WATER LOSS CONTROL
March 11, 2020
PRESENTED BY  HEATHER HIMMELBERGER, P.E.
“The Southwest EFC promotes self-reliance through innovative training and assistance focused on actionable results.”
WHAT DO YOU THINK OF WHEN YOU HEAR “WATER LOSS CONTROL PROGRAM”? 
A Water Loss Control Program is the whole collection of activities to address non-revenue water (NRW)
So What is NRW?

Water we authorized someone to use but don’t seek payment

Water that reaches a user in some way that should be paid for but either isn’t or isn’t fully paid for

Water that was produced but never reaches a user
When you do a simple equation: water produced − water sold, the resulting number represents NRW.

Water Produced − Water Sold = Non-Revenue Water

All the water you produce that generates no revenue.
A Little More Terminology

Water we authorized someone to use but don’t seek payment

Water that reaches a user in some way that should be paid for but either isn’t or isn’t fully

Water that was produced but never reaches a user

NRW

Water Losses
Difference between NRW and Water Losses is “water we authorize but don’t seek payment for”
“Water Loss” is a somewhat confusing choice of words to describe the two categories.

Water Losses

Apparent Water Loss

Real Water Loss

Water that reaches a user in some way that should be paid for but either isn’t or isn’t fully.

Water that was produced but never reaches a user.
So, one part of a water loss control program is estimating the volume of water in each of the NRW categories.
A Water Balance or Audit Can Be Used for this Purpose
One method for calculating the Water Balance is the AWWA Free Audit Software.

### Water Audit Report

**Reporting Year:**
Northern San Leandro Combined Water Sewer Storm Utility District (0007900)

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

#### Master Meter Error Adjustments

<table>
<thead>
<tr>
<th>WATER SUPPLIED</th>
<th>Value</th>
<th>Pcnt</th>
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</thead>
<tbody>
<tr>
<td>Volume from own sources</td>
<td>5,000,000</td>
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<tr>
<td>Water imported</td>
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<tr>
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#### WATER SUPPLIED

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<tr>
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<tr>
<td>2013</td>
<td>1/2013 - 12/2013</td>
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#### AUTHORIZED CONSUMPTION

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#### AUTHORIZED CONSUMPTION

<table>
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<tr>
<td>760,313</td>
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#### WATER LOSSES (Water Supplied - Authorized Consumption)

<table>
<thead>
<tr>
<th>Value</th>
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<tbody>
<tr>
<td>64,688</td>
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#### NON-REVENUE WATER

<table>
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<th>Value</th>
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<tbody>
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<td>75,000</td>
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#### SYSTEM DATA

<table>
<thead>
<tr>
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#### COST DATA

<table>
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<th>Pcnt</th>
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<tr>
<td>1,000,000</td>
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</tbody>
</table>

#### WATER AUDIT DATA VALIDITY SCORE

**Priority Areas for Attention:**
1: Volume from own sources
2: Customer metering inaccuracies
3: Total annual cost of operating water system

Based on the information provided, audit accuracy can be improved by addressing the following components:

- Unauthorized consumption volume entered is greater than the recommended default value.
- Average length of customer service line has been set to zero and a data grading score of 10 has been applied.

**Click to access definition:**

### AWWA Free Water Audit Software: Reporting Worksheet

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

**Click to add a comment:**

What the Water Audit Is

Is:

...AWWA standard approach to categorize or “account” for water

...Provides information to help prioritize actions

...Provides metrics to examine NRW over time

....Provides overall volumes and values of water in different categories
How much water does the water balance or water audit save?
0 Gallons
No matter how good your water balance or water audit is, it won’t save one drop of water or bring in one more $ of revenue
It is the actions taken by the utility that save water or generate revenue.
Actions can be based on the audit itself or they can be based on component analysis.
What the Water Audit Isn’t

Isn’t:

...Completely accurate no matter how much work you put into it

...The only option to determine what actions to take

...Comprehensive in terms of benefits (only considers $$, not other benefits)

...Able to separate out real water loss into its components
When the limitations are understood, the water audit can be a useful part of the overall water loss program.
What else makes up a water loss control program besides a water balance or an audit?
Components of a water loss control program

- Water Audit
- Tracking data for water usage by utility
- Pressure management
- Collection of data, including break data
- Theft deterrence
- Improvements to system data
- Strategic pipe replacement
- All actions related to metering (customer & Production)
- Any action taken to look for leaks
- Any action taken to address observable leaks

Goals for the Program

- Water Audit
- Tracking data for water usage by utility
- Pressure management
- Collection of data, including break data
- Theft deterrence
- Improvements to system data
- Strategic pipe replacement
- All actions related to metering (customer & Production)
- Any action taken to look for leaks
- Any action taken to address observable leaks

Water Audit Report for:  
Reporting Year:  
All volumes to be entered as: MILLION GALLONS (US) PER YEAR  
Master Meter Error Adjustments  
Any action taken to look for leaks  
Any action taken to address observable leaks

AWWA Free Water Audit Software:  

