

Appendix B

---

PowerPoint Presentations



# Water Loss Management Program Assessment Potable Water System Audits

Project Kick-Off Meeting  
May 21, 2008

# Agenda

- Introductions
- Participating Agency Contact Information
- Review Project Scope and Budget
- Review Project Schedule
- AWWA M36 Revision 3 Draft
- Water Balance Spreadsheet Software
- Consultant Data Request: Available Information/Schedule for Delivery
- References
- Open Discussion
- Next Meeting Date

# Contact Information

- Richard Bell, MWDOC, Principal Engineer/Project Manager
  - (714) 593-5003
  - rbell@mwdoc.com
- Steve Davis, Malcolm Pirnie, Inc., Project Manager
  - (949) 450-7948
  - sdavis@pirnie.com
- Andree Hunt, Malcolm Pirnie, Inc., Project Scientist
  - (949) 450-7939
  - ahunt@pirnie.com



# Participating Agency Contact Information

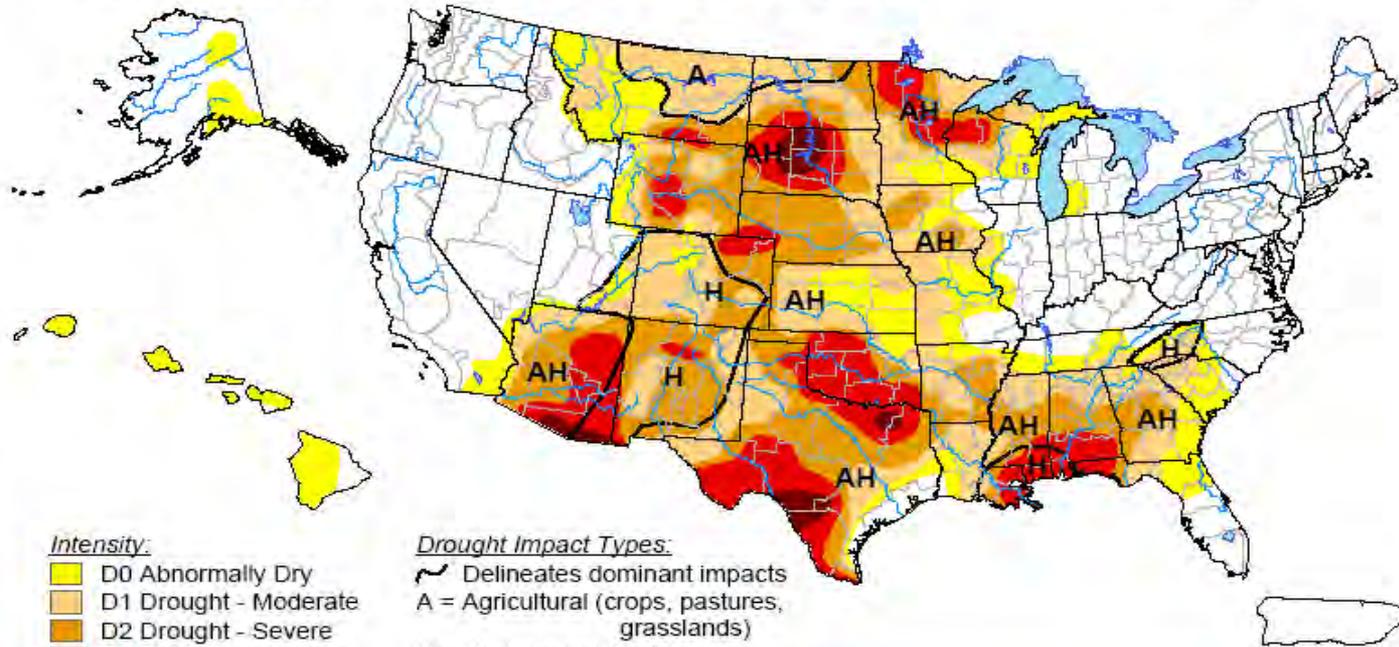
# Project Background

**What are the benefits of  
conducting a water audit?**

# Growing Pressure to Manage Water More Efficiently

## U.S. Drought Monitor

July 25, 2006  
Valid 8 a.m. EDT



### Intensity:

-  D0 Abnormally Dry
-  D1 Drought - Moderate
-  D2 Drought - Severe
-  D3 Drought - Extreme
-  D4 Drought - Exceptional

### Drought Impact Types:

-  Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*

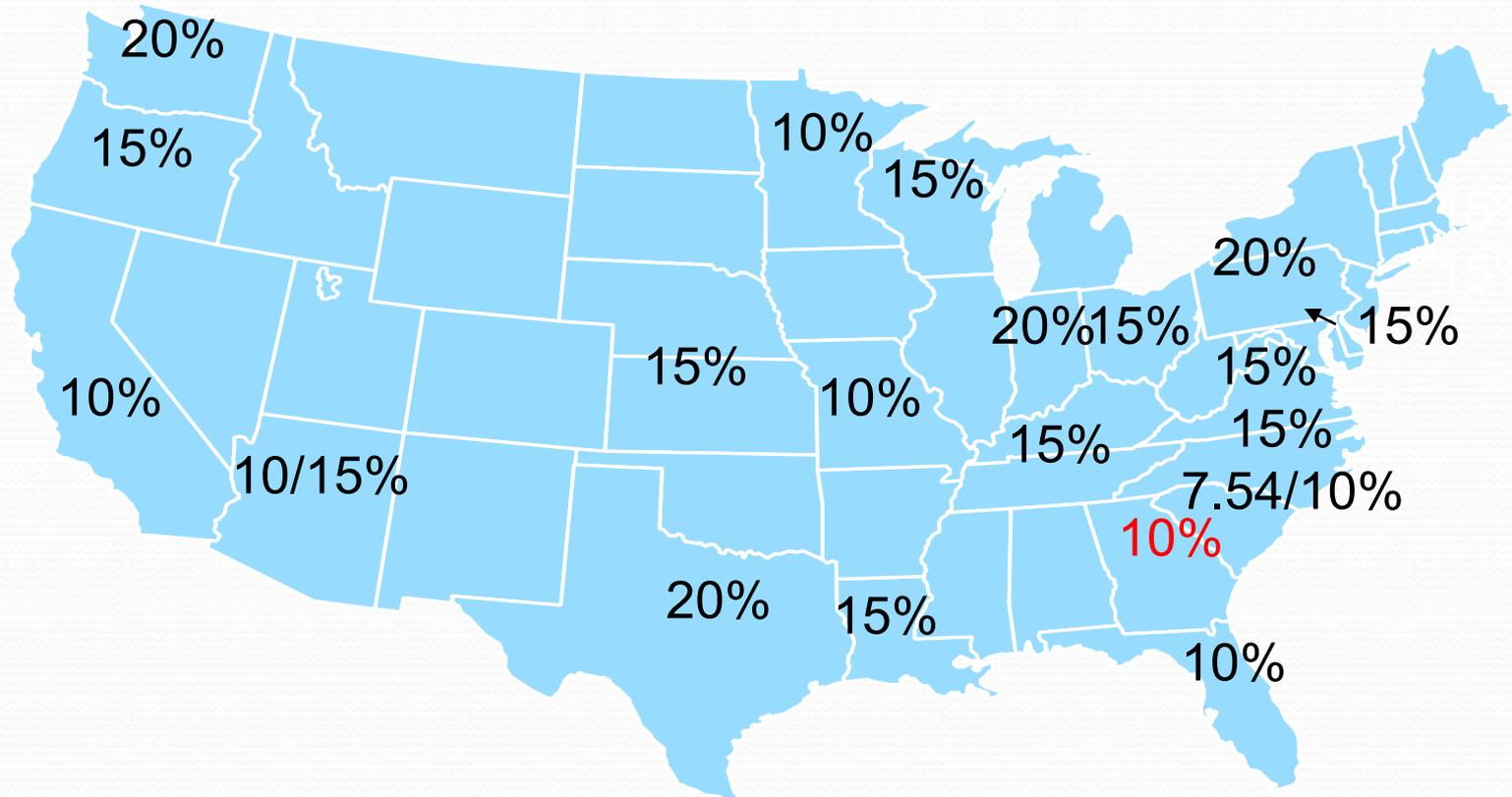


Released Thursday, July 27, 2006

<http://drought.unl.edu/dm>

Author: C. Tankersley/L. Love-Brotak, NOAA/NESDIS/NCDC

# State Regulations



“A better system of accounting is needed to instill better accountability in drinking water utilities”

# Water Loss in the Past: unstructured, reactive

- No consistent definitions for the various components of use or loss have been employed
- Worldwide, no standard definition has been found to exist for the term “unaccounted-for” water
- Percentage indicators have been found to be suspect in measuring technical performance
- Percentage indicators translate nothing about water volumes and costs
- Many water utilities have no active functions to assess or control losses

# Better Understanding Real Losses

- Most leakage losses by volume over the course of the year occur on customer service connection piping – not water mains
- Policies that place the burden on customers to repair leaks on their service connections are often inefficient
- New policies/programs to address service line leakage are needed to economically reduce this leakage

# Water Loss Control Improvements: Controlling Apparent Losses

- Measurement Technology
  - Accurate production & customer meters
  - Refined datalogging capability
  - Automatic Meter Reading gaining in use
- Improved Information Management
  - Customer Billing Systems
- Rational Policies
  - Service provision
  - Unauthorized consumption
  - Billing procedures
  - Use of fire hydrants

# Project Scope

0. Administration and Management
1. Collect and Review Data
2. Kick-off Meeting with MWDOC
3. Kick-off Meeting with Participating Systems
4. Complete Data Analysis and Formatting for IWA/AWWA Water Audit Software

# Project Scope

5. Conduct Leakage Management Program and Systems Operation Review
6. Perform Field Measurement Activities
7. Prepare Retail System Water Audit Reports
8. Recommend Follow-Up Activities for Improved Water Loss Management
9. Complete Project Report





# AWWA M36 Revision 3 Draft

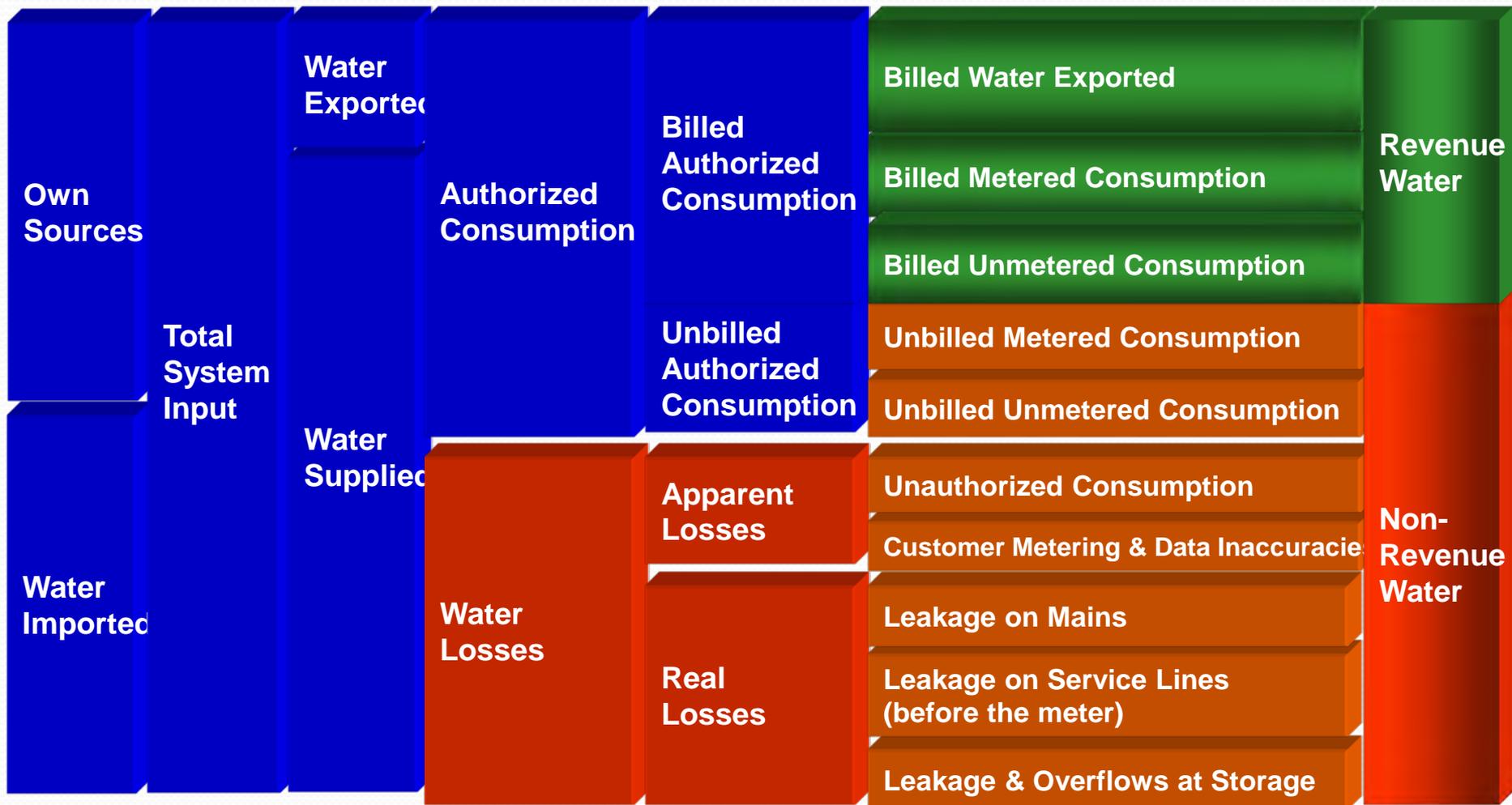
- Draft dated October 2007
- Explains the IWA/AWWA water audit methodology
- Provided an overview of the best loss control techniques

# AWWA M36 Revision 3 Draft

Contents Include:

- Conducting the Water Audit
- Identifying & Controlling Apparent Losses
- Understanding & Controlling Real Losses
- Planning & Sustaining the Water Loss Control Program
- Considerations for Small Systems

# Standard Water Balance Format



# Water Balance Spreadsheet Software

- Launched April 2006
- Available for FREE download at:  
<http://www.awwa.org/WaterWiser/waterloss/Docs/WaterAuditSoftware.cfm>
- Simple, user friendly: good for top-down audit
- “Beta tested” by 21 water utilities during 2005
- AWWA Water Loss Control Committee provides user support for the software and plans future upgrades

# Consultant Data Request

- Date needed to populate the Water Balance Spreadsheet Software and to make recommendations for water loss management activities.
- Date needed by: **June 4<sup>th</sup>**
- Please send to Richard Bell ([rbell@mwdoc.com](mailto:rbell@mwdoc.com)) or Steve Davis ([sdavis@pirnie.com](mailto:sdavis@pirnie.com)).

# Consultant Data Request

- Is the utility a party to the CUWCC MOU?
- Does the utility conduct an annual audit? If so, what method or format?
- Does the utility have a meter testing/repair shop? If not, is this contracted?

# Consultant Data Request

- Water Supply Sources
  - Water supply sources, locations, and meter designations
  - Capacity and type/size/age/manufacturer of supply meter
  - Calibration frequency and by whom
  - Calibration reports

# Consultant Data Request

- Water Supply Costs
  - Production cost per unit (\$/ mil gal) for water produced by the system.
  - Cost to purchase each unit (\$/mil gal) of MWDOC water.

# Consultant Data Request

- Water Supply/Production Data
  - Monthly metered supply data by each source for the past 3 fiscal years
  - Table showing values in cubic feet per second (cfs)
  - Table showing values in acre-feet
  - Table showing values in million gallons
  - Monthly metered supply data by each source for July thru December 2007

# Consultant Data Request

- Water Billing Data
  - Volume of billed consumption for past 3 fiscal years
    - Monthly by customer class
    - Monthly by meter size
  - Volume of billed consumption for July thru December 2007
- Unbilled Authorized Water Consumption
  - Fire fighting, fire training, fire hydrant flow tests, main flushing, hydrant flushing, street cleaning, public irrigation, public buildings, etc.

