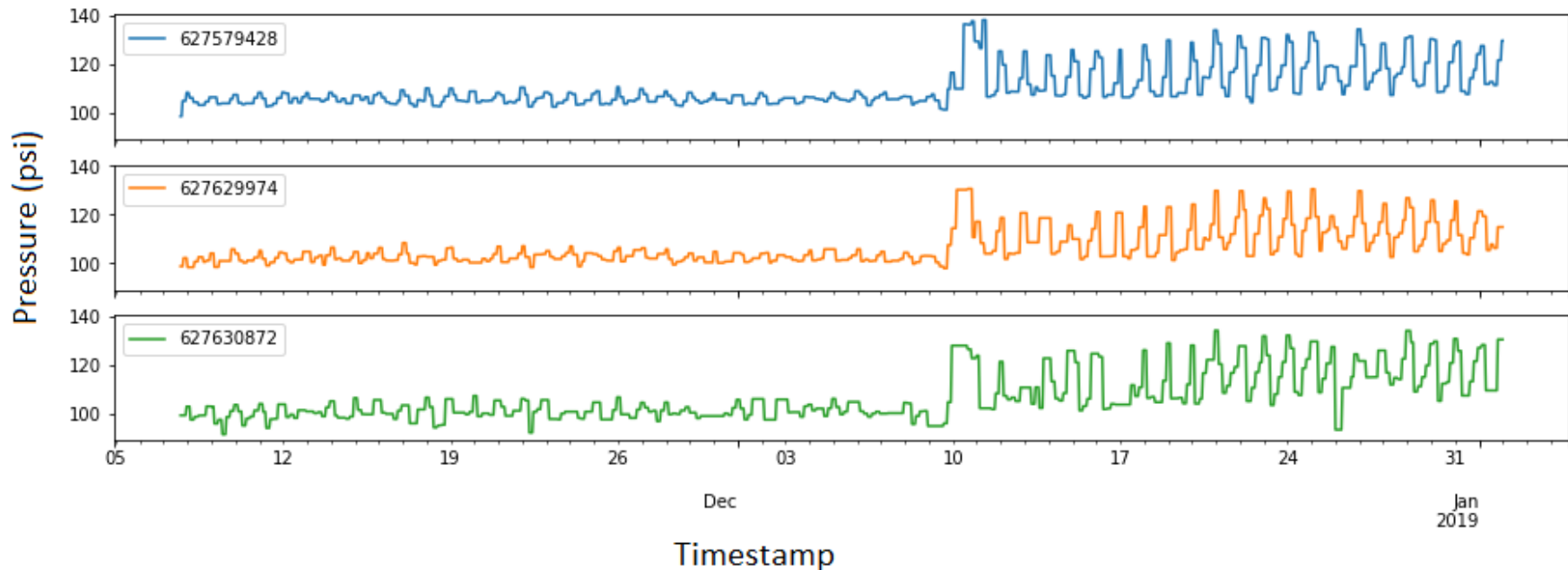


- Monitor for major changes in system pressure



- Detect anomalies

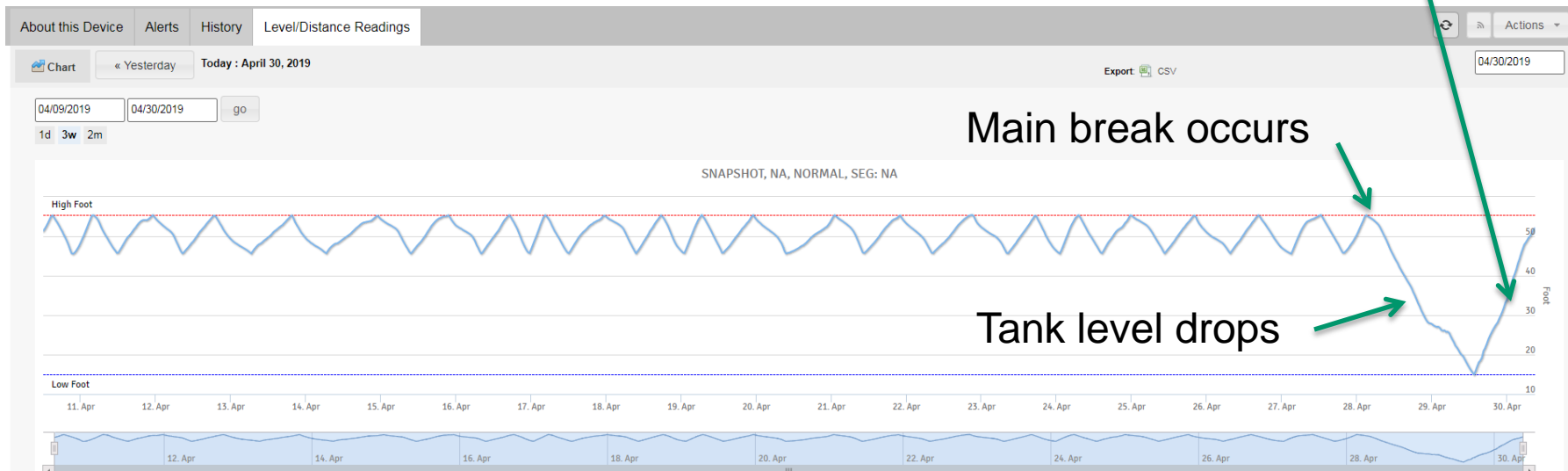
