

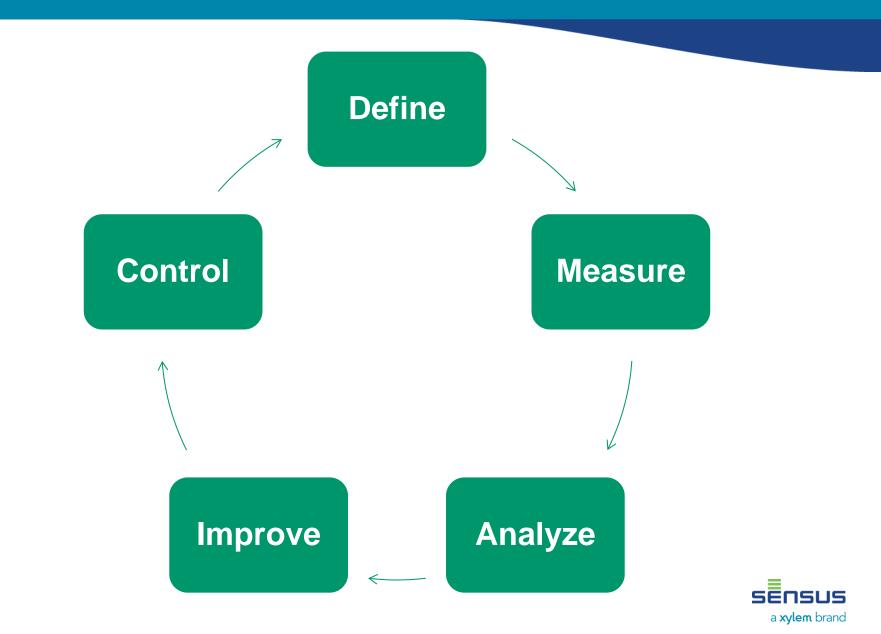


The Non Revenue Water Journey

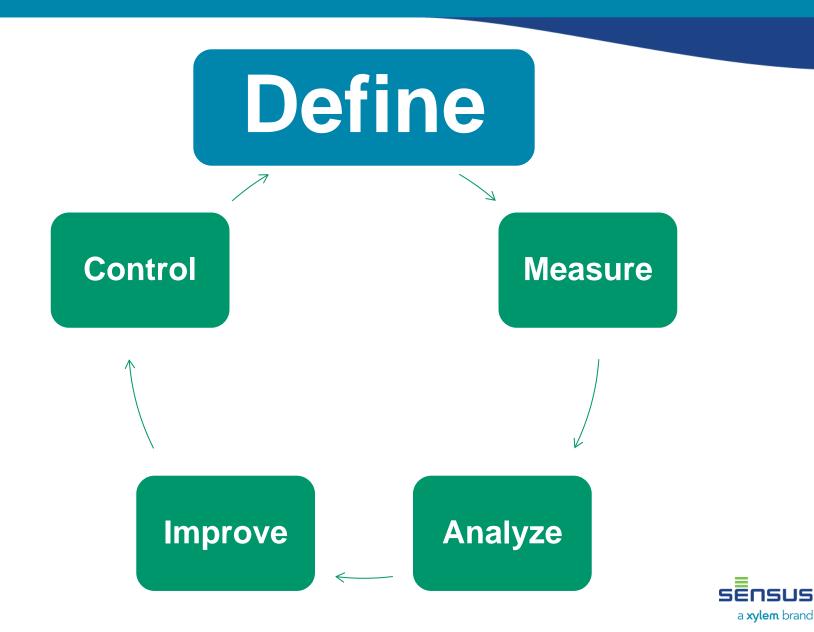
JOSEPH DRYER SOLUTION APPLICATION ENGINEER SENSUS, A XYLEM BRAND



DMAIC



DMAIC



The Chart You've Probably Seen Before

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



Define

Source: AWWA M36

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





Billed Water Exported







Billed Authorized Consumption

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



Source: AWWA M36

Billed Authorized Consumption



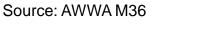






Unbilled Authorized Consumption

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





Unbilled, Metered









Unbilled, Unmetered





Construction Usage















Billed, Not Collected



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. I tenant, you may have certain rights and remedies available under MI law. If and the landlord failed to pay, you model.

