MAY 2020

AWIA Execution Lessons Learned

BLACK & VEATCH IN THE TRENCHES

THE Water Research FOUNDATION

BLACK & VEATCH

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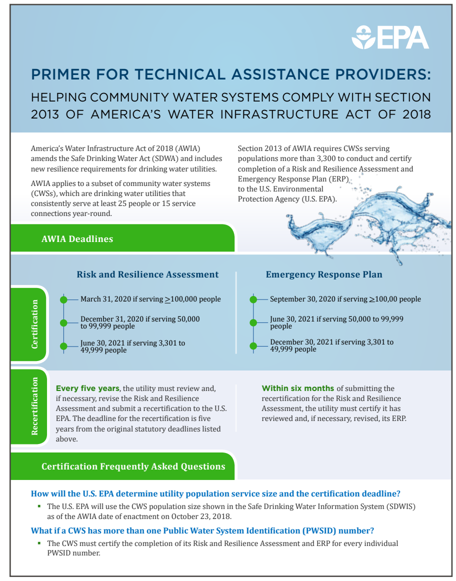
WRF Project Number: 5014

Learning from Peers

This guide focuses on lessons learned related to the implementation of the *America's Water Infrastructure Act of 2018* (AWIA) Risk and Resilience Assessment (RRA) and Emergency Response Plan (ERP) requirements. These lessons have been identified by Black & Veatch (BV) professionals who have assisted numerous large utilities (serving populations greater than 100,000) in these compliance efforts, as well as by WRF Project 5014 Project Advisory Committee (PAC) member utilities. This document's intent is to build upon the Environmental Protection Agency's (EPA's) recently released *Primer for Technical Assistance Providers: Helping Community Water Systems Comply With Section 2013 of America's Water Infrastructure Act of 2018* (EPA Primer, September 2019), which provides a high-level summary of the AWIA requirements, RRA and ERP deadlines, certification process, and other considerations for complying with those requirements.


PRIMER FOR TECHNICAL ASSISTANCE PROVIDERS:
HELPING COMMUNITY WATER SYSTEMS COMPLY WITH SECTION 2013 OF AMERICA'S WATER INFRASTRUCTURE ACT OF 2018

America's Water Infrastructure Act of 2018 (AWIA) amends the Safe Drinking Water Act (SDWA) and includes new resilience requirements for drinking water utilities.

AWIA applies to a subset of community water systems (CWSs), which are drinking water utilities that consistently serve at least 25 people or 15 service connections year-round.

Section 2013 of AWIA requires CWSs serving populations more than 3,300 to conduct and certify completion of a Risk and Resilience Assessment and Emergency Response Plan (ERP) to the U.S. Environmental Protection Agency (U.S. EPA).

AWIA Deadlines

	Risk and Resilience Assessment	Emergency Response Plan
Certification	March 31, 2020 if serving ≥100,000 people December 31, 2020 if serving 50,000 to 99,999 people June 30, 2021 if serving 3,301 to 49,999 people	September 30, 2020 if serving ≥100,00 people June 30, 2021 if serving 50,000 to 99,999 people December 30, 2021 if serving 3,301 to 49,999 people
Recertification	**Every five years**, the utility must review and, if necessary, revise the Risk and Resilience Assessment and submit a recertification to the U.S. EPA. The deadline for the recertification is five years from the original statutory deadlines listed above.	**Within six months** of submitting the recertification for the Risk and Resilience Assessment, the utility must certify it has reviewed and, if necessary, revised, its ERP.

Certification Frequently Asked Questions

How will the U.S. EPA determine utility population service size and the certification deadline?

- The U.S. EPA will use the CWS population size shown in the Safe Drinking Water Information System (SDWIS) as of the AWIA date of enactment on October 23, 2018.

What if a CWS has more than one Public Water System Identification (PWSID) number?

- The CWS must certify the completion of its Risk and Resilience Assessment and ERP for every individual PWSID number.

In addition to the lessons learned from large utility AWIA execution, this document contains a link to BV's *Resilience Literature Review Summary*, which provides information related to numerous guidance documents, standards, frameworks, and tools available to water utilities covering the various aspects of risk and resilience planning and emergency preparedness. This review summary is being developed as part of this research project.

01 AWIA SCOPE AND RECERTIFICATION

- AWIA legislation introduced amendments to the Safe Water Drinking Act, adding to the regulatory requirements for water utilities. Along with relevant guidelines and standards, it provides a useful framework for the assessment of all types of risks. **While the AWIA legislation does not have requirements for wastewater and stormwater utilities, its framework and the relevant guidelines and standards that can be applied to meet its requirements, are relevant to all types of utilities.**
- An **all-hazards approach is valuable** in understanding a utility's exposure to a range of threats, and for evaluating and prioritizing proactive and reactive strategies for risk management and mitigation.
- The type of RRA required by AWIA is not simply another type of a vulnerability assessment (VA) mandated by the *Title IV of the Public Health Security and Bioterrorism Preparedness and Response Act of 2002* (Bioterrorism Act) – **the RRA has a broader focus** which needs to be kept in mind as each utility works through its completion.
- Developing strategies to improve resilience, including physical security and cybersecurity, is required by AWIA and is to be completed after RRA completion. These strategies, and associated assessment and prioritization, are often completed as part of an overall Risk Mitigation Plan (RMP). The RMP can be incorporated in the RRA, the ERP, or as a standalone document. **Several large utilities are creating the RMP as a separate document**, ensuring that the ERP remains an "action-oriented document" that can guide a utility's emergency response.
- It is important to **regularly update the RRA, RMP, and ERP**. Complying with the AWIA requirements was more challenging for those utilities who had not updated their previous VAs, as they typically have less developed risk assessment processes and a lower quality of required information. AWIA requires reassessments every five (5) years, but many utilities may find it useful to update the results on a more frequent basis, as more information becomes available or new threats become apparent (e.g., pandemics).

02 RECOMMENDED UTILITY RESOURCES

- Utilities should ensure that adequate resources (financial and human) are provided to complete the required RRA analysis and ERP update, and to implement the resulting risk mitigation strategies. Due to the breadth of AWIA's focus (e.g., types of threats, impacts, and critical assets), the appropriate **management team members and a broad cross-section of system/technical experts should be actively involved**. Due to the high volume of information shared at AWIA-related meetings, utilities have also found AWIA to be a great opportunity to further develop middle management and promote cohesion of the management team.
- Training is helpful to properly prepare management and staff to respond to the AWIA requirements. **Good training options are available from the EPA and American Water Works Association (AWWA)**, including the AWWA Utility Risk and Resilience Certificate Program.

Training resources can be accessed at:

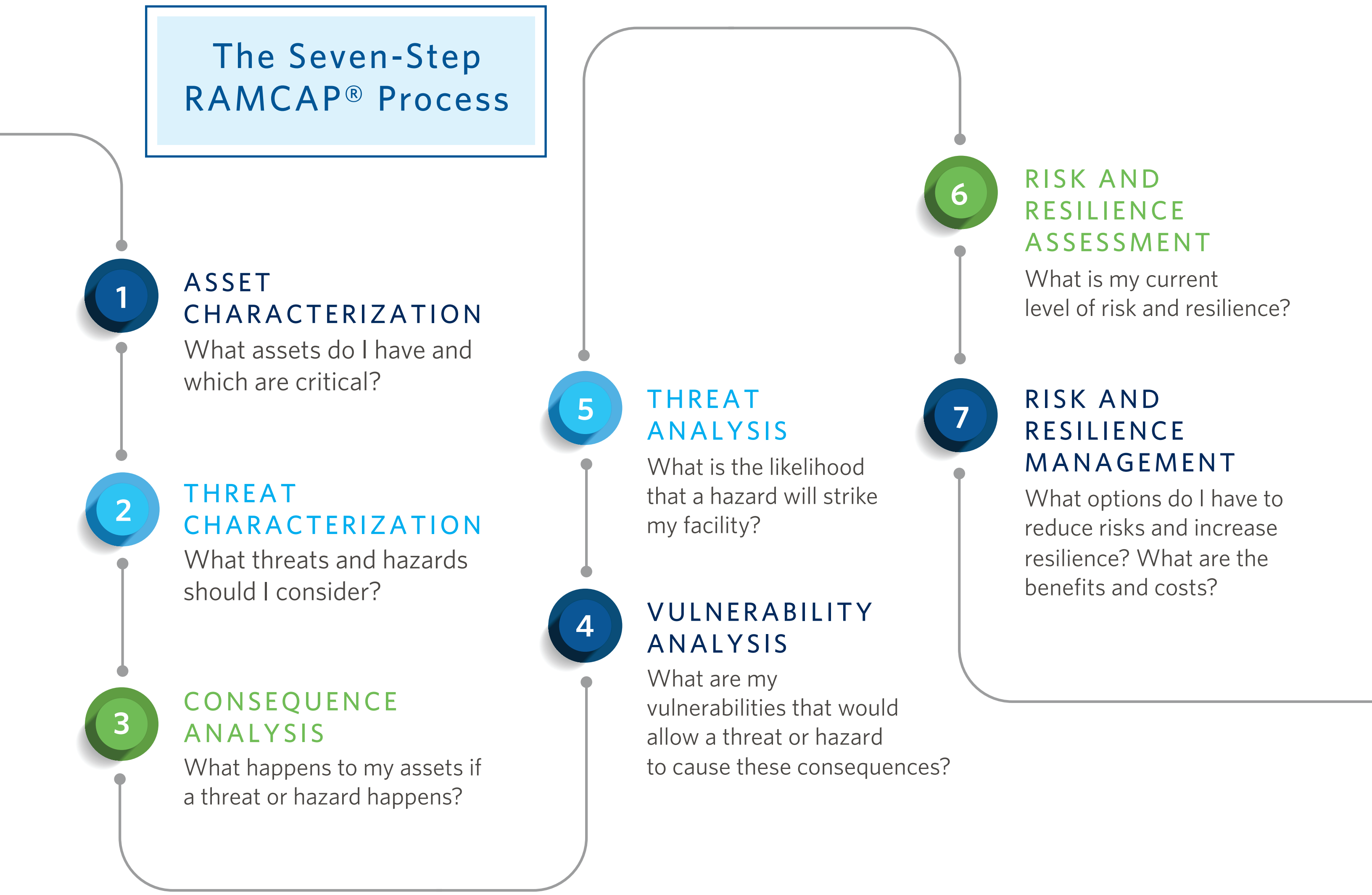
https://www.awwa.org/Events-Education/eLearning-Courses/Utility-Risk-Resilience-Certificate-Program

03 DOCUMENT MANAGEMENT

- Utilities should understand the necessity of protecting the information, analyses, and deliverables resulting from AWIA-related activities. Given the critical nature of the information, **adequate protection measures need to be taken.** Some examples for sensitive materials include:
  - Do not email documents; instead use **secure filesharing**. Many states consider all municipal emails discoverable by Freedom of Information Act (FOIA) requests.
  - Use document **passwords**. Transfer the passwords in a different method than the document transfer method (e.g., texting it to the individuals that need to know).
  - A utility's legal department is a good resource for additional guidance on protecting sensitive information. Consider if a **non-disclosure agreement** is required to limit liability.
- Before initiating an AWIA assessment, data management strategies should be organized and communicated clearly to the utility's team, as well as to any consulting teams assisting.
- Involvement of elected officials and other regional organizations (e.g., other utilities, Local Emergency Planning Committees, and local law enforcement agencies) can be beneficial, but this must be balanced with the need to carefully protect the information including in these assessments.

04 RISK AND RESILIENCE ASSESSMENTS

- Some of the RRA-related guidance from EPA and AWWA still requires interpretation. To this end, management experience and professional judgement are important in the **interpretation of the intent and requirements of the AWIA language**, and how best to apply related EPA and AWWA guidance.
- The most commonly used reference documents for the completion of RRAs are:
  - *Risk Analysis and Management for Critical Asset Protection (RAMCAP®) Standard for Risk and Resilience Management of Water and Wastewater Systems* (ANSI/AWWA J100-10 (R13), July 2010), referred to throughout this document as J100.
  - *Baseline Information on Malevolent Acts for Community Water Systems* (EPA, July 2019) for threats selected for inclusion in the RRAs.
- The J100 framework is built around a **seven-step risk and resilience assessment process** that many utilities have used as the basis for their RRA efforts.



Asset Specific Considerations

- AWIA mandates the assessment of the following asset categories. This covers a **broader set of assets** than previous VAs:
  - Source water
  - Source water collection and intake
  - Pipes and constructed conveyances
  - Physical barriers
  - Pretreatment and treatment
  - Storage and distribution facilities
  - Electronic, computer, or other automated systems (including the security of such systems) which are utilized by the system
  - Monitoring practices of the system
  - Financial infrastructure of the system
  - Use, storage, or handling of various chemicals
  - Operation and maintenance of the system
- Previous VAs can provide useful information related to assets and security posture, if the utility's system has not changed considerably. However, these VAs generally did not include natural hazards and cyber-attacks, nor did they focus on the broader aspects of system resilience. As a result, the types of **strategies included in the AWIA-based RMPs will go beyond the types of recommendations included in the VAs**.
- Utilities should develop a reasonable number of Threat-Asset Pairs (TAPs) to keep the analysis scope and detail reasonable. Based on Black & Veatch's experience, the **total number of TAPs can range from 50 to over 400**, depending upon how critical assets and threats are defined and considered. Suggestions include:
  - Eliminate threats that do not pose a credible threat (e.g., hurricanes in Chicago)
  - Focus on the "worst-reasonable-case" for the threats selected for inclusion in the RRA
  - Assume that only one threat occurs at a time
  - Develop a logical grouping of assets (e.g., group pumping stations together unless there is an impact that will materially affect the level of risk differently at various locations)
- Utilities should consider **defining critical assets at a system level** (e.g., water treatment plant), versus at a component level (e.g., primary clarification within water treatment plant).
- Utilities **should not consider back-up and other redundancy-related measures as critical assets** (e.g., back-up generation) in the initial asset identification step in the RRA process; they are more properly considered in the subsequent vulnerability evaluation portion of the risk assessment.
- The terms "process sabotage" and "sabotage" are used interchangeably throughout J100. There is no difference between these terms, and it is **recommended that utilities use only the term "sabotage" in their RRAs**.
- If a utility's raw water provider or treated water wholesaler does not provide outage information, **estimate the longest reasonable outage**. It is recommended that this be treated as a "Dependency – Loss of Vendor" Threat.

Definition of Critical Asset

Source: J100

An asset whose absence or unavailability would significantly degrade the ability of a utility to carry out its mission or would have unacceptable financial or political consequences for the owner or the community.

Too many TAPs can dilute the analysis and management-related discussions, overly complicating and expanding the analysis without commensurate benefit.

Threat-Specific Considerations

Natural Hazards

- Utilities should justify and **document why an asset category was not assessed** for natural disasters or malevolent acts (e.g., if a water utility is distribution only and does not have a treatment plant).
- Generally, utilities have a high-level of awareness of natural hazards that might impact their systems and are generally well prepared for them. **Management experience and professional judgment are critical elements to characterizing threats and developing effective recommendations.**
- EPA's *Baseline Information* document provides useful information related to various types of malevolent acts.
    - The physical security **threat numbers from the EPA can be adjusted if needed**. Adjustments can be based on utility history of security incidents or location (e.g., if a utility is adjacent to an attractive target, such as a stadium hosting large events), and local, state, or federal law enforcement intelligence.
    - The **likelihood of occurrences shown in EPA's *Baseline Information* document seem conservative** (i.e., too frequent) based upon input received from various utilities which have used this document.
- There is wide range of federal- and state-level data on natural hazards and their likelihood. Obtaining solid regionally-based information is not a "heavy lift". The following tools were available online as of the writing of this document:
    - Flooding – FEMA's Map Service Center: https://msc.fema.gov/portal/home. This flood mapping only reflects areas with 1 square mile of upstream drainage area and does not capture flooding issues in headwaters areas
    - Tornados – NOAA's Tornado Risk Assessment Historical Analysis: https://www.spc.noaa.gov/climo/online/probs/?lat=39.092&lon=-94.576&rad=100
    - Earthquakes – USGS Seismic Hazard Maps and Site-Specific Data: https://www.usgs.gov/natural-hazards/earthquake-hazards/seismic-hazard-maps-and-site-specific-data

Malevolent Acts

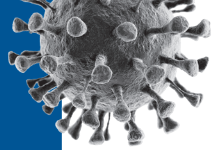
- Many utilities are reasonably security savvy and, often, have a good working knowledge of security issues. Utilities should have security policies in place and an understanding of what works well and what might need improvement. Many utilities (particularly smaller utilities) are stretched very thin, so good utility security practice may not be completely embedded.
- Many utilities, as well as the EPA, believe that the threat (both likelihood and consequence) from insiders (e.g., disgruntled employees) is greater than the threat from outside parties.
- Utilities should understand the security-related subcategories (deterrence, detection, delay, and response) and how they relate to the vulnerability score (e.g., the difference between delay, which is part of vulnerability scoring, and deterrence, which is not). This clarity is an important factor for identifying recommended countermeasures.

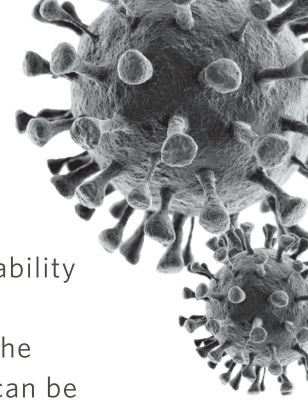
Chemical Storage and Handling

- AWIA requires an assessment of chemical handling and storage. This assessment encompasses the chemicals and associated storage facilities, and the handling practices used for chemical disinfection and treatment. Assessments under this asset category should focus on the risk of an uncontrolled release of a potentially dangerous chemical (e.g., chlorine), where applicable. **Many utilities already have ERP-type documents in place related to chemical storage and handling**.

Cybersecurity

- Measuring Supervisory Control & Data Acquisition (SCADA) system/information technology (IT) systems on the same risk scale as physical assets is a challenge. Cyber requires a different type of assessment, with different types of issues and language, and utilities often have insufficient IT/cyber staff. This creates significant challenges for effectively incorporating cyber issues with other risk types. **Maintaining the same measures of consequence, vulnerability, and likelihood allows comparison of all risks equally**.
- The most common reference documents used in completing the cybersecurity aspects of the RRAs include:
  - *NIST Cyber Security Framework 1.1* (National Institute of Standards and Technology) for the enterprise side
  - *Cybersecurity Guidance and Assessment Tool 2.0* (AWWA) for the SCADA side
- The level of investment in cybersecurity of IT and operations technology (OT) systems is variable across utilities and may fall short of good industry practice. **Utilities may need to be more aware of good industry practice related to cybersecurity** (e.g., learning from related documents provided by AWWA, WaterISAC, and others).





Other

- The COVID-19 pandemic experience demonstrates the importance of instilling the ability to consider new potential threats on a timely basis as they are identified, assessing the potential implications of those threats, and ensuring effective management of the potential impacts of disruptive events. This has been a good example of how risks can be hard to predict, but amending the AWIA deliverables over time to systematically capture these types of changes is more effective than an ad hoc response.

Risk Mitigation Plan

- Countermeasures can include all types of strategies grouped in these categories:
  - Organizational (structure, culture, etc.)
  - Planning/modeling
  - Engineering
  - Operations
  - Cybersecurity
  - Emergency response
  - Business processes
  - Performance evaluation
- Utilities should **group specific countermeasures into implementation initiatives** based upon factors, such as:
  - Utility's budgeting process – specific line items
  - Logical grouping to develop multi-year "programs" focused on specific types of assets (e.g., elevated or ground storage, regardless of type of threat) or threats (e.g., reducing potential impacts of ice storms across all relevant critical assets)
  - Other single-year recommendations

Organizational Risk Mitigation Strategies to Consider

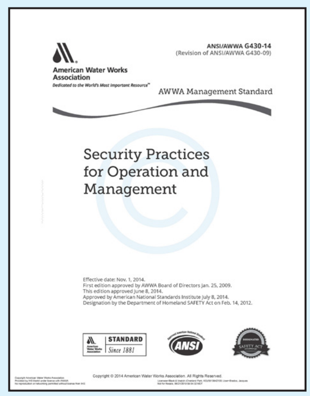
- Assign responsible person for risk/resilience management (e.g., Risk Manager)
- Develop resilience policy
- Develop digital twin of system model for operational planning and support purposes
- Identify system-related redundancy projects, including alternative water sources/interconnects, mutual aid and assistance agreements, and installing emergency power for critical operations
- Develop business continuity plan (BCP) (aka, Continuity of Operations Plan, COOP)
- Develop/enhance liaison with other regional utilities and law enforcement agencies
- Develop operational strategies to address specific TAPs
- Implement on-call contracts and blanket purchase agreements
- Secure critical parts and equipment
- Address critical staff resilience
- Develop cybersecurity policies (including Enterprise IT and SCADA systems) and cyber-specific-focused emergency response procedures/plan

Other Management Programs that Should be Linked to RRAs

- Asset management program
- Risk-informed capital and operational budget prioritization program
- Aging infrastructure replacement program
- Water resource/master planning
- Workforce planning
- Financial/revenue planning
- Climate change initiatives
- Social responsibilities initiatives

05 EMERGENCY RESPONSE PLANS

- Utilities generally prepare and respond well to disruptive events, relying heavily on experience and equipment, but often do not have well defined written procedures. **Improving the documentation of procedures should be an objective** of the ERP updating process.
- The most common reference documents used in preparing and updating ERPs include:
  - *Emergency Planning for Water and Wastewater Utilities* (AWWA, M19, 2018)
  - *Emergency Response Plan Guidance for Small and Medium Community Water Systems* (EPA, 816-R-04-002, April 2014)
  - *Emergency Response Plan Guidance for Large Community Water Systems* (EPA, 810-F-03-007, July 2003)
  - *Security Practices for Operation and Management* (ANSI/AWWA G430-14, November 2014)
  - *NFPA 1600: Standard on Continuity, Emergency, and Crisis Management* (National Fire Protection Association, 2019)
  - *Community Water Systems Emergency Response Plan Template* (EPA 816-B-19-003, July 2019)
- Utilities should **look at security issues and recommendations in a practical manner**, considering all the responsibilities and deadlines that utility management teams and staff need to address. A security solution that does not fit well into normal daily operations and activities will likely be bypassed or abandoned.
- Embedding a preparedness culture, including **regular emergency response training** with individuals at every level, will make response during times of crises smoother and quicker.



06 RISK ASSESSMENT TOOLS

- The most common risk assessment tools used by utilities to complete their RRAs include:
  - EPA's Vulnerability Self -Assessment Tool (VSAT), Web 2.0
  - Utility or contractor-developed spreadsheets and documents
- VSAT2 tool:
  - Some utilities have noted that there is a need for a more practical approach to the analysis of consequence than the approach embedded within the VSAT2 tool.
  - It is important to document and justify the selections within VSAT2. This is also true for the specific values selected for the Water, Health & Economic Analysis Tool (WHEAT) calculator inside of VSAT2.

RESILIENCE LITERATURE REVIEW SUMMARY

There are numerous guidance documents, standards, and tools available to water utilities (as well as wastewater and stormwater utilities) covering the various aspects of risk and resilience planning and emergency preparedness. Earlier in this project, BV conducted a literature review of the most relevant regulations, guidelines, frameworks, and models/tools that exist. A summary of this review has been drafted and is currently being reviewed by WRF, PAC, and this project's Participating Utilities. While this document is still in draft form, it is sufficiently developed to be a useful guide, and it can be accessed via the 5014 project page of the WRF website at **https://www.waterrf.org/system/files/resource/2020-05/ProjectPaper-5014-1.pdf**.

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2020 LIFT Technology Scan Presentation Series #9: Pipes

September 15, 2020

LIFT
Leaders Innovation Forum for Technology

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Discover the most timely and relevant innovations

Explore new technologies firsthand and understand the relevance for your utility

Spread knowledge gained across the water sector

Evaluate the applicability of the innovation for your context

Implement the innovation within the water business

Technology Scans

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Leaders Innovation Forum for Technology

159 Technologies
145 Companies

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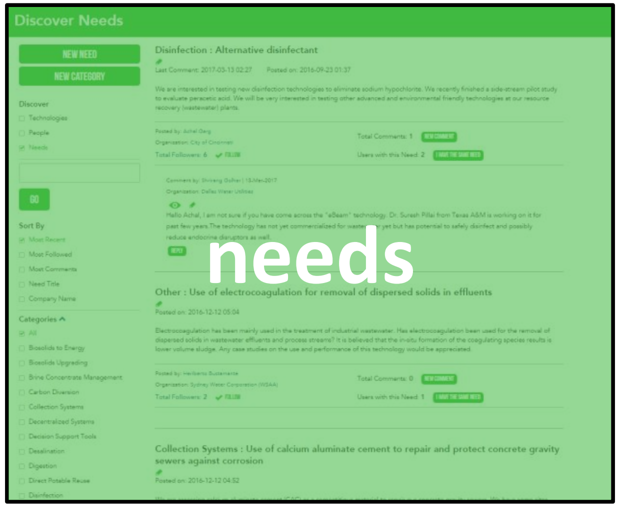

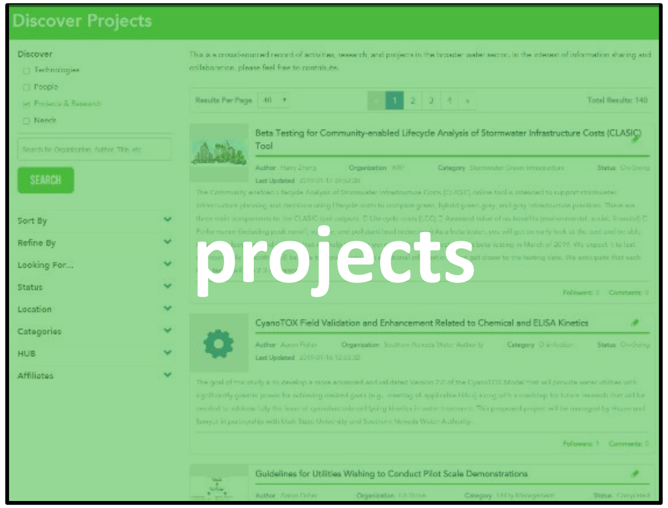

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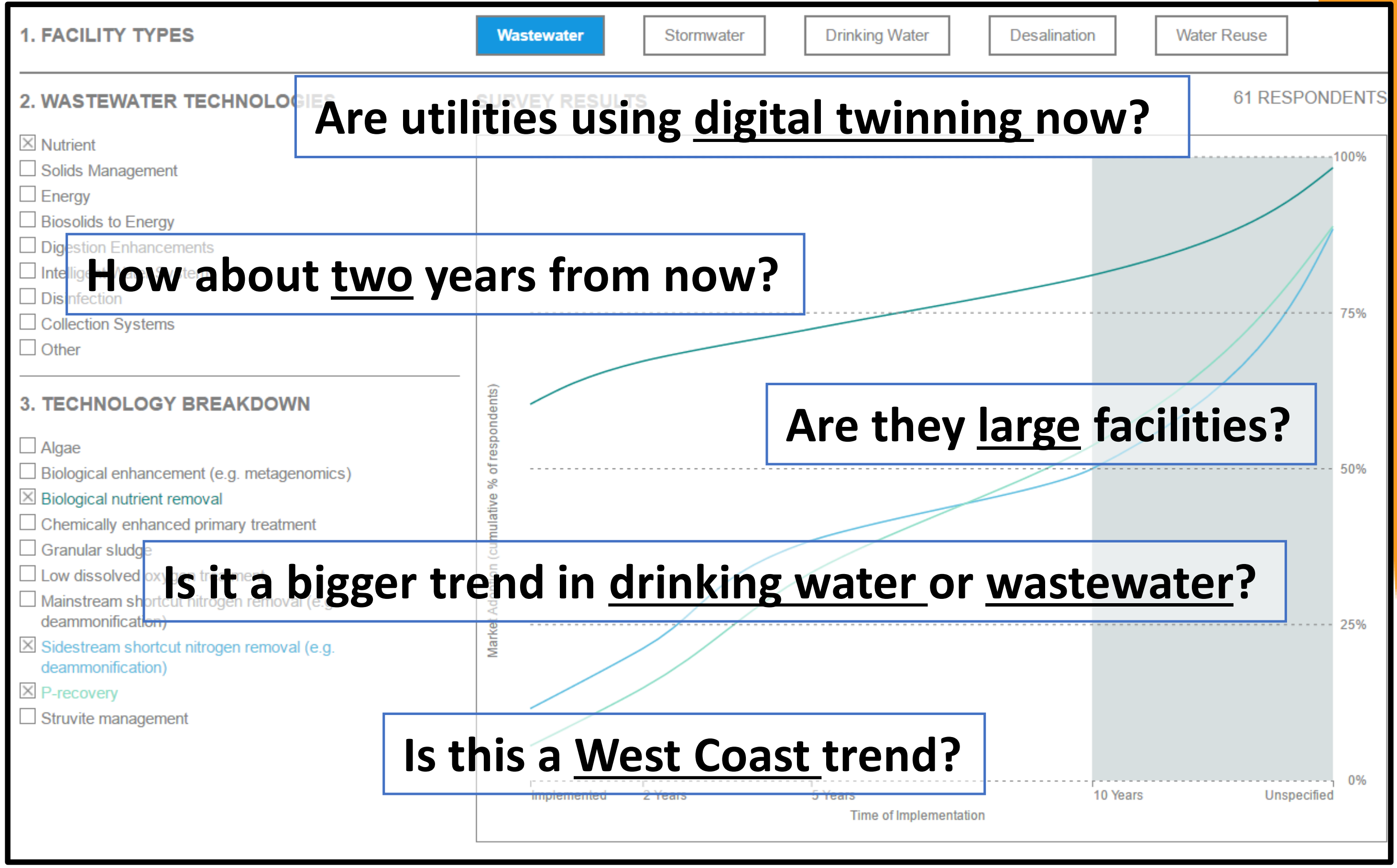
Tech Trends

www.waterrf.org/tech-trends

- Tracks what innovations are happening in the water sector
- Interactive Projection Tool for 100+ technologies
  - Compares 2017 and 2020
  - Geography
  - Size
- Collecting data for 2020 until the end of the year….



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2020 LIFT Scan Webcast Series

www.waterrf.org/lift-events

Topic	Technologies	Date
Pyrolysis	SulfaChar (Char Technologies); BFT Biosolids to Energy System (BioForceTech); Kore Infrastructure (KORE)	October 20
Leak Detection	AI Leak Detection (Voda); Scout (WatchTower Robotics); Smart Hydrant (Eramosa)	November 3
Digital Water	Industrial IoT (AMI Global); Smart Water Dashboards (AEEC/Google); eRIS (Westin Technology Solutions)	November 17

Other topics include: Digestion Enhancement, Nutrients, Sensors, Source Water Quality, Solids Treatment, Stormwater, Hydrolysis, Water Reuse, and Pipes

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Today's Agenda

1. **iPVC:** PPI America- Dave Hughes
2. **InfinitPipe:** QuakeWrap- Mo Ehsani
3. **Multi-Sensor Pipeline Inspection Systems/Pipe Penetrating Radar** SewerVue- Nicholas Goertz

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- Please type questions in the question box
- Please complete the poll about your interest in a technology at the conclusion of each presentation

PPI AMERICA, INC

iPVC - Innovative Polyvinyl Chloride Pipe

Dave Hughes
Modernizing Distribution

PPI AMERICA, INC

What is i(innovative)PVC?

