North Carolina Water Loss Program Phase 1B Workshop

January 2019

Agenda

- Welcome/Introductions
- M36 Auditing Foundations
- Breakout groups: Developing the Inputs
- Lunch
- Validity Scoring & the Data Grading Matrix
- Breakout groups: Data Validity Grades
- Supply Meter Verification & Customer Meter Testing
- Breakout Groups: Recommendations & Next Steps
- Review and Wrap-Up

Host

NC Department of Water Infrastructure

Program Management Team

Research Entity, Program Administration

Subject Matter Expert, Program Execution

Introductions

- Name
- Agency
- Position

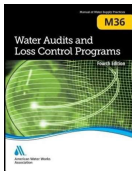
- Familiarity with water auditing and water loss control?

GOAL:

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

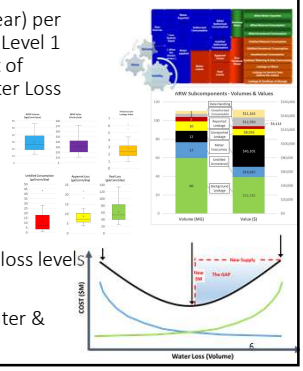
Key Tasks:

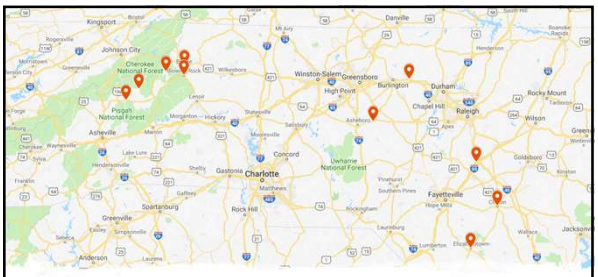
1. Training & Technical Assistance to 10 small and mid-size utilities across North Carolina
2. Analysis of pilot outcomes & opportunity for water loss & revenue recovery



Program Outcomes

- Top-Down Water Audit (prior year) per AWWA M36 Methodology, with Level 1 Validation. Includes assessment of Validity, Volume & Value for Water Loss Components
- Detailed Water Loss profiling & advanced validation
- Target setting for optimal water loss levels
- Utility Specific Next Steps for water & revenue recovery





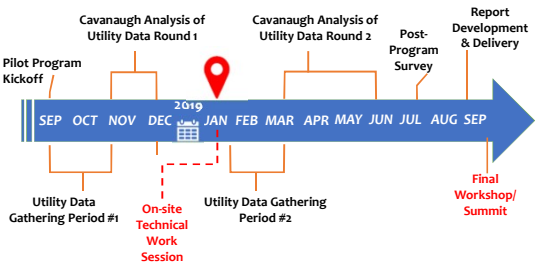
10 Participating Water Systems

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

Piedmont Region
- Ramseur
- Mebane

Coastal Region
- Benson
- Clinton
- Elizabethtown

Project Timeline

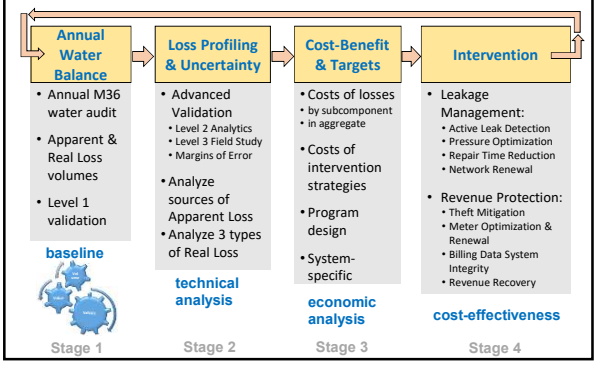


M36 Foundations

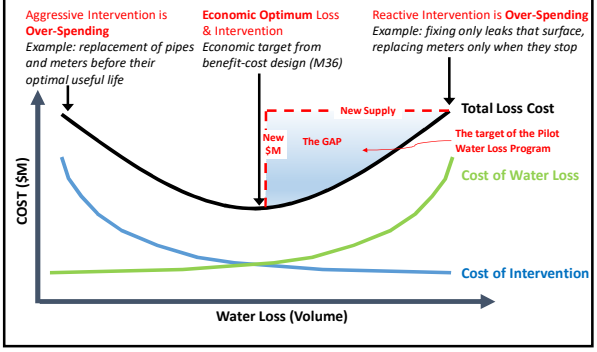
- The Big Picture
- Water Balance
- What is Non-Revenue Water
- Outcomes
- Developing the Inputs

Why a Water Audit?

