Monitoring Pressure Transients - IRWA

Badger Meter

Eric Larson

- Badger Meter Utility Solution Manager
- Illinois Class C Operator and Chemist (Bradley)
- Formerly Sr. Manager for Illinois American Water
- 75,000+ water connections, 10,000+ wastewater connections, ~10,000 lead lines, and >300 breaks a year
- Deployed fixed and cellular AMI solutions in 8 different water systems
- Multiple pressure zones, ground and surface water, multiple pump stations, elevated storage and reservoirs
- Used TELOG, oversaw VFD installations, PRV installations, check valve replacement and new installs

slido

Please download and install the
Slido app on all computers you use

What is your NRW?

ⓘ Start presenting to display the poll results on this slide.

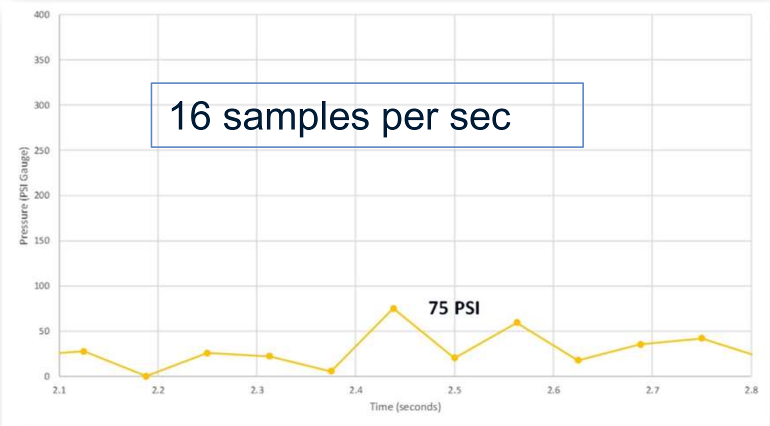
Common Challenges

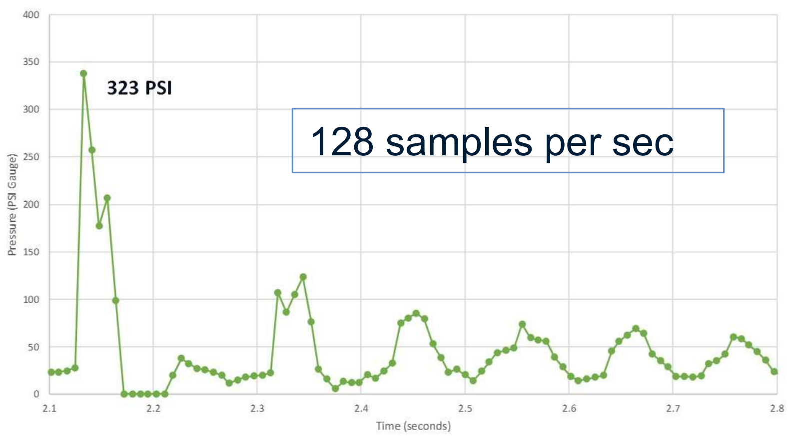
- Lack of capital budget money
- Old infrastructure
- ~1% or less main replacement per year
- Linear foot cost

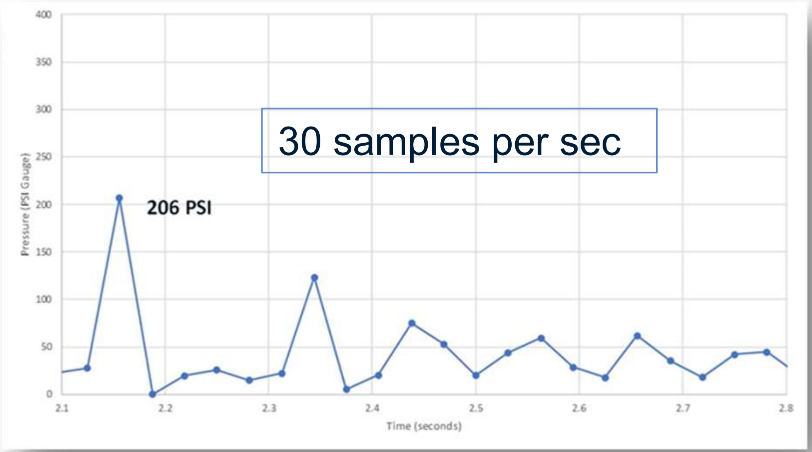
- How do we keep our current low NRW if we do not keep up 1% replacement or more?
- How do we combat our high NRW if we do not replace more than 1% or more?

Transients & High-Resolution Data

- Unwanted pressure change
- Not all data is created equal
- Static meters & pressure sensors