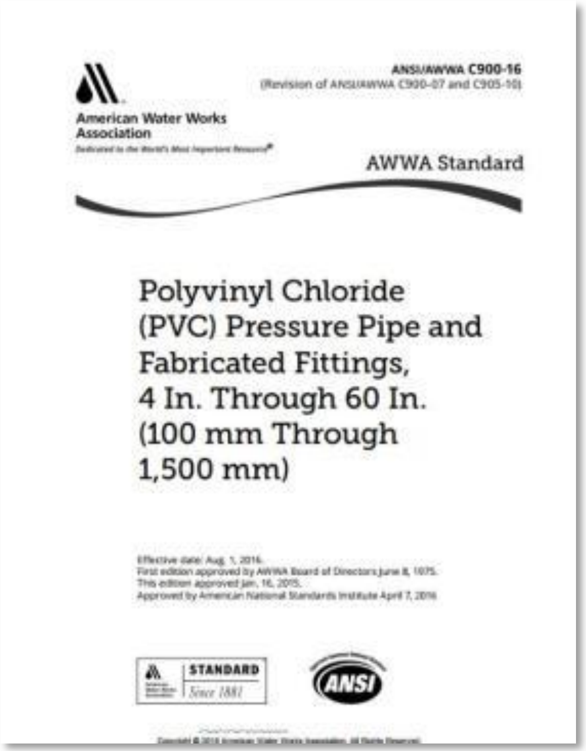
- A “ductile” PVC pipe now made by PPI in South Korea and soon to be made in the US.
- Uses a modified additive and mixing process with the PVC resin developed by LG Chem LTD.
- Tested and Installed in the US

LG Life's Good

PPI AMERICA, INC

Qualified C900 PVC pipe

- Certified as meeting AWWA C900 Pipe Standards
  - Sized appropriately for DR18 and DR14
  - Exceeds HDB, pressure, stiffness and impact testing criteria
  - Testing by NSF including NSF61
  - Available 4"-24"
- Soon to be certified for US manufacture



ANSI/AWWA C900-16

(Revision of ANSI/AWWA C900-07 and C905-10)

American Water Works Association

AWWA Standard

Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)

Effective date: Aug. 1, 2016.
First edition approved by AWWA Board of Directors June 8, 1975.
This edition approved Jan. 16, 2015.
Approved by American National Standards Institute April 7, 2016

STANDARD Since 1881

ANSI

PPI AMERICA, INC

US Tested

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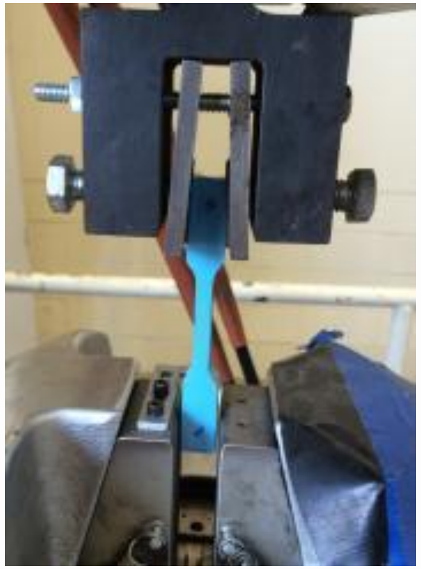
- The Water Research Foundation funded American Water to test the pipe in US
- Tests confirmed strength and ductility, examined possible modes of failure
- Tests performed by qualified U.S. based labs
  - (University of Texas-Arlington and Microbac)
- Additional testing for seismic stresses
  - (Cornell University, University of Colorado)

4

WRF Project # 4650

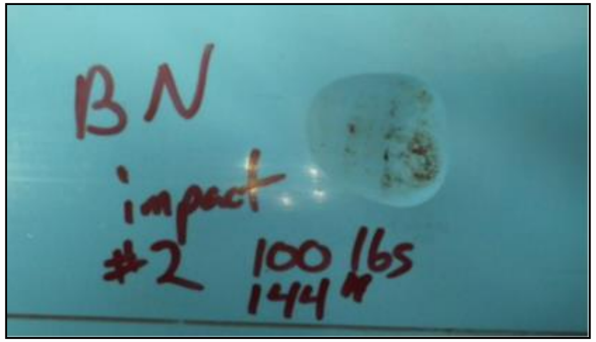


PPI AMERICA, INC

Impact Test (ASTM D2444*)

- Tested by Microbac at specified 73°F (23°C)
- 100 pounds TUP A dropped from 12 foot height (1,200 foot-pounds)
  - Minor dents observed on pipe surface
- Pipe samples further tested at 32°F (0°C)
  - Samples fractured at about 1,080 foot-pounds

Standard. TUP type A

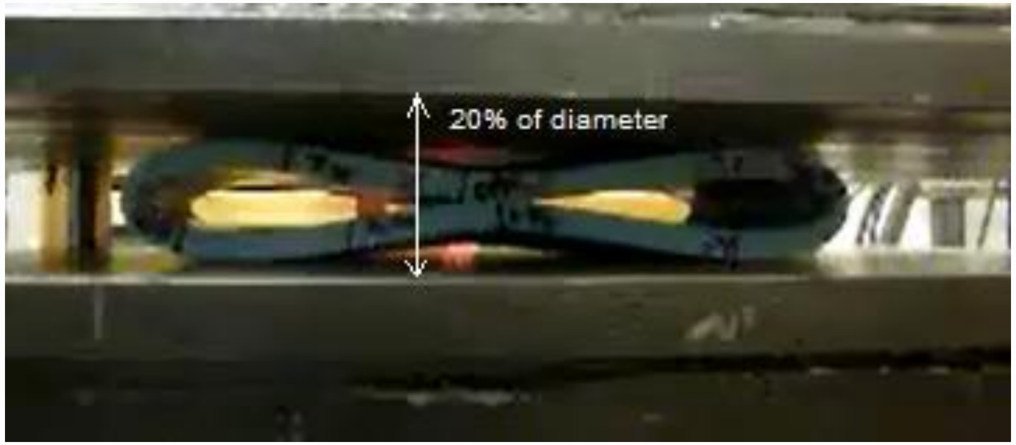


Source: Microbac Lab

PPI AMERICA, INC

Stiffness Test (ASTM D2412)

- 5% steps of deformation from 95% through 20% deflection
  - Reached 95% OD at 451 psi at 95% OD, >23% over standard
  - Deformed below 20% pipe O.D. - no wall cracking
- Maximum load– 10,100 psi

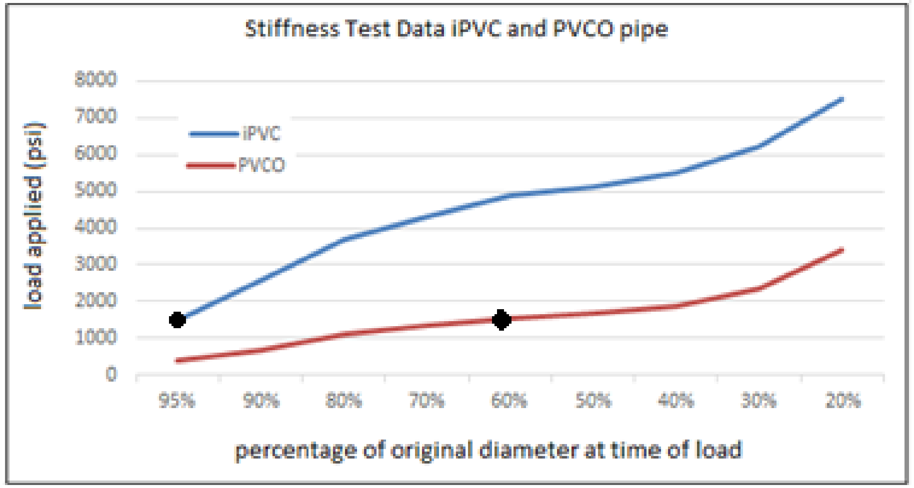


PPI AMERICA, INC

Stiffness Test Comparison

- PVCO (AWWA C909) is an extruded thin-walled PVC pipe
    - Like iPVC exhibits ductility and resistance to splitting
    - Lighter weight but more readily flexes under load

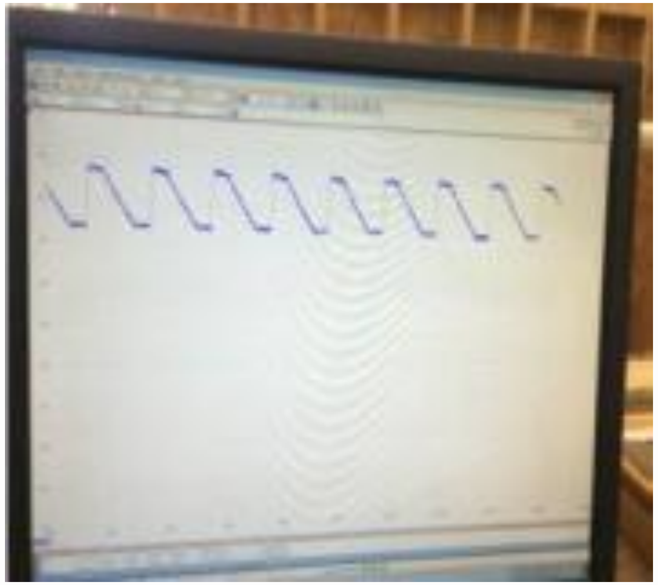
- <u>1500 PSI load, iPVC deflects 5%,</u>
- <u>1500 PSI load, PVCO deflects 40%</u>
    - 6” iPVC 0.383” thickness
    - 6” PVCO 0.221” thickness

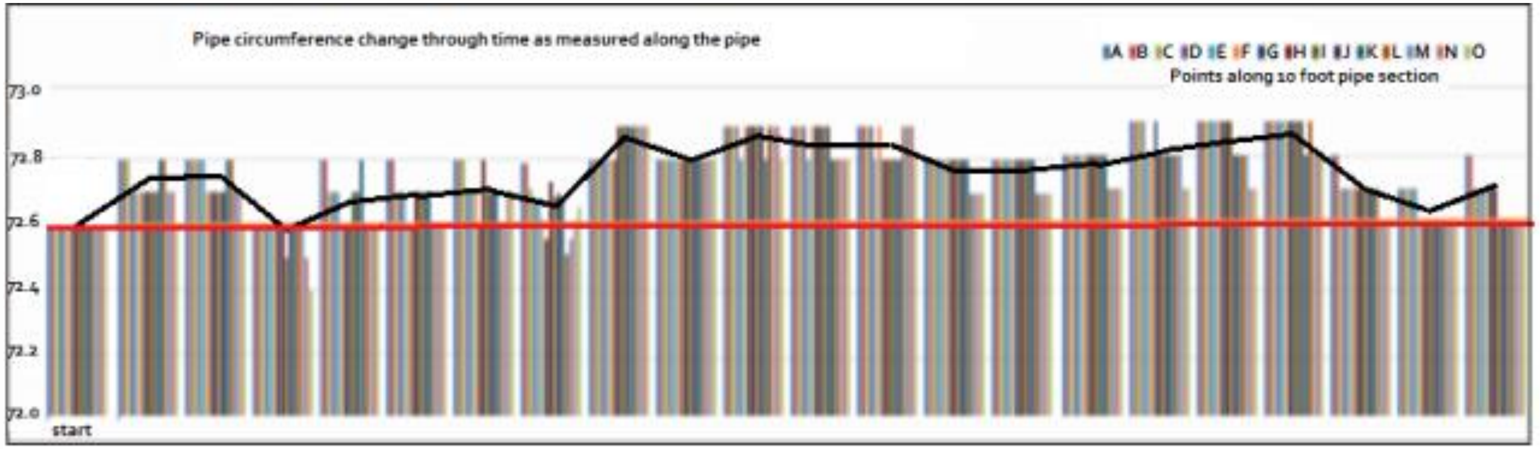


PPI AMERICA, INC

Fatigue Test (UTA Configuration)

- Surge Pressure Setup
  - 10 foot (3m) pipe cycled between 150 -225 psi
  - Over 4 Million cycles - 7 cycles/minute - 8 months
- Pipe circumferential changes less than 1.1%





PPI AMERICA, INC

Installations American Water

- Installation of 1,500 feet; 8 inch DR 18 pipe
  - Corrosion soils - replaced 55 year old cast iron pipe
  - Located in Missouri flood plain, soil saturated by flooding
  - Pipe installed in January, no issues with cold temperatures
  - Crew battle tested
- Installation of 2,200 feet; 8 inch DR 18 pipe
  - Replaced 8 inch cast iron pipe in Manville, NJ
  - Contractor installed, NJ American inspected
  - Wet tapping, cutting, pipe handing, PVC and cast iron connection, and installation of bends and hydrant lateral

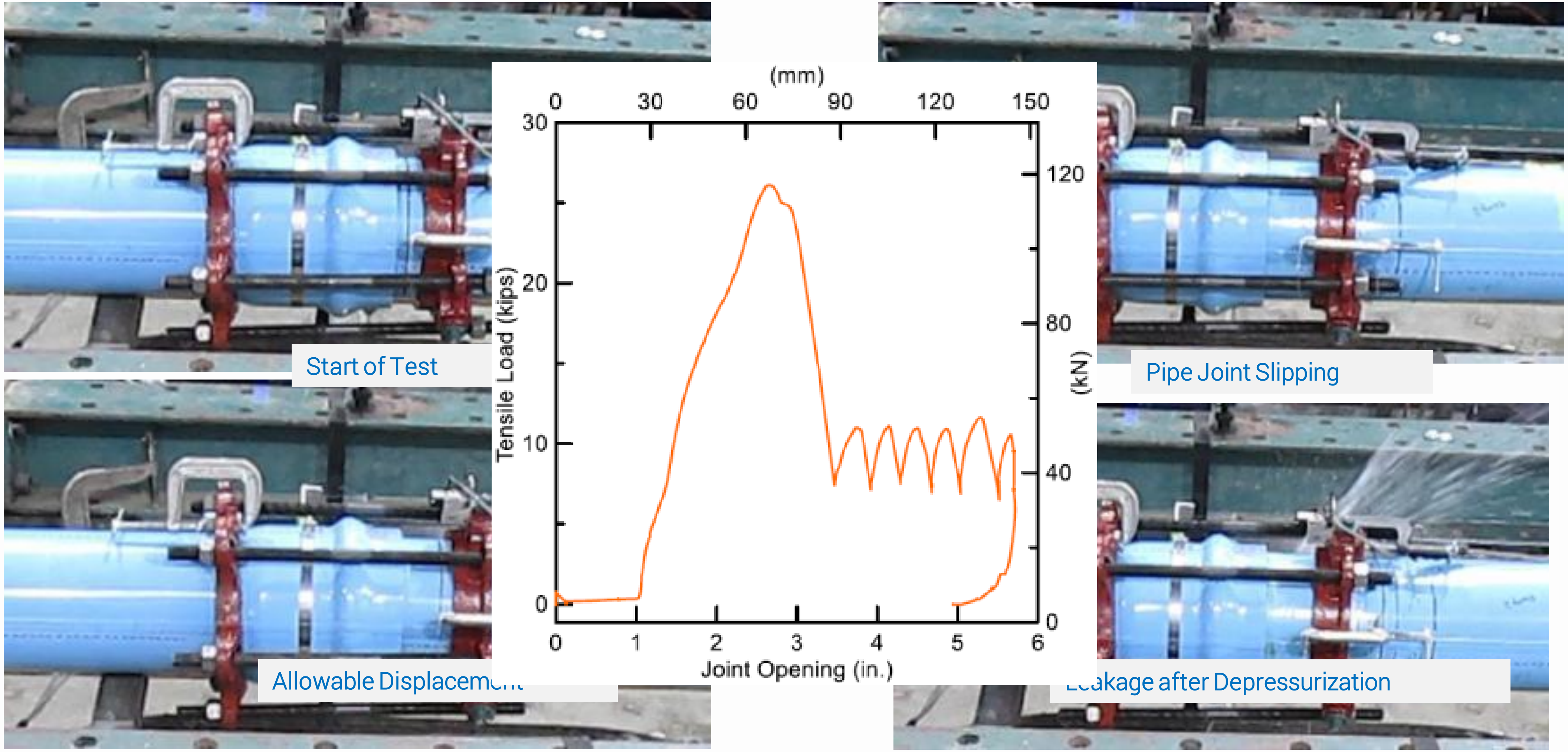
PPI AMERICA, INC

Earthquake Simulation Tests

- University of Cornell School of Civil & Environmental Engineering
  - Cornell Large Scale Lifelines Testing Facility in the Bovay Laboratory Complex
  - Have performed earthquake related testing of ductile, iron, steel and PVC pipes
- Tests performed
  - Tensile tests
  - Compression test
  - 4 Point Bending test
  - Soil Axial test
  - Split Basin test

https://lifelines.cee.cornell.edu/projects/

PPI AMERICA, INC



Pipe Tensile Test

- The first pipe attained a max tensile load of 26 kips (116 kN) at a joint opening of 2.65 inches (67 mm).
- After maximum load, 6 sudden displacements of ratcheting movement led to pullout at about 6 inches (150 mm).
- Fracture at 2 locations of the south restraining collar at the housing of the clamping teeth contributed to failure. allowing the pipe joint to open as the unit slipped.

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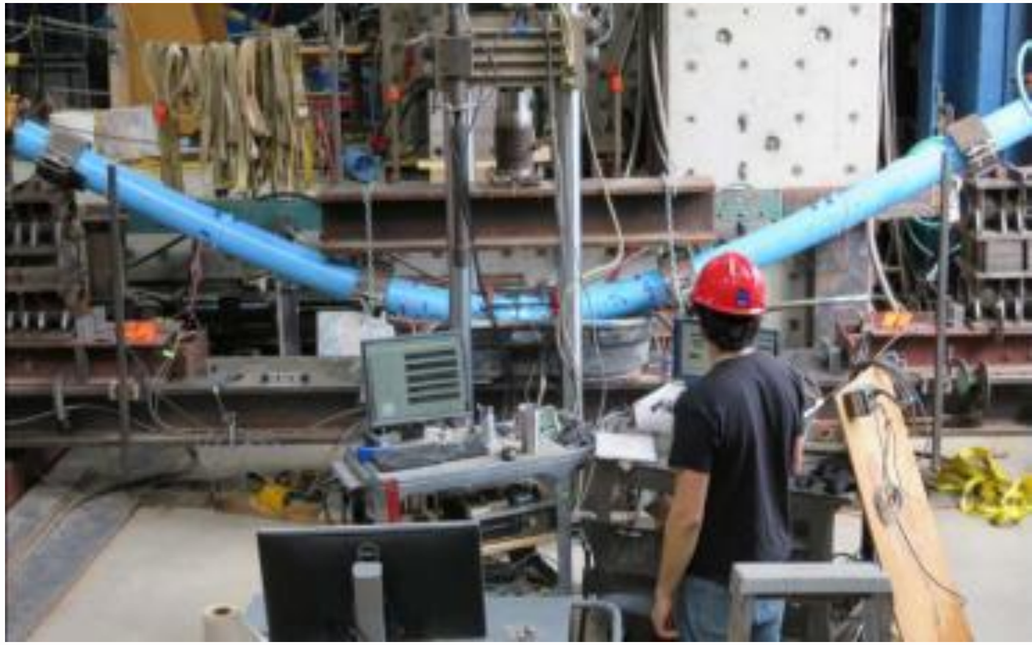
Four Point Bending Test

- Testing limits of restrained joint deflection
- Pressurized pipe is supported at 2 locations on both sides of joint.
- Deflection increased, paused at 10 inches and 18.5 inches, to observe.
- Test ended at 27 inch deflection, limit of equipment
- No leakage or loss of pressure



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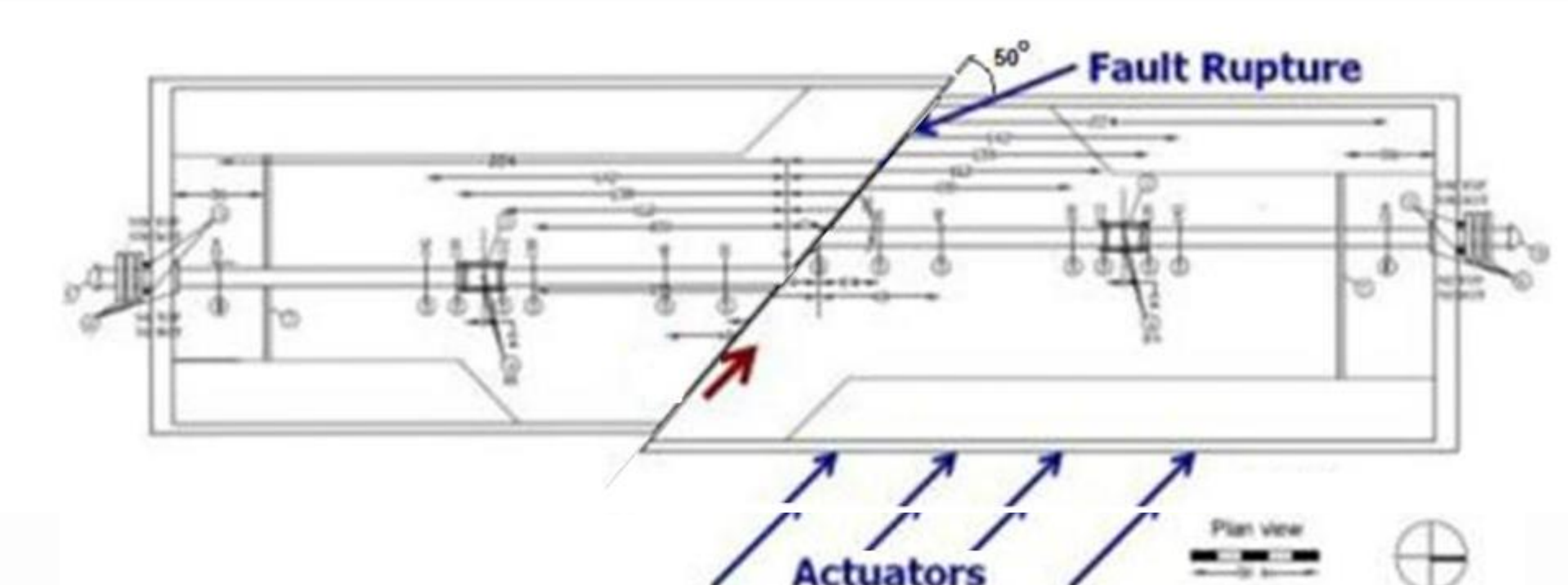
Split Basin Test

- Causes soil rupture and slip at the interface between the two parts of the test basin.
- Increasing both bending and tension stress
- Matches most severe seismic ground deformation, liquifaction

PPI AMERICA, INC

Split Basin Test

- Simulating ground shift to stretch and bend pipe



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Split Basin Test

- The split basin test June 19, 2018
- 3 pipe segments connected with joint restraints at bell and spigots
- buried in test basin granular backfill approximately 2.5 ft (0.76 m) of cover
- The south part of the basin remains stationary, while the north part is shifted

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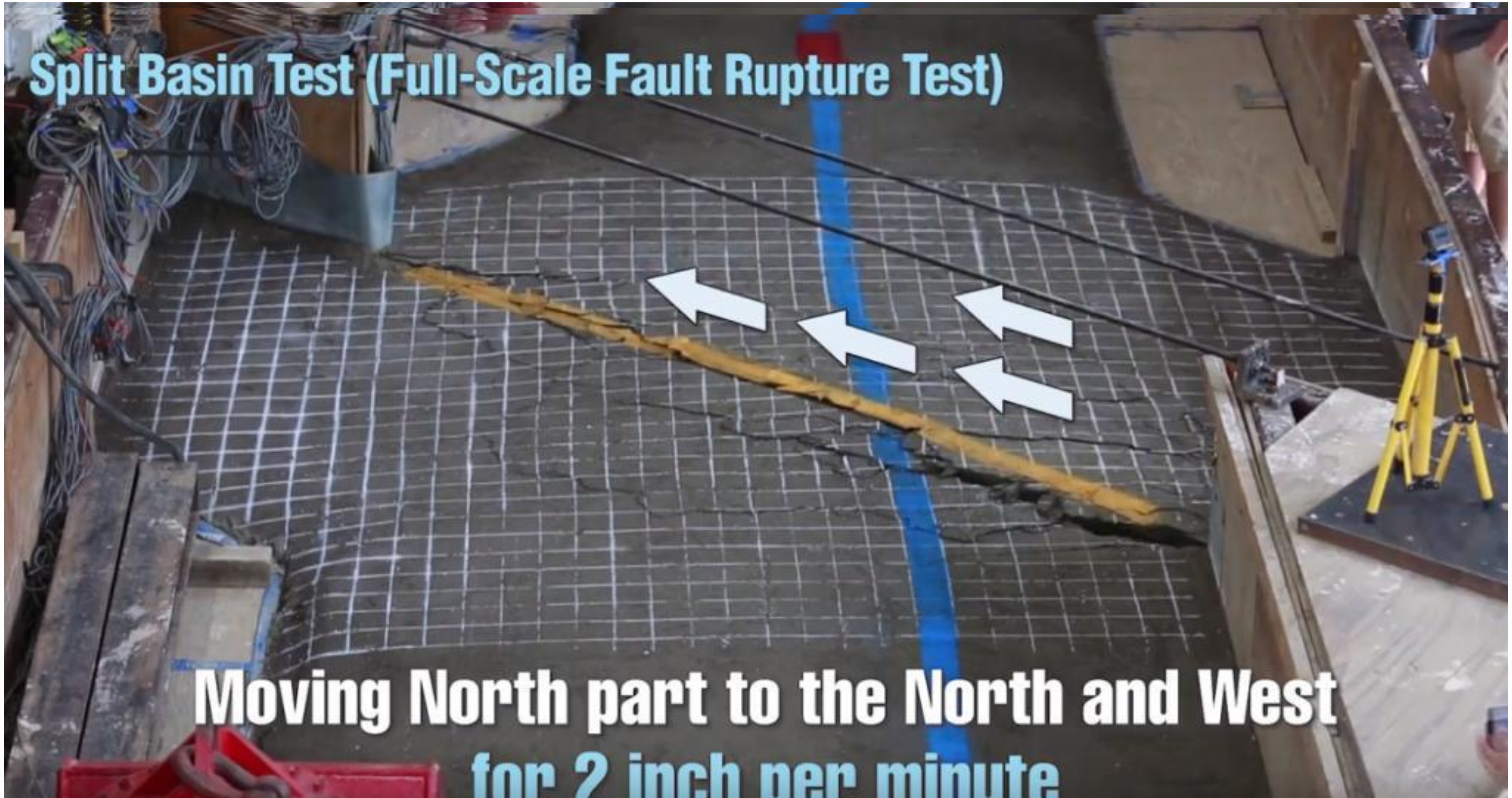
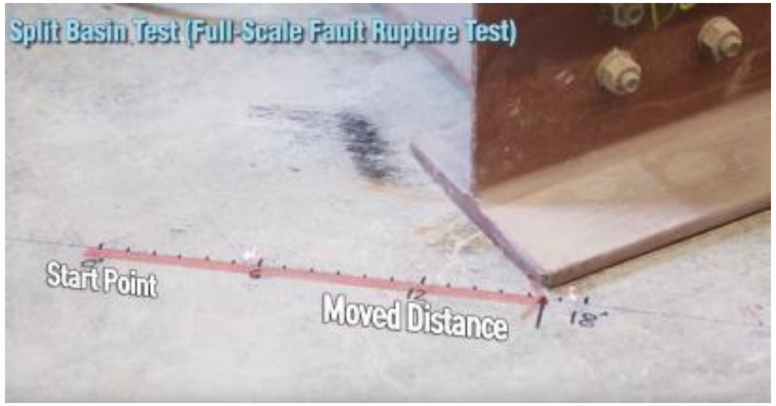
Split Basin Test



PPI AMERICA, INC

Split Basin Test

- Shifted 16.4 inches before pipe lost pressure at fixed end joint.
- Tension pull 10.5", Bending 12.5"



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Current Actions by Vendor

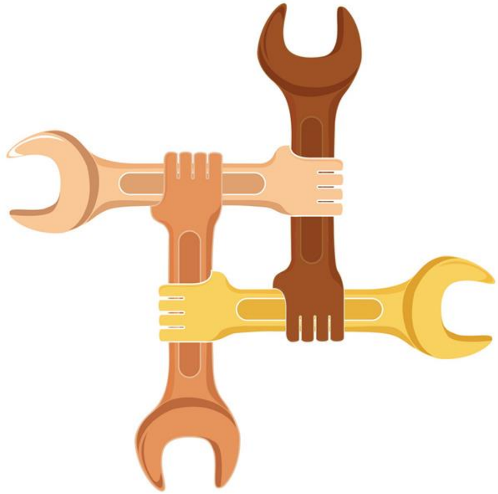
- Stress evaluation with restrained joints University of Colorado
- Sales, distribution of product in North America ongoing
- Samples available
- Certification for manufacturing facility in US
- Certification for iPVC fittings

PPI AMERICA, INC

LIFT
Leaders Innovation Forum for Technology

LIFT can help

- Innovation and Utilities Link
  - Technology validation
  - Finding partners
  - In-kind support



Help Requests- We will ask a poll during the webinar to see who is interested; names/contact information of those who replied in the affirmative will be provided after.

PPI PPI AMERICA, INC

Questions

- Agnes Lee, PPI America, Inc.
  1480 Renaissance Drive Suite 412
  Park Ridge, IL 60068
  224 500 4078
  agnes@ipvcpipe.com

- David M Hughes, Modernizing Distribution
  16454 Roan Place
  Parker, CO 80134
  215 620 6088
  dmhughesmd@gmail.com

InfinitPipe®:
A Game-Changing Onsite-Manufactured Pipe

Mo Ehsani, PhD, PE, SE

QuakeWrap Inc.

