Georgia Water System Audits and Water Loss Control Manual

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Georgia Water System Audits and Water Loss Control Manual

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The 3rd Edition (Version 1.2) of the *Georgia Water System Audits and Water Loss Control Manual* was prepared by the Georgia Association of Water Professionals (GAWP). It was written through the dedicated work of a standing subcommittee under the Georgia Water Loss Control Committee (GWLCC). GWLCC members of this subcommittee include:

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TABLE OF CONTENTS

SECTION 1–The Importance of Water Loss Auditing and Control

1.1 Background and Regulatory Drivers

Georgia is home to 2,400 public water systems, of which 1,700 are community water systems. Within our state there are more than 70,000 miles of rivers and streams, numerous ponds and lakes, and one of the most productive aquifers in the world. Georgia receives, on average, about 50 inches of rainfall annually. Yet, demands on Georgia's water resources are growing. Federal, state and local management decisions are increasingly scrutinized due to conflicts over use of shared resources. The cost of providing reliable drinking water in Georgia is also increasing due to factors such as aging infrastructure, increased energy costs, and more complex and costly changes to the requirements for safe drinking water. And even though Georgia has abundant water resources, the water resources are neither evenly distributed across the state nor does the rain that replenishes those water resources fall in equal amounts across the state in any given time period. These factors, along with population growth in Georgia, may cause some regions of the state to experience water demands that exceed locally available supply.

Georgia has embarked on several comprehensive water management strategies to meet these challenges. The ratification of Georgia's first Statewide Water Management Plan in 2008, the development of regional water management plans (2003 – 2011), and the passage of landmark water stewardship legislation (2010), signify a shift in water management that affects every facet of our water environment. Of particular importance is the need to create and support a culture of conservation throughout the state by improving how efficiently water is used.

Water system inefficiencies increase the cost of service to customers and may lead to increased raw water demands that negatively impact the natural environment. Water system audits and water loss control are valuable water management strategies that can improve the efficiency of water production and delivery in water systems of all sizes within the state.

This document, the Georgia Water System Audits and Water Loss Control Manual, serves as a "guidance manual" and describes the current best practices necessary to complete a water system audit and implement a water loss control program in Georgia. The standards for conducting audits are in accordance with the International Water Association (IWA) / American Water Works Association (AWWA) methodology for water loss auditing, and reports are submitted to the Georgia Environmental Protection Division (EPD) on an annual basis by the affected water providers.

1.2 The Georgia Water Stewardship Act

On June 1, 2010, the Governor signed the Georgia Water Stewardship Act (GWSA) of 2010 (sometimes referred to as SB 370). This Act is a multifaceted approach to water conservation and it requires specific action by water providers serving 3,300 or more in population. Approximately 250 water providers in Georgia, who provide 80 percent 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. Sec. 12-5-4 and requires the following of water providers:

- Water systems serving a population of "at least 3,300" must conduct an **annual water system audit**.
- Water systems serving a population of "at least 3,300" must implement a **water loss control program**.
- EPD requires public water systems to conduct standardized annual water loss audits according to the IWA/AWWA methodology and requires that water systems submit those audits to EPD in a timely fashion.

  - **Special Note**: 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.

1.3 Georgia EPD Reporting Process

The GWSA requires water systems to conduct water audits according to the IWA/AWWA methods, following best practices adopted by EPD. The *Georgia Water System Audits and Water Loss Control Manual* was developed around similar themes as the AWWA *Free Water Audit Software*© *(version 4.2 or later),* 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/AWWA standard as dictated by the GWSA.

- For public water systems serving at least **3,300 individuals (or population served), the GWSA requires annual water audits covering the previous calendar year to be submitted to EPD no later than March 1st of the following calendar year**. This requirement does not have an expiration date.

Special Note: The GWSA requires EPD to post all submitted audits on its website. Therefore, **electronic** submissions will be **required** from all affected water systems. Annual water audits must be submitted electronically to Lebone.Moeti@dnr.state.ga.us. If a system has special circumstances that makes it impossible to submit an annual audit by March 1st, contact EPD by email (same as above) or by telephone (404-656-2750) for additional guidance.

Documents to be submitted to EPD include:

- The water audit file in Microsoft Excel format, with all worksheets completed.

  - ***Special Note****:* In the future, water withdrawal permits, water plant operations permit controlled production increases, and Drinking Water State Revolving Fund loans through the Georgia Environmental Finance Authority (GEFA) 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 EPD's website – www.ConserveWaterGeorgia.net. Programmatic updates to include the most up-to-date version of the *Georgia Water System Audits and Water Loss Control Manual*, state regulations and rule-making processes/schedules, and additional water auditing resources can be found here.

SECTION 2–Conducting a Water Audit

2.1 General Notes

Real Losses are 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.

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, and Systematic Data Handling Errors.

The updates to the Georgia Water System Audits and Water Loss Control Manual are based on using the best management practices to complete a water audit and take into account lessons learned from the water audits conducted to date. The Metropolitan North Georgia Water Planning District convened a group of water providers in 2010 and developed an excellent guidance document to assist utilities in completing the Reporting Worksheet of the software, which has been closely referenced in the updating of this manual. Please note that updates pertaining to the latest version (5.0) of the AWWA Free Water Audit Software are indicated in RED in this manual.

Trying to achieve a water loss of zero isn't practical or expected. Understanding that water losses are broken down into two categories – real losses and apparent losses – is important as the data collection is started and then input into the water audit spreadsheet. Additional sample calculations have been included in this manual to assist in developing inputs into the audit spreadsheet.

The primary goal of reducing real losses is represented by the infrastructure leakage index (ILI) and the normalized real loss performance indicators of gallons/service connection/day or gallons/mile/day. The water audit software calculates these performance indicators. Apparent losses must be quantified as accurately as possible in order to have greater confidence in the quantity of real losses.

It should be noted that it requires several years of conducting water audits to provide more accurate data for audit inputs. This requires bottom-up activities and field studies that supplement the desk-top data entered into the audit spreadsheet. As the data validity improves over the years, ILI values and other performance indicators should not be viewed as definitive, but rather should be viewed in combination with the data integrity score over time. It is always critical to remember that the goal is to improve the validity score over time so that there is an improved understanding of both real and apparent losses. It would not be unusual for the ILI values to increase as system leakages are more reliably quantified with improved data.