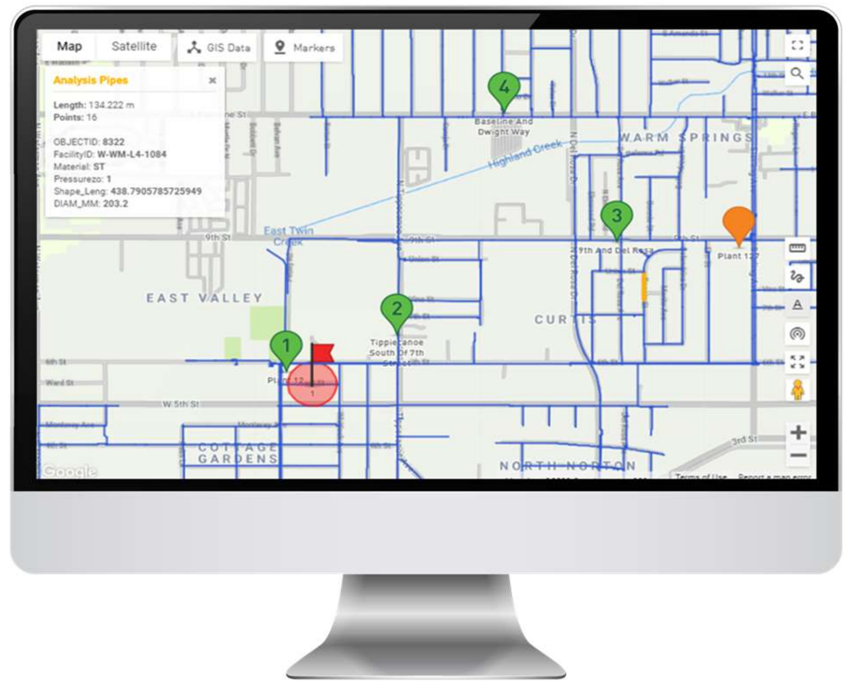


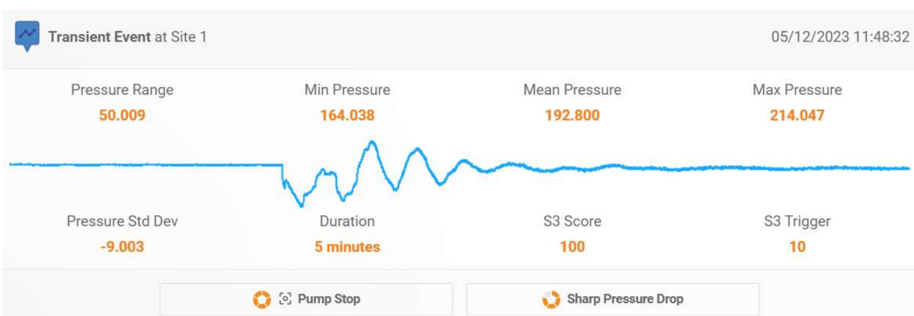




Syrinix

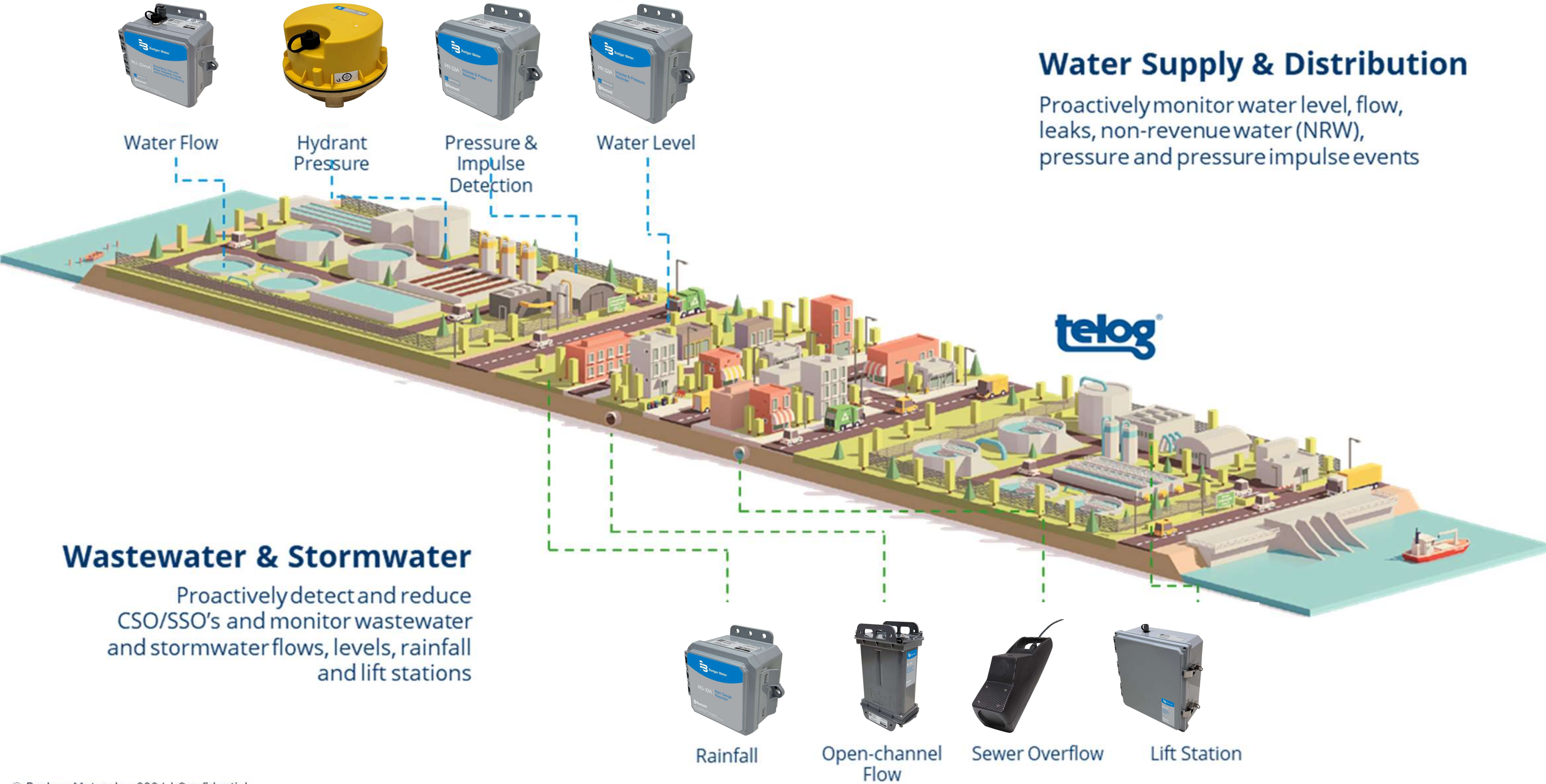
1. Transient detection and triangulation
2. Transient classification
3. Pressure alarms
4. Break alerts
5. Acoustic leak detection





Water Supply & Distribution

Proactively monitor water level, flow, leaks, non-revenue water (NRW), pressure and pressure impulse events



Wastewater & Stormwater

Proactively detect and reduce CSO/SSO's and monitor wastewater and stormwater flows, levels, rainfall and lift stations