*** YOUR SCORE IS: 60 out of 100 ***

An action to address observable leaks is a component of a water loss control program.
Components of a water loss control program

- Customer education & customer water loss control
- Repairing leaks faster
- Authorized But Unbilled Usage: Determining whether unbilled usage should be billed
- Improvements to policies & procedures
- Education and training for fire departments to reduce water hammer
- Unidirectional Flushing
- Billing system audit & Corrections
- Actions taken to fix storage tank leaks or overflows
- Water Hammer Reduction Strategies
- Efficient Reliable Accurate Billing

[Image of a water tower, policies sign, fire trucks, water hammer diagram, and a shaking water pipe illustration]
Benefits from a Water Loss Control Program

Triple Bottom Line
Key Considerations

Water loss control is a comprehensive program that is much bigger than just an audit.

To implement a comprehensive water loss control program will take cooperation & coordination between many different departments or types of personnel.

Not every action taken has to be directly related to an audit.

It’s important to consider a full range of benefits from actions taken, not just economic.

Question assumptions, such as “unavoidable” losses.
Establishing A Water Loss Task Force
If we remember back to all the components, there’s no way to do these things without a team.
Goals for a Water Loss Control Program
What is the Purpose of Your Water Loss Control Program
Your Purpose is Defined Through Setting Water Loss Control Goals
Some Examples of Categories

- Identifying & reducing theft
- Identifying & capturing lost revenue
- Reducing real losses
- Improving repair intervention strategies
- Conserving water supplies
- Improving asset management program

What other goals??
The Goals Can be Thought of as the Roadmap to Where You’re Going & How You’ll Get There
## Developing Goals

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
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</table>
| **Meaningful** | Relevant to staff and stakeholders  
Provides a clear picture of performance                                      |
| **Measurable** | Can be measured in a cost-effective manner  
Expressed as a qualitative or quantitative measure                           |
| **Consistent** | Consistent with industry practice  
Measurement is reproducible by others                                        |
| **Useful**     | Helps manage the utility  
Encourages improvement                                                        |
| **Unique**     | Describes a specific attribute of utility services or activities  
Independent of other goals                                                   |
Let’s look at a few potential goals
A Goal Related to Real Water Loss……

The Water Utility will reduce the total quantity of real water loss by 5% (as measured by the total real water loss from one year to the next, not % of total supplied volume)
Another Goal Related to Apparent Water Loss…….

The Water Utility will replace 5% of its smaller customer meters every year such that every meter will be replaced in 20 years. The larger customer meters will be replaced at a rate of 10% per year such that all larger commercial meters are replaced every 10 years.
CONSIDER HOW GOALS CHANGE YOUR OPERATION AND MANAGEMENT
Understanding the Water Balance and/or Audit
UNACCOUNTED FOR WATER
BASED ON THE THEORY THAT WHAT GOES IN…

…COMES OUT SOMEWHERE

IN  DISTRIBUTION SYSTEM  OUT

IN  OUT
EITHER YOU’RE GETTING PAID
OR YOU’RE NOT
A BLUE & GREEN PROBLEM
WATER THAT ISN’T GOING WHERE WE WANT IT TO

MONEY THAT WE’RE NOT GETTING, BUT COULD BE
BECAUSE THE WATER BALANCE IS ABOUT....

INS = OUTS
The Ins

Volume From Own Sources

Or

Imported Water

Or

Imported Water

Volume From Own Sources

= System Inputs
The Ins & The First Out

System Inputs

Total In

Water Supplied To Your System

Or

Exported to Another System

Supplied To Your System

The first “out” is water exported
The Outs ... 

- Authorized Usage Billed
- Non-Revenue Water

= 

- Billed Metered Usage
- Billed Unmetered Usage

Referred to as Revenue Water
The Outs ...

Authorized Usage Billed

Non-Revenue Water

=  

Authorized Un-billed Usage
Apparent Losses
Real Losses

Referred to as

Non-Revenue Water
The Outs ...

<table>
<thead>
<tr>
<th>Authorized Un-billed Usage</th>
<th>=</th>
<th>Authorized Metered Un-billed Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent Losses</td>
<td>=</td>
<td>Authorized Un-Metered, Un-billed Usage</td>
</tr>
<tr>
<td>Real Losses</td>
<td>=</td>
<td>Unauthorized Usage (theft)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Customer Meter Inaccuracies</td>
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<tr>
<td></td>
<td></td>
<td>Systematic Data Handling Errors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leakage on Mains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leakage on Services</td>
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<tr>
<td></td>
<td></td>
<td>Leakage &amp; Overflows at Tanks</td>
</tr>
</tbody>
</table>

Non-Revenue Water
Which Outs Can Be Measured?

- Authorized Un-billed Usage
- Apparent Losses
- Real Losses

- Authorized Metered Un-billed Usage
  - Authorized Un-Metered, Un-billed Usage
  - Unauthorized Usage (theft)
  - Customer Meter Inaccuracies
  - Systematic Data Handling Errors
  - Leakage on Mains
  - Leakage on Services
  - Leakage & Overflows at Tanks

Non-Revenue Water
How Do You Measure Unbilled, Metered Usage?