ally Pressure Readings

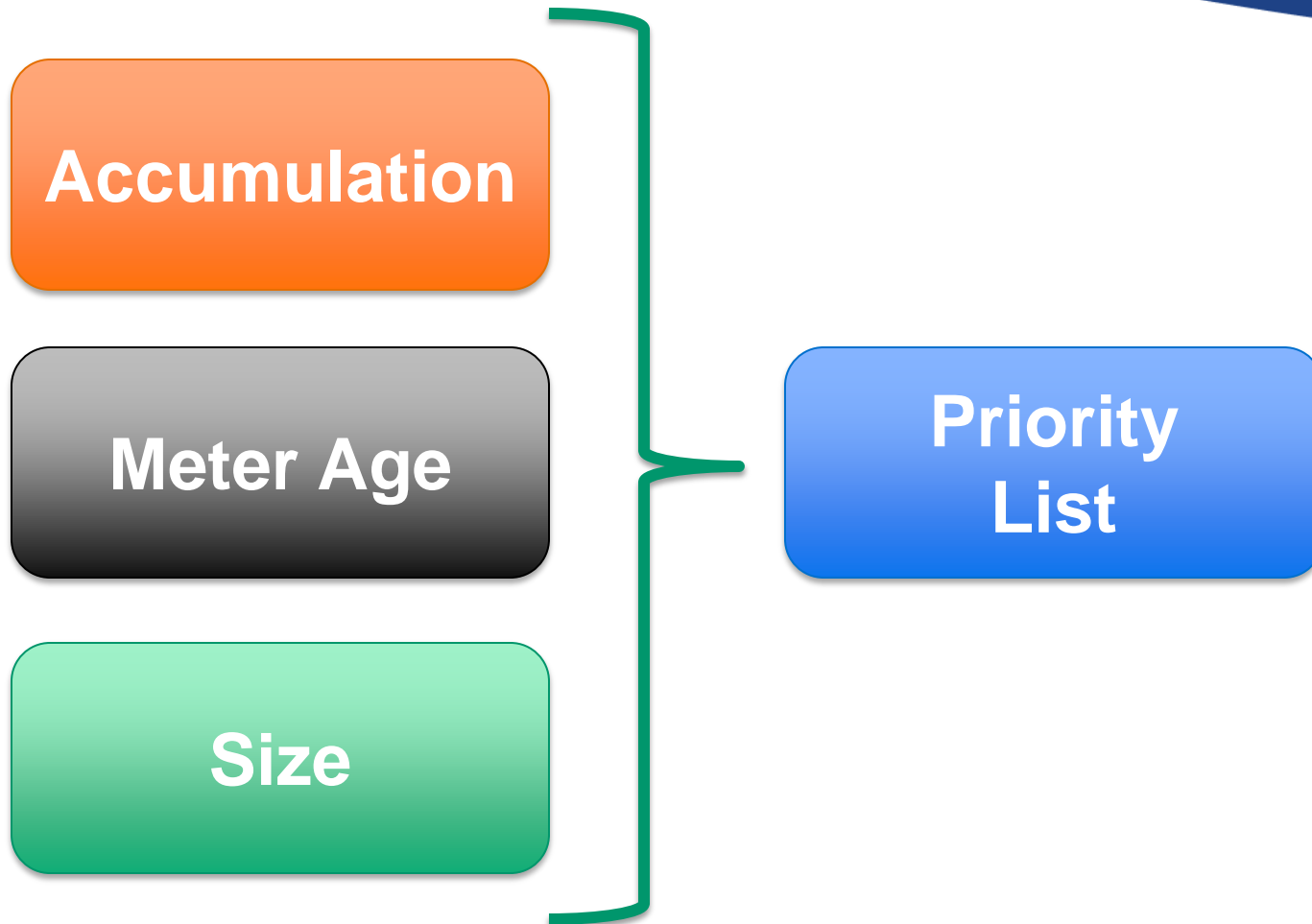


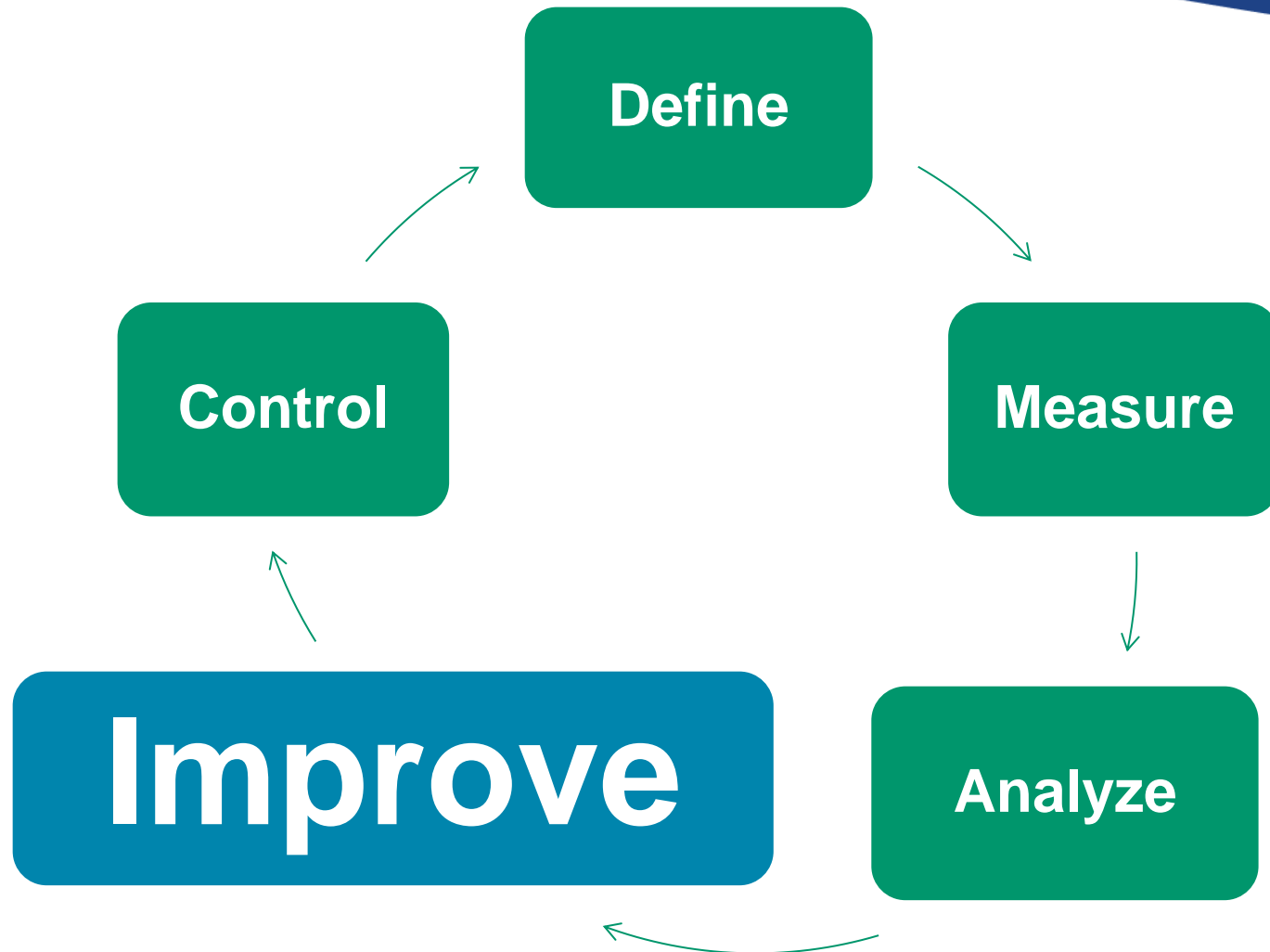
Example: Three (3) ally meters in a pressure zone all show large diurnal swings in pressure after crew addresses leak. Boundary valve left open? Coincidental PRV failure?

