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Georgia Water System Audits & Water Loss Control Manual

PRODUCED FOR:

GEORGIA
Department of Natural Resources
Environmental Protection Division

WRITTEN BY:

Georgia Association of Water Professionals
Water Loss Control Committee

Version 3.0 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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Summary of Version 3.0 Manual Updates

- *This version of the manual has been updated to match the methodology used with the American Water Works Association Free Water Audit Software version 6 software product.*
- *Various readability and clarity improvements*
- *Section 3 – Data Validity: This is a new section in the manual, emphasizing the importance of accurate and complete data in water loss control efforts.*
- *Section 4 – Validating a Water Audit: This section has been reorganized to be more useful in the validation process.*
- *Section 5 – Planning a Water Loss Control Program: This section has been updated to provide additional narrative on the Water Loss Control Program and demonstration of progress.*

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Section 1 – The Importance of Water Loss Auditing and Control

1.1 Introduction

This Manual is intended to support the ongoing efforts of water utilities, water professionals, and citizens of the State of Georgia to efficiently utilize available water resources. The document is focused on version 6.0 of the Free Water Audit Software (FWAS) developed and made available by the American Water Works Association (AWWA). The following sections:

- present the current iteration of the FWAS;
- discuss issues related to the validity of data;
- provide guidance for the validation of audits by qualified individuals; and,
- provide background for the development and enhancement of Water Loss Control Programs.

It is anticipated that the work related to the Water Loss Control Program and water audit efforts will prove critical to the ongoing sufficiency of this critical resource.

1.2 Background and Regulatory Drivers

Georgia is home to nearly 2,500 Public Water Systems (PWS: water systems that provide water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days per year), of which nearly 1,800 are community water systems (public systems supplying water to the same population year-round). Georgia's water resources include more than 70,000 miles of rivers and streams, numerous ponds and lakes, and one of the most productive groundwater aquifers in the world. Georgia receives about 50 inches of rainfall annually. Demands on Georgia's water resources continue to grow as the population increases. 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 aging infrastructure, increased energy costs, climate change, and updates to safe drinking water standards. Even though Georgia has abundant water resources, these resources and the rainfall that replenishes them are not evenly distributed across the state and can experience significant fluctuations over time. 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), created a shift in water management that affected every facet of Georgia's water environment. Of particular importance was 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 Version 3.0, serves as a guidance manual and describes the current best practices necessary to complete and validate a water system audit, and to develop an effective Water Loss Control Program in Georgia. Water audits using the AWWA Version 6 software are submitted annually to the Georgia Environmental Protection Division (EPD) by all water utilities in Georgia regulated under SB 370, as described in Section 1.3 below.

1.3 Rules for Public Water Systems to Improve Water Supply Efficiency

In June 2015, the Board of the Department of Natural Resources (DNR) adopted 'Rules for Public Water Systems to Improve Water Supply Efficiency', Chapter 391-3-33. The purpose of these rules was to establish policies, procedures, requirements, and standards as included in the Georgia Water Stewardship Act (GWSA) of 2010 (sometimes referred to as SB 370). This Act is a multifaceted approach to water conservation and 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 currently affected by this Act. 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 these

audits to EPD in a timely fashion. 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.

1.4 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*© *(currently Version 6.0),* and provides supplemental assistance for water providers to utilize this software. This software utilizes the required methodology for performing an acceptable water audit in Georgia and 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 a calendar year to be submitted to EPD no later than March 1st of the following year.

The GWSA requires EPD to post all submitted audits on its website. For this reason, electronic submissions are required from all affected water systems. Annual water audits must be submitted electronically to Water.Audits@dnr.ga.gov.

Documents to be submitted annually to EPD include the water audit file in Microsoft Excel format, with all worksheets completed, the QWLA Certificate, and the basis of documentation in the Comments Tab or attached in comparable format.

State-issued water withdrawal permits, water plant production permits 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.

Updated information and technical resources on the Water System Audits and Water Loss Control Programs are available online under the Water Loss Auditing section of GAWP's website (www.gawp.org) and on EPD's website (https://epd.georgia.gov/watershed-protection-branch/water-efficiency-and-water-loss-audits). 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 are available at these websites.

