Georgia Water System Audits and Water Loss Control Manual

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Program Background

Georgia Regulatory Drivers

Georgia is home to 2,400 public water systems. Our state sustains over 70,000 miles of rivers and streams and one of the most productive aquifers in the world. Yet, demands on Georgia's water resources are growing. Federal, state and local management decisions are increasingly scrutinized due to shared resources. The cost of providing reliable water in Georgia (and throughout the US) is increasing because of aging infrastructure and natural disasters (such as drought and flood events). And, although Georgia water supplies are seemingly abundant, many regions are experiencing and/or forecasting demands that may exceed available supplies.

To face these increasing water management challenges, the State of Georgia has embarked on comprehensive water management strategies. The ratification of Georgia's first State-wide Water Management Plan (2008), the development of regional water management plans (2003 through 2011), and the passage of landmark water stewardship legislation (2010) signify management efforts that affect every facet of our water environment. Of particular importance is the imminent need to create a culture of conservation in the State of Georgia by improving how efficiently water is used throughout the state.

Every gallon of water lost or wasted due to system inefficiencies comes at increasing cost to our communities and our natural environments, especially in areas where demands exceed supplies. Water system audits and water loss control are valuable water management strategies that can improve the efficiency of water production and delivery within all water systems in the state.

The Georgia Water Stewardship Act (GWSA) of 2010 (SB 370 and HB 1094) serves as a catalyst for creating Georgia's *culture of water conservation* among water managers. The GWSA addresses the need for monitoring and improving water efficiency within the state's public water systems. The GWSA also mandates that the state develop a technical assistance program to provide guidance for public water systems facing this new mandate to improve system efficiency.

The Georgia Water Stewardship Act/Senate Bill 370

On June 1, 2010 the Governor signed the Georgia Water Stewardship Act (GWSA) of 2010 (SB 370). This Act is a landmark, multifaceted approach to water conservation and it requires specific action by water providers serving over 3,300 in population. Approximately 250 water providers in Georgia, who provide 80% of the potable water to the State's population, are affected by this Act (as of 2011). Specific to public water systems, Section 3 of the GWSA amends O.C.G.A 12-5-4 and requires the following of water providers:

- Water systems serving a population "equal to or greater than 3,300" must conduct an **annual water system audit**.
- Water systems serving a population "equal to or greater than 3,300" must implement a **water loss control program**.
- GA DNR will develop minimum guidelines which will require public water systems to conduct standardized annual water loss audits according to the International Water Association (IWA) method/standard and will require water systems to submit those audits to the Environmental Protection Division (GA EPD) in a timely fashion.

- **Special Note**: GA EPD uses an allocation factor of 2.6 "persons per connection" when determining "population served" from the number of metered connections in a residential water system.

GA EPD Reporting Process, Requirements, and Technical Support

The GWSA requires water systems to conduct water audits according to the International Water Association methods, following best practices adopted by GA DNR. The GA Manual has been developed in an effort to define and describe the *best practices* to undertake for Georgia water systems to comply with the GWSA. The GA Manual has been developed around similar themes as the American Water Works Association (AWWA) *Free Water Audit Software ©, (version 4.2)* and provides supplemental assistance for water providers to utilize this *software*. This software is the required methodology for performing an acceptable water audit in Georgia and it follows the required IWA standard as dictated by the GWSA of 2010.

- For public water systems serving **at least 10,000 individuals** (or population served) **the GWSA requires initial water audits be submitted to EPD no later than March, 2012**.

  Initial water audits will cover the time period between January **1, 2011 and December 31, 2011** (the 2011 **calendar** year). Systems will submit the final results of this water audit to GA EPD no later than March 2012.

- For public water systems serving **at least 3,300 individuals** (or population served) **and up to 10,000 individuals** (or population served) **the GWSA requires initial audits be submitted to GA EPD no later than March 2013.**

- **Special Note:** Initial water audits will cover the time period between **January 1, 2012 and December 31, 2012** (the 2012 **calendar** year). Systems will submit the final results of this water audit to GA EPD no later than March 2013.

For those few water systems that may need an extension in submitting their reports due to technical limitations (such as two-month billing cycles, etc.), EPD will address the situation on a case-by-case basis. Please contact the GA EPD Watershed Protection Branch for more information.

Document(s) to be submitted to GA EPD include the following:

- The current water audit file associated with your excel workbook to include the "Informational Instruction Sheet" (ALL excel files in their entirety should be submitted).

- The GWSA of 2010 requires EPD to post all submitted audits on the Internet. Therefore, **electronic** submissions will be **required** from all affected water systems.

***Special Note**:* In the future, water withdrawal permits, water plant production increases, and Drinking Water State Revolving Funds/Georgia Environmental Finance Authority (DWSRF/GEFA) loans may take into consideration water audit results and the development and implementation of water loss control programs.

Special Note: Updated information and technical resources on the Water System Audit and Loss Control Program are available online under the Water Loss Auditing section of GAWP's website www.gawp.org and on GA EPD's website at www.ConserveWaterGeorgia.net. Programmatic updates to include the most up to date version of the *GA Water System Audits and Water Loss Control Manual*, tentative technical workshop dates, official rules and rule-making processes/schedules, and additional water auditing resources can be found here. As more material and resources are developed and become available they will be posted at both online locations indicated above.

Required Methodology for Water Audits

American Water Works Association *Free Water Audit Software ©, (version 4.2)*

Special Note: It is the "policy" of GA EPD to use this software for **all** water systems affected by the Georgia Water Stewardship Act requirements. The *AWWA Free Water Audit Software* © is not intended to provide a full and detailed water audit. For guidance on comprehensive auditing procedures see AWWA's M36 publication *Water Audits and Loss Control Programs*. The software **does** allow water utilities to quickly compile a preliminary audit in a standardized and transparent manner advocated by GA EPD and all of the parties involved in the construction of this manual.

The *AWWA Free Water Audit Software* © includes ten worksheets in a spreadsheet file. The first worksheet provides instructions on the use of the software. The majority of data is entered on the second worksheet, the *Reporting Worksheet*, which prompts the user to enter standard water supply information such as the volume of water supplied, customer consumption, distribution system attributes, and quantities of losses.

Realizing that many water utilities don't typically tabulate all of this data, the software allows the user to enter either known (measured) or estimated (approximated) values. The software then calculates a variety of performance indicators which are very useful in quantifying system performance.

How to Download the *AWWA Free Water Audit Software ©*

To download the ***AWWA Free Water Audit Software*** **©** visit the following website and agree to the terms of the ***User Agreement***.

Please note the software is in **Microsoft Excel** format.

http://tinyurl.com/auditsoftware

Definition of Key Terms and Water Loss Concepts

Note: The following are standardized definitions and *performance indicators* used in the IWA/AWWA Water Audit Methodology. Some definitions may vary slightly between water providers based on political decisions and internal billing policies.

- ***Water Losses****:* The difference between System Input Volume and Authorized Consumption, consisting of Apparent Losses plus Real Losses.
- ***Apparent Losses***: Unauthorized Consumption, all types of customer metering inaccuracies, and systematic data handling errors in customer billing operations.
- ***Apparent Losses Performance Indicator*** [gal/service connection/day]: A basic performance indicator that assesses Apparent Losses. Normalizing the apparent losses calculated through the water audit provides the water utility with a mechanism to monitor these losses as system conditions change and as water loss control measures are implemented.
- ***Real Losses:*** The annual volumes lost through all types of leaks and breaks in water mains and service connections, up to the point of customer metering. Real losses also include overflows from treated water storage tanks or reservoirs.
- ***Real Losses Performance Indicator*** (***Basic Determination*****)** [gal/**service connection**/day]: If the water system connection density is **less** than 32/mi, then use [gal/**miles of mains**/day]. Useful for target setting within a single water system.

- ***Real Losses Performance Indicator*** (***Intermediate Determination***) [gal/**service connection**/day/**psi**]: If the water system connection density is less than 32/mi, then use [gal/**mi of mains**/day/**psi**]). More detailed than previous calculation because system pressure is included in calculation (psi) and useful for target setting within a single water system.

- ***Authorized Consumption****:* The annual volume of metered and/or unmetered water consumed by registered customers, the water supplier, and others who are authorized to do so.

- ***Revenue Water***: The components of the System Input Volume that are billed and produce revenue.

- ***Nonrevenue Water****:* The sum of Unbilled Authorized Consumption, Apparent Losses and Real Losses. The term *Nonrevenue Water* should be used instead of the term imprecise term *Unaccounted-for Water*. It is recognized that **some** of this component water of Nonrevenue water is authorized consumption (unbilled).

- ***Nonrevenue water by Cost***: ***Performance Indicator***: The value of non-revenue water as a percentage of the annual cost of running the system. This is a good financial indicator that quantifies the financial impact to the water utility from losses when broken down into authorized and unauthorized components. This indicator could be used when issuing bonds, setting water rates, or other financial functions.

- ***Nonrevenue Water by Volume***: This indicator has value as a very basic, high-level financial indicator; however, it is misleading to employ this indicator as a measure of operational efficiency. This indicator should not be used for performance tracking, system comparisons, or benchmarking.

- ***Unavoidable Annual Real Losses*** (UARL): Reported in gallons, based on miles of mains, number of service connections, total length of customer service connection pipe from curb stop to customer meter, and average system pressure. The UARL is a theoretical reference value representing the technical low limit of leakage that would exist in a distribution even if all of today's best leakage control technology could be successfully applied in that system. The UARL is not a performance indicator but is used as the denominator in calculating the Infrastructure Leakage Index (ILI). No system can achieve *zero water loss* because water distribution systems are not perfectly sealed. The UARL is a system-specific calculation that varies among systems as the miles of pipe increases, system pressure changes, connections are added/lost, and other system changes are made.

