Using Water Audits to Understand Water Loss

A Joint Presentation of the USEPA Office of Groundwater and Drinking Water and the

American Water Works Association

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Acknowledgements

EPA appreciates the assistance of the American Water Works Association and today's speakers in developing and presenting today's webinar.

Speakers

Michael J. Finn, P.E.

Michael Finn is an Environmental Engineer with the Environmental Protection Agency's Office of Groundwater and Drinking Water, Drinking Water Protection Branch. He joined EPA in 2001 to work on the development of the Long Term 2 Enhanced Surface Water Treatment Rule, the Stage 2 Disinfection By Products Rule and the Groundwater Rule and the related guidance documents. He is currently working with States and public water systems on the implementation of those rules as well as water availability, water efficiency and energy efficiency in public water systems.

Gary B. Trachtman, P.E.

Gary Trachtman is a Principal Environmental Engineer with Malcolm Pirnie/Arcadis. He has performed water audits for water systems ranging from 30,000 to 400,000 accounts, and has recommended and assisted with implementation of programs for reducing and managing Non-Revenue Water. He is the chair of the AWWA Water Loss Control Committee's Subcommittee on Water Audit Regulatory Practices and a contributor/editor for the AWWA M36 Manual on Water Audits and Loss Control Programs (3rd ed., 2009). He has been a co-author and presenter on Water Loss Management topics at numerous AWWA technical sessions and workshops.

Speakers

Will J. Jernigan, P.E.

Will Jernigan is the Asheville Branch Manager with Cavanaugh and Associates in Asheville North Carolina. Will has worked with over 30 water systems in the Southeastern U.S. to perform water audits and implement water efficiency programs. Will has published technical papers on auditing and water efficiency programs and presented at numerous national and regional conferences. He is a member of the AWWA Water Loss Control Committee.

George Kunkel, P.E.

George Kunkel is the Water Efficiency Program Manager for the Philadelphia Water Department. Mr. Kunkel has lead the successful Non-revenue Water reduction efforts at the Philadelphia Water Department for twenty years. He is a frequent presenter on water loss topics and is co-author of the text *Water Loss Control* (2nd ed., 2008). He has worked on numerous water loss projects in AWWA and the Water Research Foundation and was the recipient of the 2010 Water Star Award presented by the Alliance for Water Efficiency.

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Overview

- Introduction-Managing Water Loss
  - Michael Finn, OGWDW, U.S. EPA Headquarters
- Introduction to Water Audits
  - Gary Trachtman, Malcolm Pirnie/Arcadis
- A Small System Case Study
  - Will Jernigan, Cavanaugh and Associates
- Utility Perspective on Water Audits
  - George Kunkel, Philadelphia Water Department
- Questions and Answers

Goals of the Webinar

- Understand water availability issues, the benefits of water loss control and steps to control water losses
- Introduce the water audit process and a water audit tool
- Provide an example of water audit application in a small water system
- Provide a utility perspective on conducting water audits and using the results

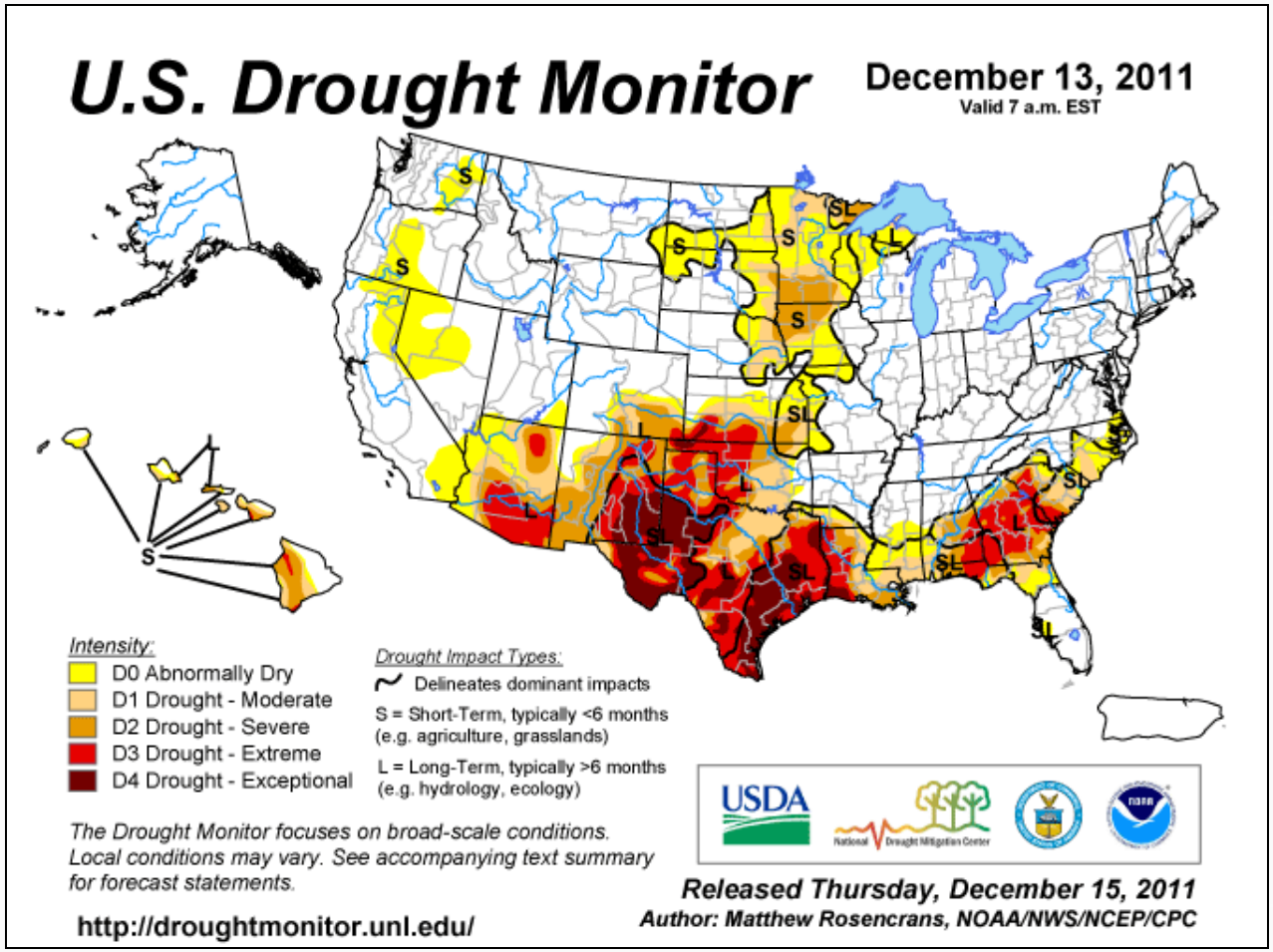
Water Scarcity

- Water supplies and demand are impacted by:
  - Population growth and economic trends
  - Legal decisions
  - Short-term and long-term climate change
  - Emerging contaminants
  - Infrastructure and technology (dams, transmission, etc.)
- Constraints on water use exist and are likely to increase over time

Water Availability in the United States

- Drought exists somewhere in the United States virtually always
- 2011-2012 drought in Texas is the “worst ever”

1/26/2012



Options for Dealing With Water Scarcity

Supply side options are limited:

- Many existing resources are currently stressed
- Competition for new water resources
  - New water rights may be limited or difficult to obtain (e.g., State or local regulations and policies may limit withdrawals to protect endangered species.)
- Competition over existing, multi-use water sources
  - Hydropower, recreation, drinking water, ecological, etc.
- Quantity/quality issues with new sources
  - Alternate sources are likely to be lower quality, farther away, or both
    - Increased expense and energy consumption to move and treat

Options for Dealing With Water Scarcity
Demand side options

- System programs
  - Water Loss- Metering, water audits, leak detection and repair/replacement
  - Pressure management, etc.
- Conservation and water efficiency as a new source of water
  - Reduces need to find new sources
  - Extends the life of existing sources
- Can start simple-Conservation pricing, public education, water audits, retrofit programs

Demand side-improved system knowledge

- Estimated service population
- Estimated service area (square miles)
- Total annual water supply
- Types and number of service connections
- Total system demand
  - Metered sales
  - Unmetered sales
  - Non-revenue water (apparent and real losses)
- Average-day demand
- Maximum-day demand
- Rate structure

Demand side-Water Loss Control

- A water loss control program helps to identify real, or physical losses of water from the distribution system and apparent losses, or water that is consumed, but not accounted for.
- Physical losses- increased production/pumping demands, costs of additional energy and chemical usage for lost water.
- Apparent losses-loss of revenue because the water is consumed, but not accounted for and not billed.
- Water loss control- assists in generating revenue and meeting water demands

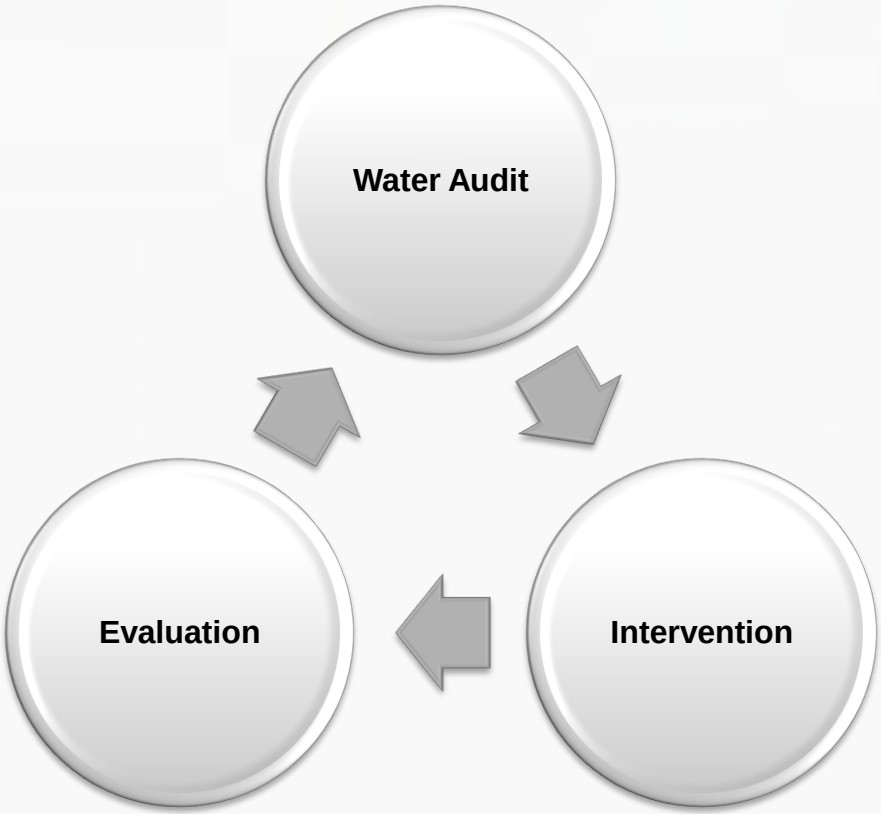
Water Loss Control-Benefits

- Water availability-defer development of new sources, reduce or eliminate need for supplemental/purchased supplies
- Economic and Population Changes-meet new industry demands, reduce need for plant expansion
- Climate change and Drought-reduce severity of impacts from drought and climate change

Water Loss Control-Benefits

- Operational and Maintenance Costs-reduce power consumption, pipe failures, treatment chemical and disinfectant use
- Regulatory Requirements-some states require water audits and/or have standards for non-revenue water
- Public Service Responsibilities- reduce service interruptions and repair costs, deferred/reduced rate increases, improved system reliability
- Social Responsibility and Conservation-conserves water and energy resources, reduced materials for maintenance and repair => potential decreased greenhouse gas emissions

Components of a Water Loss Control Program



Water Audits

- Foundation and critical first step in water loss control
- Quantifies the integrity of the distribution system
- Basis for plans/projects to address losses
- “Top down” audits use existing data and information
- Basic or limited audit has value in prioritizing
- Resources to complete audits are available

Resources

- Control and Mitigation of Drinking Water Losses in Distribution Systems. EPA 816-R-10-19. http://water.epa.gov/type/drink/pws/smallsystems/technical_help.cfm
- AWWA Free Water Audit Software.
- Texas Water Development Boards' *Water Loss Audit Manual*(2008).http://www.twdb.state.tx.us/assistance/conservation/Municipal/Water_Audit/wald.asp.
- Georgia Department of Natural Resources' *Georgia Water Systems Audits and Water Loss Control Manual* (2011) http://www.gaepd.org/Files_PDF/GaWaterLossManual.pdf
- 1998 EPA Water Conservation Plan Guidelines http://www.epa.gov/watersense/pubs/guide/htm

American Water Works Association

AWWA Water Loss Control Committee

Mission: To increase water utility awareness of the nature and extent of water loss in the industry and improve the level of water accountability employed by water suppliers; by furthering the science and application of water accounting, leakage and pressure management and universal metering systems.

AWWA Staff Contact: Ms. Lois M. Sherry lsherry@awwa.org
Phone: 303 347-6284 Fax: 303 794-6303

WLCC's Subcommittee on Regulatory Practices for Water Audits monitors and reports on water loss management activities and policies developing within the regulatory community, and identifies opportunities to further the WLCC's outreach program, to assist water utilities and the regulatory community in understanding the principles and practices of effective management of non-revenue water.

AWWA USEPA Webcast

Using Water Audits to Understand Water Loss

Segment 2

Introduction to Water Audits

January 26, 2012

Segment Agenda

- History and Development of the Water Audit
- Regulatory and Financial Drivers
- Water Audits (Overview)
- AWWA Water Audit Software (A Closer Look)
- Next Steps – Working Toward Economic Levels of Apparent and Real Losses
- NRW Management as Part of the Water Supply Portfolio
- References and Parting Words

Non-Revenue Water

~~Unaccounted-for-Water~~ ➡ Non-Revenue Water (NRW) =

Real Losses

Apparent Losses

Unbilled Authorized Consumption

Source

WTP

Source Meter

Reservoir

Transmission Main

Distribution Network

Customer Meter

Residence

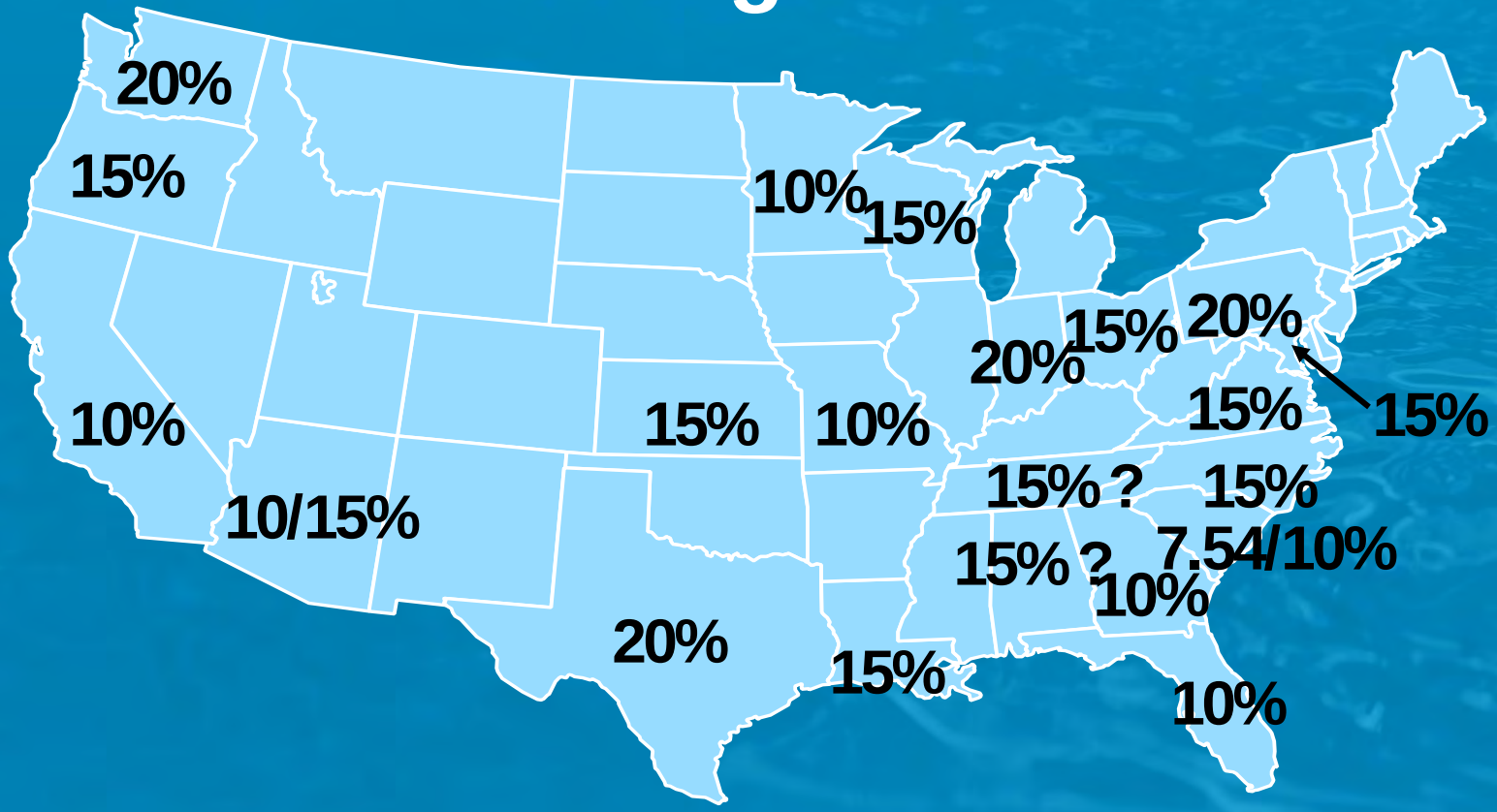
Inaccuracy

Theft

Past Water Loss: Unstructured and Reactive

- No consistent definitions for the various components of use or loss were employed
- Worldwide, no standard definition was found to exist for the term “unaccounted-for water”
- Percentage indicators were found to be suspect in measuring technical utility performance
- Percentage indicators translate nothing about water volumes lost and values of lost water
- Many water utilities had no active functions to assess or control losses (auditing)

AWWA "States Survey" Project (2001)
State Regulations



"A better system of accounting is needed to instill better accountability in drinking water utilities", AWWA Water Loss Control Committee (2003)

The Original Construct is Flawed

Adjusted Supply - [Adjusted Consumption + Fires + Flushing] = Lost Water

$$\frac{\text{Lost Water}}{\text{Adjusted Supply}} \quad 100\% = \text{“\% UAW”}$$

BUT……

- **Increasing consumption without reducing lost water volume reduces the “% UAW”**

- **“% UAW” does not directly recognize the $ value of the physical (real) and paper (apparent) losses**

Learn More About the Weaknesses of "Unaccounted-for Water"

Go to the AWWA website homepage at: www.awwa.org

In the search box in the upper right of the homepage type "unaccounted for water"

Click on the first entry in the list:
"Water Loss Control Terms Defined"

This goes to a webpage explaining in detail the problems with "unaccounted for water"

History: AWWA Water Audit Methodology

- Method published in 2000 by IWA Water Loss Task Force with AWWA participation
- All water goes to either consumption or loss - with definitions for all uses and water losses
- Designed to function for all units of measure
- Includes performance indicators for realistic assessments, benchmarking, and target-setting
- AWWA WLCC recommended IWA Water Balance and Performance Indicators in 2003

American Water Works Association

Journal

August 2003 Volume 95 Number 8

Top 10 trends
and market developments,
page 34

Financial Concerns

financial concerns

BY AWWA WATER LOSS CONTROL COMMITTEE

COMMITTEE REPORT:

Applying worldwide BMPs in water loss control

AWWA
August 2003

Water Loss Control Committee

Opflow Online

Volume 32, No. 5 May 2006

Unaccounted for No More

Water Audit Software Assesses Water Loss

By George Kunkel

Water utilities now have a standardized tool to determine water supply efficiency: a spreadsheet software package for compiling a basic audit of water supply operations, developed by AWWA's Water Loss Control Committee. The software is available to anyone for free download.

The software was developed to

- promote the best-practice water audit method developed by the International Water Association and AWWA,
- assess water supply efficiency in a standard, reliable manner, and
- give utilities a simple, user-friendly way to compile and compare their water audit data with other utilities.

The WLC Committee envisions that many utilities will find the software highly useful through defining their water loss standing and revealing the effects of losses on operations and revenue streams.

Water Audits are a Sound Business Practice

Metering and Accountability

The American Water Works Association (AWWA) recommends that every water utility accurately meter all water taken into its system and all water distributed from its system at its customers' point of service, read its meters at sufficiently frequent intervals to support its rate structures and provide accurate bills to its customers. **AWWA also recommends that utilities conduct regular water audits to ensure accountability.**

Customers reselling utility water such as apartment complexes, wholesalers, agencies, associations, or businesses should be guided by principles that encourage accurate metering, consumer protection, and financial equity.

Metering and water auditing provide an effective means of managing water system operations and essential data for system performance studies, facility planning, and the evaluation of conservation measures. Water audits evaluate the effectiveness of metering and meter reading systems, as well as billing, accounting, and loss control programs. Metering consumption of all water services provides a basis for assessing users equitably and encourages the efficient use of water.