1.5 Qualified Water Loss Auditor Program Description

Water audits are most useful when the data input into the audit reliably reflects the reality of utility operations and performance. To ensure that the audit is representative of utility practices, a knowledgeable evaluation of such data is essential to validate and correct data. Validation has proven useful even for water utilities experienced in the water audit process.

Data validation is a quality control process conducted to verify, and improve as needed, the data inputs and gradings of the water audits submitted by water utilities. Data validation should be conducted by a party skilled in the procedures of the data validation process prescribed by the Qualified Water Loss Auditor certification program. This is typically a third party to the water utility; however, the water audit may be validated by a member of the utility if that person is trained as a Qualified Water Loss Auditor (QWLA).

EPD has created a program for individuals to become qualified and competent to sign off on required water audits in the state of Georgia. The certification program is currently administered by the Georgia Association of Water Professionals (GAWP) with oversight by EPD. Water audits in Georgia follow American Water Works Association (AWWA) methodology utilizing the latest version of the Free Water Audit Software (FWAS) and the Water Research Foundation’s Water Audit Level 1 Validation Guidance Manual.

In Georgia, the individual that reviews and validates the water loss audit is referred to as a QWLA. AWWA and training materials from other states often refer to these third parties as validators, so one should be mindful when using these other materials that these terms may be being used interchangeably.

The GA QWLA certification program includes these minimum requirements to obtain certification:

1. Candidates are required to complete the four-hour “Basic Water Loss & Auditing” class as a prerequisite to the full QWLA Certification Class & Exam.
2. All candidates must complete the 16-hour QWLA Certification class as a prerequisite to taking the exam.
3. All candidates must pass the QWLA exam with a minimum score of 70%. The exam includes both a number of questions and a practical audit.

It is suggested that candidates first have experience working as a team member preparing required data and supporting documents needed to complete a water audit. Experience with Microsoft Excel is essential as supporting documents and AWWA FWAS are based on this software platform.

Beginning in January 2025, QWLA Certifications will operate on a three-year continuing education cycle. Continuing education requirement can be met by:

1. Preparing or validating at least two AWWA FWAS current version water audits, and
2. Completion of four (4) hours of water loss control or water auditing training.

A searchable directory of Georgia Qualified Water Loss Auditors will be maintained on the GAWP and/or Georgia EPD websites.

Section 2 – Conducting a Water Audit

2.1 General Notes

This version of the Georgia Water System Audits and Water Loss Control Manual include updates to industry best practices including new versions of the AWWA M36 Manual and AWWA Free Water Audit Software ®.

The goal of the water audit is to properly and accurately quantify where treated water goes after it enters the distribution system. This includes the components and volumes of water consumption and water losses, which can further be broken down to real (leakage) losses and apparent (customer) losses. The water audit software calculates performance indicators that can be used for benchmarking, goal setting and tracking progress.

The methodology described in this section is a top-down approach, which relies on existing data that is collected and input into the software. Due to the methodical nature of the top-down audit, apparent losses must be quantified as accurately as possible to have greater confidence in the resulting quantity of real losses. This top-down approach can be later followed up with bottom-up techniques to validate the input data.

Several years of conducting water audits should provide more accurate data for water audit inputs. However, this requires bottom-up activities and field studies to supplement the desktop data entered into the water audit spreadsheet. As the data validity improves over the years, performance indicators should be viewed in combination with the data validity score over time. It is important to note that the goal is to improve the validity score over time so that there is an improved understanding of both real and apparent losses. Apparent losses must be quantified as accurately as possible to have greater confidence in the quantity of real losses which are quantified as the difference between total losses and apparent losses.

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 personnel who may become involved in the water audit process. A hard-copy or online folder with a Microsoft Excel or Word file showing where the input data originated and how the calculations were performed should be accessible to various personnel to maintain continuity in subsequent years. The water auditor should take full advantage of the comment fields related to each data input in the water audit software. There is also a blank page included in the water audit software that can be used for notes and documentation. There are several pieces of documentation required as part of the validation process. The required documentation is discussed in Section 4.2 along with supplemental information that may be useful to both the utility and the QWLA.

