# National Context

## Water Loss Control and The Future of the Industry

Steve Cavanaugh
President
Cavanaugh

wrri
NC WATER RESOURCES RESEARCH INSTITUTE

NC
Water Infrastructure
ENVIRONMENTAL QUALITY

CAVANAUGH
Stewardship Through Innovation

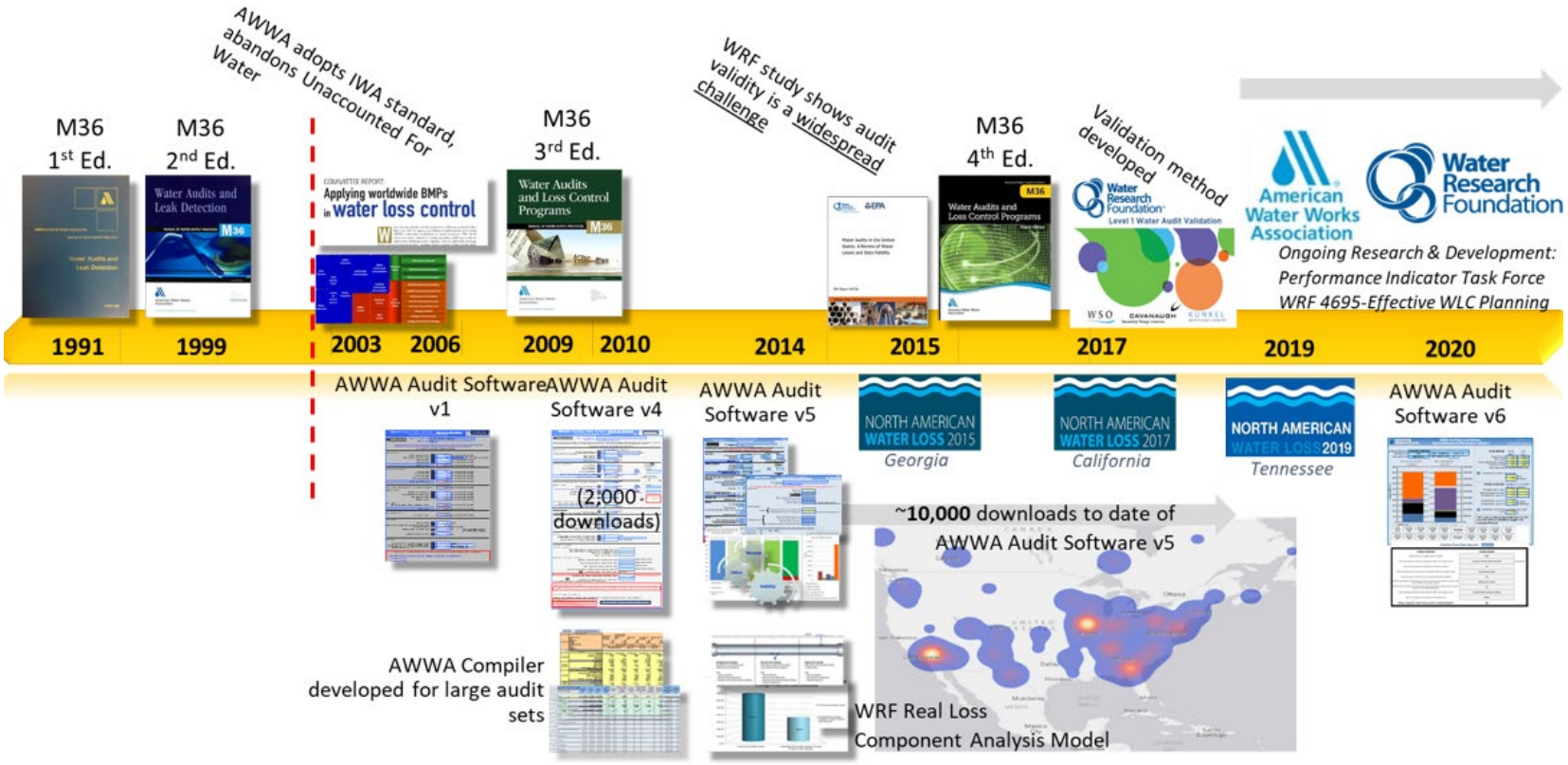
# Drivers and National Landscape

Historical perspective / timeline

Regulatory landscape

- State Programs
- Programs and outputs

# IWA/AWWA M36 Methodology – State of the Art Water Auditing & Loss Control



# Relevance: Public Relations


# Relevance: Public Relations

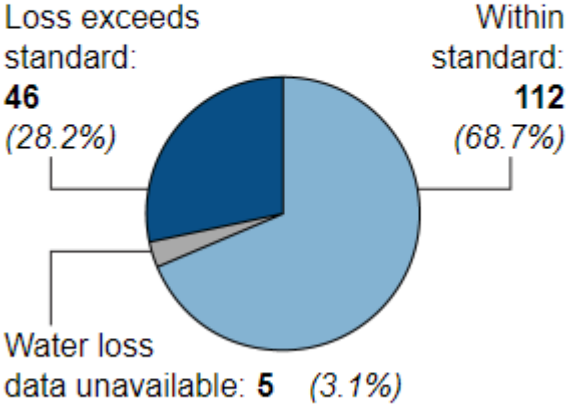
## SAWS reveals 9 billion gallons of water wasted last year

by APRIL MOLINA | Wednesday, November 1st 2017

**Communities compliant with Illinois water loss standard**

*For 163 Illinois municipalities that received Lake Michigan water in 2016*

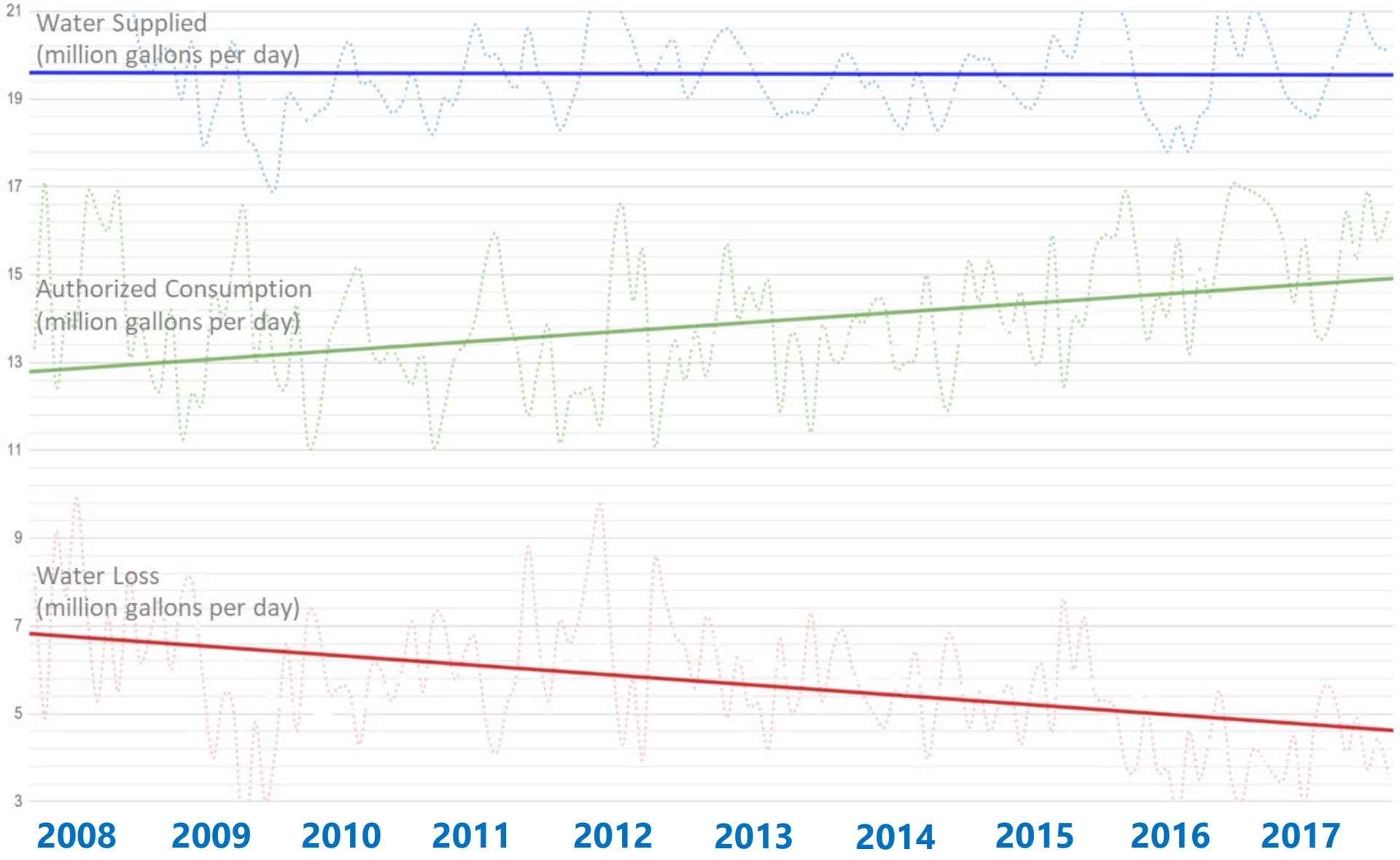
***Illinois standard: 12% water lost***




SOURCE: Tribune reporting, Illinois Department of Natural Resources

CHICAGO TRIBUNE

# Increased Supply



# Relevance: Impacts on Bond Ratings

STANDARD & POOR'S RATINGS SERVICES
McGRAW HILL FINANCIAL

MOODY'S

Strong – Utility has performed a water audit consistent with the AWWA M-36 methodology on an annual basis for the prior five years. The utility has a well-structured and documented Non-Revenue Water Management Program that includes ongoing leak detection work and annual accuracy testing of finished water meters and a representative sample of customer meters.

Good – Utility has performed a water audit consistent with the AWWA M-36 methodology on an annual basis for the prior three years. The utility has engaged in specific components of a Non-Revenue Water Management Program such as periodic finished water meter testing, accuracy testing of samples of customer meters and active leak detection.

Standard – Utility has performed a water audit consistent with the AWWA M-36 methodology but does not do so on an annual basis. The utility tracks some basic water loss information on a monthly basis but does not have an active Non-Revenue Water Management Program.

Vulnerable – Utility has not performed a water audit consistent with the AWWA M-36 methodology and does limited tracking of some basic water loss information on a monthly basis. This information is generally reported on a percentage of volume-supplied basis.

**#48 Enterprise Risk Profile Assessment Factors (Table 10)**

05 SEPT 2018

**Rating Action: Moody's upgrades to Aa1 Asheville, NC's outstanding $43.4M Water Revenue Enterprise bonds; Outlook stable**

New York, September 05, 2018 -- Moody's Investors Service has upgraded the rating to Aa1 from Aa2 on the City of Asheville, NC's $43.4 million Water System Revenue Refunding Bonds, Series 2015. The outlook is stable.

RATINGS RATIONALE

The upgrade to the high quality Aa1 rating reflects the growing size and diversity of the service area's economic base, strong management practices including comprehensive fiscal policies, an active pay-go capital improvement program, regular rate reviews and long term planning. The rating also incorporates ample debt service coverage (4.3 times) and liquidity levels (1,229 days cash on hand). Legal provisions are satisfactory (1.2x rate covenant) with no debt service reserve requirement which is offset by maintenance of healthy reserves.

RATING OUTLOOK

The stable outlook reflects our expectation of continued sound financial operations and stability within the service area.

FACTORS THAT COULD LEAD TO AN UPGRADE

-Maintenance of high debt service coverage levels

-Reduction of water leakage rate

-Reduction of water leakage rate

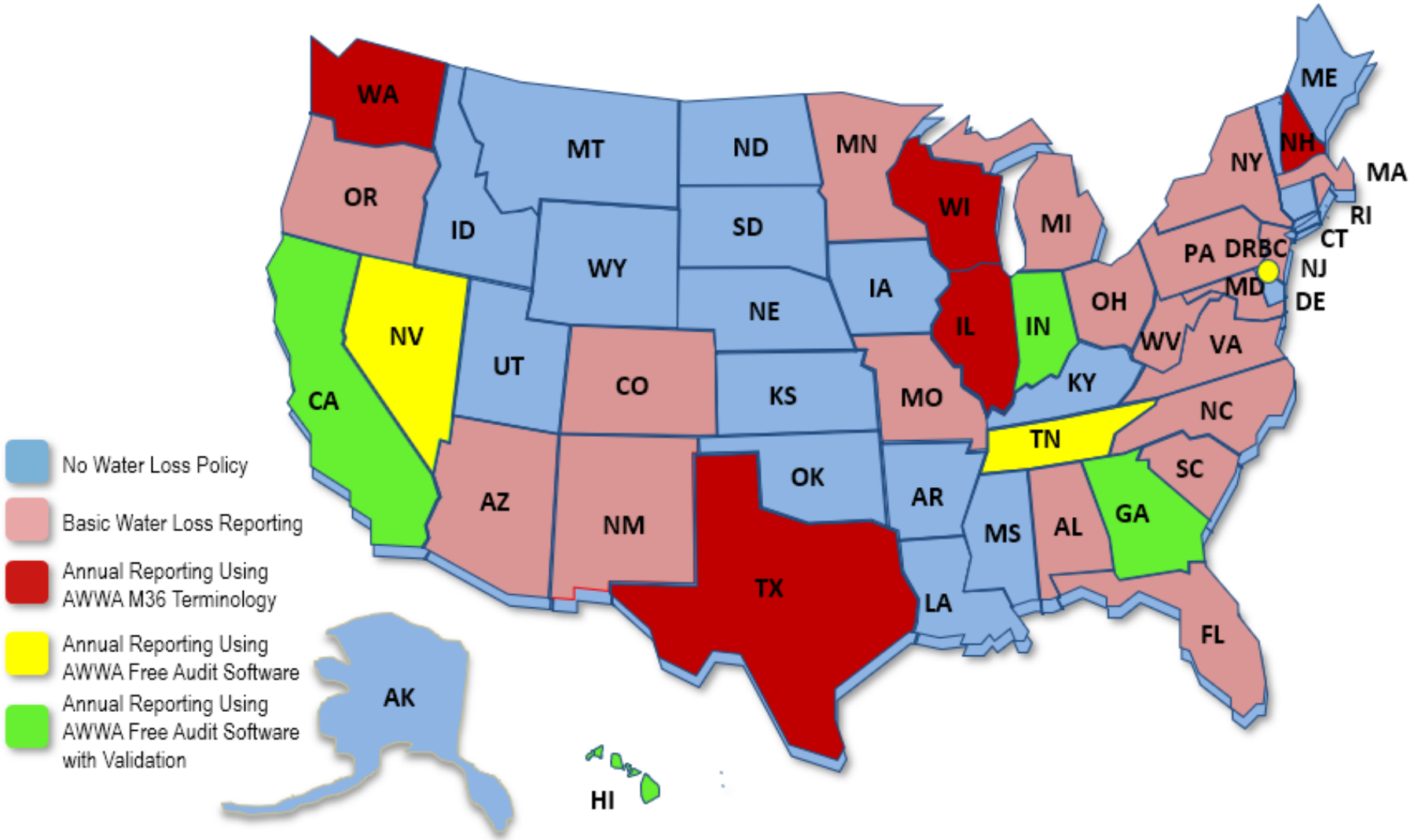
FACTORS THAT COULD LEAD TO A DOWNGRADE

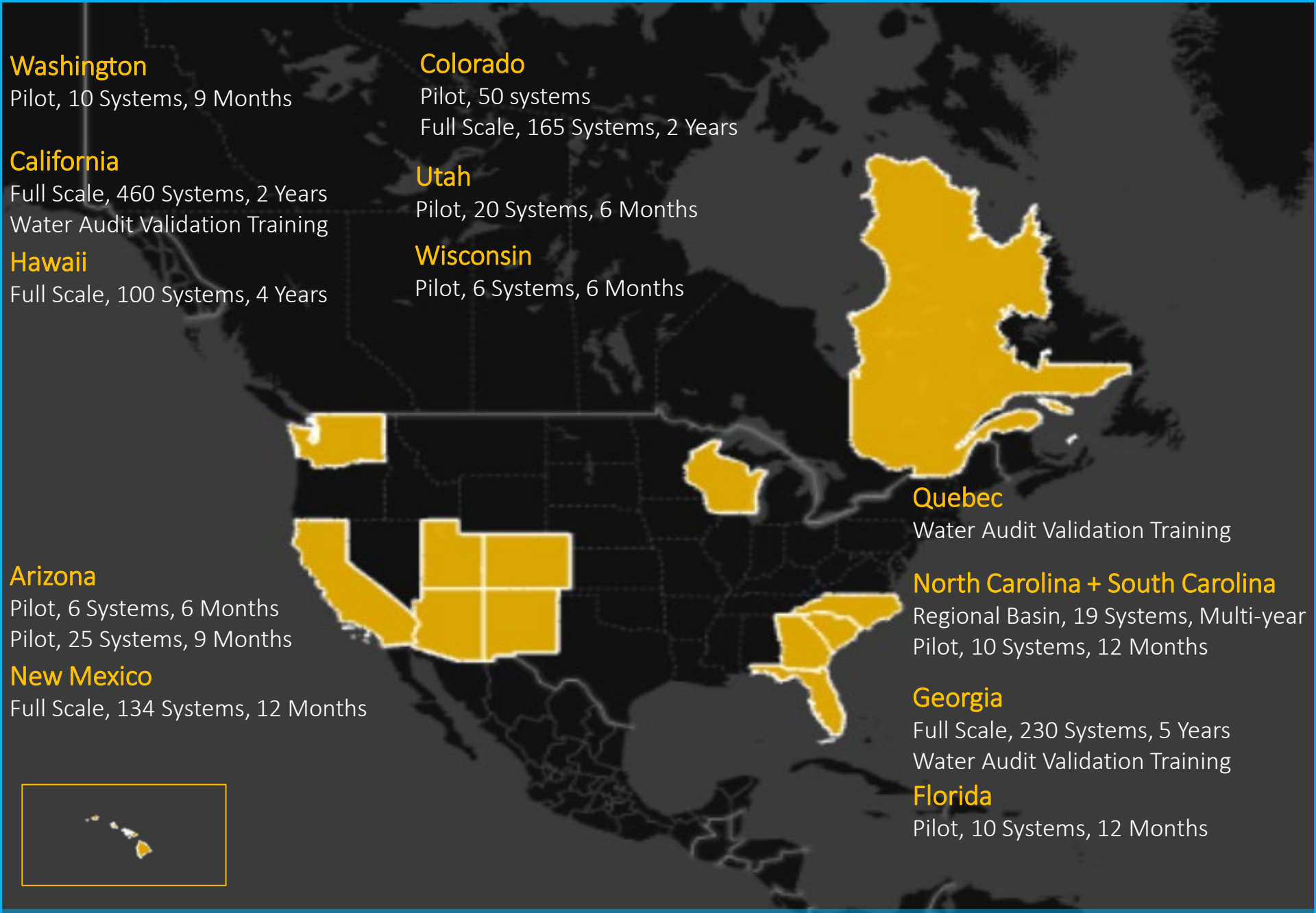
-Debt service coverage falling below current projections

-Significant increase in debt ratio

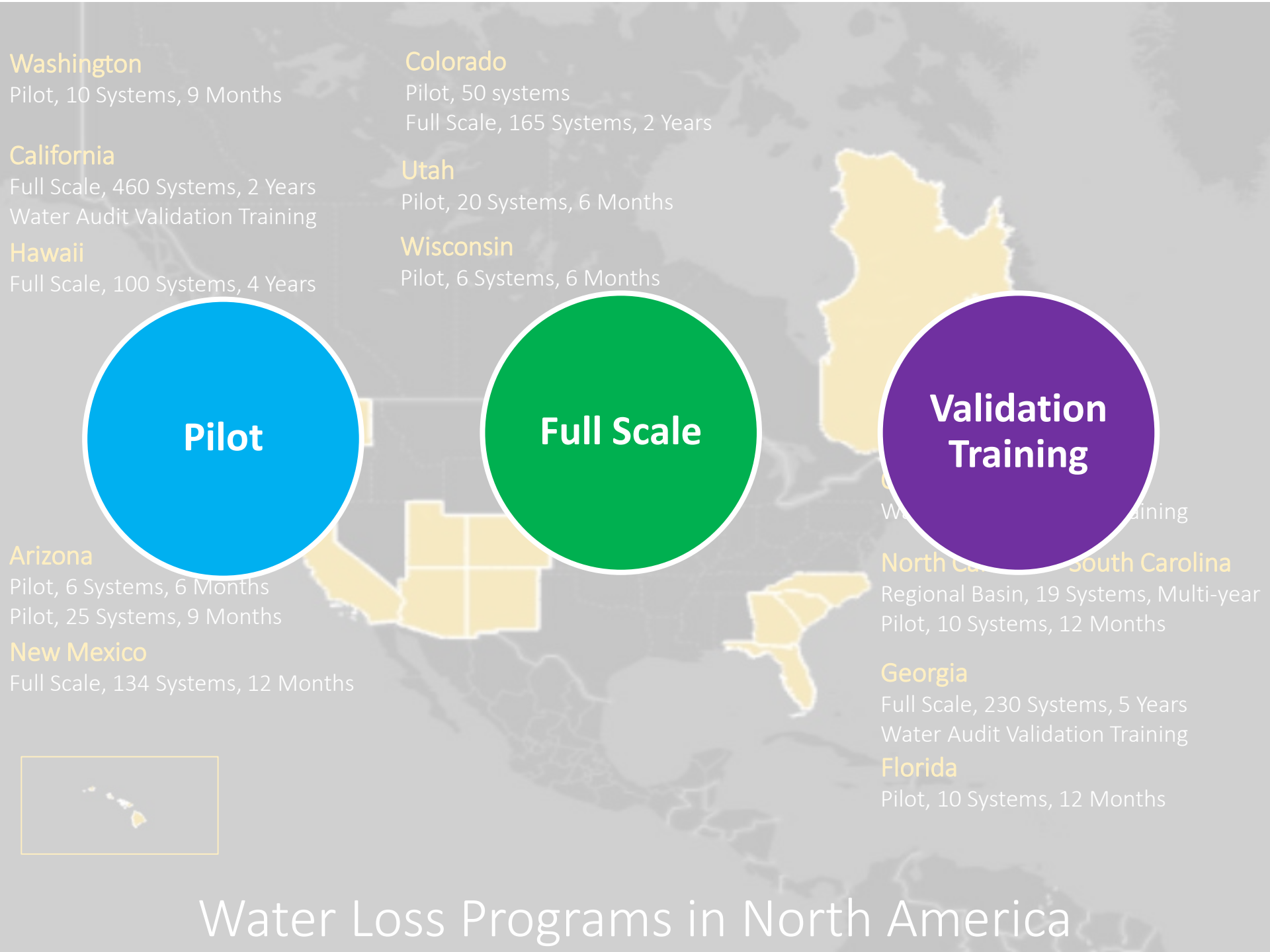
-Material deterioration of the customer base and economic profile