Remote Monitoring Functionability

Measurement

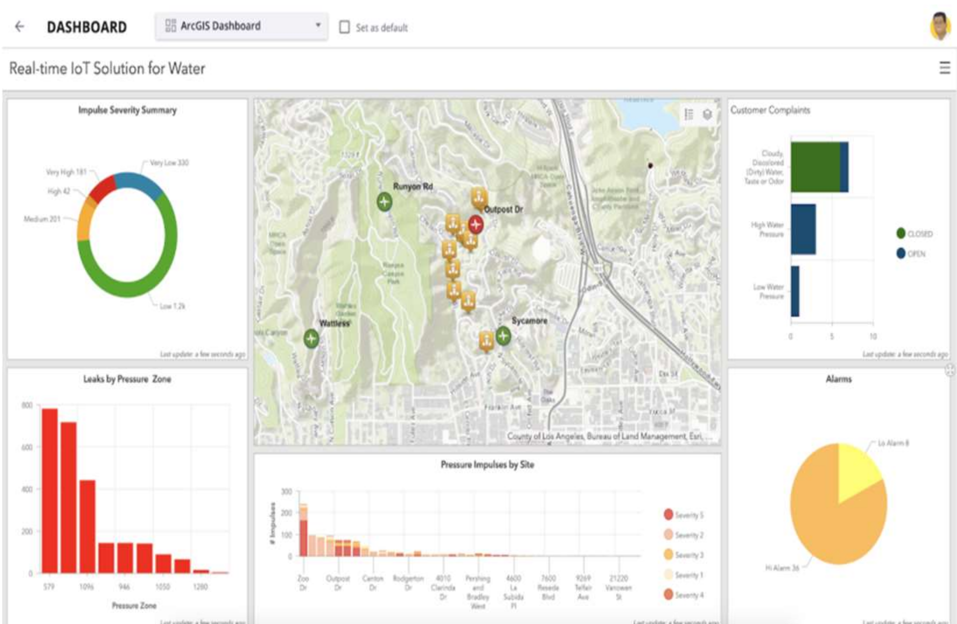
- Single and Muti-Input units for Water Cycle
- Configurability

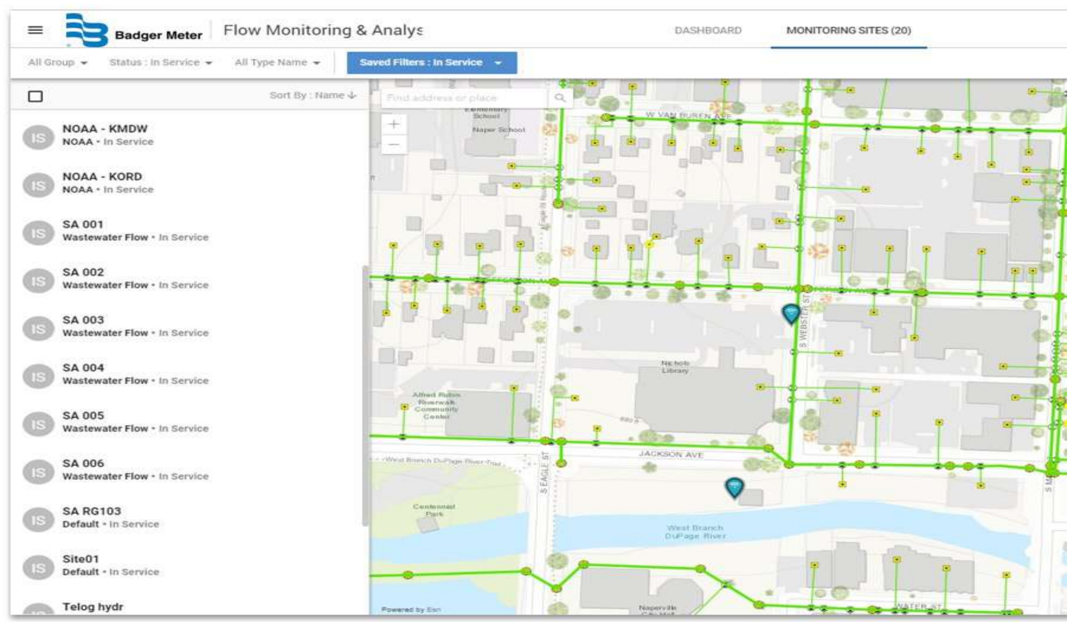
Connectivity

- Cellular enabled devices
- Display-less RTU
- Multi-input for general data backhaul

Insights & Action

- Time Series Data
- Esri Arc GIS connector, API
- Alarm/Alert





866.DIP.PIPE

PRESSURE CLASS/THICKNESS CLASS

SELECTION TABLE FOR DUCTILE IRON PIPE

U.S. PIPE AND FOUNDRY COMPANY / 866.DIP.PIPE / WWW.USPIPE.COM

P 3

This table shows pressure class of pipe necessary for the rated water working pressures. The thicknesses in this table are equal to or in excess of those required to withstand the rated working pressures plus a surge allowance of 100 psi. Ductile Iron pipe for working pressures higher than 350 psi available.

SHORT FORM SPECIFICATION;

1. **Scope**

   1.1. This specification covers the general requirements for U.S. Pipe Ductile Iron Pressure Pipe for conveying water and other liquids.

2. **Conformance**

   2.1. Pipe
   Ductile Iron Pipe, 3" through 64", shall meet the requirements of ANSI/AWWA C151/A21.51 and ANSI/AWWA C150/ A21.50.

Thickness, Dimensions and Weights of TYTON®, TR FLEX® and HP LOK® Joint Ductile Iron Pipe

Size *Inches*	Pressure Class *psi*	Nominal Thickness *Inches*	OD* *Inches*	TYTON® Joint	TR FLEX® Joint	HP LOK® Joint
				Avg. Wt. Per Ft.† *Pounds*		
4	350	0.25	4.80	10.9	11.7	
6	350	0.25	6.90	16.0	17.2	
8	350	0.25	9.05	21.1	23.1	
10	350	0.26	11.10	27.1	30.0	
12	350	0.28	13.20	34.8	38.6	
14	250 300 350	0.28 0.30 0.31	15.30 15.30 15.30	40.4 43.3 44.7	46.4 53.9 50.6	
16	250 300 350	0.30 0.32 0.34	17.40 17.40 17.40	49.3 52.5 55.8	56.4 59.7 63.1	
18	250 300 350	0.31 0.34 0.36	19.50 19.50 19.50	57.2 62.6 66.2	65.6 71.1 74.7	
20	250 300 350	0.33 0.36 0.38	21.60 21.60 21.60	67.5 73.5 77.5	77.8 83.9 87.8	
24	200 250 300 350	0.33 0.37 0.40 0.43	25.80 25.80 25.80 25.80	80.8 90.5 97.7 104.9	93.9 103.6 110.8 118.1	
30	150 200 250 300 350	0.34 0.38 0.42 0.45 0.49	32.00 32.00 32.00 32.00 32.00	103.5 115.5 127.5 136.5 148.4	120.0 131.9 143.9 155.1 165.0	120.0 131.9 143.9 155.1 165.0