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SENSUS



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





Customer Metering Inaccuracies

- 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



Large Meter Accuracy (Wholesale)





Unauthorized Consumption





Systematic Data Handling Errors

Define

04/15/2019 14:42

ERT Cod	e ERT Type	Trunc. Factor	Dials	Read Type	Multiplier
02	50 +3	0	7	04	1000.00000
03	100w +1	0	7	07	10.00000
11	100w +1	0	7	01	10.00000
11		0	5	06	100.00000
11	100w +2	0	5	10	1000.00000
11	100w +3	2	5	08	1.00000
11	100w -2		5	09	1.00000
11	100w -2	2		07	10.00000
13	60w +1	0	5		10.00000
13	60W +1	0	7	01	
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

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Real Losses



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

Source: AWWA M36



Leakage on Mains

Define

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Leakage at Services



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







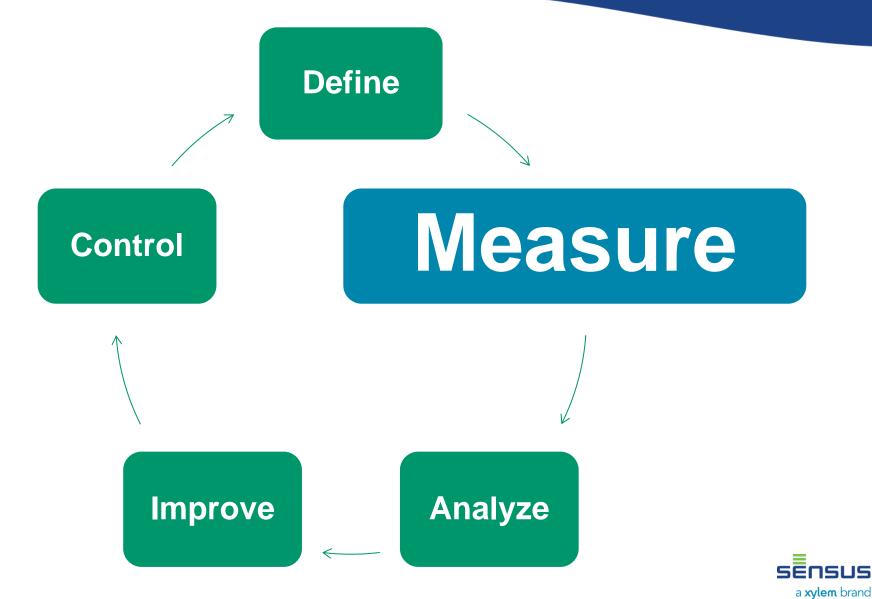
Leakage and Overflows at Storage



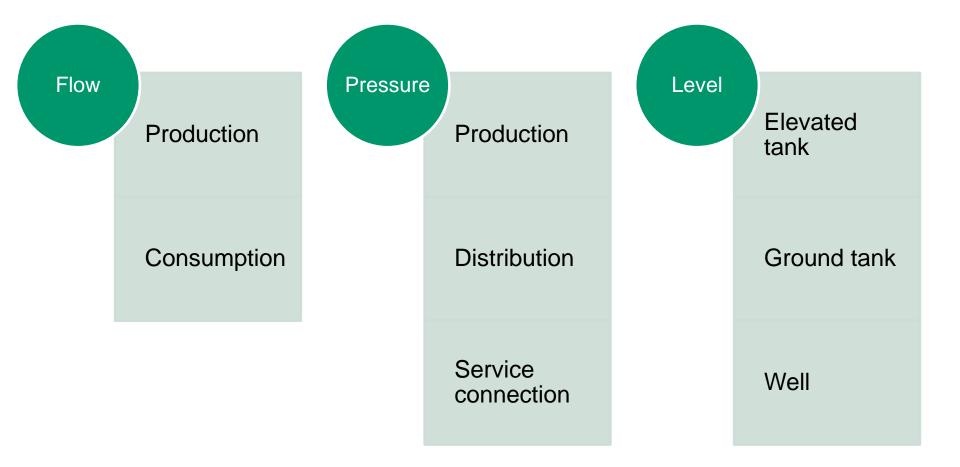




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What do we measure?

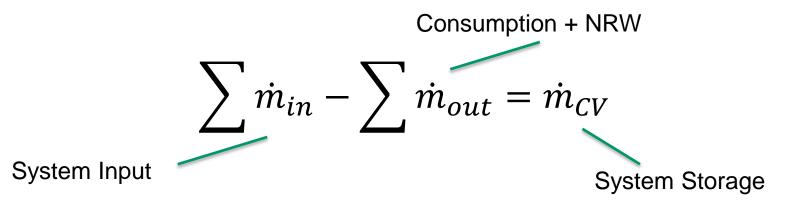




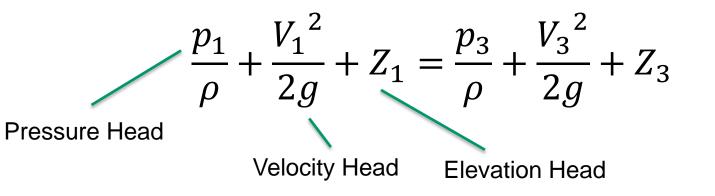
Why do we measure those things?