In Georgia, water audits are required to be conducted over the 12-month calendar year (January-December). Some water systems may have different fiscal operating years and one method to adjust is to conduct rolling 12-month audits for the calendar year reporting cycle. 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 results in the various personnel involved in collecting and reporting the data becoming more familiar with what is expected when the time comes to compile and 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 6.0 or later)

The current version of the AWWA Free Water Audit Software© (FWAS) is version 6.0, released in 2020. Version 6.0 has several enhanced features and functionalities, including:

- *Interactive Data Grading to improve consistency, objectivity, and transparency in grade assignment for each input,*
- *A blank sheet tab within the audit for user calculations,*
- *A dashboard to facilitate Key Performance Indictor (KPI) analysis,*
- *KPI updates to reflect AWWA's 2020 position, and*
- *KPIs are shown on a gauge against industry ranges based on more recent North American data.*

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 top-down water 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 there is no need to register/login (no cost) to the AWWA website before downloading the software. The software is in Microsoft Excel format in a .xlsx format.

The AWWA *Free Water Audit Software©* includes multiple worksheets in a spreadsheet file. The first "Start Page" provides instructions on the use of the software. *It is essential to complete the* *administrative inputs on this 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 *Worksheet*, which prompts the user to enter standard water supply information such as the volume of water supplied, customer consumption, distribution system attributes, and financial information.

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. The data grading is determined through the use of the "Interactive Data Grading" sheet. 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. A further discussion of the derivation and interpretation of water audit results is provided as Section 2.8 of this manual.

An additional step in the audit process that is required and which many utilities will find helpful is the preparation of a graphic schematic of the water supply and distribution system. The audit preparer should produce a drawing that details how raw water is obtained, processed, and entered into the distribution system. This schematic should include the approximate location of raw water meters (if applicable), production meters, well meters, clearwells, plant water lines, import meters, export meters, and any other relevant appurtenances. The purpose of the schematic is to visually illustrate the structure of the Water System so that a water audit boundary can be established. Creating this boundary will help the utility focus on how and what is included in the water audit. The schematic also serves as a guide to the QWLA who may not be familiar with the utility and EPD. Having a schematic allows the audit preparation team to be able to work from a common understanding of the components that need to be addressed in the water audit.

System schematics, including boundary meters, can be very simple. They can be hand drawn, or created using any basic software the auditor is familiar with like MS word, MS excel, MS PowerPoint, Google docs, Google sheets, etc.

Two Figures are provided below:

Figure 2.1 shows a system schematic for a relatively uncomplicated system and Figure 2.2 shows a system schematic along with a redline indicating the audit and meter boundaries for a more complex system.