# AWWA M36
# Regulatory Landscape

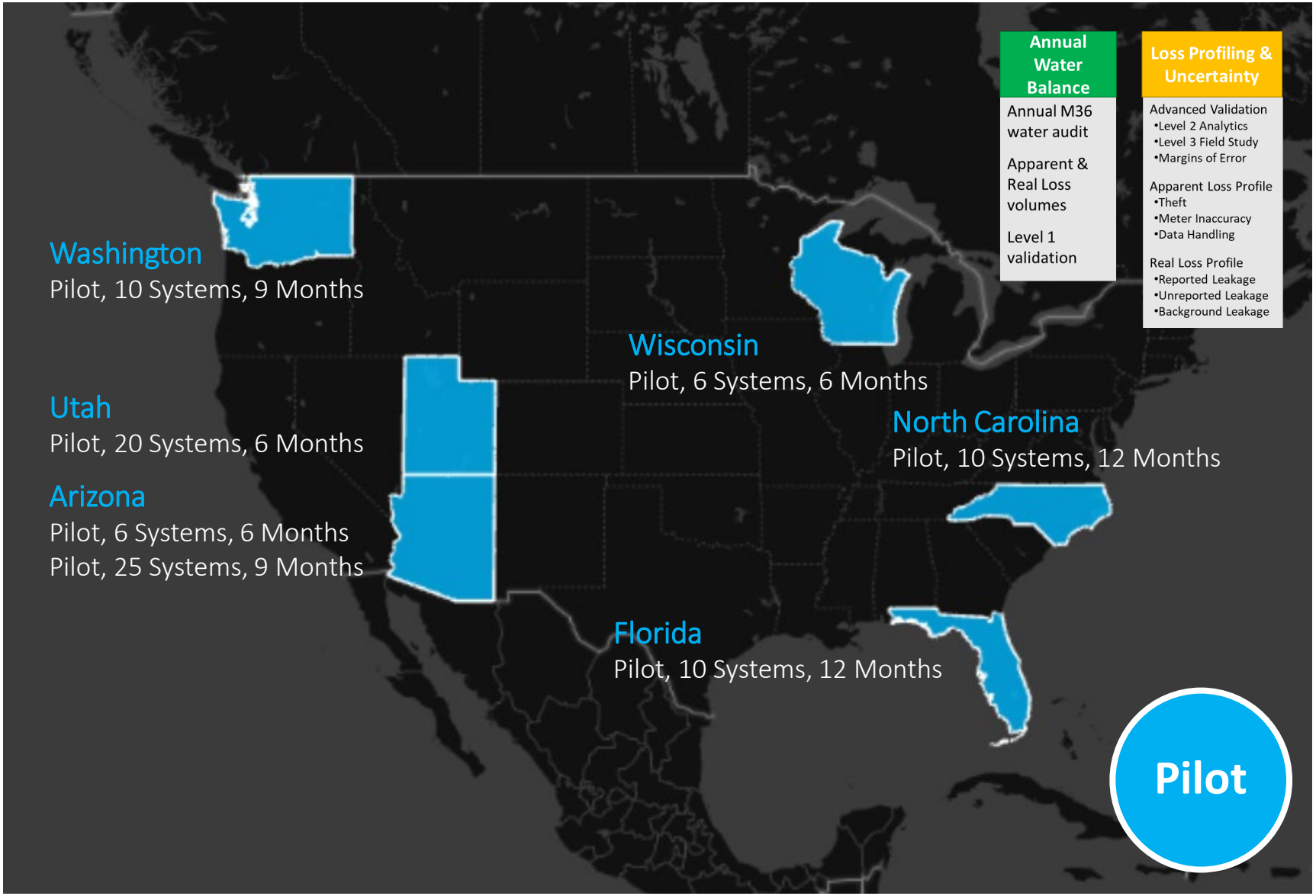





# Water Loss Programs in North America




# Water Loss Programs in North America


Annual Water Balance
Annual M36 water audit
Apparent & Real Loss volumes
Level 1 validation
Loss Profiling & Uncertainty
Advanced Validation
•Level 2 Analytics
•Level 3 Field Study
•Margins of Error
Apparent Loss Profile
•Theft
•Meter Inaccuracy
•Data Handling
Real Loss Profile
•Reported Leakage
•Unreported Leakage
•Background Leakage
Washington
Pilot, 10 Systems, 9 Months
Wisconsin
Pilot, 6 Systems, 6 Months
Utah
Pilot, 20 Systems, 6 Months
North Carolina
Pilot, 10 Systems, 12 Months
Arizona
Pilot, 6 Systems, 6 Months
Pilot, 25 Systems, 9 Months
Florida
Pilot, 10 Systems, 12 Months
Pilot

# North Carolina

Pilot

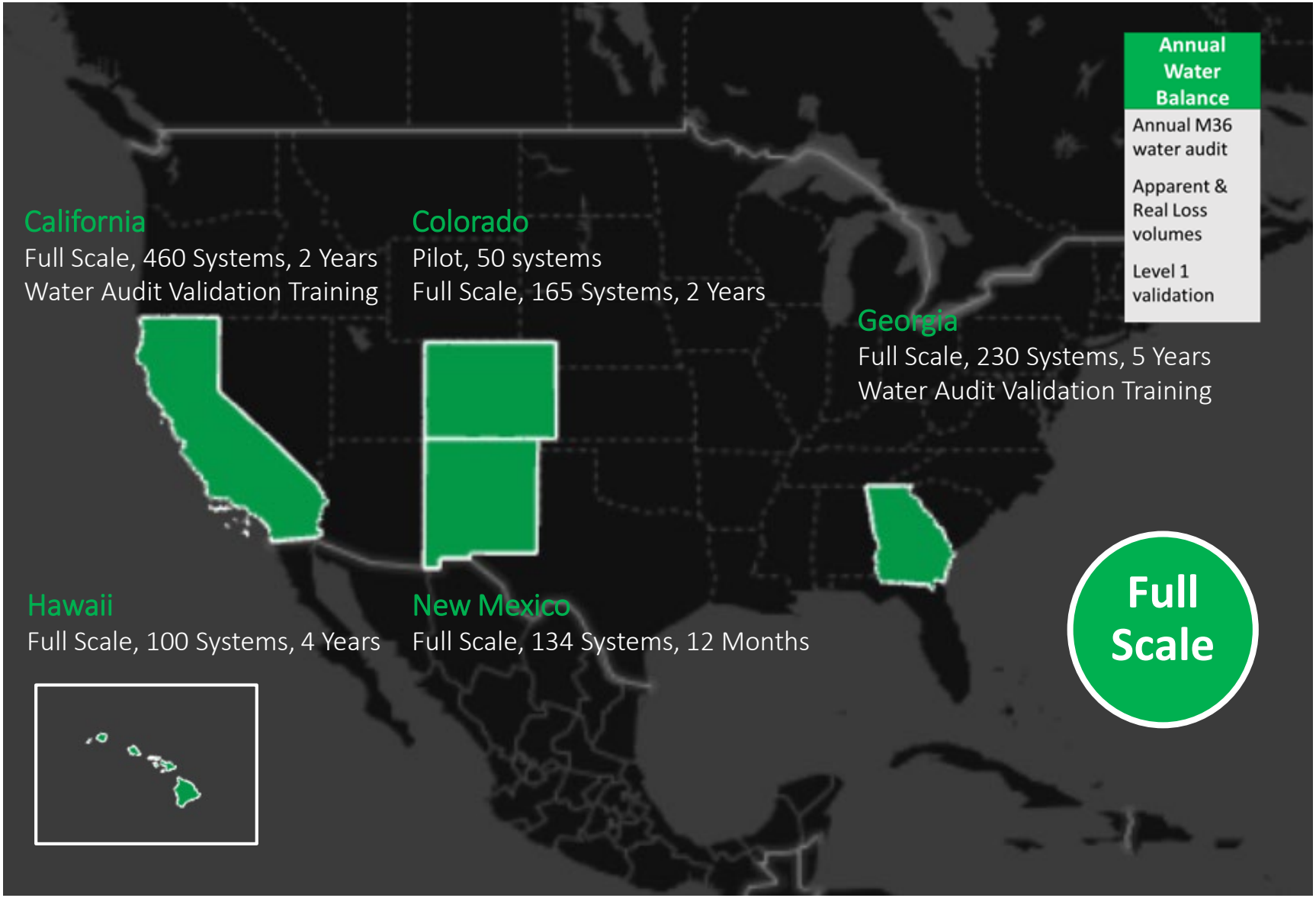

NC Water Infrastructure ENVIRONMENTAL QUALITY

wrri NC WATER RESOURCES RESEARCH INSTITUTE

**Standard Pilot**

**10 Water Systems**

**Technical Training and Assistance through Level 1 Validation + Real Loss Component Analysis**


Annual Water Balance
Annual M36 water audit
Apparent & Real Loss volumes
Level 1 validation
California
Full Scale, 460 Systems, 2 Years
Water Audit Validation Training
Colorado
Pilot, 50 systems
Full Scale, 165 Systems, 2 Years
Georgia
Full Scale, 230 Systems, 5 Years
Water Audit Validation Training
Hawaii
Full Scale, 100 Systems, 4 Years
New Mexico
Full Scale, 134 Systems, 12 Months
Full Scale

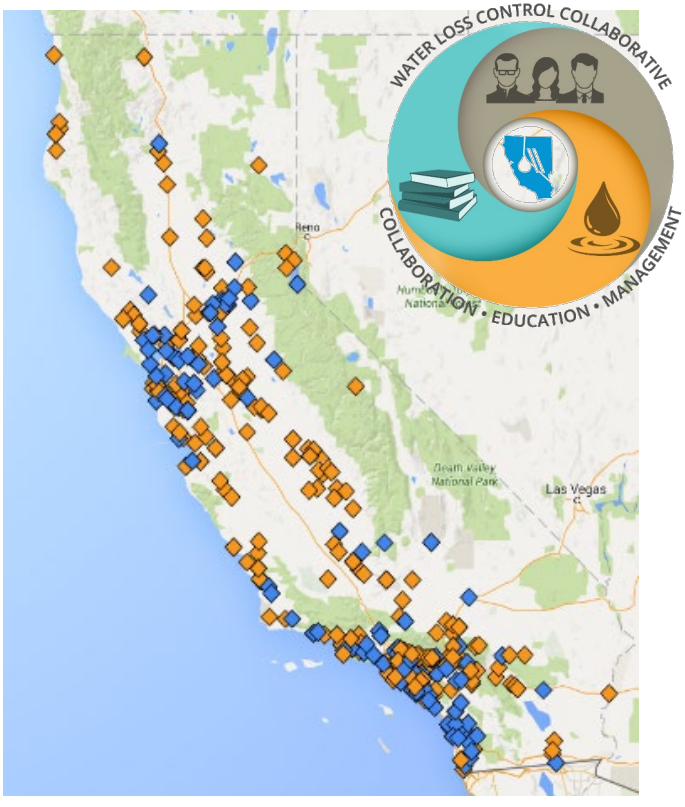
# California

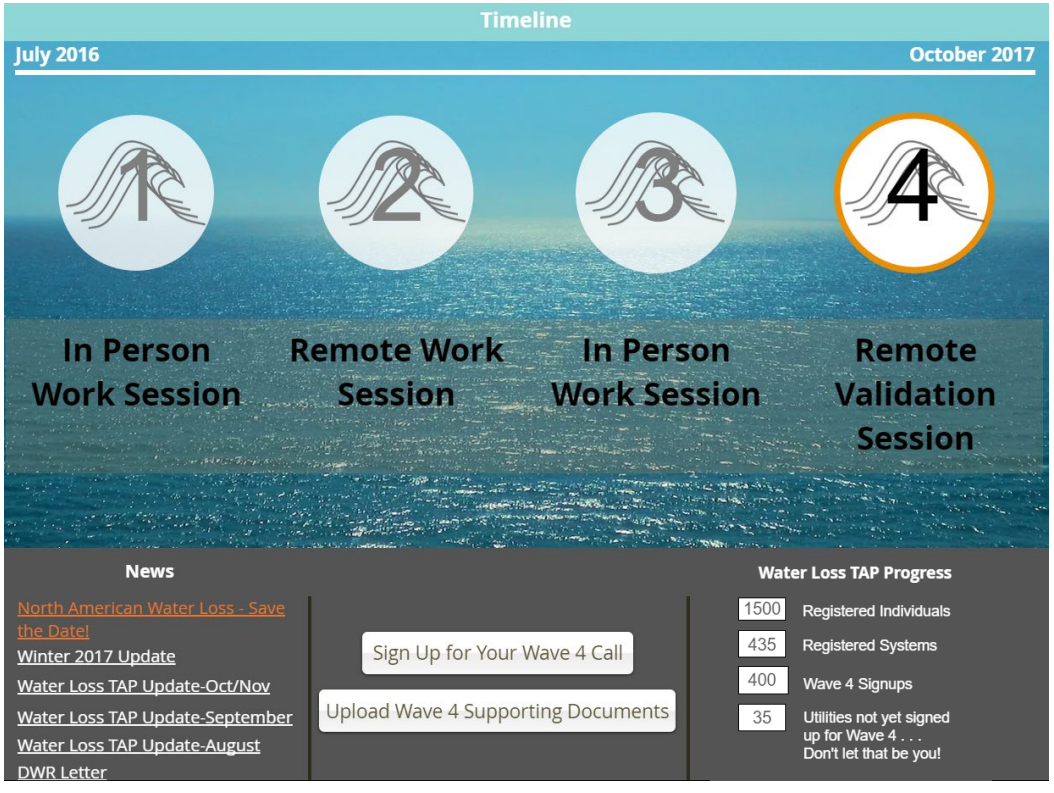
Full Scale

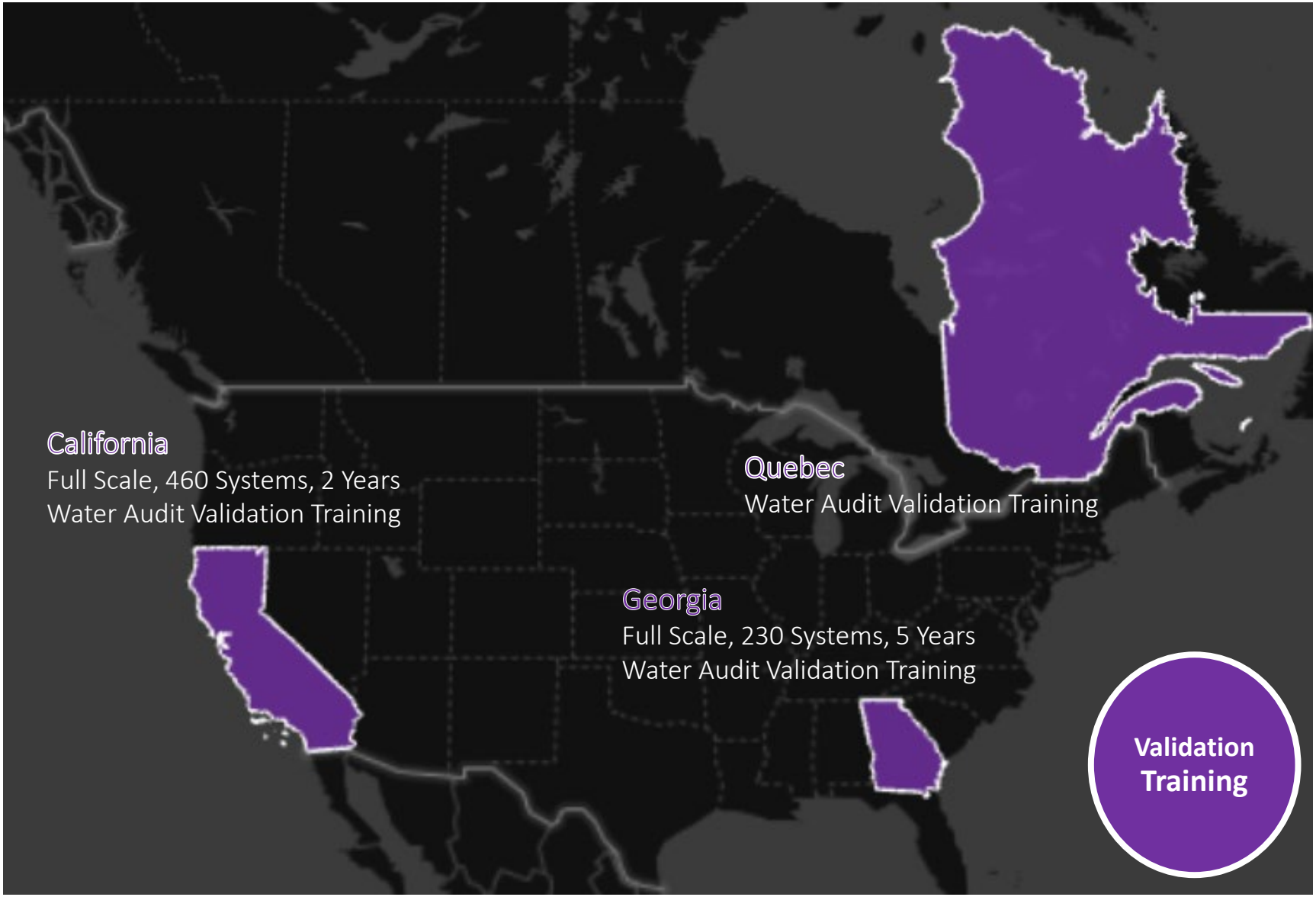
- Under regulatory framework
- Multiple Tracks based on experience
- Technical assistance:
  - AWWA M36 methodology
  - Level 1 Validation

American Water Works Association California-Nevada Section

CALIFORNIA Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS



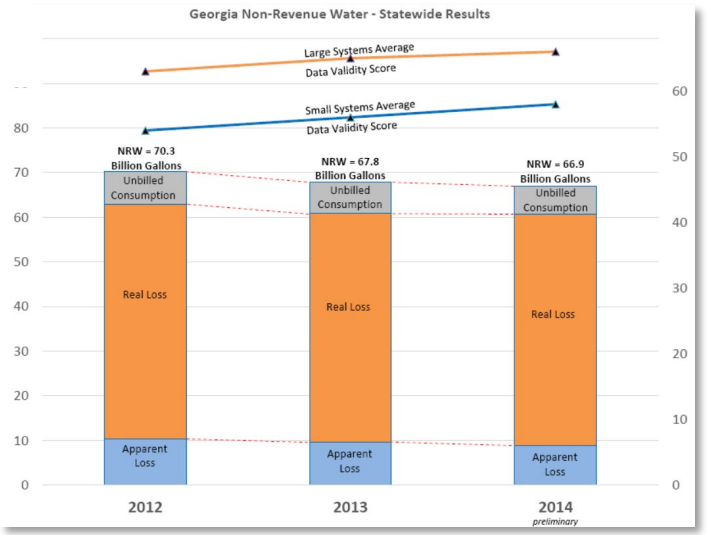




California
Full Scale, 460 Systems, 2 Years
Water Audit Validation Training
Quebec
Water Audit Validation Training
Georgia
Full Scale, 230 Systems, 5 Years
Water Audit Validation Training
Validation
Training