Measure

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

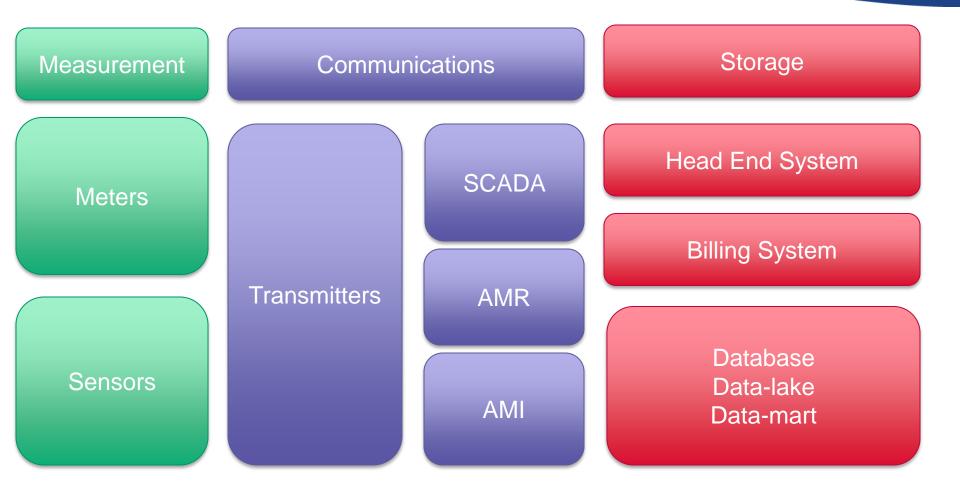


Conservation of energy





How do we measure?





Flow Measurement



Transmitters



Data Communication

- AMR
- AMI
- SCADA
- Cellular









Pressure Monitoring

Measure

PRV Booster pump Interconnect Blow off valve Sampling point Backflow Meter test port Service connection One time Once per minute Once per 15 minutes Once per hour