USP-0550-Pressure-Thickness-Class_v01042019.pdf

HDPE IRON PIPE SIZE (IPS) PRESSURE PIPE PE4710

		DR 7 (333 psi)			DR 7.3 (318 psi)			DR 9 (250 psi)			DR 9.3 (241 psi)			DR 11 (200 psi)			DR 13.5 (160 psi)		
Pipe Size	Avg OD	Min Wall	Avg ID	Weight lb/ft	Min Wall	Avg ID	Weight lb/ft	Min Wall	Avg ID	Weight lb/ft	Min Wall	Avg ID	Weight lb/ft	Min Wall	Avg ID	Weight lb/ft	Min Wall	Avg ID	Weight lb/ft
1/2	0.840	0.120	0.59	0.12	0.115	0.60	0.11	0.093	0.64	0.10	0.090	0.65	0.09	0.076	0.68	0.08	0.062	0.71	0.07
3/4	1.050	0.150	0.73	0.19	0.144	0.75	0.18	0.117	0.80	0.15	0.113	0.81	0.15	0.095	0.85	0.12	0.078	0.88	0.10
1	1.315	0.188	0.92	0.29	0.180	0.93	0.28	0.146	1.01	0.23	0.141	1.02	0.23	0.120	1.06	0.20	0.097	1.11	0.16
2	2.375	0.339	1.66	0.95	0.325	1.69	0.91	0.264	1.82	0.77	0.255	1.83	0.74	0.216	1.92	0.64	0.176	2.00	0.53
3	3.500	0.500	2.44	2.06	0.479	2.48	1.98	0.389	2.68	1.66	0.376	2.70	1.61	0.318	2.83	1.39	0.259	2.95	1.16
4	4.500	0.643	3.14	3.40	0.616	3.19	3.28	0.500	3.44	2.75	0.484	3.47	2.67	0.409	3.63	2.30	0.333	3.79	1.91
5 3/8	5.375	0.768	3.75	4.85	0.736	3.81	4.68	0.597	4.11	3.92	0.578	4.15	3.81	0.489	4.34	3.29	0.398	4.53	2.73
5	5.563	0.795	3.88	5.20	0.762	3.95	5.02	0.618	4.25	4.20	0.598	4.29	4.08	0.506	4.49	3.52	0.412	4.69	2.92
6	6.625	0.946	4.62	7.36	0.908	4.70	7.12	0.736	5.06	5.96	0.712	5.11	5.79	0.602	5.35	4.99	0.491	5.58	4.15
7	7.125	0.976	5.06	8.23	0.976	5.06	8.23	0.792	5.45	6.89	0.766	5.50	6.70	0.648	5.75	5.78	0.528	6.01	4.80
8	8.625	1.232	6.01	12.48	1.182	6.12	12.06	0.958	6.59	10.09	0.927	6.66	9.81	0.784	6.96	8.46	0.639	7.27	7.03
10	10.750	1.536	7.49	19.40	1.473	7.63	18.74	1.194	8.22	15.68	1.156	8.30	15.24	0.977	8.68	13.14	0.796	9.06	10.92
12	12.750	1.821	8.89	27.28	1.747	9.05	26.36	1.417	9.75	22.07	1.371	9.84	21.44	1.159	10.29	18.49	0.944	10.75	15.36
14	14.000	2.000	9.76	32.90	1.918	9.93	31.78	1.556	10.70	26.61	1.505	10.81	25.85	1.273	11.30	22.30	1.037	11.80	18.52
16	16.000	2.286	11.15	42.97	2.192	11.35	41.51	1.778	12.23	34.75	1.720	12.35	33.76	1.455	12.92	29.12	1.185	13.49	24.19
18	18.000	2.571	12.55	54.37	2.466	12.77	52.53	2.000	13.76	43.97	1.935	13.90	42.73	1.636	14.53	36.84	1.333	15.17	30.61
20	20.000	2.857	13.94	67.13	2.740	14.19	64.85	2.222	15.29	54.28	2.151	15.44	52.77	1.818	16.15	45.49	1.481	16.86	37.79
24	24.000	3.429	16.73	96.68	3.288	17.03	93.39	2.667	18.35	78.18	2.581	18.53	75.98	2.182	19.37	65.52	1.778	20.23	54.44