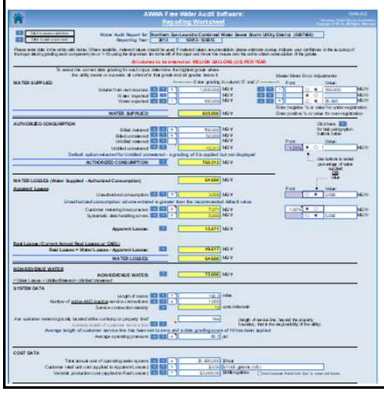
The Big Picture: Economic Intervention



AWWA M36 Economic Optimum



www.awwa.org/waterlosscontrol



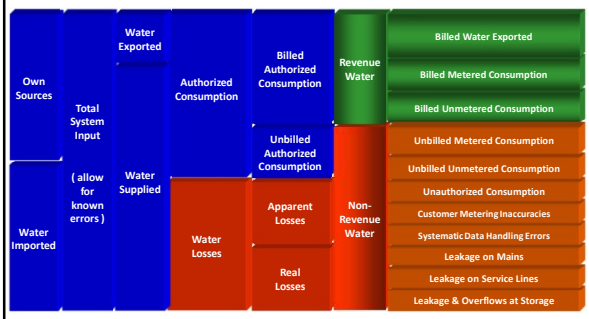
Industry Standard (M36)

Free

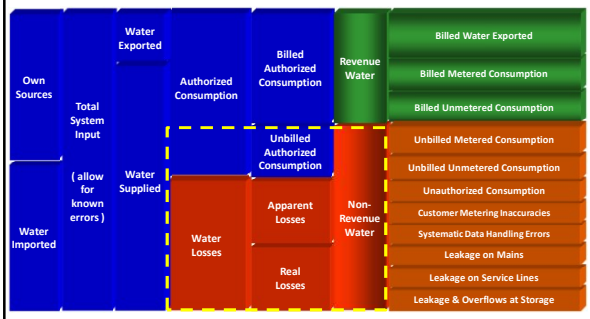
Defaults provided

~13 Volume Inputs
~7 System Data Inputs

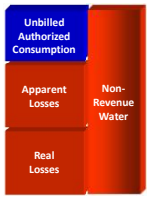
The Water Balance & Water Auditing



The Water Balance & Water Auditing



Non-Revenue Water



Non-Revenue Water

- Fire Dept Usage
- Operational Flushing
- Tools for control include efficient flushing practices and awareness campaigns

Unbilled Authorized Consumption

- Non-physical / revenue loss - slow meters, billing issues and theft
- Cost impacts at 'retail' rate.
- Tools for control include data management, quality control policies/practices, & meter testing & repair

Apparent Losses

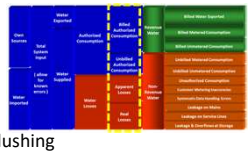
- Physical loss - leakage
- Cost impacts at 'wholesale' rate
- Tools for control include leakage and pressure management

Real Losses

Non-Revenue Water

QUIZ!