- **Note**: **The UARL calculation has not yet been proven fully effective for very small or very low pressure water systems**.
  - **If**: (Lm x 32) + Nc < 3,000 (where Lm = length of mains, Nc = number of customer service connections)
  - **Or**: P < 35 psi, where P = average system pressure
  - **Then** the calculated UARL may **NOT** be valid. The AWWA Free Water Audit Software© will not calculate a UARL value for systems that meet these conditions.

- ***Infrastructure Leakage Index*** **(ILI):** The ILI is calculated by dividing Current Annual Real Losses (CARL) by UARL. (ratio of CARL to UARL) The ILI is the best performance indicator for benchmarking leakage **within** an individual water provider because it is a dimensionless performance indicator. **Because UARL cannot effectively be calculated for systems with less than 3,000 connections or with a service connection density of less than 16 connections per mile, an ILI score cannot be calculated for these type systems.** The ILI is indeed an effective performance indicator for comparing a utilities operational management of real losses. An ILI close to "1" indicates the utility's real losses are close to the UARL and therefore further reductions in real water losses might be unattainable or uneconomical. A utility's ILI can fluctuate annually depending on the data collection for each year and therefore should be considered in conjunction with a utility's data validity score. ***It is important to remember that the ILI is only one measure of system efficiency. One must look at anomalies such as large single occurrence leaks and any other outlying factors when assessing all water losses.***

- **Operational Basic Real Loses (Op24):** Performance indicator for systems with less than 3,000 service connections and service connection densities of less than 32/mi. This indicator is defined as gal/miles of water main/day.

- ***Validation***: The process of validation confirms the integrity of the component water consumption and loss values in the water audit. The validation of all performance indicators and values used in the determination of these indicators is of utmost importance. Data of low validity **will** lead to inaccurate performance indicator values and poor guidance for the water utility. No matter how sound the auditing process, poor data gives an inaccurate picture of the water system and its performance.

- ***The Water Audit Data Validity Level/Score****:* This is a composite rating of a utility's confidence and accuracy of data entered into the *AWWA Free Water Audit Software*©. A lower score means the data is less reliable and the utility should focus on improving its data inputs so the software can accurately assess the system water losses. **Note**: It is much better to have a high data accuracy score and a moderate ILI score than to have a low data score and ILI of "1".

Using Water Audits as the Foundation for Controlling Water System Losses

Implementing Water Audits and their Correlation to Loss Control Programs

In Georgia, over 1,700 Community Water Systems provide potable water to their customers reliably and safely every day. The approximately 250 water systems that serve populations greater than 3,300 provide potable water to 80% of the State's population. The quantitative accounting of that water from treatment and pumping to the end customer or user is referred to as water auditing. Georgia's Comprehensive State-wide Water Management Plan refers to water as "the most important natural resource to the state's future". Understanding how this most important resource is managed then becomes critical to Georgia's future as well. The *2010 Georgia Water Stewardship Act* reinforced this concept by requiring all public water systems serving over 3,300 in population to complete formal water audits of their potable water supplies.

The distribution of potable water utilizes a complex system of infrastructure, most of which is located underground. Water losses can occur throughout this system, and compiling a valid and thorough water audit can help water systems understand where the losses are occurring in order to minimize them. Once source losses are quantified and valuated an appropriate response plan can be developed to control them. A water audit should be performed on a regular basis to evaluate the performance of the loss control program, further improve the component data used and identify any sources of new losses.

Cost of Water Loss for Water Utilities

The loss of water through distribution of potable water has a direct financial impact on the water system. The more water loss a system experiences, the more water has to be produced and ultimately delivered to meet the customer needs. This added expense can cause unexpected fluctuations in a water systems' financial stability. Moreover, where there are limited or shared water resources, real water loss contributes to water supply and financial vulnerability. In addition, ensuring proper metering and controlling unauthorized use is critical to capture revenue needed by the water system to operate sustainably. The cost of water losses for water utilities can occur in many ways and the water audit helps identify and quantify each of these.

It is ultimately up to the water provider to take these results and determine the most cost effective method to address and/or respond to water loss. It must also be understood from the onset that certain issues may not resolve themselves regardless of what actions are taken.

Appropriate Indicators of Water System Performance (ILI, Types of Consumption and Losses)

Upon completion of the water audit, it is valuable to use the results in order to calculate and quantify *system performance indicators*. These indicators can be used by the water system to tailor their water loss control program. First, it is important to define the results of the water audit. The water audit fundamentally is a water balance with the system input on one side, and water delivered or lost on the other. Water successfully delivered to its intended user is termed **authorized consumption**. The balance of all water in the system is termed simply **water losses**. These water losses are then broken down into **real losses** and **apparent losses**. Real losses (also called physical losses) are defined as losses through all types of leaks and breaks on water mains and service connections up to the point of customer metering; as well as overflows at service reservoirs [storage tanks] (AWWA, 2009). Apparent losses (also known as paper or economic losses) include unauthorized consumption (theft) and all types of customer metering inaccuracies and systematic data handling errors (AWWA, 2009).

Another term, **non-revenue water**, includes real and apparent losses as well as unbilled authorized consumption. Due to political decisions involved in non-revenue water it is not a viable term to use when quantifying system performance and efficiency. Often water providers are **instructed** to provide water services that are not billed but indeed these uses are authorized by governing bodies, etc.

Current annual real losses (CARL) calculated from the water audit is used in determining a water system's **Infrastructure Leakage Index (ILI)**. This is derived by dividing the CARL by the **Unavoidable Annual Real Loss (UARL)**, a theoretical minimum level of real losses the water system could achieve if all of today's best technology could be applied (AWWA, 2009). The UARL is specific to the water system, and avoids the "one size fits all" application of water system performance. It is recognized that leakage in any water distribution system can never be totally eliminated; and there is no reasonable expectation that such is possible (AWWA, 2009). Once a water system has moved past the initial auditing and water loss control phase, real loss reduction can then be tracked using alternate indicators, such as real losses/service connection/day or real losses/mile of mains/day.

It is important for a water system throughout the course of periodically performing water audits to strive to improve the quality of the input data. This is described as the *validity* of the data, and the more valid the data, the more confident water systems can be in prioritizing programs for their water loss control program.

The Future of Water Conservation, Efficiency, and Water Loss Programs

Water loss control and the reduction of unauthorized non-revenue water is becoming an important focus for the water industry. As water systems develop their water conservation and efficiency programs, water loss control programs and unauthorized non-revenue water reduction goals should be included as a primary component. Implementation of these programs demonstrates that the water system is conserving its resources, and sets a good example for customers to increase their own efficiency and participate in water conservation programs. In addition, real water loss reduction will result in reduced chemical and energy used for the production and distribution of potable water.

GA's Preferred Audit Methodology: The IWA/AWWA Water Balance Concept

Background

The International Water Association (IWA) and the American Water Works Association (AWWA) recommend the **IWA/AWWA Water Audit Methodology** as the current best management practice for drinking water utilities to compile a water audit of their operations. This methodology was developed by considering the best practices utilized around the world to create a single, standard best management practice that could be fairly applied internationally to systems of varying sizes and types. The IWA/AWWA Water Audit Methodology allows system operators to identify the points of entry and exit of water throughout the distribution system and quantify consumption and loss of water. There are two appropriate approaches to the water audit process:

1. Top-Down Approach – Analysis of system using information from records, procedures, data, etc.

2. Bottom-Up Approach – Validating the top-down results with actual field measurements, physical inspections, and flowcharting billing systems.

Two steps are involved in completing the top-down approach: 1) quantifying water consumption and water loss and 2) undertaking the water balance calculation. The water balance calculation compares the distribution system input volume with the sum of customer consumption and losses (estimated or known). In **Table 1** the sum of all of the components in each column are equal, therefore they “balance”. The *AWWA Free Water Audit Software* © is a top-down water audit software that is used to perform the water balance calculation by inputting data gathered from available records.

Table 1: Water Balance Table

<table>
<tr><td rowspan="9">Water From Own Sources (corrected for known errors)</td><td rowspan="11">System Input Volume</td><td>Water Exported</td><td rowspan="5">Authorized Consumption</td><td rowspan="3">Billed Authorized Consumption</td><td>Billed Water Exported</td><td rowspan="3">Revenue Water</td></tr>
<tr><td rowspan="10">Water Supplied</td><td>Billed Metered Consumption</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td rowspan="2">Water Imported</td><td>Leakage and Overflows at Utility’s Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections Up to Point of Customer Metering</td></tr>
</table>

Table 1: AWWA, Third Edition, 2009

The IWA/AWWA Water Audit Methodology is most beneficial in providing rational terms and definitions and a standard set of **performance indicators**. The fourth column of the water balance in Table 1 identifies the most basic categories of water use, authorized consumption and water losses. In essence, all water can be quantified, either measured or estimated, and thus no water is unaccounted-for. The use of the term unaccounted-for water is considered imprecise and it is recommended that this term **not** be employed in water auditing and loss control assessments.

Indicators of Performance

The terminology developed for the IWA/AWWA Water Audit Methodology includes a variety of performance indicators to consistently assess water loss across water resources management, financial policies, and operational perspectives. Financial performance indicators are useful in assessing a water utility's fiscal standing regarding water losses while operational performance indicators are useful in assessing a water utility's operational efficiency regarding water losses.

Table 2. (Performance Indicators) is adapted from the *AWWA M36 Manual* and explains the performance indicators in the water audit methodology.