An effective metering program relies upon the proper sizing, typing, and installation of meters and periodic performance testing, repair, maintenance, and ultimate replacement of all meters. **Accurate metering, water auditing and effective water loss control promote an equitable recovery of revenue based on level of service and wise use of available water resources.**

AWWA Water Loss Control Committee, 2010

Regulatory and Financial Drivers

- **Withdrawal Permitting**
  FL Water Management Districts
  - **GW Consumptive Use Authorization is subject to implementation of an approved Water Loss Control Program**

- **Best Management Practices (including Water Audits)**
  CA Urban Water Conservation Council
  GA Board of Natural Resources

- **Water Auditing Requirements**
  TX WDB, NC SWIC, PA PUC/DRBC, NM OSE/RWA, TN UMRB/WWFB

- **Project Funding**
  NC Agencies

- **Other**
  PSC/PUCs - Justify Meter Repair/Replacement Programs

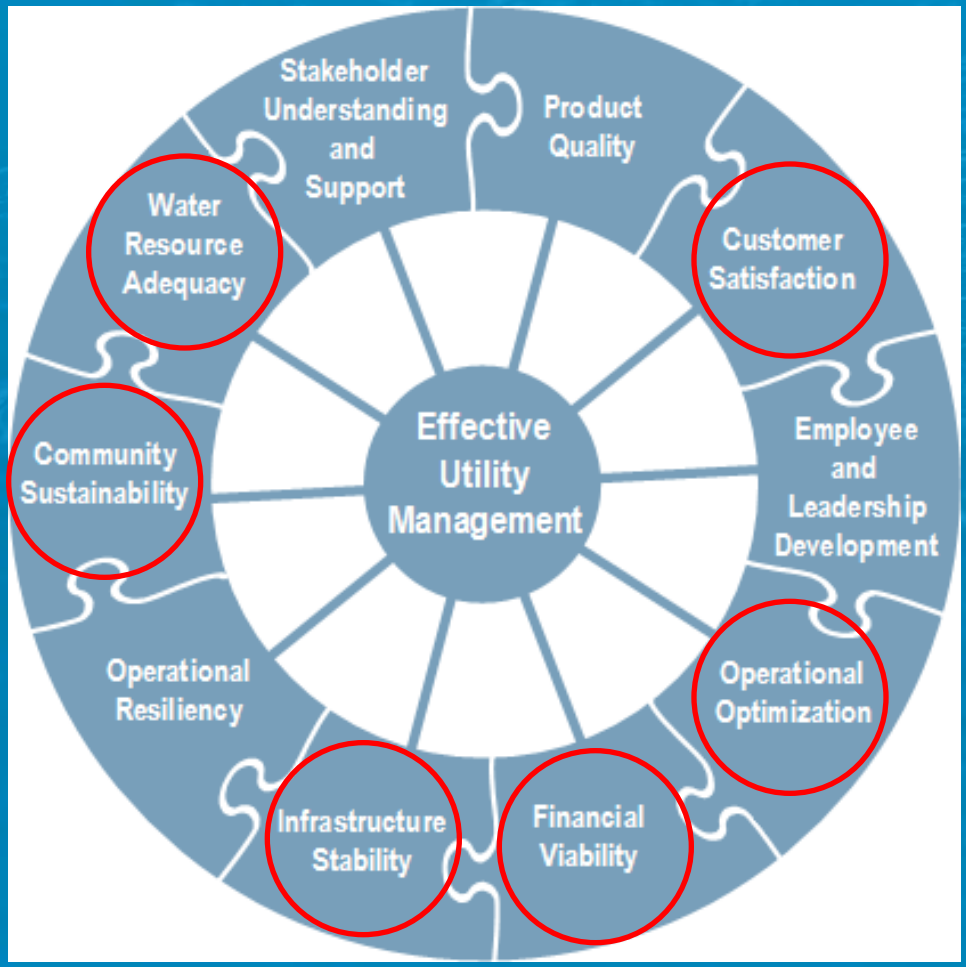
Sustainable Infrastructure: Federal Guidance

- **EPA's Four Pillars of Sustainable Infrastructure - EPA believes that the following practices will help utilities to operate more sustainably:**

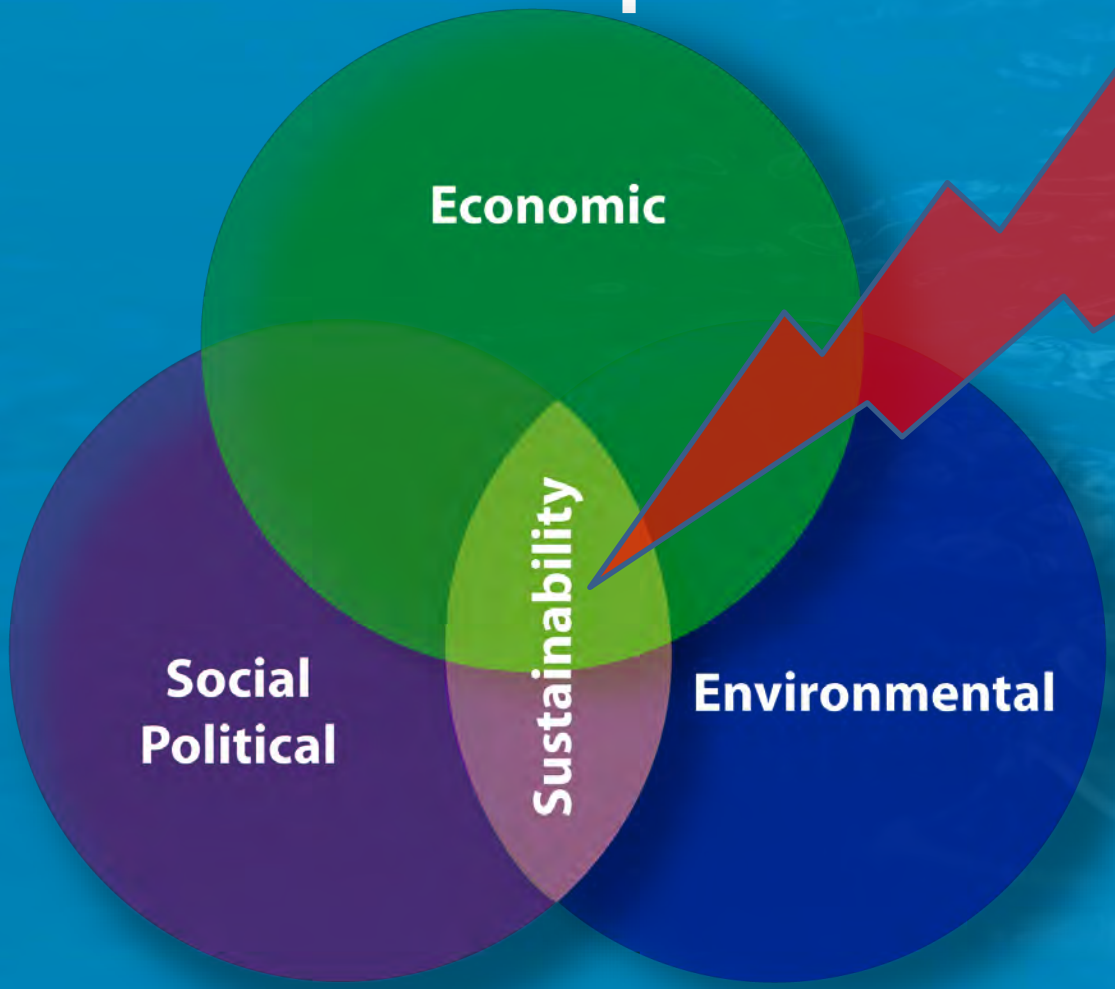
  - **Full Cost Pricing**
  - **Better Management**
  - **Efficient Water Use**
  - **Watershed Approaches**

10 Attributes of Effectively Managed Water Utilities

- Utilities use EUM attributes as a flexible framework to set goals and service levels, to monitor and measure progress, and to recognize success.
- NRW Management enhances all of these attributes, some directly
- EUM is a basis for AMWA's annual recognition program



NRW Management Enhances the "Triple Bottom Line"



Triple Bottom Line

NRW Management

Helps optimize economic, social, and environmental performance

"Providing an adequate and reliable water supply of desired quality - now and for future generations - in a manner that integrates economic growth, environmental protection and social development" (AWWA)

Lower NRW Helps Manage Operating Costs and Environmental Impacts

For a water treatment plant virtually all GHG emissions come from:

- **Electricity: 88%**

  Mainly pumping: raw water, high service, backwash, distribution system boosters

- **Fuels: 11.5%**

  Vehicles, space heating, and generators

Source: AWWARF,2007

Other Drivers

Physical Losses

Consider Raw Water Transmission, Plant Maintenance, and Treatment Process Water Use Efficiency when evaluating losses between sources and entry point to distribution system, e.g.,:

- **Metering of Process Use**
- **Backwash Water Recycling**
- **Membrane Process Reject Water**
- **Raw Water Storage Tanks**
- **Pumping equipment (seals)**
- **Pipe joints**

Other Drivers

Paper Losses

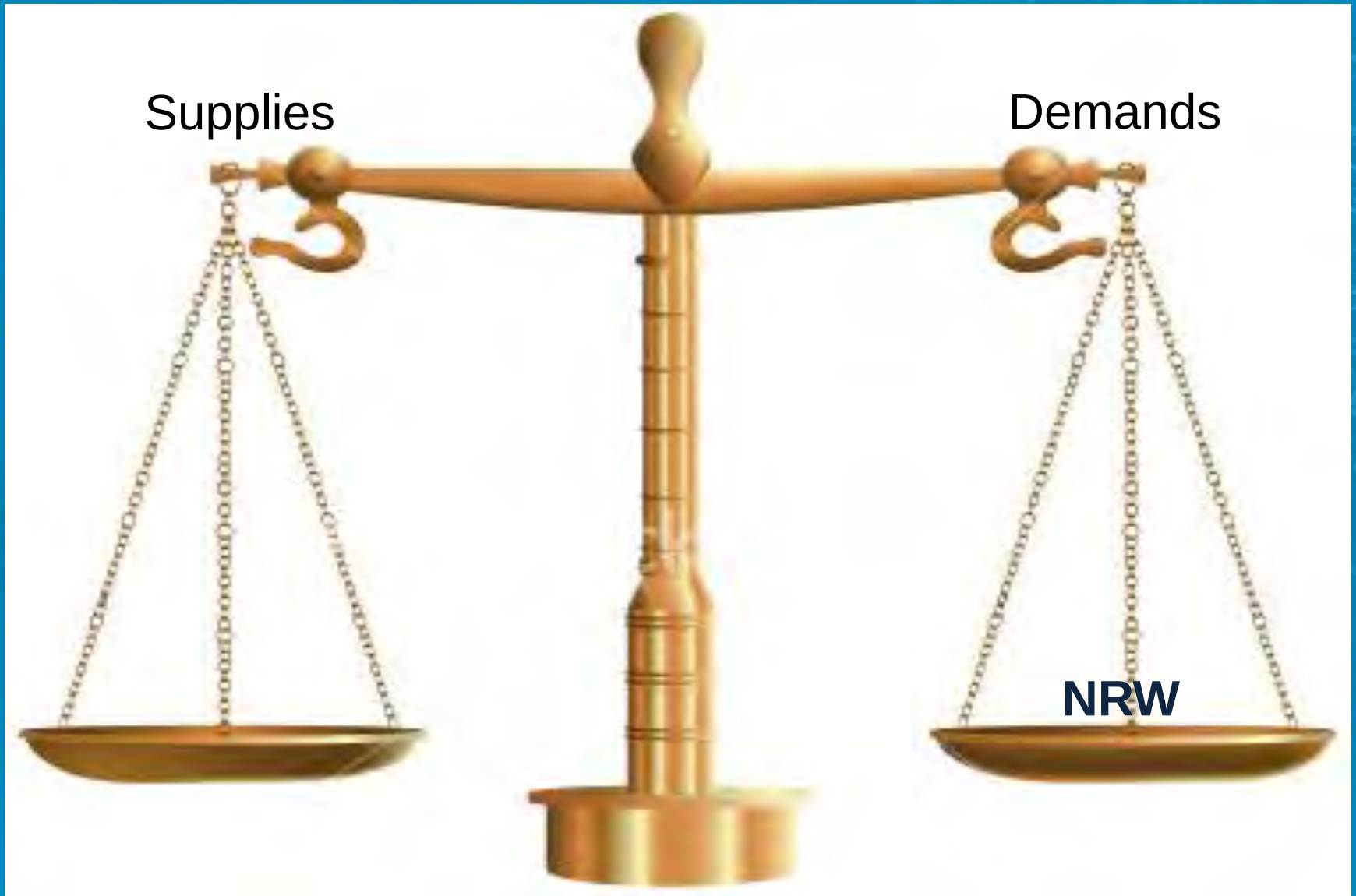
Consider Meter Reading and Billing System issues that complicate accurate accounting of water consumption and revenue collection:

- **Read-to-Bill Process Errors**
- **Billing System Adjustments ($ and Volume)**
- **Customer Account Protocols**
  - **New Accounts**
  - **Inactive Accounts**
  - **Changes to Accounts**

A *Water Audit* Defines the Problem

It Sets the *Context* for Responsible Action Consistent with Available Water, Staff, and Financial Resources

Water Balance and Context



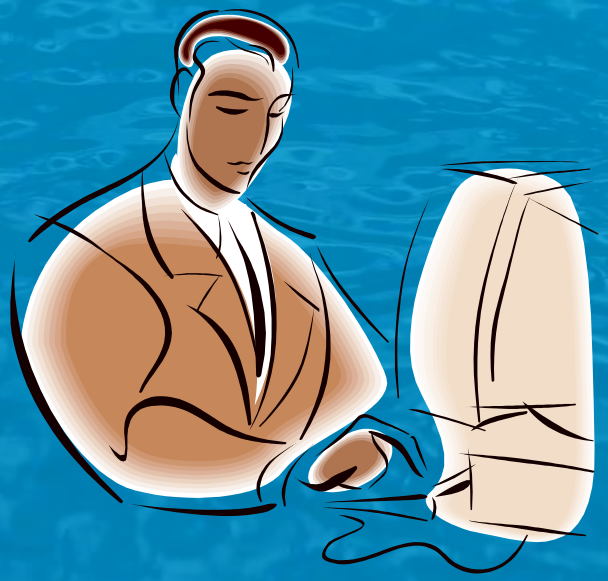
Conducting a Water Audit

"Top-down approach"
complemented by

Component analysis
and
"Bottom-up approach"

Top Down Audit

- Basic “desk top” exercise
- Use of current data
- Very little field work
- Preliminary/rough draft
- Water Balance
- Typically annual



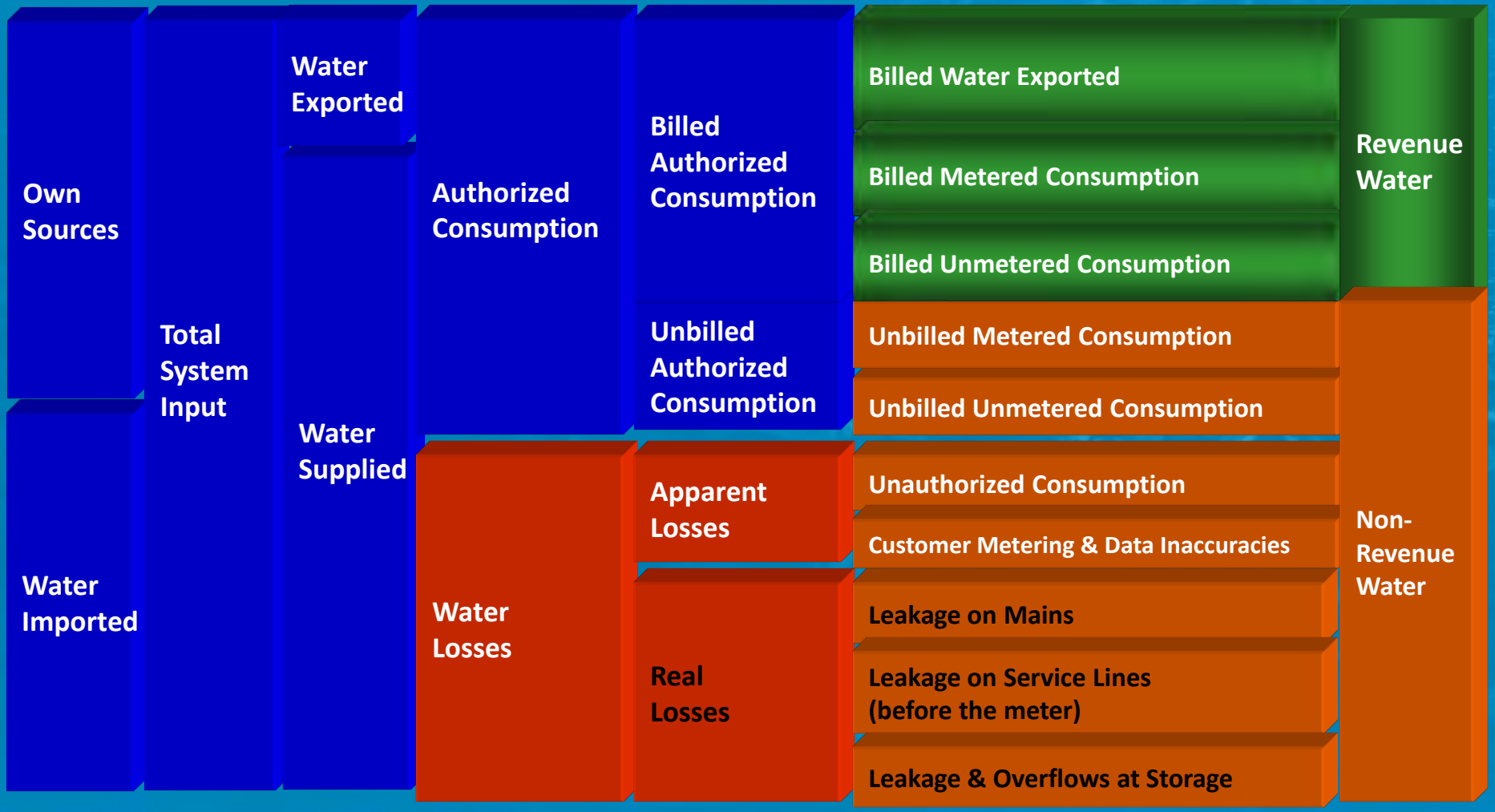
How Can the Top-Down Audit Help the Utility?

- Shows deficient areas within the utility
- Shows the need to implement the use of benchmarks or performance indicators
- Asks the question “Where in the system are we losing water (and/or revenue)?”
- Asks “How can we prevent the losses?”
- Determines value of lost water
- Can increase utility financial standing

Advantages of IWA/AWWA Methodology

- **Structured as standard international best practice methodology and terminology.**
- **Accounts for all water uses and calculates non-revenue water (NRW).**
- **Adopts a specific method for calculating unavoidable annual real losses (UARL).**
- **Incorporates losses per mile of main per psi.**
- **Water utilities worldwide can be compared on the basis of water loss performance indicators.**

What is Non-Revenue Water (NRW)?



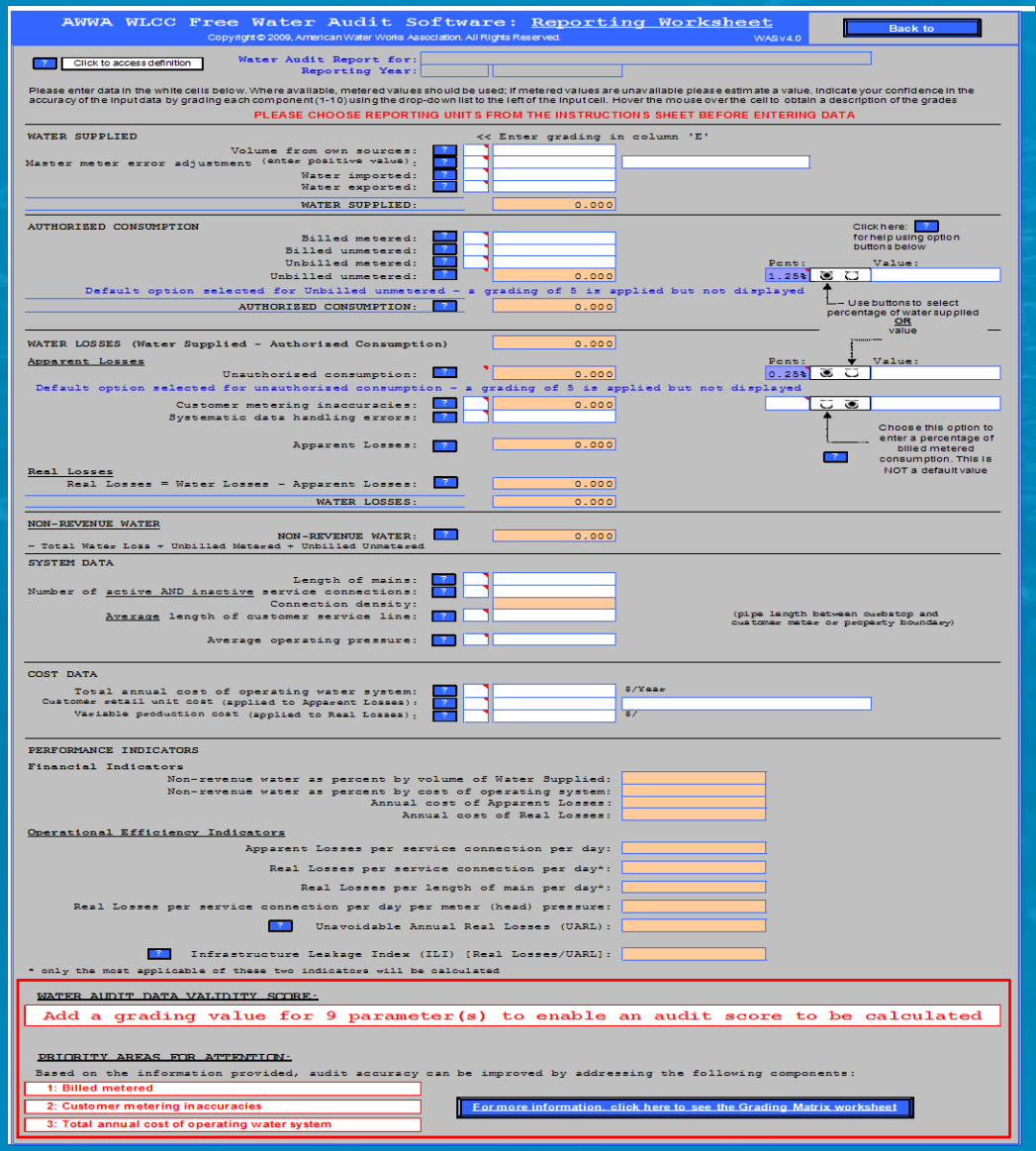
AWWA WLCC Water Audit Software

v 4.2 available **free** from AWWA at: **waterwiser.org** or **awwa.org**

Self-help features (data validity, BMP guidance)

Download Validated Data Sets and Report for Benchmarking, Audit Results Compiler)

"Top-Down Approach"



AWWA Water Loss Control Committee (WLCC) Free Water Audit Software v4.2

WAS v4.2

PURPOSE: 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 water audit format.