QUIZ

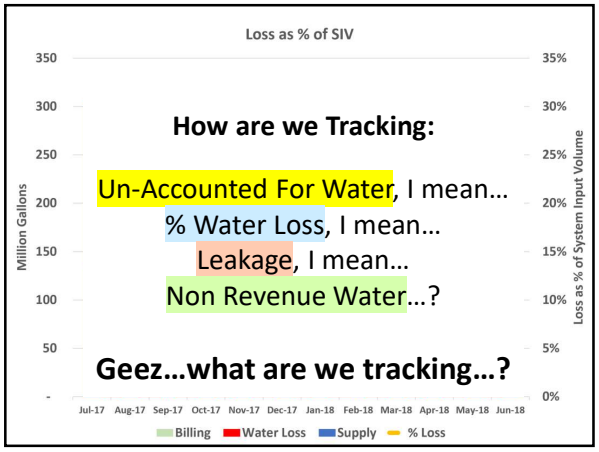


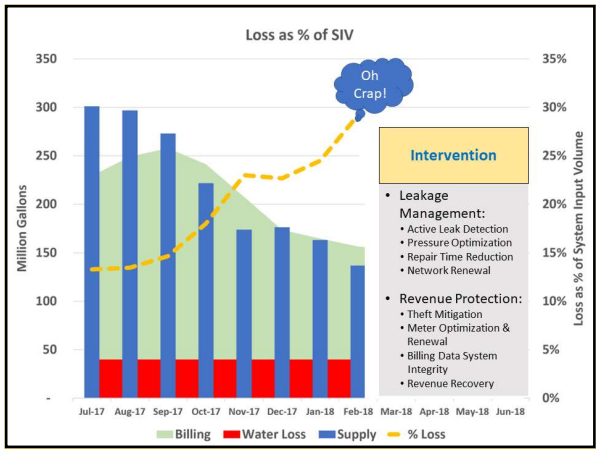
Fire Department flushing
Under registering customer meters
Pipe joint leakage
Water theft
DOT usage
AMR device transmission failure
Water main break
Storage tank overflows