# Georgia

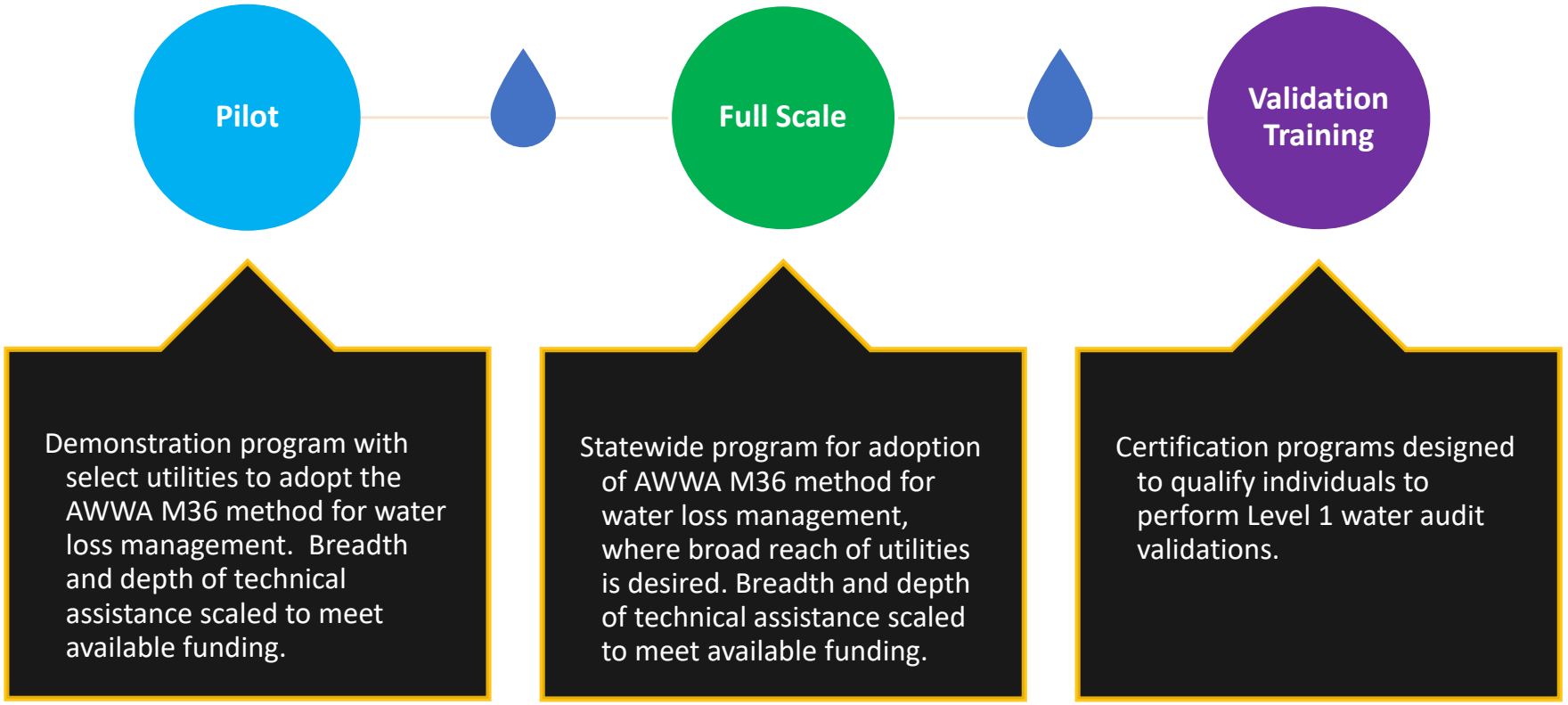
**Validation Training**

- Under regulatory framework
- Multiple Tracks
- Extended touchpoints of technical assistance
- Multiple phases over several years


| 2010 | 2011 | 2012 | 2013 | 2014 | 2015-16 |
|---|---|---|---|---|---|
| Following 2008 Drought, the Water Stewardship Act was Passed into Law | Annual AWWA Auditing Begins,<br>Initial Workshops (all systems)<br>WLC Committee Formed<br>*V1.0 Manual Published* | **Phase 1:**<br>Statewide Training on Water Auditing<br>(Small systems) | **Phase 1A:** Validation of 2011 Audits<br>**Phase 2:**<br>Statewide Technical Assistance Projects<br>(Small Systems) | **Phase 1B:** Validation of 2012,2013 Audits<br>*V1.2 Manual Published*<br>**Phase 2A:**<br>Statewide Technical Assistance Projects<br>(Small Systems) | **Phase 1C:**<br>Audit Certification Program kicks in with 2015 Audits<br>*V2.0 Manual Published*<br>**Phase 2B:**<br>Statewide Technical Assistance Projects<br>(Large Systems) |

# Training and Technical Assistance Programs



# NC Water Loss Control Pilot Program

## Leading utilities down the road to viability

Drew Blackwell
NRW Program Manager
Cavanaugh

wrri
NC WATER RESOURCES RESEARCH INSTITUTE

NC
Water Infrastructure
ENVIRONMENTAL QUALITY

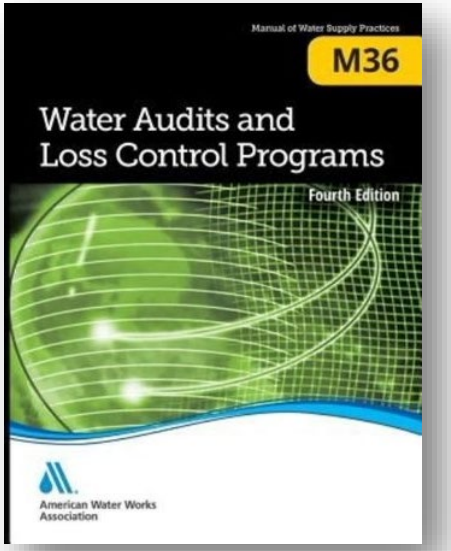
CAVANAUGH
Stewardship Through Innovation

# GOAL:

## Demonstration of AWWA M36 methodology for cost-effective water loss management

Key Tasks:

1. Training & Technical Assistance to 10 small and mid-size utilities across North Carolina
2. Analysis of pilot outcomes & opportunity for water loss & revenue recovery




NC
Water Infrastructure
ENVIRONMENTAL QUALITY


Bakersville, NC
Gateway to the Roan, Home to the Arts


TOWN OF BANNER ELK, NORTH CAROLINA
1911


TOWN OF BENSON
NORTH CAROLINA
CHARTERED 1887


Town of Blowing Rock
1889
North Carolina


BOONE
North Carolina


TOWN OF BURNSVILLE
YANCEY COUNTY
MONUMENT OF CAPTAIN OTWAY BURNS
NORTH CAROLINA


1822
CLINTON
NORTH CAROLINA

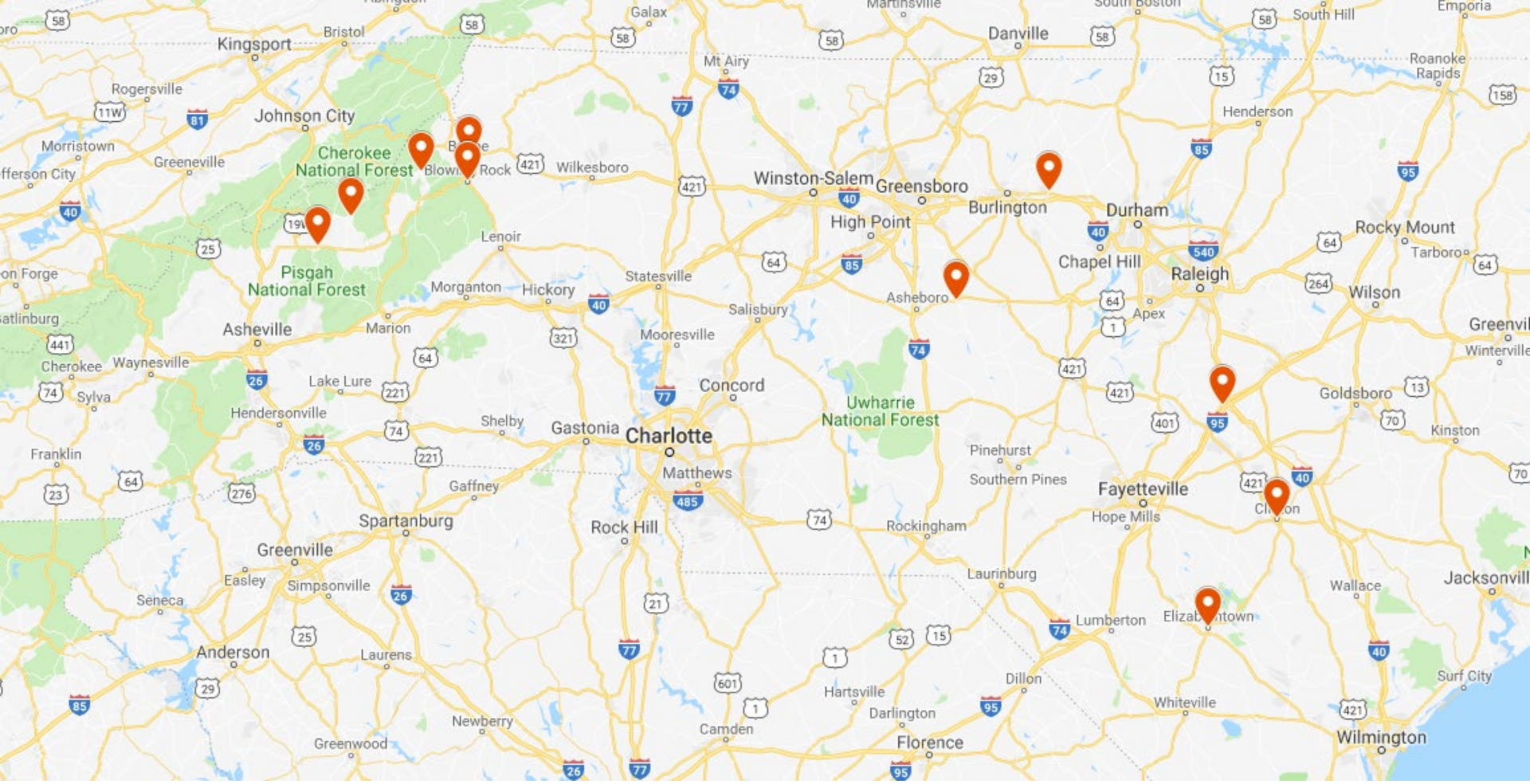

The Town Of Elizabethtown
17 North Carolina 73


CITY OF MEBANE
1881


Ramseur
Where Family and Friends Meet


wrri
NC WATER RESOURCES RESEARCH INSTITUTE


CAVANAUGH
Stewardship Through Innovation




# 10 Participating Water Systems

**Western Region**

- Burnsville
- Banner Elk
- Bakersville
- Blowing Rock
- Boone

**Central Region**

- Ramseur
- Mebane

**Eastern Region**

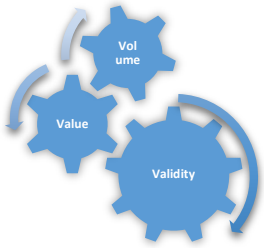
- Benson
- Clinton
- Elizabethtown

# The Big Picture: Economic Intervention

## Annual Water Balance

- Annual M36 water audit
- Apparent & Real Loss volumes
- Level 1 validation

**baseline**




Stage 1

## Loss Profiling & Uncertainty

- Advanced Validation
  - Level 2 Analytics
  - Level 3 Field Study
  - Margins of Error
- Analyze sources of Apparent Loss
- Analyze 3 types of Real Loss

**technical analysis**

Stage 2

## Cost-Benefit & Targets

- Costs of losses
  - by subcomponent
  - in aggregate
- Costs of intervention strategies
- Program design
- System-specific

**economic analysis**

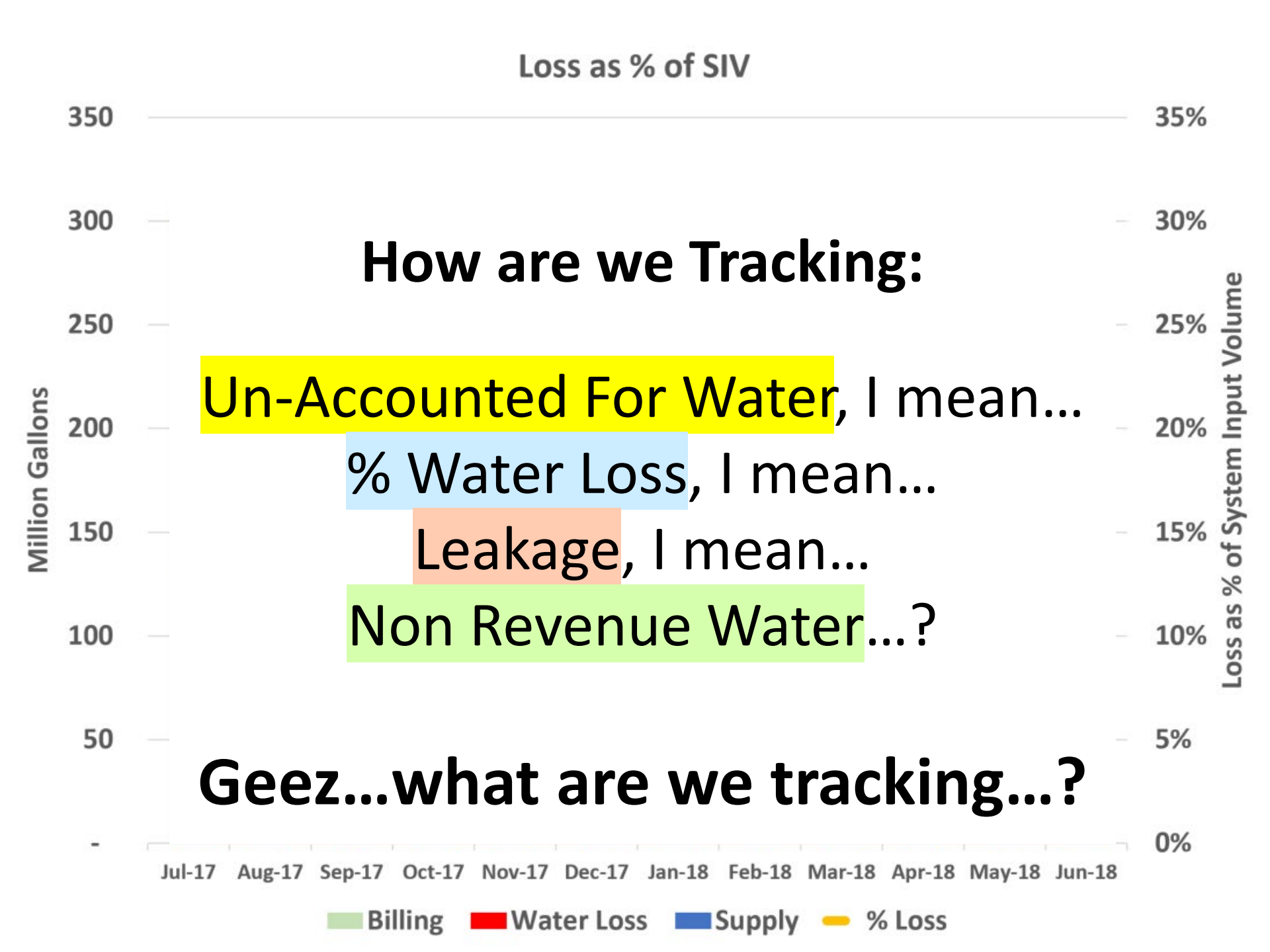
Stage 3

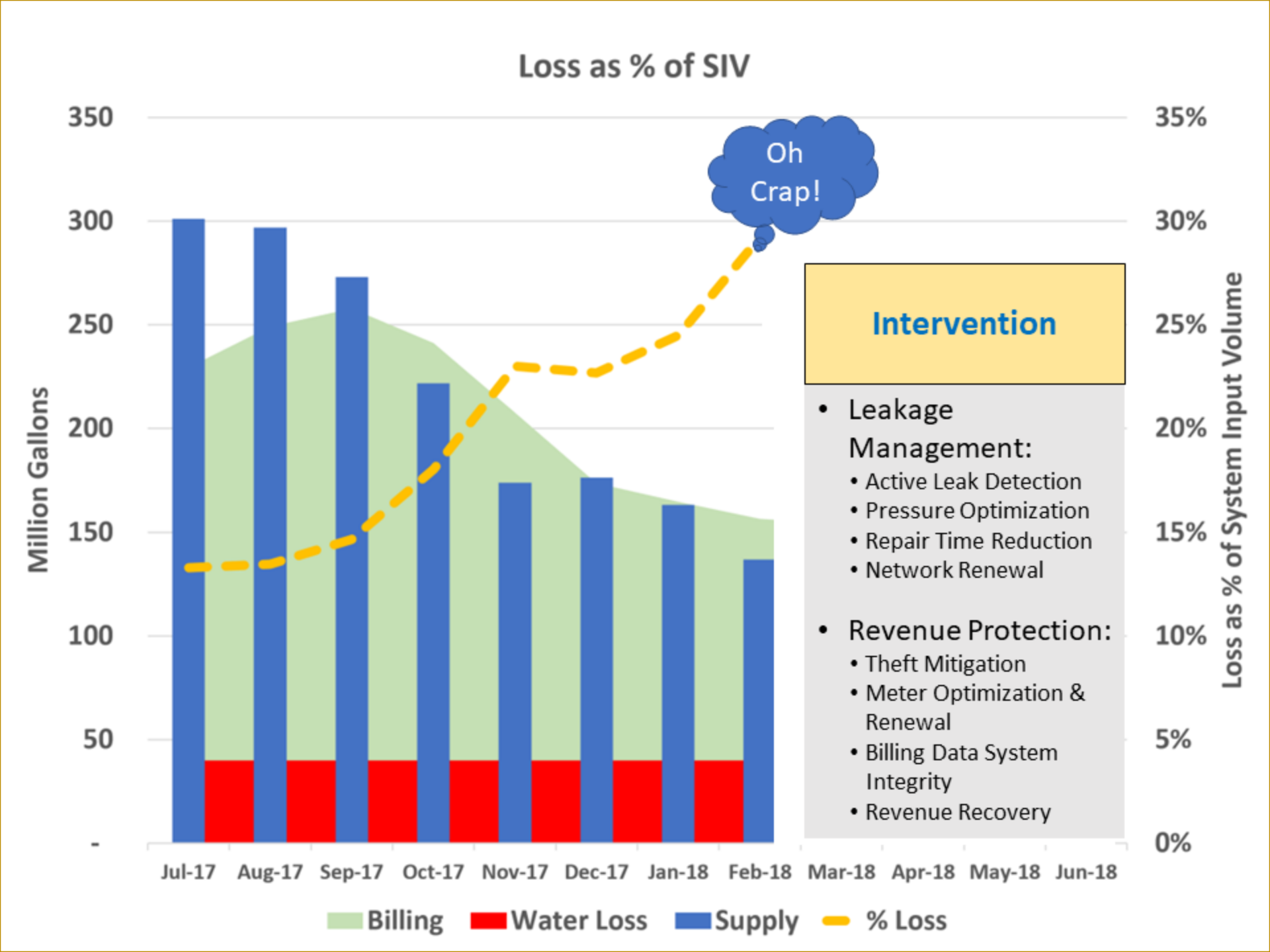
## Intervention

- Leakage Management:
  - Active Leak Detection
  - Pressure Optimization
  - Repair Time Reduction
  - Network Renewal
- Revenue Protection:
  - Theft Mitigation
  - Meter Optimization & Renewal
  - Billing Data System Integrity
  - Revenue Recovery

**cost-effectiveness**

Stage 4


Loss as % of SIV
350
300
250
200
150
100
50
-
35%
30%
25%
20%
15%
10%
5%
0%
Million Gallons
Loss as % of System Input Volume
How are we Tracking:
Un-Accounted For Water, I mean…
% Water Loss, I mean…
Leakage, I mean…
Non Revenue Water…?
Geez…what are we tracking…?
Jul-17
Aug-17
Sep-17
Oct-17
Nov-17
Dec-17
Jan-18
Feb-18
Mar-18
Apr-18
May-18
Jun-18
Billing
Water Loss
Supply
% Loss

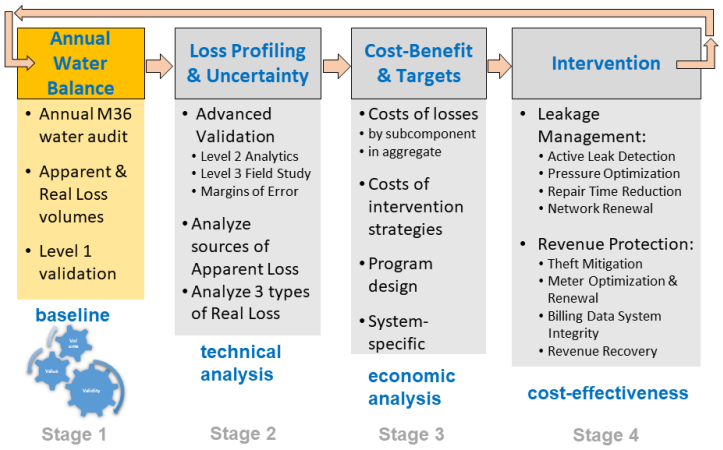

Loss as % of SIV
350
300
250
200
150
100
50
-
Million Gallons
35%
30%
25%
20%
15%
10%
5%
0%
Loss as % of System Input Volume
Oh Crap!
Intervention
• Leakage Management:
• Active Leak Detection
• Pressure Optimization
• Repair Time Reduction
• Network Renewal
• Revenue Protection:
• Theft Mitigation
• Meter Optimization & Renewal
• Billing Data System Integrity
• Revenue Recovery
Jul-17
Aug-17
Sep-17
Oct-17
Nov-17
Dec-17
Jan-18
Feb-18
Mar-18
Apr-18
May-18
Jun-18
Billing
Water Loss
Supply
% Loss

