

AWWA M36 Water Audits Training Funded by MassDEP

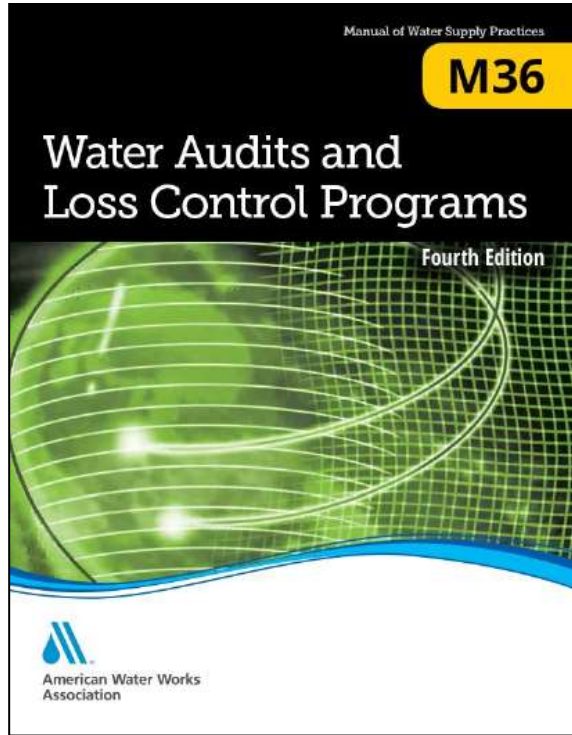
MassDEP CERO Training
June 27, 2019

Water Audit Course Outline

- 10:00-11:00am Overview of M36 Audit process, definitions and terminology, basic data needs, and walking through the M36 Audit Spreadsheet
- 11:00-11:15am Break
- 11:15am-12:15pm Review Water Balance, Performance Indicators, and Water Loss Control Strategies
- 12:15-12:45pm Lunch
- 12:45-2:00pm Group Q&A and roundtable discussion, final thoughts, and evaluations



AWWA M36



1. AWWA Water Audit M36-4th Edition
2. Using the AWWA water audit spreadsheet
3. Water audit helps control water losses
4. Tested on medium and large water systems

Why Would We Do An Audit?

- Curiosity?
- Revenue Management
- Assist with Conservation
- Higher Customer Confidence
- Set Capital Priorities
- Respond to Regulations



You may not understand all of the benefits until completing an Audit

Definitions and Terminology

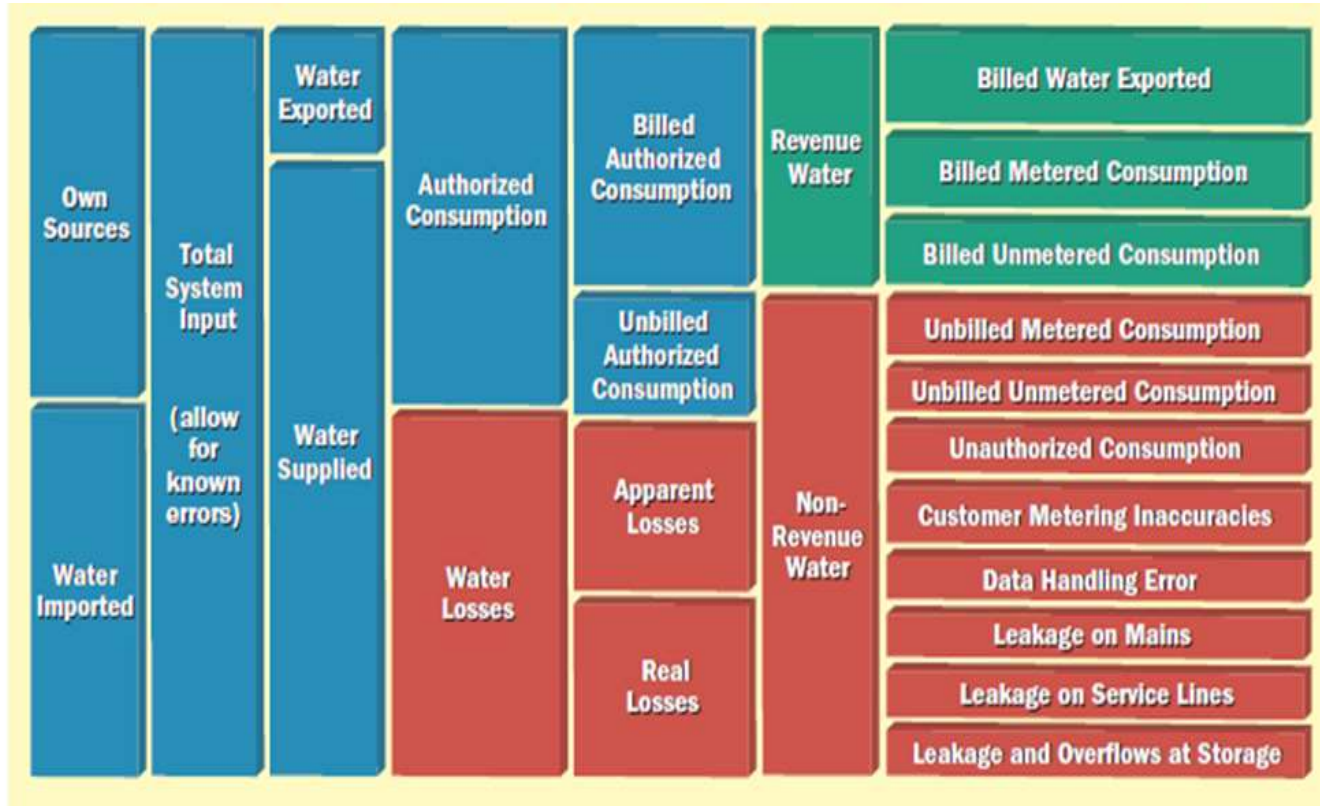
1. No more “un-accounted for water” – M36 accounts for all water
2. Water Losses are broken down into Apparent and Real Losses



Navigating a Water Audit Program

1. Data collection
2. Project Kickoff Team meetings
3. Review data provided
4. Follow up questions
5. Fill in spreadsheet; more questions
6. Revise spreadsheet
7. Study results