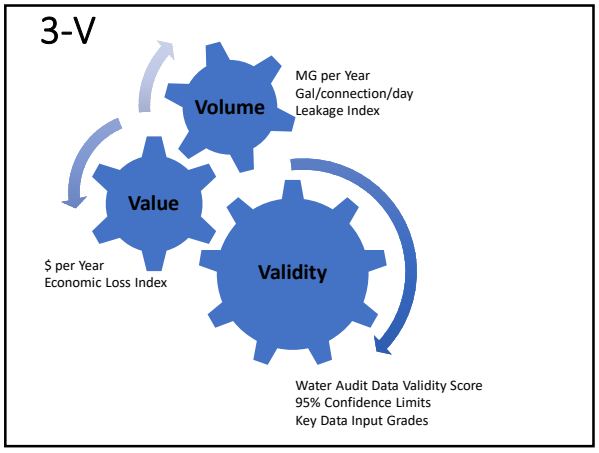
Unaccounted-For Water & % of Supply

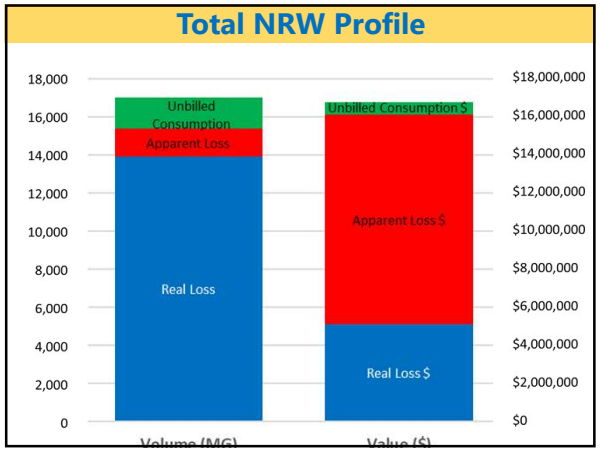




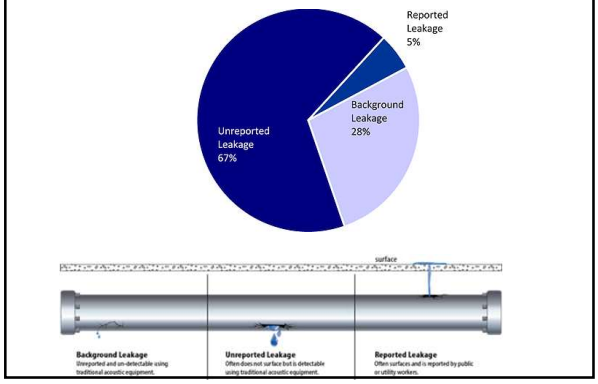




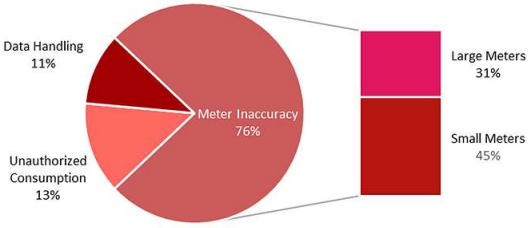




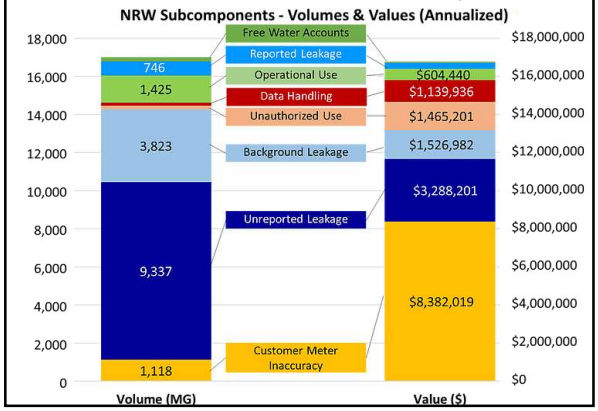
Real Loss Profile

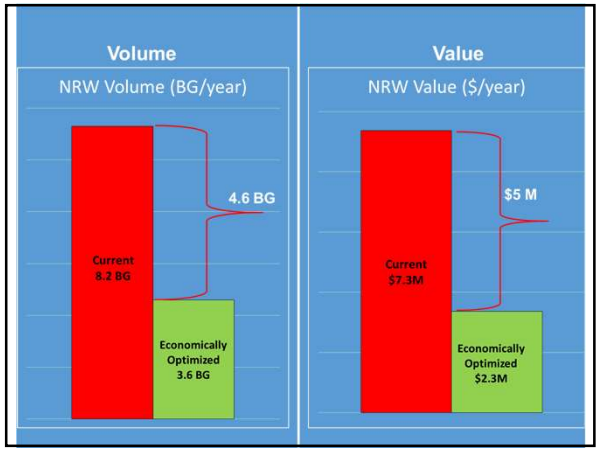


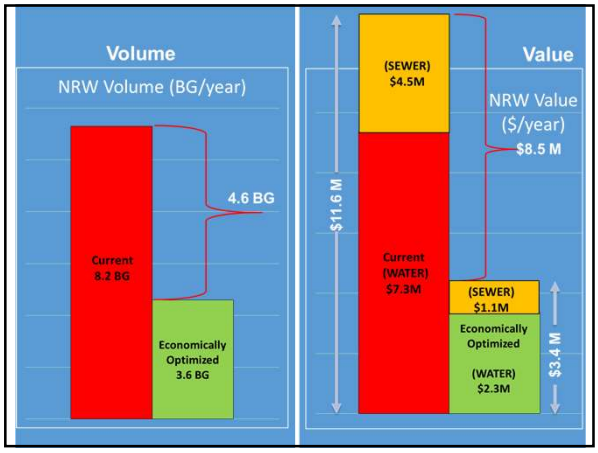
Apparent Loss Profile

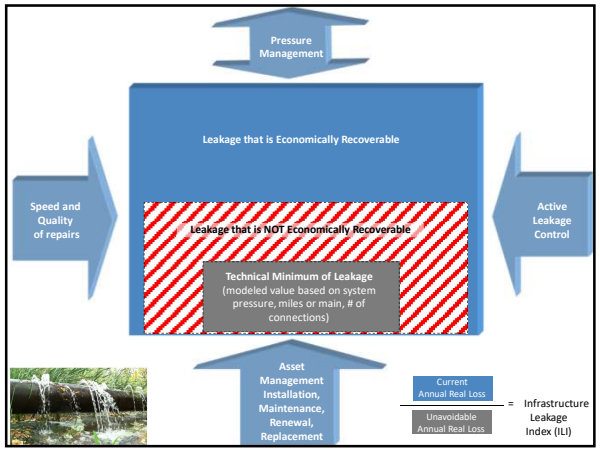


Total NRW Profile (with subcomponents)