► Logger AMI Cellular SCADA



Pressure Monitoring







Pressure Monitoring

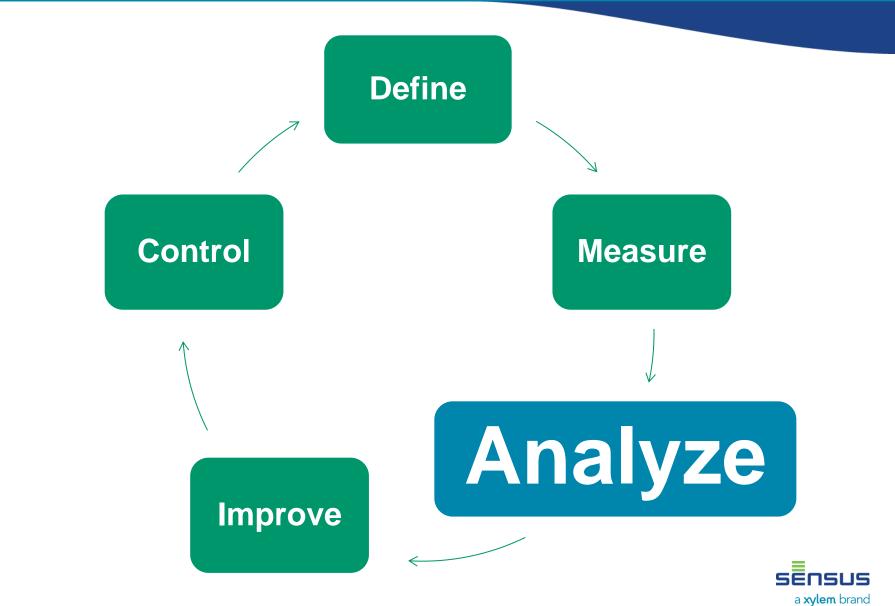








DMAIC



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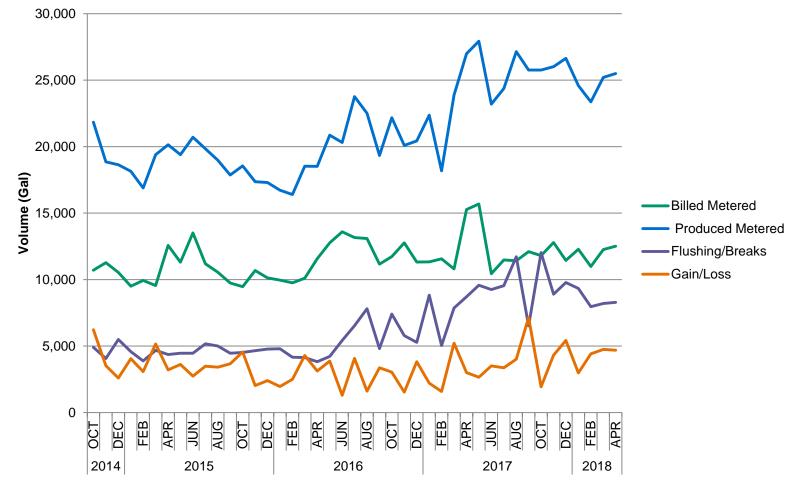
Water Balance

Analyze

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Water Balance: Monthly Trending

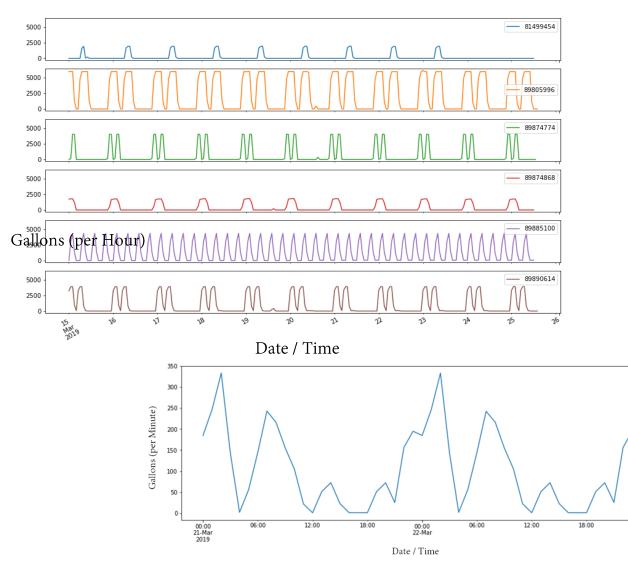




Analyze

Leveraging Hourly Consumption



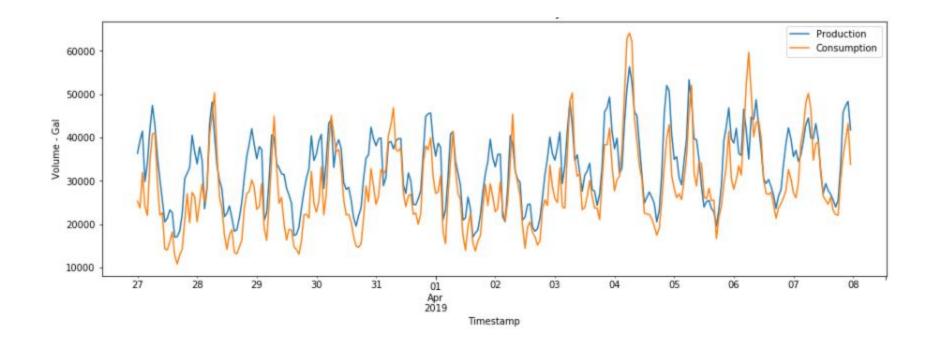




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Water Balance: Time Resolution