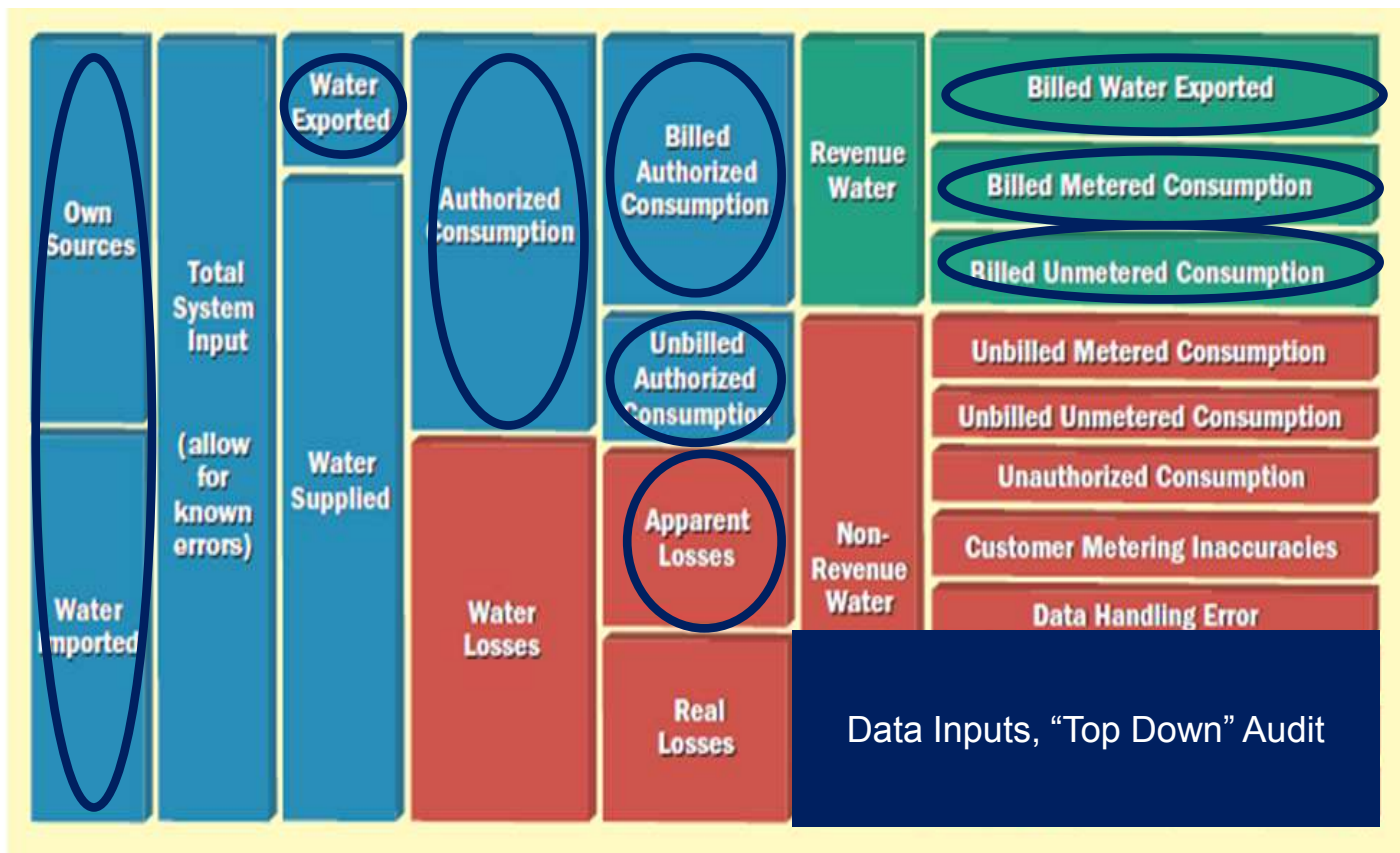
The Water Balance



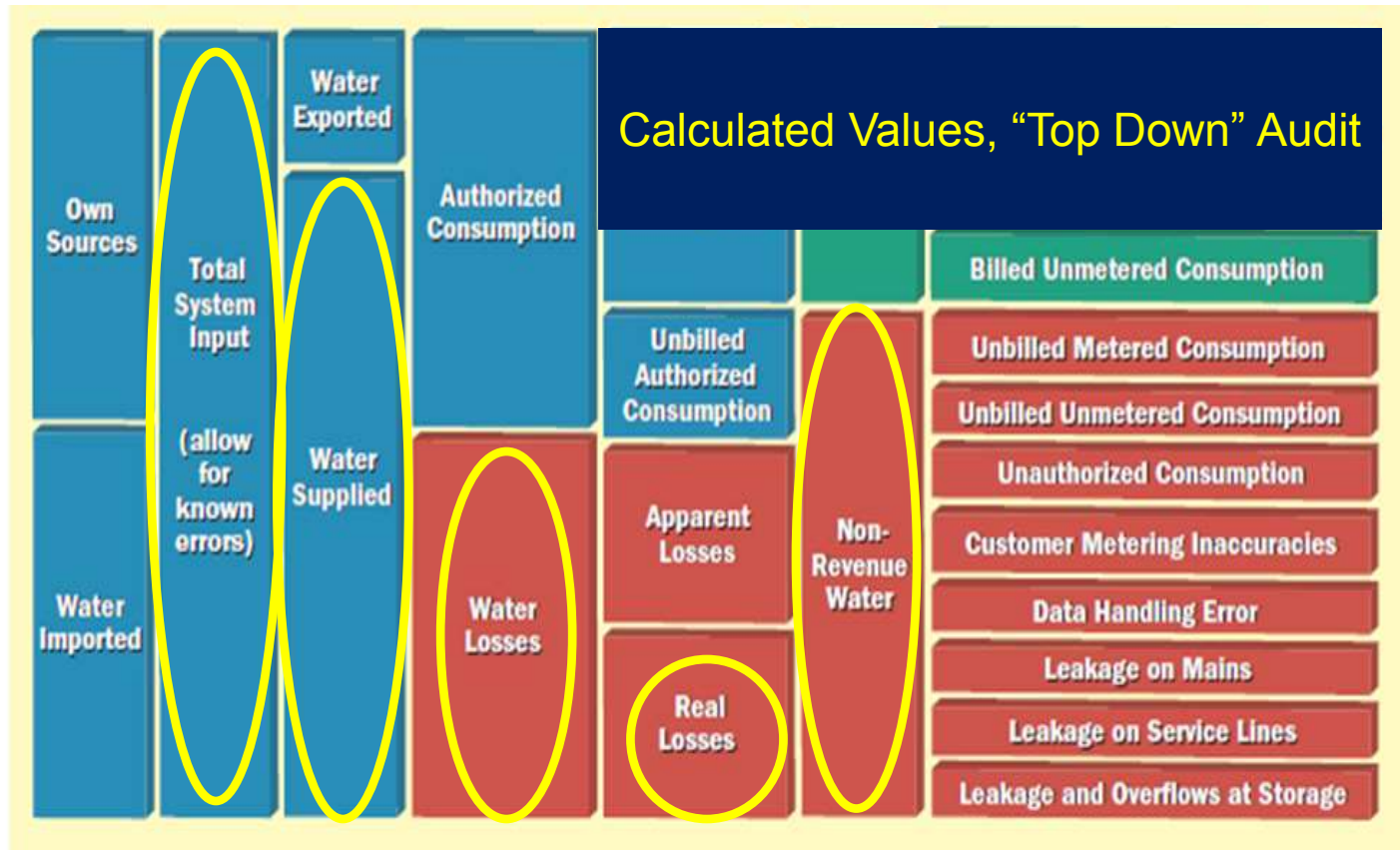
M36 Talks About

1. “Top Down” approach
Water balance....in vs out
 - Quantifies losses
 - Assigns value to losses
2. “Bottom Up” approach
 - Searches out causes of losses





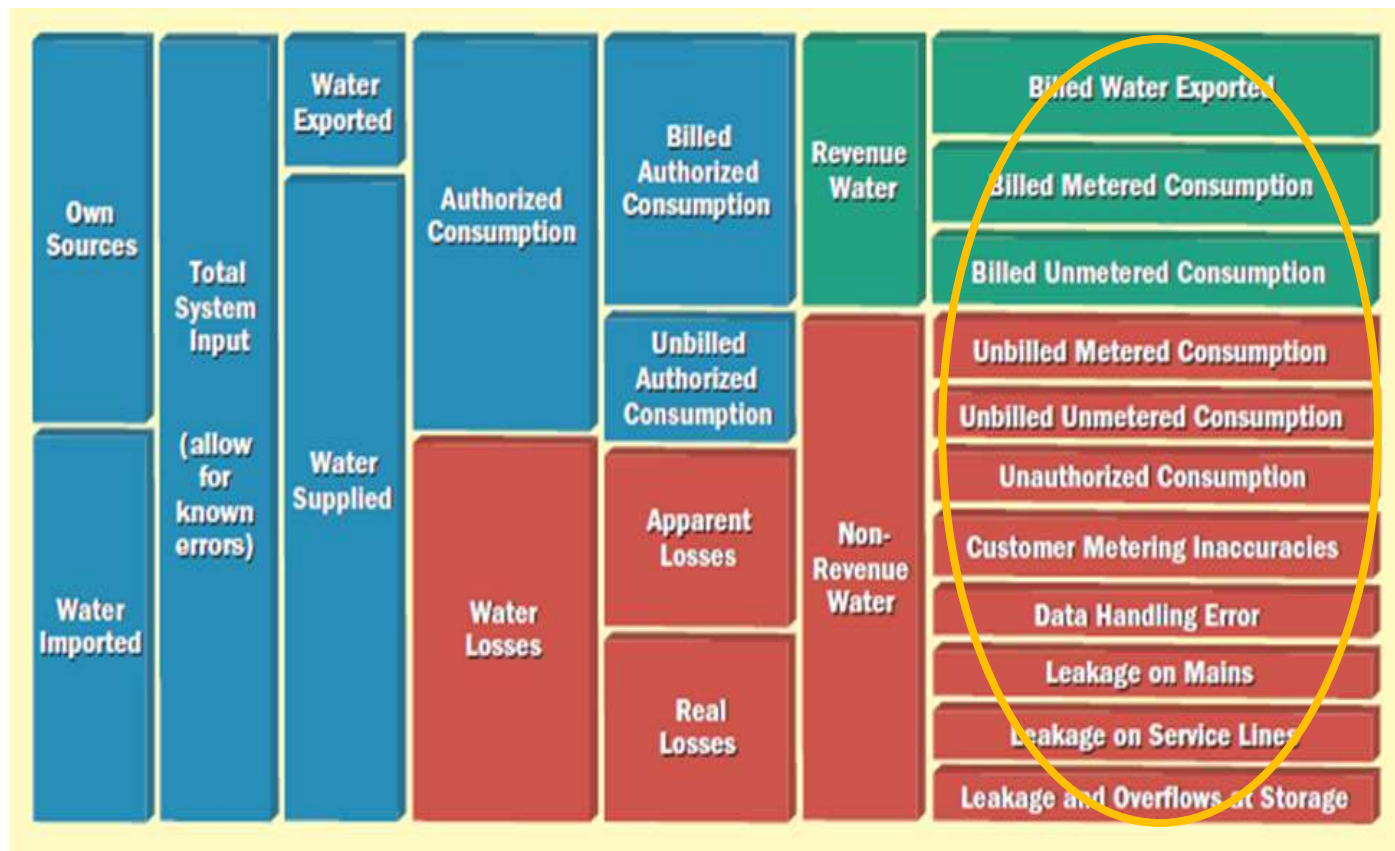
Numbers you enter in spreadsheet



Bottom Up Approach

- Searches out causes of losses
 - Better measurements (metering)
 - Physical inspections
 - Evaluation of billing and data management