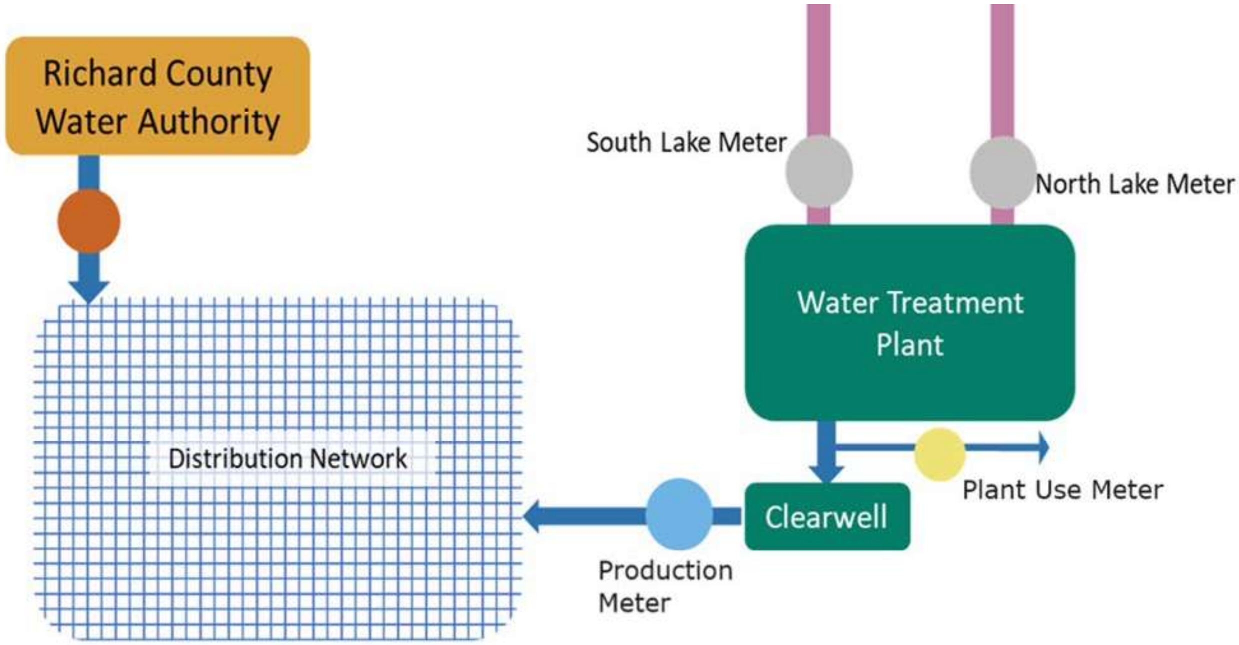

Figure 2.1: Simple System Schematic

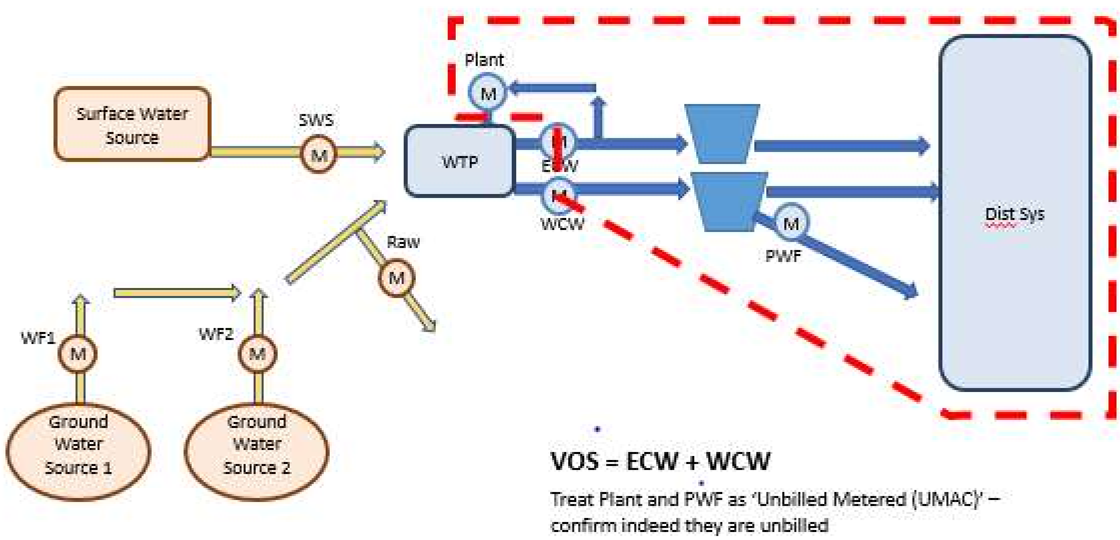

Figure 2.2 Complex System Schematic:

2.3 Reporting Worksheet - WATER SUPPLIED

The water supplied section of the FWAS quantifies the total volume of treated water that enters the distribution system.

2.3.1 Volume from Own Sources (VOS)

VOS is the amount of water leaving the water treatment plant(s) as recorded by production master meter(s). This value can be obtained from monthly operating reports submitted to EPD. This information should be listed by meter and by month for each production meter. Groundwater (well) that is metered and goes into the distribution system should be included and should also be listed by meter and by month.

- List the treated water sources to ensure none are overlooked. Groundwater that directly enters the distribution system should also be included. Groundwater that is treated at a water treatment plant will be counted by the production meter.
- The term "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 also be referred to as master meters.
- A spreadsheet of information for this input is a required document for validation by a QWLA. If the information is not presented by meter and by month, the water audit **cannot** be validated.

2.3.2 VOS Error Adjustment (VOSEA)

Adjustments should be 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.

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.

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 process 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.

These two terms should not be confused or assumed to be 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 usually the largest and most important input in the water audit. If calibration and/or flow verification have been undertaken, it should be documented. Those documents are required documentation for validation by a QWLA.