Capture additional insights into system behavior

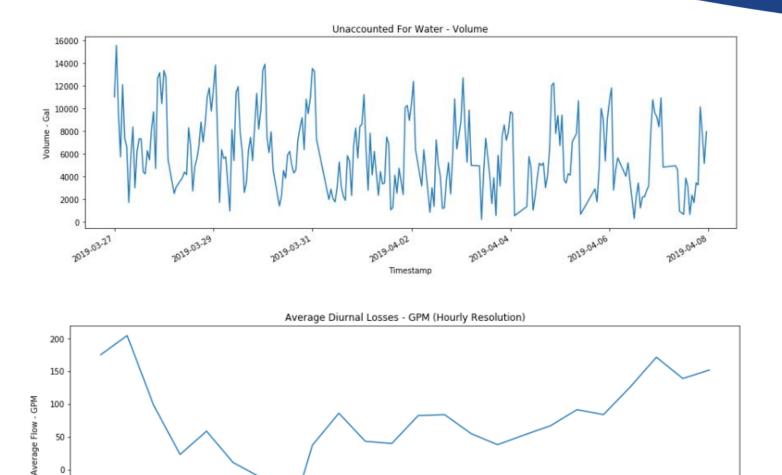




Analyze

Water Balance: Time Resolution

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Hour



20

15

Analyze

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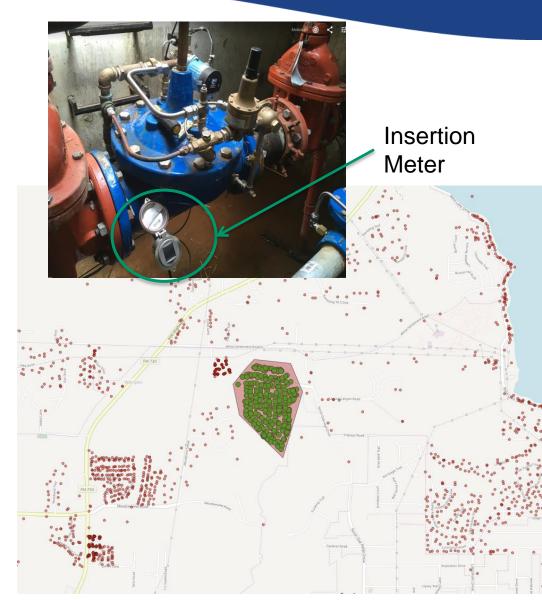
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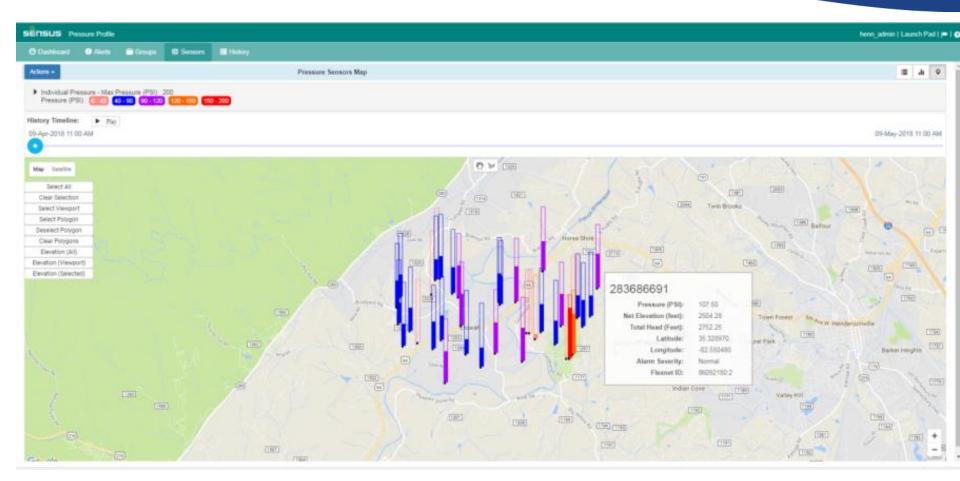
Water Balance: Space Resolution