A joint initiative of:

The Water Research Foundation®

Water Environment Federation® the water quality people®

Current Pipeline Construction Practice

- Pipes made in 6-40 ft long segments
- Transportation is costly
- Joined in the field
- Safety
- Corroding Materials
- Provide coating or cathodic protection
- Leaking Joints

History of the Development

1987: Introduced Fiber Reinforced Polymer (FRP) for repair & strengthening of Buildings Bridges

1998: Use of FRP to repair large-diameter pipes

2010: Introduced sandwich FRP pipe construction

2014: Introduced InfinitPipe®

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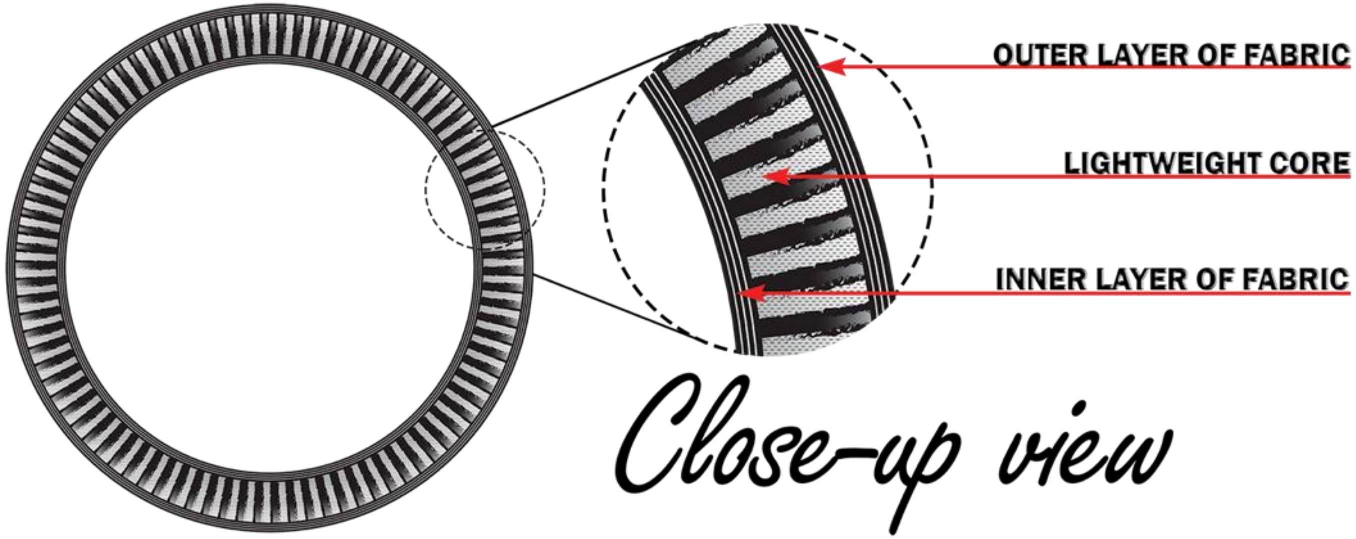
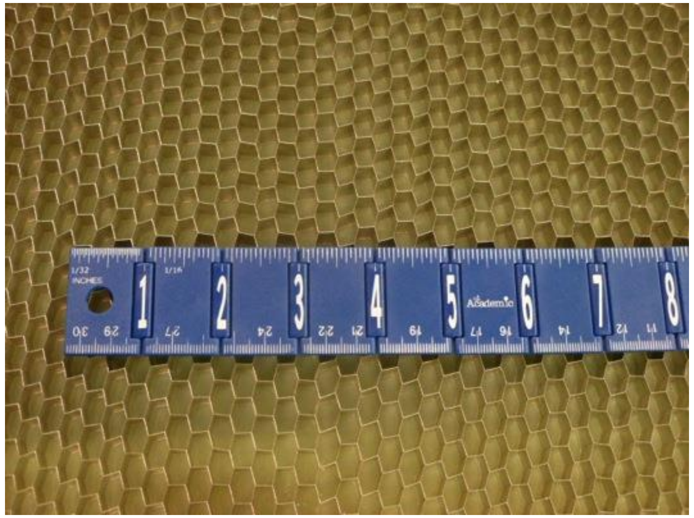
Sandwich Construction FRP Pipe





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CASE STUDY: Gillies Road Culvert

Cairns, QLD

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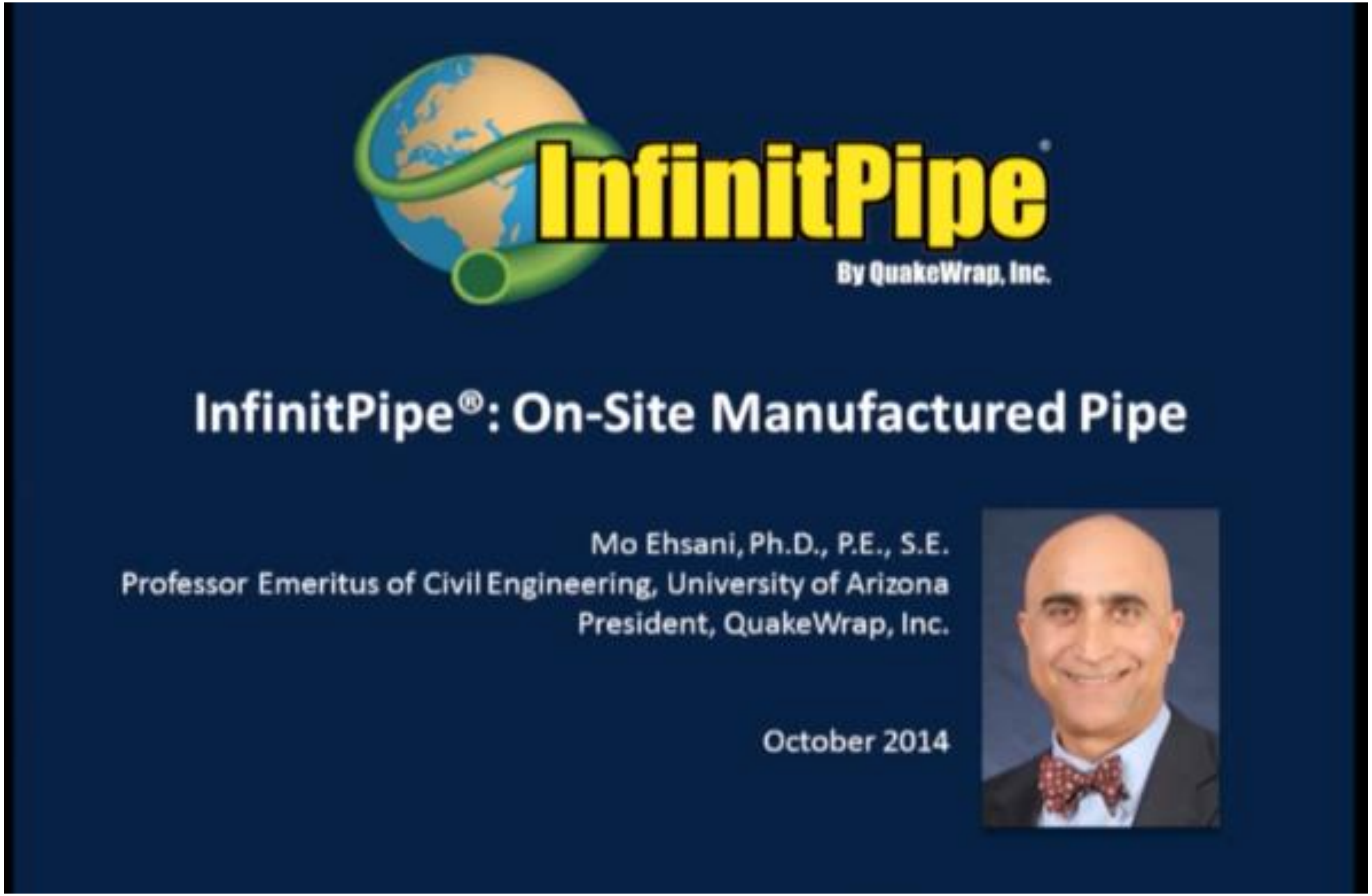
ASCE 2016 Innovation Award

StifPipe®: winner of 2016 ASCE Innovation in the catergory "Green Engineering"

Original Proof of Concept

Watch Video at: https://tinyurl.com/rx4wj75

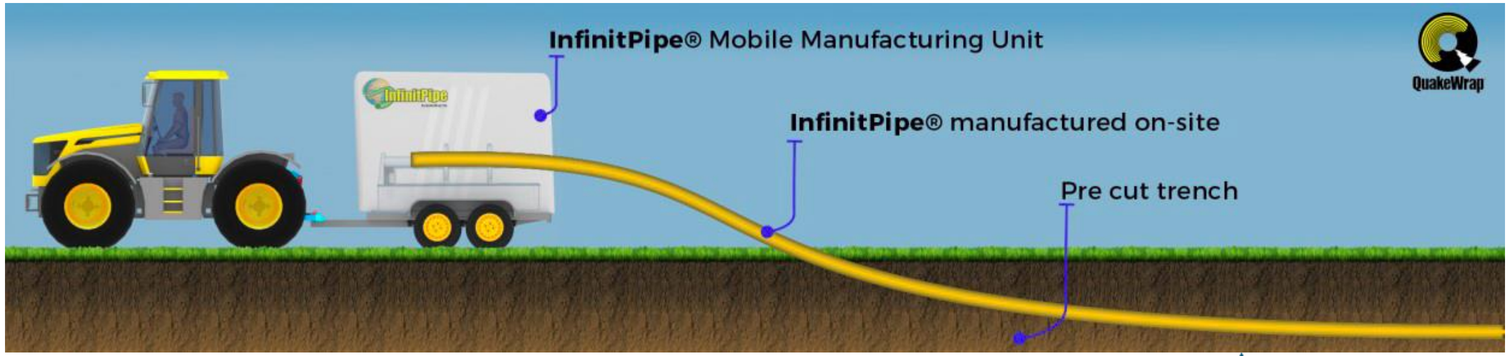


ADVANTAGES OF InfinitPipe™
By QuakeWrap, Inc.

- Built on-site to any length
- No joints to leak
- Designed for any pressure
- Virtually no transportation cost
- Materials do not corrode
- No cathodic protection req'd
- Directly placed in trench
- Construction begins immediately
- Weighs about 15%
- Sustainable Green Tech
- Costs lower than similar pipes

FUNDING OF THE DEVELOPMENT

- All the development to this point with internal funding!
- NSF: SBIR Phase I; $150,000; 2014
- USDA: SBIR Phase I; $100,000; 2017
- USDA: SBIR Phase II; $625,000; 2019-2021



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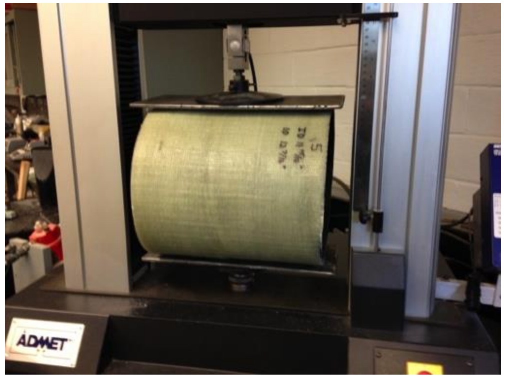
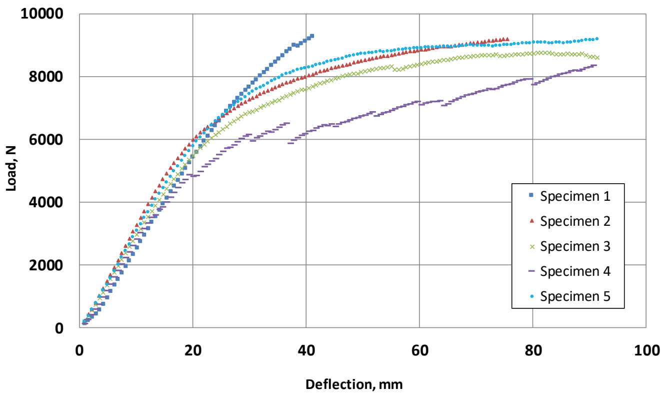
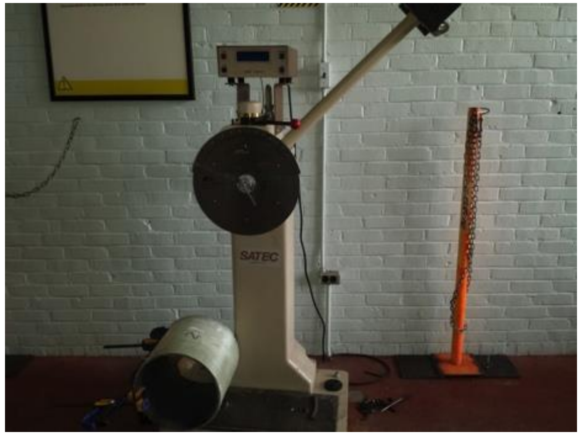
Tests of InfinitPipe at LA Tech Univ.

Ring Stiffness

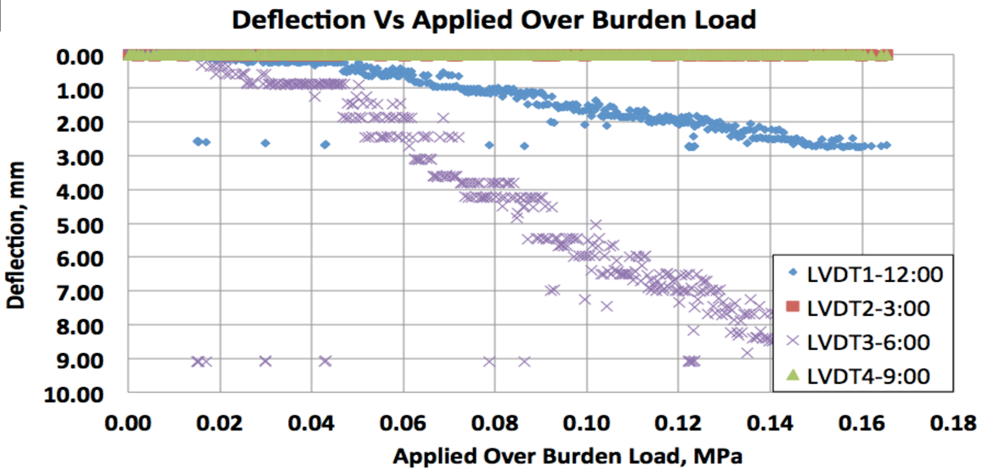




Charpy Impact



Over Burden Pressure



Conclusion: Pipe behavior is like other pipes.

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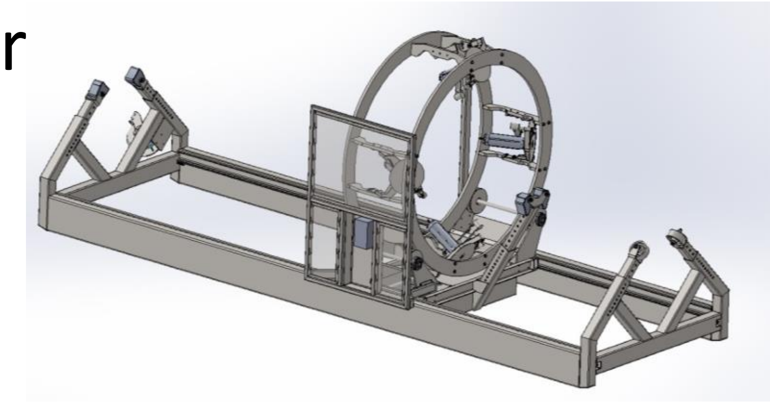
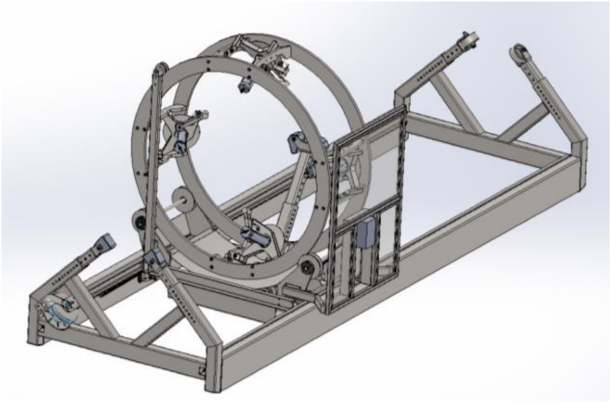
CURRENT STATUS

- Significant Improvements in Manufacturing have been made:
  - Resin
  - Mandrel
  - Curing System
- New Mobile Manufacturing Unit (MMU) will be completed in Nov. ’20
- Fits in 20-ft x 8-ft container





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TEAM MEMBERS

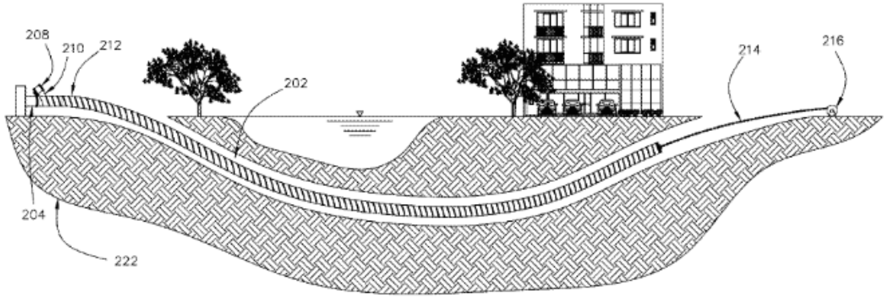
- Mo Ehsani, PhD, PE, SE -- President & CEO
- Pipeline Division:
  - Firat Sever, PhD, PE, BCEE – Manager
  - Owen Yan, PhD – Design Engineer
  - Matt Winn, BS – Mechanical Laboratory Technician/Fabricator
  - McKay Barley – Lab Assistant
- Sales, Marketing & Support Staff

Intellectual Property

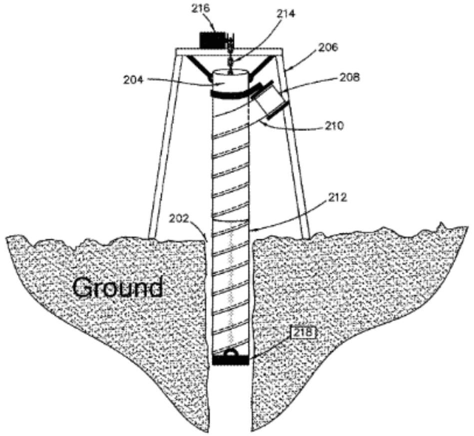
- Registered Trademark:

  InfinitPipe®, issued Jan. 17, 2014

- U.S. Patents Issued:
- Ehsani, M. "Trenchless Pipe-Laying," U.S. Patent #10,436,350 issued Oct. 8, 2019



- Ehsani, M. "Methods and Apparatus for Mining Copper," U.S. Patent #10,571,052 issued Feb. 25, 2020



- Additional Patent Applications Pending

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LIFT Assistance

- Outreach to the community
- Identifying potential customers for pilot projects such as:
  - Long distance water conveyance (water utilities; irrigation districts)
  - Canal lining (irrigation districts)
  - Casing for wells
- Identifying business partners

Thank you for your Attention!

Questions?

Mo@QuakeWrap.com

Phone: (520)791-7000 ext. 122

Watch over 120 videos at: YouTube.com/QuakeWrapInc

For Papers: www.QuakeWrapUniversity.com/papers

QuakeWrap.com

PipeMedic.com

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SewerVUE
IN-PIPE GPR

Nicholas Goertz

e: n.goertz@sewervue.com

p: 604-421-0600

A joint initiative of:

THE Water Research FOUNDATION®

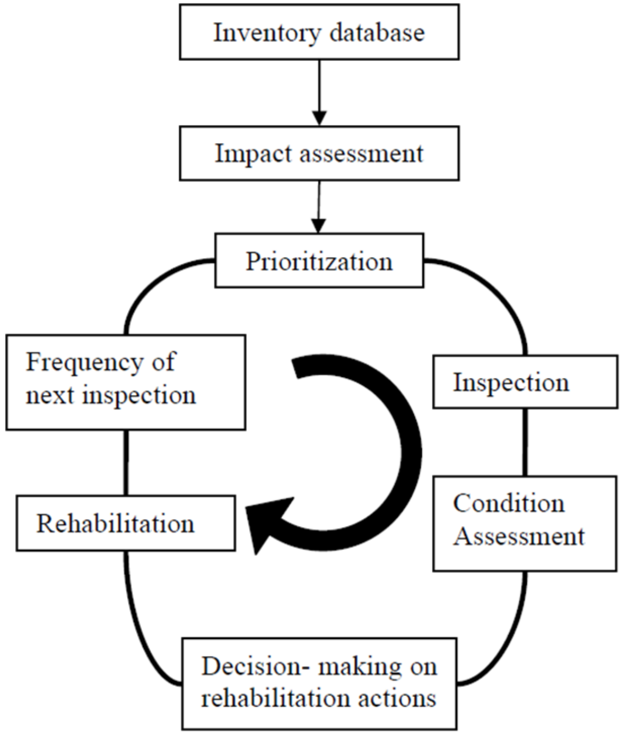
Water Environment Federation® the water quality people®

Company Background

- SewerVUE is a technology and service provider to the global water and wastewater infrastructure assessment market.
- SewerVUE's patented and proprietary pipe inspection technologies provide the only complete condition monitoring solution for non-ferrous water and wastewater pipes.
- Worldwide application, the technology has been proven in North America, Europe, Hong Kong and Australia.
- Make the world a better place by eliminating pipe failures and sewage spills.

Problem Statement

- Do I have a bad pipe?

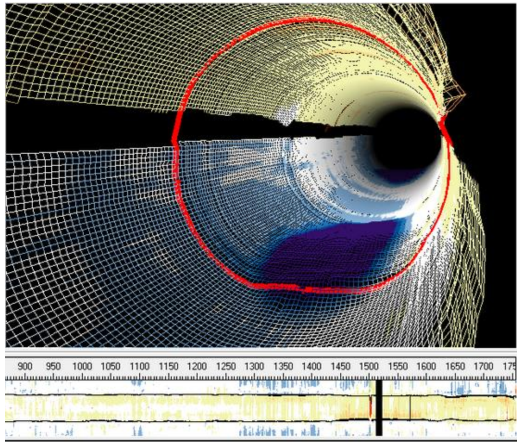


Source: McDonald and Zhao, 2001

Figure 2-1: Condition Assessment

3 Tiered Approach

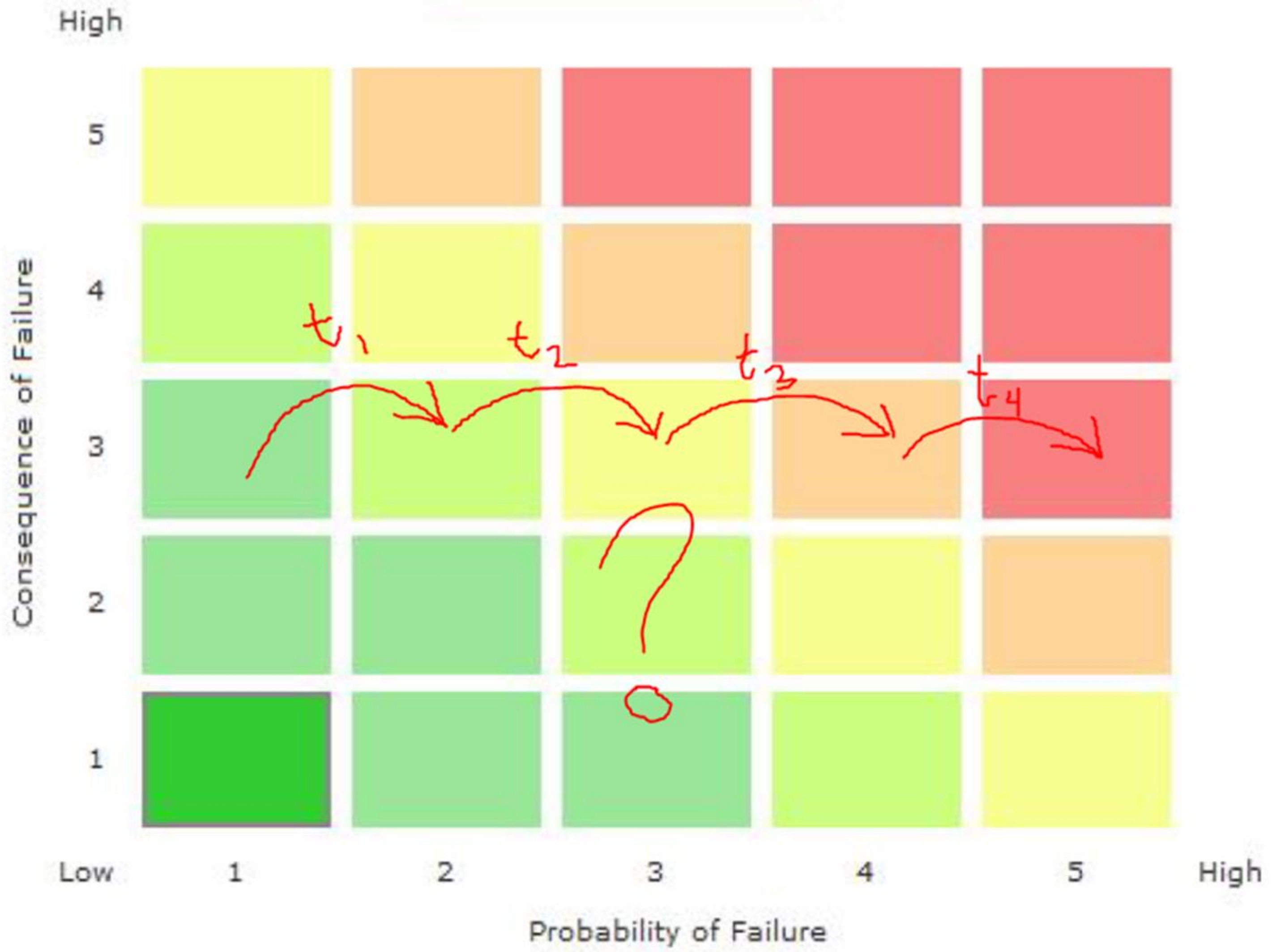
T1 → T2 → T3



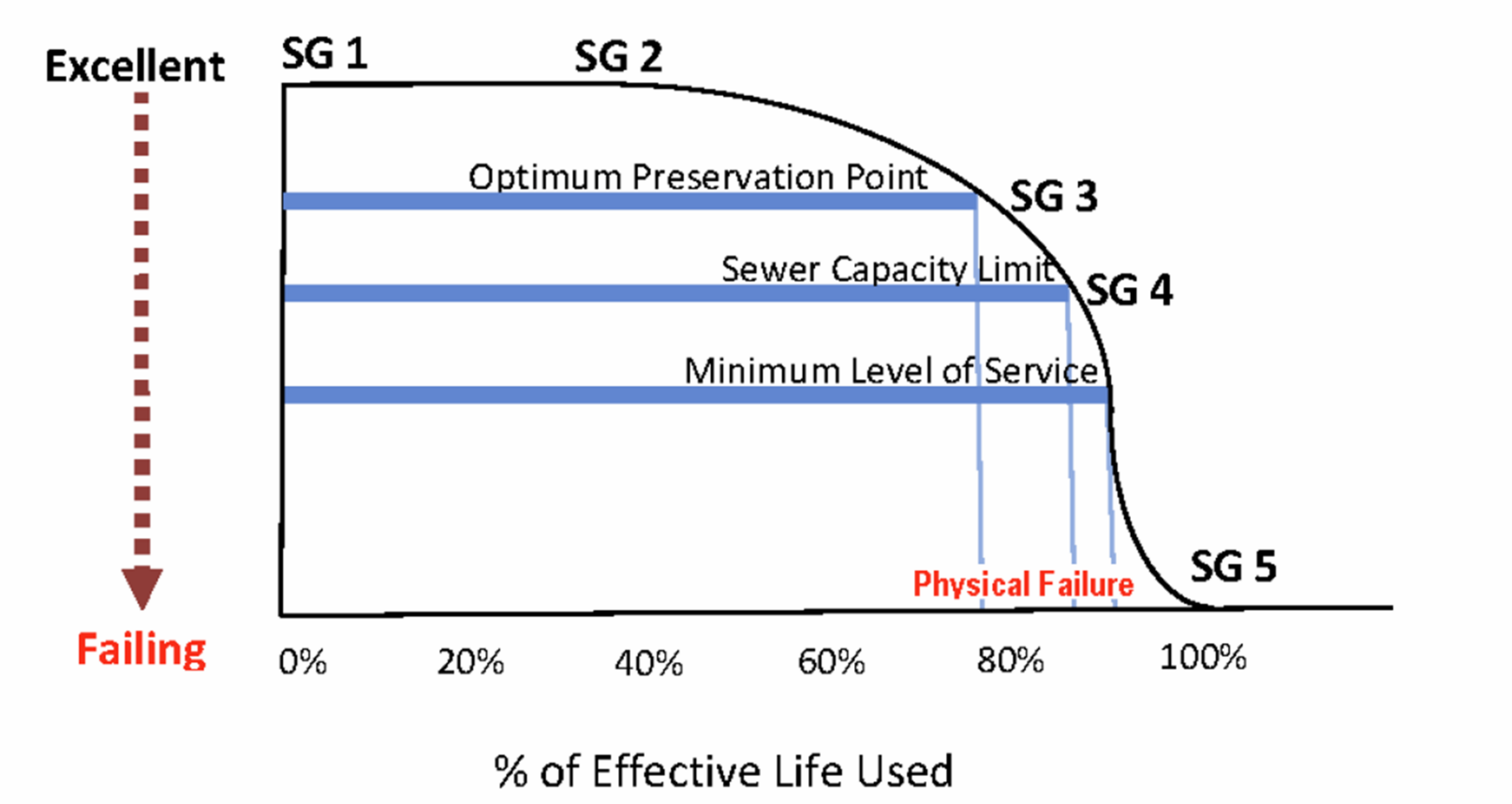
SewerVUE IN-PIPE GPR

What happened!?

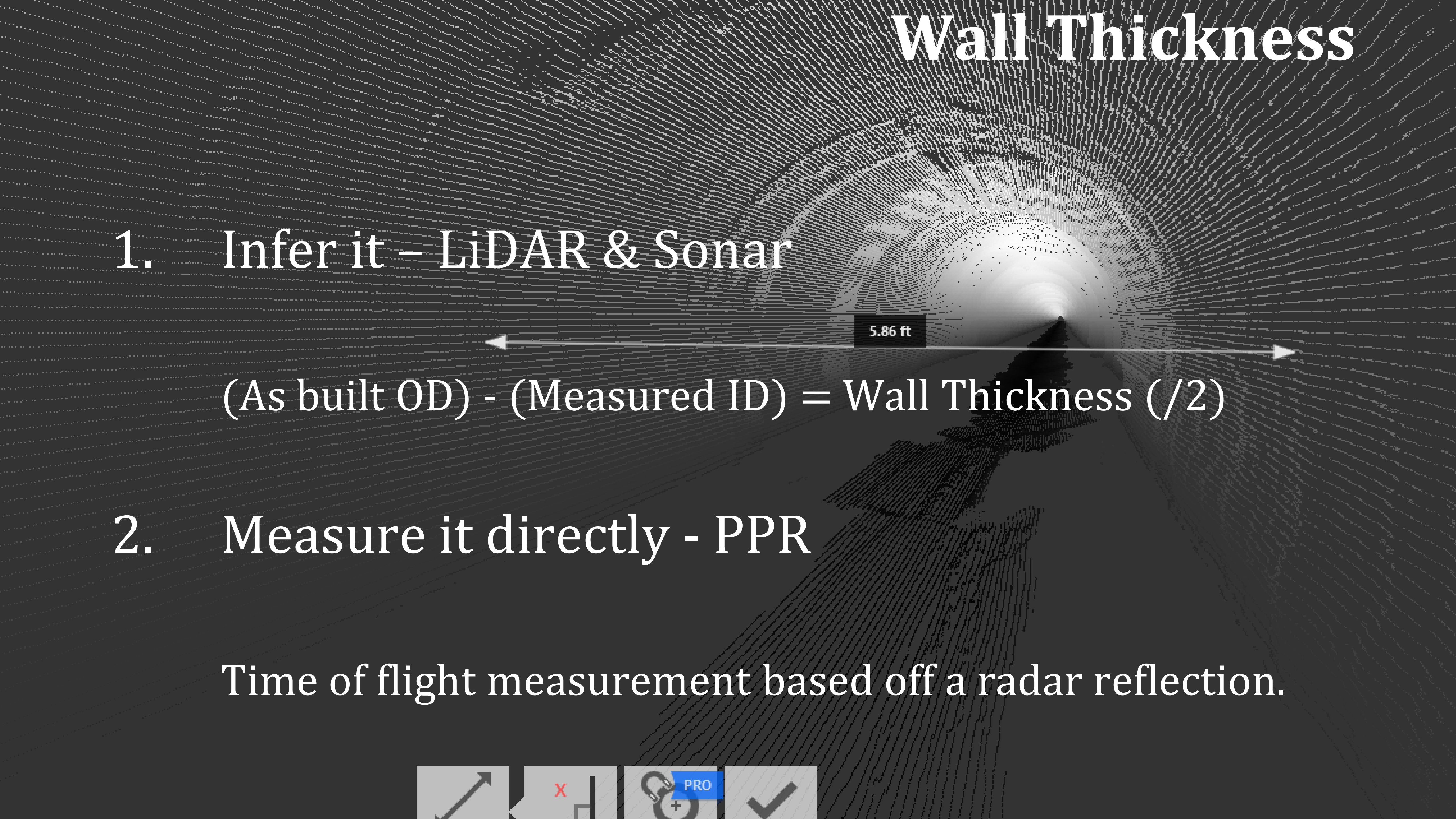
How long?


High
5
4
3
2
1
Consequence of Failure
t1
t2
t3
t4
?
Low
1
2
3
4
5
High
Probability of Failure

What we'll tell you…



Wall Thickness



1. Infer it – LiDAR & Sonar

   (As built OD) - (Measured ID) = Wall Thickness (/2)

2. Measure it directly - PPR

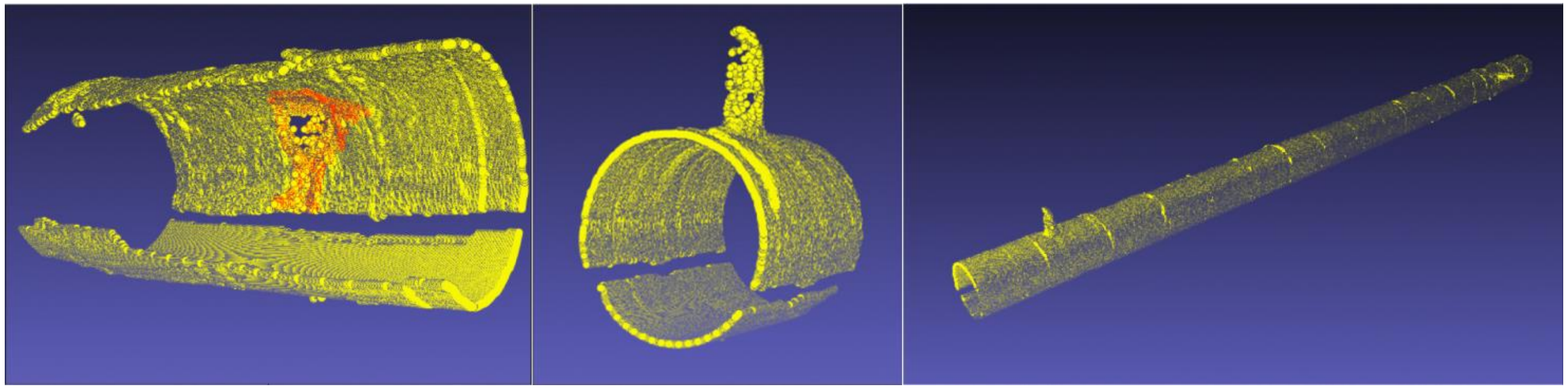
   Time of flight measurement based off a radar reflection.