USE: The spreadsheet contains several separate worksheets. Sheets can be accessed using the tabs towards the bottom of the screen, or by clicking the buttons on the left below. Descriptions of each sheet are also given below.

THE FOLLOWING KEY APPLIES THROUGHOUT:

- Value can be entered by user
- Value calculated based on input data
- These cells contain recommended default values

Please begin by providing the following information, then proceed through each sheet in the workbook:

NAME OF CITY OR UTILITY: COUNTRY:

REPORTING YEAR: START DATE(MM/YYYY): END DATE(MM/YYYY):

NAME OF CONTACT PERSON: E-MAIL: TELEPHONE: Ext.

PLEASE SELECT PREFERRED REPORTING UNITS FOR WATER VOLUME:

Click to advance to sheet… Click here: ? for help about units and conversions

Instructions	The current sheet
Reporting Worksheet	Enter the required data on this worksheet to calculate the water balance
Water Balance	The values entered in the Reporting Worksheet are used to populate the water balance
Grading Matrix	Depending on the confidence of audit inputs, a grading is assigned to the audit score
Service Connections	Diagrams depicting possible customer service connection configurations
Definitions	Use this sheet to understand terms used in the audit process
Loss Control Planning	Use this sheet to interpret the results of the audit validity score and performance indicators

Comments:

Add comments here to track additional supporting information, sources or names of participants

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

Definitions

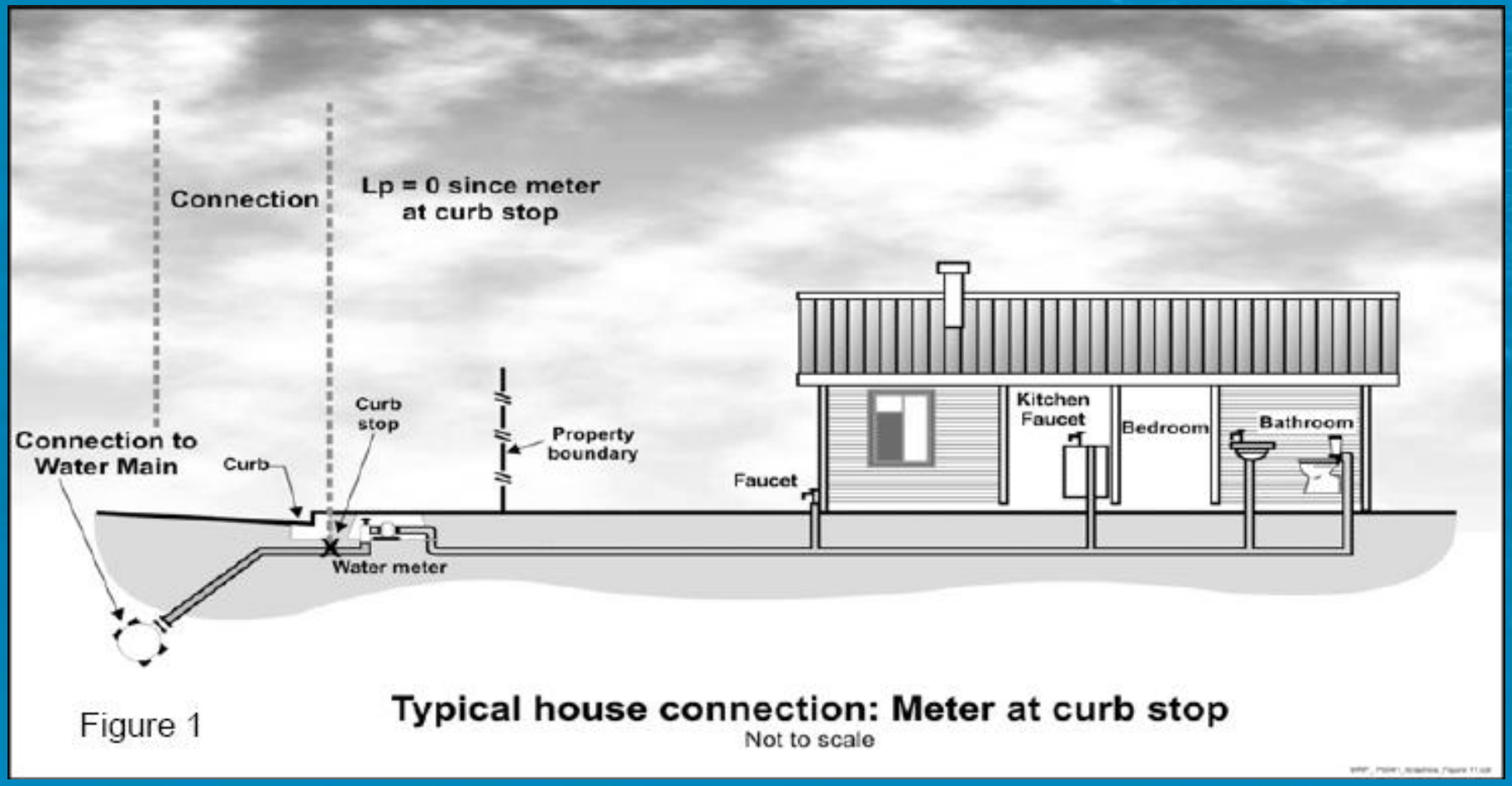
AWWA WLCC Free Water Audit Software: Definitions

WAS v4.2

Back to Instructions

Item Name		Description
Apparent Losses	Find	= unauthorized consumption + meter under-registration + data handling errors Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus unauthorized consumption (theft or illegal
AUTHORIZED CONSUMPTION	Find	= billed metered + billed unmetered + unbilled metered + unbilled unmetered The volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water suppli

Customer Service Line Diagram
Meter at Curb Stop



Water Audit Data Validity Score

- Grades assigned to each data component to describe confidence and accuracy of input data

- Audit accuracy often improved most by improving accuracy of:
    - Volume from own sources
    - Water imported
    - Billed metered consumption

Confidence in Water Supplied Data

For optimum confidence and accuracy:

- **Meter 100% of production and imported sources**
- **Conduct semi-annual accuracy testing and calibration**
- **Have less than 10% of source meters outside of +/-3% accuracy**

Confidence in Consumption Data

For optimum confidence and accuracy:

- **Maintain 95% meter reading success rate, or launch AMR trials**
- **Implement large scale customer meter testing and replacement program**
- **Use computerized billing with routine auditing**
- **Conduct annual third party audit verification**

Customer Metering Inaccuracies

- **No longer a default value in Version 4.2-**

  Need to determine based on meter data

- **Consider cumulative volume, meter size, and meter type for optimum accuracy**

Water Audit Data Validity Level/Score

- Level I (0-25)
- Level II (26-50)
- Level III (51-70)
- Level IV (71-90)
- Level V (91-100)

Characterizing Data Validity

AWWA WLCC Free Water Audit Software: Grading Matrix

WASv 4.0

Back to Instructions

In the Reporting Worksheet, grades were assigned to each component of the audit to describe the confidence and accuracy of the input data. The grading assigned to each audit component and the corresponding recommended improvements and actions are highlighted in yellow. Audit accuracy is likely to be improved by prioritizing those items shown in red

Grading

	n/a	1	2	3	4	5	6	7	8	9	10
Volume from own sources:	Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)	Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of water production sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of water production sources are metered, other sources estimated. Occasional meter accuracy testing	Conditions between 4 and 6	At least 75% of 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 conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of water supply sources are metered, meter accuracy testing and electronic calibration conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of water production sources are metered, meter accuracy testing and electronic calibration conducted semi-annually, with less than 10% found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Volume from own Sources" component:		to qualify for 2: Organize efforts to begin to collect data for determining volume from own sources	to qualify for 4: Locate all water production sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered water production sources and replace any obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all source meters. Complete installation of meters on unmetered water production sources and complete replacement of all obsolete/defective meters.		to qualify for 8: Conduct annual meter accuracy testing on all meters. Complete project to install new, or replace defective existing, meters so that entire production meter population is metered. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing for all meters. Repair or replace meters outside of +/- 6% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.
Master meter error adjustment:	Select n/a only if the water utility fails to have meters on its sources of supply, either its own source, and/or imported (purchased) water sources	Inventory information on meters and paper records of measured volumes in crude condition; data error cannot be determined	No automatic datalogging of production volumes; daily readings are scribed on paper records. Tank/storage elevation changes are not employed in calculating "Volume from own sources" component. Data is adjusted only when grossly evident data error occurs.	Conditions between 2 and 4	Production meter data is logged automatically in electronic format and reviewed at least on a monthly basis. "Volume from own sources" tabulations include estimate of daily changes in tanks/storage facilities. Meter data is adjusted when gross data errors occur, or occasional meter testing deems this necessary.	Conditions between 4 and 6	Hourly production meter data logged automatically & reviewed on at least a weekly basis. Data adjusted to correct gross error from equipment malfunction and error confirmed by meter accuracy testing. Tank/storage facility elevation changes are automatically used in calculating a balanced "Volume from own sources" component.	Conditions between 6 and 8	Continuous production meter data logged automatically & reviewed daily. Data adjusted to correct gross error from equipment malfunction & results of meter accuracy testing. Tank/storage facility elevation changes are automatically used in "Volume from own sources" tabulations.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically balances flows from all sources and storages; results reviewed daily. Mass balance technique compares production meter data to raw (untreated) water and treatment volumes to detect anomalies. Regular calibrations between SCADA and sources meters ensures minimal data transfer error.
Improvements to attain higher data grading for "Master meter error adjustment" component:		to qualify for 2: Develop plan to restructure recordkeeping system to capture all flow data; set procedure to review data daily to detect input errors	to qualify for 4: Install automatic datalogging equipment on production meters. Identify tanks/storage facilities and include estimated daily volume of water added to, or subtracted from, "Water Supplied" volume based upon changes in storage		to qualify for 6: Review hourly production meter data for gross error on, at least, a weekly basis. Begin to install instrumentation on tanks/storage facilities to record elevation changes. Use daily net storage change to balance flows in calculating "Water Supplied" volume.		to qualify for 8: Complete installation of elevation instrumentation on all tanks/storage facilities. Continue to use daily net storage change in calculating balanced "Volume from own sources" component. Adjust production meter data for gross error and inaccuracy confirmed by testing.		to qualify for 10: Link all production and tank/storage facility elevation change data to a Supervisory Control & Data Acquisition (SCADA) System, or similar computerized monitoring/control system, and establish automatic flow balancing algorithm and regularly calibrate between SCADA and source meters.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flow meters. Continue to replace or repair meters as they perform outside of desired accuracy limits.
Water Imported:	Select n/a if the water utility's supply is exclusively from its own water resources (no bulk purchased/ imported water)	Less than 25% of imported water sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of imported water sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of imported water sources are metered, other sources estimated. Occasional meter accuracy testing	Conditions between 4 and 6	At least 75% of imported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of imported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of imported water sources are metered, meter accuracy testing and/or electronic calibration conducted semi-annually, with less than 10% found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Water Imported Volume" component:		to qualify for 2: Review bulk water purchase agreements with partner suppliers; confirm requirements for use and maintenance of accurate metering. Identify needs for new or replacement meters with goal to meter all imported water sources.	To qualify for 4: Locate all imported water sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered imported water interconnections and replace obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all imported water meters. Continue installation of meters on unmetered exported water interconnections and replacement of obsolete/defective meters.		to qualify for 8: Complete project to install new, or replace defective, meters on all imported water interconnections. Maintain annual meter accuracy testing for all imported water meters. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing for all meters. Repair or replace meters outside of +/- 6% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.

AWWA WLCC Free Water Audit Software: Grading M

In the Reporting Worksheet, grades were assigned to each component of the audit to describe the confiden component and the corresponding recommended improvements and actions are highlighted in yellow. Audit accu

Grading

	n/a	1	2	3	4	5	
Volume from own sources:	Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)	Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of water production sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of water production sources are metered, other sources estimated. Occasional meter accuracy testing	Conditions between 4 and 6	p mete sou m a elect ann teste
Improvements to attain higher data grading for "Volume from own Sources" component:		to qualify for 2: Organize efforts to begin to collect data for determining volume from own sources	to qualify for 4: Locate all water production sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered water production sources and replace any obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all source meters. Complete installation of meters on unmetered water production sources and complete replacement of all obsolete/defective meters.		Con all n or re e met
Master meter error adjustment:	Select n/a only if the water utility fails to have meters on its sources of supply, either its own source, and/or imported	Inventory information on meters and paper records of measured volumes in crude condition; data error cannot be determined	No automatic datalogging of production volumes; daily readings are scribed on paper records. Tank/storage elevation changes are not employed in calculating "Volume from own sources" component. Data is adjusted only when	Conditions between 2 and 4	Production meter data is logged automatically in electronic format and reviewed at least on a monthly basis. "Volume from own sources" tabulations include estimate of daily changes in tanks/storage facilities. Meter data is adjusted	Conditions between 4 and 6	Hou revi basis gro malfu by Tan chan

Validation of Data

- **Top-down audit is considered preliminary**
- **Grading system assists in data validation**
- **Validation will question or confirm preliminary water audit data**
- **Assessment of results determines areas of focus**

Successful water loss management requires valid data!

Performance Indicators

- **Included in AWWA Free Water Audit Software**
- **Categories:**
  - **Financial**
  - **Operational**
  - **Apparent Losses Normalized**
  - **Real Losses Normalized**
  - **Infrastructure Leakage Index (ILI)**

Operational Performance Indicators

Level 1 (Basic) Operational PI (Op24*)=
Real Distribution Losses in Gallons per Service Line per Day

Level 2 (Intermediate) Operational PI (Op24*) =
Real Distribution Losses in Gallons per Service Line per Day per PSI of Operating Pressure

Level 3 (Detailed) Operational PI (Op25*) =

$$\frac{\text{Annual Real Losses}}{\text{Unavoidable Annual Real Losses (UARL)}} = \text{Infrastructure Leakage Index (ILI)}$$

Also see Table 2-19, AWWA M36. ** from IWA, 2000.*

Infrastructure Leakage Index (ILI) Performance Indicator

General Guidelines for Target ILI (w/o Full Economic Analysis of Leakage Control Options)			
Target ILI Range	Financial	Operational	Water Resources
1.0 – 3.0	**Sources costly to develop and ability to raise rates is limited**	**Higher ILI requires infrastructure expansion or add'l water resources**	**Available water resources are limited and difficult to obtain**
>3.0 – 5.0	Sources available at reasonable expense and rate increases are tolerable	Existing infrastructure adequate to meet long-term needs with leakage management controls in place	Water resources sufficient for long-term needs, but demand management interventions are included in long-term planning
>5.0 – 8.0	Inexpensive source development and low water rates	Superior infrastructure reliability, capacity and integrity, immune from water supply shortages	Water resources are plentiful, reliable and easily extracted.
>8.0	Operational and financial considerations may allow ILI >8.0, but not an effective utilization of water resources. Other than as an incremental achievement, ILI >8.0 is discouraged.		
<1.0	World class utility or world class validity problem? Latter is likely if extensive leakage control is not practiced; conduct field measurements to verify data.		

ILI = 1.38 (Example)

Adapted from AWWA WLCC, Water Audit Software v4.2, 2010

Performance Indicators

Function	Level*	Code*	Performance Indicator	Comments
Financial: Non-revenue water by volume	1 Basic	Fi36	Volume of Non-revenue water as % of System Input Volume	Easily calculated from the water balance, has limited value in high-level, financial terms only; i is misleading to use this as a measure of operational efficiency
Financial: Non-revenue water by cost	3 Detailed	Fi37	Value of Non-revenue water [% of annual cost of running the system]	Incorporates different unit costs for Non-revenue components, good financial indicator
Operational: Apparent Losses	1 Basic	Op23	[gallons/service connection/day]	Basic but meaningful PI for apparent losses. Easy to calculate once apparent losses are quantified
Operational: Real Losses	1 Basic	Op24	[gallons/service connection/day] or [gallons/mile of mains/day] (only if service connection density is less than 32/mile)	Best of the simple "traditional" performance indicators, useful for target setting, limited use for comparisons between systems
Operational: Real Losses	2 Intermediate		[gallons/service connection/day/psi of pressure] or [gallons/mile of mains/day/psi of pressure] (only if service connection density is < 32/mile)	Easy to calculate this indicator if the ILI is not yet known, useful for comparisons between systems
Operational: Unavoidable Annual Real Losses	3 Detailed	UARL	UARL (gallons) = (5.41Lm + 0.15Nc + 7.5Lc) x P, where Lm = length of water mains, miles Nc = number of service connections Lc = total length of private service connection pipe, miles = Nc x average distance from curbstop to customer meter, Lp P = average pressure in the system, psi	A theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. A key variable in the calculation of the Infrastructure Leakage Index (ILI). The UARL calculation is not valid for systems with less than 3,000 service connections.
Operational: Real Losses	3 Detailed	Op25	Infrastructure Leakage Index (ILI) (dimensionless) = CARL/UARL	Ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL); best indicator for comparisons between systems

Ref. Table 2-19 AWWA M36, 3rd edition, 2009

AWWA WLCC Free Water Audit Software: Reporting Worksheet

WAS v4.0

Back to Instructions

? Click to access definition

Water Audit Report for: Utility A

Reporting Year: 2007 7/2006 - 6/2007

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 (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: ACRE-FEET PER YEAR

WATER SUPPLIED

<< Enter grading in column 'E'

Volume from own sources:	?	8	21,792.000		acre-ft/yr
Master meter error adjustment (enter positive value):	?	3	600.000	under-registered	acre-ft/yr
Water imported:	?	9	11,533.000		acre-ft/yr
Water exported:	?	n/a			acre-ft/yr
WATER SUPPLIED:			33,925.000		acre-ft/yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

Billed metered:	?	9	31,644.000		acre-ft/yr
Billed unmetered:	?	n/a			acre-ft/yr
Unbilled metered:	?	8	52.000		acre-ft/yr
Unbilled unmetered:	?		424.063		acre-ft/yr

Pcnt: 1.25% Value:

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

AUTHORIZED CONSUMPTION:	?		32,120.063		acre-ft/yr

Use buttons to select percentage of water supplied OR value

WATER LOSSES (Water Supplied - Authorized Consumption)

1,804.938 acre-ft/yr

Apparent Losses

Pcnt: 0.25% Value:

Unauthorized consumption:	?		84.813		acre-ft/yr

Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

Pcnt: 2.00% Value:

Customer metering inaccuracies:	?	5	646.857		acre-ft/yr
Systematic data handling errors:	?	5			acre-ft/yr

Systematic data handling errors are likely, please enter a non-zero value; otherwise grade = 5

Apparent Losses:	?		731.670		

? Choose this option to enter a percentage of billed metered consumption. This is NOT a default value

Real Losses

Real Losses = Water Losses - Apparent Losses:	?		1,073.268		acre-ft/yr
WATER LOSSES:			1,804.938		acre-ft/yr

NON-REVENUE WATER

NON-REVENUE WATER:	?		2,281.000		acre-ft/yr

SYSTEM DATA

Length of mains:	?	9	590.0	miles
Number of active AND inactive service connections:	?	4	52,300	
Connection density:			89	conn./mile main
Average length of customer service line:	?	10	0.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	8	63.0	psi

COST DATA

Total annual cost of operating water system:	?	4	$29,000,000	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	8	$1.39	$/100 cubic feet (ccf)
Variable production cost (applied to Real Losses):	?	8	$358.00	$/acre-ft/yr

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume of Water Supplied:	6.7%
Non-revenue water as percent by cost of operating system:	3.4%
Annual cost of Apparent Losses:	$443,014
Annual cost of Real Losses:	$384,230

Operational Efficiency Indicators

Apparent Losses per service connection per day:	12.49	gallons/connection/day
Real Losses per service connection per day*:	18.32	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	0.29	gallons/connection/day/psi
? Unavoidable Annual Real Losses (UARL):	253.79	million gallons/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	1.38	

* only the most applicable of these two indicators will be calculated

WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 69 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: Master meter error adjustment

2: Volume from own sources

3: Total annual cost of operating water system

For more information, click here to see the Grading Matrix worksheet

Water Balance (Software Output)

AWWA WLCC Free Water Audit Software: Water Balance

WAS v4.0

Water Audit Report For:	Report Yr:

Own Sources (Adjusted for known errors) 0.000	Water Exported 0.000	Billed Water Exported			
	Water Supplied 0.000	Authorized Consumption 0.000	Billed Authorized Consumption 0.000	Billed Metered Consumption (inc. water exported) 0.000	Revenue Water 0.000
				Billed Unmetered Consumption 0.000	
			Unbilled Authorized Consumption 0.000	Unbilled Metered Consumption 0.000	Non-Revenue Water (NRW) 0.000
				Unbilled Unmetered Consumption 0.000	
		Water Losses 0.000	Apparent Losses 0.000	Unauthorized Consumption 0.000	
				Customer Metering Inaccuracies 0.000	
				Systematic Data Handling Errors 0.000	
Water Imported 0.000			Real Losses 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	

Water Loss Control Planning Guide

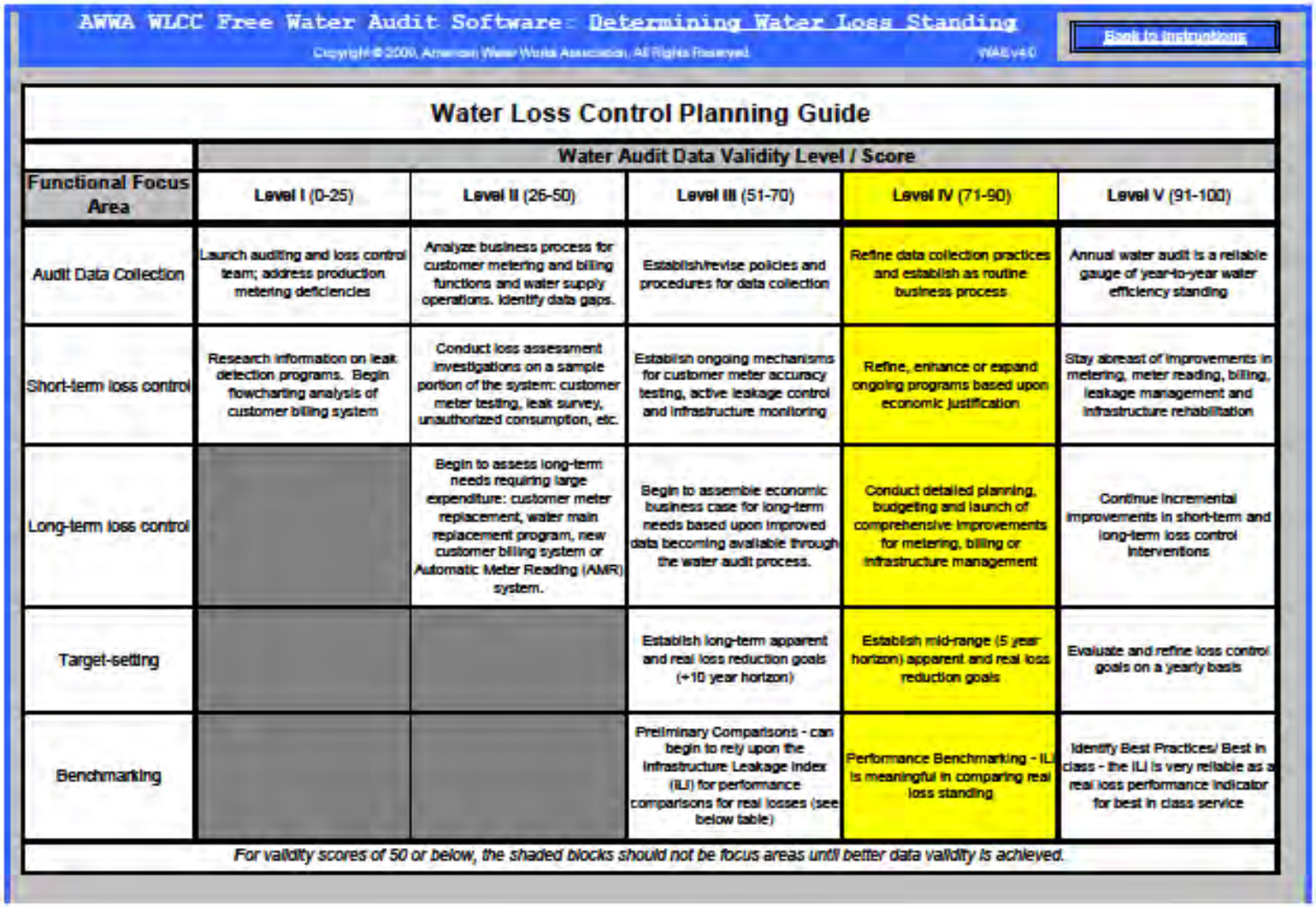
Water Audit Data Validity Level/Score (IV / 73)*

ID Functional Focus Area(s) for Enhancement

- **Audit Data Collection**
- **Short-term Loss Control**
- **Long-term Loss Control**
- **Target-setting**
- **Benchmarking**

*** Weighted hypothetical result of user consensus for Grading Matrix category scores (100-point scale)**

BMPs for Improving Data Validity and Water Loss Control



AWWA WLCC Free Water Audit Software: Determining Water Loss Standing

WAEv4.0

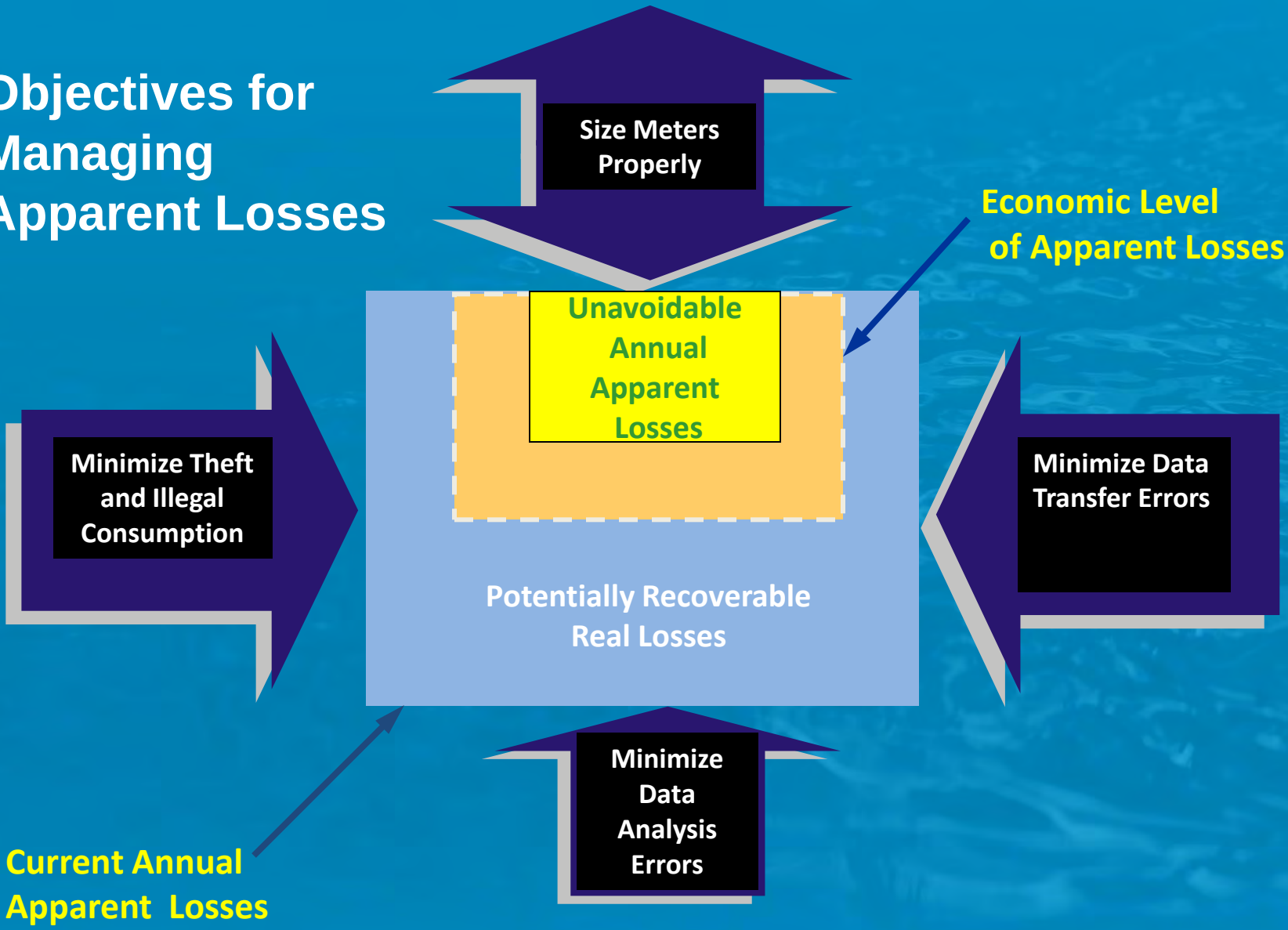
Back to Instructions

Water Loss Control Planning Guide

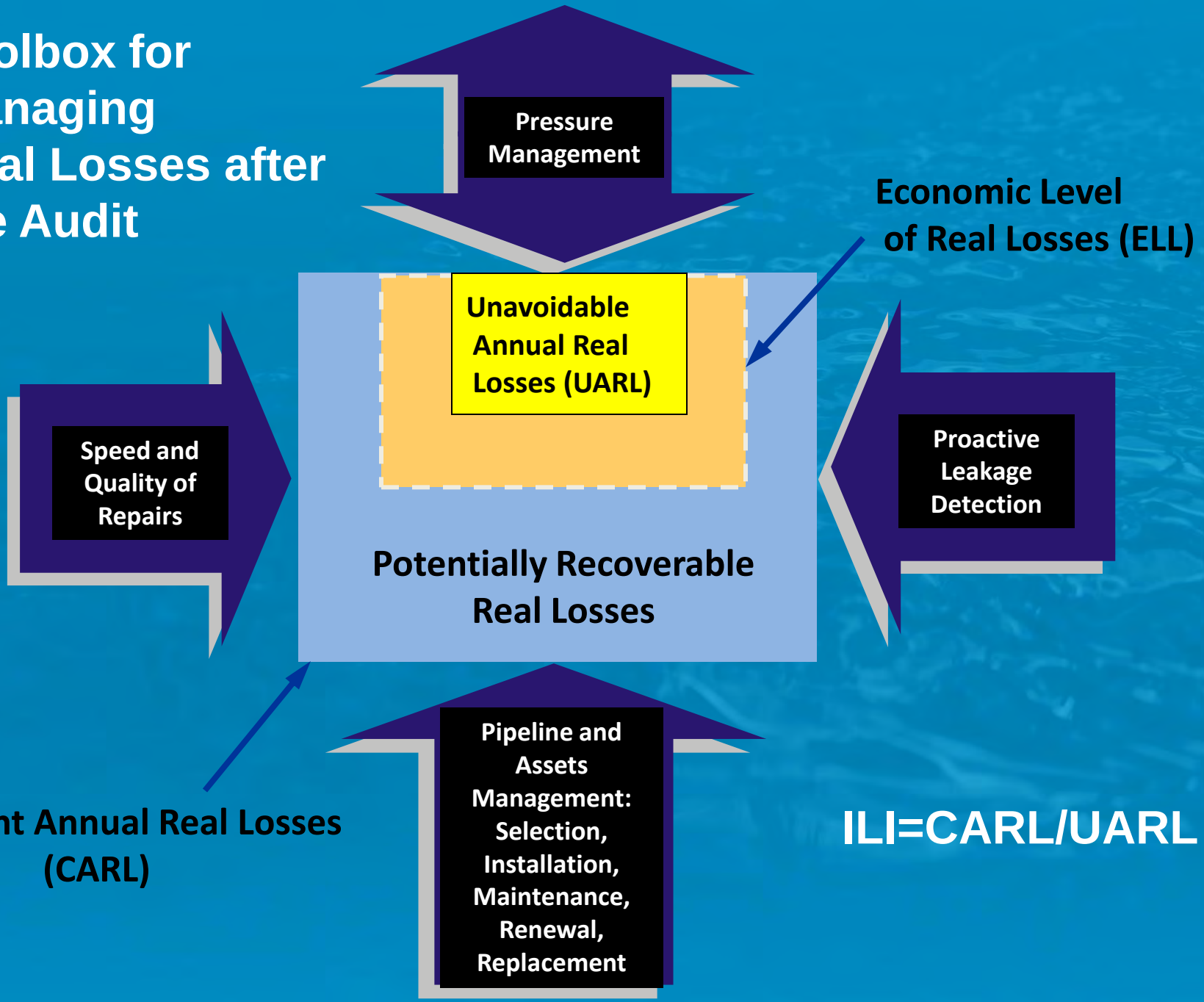
Functional Focus Area	Water Audit Data Validity Level / Score				
	Level I (0-25)	**Level II** (26-50)	**Level III** (51-70)	**Level IV** (71-90)	**Level V** (91-100)
Audit Data Collection	Launch auditing and loss control team; address production metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs. Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)	Performance Benchmarking - ILI is meaningful in comparing real loss standing	Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.

Objectives for Managing Apparent Losses



Toolbox for Managing Real Losses after the Audit



Determining Economic Levels of Losses

- Requires Benefit Cost analysis for potential water loss reduction activities
- Considers site-specific Water Resource, Financial, and Operational conditions
- Compares value of losses to annual O&M costs

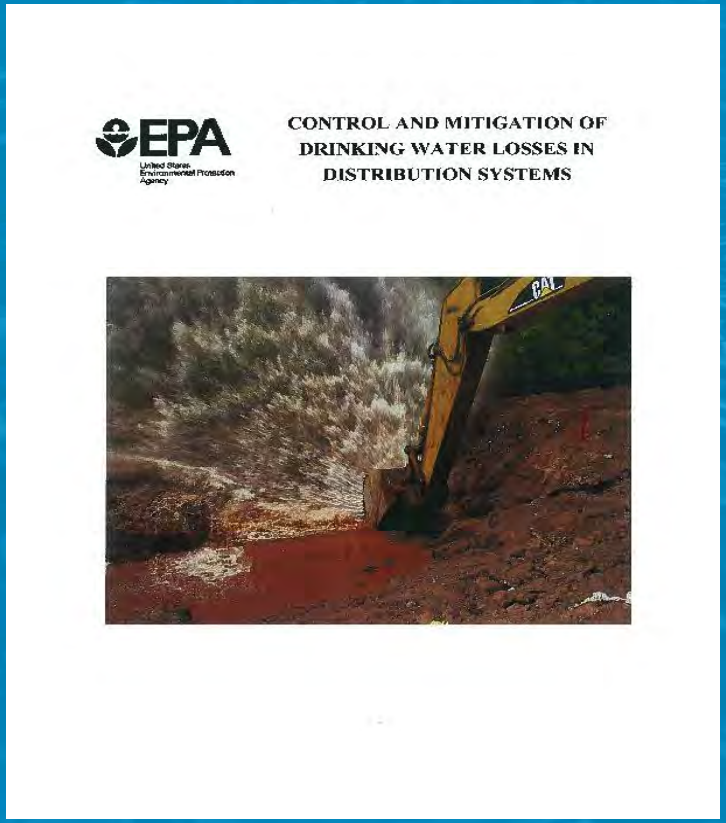
“It’s all about the gallons and what they are worth!”

NRW Management in the Water Supply Portfolio

References

USEPA

Control and Mitigation of Drinking Water Losses in Distribution Systems



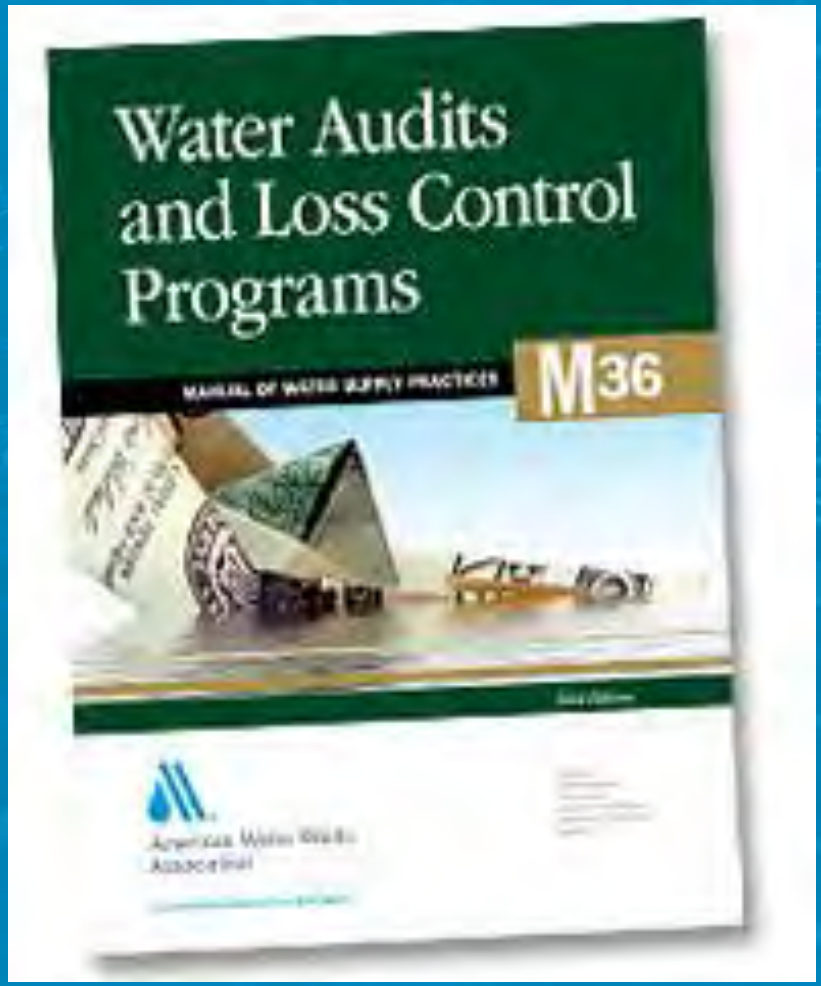
Office of Water (4606M)
EPA 816-R-10-019
water.epa.gov/drink
November 2010

References

AWWA M36

Water Audits and Loss Control Programs

Third Edition - 2009



Additional NRW Guidance

- AWWA M6 (Meters and Meter Testing)
- AWWA M22 (Sizing Service Lines)
- WLCC Outreach (Section Meetings)
- AWWA Section Programs on Water Use Efficiency
- Alliance for Water Efficiency (www.a4we.org)
- AWWA Opflow
- AWWA Water:\STATS Database (2002)
- TX Water Development Board
  - Water Loss Audit Manual for Texas Utilities
- Other Texts
  - Water Loss Control Manual (Thornton)
  - Water Loss Control, 2nd Ed. (Thornton, Sturm, Kunkel)

Parting Words

"Measurement is the first step that leads to control and eventually to improvement.

If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it.“

- H. James Harrington


Water Auditing
Just Do It!!!
Gary.Trachtman@arcadis-us.com

Segment 3:

a small system case study in water loss control and revenue recovery

CAVANAUGH

Stewardship Through Innovation

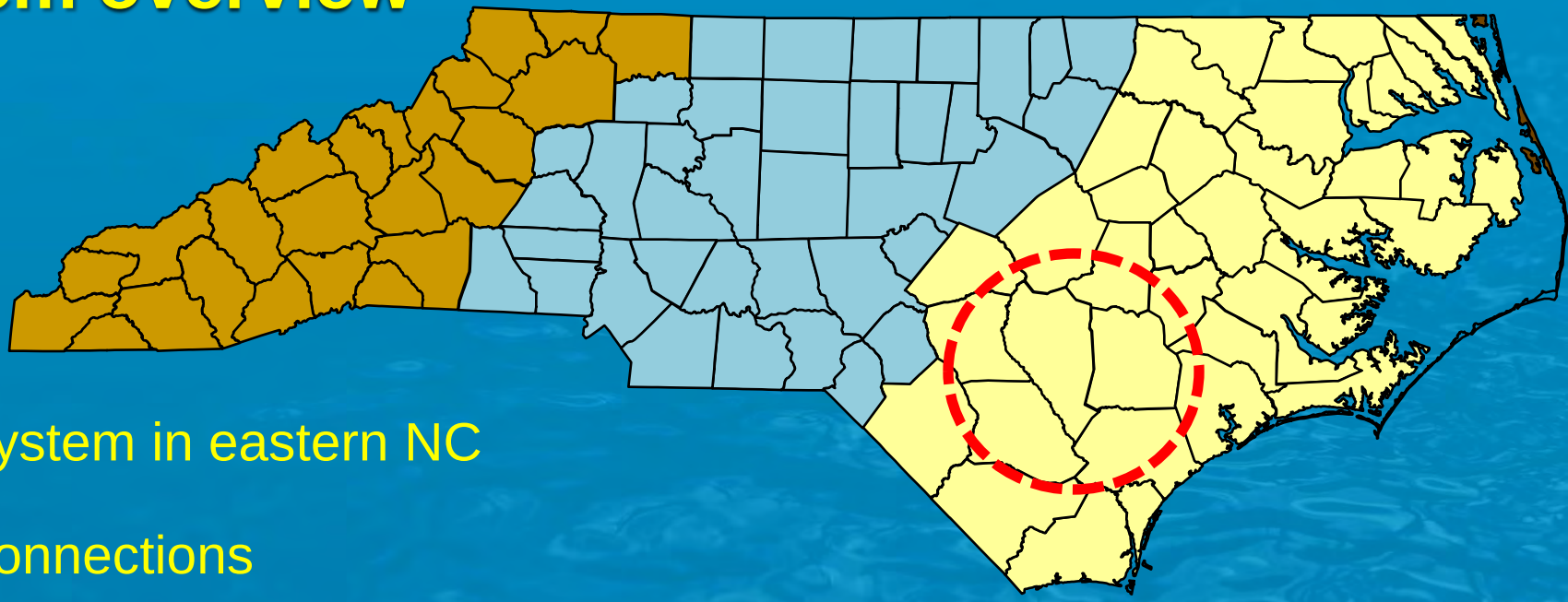
Segment Agenda

The compelling story of a small system in the Southeast U.S.