# **Water Loss Management Program Assessment**

## **Potable Water System Audits**

**December 17, 2008**

**MALCOLM  
PIRNIE**

# Agenda

- **Introductions/Project Status**
- **Authorized Unmetered Consumption**
  - a. **Types**
  - b. **Utility procedures, methods, and sources of data**
  - c. **Discuss options that can improve estimates**
- **Water Meters**
  - I. **Meter inventories**
  - II. **Accuracy test data and methods**
  - III. **Demand characterization**
  - IV. **Meter replacement criteria**
    - **Age**
    - **Cumulative Volume**
- **Next Meeting Date**



# Contact Information

- **Richard Bell, MWDOC, Principal Engineer/Project Manager**
  - (714) 593-5003
  - [rbell@mwdoc.com](mailto:rbell@mwdoc.com)
- **Steve Davis, Malcolm Pirnie, Inc., Project Manager**
  - (949) 450-7948
  - [sdavis@pirnie.com](mailto:sdavis@pirnie.com)
- **Andree Hunt, Malcolm Pirnie, Inc., Project Scientist**
  - (949) 450-7939
  - [ahunt@pirnie.com](mailto:ahunt@pirnie.com)

# Overview of Future Consultant/Agency/MWDOC Responsibilities

Task	Malcolm Pirnie	Agencies	MWDOC
<i>Task 1-3: Complete</i>			
<b>Task 4: Conduct Leakage Management Program and Systems Operation Review</b>	<ul style="list-style-type: none"> <li>• Review leak history and management information gathered from each system.</li> <li>• Perform component analysis to model leakage volumes.</li> <li>• Recommend improvements to each leak management program.</li> </ul>	<ul style="list-style-type: none"> <li>• Provide requested information regarding leakage detection and management.</li> </ul>	
<b>Task 5: Perform Relevant Field Measurement and Activities</b>	<ul style="list-style-type: none"> <li>• Recommend field measurement activities.</li> <li>• Perform statistical analyses on data collected.</li> <li>• Contract with field services firm to perform field measurement activities.</li> </ul>	<ul style="list-style-type: none"> <li>• Recommend locations for field measurements.</li> </ul>	<ul style="list-style-type: none"> <li>• Obtain testing equipment.</li> <li>• Approve subcontractor to perform field measurement activities.</li> </ul>

Task	Malcolm Pirnie	Agencies	MWDOC
<b>Task 6: Prepare Retail System Water Audit Reports</b>	<ul style="list-style-type: none"> <li>• Document water audit results and findings for each utility.</li> </ul>		
<b>Task 7: Provide Recommendations for Follow-Up Activities for Improved Water Loss Management</b>	<ul style="list-style-type: none"> <li>• Recommend activities to reduce apparent and real water losses and to assess the economic feasibility of water loss reduction activities.</li> </ul>		
<b>Task 8: Complete Project Report</b>	<ul style="list-style-type: none"> <li>• Prepare a draft report documenting data collected, audit results, leakage management program assessments, and field data collection results and analysis.</li> </ul>	<ul style="list-style-type: none"> <li>• Provide comments on draft report</li> </ul>	<ul style="list-style-type: none"> <li>• Provide comments on draft report</li> </ul>

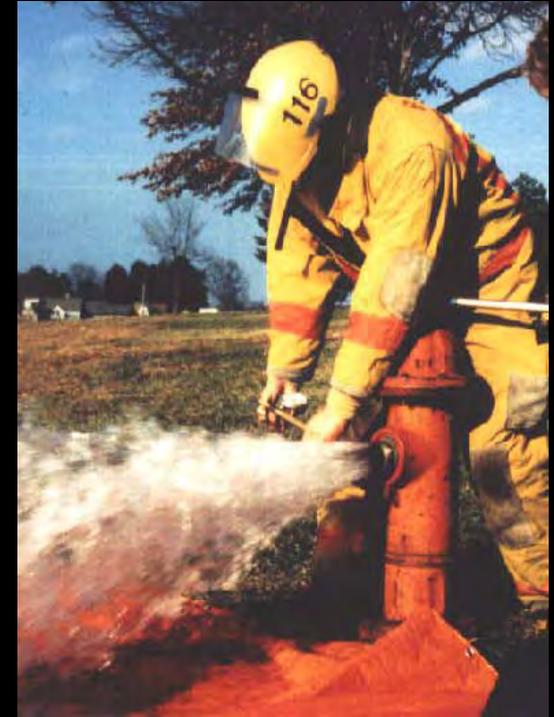
# Water Audit Results

	Moulton	Laguna	Tustin	Brea	Huntington
<b>SYSTEM DATA</b>					
Length of mains:	740	134	172	162	590
Number of <u>active AND inactive</u> service connections:	53,533	7979	14,124	11745	52,300
Connection density:	72	60	82	72.5	89
Average length of customer service line:	20	20	20	20	20
Average operating pressure:	?	?	50.0	?	63.00
<b>COST DATA</b>					
Total annual cost of operating water system:	?	8,824,547	11,649,391	11,118,011	29,000,000
Customer retail unit cost (applied to Apparent Losses):	?	?	1.99	?	1.39
Variable production cost (applied to Real Losses):	?	?	379.64	?	358.00

# C. Unbilled Unmetered Authorized Consumption

The most common occurrences include:

- Firefighting, hydrant testing, and training
- Flushing water mains, storm inlets, and sewers
- Street cleaning
- Landscaping/irrigation
- Decorative water facilities
- Construction sites
- Water consumption at public buildings not included in the customer billing system.



# Quantifying Unmetered Water Usage

## Methodologies

- I. Portable Meters
- II. Estimation Methods
  - General estimation techniques
  - Practical assessments



# I. Portable Meters

If no meters exist at a water source, a portable meter can be used to estimate flow.

- Portable meters can be brought to the site and installed on source piping just downstream of the water source.
- A minimum of 24 hours of continuous metering is recommended.



# I. Portable Meters

One such meter is a portable, non-invasive, ultrasonic water meter:

- Clamps onto outside of the pipe
- Uses ultrasound to measure water flow in the pipe
- Requires a pipe diameter of at least 1.5 inches
- Does not perform well on some PVC piping

## II. Estimation Methods

**If a portable meter is not feasible, estimation and practical assessments should be made.**

- **Use a default value of 1.25% of water supplied for the entire authorized unmetered category.**
- **The California Department of Water Resources used 1-2% of the average total metered use for the previous 5 years to estimate their unmetered water usage for fire and line flushing.**

## II. Estimation Methods

If consumption is significantly greater than the default value, obtain detailed estimates through:

- i. Batch Procedure
- ii. Discharge Procedure
- iii. Comparison Procedure



## **i) Batch Procedure**

**Used when water is transported by tank truck or container.**

- **Multiply the volume of the tank/container by the number of times it is filled from the distribution system.**
- **Careful record keeping is necessary for accurate estimates:**
  - **What is the number of trucks in operation?**
  - **What is the volume of water a truck transports?**
  - **The street cleaning and sewer flushing departments should be able to provide the necessary data.**

## ii) Discharge Procedure

**When water is applied directly from a pipe , sprinkler system, fire hydrant, etc .**

- **Multiply the rate of water discharge by the total time it flows.**
- **Example: fire flows = # of events x flow rate x duration.**
- **Multiply the flow rate of a garden hose in gallons per minute times the number of minutes of use.**
- **When water pump performance characteristics are known, a volume estimate can be derived by multiplying the number of hours that the pump was operated during the year by the average pumping rate.**

### iii) Comparison Procedure

For some facilities and areas, such as schools, swimming pools, and construction sites, consumption figures may be adapted from similar facilities elsewhere.

- By comparing facilities, an estimate can be developed.
- Better estimates result if the facility has similar:
  - Size
  - Hours of operation
  - Type of use
  - Landscaping
  - Most other details



# Authorized Unmetered Consumption Recommendations

**According to the AWWA WLCC water audit guidelines, authorized unmetered consumption in most water utilities is a small component, which is very often substantially overestimated.**

- This component has many sub-components of water use which are often tedious to identify and quantify.**
- Because of this and the fact that it is usually a small portion of the water supplied, it is recommended that the auditor apply the default value of 1.25% of the volume from own sources.**
- If the water utility already has well-validated data that gives a value substantially higher/lower than the default volume, this value can be entered.**

# Customer Water Meters

## I. Meter inventories

I. Size

II. Manufacturer

III. Age (years in service)

IV. Cumulative volume by meter

## II. Accuracy test data and methods

I. Existing meter accuracy testing procedures and results

## III. Replacement Criteria

I. Age, cumulative volume, or accuracy level at which a meter is replaced

II. Cost for meter replacement



# DEMAND CHARACTERIZATION

## Meter-Master 100EL



# METER-MASTER CHARACTERISTICS

## FEATURES

- *Quick/Easy Setup*
- *Portable*
- *Rugged*
- *High Resolution*
- *Securable*
- *Submersible*
- *Accuracy Verification*
- *RF Communications*
- *Standard Pulse Input*
- *Dual Memory Options*
- *Universal Compatibility*

## APPLICATIONS

- *Customer Service*
- *Billing Disputes*
- *Meter Sizing*
- *Meter Maintenance*
- *Conservation*
- *Hydraulic Modeling*
- *Demand Monitoring*
- *Cost of Service Studies*
- *Water Audits*

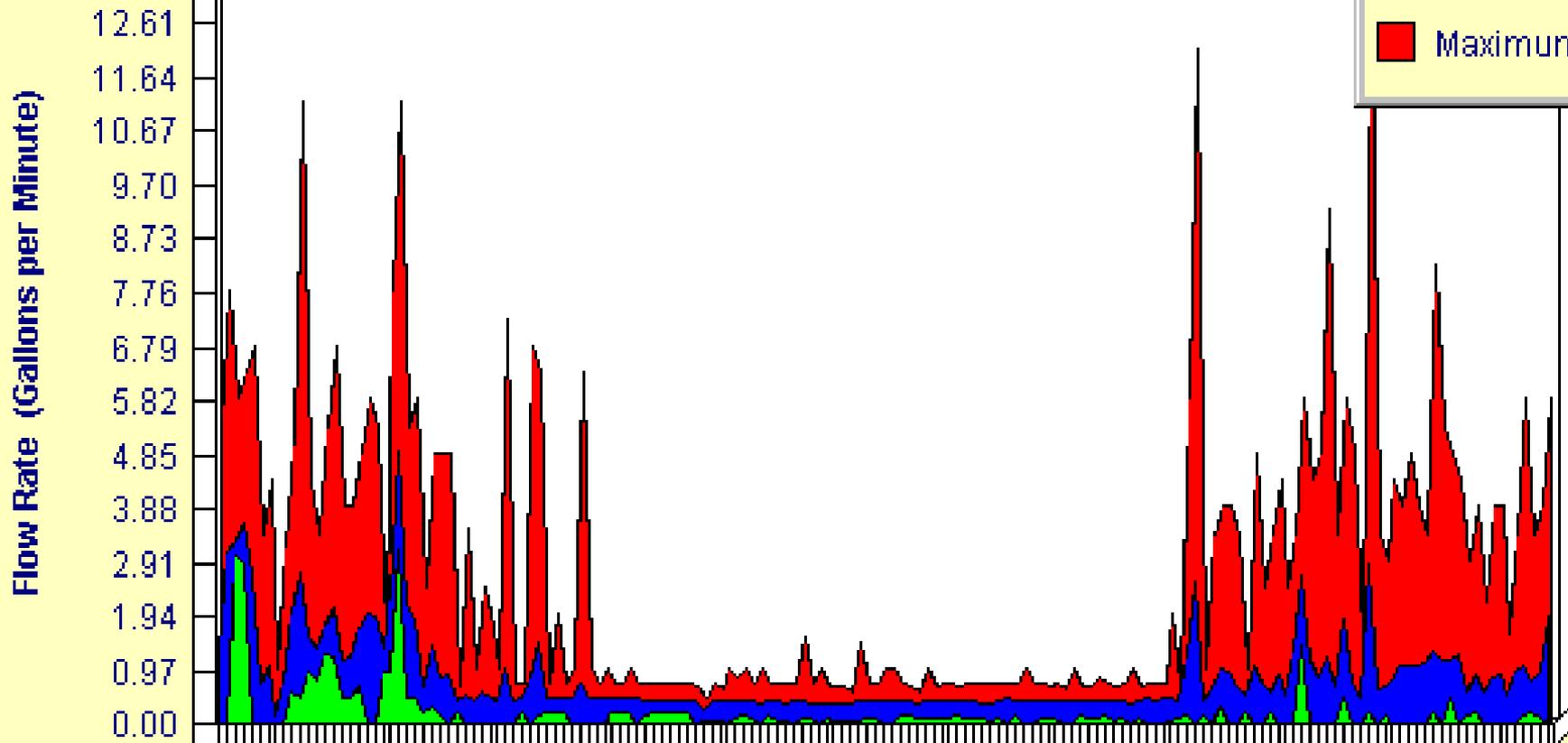




# Medical Products, Inc.

Legend

- Minimum
- Average
- Maximum



6/8/95 1:54:36 PM to 6/9/95 2:12:36 PM

Exit

Help

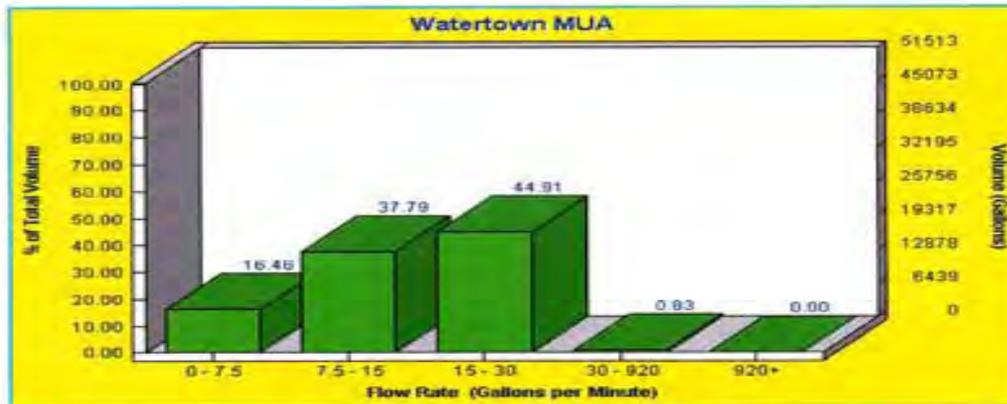
# Flow Report

## Location Information

ID 11075  
 Name Watertown MUA  
 Address Cooper Road  
 City Evanston  
 State/Prov Pennsylvania  
 Postal Code 19002  
 Phone 888-388-3569  
 Notes Meter Size Check

## Meter Information

Make Sensus  
 Model Turbo  
 Size W-2000  
 Unit Gallons



## Flow Range

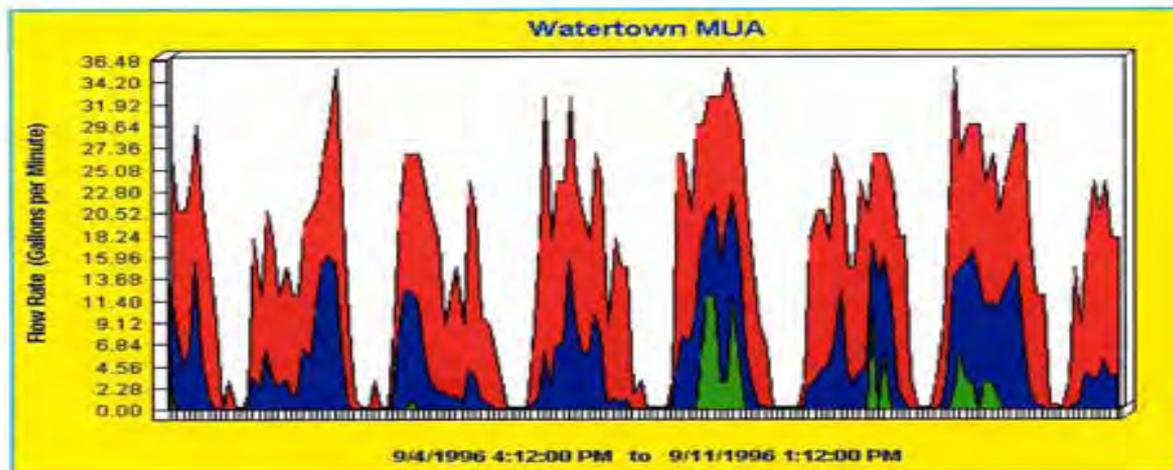
0 - 7.5  
 7.5 - 15  
 15 - 30  
 30 - 920  
 920+