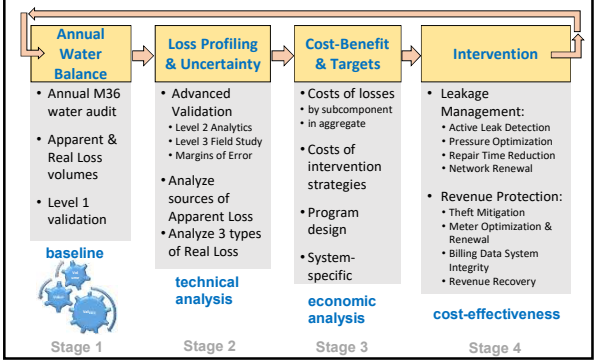






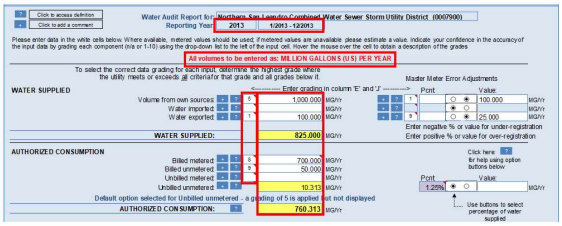


The Big Picture: Economic Intervention



AWWA Free Water Audit Software

Developing the Inputs



Developing the Inputs

1. Assemble supporting documents
2. Develop the data inputs
3. Check the metrics

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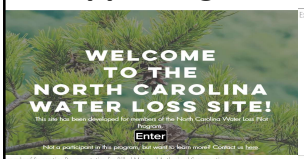
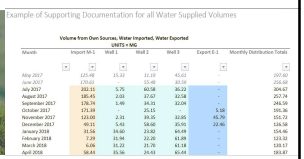
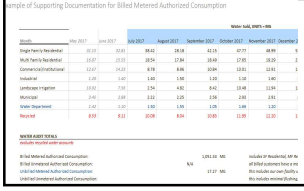
→ Must-have docs

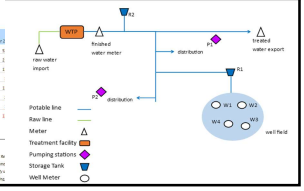
→ Good-to-have docs

Step 1 – Assemble the Supporting Documents









Developing the Inputs

1. Assemble supporting documents
2. Develop the data inputs
3. Check the metrics

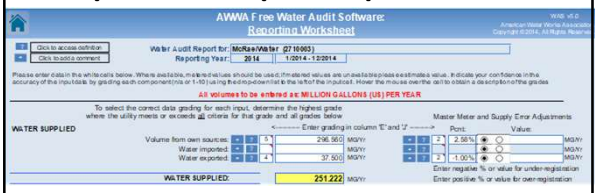
→ Must-have docs

→ Good-to-have docs

→ Build it from supporting docs

→ Look for gremlins

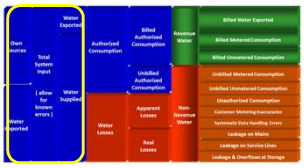
Step 2 – Develop the Inputs

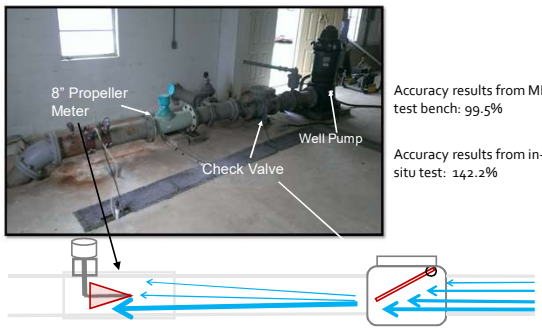


- **Develop the Input**
  - Trace from production reports
  - Trace from testing reports
- **Look for Gremlins**
  - Missing or extra volumes
  - Mismatched timeframe
  - Error adjustment should be a weighted average of test results (if available)
  - Wrong + or – on error adjustment

Gremlins in Water Supplied

1. Meter wear
2. Meter location
3. Meter selection
4. Meter programming
5. Flow data archiving





Accuracy results from MFR test bench: 99.5%

Accuracy results from in-situ test: 142.2%

Courtesy MESCO

Flow Data Archiving

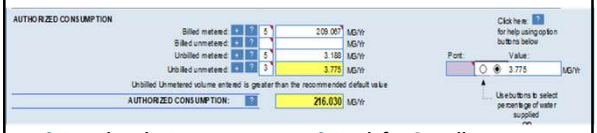
- Production flow data should be reviewed every business day for data gaps
- Gaps occur due to:
  - Unplanned interruption: lightning strike, power failure
  - Planned interruption: instrumentation calibration
- Gaps in water flow data should be quantified and added back to the daily total

Example of Water Pumping Data Gaps an

8/15/2012, hrs	High Service Pumping Rate, mgd actual flow	High Service Pumping Rate, mgd raw recorded data
0:00	8.69	8.69
1:00	8.65	8.65
2:00	8.32	8.32
3:00	8.11	8.11
4:00	7.94	0
5:00	8.02	0
6:00	8.44	0
7:00	8.98	0
8:00	9.34	0
9:00	9.25	0
10:00	9.17	0
11:00	9.12	9.12
12:00	9.27	9.27
13:00	9.22	9.22
14:00	9.08	9.08
15:00	8.99	8.99
16:00	9.14	9.14
17:00	9.18	9.18
18:00	9.25	9.25
19:00	9.22	9.22
20:00	8.82	8.82
21:00	8.78	8.78
22:00	8.75	8.75
23:00	8.71	8.71
0:00	8.68	8.68
Total	212.43	151.29
Average	8.85	6.30
Difference		2.55

(Source: AWWA M36 Publication, 4th Ed.)