How to get started

How to sustain

System overview



Small system in eastern NC

5,000 connections

Mostly residential, some bulk/commercial/industrial

50 miles of pipe

Annual revenue – water & sewer = $ 4.5 M

Water Audit – Top Down

WATER SYSTEM KEY PERFORMANCE INDICATORS
Benchmark Year FY 10

System Input Volume	611.46 MG / year	Data Confidence: (out of 100)	60

Operational Efficiency Indicators			% of System Input Volume
Non-Revenue Water	146.72 MG / year		24.0%
Water Loss	131.91 MG / year		21.6%
Apparent Loss	20.89 MG / year	3.4%	
Real Loss	111.02 MG / year	18.2%	
Unbilled Consumption	14.81 MG / year		2.4%
Unavoidable Annual Real Loss (UARL)	17.71 MG / year		2.9%
Infrastructure Leakage Index (ILI) :	6.27 [Real Loss/UARL]		

Water Supplied 610 MG (1.7 mgd)

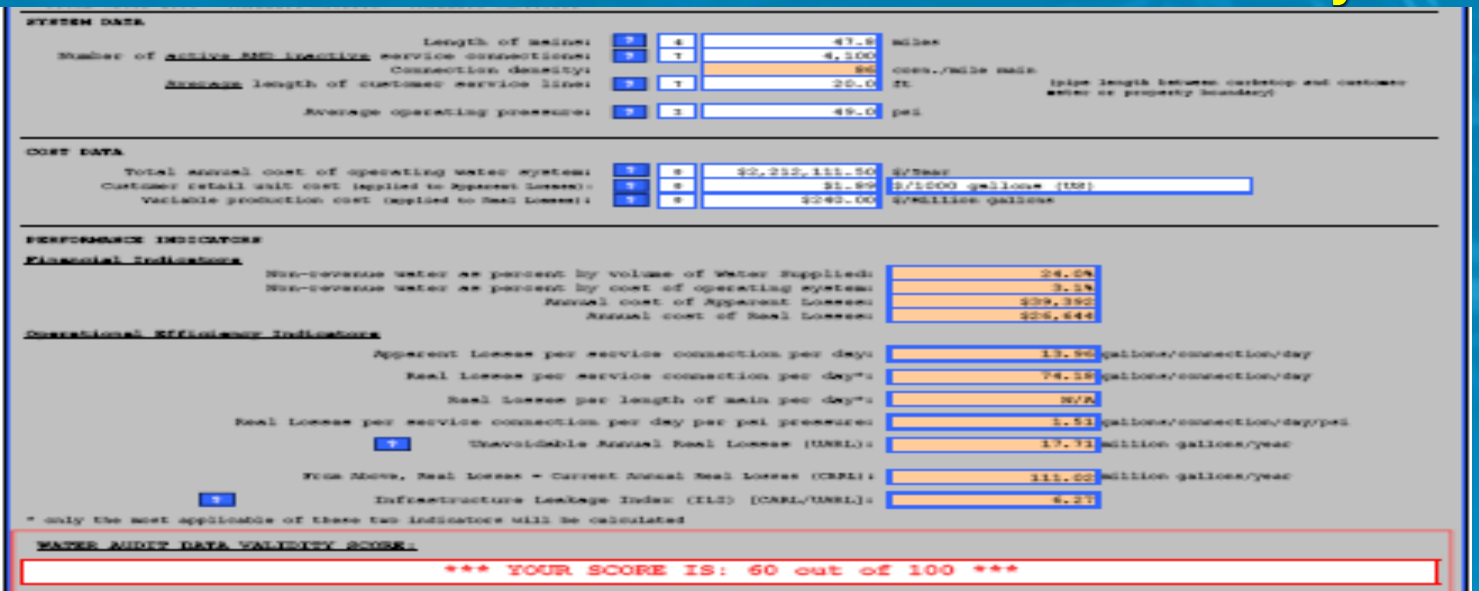
NRW 150 MG (24%)

Water Loss 130 MG (22%)

Real – 85% of Water Loss

Apparent – 15% of Water Loss

Data Validity Score - 60



Water Efficiency Program

Monthly team meetings & KPI tracking

Detailed monthly review of billing codes and high revenue accounts

Large meter testing and repair

Select meter right-sizing

Pilot active leak detection survey & repair

Results

What was found….

Large meters under-registering

Large meters improperly coded for billing units

Stopped meters that had fallen off the exceptions-report

Turbine meters in incorrect applications

Substantial leaks identified and located in pilot leak survey

Results

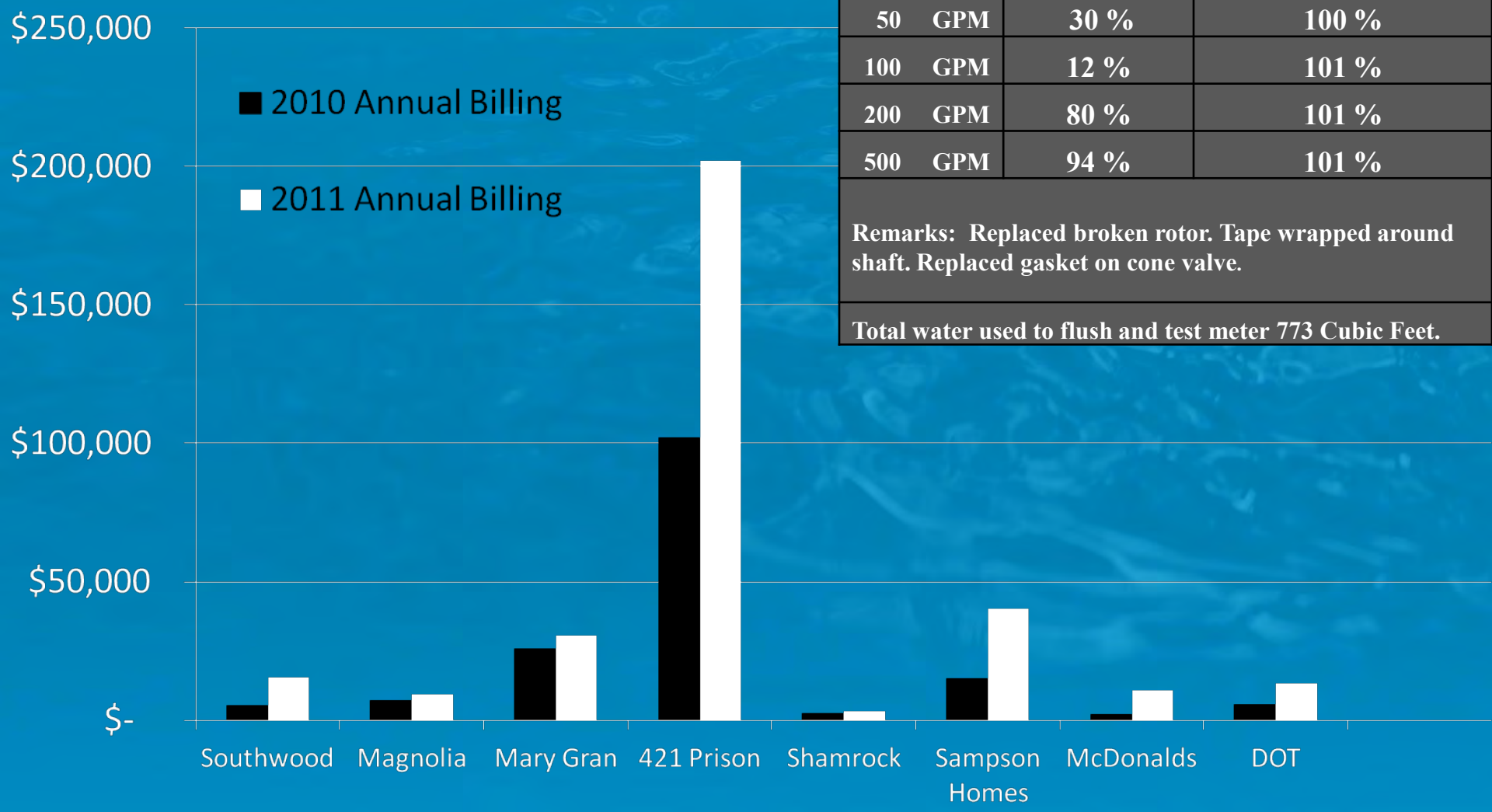
From meter testing and repair

Reading before test	Reading after test
A -022545	A -022618
B -73871000	B -73871700

	As Found	As Left
5 GPM	50 %	100 %
25 GPM	54 %	98 %
50 GPM	30 %	100 %
100 GPM	12 %	101 %
200 GPM	80 %	101 %
500 GPM	94 %	101 %

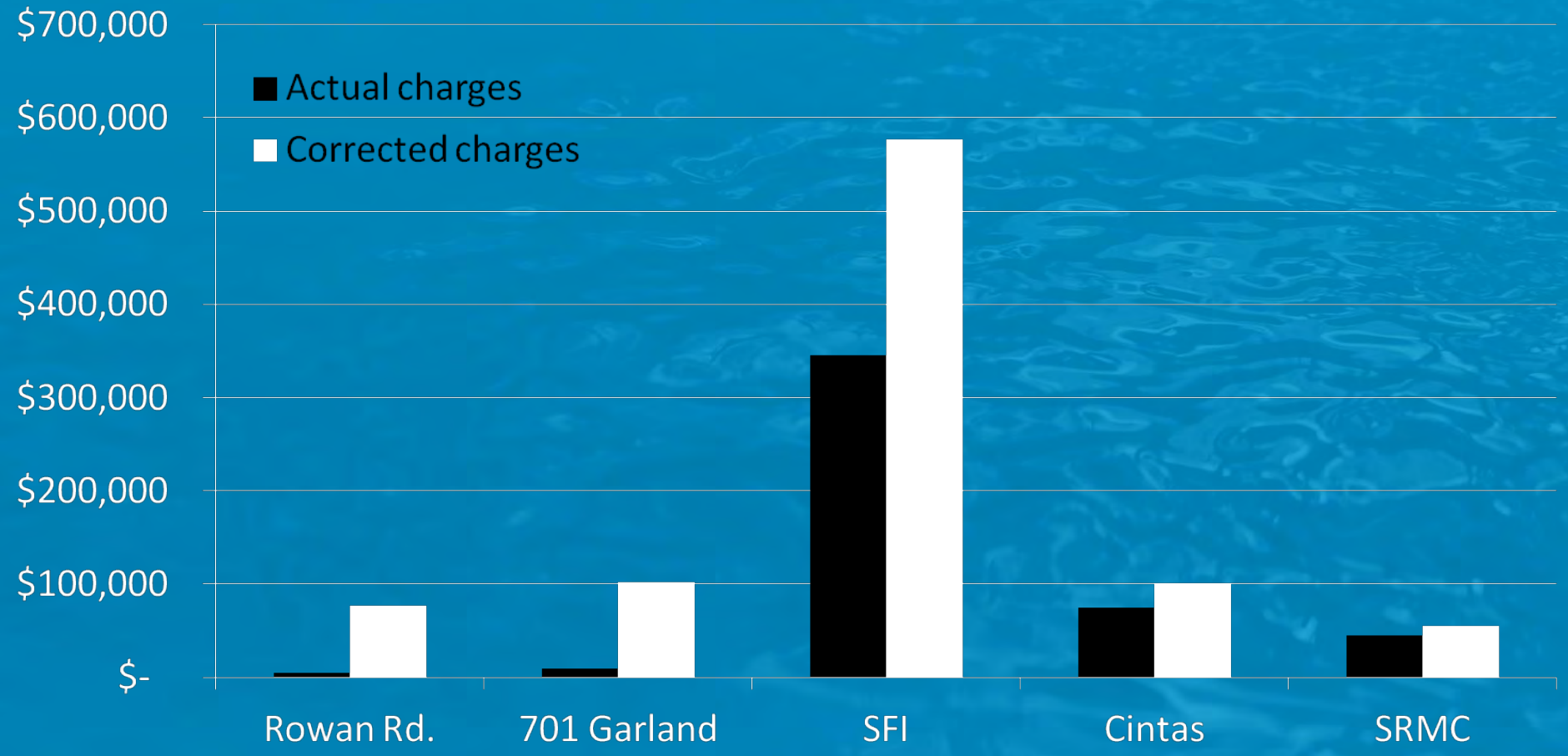
Remarks: Replaced broken rotor. Tape wrapped around shaft. Replaced gasket on cone valve.

Total water used to flush and test meter 773 Cubic Feet.



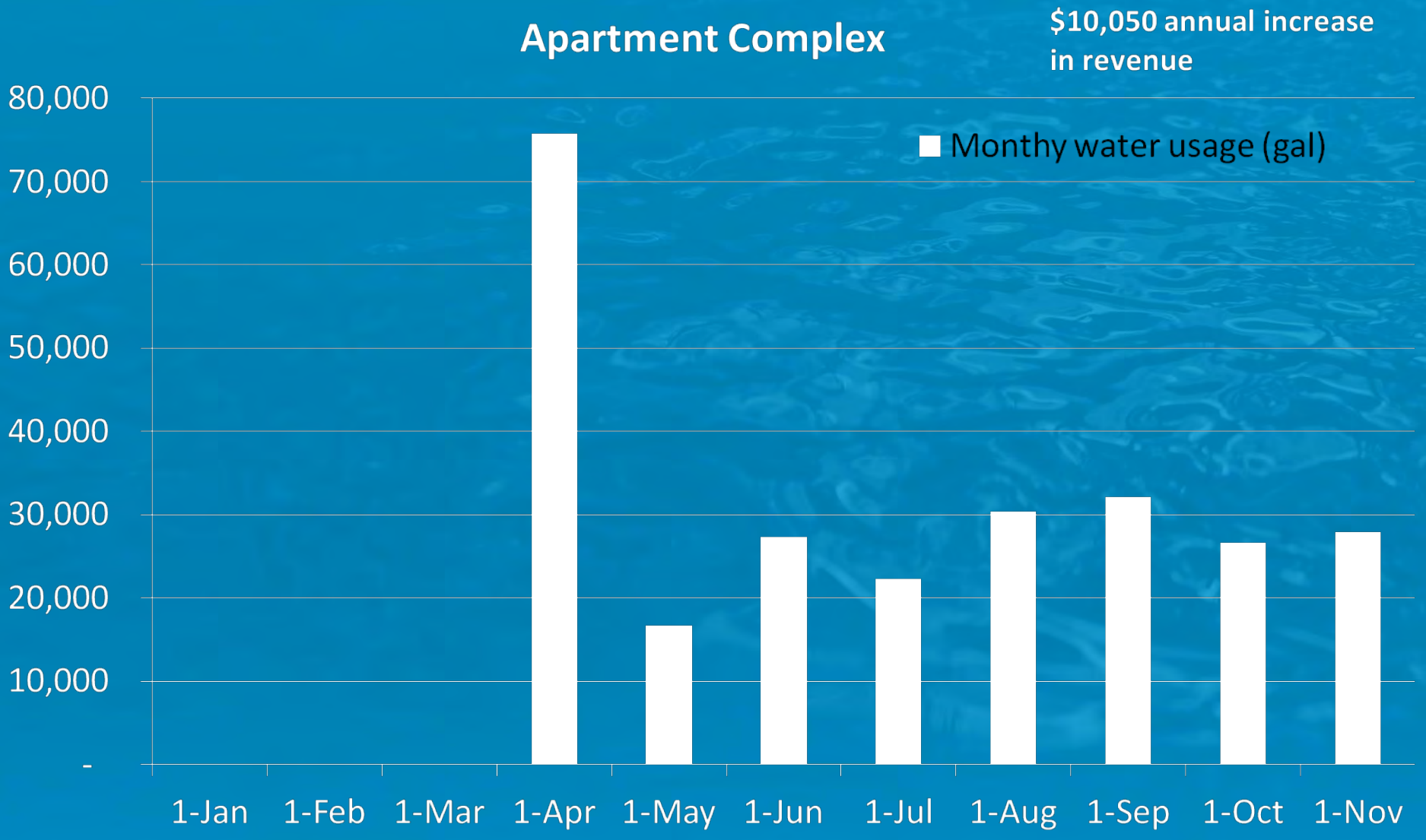
Results

From billing codes and practices review (water and sewer)