The need to maintain complete and accurate documentation used in conducting water audits is critical, not only because they may be subject to EPD audit, but also because this documentation provides the basis of calculations for the water audit and will be used by future new personnel who will eventually become involved in the audit process. A folder with a Microsoft Excel or Word file showing where the data originated and how the calculations were performed should be accessible to a number of personnel to maintain continuity in subsequent years.

Water audits are required to be conducted over the 12-month calendar year. While water systems may have different fiscal operating years, based on the experience of the first two years of water audits, the best approach for the calendar year reporting cycle is the internal use of rolling 12-month audits. These audits are based on tracking data on a month-to-month basis, and become part of the standard operating procedure in managing the water system. This forces various personnel involved in collecting and reporting the data to be more familiar with what is expected and not overwhelmed when the time comes to submit the annual audit. This also allows changes in data trends to be tracked throughout the year and analyzed for any anomalies.

2.2 Required Methodology for Water Audits

AWWA Free Water Audit Software© (version 4.2 or later)

The current version of the AWWA Free Water Audit Software© is version 5.0, released in 2014. While EPD will accept the previous version (4.2) for the 2014 audit submittal (by March 1st, 2015), utilities are strongly encouraged to use version 5.0, as it has several enhanced features and functionality, including:

- *Inputs & Outputs separated into 2 tabs*
- *Meter error adjustment for all water supplied components*
- *Clarifications and enhancements to grading matrix*
- *Clarifications and enhancements to definitions*
- *New Water Loss Dashboard for visual display of non-revenue water components*
- *New comments page for capture of essential supporting information*

Version 5.0 will be the required format beginning with the 2015 audit submittal (by March 1st, 2016).

Special Note: It is EPD policy to use this software for **all** water systems affected by the GWSA 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 EPD. To download the **AWWA *Free Water Audit Software*©** visit the AWWA website (see Reference section on last page of this document). Please note that you will need to register/login (no cost) to the AWWA website before downloading the software.

Please note the software is in Microsoft Excel format.

The AWWA *Free Water Audit Software*© includes multiple worksheets in a spreadsheet file. The first worksheet provides instructions on the use of the software. *It is essential to complete the administrative inputs on the instructions tab, including but not limited to the utility's PWS ID# and the units of reporting (typically Million Gallons).* 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.

It is understood that many water utilities do not typically tabulate all of this data, therefore, some of the values may be easier to determine than others. All data entry cells should be completed. If the input value is known and verified, its data grading should be higher; if the input value is estimated, its data grading should be lower. Some input cells provide a default value and default data grading that can be used until more accurate data is acquired. In addition, the software calculates a variety of performance indicators that are very useful in quantifying system performance. Refer to Section 2.8 in this manual for further discussion on the derivation and interpretation of audit results.

2.3 Reporting Worksheet - WATER SUPPLIED

The "water supplied" section quantifies the total volume of treated water that is pumped into the distribution system.

Volume from Own Sources (VFOS)

This 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 EPD.

- List the treated water sources to ensure none are overlooked. Groundwater that directly enters the distribution system should be added. Groundwater that is treated at a water treatment plant will be counted by the production meter.

- The "master meter" in this section refers only to the finished water meters measuring flow input into the distribution system, and does not refer to any large customer meters that may casually be referred to as master meters.

VFOS Master Meter and Supply Error Adjustment

The adjustments made to the production master meter(s) recorded volumes based on meter flow verification that accounts for errors in measurement, calibration, data gaps from communication interruptions or other data archival issues.

Special Note: Because no water meter is 100 percent accurate 100 percent of the time, a value for this input - however minimal - should be entered in this cell. Zero is not a realistic input.

Special Note: An important distinction should be drawn between 'flow verification' and 'calibration'. Flow verification is the act of confirming the accuracy of the primary metering device – the measuring element. Flow verification requires an independent measurement, typically by a second meter in series with the first, to provide comparative readings. Comparative readings are what provide us with the ability to quantify the error.

Calibration is the act of making modifications to the secondary electronic device – the output device where the flowmeter's measured values are converted and communicated. Typically this can be a differential pressure transducer or cell that converts the flowmeter measurement into a common electronic signal (i.e., 4-20 mA) used in the telemetry or SCADA system.

Be careful not to confuse these two terms, or to assume they are the same. Flow verification is for the primary metering device, calibration is for the secondary electronic device, and both are vital in providing the highest degree of confidence in the water supplied volume, which is the most important input in the water audit.

- Production master meters should be flow verified and calibrated annually at a minimum, per EPD requirements. Flow verification and calibration records should document the existing meter reading, as well as the adjustment made to the meter to calculate the over/under calibration difference as a percentage. Adjustments to the production master meter based on the flow verification report are entered in this field following *Example 1*.

- ➢ If the meter is flow verified and calibrated more frequently (i.e., quarterly), calculate a flow-weighted average following *Example 2*.

- ➢ If there are multiple production master meters operating in parallel, provide an average weighted by flow volume to determine the total master meter and supply error adjustment.

- ***Special Note:*** It is unlikely that a utility will enter a grading value of 10 in column E and enter an error adjustment of zero. Even with very good data, a meter adjustment is likely; therefore a volume associated with this adjustment should be entered. While storing flow verification and calibration data as a new tab in a companion workbook is always recommended, keeping a copy of the independent meter flow verification and calibration results is strongly recommended.

Example 1 - Meter flow verified annually:

Flow Verification Date	Test Meter Accuracy	Subject Meter Accuracy	Percent Error	Water Produced in Year	Annual Master Meter and Supply Error Adjustment
Jan-1-09	100%	98.5%	-1.5%	100 million	-1.50 million
Total Master Meter and Supply Error Adjustment(-0.015) x (100 million)=					-1.50 million

- Note: For this example, select "under-register" from the drop-down box because the meter under-registered the volume by 1.5 million gallons.