# Round 1 Process

## Round 1

Water Loss Control Program Development → Auditing/ Validation Training & Mobilize Data Gathering → Guidance on Data Gathering → Audit Data Submission

Preliminary Water Audit for each Utility → Level 1 Validation for each Utility



# What utilities put into it…

- Gathered requested data:
  - Supply volumes: per meter, per month
  - Consumption: per class, per month
  - System data: length of mains, operating pressure, etc
  - Cost data: total annual costs, customer retail rates, cost to produce water
- Compiled the AWWA Water Audit for Calendar Year 2017
- Attended 1-day workshop

# AWWA Free Water Audit Software

www.awwa.org/waterlosscontrol

American Water Works Association

**AWWA Free Water Audit Software:**
**Reporting Worksheet**

WAS v5.0



? Click to access definition
+ Click to add a comment

Water Audit Report for: Northern San Leandro Combined Water Sewer Storm Utility District (0007900)
Reporting Year: 2013 1/2013 - 12/2013

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

**All volumes to be entered as: MILLION GALLONS (US) PER YEAR**

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

<---------- Enter grading in column 'E' and 'J' ---------->

Master Meter Error Adjustments

| | | | Pcnt: | Value: | |
|---|---|---|---|---|---|
| **WATER SUPPLIED** | | | | | |
| Volume from own sources: | 5 | 1,000.000 MG/Yr | | 100.000 | MG/Yr |
| Water imported: | | MG/Yr | | | MG/Yr |
| Water exported: | 1 | 100.000 MG/Yr | 9 | 25.000 | MG/Yr |
| **WATER SUPPLIED:** | | **825.000** MG/Yr | | | |
| **AUTHORIZED CONSUMPTION** | | | | | |
| Billed metered: | 8 | 700.000 MG/Yr | | | |
| Billed unmetered: | 9 | 50.000 MG/Yr | | | |
| Unbilled metered: | | MG/Yr | | | |
| Unbilled unmetered: | | 10.313 MG/Yr | 1.25% | | MG/Yr |
| **AUTHORIZED CONSUMPTION:** | | **760.313** MG/Yr | | | |
| **WATER LOSSES (Water Supplied - Authorized Consumption)** | | **64.688** MG/Yr | | | |
| **Apparent Losses** | | | | | |
| Unauthorized consumption: | 10 | 3.000 MG/Yr | | 3.000 | MG/Yr |
| Customer metering inaccuracies: | 5 | 7.071 MG/Yr | 1.00% | | MG/Yr |
| Systematic data handling errors: | 4 | 5.000 MG/Yr | | 5.000 | MG/Yr |
| **Apparent Losses:** | | **15.071** MG/Yr | | | |
| **Real Losses (Current Annual Real Losses or CARL)** | | | | | |
| **Real Losses = Water Losses - Apparent Losses:** | | **49.617** MG/Yr | | | |
| **WATER LOSSES:** | | **64.688** MG/Yr | | | |
| **NON-REVENUE WATER** | | | | | |
| **NON-REVENUE WATER:** | | **75.000** MG/Yr | | | |
| **SYSTEM DATA** | | | | | |
| Length of mains: | 7 | 100.0 miles | | | |
| Number of active AND inactive service connections: | 6 | 1,000 | | | |
| Service connection density: | | 10 conn./mile main | | | |
| Are customer meters typically located at the curbstop or property line? | | Yes | | | |
| Average length of customer service line: | | | | | |
| Average operating pressure: | 6 | 60.0 psi | | | |
| **COST DATA** | | | | | |
| Total annual cost of operating water system: | 5 | $1,000,000 $/Year | | | |
| Customer retail unit cost (applied to Apparent Losses): | 7 | $3.50 $/1000 gallons (US) | | | |
| Variable production cost (applied to Real Losses): | 7 | $3,000.00 $/Million gallons | | | |

= Water Losses + Unbilled Metered + Unbilled Unmetered

Click here: ? for help using option buttons below

Use buttons to select percentage of water supplied **OR** value

Default option selected for Unbilled unmetered - a grading of 5 is applied but not displayed

Unauthorized consumption volume entered is greater than the recommended default value

Enter negative % or value for under-registration
Enter positive % or value for over-registration

(length of service line, beyond the property boundary, that is the responsibility of the utility)

Average length of customer service line has been set to zero and a data grading score of 10 has been applied

Use Customer Retail Unit Cost to value real losses

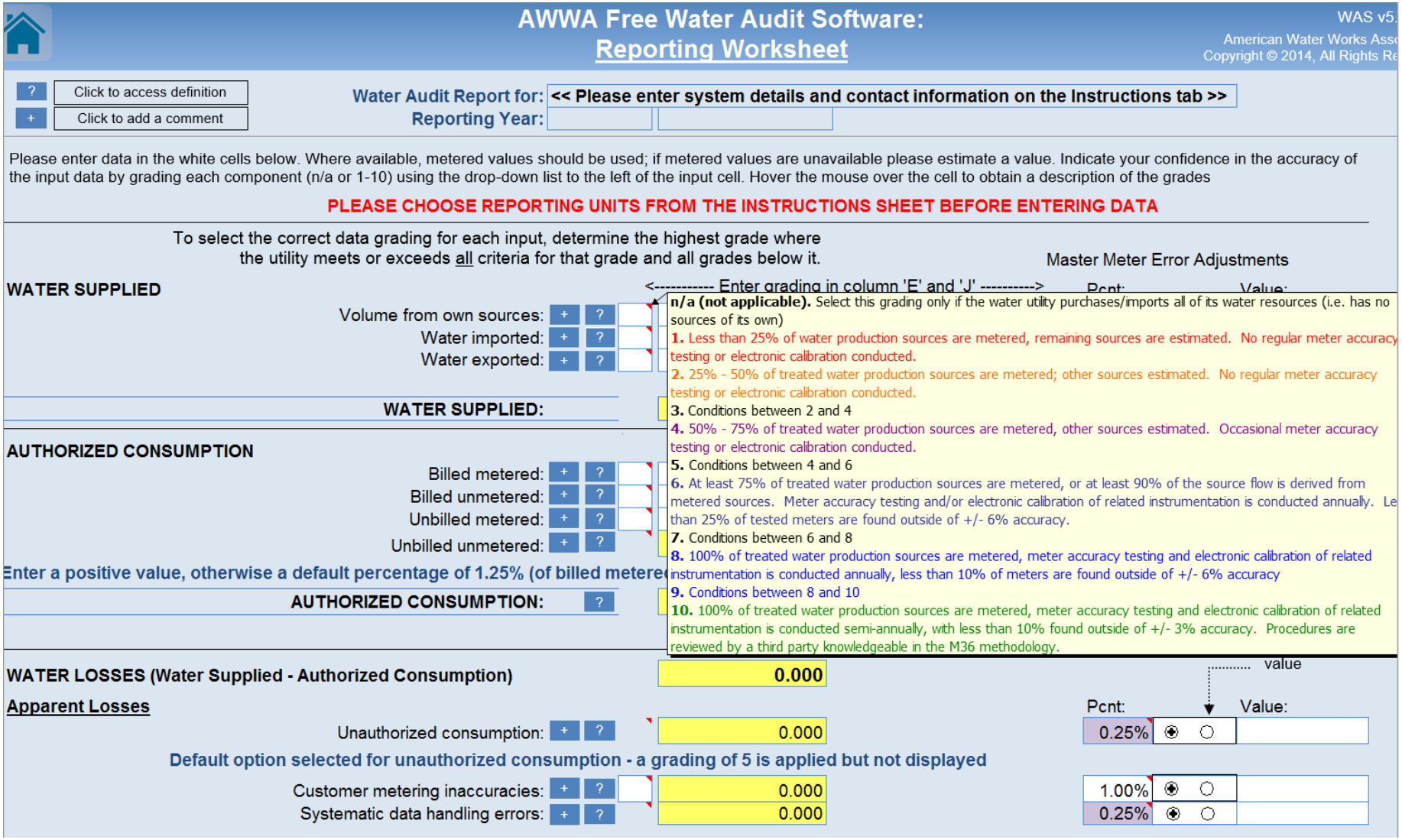

Industry Standard (M36)

Free

Defaults provided

~13 Volume Inputs
~7 System Data Inputs

# AWWA Free Water Audit Software© (V5.0) Data Grading



# AWWA Free Water Audit Software

## Performance Indicators/Metrics

**AWWA Free Water Audit Software:**
**System Attributes and Performance Indicators**

WAS v5.0



Water Audit Report for: City of Orem (UT4900332)
Reporting Year: 2016 7/2015 - 6/2016

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 55 out of 100 ***

| | | | |
|---|---|---|---|
| + | Real Losses: | 555.653 | MG/Yr |
| = | **Water Losses:** | **772.682** | MG/Yr |
| ? | Unavoidable Annual Real Losses (UARL): | 170.51 | MG/Yr |
| | Annual cost of Apparent Losses: | $233,740 | |
| | Annual cost of Real Losses: | $213,979 | Valued at **Variable Production Cost** |

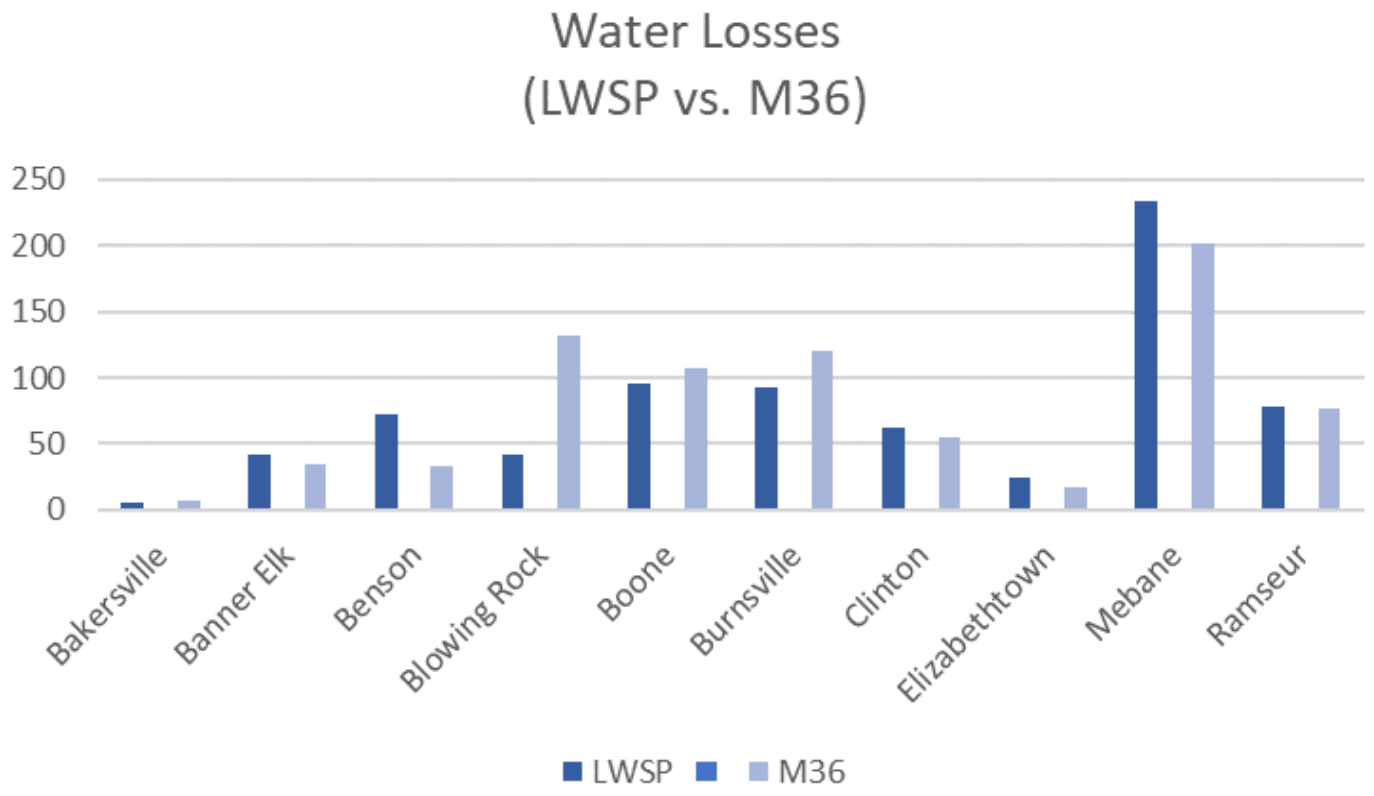
Return to Reporting Worksheet to change this assumpiton

**Performance Indicators:**

| | | | |
|---|---|---|---|
| Financial: | Non-revenue water as percent by volume of Water Supplied: | 14.8% | |
| | Non-revenue water as percent by cost of operating system: | 5.0% | Real Losses valued at Variable Production Cost |
| Operational Efficiency: | Apparent Losses per service connection per day: | 26.11 | gallons/connection/day |
| | Real Losses per service connection per day: | 66.85 | gallons/connection/day |
| | Real Losses per length of main per day*: | N/A | |
| | Real Losses per service connection per day per psi pressure: | 0.77 | gallons/connection/day/psi |
| | From Above, Real Losses = Current Annual Real Losses (CARL): | 555.65 | million gallons/year |
| ? | Infrastructure Leakage Index (ILI) [CARL/UARL]: | 3.26 | |

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

# Current Water Loss Tracking vs. AWWA M36 Methodology



# Purpose of Level 1 Validation

1) review of audit methodology and volume determination
2) review of Data Validity Grade selection

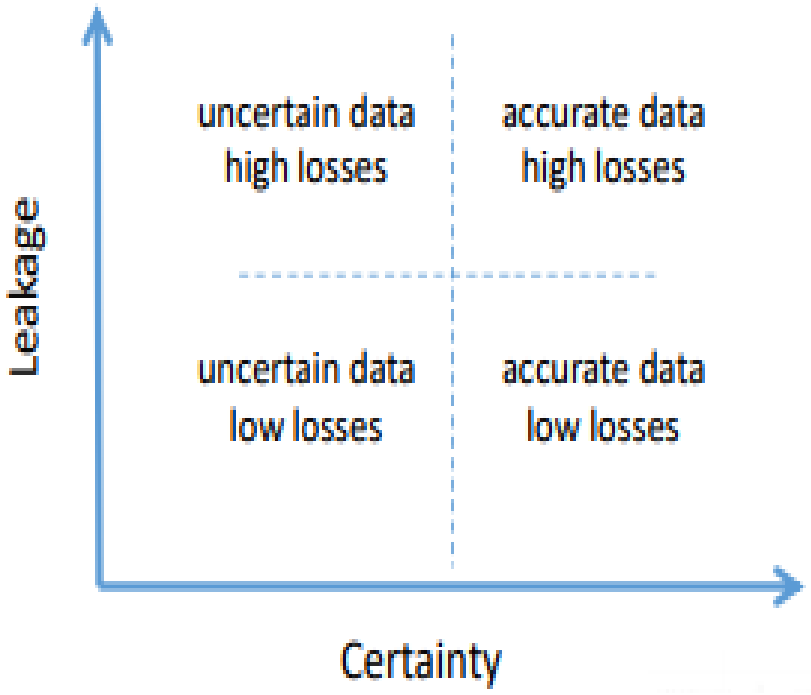
# Level 1 Validation Tools:

- Discussion with Validator
- Supporting Documentation

# The BEST(?) Number

# 100

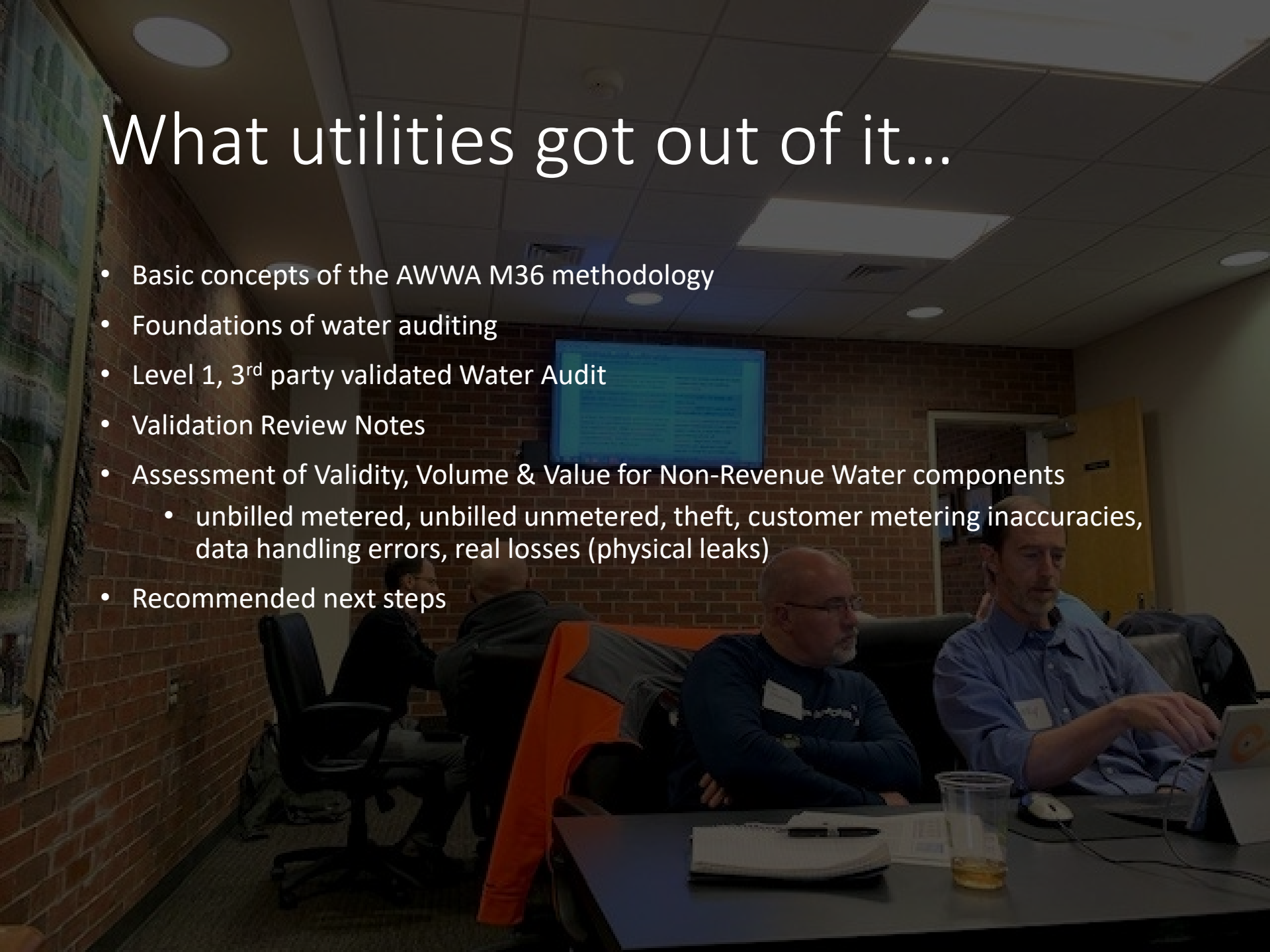
# The BEST(?) Number



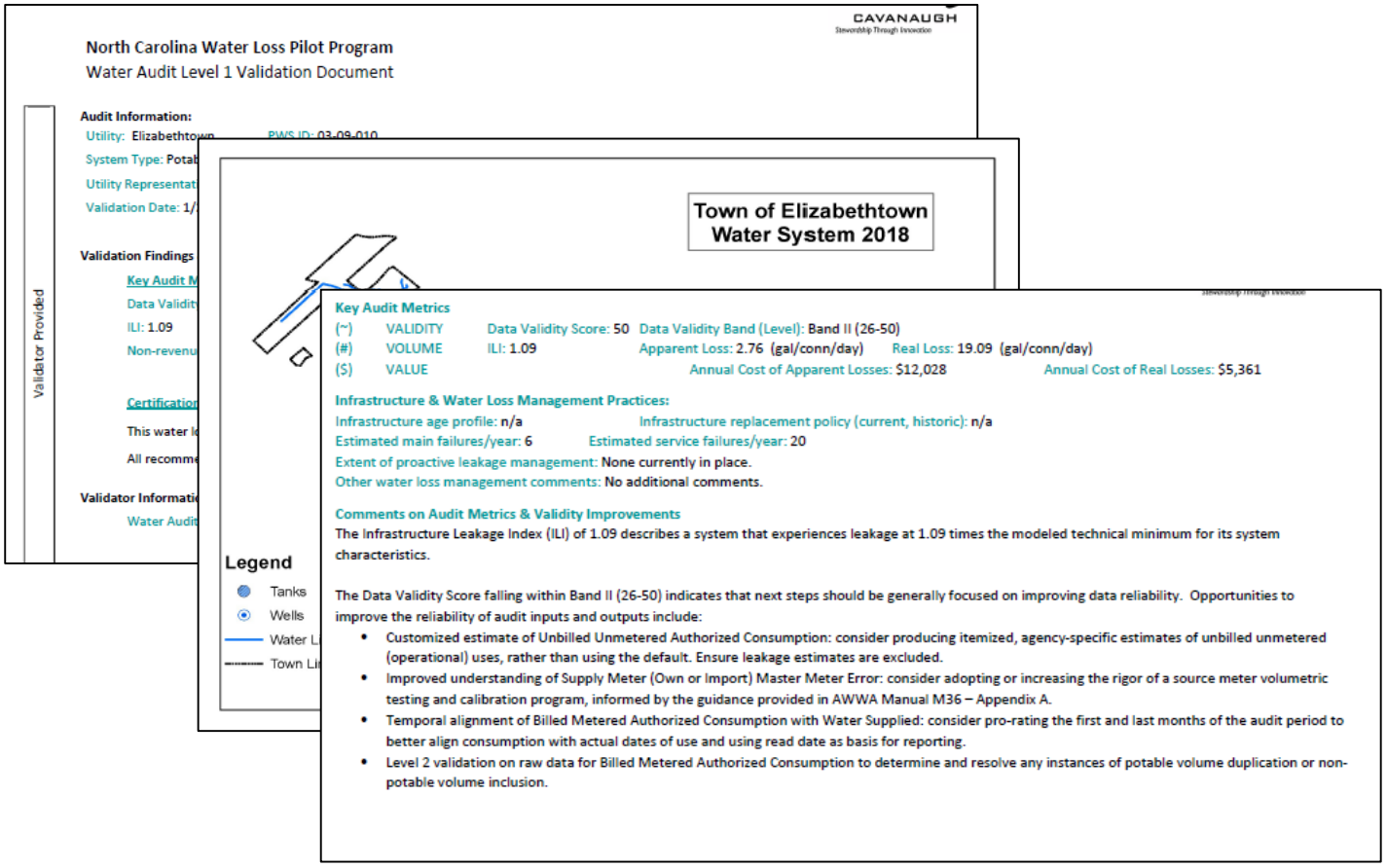

*VS.*

# What utilities got out of it…

- Basic concepts of the AWWA M36 methodology
- Foundations of water auditing
- Level 1, 3rd party validated Water Audit
- Validation Review Notes
- Assessment of Validity, Volume & Value for Non-Revenue Water components
  - unbilled metered, unbilled unmetered, theft, customer metering inaccuracies, data handling errors, real losses (physical leaks)
- Recommended next steps