- Storage tank not covered by SCADA
- Installed pressure sensor at outlet for level measurement
 - Utility used Smart Gateway sensor interface – AMI radio – to read sensor and transmit data
- Main break on Sunday 4/28
- Tank level drops, alerts utility

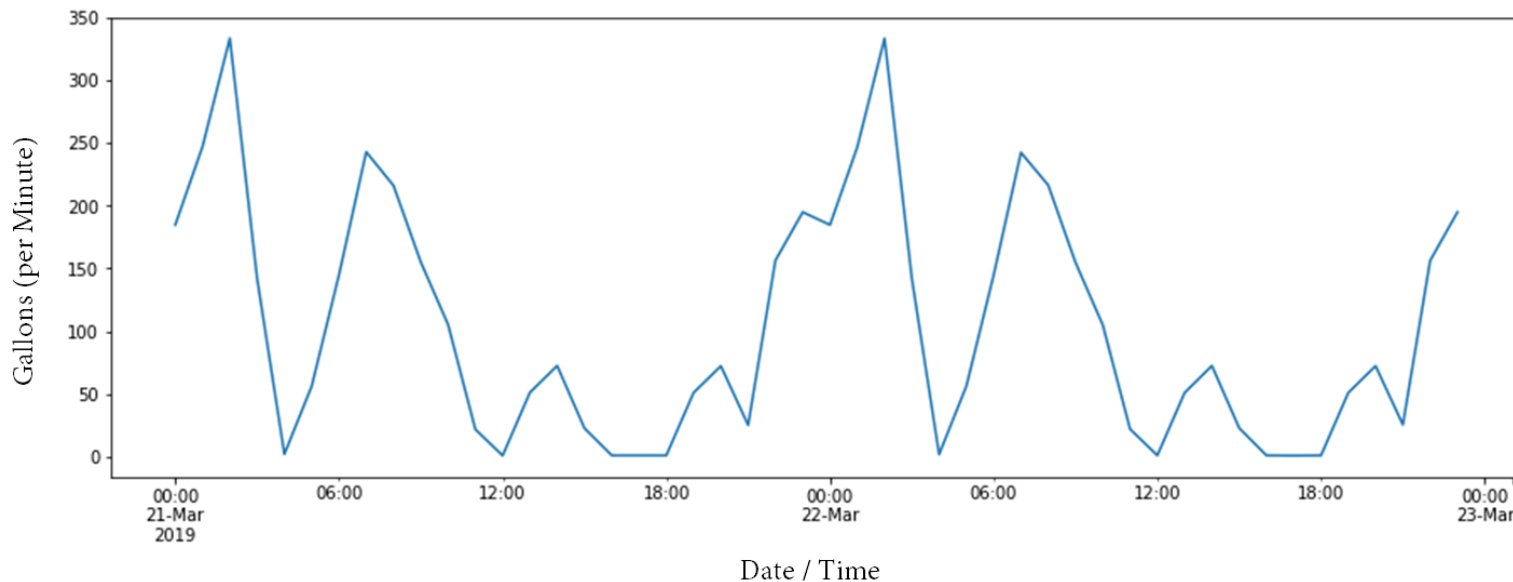
Break repaired
Tank filled







- Act on insights and findings from the analyze phase
- Required actions in improve phase will vary
- Examples:
 - Flushing consumption findings
 - PRV set point findings