- Production master meters should be calibrated annually at a minimum. Flow meter 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.
- If a meter is flow verified and calibrated more frequently (i.e., semi-annually or quarterly), a flow-weighted average should be calculated.
- If there are multiple production master meters operating in parallel, an average weighted by flow volume should be developed to determine the total master meter and supply error adjustment.
- Version 6.0 of the FWAS no longer requires the input of over or under-registration. All numbers are entered as positive numbers and additional input boxes allow the preparer to choose over or under-registration.

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 required.

2.3.3 Water Imported (WI)

This is the water purchased from a neighboring utility or regional water authority. Water Imported quantities and documentation are required for validation and should be listed by meter by month.

2.3.4 WI Error Adjustment (WIEA)

Meters that measure Water Imported 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.

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.

2.3.5 Water Exported (WE)

This is the water sold to a neighboring utility or regional water authority. Documentation of Water Exported is a required document for validation. Values should be listed by month and by meter.

2.3.6 WE Error Adjustment (WEEA)

Water export meters should be tested (flow verified and calibrated, depending on the meter type) regularly. The adjustments made to the export 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.

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 Section 6 of this manual. The sources listed in Section 6 are not exhaustive and are provided only as a guide for potential sources of data. The documentation of Authorized Consumption categories in this section are required documentation for validation. This data should be presented by month and by use type or category.

2.4.1 Billed Metered Authorized Consumption (BMAC)

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

This quantity does not include wholesale water sent to neighboring water systems; these wholesale customers are entered in the "Water Exported" section of the Worksheet (See Section 2.3.5).

Care should be used 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. It is recommended that estimated billing be kept to a minimum and only used when absolutely necessary. Similarly, when adjustments are needed on a bill those adjustments should be made in dollar amount and **not in volume**, unless the meter reading was actually erroneous.

2.4.2 Billed Unmetered Authorized Consumption (BUAC)

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 permanent unmetered customers, installing a permanent meter is recommended to obtain actual consumption.

2.4.3 Unbilled Metered Authorized Consumption (UMAC)

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.). This also includes water used by the utility. Lift stations, booster stations, construction facilities should all be metered to provide accurate use data. Although these are not retail meters, they should be treated like retail meters and read monthly. It is also recommended to include these meters in the meter population subject to meter testing.

2.4.4 Unbilled Unmetered Authorized Consumption (UUAC)

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

- Utilities may select the default number of 0.25 percent of billed authorized consumption 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

In this top-down water audit, values are entered for the Apparent Loss components, and the Real Losses are then calculated by the software as the remaining volume. This section describes the inputs for Apparent Losses.

Apparent losses account for errors generated while collecting customer consumption data. The three categories of apparent losses include Systematic Data Handling Errors, Customer Metering Inaccuracies, and Unauthorized Consumption. The following sub-sections provide descriptions of each type of loss and methods of measuring or estimating these losses. More specific sources of data within each category are provided in Section 6 of this manual. The sources listed in Section 6 are not exhaustive and are provided only as a guide for potential sources of data.

2.5.1 Systematic Data Handling Errors (SDHE)

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) and Advanced Metering Infrastructure (AMI) 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 Authorized volume (BMAC + BUAC)*
- For more detailed guidance on this topic, refer to the AWWA *M36 Manual*.

2.5.2 Customer Metering Inaccuracies (CMI)

These are inaccuracies that result from wear, improper sizing, or maintenance of meters. The value is input as a percent or volume 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, current AWWA guidelines suggest weighting as follows – for small meters: 15 percent for low flow, 50 percent mid flow and 35 percent high flow ranges; for large meters: 10 percent low flow, 65 percent mid flow, 25 percent high flow. See *Example 1 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. However, this number should not be estimated too high, as it can affect the resulting Real Loss values.
- 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 1 – 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%x50.00%* + 98.00%x35%* = 96.85%

   Large = 90.00%x10.00%* + 97.00%x65.00%* + 101.00%x25%* = 97.30%

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

   96.85%x58.30% + 97.30%x41.70% = 97.04%.

In this example, the total weighted accuracy of the customer meters (large and small, combined) is 97.04%. Therefore, the inaccuracy of the customer meters would be:

100.0% - 97.04% = 2.96%. Thus, “2.96” and “percent” are what should be input into the audit for Customer Metering Inaccuracies for this example.