All permanent locations of authorized, un-billed usage should be metered.

Meters should be read monthly.
How Do You Measure Meter Inaccuracies?

Customer meters can be tested to see how accurate they are.

Usually only a portion of the meters are actually tested and that data used to make assumptions about the accuracy of the rest.
Which Outs Can Be Estimated?

**Authorized Un-billed Usage**  
- Apparent Losses  
- Real Losses

=  

**Non-Revenue Water**  
- Authorized Metered Un-billed Usage  
  - Authorized Un-Metered, Un-billed Usage  
  - Unauthorized Usage (theft)  
  - Customer Meter Inaccuracies  
  - Systematic Data Handling Errors  
  - Leakage on Mains  
  - Leakage on Services  
  - Leakage & Overflows at Tanks
How Do You Estimate Authorized Un-Metered, Un-billed Usage?

Track the occurrences of this type of usage (where, when, for how long, estimates of flow)

Use temporary meters when possible, or to estimate flows
How Do You Estimate Theft?

Look for instances where theft has occurred and make estimates of how prevalent the theft is to estimate total theft.

Very difficult estimate. Probably small overall and not worth the effort to estimate for most systems.
How Do You Estimate Systematic Data Handling Errors?

Audit of meter reading process.

Audit of billing process and billing system.
Which Outs Have to Be Calculated?

- Authorized Un-billed Usage
- Apparent Losses
- Real Losses

= Authorized Metered Un-billed Usage

- Authorized Un-Metered, Un-billed Usage
- Unauthorized Usage (theft)
- Customer Meter Inaccuracies
- Systematic Data Handling Errors
- Leakage on Mains
- Leakage on Services
- Leakage & Overflows at Tanks

Non-Revenue Water
Calculating the Real Losses

All the water supplied to the system (All the Ins) - All the Outs that can be measured or estimated = Real Water Loss
Real Losses Can’t Be Broken Down Based On the Water Balance or Water Audit

Real Losses

\[
\text{Leakage on Mains} \quad \text{Leakage on Services} \quad \text{Leakage & Overflows at Tanks}
\]
## The Financial Side of Non-Revenue Water

<table>
<thead>
<tr>
<th>Authorized Un-billed Usage</th>
<th>Authorized Metered Un-billed Usage</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Customer Retail Cost</td>
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</tr>
<tr>
<td>Apparent Losses</td>
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</tr>
<tr>
<td>Customer Retail Cost</td>
<td></td>
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<tr>
<td>Real Losses</td>
<td></td>
</tr>
<tr>
<td>Variable Production Cost</td>
<td></td>
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<tr>
<td></td>
<td>Valued at Customer Retail Cost</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valued at Variable Production Cost</td>
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<td>Leakage on Mains</td>
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<td>Leakage &amp; Overflows at Tanks</td>
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<tr>
<td></td>
<td>Systematic Data Handling Errors</td>
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</table>
What is the Customer Retail Cost?

The price the customer pays for water service. Considers flow-weighted averaging for different customer classes that are charged differently.

Can include other services, such as wastewater, if that service is billed based on the VOLUME of water used.
What is the Variable Production Cost?

Includes only the costs that change directly with volume of water produced. It represents the cost of producing the next million gallons after you’ve already produced the rest of the usage.

Can include items such as energy use for pumping, chemical usage, treatment costs, wear and tear on equipment.
You Can Choose to Value All Categories at Customer Retail Cost Instead of VPC

Authorized Un-billed Usage

Customer Retail Cost

Real Losses

Customer Retail Cost

Why Might You Want To Do This?

Authorized Metered Un-billed Usage

Customer Retail Cost

Leakage & Overflows at Tanks

Unauthorized Usage (theft)

Customer Meter Inaccuracies

Leakage on Mains

Systematic Data Handling Errors

Leakage on Services
Putting It All Together...

... To Get the Water Balance
Remember One Portion is Calculated

So How Does Data Quality Affect this?
All Data Errors Show Up Here, Positive Or Negative

Input

Actual Numbers

All the Outputs Except Real Water Loss

Real Water Loss

Input Over-Counted

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Input
All Data Errors Show Up Here, Positive Or Negative

- Real Losses
- Main Leaks
- Service Leaks
- Storage Leaks & Overflows
- Non-Revenue Water

Actual Numbers
- Input
- All the Outputs Except Real Water Loss
- Real Water Loss

Outputs Under-Counted
- Input
- All the Outputs Except RWL
- RWL Under-Counted
- RWL

Outputs Over-Counted
- Input
- All the Outputs Except Real Water Loss
- RWL Over-Counted
- RWL
**M36 Water Audit Is A Way to Calculate the Water Balance**
<table>
<thead>
<tr>
<th>Instructions</th>
<th>Reporting Worksheet</th>
<th>Comments</th>
</tr>
</thead>
</table>