Table 2: **Indicators of Performance for Non-revenue Water and Water Losses**

Performance Indicator	Function	Description
Volume of Non-revenue water as a percentage of system input volume	Financial - Non-revenue water by volume	Can be calculated from a simple water balance; good only as a general financial indicator. This indicator should not be used to assess operational efficiency.
Volume of Non-revenue water as a percentage of the annual cost of running the water system	Financial - Non-revenue water by cost	Allows different unit costs for Non-revenue water components
Volume of Apparent Losses per service connection per day	Operational - Apparent Losses	Basic but meaningful indicator once the volume of apparent losses has been calculated or estimated
Real Losses as a percentage of system input volume	Inefficiency of use of water resources	Unsuitable for assessing efficiency of management of distribution systems
Normalized Real Losses - Gallons/service connection/day when the system is pressurized	Operational: Real Losses	Good operational performance indicator for target-setting for real loss reduction
Unavoidable Annual Real Losses (UARL) UARL (gallons/day) = (5.41Lm + 0.15Nc + 7.5Lc) x P	Lm = length of water mains, miles Nc = number of service connections Lc = total length of private 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) Note: this equation has not been proven fully effective for very small systems and low pressure systems. If: (Lm x 32) + Nc < 3,000, where Lm = length of mains, Nc = number of customer service connections, or P < 35 psi, where P = average system pressure Then the calculated UARL may not be valid. The AWWA Free Water Audit Software© will not calculate a UARL value for systems that meet these conditions
Infrastructure Leakage Index (ILI)	Operational: Real Losses	Ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL); good for operational benchmarking for real loss control.

Table 2: AWWA, Third Edition, 2009

Performing the Water Balance Calculation

The ***AWWA Free Water Audit Software ©*** *Version 4.2* is the recommended tool for calculating a system's *water balance*. This Excel based software can be downloaded for free from the following AWWA webpage at ***http://tinyurl.com/auditsoftware****.* The water audit should be completed annually by the water utility with a goal to achieve a high level of data validity **and** improved water audit results over time. Documentation is critical and it is recommended that the user create a separate Excel workbook in which to store input data along with notes describing the data and its sources. This workbook will be helpful in completing the software for future audits.

In order to compile the water audit, the water utility must assemble records and data from various sources that run across the spectrum of water utility activities and functions. Therefore a team effort is needed to complete the water audit. This effort must involve multiple departments that are directly or indirectly involved in managing the system's water losses, or have access to needed data. Data will need to be gathered on production metering, distribution system pressures, leak detection and repair, customer metering and billing, authorized consumption, water conservation activities, the cost of water, infrastructure rehabilitation, and other related areas. Suggested departments to involve in data collection are Billing, Meter Maintenance, Fire Department, Construction Management, System Maintenance and Leak Detection.

There are nine worksheet tabs in the Audit Software Excel workbook: **Instruction Worksheet**, **Reporting Worksheet**, **Water Balance Worksheet**, **Grading Matrix**, **Service Connection Diagram**, **Definitions**, **Loss Control Planning Worksheet**, **Example Audit (1**) and **Example Audit (2**). The following information outlines each of the worksheets in more detail and how to use them to complete the water audit.

> **Instructions –** This tab is a basic overview of the software including explanations of each sheet and the color coding of cells. A few cells require information be entered about the utility, contact person's name, units of measurement, and other background information.
>
> **Note: EPD requires water providers to consistently cover the same CALENDAR (12 month) period for each audit.** You must record the period dates actually used in the spreadsheet.

Reporting – Data is entered into this sheet to calculate the water balance. There are approximately 30 cells that require data entry and a few allow for default values to be used. A red triangle in the corner of a cell indicates a helpful comment exists for the cell and will popup if the cursor is held over the cell. Blue boxes with question marks navigate to the definition for that cell, which is in the Definitions sheet. While entering data in the worksheet and assigning data validity scores, the Grading Matrix tab should be referenced.

Water Balance – This tab provides a breakdown of water uses based on the values entered in the Reporting Worksheet. Utilities should use the reported values in this sheet for evaluating their system input volume with the sum of customer consumption and losses. Additionally, each of the identified categories can be compared year to year to identify progress and system changes.

Grading Matrix – The grading matrix provides descriptive scoring information for the reporting worksheet on how to assign a data validity score to each input value. In addition this sheet provides the user with clear guidance of what is involved and required to move from a current validity score to a higher validity score. The clear definitions of what is required at each level of confidence/validity help to ensure consistency across utilities when assigning scores to inputs.

Service Connection Diagram – A visual reference for some of the terms regarding the Service Data section in the Reporting Worksheet. This tab should be referred to heavily when completing the System Data section of the Reporting Worksheet. The Service Connection Diagram is particularly helpful in clarifying what is meant by Average Length of Customer Service Line. This number should be zero for almost all water utilities in Georgia unless the meter is located within the house, which is typically only done in cold weather climates.

Definitions – Definitions of all the terms used in the Reporting Sheets and Water Balance. In addition to providing guidance on what is meant by each term, the definitions provide explanations of how the values in the Water Balance are calculated.

Loss Control Planning Diagram – Guidance on how to interpret the utility's Data Validity score and the ILI as reported in the Reporting Worksheet is provided in this worksheet. This guidance highlights where the systems total data validity score falls and provides guidance for improvement in data collection, short term loss control, long term loss control, target setting, and benchmarking.

Example Audit 1 (Million Gallons) – An example of Philadelphia Water Department's completion of the audit to demonstrate what the Reporting Worksheet looks like using million gallons as the unit of measure is available in this tab.

Data Entry in the *AWWA Free Water Audit Software* © Excel Workbook

The **Metropolitan North Georgia Water Planning District** (MNGWPD) convened a group of water providers and developed an excellent guidance document to assist utilities in completing the Reporting Worksheet of the software. The MNGWPD Water Audit Software Guidance Document (Software Guidance Document) provides additional guidance specifically relevant for Georgia systems in the *Metro* area and also includes helpful tips for collecting and analyzing data for the software. The document is available at no cost for download from the MNGWPD homepage at www.northgeorgiawater.org . The following section includes highlights from the Software Guidance Document to assist in completing each section in the worksheet. For detailed explanations refer to the full Guidance Document.

Water Supplied

- Water Supplied is the section of the software that documents the total volume of treated water that leaves the water treatment plant or other treated water sources and enters the distribution system.

- **Volume From "Own Sources"** is the amount of water leaving the water treatment plant recorded by the production master meter(s). This number can be obtained from monthly operating reports submitted to GA EPD. It is recommended that a list be made of the treated water sources to ensure none are forgotten; groundwater that directly enters the distribution system should be included in this list, but not groundwater that is treated at a water treatment plant. The *master meter* in this section refers only to the production master meter(s) or the last meter(s) measuring flow into the distribution system and does not refer to any large customer meters that may be referred to as master meters away from the water treatment facility.

- **Production Master Meter Error Adjustment** refers to the adjustments made to the production master meter(s) based on meter calibration that accounts for errors in measurement, calibration, or other random errors. A negative number for meter error cannot be entered. Select *under-registered* or *over-registered* from the drop down menu depending on the meter's reading prior to calibration. Refer to the Software Guidance Document for more information on meter calibration recommendations. Since no water meter is 100% accurate, a positive number – however minimal – should be entered in this cell. Zero is not an acceptable entry for this cell.

- **Water Imported** refers to water purchased from a neighboring utility or regional water authority. Meters that measure this volume are typically calibrated by the seller and therefore reflected in the bill received from the seller. As the purchaser – especially if a majority of the utility supply is imported – the accuracy of this meter(s) should be regularly verified.

- **Water Exported** refers to water sold to a neighboring utility or regional water authority. Adjustments to water export meters should be reflected in the water bill sent to the customer and included in the water exported number. If a water system exports water and enters the annual volume of exports into this cell, the auditor must be certain that this volume is not also included in the Billed Metered component of Authorized Consumption. This would effectively "double-count" this volume and make Non-revenue water appear to be less than it really is.

- **Authorized Consumption** refers to the volume of water that is used by all authorized customers. This category does not include water sold to other utilities, which is considered water exported. The general categories with basic descriptions of authorized consumption are listed below. More specific sources of data within each category are provided in the Metro Water District Software Guidance Document.

- The **Billed Metered** component includes water that is metered and billed for domestic, commercial, industrial or government customers. This number does not include wholesale water sent to neighboring water systems; these wholesale customers are entered in the "Water Exported" section of the Reporting Worksheet.

- The **Billed Unmetered** component includes water that is not metered but is billed and may include customers who are not metered but charged a fixed fee or other method, or customers with estimated usage. For long term or permanent unmetered customers, installing a permanent meter is recommended to obtain actual consumption.

- The **Unbilled Metered** *category* includes water that is metered but not billed, such as water provided free of charge for municipal purposes (unbilled public facilities, unbilled public irrigation, etc.).

- The **Unbilled Unmetered** *category* includes unmetered water that is unbilled for authorized uses such as; fire fighting, flushing of mains or sewers, street cleaning, etc. All utilities should select the default number of 1.25% of the volume from own sources unless they can compile accurate data to justify a different number. If a utility decides to calculate its own estimate of unbilled unmetered water, supporting data should be saved in a companion workbook to explain how the data value was calculated. Refer to the Software Guidance Document for a more comprehensive list of potential unbilled unmetered uses if collecting data to calculate unbilled unmetered water.

Water Losses

Apparent losses occur from errors generated while collecting customer consumption data. The three categories of apparent losses include *Unauthorized Consumption*, Cu*stomer Metering Inaccuracies*, and *Systematic Data Handling Errors*. The following provides descriptions of each type of apparent loss and methods of to quantify these losses. Real Losses are calculated by the Software as the difference between Water Losses and Apparent Losses. The general water loss components are listed below with basic definitions; more specific sources of data within each component are provided in the Software Guidance Document.

- The **Unauthorized Consumption** category includes theft of water such as illegal connections, unauthorized use of fire hydrants, meter tampering, etc. Water providers should use the default number of 0.25% of volume from own sources provided in the software unless they can compile accurate data to demonstrate why their number is more representative than the volume generated using the default. Supporting data should be saved in a companion workbook and the Software Guidance Document includes a more comprehensive list of potential sources of unauthorized consumption.