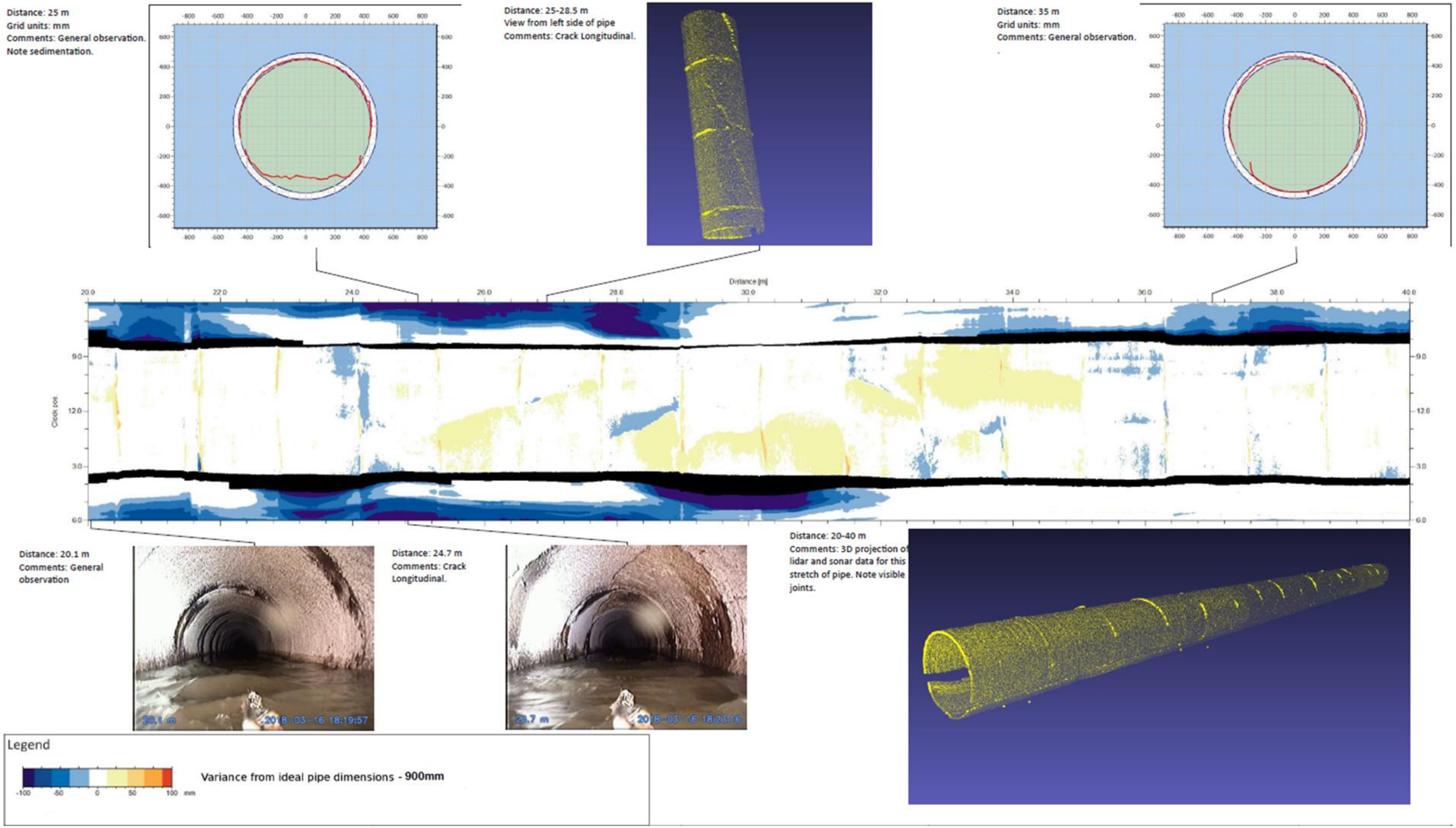
The Technology

- Float-based multi-sensor inspection (MSI) platform for water and wastewater pipelines.
- It uses a suite of quantitative measuring technologies including LiDAR, sonar, gas monitor, temperature sensor and high-definition CCTV to gather condition information from inside large diameter pipes.
- Various components have been employed as single use, purpose built platforms in multiple prototype stages over a multi-year development period. None fit for commercial production or operation. Through this project we intend to develop a state of the art, commercial-ready build.

The Technology

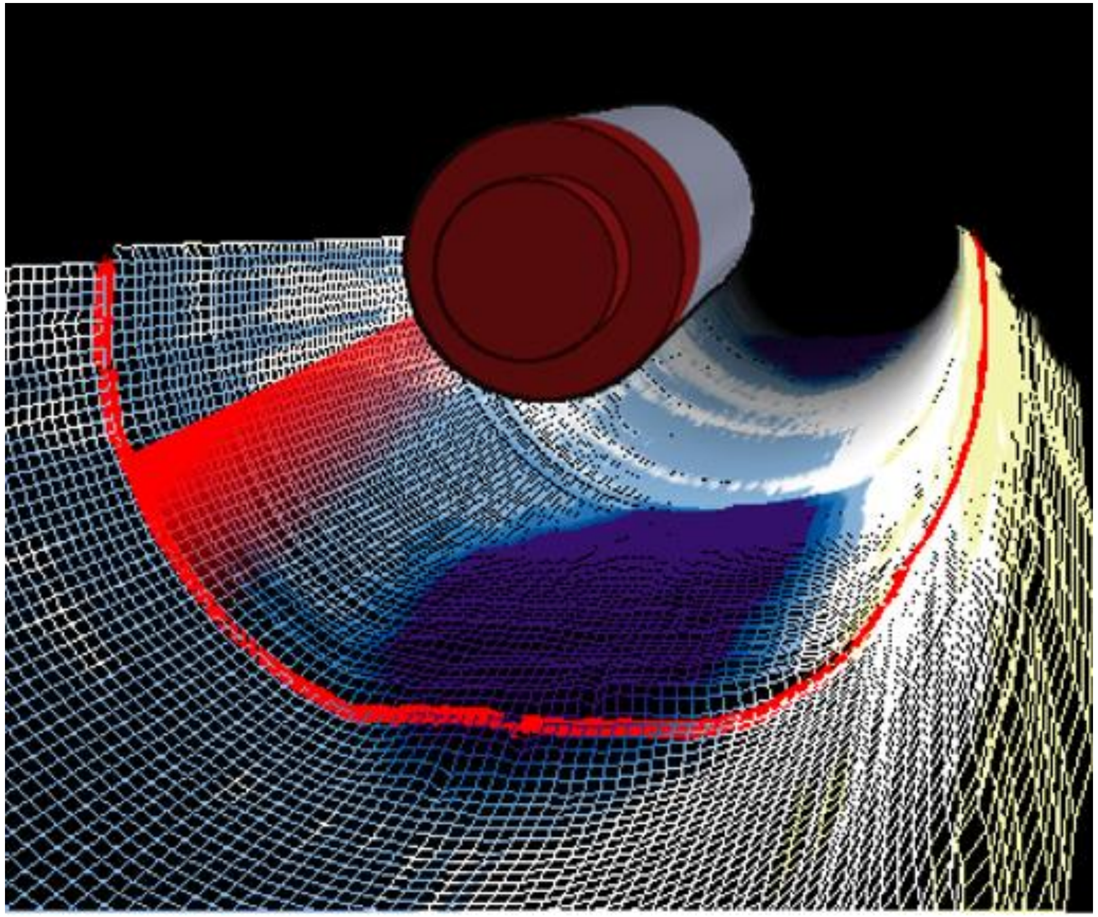
- The MSI Float uses 3-D LiDAR, sonar, and high-definition CCTV to collect quantitative data from pipes.
- LiDAR and sonar are used to construct a high-resolution 3-D point cloud representing the interior of the pipe above and below the flow line.




Distance: 25 m
Grid units: mm
Comments: General observation.
Note sedimentation.
Distance: 25-28.5 m
View from left side of pipe
Comments: Crack Longitudinal.
Distance: 35 m
Grid units: mm
Comments: General observation.
Distance [m]
Clock pos.
Distance: 20.1 m
Comments: General observation
Distance: 24.7 m
Comments: Crack Longitudinal.
Distance: 20-40 m
Comments: 3D projection of lidar and sonar data for this stretch of pipe. Note visible joints.
Legend
Variance from ideal pipe dimensions - 900mm
-100 -50 0 50 100 mm

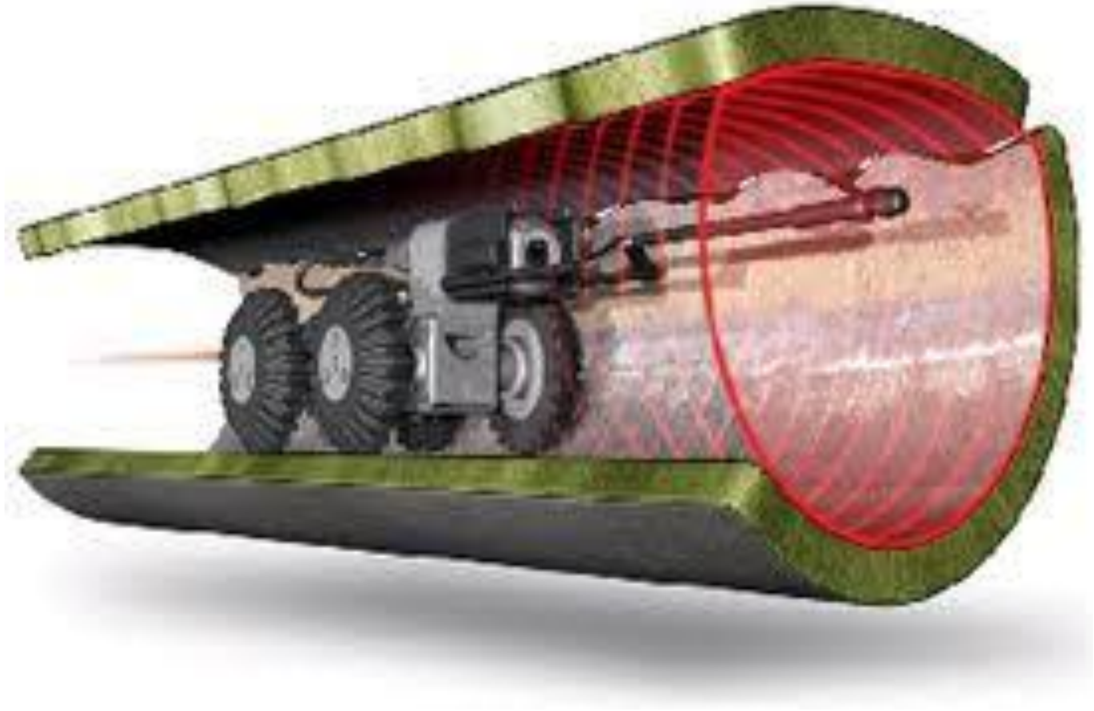
Sonar

- Uses sound waves with a specific frequency, pulse length, and beam width to image the floor underwater
- Emitted sound waves reflect back from the surface
- Presence of water is necessary
- Well understood, relatively uncomplicated

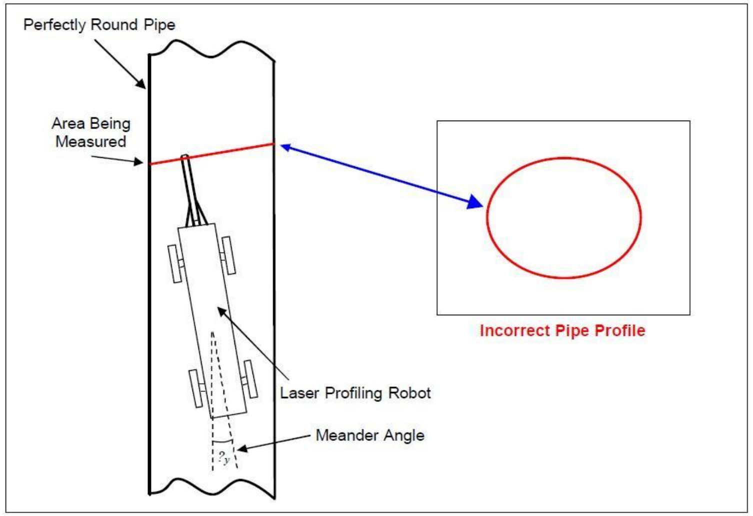


Laser Profiling

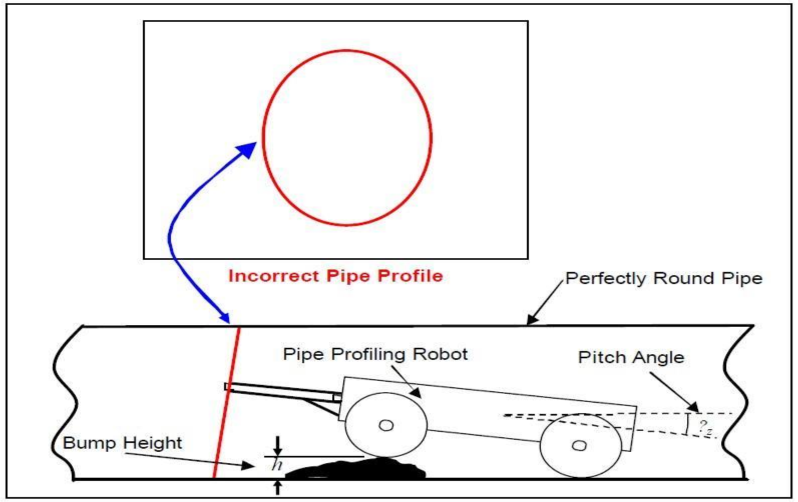
- Laser projects a ring of light against the
  interior wall
- Points on the laser ring imaged with a calibrated digital camera
- Distance is derived from the digital images by pixel counting and triangulation
- Assumes laser ring is perpendicular to pipe wall



Laser Profiling Errors



- Top view of robot meanders, and results in erroneous ovality
- Side view of robot on bump or offset joint
- Depth measurements are not accurate if the incident light wave is not perpendicular to the surface (most ring lasers)
- Andy Dettmer, PhD



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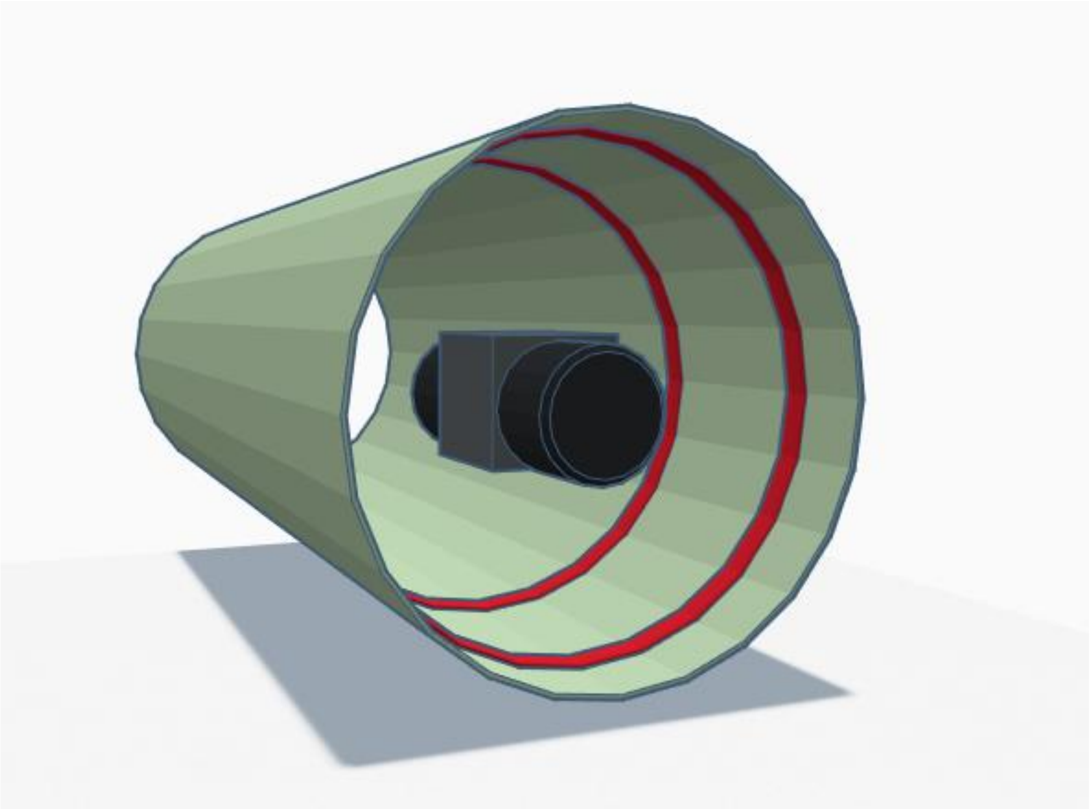
LiDAR and Laser

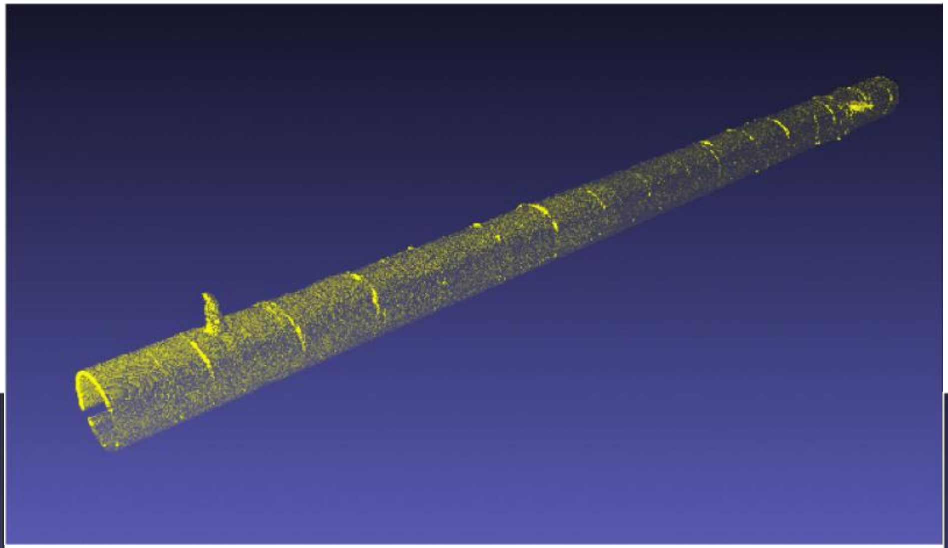
- Relatively new, less understood
- Ring laser (a.k.a. Laser Profiling)
- LiDAR
- 3D LiDAR

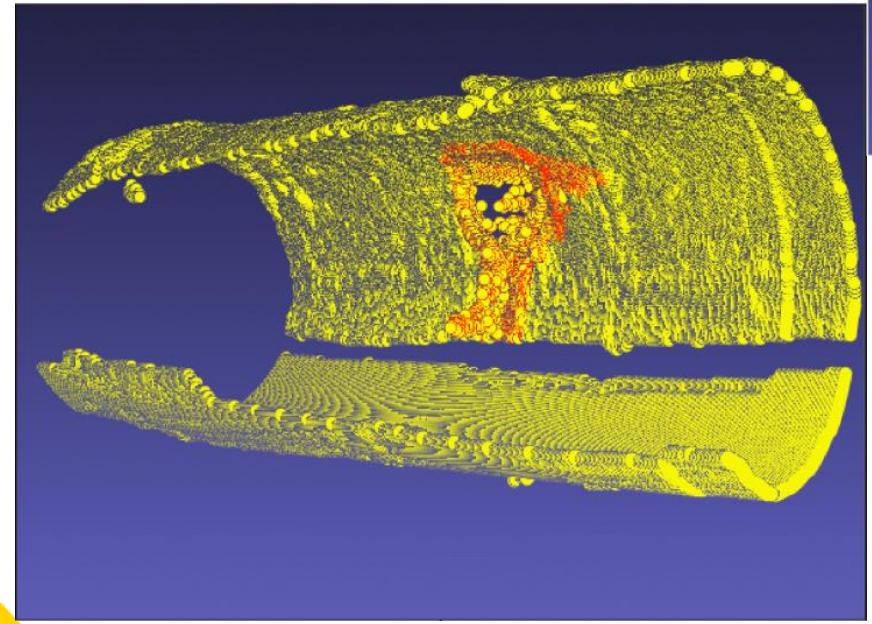


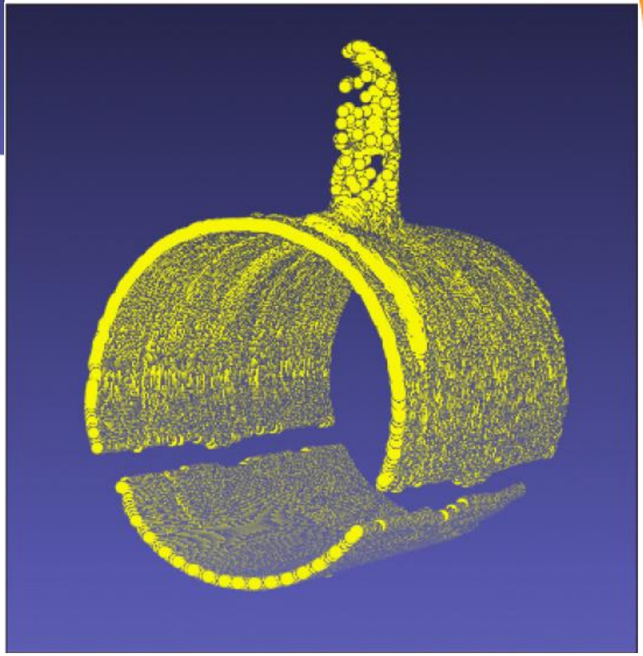
LiDAR and 3D LiDAR

- **Li**ght + RA**DAR** = LiDAR
- Scanning laser moves back and forth in a single pane
- Illuminates a target with a laser and analyzes the reflected light
- Distance determined from “time of flight”
- High accuracy, increases with pipe size

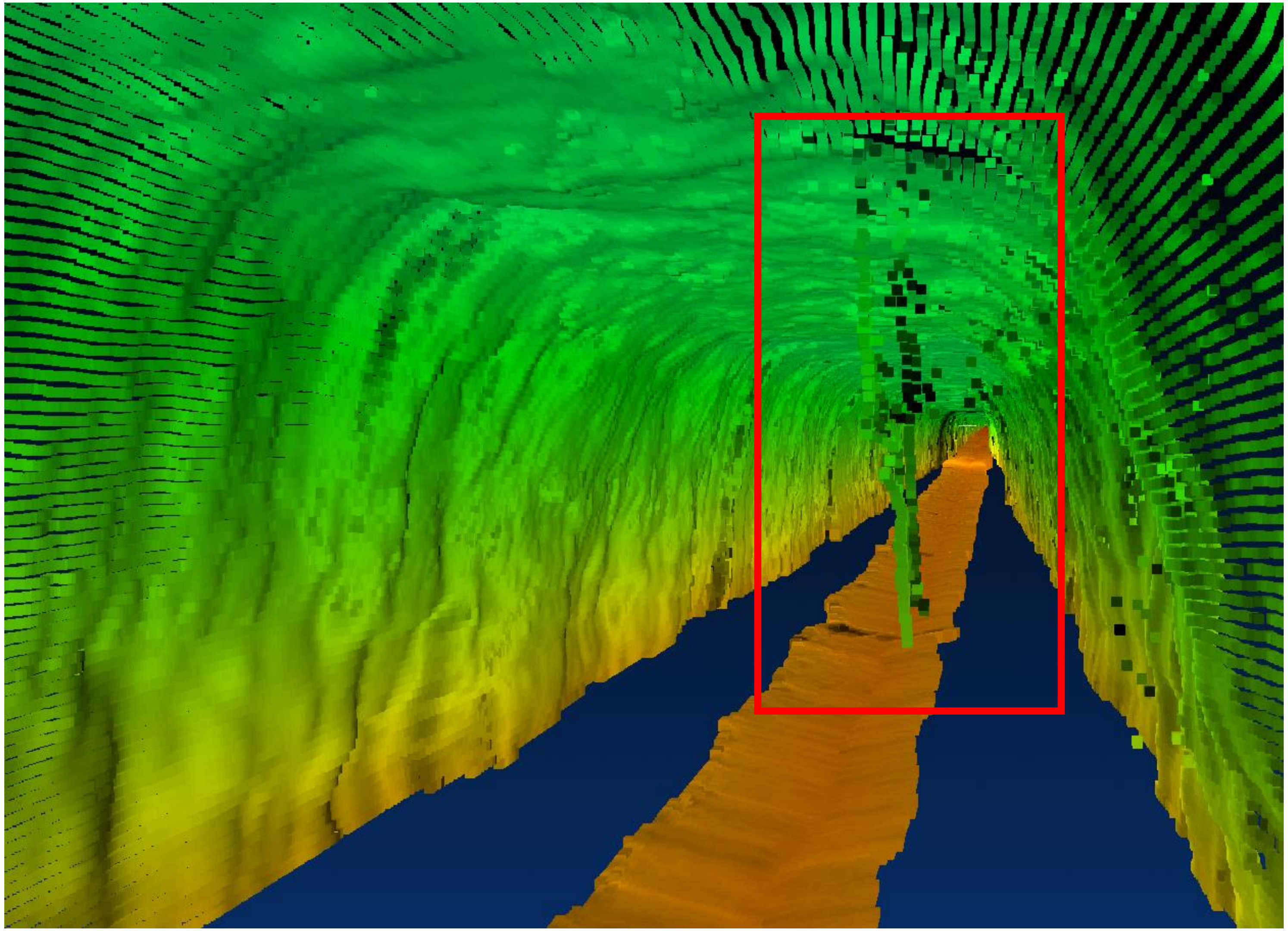
LiDAR and 3D LiDAR







LiDAR and 3D LiDAR



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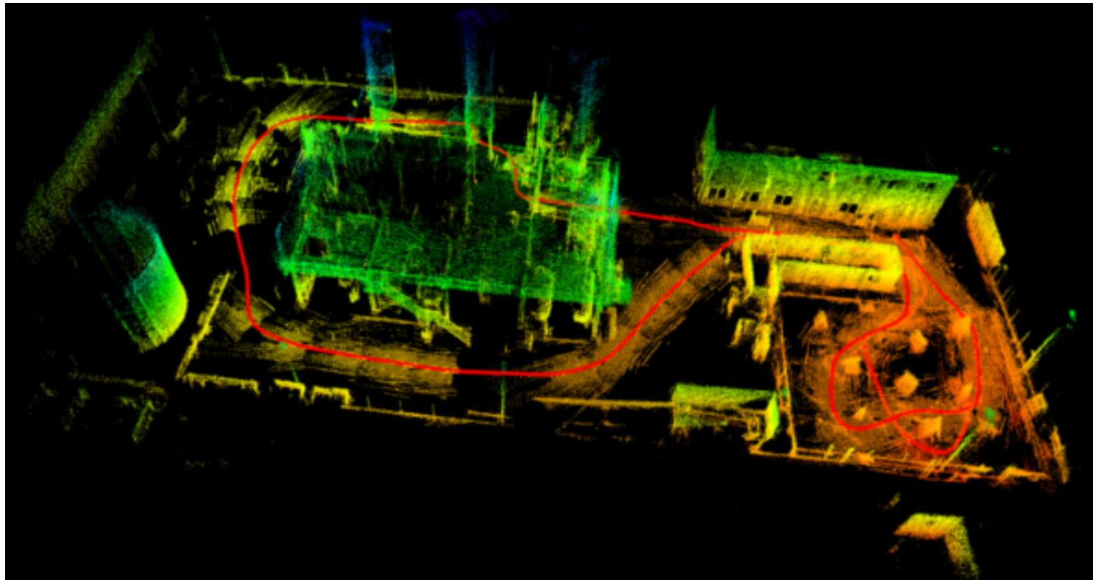
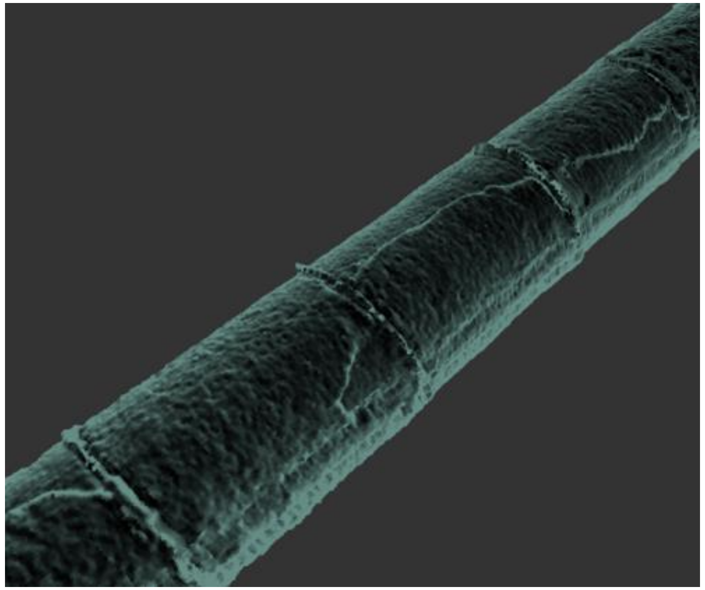
SLAM Algorithms

- **Simultaneous Localization And Mapping**
- Instantaneous point clouds
- Automated reporting
- Accuracy and repeatability issues…. for now.



The Technology

- Dedicated software will combine 3D LiDAR sonar and CCTV data to create a detailed, sub cm accurate x,y,z point cloud.
- The resulting point cloud allows municipal engineers to quantify important features such as cracks, sags, ovality and sediment volume.
- Accurate survey results will be instrumental in designing rehabilitation and/or maintenance plans.



How LIFT can help?

- The first step in adopting multi-sensor inspections with the MPIS Float is to work with SewerVUE on a pilot scale inspection project. The pilot work would be done by SewerVUE technicians.
- The first step is to identify a pipe or pipes that would benefit from a multi-sensor inspection. A total scope of 2-5 km of pipe is ideal for a pilot project. A line that is mostly straight with easy access can keep the cost of the pilot down, but more complicated lines are possible too. It is also possible to include multiple lines in the pilot.
- Upon completion of the inspection work, SewerVUE will deliver a full MSI report of the inspected lines. By selecting a line that is of particular interest to the owner, more meaningful assessment of the results of advanced multi-sensor surveying is possible.