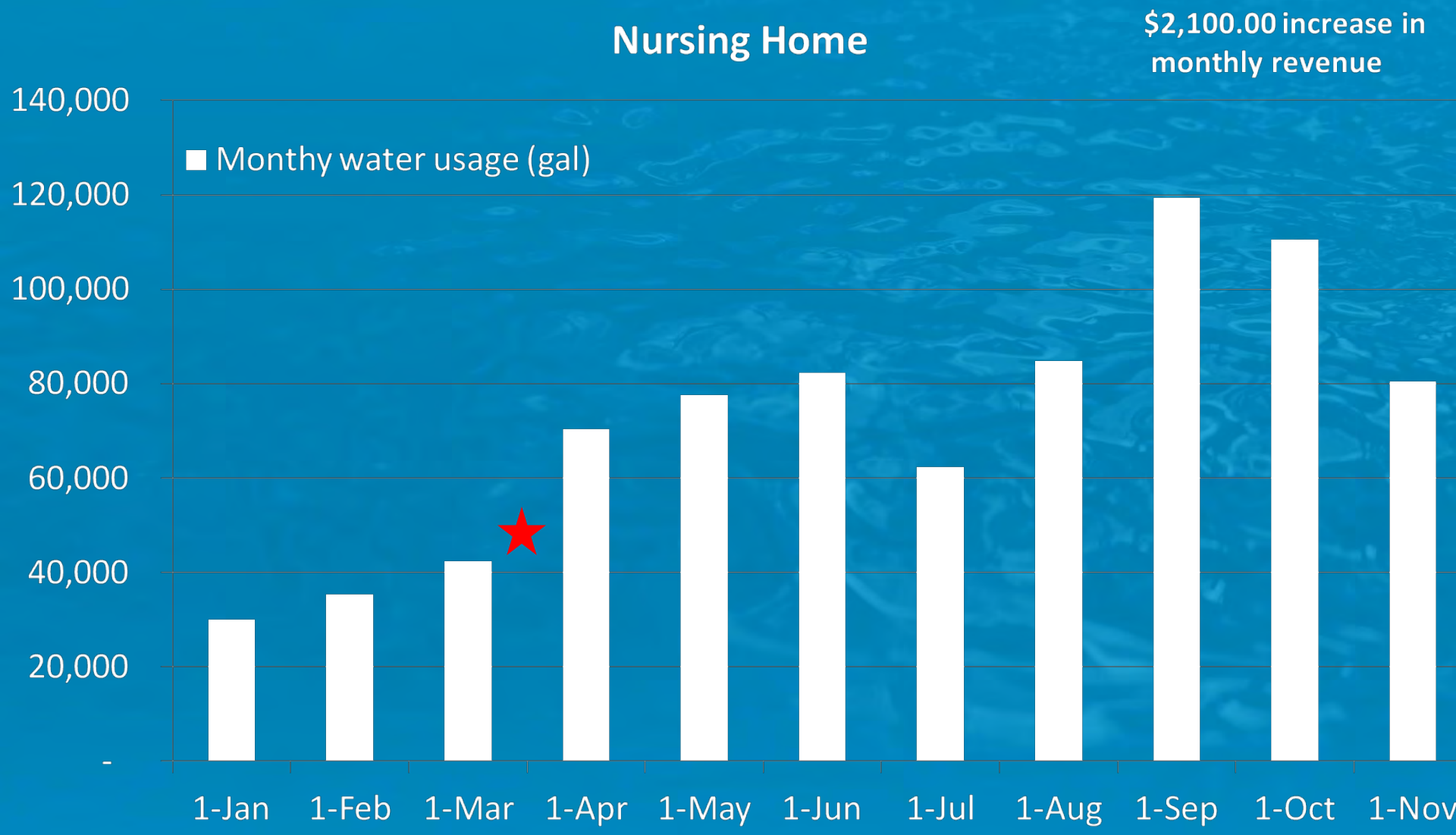
Results

From stopped meter



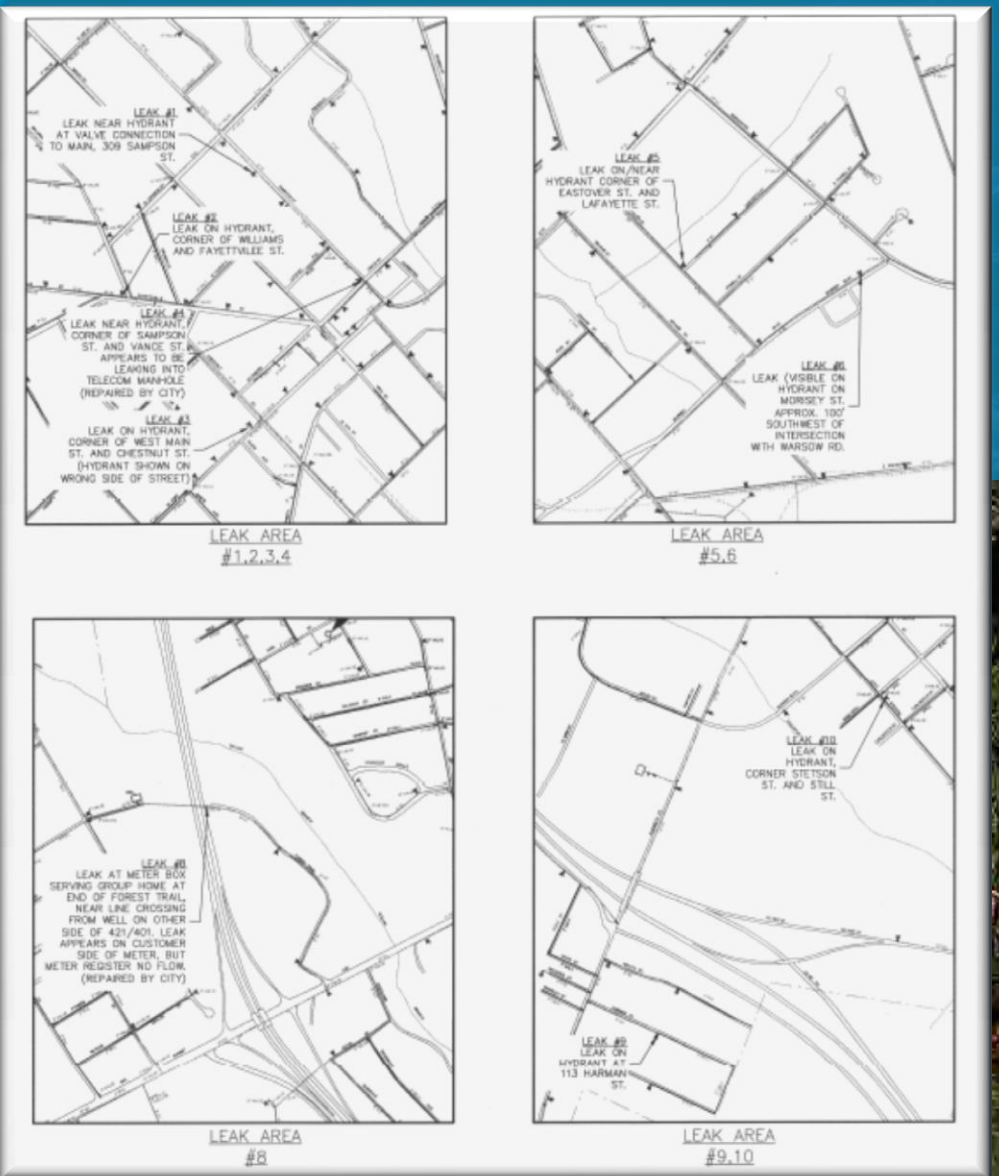
Year 1 - Results

From meter right-sizing



Results

From Pilot Active Leak Detection Survey & Repair



10 leaks located and repaired

Estimated aggregate of 100 gpm or 0.14 mgd

Establishment of survey frequency

Timeline

- Water Audit

OCT 2010

NOV 2010

- Water Efficiency Program Development

- Water Efficiency Program Implementation

DEC 2011

JAN 2011

- Billing Codes review and improvement

- Pilot Leak Survey & Repair

FEB 2011

- Began Large Meter Testing & Repair

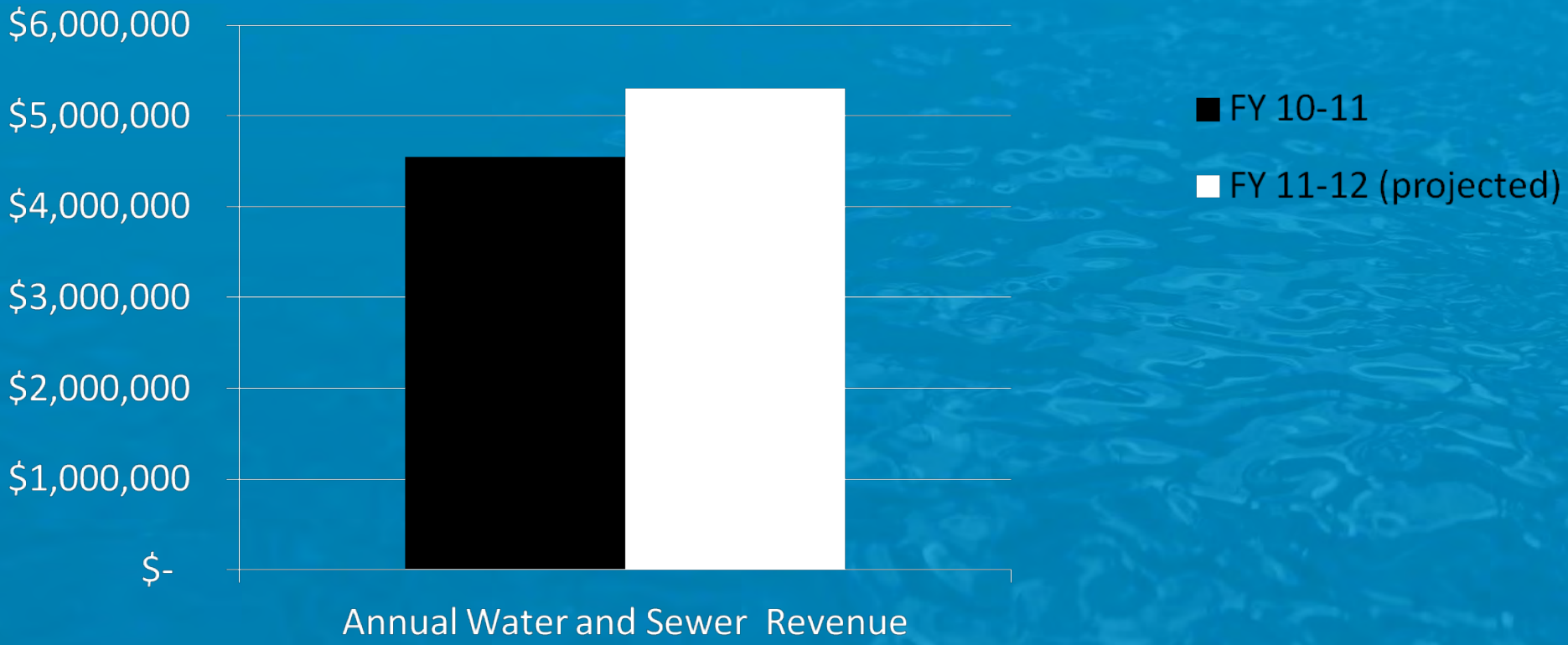
MAR 2011

- Annual Water Audit & Program Review/Renew

EARLY 2012

Year 1 - Results

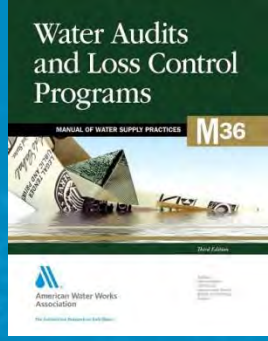
Cumulative effect



Projected Annual Revenue Increase = $750,000

	FY 10-11	Projected for FY 11-12
NRW	150 MG (25%)	92 MG (15%)
Data Validity	60	70

How to get started



Top down audit with Data Validity scoring

ID weakest areas of Data Validity and greatest areas of Water Loss

Establish monthly data collection routine

Determine program initiatives for Water Loss and Data Validity

Get a gameplan for short, medium and long term program initiatives

How to sustain

Every month – review data as a team

Every month – assess progress and next steps for program initiatives

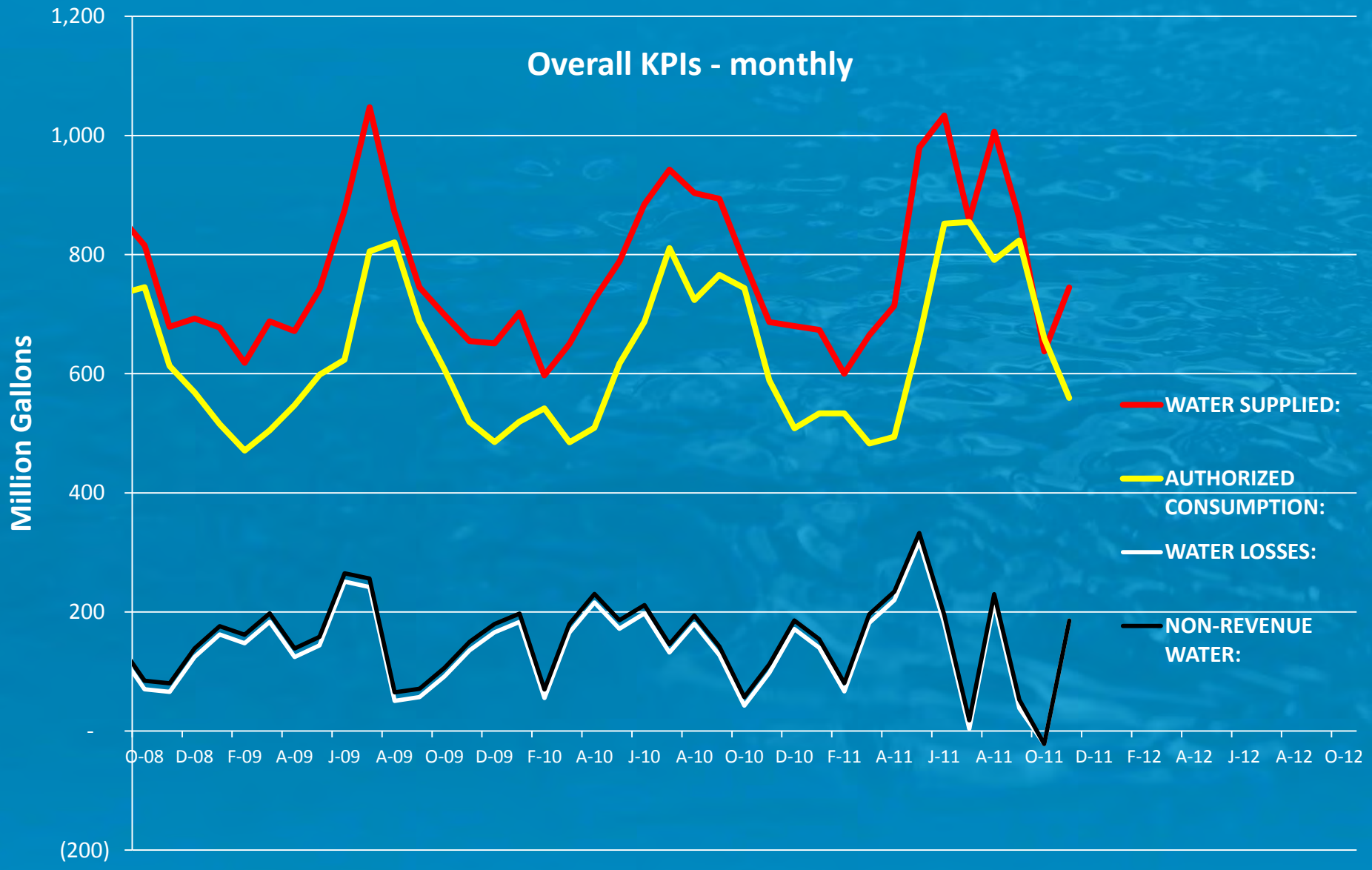
Build a culture of efficiency

Focus on Data Validity

Benchmark

Document and share successes

KPI tracking



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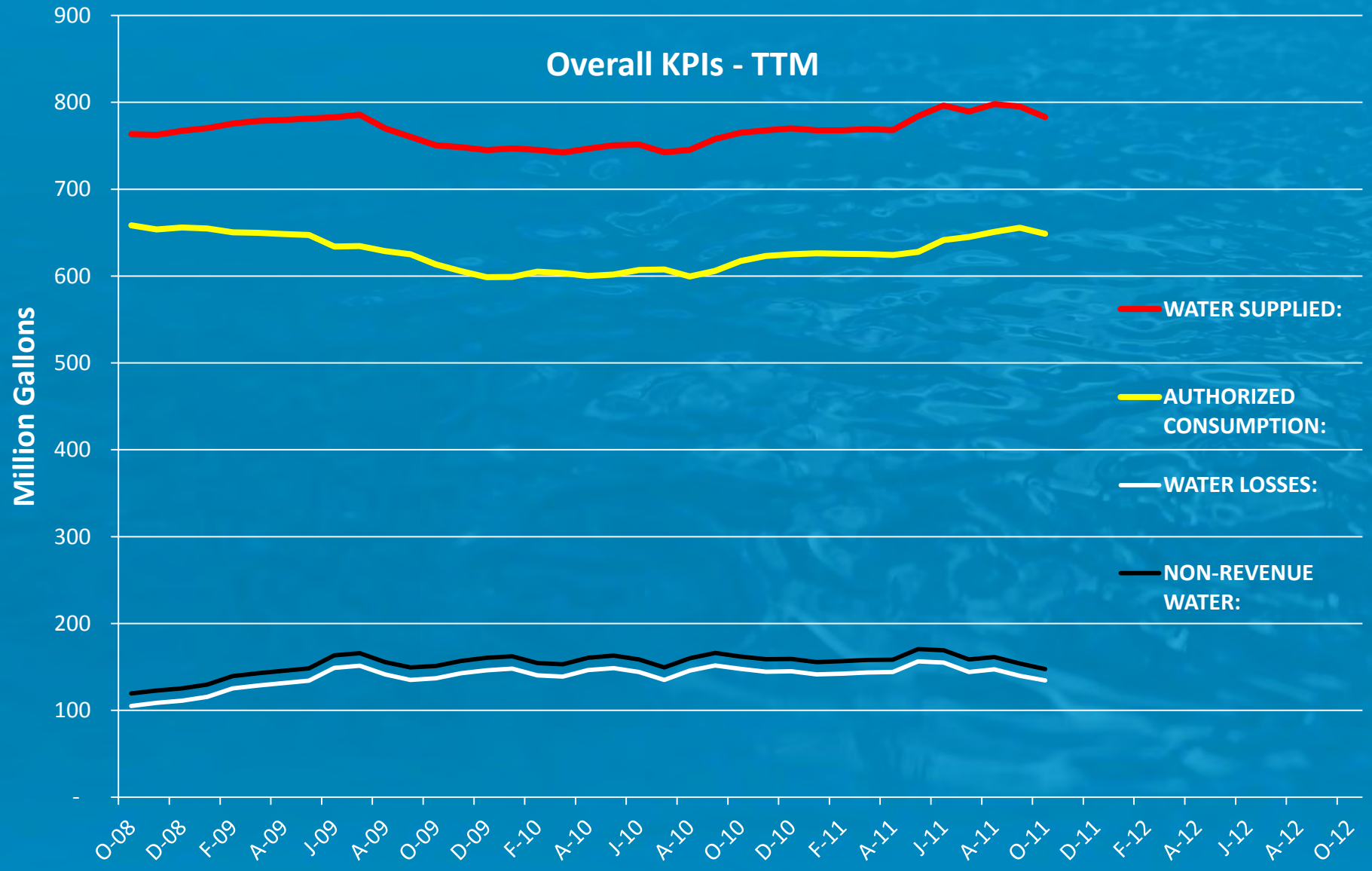
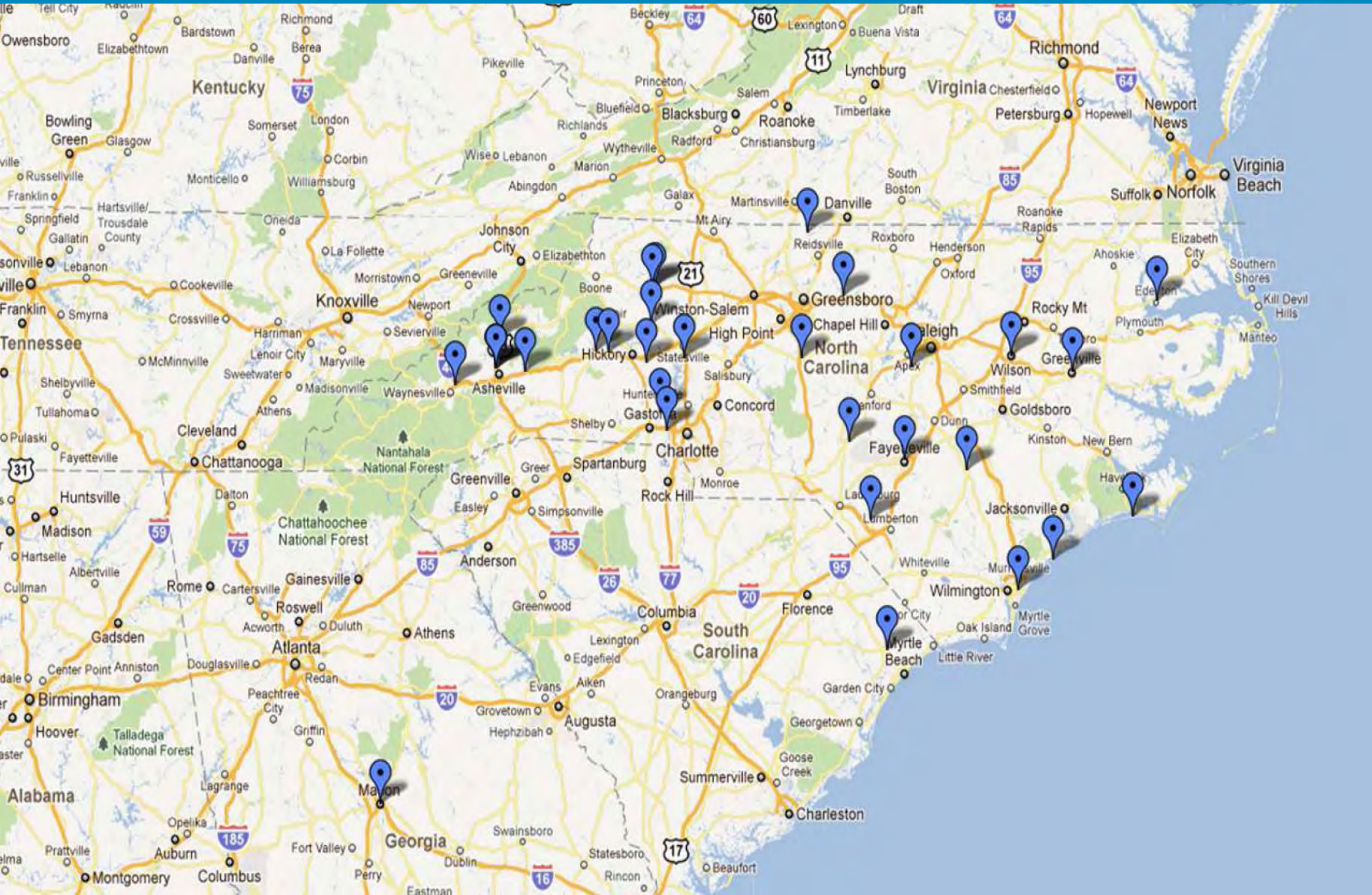


An emerging practice



An emerging practice

Key Performance Indicator	#	Average	Range		
Number of Connections	31	11,000	100	-	100,000
Apparent Losses (gal/conn/day)	31	17	1	-	87
Real Losses (gal/conn/day)	31	76	15	-	266
Infrastructure Leakage Index (ILI)	31	3.3	1.1	-	9.8
Water Audit Data Validity Score	31	58	43	-	82
NRW as a % by Volume	31	24 %	5 %	-	67 %
NRW as a % by Cost	31	18 %	6 %	-	26 %
NRW as annual cost	31	$ 470 k	$ 23 k	-	$ 2.6 M

Source: Cavanaugh & Associates, P.A.

Takeaway

How much of your water is NRW?

How much is it costing you?

Get started

Sustain

Will Jernigan, P.E., LEED® AP

will.jernigan@cavanaughsolutions.com

water you missing?