- **Customer Metering Inaccuracies** result from wear, improper sizing or maintenance of meters. If a utility has a meter testing/calibration/replacement program, the average calibration difference for the old meters is entered in this category. If a utility does not yet have a meter testing/calibration/replacement program, the manufacturers' default (typically

2%) may be used for this entry. Typically, inaccurate customer meters tend to under-register rather than over register flow, particularly if they have served a long life or passed a high cumulative flow volume. NOTE: AWWA publishes two guidance manual that can be referenced for sizing water service lines and sizing of meters, as well as maintain an accurate customer meter population. Refer to *Sizing Water Service Lines and Meters* (M22) and *Water Meters – Selection, Installation, Testing and Maintenance* (M6) for specific guidance.

- **Systematic Data Handling Errors** occur between the meter readings and billing systems. Types of errors include billing system entry errors, account adjustments, skewed estimates, poor accounting, etc.

System Data

The System Data portion of the worksheet describes the physical characteristics of the distribution system. Components are broken down as follows:

• **Length of Mains**: Total length of water distribution pipelines, including fire hydrant leads. This length does not include customer service connection lines, which are included in the average length of customer service line value.

• **Number of Active and Inactive Service Connections**: These include all physical service connection lines, not just the number of accounts in the system because one account could have multiple connections.

• **Average Length of Customer Service Line**: This number should be zero for all Georgia water utilities unless the meter is located within the house (which is typically only done in cold weather climates).

• **Average Operating Pressure**: The average system pressure is a very important parameter in calculating the unavoidable annual real losses (UARL). All systems are unique and the pressure will vary based on the extent of the system, the elevation changes, the demand patterns, and other local considerations. To limit the variability in pressure measurements that might skew the IWA/AWWA water loss results, utilities should refer to the Metro Water District Software Guidance Document for various ways to calculate system pressure. AWWA's M-36 manual also serves as an excellent resource for determining average operating pressure.

Cost Data

- **Total Annual Cost of Operating Water System:** These costs should include all the costs for operating just the water system, as stated in its definition in the Definitions tab. Additional costs to consider include shared equipment, bond paybacks, and wholesale water purchases. Costs to operate wastewater, biosolids, or other non-potable water operations should not be included.

- **Customer Retail Unit Cost**: As stated in the definition, this is the charge that customers pay for water service and is applied to apparent losses. Be sure to apply the correct units that match the billing units; for example, if water volumes are in million gallons, the cost should be presented in $/1,000 gallons. With tiered water rates, a weighted average is recommended. The weighted-average may simply be calculated by dividing the total year end revenue from water sales by the total gallons produced. The customer retail unit cost should NOT include additional charges for sewer, stormwater, or biosolids processing if these are based on water consumption. Although these charges are based upon the volume of potable water consumed, they will skew the results for the priority areas for attention.

- **Variable Production Cost**: The current unit cost to treat and distribute water to the system. Include the costs associated with production of water (including distribution pumping costs) and wholesale water purchases. Divide the total cost by the volume of water produced.

Interpreting Software Results

Based on the data entered and the validity scores given to each data entry, the Software calculates the values of the performance indicators for the utility. Of these outputs, three parameters stand out in importance: 1.) Infrastructure Leakage Index (ILI), 2.) Water Audit Data Validity Score, 3.) Priority Areas for Attention and 4.) Normalized Real Loss Indicator.

Infrastructure Leakage Index (ILI) is the ratio of current annual real losses (CARL) to unavoidable annual real losses (UARL). The ILI is an effective performance indicator for comparing utilities in operational management of real losses. An ILI close to “1” indicates the utility’s real losses are close to the unavoidable annual real loss level and therefore further reductions in real water losses might be unattainable. A utility’s ILI will fluctuate annually depending on the data collection for each year and therefore should be considered in conjunction with a utility's data validity score and ILI score from previous years.

- **Water Audit Data Validity Score** is a rating of a utility's confidence and accuracy of data entered into the software on a scale from 0 – 100 (all of the 18 data entry components on the Reporting Worksheet of the Software can be rate for data integrity with a grading up to 10, and a maximum Data Validity Score of 100). A lower score means the data is less reliable and the utility should focus on improving its data inputs so the software can accurately assess the system water losses. A utility just starting the water audit process and data collection will more than likely have a low data validity score. As a utility's data collection improves, the water audit data validity score should also improve. It is better for a utility to have a higher data validity score and a moderate ILI score than to have a low data score and ILI of "1". Refer to the Loss Control Planning worksheet of the Software in order to interpret the Data Validity Score and obtain guidance on the best actions moving forward relative to the use of the data.

- **Priority Areas for Attention** are listed in order of "suggested" importance with the first being the area identified by the software that the utility should focus efforts on to improve the water audit data and results for the next year. These priority areas are determined based on the data grading entered in the reporting spreadsheet. The utility should focus on improving data collection in the suggested three priority areas for attention given by the software. By addressing one or more of these areas, the utility's data **validity** score and/or the validity of the performance indicators – including the ILI – will improve. For example, if the first priority area listed was billed metered, the utility would focus on improving the percent of customers with volume-based meters installed; in turn, the utility's data confidence for this input would increase, thus improving the overall data validity score and the validity of the calculated ILI value. Addressing these priority areas may help the utility use resources effectively to improve its water audit results. These priorities do **not** represent areas that need to be addressed to reduce any particular loss.

- **Normalized Real Loss Indicator** is a performance indicator that may gain greater prominence moving forward as the AWWA Water Loss Control Committee is promoting a new structure of leakage classifications (gallons per connection per day or gallons per mile per day for smaller systems) The Loss Control Planning tab should be used for suggestions on how to improve a utility's data validity score. The **AWWA M36 Manual**

Water Audits and Loss Control Programs is another reference to assist with implementing water loss control measures to improve the validity of the water audit and reliability of the calculated performance indicators. This reference can be obtained at the following American Water Works Association website: www.awwa.org

Data Integrity Processes and Establishing Confidence in Data Used

Data Validity is the most <u>critical</u> aspect of the Water System Audit and Water Loss Control Program.

Introduction

Systems utilizing the *AWWA Free Water Audit Software©* will likely realize the resulting output can be grossly inaccurate in representing the degree of system performance if inaccurate input data is used. A clear example of this is when production meter information is over-registering, indicating a higher-than-actual volume of water being input into the system. If this number is carried through the water balance equation without validation, the resulting *real loss* prediction will be higher than what is actually occurring. This can cause water systems to arrive at incorrect conclusions, purchase leak detection equipment, or commission a "search for real losses" that is of marginal value.

Some of the common reasons that incorrect data can occur include a reluctance to change due to apathy, historical efforts, or postponing initiatives while waiting on "better data" to become available.

Water loss audit experts emphasize the importance of data validity. It is critical to embrace the need for continuous improvement in data validity. It must be *the* top priority in water auditing and loss control efforts!

Steps to Continuous Improvement and Establishing a Culture of Water Efficiency

Providing clear and routine procedures for gathering and reporting data helps water system personnel consistently gather and recognize the importance of accurate information. The goal must be the establishment of the AWWA method as a routine business procedure. Many utilities find that as these best-practices become routine, they not only experience improved Data Validity, but an inherent demand-side conservation that occurs due to increased utility staff awareness, which in turn can lead to a reduction in Non-Revenue Water.

However, it is imperative that appropriate feedback is provided relative to the data that is supplied. It is also important to let staff members know how their data plays a role in measuring overall system performance. Clearly establishing a flowchart of who provides the data (and why) can be helpful, especially when staff transitions occur.

An annual water audit which uses twelve months of data is critical to establish the initial baseline for both loss control and revenue recovery efforts. Typically the annual water audit can be used to recalculate and compare improvements in Data Validity, Real Losses, and Apparent Losses year after year. The Annual Water Audit also includes updated variable production and retail cost data, upon which the value of all water loss is determined.

In concert with this, many systems have embraced a proactive culture of efficiency and have recognized significant value in performing general monthly tracking as a more frequent, but more general, assessment of water efficiency standing. This assessment compares the "volume supplied" quantity to the "authorized consumption" quantity and looks at the difference of these volumes. However, both of these quantities should be compiled using a "12-month rolling average" approach (current month of data is added to prior 11 months of data and divided by twelve). In this way, the system is able to perform a quality control check monthly, as well as provide for data trending and ongoing analysis which can be very useful. This is quite helpful in allowing for a faster implementation of corrective action.

The exercise of a team approach in reviewing the input data as well as the results can provide critical feedback. In the early stages of the rolling twelve-month tracking it is not uncommon to see wide variation in the data. In the initial months, when data validity is lower, a system may see lower real loss numbers only to be followed by a spike in the same value as data validity improves. Because variability is inherent between recording periods for production data versus consumption data, it is helpful to maintain water audit monthly input data in both "raw" and a "rolling twelve month average" format. Raw data can reveal individual anomalies, such as isolated incidents of leakage or production meter data gaps. Rolling twelve month average data can reveal performance trends, such as the emergence of new leakage and production meter drift.

Improving your Data Validity

In the *AWWA Free Water Audit Software©* and in the *AWWA M-36 Manual* specific direction is provided how to improve a data validity score. The listing below ranks the Water Audit *inputs* in a suggested order of maximum impact to the validity of the output.

Note: The *AWWA Free Water Audit Software©* includes 18 data input components including water volumes, system data and cost data. Each of the gradings ranges from 1-10 and the user selects the appropriate grading based upon their operational practices. For several parameters a default value option is offered. Based upon the gradings of all data inputs, the Software calculates a composite Data Validity Score that falls between 1 – 100. Following are strong practices that systems should undertake for reliable water supply operations and to maintain a high level of water audit data validity.