Nicholas Goertz

e: n.goertz@sewervue.com

p: 604-421-0600

A joint initiative of:

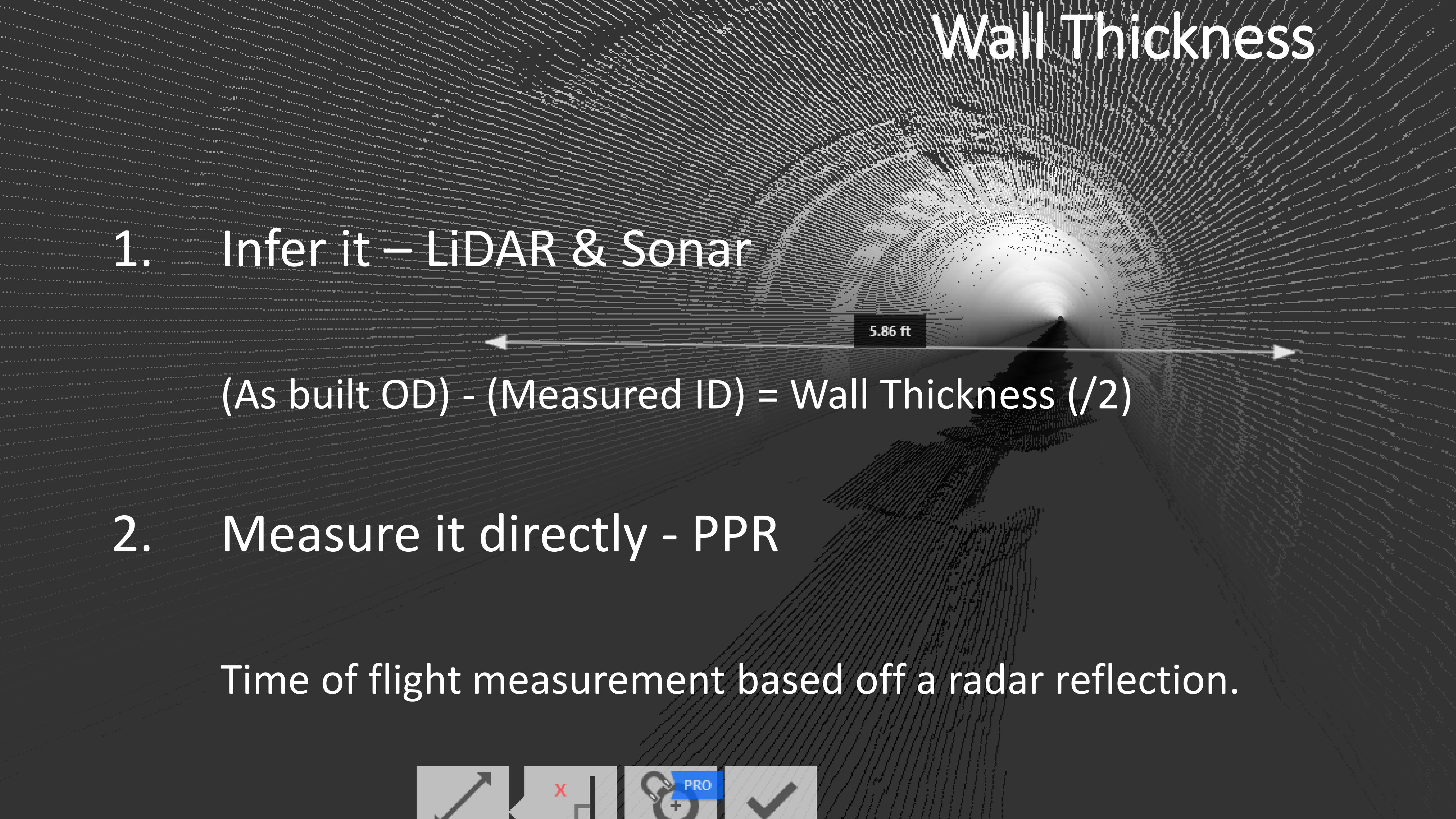
Wall Thickness

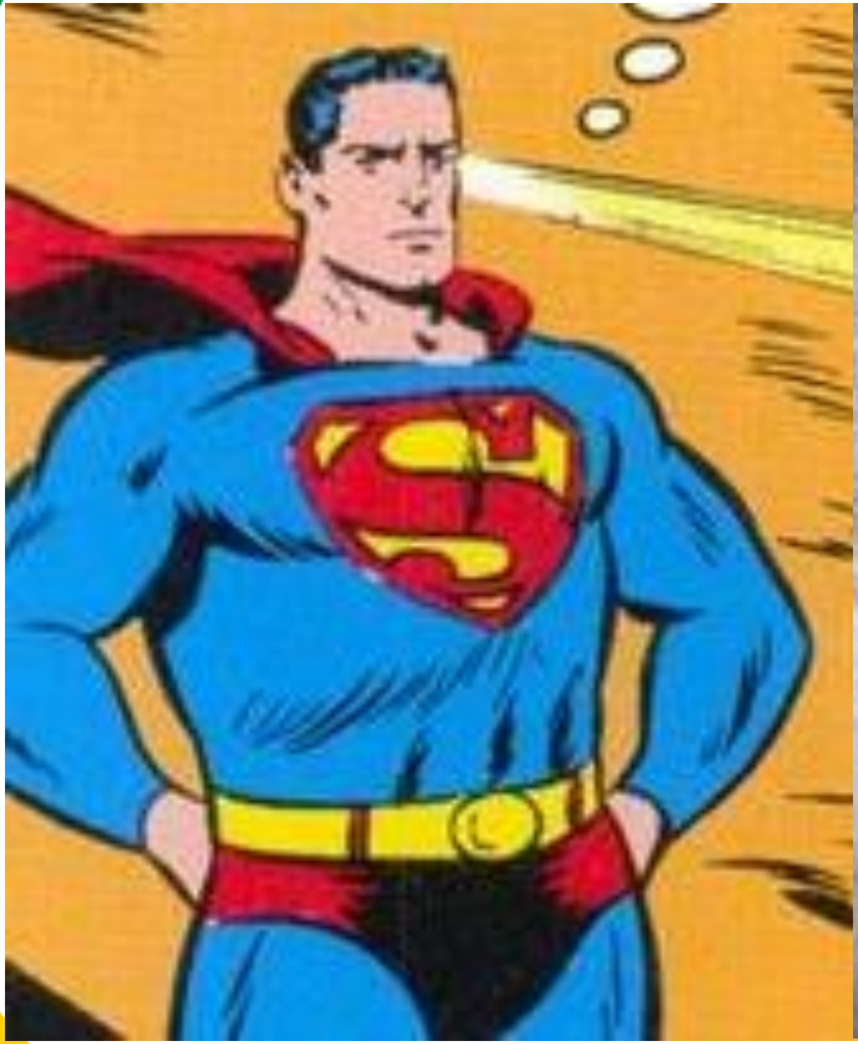
1. Infer it – LiDAR & Sonar

(As built OD) - (Measured ID) = Wall Thickness (/2)

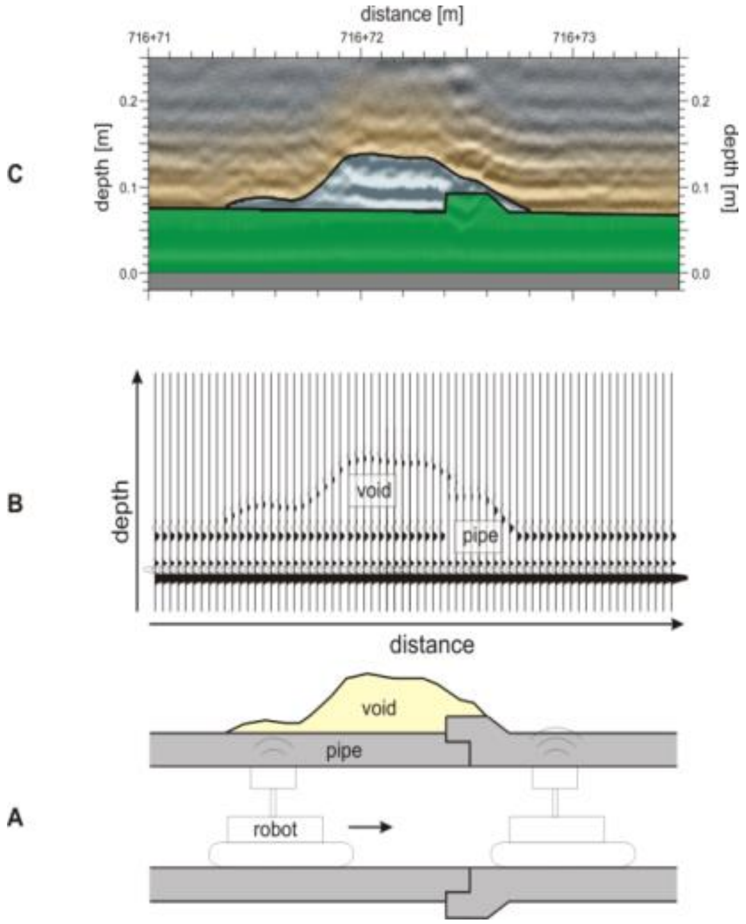
2. Measure it directly - PPR

Time of flight measurement based off a radar reflection.



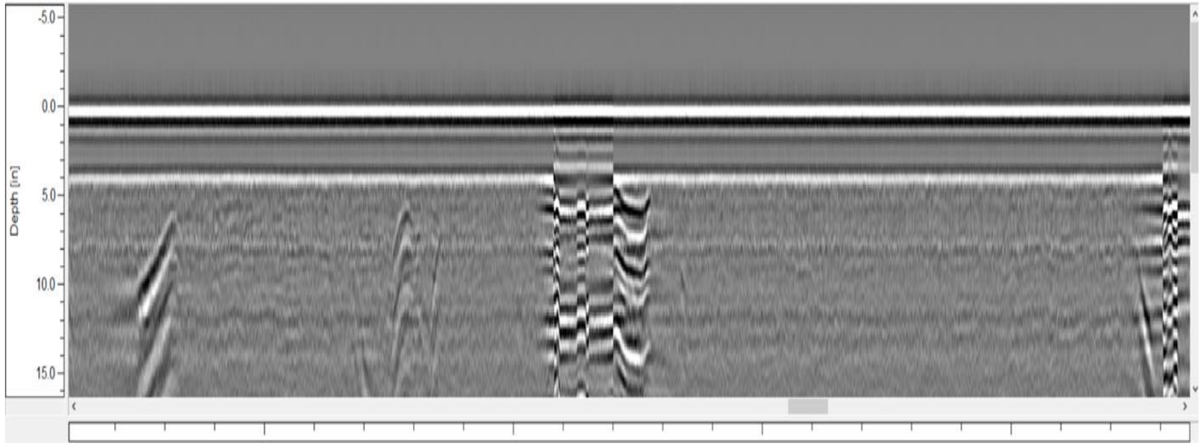


PPR Principle



- Ideal for non-metallic gravity sewer and water pipes. (RCP, HDPE, BWK, VCP, ACP!)
- Uses high frequency EM wave
- Antennas make direct contact with pipe wall.
- Measures remaining wall thickness and detects voids developing on the outside of the pipe.

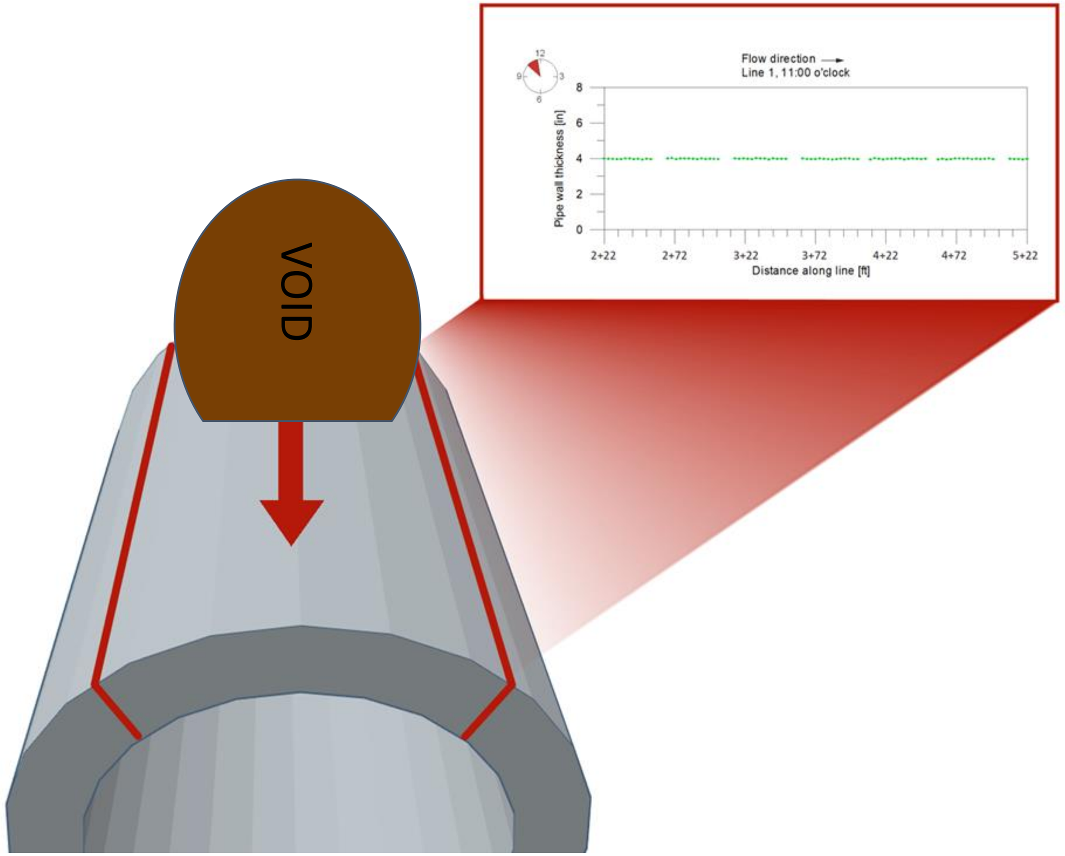
PPR Basic Concepts



- EM waves travel at different speeds through different mediums
- A value is assigned to these mediums to represent this difference in velocity, the “dielectric constant.”
- When EM waves encounter an interface between different materials, a portion of the wave is refracted, diffracted, and reflected

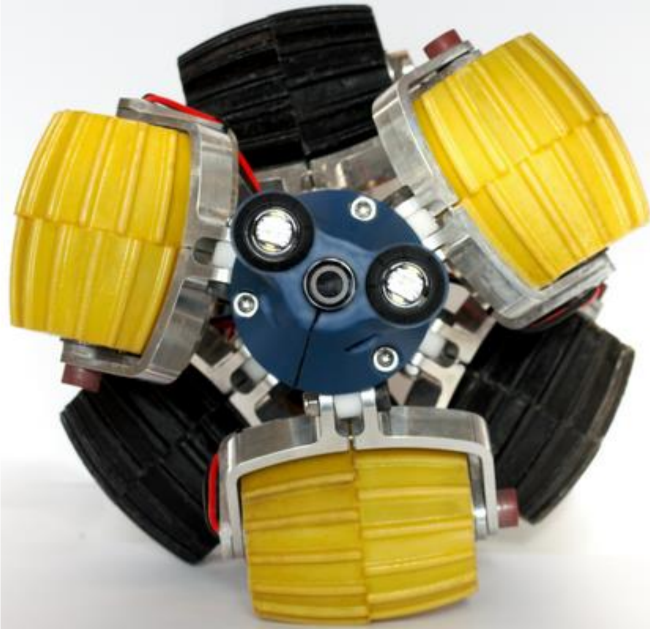
PPR Basic Concepts

- Reflected waves are detected by the receiving antenna and recorded as a single trace (A-scan)
- Process is repeated continuously to build a profile (B-scan) of the entire survey line
- Processed data reveals wall thickness, rebar depth, and voids



Okay… so how do you deploy these sensors?

PPR Deployment



Ideal for 10”-18”

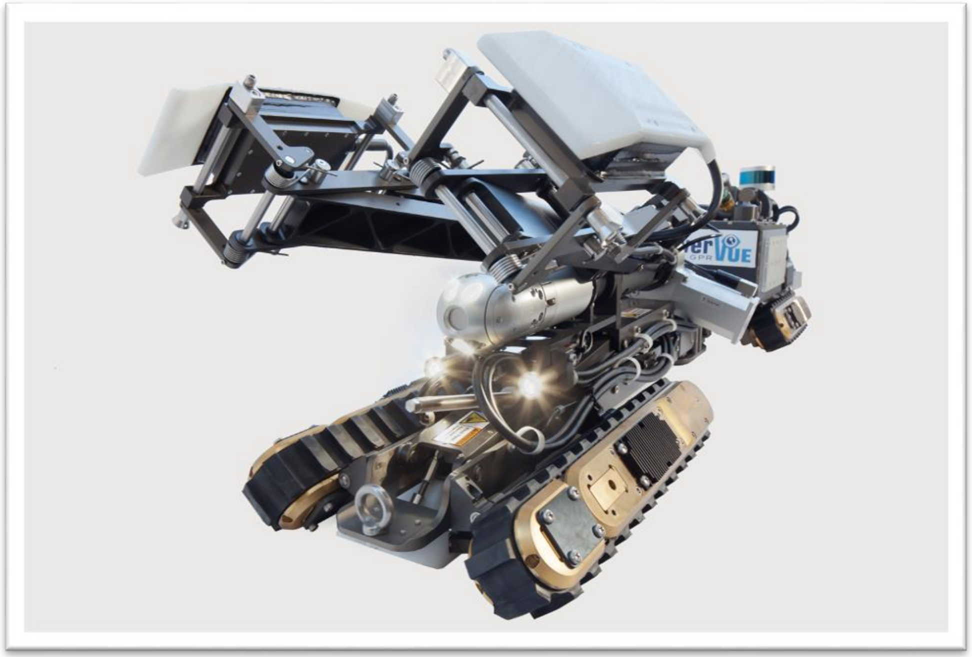
Ideal for 21”-42”

Ideal for 48”+

Man Entry Inspection

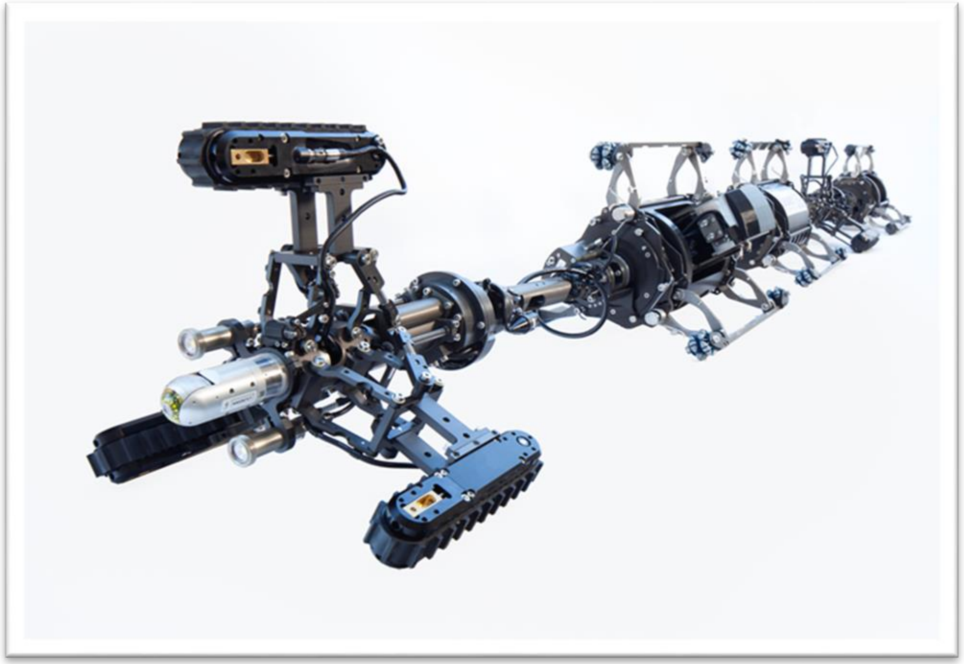
- **Pros**:
  - Used for large diameter pipes, where manned entry is safe.
  - Flexible data collection
  - Speed
- **Cons**:
  - Risk of confined space entry
  - Flow
  - Pipe size (e.g. < 48 inch)

4th Generation Surveyor

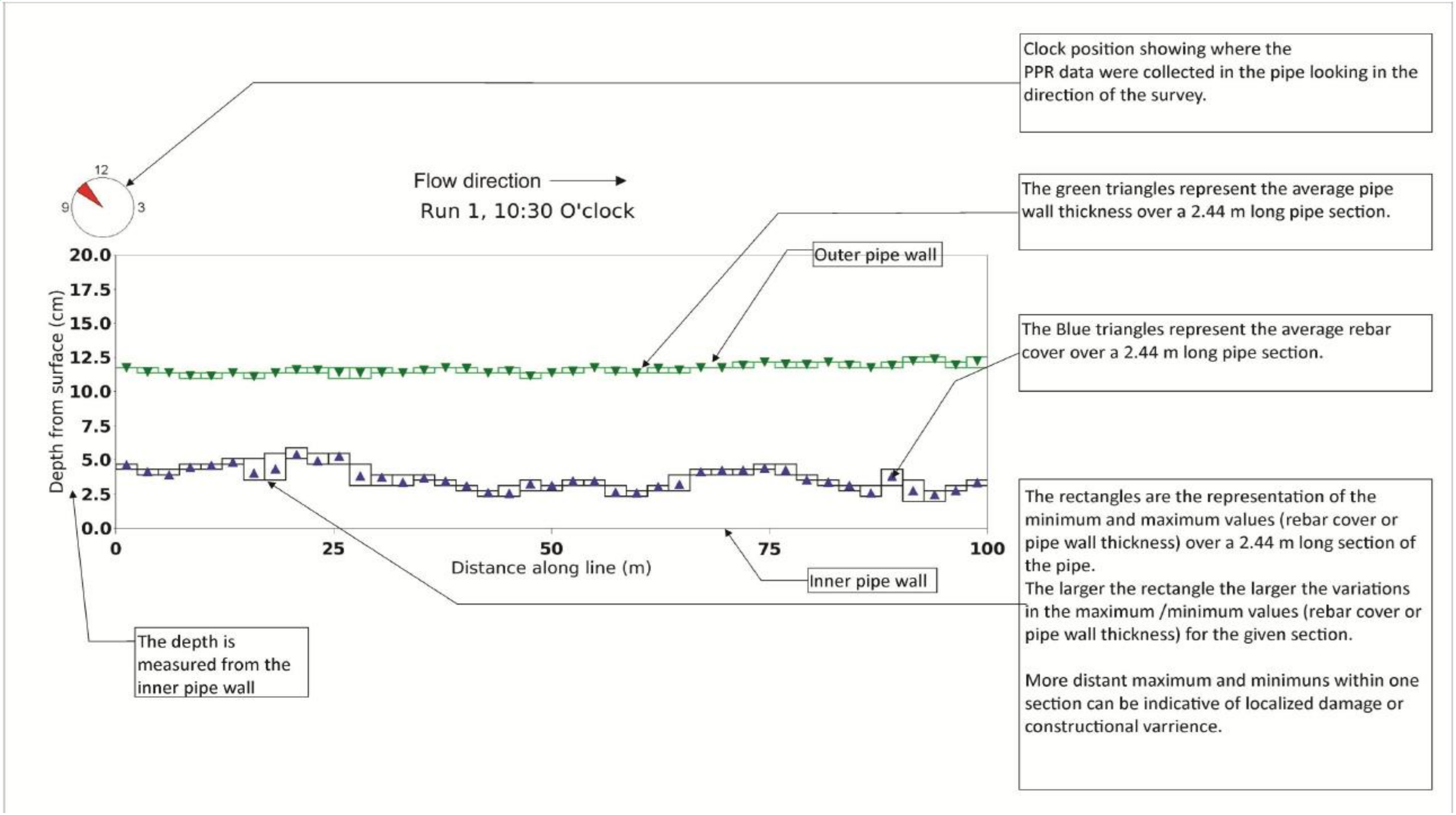


- Ideal for 21”-48” pipes
- PPR
- LiDAR
- CCTV

Asbestos Cement Pipe Scanner



- Ideal for 10”-18” pipes
- CCTV
- PPR



Clock position showing where the PPR data were collected in the pipe looking in the direction of the survey.
12
9
3
Flow direction
Run 1, 10:30 O'clock
The green triangles represent the average pipe wall thickness over a 2.44 m long pipe section.
Outer pipe wall
The Blue triangles represent the average rebar cover over a 2.44 m long pipe section.
Depth from surface (cm)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0
25
50
75
100
Distance along line (m)
Inner pipe wall
The rectangles are the representation of the minimum and maximum values (rebar cover or pipe wall thickness) over a 2.44 m long section of the pipe.
The larger the rectangle the larger the variations in the maximum /minimum values (rebar cover or pipe wall thickness) for the given section.
More distant maximum and minimuns within one section can be indicative of localized damage or constructional varrience.
The depth is measured from the inner pipe wall

Asbestos Cement Pipe

Numerous studies have attempted to develop mathematical models for predicting useful life of AC pipe based on factors such as age, date of installation, and pipe classification.

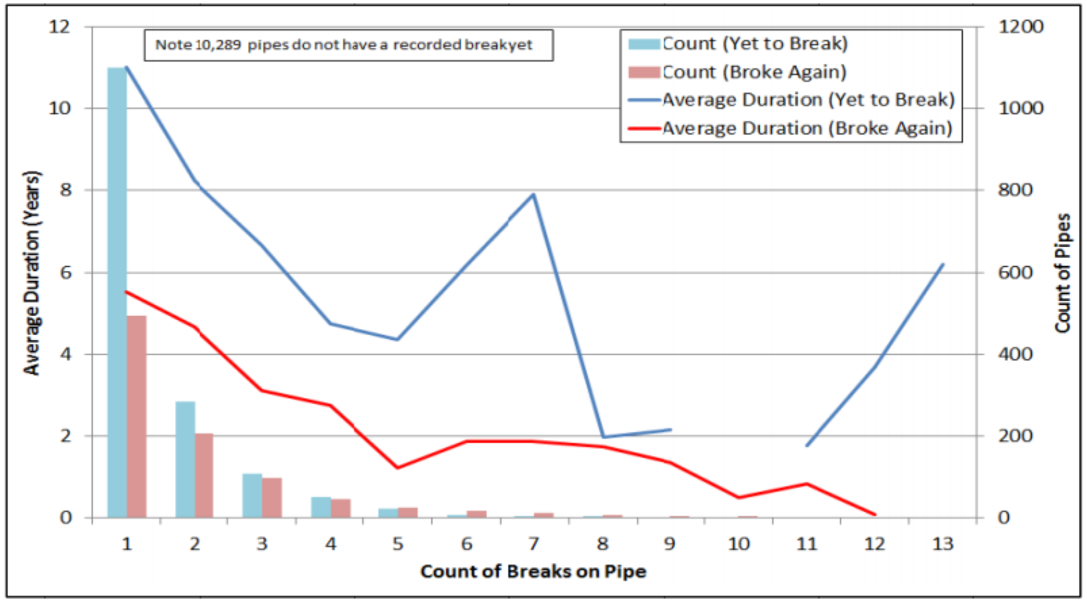
Strategic Management of AC Pipe in Water Systems	*Development of an Effective Management Strategy for Asbestos Cement Pipe*	*Prediction of Asbestos Cement Water Pipe Ageing and Pipe Prioritization using Monte Carlo Simulation*
D. Spencer; M. Walis; X. Irias; C. Dodge; R. Sakaji; R. Bueno; D. Ellison; and G. Bell, Pipelines 2015 .	D. Spencer; D. Ellison; G. Bell; S. Reiber; K. Von Aspern; and V. Snoeyink, Water Research Foundation.	Punurai and Davis, Engineering Journal vol. 21, issue 2.
2015	2015	2017

Localized factors such as soil pH, system pressure, and soil shrink-swell cycles, etc. limit their effectiveness.

Asbestos Cement Pipe

- Metrics like past breaks, pipe class (I or II), and diameter could be somewhat predictive of future breaks.

- But only after the pipe has started to exhibit failure…



LIFT

THE Water Research FOUNDATION

Water Environment Federation
the water quality people

Asbestos Cement Pipe

- AC pipes have two main modes of failure:
- Circumferential failure due to mechanical loading
- Longitudinal failure due to material corrosion
- Longitudinal failures (delamination, pockmarking, etc.) occur in 80% of burst AC pipes.

Delaminated areas of AC pipe

Pockmarking

Delamination

LIFT

THE Water Research FOUNDATION

Water Environment Federation the water quality people

How LIFT can help?

- Point us in the direction of your problem pipes.
  - Find a long straight section of pipe (cheap mob)
  - Ideally of significant interest (more value to you)

- Start pilot project and talk next steps with the “good stuff” in hand.

LIFT

QUESTIONS?

SewerVUE
IN-PIPE GPR

A joint initiative of:

THE Water Research FOUNDATION®

Water Environment Federation®
the water quality people®

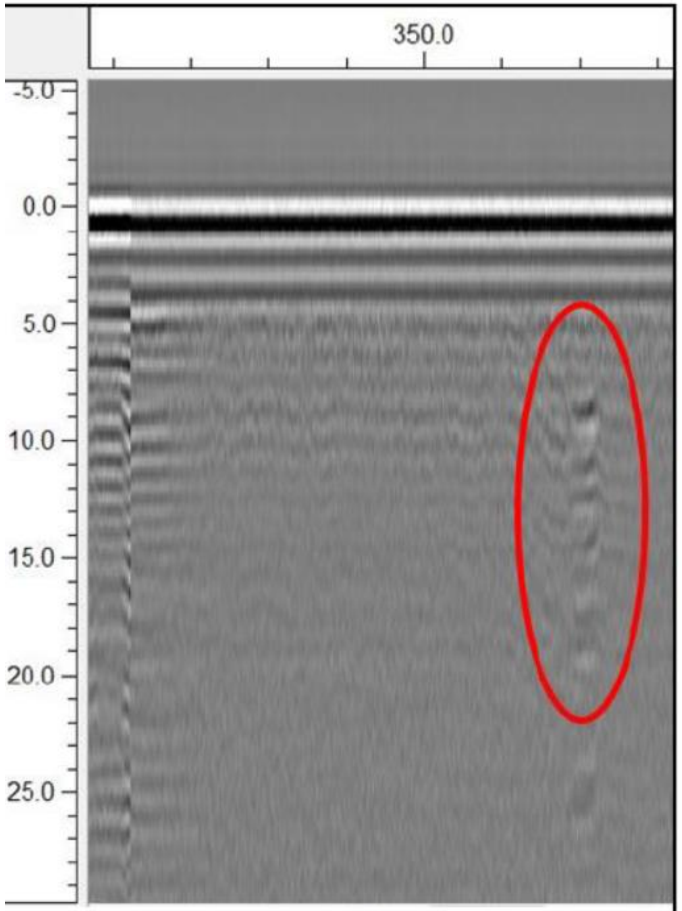


Figure 3: Potential void space.

Likely void space characteristics:
Strong reflection, low frequency multiples and polarity change.

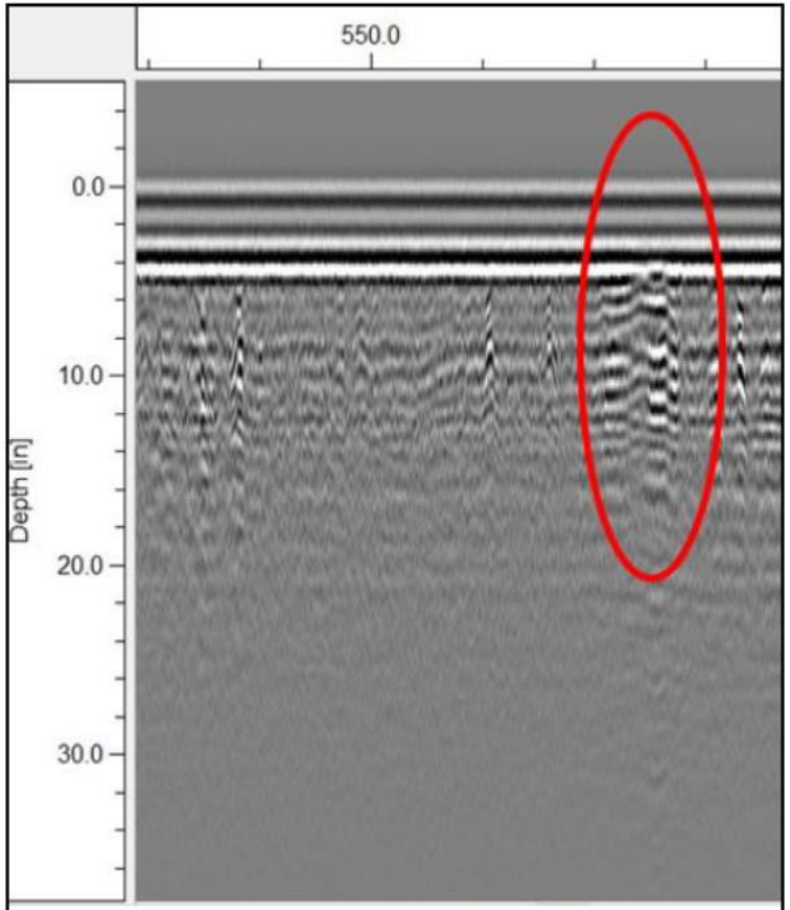


Figure 4: Likely void space.

Likely void space characteristics:
Visible polarity change with an amplitude increase that stands out from its surroundings.