# Round 1 Recommendations



CAVANAUGH
Stewardship Through Innovation

North Carolina Water Loss Pilot Program
Water Audit Level 1 Validation Document

Audit Information:
Utility: Elizabethtown PWS ID: 03-09-010
System Type: Potab
Utility Representat
Validation Date: 1/

Validation Findings
Key Audit M
Data Validit
ILI: 1.09
Non-revenu

Certificatio
This water l
All recomme

Validator Informati
Water Audit

Validator Provided

Town of Elizabethtown
Water System 2018

Legend
Tanks
Wells
Water L
Town Li

Key Audit Metrics
(~) VALIDITY Data Validity Score: 50 Data Validity Band (Level): Band II (26-50)
(#) VOLUME ILI: 1.09 Apparent Loss: 2.76 (gal/conn/day) Real Loss: 19.09 (gal/conn/day)
($) VALUE Annual Cost of Apparent Losses: $12,028 Annual Cost of Real Losses: $5,361

Infrastructure & Water Loss Management Practices:
Infrastructure age profile: n/a Infrastructure replacement policy (current, historic): n/a
Estimated main failures/year: 6 Estimated service failures/year: 20
Extent of proactive leakage management: None currently in place.
Other water loss management comments: No additional comments.

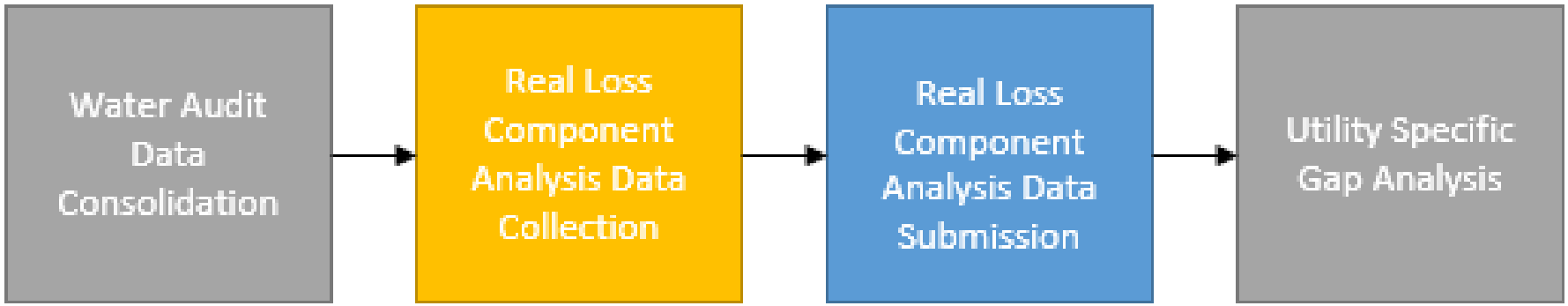
Comments on Audit Metrics & Validity Improvements
The Infrastructure Leakage Index (ILI) of 1.09 describes a system that experiences leakage at 1.09 times the modeled technical minimum for its system characteristics.

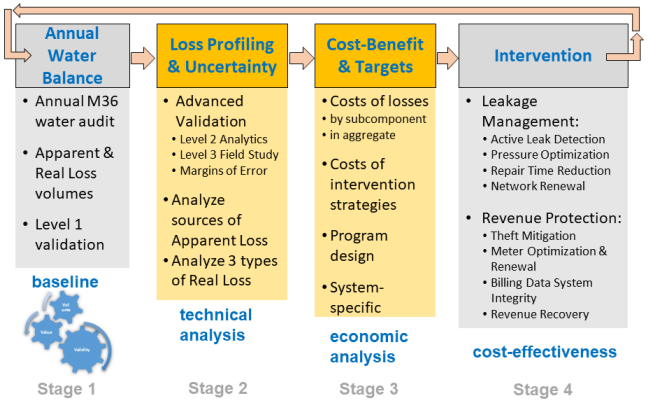
The Data Validity Score falling within Band II (26-50) indicates that next steps should be generally focused on improving data reliability. Opportunities to improve the reliability of audit inputs and outputs include:

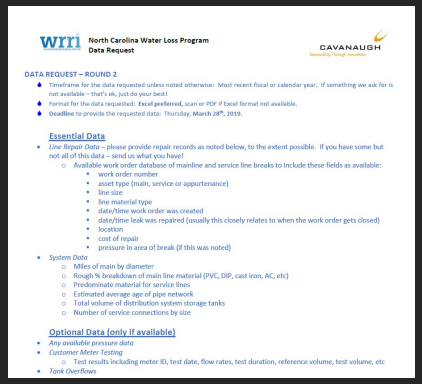
- Customized estimate of Unbilled Unmetered Authorized Consumption: consider producing itemized, agency-specific estimates of unbilled unmetered (operational) uses, rather than using the default. Ensure leakage estimates are excluded.
- Improved understanding of Supply Meter (Own or Import) Master Meter Error: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A.
- Temporal alignment of Billed Metered Authorized Consumption with Water Supplied: consider pro-rating the first and last months of the audit period to better align consumption with actual dates of use and using read date as basis for reporting.
- Level 2 validation on raw data for Billed Metered Authorized Consumption to determine and resolve any instances of potable volume duplication or non-potable volume inclusion.

# Round 2 Process

## Round 2





wrri North Carolina Water Loss Program
Data Request

CAVANAUGH

DATA REQUEST – ROUND 2

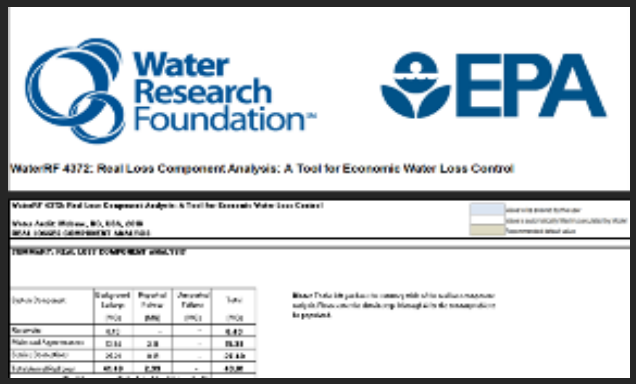
- Timeframe for the data requested unless noted otherwise: Most recent fiscal or calendar year. If something we ask for is not available – that's ok, just do your best!
- Format for the data requested: Excel preferred, scan or PDF if Excel format not available.
- Deadline to provide the requested data: Thursday, March 28th, 2019.

Essential Data

- *Line Repair Data* – please provide repair records as noted below, to the extent possible. If you have some but not all of this data – send us what you have!
  - Available work order database of mainline and service line breaks to include these fields as available:
    - work order number
    - asset type (main, service or appurtenance)
    - line size
    - line material type
    - date/time work order was created
    - date/time leak was repaired (usually this closely relates to when the work order gets closed)
    - location
    - cost of repair
    - pressure in area of break (if this was noted)
- *System Data*
  - Miles of main by diameter
  - Rough % breakdown of main line material (PVC, DIP, cast iron, AC, etc)
  - Predominate material for service lines
  - Estimated average age of pipe network
  - Total volume of distribution system storage tanks
  - Number of service connections by size

Optional Data (only if available)

- *Any available pressure data*
- *Customer Meter Testing*
  - Test results including meter ID, test date, flow rates, test duration, reference volume, test volume, etc
- *Tank Overflows*



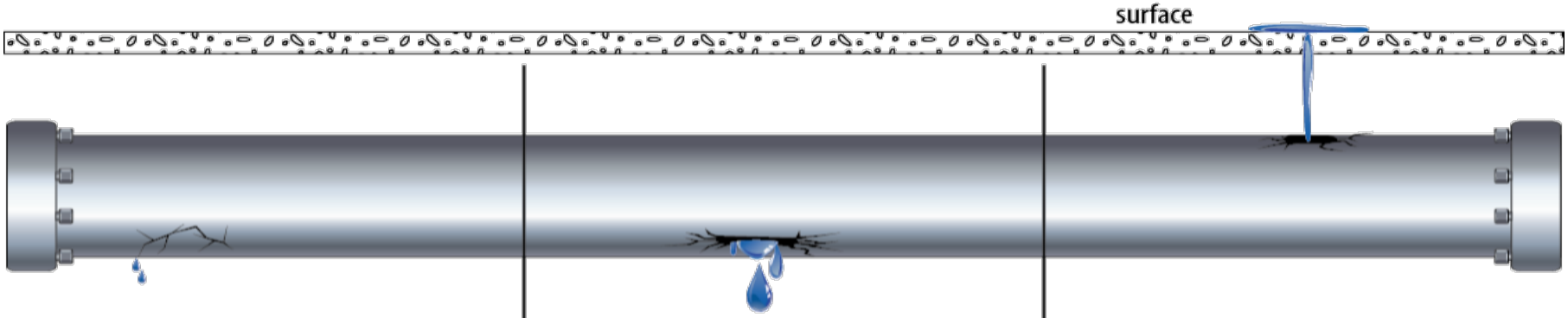

# What utilities put into it…

- Gathered requested data:
  - Line repair data: work order number, asset type, line size/material, date/time, location, cost of repair
  - Additional system data: miles of main by diameter, breakdown of pipe material by %, age of pipe network, total volume of storage tanks
- Attended webcast of Round 2 that delivered basic concepts of Real Loss Component Analysis

# Identified different types of leaks


*Figure 1: Sub-Components of Real Loss (graphic credit WRF)*

# Selecting the Right Tool




**Background Leakage**
Unreported and un-detectable using traditional acoustic equipment.

Tools
Pressure Management
Main & service replacement
Reduction in number of joints/fittings

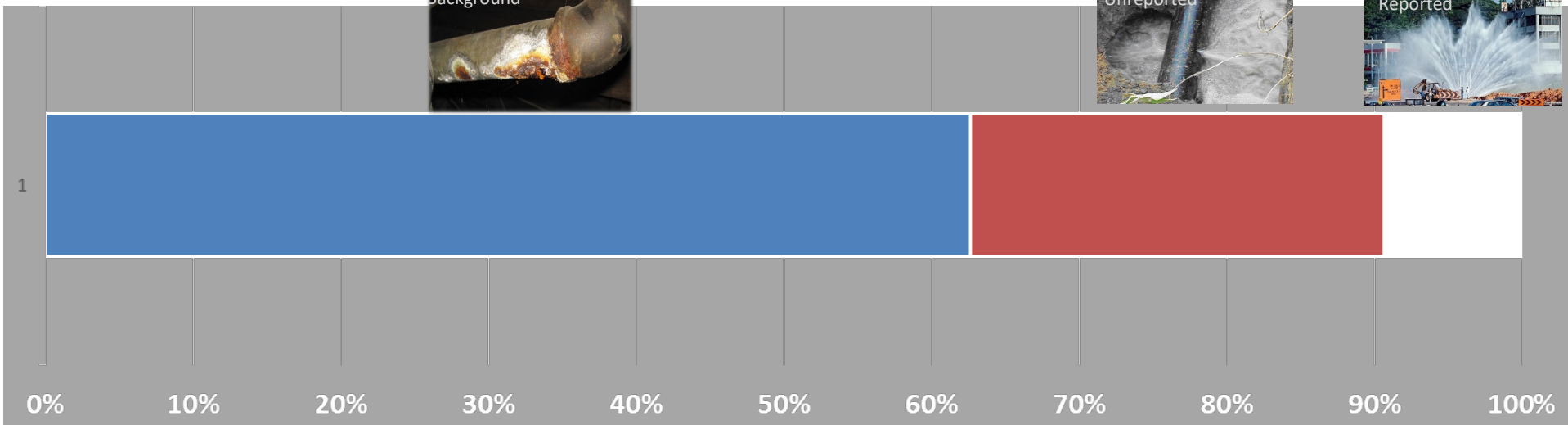
**Unreported Leakage**
Often does not surface but is detectable using traditional acoustic equipment.

Tools
Pressure Management
Main & service replacement
Reduction in number of joints/fittings
Proactive Leak Detection

**Reported Leakage**
Often surfaces and is reported by public or utility workers.

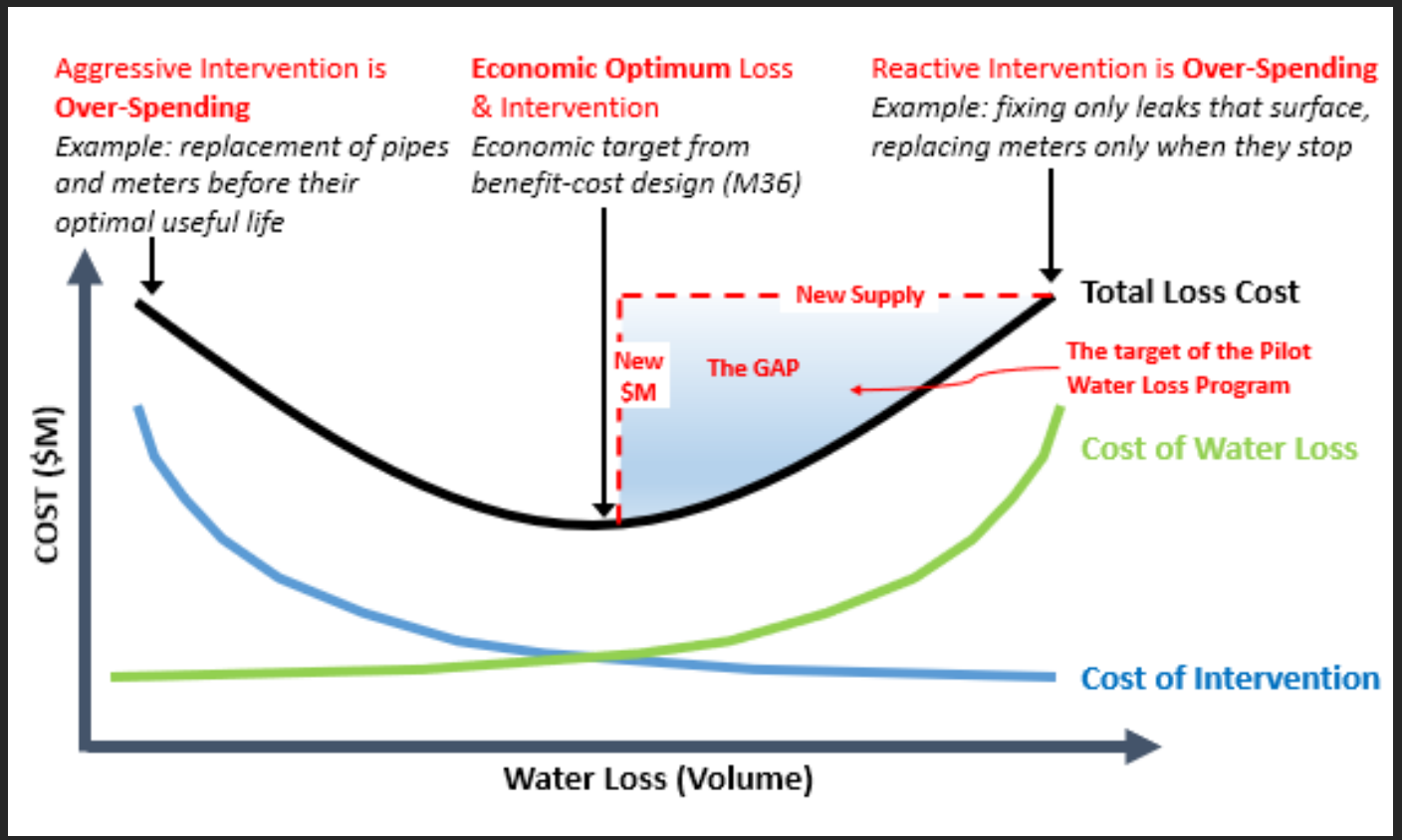
Tools
Pressure Management
Main & service replacement
Optimized repair time



# What utilities got out of it…

- Basic concepts of Real Loss Component Analysis
- Economic Analysis for water loss intervention



# Round 2 Recommendations

*Recommended next steps include:*

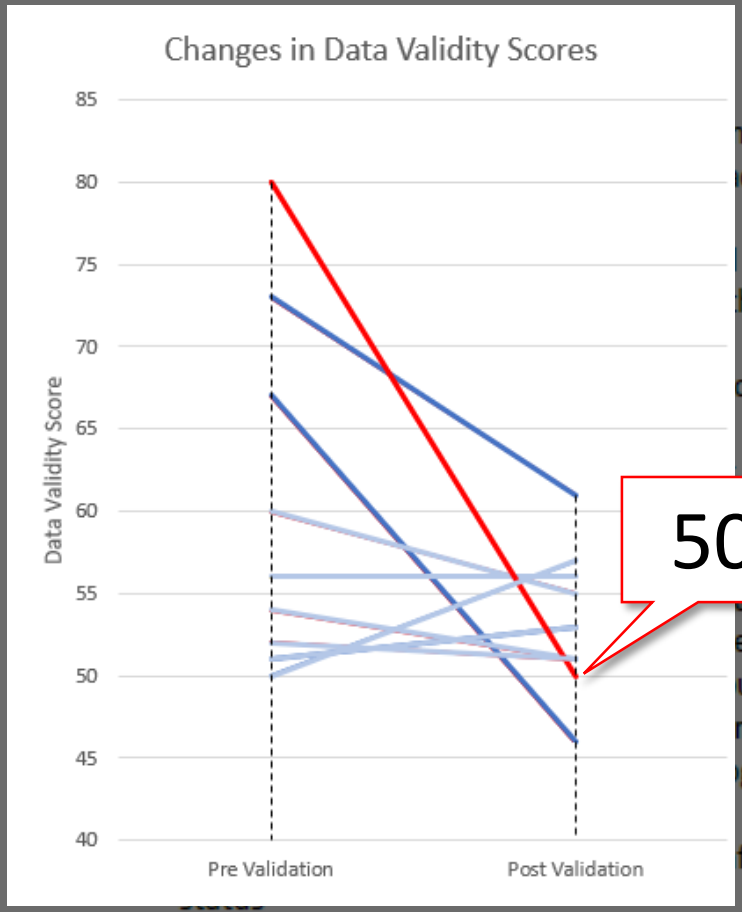
Data Validity and Program Management

- Develop the water balance annually using the AWWA Free Water Audit Software
  - Develop and maintain a monthly tracking mechanism to be consistent with M36
  - methodology;
  - Develop a plan for internal/external communication of efforts and results;
  - Develop unbilled, unmetered authorized consumption strategy to include awareness, estimate methods and tracking;
  - Continue to implement data collection practices to conduct water balance on segments of the overall system
- Asses feasibility of Supply Meter testing

Leakage Management

- Develop and implement Proactive Leak Detection Program to include:
  - In-depth technology identification and applicability analysis
  - Capital vs. Operational cost development
  - Implementation schedule and budget
- Evaluate establishment of District Metered Areas for leakage management
- Develop Pressure Optimization Pilot program for reduction in break frequencies and background leakage component
- Conduct regular meetings of internal staff to review data tracking, trends and intervention project status

# Round 2 Recommendations




- Continue annual practice of completing water audit
  - Start with Calendar Year 2018 and refer to recommendations in 2017 review notes
- Assess feasibility of annual supply meter testing; both volumetric testing and electronic calibration