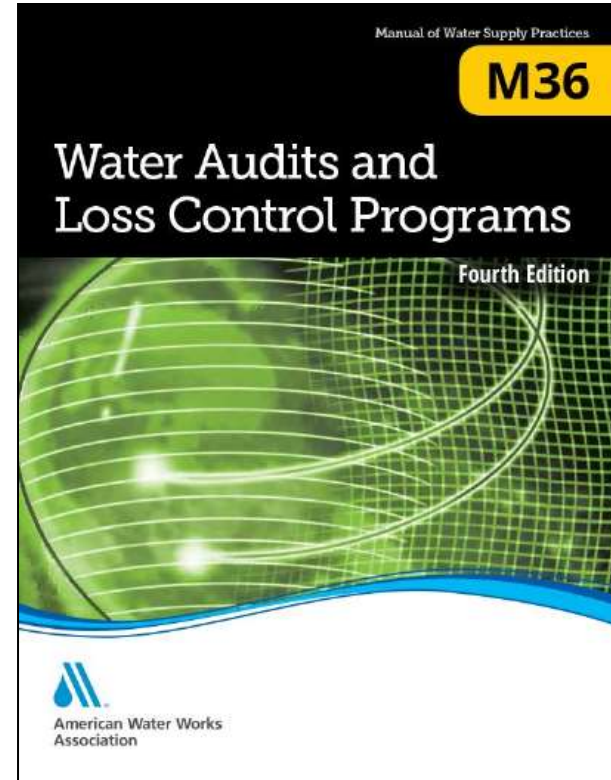
This is your “biggest bang for the water loss control buck”.



Tasks of the Water Audit

1. Establish water system description
 2. Determine Water Supplied to the Distribution System
 3. Quantify Billed Authorized Consumption
 4. Quantify Unbilled Authorized Consumption
 5. Quantify Water Losses
 6. Quantify Apparent Losses
 7. Quantify Real Losses
 8. Calculate “Non-revenue” Water
 9. Assign Costs of Apparent and Real Losses
 10. Calculate Performance Indicators
 11. Compile the Water Balance
-

Free Audit Software – Ver. 5.0 (2014)



Start Here

- AWWA Audit Spreadsheet
- FREE
- The Instruction Sheet

AWWA Free Water Audit Software v5.0
Copyright Water Works Association Copyright © 2014. All Rights Reserved.

This spreadsheet-based water audit tool is designed to help quantify and track water losses associated with water distribution systems and identify areas for improved efficiency and cost recovery. It provides a "top-down" summary water audit format, and is not meant to take the place of a full-scale, comprehensive Auditors are strongly encouraged to refer to the most current edition of AWWA M36 Manual for Water Audits for detailed guidance on the water auditing process and targetting loss reduction levels.

Below:

Please begin by providing the following information

Name of Contact Person:

Email Address:

Telephone (incl. Ext.):

Name of City / Utility:

City/Town/Municipality:

State / Province:

Country:

Year:

Start Date: Enter MM/YYYY numeric format

End Date: Enter MM/YYYY numeric format

Audit Preparation Date:

Volume Reporting Units:

PWSID / Other ID:

The following guidance will help you complete the Audit

All audit data are entered on the [Reporting Worksheet](#)

Value can be entered by user

Value calculated based on input data

These cells contain recommended default values

Use of Option (Radio) Buttons: ☒ 0.25% ☐

Select the default percentage by choosing the option button on the left

To enter a value, choose this button and enter a value in the cell to the

The following worksheets are available by clicking the buttons below or selecting the tabs along the bottom of the page

Instructions The current sheet. Enter contact information and basic audit details (year, units etc)	Reporting Worksheet Enter the required data on this worksheet to calculate the water balance and data grading	Comments Enter comments to explain how values were calculated or to document data sources	Performance Indicators Review the performance indicators to evaluate the results of the audit	Water Balance The values entered in the Reporting Worksheet are used to populate the Water Balance	Dashboard A graphical summary of the water balance and Non-Revenue Water components
Grading Matrix Presents the possible grading options for each input component of the audit	Service Connection Diagram Diagrams depicting possible customer service connection line configurations	Definitions Use this sheet to understand the terms used in the audit process	Loss Control Planning Use this sheet to interpret the results of the audit validity score and performance indicators	Example Audits Reporting Worksheet and Performance Indicators examples are shown for two validated audits	Acknowledgements Acknowledgements for the AWWA Free Water Audit Software v5.0

If you have questions or comments regarding the software please contact us via email at: info@awwa.org

[Instructions](#) | [Reporting Worksheet](#) | [Performance Indicators](#) | [Comments](#) | [Water Balance](#) | [Dashboard](#) | [Grading Matrix](#)

AWWA Free Water Audit Software
Reporting Worksheet

Water Audit Report for: **Recreational Water Co. (0000001)**
Reporting Year: **2016** | **10000** | **10000**

Please enter data in the white cells below. Where available, entered values should be used. If entered values are unavailable, please estimate a value. Indicate your confidence in the accuracy of the input data by giving each component a score of 1-5 using the drop-down to the left of the input field. Hover the mouse over the cell to obtain a description of the grades.

All input values to be entered on the LCM Data Entry (LCE) tab.

To enter 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.

WATER SUPPLIED

Enter grading in column "I" and "J"

Master Meter and Supply Error Adjustment

Volume from own sources: **0.00** MGD
Water imported: **0.00** MGD
Water exported: **0.00** MGD

WATER SUPPLIED: **0.00** MGD

AUTHORIZED CONSUMPTION

Click here for help using system buttons below

Unmetered consumption: **0.00** MGD
Unmetered consumption: **0.00** MGD
Unmetered consumption: **0.00** MGD
Unmetered consumption: **0.00** MGD

AUTHORIZED CONSUMPTION: **0.00** MGD

WATER LOSSES (Water Supplied - Authorized Consumption)

Water Losses: **0.00** MGD

Unmetered consumption: **0.00** MGD
Customer metering inaccuracies: **0.00** MGD
Systematic data handling errors: **0.00** MGD

Apparent Losses: **0.00** MGD

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses: **0.00** MGD

WATER LOSSES: **0.00** MGD

NON-REVENUE WATER

Non-Revenue Water: **0.00** MGD

SYSTEM DATA

Length of main: **0.00** miles
Number of active M&M service connections: **0.00**
Service connection density: **0.00** connections/mile

Are customer meters typically located at the curbside or property line? **No**
Length of service line (beyond the property boundary, this is the responsibility of the utility): **0.00** miles

Average operating pressure: **0.00** psi

COST DATA

Total annual cost of operating water system: **\$0.00**
Customer retail unit cost (exclusive of Apparent Losses): **\$0.00** per 100 cubic feet
Variable production cost (applied to Real Losses): **\$0.00** per 100 cubic feet

WATER AUDIT DATA VALIDITY SCORE

YOUR SCORE IS: 75 out of 100

A weighted look at the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score.