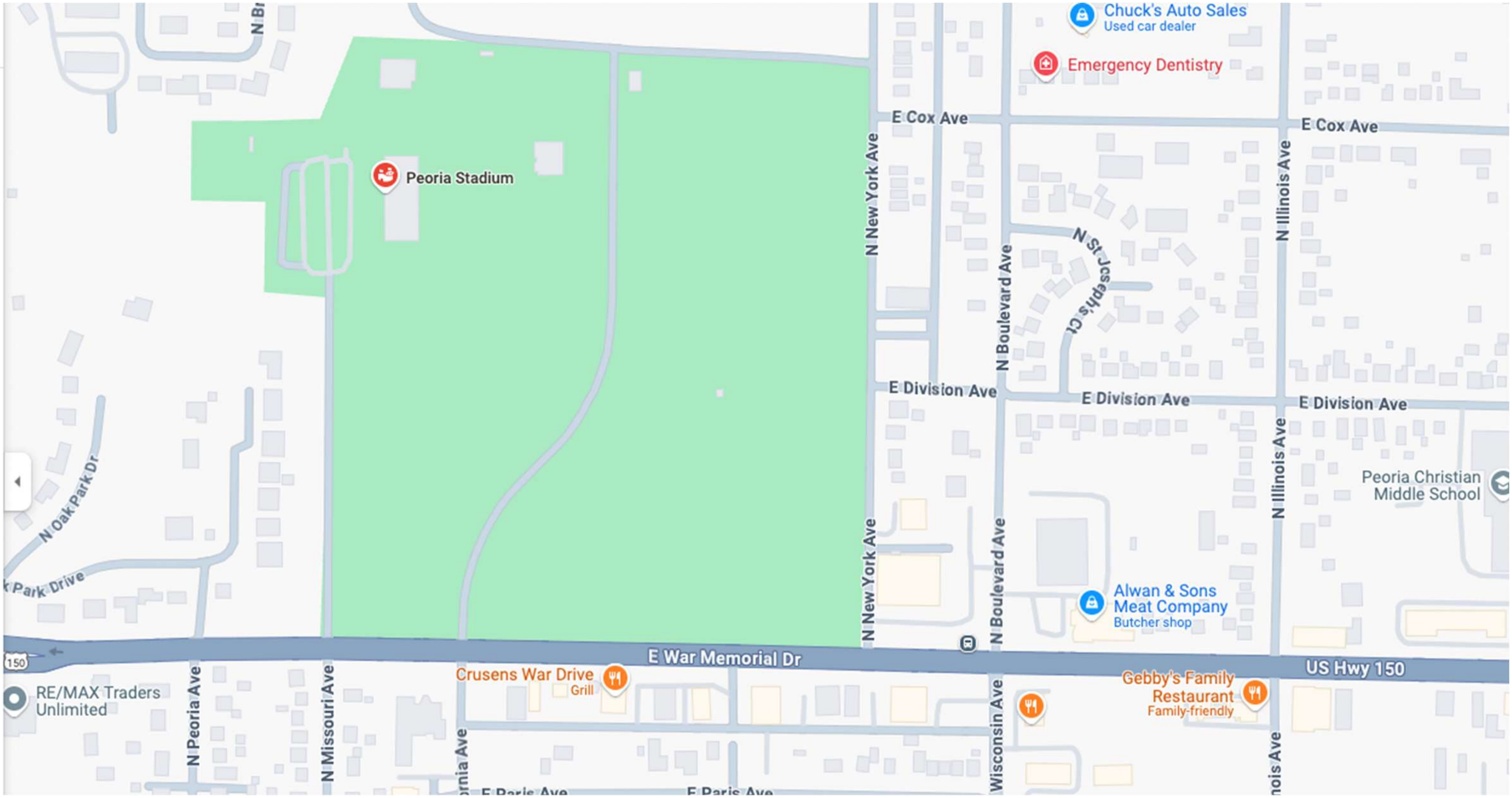
HDPESpecSheet4710 .pdf

A Special Note

- Pressurized system
- Pushing additional pressure
- Rigid system
- Something is going to give
- Minimal leakage can act as a relief
- Best system has minimal expansion pressure
- Best system is designed to handle expansion pressure

Setting the Stage...

- Peoria, IL ~56,000 connections
- 770+ miles of main
- Lead, galvanized, 2" "mains"
- Older system
- 1% or less
- Multiple pressure zones
- 20%+ NRW
- Planning Engineer



Chuck's Auto Sales
Used car dealer
Emergency Dentistry
E Cox Ave
E Cox Ave
Peoria Stadium
N New York Ave
N Boulevard Ave
N St Joseph's Ct
N Illinois Ave
E Division Ave
E Division Ave
E Division Ave
Peoria Christian
Middle School
N Oak Park Dr
Park Drive
Alwan & Sons
Meat Company
Butcher shop
E War Memorial Dr
US Hwy 150
150
Crusens War Drive
Grill
Gebby's Family
Restaurant
Family-friendly
RE/MAX Traders
Unlimited
N Peoria Ave
N Missouri Ave
Wisconsin Ave
E Paris Ave
E Paris Ave

Water Distribution & Supply Monitoring Applications

Pressure, Transients & Level

Pressure & Transient

Pressure, Transients, Flow, Level, Water Quality

Flow

- Non-Revenue Water
- Night Flow Analysis
- District Metering
- Billing

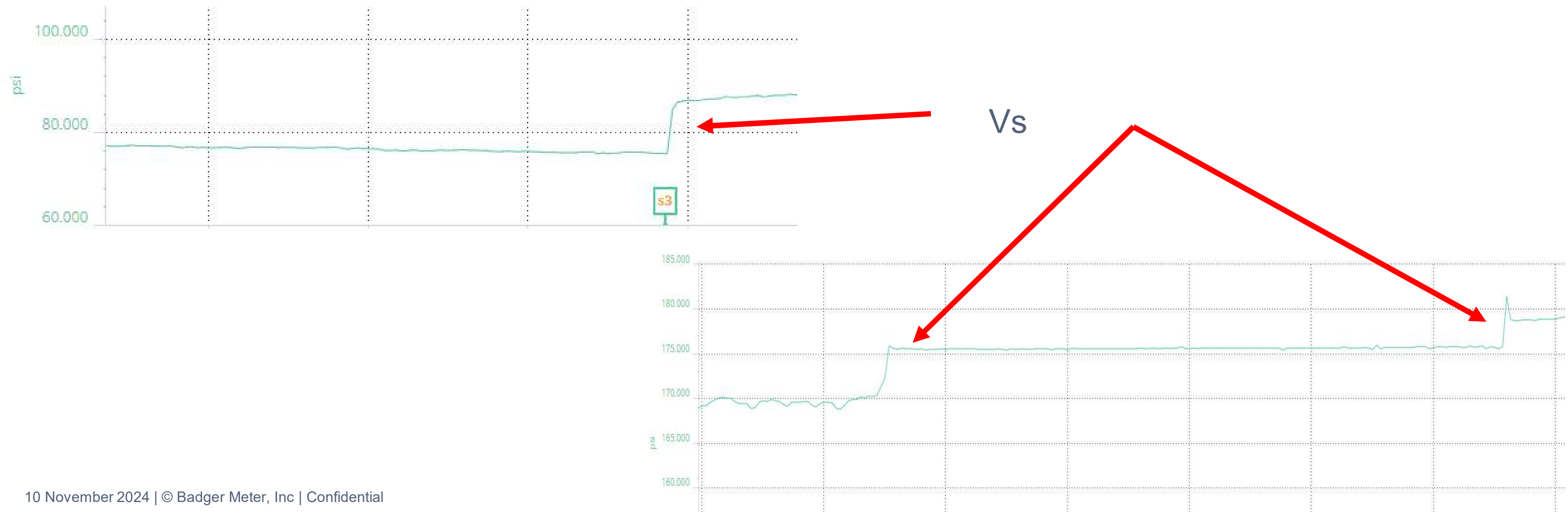
Pressure

- Non-Revenue Water
- Hydraulic model calibration
- C - Factor Testing
- Fire Flow Testing
- Transient/Impulse Monitoring
- Force Main
- Line Breaks
- Boil Water Notices
- Pressure Relief Valve, Pressure Reducing Valve
- Booster Pump
  - Others
- Pump Station
- Water Quality

1. Double Pump Start

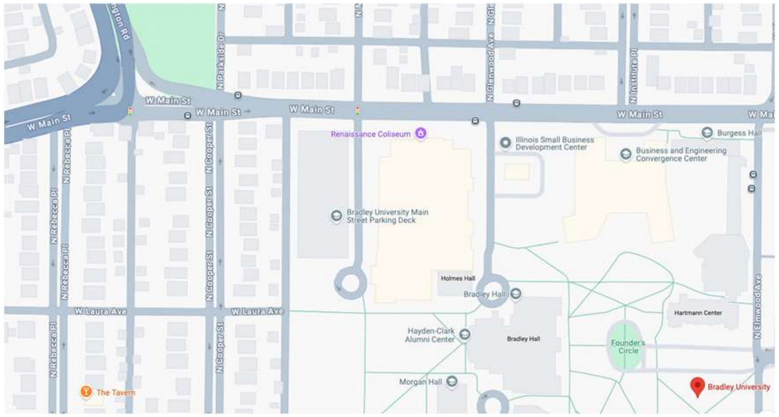
Utility has a production site with multiple pumps. They are triggered together instead of programmed to time delay start. This creates large initial pressure surges even with VFDs on the pumps.