**DATA ENTRY COMPONENTS**

- Water Balance
- Dashboard
- Grading Matrix
- Service Connection
- Diagram
- Definitions
- Loss Control
- Planning
- Example Audits
Water Audit Report for: [Citizen's Name]
Reporting Year: 2013

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

<table>
<thead>
<tr>
<th>Master Meter Error Adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Supplied</td>
</tr>
<tr>
<td>Pcnt:</td>
</tr>
<tr>
<td>Value:</td>
</tr>
<tr>
<td>Volume from own sources:</td>
</tr>
<tr>
<td>+    ? 5</td>
</tr>
<tr>
<td>1,000.000</td>
</tr>
<tr>
<td>MG/Yr</td>
</tr>
<tr>
<td>Water imported:</td>
</tr>
<tr>
<td>+    ?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Water exported:</td>
</tr>
<tr>
<td>+    ? 1</td>
</tr>
<tr>
<td>100.000</td>
</tr>
<tr>
<td>MG/Yr</td>
</tr>
</tbody>
</table>

**WATER SUPPLIED:** 825.000 MG/Yr

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

**AUTHORIZED CONSUMPTION**

<table>
<thead>
<tr>
<th>Authorized Consumption</th>
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</thead>
<tbody>
<tr>
<td>Billed metered:</td>
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<tr>
<td>+    ? 8</td>
</tr>
<tr>
<td>700.000</td>
</tr>
<tr>
<td>MG/Yr</td>
</tr>
<tr>
<td>Billed unmetered:</td>
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<tr>
<td>+    ? 9</td>
</tr>
<tr>
<td>50.000</td>
</tr>
<tr>
<td>MG/Yr</td>
</tr>
<tr>
<td>Unbilled metered:</td>
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<tr>
<td>+    ?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Unbilled unmetered:</td>
</tr>
<tr>
<td>+    ? 9</td>
</tr>
<tr>
<td>10.313</td>
</tr>
<tr>
<td>1.25%</td>
</tr>
</tbody>
</table>

**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 0.25%
  - Customer metering inaccuracies: + 5 ? 7.071 MG/Yr 1.00%
  - Systematic data handling errors: + 4 ? 5.000 MG/Yr 0.25%

**Apparent Losses:** 15.071 MG/Yr

**Real Losses (Current Annual Real Losses or CARL):** 49.617 MG/Yr

**NON-REVENUE WATER**

**NON-REVENUE WATER:** 75.000 MG/Yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

**SYSTEM DATA**

<table>
<thead>
<tr>
<th>Length of mains:</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
</tr>
<tr>
<td>100.0 miles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of active AND inactive service connections:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
</tr>
<tr>
<td>1,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service connection density:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 conn./mile main</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average length of customer service line:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average operating pressure:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**COST DATA**

<table>
<thead>
<tr>
<th>Total annual cost of operating water system:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,000,000/Year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Customer retail unit cost (applied to Apparent Losses):</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3.50/1000 gallons (US)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable production cost (applied to Real Losses):</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3,000.00/Million gallons</td>
</tr>
</tbody>
</table>

**WATER AUDIT DATA VALIDITY SCORE**

*** YOUR SCORE IS: 60 out of 100 ***

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

**PRIORITY AREAS FOR ATTENTION:**
1: Volume from own sources
2: Customer metering inaccuracies
3: Total annual cost of operating water system

Based on the information provided, audit accuracy can be improved by addressing the following components:

- Unauthorized consumption volume entered is greater than the recommended default value
- Average length of customer service line has been set to zero and a data grading score of 10 has been applied
- Are customer meters typically located at the curbstop or property line?

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.
Reporting Worksheet: Authorized Consumption

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

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

AUTHORIZED CONSUMPTION: ? 760.313 MG/Yr

Use buttons to select percentage of water supplied

Click here: for help using option buttons below

Value: MG/Yr

Pcnt: 1.25%

### Reporting Worksheet: Apparent Losses

**WATER LOSSES (Water Supplied - Authorized Consumption)**

<table>
<thead>
<tr>
<th>Apparent Losses</th>
<th>Value (MG/Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unauthorized consumption: + ? 10</td>
<td>3.000</td>
</tr>
<tr>
<td>Customer metering inaccuracies: + ? 5</td>
<td>7.071</td>
</tr>
<tr>
<td>Systematic data handling errors: + ? 4</td>
<td>5.000</td>
</tr>
<tr>
<td><strong>Apparent Losses:</strong></td>
<td><strong>15.071</strong></td>
</tr>
</tbody>
</table>

**Real Losses (Current Annual Real Losses or CARL)**

**Real Losses = Water Losses - Apparent Losses:**

<table>
<thead>
<tr>
<th>Value (MG/Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>49.617</strong></td>
</tr>
</tbody>
</table>

**WATER LOSSES:**

<table>
<thead>
<tr>
<th>Value (MG/Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>64.688</strong></td>
</tr>
</tbody>
</table>
Reporting Worksheet: System Characteristics