PRIORITY AREAS FOR ATTENTION

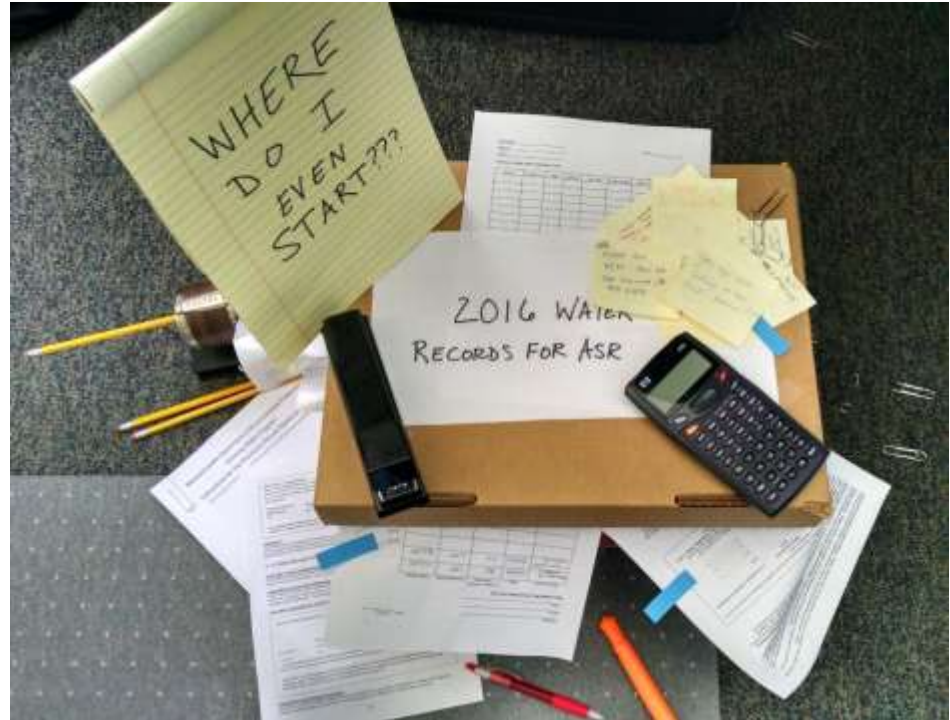
Based on the information provided, audit accuracy can be improved by addressing the following components:

- Volume from own sources
- Unmetered consumption

Reporting Worksheet

Basic Approach for Data input

1. Collect data
2. Enter your best numbers
3. Rate the “confidence” you have in each number



Grading Matrix

- Rate the confidence in the input data

- Scale of 1 – 10
- Used to help identify areas to dig deeper for future iterations

[illegible]

Task 1: System Information

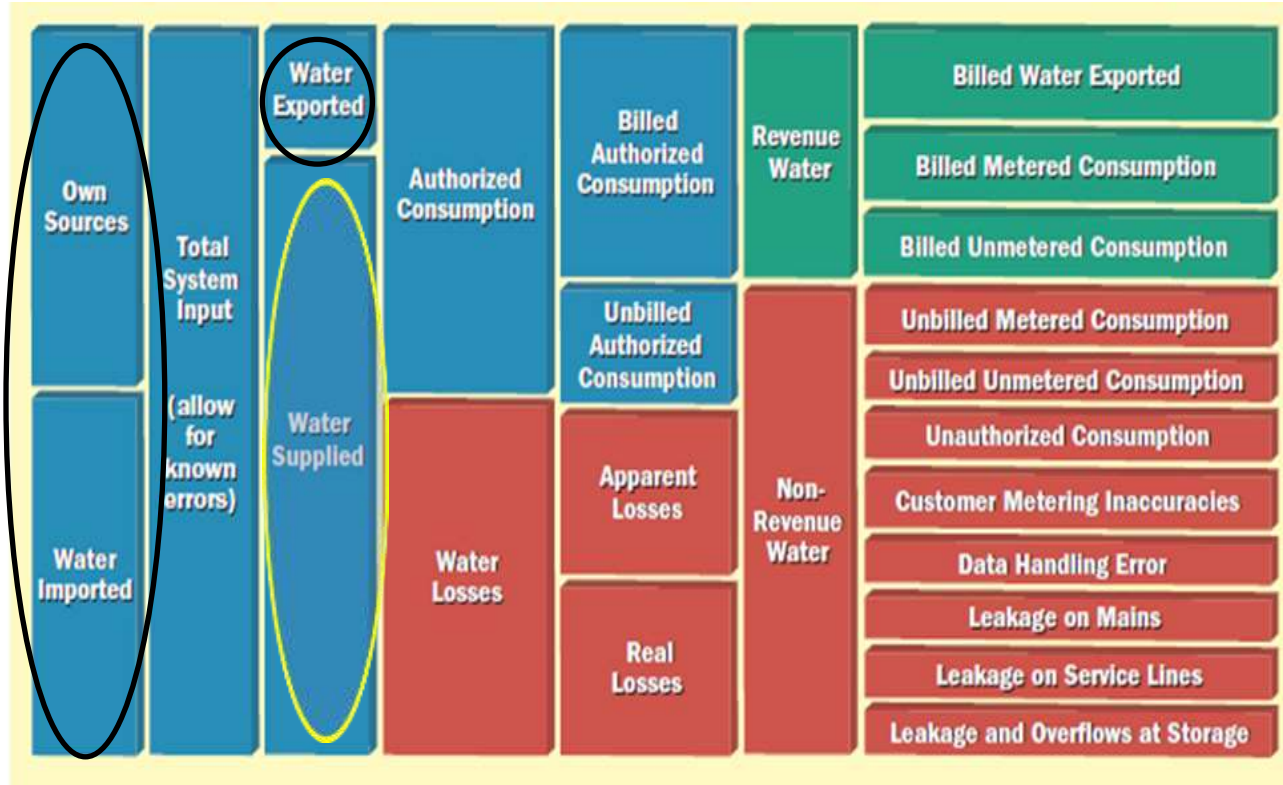
- Collect Basic System Information
 - Scope of Audit
 - Period of time, % time pressurized
 - Infrastructure description
 - Number of service connections, miles of main
 - Financial data
 - Total operational cost, cost of water, billing rates

System Information

SYSTEM DATA

Length of mains:	8	135.0	miles
Number of <u>active AND inactive</u> service connections:	6	6,662	
Service connection density:	49	49	conn./mile main
Are customer meters typically located at the curbstop or property line?	No		
Average length of customer service line:	6	62.0	ft (length of service line, <u>beyond</u> the property boundary, that is the responsibility of the utility)
Average operating pressure:	8	83.0	psi

Task 2: Water Supplied to System



$$(\text{Own Sources}) + (\text{Water Imported}) - (\text{Water Exported}) = \text{Water Supplied}$$

Water Supplied

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.

WATER SUPPLIED

Volume from own sources: MG/Yr
Water imported: MG/Yr
Water exported: MG/Yr

Enter grading in column 'E' and 'J'

Master Meter and Supply Error Adjustments

		Pcnt:	Value:	
+	?	6	0.03%	☒ ☐
+	?			☒ ☐
+	?			☒ ☐

Enter negative % or value for under-registration

Enter positive % or value for over-registration

WATER SUPPLIED:

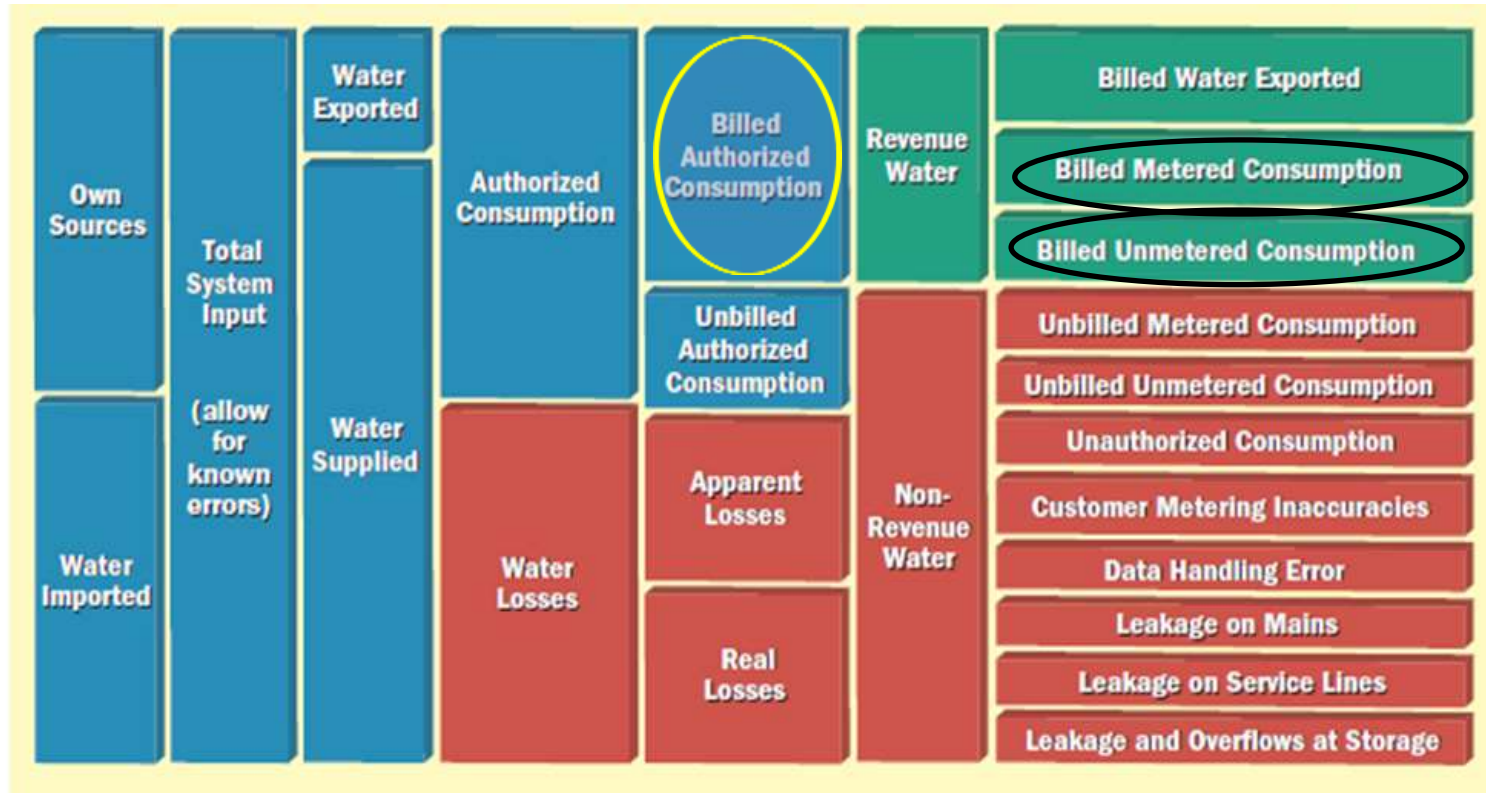
595.867 MG/Yr

Task 2: Water Supplied to System

- Water Supplied
 - Volume of Treated Water into distribution system
 - Own sources, imported sources
 - Corrections essential (System Input Volume, SIV)
 - Enter corrected master metered volumes
 - Subtract Billed Water Exported to get Water Supplied



Task 3: Billed Authorized Consumption



Task 3: Billed Authorized Consumption

AUTHORIZED CONSUMPTION

Billed metered:	+ 7	514.014	MG/Yr
Billed unmetered:	+ n/a	0.000	MG/Yr
Unbilled metered:	+ 8	3.086	MG/Yr
Unbilled unmetered:	+ 7	21.924	MG/Yr

Unbilled Unmetered volume entered is greater than the recommended default value

AUTHORIZED CONSUMPTION: **539.024** MG/Yr

Click here: for help using option buttons below

Pcnt: ☐ Value: ☐ 21.924 MG/Yr

Use buttons to select percentage of water supplied
OR

Task 3: Billed Authorized Consumption

- Quantify Billed Authorized Consumption aka Revenue
 - Compile meter consumption for the appropriate billing cycles
 - Adjust for lag time in meter readings
 - Compile volume of billed/authorized consumption
 - Consider records handling to facilitate future audits
 - Consider modifying AMR timing to coincide with audit period



Adjusting for Lag Time

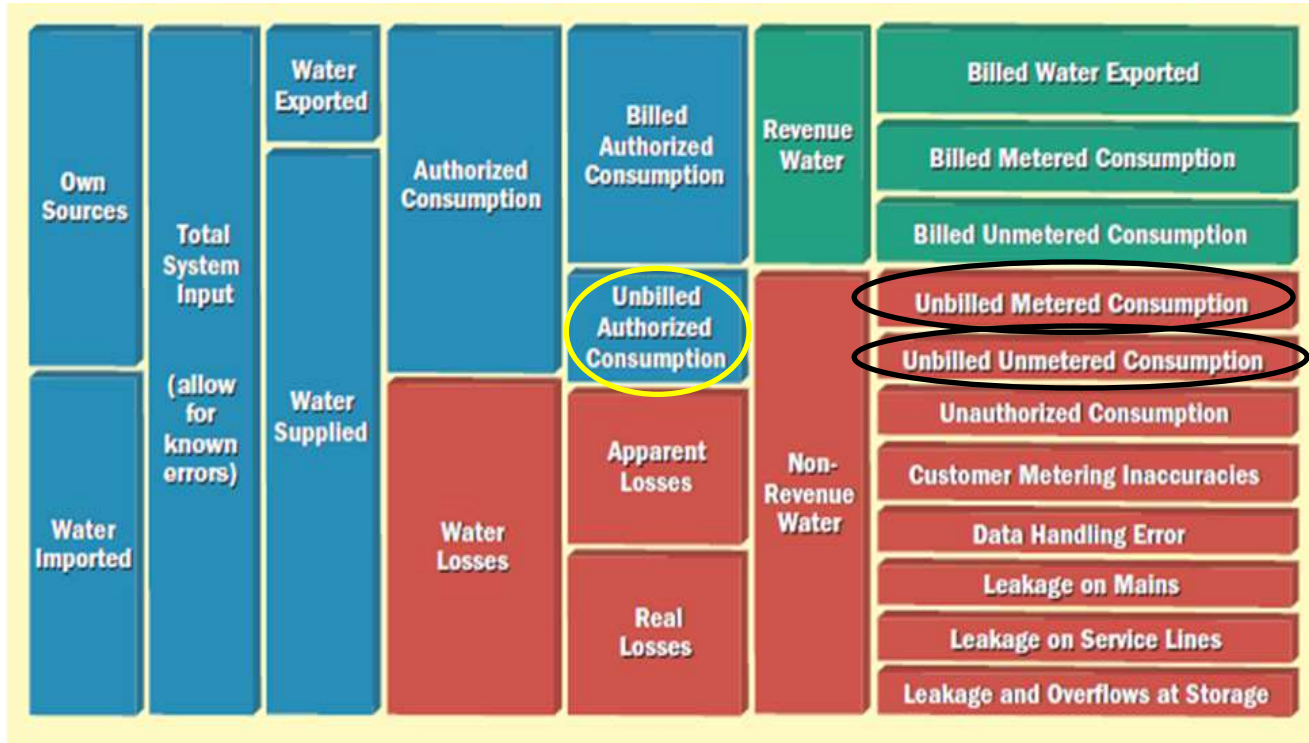
- Meter readings adjusted to match Audit period
- Prorate readings for first and last period
 - Ratio: Days in Audit period/days in billing period
 - Subtract if water delivered before audit period
 - Add water if delivered before end of audit period
 - Separate correction for each Meter Route
 - If read dates are different

As needed, adjust for each customer class

Example Data Sources

- Billed Metered
 - Residential
 - Agriculture
 - Municipal/institutional
 - Commercial
 - Construction site (hydrant)
- Billed Unmetered – Flat Rate
 - Community gardens
 - Size
 - Municipal buildings/Libraries
 - Size/use
 - Seasonal Users
 - Size/use

Task 4: Unbilled Authorized Consumption



Unbilled Water Provided as a
Matter of Policy

Unbilled Authorized Consumption

AUTHORIZED CONSUMPTION

Billed metered:	+	7	514.014	MG/Yr
Billed unmetered:	+	0	0.000	MG/Yr
Unbilled metered:	+	8	3.086	MG/Yr
Unbilled unmetered:	+	7	21.924	MG/Yr

Unbilled Unmetered volume entered is greater than the recommended default value

AUTHORIZED CONSUMPTION: MG/Yr

Click here: for help using option buttons below

Pcnt: ☐ Value: MG/Yr

Use buttons to select percentage of water supplied
OR

Task 4: Unbilled Authorized Consumption

Quantify Unbilled Authorized Consumption

- Consistent with supplier by-laws – may include municipal buildings
- Firefighting and training, system flushing, street cleaning, water consumption at public facilities – some of these may or may not be metered
- Use metered measurements or best estimates
 - Minimize estimation if possible
 - Estimates need to be objective and realistic



Authorized Consumption (Unbilled)