## Percentage

16.46  
 37.79  
 44.91  
 0.83  
 0.00

## Volume

8,480.84  
 19,467.85  
 23,134.25  
 429.63  
 0.00



One  
 Week  
 Flow  
 Report

% and  
 Volume  
 In each  
 Flow  
 Range

**City of Scottsdale, AZ  
Residential Water Meter Study**

**December 2008**

Percent Flow in Each Flow Range by Meter Size- Normalized Average

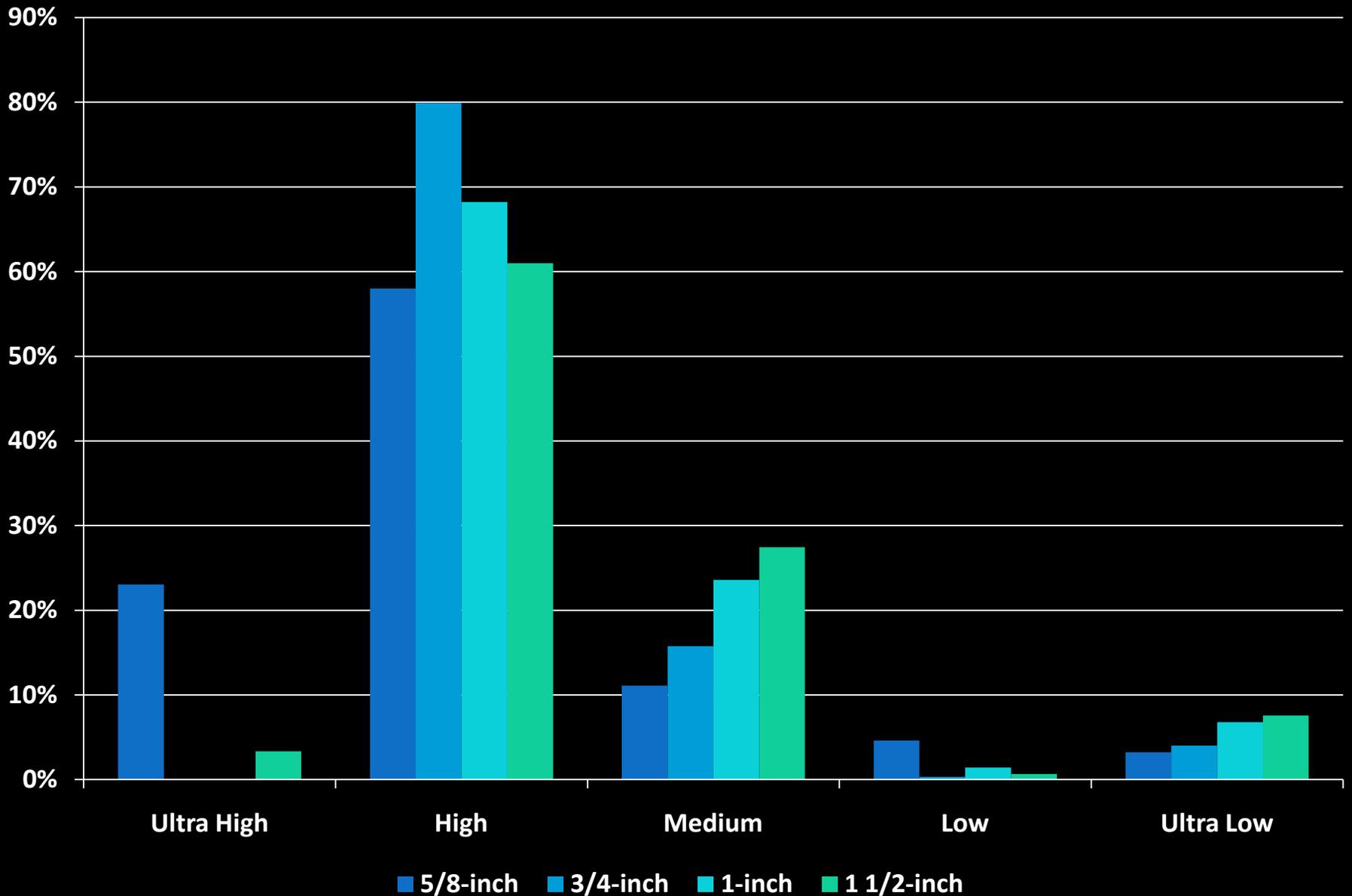
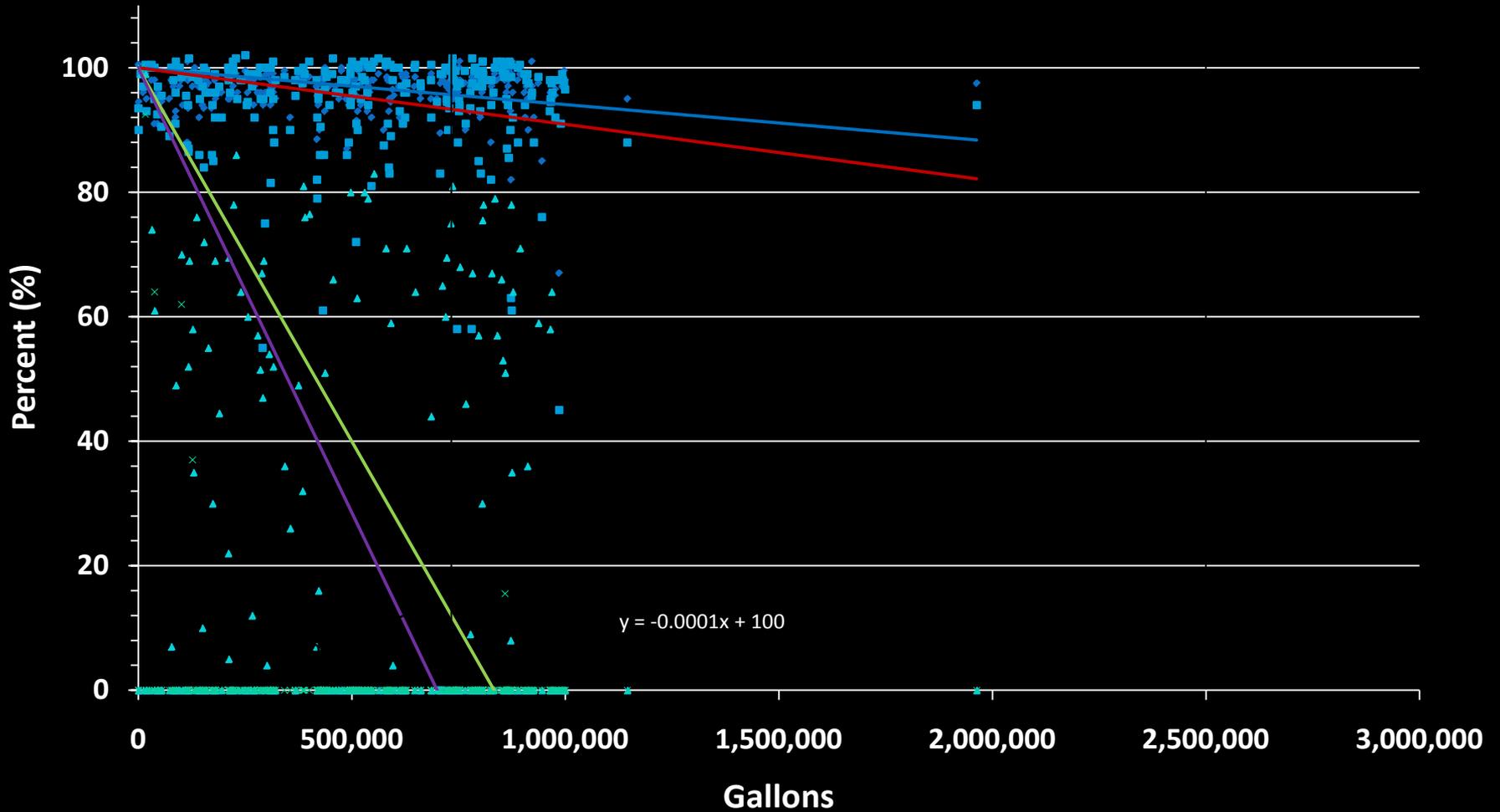
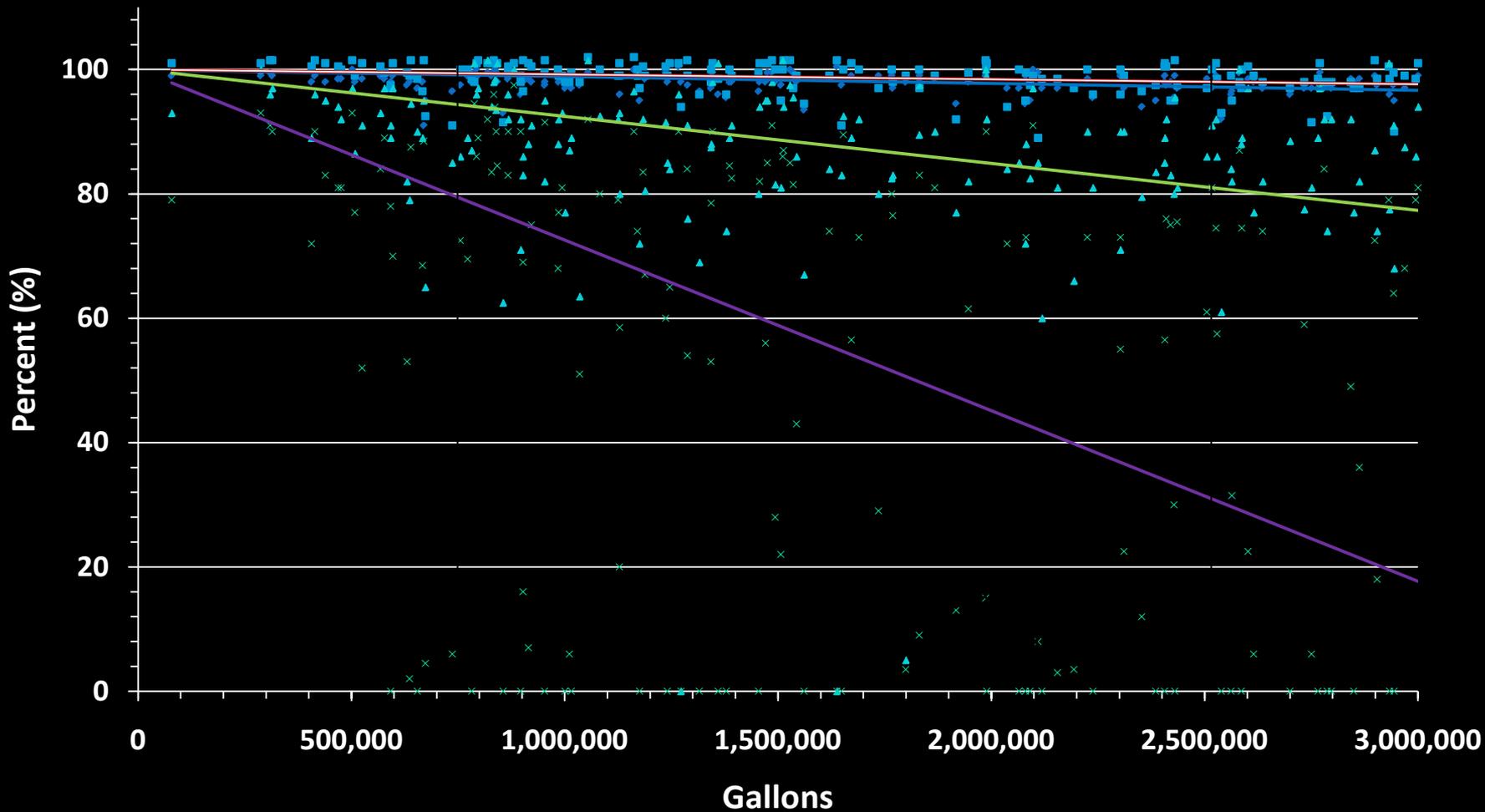


Figure 4.1: 5/8-Inch Meters Cumulative Flow vs. Accuracy



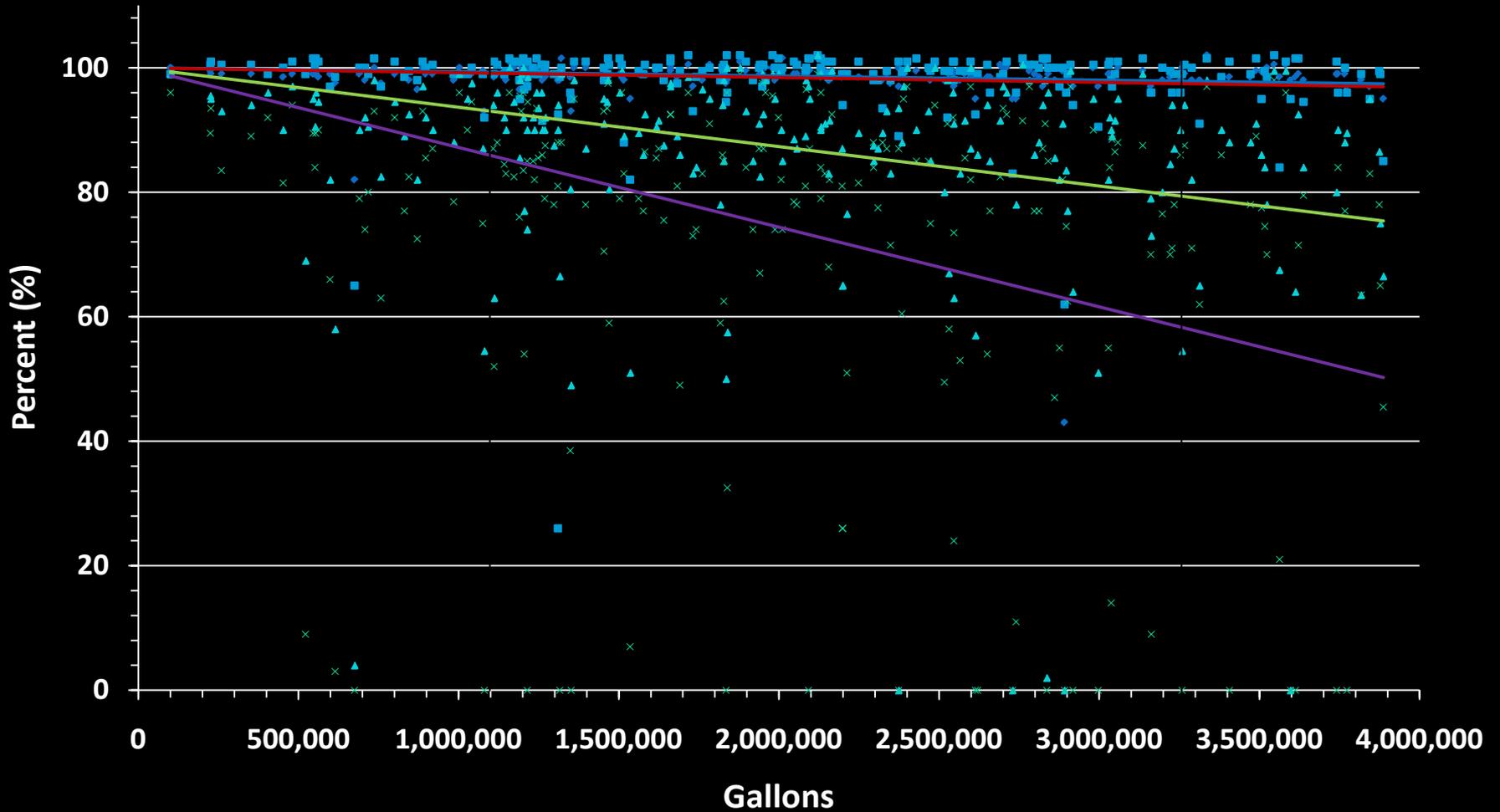
- ◆ High Flow
- Medium Flow
- ▲ Low Flow
- × Ultra Low Flow
- Linear (High Flow)
- Linear (Medium Flow)
- Linear (Low Flow)
- Linear (Ultra Low Flow)