**SYSTEM DATA**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of mains:</td>
<td>100.0</td>
</tr>
<tr>
<td>Number of active AND inactive service connections:</td>
<td>1,000</td>
</tr>
<tr>
<td>Service connection density:</td>
<td>10</td>
</tr>
</tbody>
</table>

Are customer meters typically located at the curbstop or property line?  Yes

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

Average operating pressure: 60.0 psi
## Reporting Worksheet: Financials

### COST DATA

<table>
<thead>
<tr>
<th>Description</th>
<th>Grade</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total annual cost of operating water system:</td>
<td>5</td>
<td>$1,000,000 $/Year</td>
</tr>
<tr>
<td>Customer retail unit cost (applied to Apparent Losses):</td>
<td>7</td>
<td>$3.50 $/1000 gallons (US)</td>
</tr>
<tr>
<td>Variable production cost (applied to Real Losses):</td>
<td>7</td>
<td>$3,000.00 $/Million gallons</td>
</tr>
</tbody>
</table>

- Use Customer Retail Unit Cost to value real losses
OUTCOMES: THE THREE Vs

Volume of Water in Each Category

Volume

Value

Validity

Value of Non-Revenue Water in Each Category

Individual Data Grades & Overall Validity Score
CALCULATED WATER BALANCE:

<table>
<thead>
<tr>
<th>Own Sources (Adjusted for known errors)</th>
<th>Water Exported</th>
<th>Billed Water Exported</th>
<th>Revenue Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.000</td>
<td>5.010</td>
<td>5.010</td>
</tr>
<tr>
<td>System Input</td>
<td>9.248</td>
<td>5.626</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Billed Authorized Consumption</td>
<td>5.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Billed Metered Consumption (water exported is removed)</td>
<td>5.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Billed Unmetered Consumption</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unbilled Authorized Consumption</td>
<td>0.616</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unbilled Metered Consumption</td>
<td>0.500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unbilled Unmetered Consumption</td>
<td>0.116</td>
</tr>
<tr>
<td>Water Supplied</td>
<td>9.248</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apparent Losses</td>
<td>0.218</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unauthorized Consumption</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Customer Metering inaccuracies</td>
<td>0.230</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Systematic Data Handling Errors</td>
<td>0.013</td>
</tr>
<tr>
<td>Water Losses</td>
<td>3.622</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Real Losses</td>
<td>3.304</td>
</tr>
<tr>
<td>Water imported</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Non-Revenue Water (NRW)                |                |                       |              |
|                                        |                | Leakage on Transmission and/or Distribution Mains | 0.013 |
|                                        |                | Not broken down |
|                                        |                | Leakage and Overflows at Utility’s Storage Tanks | 0.013 |
|                                        |                | Not broken down |
|                                        |                | Leakage on Service Connections | 0.013 |
|                                        |                | Not broken down |

Water Audit Report for: Green Village Water Utility (ssssxxx)
Reporting Year: 2016
Data Validity Score: 50

7/2015 - 6/2016
DASHBOARD:

Volumes

Values

Total Volume of NRW = 75 MG/yr

Total Cost of NRW = $93,354
**PERFORMANCE INDICATORS:**

### System Attributes:

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent Losses</td>
<td>0.318 MGYr</td>
</tr>
<tr>
<td>Real Losses</td>
<td>3.304 MGYr</td>
</tr>
<tr>
<td><strong>Water Losses</strong></td>
<td>3.622 MGYr</td>
</tr>
</tbody>
</table>

**Unavoidable Annual Real Losses (UARL):** See limits in definition MGYr

**Annual cost of Apparent Losses:** $537

**Annual cost of Real Losses:** $1,026 Valued at Variable Production Cost

### Performance Indicators:

#### Financial:

- Non-revenue water as percent by volume of Water Supplied: 45.8%
- Non-revenue water as percent by cost of operating system: 4.1% Real Losses valued at Variable Production Cost

### Operational Efficiency:

- Apparent Losses per service connection per day: 7.64 gallons/connection/day
- Real Losses per service connection per day: 61.56 gallons/connection/day
- Real Losses per length of main per day*: N/A
- Real Losses per service connection per day per psi pressure: 1.63 gallons/connection/day/psi

From Above, Real Losses = Current Annual Real Losses (CARL): 3.30 million gallons/year

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

Volume

Value

Validity

Accuracy

Volume of Water in Each Category

Value of Non-Revenue Water in Each Category

Individual Data Grades & Overall Validity Score

WHAT’S MISSING?
PERFORMANCE INDICATORS:

The performance indicators are presented as single numbers.

The data validity score does not directly indicate data accuracy. It is a proxy, which may be better or worse than the actual accuracy.
REAL LOSSES WITH DIFFERENT MARGINS OF ERROR
ACCURACY OF AUDIT RESULTS

The accuracy of the results of the audit are based on the quality and accuracy of all of the inputs.

Are all of those entries accurate? Could they ever be? Why or why not?

Let’s look at some examples.
Well metering

What’s wrong with this picture?