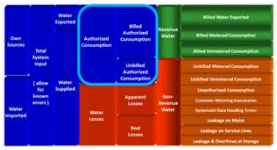
Step 2 – Develop the Inputs



- **Develop the Input**
  - Trace from billing reports
  - Trace from flushing (etc) tracker
- **Look for Gremlins**
  - Billing report Gremlins
  - Double counting Water Exported in Billed Metered
  - Double counting Unbilled Metered in Billed Metered
  - Including leaks / breaks in Unbilled Unmetered

Gremlins in Authorized Consumption

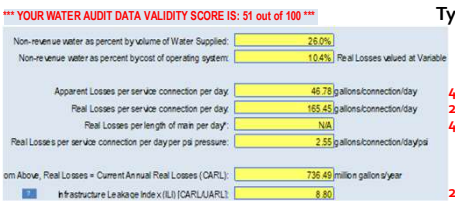
6. Duplicate volumes
7. Non-potable volumes
8. Missing volumes
9. Mismatched timeframes



Developing the Inputs

1. Assemble supporting documents
   - → Must-have docs
   - → Good-to-get docs
2. Develop the data inputs
   - → Build it from supporting docs
3. Check the metrics
   - → Look for gremlins
   - → Sanity check
   - → Inside typical ranges
   - → Metrics versus practices

Step 3 – Check the Metrics



- **Metrics versus Practices**
  - Inside the range – are they high, mid, or low?
  - How does that compare to the water loss management practices?

Break-out Groups

- Developing the Inputs: Level 1 Validation Session, Part 1

Validity Scoring & the Data Grading Matrix

- Developing the Inputs: Level 1 Validation Session, Part 1

Data Validity Grades

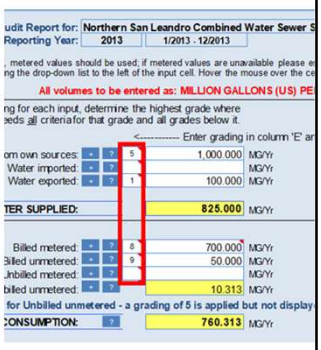
Data validity grades (DVGs) document utility practices of:

- Data collection
- Data review
- Instrument maintenance

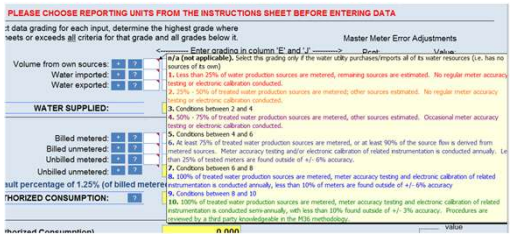
Each audit input is assigned a DVG between 1 and 10 based on criteria

DVG criteria are predominantly qualitative

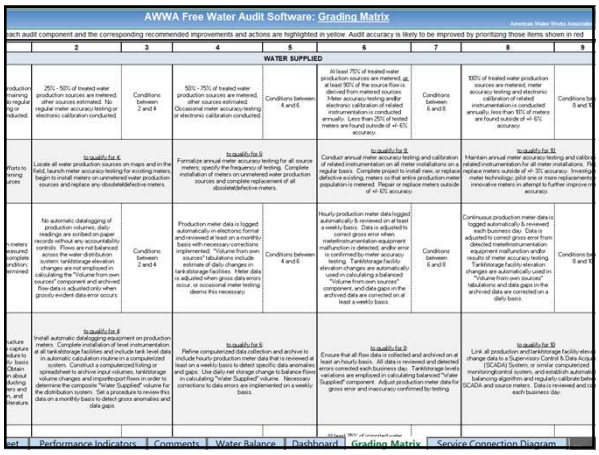
DVGs are NOT a measure of accuracy!