Figure 4.2: 3/4-Inch Meters Cumulative Flow vs. Accuracy



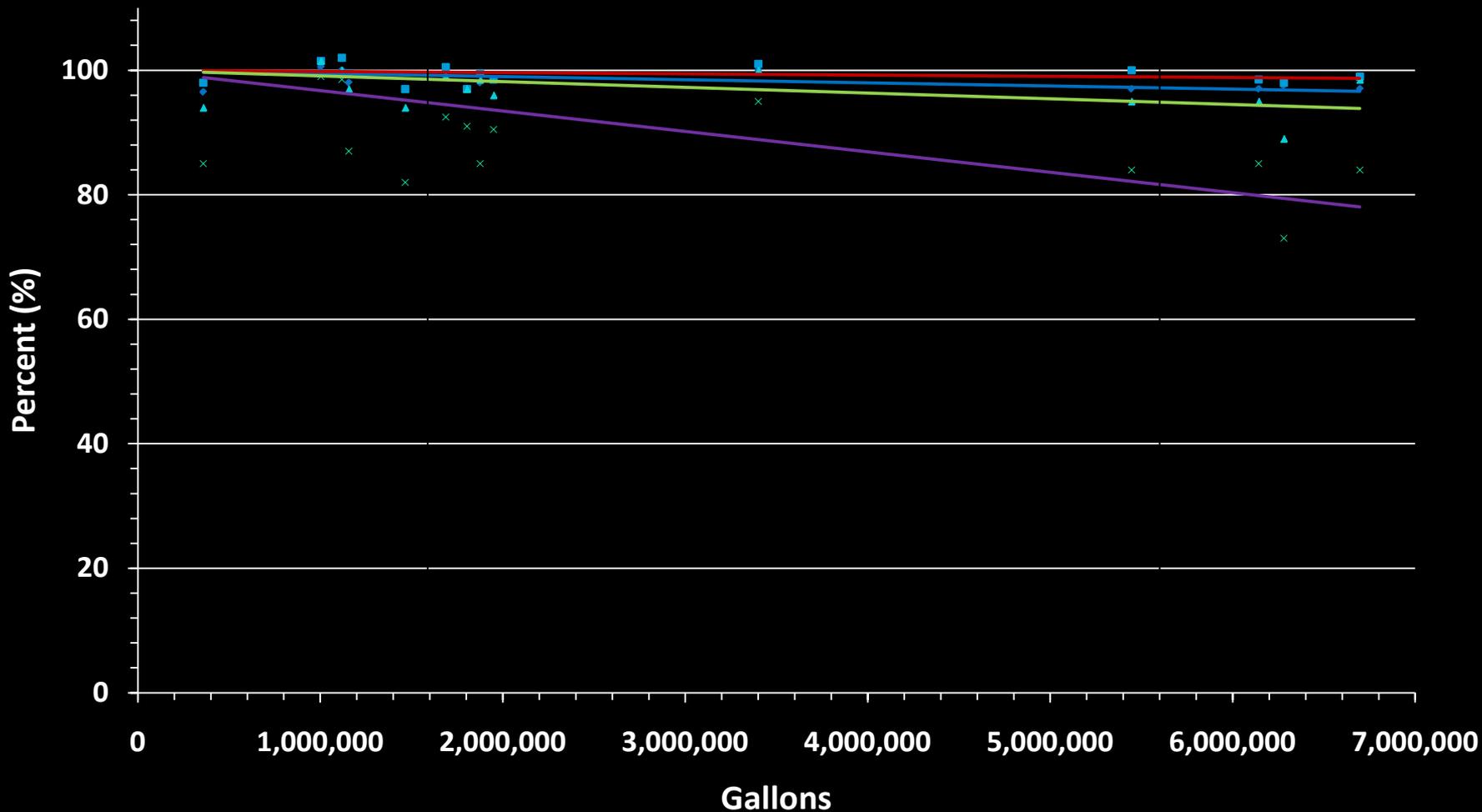
- ◆ High Flow
- Medium Flow
- ▲ Low Flow
- × Ultra Low Flow
- Linear (High Flow)
- Linear (Medium Flow)
- Linear (Low Flow)
- Linear (Ultra Low Flow)

Figure 4.3: 1-Inch Meters Cumulative Flow vs. Accuracy



- ◆ High Flow
- Medium Flow
- ▲ Low Flow
- × Ultra Low Flow
- Linear (High Flow)
- Linear (Medium Flow)
- Linear (Low Flow)
- Linear (Ultra Low Flow)

Figure 4.4: 1 1/2-Inch Meters Cumulative Flow vs. Accuracy



- ◆ Hi test
- Med test
- ▲ Low test
- × Extra low test
- Linear (Hi test)
- Linear (Med test)
- Linear (Low test)
- Linear (Extra low test)

# Next Meeting Date

January 2009?



# Questions/Discussion



# **MWDOC Water Loss Control: CUWCC BMP 1.2 Workshop**

**Stephen E. Davis, P.E., BCEE  
Vice President  
Malcolm Pirnie, Inc  
Irvine, CA**

**October 13, 2009**

**MALCOLM  
PIRNIE**

# Meeting Contents

- ▶ **Project Tasks**
    - **Consultant To-Do List**
    - **Agency To-Do List**
  - ▶ **Changes to Water Audit Methodology**
    - **AWWA Water Audit Software Version 4.0**
    - **Data Validation Scoring**
  - ▶ **BMP 1.2 Water Loss Control- Status and Overview**
  - ▶ **Field Work Recommendations**
- 

# Contact Information

- **Richard Bell, MWDOC, Principal Engineer/Project Manager**
    - (714) 593-5003
    - [rbell@mwdoc.com](mailto:rbell@mwdoc.com)
  - **Steve Davis, Malcolm Pirnie, Inc., Project Manager**
    - (949) 450-7948
    - [sdavis@pirnie.com](mailto:sdavis@pirnie.com)
  - **Andree Hunt, Malcolm Pirnie, Inc., Project Scientist**
    - (949) 450-7939
    - [ahunt@pirnie.com](mailto:ahunt@pirnie.com)
- 

# Overview of Future Consultant/Agency/MWDOC Responsibilities

Task	Malcolm Pirnie	Agencies	MWDOC
<i>Task 1-3: Complete</i>			
<b>Task 4:</b> Conduct Leakage Management Program and Systems Operation Review	<ul style="list-style-type: none"> <li>• Review leak history and management information gathered from each system.</li> <li>• Perform component analysis to model leakage volumes.</li> <li>• Recommend improvements to each leak management program.</li> </ul>	<ul style="list-style-type: none"> <li>• Provide requested information regarding leakage detection and management.</li> </ul>	
<b>Task 5:</b> Perform Relevant Field Measurement and Activities	<ul style="list-style-type: none"> <li>• Recommend field measurement activities.</li> <li>• Perform statistical analyses on data collected.</li> <li>• Contract with field services firm to perform field measurement activities.</li> </ul>	<ul style="list-style-type: none"> <li>• Recommend locations for field measurements.</li> </ul>	<ul style="list-style-type: none"> <li>• Obtain testing equipment.</li> <li>• Approve subcontractor to perform field measurement activities.</li> </ul>

Task	Malcolm Pirnie	Agencies	MWDOC
<b>Task 6: Prepare Retail System Water Audit Reports</b>	<ul style="list-style-type: none"> <li>• Document water audit results and findings for each utility.</li> </ul>	<ul style="list-style-type: none"> <li>• Reformat in new AWWA software with data validation</li> </ul>	
<b>Task 7: Provide Recommendations for Follow-Up Activities for Improved Water Loss Management</b>	<ul style="list-style-type: none"> <li>• Recommend activities to reduce apparent and real water losses and to assess the economic feasibility of water loss reduction activities.</li> </ul>		
<b>Task 8: Complete Project Report</b>	<ul style="list-style-type: none"> <li>• Prepare a draft report documenting data collected, audit results, leakage management program assessments, and field data collection results and analysis.</li> </ul>	<ul style="list-style-type: none"> <li>• Provide comments on draft report</li> </ul>	<ul style="list-style-type: none"> <li>• Provide comments on draft report</li> </ul>

# Agency To Do List

- ❑ **Complete/review spreadsheet audit**
- ❑ **Complete Water Audit Data Validity Score**
- ❑ **Confirm field work needs**
  - **Report/document existing activities**

# Validation of Data

- ▶ Top-down audit is considered preliminary
- ▶ Grading system assists in data validation
- ▶ Validation questions or confirms preliminary water audit data
- ▶ Assessment of results determines areas of focus

***Successful water loss management  
requires valid data!***



# *Spreadsheet-Based Water Loss Audit Tool*

**•The Old ----**



**•The New!**



# **AWWA Free Water Audit Software**

- ▶ **April 2006 First commercial version of software 2.0**
  - ▶ **August 2007 Second version of software 3.0**
  - ▶ **April 2009, M36 Third Edition published**
  - ▶ **May 2009, Software Version 4.0 published**
- 

# **AWWA WLCC Water Audit Software- What's New?**

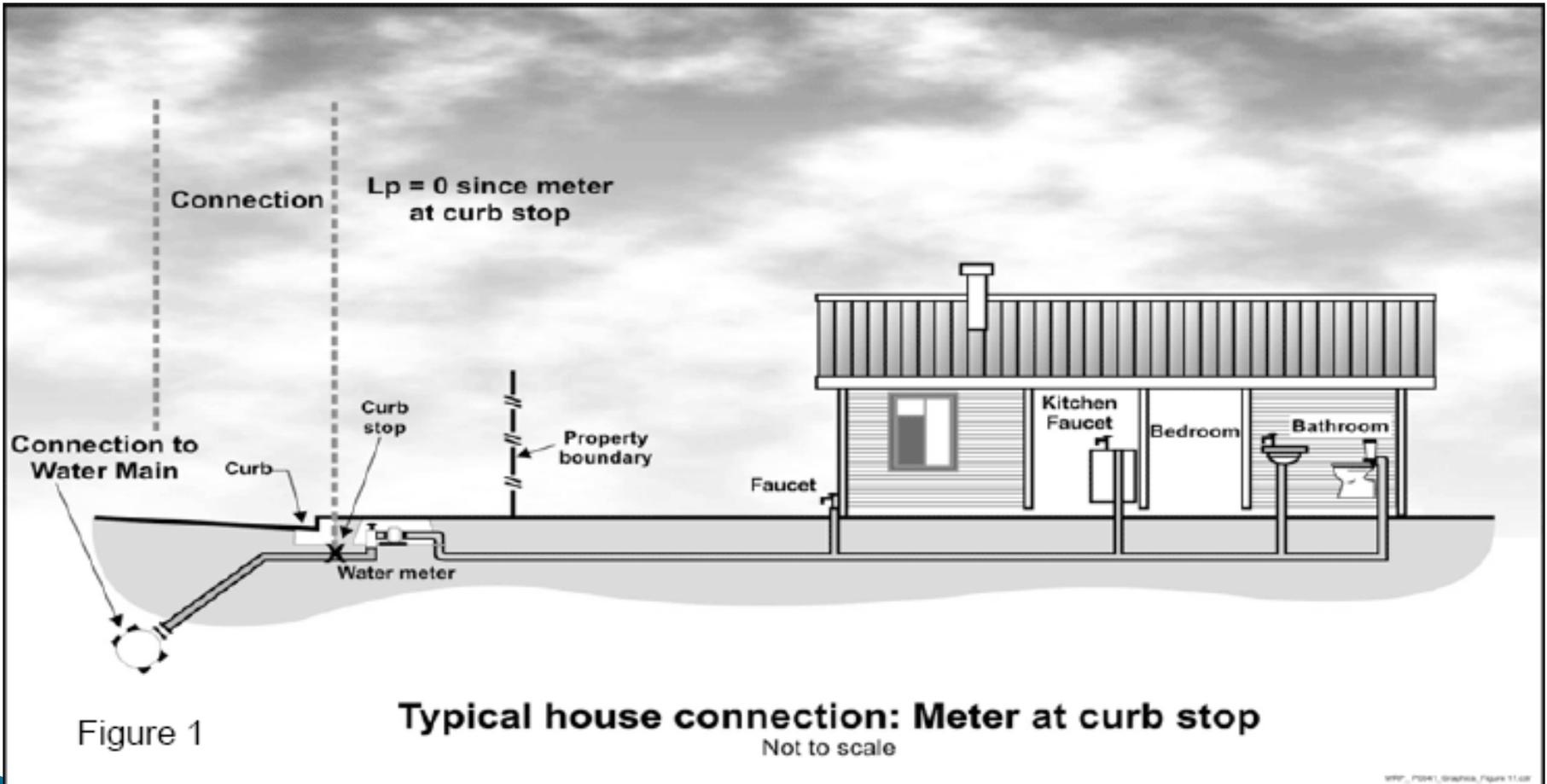
## ***Water Audit Data Validity Score***

- ▶ **Provides a label for the “quality” of the data**
  - ▶ **Data grading capability is a significant enhancement from previous versions**
- 

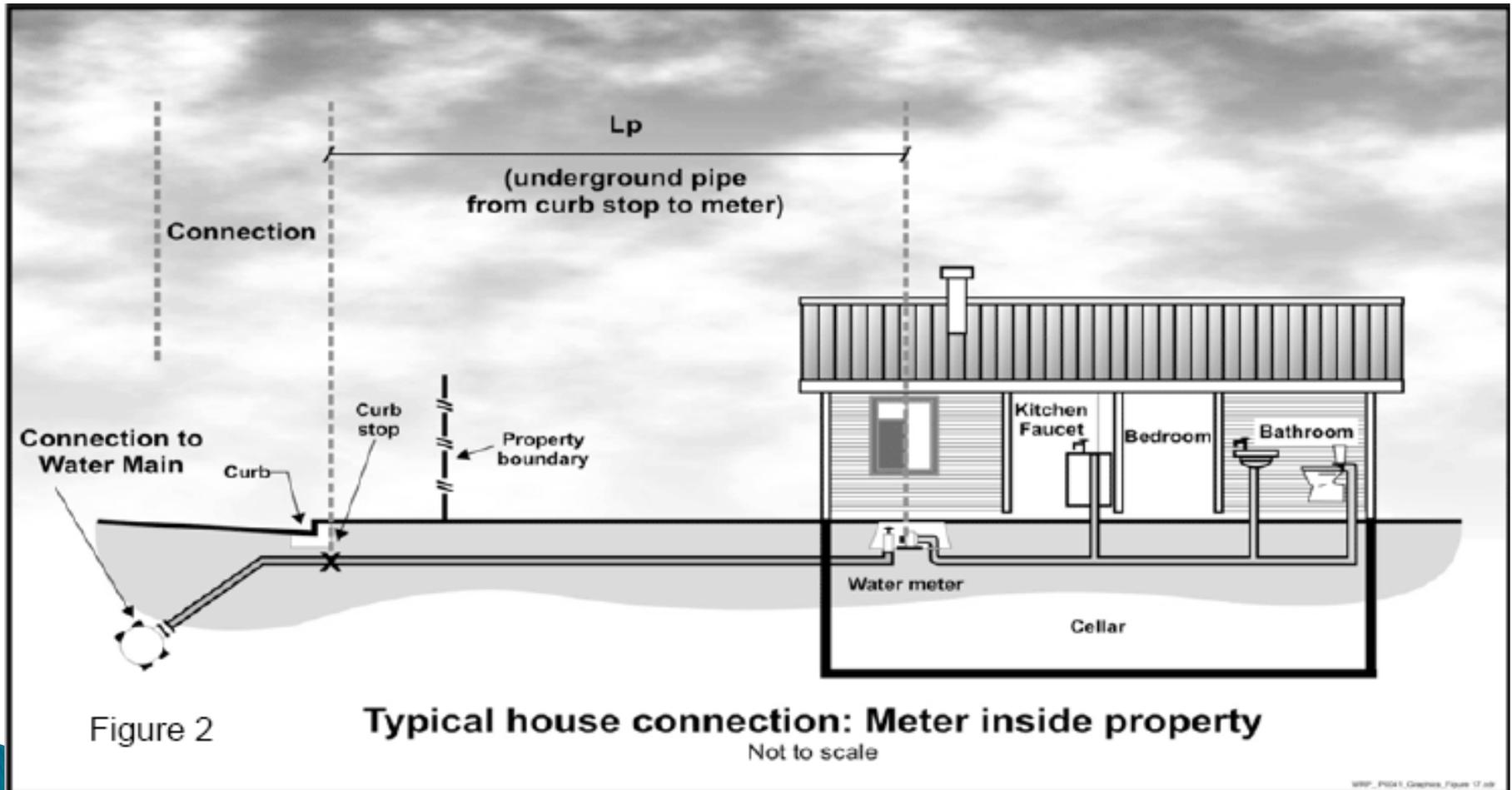
# Water Audit Data Validity Score

- ▶ **Grades assigned to each data component to describe auditor confidence and accuracy of input data with explicit defined criteria**
- ▶ **Audit accuracy improved most by improving the confidence in the following audit inputs:**
  - **Volume from own sources (metering)**
  - **Water imported (metering)**
  - **Billed metered consumption (metering)**

# Customer Service Line Diagram: Meter at Curb Stop



# Customer Service Line Diagram: Meter Inside Property



# Water Supplied Data Confidence

**For optimum confidence and accuracy:**

- ▶ **Meter 100% of production and imported sources**
  - ▶ **Conduct semi-annual accuracy testing and calibration**
  - ▶ **Less than 10% of source meters outside of  $\pm 3\%$  accuracy**
- 

# Consumption Data Confidence

**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 4.0- Need to determine based on meter data**
  - ▶ **Consider cumulative volume, meter size, and meter type**
  - ▶ **Longevity specific to utility water quality**
- 

# 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)**
- 

# What Do We Do With The Audit Data?

- ▶ **Don't predetermine a solution to an undefined problem.**
  - ▶ **The audit defines the problem.**
  - ▶ **Focus on high value losses and supply losses as determined by the audit.**
  - ▶ **Separate apparent loss problems from real loss problems.**
- 

# **CUWCC BMP 1.2 Water Loss Control**

- ▶ **Revision to the CUWCC's water audits BMP, formerly know as BMP 3 System Water Audits, Leak Detection and Repair**
  - ▶ **Presented at the June 11 CUWCC Plenary Meeting**
  - ▶ **Revised by the Steering Committee on August 13<sup>th</sup> to address MOU signatory comments**
  - ▶ **Voting ended September 15<sup>th</sup> – Mods Passed**
- 

# A. Implementation Sequence

1. **Standard Water Audit & Water Balance**
  2. **Validation**
  3. **Economic Values**
  4. **Component Analysis**
  5. **Interventions**
  6. **Customer Leaks**
- 

## B. Implementation Schedule

1. For Agencies signing the MOU after Dec. 31, 2008, implementation shall commence no later than July 1 of the year following the year the agency signed the MOU
  - a. Agencies shall provide a full BMP 1.2 report for the first reporting period after implementation and for each reporting year thereafter.
  