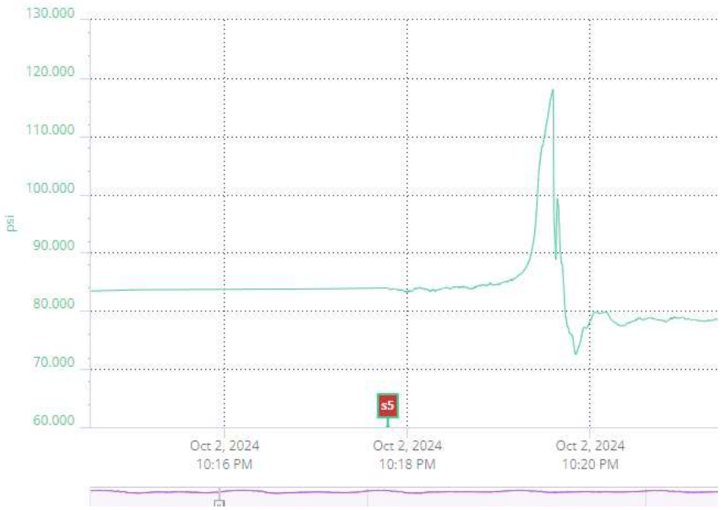
Pressure wave shows X PSI jump. When time delayed there are two ½ X PSI jumps instead or less.



2. Customer induced pressure transient

Large customer has booster station or large on/off demand cycle. Have seen university housing and hospital boiler systems with valve opening causing pressure drop and then a hard stop causing a surge just outside the premise. Telog data recording captures those swings which do not line up with SCADA pumping data. Working with the customer, the customer operations and be overlaid with Telog data. This could rule in or out customer induced transients causing premature pipe failure.



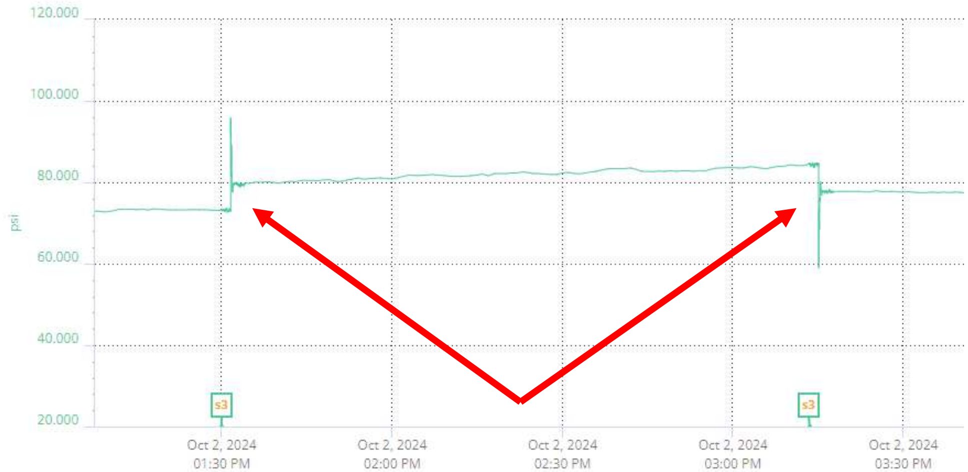


3. Uncalibrated VFD

1. Utility's pumps have VFDs. The VFDs are starting too high of power and causing unnecessary pressure spikes. Pressure spike on pump turn on.

2. Pumps are also not time delayed power ramp downs. This creates a pressure vacuum slam. Pressure cliff on pump turn off.

3.Pumps are not calibrated to run continuously. Pressure shows spikes and cliffs. Possible in larger demand systems to run continuously.



slido

Please download and install the
Slido app on all computers you use

What is your biggest challenge to addressing NRW?

ⓘ Start presenting to display the poll results on this slide.

Return on Investment

SYRINIX Return On Investment (ROI)		
Assume	100	Main breaks a year
	40	Service line breaks a year
Assume	15%	Reduction in main breaks a year
	10%	Reduction in service line breaks a year
Means	15	fewer main breaks a year
	4	fewer service line breaks a year
Means	$68,400	Annual main break cost avoidance
	$8,240	Annual service line break cost avoidance
	$76,640	**Annual Total Cost Avoidance**

Syrinix Investment		
	10	Devices
	$4,500	$ per device
	$7,500	Advisory Services
	$52,500	**Total Investment**

Main Break Cost Inputs	
3	Employees
4	Hours
$30	Hourly Rate
$200	Clamp
$3,500	Paving Restoration
$500	Misc (fuel, consumables, traffic signage, tools, permit)
$4,560	All in cost for main break

Service Line Break Cost Inputs	
3	Employees
4	Hours
$30	Hourly Rate
$200	Clamp
$1,000	Restoration
$500	Misc (fuel, consumables, traffic signage, tools, permit)
$2,060	All in cost for service line break

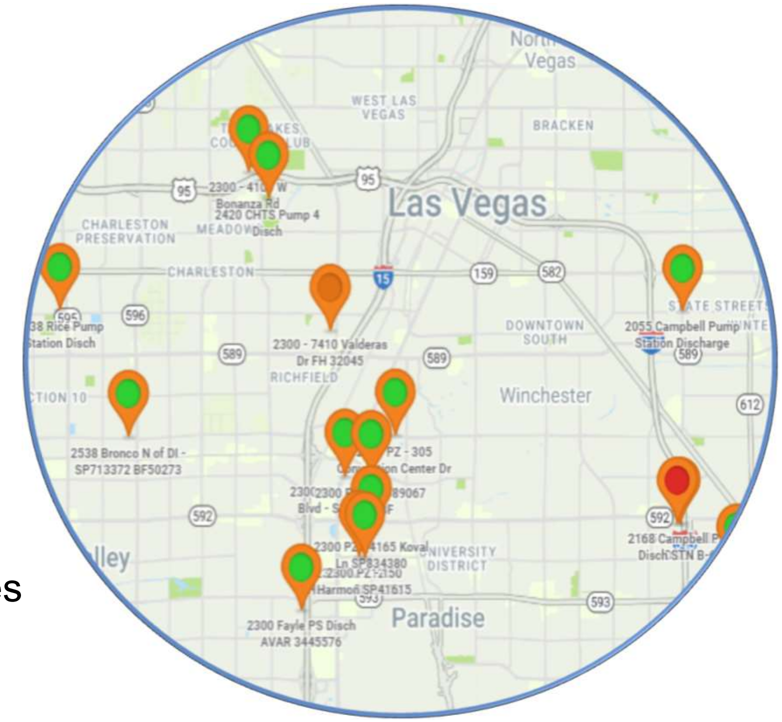
ROI Calculation	
Return	$76,640
Investmen	$52,500
1 yr ROI	**145.98%**
2 yr ROI	**291.96%**