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





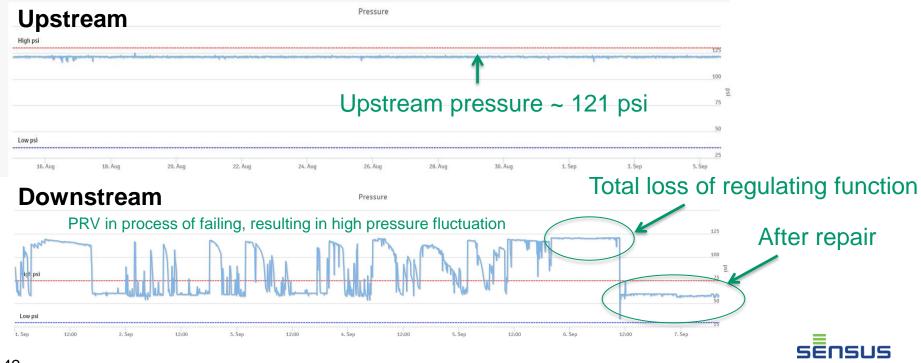




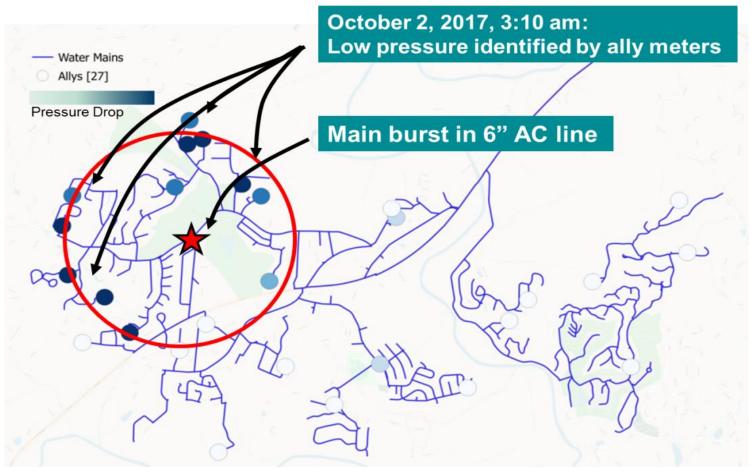
Analyze

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



Monitor for major changes in system pressure

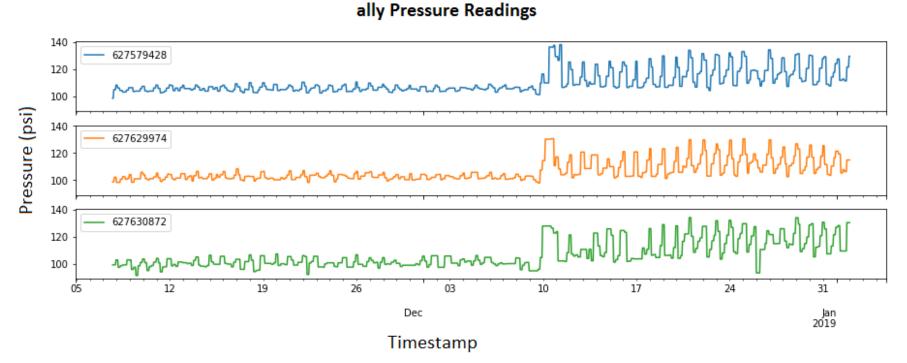




Analyze

Analyze

Detect anomalies

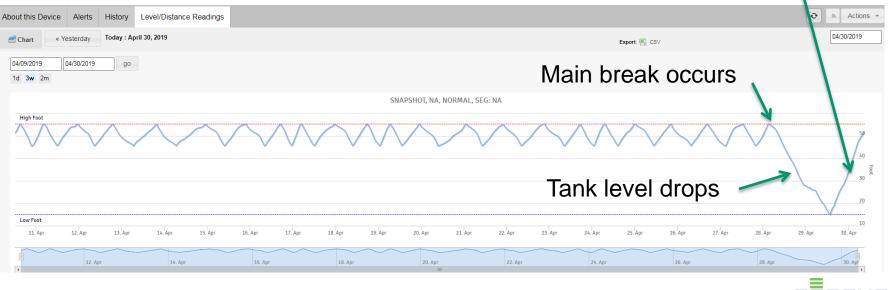


Example: Three (3) ally meters in a pressure zone all show large diurnal swings in pressure after crew addresses leak. Boundary valve left open? Coincidental PRV failure?