Example 2 – Meter flow verified quarterly:

Flow Verification Date	Test Meter Accuracy	Subject Meter Accuracy	Percent Error	Water Produced in Quarter	Quarterly Master Meter and Supply Error Adjustment
Jan-1-09	100%	98.5%	-1.5%	20 million	- 0.3 million
Apr-1-09	100%	99.0%	-1.0%	30 million	- 0.3 million
Jul-1-09	100%	99.0%	-1.0%	40 million	- 0.4 million
Oct-1-09	100%	101.5%	+1.5%	10 million	0.15 million
Total Master Meter and Supply Error Adjustment (sum of 4 numbers) =					-0.85 million

- Note: For this example, using software version 5.0 or newer (recommended), enter this input (cell N15) as a negative number since it represents under-registration. If using software version 4.2 (not recommended), enter the input (cell G15) as a positive value and select "under-registration" from the adjacent dropdown menu.

Water Imported (WI)

This is the water purchased from a neighboring utility or regional water authority.

- ➢ Meters that measure this volume should be verified by the seller and thus be reflected in the bill received from the seller. The purchaser (the Utility completing the water audit) should request documentation to verify the accuracy of these meters regularly.

WI Master Meter and Supply Error Adjustment

The adjustments made to the import meter(s) recorded volumes are based on meter flow verification that accounts for errors in measurement, calibration, data gaps from communicating interruptions or other data archival issues. *Using software version 5.0 or newer (recommended), enter this input as a positive value or percent for over-registration, and a negative value or percent for under-registration. If using software version 4.2 (not recommended), the error adjustment must be figured separately and included in the Water Imported input (cell G16).*

Water Exported (WE)

This is the 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.
- Water export meters should be tested (flow verified and calibrated, depending on the meter type) regularly. For large water exporters (20% or more of produced water is exported), the testing interval should be consistent with production master meter testing. For smaller water exporters, meters measuring exported water should be tested at least once every 3 years.

WE Master Meter and Supply Error Adjustment

The adjustments made to the export meter(s) recorded volumes based on meter flow verification that accounts for errors in measurement, calibration, data gaps from communicating interruptions or other data archival issues. *Using software version 5.0 or newer (recommended), enter this input as a positive value or percent for over-registration, and a negative value or percent for under-registration. If using software version 4.2 (not recommended), the error adjustment must be figured separately and included in the Water Exported input (cell G17).*

2.4 Reporting Worksheet - AUTHORIZED CONSUMPTION

Authorized consumption refers to the volume of water that is used by an authorized customer. This category does not include water sold to other utilities, which is considered water exported in Section 2.3. The general categories with basic descriptions of authorized consumption are listed below. More specific sources of data within each category are provided in **Table 5**

(Section 4.2). The sources listed in **Table 5** are not exhaustive, and are provided only as a guide for potential sources of data.

Billed Metered

This category includes water that is metered and billed for domestic, commercial, industrial or institutional customers.

- ➢ It is recommended that water providers periodically check meter readings on inactive accounts to identify billed metered usage that would not be identified during normal meter reading routes because the meter is considered inactive.

Special Note: 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 (See Section 2.3).

Special Note: Use care when considering estimated bills. Estimated bills and bill adjustments during the same time period are considered billed metered if there is a meter. If estimated consumption is reduced based on better available data, these negative adjustments are considered an Apparent Loss.

Billed Unmetered

This category includes water that is not metered, but is billed and may include customers who are not metered but are 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.

Unbilled Metered

This 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.).

Unbilled Unmetered

This category includes unmetered water that is unbilled for authorized uses such as firefighting, flushing of mains or sewers, street cleaning, etc.

- ➢ Utilities may select the default number of 1.25 percent of the Volume from Own Sources unless they can compile accurate data to justify a different number. Supporting data should be saved in a companion workbook.

- It is recommended that water providers focus on billed metered and billed unmetered data before focusing on unbilled unmetered as it is typically a small percentage of use.
- It is recommended that water providers install meters on all permanent structures regardless of whether it is billed or unbilled to improve data quality.

2.5 Reporting Worksheet - WATER LOSSES

Apparent losses account for errors generated while collecting customer consumption data. The three categories of apparent losses include Unauthorized Consumption, Customer Metering Inaccuracies, and Systematic Data Handling Errors. The following Section provides descriptions of each type of loss and methods of measuring these losses. Real Losses are calculated by the software. More specific sources of data within each category are provided in **Table 6 (Section 4.3)**. The sources listed in **Table 6** are not exhaustive, and are provided only as a guide for potential sources of data.

Unauthorized Consumption

This category includes theft of water such as illegal connections, unauthorized use of fire hydrants, meter tampering, and any other type of water theft.

- Water providers should use the default number of 0.25 percent of the Volume from Own Sources provided in the software unless they can compile accurate water theft data. Supporting data should be saved in a companion workbook.

Customer Metering Inaccuracies

These are inaccuracies that result from wear, improper sizing or maintenance of meters. The value is input as a positive percentage, between 1 percent and 10 percent into the audit.

- If a utility has a meter testing program in place, the accuracy test results for small and large meters should be utilized to calculate this value as a total weighted average, based on consumption (*see Example 3 calculation below*).
- To perform this total weighted average calculation, meter test results for low, mid and high flow ranges must be combined into a single weighted average based on volume, for small and large meters, respectively. The most accurate method to determine the weighting for the three flow ranges is to flow log a sample of meter accounts. In lieu of this flow logging, AWWA guidelines suggest weighting as follows – 15 percent for low flow, 70 percent mid flow and 15 percent high flow ranges. See *Example 3 calculation*

below for further guidance on using these weightings to reach a weighted average for meter test results.

- If a utility does not yet have a meter testing program in place, judgment must be used to estimate the inaccuracy of large and small meters, based on known condition, age and cumulative usage of the meter population.
- AWWA publishes two guidance manuals that can be referenced for sizing water service lines and sizing of meters, as well as maintaining 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.
- For more detailed guidance on this topic, refer to the AWWA *M36 Manual*.

Example 3 – Customer Metering Inaccuracies Calculation

Total water sold in Audit year = 600,000,000 gal
Total water sold through small meters (up to 2") = 350,000,000 gal (58.30% of total)
Total water sold through large meters (>2") = 250,000,000 gal (41.70% of total)

	Low Flow Range	Mid Flow Range	High Flow Range
Small meter test results:	87.00%	99.00%	98.00%
Large meter test results:	90.00%	97.00%	101.00%

1. Find the weighted average for small and large test results, respectively:

Small = 87.00%x15.00% + 99.00%x70.00% + 98.00%x15% = 97.05%
Large = 90.00%x15.00% + 97.00%x70.00% + 101.00%x15% = 96.55%

2. Find the weighted average between the small and large meter weighted averages, based on volume of water sold:

97.05%x58.30% + 96.55%x41.70% = 96.84%.