Data Validity Grading Matrix



MEET, BEAT, OR RETREAT -- Meet all criteria at a grade for that grade to apply or drop to a lower grade


AWWA Free Water Audit Software: Grading Matrix

Data Validity Grading – Additional Guidance

VOLUME FROM OWN SOURCES – DVG CRITERIA	ADDITIONAL GUIDANCE
1. Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing or electronic calibration conducted.	
2. 25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing or electronic calibration conducted.	Manufacturer testing certificate for newly installed meter does not qualify as accuracy testing
4. 50% - 75% of treated water production sources are metered, other sources estimated. Occasional meter accuracy testing or electronic calibration conducted.	% of source metric is for volume, not meter count Occasional = within last 5 years but less than annually, for <90% of source flow
6. At least 75% of treated water production sources are metered, or at least 90% of the source flow is derived from metered sources. Meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Accuracy testing = precise & independent volumetric measurement in-situ against subject meter for at least 90% of the source flow by volume OR Calibration = alignment of flow range conversion with signal span output (typically 4-20mA DC) and SCADA output

Break-out Groups

- Data Validity Grades: Level 1 Validation Session, Part 2

Supply & Customer Metering

- Supply Meter Verification
- Customer Meter Testing

Supply Metering

High flowrate applications

Venturi, Orifice, Magnetic, Ultrasonic

Medium, low flowrate applications

Turbine, Propeller, Positive Displacement

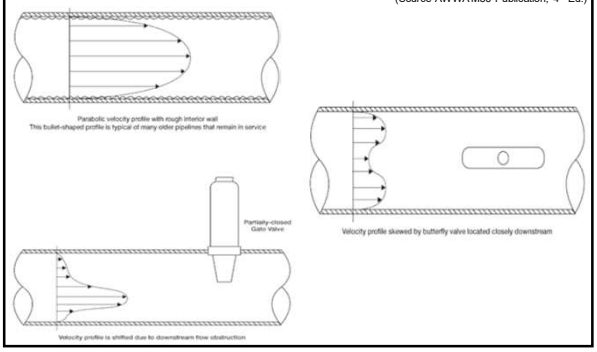
36-inch Venturi Meter
(Source: Primary Flow Control)

60-inch magnetic flowmeter being installed in Philadelphia, PA

Insertion magnetic flowmeter in use on a 30-in. pipeline in Birmingham, Al

Basic Pipeline Hydraulics

(Source AWWA M36 Publication, 4th Ed.)



Proper Meter Siting

Flowmeter Type	Recommended Lengths of Straight Pipe* (stated in terms of number of upstream pipe diameters for the given metering application)
Venturi	4–10 diameters—depending on the type of any flow-disturbing obstruction in the pipeline
Orifice	5 diameters
Flow tube	4–10 diameters—depending on the type of any flow-disturbing obstruction in the pipeline
Pitot tube	10 diameters
Propeller	5 diameters
Turbine	25 to 30 diameters
Turbine (with flow-straightening element)	10 diameters
Magnetic	5 diameters
Ultrasonic (Doppler shift)	7–10 diameters
Ultrasonic (pulse transmission†)	7–10 diameters (and 5 diameters downstream)

*Information is based on engineering judgment and conservative best practice observed in the water industry by AWWA Water Loss Control Committee members (Source: AWWA M36 Publication, 4th Ed.)

†Includes transit time flowmeters

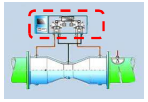
Proper Meter Siting

Proper Meter Siting

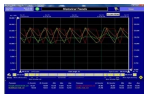
What Constitutes a Meter?

Primary Device: Measuring Element
Conducts the measurement

Secondary Device: Register, Transmitter
Converts, communicates the measurement



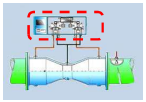
Tertiary Device: Remote Database
Records, archives the measurement



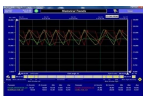
Accuracy Testing v. Calibration

Primary Device: Accuracy Testing
Independent measurement for comparison

Secondary Device: Calibration
Checks alignment of primary measurement to register and signal output



Tertiary Device: Calibration
Checks alignment of secondary signal to SCADA output