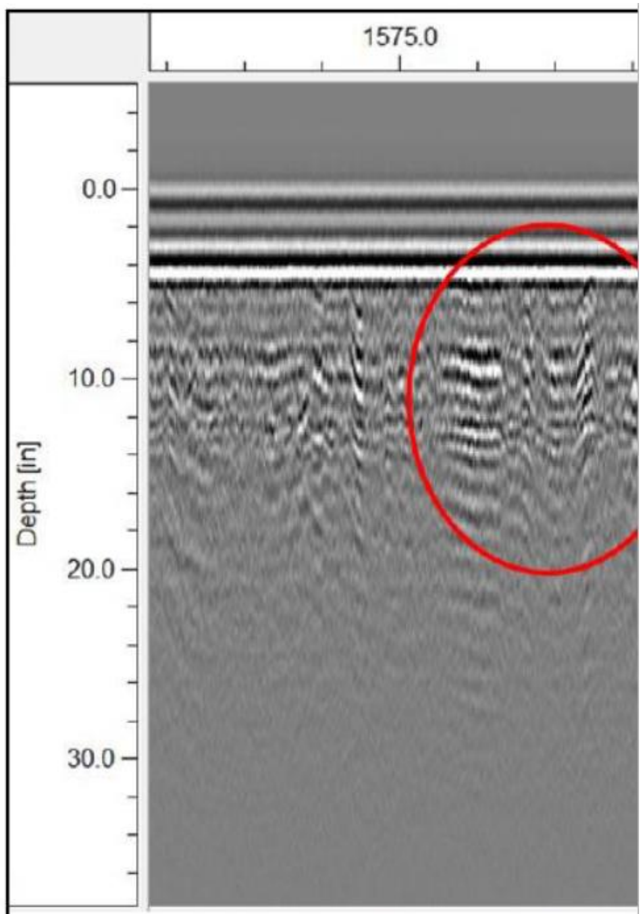


Figure 5: Increase of water content.

Water content increase characteristics:
Amplitude increase is a sign of potential increase in water content.

Thank You

- Aaron Fisher afisher@waterrf.org
- David Morroni dmorroni@waterrf.org

www.waterrf.org/lift

Leaders Innovation Forum for Technology

Webcast

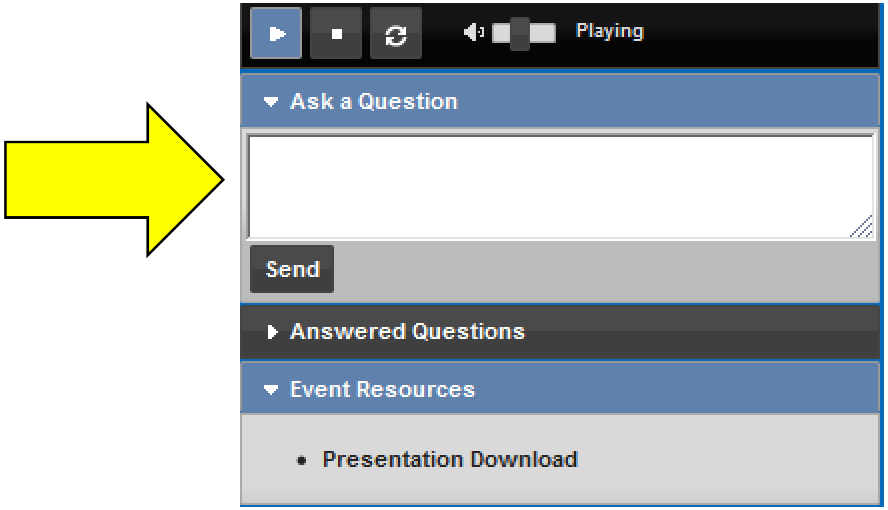
AMI Meter Data Analytics

September 29, 2020

Housekeeping Items

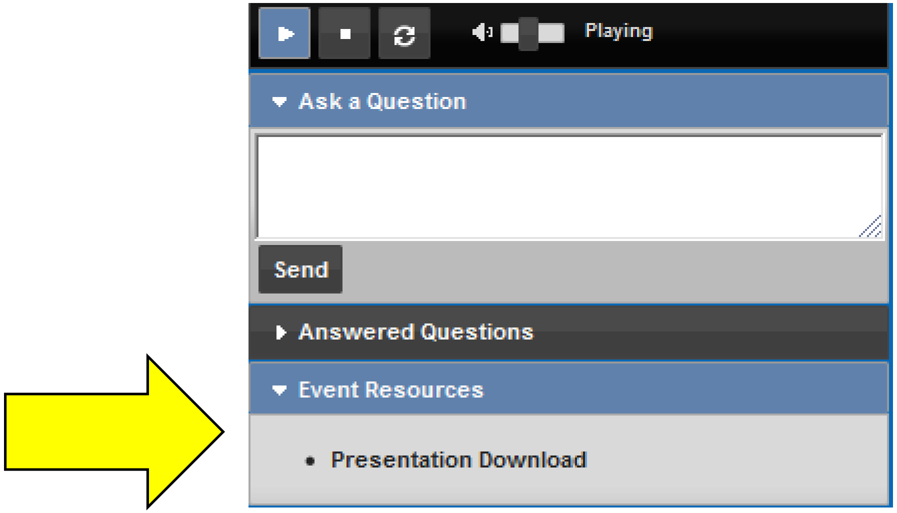
- Submit questions through the question box at any time! We will do a Q&A near the end of the webcast.
- Slides and a recording of the webcast will be available at www.waterrf.org.
- A certificate of completion will be generated after the webcast. Any questions, please contact msuazo@waterrf.org.
- Survey at the end of the webcast.

Input your webcast questions here



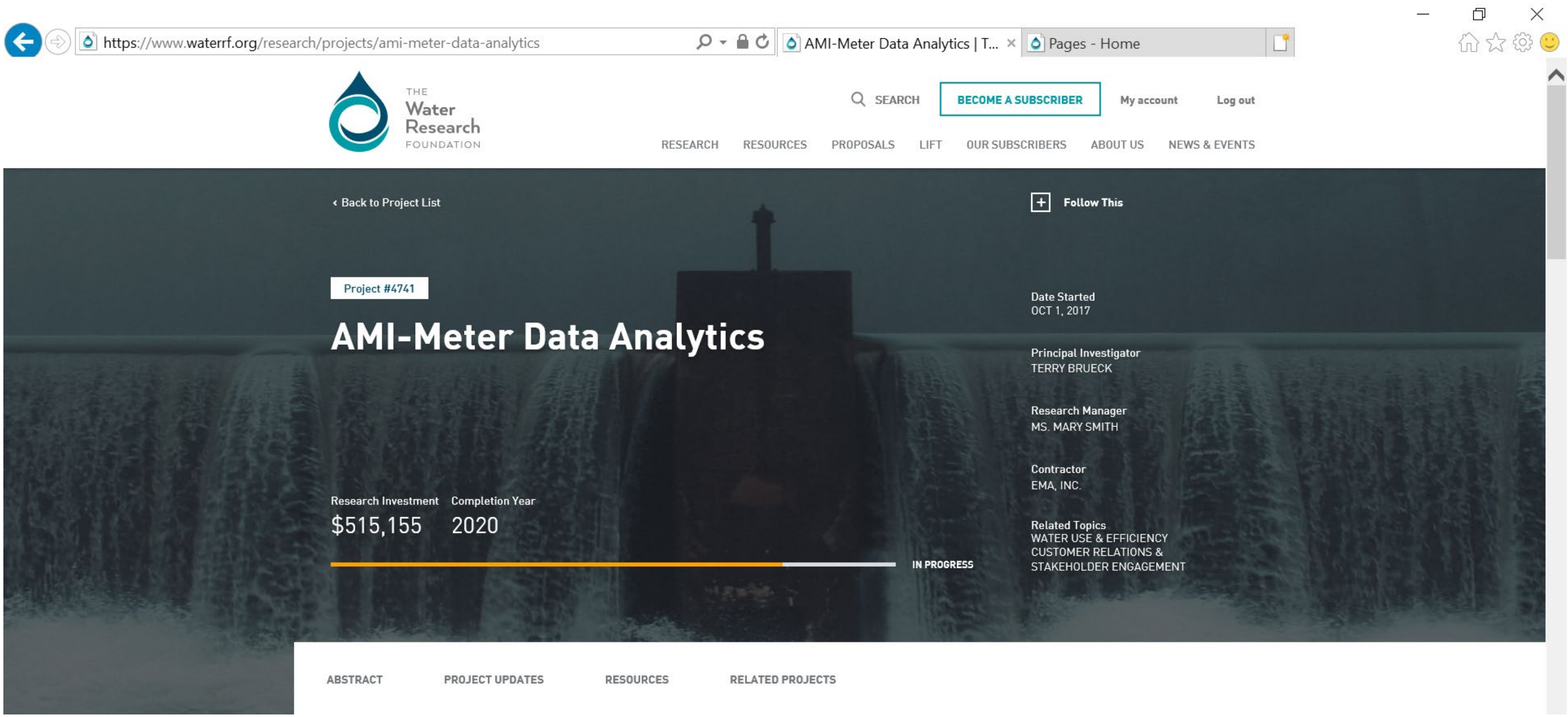
Q&A at end of webcast

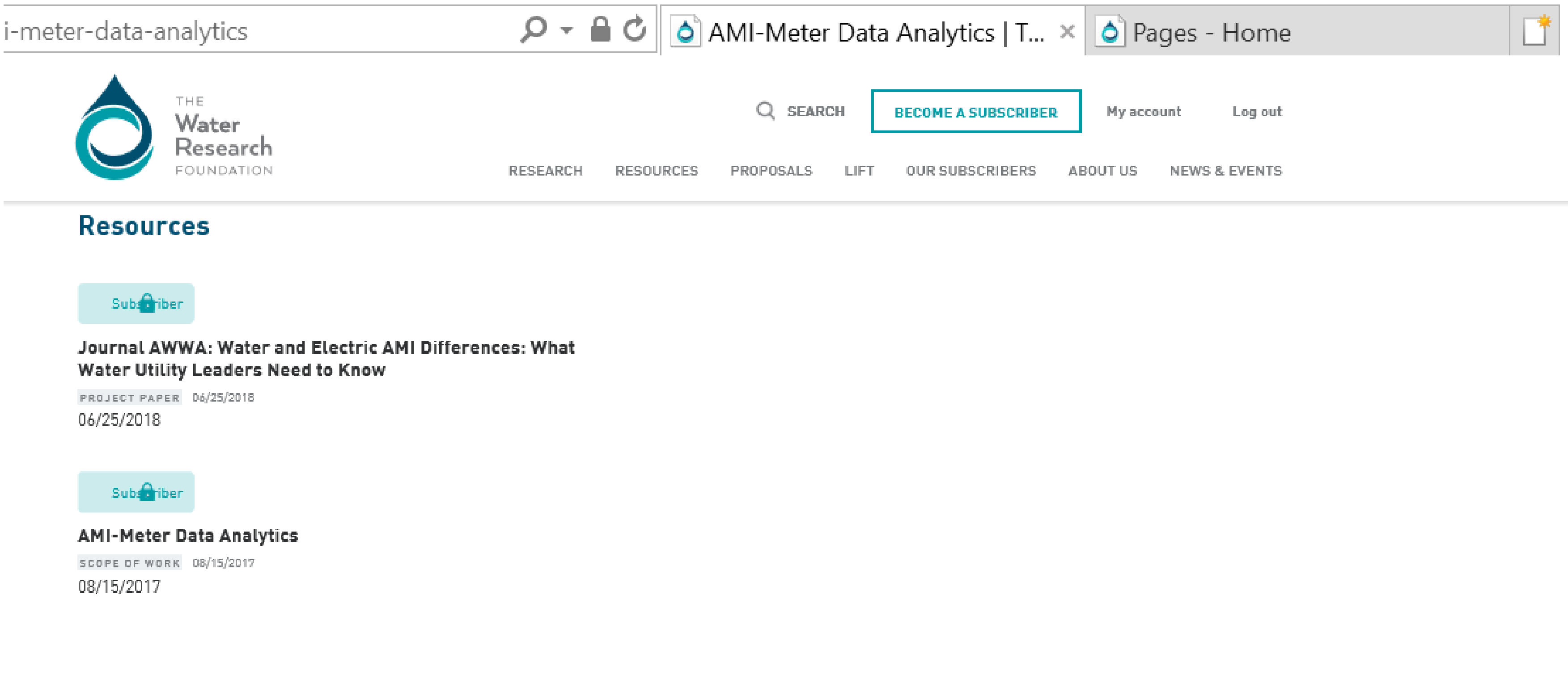
Download presentation



Slides and recording will be available within 24 hours after the webcast

Enter 4741 into Search Function

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SCOPE OF WORK 08/15/2017
08/15/2017

Terrance M. Brueck, CEO
EMA, Inc.

Webcast Agenda

1. Project Background and Research Approach
2. Utility Participant Practices and Examples
3. Meter Testing and Performance Analysis
4. Leading Practice Examples and Utility Recommendations
5. Additional Research and Use of Results

SECTION 1

Project Background and Research Approach

Project Purpose: Identify Leading Practices for Leveraging AMI* Data

1. **To improve interactions with utility customers**, including questions on billing, water use alerts, and customer information to enable changes in water use habits.
2. **To improve processes and accuracy of water accounting** for water audits and gain insights into apparent and real water losses including water theft (by meter tampering).
3. **To improve meter management practices**, including meter maintenance and replacement strategies based on actual meter performance and accuracy.

*Advanced Metering Infrastructure – meter reading via fixed-network radio, cellular, LoRa, etc., typically two-way communications.

WRF and EMA Project Team
(WRF Project #4741)

Water Research Foundation Project Manager
- Mary Smith

Principal Investigator, EMA
- Terry Brueck

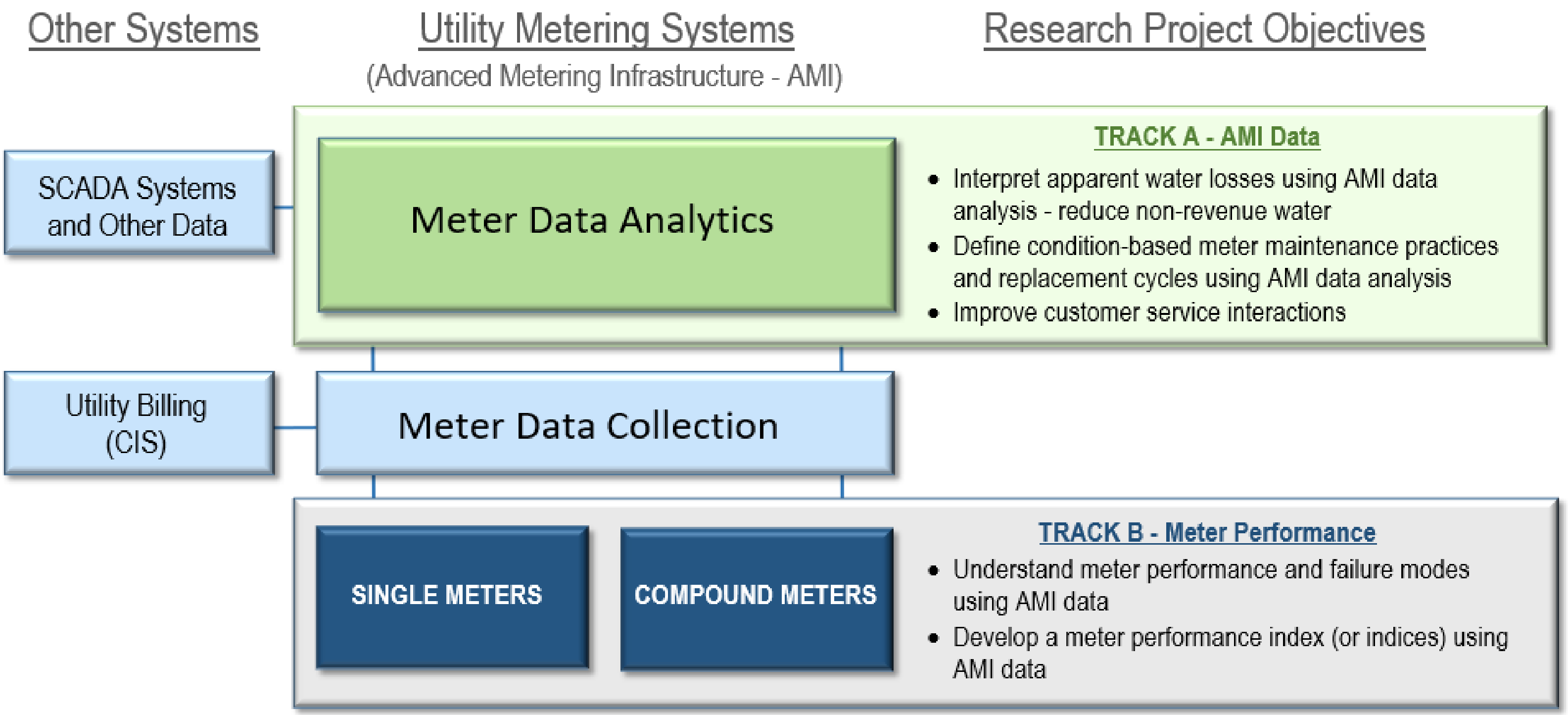
Research Track Leads, EMA
- Jon Varner, AMI Data
- Claude Williams, Meter Performance

Project Coordinator, EMA
- Penny Brink

Participating Utilities Included Years of AMI Meter Data Use

- Toronto Water (Sponsor)
- DC Water (Co-Sponsor)
- Albuquerque Bernalillo County Water Utility Authority
- City of Baltimore Department of Public Works
- Great Lakes Water Authority
- Suez NJ
- Toho Water Authority
- University of Florida (Program for Resource Efficient Communities – PREC)

Approach and Objectives Were Based on 2 Tracks of Research

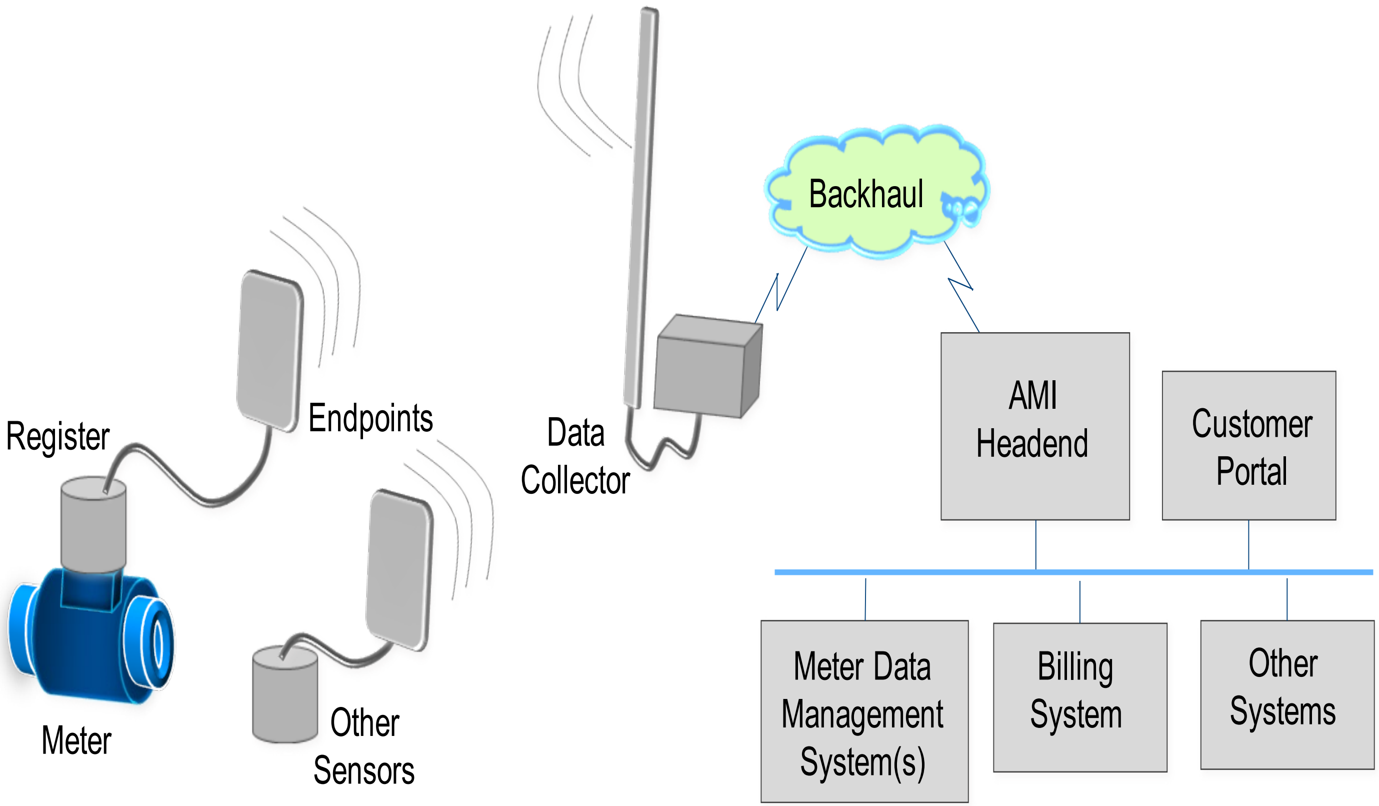


Approach Analyzed Existing AMI Data and Metering Practices

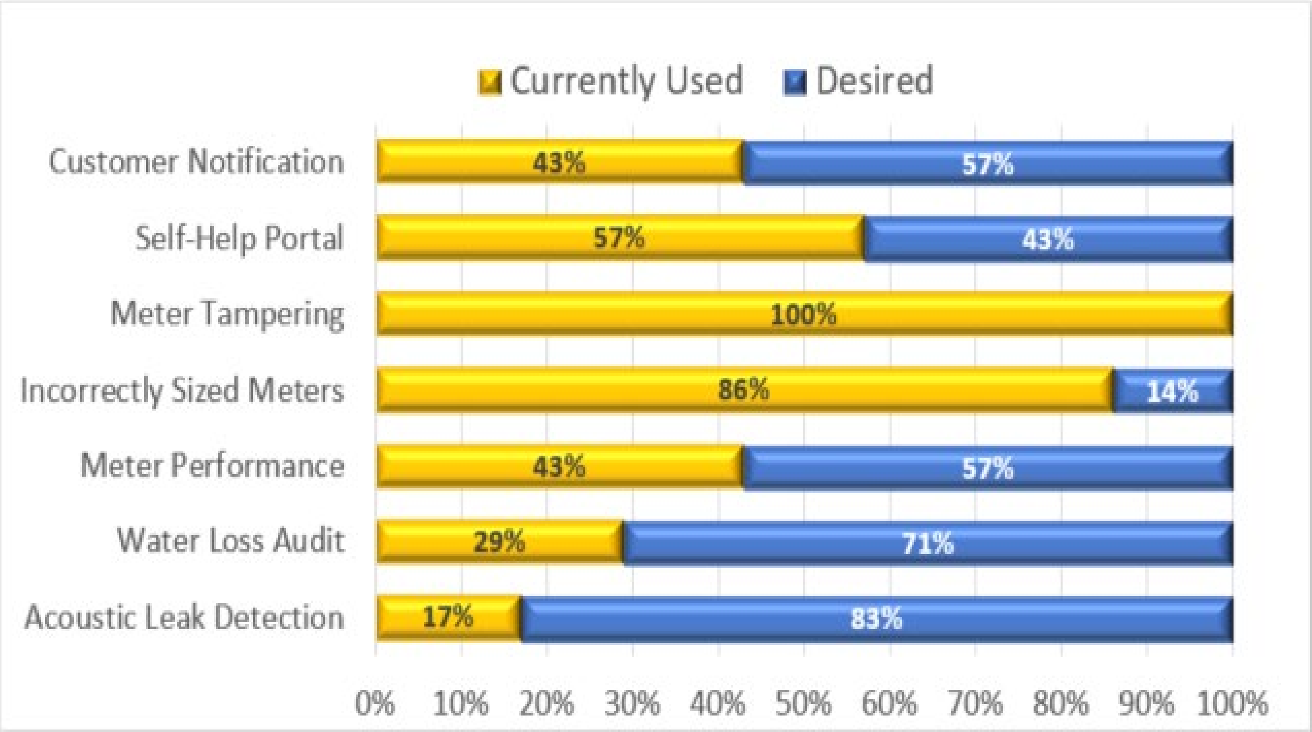
- Existing methods and leading practices were defined from utility use of AMI systems/data
- Meter test data was analyzed to correlate with AMI data using routine testing

Utility Participants Had Various AMI Technology and Meter Vendors

AMI Meter Data Included Hourly, 4-Hour, and 6-Hour Readings



Utilities Initially Defined "Currently Used" and "Desired" Practices



Customer Notification	• Notify customer of inside leaks (leaks downstream of their meter) - establish email/text alert notifications
Self-Help Portal	• Implement a self-help portal - show consumption (daily) with comparison to prior usage and/or typical usage
Meter Tampering	• Identify meter tampering / water theft
Incorrectly Sized Meters	• Identify incorrectly sized meters (including large meter mis-applied meter analysis
Meter Performance	• Use AMI data to determine when maintenance is required for a meter based on performance
Water Loss Audit	• Improve Water Loss Audit processes using Daily and Monthly Consumption Quantification
Accoustic Leak Detection	• Accoustic Leak Detection (in distribution system)

Track A Defined Utility Participant Use of AMI Data and Analytics

Surveys and Case Studies included:

1. Customer interactions
2. Water Accounting
3. Meter Management

Track B Analyzed Meter Testing to Correlate with AMI Data

Selected Sizes/Types – Single and Compound

- Gather AMI data: meter readings at the lowest available time frequency
- Gather background data for the meter including meter size, meter type, meter manufacturer, installation date, dates of meter rollover
- Measure meter accuracy on certified test benches following AWWA standard procedures (M6)
- Assess meter condition and test data

SECTION 2

Utility Participant Practices and Examples

Utility Practices Use AMI Data For Customer Interactions

● SIGNIFICANT PRACTICE ○ SOME/LIMITED PRACTICE

Report Section	Topic	Utility: Albuquerque Bernalillo County Water Utility Authority	City of Baltimore Department of Public Works	DC Water	Great Lakes Water Authority	Suez NJ	Toho Water Authority	Toronto Water
CUSTOMER INTERACTIONS								
4.4.1	Water Usage Alerts	●		●	●	●	●	●
4.4.2	Customer Inquiry Support	●	●	●	●	●	●	●
4.4.3	On-Site Service Dispatch	●		●	●	●	●	●
4.4.4	Water Conservation	●		○		●	●	○
4.4.5	Conservation Mandates						●	
4.4.6	Leak Detection	●	○	○		○	○	●
4.4.7	Water Usage Information for Customers	●	●	●	●	●	●	●
4.4.8	Bill Accuracy	●	●	●	●	●	●	●
4.4.9	Reducing High Bill Complaints	●	●	●	●	●	●	●

AMI Data and Analytics For Customer Interactions

- Improve response to customer inquiries about water usage and billing
- Proactively notify customer of high consumption / leaks
- Help customers comply with water conservation policies

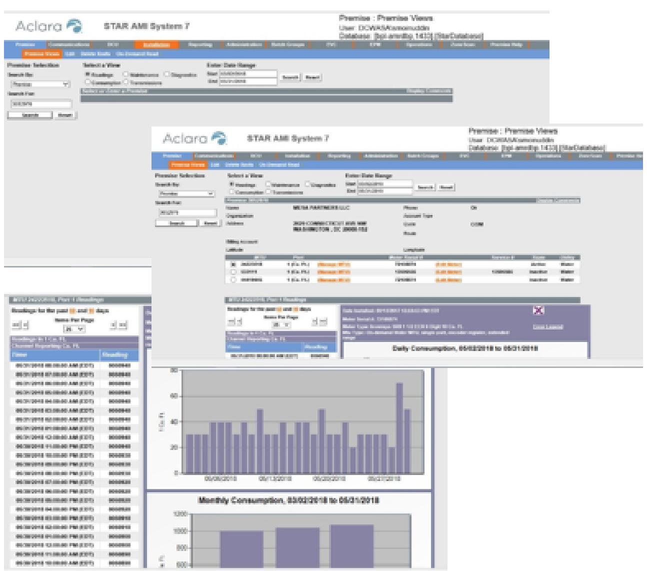
DC Water Leverages Customer Portal System to Notify Customer of High-Usage

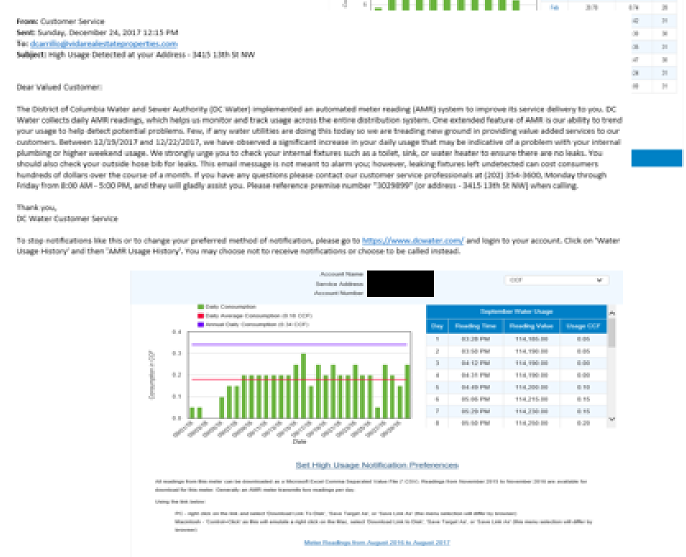
dc water is life

HUNA

DC Water's High Usage Notification Application (HUNA) leverages AMI data to enhance the customer experience. Usage can be viewed hourly, daily or month and download detailed read data for offline analysis. Customers can also compare their usage against their neighbors (on the block, zip code or ward) or the entire rate class.

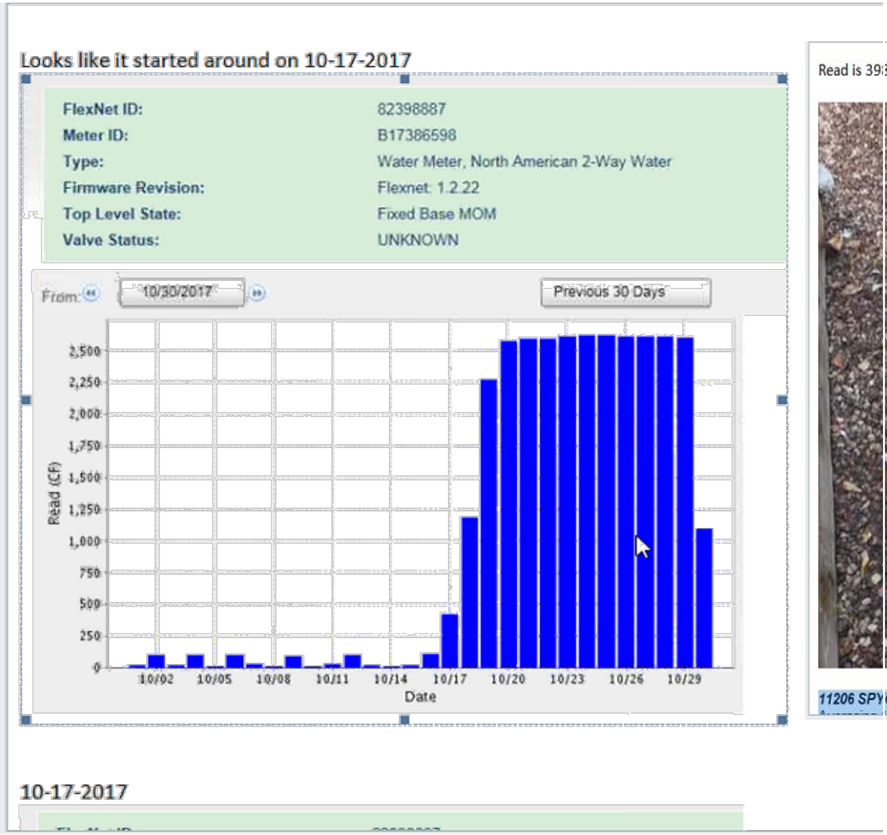
HUNA also analyzes new reads as they are collected against individual customer historical usage patterns and if it detects high usage conditions it will call, text and/or email customers an alert. Customers can set their own usage thresholds and can set up to 4 text, phone and/or email addresses to be notified when usage anomalies are detected. This is especially useful for rental properties when an owner, tenant and/or management company needs to be contacted.