- Meter all finished (production) water inputs.
- Testing and calibration - both flow and instrumentation - of all finished water meters on at least an annual basis.
- Computerized billing data should be digitally archived for easy retrieval and analysis.
- Conduct periodic flow-charting audits of the information flow in the Customer Billing System in order to uncover any gaps or omissions that allow water supply to go unbilled, or under-billed.
- Development of a routine meter testing program that serves as the basis of a customer meter replacement program that considers meters' cumulative consumption limits on accuracy, as well as meter age.
- Develop clear written policies and procedures for supplying all unbilled, unmetered but authorized consumption.
- Estimate all unmetered consumption, based on formula of typical flow rate times typical time.
- Fully document any estimated consumption calculations.
- Validate estimated consumption calculations by metering a statistically significant representative sample size of estimated customer accounts.
- Minimize estimated authorized consumption, move towards 100% metered connections as budget allows.

Water Loss Control Programs

Identifying Water Losses: *Apparent* vs. *Real* Losses

In this section a review of Apparent Losses and Real Losses is presented. It should be clearly understood that these two areas are the true *Water Losses* (Figure One). In the past, the term "Unaccounted for Water" was frequently used to describe **all** water losses. This term was found to lack a consistent definition and application by water utilities universally and AWWA recommends against its use. The *IWA/AWWA Water Audit Method* advocates that water utilities should account for **all** water they manage and move to enact controls for those losses that **can** be economically managed to recover lost revenue and/or reduce water production costs and withdrawals from water resources.

Figure 1: IWA/AWWA Water Audit Method and Apparent vs. Real Losses

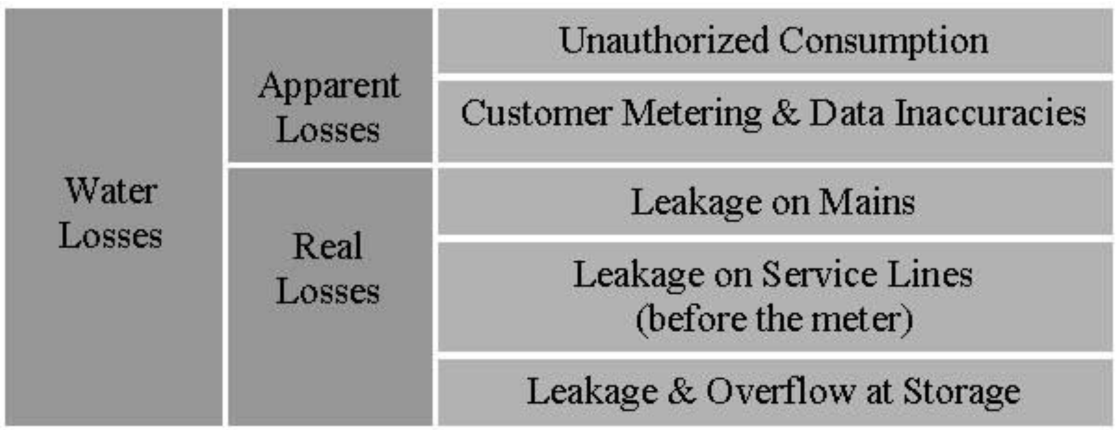

Figure 1: AWWA, Third Edition, 2009

Apparent Losses occur due to errors generated while collecting and storing customer usage data. The three categories of apparent losses include:

- Unauthorized Consumption
- Customer Metering Inaccuracies
- Systematic Data Handling Errors

Real Losses are calculated by the *AWWA Free Water Audit Software©* basically as the difference between water supplied and water identified as authorized and/or apparent losses.

The three sub-categories are not specifically broken down in the current version of the software. The three categories of real losses include:

- **Water Main Leakage:**
    - Confirmed and documented losses from water main breaks, leaking valves, leaking/broken hydrants and similar physical problems.
    - Calculated leaks derived from the water distribution system main and pressure similar to an acceptance test for new lines. Examples are seepage from a worn or damaged gasket or slightly offset pipe joint.

- **Service Line Leakage:**
    - (Minimal in Georgia since the meters are typically close to the main distribution line). Note: In northern climates the service line typically runs from the main to the interior of the house in order to protect the meter from freezing, thus giving more length of service line pipe for leaks to occur.

- **Storage Tank Leakage:**
    - Typically this is an *operational leak* such as faulty or improperly set altitude valves, leaking pumps, and appurtenances like Air or Pressure Relief Valves.

    - It should be noted that one of the quickest ways to reduce loss in this category is to directly address any storage tank leakage and overflows, especially if SCADA is relied on and tanks are not physically visited at full level on a regular basis.

Note: It is recommended that the water system create a **separate spreadsheet** to use for tracking the volume of water saved in the various component categories (and the various methods used) and to relate to revenue recovery or cost reduction as appropriate.

Figure 2: Potential Causes of Apparent Losses

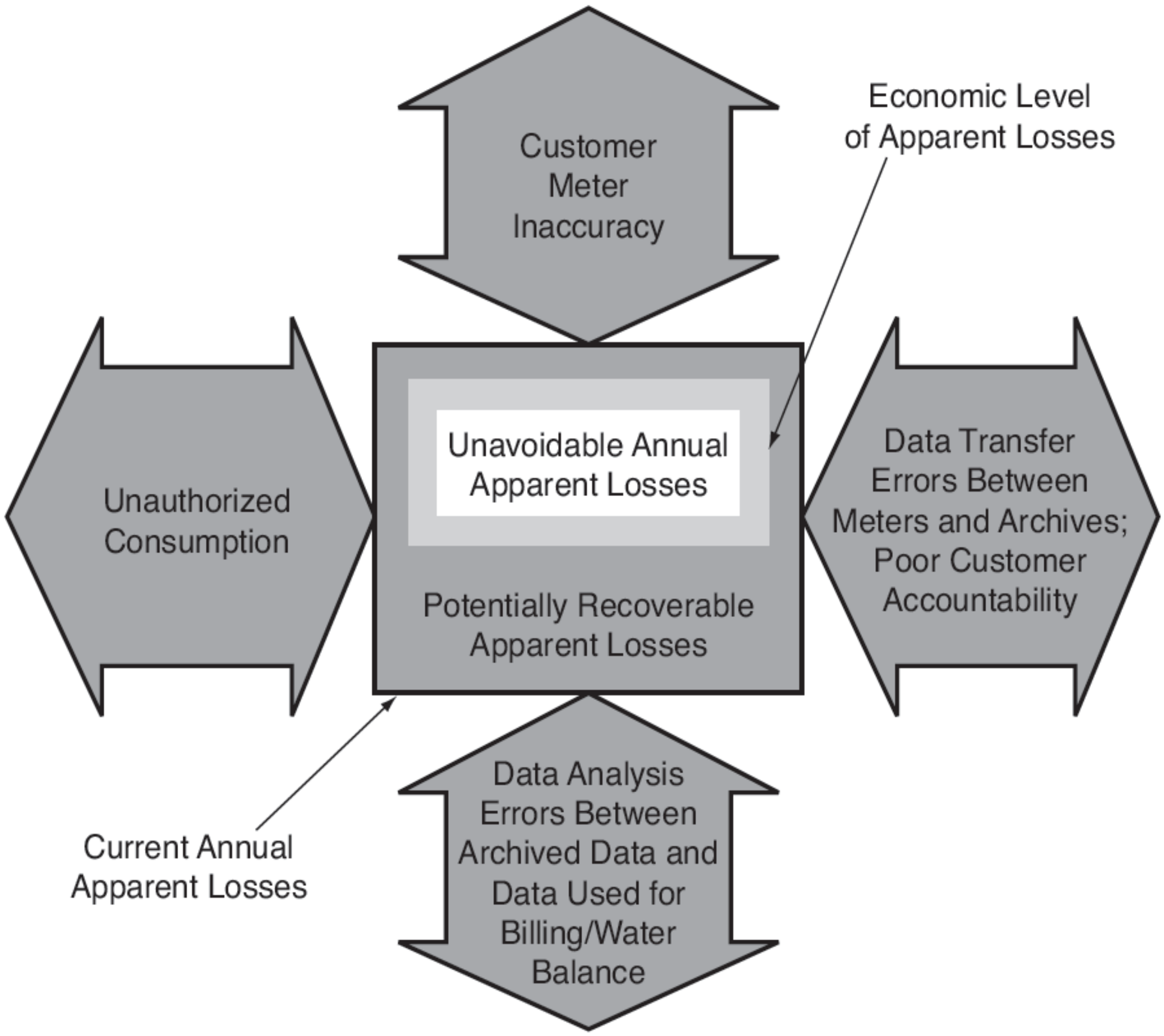

Figure 2: AWWA, Third Edition, 2009

NOTE: As each component receives more or less *attention*, the losses will increase or decrease as the operator strives to keep losses to a minimum. Extensive examples are available in AWWA *M36* that can be utilized to develop your informal program.

Identifying and Minimizing Apparent Losses

The general categories with basic descriptions of water losses are listed below. More specific sources of data within each category are provided in **Table 3**. The sources listed in **Table 3** are not all inclusive and are provided only as a guide on potential sources of data which will be needed to complete your informal audit.

- **Unauthorized Consumption**

  This category includes theft of water such as illegal connections, unauthorized use of fire hydrants, meter tampering, etc.

  - Water providers should use the default number of 0.25% provided in the software unless they can compile accurate data to demonstrate why their number is different. Supporting data should be saved in a new tab in the companion workbook for future reference.

  - Ways to minimize unauthorized consumption include but are not limited to reassessing policy and regulations for permitted water supply services, public education on theft, cooperation with other entities to report violations, better trained meter readers, theft bounties or rewards, more secure hydrant locks, etc.