In this example, the total weighted *accuracy* of the customer meters (large and small, combined) is 96.84%. Therefore, the *inaccuracy* of the customer meters would be:

100.00% - 96.84% = 3.16%. Thus, "3.16" is what should be input into the audit for Customer Metering Inaccuracies for this example.

Systematic Data Handling Error

These are errors occurring between the meter readings and billing systems.

- Errors include billing system entry errors, account adjustments, skewed estimates, poor accounting, etc.
- Automatic Meter Reading (AMR) systems can reduce systematic data handling errors compared to manual meter reading systems.

- It is recognized that this value is difficult to quantify. Unless you have conducted a detailed analysis on your billing system database for this purpose, it is recommended to utilize the following default value:
    - *0.25 percent of the Billed Metered volume*
- For more detailed guidance on this topic, refer to the AWWA *M36 Manual*.

2.6 Reporting Worksheet - 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

This is the total length of transmission and distribution pipelines in the system; enter this value in units of miles.

Special Note: Length of mains input should not include service lines.

Number of Active and Inactive Service Connections

These include all physical connections to the main, 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 water utilities unless a utility's meters are located beyond the customer property line. In Georgia, most or all utilities will use an input value of zero with a data grading of 10. *Using software version 5.0 or newer (recommended), select "Yes" to the question "Are customer meters typically located at the curbstop or property line?" This will result in the auto-population of the correct input and grade for this entry*. A diagram with corresponding description is provided in the software on the tab "Service Connection Diagram".

Average Operating Pressure

The average system operating 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 water audit results, the following standards for pressure measurements are recommended.

- Tank Elevations – It is recommended that the tanks be at the midpoint of normal daily operations. For example if the tanks fluctuate between 60 percent full and 100 percent full, then the measurement should be at 80 percent full. If the tanks operate between zero percent full and 100 percent full, then 50 percent full represents the midpoint.
- Time of Day – Midday is recommended because tanks are typically filled at night, when 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 by averaging the pressure at each node in the model. Systems should calibrate the model with field pressure data to verify model accuracy.
  - For water systems with a single pressure zone, a representative sample of static pressure readings across the zone should be taken and averaged. See *Example 4 calculation* below.
  - For water systems with multiple pressure zones, a representative sample of static pressure readings across each zone should be taken, and then the averages for all zones should be combined into a total weighted average, based on miles of main per zone. See *Example 5 calculation* below.
- For more detailed guidance on this topic, refer to the AWWA *M36 Manual*.

Example 4 – Single Pressure Zone Calculation
12 readings taken, measured in psi: 55, 50, 72, 41, 47, 45, 51, 45, 50, 90, 84 and 66.
Average Operating Pressure = (55+50+72+41+47+45+51+45+50+90+84+66) / 12 = 58 psi.

Example 5 – Multi-Pressure Zone Calculation
A system has 3 pressure zones – A, B and C. Total miles of main in the system = 210 miles.
Zone data is as follows:

Zone	Average Zone Pressure (psi)*	Miles of Main	Weighted % of Total Miles of Main
A	76	102	= 102/210 = 48.6%
B	61	32	= 32/210 = 15.2%
C	92	76	= 76/210 = 36.2%

*calculated using the method presented in *Example 4* – Single Pressure Zone Calculation

Average Operating Pressure = (76psi x 48.6%) + (61psi x 15.2%) + (92psi x 36.2%) = 79.5 psi.

2.7 Reporting Worksheet - 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 software.

- If applicable, include costs of shared equipment, debt service payments, and wholesale water purchases.
- Document where the cost figures come from, and any calculations or assumptions made.
- Where possible, account for the specific water system costs. If it is a combined water and sewer system budget, use a reasonable basis for splitting out the water portion of the costs. See *Example 6 calculation* below.

Special Note: Costs to operate wastewater or other non-potable water operations should not be included.

Example 6 – Annual Operating Cost Calculation

A system has a combined water and sewer operating budget of $2,230,000. There is one water plant and one wastewater plant. The number of water customers is approximately equal to the number of sewer customers. In this example, it would be reasonable to allocate 50 percent of the operating budget to water.

Total Annual Operating Cost = $2,230,000 x 50% = $1,115,000.

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 (MG), the cost should be presented in $/1,000 gallons ($/Kgal).
- With tiered water rates, a weighted average is recommended. The weighted-average may simply be calculated by dividing the total year-end billings from retail, volumetric water sales by the total gallons sold. See *Example 7 calculation*.

Example 7 – Customer Retail Unit Cost Weighted Average Calculation

Billed Metered (Annual Figure): 15,752 MGY * 1,000 Kgal/MG= 15,752,000 Kgal
Billings from Water Sales (Annual Figure): $63,638,080
Customer Retail Unit Cost = $63,638,080 / (15,752,000 Kgal) = $4.04/Kgal

Special Note: Both M36 and the *Free Water Audit Software*© definitions make reference to including additional charges for sewer, stormwater, or biosolids residuals processing if these are based on water consumption. However, for consistency among all Georgia utilities regarding reporting to EPD, it is recommended not to include these additional charges. Advanced methods for calculating customer retail unit cost are described in M36 and should be considered when evaluating apparent loss reduction and control programs.

Variable Production Cost

This is the current unit cost to treat and distribute water to the system. This cost is calculated per million gallons of water produced or purchased.

Include the variable costs from the audit year associated with production of water (including distribution pumping costs) and wholesale water purchases. Divide the total cost by the volume of water produced.

Other variable costs that go up based on amount of water produced or purchased (residuals treatment and disposal, wear and tear of pumping equipment, etc.) should also be included, if known and applicable. Advanced methods for calculating variable production cost are described in M36 and should be considered when evaluating real loss reduction and control programs. See *Example 8 calculation.*

Example 8 – Variable Production Cost Calculation

Total Variable Costs Divided by Water

Water Supplied: 1,321 MGY

Energy Costs for pumping and treatment (electric, natural gas, diesel, etc.): $575,000

Chemical Costs (treatment at WTP and in distribution system, if applicable): $354,500

Cost of Water Imported: $120,456

Variable Production Cost = ($575,000 + $354,500 + $120,456) / 1,321 MGY = 794.82 $/MG.