2. A benchmark for the performance indicator in terms of water loss standard will be determined after the first 4 years data collected based upon the data reported by agencies. The performance indicator and benchmark will be voted upon by the Council by year 6 of this revision. Ongoing data collection and data reporting requirements will be decided upon as part of this process.

# C. Coverage Requirements

- 1. Agencies to compile the standard water audit and balance annually using the AWWA Software. Beginning in the 2nd year of implementation, agencies to test source, import, and production meters annually.**

## C. Coverage Requirements (Cont.)

- 2. Agencies shall improve the data accuracy and data completeness of the standard water balance during the first four years of implementation. Agencies shall achieve a Water Audit Data Validity score of 66 or higher using the AWWA software no later than the end of the first four-year period and shall achieve a Data Validity Level IV no later than the end of the 5<sup>th</sup> year of implementation. Estimations for data that are not directly measured should be improved using the methods outlined by the AWWA.**

## C. Coverage Requirements (Cont.)

- 3. Agencies shall seek training in the AWWA water audit method and component analysis process (offered by CUWCC or AWWA) during the first four years of BMP implementation. They shall complete a component analysis of real losses by the end of the fourth year and update this analysis no less frequently than every four years.**
- 

## C. Coverage Requirements (Cont.)

4. **Beginning in the fifth year of implementation, through the tenth year of implementation, agencies shall demonstrate progress in water loss control performance as measured by the AWWA software real loss performance indicator “gallons per service connection per day” (or “gallons per mile of mains per day” if system density is less than 32 service connections per mile) by one of the following:**
  - a. **Achieving a performance indicator score less than the agency’s score the previous year (gallons per day per connection);**
  - b. **Achieving a performance indicator score less than the average of the agency’s scores for the previous three years; or**
  - c. **In year 6 and beyond, reducing real losses to or below the benchmark value determined in the Council’s process referenced in section B2.**

## **C. Coverage Requirements (Cont.)**

- 5. Agencies shall repair all reported leaks and breaks to the extent cost effective. By the end of the second year, agencies shall establish and maintain a record-keeping system for the repair of reported leaks, including time of report, leak location, type of leaking pipe segment or fitting, and leak running time from report to repair. By the end of the fourth year, agencies shall include estimated leakage volume from report to repair and cost of repair (including pavement restoration costs and paid-out damage claims, if any).**
  - 6. Agencies shall locate and repair unreported leaks to the extent cost effective.**
- 

## **D. Requirements for Documenting BMP Implementation**

- 1. Agency shall submit the completed AWWA Standard Water Audit and Water Balance worksheets in the BMP 1.2 report form every reporting period.**
- 2. For each reporting period, agency shall keep and make available validation for any data reported.**
- 3. Agency shall maintain in-house records of audit results and methodologies and shall incorporate results into future annual standard water balances.**
- 4. Agency:**
  - a. keeps records of intervention(s) performed, including standardized reports on leak repairs, the economic value assigned to apparent losses and to real losses, miles of system surveyed for leaks, pressure reduction undertaken for loss reduction, volumes of water saved, and costs of intervention(s); and**
  - b. prepares a yearly summary of this information for submission to the Council.**

# Summary- BMP 1.2 Implementation

Year	Coverage Requirements
1+	<ul style="list-style-type: none"><li>•Provide Full BMP 1.2 Report</li><li>•Complete audit using AWWA software</li><li>•Repair all cost-effective reported leaks and breaks</li><li>•Locate and repair unreported leaks when cost-effective</li></ul>
2+	<ul style="list-style-type: none"><li>•Test source, import, and production meters annually</li><li>•Establish/maintain a record-keeping system for the repair of reported leaks</li></ul>
4+	<ul style="list-style-type: none"><li>•Record estimated leakage volume from report to repair and cost of repair</li><li>•Achieve Data Validity Score of 66 or higher</li></ul>
5-10	<ul style="list-style-type: none"><li>•Achieve Data Validity Score AWWA Level IV</li><li>•Demonstrate progress in water loss control performance as measured by “gallons per service connection per day”</li></ul>

# Field Work- Recommendations

- ▶ **BMP 1.2 is focused on real losses (real water conservation by the utility)**
- ▶ **Field work should focus on meeting BMP 1.2 coverage requirements.**
  - **Leak detection**
  - **Component analysis**
  - **Improving data validity score**



## Proposed Service Contractor:



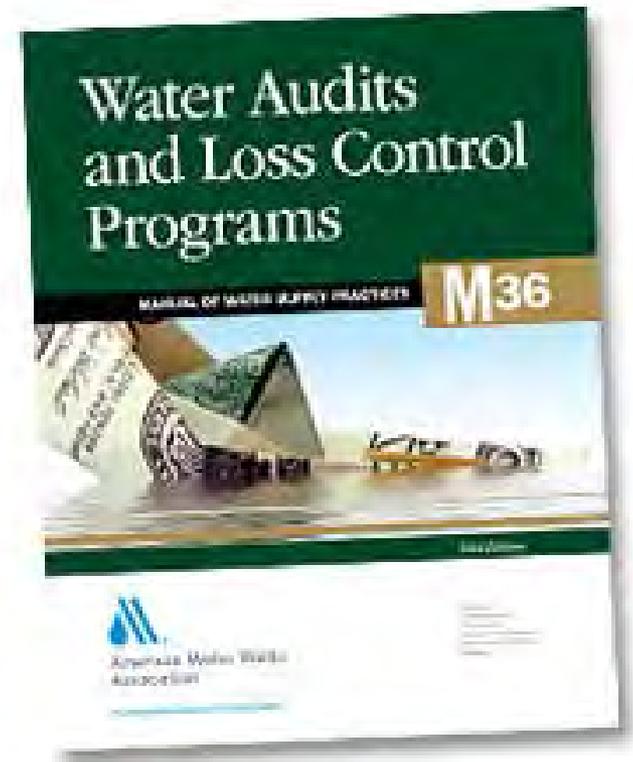
- ▶ Large water meter testing, evaluation, and maintenance
- ▶ **Water Distribution System Leak Surveys and Pin-Pointing**
- ▶ Valve Locating, Exercising and Computerized Mapping
- ▶ Fire Hydrant Testing
- ▶ Water Main Flushing
- ▶ Water Main Locating
- ▶ 24-hour Flow Testing, C-Factor Testing, Pump Curves and Head Loss

# **M36 Goals of Water Audits:**

- 1. Improve water resources management**
  - 2. Optimize revenue recovery**
  - 3. Minimize operational disruptions**
  - 4. Increase water system integrity**
- 

# AWWA M36 Background

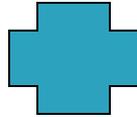
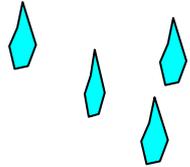
- ▶ **First edition in 1991**
- ▶ **Second edition in 1999**
  - Minor updates
- ▶ **Third edition in 2009**
  - Advances in audit methodology
  - Incorporates IWA method
  - Incorporates AWWA software



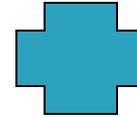
# Non-Revenue Water

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

Real Losses



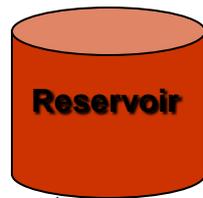
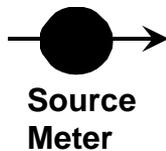
Apparent Losses



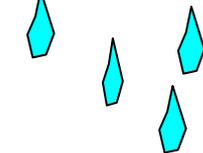
Unbilled Authorized Consumption



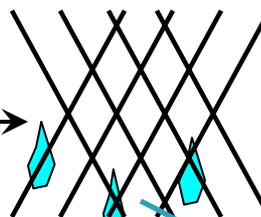
Source



Transmission Main



Distribution Network



Customer Meter



Residence



Inaccuracy



Theft



# Conducting a Water Audit



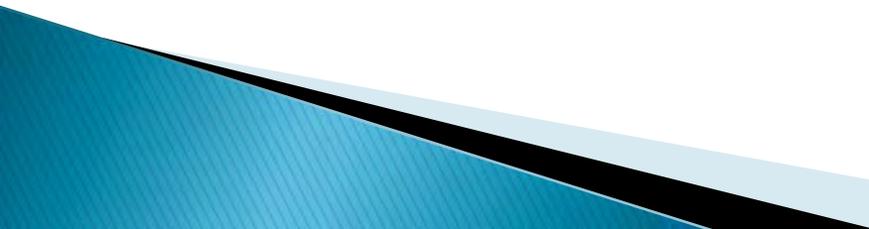
1. **Top-Down Approach**
2. **Component Analysis**
3. **Bottom-up Approach**

# 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?”
  - ▶ Asks “How can we prevent the losses?”
  - ▶ Determines value of lost water
  - ▶ Can increase utility financial standing
- 

# Water Loss = Non Revenue Water

## ▶ Real losses

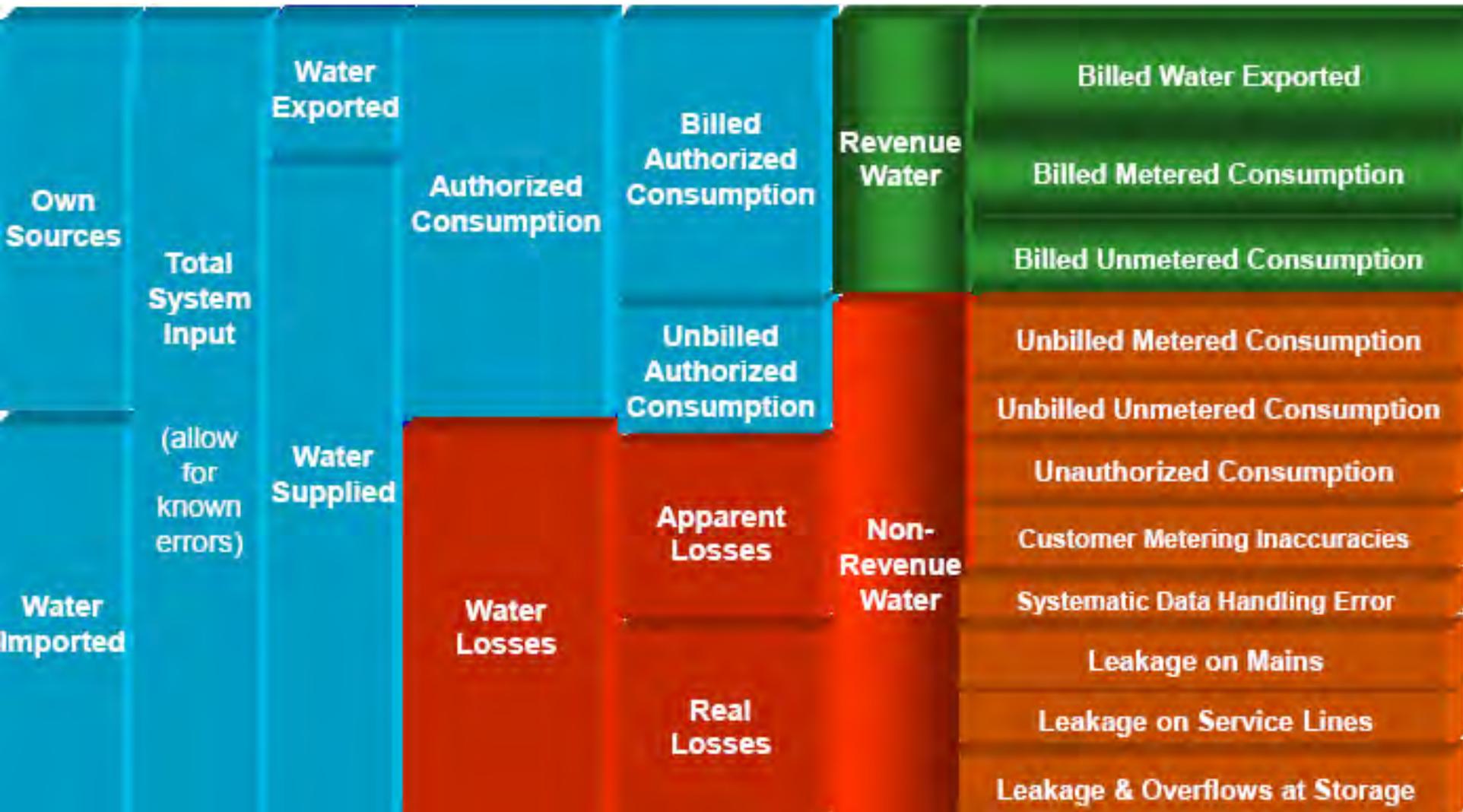
- Reported leaks
- Unreported leaks



## ▶ Apparent losses

- Customer meter under-registering
- Unauthorized consumption (theft)
- Billing adjustments and waivers

# IWA/AWWA Water Balance



# Apparent Losses

- ▶ **Unauthorized Consumption**
    - Fire hydrant theft
    - Unauthorized connections
  - ▶ **Meter Inaccuracies**
    - Under registering
    - Improper installation
  - ▶ **Accounting discrepancies**
    - Non-billed accounts
    - Billing software inaccuracies
    - Waivers
- 

# Apparent Losses

- ▶ Typically are the most costly losses, since they are valued at the retail water rate
- ▶ Reducing apparent losses increases revenue but does not create new water
- ▶ Reducing apparent losses may generate sufficient new revenue to fund other necessary forms of loss control
- ▶ Typically quantified first:  
 $\text{Water supplied} - \text{water consumed} - \text{apparent losses} = \text{real losses}$

# Real Losses

- ▶ **Physical losses from leaks, breaks, and overflows, up to the point of customer metering**
- ▶ **Calculated in top-down audit as:**  
**Water Losses – Apparent Losses = Real Losses**
- ▶ **Verified by component analysis and field measurements**
- ▶ **Reducing real losses creates a new resource (e.g. water conservation)**

# Definition of Real Losses

- ▶ **The physical escape of water from the system, including:**
  - Pipe breaks and leaks
  - Leakage from pipe joints and fittings
  - Reservoir and tank leakage
  - Reservoir and tank over flows
- ▶ **Real losses occur prior to the point of end delivery**



# Visual Main Leaks- Reported



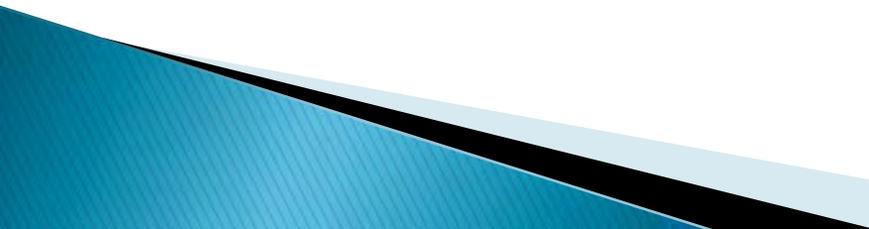
# Hidden Main Leaks- Non Reported



# Hidden Meter Set Leaks- Non Reported



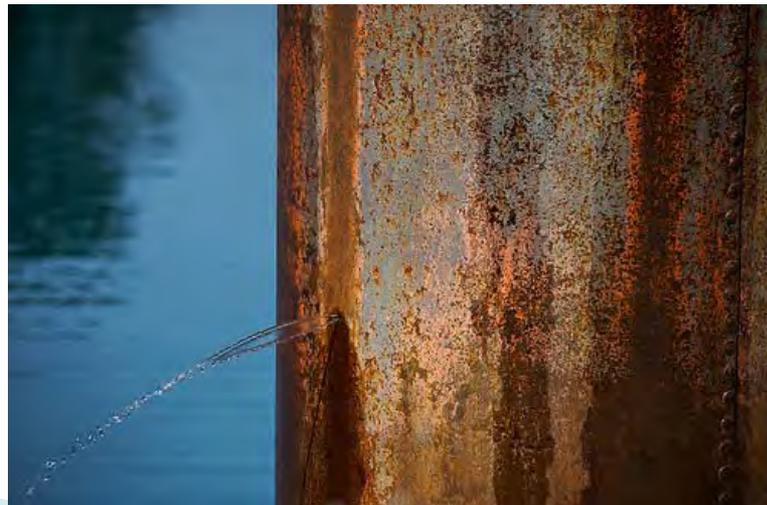
# Reasons for Distribution System Leakage