Leveraging Level Data

- 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



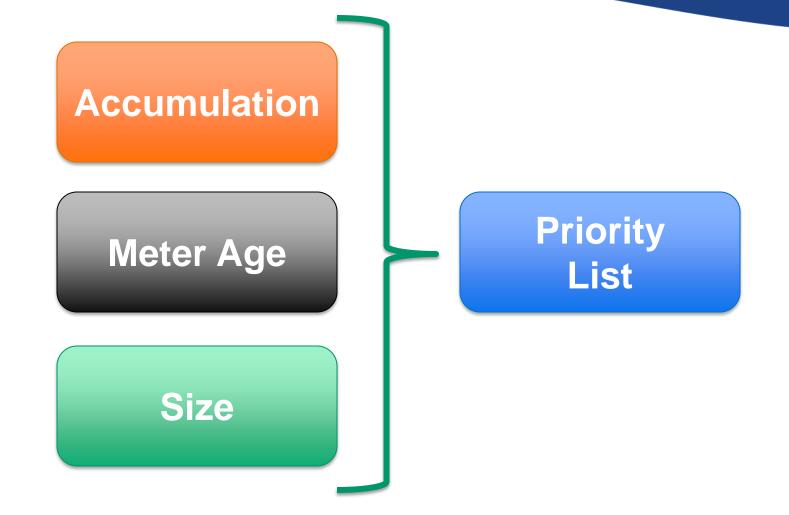
Analyze

Break repaired

Tank filled

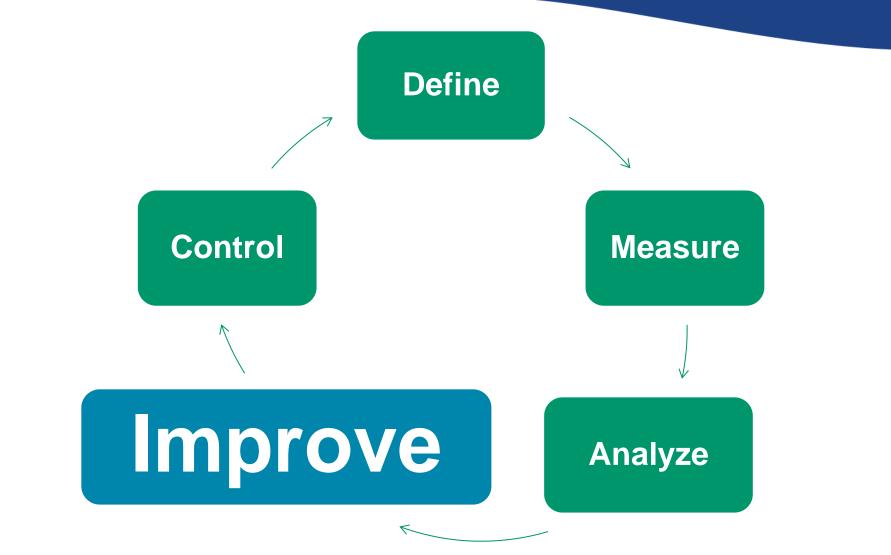
Addressing Apparent Losses

Analyze





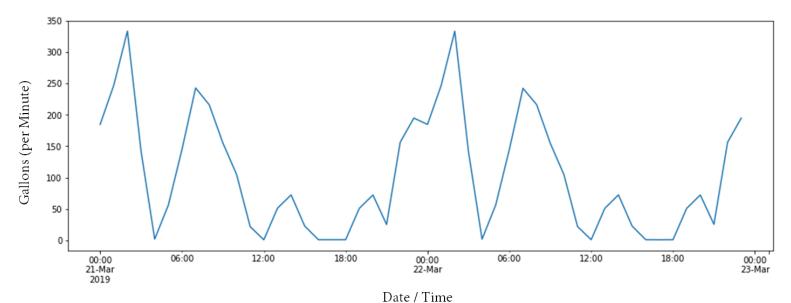
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Utility Unique

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





Pillars of Leakage Control

Pressure Management Losses flex with pressure **Real Losses** Recoverable Not Economically Active Leakage Speed & Quality Feasible to Recover Control of Repairs Not Technically Recoverable **Unavoidable Annual Real Losses** Pipeline & Asset Management Source: AWWA M36, 3rd ed SENSUS

Improve

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Leakage as a Function of Pressure

PERFORMANCE MEDIAN AVERAGE UNIT **FILTERS** n **INDICATOR** \$ / 1,000 gallons 1,545 passes customer retail unit cost check \$4.67 \$8.33 customer retail unit cost financial \$ / million gallons passes variable production cost check \$950.00 \$2.085.28 1,489 variable production cost passes both cost checks NRW as % of operating cost 7.8% % of operating cost 630 passes volumetric validity checks 10.2% does not come from Texas (operating cost not reported) 14.88 gallons / serv conn / day 1,290 passes volumetric validity checks 5.73 Apparent Losses passes volumetric validity check 812 51.81 gallons / serv conn / day 39.88 service connection density \geq 32 conn / mile of main Real Losses (serv conn) operational passes volumetric validity checks gallons / mile of main / day 478 785.54 1,132.42 service connection density < 32 conn / mile of main Real Losses (mains) passes volumetric validity checks 812 0.59 0.79 gallons / serv conn / day / PSI service connection density \geq 32 conn / mile of main Real Losses (pressure) passes basic volumetric validity checks (dimensionless) 644 2.48 3.12 ILI UARL calculation applies $-(32 \text{ x } Lm) + Nc \ge 3,000$ passes basic volumetric validity checks 71.7 points out of 100 679 73.1 does not come from Texas data validity score

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

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



Pressure Management

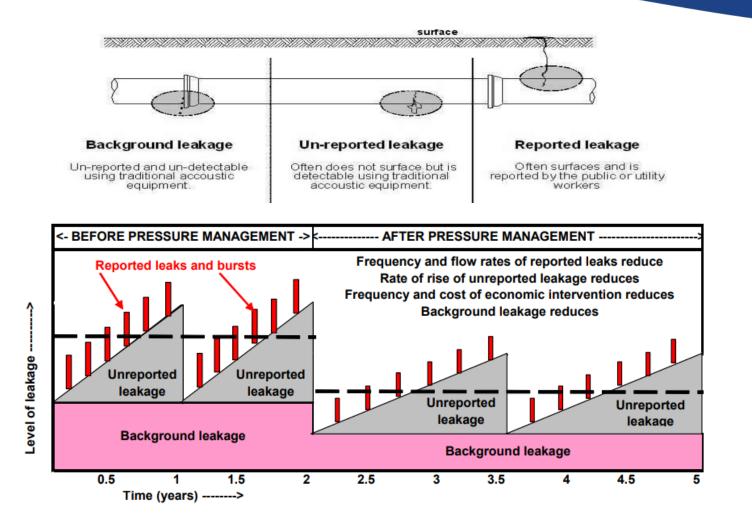


Figure 1: Influence of pressure management on BABE components of Real Losses Source: Fantozzi & Lambert (2007)