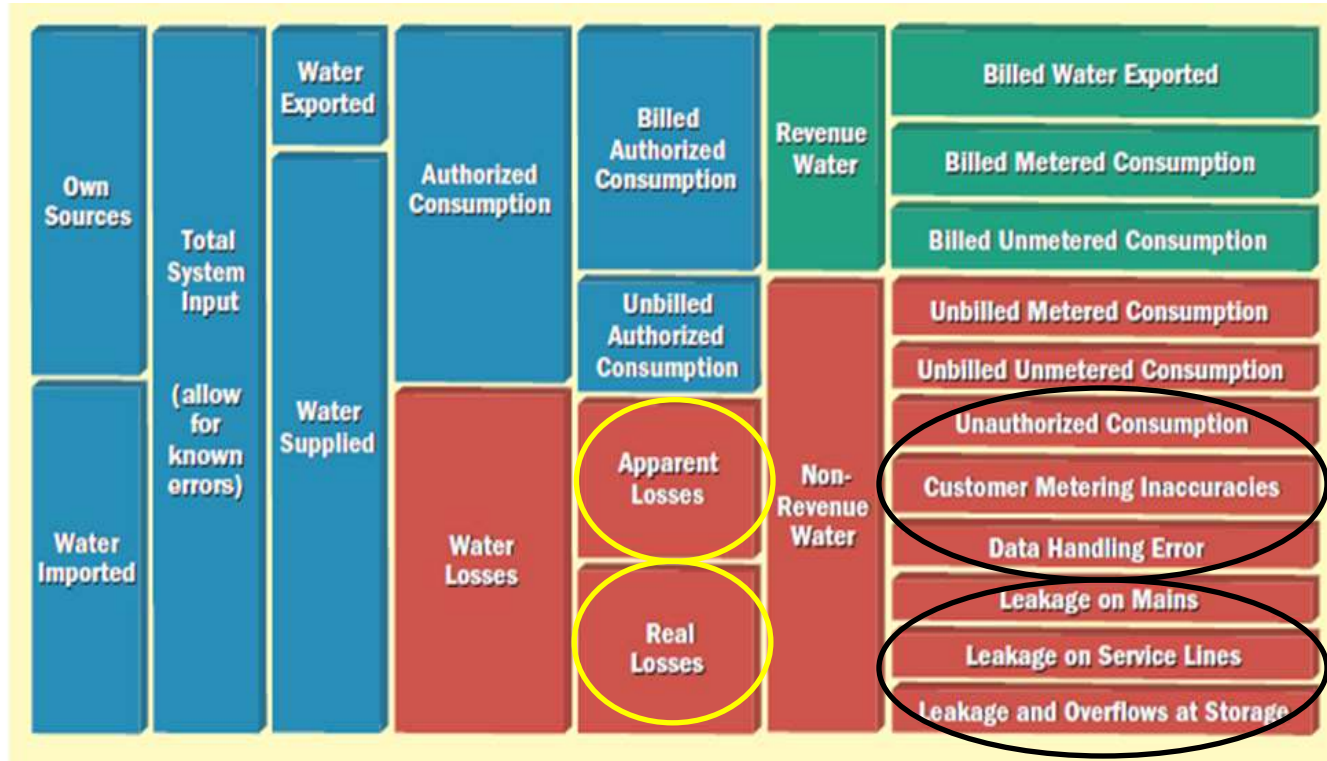
- Quantify Unbilled Authorized Consumption
 - Compile unbilled metered consumption
 - Compile unbilled unmetered consumption
 - Compile volume of unbilled/authorized consumption
 - Review CEMU Data
 - Consider developing forms and/or spreadsheets to better track unbilled consumption for future audits



Example Unbilled Authorized

- Unbilled Metered
 - Municipal Buildings
 - Municipal Fields/Parks
 - Water/Sewer Facilities
 - DPW Use
- Unbilled Unmetered
 - Community gardens
 - Cemeteries
 - Bleeders
 - Tank overflows
 - Fire fighting/training
 - Yes, you should include leak detection and breaks

Task 5: Quantify Water Losses



2 Kinds of Water Losses

Calculating Water Losses

WATER LOSSES (Water Supplied - Authorized Consumption)		56.843 MG/Yr
Apparent Losses		
Unauthorized consumption:	+ 7	1.490 MG/Yr
Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed		
Customer metering inaccuracies:	+ 7	0.000 MG/Yr
Systematic data handling errors:	+ 7	1.285 MG/Yr
Default option selected for Systematic data handling errors - a grading of 5 is applied but not displayed		
Apparent Losses:	7	2.775 MG/Yr
Real Losses (Current Annual Real Losses or CARL)		
Real Losses = Water Losses - Apparent Losses:	7	54.068 MG/Yr
WATER LOSSES:		56.843 MG/Yr

Pent: ☒ ☐ Value:

☒ ☐ MG/Yr

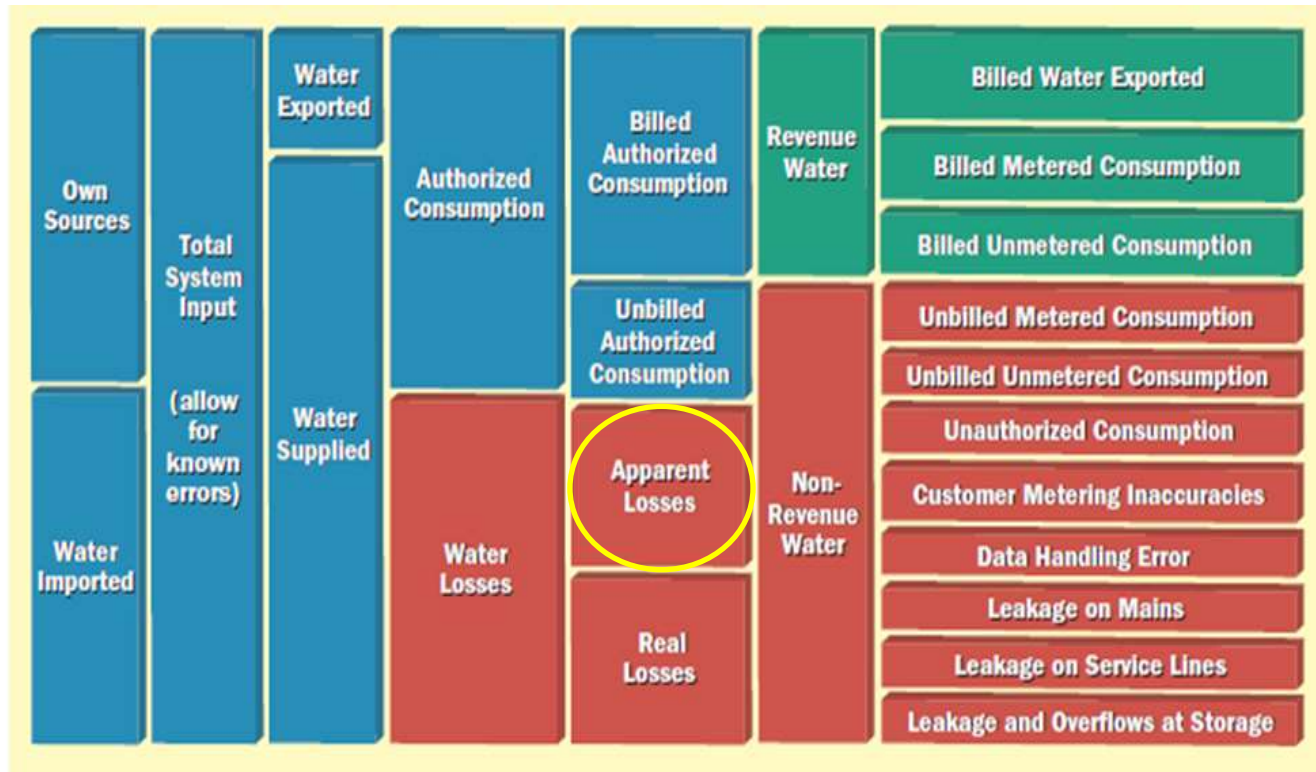
☒ ☐ MG/Yr

Task 5: Quantify Water Losses

- Quantify Water Losses
 - Apparent losses relate to billing and records keeping
 - Real losses relate to water leaving system