1. **Poor installation and workmanship**
  2. **Poor materials (pipeline, bedding, and backfill)**
  3. **Mishandling of materials prior to installation**
  4. **Incorrect backfill**
  5. **Pressure transients**
  6. **Pressure fluctuations**
  7. **Excessive pressure**
  8. **Corrosion (internal and external)**
  9. **Vibration and traffic loading**
  10. **Environmental conditions (hot and cold)**
  11. **Lack of proper scheduled maintenance**
  12. **Lack of leakage monitoring**
  13. **Disturbance by other utilities (sewer rehabilitation)**
- 

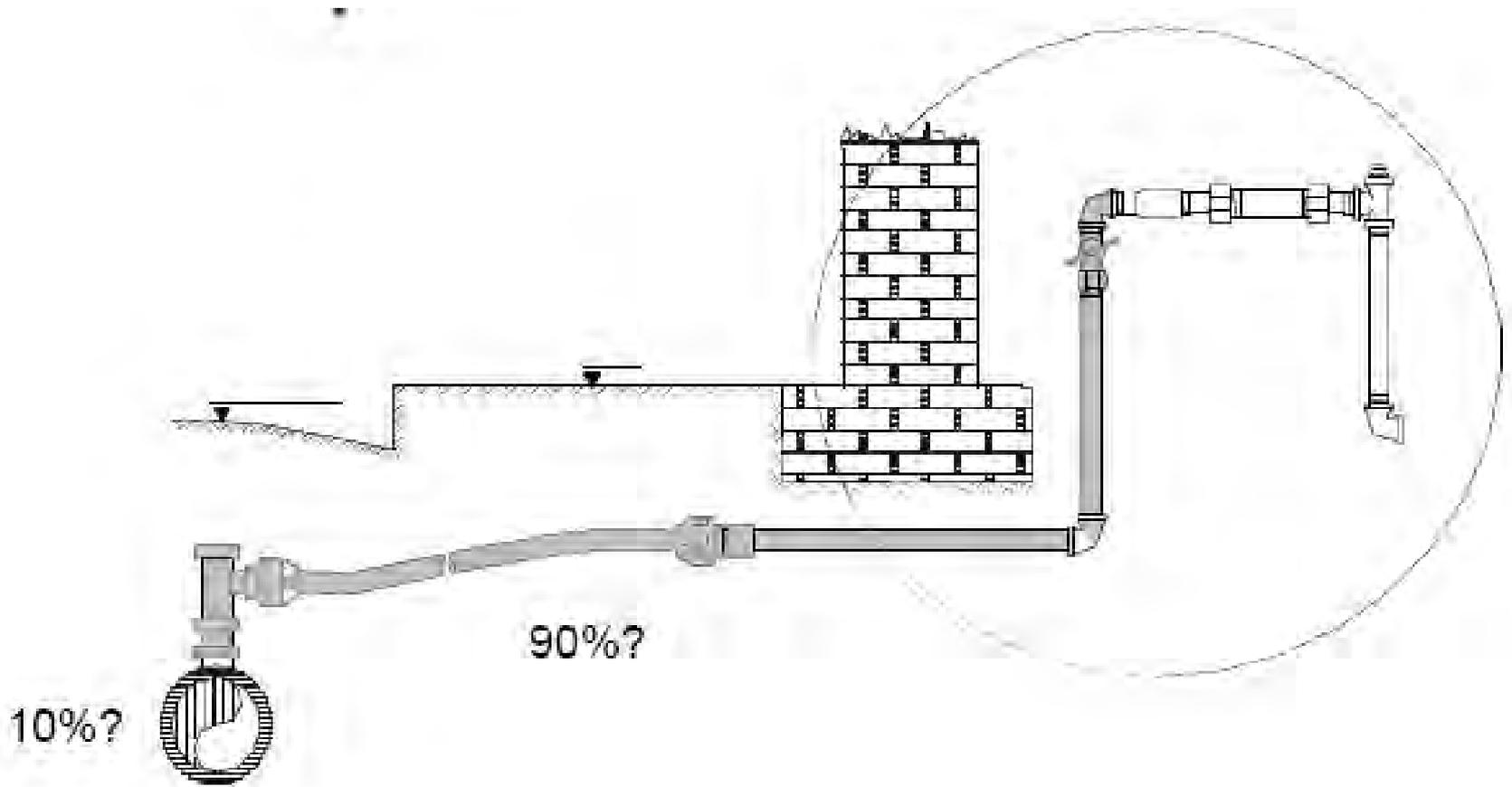
# System Storage Leaks



# Reservoir and Tank Leakage



# Leaks Occur at System Weak Spots

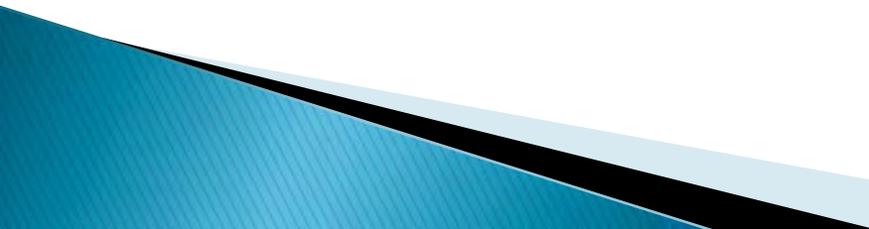


© Original Artist  
Reproduction rights obtainable from  
[www.CartoonStock.com](http://www.CartoonStock.com)

# Fixing leaks has its own challenges

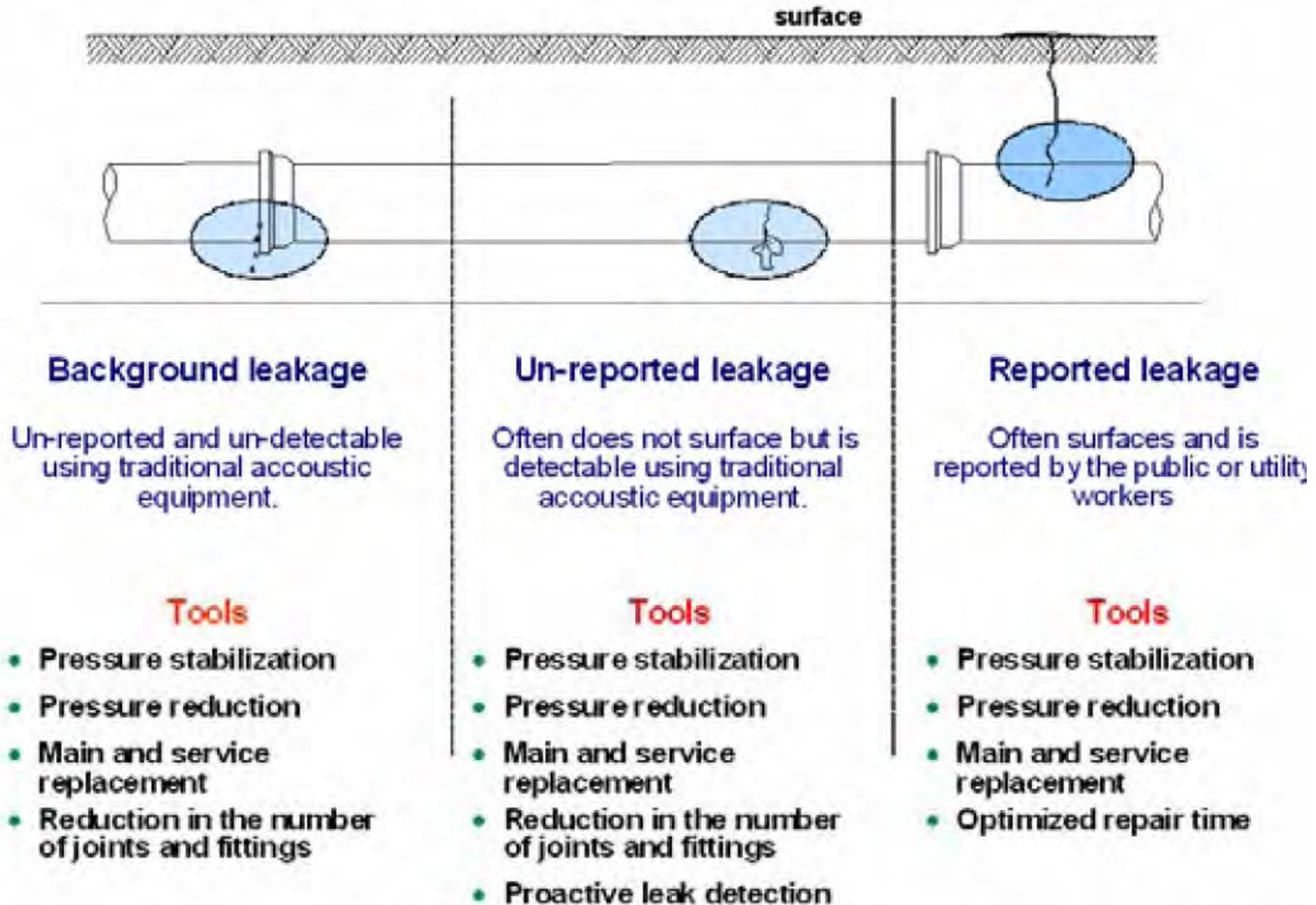


# Component Analysis

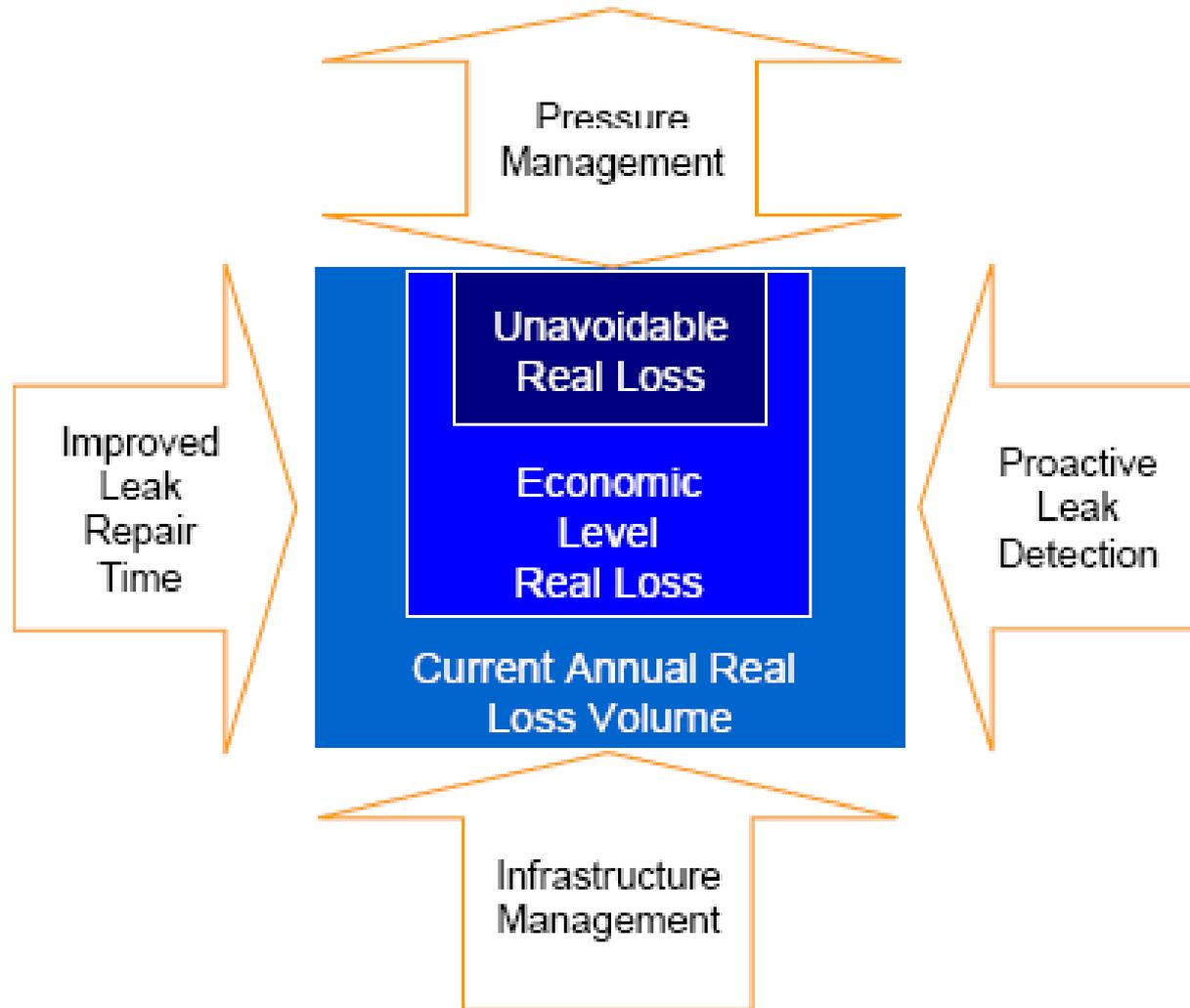
- ▶ **Validates top down results with field measurements, including:**
    - **Leakage losses from integrated zonal or District Metered Area (DMA) nightflows**
    - **Physical inspection of customer sites and meters**
    - **Process flowcharting of billing systems**
- 

# Component Analysis Model-

## There are Existing Tools for the Job



# Real Loss Management Tool Box



# Operational Performance Indicators

**Level 1 Operational PI =**

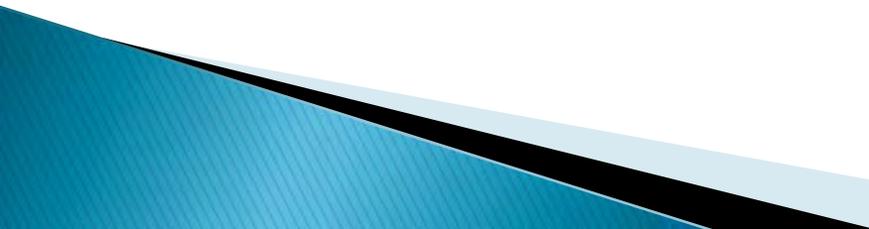
**Real Distribution Losses in Gallons Per Service  
Line Per Day Per PSI of Operating Pressure**

**Level 3 Operational PI =**

**Annual Real Losses**

**Unavoidable Annual Real Losses (UARL)**

**= Infrastructure Leakage Index (ILI)**



# **IWA Definition of Pressure Management:**

- ▶ **The practice of managing system pressures to the optimum levels of service- ensuring sufficient and efficient supply to legitimate uses while:**
  - **Reducing unwanted demands or theft**
  - **Eliminating transients and faulty level controls**
  - **Eliminating variations due to changing head loss**
  - **Reducing unnecessary or excess pressures**