Poor installation.
Interconnects (Water Purchased)

Who is metering?

Who is calibrating?

Do you know where they all are?
BILLING ISSUES: STOPPED METERS

How many customers?

How long are they going unbilled?

How are you handling estimated billings that overlap year end?
METER INVENTORIES
Lag Time Correction

Meter Route 1

Meter Route 2

Meter Route 3

Year End
Customer Meter Sizing:
Customer Meter Accuracy:

Typical Accuracy Curve for a 5/8" Meter
Unmeasured Flow?
DATA ISSUES

Electronic Calibration

1 1 10 100
ARCHIVED CUSTOMER DATA

Are you retrieving what you archived correctly?

One system showed every archived customer as 4000 GAL regardless of actual usage

Crystal reports retrieval problem
CORRECTED BILLING OR CREDITS

How do leak repair credits impact your volumes?
ZERO CONSUMPTION

Is there no consumption?
Is it tampering?
Is it equipment failure?
Are you cross checking closed and suspended accounts?
Or new accounts that may not have been entered into the system.
IMPORTANT THAT WE UNDERSTAND THAT WE CAN HAVE A REALLY GOOD AUDIT BUT PROBABLY NEVER A PERFECT AUDIT
DATA GRADES

When you know better you do better.

~ Maya Angelou
The Data Grade for Billed Metered is Related to:

Whether customers receive volume-based billing
Meter reading practices
Meter records data handling practices
Meter replacement practices
Data Validity Grading is Qualitative NOT Quantitative
DATA GRADE ENTRY

AWWA Free Water Audit Software: Reporting Worksheet

Water Audit Report for: Watertown USA Water Treatment Works (XXXXXXX)
Reporting Year: 2014

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 (via 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.

WATER SUPPLIED

<table>
<thead>
<tr>
<th>Component</th>
<th>Grade</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume from own source</td>
<td>6</td>
<td>95.206</td>
</tr>
<tr>
<td>Water imported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water exported</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WATER SUPPLIED: 95.206 MGYr

AUTHORIZED CONSUMPTION

<table>
<thead>
<tr>
<th>Component</th>
<th>Grade</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billed metered</td>
<td>6</td>
<td>80.468</td>
</tr>
<tr>
<td>Billed unmetered</td>
<td>8</td>
<td>0.048</td>
</tr>
<tr>
<td>Unbilled metered</td>
<td>1</td>
<td>1.250</td>
</tr>
<tr>
<td>Unbilled unmetered</td>
<td>2</td>
<td>1.450</td>
</tr>
</tbody>
</table>

Authorized Consumption: 83.156 MGYr

WATER LOSSES (Water Supplied - Authorized Consumption)

<table>
<thead>
<tr>
<th>Loss</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent losses</td>
<td>14.995</td>
</tr>
</tbody>
</table>

Master Meter and Supply Error Adjustments

Part: Value:

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

Data Grades
WHAT GRADE SHOULD I USE?

Hover the cursor over the red triangle in the corner.
**WHAT GRADE SHOULD I USE?**

The Data Grades will show up in a pop-up box.

<table>
<thead>
<tr>
<th>WATER SUPPLIED:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Billed metered: + 6</td>
<td></td>
</tr>
<tr>
<td>Billed unmetered: + 8</td>
<td></td>
</tr>
<tr>
<td>Unbilled metered: + 1</td>
<td></td>
</tr>
<tr>
<td>Unbilled unmetered: + 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RIZED CONSUMPTION:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 7</td>
<td></td>
</tr>
</tbody>
</table>

If you can meet or exceed **ALL** the criteria, for a line move to the next line.

Once all lines for a grade are checked move to the next higher number.
## Volume from own sources

<table>
<thead>
<tr>
<th>GRADE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)</td>
</tr>
<tr>
<td>1</td>
<td>Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing or electronic calibration conducted.</td>
</tr>
<tr>
<td>2</td>
<td>25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing or electronic calibration conducted.</td>
</tr>
<tr>
<td>3</td>
<td>Conditions between 2 and 4</td>
</tr>
<tr>
<td>4</td>
<td>50% - 75% of treated water production sources are metered, other sources estimated. Occasionally meter accuracy testing or electronic calibration conducted</td>
</tr>
<tr>
<td>5</td>
<td>Conditions between 4 and 6</td>
</tr>
<tr>
<td>6</td>
<td>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.</td>
</tr>
<tr>
<td>7</td>
<td>Conditions between 6 and 8</td>
</tr>
<tr>
<td>8</td>
<td>100% of treated water production sources are metered. Meter accuracy testing and electronic calibration of related instrumentation is conducted annually. Less than 10% of meters are found outside of +/- 6% accuracy</td>
</tr>
<tr>
<td>9</td>
<td>Conditions between 8 and 10</td>
</tr>
<tr>
<td>10</td>
<td>100% of treated water production sources are metered. Meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually, with less than 10% found outside of +/- 3% accuracy. Procedures are reviewed by a third party knowledgeable in the M36 methodology</td>
</tr>
</tbody>
</table>
Water Audit Data Grading Sheets

Sheets were created by the SW EFC and are available on our website

A significant component of the water loss Water Audit Software is data grading. As you will see when you review the AWWA Water Audit software, each data input and output you report in the software is graded for reliability on a scale of 1-10. However, due to the software’s Excel format, the data grading criteria are somewhat difficult to read in the spreadsheet. For your convenience we have reproduced the grading criteria and instructions for each input on the attached PDF Document.