Task 6: Apparent Losses



Calculating Apparent Losses

- Sources of Losses

- Inaccurate meters
- Systematic Data handling errors



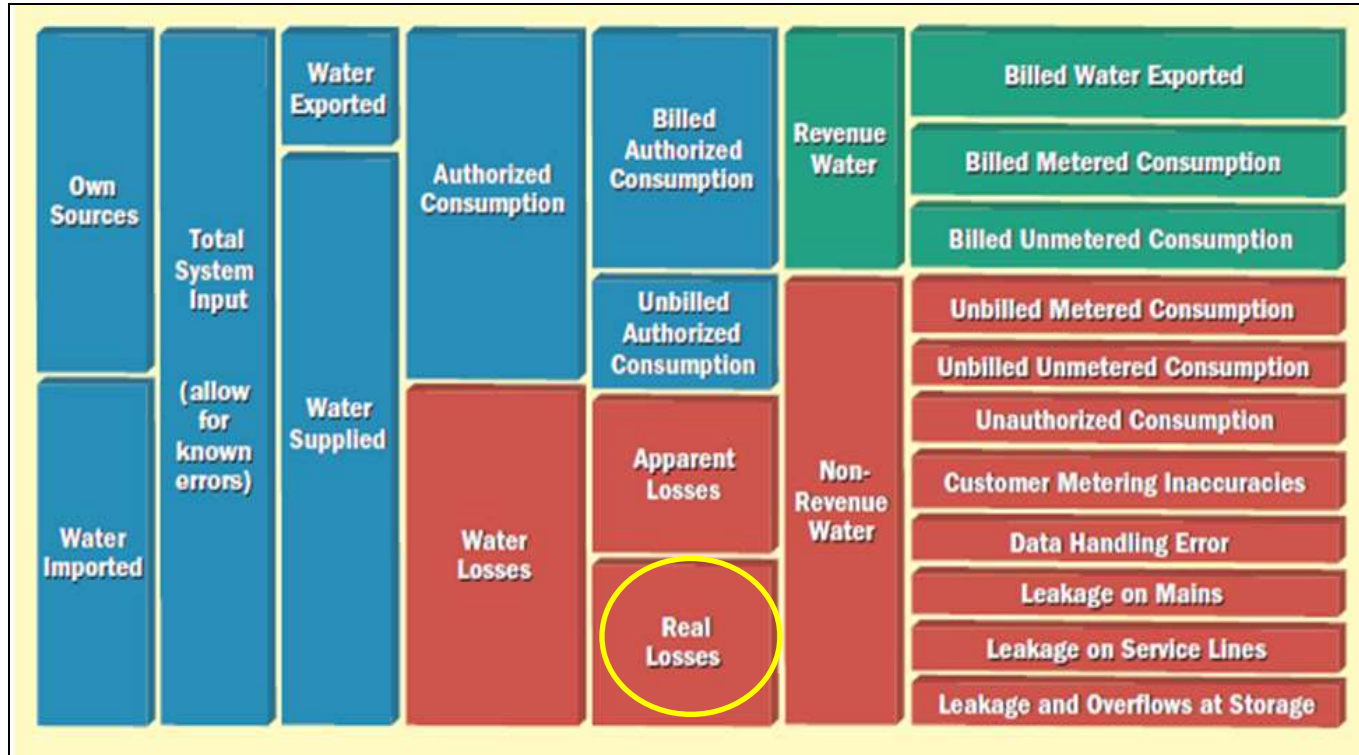
- Based on

- Meter records
- Policy evaluation
- Water system history

OR

- M36 Default Estimate

Task 7: Real Losses



Real Losses = Water Losses –
Apparent Losses

Task 7: Real Losses

- Real Losses (calculated by spreadsheet)
 - Total water losses minus apparent losses
 - An approximation
 - Gut check.....based on records

Save Water
Save Money

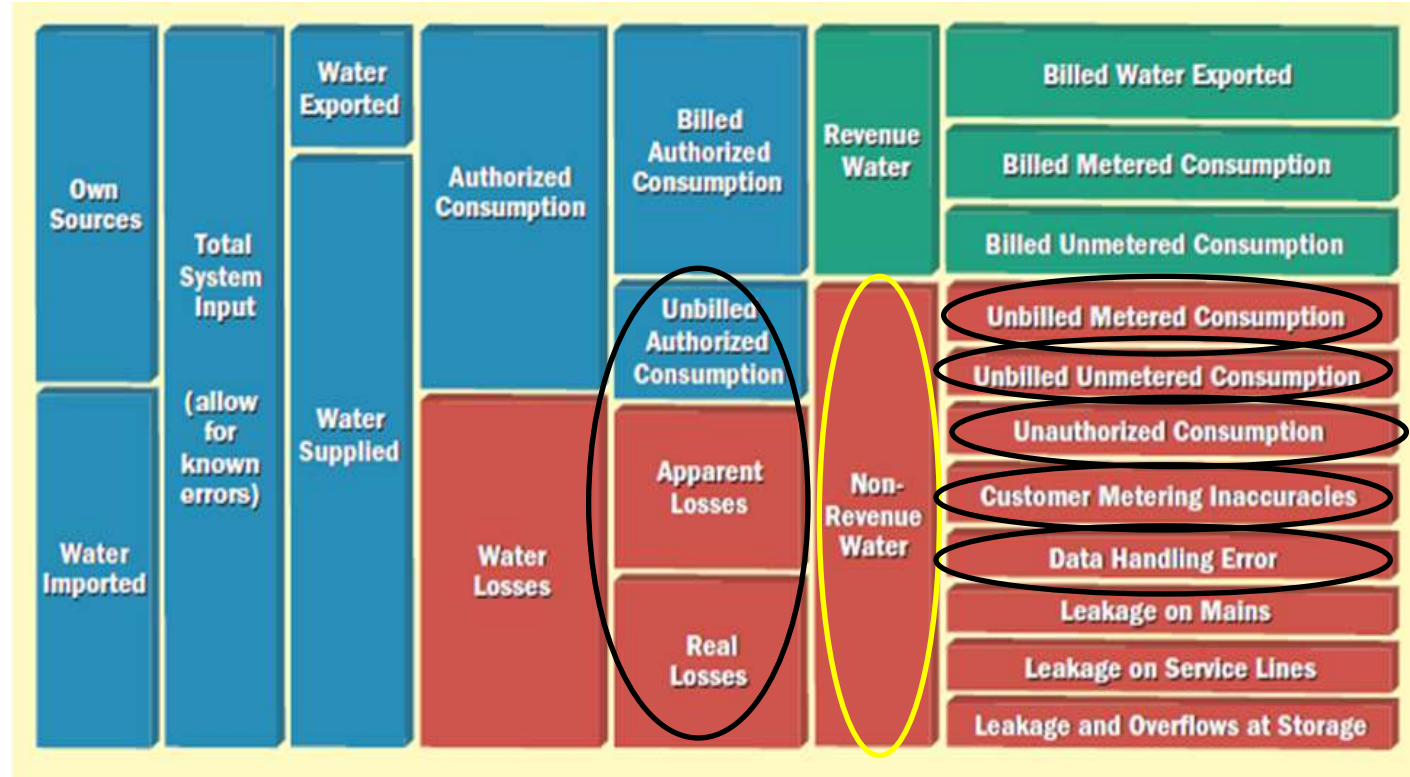


Accuracy of “Real Losses” depends on
accuracy of prior calculations

Value of Losses

- Apparent Losses valued at retail rates
 - Supplied but not paid for
 - Meter read errors, unbilled accounts
- Real Losses valued as “Delivered Water”
 - Annual Operating Budget divided by water delivered

Task 8: Calculate Non-revenue Water



Non-Revenue Water increases
rates for paying customers

Task 8: Calculate Non-Revenue Water

- Calculate “Non-revenue” Water
 - Add Water Losses to Unbilled Authorized Consumption

This calculation is done by the spreadsheet



NON-REVENUE WATER

NON-REVENUE WATER:

?

81.853 MG/Yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

In addition, the audit calculates the costs of nonrevenue water

No recovery of costs to produce and treat “Non-Revenue” Water

Task 9: Assigning Costs

- Enter cost data per audit spreadsheet
- Understand the “value” of losses
- Cost of Apparent Losses
- Cost of Real Losses
- Prioritize water loss control efforts
 - Money in the right places



Costs help set objectives and priorities

Calculate Cost of Losses

COST DATA

Total annual cost of operating water system:	+	?	9	\$4,366,489	\$/Year
Customer retail unit cost (applied to Apparent Losses):	+	?	8	\$7.53	\$/100 cubic feet (ccf)
Variable production cost (applied to Real Losses):	+	?	8	\$593.75	\$/Million gallons

☐ Use Customer Retail Unit Cost to value real losses

System Attributes:

Apparent Losses:	2.775	MG/Yr	
+	Real Losses:	54.068	MG/Yr
=	Water Losses:	56.843	MG/Yr
?	Unavoidable Annual Real Losses (UARL):	70.17	MG/Yr
	Annual cost of Apparent Losses:	\$27,931	
	Annual cost of Real Losses:	\$32,103	Valued at Variable Production Cost

Return to Reporting Worksheet to change this assumption

Task 10: Performance Indicators

- Examples of straightforward indicators
 - Volume of non-revenue water as a percent of water supplied
 - Value of non-revenue water as a percentage of the cost of operating the system
 - Volume of Apparent Losses divided by number of service connections per day



Task 10: Performance Indicators

- Examples of Complex Indicators
 - Real Losses divided by number of service connections per day per system pressure (psi)
 - Unavoidable Annual Real Losses (UARL)
 - Infrastructure Leakage Index (CARL/UARL)
 - CARL (Current Annual Real Losses)
 - UARL (Unavoidable Annual Real Losses)



Calculating Performance Indicators

[Return to Reporting Worksheet to change this assumption](#)

Performance Indicators:

Financial: { Non-revenue water as percent by volume of Water Supplied: 13.7%
Non-revenue water as percent by cost of operating system: 1.7% Real Losses valued at Variable Production Cost

Operational Efficiency: { Apparent Losses per service connection per day: 1.14 gallons/connection/day
Real Losses per service connection per day: 22.24 gallons/connection/day
Real Losses per length of main per day*: N/A
Real Losses per service connection per day per psi pressure: 0.27 gallons/connection/day/psi

From Above, Real Losses = Current Annual Real Losses (CARL): 54.07 million gallons/year