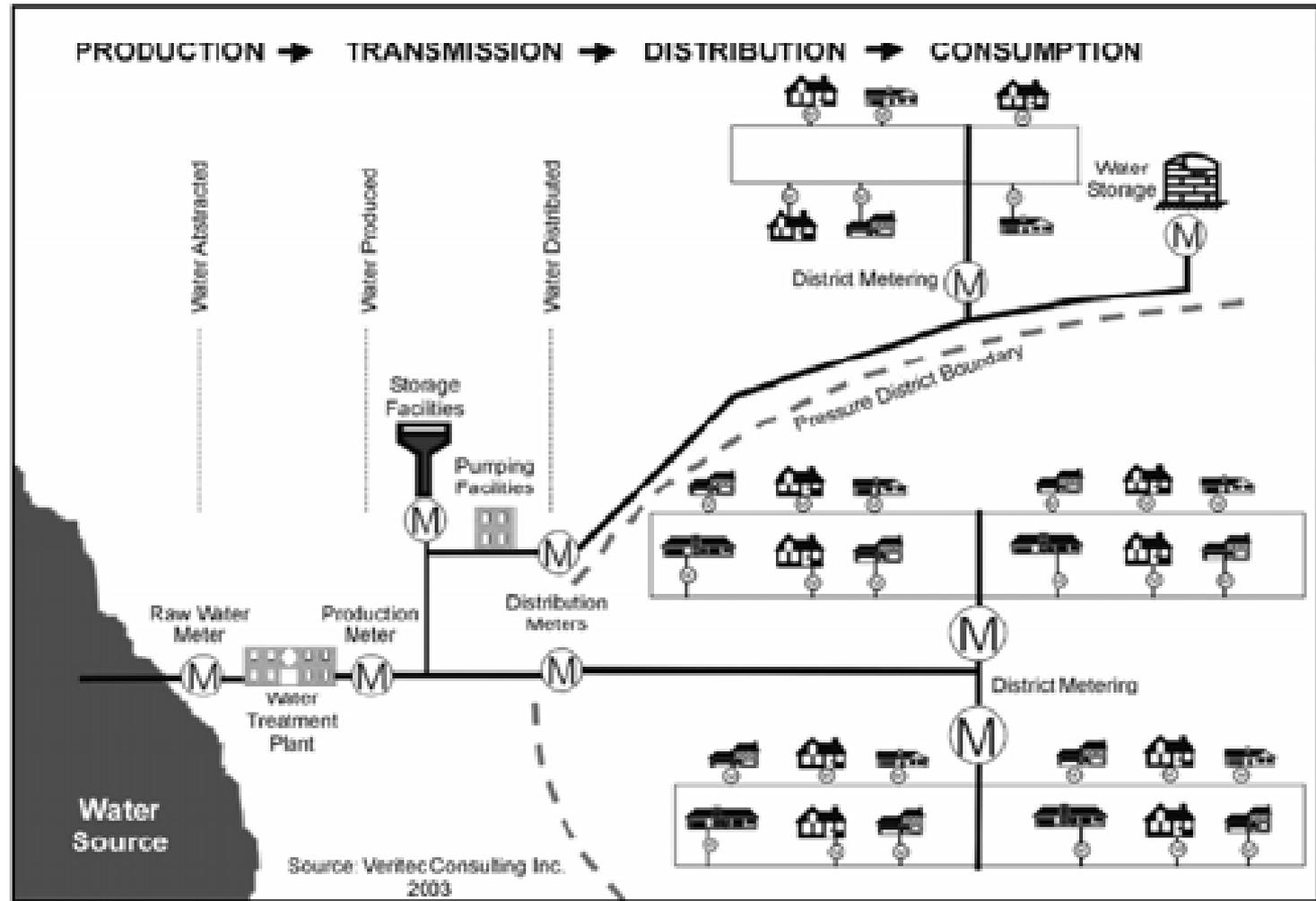
# Pressure Management Tools

- ▶ **Introduction of pressure-controlled areas (pressure zones)**
  - ▶ **Fixed outlet pressure control**
  - ▶ **Advanced flow-modulated pressure control**
  - ▶ **Altitude and level control**
  - ▶ **Transient control**
- 

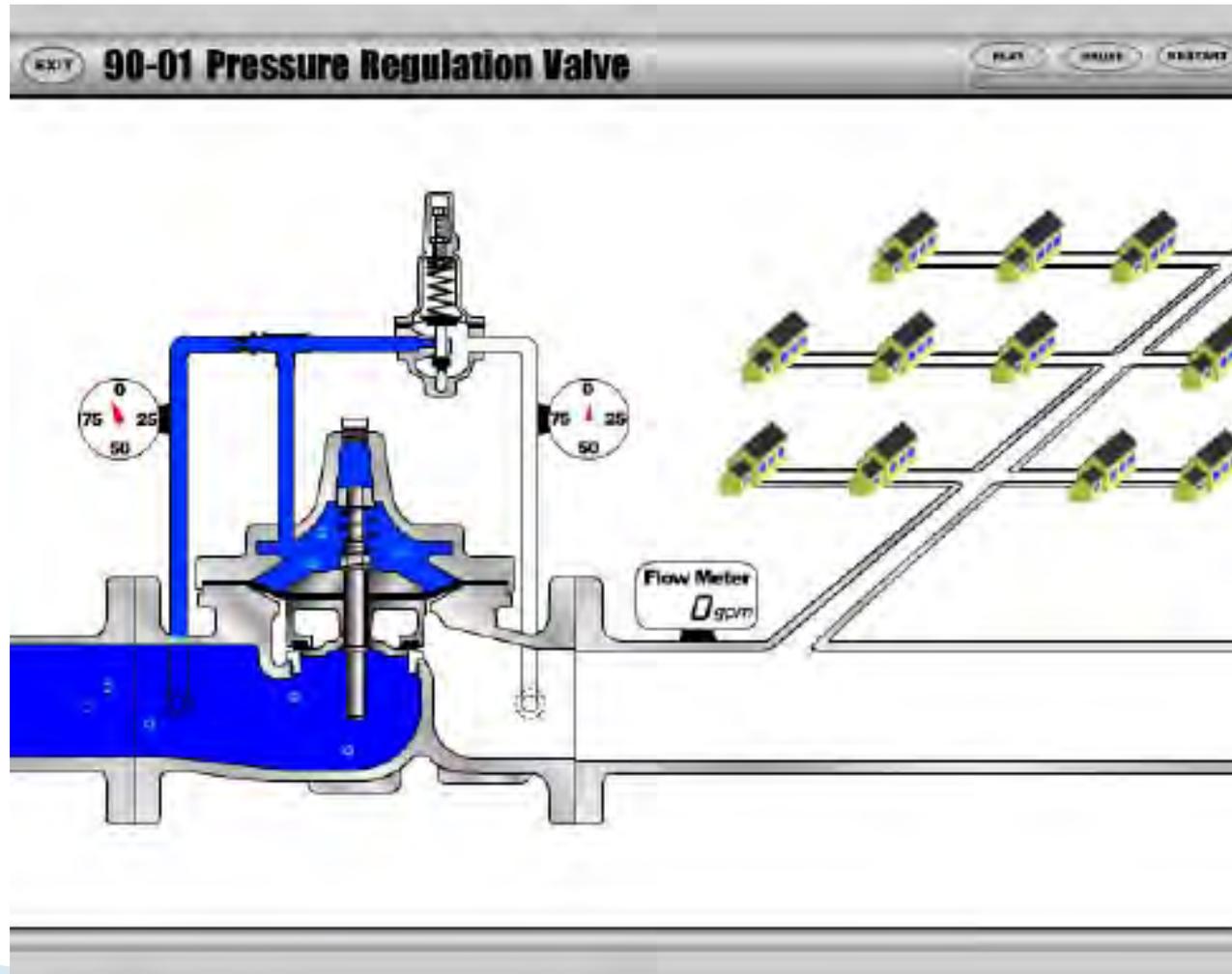
# Benefits of Pressure Management

- ▶ **Reduction of Real Losses**
  - ▶ **Reduction of new leaks/breaks = extended infrastructure life**
  - ▶ **Possible water conservation tool**
  - ▶ **Increased energy efficiency**
  - ▶ **Ensures minimum standards are met**
- 

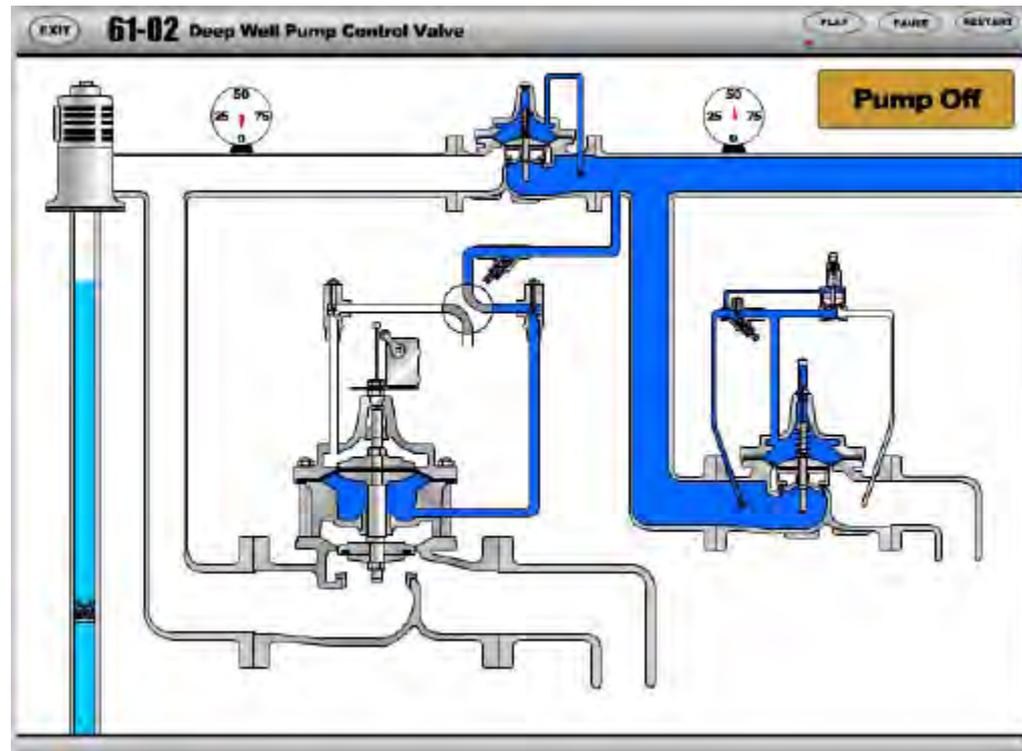
# Real Loss Control - District Control & Pressure Management