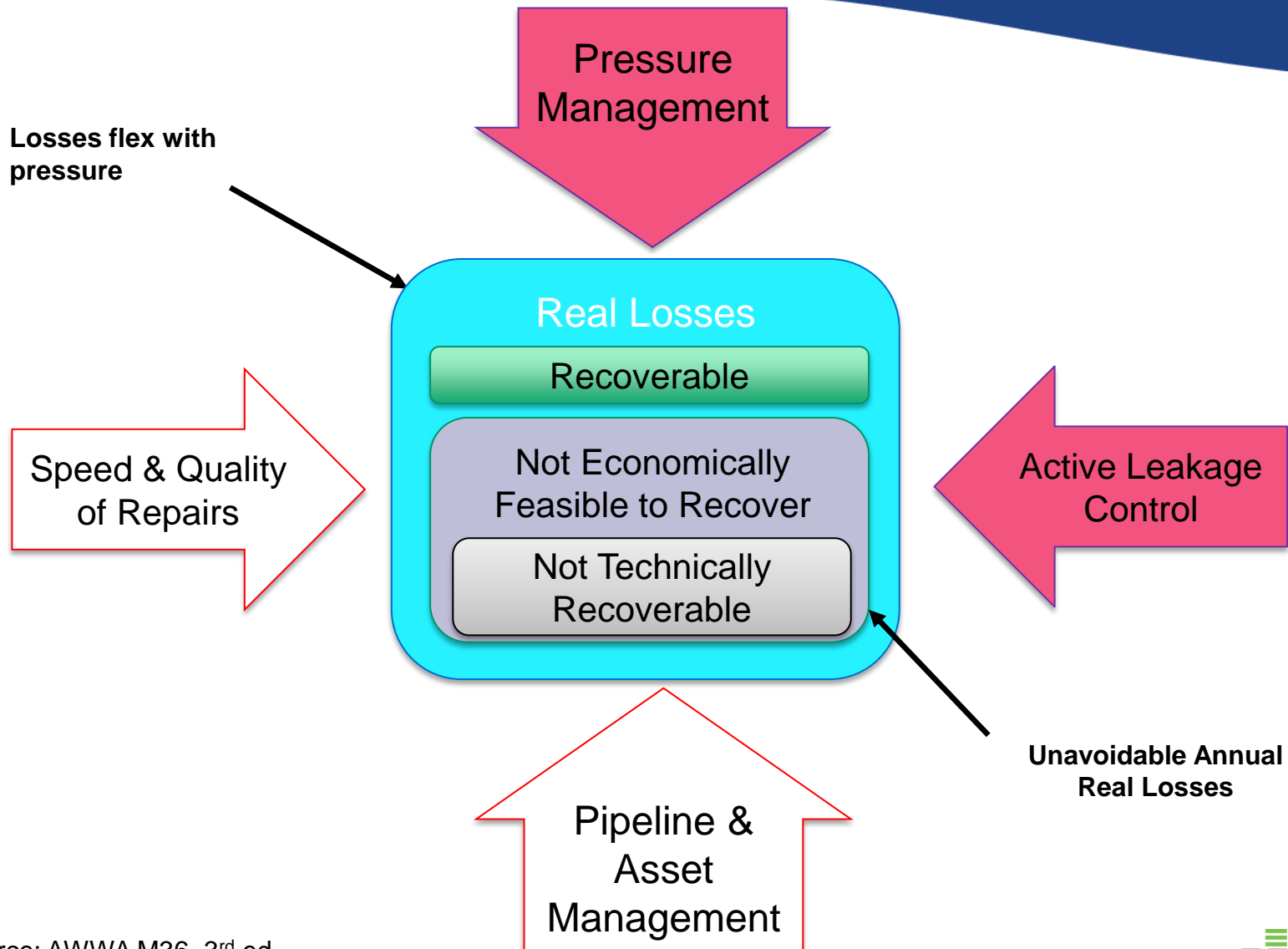


Table ES.3 Composite water audit data set median performance indicators

| | PERFORMANCE INDICATOR | MEDIAN | AVERAGE | UNIT | <i>n</i> | FILTERS |
|--------------------|----------------------------|----------|------------|---------------------------------|----------|--|
| <i>financial</i> | customer retail unit cost | \$4.67 | \$8.33 | \$ / 1,000 gallons | 1,545 | passes customer retail unit cost check |
| | variable production cost | \$950.00 | \$2,085.28 | \$ / million gallons | 1,489 | passes variable production cost check |
| | NRW as % of operating cost | 7.8% | 10.2% | % of operating cost | 630 | passes both cost checks passes volumetric validity checks does not come from Texas (operating cost not reported) |
| <i>operational</i> | Apparent Losses | 5.73 | 14.88 | gallons / serv conn / day | 1,290 | passes volumetric validity checks |
| | Real Losses (serv conn) | 39.88 | 51.81 | gallons / serv conn / day | 812 | passes volumetric validity check service connection density ≥ 32 conn / mile of main |
| | Real Losses (mains) | 785.54 | 1,132.42 | gallons / mile of main / day | 478 | passes volumetric validity checks service connection density < 32 conn / mile of main |
| | Real Losses (pressure) | 0.59 | 0.79 | gallons / serv conn / day / PSI | 812 | passes volumetric validity checks service connection density ≥ 32 conn / mile of main |
| | ILI | 2.48 | 3.12 | (dimensionless) | 644 | passes basic volumetric validity checks UARL calculation applies – $(32 \times Lm) + Nc \geq 3,000$ |
| | data validity score | 73.1 | 71.7 | points out of 100 | 679 | passes basic volumetric validity checks does not come from Texas |

Source: EPA/WRF Water Audits in the US: A review of Water Losses and Data Validity