Special Note: *Software version 5.0 or newer (recommended) includes an optional check box on the reporting worksheet beside the Variable Production Cost input, which allows the auditor to use the Customer Retail Unit Cost to value real losses. This may be appropriate in circumstances of constrained water resources with water restrictions in effect, where the reduction of real losses could result in the sale of like volumes of water to customers, thereby allowing new development to occur without increasing water withdrawals. The default setting for this check box is "unchecked", with real loss valued at the Variable Production Cost.*

2.8 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, five parameters stand out in importance: 1) infrastructure leakage index (ILI), 2) data validity score, 3) priority areas for attention, 4) operational basic real losses and 5) operational basic apparent losses.

- **Data Validity Score** is a rating of a utility's confidence and accuracy of data entered into the software on a scale from zero to 100 (all of the 18 data inputs on the Reporting Worksheet are graded 1 to 10, and a composite data validity score [maximum of 100] is calculated by the 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. 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. A "good" data validity score is one that is considered *reflective*, be it high, low or in-between. 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.

- **Infrastructure Leakage Index** (ILI) is the ratio of current annual real losses (CARL) to unavoidable annual real losses (UARL). For most utilities the ILI can be an effective performance indicator for operational management of real losses. When the data validity score is high, 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 not be cost effective. 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 from previous years.

- **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 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. By addressing one or more of these areas, the utility's data validity score and 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 will 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.

- ***Operational Basic Apparent Losses (Op23)*** is a basic performance indicator that assesses Apparent Losses in gal/service connection/day. 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.

- ***Operational Basic Real Losses (Op24)*****:** is a basic performance indicator that assesses Real Losses in gal/service connection/day or gal/miles of main/day depending on the utility's connection density. This indicator is useful for target setting, and has limited use for comparisons between systems.

SECTION 3–Planning a Water Loss Control Program

3.1 Improving Data Validity

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

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 that uses 12 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 utility 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 12 month average data can reveal performance trends, such as the emergence of new leakage and production meter drift.

Maximum Impact to Improve your Data Validity

In the AWWA *Free Water Audit Software*© and in the AWWA *M-36 Manual* specific direction is provided on 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 range from one to 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 ranges between 1 and 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 to the distribution system.
- Flow verification and calibration (primary and secondary devices) - 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.
- Develop 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 percent metered connections as budget allows.

3.2 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 1). 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

<u>Apparent Losses</u> 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

<u>Real Losses</u> are calculated by the AWWA *Free Water Audit Software*© 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.

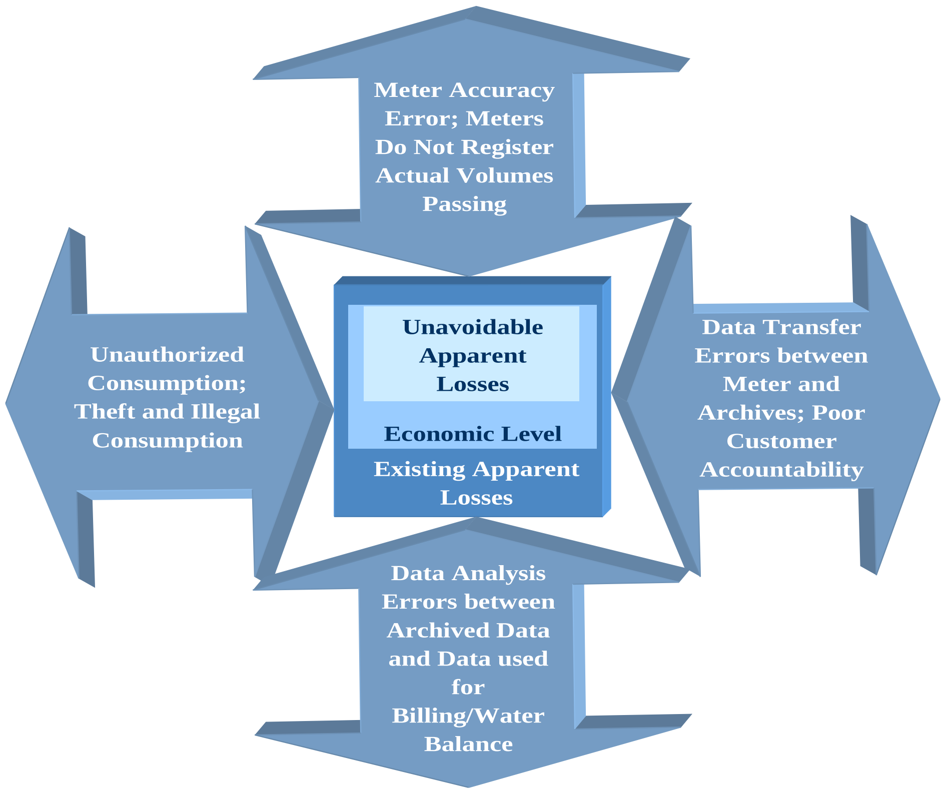
- **Service Line Leakage:**
    - This type of loss is minimal in Georgia since the meters are typically close to the main distribution line. In northern climates, the service line typically runs from the main to the interior of the house in order to protect the meter from freezing, thus giving more 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 supervisory control and data acquisition (SCADA) is relied upon, 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: The Four-Pillar Approach to the Control of Apparent Losses



Source: AWWA Manual M36, *Water Audits and Loss Control Programs* (2009).

Figure 2 provides a representation on controlling apparent water losses through ensuring meters accurately register the water passing through them, removing data transfer (or transcription) errors from the meter, assuring analytical processes are validated for billing or water usage, and clamping down on theft and illegal consumption of water. 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.

3.3 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 1**. The sources listed in **Table 1** 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 percent provided in the software unless they can compile accurate water theft data. 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.

  - Solutions to minimize inaccuracies 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.

  - Solutions to minimize errors 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 may constitute an apparent loss. All adjustments should be reviewed closely to determine the appropriate categorization as billed metered, billed unmetered, unbilled metered or apparent loss.

Table 1: 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 oversized 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"

3.4 Impact of Real Water Losses and How They Occur

The information provided in **Table 2** 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 (1.043 MG apparent loss water volume ×$2.34 per thousand gallons for the example), while real losses are valued at the water provider's variable production cost (3,718 MG × $425 per MG for the example). 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 or additional purchased water.