Las Vegas Valley Water District Reduces Breaks by 30%

Objective
Transient and break reduction through pressure monitoring

Solution
75% permanent installation of PIPEMINDER standard sensors, 25% floating installations

Outcome
- Correlating pressure data with SCADA data revealed valve operations were causing severe transients
- Changed valve speed on discharge pumps
- Replaced problematic check valves with motor operated valves
- Permanent monitoring at critical pump stations
- Formula 1 Track is one of their monitored areas



4. Uncalibrated or failed PRV

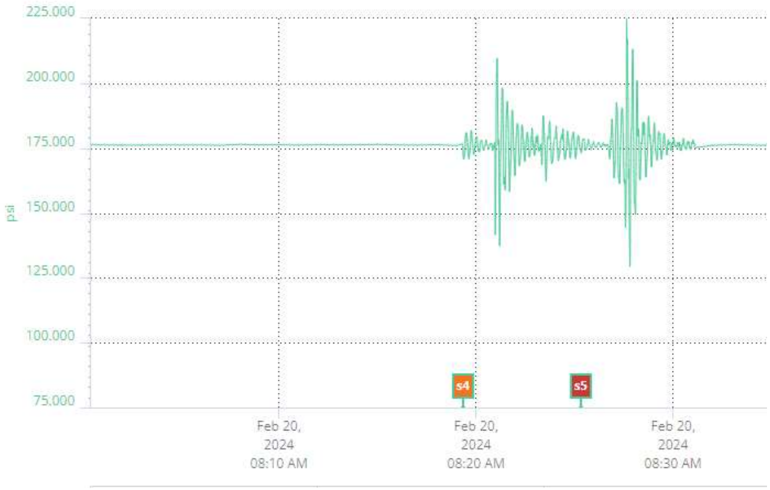
1. Utility has pressure reducing/restricting valves. Pressure spike is showing inside PRV zone. PRV has not been calibrated.

2. Pressure spike is showing higher than PRV desired setting. PRV settings have not been calibrated correctly.

3. PRV has failed. Pressure spike and cliffs are showing inside PRV zone.

5. Hydrant Misuse

Hydrants are being opened or closed too fast.

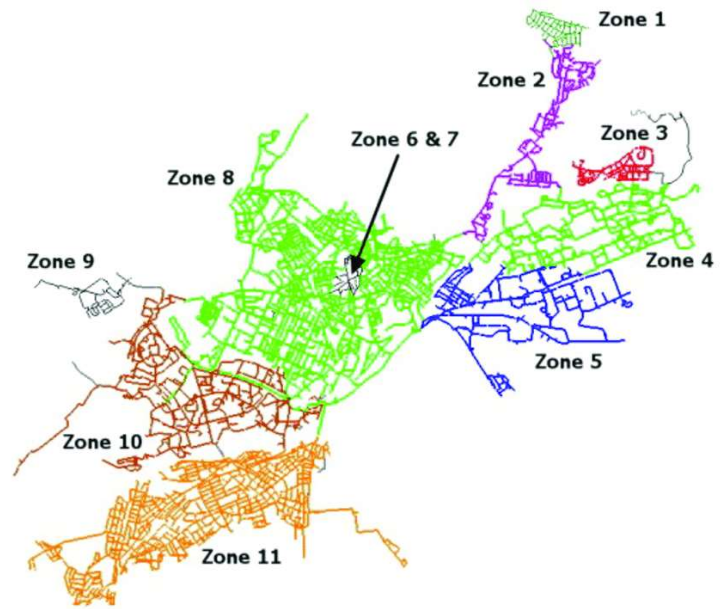


6. Non-isolated Zones

1. Utility has pressure zones managed by street in line water valves. Pressure graph showing higher pressure than expected. Cause is linked to open or partially opened valves that by design of zone should be closed.

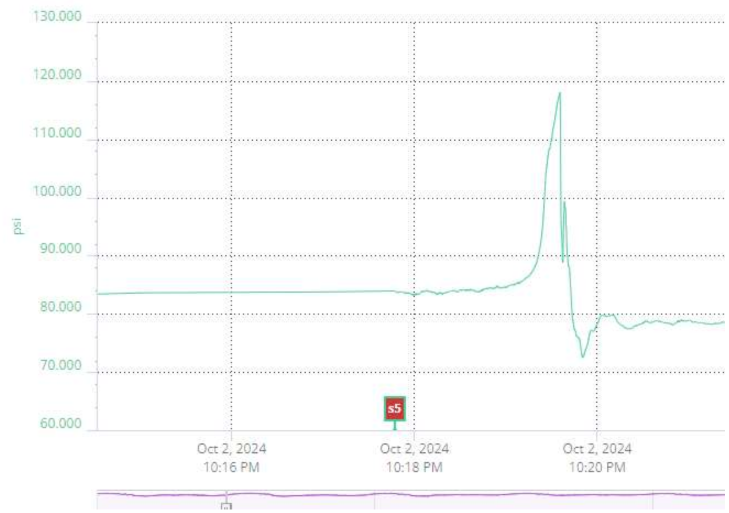
2. Pressure graph showing higher pressure than expected. Cause is linked to broken valve that by design of zone should be closed.

3. Pressure graph showing too little pressure. Cause is too few open valves into isolated zone. This could be by mistake or by poor design.