# Show me the Data (and the Money)

## Program results

Drew Blackwell
NRW Program Manager
Cavanaugh

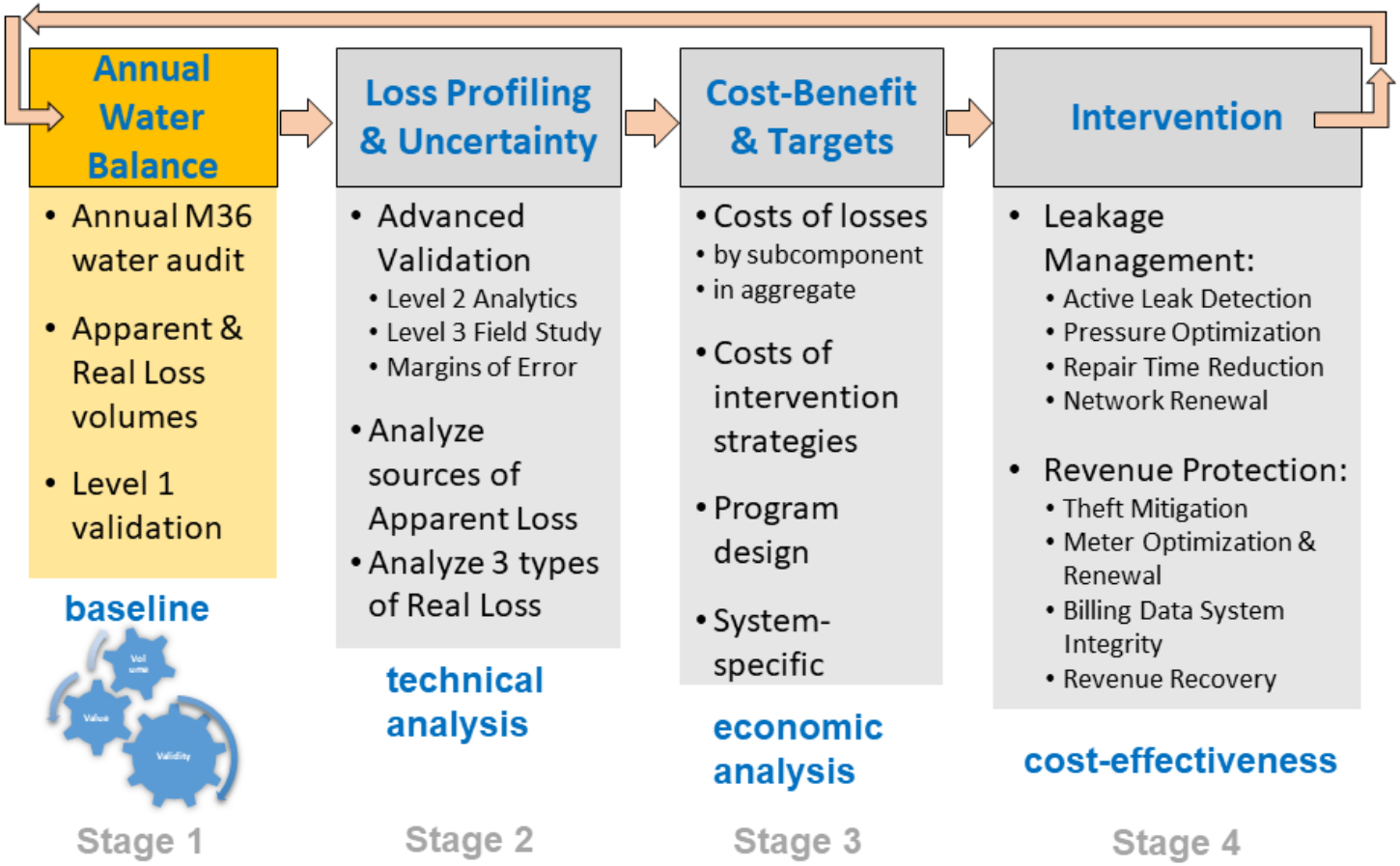
Will Jernigan
Director of Water Efficiency
Cavanaugh

wrri
NC WATER RESOURCES RESEARCH INSTITUTE

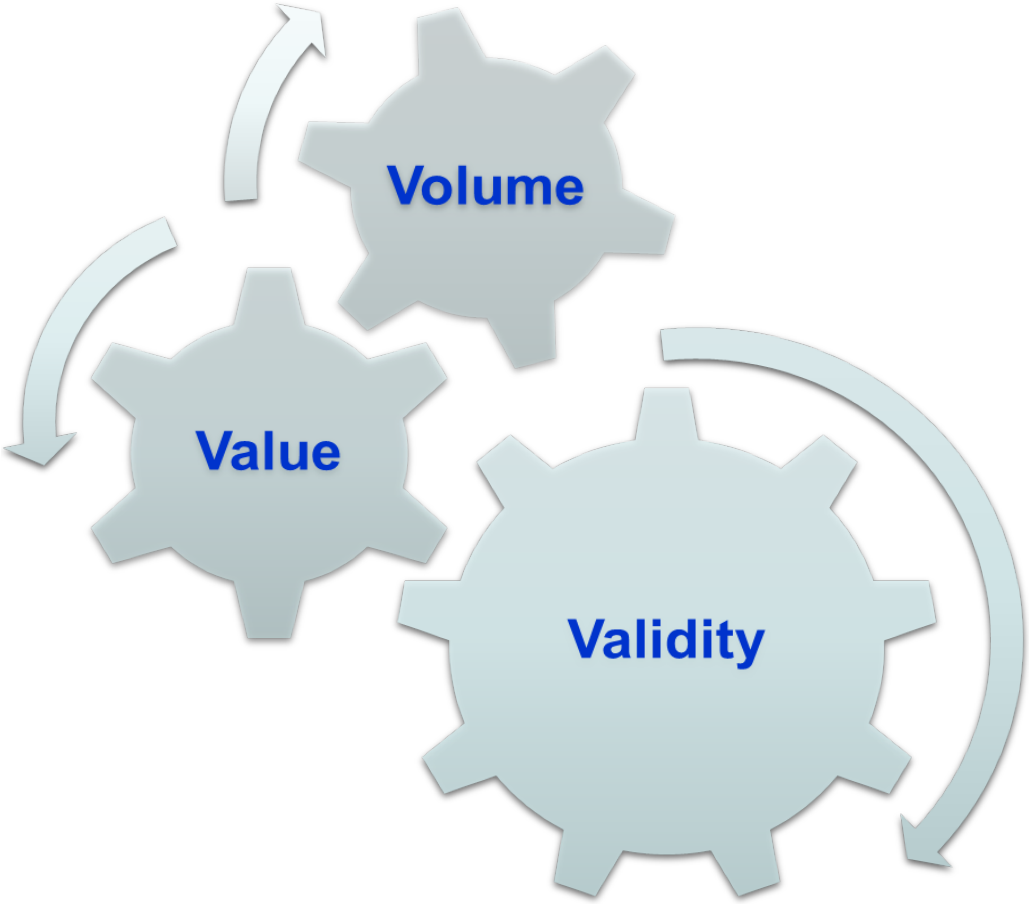
NC
Water Infrastructure
ENVIRONMENTAL QUALITY

CAVANAUGH
Stewardship Through Innovation

# Round 1 Results



# Interpreting the Results - Validation Outcomes



# If self-reported, how realistic are our results?

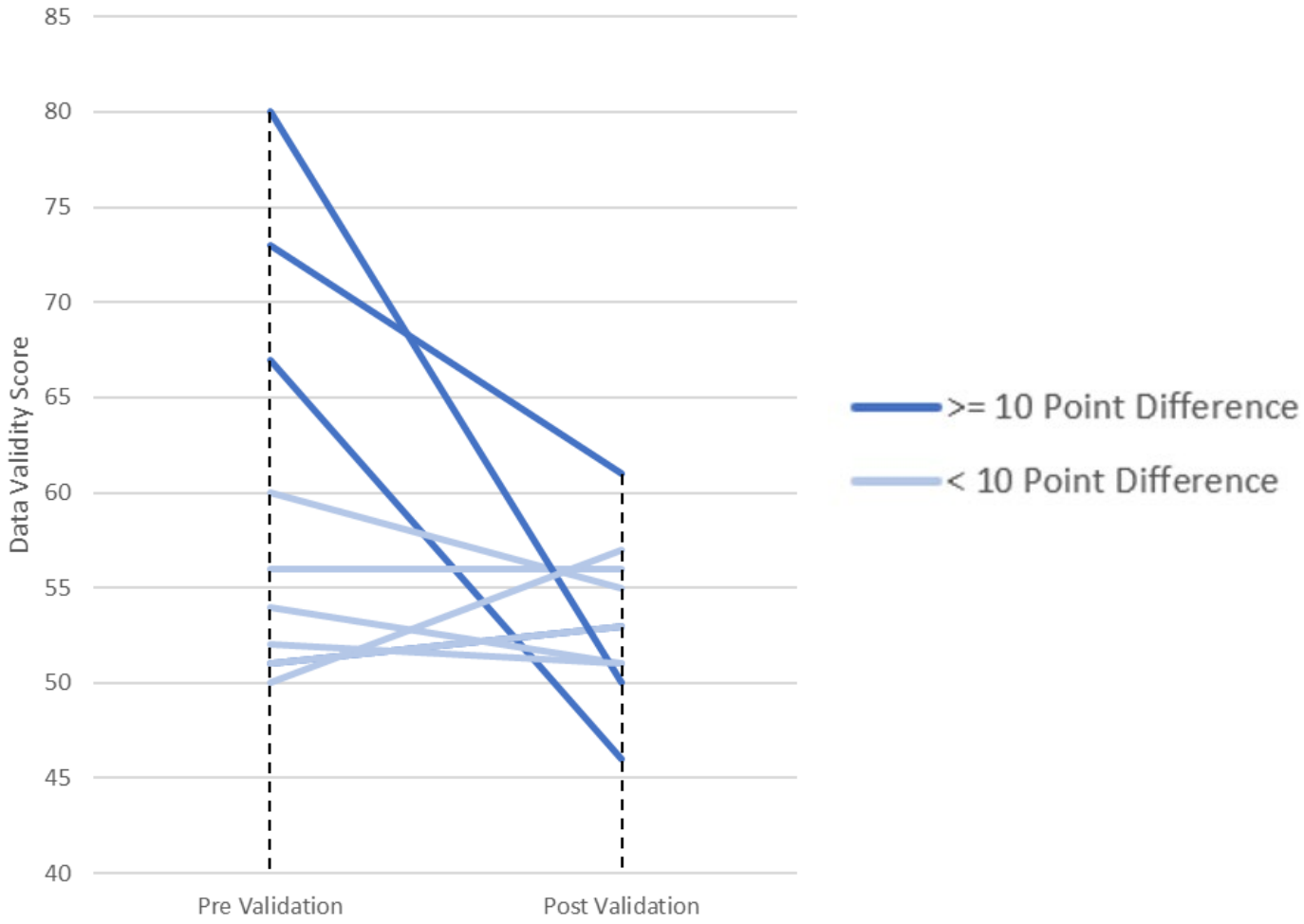
## Pre-Validation

| | min | median | max | units |
|---|---|---|---|---|
| **Customer Metering Inaccuracies** | 0 | 0.302 | 17.118 | *million gal* |
| **Customer Retail Unit Cost** | $ 3.78 | $ 5.82 | $ 1,165,161.74 | *$ / 1,000 gal* |
| **Variable Production Cost** | $ 2.70 | $ 628.28 | $ 2,751.38 | *$ / million gal* |
| **Annual Cost of Apparent Losses** | $ 1,821.43 | $ 18,930.54 | $ 937,618,387.40 | *$* |
| **Annual Cost of Real Losses** | $ 0.19 | $ 52,003.41 | $ 203,927.89 | *$* |
| **Non-Revenue Water as % by Cost of Operating System** | 1% | 9% | 67967% | *% of operating cost* |

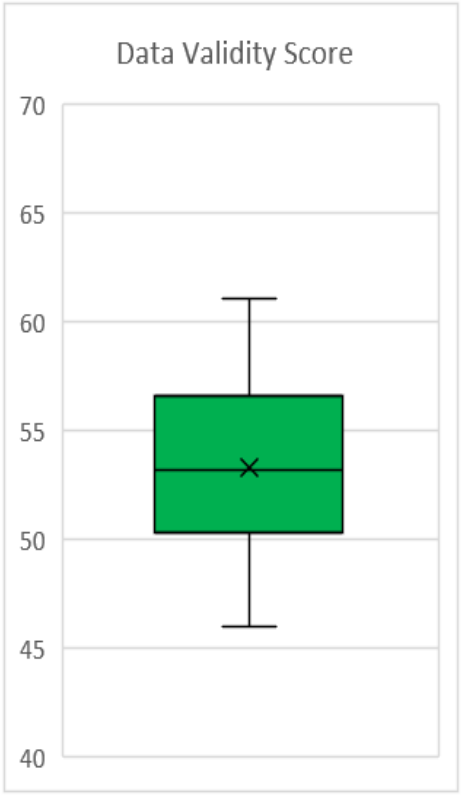
## Post-Validation

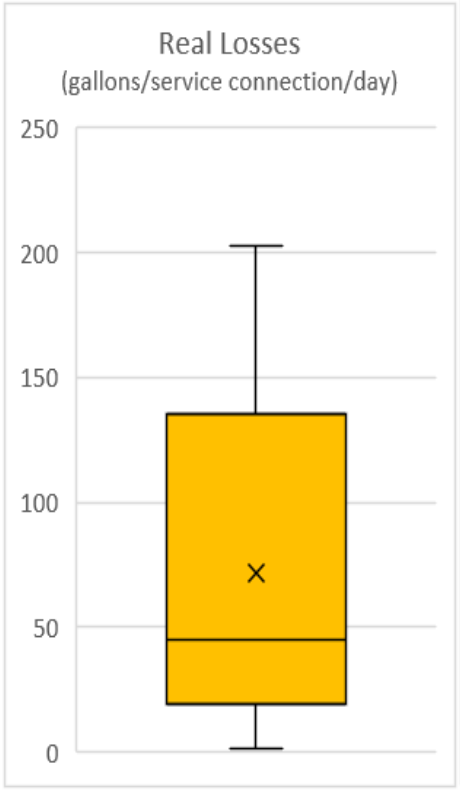
| | min | median | max | units |
|---|---|---|---|---|
| **Customer Metering Inaccuracies** | 0.383 | 2.023 | 16.164 | *million gal* |
| **Customer Retail Unit Cost** | $ 4.00 | $ 8.91 | $ 13.78 | *$ / 1,000 gal* |
| **Variable Production Cost** | $ 188.77 | $ 536.50 | $ 2,751.38 | *$ / million gal* |
| **Annual Cost of Apparent Losses** | $ 2,426.31 | $ 47,804.14 | $ 252,384.93 | *$* |
| **Annual Cost of Real Losses** | $ 1,267.23 | $ 34,064.76 | $ 203,927.89 | *$* |
| **Non-Revenue Water as % by Cost of Operating System** | 0.5% | 10.3% | 62.4% | *% of operating cost* |