CAVANAUGH

Stewardship Through Innovation

Utility Perspective on Water Audits

Webinar: Using Water Audits to Understand Water Loss

January 26, 2012

George Kunkel P.E.
Philadelphia Water Department
george.kunkel@phila.gov

Water Accountability & Efficiency

- *It is possible to be:*
  - ***Accountable**, but <u>not</u> efficient*

however:

- *It is impossible to be:*
  - ***Efficient**, if you are <u>not</u> first accountable*

A reliable auditing structure and process must be in place before efficiency can be assessed and optimized

Depleted Lake Oroville Reservoir, CA (2009)

Focus of this Segment

- *Reiterate the Key Points of the program*
- *Present information on the North American Validated Water Audit Dataset*
- *Provide insights from progress and lessons learned from long-term water loss control in Philadelphia*

Key Point

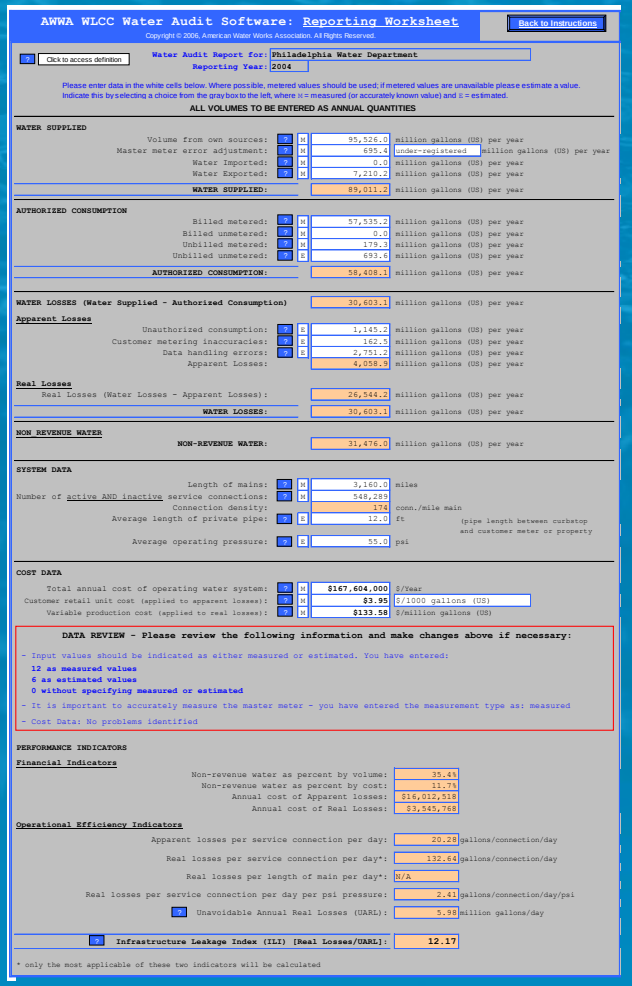
- *Water auditing:* ***Just Get Started!!!***
  - *Great tools exist*
  - *Your data will never be 'perfect'; don't wait for it to be*
  - *Other utilities are compiling water audits*
  - *Many water utilities are or will soon be required to submit water audits:*
    - *Texas (2005, 2010 and beyond)*
    - *Georgia in 2012*
    - *Delaware Basin utilities 2013*

Key Point

- *Water Utilities should compile the best practice water audit on an annual basis as a standard business practice*
  - *The annual water audit is the basis for 'accountability' in water supply operations*
  - *Water utilities cannot act as good stewards of water resources if they fail to routinely audit their supplies*

AWWA Water Loss Control Committee: Water Audit Data Collection Initiative 2011

- Goal: create a dataset of validated water utility water audit data (IWA/AWWA Method)
- Steps:
  - Enlist water motivated utilities willing to employ best practices in water auditing
  - Gather the water audit data via AWWA Free Water Audit Software©
  - Conduct a 60-90 minute telephone interview w/ WLC Committee members
  - Post the utility data on the AWWA website as examples of best practice adopters and their data – August 2011
- Primary Focus: “Validation” of data



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Water Exported:	M	7,210.2	million gallons (US) per year	
WATER SUPPLIED:		89,011.2	million gallons (US) per year	

AUTHORIZED CONSUMPTION

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Billed unmetered:	M	0.0	million gallons (US) per year
Unbilled metered:	M	179.3	million gallons (US) per year
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AUTHORIZED CONSUMPTION:		58,408.1	million gallons (US) per year

WATER LOSSES (Water Supplied - Authorized Consumption): 30,603.1 million gallons (US) per year

Apparent Losses

Unauthorized consumption:	E	1,145.2	million gallons (US) per year
Customer metering inaccuracies:	E	162.5	million gallons (US) per year
Data handling errors:	E	2,751.2	million gallons (US) per year
Apparent Losses:		4,058.9	million gallons (US) per year

Real Losses

Real Losses (Water Losses - Apparent Losses):		26,544.2	million gallons (US) per year
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NON-REVENUE WATER

NON-REVENUE WATER: 31,476.0 million gallons (US) per year

SYSTEM DATA

Length of mains:	M	3,160.0	miles	
Number of active AND inactive service connections:	M	548,289		
Connection density:		174	conn./mile main	
Average length of private pipe:	E	12.0	ft	(pipe length between curbstop and customer meter or property
Average operating pressure:	E	55.0	psi	

COST DATA

Total annual cost of operating water system:	M	$167,604,000	$/Year
Customer retail unit cost (applied to apparent losses):	M	$3.95	$/1000 gallons (US)
Variable production cost (applied to real losses):	M	$133.58	$/million gallons (US)

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PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	35.4%
Non-revenue water as percent by cost:	11.7%
Annual cost of Apparent losses:	$16,012,518
Annual cost of Real Losses:	$3,545,768

Operational Efficiency Indicators

Apparent losses per service connection per day:	20.28	gallons/connection/day
Real losses per service connection per day*:	132.64	gallons/connection/day
Real losses per length of main per day*:	N/A	
Real losses per service connection per day per psi pressure:	2.41	gallons/connection/day/psi
Unavoidable Annual Real Losses (UARL):	5.98	million gallons/day
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	12.17	

* only the most applicable of these two indicators will be calculated

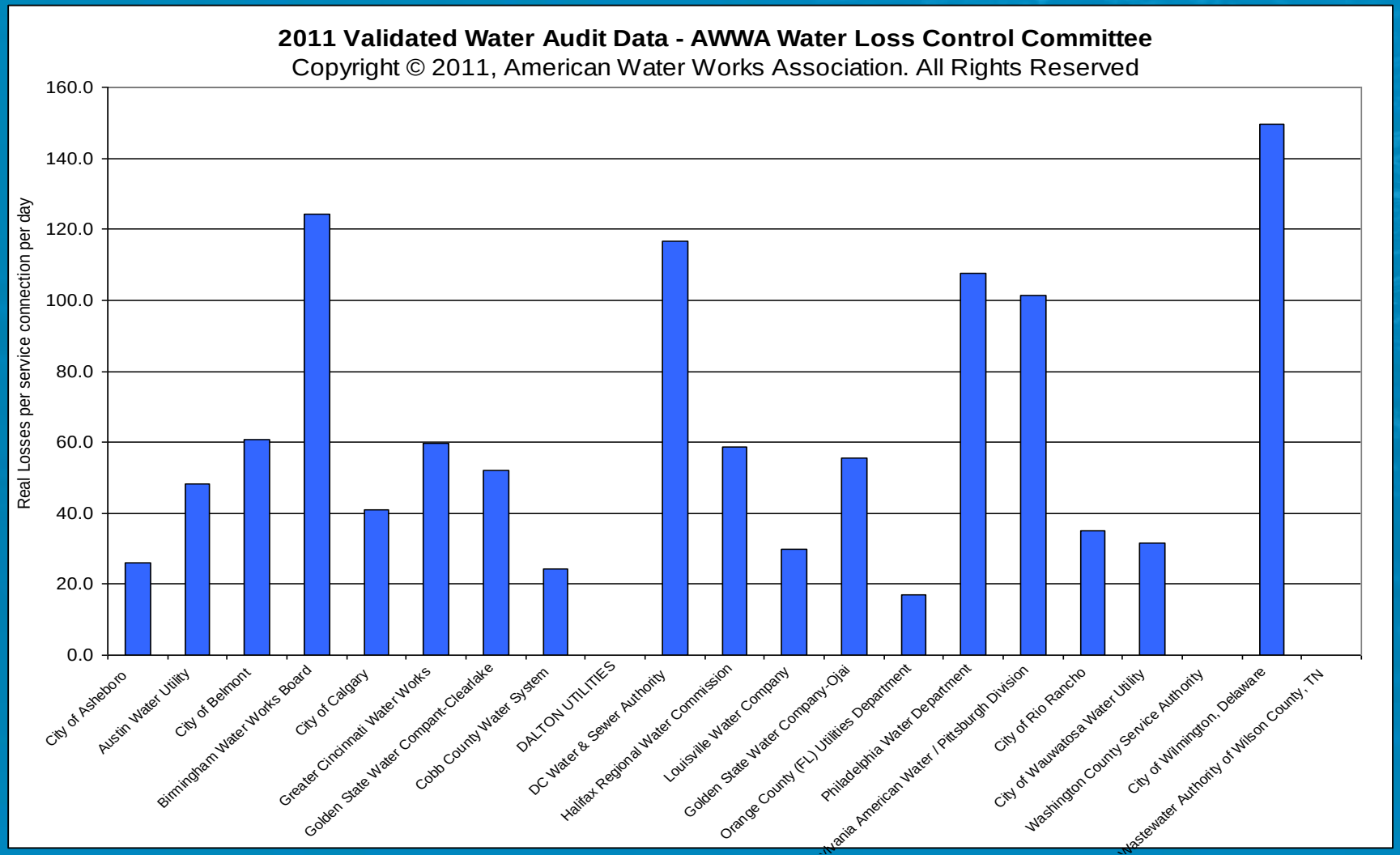
AWWA Free Water Audit Software©

Companion "Compiler" Software

- EXCEL spreadsheet tool that allows data from multiple water audits to be "compiled" into one spreadsheet
- Data can be copied to user's EXCEL files
- Available for free download from AWWA website

Administrative	Name of City or Utility	City of Asheboro	Austin Water Utility	City of Belmont
	Country	USA	United States	USA
	Reporting Year	FY08-09	2010	FY 09-10
	Start Date	7/1/2008	10/1/2009	7/1/2009
	End Date	6/1/2009	9/1/2010	6/30/2010
	Name of Contact Person	Michael Rhoney	Dan Strub	Chuck Flowers
	E-Mail	mrhoney@ci.asheb	dan.strub@ci.austi	cflowers@cityofbel
	Telephone	336-626-1234	512-972-0349	704-825-0512
	Telephone Ext			
Audit Data				
Water Supplied	Volume Units	Million gallons (US)	Million gallons (US)	Million gallons (US)
	Volume From Own Sources	1,491.690	43,786.936	593.075
	Master meter error adjustment	138.572	893.611	12.104
	Water imported	-	-	-
	Water exported	-	-	-
	WATER SUPPLIED	1,630.262	44,680.547	605.179
Authorized Consumption	Billed metered	1,311.441	39,367.872	438.054
	Billed unmetered	-	311.434	-
	Unbilled metered	35.791	90.417	-
	Unbilled unmetered	113.521	191.471	45.612
	Unbilled unmetered (1 = Default; 2 = Value)	2	2	2
	AUTHORIZED CONSUMPTION	1,460.753	39,961.194	483.665
Water Losses	**WATER LOSSES (Water Supplied - Authorized Consumption)**	169.509	4,719.353	121.513
	Unauthorized consumption	4.076	125.480	1.513
	Unauthorized consumption (1 = Default; 2 = Value)	1	2	1
	Customer metering inaccuracies	41.667	857.613	18.252
	Systematic data handling errors	-	24.885	-
	Apparent Losses	45.743	1,007.978	19.765
	Real Losses = (Water Losses - Apparent Losses)	123.766	3,711.375	101.748
	WATER LOSSES	169.509	4,719.353	121.513
Non-Revenue Water	**NON-REVENUE WATER**	318.821	5,001.241	167.125
System Data	Length of mains	237	3,639	95
	Number of active AND inactive service connections	13,000	210,893	4,600
	Connection density	54.9	58.0	48.4
	Average length of customer service line	20	0	20
	Average operating pressure	75	77.3	66
Cost Data	Total annual cost of operating water system	$3,048,480	$168,249,678	$1,357,542
	Customer retail unit cost (applied to Apparent Losses	$5.90	$3.91	$6.98
	Customer retail unit cost (units)	$/100 cubic feet (cc	$/1000 gallons (US	$/1000 gallons (US
	Variable production cost (applied to Real Losses)	$510.00	$341.00	$330.00
Performance Indicators				
Financial Indicators	Non-revenue water as percent by volume	19.6%	11.2%	27.6%
	Non-revenue water as percent by cost	16.4%	3.2%	13.7%
	Annual cost of Apparent Losses	$360,779	$3,941,194	$137,961
	Annual cost of Real Losses	$63,121	$1,265,579	$33,577
Operational Efficiency Indicators	Apparent Losses per service connection per day	9.640	13.095	11.772
	Real Losses per service connection per day*	26.084	48.215	60.600
	Real Losses per length of main per day*	N/A	N/A	N/A
	Real Losses per service connection per day per psi pressure	0.348	0.624	0.918
	Unavoidable Annual Real Losses (UARL)	98.591	1,447.995	32.151
	Infrastructure Leakage Index (ILI) [Real Losses/UARL]	1.255	2.563	3.165

AWWA Water Audit Compiler© features readily displayed graphs



Real (leakage) losses in gal/service connection/day: good for performance tracking

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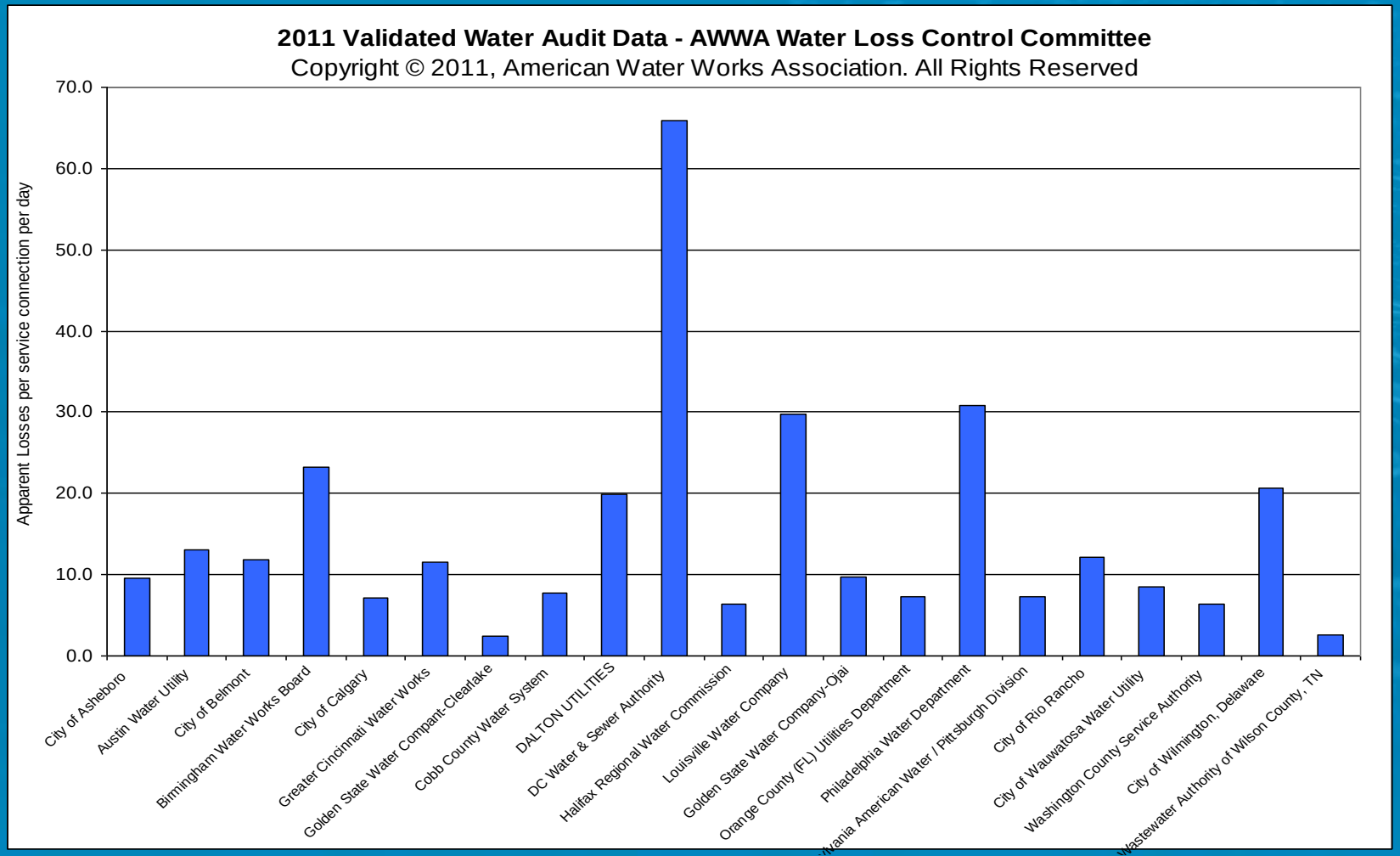

Apparent (non-physical) losses in gal/service connection/day: good for performance tracking

AWWA Water Loss Control Committee

Water Audit Data Collection Initiative 2011

- 2011 Data Collection notables:
  - 21 water utilities (19 USA, 2 Canada)
  - 17 systems over 10,000 connections; 4 systems under 10,000 connections
- Observations from the data:
  - Validation results: ave data validity score dropped from 78 to 74 after validation
  - Wide variation in production costs: $183/mg (KY) to $2,110/mg (TN) – ave. $726/mg
  - Customer retail costs: ave. $4.57/1,000 gals Range $1.11/1,000 gals to $8.38/1,000 gals
  - Ave apparent losses: 15 gal/connection/day
  - Ave real losses: 63 gal/connection/day

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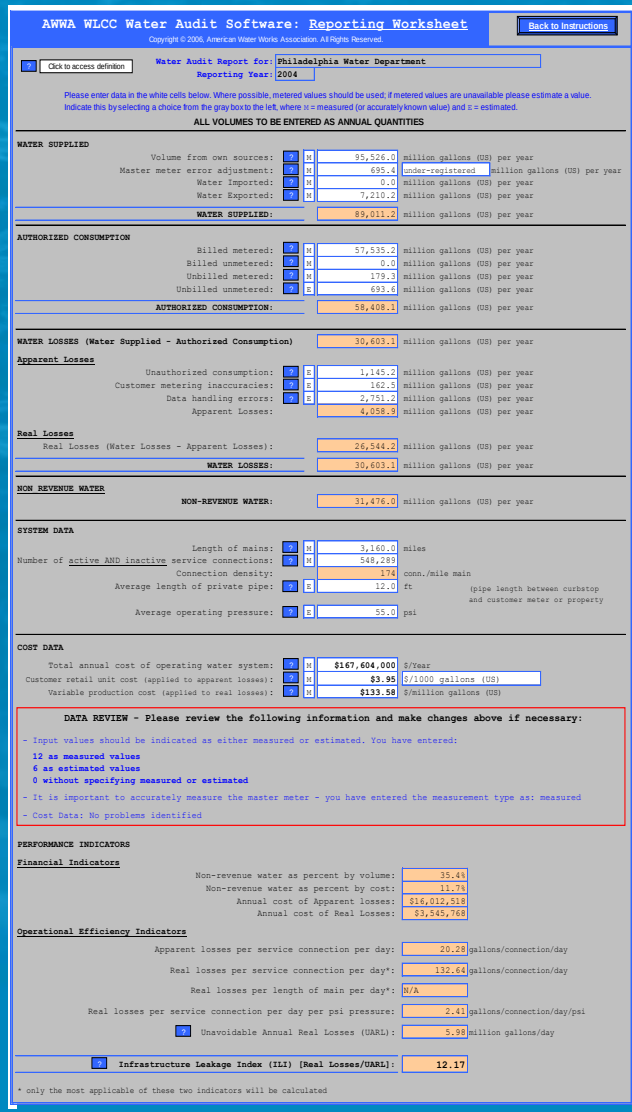
AWWA North American Validated Water Audit Data Collection Initiative – moving forward

- Conduct data collection and validation again in 2012 as an annual initiative
- Strive to increase the number of validated audits to 30
- Requirements for utility participation
  - Must submit current year data in AWWA Free Water Audit Software©
  - Utility is identified (no anonymous data)
  - Utility agrees to allow data to be posted on AWWA website and in industry presentations
  - Participating utilities received copies of all analysis and reports compiled during the initiative



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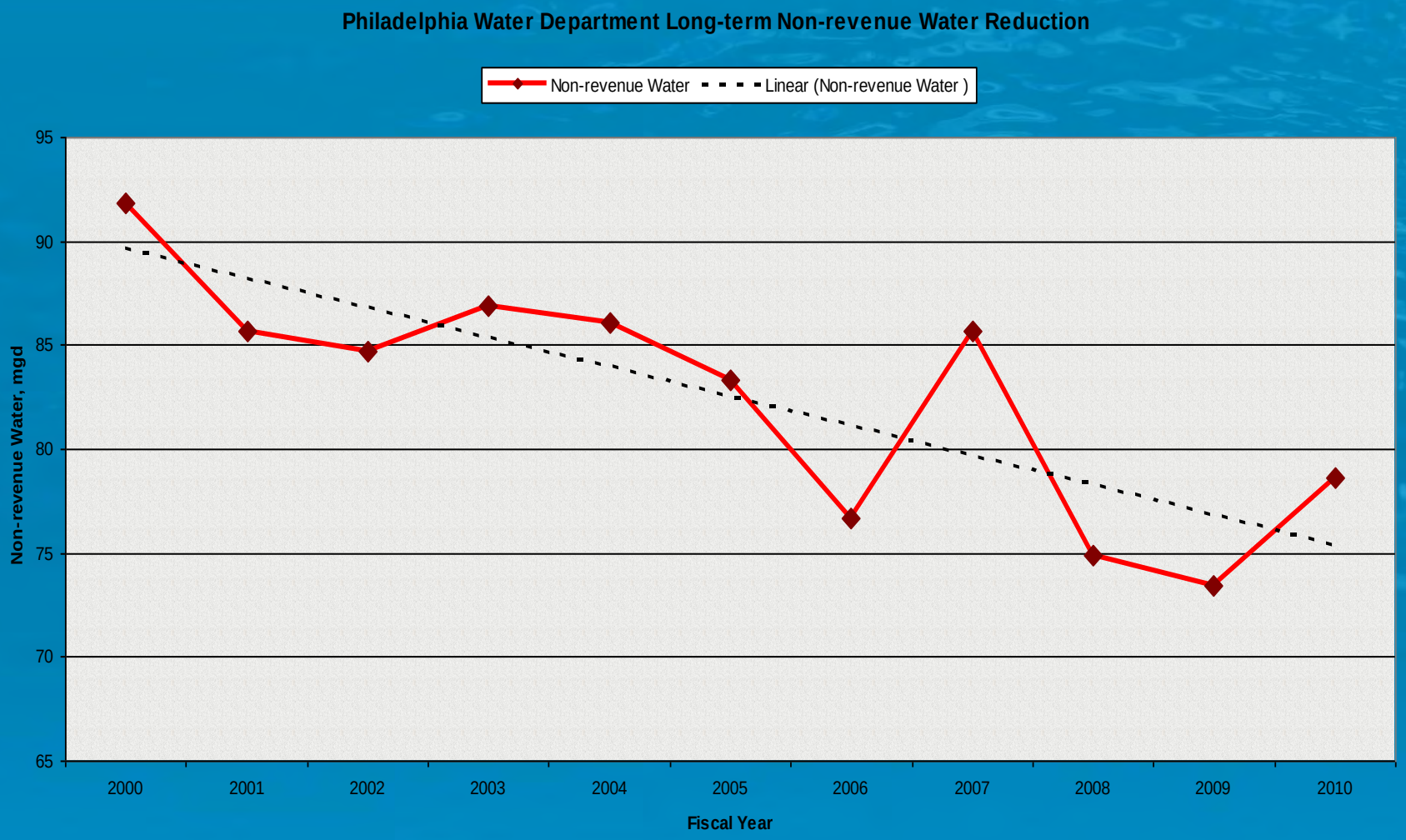
Key Point