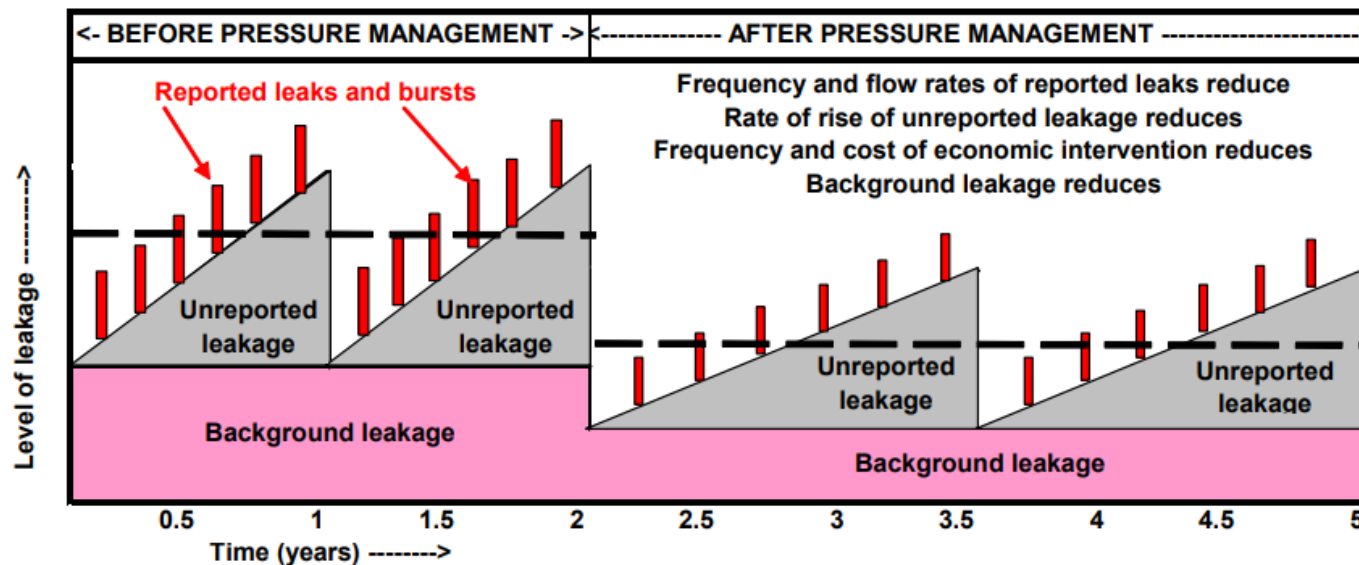
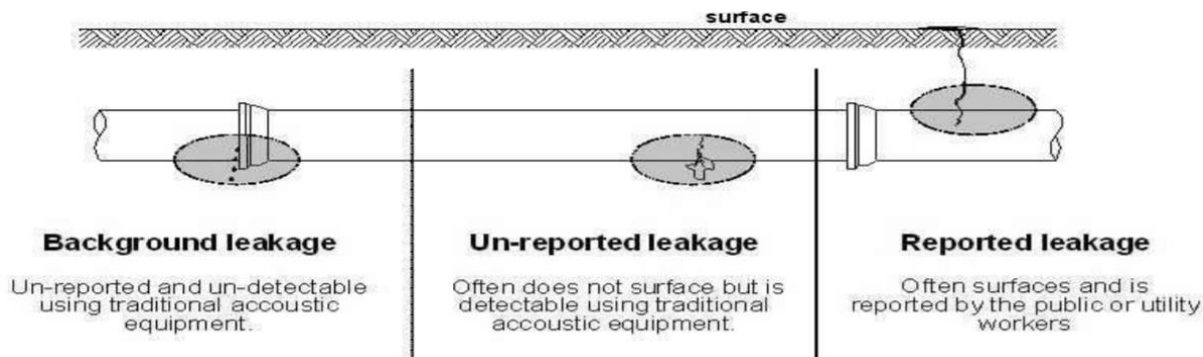


Figure 1: Influence of pressure management on BAGE components of Real Losses
 Source: Fantozzi & Lambert (2007)

- Monitoring pressure throughout the distribution system provides unique advantage for pressure management
- Enhanced system visibility
- Confidence in full range in system and if minimum levels maintained
- Diurnal, weekly, or seasonal management strategies can be used

- Utilize insights and monitoring from pressure and level data
- Respond proactively to issues *before* a customer complaint or critical thresholds reached such as 20 PSI boil water notice requirement

Sensus Notification - Alerts - Pressure Alarm

alarm-notification-do-not-reply@flexnet.net

[If there are problems with how this message is displayed, click here to view it in a web browser.](#)


Sent: Wed 2/20/2019 12:55 AM

To:

WATER

Sensus - DM Notification Service

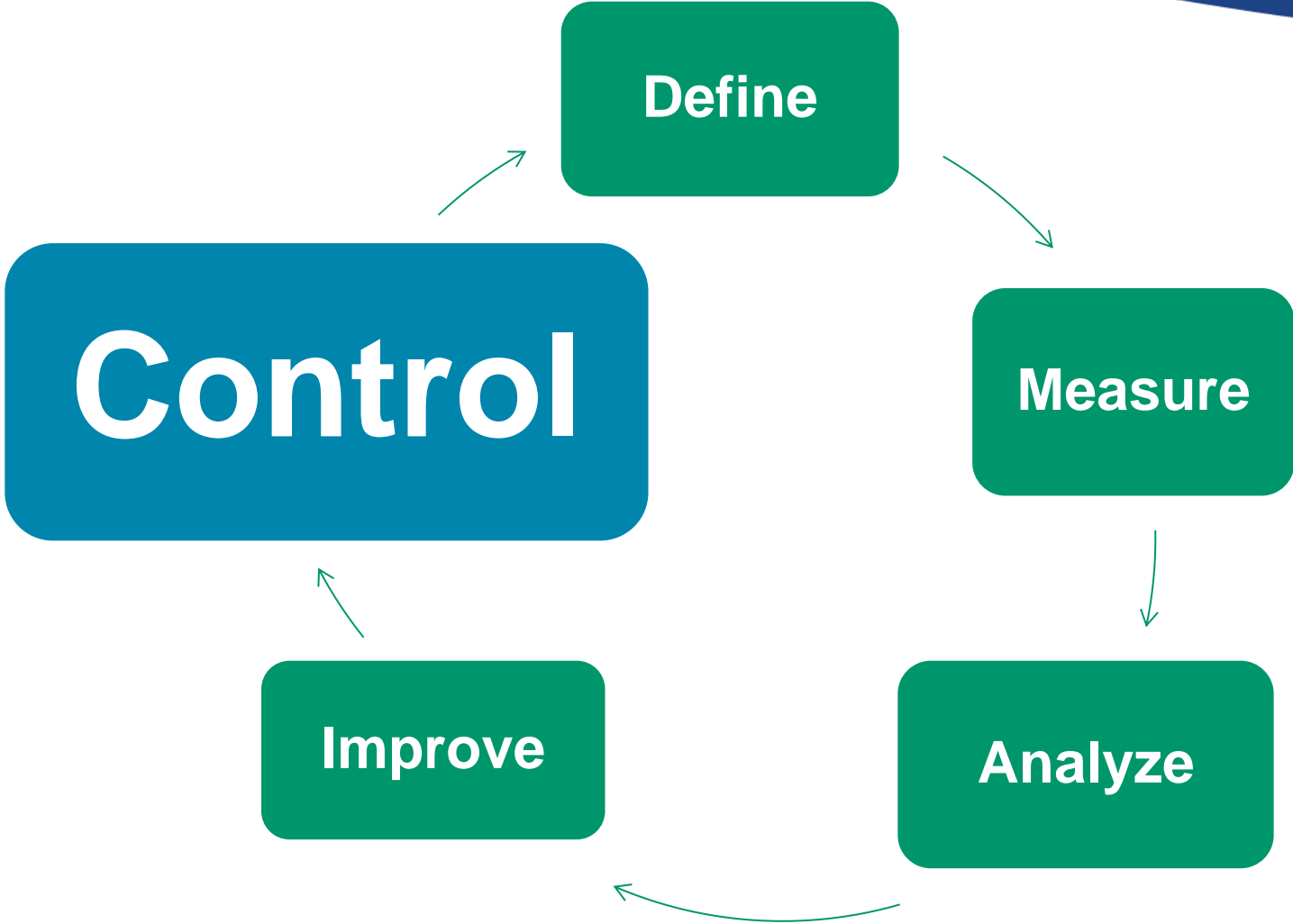
Active alerts - Pressure Alarm

| Device ID | Network Address | Device Type | Alert Category | Alert Severity | Alert | Alert Time |
|---------------|-----------------|-------------|----------------|--|---------------------|---------------------------|
| RM2_120001113 | 656872025 | Sensor | Feature |  Critical | High Pressure Alarm | 02/16/2019 02:15:00 AM |

Alert Thresholds

High Threshold

Alarm will be triggered if Pressure is at or above 64.0 psi for 1 sample reading(s) which are every 15 Minutes