Pressure Management

- 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



Proactive Asset Management

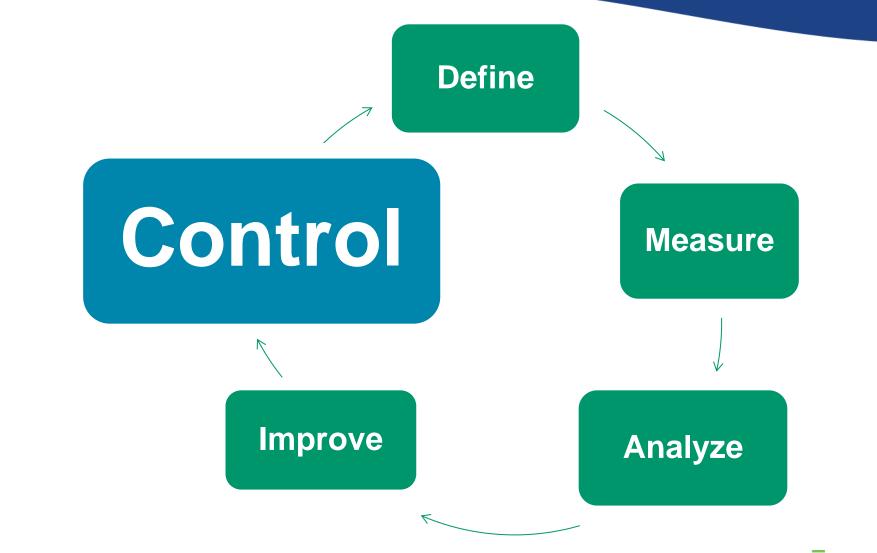
Improve

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- 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. 							
 If there are proble Sent: Wed 2/20/2019 		ge is displayed, o	click here to view it i	n a web browser.			
To:			Alert Thresholds				
WATER Sensus - DM Notification Service			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		
Active alerts -	Pressure Alarm						
Device ID	Network Address	Device Type	Alert Category	Alert Severity	Alert	Alert Time	
RM2_1200011	113 656872025	Sensor	Feature	Cr Critical	High Pressure Alarm	02/16/2019 02:15:00 AM	=

DMAIC









- 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...



Refining Measurement

Control

- 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





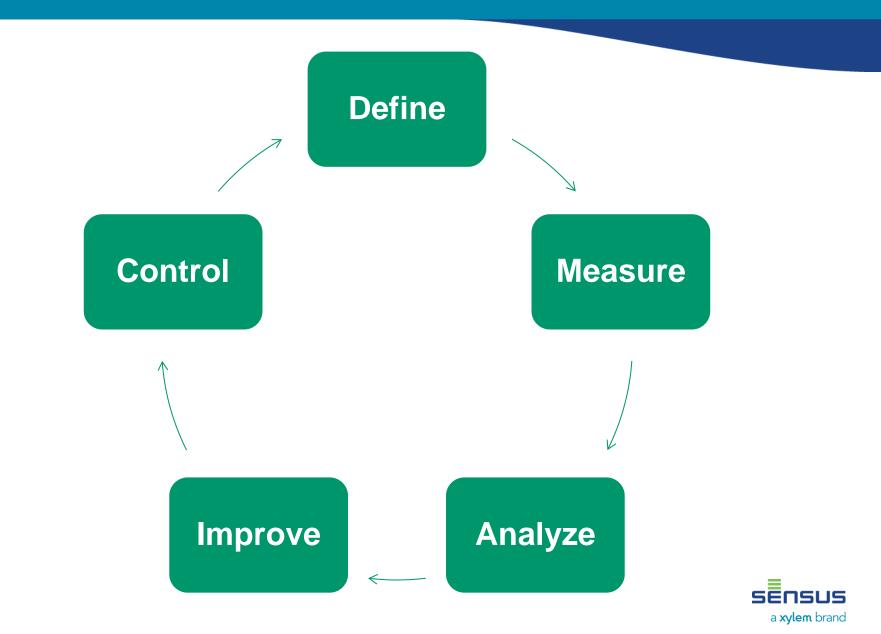
Refining Analysis

Control

- 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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