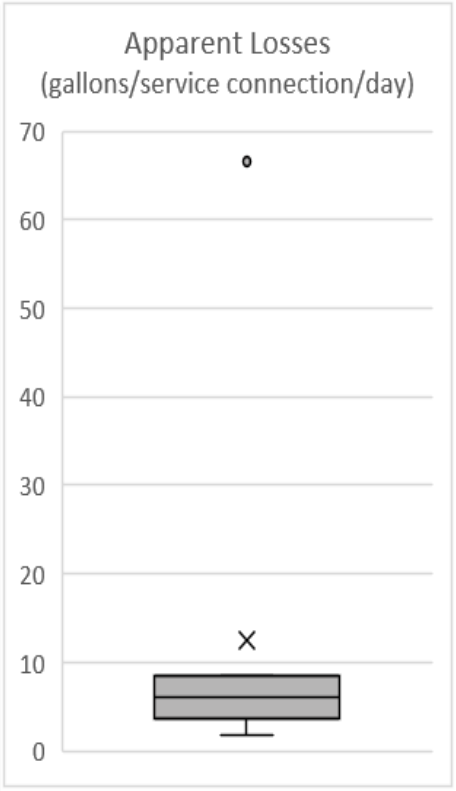
# Changes in Data Validity Scores

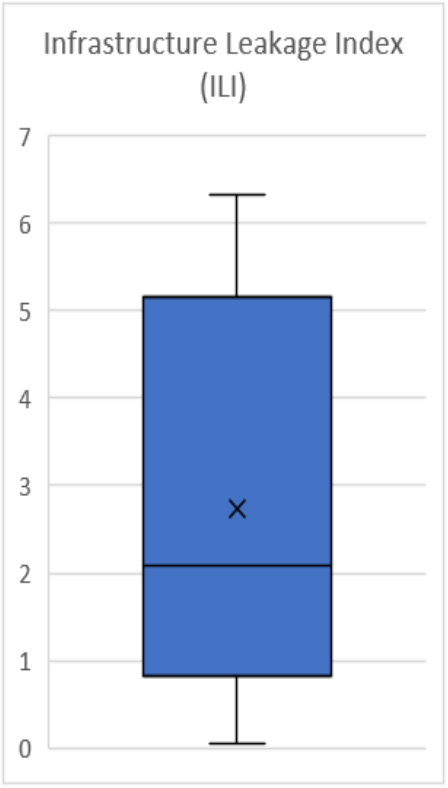


# Post Level 1 Validation Outputs



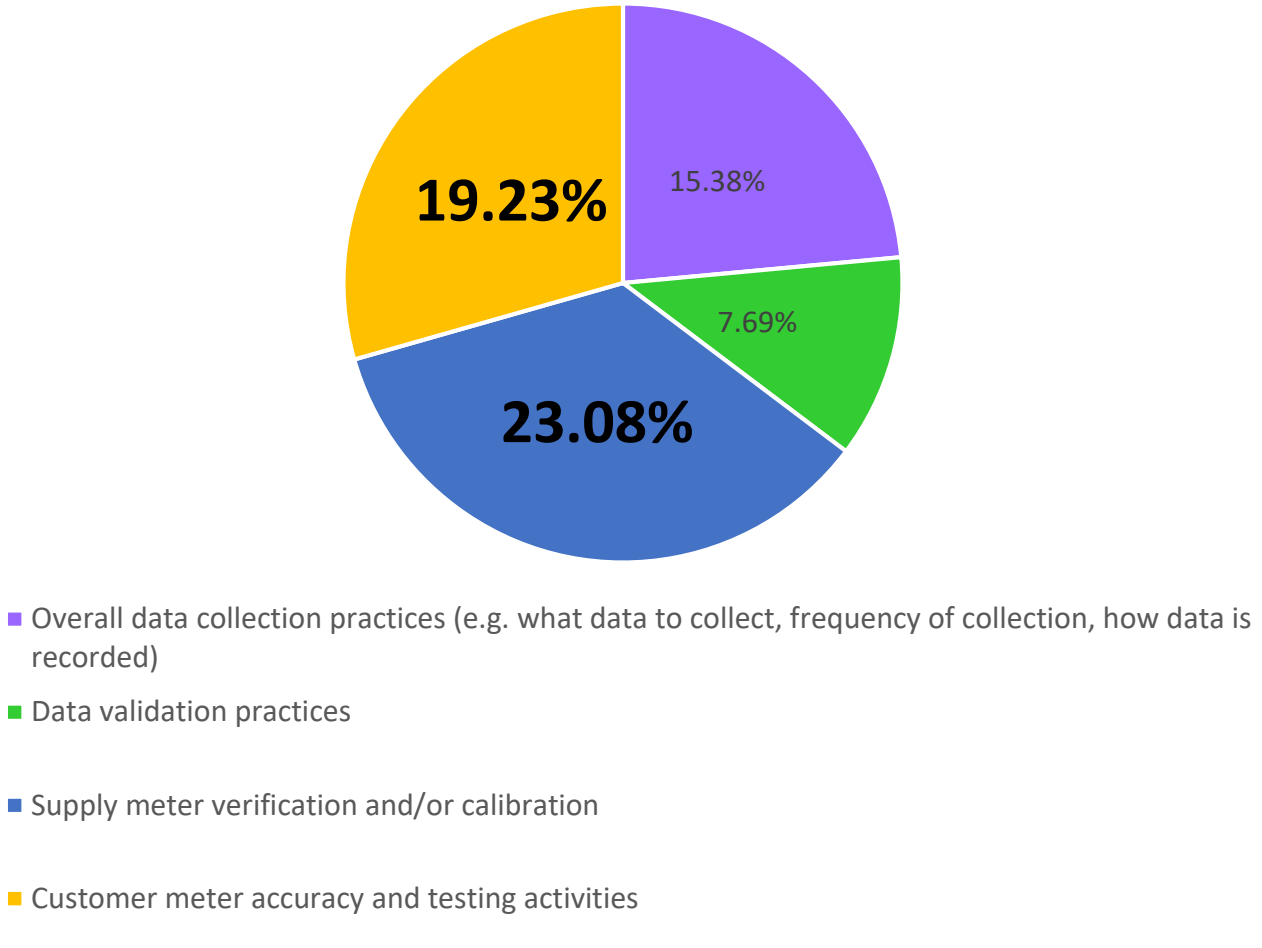



# Improving Data Validity

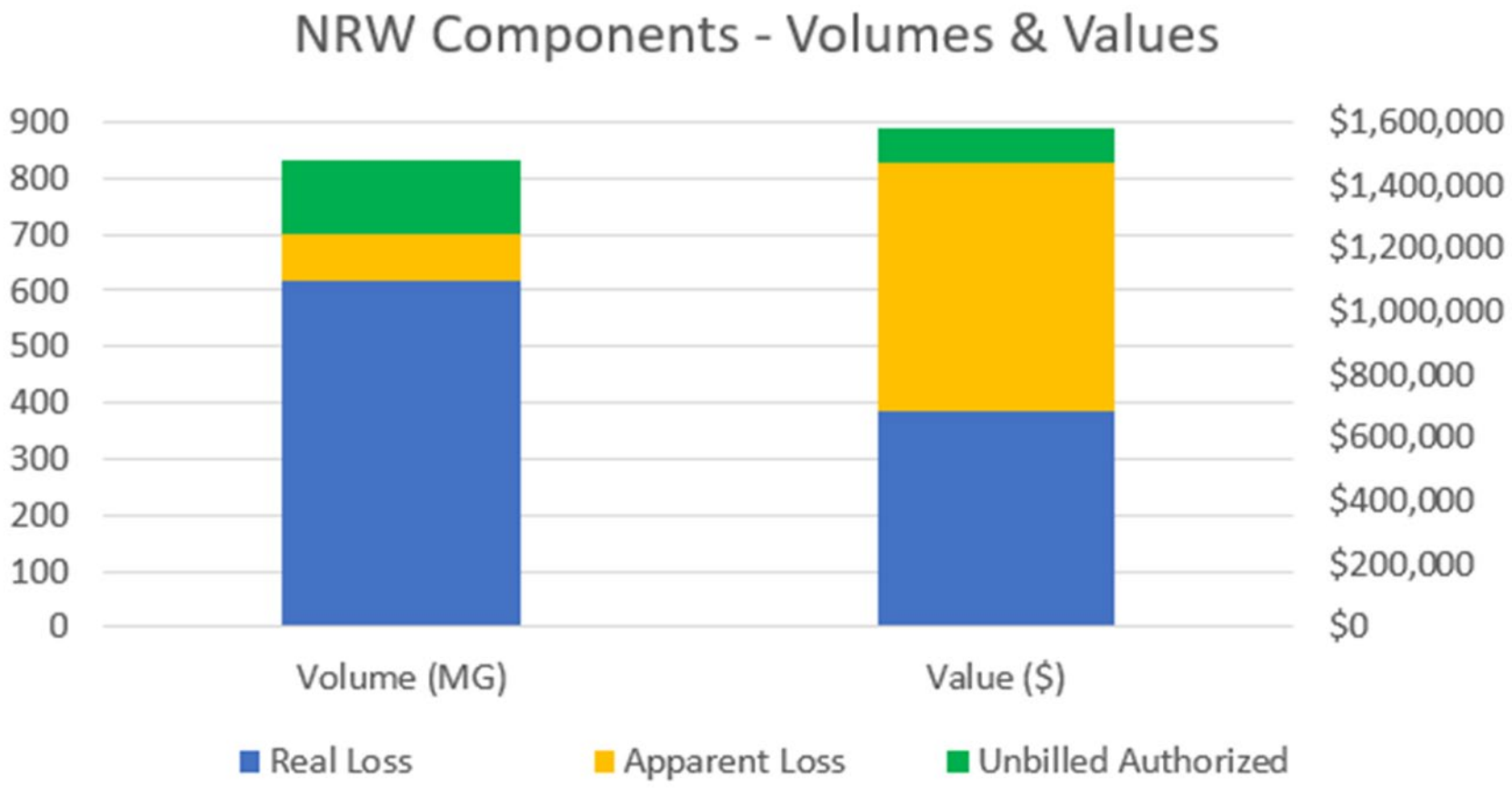
**Supply meter testing:** in-situ, insertion, clamp-on, volumetric displacement

**Customer meter testing:** study accuracy of the meter stock Calculate an Apparent Loss volume due to metering inaccuracy, inform proactive management of meter stock's accuracy

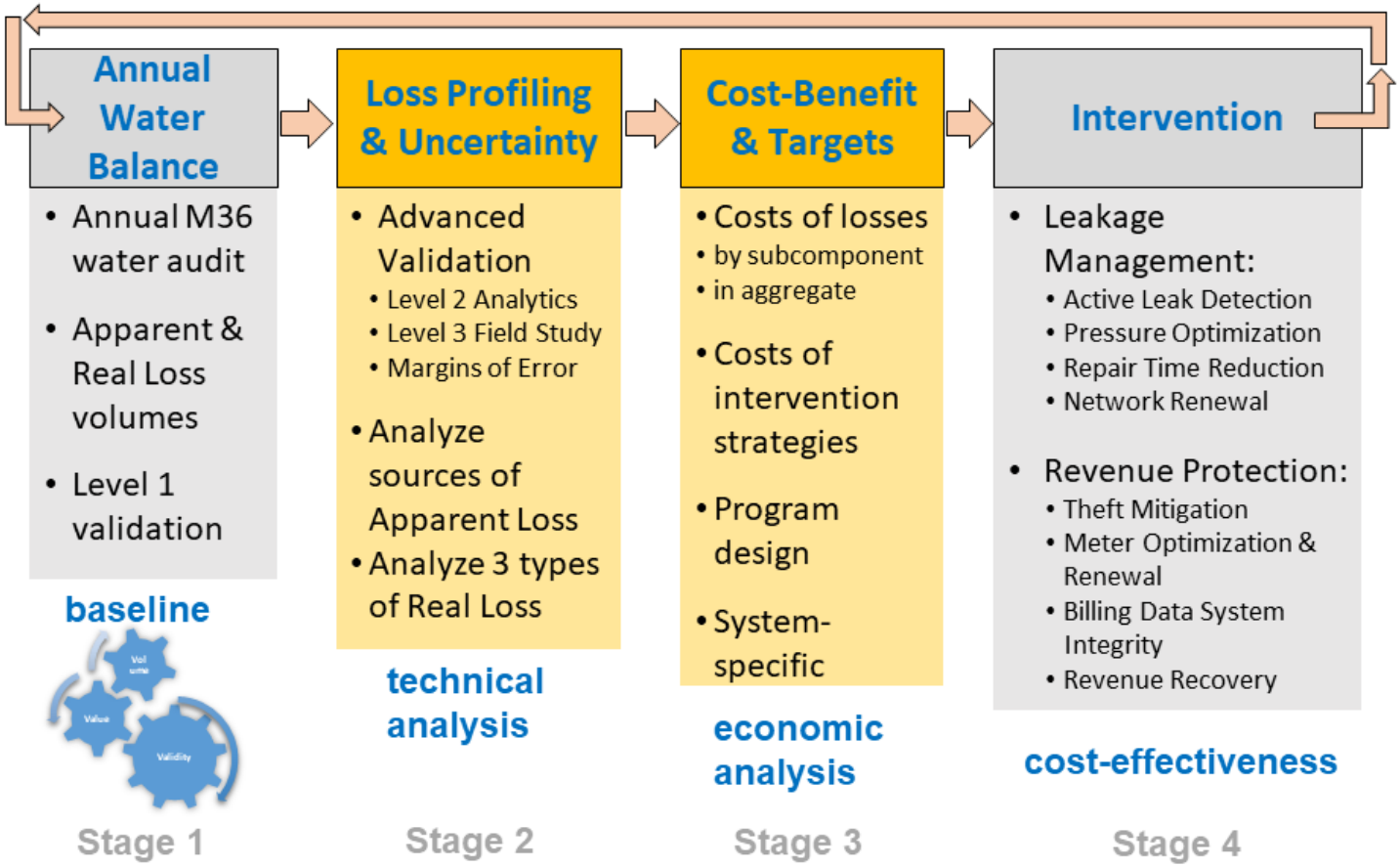
# As a result of participation in the Water Loss Pilot Program, in which of the following areas did you discover specific opportunities for improving water loss in your system?



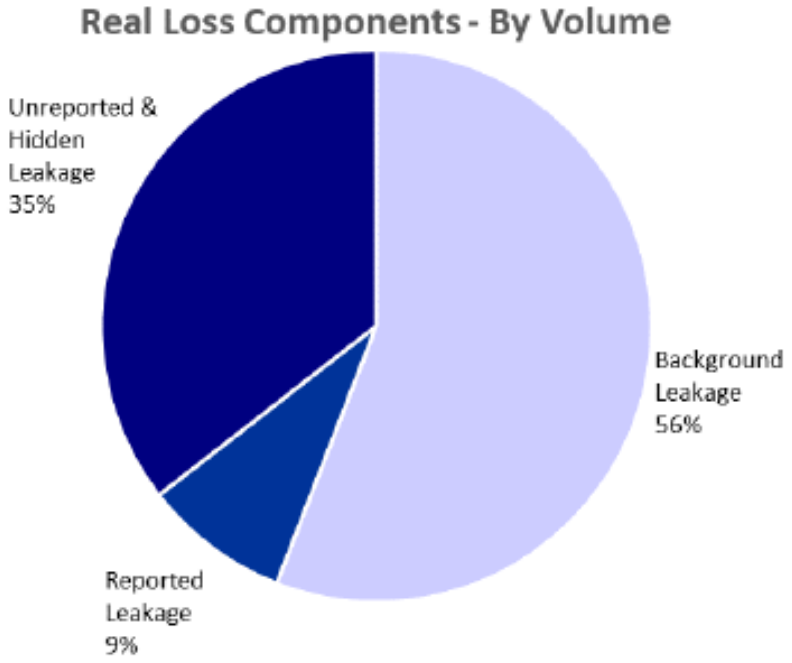
# Aggregate Results – Round 1



# Round 2 Results

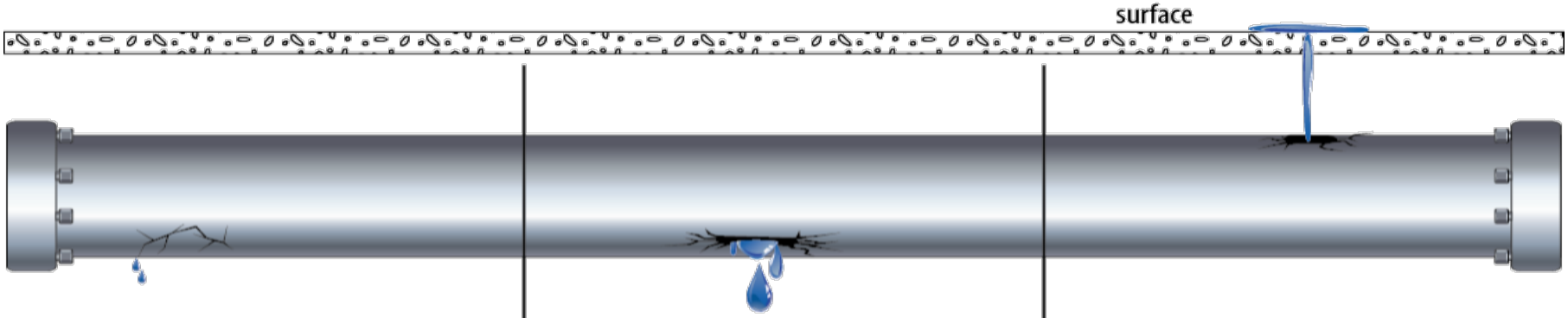


# Real Loss Profile - Example




| REAL LOSS COMPONENT ANALYSIS RESULTS | | | | |
|---|---|---|---|---|
| System Component | Background Leakage | Reported Failures | Unreported Failures | Total |
| | (MG) | (MG) | (MG) | (MG) |
| Reservoirs | 0.20 | - | - | **0.20** |
| Mains and Appurtenances | 3.38 | 0.91 | - | **4.28** |
| Service Connections | 5.00 | 0.41 | - | **5.41** |
| Total Annual Real Loss | **8.57** | **1.32** | - | **9.89** |
| | | | ***Real Losses as Calculated by Water Audit*** | **15.33** |
| | | | ***Hidden Losses/Unreported Leakage Currently Running Undetected*** | **5.44** |

# Selecting the Right Tool




**Background Leakage**
Unreported and un-detectable using traditional acoustic equipment.

Tools
Pressure Management
Main & service replacement
Reduction in number of joints/fittings

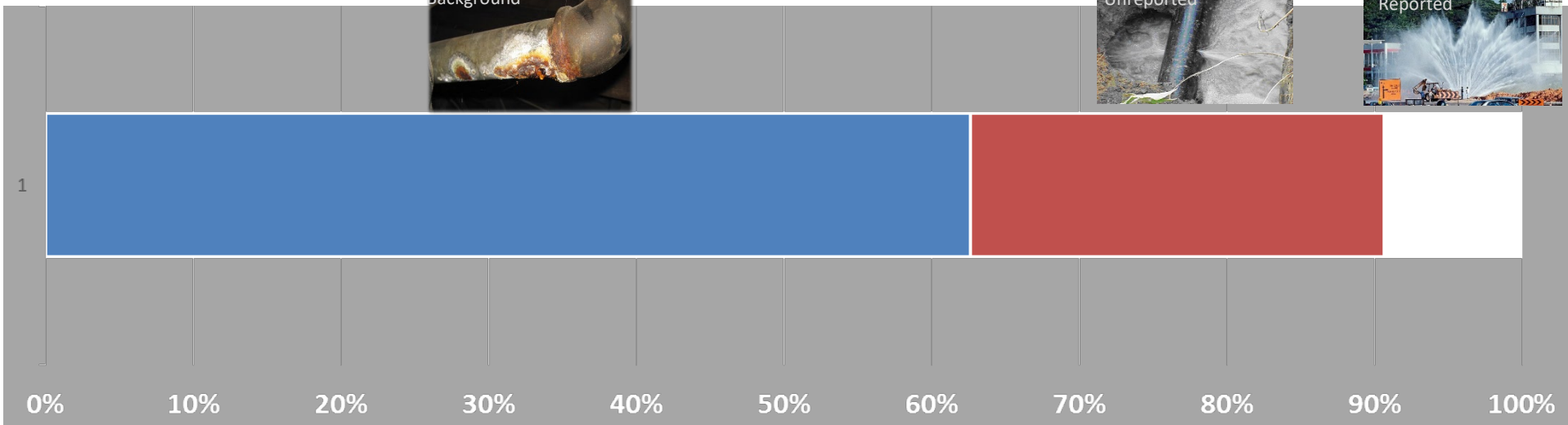
**Unreported Leakage**
Often does not surface but is detectable using traditional acoustic equipment.

Tools
Pressure Management
Main & service replacement
Reduction in number of joints/fittings
Proactive Leak Detection

**Reported Leakage**
Often surfaces and is reported by public or utility workers.

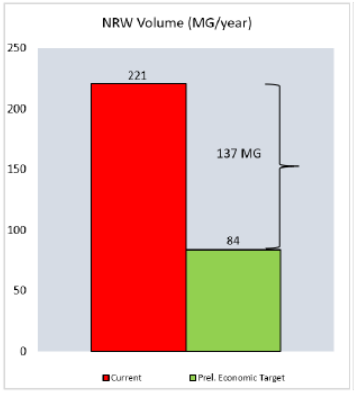
Tools
Pressure Management
Main & service replacement
Optimized repair time

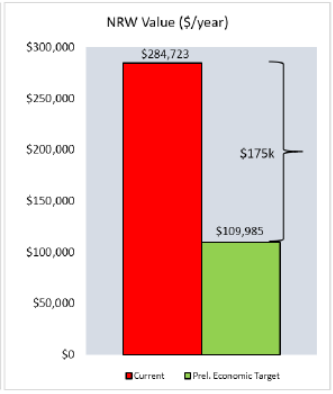


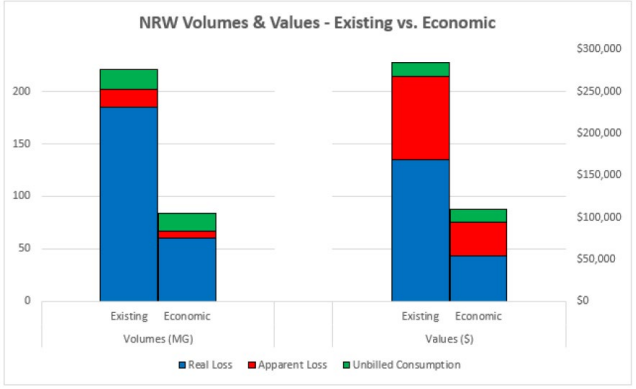



# Economic Analysis – Example 1

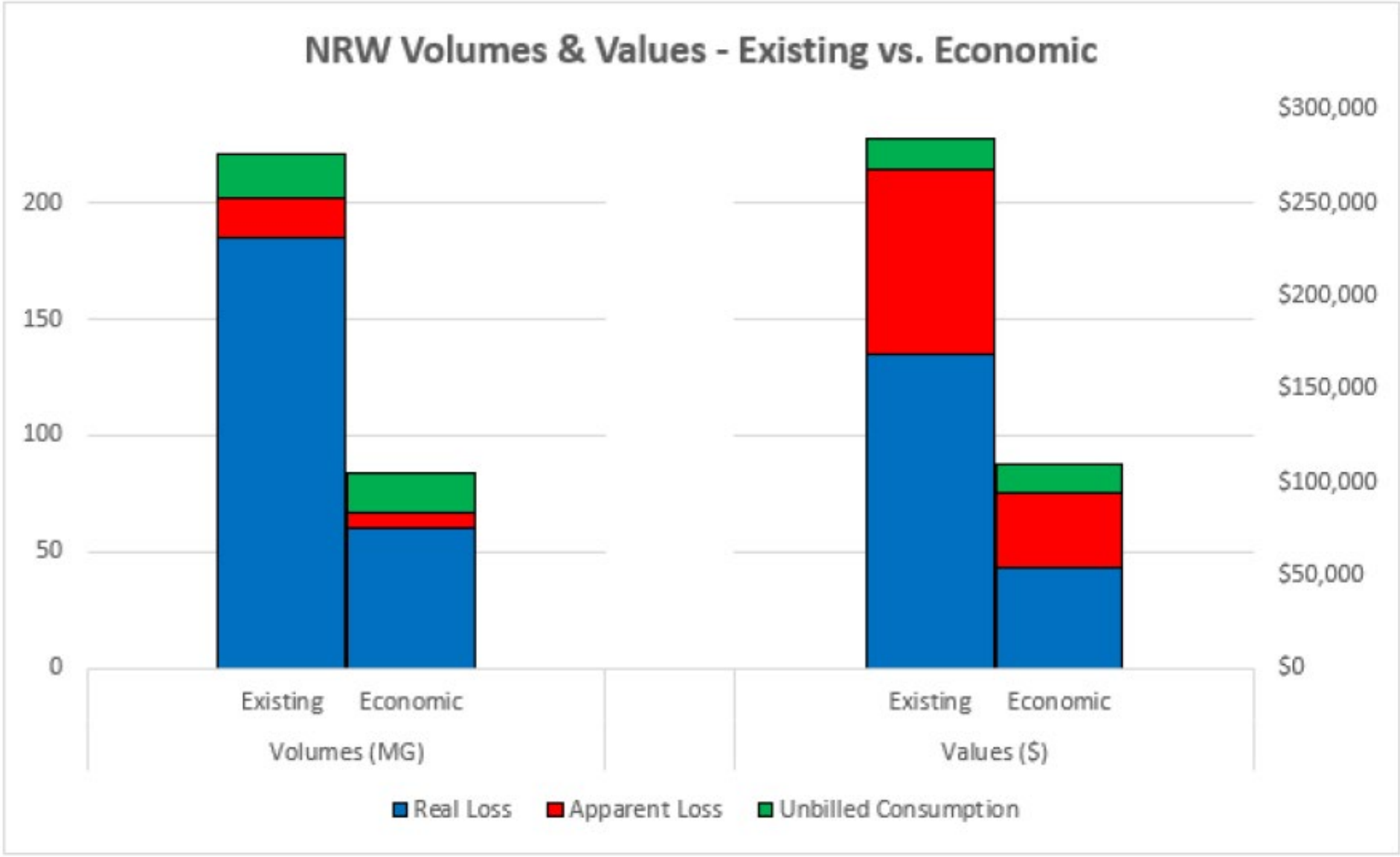
| Fiscal Year 2017/2018 | | | | | |
|---|---|---|---|---|---|
| | | | 95% Confidence Limits (+/-) | | |
| **Economic Metrics** | **Volume** | | **Low** | **High** | **%** |
| Non-Revenue Water (Existing) | 221 | MG/yr | 181 | 261 | 18.2% |
| Non-Revenue Water (Economic) | 84 | MG/yr | 67 | 100 | 19.7% |
| Target NRW Recovery ("Gap") | 137 | MG/yr | 110 | 164 | 19.7% |
| | **Value (Primary + Secondary)** | | | | |
| Non-Revenue Water $ (Existing) | $284,723 | $/yr | $245,580 | $323,865 | 13.7% |
| Non-Revenue Water $ (Economic) | $109,985 | $/yr | $88,345 | $131,626 | 19.7% |
| Target NRW Recovery $ ("Gap") | $174,737 | $/yr | $140,357 | $209,118 | 19.7% |
| NRW Economic Index | **2.6** | ratio of current vs optimum NRW cost | | | |
| **Technical Metrics** | | | | | |
| Unbilled Consumption | 9.3 | gal/conn/day | 8.2 | 10.4 | 11.6% |
| Apparent Loss | 8.5 | gal/conn/day | 7.3 | 9.7 | 14.0% |
| Real Loss | 92.7 | gal/conn/day | 73.4 | 112.1 | 20.8% |
| Infrastructure Leakage Index | 4.8 | | 3.7 | 5.8 | 21.6% |
| Data Validity Band (Level) | Band III (51-70) | | | | |