Supply Meter Testing

Insertion type

Clamp-on

Comparative apparatus

Volumetric displacement

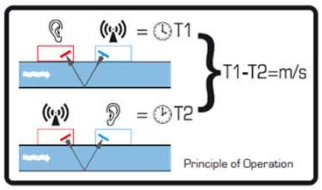
Factory bench test

Supply Meter Testing

Insertion type

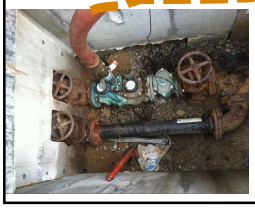
Supply Meter Testing

Clamp-on



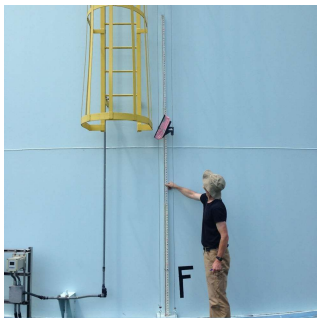
Supply Meter Testing

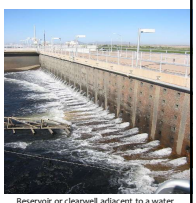
Comparative apparatus



Supply Meter Testing

Volumetric displacement

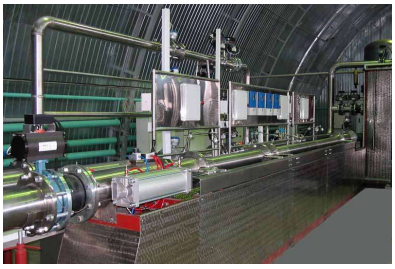




Reservoir or clearwell adjacent to a water treatment plant

Supply Meter Testing

Factory bench test



Supply Meter Testing

Other considerations

- Flow rates
- Test location (if insertion or clamp-on)
- Test duration

Supply Meter Testing -- Summary

Method	Advantages	Limitations
Insertion type	Minimize the unknowns by verifying the flow condition and inside area of the pipe, can make this a very reliable method No interruption to operations	Requires a good test site! Lower test flowrates can affect uncertainty Specialized equipment and expertise required
Clamp-on	Easier to do, no tap required No interruption to operations	Requires a good test site! Signal distortion depending on pipe material can affect accuracy, and there's no verification of flow conditions via flow profile or of inner diameter
Comparative apparatus	More control over the flow condition and the test reliability	Typically only practical for smaller line applications Supply is interrupted during test
Volumetric displacement	Can be reliable method Potentially done internally and frequently	Requires a reservoir nearby, reliable field verification of reservoir geometry, including internal components (baffles etc) and all associated plumbing/valves Level sensing must be calibrated and reliable Production is typically interrupted during test
Factory bench test	Get to test it under ideal conditions	Only tested under ideal conditions! Not practical for larger meters Meter is out of service for test

Customer Meter Testing

Goals:

- Study accuracy of the meter stock
- Calculate an Apparent Loss volume* due to metering inaccuracy
- Inform proactive management of meter stock's accuracy

in the Water Balance, our understanding of Apparent Losses directly impacts our understanding of Real Losses

Small Meter Testing Programs

1. Design Meter Test Sample
2. Test Meters
3. Analyze & Apply Results

Small Meter Testing Programs

1 Design Meter Test Sample

- Representative and random meter sample → *remember our goal is to appreciate the accuracy of the **whole population***
- What sample size is big enough?

Small Meter Testing Programs

2 Test Meters

- Careful with meter transport
- Test at low, medium, and high flows
- Document thoroughly
  - include reference volume, testing flow rate, meter totalizer reads, all meter information
  - compile data in analysis-friendly format

Small Meter Testing Programs

3 Analyze & Apply Test Results

- Organize all test results
- Analyze accuracy findings *
- Consider confidence limits
- Calculate Apparent Loss Volumes

Small Meter Testing Programs

Meter Size	Meter Population	Test Sample Size	Volume-Weighted Average Accuracy	95% Confidence Limit of Accuracy
5/8"	13,548	66	92.0%	4.0%
3/4"	1,392	10	98.5%	0.4%
1"	2,145	20	96.9%	2.3%
1-1/2"	311	5	94.0%	3.8%
2"	391	13	97.6%	1.7%

Small Meter Testing Programs

* Value of random sampling
* Average across different flow rate results
* Add layer of consumption to calculate Apparent Losses due to meter inaccuracy

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* Appreciate spread of results, confidence limits
* Tread carefully re: correlations
* Continue to test for more insight

Large Meter Testing Programs

- Fewer, more important meters!
- Individual assessment
- Prioritize by consumption
- Flow profiling is key

1 Design Meter Test Sample → 2 Test Meters → 3 Analyze & Apply Results

Break-out Groups

- Next Steps: Level 1 Validation Session, Part 3
  - Pending Items
  - Recommendations

Next Steps

- Homework items/timeframe
- Round 1 Validation Notes
- Data Request Round 2

North Carolina Water Loss Program
Phase 1B Workshop
January 2019

NC Water Infrastructure | wrri NC Water Resources Research Institute | CAVANAUGH Stewardship Through Innovation