Table 2: Financial Performance Indicators for Large Water Provider Case Study

Parameter	Result
Annual Cost of Apparent Loss	$2,441,000
Annual Cost of Real Loss	$1,580,000
Total Annual Cost of Water Loss	$4,021,000
Total System Operating Cost	$30,000,000
NRW (Percent of System Operating Cost)	13.4%

The significance of the data in **Table 2** is that it provides a basis against which the costs of improved water loss management can be evaluated to determine a scale of appropriate investment. As noted previously, real losses represent operating inefficiency because of the increased volume of treated water that must be produced or purchased to offset water lost through events such as leaks, pipe breaks and tank overflows. However, practical considerations dictate that real water losses cannot be completely eliminated and a portion of real losses are unavoidable. **Table 3** summarizes the operational efficiency indicators for the same evaluation period.

Table 3: Operational Efficiency Indicators for Large Water Provider Case Study

Indicator	Result
Unavoidable Annual Real Losses – Billion Gallons (BG)	1.6
Average Real Losses for Audit Year (BG)	3.7
Infrastructure Leakage Index	2.3

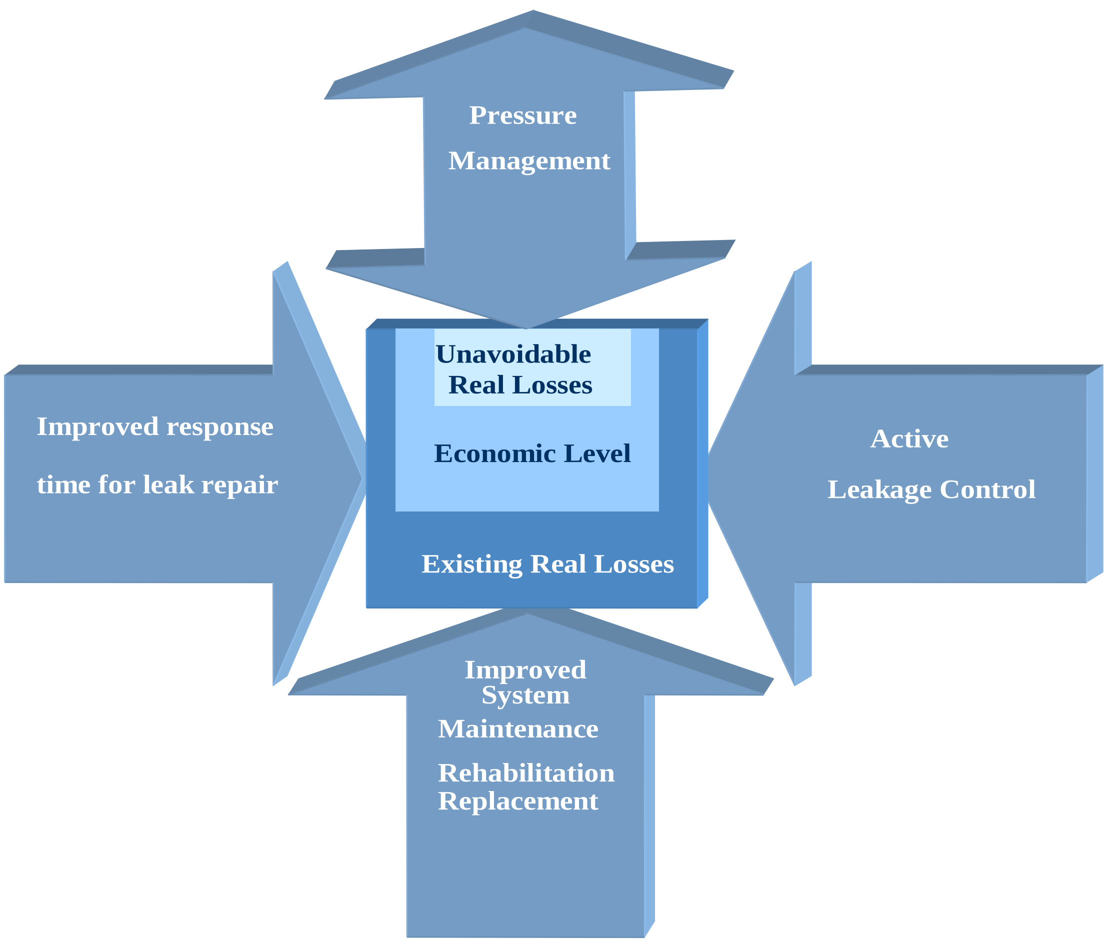
Using the variable production cost of $425 per million gallons, the value of the water provider's *avoidable* annual real losses is between $500,000 to $1,000,000 over the study period.

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

3.5 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: The Four-Pillar Approach to the Control of Real Losses



Source: AWWA Manual M36, *Water Audits and Loss Control Programs* (2009).

3.6 Role of Water Pressure on Distribution Systems and Leakage

The average system pressure is a very important parameter in calculating the unavoidable annual real losses (UARL), and system pressure is by far the greatest influencing factor for leakage in a distribution system. 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. An extensive body of work exists in the field of pressure management and its part of a broader real loss reduction and control program. For more detailed guidance on this topic, refer to the AWWA *M36 Manual*.

3.7 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. **Table 4** summarizes ILI target setting guidance from AWWA.

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 4: Infrastructure Leakage Index Target-Setting Guidance *(From* AWWA *M36 Manual)*

Note: This guidance is presented in lieu of performing a full economic analysis of leakage control options.
Note: Utilization of ILI or other performance indicators if the data validity scores less than50 is premature and unreliable.

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.		

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.

3.8 Ways to Manage Your Water Loss Control 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 component and an 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 people. 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 percent)
- Ground microphones (36 percent)
- Listening sticks (27 percent)
- Leak Noise loggers (22 percent)

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 three rounds of the data initiative have not been completed. More than 250 water utilities from across the U.S. and Canada are included in the data set, ranging in size from 3,000 connections to more than 500,000 connections. This includes validated data from large and small Georgia utilities from 2011 and 2012, respectively. The data and calculated performance indicators from this dataset serve as a useful initial view into the supply-side water efficiency standing of North American water utilities. While this initial dataset 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 ongoing 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 AWWA 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 as applied to their data were 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 one year, five years, etc.).
4. Progress-to-date compared to goals.
5. Calculated benefit from the primary activities, to date.
6. Return on investment to date.
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.