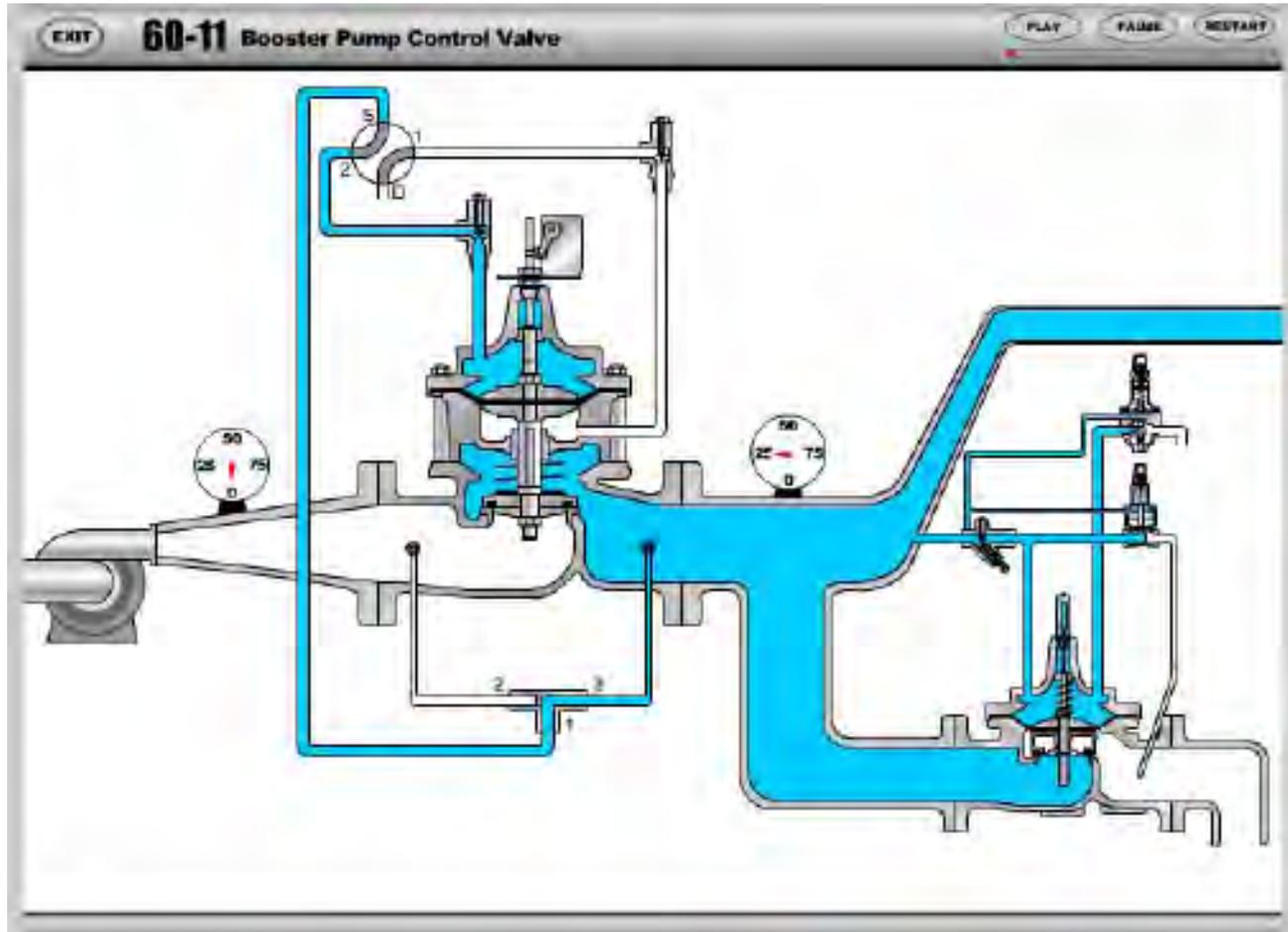
# Pressure Reduction



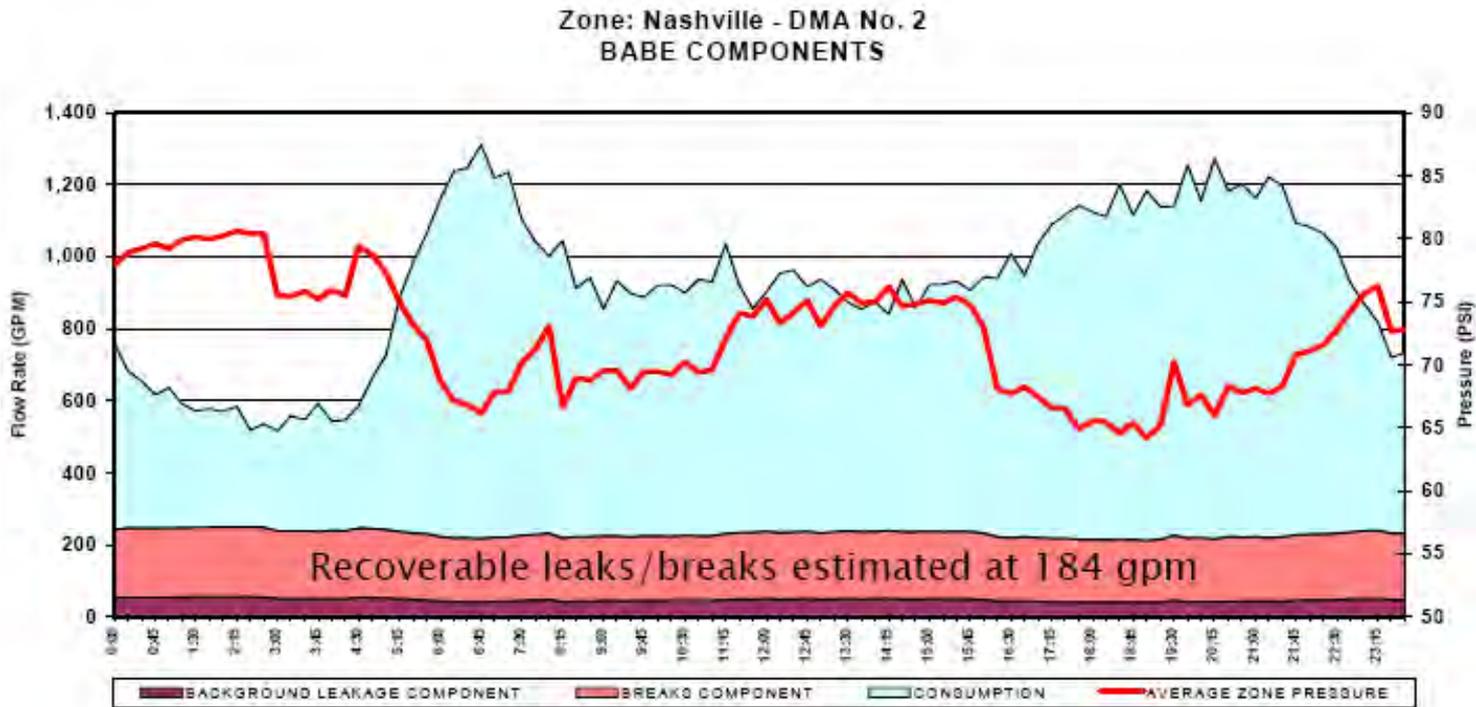
# Well Pump Control



# Booster Pump Control

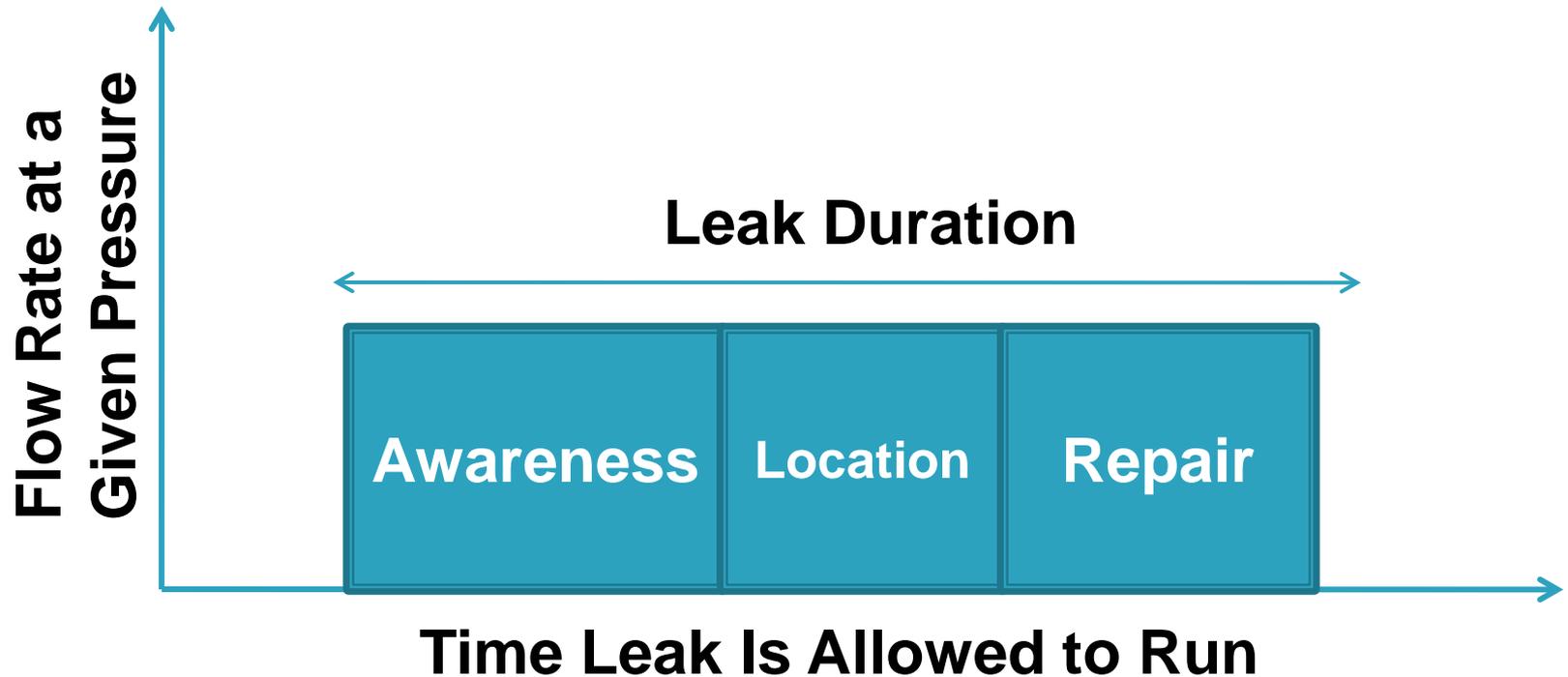


# Bottom Up Measurements Before Detection and Repair



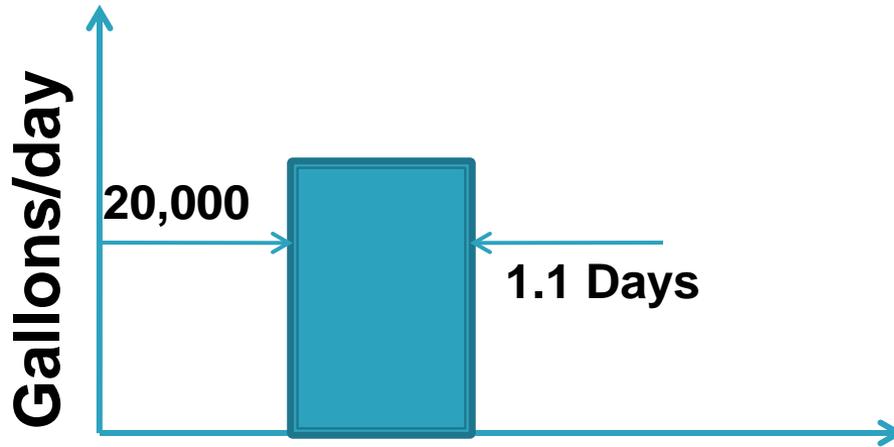
Verifies the annual data and shows immediate results for pilot interventions

# Effect of Time on Leakage Losses- ALR Concept

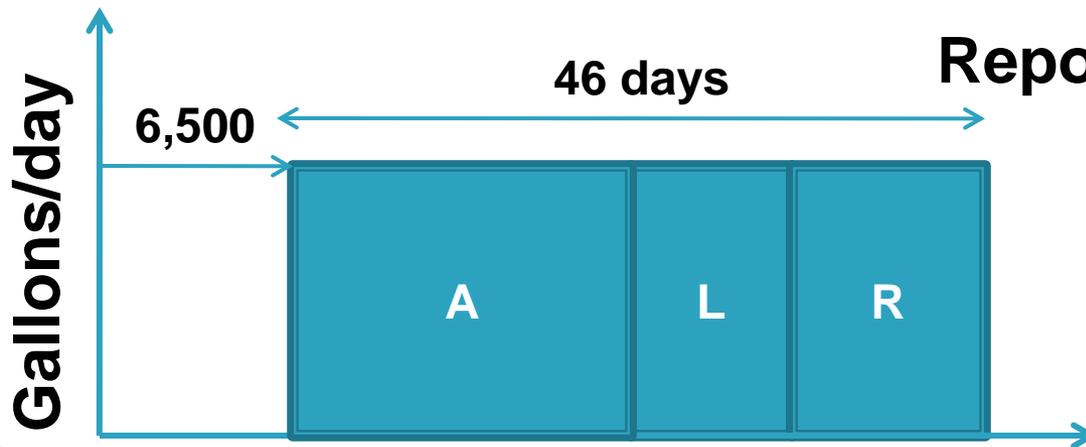


***Numerous small, hidden leaks account for the greatest overall volume of leakage losses***

# Leakage Losses Affected by Run Time



**Reported Main Break  
22,000 gal**



**Reported Customer-Side  
Service Break  
299,000 gal**

# Leak Detection Process

## Localize

- Noise logging
- Measure intensity and speed

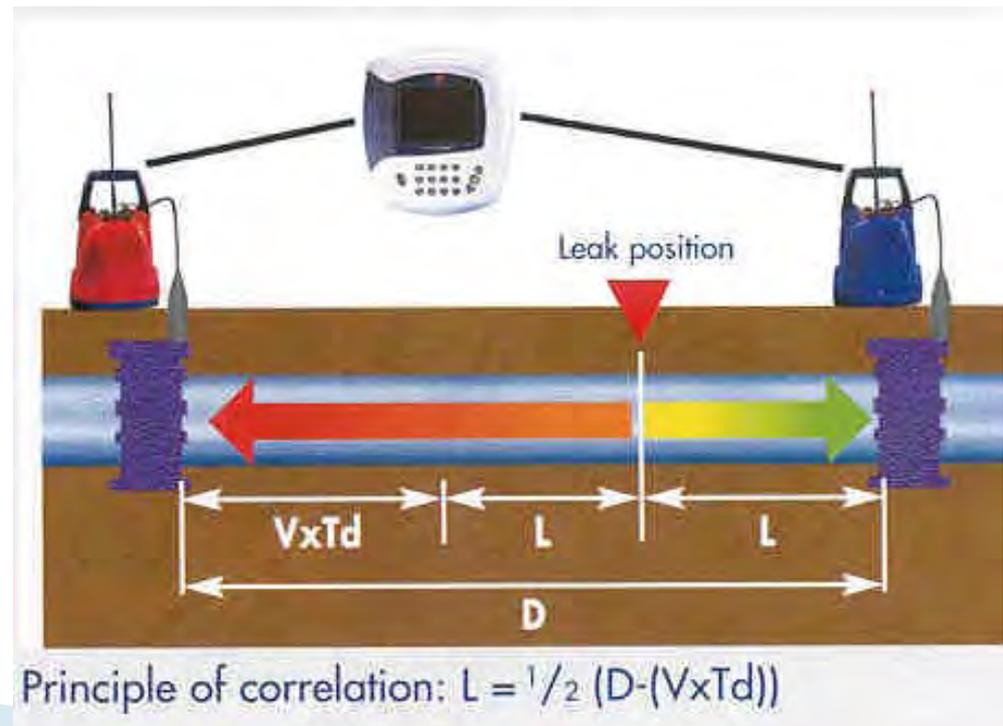
## Locate

- Noise correlation
- Two or three sensors
- Measure noise arrival time

## Confirm

- Human acoustic field confirmation

# Leak Pinpointing & Repair



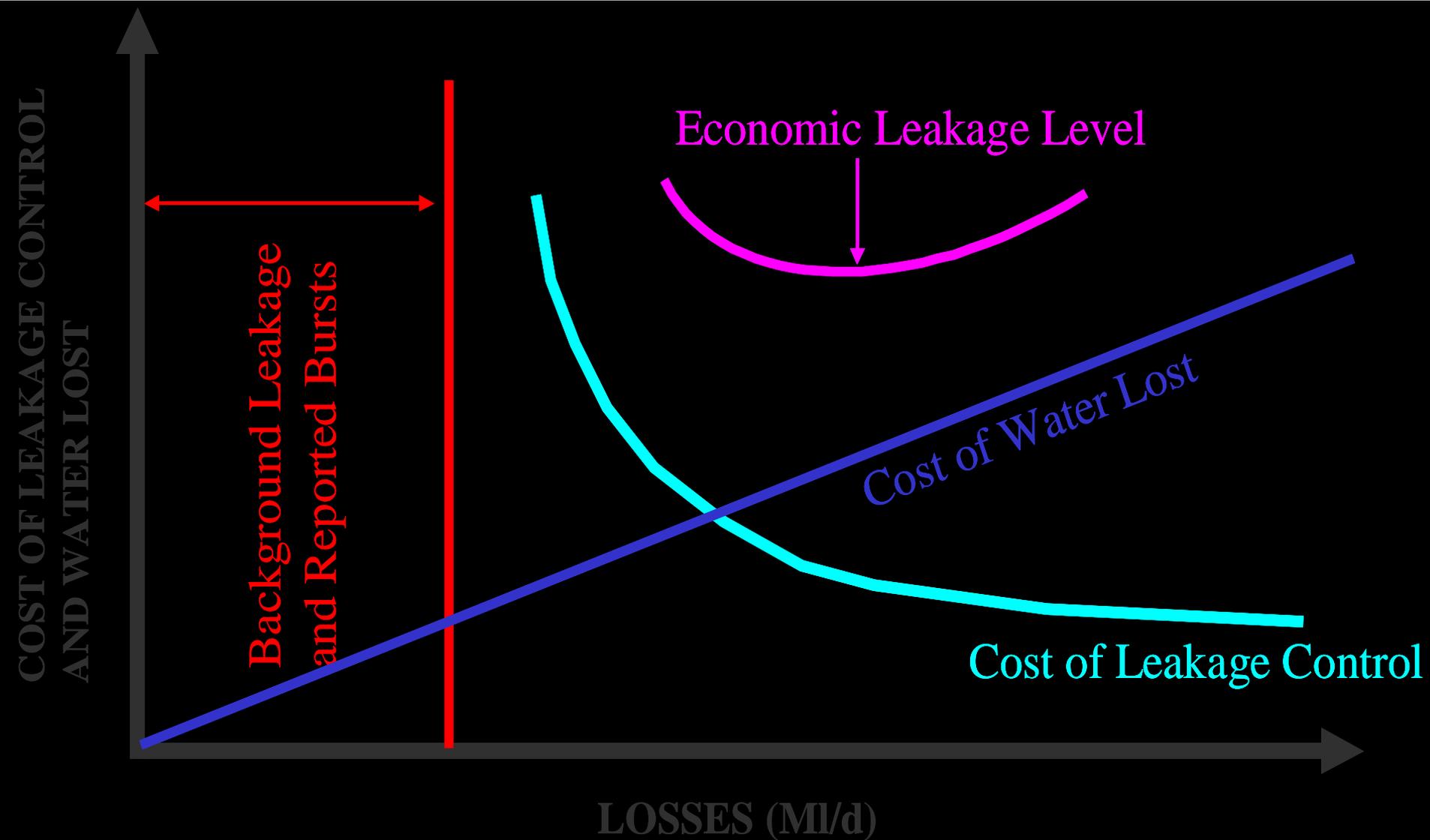
# Real Loss Control: Infrastructure Management



# Start with the Fastest Payback Options

- ▶ **Set upset limit for annual operating expenses**
  - ▶ **When hit, look to longer term capital investment**
  - ▶ **Sometimes it's better to have surgery than take an aspirin**
  - ▶ **Look at your component analysis and statistics**
  - ▶ **Optimize value of water saved with expenses**
  - ▶ **Make informed economic decisions**
- 

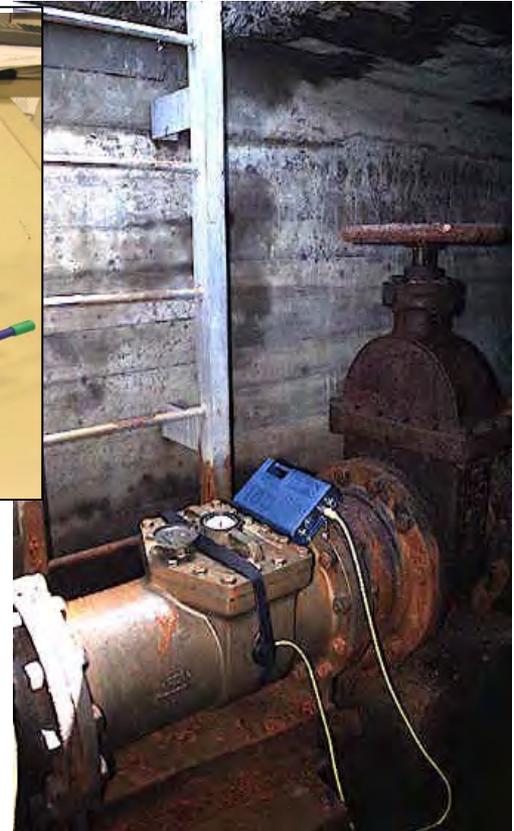
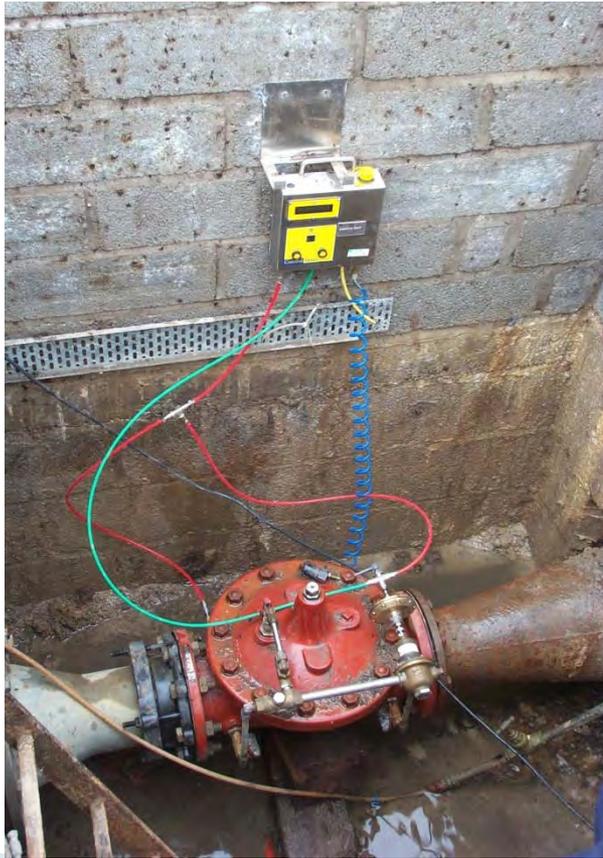
# Target methods that minimize cost of leakage control and lost water



# You still need to conduct fieldwork...



# ..and Maintain Water Loss Reduction Strategies



# Questions?

Email: [sdavis@pirnie.com](mailto:sdavis@pirnie.com)

Irvine Office: 949-450-7948