* Flow weightings shown in this example for low, mid, and high flow ranges are for illustration only. The optimal determination of % volume weighting for each flow range should come from sample flow logging of small and large meters for a given utility.

2.5.3 Unauthorized Consumption (UC)

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 Billed Authorized volume (BMAC + BUAC) provided in the software unless they can compile accurate water theft data.
- Supporting data should be saved in a companion workbook.

2.6 Reporting Worksheet – SYSTEM DATA

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

2.6.1 Length of Mains (Lm)

This is the total length in miles of transmission and distribution pipelines in the system. The Length of Mains input should include fire hydrant lead lengths but should not include customer service line lengths.

2.6.2 Number of Service Connections (Nc)

These include all physical customer connections to the main, not just the number of accounts in the system because one account could have multiple connections, or some accounts may be inactive. This input should also include fire line connections that are separate from the service flow meter and may use a double detector check.

2.6.3 Average Length of Customer Service Line (Lp)

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 6.0 or newer, select "Yes" to the question "Are customer meters typically located at the curbstop/property line?" This will result in the auto-population of the correct input and data validity grade for this entry. A diagram with corresponding description is provided in the software on the tab "Service Connection Diagram".

2.6.4 Average Operating Pressure (AOP)

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 tanks be considered 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 average 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 (if distributed well across the system) or across the pipe lengths in the model (for better representation). 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 can be taken and averaged. See *Example 2 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 3 calculation* below.

- For more detailed guidance on this topic, refer to the AWWA *M36 Manual*.

Example 2 – 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 3 – Multi-Pressure Zone Weighted Average 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

2.7.1 Customer Retail Unit Charge (CRUC)

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. Other options include $/100 cubic feet (ccf).
- 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 4 calculation*.

Example 4 – Customer Retail Unit Charge 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

Both M36 and the FWAS definitions make reference to including additional charges for sewer, stormwater, or biosolids residuals processing if these are based on water consumption. The CRUC should also include additional charges for sewer, stormwater, or biosolids processing, but only to the extent that these charges are based on the volume of potable water consumed. Advanced methods for calculating customer retail unit cost are described in M36 and should be considered when evaluating apparent loss reduction and control programs.

2.7.2 Variable Production Cost (VPC)

The variable production cost is the current unit cost to treat and distribute water throughout the system, calculated as dollars per million gallons of water produced or purchased. This typically includes energy and chemicals, but not salaries.

Variable costs from the audit year associated with production of water (including distribution pumping costs) and wholesale water purchases should be included and divided by the volume of water produced.

Other variable costs that increase 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. These advanced methods include analyzing which variable costs would directly reduce when leakage is reduced. If reduction in leakage anywhere in the distribution network would be indiscriminate with regards to which water supply would correspondingly be reduced, then the volume-weighted average method (as presented in Example 5) is recommended to determine VPC. However, leakage reduction would directly result in a reduction of water supply required from the most expensive source, then the highest-cost method is recommended to determine VPC. The highest-cost method is further detailed in the AWWA M36 Manual.

Example 5 – Variable Production Cost Calculation

Total Variable Costs Divided by Water Supplied

Water Supplied: 1,321 MGY (includes produced and imported water, and no exported water)

Energy Costs for treatment and distribution pumping (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.

2.7.3 Total Annual Operating Cost

Historically, this was a required input for the FWAS, it is now optional in version 6.0. It is strongly encouraged to include this data in the audit. If a utility populates this input, these costs should include all the costs for operating the water system only, as stated in its definition in the software.

- If applicable, include costs of equipment and staff, debt service payments, and wholesale water purchases.
- Document where the cost figures come from, and any calculations or assumptions made in deriving the figures.
- Where possible, account for the specific water system costs through financial auditing. If it is a combined water and sewer (and possibly stormwater) system budget or there are shared costs that cannot be itemized, use a reasonable basis for splitting out the water portion of the costs. See *Example 6 calculation* below.

Costs to operate wastewater, stormwater 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.