- *Focus on volumes of water and costs*
  - *Volumes reflect the commodity that water utilities manage*
  - *Costs are important to everyone*
  - *Each parameter needs to be tracked every year!*

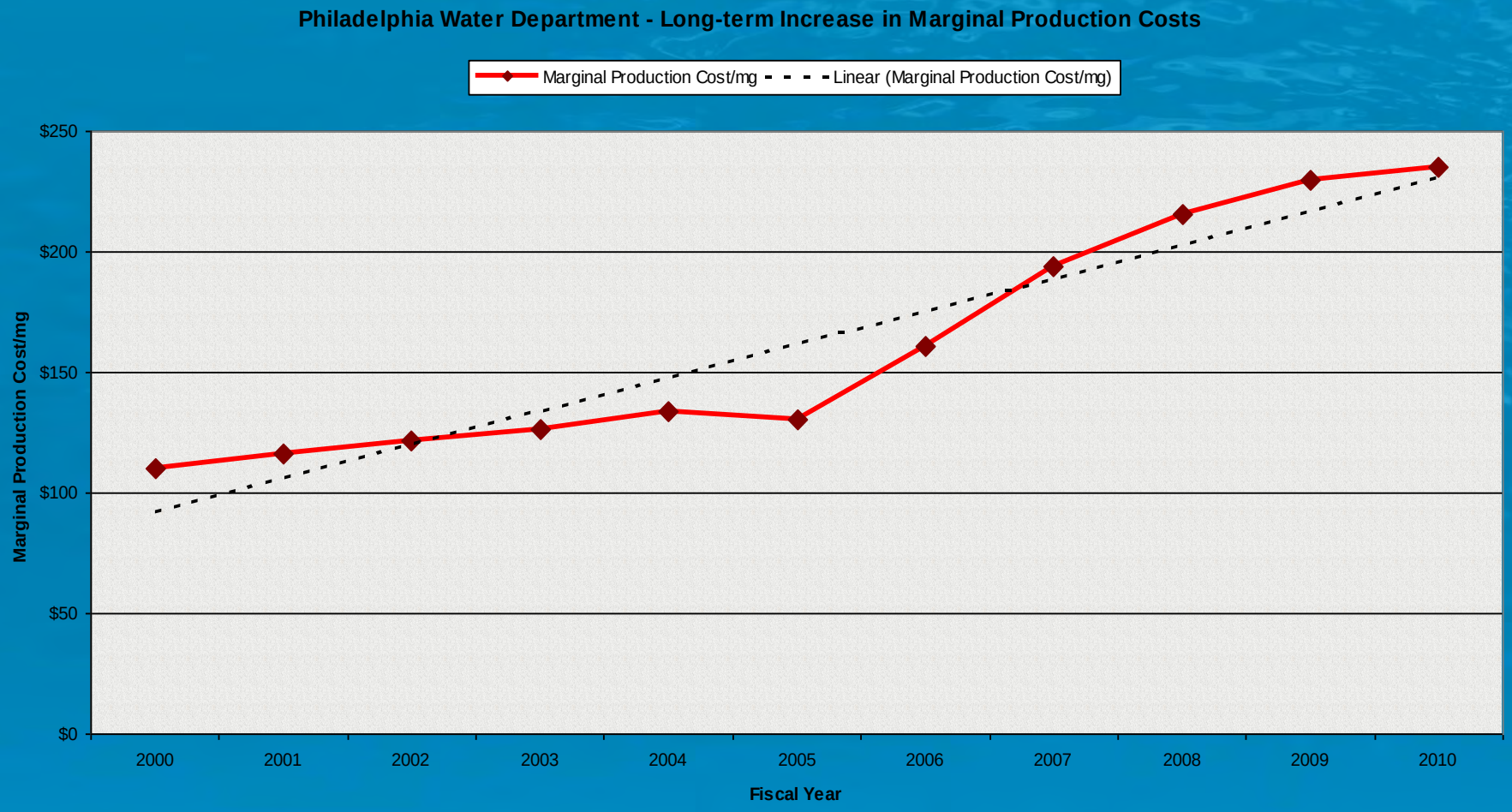
Philadelphia Water Department

- First water utility in the United States to employ the IWA/AWWA Water Audit Method
- Non-revenue water reduction of over 50 mgd since 1994
- Industry leader in piloting innovative methods and conducting outreach to stakeholders including utilities, regulatory & other agencies

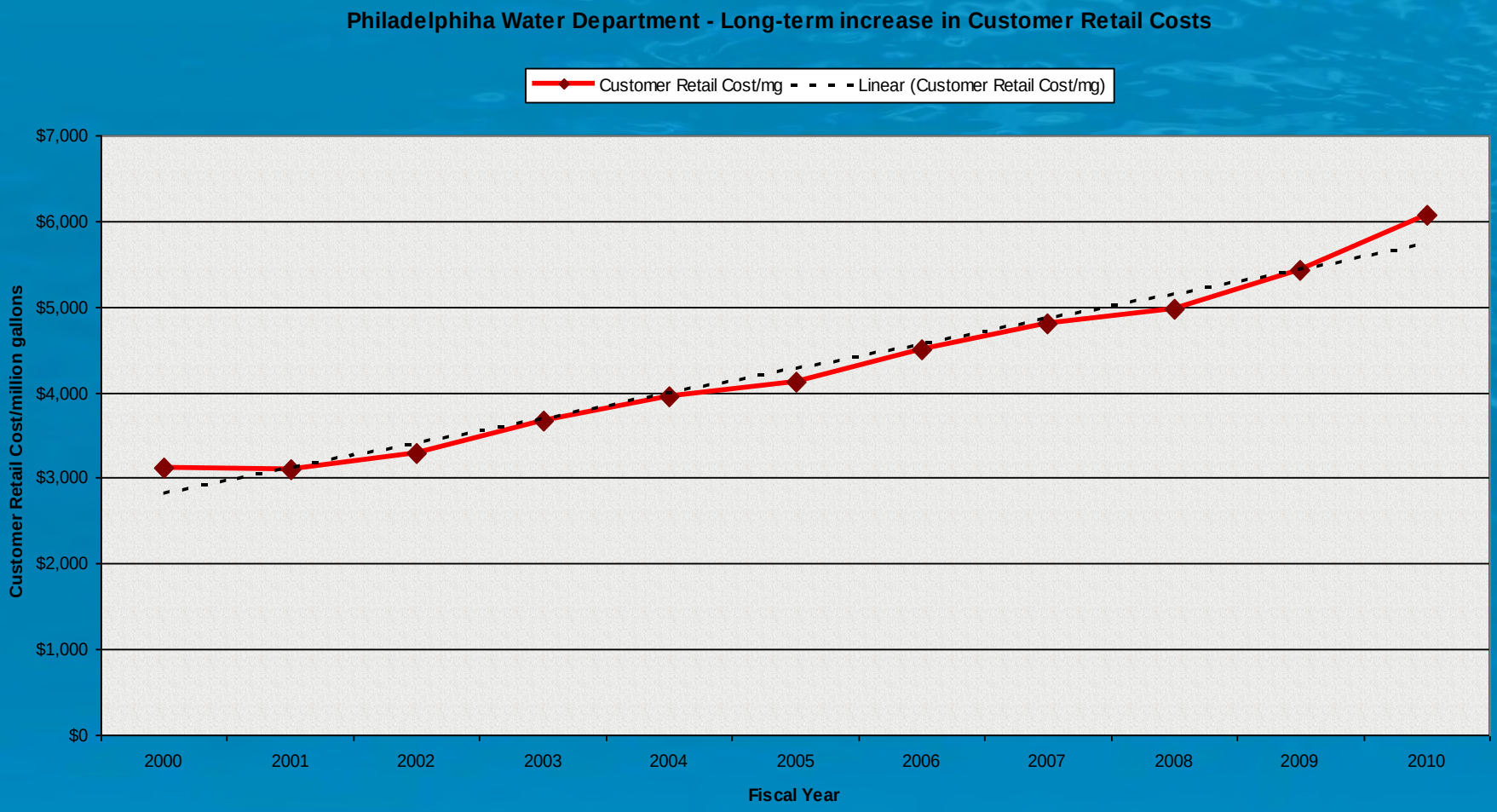
PWD's Long-term Non-revenue Water Reduction



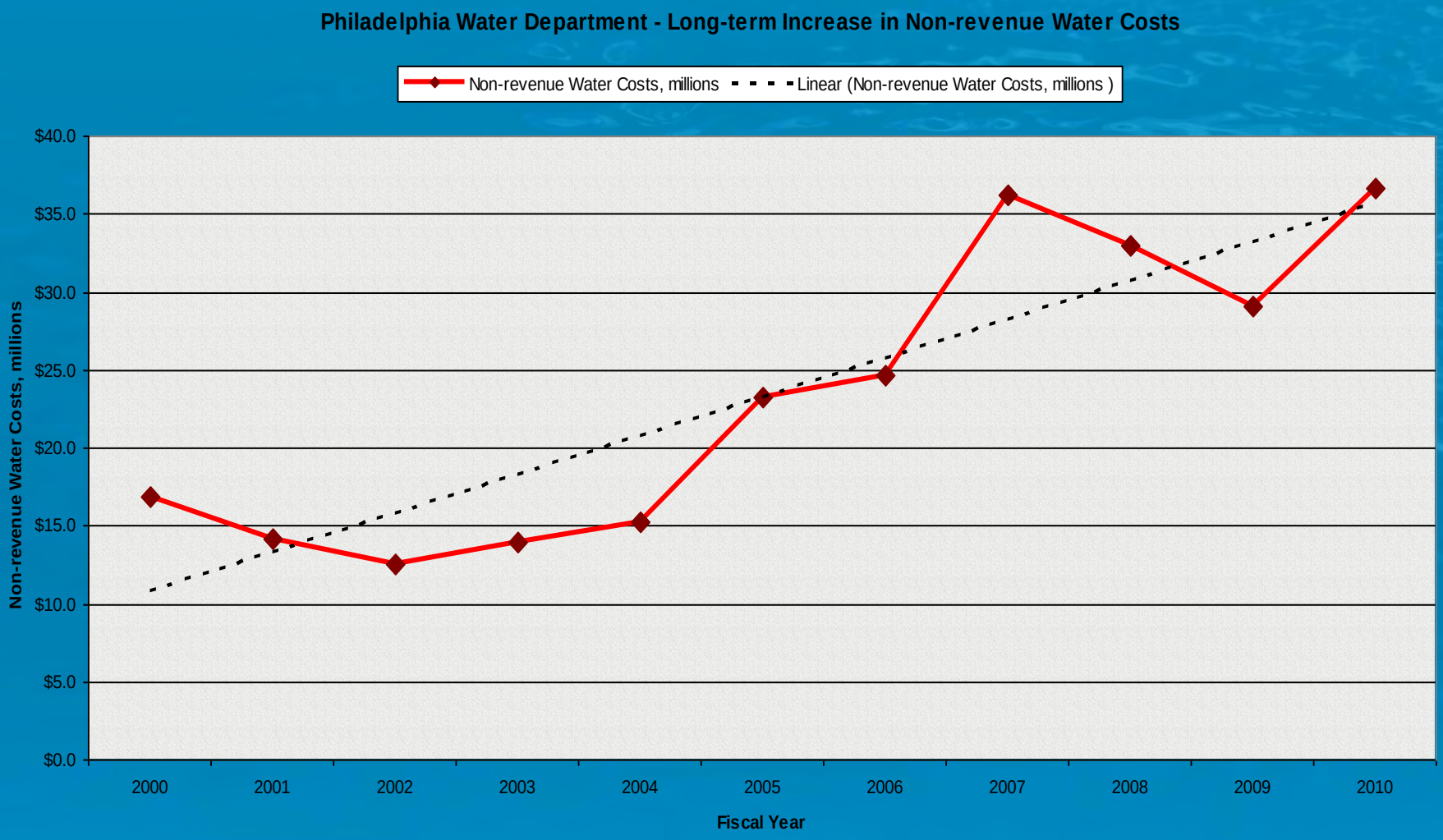
PWD's Increasing Production Costs



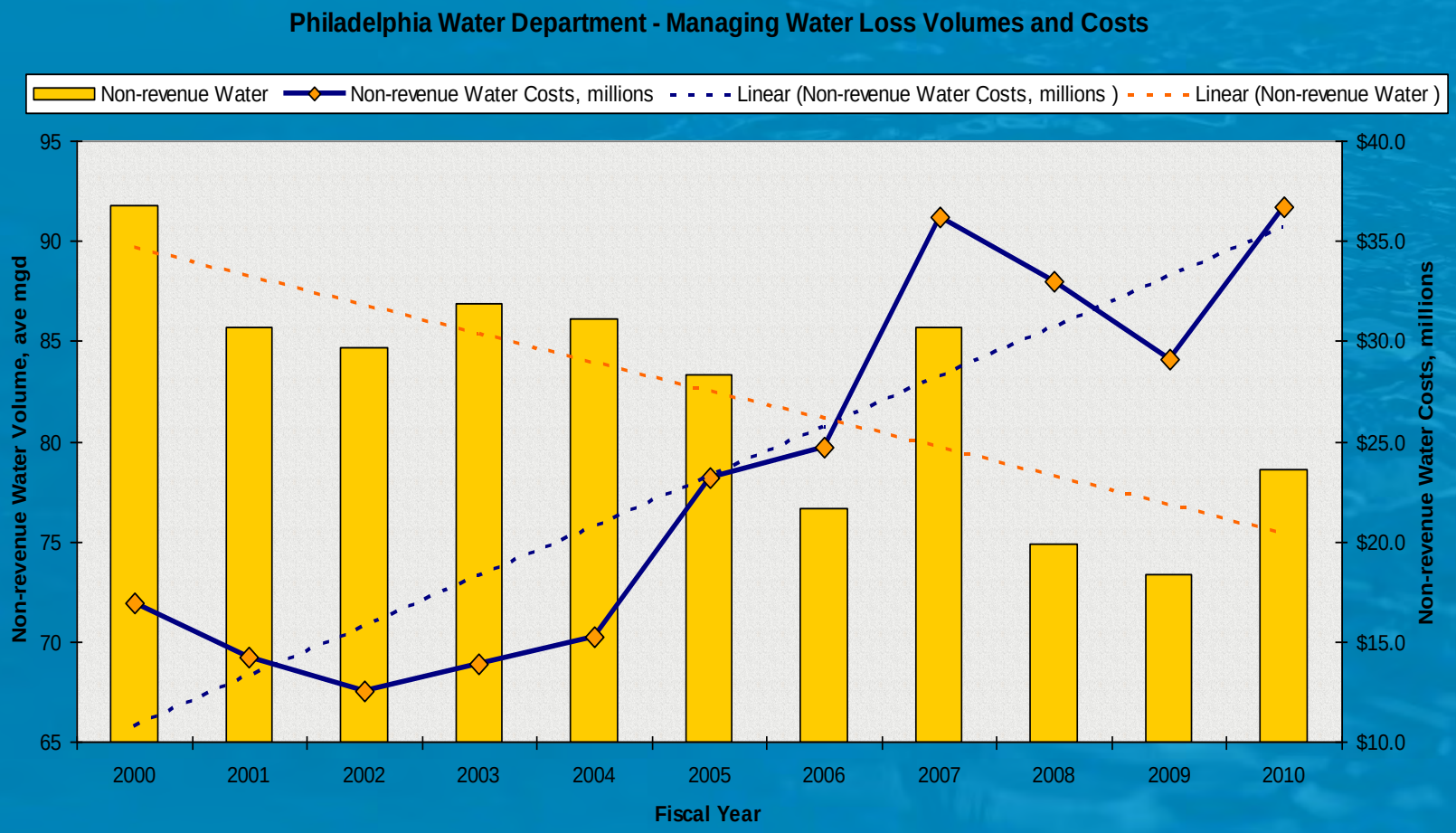
PWD's Increasing Customer Retail Costs



PWD: the annual cost of Non-revenue Water



PWD: Declining Losses but Increasing Costs



Water Loss levels and costs are always changing

Water Auditing and loss control must be regular activities!

Philadelphia's Water Audit Summary

July 1, 2009 - June 30, 2010 in Million Gallons Per Day (mgd)

Water into Supply -	244.4	mgd	
Customer Billed Consumption	- 167.8	mgd	
Unbilled Water	76.6	mgd	
Unbilled Auth. Consumption	2.0	mgd	$ 779,000
Apparent Losses	17.0	mgd	$30,034,000
Real Losses	59.6	mgd	$ 5,868,000
Non-revenue Water	78.6	mgd	$36,522,000

NRW by volume = 78.6 mgd /225.0 mgd = **34.9%**

NRW by cost = $US 36.5 million/ $US 224 million = **16.3%**

Apparent Loss indicator = 17 mgd / 553,115 connections = **30.7 gallons/connection/day**

Real Loss indicator = 59.6 mgd / 553,115 connections = **107.7 gallons/connection/day**

Unavoidable Annual Real Losses (UARL) **= 6.0 mgd**

Infrastructure Leakage Index (ILI) = 59.6 / 6.0 = **9.9**

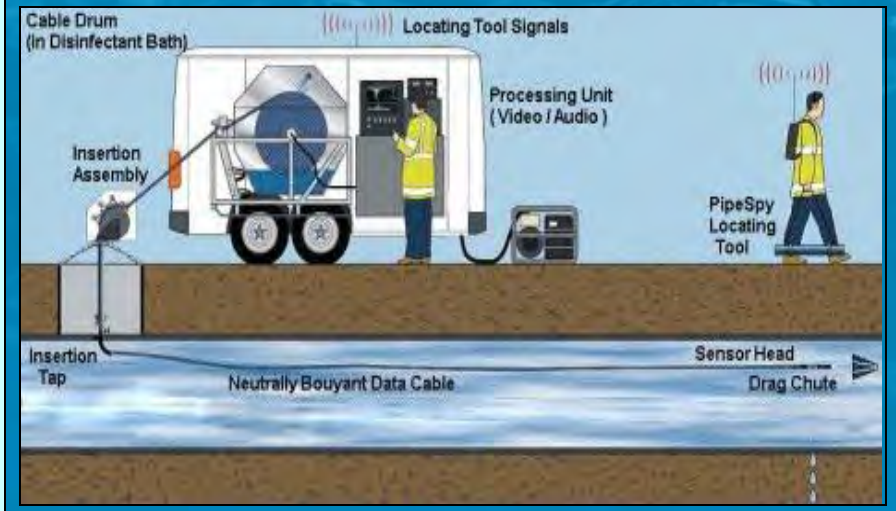
Revenue Protection & Reinspection Programs

PWD - WRB Revenue Recovery History							
PWD Revenue Protection Program					WRB Reinspection		Total
Fiscal Year	Accounts Recovered	Water Recovered, mgd	Revenue Recovered	Categories of Greatest Recovery**	Reinspection Recoveries	Reinspections Revenue Recovery	Total Recovered Revenue
2010	2,467	1.49	$2,384,528	Investigation of Zero Consumption accounts: 61% of 2,467 recovered accounts were "missing meter"	1,516	$169,733	$2,554,261
2009	1,659	1.00	$1,603,540	Investigation of Zero Consumption accounts: 80% of 1,659 recovered accounts were "missing meter"	1,632	$199,732	$1,803,272
2008	n/a	0.4	$636,250	n/a	2,597	$390,670	$1,026,920
2007	449	0.36	$531,400	NB9 (Vacant properties) & NB3 (Shutoff for non-payment)	2,984	$340,380	$871,780
2006	1,436	1.01	$1,413,000	Estimated Accounts (#1), Non-billed Accounts (#3,#9) and Zero Consumption Accounts	2,513	$209,768	$1,622,768
2005	2,397	1.74	$2,835,000	NB3 & Zero consumption accounts	2,553	$249,261	$3,084,261
2004	1,941	1.67	$2,003,000	Zero consumption accounts 0.74 MGD; tampering is most common cause of lost water in this group	1,991	$446,327	$2,449,327
2003	1,360	1.14	$1,782,000	Zero Consumption Accounts	2,221	$604,379	$2,386,379
2002	932	0.69	$1,037,000	Zero Consumption Accounts	2,721	$668,932	$1,705,932
2001	711	5.81	$2,900,000	Missing Accounts, Hand Estimates, NB6 accounts	3,261	$498,952	$3,398,952
2000	716	1.39	$2,100,000	NB6 accounts	2,737	$393,949	$2,493,949
Total	**14,068**	**16.7**	**$19,225,718**		**26,726**	**$4,172,083**	**$23,397,801**

Average $2 million/year in missing revenue has been captured!

Leakage Management

- PWD has determined its Economic Level of Leakage (ELL) to be 45 mgd vs. current level of 60 mgd
- PWD addresses leakage via:
  - Regular acoustic surveys
  - Service line repairs customer assistance program
  - Inline transmission pipeline leak detection
  - Select district metered areas
  - Pressure management
  - Pipeline replacement



Sahara inline leak detection technology

Leading the Water Loss Control Program is like Conducting an Orchestra

Directing multiple activities to achieve harmonious performance

Summary

KEY POINTS

- *Water Audits: get started!*
- *Compile the water audit on an annual basis*
- *Key on volumes & costs; employ the performance indicators*
- *Use the Water Audit findings to guide the loss control strategy*
- *PWD has taken a strategic, persistent approach to water loss control and is cost-effectively containing Non-revenue Water*

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