3.9 Financing Sources Matrix

Funding Option	Funding Option Characteristics	Contact information (website)
Federal/state loan or grant programs		
Georgia Environmental Finance Authority (GEFA)	• Low-interest loans and some grant funds • Quick approvals • Apply year-round • Interest rate reductions for water conservation projects	www.gefa.org
Georgia Department of Community Affairs (DCA)	• Community Development Block Grant Program • Grant funds with a $500,000 maximum per project • Very competitive program • Annual funding cycle; applications due April 1 of each year	www.dca.state.ga.us/communities/cdbg
United State Department of Agriculture (USDA)	• Low-interest loans and grants • 40-year financing terms • Apply year-round	www.rurdev.usda.gov/GAHome.html
Environmental Protection Agency (EPA)	• Competitive grant programs may exist for small water systems • EPA is supportive of local water loss initiatives	water.epa.gov/drink
Private Funding		
Local Banks	• Borrowing remains at the local community • Local banks often desire to provide funding for local projects	Contact your local bank
Bond Market	• A referendum is typically required to issue a municipal bond • The bond market can provide a variety of repayment options	www.bloomberg.com/news/bonds
Private Banks	• Large regional or national banks will provide funds for a variety of infrastructure activities	Contact your regional bank
Performance Contracting	• Cost of borrowing can be paid from water loss savings • Private performance contracting companies will fund projects through a guarantee of cost savings	www.energyservicescoalition.org
Self-funding		
SPLOST tax	• A referendum is typically required to create a SPLOST tax • Funds can be used for a variety of activities	N/A
General Fund	• Does not require borrowing funds from third-party • All tax payers pay for the project, though all tax payers may not be customers of the water system	N/A
Water Enterprise Fund	• Operating funds typically exist for water loss projects • Funds can be used for a variety of activities • Customers of the water system directly pay for the project	N/A

Section 4 –Supplemental Information

4.1 Definitions

Note: The following are standardized definitions (normal font) and performance indicators (in *italics*) used in the IWA/AWWA water audit methodology. Some definitions may vary slightly between water providers based on political decisions and internal billing policies.

- ***Apparent Losses***: Unauthorized consumption, all types of customer metering inaccuracies, and systematic data handling errors in customer billing operations.
- **Authorized Consumption**: The annual volume of metered and unmetered water consumed by customers, the water supplier, and others who are authorized to do so. This does not include water sold to other utilities, which is considered water exported.
- **Average Length of Customer Service Line**: Distance beyond the customer property line that the utility is responsible for maintaining, typically zero in Georgia.
- **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.
- **Billed Metered Water:** This includes retail water that is metered and billed for domestic, commercial, industrial or government customers. This number does not typically include wholesale water sent to neighboring water systems.
- **Billed Unmetered Water:** This includes water that is not metered but is billed and may include customers who are not metered, but charged only a fixed fee or other method, or customers with estimated usage.
- **Cost of Operating Water System—Total Annual:** These costs include those for operations, maintenance and any annually incurred costs for long-term upkeep of the drinking water supply and distribution system. It should include the costs of day-to-day upkeep and long-term financing such as repayment of debt for infrastructure expansion or improvement. Typical costs include employee salaries and benefits, materials, equipment, insurance, fees, administrative costs and all other costs that exist to sustain the drinking water supply. Depending upon water utility accounting procedures or regulatory agency requirements, it may be appropriate to include depreciation in the total

of this cost. Costs to operate wastewater and other non-potable water operations should not be included.

- **Customer Metering Inaccuracies:** Inaccuracies result from wear, improper sizing or maintenance of meters.

- **Customer Retail Unit Cost**: This is the overall charge that customers pay for water service per unit of water and is applied to apparent losses.

- **Data Validity 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**: A "good" data validity score is one that is considered *reflective*, be it high, low or in-between.

- **Economic Level of Leakage (ELL):** ELL can be broadly defined as the level of leakage at which any further investment in leakage reduction would incur costs in excess of the benefits derived from the savings. This includes both the cost of producing the water as well as the avoided cost of replacing the water. It should also be noted that economic evaluations performed on real loss reduction activities should only be performed when several years of water audits have been conducted and data validity has been improved to reflect the reliability of the audit to make the use of performance indicators meaningful. For more detailed guidance on this topic, refer to the AWWA M36 Manual.

- **Infrastructure Leakage Index (ILI)**: ILI is the ratio of current annual real losses (CARL) to unavoidable annual real losses (UARL). For most utilities the ILI can be an effective performance indicator for operational management of real losses. When the data validity score is high, an ILI close to "one" indicates the utility's real losses are close to the unavoidable annual real loss level and therefore further reductions in real water losses might not be cost effective. 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 from previous years.

  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.

- **Length of Mains**: Total length of water distribution pipelines, including fire hydrant leads. This length does not include customer service connection lines.

- **Non-revenue Water**: The sum of unbilled authorized consumption, apparent losses and real losses. The term *non-revenue water* should be used instead of the imprecise term *unaccounted-for water*. It is recognized that **some** of this component water of non-revenue water is authorized consumption (unbilled).

- **Non-revenue Water Percent by Cost**: 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.

- **Non-revenue Water Percent 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.

- **Number of Active and Inactive Service Connections**: The number of customer service connections, extending from the water main to supply water to a customer. Please note that this includes the actual number of distinct piping connections, including fire connections, whether active or inactive. This may differ substantially from the number of customers (or number of accounts).

- **Operational Basic Apparent Losses (Op23)**: A basic performance indicator that assesses apparent losses in gal/service connection/day. 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.

- **Operational Basic Real Losses (Op24)**: A basic performance indicator that assesses Real Losses in gal/service connection/day or gal/miles of main/day depending on the utility's connection density. This indicator is useful for target setting, and has limited use for comparisons between systems.

- **VFOS Master Meter and Supply Error Adjustment**: An estimate or measure of the degree of inaccuracy that exists in the master (production) meters measuring the annual Volume from Own Sources, and any error in the data trail that exists to collect, store and report the summary production data.