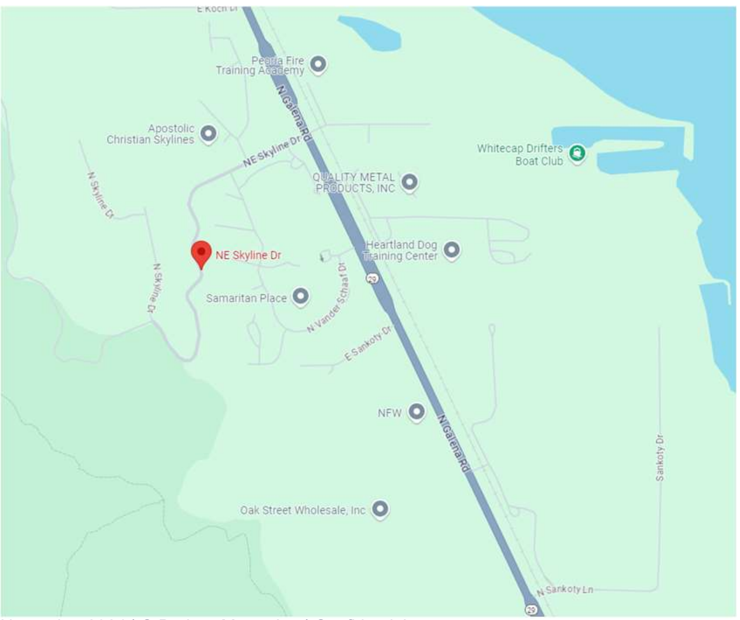
7. Check Valve Performance

Utility has one way check valves post production and booster stations. Check valve is aged. Needs maintenance or replacement. Check valve is sticking when should be opening. Pressure builds as pump is pumping. Check valve swings open and pressure surge is introduced to system. Pressure spikes and cliffs show on pressure graph. Can be mistaken as VFD not calibrated.

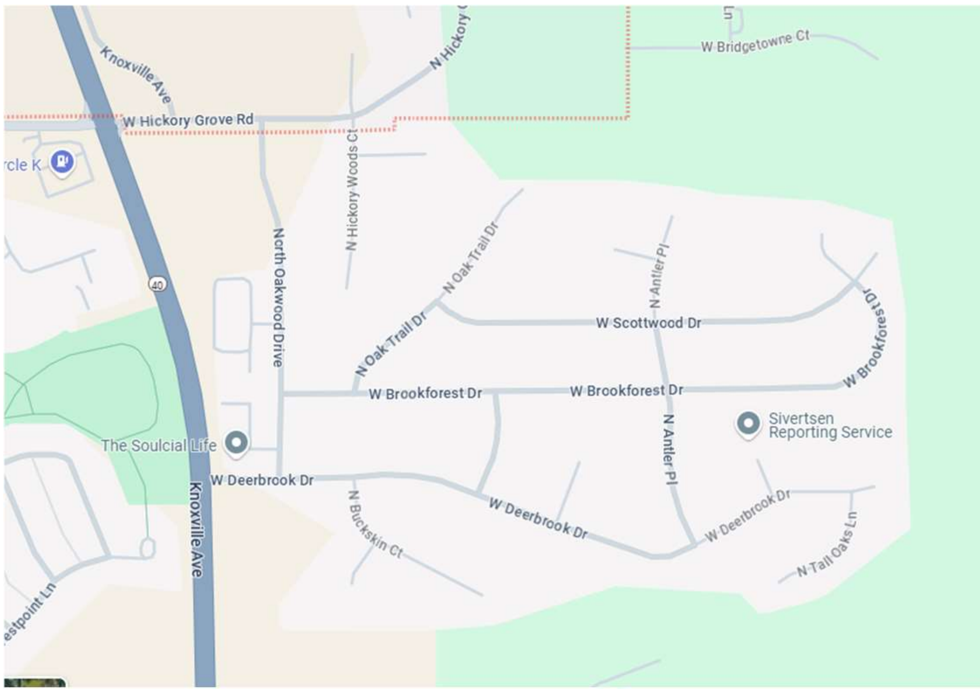


8. Lack of Check Valve

Pumps turn on. Nearby hill runs low pressure at the top. When pump turns off, there is a vacuum pull at the top of the hill. Top of hill customers experience zero pressure and noise. Pressure graph shows pressure cliffs. Installation of check valve on hill corrects issue.

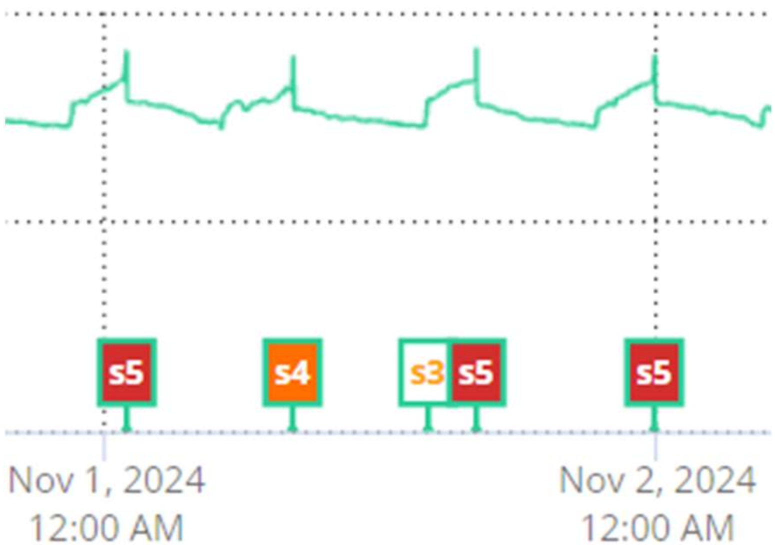


9. Dead end runs (includes PRV entry and non PRV zones)



10. Over aggressive pumping schedule

Refilling tank multiple times a day without letting the tank fully cycle.



Additional Measures

- Blow off valves / hydrants
- Looping water mains / eliminate dead ends
- Variable frequency drives
- Pressure reduction valves
- Pressure zones

*** Best designed system has minimal expansion pressure

*** Best designed system handles expansion pressure

slido

Please download and install the
Slido app on all computers you use

I need help with...

ⓘ Start presenting to display the poll results on this slide.

Contact

Eric Larson

Utility Solutions Manager

elarson@badgermeter.com

Legal Disclaimer

Statements of fact and opinions stated during the presentation or within these slides are those of the participants individually and, unless expressly stated to the contrary, are not the opinion or position of Badger Meter, Inc. This information presented is provided "as is" with no guarantees of completeness, accuracy, or timeliness. Badger Meter, Inc. does not make any separate guarantees or warranties, express or implied, regarding the information contained herein. To the fullest extent permissible pursuant to applicable law, Badger Meter, Inc. disclaims all warranties, express or implied, including but not limited to implied warranties of merchantability and fitness for a particular purpose.

Badger Meter