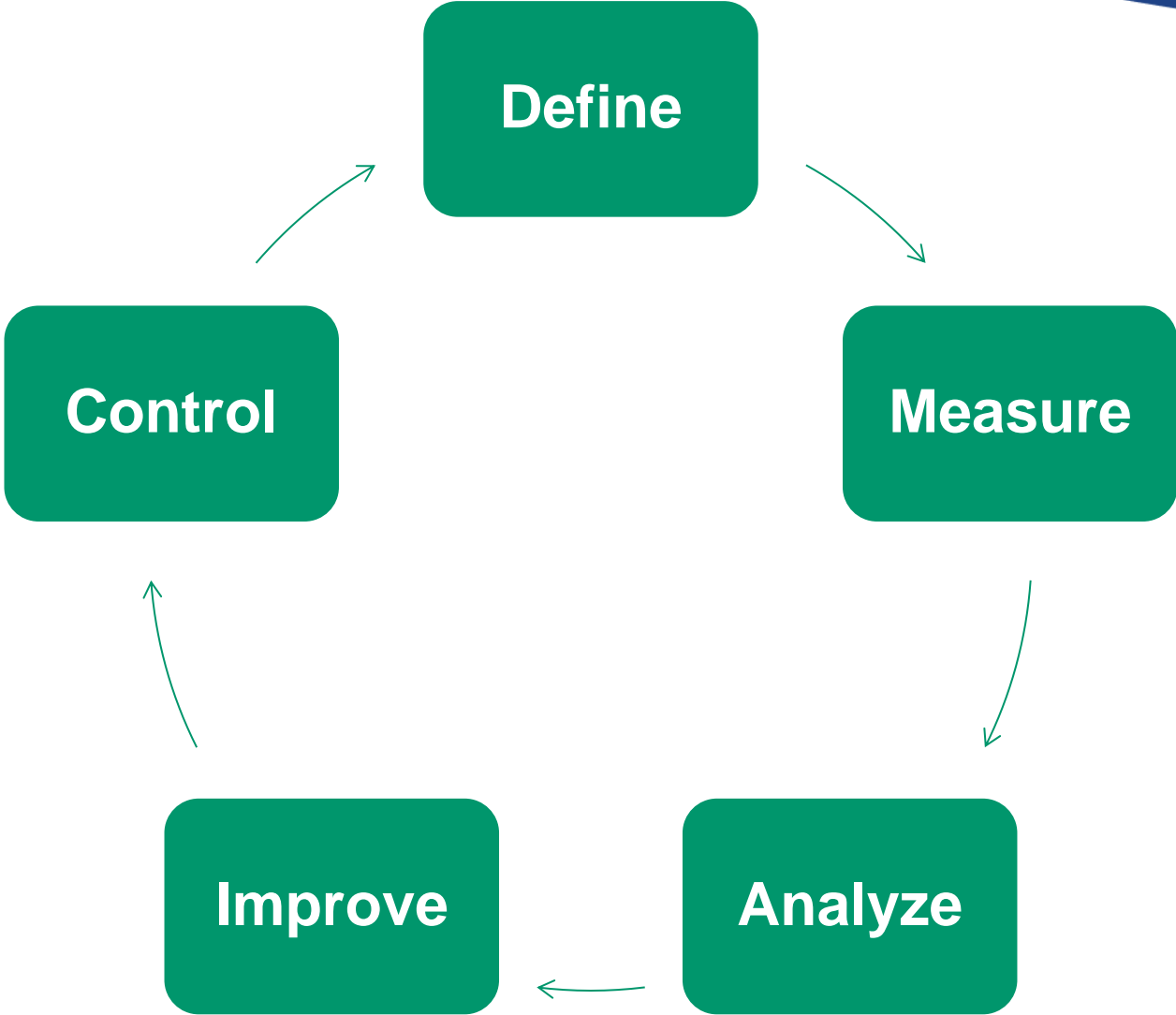
- Ongoing measurement and analysis allows utility to monitor for issues
- Establish programs and business processes leveraging this system:
 - Ongoing large meter testing
 - More efficient processes for asset maintenance and management
- Narrow the focus on problem areas identified by water balance or pressure monitoring...

- Utilize insights from *Analyze*
- High rate sensors (pressure and acoustic) to areas of highest concern
- In-situ inspection on large metal mains
- Acoustic correlation
- Additional pressure sensors
- Additional DMAs / zones



- Gain insights into pressure transients from high rate data
 - Determine risk factors for main segments considering age, material, etc.
- Utilize more advanced methods for apparent loss discovery from meter data

DMAIC



Questions?

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- (919) 907 - 9479