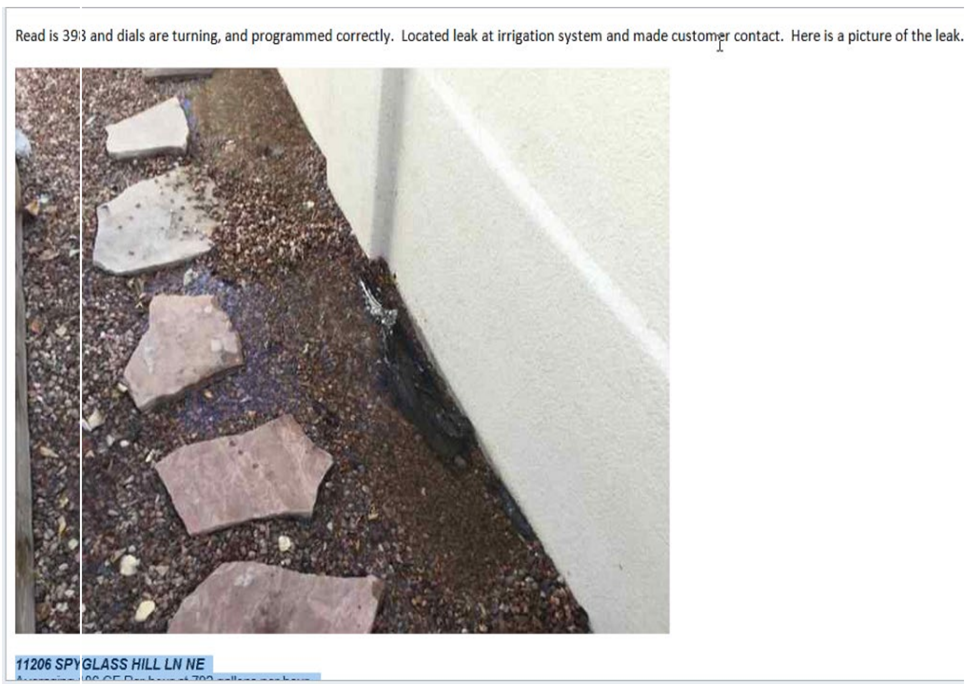


AMI Data Identifies Customer Leaks More Quickly in Albuquerque

AMI report suggested a large (continuous) leak



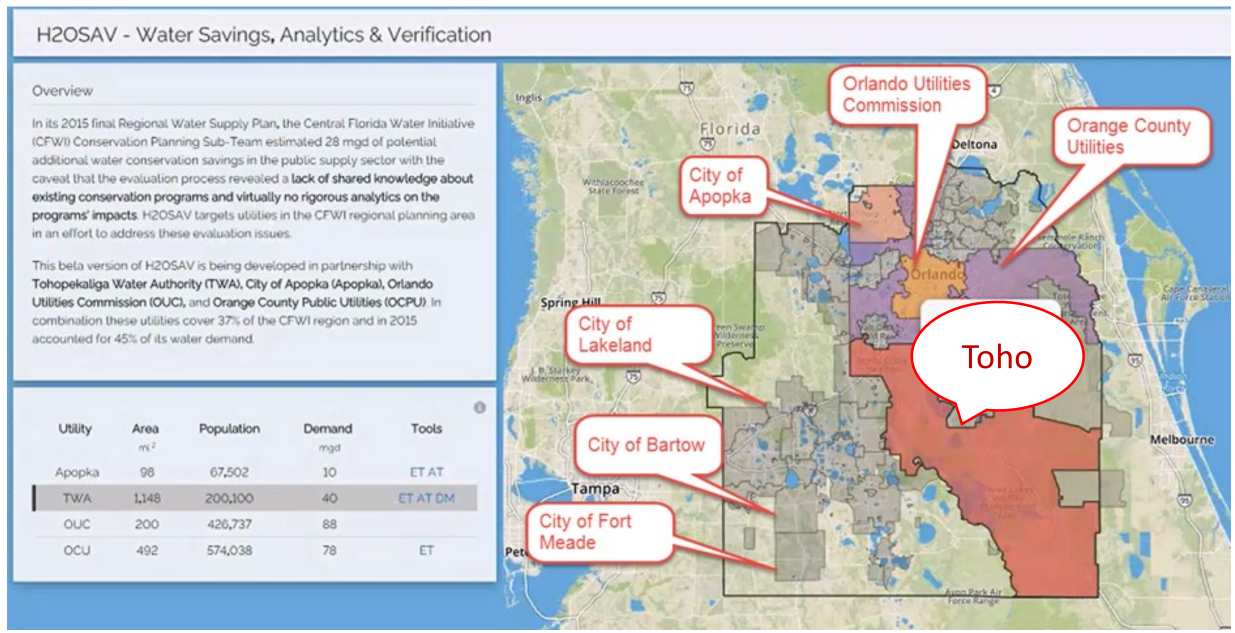
Field workers checked the meter (okay) then located the leak - irrigation system



AMI Data Is Improving Water Conservation in Central Florida

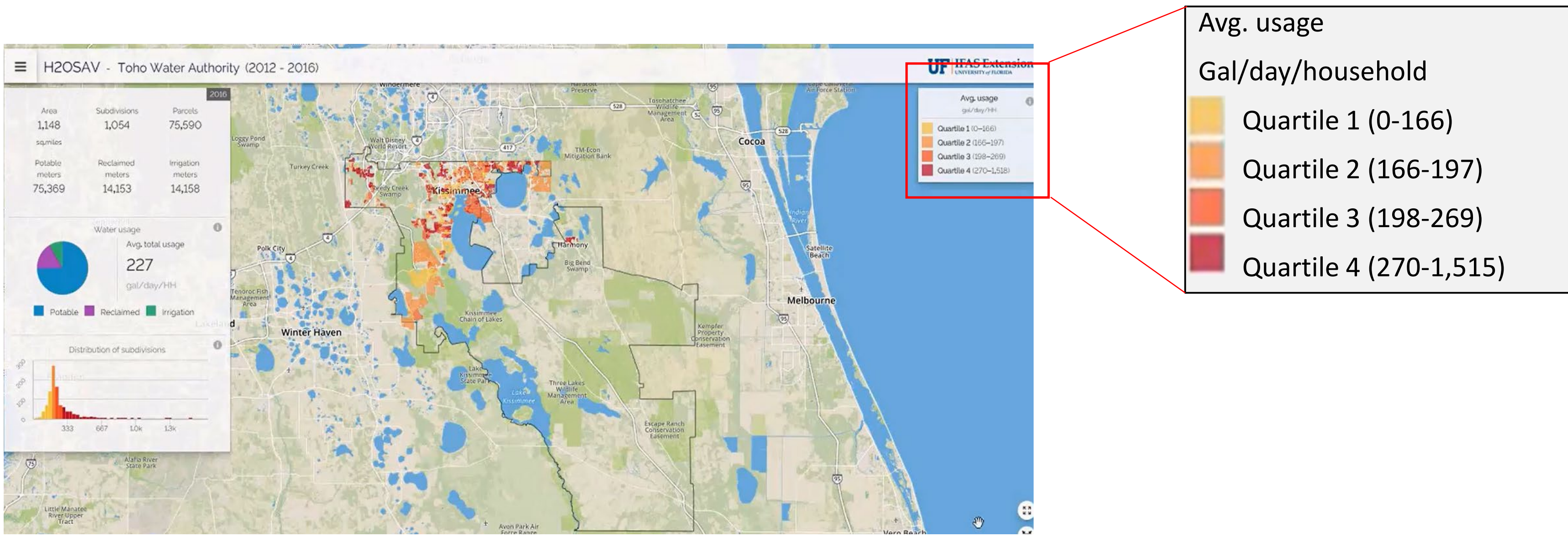
- Planning and modeling assessments indicate that central Florida is facing a water shortage in the near future

Toho Water Authority is working with University of Florida team to develop analytical tools for water conservation



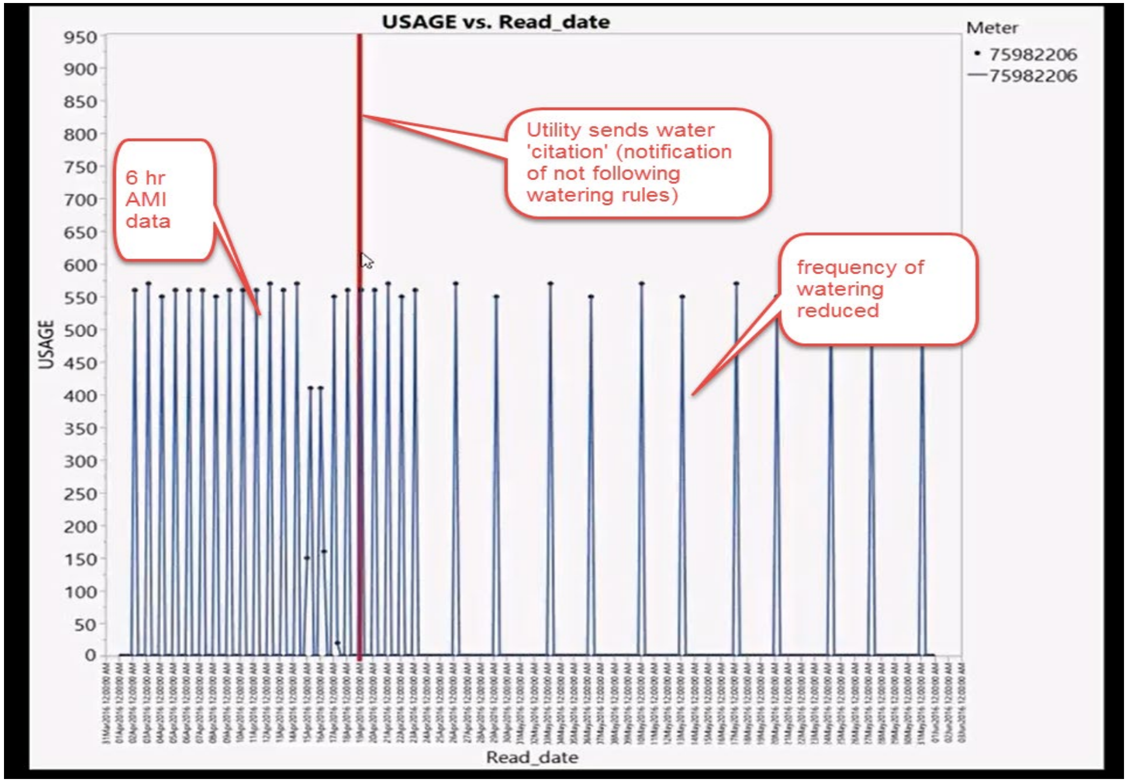
Analytics Using AMI Data Expose the Highest Water Users

- Spatial tools show the customers and sub-divisions using the most water.



Citations Trigger Customers to Reprogram Their Irrigation Systems

- Toho issues citations to customers that water more than the mandated 2 days per week
- Utility workers help customers reprogram their irrigation systems



Utility Practices Use AMI Data for Water Accounting

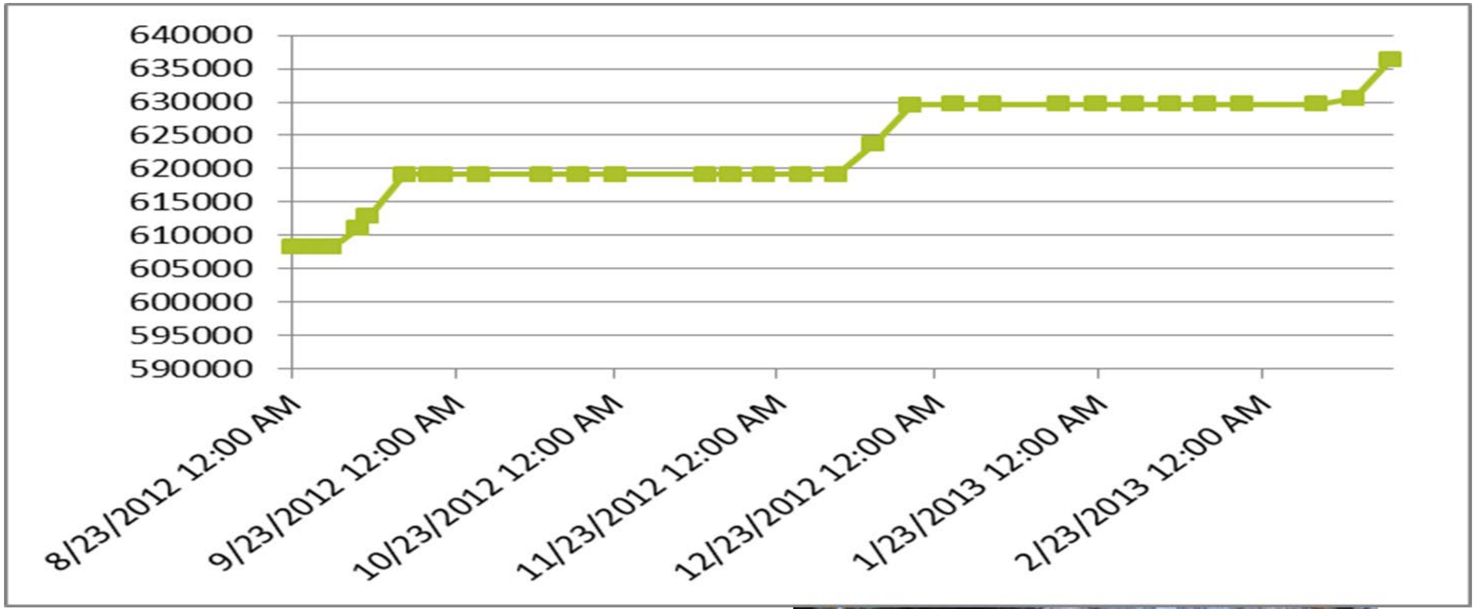
● SIGNIFICANT PRACTICE ○ SOME/LIMITED PRACTICE

		Utility						
Report Section	Topic	Albuquerque Bernalillo County Water Utility Authority	City of Baltimore Department of Public Works	DC Water	Great Lakes Water Authority	Suez NJ	Toho Water Authority	Toronto Water
WATER ACCOUNTING								
4.5.1	Water Theft, Meter Tampering and Reverse Flow	○	○	○		●	○	○
4.5.2	Multiple Meter Situations				●		●	
4.5.3	Distribution Area Management				○	○	○	
4.5.4	Apparent Versus Real Water Loss					○		
4.5.5	Water Audits	○	○	○		○	○	○
4.5.6	Pressure Management Strategies Using AMI Data	○						

AMI Data and Analytics for Water Accounting

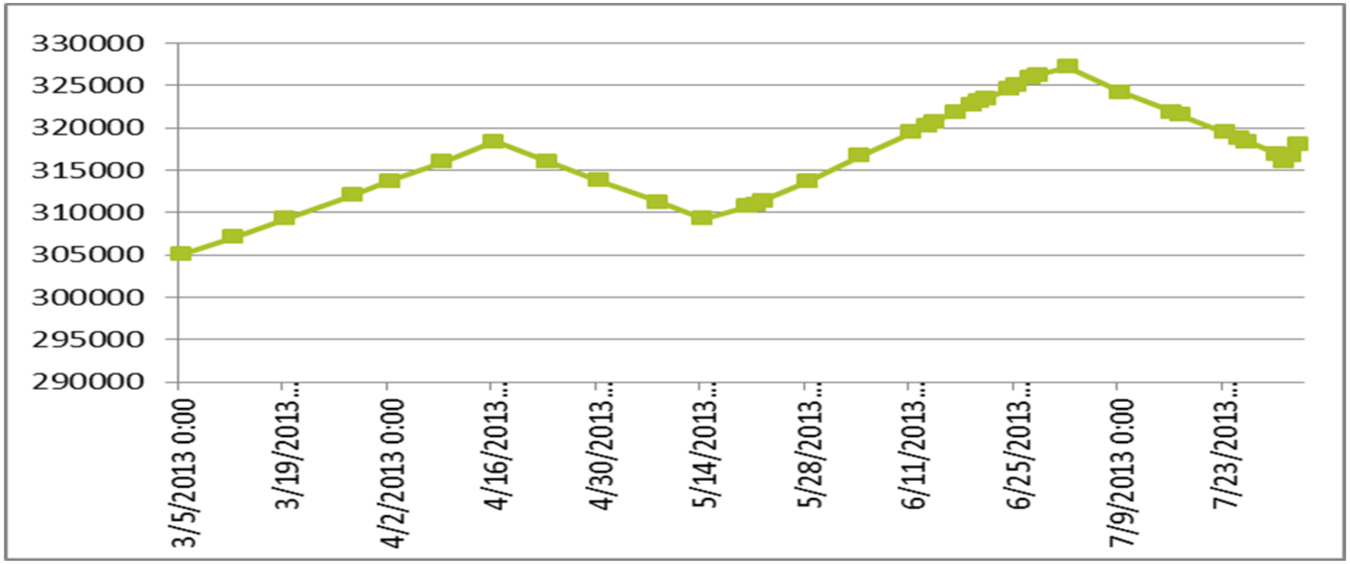
- Meter Tampering Detection
  - Reduce water theft by recognizing and addressing usage patterns that suggest meter tampering
- District Metering Analysis (DMA or zonal metering)
  - Prioritize infrastructure investments through district or zone meter area analysis
  - Identify areas of highest real water loss by comparing hourly “water-in to water-out”

Suez NJ AMI Data Shows Tampering - Periodic Register/Meter Removal



- Apartment Building with 1" meter
- Uses ~6000 gallons per day
- **Back-billed $61,000**

Suez NJ AMI Data Shows Tampering - Periodic Reversing of the Meter



- Apartment Building with 3/4" meter
- Uses ~2500 gallons per day
- **Back-billed $27,000**

4/2/2013 10:16	313700	17
4/9/2013 10:13	316005	23
4/16/2013 10:50	318405	24
4/23/2013 11:05	316030	-24
4/30/2013 10:42	313790	-22
5/8/2013 10:53	311280	-25
5/14/2013 10:54	309260	-20
5/20/2013 15:08	310700	14

Utility Practices Use AMI Data for Meter Management

● SIGNIFICANT PRACTICE ○ SOME/LIMITED PRACTICE

		Utility						
Report Section	Topic	Albuquerque Bernalillo County Water Utility Authority	City of Baltimore Department of Public Works	DC Water	Great Lakes Water Authority	Suez NJ	Toho Water Authority	Toronto Water
METER MANAGEMENT								
4.6.1	Small and Intermediate Meter Replacement	○		○		○	○	○
4.6.2	Large Meter Maintenance					○		○
4.6.3	Compound Meter Maintenance							○
4.6.4	Register Maintenance	○	○	○	○	○	○	○
4.6.5	Meter Testing Management							
4.6.6	Meter Sizing	●	●	●	○	●	●	●
4.6.7	Meter Maintenance Program Management							

AMI Data and Analytics for Meter Management

- Meter Sizing for Large Use Customers
  - Use AMI data to properly size meters for improved flow measurement accuracy
- Reducing "Truck Rolls"
  - Minimize visits by field workers for meter reads and for other investigations related to meters
- Meter Maintenance/Replacement
  - Use meter performance to define maintenance frequency and drive replacement cycles

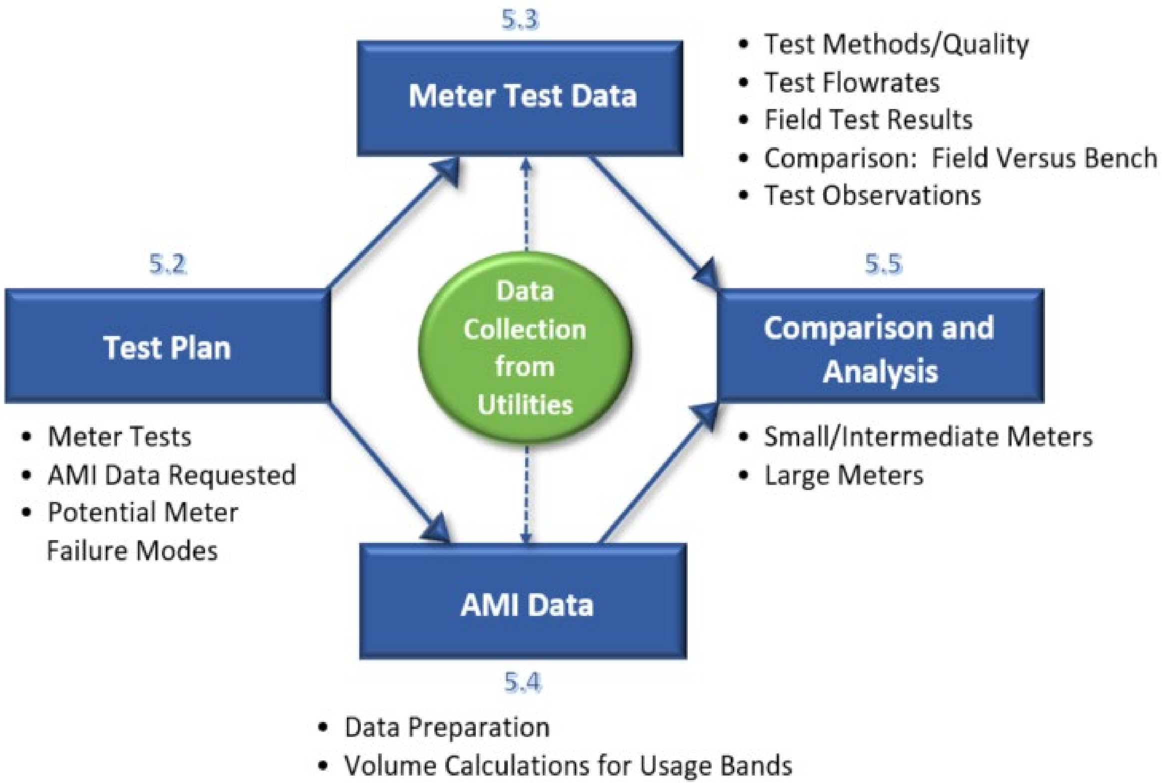
AMI Data Improves Responses to Customer Questions for Baltimore

- Before AMI - "If someone had a spike in consumption … the assumption was we did something wrong. When we received a high bill complaint, the first thing would be to roll a truck."
- After AMI – "**Now the first step is to look at the AMI data** and often we see a continuous consumption pattern – then ask the property owner check for leaks, check toilets, things like that – **before we go out**."

SECTION 3

Meter Testing and Performance Analysis

Meter Performance Analysis Correlated AMI History With Test Data

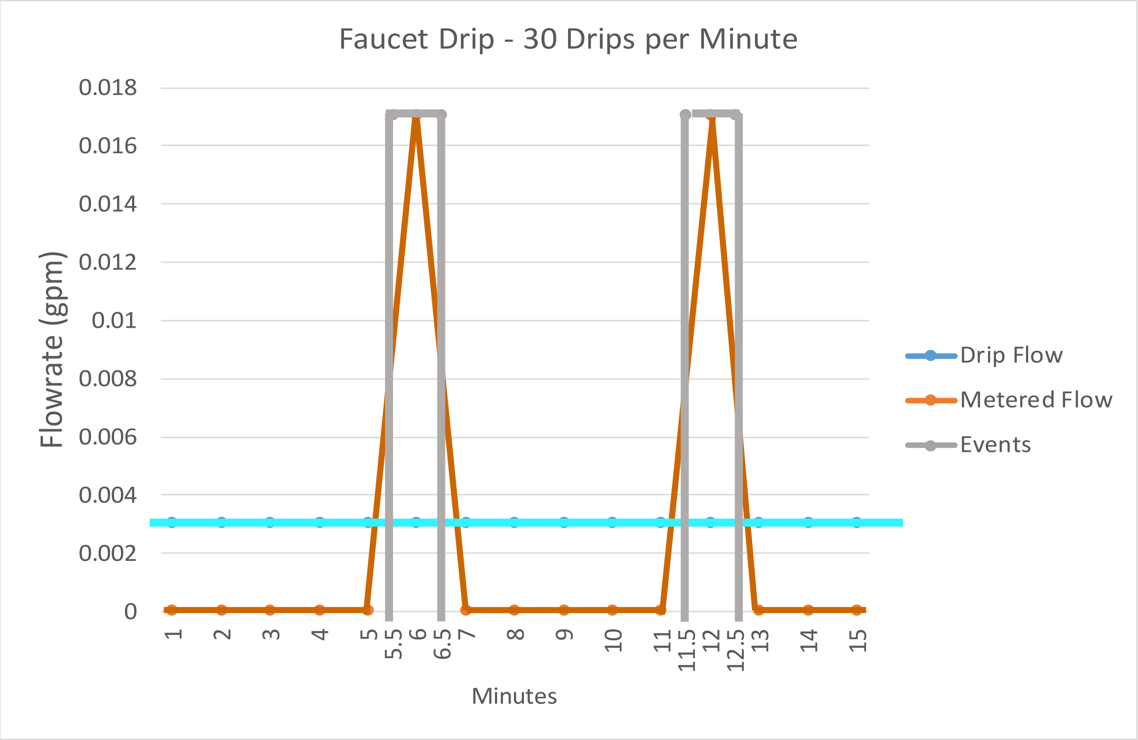


Utility participant's test data was from their routine meter testing programs, except for some testing at low-low flowrates. No specialized or independent meter testing was conducted.

Small and Intermediate Meter Challenges

- Includes Residential (1-4 families) or Light Commercial
- Usage is mostly in short-duration events
- Challenges for AMI data analytics
  - Reading intervals are less frequent than most usage events
  - Reading resolution is often less than most usage events
  - Low-low and low band continuous usage may indicate leakage – not always present in AMI data
  - Other usage bands may represent meter performance/accuracy at higher rates
- Meter accuracy typically degrades at low flows for mechanical meters (e.g. nutating disc type)

Small Leaks May Not Be Detectable With AMI Data – Example Faucet Drip

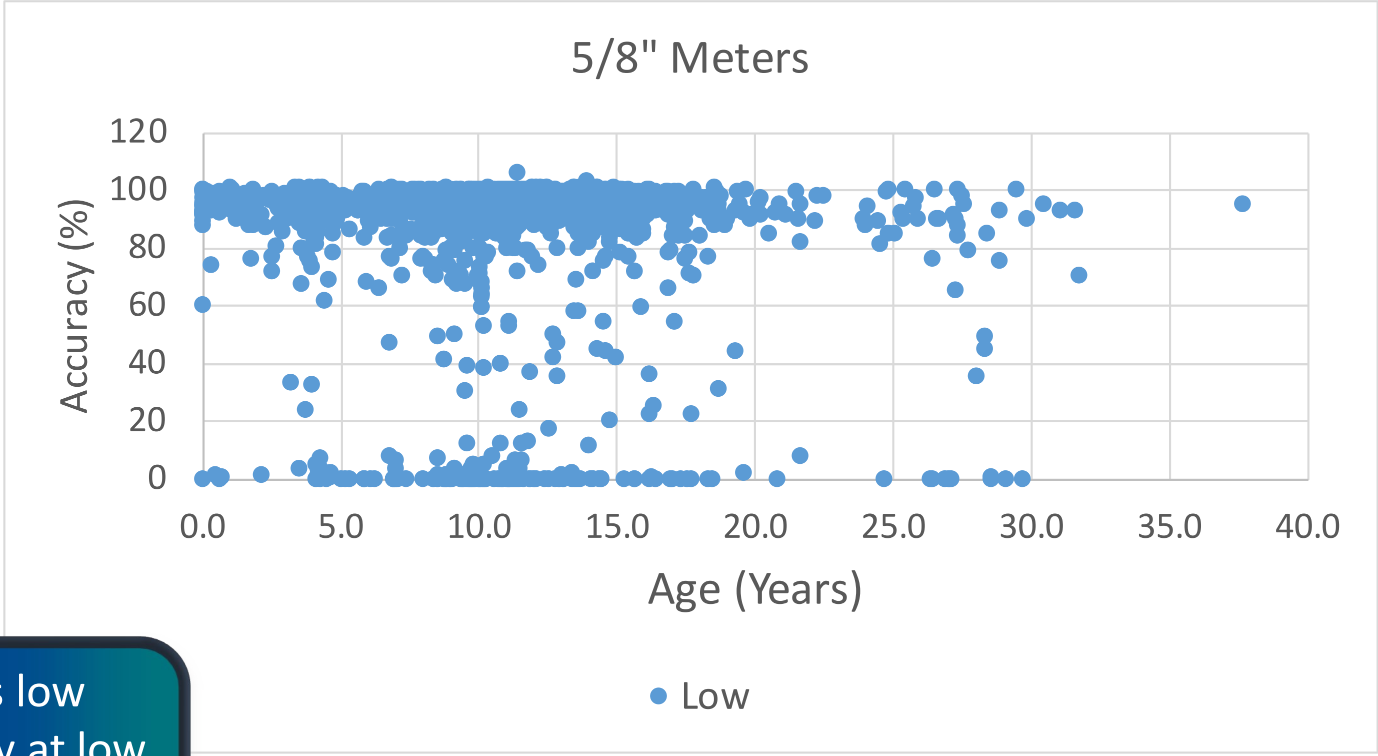


Assumes Meter Registers 100% of Leakage

0.1 gal in 34 min
0.1 cf in 250 min
Low-low Range

- A continuous leak appears as spikes (rotations) of metered flow.
- Some AMI meter endpoints include internal diagnostics with data flags for continuous low flow, reverse flow, low battery, cut wires, register malfunction, etc.

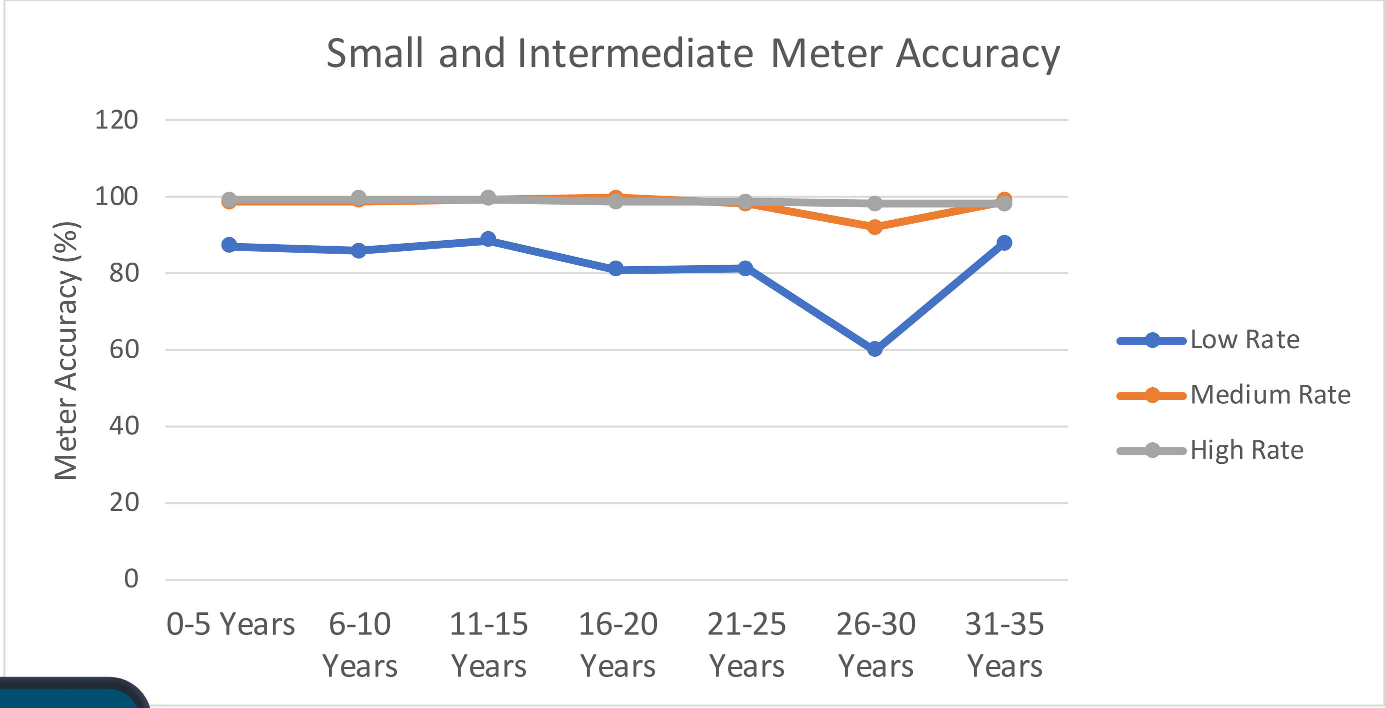
Example Small Meter Test Data Showed Variable Low Flow Accuracy



Does low accuracy at low rate affect metered total?