- **Customer Metering Inaccuracies**

  These are inaccuracies that result from the improper sizing or maintenance of meters.

  - If a utility has a meter testing/replacement program, the average *calibration difference* for the old meters is entered in this category. Water providers may choose to develop an average calibration difference based on the size and the model of meter.

  - If a utility does not yet have a meter testing/replacement program, the manufacturers' default (typically 2%) may be used for this entry. Typically, meters under register when they are inaccurate.

  - Ways to minimize this category are to operate a proper meter testing and replacement program, utilize a meter sizing program rather than having meters chosen by cost, periodic review of the usage compared to meter sizing to determine if a different size or type of meter is more appropriate, etc.

- Water providers are encouraged to refer to *AWWA's Manual M6* (Water Meters, Selection, Installation, Testing and Maintenance) or *AWWA Manual M22* (Sizing Water Service Lines and Meters) for more information.

- **Systematic Data Handling Errors**

These are errors occurring between the point of data input as meter readings and the data output or archived in customer billing systems.

- Errors include billing system entry errors, account adjustments, invalid zero consumption readings, meter rollover, meter change out, etc.

- Ways to minimize include enhanced QA/QC on data entry, switching from manual to automated meter readings (AMR), enhanced software, and detailed comparisons of water production to water billed over time.

NOTE: Use care when considering *estimated bills*. If estimated consumption is reduced based on better available data, these negative adjustments can constitute an Apparent Loss. If estimated consumption is increased, the difference is considered billed metered. All other estimates or adjustments should be included in the appropriate Authorized Consumption category; either billed metered or billed unmetered. Estimated bills and bill adjustments during the same time period should be considered billed metered. Bills that are estimated for a longer period should be considered billed unmetered.

Table 3: Potential Causes of Apparent Losses

Unauthorized Consumption	Customer Metering Inaccuracies	Systematic Data Handling Errors	
Entities that are NOT AUTHORIZED to use water	**Field Measurement / Calibration Issues**	**Internal Data Handling /Transfer Errors**	**Data Analysis / Billing Program Errors**
Unauthorized fire hydrant usage	Calibration Errors	Manual adjustments to usage (hand)	Improper or erroneous multipliers
Connection to unmetered fire line	Meter installation errors	Adjustments that replace original data	Manual adjustments to bills but not volumes (changed entry)
Customer installed bypass (residential or commercial)	Open/leaking bypass valve	Long term "no reads"	Usage adjustments based on short term estimates
Unauthorized connections to other systems (border areas)	Under or over sized meters or improper type of meter	Improperly recorded meter data from crossed meters	Adjustments due to known leakages
Fire Sprinkler system testing (private or industrial)	Tampering with meter reading equipment	Estimated readings from malfunction or exchange of meters (excludes temporary inclement weather issues)	Adjustments that do not leave original data in place and change it to a new reading
Internal connection to fire line by entity or staff	Improper repair of meter reading equipment	Procedural/data entry errors for change outs and new meters	Adjustments to prior year volumes (entry update)
Meter Vandalism (internal or external)	Untimely meter installations	Improper programming of AMR equipment	Long term "no reads" are not flagged
Fountains/ water features (unmetered but **authorized**)	Untimely final reads	Non-billed status. Meter is in place and not being read (rental, vacancy, etc.)	Computer / Billing Software issues (malfunctions, programming errors, etc.)
Special Events (unmetered but **authorized**)	Buried/"lost" meters	Customer meters left unread due to account setup problems	Inconsistent policy interpretations by staff
Infrastructure Cleaning (streets, bus stops, etc.) (unmetered but **authorized**)	Equipment failure	Using a combined large/small meter calibration error	Customer lost in system
Line Disinfection by contractors(unmetered but **authorized**)		Customer *lost* in system with incorrect contact info.	Improper programming of AMR equipment
Repair efforts by others with unreported system damage (unmetered but **authorized**)		AMR equipment failure	Discretionary decisions or political "adjustments"

Table 3: MNGWPD

Impact of Real Water Losses and How They Occur

The data in **Table 4** can be used to compare audit results to see if they are generally consistent with those experienced by systems of a similar size. Although the expression of *non-revenue water* as a percentage of the total volume supplied is useful for purposes of benchmarking and comparison, it is important to note that there is no industry standard for acceptable levels of Non-Revenue Water.

Table 4: Sample Water Loss Indicator Data for Large Systems

Parameter	AWWA Survey [(2)]
Volume Supplied – Billion Gallons (BG)	2,671
Water Losses (BG)	
Real	237
Apparent	94
Total NRW	331
Non-Revenue Water (% by Volume)	12.4%

(2) 2002 AWWA Survey; results are cumulative for 96 systems each serving more than 100,000 persons

The following information provided in **Table 5** summarizes the financial implications of water losses from a sample large water provider. In the table, apparent losses are valued at the entity's customer retail unit cost of water ($2.34) per thousand gallons for the example), while real losses are valued at the water provider's variable production cost ($425 per million gallons). This approach reflects the fact that apparent losses represent lost revenue, while real losses represent inefficiency and must be offset through production of additional treated water.

Table 5: Financial Performance Indicators for Large Water Provider Case Study

Parameter	Result
Annual Cost of Water Loss	
Apparent Loss	$1,243,500
Real Loss	$1,312,500
Total	$2,556,000
NRW (% of System Operating Cost)	9.6%

The significance of the data in **Table 5** is that it provides a basis against which the costs of improved water loss management can be evaluated to determine a *return on investment*. As noted previously, real losses represent operating inefficiency because of the increased volume of treated water that must be produced to offset water lost through events such as leaks, pipe breaks and tank overflows. However, it must be noted that practical considerations dictate that real water losses cannot be completely eliminated and a portion of real losses are unavoidable. **Table 6** summarizes the operational efficiency indicators for the same evaluation period.

Table 6: Operational Efficiency Indicators for Large Water Provider Case Study

Indicator	Result
Unavoidable Annual Real Losses – Billion Gallons (BG)	1.6
Average Real Losses for 2004-2007 (BG)	3.2
Infrastructure Leakage Index	2.0

Using the variable production cost of $425 per million gallons, the value of the water providers' *avoidable* annual real losses was approximately $700,000 over the study period.

Note: This example assumes NO additional costs are incurred by acquiring "new" water. In actuality this costs could be a significant component of determining the most cost effective measure to undertake first.

Characterizing, Locating and Quantifying Leakage Events

Proactive leakage management is designed to control the *real* portion of water loss, which includes leaks on mains and service lines and overflows at storage facilities. **Figure 3** illustrates the four components of controlling real losses. As each component receives more or less attention, the losses will increase or decrease from each category.

Figure 3: Control of Real Losses

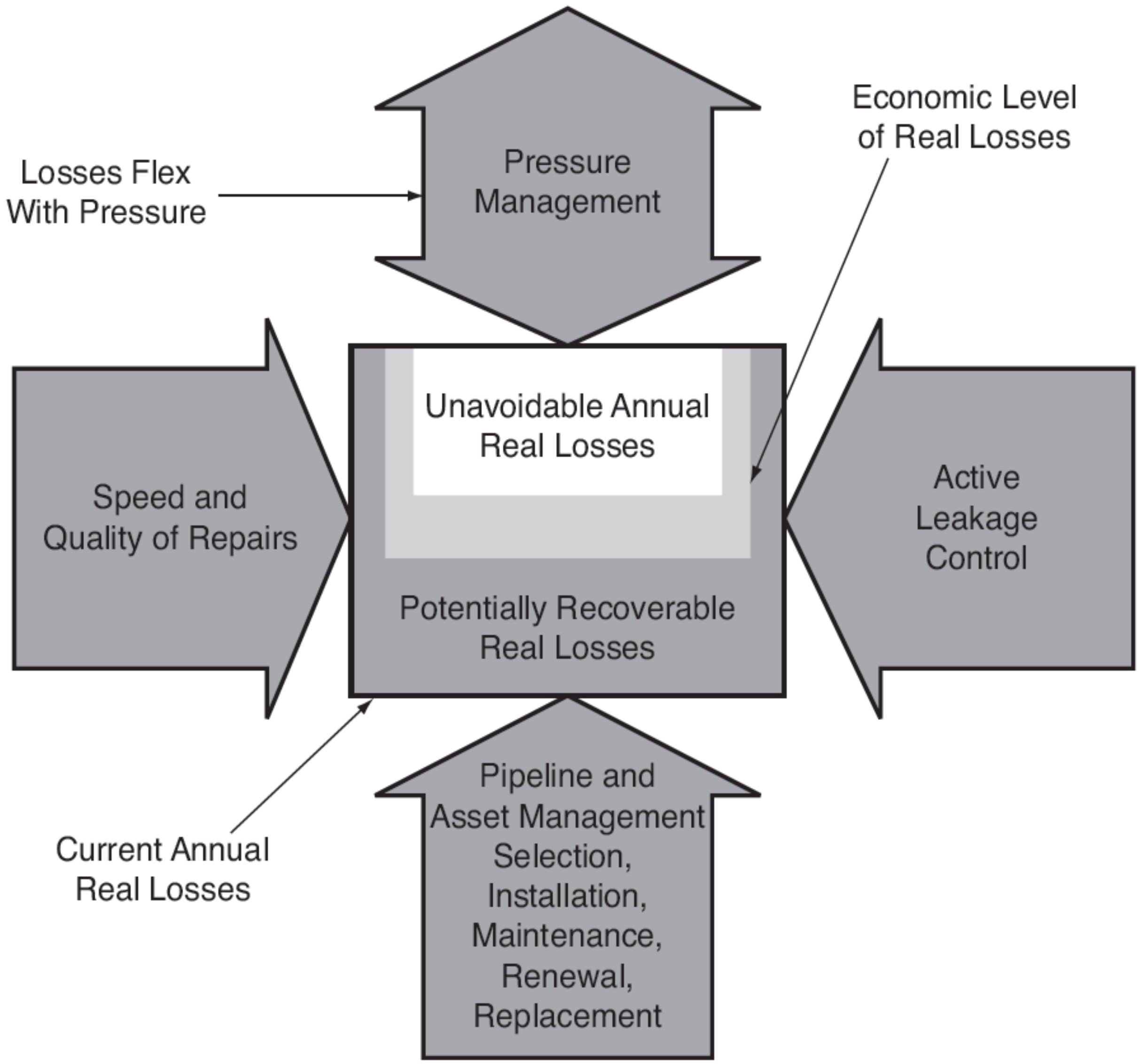

Figure 3: AWWA Manual M36, Water Audits and Loss Control Programs (Third Edition, 2009).