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.

The data grades will be entered in columns E and J of the worksheet in cells denoted with a red triangle in their upper right hand corners as shown in the image at the left. Click on the image to expand.

Download the Water Audit Data Grading PDF Document HERE

http://southwestefc.unm.edu/
A More Objective Way...

# WATER LOSS AUDIT DATA VALIDITY WORKSHEET

**BETA Ver. 0.12 Date: 1/8/2018**

ADAPTED FROM THE AWWA WATER AUDIT SOFTWARE 2016

## DV01 VOLUME FROM OWN SOURCES:

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer (Select most appropriate answer from pull down menu):</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Does your utility import/purchase ALL of its water supply? (Your utility has no sources of its own.)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>What percentage of your water production sources are metered?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>How often are the meters tested and/or calibrated for accuracy?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>If you test your meters, how accurate are they?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Are your procedures reviewed by a 3rd party knowledgeable about M36 methodology?</td>
<td></td>
</tr>
</tbody>
</table>

Data Validity Score: 0

## DV02 VOLUME FROM OWN SOURCES MASTER METER AND SUPPLY ERROR ADJUSTMENT:

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer (Select most appropriate answer from pull down menu):</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are your sources of supply metered?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>How are tank/storage elevation changes employed in calculating ‘volume from own sources’ component?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>How is your production supply volume logged and reviewed?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>How and when is source meter data adjusted to account for error?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N/A - Leave answer field blank</td>
<td></td>
</tr>
</tbody>
</table>

Data Validity Score: 0
Tool was created by the SW EFC and is available on our website

http://southwestefc.unm.edu/

As an alternative to the Water Audit Data Grading Sheets we have also created the Water Loss Audit Data Validity Worksheet (insert link), an Excel tool that will allow you to answer specific questions related to each audit data point and have your data validity scored automatically. Please note that while we have tested this tool thoroughly, it is still under development and you are previewing a beta version. The goal in developing this worksheet is to offer an easier method for obtaining data validity scores for the AWWA Water Audit Software, but (for now at least) the data validity scores generated by this worksheet are approximations only, and the only official score comes from the AWWA software. There are detailed instructions contained on the first tab in the Worksheet, which include instructions for reporting any errors you may find. The Water Loss Audit Data Validity Worksheet was created using Excel 2016 and may not function correctly on older versions of Excel.

Download the Data Validity Tool ➔ HERE

Note: This file is compressed and must be extracted prior opening.
Water Audit Report for:
Reporting Year:
All volumes to be entered as: MILLION GALLONS (US) PER YEAR

Master Meter Error Adjustments

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water supplied</td>
<td>825.000 GY</td>
</tr>
<tr>
<td>Authorized consumption</td>
<td>760.313 GY</td>
</tr>
<tr>
<td>Water losses</td>
<td>64.688 GY</td>
</tr>
<tr>
<td>Non-revenue water</td>
<td>75.000 GY</td>
</tr>
</tbody>
</table>

WATER SUPPLIED

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume from own sources</td>
<td>1,000.000 GY</td>
</tr>
<tr>
<td>Water imported</td>
<td>100.000 GY</td>
</tr>
<tr>
<td>Water exported</td>
<td>1.000,000 GY</td>
</tr>
</tbody>
</table>

AUTHORIZED CONSUMPTION

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billed metered</td>
<td>700.000 GY</td>
</tr>
<tr>
<td>Billed unmetered</td>
<td>50.000 GY</td>
</tr>
<tr>
<td>Unbilled metered</td>
<td>10.313 GY</td>
</tr>
<tr>
<td>Unbilled unmetered</td>
<td>1.000,000 GY</td>
</tr>
</tbody>
</table>

WATER LOSSES (Water Supplied - Authorized Consumption)

<table>
<thead>
<tr>
<th>Loss Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unauthorized</td>
<td>3.000 GY</td>
</tr>
<tr>
<td>Customer metering inaccuracies</td>
<td>7.071 GY</td>
</tr>
<tr>
<td>Systematic data handling errors</td>
<td>5.000 GY</td>
</tr>
</tbody>
</table>

Real Losses (Current Annual Real Losses or CARL)

<table>
<thead>
<tr>
<th>Loss Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Losses = Water Losses - Apparent Losses</td>
<td>49.617 GY</td>
</tr>
</tbody>
</table>

Non-revenue Water

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NON-REVENUE WATER</td>
<td>75.000 GY</td>
</tr>
</tbody>
</table>

System Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of mains</td>
<td>100.0 miles</td>
</tr>
<tr>
<td>Number of active AND master service connections</td>
<td>1,000</td>
</tr>
<tr>
<td>Service connection density</td>
<td>10 conn./mile main</td>
</tr>
</tbody>
</table>

THE AUDIT IS A TOP DOWN APPROACH
THERE ARE BOTTOMS UP APPROACHES AS WELL: COMPONENT ANALYSIS
A BOTTOMS UP APPROACH CAN BE USED TO TARGET ACTION

Needs to be based on data

Can be compared to audit results

Check component data as well as audit results to see the benefits of your actions
An Example of Bottoms Up Approach
Finalized AM Plan

45% Reduction in Break Rate (and associated costs)
A Five-Year Cost Avoidance was approximately $9 Million
With Extra Time and Funds: Reduction in Estimated Inoperable Meters
Also Started Valve Exercising Program
<table>
<thead>
<tr>
<th>Helps to Address</th>
<th>The Toolbox (Basic)</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Validity, Data Results Out of Range</td>
<td>1 - Validation of supply &amp; consumption volumes; Look for Data Grade Improvements</td>
<td>Low-Mid</td>
</tr>
<tr>
<td>Validity, Billed Unmetered Use, Unbilled Unmetered Use</td>
<td>2 - Estimating and tracking unmetered use</td>
<td>Low</td>
</tr>
<tr>
<td>Validity</td>
<td>3 - Master Meter Annual Testing Program</td>
<td>Low - Mid</td>
</tr>
<tr>
<td>Validity; Other Benefits Related to Asset Inventory &amp; Management</td>
<td>4 – Mapping the System</td>
<td>Low - Mid</td>
</tr>
<tr>
<td>Authorized, Unbilled usage</td>
<td>5 – Review Policies &amp; Procedures for unbilled customers</td>
<td>Low</td>
</tr>
<tr>
<td>Unbilled unmetered</td>
<td>6 - Unidirectional flushing program</td>
<td>Low</td>
</tr>
<tr>
<td>Unbilled Unmetered Use</td>
<td>7 - Installing meters on unmetered connections</td>
<td>Mid</td>
</tr>
<tr>
<td>Customer metering inaccuracy</td>
<td>8 - Meter testing &amp; replacement</td>
<td>Mid-High</td>
</tr>
<tr>
<td>Unauthorized Use</td>
<td>9 - Theft Deterrence</td>
<td>Low - Mid</td>
</tr>
<tr>
<td>Systematic Data Handling Errors</td>
<td>10 - Billing system audit</td>
<td>Low-Mid</td>
</tr>
<tr>
<td>Real Losses</td>
<td>11 – Collecting &amp; Analyzing Break Data</td>
<td>Low</td>
</tr>
<tr>
<td>Real Losses</td>
<td>12 - Improve speed/quality of repairs</td>
<td>Low</td>
</tr>
<tr>
<td>Real Losses</td>
<td>13 - Locate &amp; eliminate pressure transients (surges, water hammer)</td>
<td>Low-Mid</td>
</tr>
<tr>
<td>Real Losses</td>
<td>14 – Night Flow Analysis</td>
<td>Mid</td>
</tr>
<tr>
<td>Real Losses</td>
<td>15 - Reduce peak and overall pressure</td>
<td>Mid-High</td>
</tr>
<tr>
<td>Real Losses: Leakage on Mains</td>
<td>16 – Main Replacement</td>
<td>High</td>
</tr>
<tr>
<td>Real Losses: Leakage on Services</td>
<td>17 – Service Replacement</td>
<td>Mid - High</td>
</tr>
<tr>
<td>Real Losses: Unreported Leaks</td>
<td>18 - Acoustic leak survey</td>
<td>Mid</td>
</tr>
<tr>
<td>Real Losses: Overflows and Leakage on Storage Tanks</td>
<td>19 – Tank Management, Data Collection, &amp; Inspection</td>
<td>Low</td>
</tr>
</tbody>
</table>

Remember, there are lots and lots of tools that can be used. It comes back to the fact that a water loss control program is multi-faceted so there needs to be lots of tools.
Resources to Assist with Water Loss Control: Water Loss Switchboard

AWWA Free Water Audit Software v5.0 (2014)

GA Water System Audit and Water Loss Control Manual

The Water Audit Handbook for Small Drinking Water Systems

Search resources...
Potential Changes to Water Audit Software in V6

- Minor changes to the name of the data entry page and minor changes to the data entry
- Data grades are all questions not selecting whether you meet criteria
- Not all data grades are possible between 1 and 10
- Total cost of operation has been removed
- Some default percentages changed.
- Can put in percent errors for customer meters of any amount
- Only enter positive numbers in meter error and check a box whether it is over or under
- Total cost of operation has been removed
Potential Changes to Water Audit Software in V6

The dashboard shows on the page with the metrics.

Both volume and value dashboards appear instead of toggling between them.

Some metrics are eliminated

New metrics are added

Every system gets an ILI score.