2.8 Interpreting Software Results

Based on the data entered and the data validity grades calculated by the Interactive Data Grading for each data entry, the software calculates results and performance indicators for the water audit on the Dashboard tab. This includes the volumetric and dollar components of Non-Revenue Water (NRW) in a side-by-side chart. Also included are the KPIs in a gauge-style format comparing the current water audit results with any user-entered Target Value and with percentiles from other validated water audit results. See the Guidance on the Dashboard tab for further information and "suitable purposes" of each KPI.

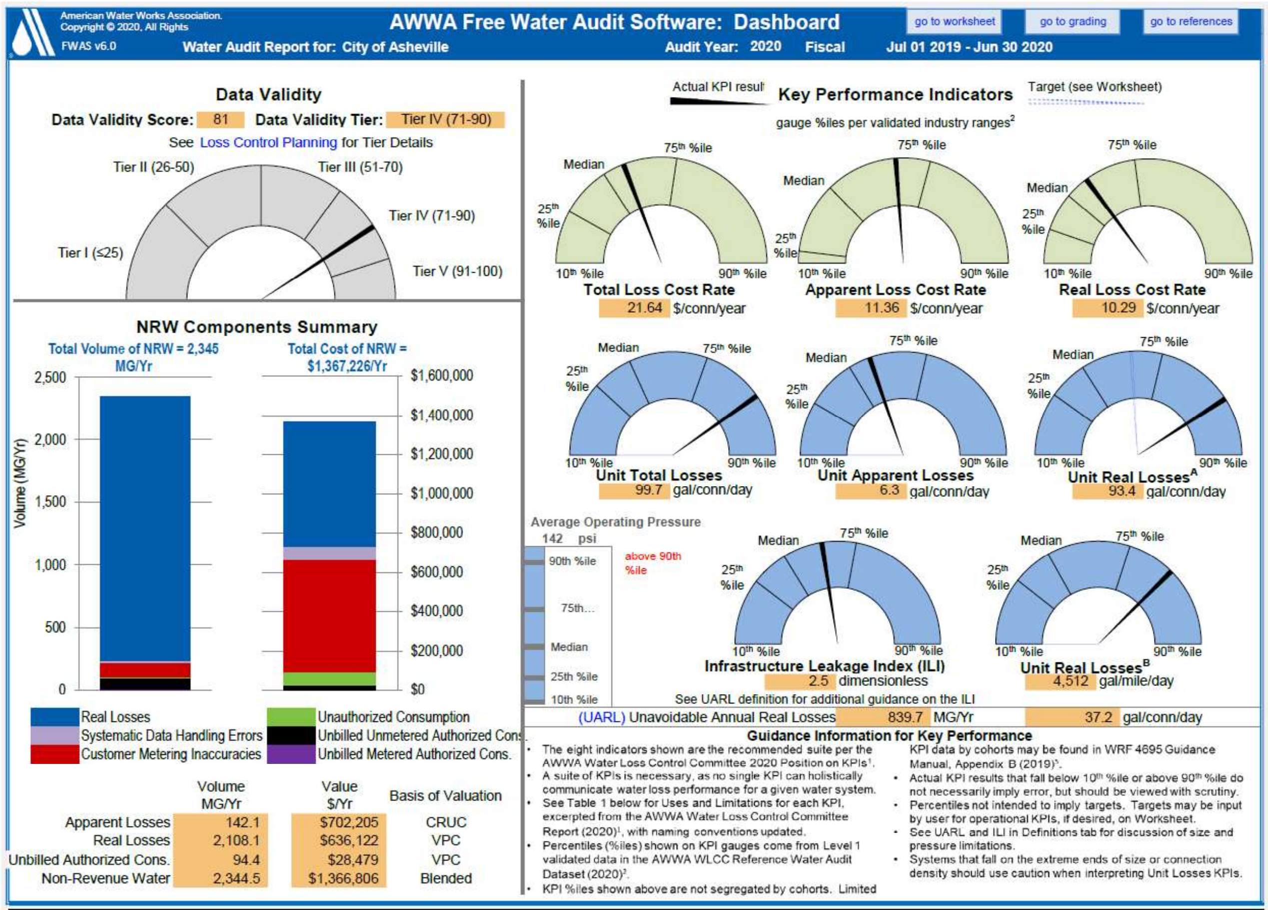

Figure 2.3: Dashboard Tab of the AWWA Free Water Audit Software, Version 6.0

Section 3 – Data Validity

3.1 Data Validity as a Concept

In a world increasingly driven by the analysis and utilization of information, the accuracy and appropriateness of the underlying data, or data validity, is of ongoing concern. In order to be useful and effective, data must not only be as accurate as reasonably possible, but also must be sufficiently comprehensive and appropriate to reflect the pertinent considerations for any decision-making process. Without valid data, that is accurate and comprehensive, any related analyses can be inappropriate or otherwise flawed.