? Infrastructure Leakage Index (ILI) [CARL/UARL]: 0.77

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

Task 11: Compile the Water Balance

- Compile the Water Balance
 - Review the water balance
 - All columns add up to the same sum
 - Check...do the numbers seem reasonable?
 - Assigning a likely degree of error is an essential step
 - Go after apparent losses based on uncertainty
 - Use the Grading Matrix:



Task 11: Water Balance Sheet

AWWA Free Water Audit Software: Water Balance

WAS v5.0
American Water Works Association
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Water Audit Report for: **Exceptional Water Co. (0000001)**

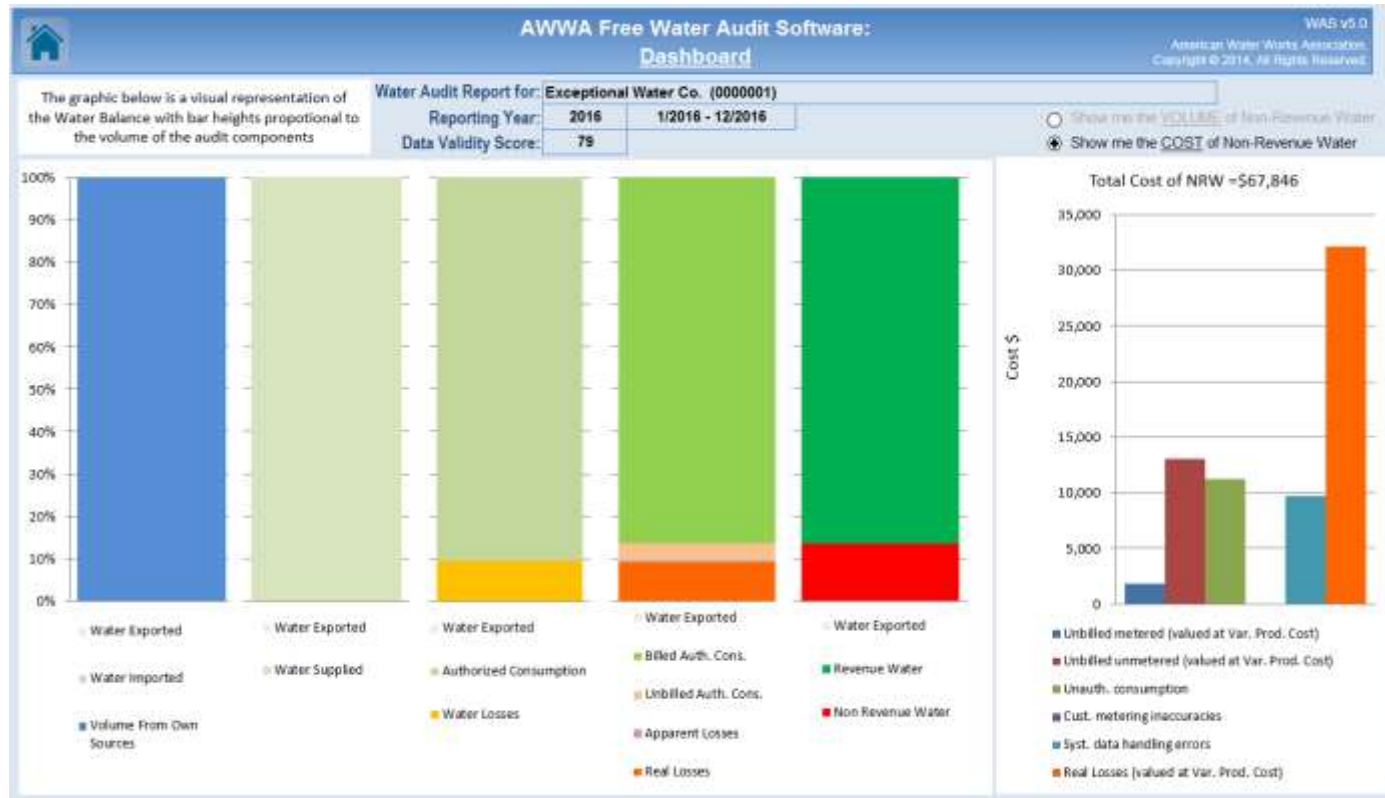
Reporting Year: **2016** 1/2016 - 12/2016

Data Validity Score: **79**

Own Sources (Adjusted for known errors) 595.867	Water Exported 0.000	Billed Water Exported:			
	Authorized Consumption 539.024	Billed Authorized Consumption	Billed Metered Consumption (water exported is removed)	Revenue Water	514.014
		514.014	514.014		
		Unbilled Authorized Consumption	Billed Unmetered Consumption		
			0.000		
	Water Supplied 595.867	Apparent Losses 2.775	Unbilled Metered Consumption	Non-Revenue Water (NRW)	81.853
			3.086		
			21.924		
			1.490		
	Water Losses 56.843	Real Losses 54.068	Customer Metering Inaccuracies		
			0.000		
			Systematic Data Handling Errors		
			1.285		
Water Imported 0.000	Leakage on Transmission and/or Distribution Mains Not broken down				
Leakage and Overflows at Utility's Storage Tanks Not broken down					
Leakage on Service Connections Not broken down					
Not broken down					

Calculated by the spreadsheet
based on prior input

Dashboard



Audit Results

“PRIORITY AREAS FOR ATTENTION”

Calculated by the spreadsheet based on input

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 79 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:

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

1: Volume from own sources

2: Billed metered

3: Unauthorized consumption

Methods for Controlling Losses

- Controlling Apparent Losses
 - Test customer meters, replace
 - Reduce data handling errors
 - Eliminate unauthorized consumption

Data base to track age and accuracy of residential meters



Methods for Controlling Losses

- Controlling Real Losses
 - Zone flow measurement
 - Acoustic leak detection
 - Replacement of old mains
 - Timely repair
 - System components
 - Customer lines
- Component Analysis

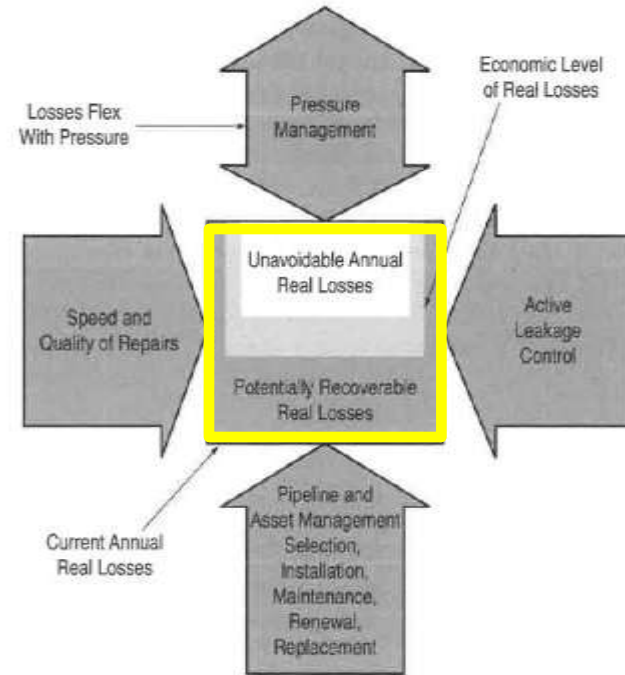


Loss Control Target: Shrink the Box

Benefits vs Costs

Real Loss Control

1. Pressure management
2. Speed of repairs
3. Active leak control
4. System management and maintenance



How much does it cost
to shrink the box?

Best Management Practices

- Annually test the accuracy of the flow through the finished and raw water master meters and simultaneously calibrate the electronics/update SCADA
- Replace old inaccurate source meters
- Standardize meter reading system
- Right size and test large customer meters
- Audit accounts for type of use and consumption history for inconsistencies to help identify potential theft
- Verify the correct number of fixed zeros on customer meters
- Flag low consumption and high consumption on customer accounts and (if possible) flag leaks and meter tampering
- Conduct a one month audit during minimal CEMU volume potential to improve water balance and better pinpoint real vs apparent losses
- Conduct a mini audit of each pressure zone within the system to target problematic areas

Best Management Practices

- Communicate the importance of recording water use to water employees and other departments; collect more accurate estimations of each department annual usage
- Monitor and record unmetered uses such as unmetered fire (tests) services
- Perform annual system wide leak detection survey and document leak repairs starting from the first point of awareness to isolation/shutdown plus duration of repair work – confirm leak detection survey flow rate estimations
- Implement improved tracking methods for all unmetered consumption; report volumes on ASR as applicable
- Have more than one person review the data reported in the ASR for quality control and education of additional employees
- Map metered accounts vs private wells to locate potential unauthorized usage

Group Q&A and Roundtable Discussion

Final Thoughts and Evaluations

The free AWWA M36 Water Audit Software
can be found at:

<https://www.awwa.org/Resources-Tools/Resource-Topics/Water-Loss-Control>