Compare customer usage AMI data before and after meter replacement to show if low flow accuracy significantly affects metered usage (potential revenue)

Example Small/Intermediate Meter Accuracy Was Slightly Age Dependent



Overall accuracy declines slightly over 35 years

Meter accuracy (M6) is defined by weighted flow rates, from research conducted in 1982:

- 15% Low
- 70% Medium
- 15% High

Customer Usage Changes (AMI Data) Did Not Correlate With Meter Accuracy

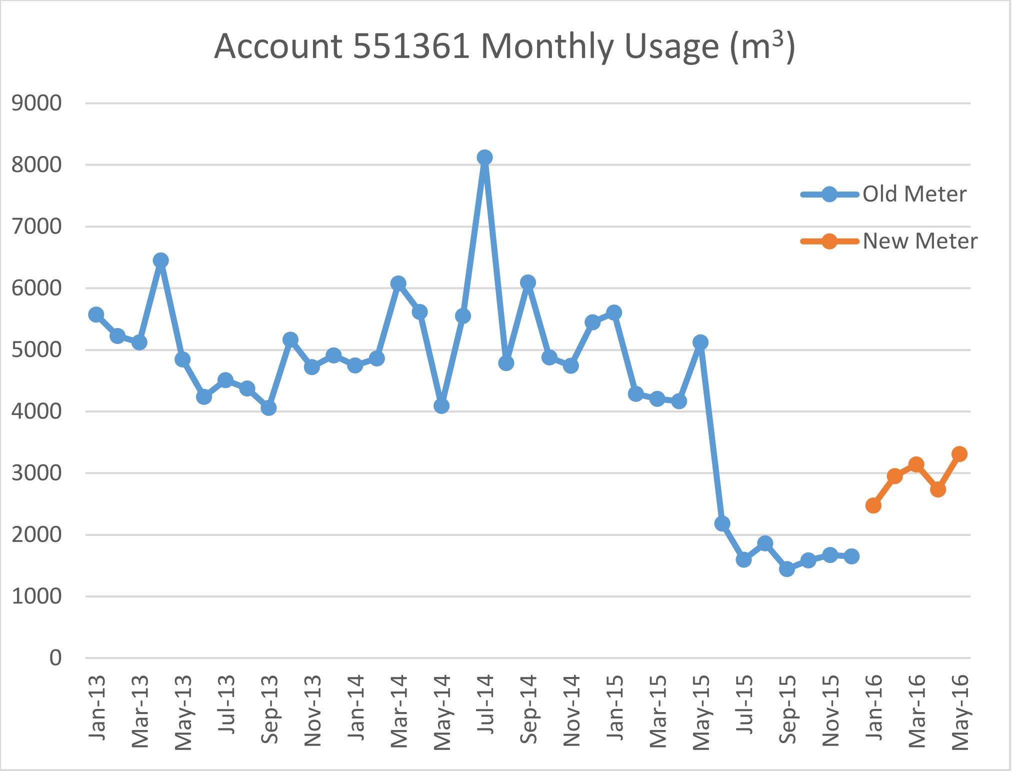
Utility ABC	Decrease > 20%	Decrease >0% to 20%	Increase
% of Meters	57%	10%	33%
Meters with low accuracy	43%	50%	58%

Utility XYZ	Decrease > 20%	Decrease >0% to 20%	Increase
% of Meters	46%	15%	31%
Meters with low accuracy	0%	0%	0%

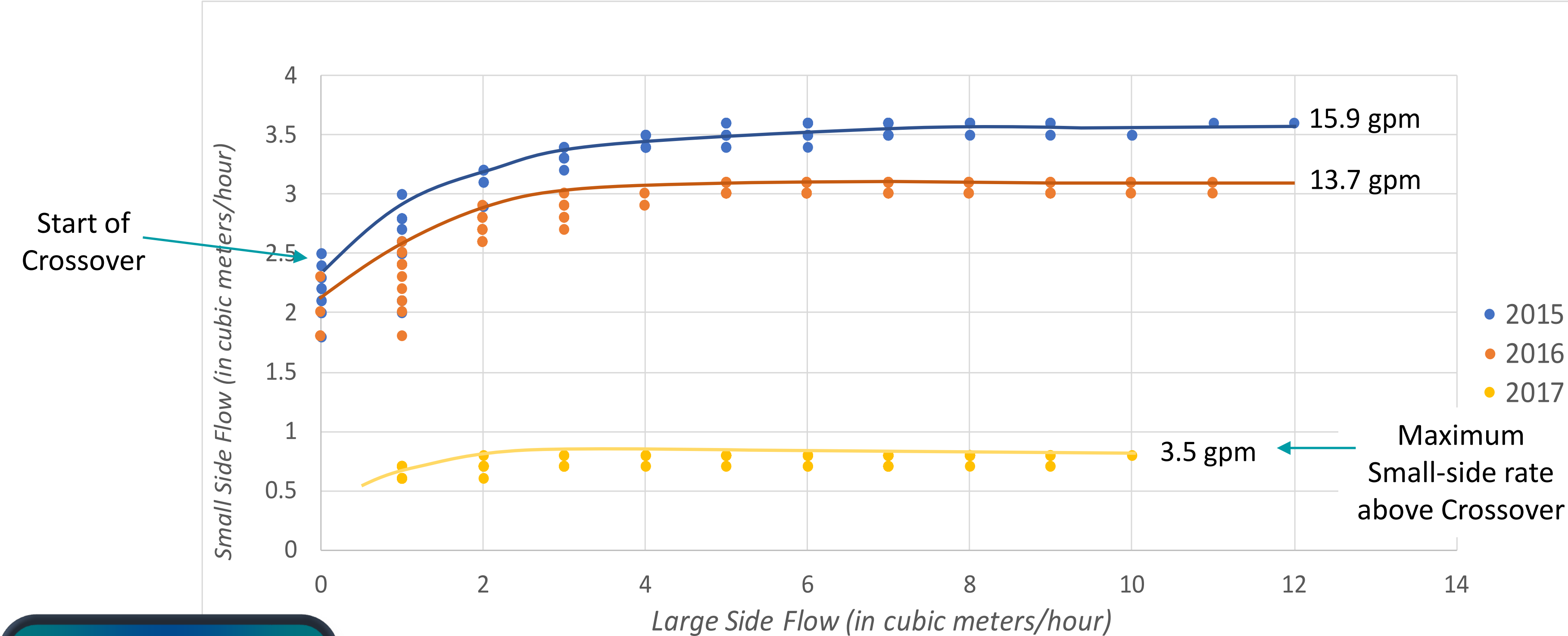
- With data sets available for small/intermediate meters (age 10-15 years), ***no correlation*** between customer ***usage trend*** and ***meter accuracy***
- The AMI Analytics Challenge:
  Customer usage changes mask changes in meter performance

One Example: Drop in Total Usage Did Indicate Loss of Meter Accuracy

- Large drop in consumption needs to be sustained before taking action
- Before and after replacement shows change in customer usage



Crossover Rate Change Is Valid Indicator of Compound Meter Performance



'Curve' is not dependent on user demand

Compound meter analytics require AMI data transmission of both metered flow signals, to show large-side and small-side flows.

Example Compound Meter Crossover Determines Maintenance Requirement

Size	Crossover (GPM)	Number of Meters	Low Accuracy Meters	% of Low Accuracy
3" x 5/8"	>9.0	19	3*	16%
	5 to 9	11	8	73%
	<5.0	7	7	100%
4" x ¾"	>10.0	27	1	4%
	7 to 10	3	0	0%
	<7.0	2	2	100%
6" x 2"	>40.0	1	0	0%
8" x 2"	>40.0	39	0	0%
10" x 2"	>40.0	28	0	0%

*These meters had low accuracy at crossover and were read at 4-hour intervals.

- AMI data show Crossover (max small-side flow above crossover) **<u>is a reliable indicator of meter condition/accuracy</u>**
- Data shown in the table are from five utilities

Research Results From AMI and Meter Test Data

For small and intermediate meters

- With the data sets available, the research found ***no correlation*** between customer ***usage trend*** and ***meter accuracy***
- Changes in customer usage levels and test quality mask changes in meter performance
- Many meters have acceptable performance after 20 years
- Meter replacement decisions should include before/after usage comparisons (otherwise revenue recovery may be optimistic)

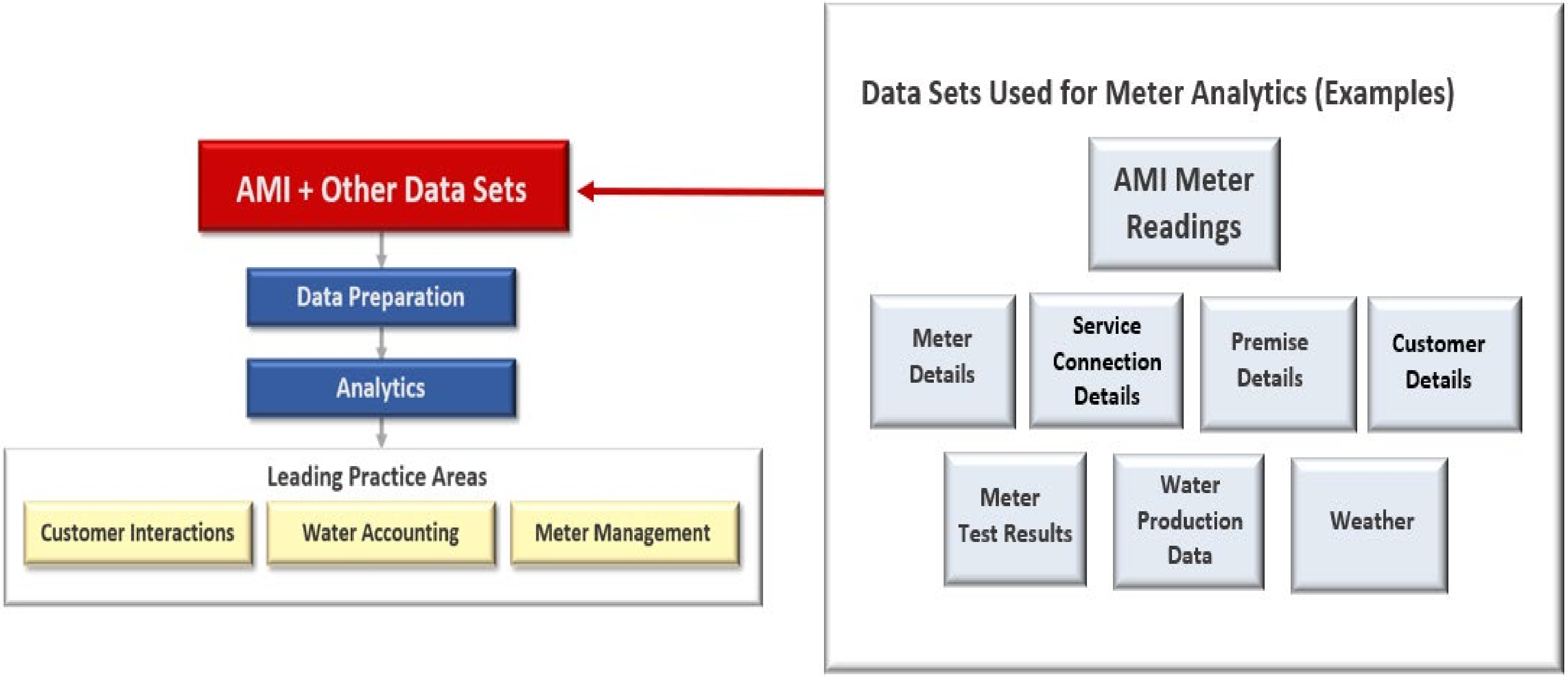
For large compound meters

- Changes in crossover point is reliable indicator of meter performance/accuracy and likely source of apparent water loss (significant revenue recovery)

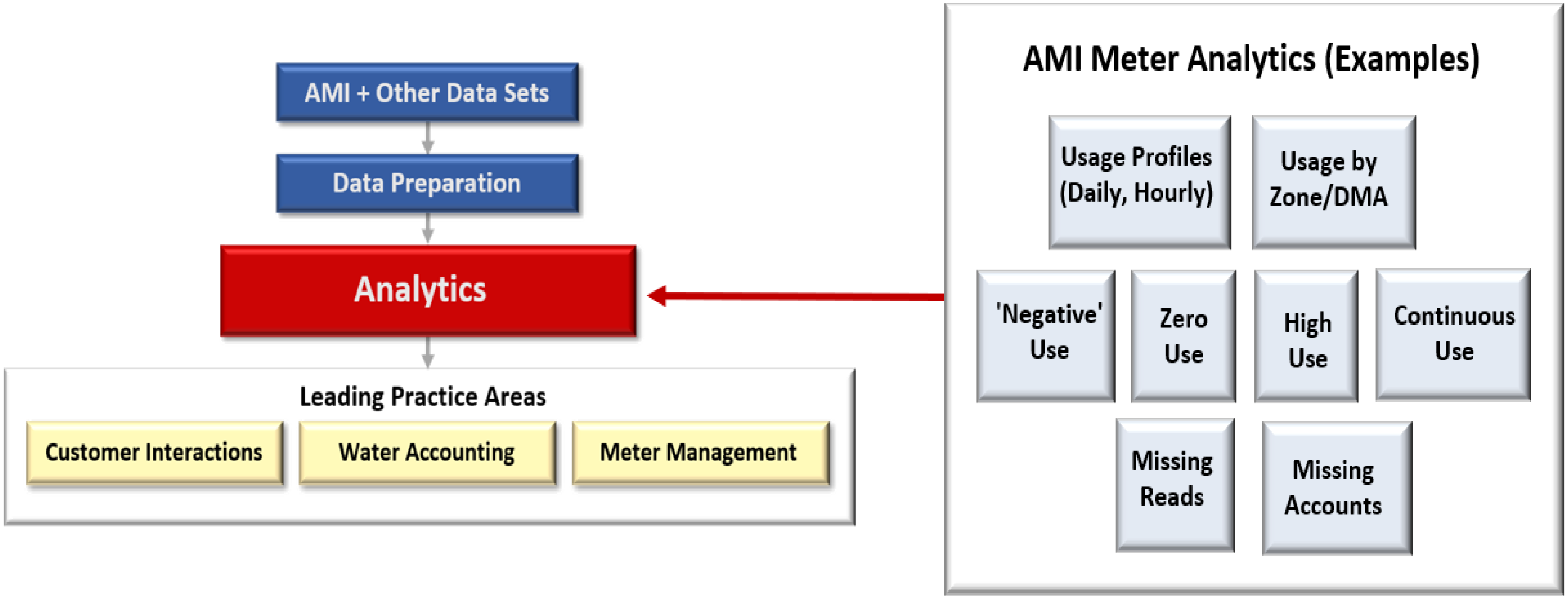
SECTION 4

Leading Practice Examples and Utility Recommendations

Example Data Sets Used for Meter Analytics



Examples of AMI Data Analytics Developed by Water Utilities

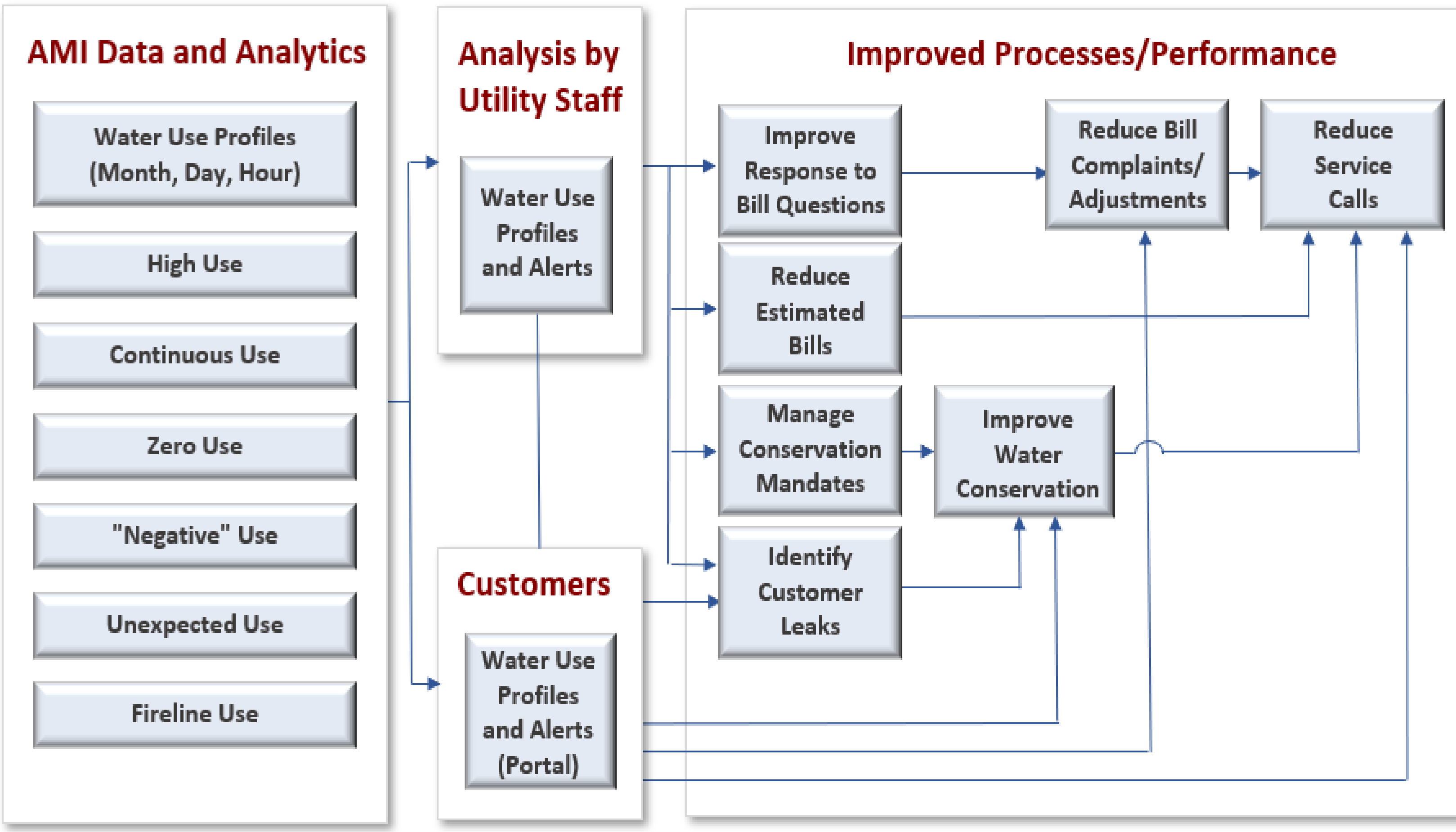


Recommendations to Improve Customer Interactions

- Make AMI data available to utility staff for resolving customer water usage questions or billing disputes.
- Link water usage information to a customer portal for usage trends and alerts – allow for customer-specific alert limits to avoid nuisance alerts.

- Water conservation or residential efficiencies can be encouraged by comparative usage data for similar neighboring properties and irrigation usage alert messages.

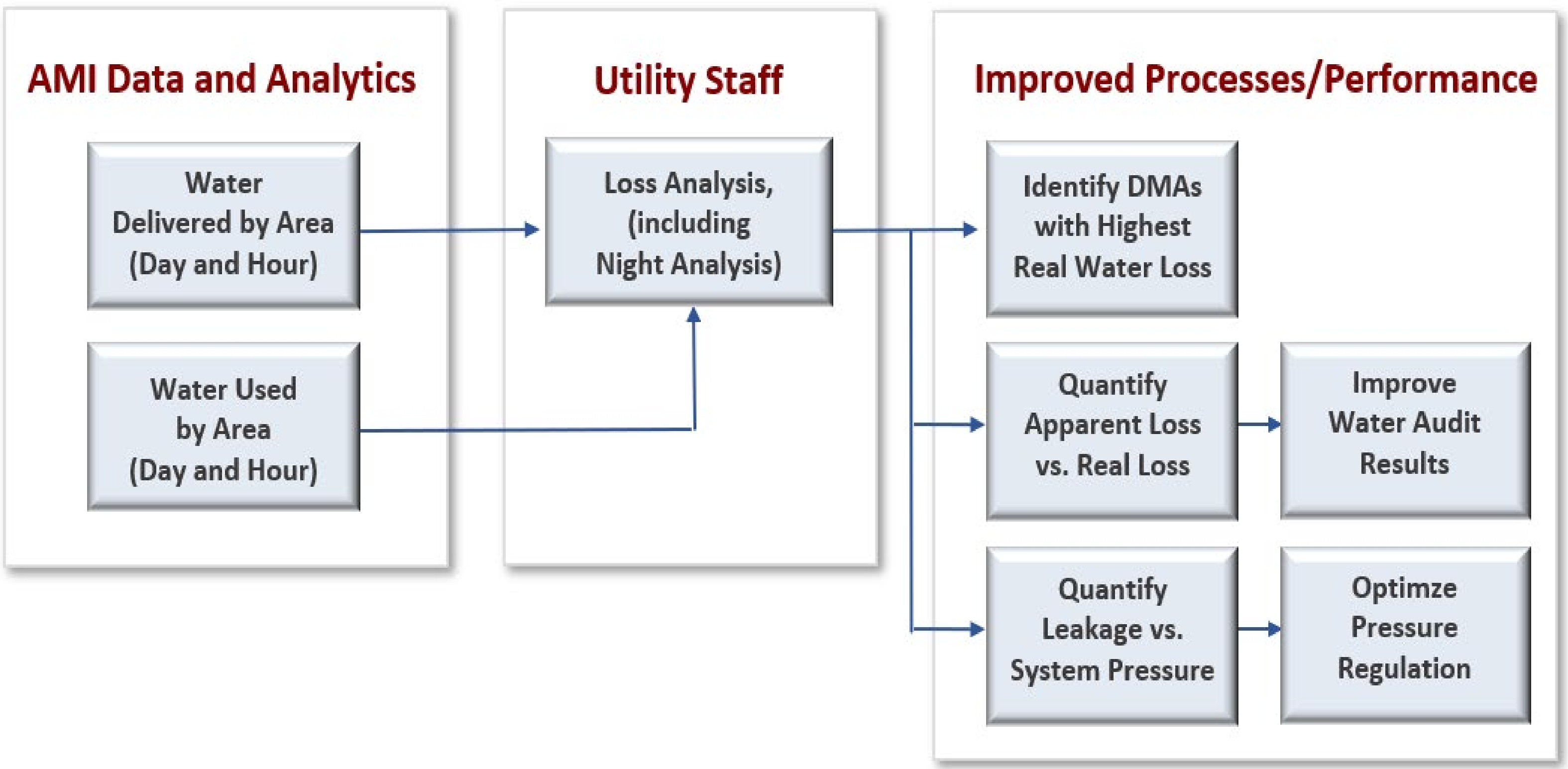
AMI Data Analytics Improve Utility Processes for Customer Interactions



Recommendations to Improve Water Accounting

- Use AMI analytics to identify water theft, including zero usage and other anomalies compared to historical patterns.
- Using AMI data to better understand distribution system performance:
  - Enable water mass balances in District Metered Areas (DMAs) to measure water losses with increased frequency (e.g. daily accounting)
  - Differentiate between apparent and real water losses
  - Improve water audits with more accurate usage data and frequency of audit processes
  - Following main breaks or system flushing, identify meters showing zero usage caused by debris entrained in the meters
- Consider use of AMI system for pressure monitoring to improve pressure regulation, leak management, and infrastructure renewal

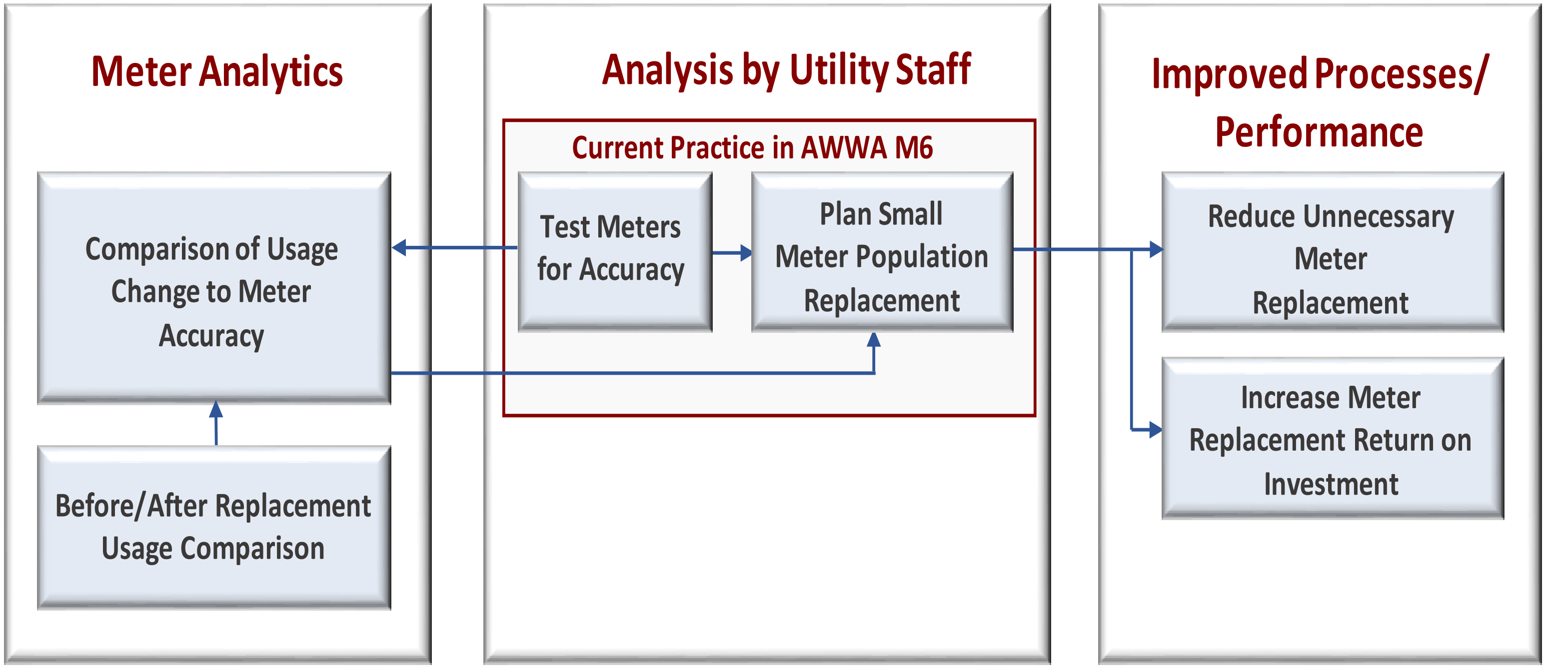
District Metering Analysis (DMA) Quantifies Water Loss Using AMI Data



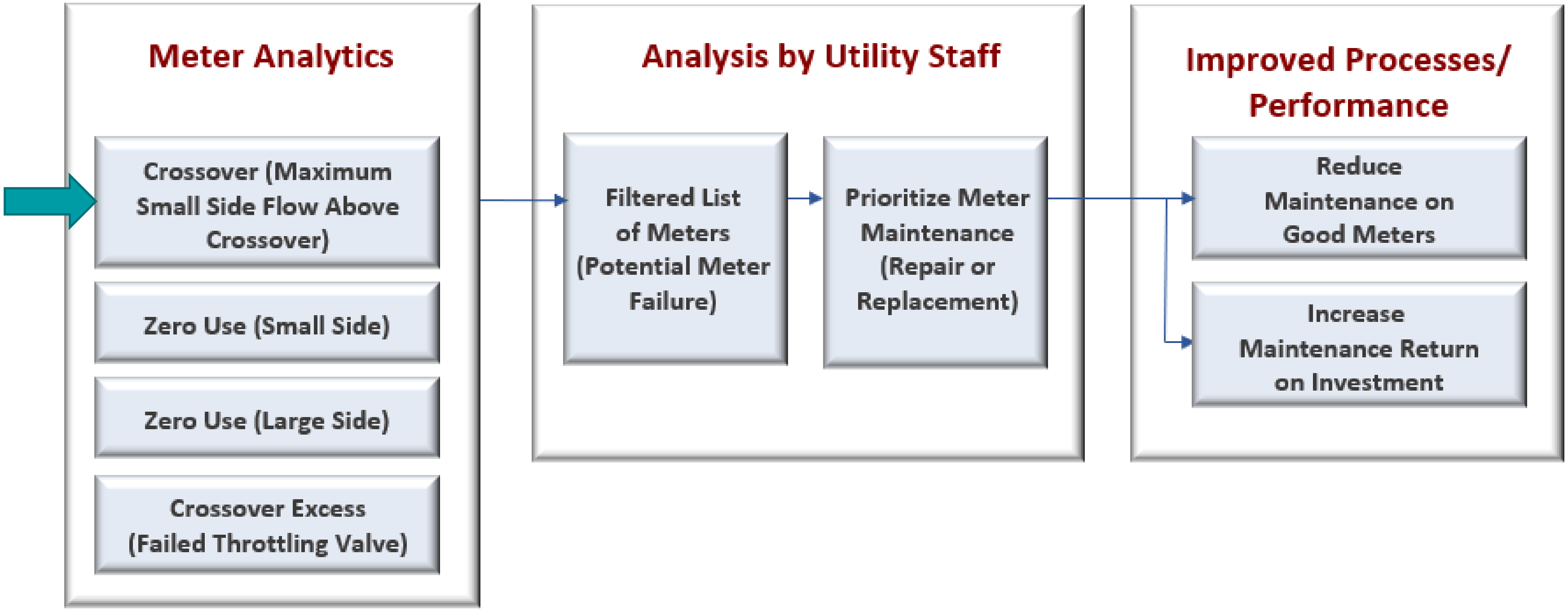
Recommendations to Improve Meter Management

- Use AMI data of customer usage patterns to "right size" when replacing meters
- Differentiate between under-registering meters (loss of accuracy) and reductions in actual usage (e.g. water conserving appliances, reduced occupancy, usage behaviors, etc.) by customer interactions
- Compare customer usage AMI data before and after meter replacement to show if meter accuracy significantly affects customer usage (potential revenue)
- Statistically sample and test in-service meters based on throughput or age to create a cohort of meter accuracy
- Use AMI data analytics to track the performance of compound meters - adjust maintenance and calibrations schedules accordingly

AMI Data (before/after comparison) Can Improve Replacement of Small Meters



AMI Analytics for Compound Meters *Do* Indicate a Need for Maintenance – Using the Crossover Point



Recommendations to Improve Meter Testing

- Perform quality control and quality assurance on meter testing - include repeatability (duplicate tests) as well as flow ramp-up and ramp-down
  - Reliability of test results is important in resolving customer disputes and in making sound business decisions on meter replacement
  - Comparing consumption before and after meter replacement should be used as part of quality assurance for meter testing
- In-service meters removed for testing should be protected through proper handling, packaging, transport, storage, and set-up prior to testing
  - Bench test results are susceptible to error from change in meter condition after removal from service
- For large meters, the reliability of test results (repeatability or leakage in field tests) needs to be considered in conducting maintenance or replacing meters

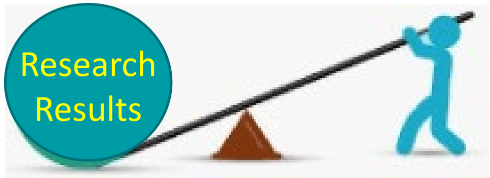
SECTION 5

Additional Research and Use of Results

Additional Recommended Research

- **Customer Interactions** - given differing customer profiles, what methods and tools are most effective in use of AMI data to achieve different objectives (e.g. leak alerts, conservation behavior, billing inquiry, etc.)?
- **Water Accounting** – to better understand water losses (real and apparent), what practices for AMI data will improve and extend the use of water audits and DMAs?
- **Meter Management** – what practices using AMI data and other data sets will optimize the total economic lifecycle of meters, considering replacement efficiencies and sample testing of in-service meters?
- **Meter Testing** – what meter testing and handling practices need to be improved or updated in M6 to provide utilities with consistent, accurate test results for correlation with AMI data analysis?

How to Leverage the Research Results



- AMI Analytics Improve the Business Case
  - Improve the business case for AMI by including benefits of data analytics for customer interactions, water accounting, meter management, and correlating AMI data with meter test results
- Clarify Upfront What You Want From:
  - Meter Data Management (MDM) System
  - Customer Portal System
- Manage every meter as an asset (revenue source) to be maintained/tested
  - Implement a meter management program - statistically sample/test in-service meters based on throughput or age to create a cohort of meter accuracy
  - Compare usage data with meter test results, including before and after meter replacement
  - Use AMI data, meter maintenance and test results to drive replacement plans
- Plan for new staff roles and responsibilities
  - Technicians for AMI system to assure high read-success-rate for all meters
  - IT specialists and data scientists for evolving AMI data analytics and customer portal capabilities
  - Metering specialists for accurate bench and in-situ maintenance/testing

Questions?

Thank You

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www.waterrf.org