Role of Water Pressure on Distribution Systems and Leakage

Average Operating Pressure

The average system pressure is a very important parameter in calculating the unavoidable annual real losses (UARLs). All systems are unique and the pressure will vary based on the average geographic size of the system, the elevation changes, the demand patterns, and other local considerations. To limit the variability in pressure measurements that might skew the IWA/AWWA water audit results, the following standards for pressure measurements are recommended (readers are encouraged to refer to the MNGWPD document and the *AWWA M36 Manual*).

- Tank Elevations – It is recommended that the tanks be at the midpoint of normal daily operations. For example if the tanks fluctuate between 60% full and 100% full, then the measurement should be at 80% full. If the tanks operate between 0% full and 100% full, then 50% full represents the midpoint.

- Time of Day – Midday is recommended because tanks are typically filled at night, so pressure will be the highest. In the morning, the demand is the highest so the pressure will be the lowest. Midday (Noon) is a more representative time for pressure in most systems.

- There are several basic methods for calculating average operating pressure.

  - For water systems with a distribution model, an average pressure can be easily calculated. Systems should calibrate the model with field pressure data to verify model accuracy.

  - For water systems with multiple pressure zones, the average pressure should be calculated based on the length of water main in each zone using the distribution model.

  - Systems that cover a relatively flat terrain <50 ft. variation can sample static pressures at hydrants evenly distributed throughout the system (30 minimum recommended). The arithmetic average of these readings can be used. Data should be adjusted by 1-2 psi to account for elevation difference between hydrant and the distribution line.

  - Systems that have varying terrain (>50 ft.) can sample static pressures at hydrants distributed throughout the system representative of the terrain (30 hydrants minimum are recommended). The results can be used to calculate an average elevation and weighted average pressure of the entire water distribution system.

Controlling *Real* Water Losses: Leakage & Pressure Management Programs

Establishing Baseline ILI and Target Level ILI for Leak Reduction

The ILI calculated by the AWWA Free Water Audit Software© is a very important benchmark for water system planning. As mentioned previously, it can also be used as a target setting-mechanism, but only for water systems just starting their water auditing process. Each water system should determine their own target ILI, based on operational, financial and water resources considerations. The target-setting assessment is unique to each system, so no system should utilize a leak reduction target established for another system..

The *AWWA M36 Manual* provides guidelines for using the ILI as a preliminary target-setting tool within a specific water provider. The determination of a system specific ILI should take into account water resource availability, operational considerations, and financial goals of the water provider.

Once a water system has moved past the initial auditing and has a basic leakage management program in effect, real loss reduction can then be tracked using several indicators such as real losses/service connection/day or real losses/mile-of-mains/day/psi of pressure. These indicators allow for quantifiable financial spending and recovery goals. Over time, the water system can track their progress and success using these additional performance indicators from the water audit.

Table 8: Target Infrastructure Leakage Index Guidance

Note: Guidance is presented in lieu of performing a full economic analysis of leakage control options.

Note: Utilization of ILI with data validity scores <50 is misleading and considered inappropriate.

Target ILI Range	Water Resources Considerations	Financial Considerations	Operational Considerations
1.0 – 3.0	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop	Water resources are costly to develop or purchase	Operating with leakage above this level would require expansion of infrastructure or new water resources
3.0 – 5.0	Resources are sufficient if good demand management measures are in place	Water resources can be developed or purchased at reasonable expense	Existing supply infrastructure is sufficient as long as leakage is controlled
5.0 – 8.0	Water resources are plentiful, reliable and easily extracted	Cost to purchase or obtain/treat water is low, as are rates charged to customers	Superior reliability, capacity and integrity of infrastructure make the system immune to supply shortages
Greater than 8.0	Although operational and financial considerations may allow a long-term ILI greater than 8.0, such a level is not an effective utilization of water as a resource. Setting a target level greater than 8.0 – other than as an incremental goal to a smaller long-term target – is discouraged.		
Less than 1.0	If the calculated ILI value is 1.0 or less, two possibilities exist: a) world class low leakage levels are being maintained, or b) a portion of the data may be flawed.		

Table 8: AWWA M36 Manual, Third Edition, 2009

Regardless of the calculated ILI each water provider must establish individual goals to work toward that apply strictly to the system. Numerous combinations of improvements are listed in the various tables describing different parameters and what it takes to achieve the next level of *effectiveness*. The system should give careful consideration toward establishing an ongoing water loss control program and water conservation program.

Active Leakage Control and Timely Leak Repair Programs

Leak management programs are organized according to the “four-component” approach for water loss control developed by the IWA/AWWA.

As noted previously, physical losses in the distribution system are referred to as real losses. Real losses, which consist of a recoverable and unavoidable component, include leakage on transmission and distribution mains, leakage and overflows at the system’s storage tanks, and leakage on service connections up to the customer meter.

Cost-effective management of real losses in a water distribution system can be achieved by examining the potential causes, evaluating potential activities for minimizing these causes, and implementing those activities deemed most appropriate. The desired objective is to achieve the economic level of real losses as appropriate for each water distribution system.

In 2002, AWWA conducted a survey of 96 water systems, each serving more than 100,000 persons. The results of this survey indicated that the most common leakage management techniques employed by these systems included the following leak detection technologies:

- Leak noise correlation (43%)
- Ground microphones (36%)
- Listening sticks (27%)
- Leak Noise loggers (22%)

In 2011, the AWWA Water Loss Control Committee began an initiative of assembling validated water audit data, for the purposes of establishing reliable industry benchmarks. At the time of publication of this document, the first round of the data initiative has been completed. Twenty-one (21) water utilities from across the US and Canada are included in the data set, ranging in size from 3,000 connections to over 500,000 connections. The data and calculated performance indicators from this data set serve as a useful initial view into the water efficiency standing of North American water utilities. While this initial data set is small, additional utility participation is expected in each subsequent year of the effort. It should be noted that this is an initial data set, and at least three (3) years of data compilation and analysis will be required to represent a robust data set for stronger benchmarking. The most important aspect of this undertaking was the validation process employed by the Water Loss Control Committee, which involves conference calls with water utility personnel to ascertain their water supply and business practices and to ensure that the data gradings they applied to their data was consistent with the criteria set forth in the AWWA Free Water Audit Software©. Information on this effort exists on the AWWA website.

Implementing Pilot Programs for Leakage Management

Subsequent recommendations in this category cover investment in additional leak detection resources and strategies such as in-house crews, equipment, contractors, and operational changes including active pressure management. When evaluating the feasibility of each option and selecting the best tools for the system, it is necessary to determine the potential payback associated with each option.

The use of leak noise loggers as a method for reducing the run time of unreported leakage is becoming more common. These devices are programmed to listen for leak signatures during low demand periods, typically during overnight hours when vehicular traffic is generally at a minimum. They record leak noise data for later analysis of potential leak occurrences. Leak noise loggers complement the conventional leak survey and detection methods while utilizing a fraction of the manpower required using conventional leak detection equipment. These devices, which are typically placed in valve boxes on top of valve operators at intervals of approximately 1,000 feet, allow the operator to pinpoint the precise location of the leak.

Leak noise loggers may also be used in conjunction within District Metered Areas (DMA) although this might represent a duplicate level of active leakage control. In creating a DMA a portion of the distribution system is temporarily or permanently re-configured to measure all inflows at one or two entry points to an isolated area on a continuous basis. The inflows would then be compared to the sum of customer meters within the isolated area to determine potential leakage. It is important to note that care must be taken when establishing the DMAs to ensure that acceptable water quality and adequate domestic service and fire protection capability are maintained.

The frequency of leak detection system surveys vary within the industry, with some large utilities targeting a cycle time of one year. For each system, a more readily attainable goal such as three to five years is an appropriate target. As the system's data collection and evaluation process improves to allow a more accurate assessment of real versus apparent losses, the applicability of a targeted leak detection cycle can be revisited and the leak survey frequency adjusted accordingly.

Management Decisions

In determining resource requirements, the system must also consider the amount of effort required to address emergency and work order responses, and how this effort may be reduced through increased proactive leak detection activity.

It is important to note that an increased investment in proactive leak detection will elicit an initially increased number of unreported leak work orders generated for response by the system's leak repair crews. In order to effectively manage real water loss, the system will need to determine an appropriate level of investment in repair crews and equipment to maintain its desired response goal. The objectives for this process should include:

1. Quantifying the backlog of leak repair work to be done,
2. Identifying a reasonable time frame in which to eliminate those existing work orders,
3. Establishing baseline estimates of work orders generated on a monthly basis and
4. Setting performance metrics that would allow the system to address the estimated quantity of work orders and eliminate the existing backlog in a timely manner.