- **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 all include overflows from treated water storage tanks or reservoirs.

- **Revenue Water**: The components of the system input volume that are billed and produce revenue.

- **Systematic Data Handling Errors**: Apparent losses caused by accounting omissions, errant computer programming, gaps in policy, procedure, and permitting/activation of new billing accounts; and any type of data handling lapse that results in under-stated customer water consumption in summary billing reports. Utilities typically measure water consumption registered by water meters at the customer premises.

- **Unavoidable Annual Real Losses (UARL)**: These losses are 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 system 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.

    - **Special 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 reliable. The AWWA *Free Water Audit Software*© will not calculate a UARL value for systems that meet these conditions.

- **Unbilled Metered Water**: This 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.).

- **Unbilled Unmetered Water**: This includes unmetered water that is unbilled for authorized uses such as; firefighting, flushing of mains or sewers, street cleaning, etc.

- **Unauthorized Consumption**: This includes theft of water such as illegal connections, unauthorized use of fire hydrants, meter tampering, etc.

- **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.

- **Variable Production Cost**: The current unit cost to treat and distribute water to the system. This includes the variable costs associated with the production of water (including treatment and distribution pumping costs) and wholesale water purchases.

- **Volume from "Own Sources"**: The amount of finished water leaving the water treatment plant, entering the distribution network and recorded by the production master meter(s).

- **Water Exported**: Water sold to a neighboring utility or regional water authority.

- **Water Imported**: Water purchased from a neighboring utility or regional water authority.

- **Water Losses**: The difference between System Input Volume and Authorized Consumption, consisting of Apparent Losses plus Real Losses.

- **Water Supplied**: The total volume of treated water that leaves the water treatment plant or other treated water sources and enters the distribution system.

- **WE Master Meter and Supply Error Adjustment:** The adjustments made to the export meter(s) recorded volumes based on meter flow verification that accounts for errors in measurement, calibration, data gaps from communicating interruptions or other data archival issues.

- **WI Master Meter and Supply Error Adjustment:** The adjustments made to the import meter(s) recorded volumes based on meter flow verification that accounts for errors in measurement, calibration, data gaps from communicating interruptions or other data archival issues.

4.2 Sources of Data for Authorized Consumption (Table 5)

Table 5: Sources of Data for Authorized Consumption			
Billed Metered	**Billed Unmetered**	**Unbilled Metered**	**Unbilled Unmetered**
Any location with a meter and receiving a bill	**Any location receiving a bill and does not have a meter**	**Any metered account that does not have a bill**	**Any consumer that does not have a meter or bill and is AUTHORIZED to use the water**
Industrial customers	Unmetered systems or areas	Institutional customers	Firefighting and other fire dept. uses (testing and training)
Commercial customers	Flat rates	Government irrigation meters	Line flushing (automatic and manual)
Residential customers	County/City construction projects including free water		
Institutional customers		Line disinfection	Line disinfection
Irrigation meters		Vactors (pipeline cleaning, street cleaning, dust control, etc.)	Vactors (pipeline cleaning, street cleaning, dust control, etc.)
Fire hydrant meters			
Private fire lines	Private fire lines		
Volume sales to tanks/trailers within service area using a meter	Volume sales to tanks/trailers within service area using container volume or other calculation		Repair efforts by others (private utility services)
Water Authority / Government	Water Authority / Government	Water Authority / Government	Water Authority / Government
Schools	Schools	Schools	Schools
Religious/charity institutions	Religious/charity institutions	Religious/charity institutions	Religious/charity institutions
Special events	Special event (set fee for service)	Special events	Special events
Infrastructure cleaning (streets, bus stops, etc.)	Infrastructure cleaning (streets, bus stops, etc.)	Infrastructure cleaning (streets, bus stops, etc.)	Infrastructure cleaning (streets, bus stops, etc.)
Pools (filling and maintenance)	Pools (filling and maintenance)	Pools (filling and maintenance)	Pools (filling and maintenance)
Water fountains/features	Water fountains/features	Water fountains/features	Water fountains/features
Special contract sales for cash or in-kind services	Special contract sales for cash or in-kind services	Special contract sales for cash or in-kind services	Special contract sales for cash or in-kind services

Notes:

1. Several water uses may apply to several categories based on the system.
2. This list is not all inclusive, but rather a guide for collecting system data.

4.3 Sources of Data for Apparent Losses (Table 6)

Table 6: Sources of Data for 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 oversized meters or improper type of meter	Improperly recorded meter data from crossed meters	Adjustments due to known leakages
Fire sprinkler system testing (private)	Improper repair of 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 staff	Untimely meter installations	Procedural/data entry errors for change outs and new meters	Adjustments to prior year volumes (entry update)
Meter or reading equipment vandalism (internal or external)	Buried/"lost" meters	Improper programming of AMR equipment	Long term "no reads" are not flagged
Water fountains/features	Meter failure	Non-billed status where meter is in place and not being read (rental, vacancy, abandoned, sale property)	Computer / Billing software issues (malfunctions, programming errors, etc.)
Special events		Customer meters left unread due to account setup problems	Inconsistent policy interpretations by staff
Pools and operations of		Untimely final reads	Customer lost in system
Infrastructure cleaning (streets, bus stops, etc.)		Using a combined large/small meter calibration error	Improper programming of AMR equipment
Line disinfection (contractors)		Customer lost in system	Political "adjustments"
Repair efforts by others with unreported system damage		AMR equipment failure	

Section 5 - References and Resources

- AWWA *Free Water Audit Software*©
  http://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx

- AWWA M36: *Water Audits and Loss Control Programs* (published 2009, 3rd Edition).
  www.awwa.org

- Georgia AWWA Water Loss Control Committee
  www.gawp.org

- AWWA Water Loss Control Committee
  http://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx

- Georgia Water Stewardship Act
  http://www.gaepd.org/Files_PDF/Water/sb370.pdf

- Georgia Water Conservation Plan
  http://conservewatergeorgia.net

- Alliance for Water Efficiency – Tracking Tool
  http://www.allianceforwaterefficiency.org/Tracking-Tool.aspx

- AWWA M-22: *Sizing Water Service Lines and Meters.*
  www.awwa.org

- AWWA M-6: *Water Meters – Selection, Installation, Testing, and Maintenance.*
  www.awwa.org