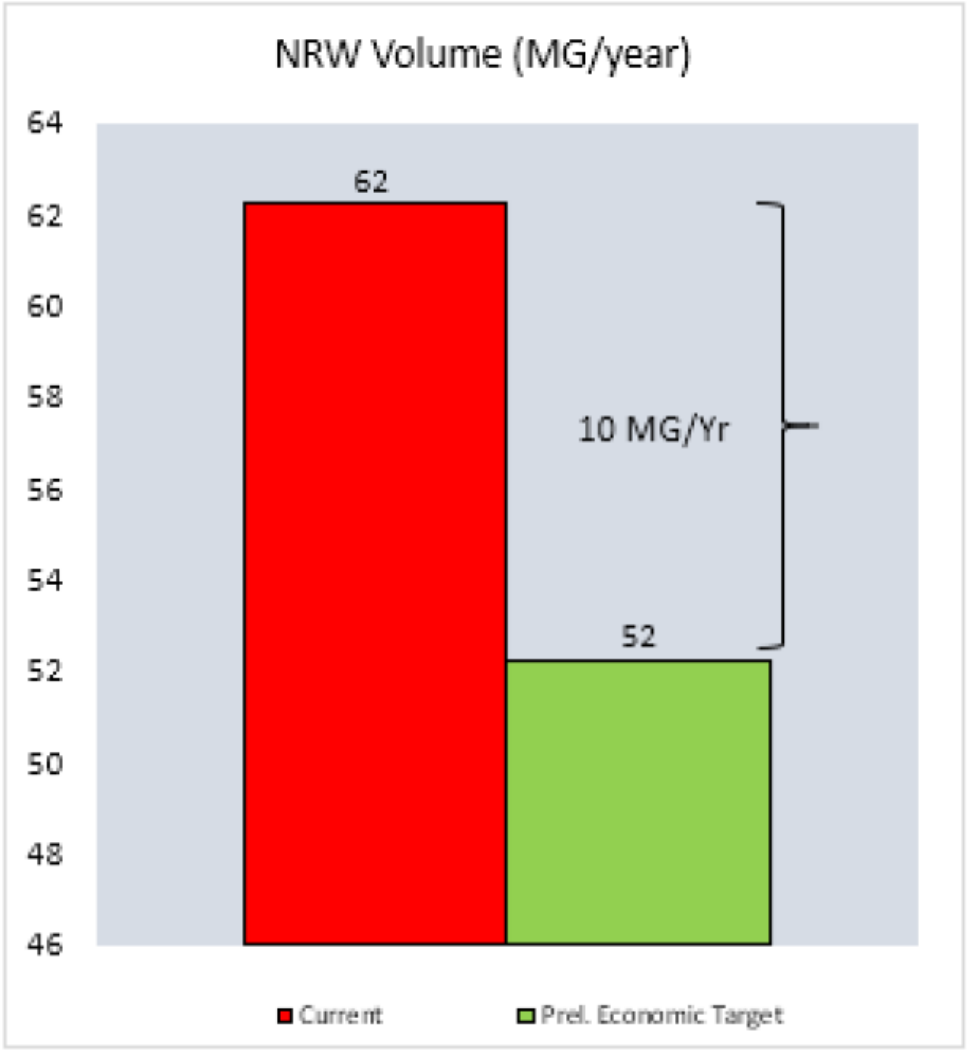



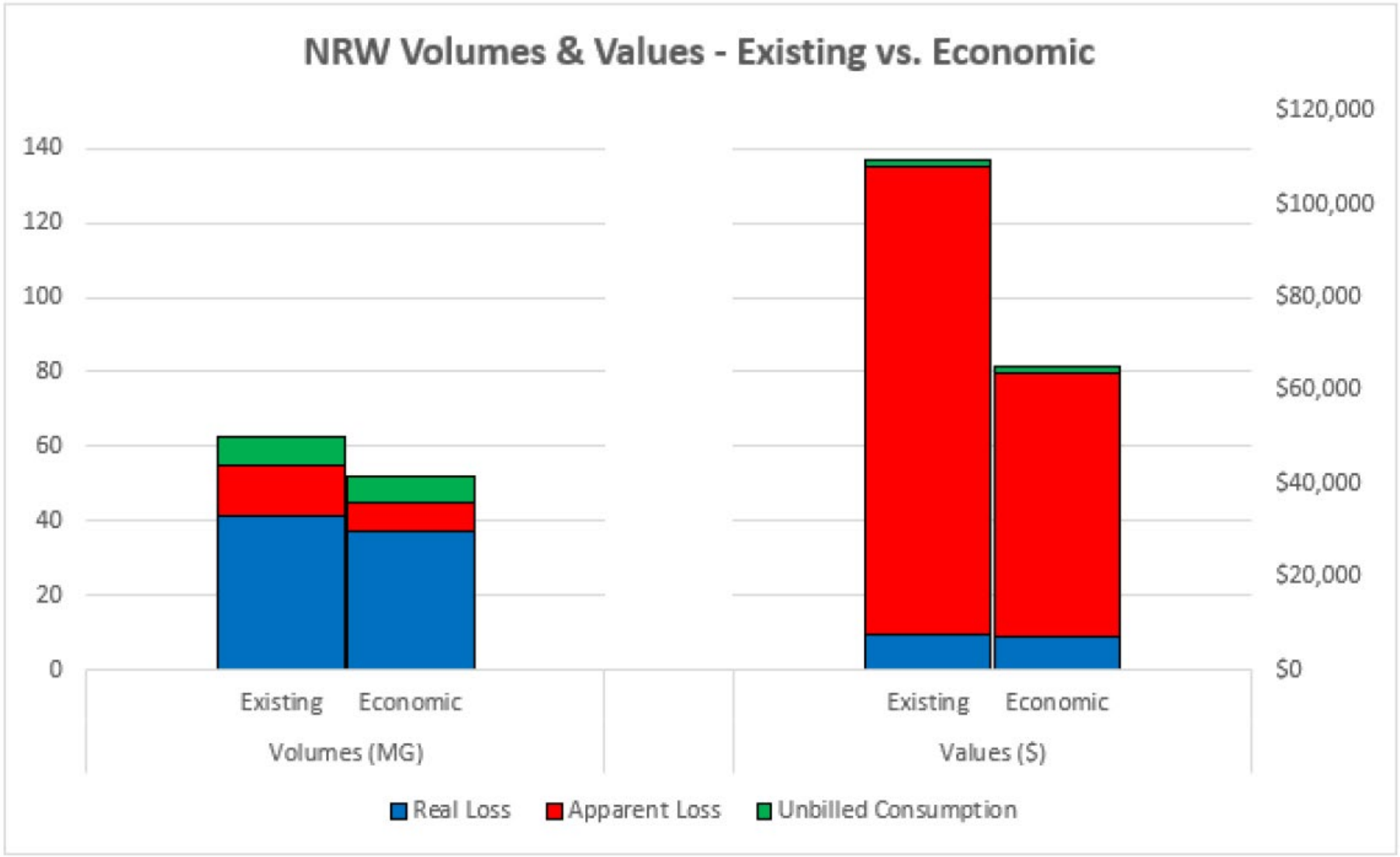
# Economic Analysis – Example 1



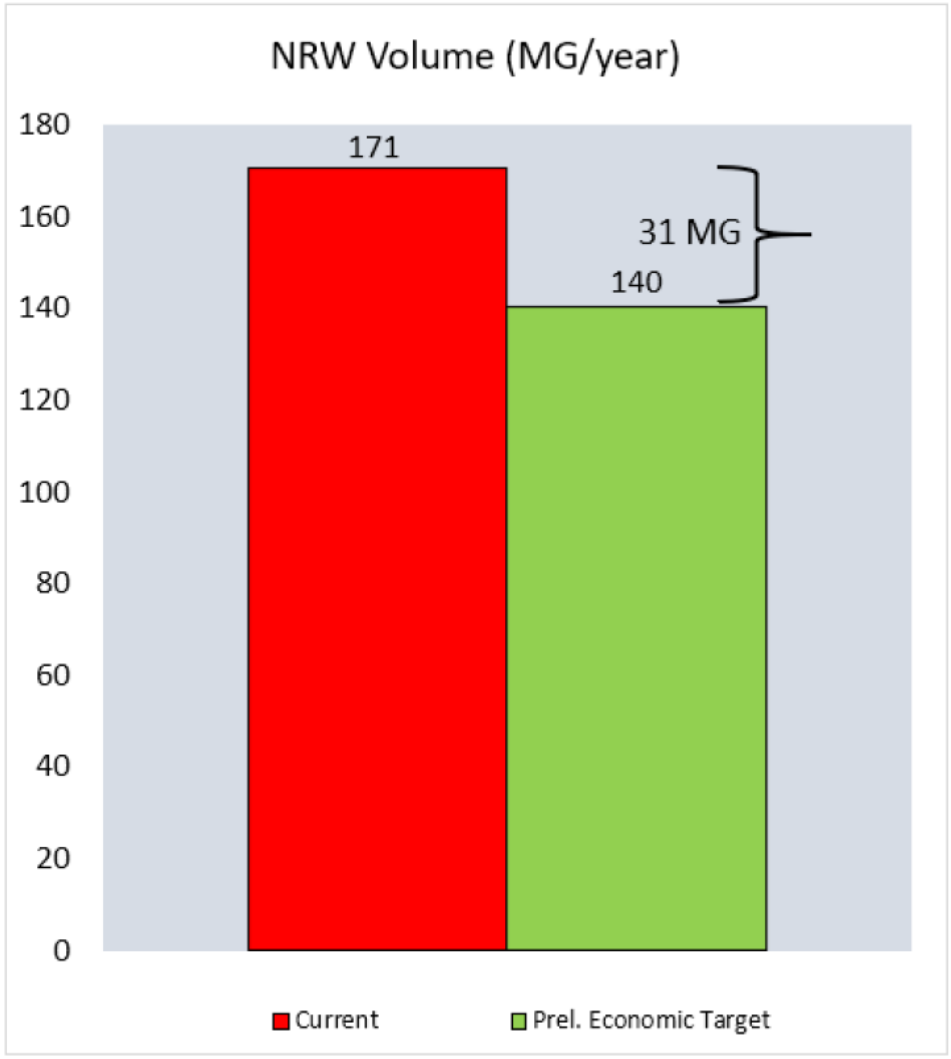
# Economic Analysis – Example 2



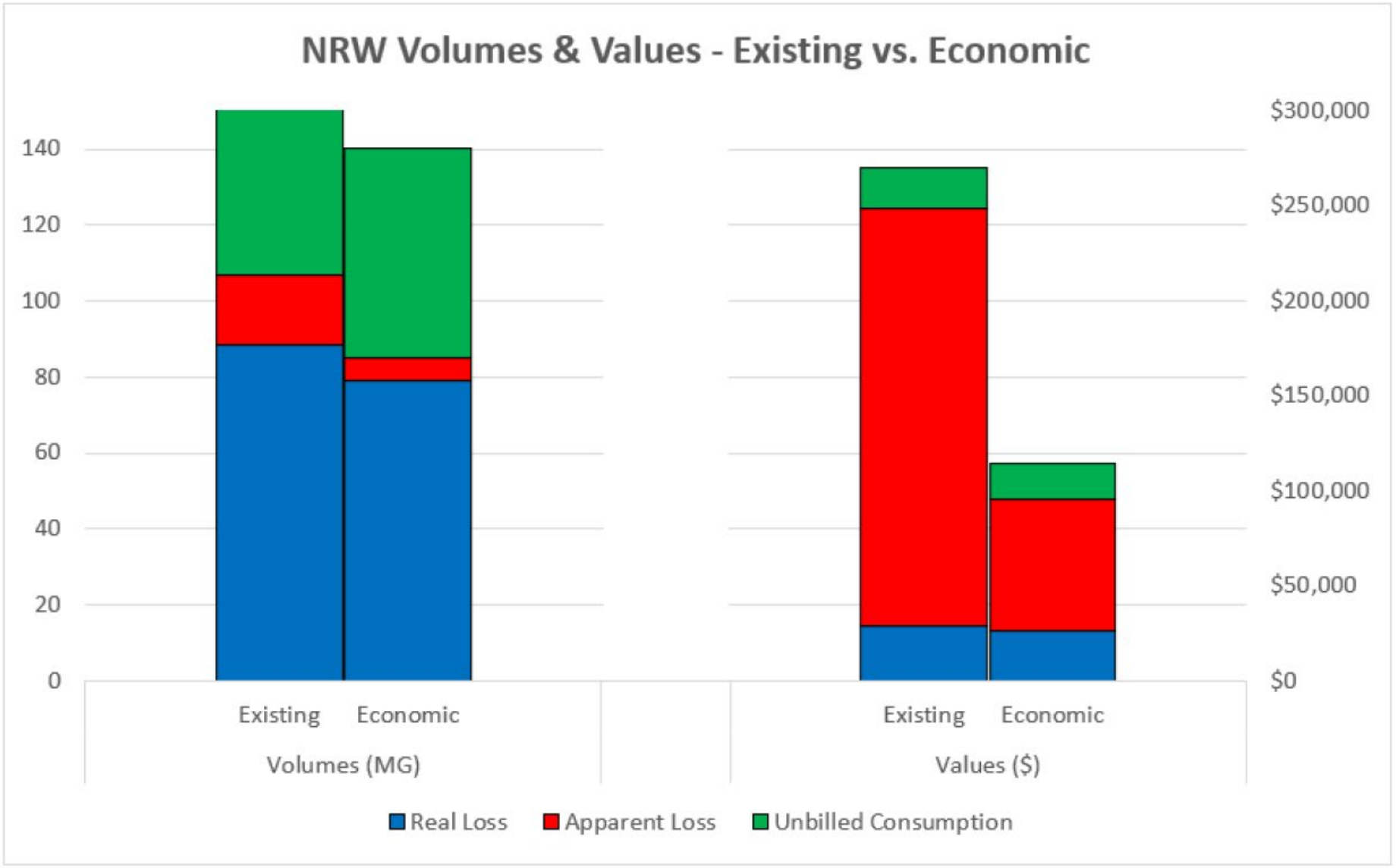

# Economic Analysis – Example 2



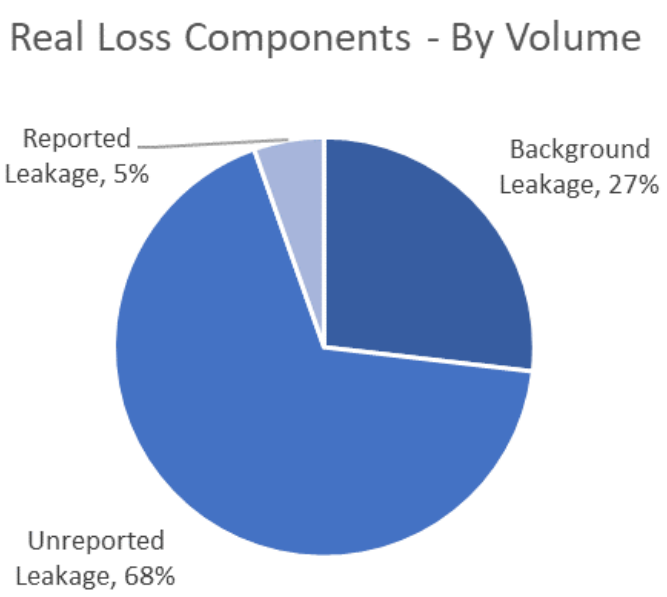
# Economic Analysis – Example 3

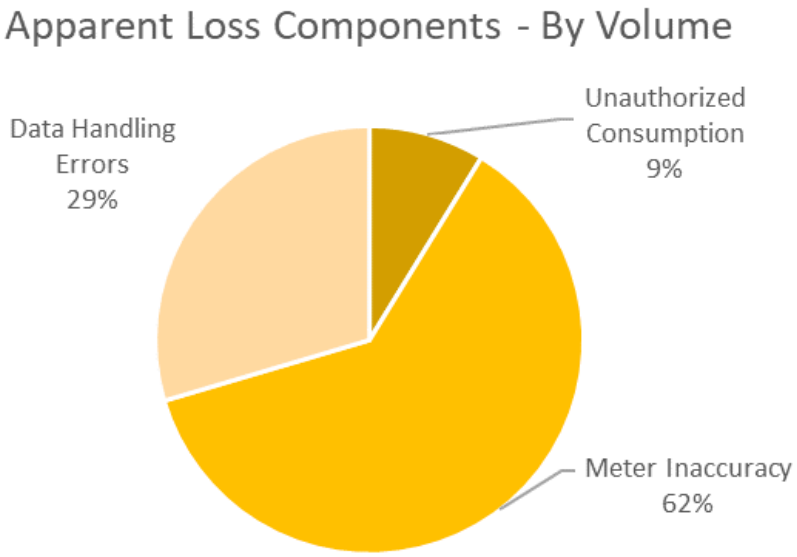



# Economic Analysis – Example 3



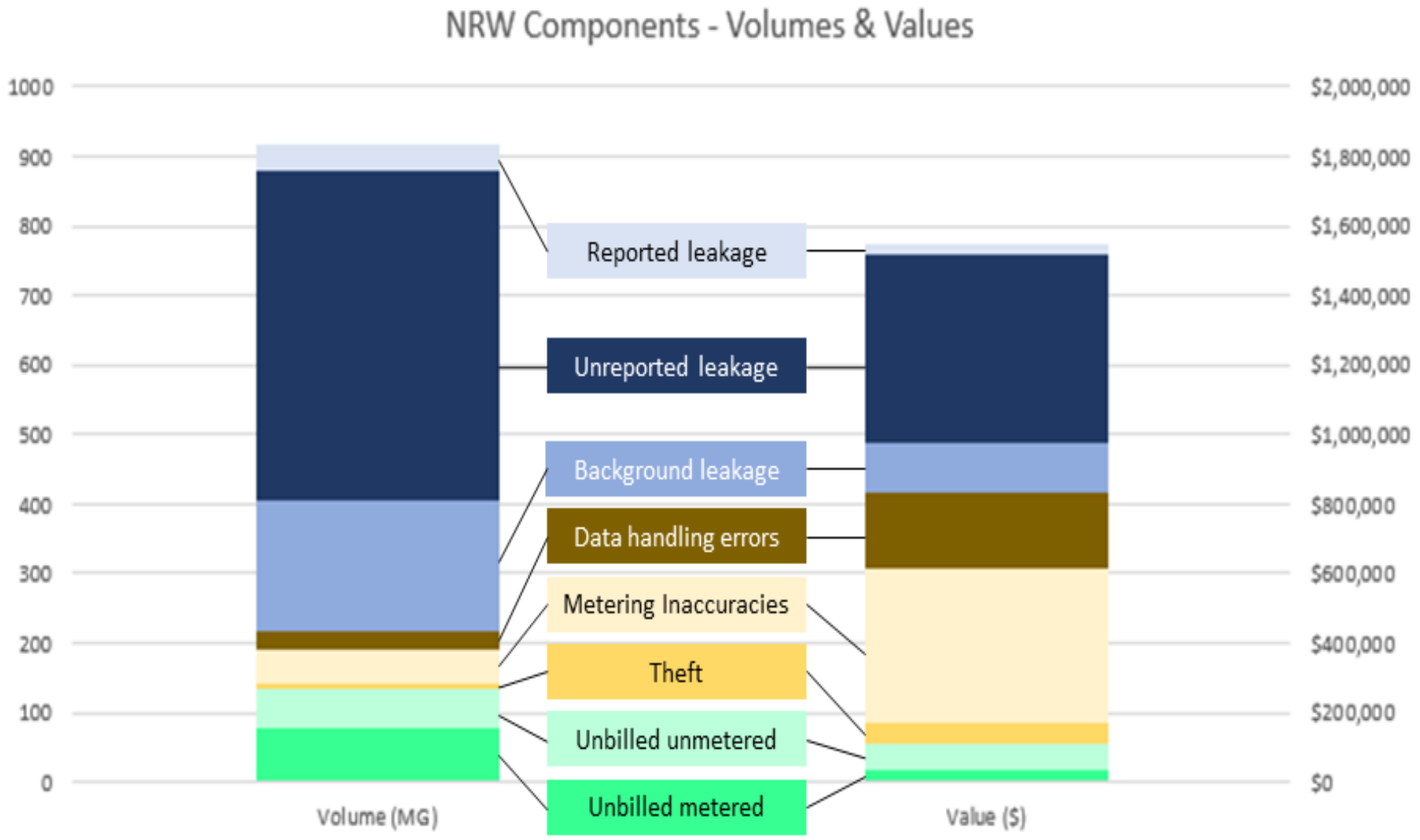
# Aggregate Results – Round 2




Background Leakage  Unreported Leakage  Reported Leakage  Unauthorized Consumption  Meter Inaccuracy  Data Handling Errors

# Aggregate Results – Round 2



Questions?