Revenue Recovery from Water Loss Control Activities

Water loss control programs can have significant financial benefits if developed and implemented properly. First, apparent loss reduction will directly increase income to the water system, due to the nature of apparent losses being valued at the retail water rate. Activities to reduce unauthorized consumption can include GIS mapping of water meters to analyze customers that may not be metered, installation of detector checks or meters on customer fire lines to prevent cross connection, fire hydrant locks, better enforcement of unauthorized fire hydrant use, and a door-to-door customer census, to name a few.

The other component of apparent loss is the business process of accurately metering, reporting, billing and collecting water usage fees. This process can be quite extensive, and may include installation of appropriate size meters on all authorized users, a proactive customer meter calibration and replacement program, and consideration for Automated Meter Reading (AMR) systems or Advanced Metering Infrastructure (AMI), customer service practices (everything from account setup to billing adjustments), billing frequency, bill format, billing rates, and collection practices. An extensive business practices audit of these can be performed to determine which will provide the most improvement and financial benefit.

While revenue recovery is more directly related to reduction of apparent losses, an effective real loss reduction program can also contribute to the water system's financial improvement. Real loss reduction not only reduces day-to-day operational costs by reducing the amount of water needed to produce and distribute (usually through pumping), it can also reduce overall system demand and defer costly capital improvements in production and distribution infrastructure or water resources expansion. Direct savings from real loss reduction is calculated using the production (and pumping) cost of water, but the financial benefits extend beyond this direct calculation. Activities can include pressure management to reduce background leakage, improved response time for leak/break repair, an active leak detection and management program, and proactive asset maintenance and rehabilitation.

Reporting Outcomes and Benefits of a Water Loss Control Program

Obviously, there can be great benefits derived from the implementation of an effective water loss control program, but it is critical to document and report those benefits. The fundamental step in that process is to annually compile a comprehensive water audit as a standard business practice. This allows for tracking of progress and success by trending the results and performance indicators. However, a complete reporting of all activities under the water loss program includes the following (suggested activities include):

1. Setting goals for primary activities (gallons reduced, miles of main surveyed or replaced, number of meters calibrated or repaired, etc)
2. Expected benefit from the primary activities (financial, operational or water resources)
3. Projected timeline for the primary activities(to be performed in 1 year, 5 years, etc)
4. Progress-to-date compared to goals

5. Calculated benefit from the primary activities, to date
6. Return on investment to date, and
7. Next steps for the primary activities (continued activities and expected future benefits or discontinue activity due to completion or failure)

Chapter 6 of the *AWWA M36 Manual* provides a good framework for establishing a water loss control program with a cross-functional team of members from departments across the water system including customer service, meter maintenance, meter reading, leak repair, water production, distribution maintenance, operations, engineering, management, etc. Having this broad representation included in the long term planning for the program not only provides needed input and feedback, but also an understanding of the data needed for periodic completion of the water audit and reporting status on the program activities. Upon the compilation and calculation of the water loss control program successes and benefits, it is important to communicate the value and benefits of the water loss control program to all staff of the water system and to the customers and other external stakeholders. An effective program, successfully communicated to the public can have many benefits related to water system operation.

Finance Sources for Water Audits and Water Loss Control Plans

Public Financing Options

The Georgia Environmental Finance Authority (GEFA) provides low-interest water infrastructure financing for local government water utilities. GEFA has two loan programs, the **Georgia Fund** and the **Drinking Water State Revolving Fund** (DWSRF), and one technical assistance program, the **2011 DWSRF Small System Technical Assistance Set-Aside** that can be used by water utilities to support water loss control projects.

The Georgia Fund (state-funded) and the Drinking Water State Revolving Fund (federally-funded) can fund the following types of projects:

- Leak Repair – Financing the repair of leaks such as the replacement of leaky water lines.
- Line Rehabilitation and Replacement – Leaks can be avoided by reconditioning and/or replacing lines before the end of their useful life.
- Pressure Management – Since higher pressure can lead to more severe leakage, methods such as using pressure reducing valves to regulate water supply pressure in various zones of the water system can reduce water loss.
- New Water Meter Installation – Installing residential and commercial water meters for the first time on unmetered accounts is an important step towards measuring all water use and reducing non-revenue water. Metering can also assist a local water utility in a comprehensive billing strategy.
- Water Meter Replacement – Replacing older, inaccurate water meters with newer, accurate meters.

In addition, through the 2011 DWSRF Small System Technical Assistance Set-Aside**,** GEFA has reserved approximately $640,000* to provide assistance to small systems to conduct water audits consistent with the Georgia Water Loss Control Manual and to locate leaks in their water systems. GEFA plans to develop a competitive application process in order to provide these technical assistance grants to local government water systems serving between 3,300 and 10,000 customers. GEFA will use this funding to hire a contractor or contractors to assist small systems in conducting water loss audits. GEFA will use the results of the audits to provide further assistance to those small systems with high water loss. Once the water loss audits are complete and the leak detection analyses finalized, GEFA will offer attractive financing terms to these small local governments to repair these leaks through the use of a low-interest loan from one of GEFA's loan programs.

Potentially Eligible Water Loss Activities through the 2011 DWSRF Small System Technical Assistance Set-Aside:

- Water Auditing – Auditing is an important first step for utilities to determine their total non-revenue water and the scale of real and apparent water loss in their system. Audit assistance is available to small systems (3,300 – 10,000 customers/population served) through the Drinking Water SRF Small System Technical Assistance Program.

- Leak Detection – Several practices can help utilities to detect leaks within a water system, such as ultrasonic listening and advanced flow monitoring. Leak detection is available to small systems (3,300 – 10,000 customers/population served) through the Drinking Water SRF Small System Technical Assistance Program.

Private Financing Options

Through **Performance Contracting**, water utilities can pay for water loss control projects provided by a qualified contractor from the projected water savings of that project resulting in cost neutral undertaking. The projected savings must meet or exceed the cost of the project, and the contractor is responsible for any shortfall that may occur.

The benefits to a water utility include preserving limited budget dollars which can be used for other needed services and activities, paying for needed capital water improvements from water and energy savings and reducing high maintenance costs due to inadequate, aging, or obsolete infrastructure.

Performance contracting is commonly used in the energy sector to implement energy upgrades. In 2010, the Georgia State Legislature passed a constitutional amendment to facilitate performance contracting for energy and water savings at state and local government facilities. It is very important when employing performance contracting that the contract language very explicitly identify the measures and milestones that constitute performance achievement and cost savings garnered in the work effort, since payment to the contractor will be based upon these tangible savings. In addition there if often a large expense associated with terminating a contract early for non-performance.

Private Loans or Bonds

While “water loss control work" is usually accomplished from operating funds, water utilities are also accustomed to accessing the municipal bond market or securing private loans. The municipal bond market can be accessed to implement water audits, leak detection and leak abatement programs which will amortize the costs of such programs over 20 years or more and thus may result in a more cost-effective program.

Operating Funds

Most utilities fund water loss assessments and leakage management programs from their annual operating budgets. This approach is an effective strategy for ongoing water loss management. This approach allows the utility to keep their real water losses low and avoid large scale capital projects which require significant expenditure and debt.

Rate Reductions Offered for GEFA Financial Products

*Lower Interest Rate Encourages Water Conservation Projects**

Georgia communities can now take advantage of lower interest rates for environmental infrastructure projects that conserve water. The GEFA board of directors approved a 1 percent interest rate reduction on all water conservation loans made from the Georgia Fund, the Clean Water State Revolving Fund (CWSRF) and the Drinking Water State Revolving Fund (DWSRF). Depending on the fund source, interest rates for qualifying projects could be as low as 2 percent.

GEFA loan programs can be used by local government water utilities to finance a broad range of water conservation projects in the areas of utility-water loss and end-use water efficiency.

The one percent interest rate reduction applies to all stand-alone water conservation projects. The eligible projects under the Georgia Fund, CWSRF and DWSRF loan programs include:

- Installing or retrofitting water efficient devices, such as plumbing fixtures and appliances;

- Implementing incentive programs to conserve water, such as rebates for water efficient fixtures;
- Installing water meters in previously unmetered areas;
- Replacing broken or malfunctioning water meters or upgrading existing water meters with Automatic Meter Reading (AMR) systems;
- Recycling and water use projects replacing potable sources with non-potable sources; and
- Replacing or rehabilitating distribution pipe to reduce water loss and prevent water main breaks.

* GEFA Press Release Issued 5/18/2011

References and Resources

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- Georgia EPD Coastal Guidance Document: *Water Loss Control Programs*, (August 2007) http://www1.gadnr.org/cws
- Metropolitan North Georgia Water Planning District, *Water Audit Software Guidance Document* (May 2010) www.northgeorgiawater.org
- Water Loss Audit Manual for Texas Utilities, www.waterlosstexas.org
- Alliance for Water Efficiency – *Tracking Tool*, http://tinyurl.com/alliance-tracking-tool
- Georgia Water Stewardship Act, http://tinyurl.com/ga-water-stewardship-act
- AWWA M-22: *Sizing Water Service Lines and Meters* (Second Edition, 2004) www.awwa.org, http://www.awwa.org/bookstore
- AWWA M-6: *Water Meters – Selection, Installation, Testing, and Maintenance* (Fourth Edition, 1999) www.awwa.org, http://www.awwa.org/bookstore
- EPA Water Efficiency Page, http://www.epa.gov/WaterSense/water_efficiency/index.html
- Georgia Water Conservation Plan, http://conservewatergeorgia.net
- AWWA Water Loss Control Committee, http://tinyurl.com/water-loss-committee-contact
- *Validated Water Audit Data for Reliable Benchmarking* (2011), http://tinyurl.com/water-loss-benchmarks
- *AWWA WATER STATS*, Data from 339 drinking water utilities in the United States and Canada. The survey included sections on water auditing, customer meter management and leakage management and is the first North American survey to gather water audit data in the format of the IWA/AWWA water audit methodology, http://tinyurl.com/AWWA-Distribution-Survey