3.2 The importance of Data Validity

Data Validity is one of the most critical aspects of the Water Audit and Water Loss Control Program. Data validity is determined through a process of checking the integrity, accuracy, and quality of data and this process should be evaluated before making significant decisions on water loss investments and programs.. For this reason, all reasonable and economically feasible efforts should be made to improve the data validity of the water audit data. The AWWA *Free Water Audit Software* includes an Interactive Data Grading Worksheet that highlights the specific next steps that can be undertaken to improve the data validity in each of the 18 input areas. Developing a Water Loss Control Program utilizing an audit with a low data validity score, for example below 50, can result in a costly and ineffective program. Under *Priority Areas for Attention,* the audit provides three utility specific areas for improvement. These should be reviewed and considered first when improving data validity. A utility will eventually reach a data validity score where further improvement will be more extensive and significantly more costly while resulting in only incremental improvement. Analysis should be done to determine if these more extensive efforts would result in an audit that would significantly improve system benchmarking and the development of water loss control program.

3.3 The Data Validation Process

Water audits compiled by water utilities are most useful when the data input into the Audit reliably reflects the reality of utility operations and performance. To assess the validity, or quality, of the Audit data inputs, each input into the FWAS is graded on a scale of 1-10, with lower validity inputs given a low grading and higher validity inputs assigned a higher grading. Criteria for grading are given in the Interactive Data Grading Worksheet of the FWAS (excerpt provided as Figure 3.1).

Water utilities compile the annual water audit by gathering data generated from utility operations (information systems, reports, staff accounts) and placing them in the proper component of the FWAS. The auditor answers a series of questions for each input by comparing the characteristics of the data sources and utility practices with those listed in the Interactive Data Grading Worksheet, and based on these answers, the FWAS automatically assigns the most representative grading.

3.3.1 Quality of Data in Water Audits

Particularly for water utilities that are new to the water audit process, some of this *self-reported* data may not have a high degree of accuracy, and some of the data gradings may not be representative of the utility practices that generated the data inputs. An evaluation of such data is essential to correct less representative data. Even for those utilities experienced in the water audit process, such a validation assessment has proven highly useful.

Data validation is a quality control process conducted to verify – and improve as needed – the data inputs and gradings of the water Audits submitted by water utilities. It includes reviews that should be employed once the utility water auditor has submitted the self-reported water Audit to the appropriate authority. Data validation should be conducted by an individual skilled in the procedures of the data validation. The water Audit may be validated by a member of the utility – possibly the auditor – if that person is trained as a QWLA in the data validation procedures.

The Data Validation Process includes five levels of data quality which are listed below:

- Self-reported
- Filtered
- Level 1 Validation
- Level 2 Validation
- Level 3 Validation

All Public Water Systems (PWS) in the State of Georgia serving more than 3,300 people must submit a water Audit that has undergone a Level 1 Validation by a QWLA. While such Georgia PWS may also choose to perform Level 2 and Level 3 Validations the self-reported and filtered audits **do not meet** the State of Georgia's water loss auditing requirements.

Validated audits - Unlike self-reporting and filtering, data validation conducts in-depth review of the data sources and practices of the water utility. Validation can be performed at up to three levels depending on available time and resources, and the level of sophistication needed for the use of the water Audit results.

3.3.2 The Interactive Data Grading of the AWWA FWAS

All numeric inputs of the water Audit are input into the AWWA FWAS using the Worksheet tab of the FWAS. These include the volumes of water supplied, billed consumption, and apparent losses, as well as system attribute and cost data. Water utilities arrive at the value of these data inputs in a variety of ways. For most audit components, the utility auditor uses a measured or estimated volume. For certain components, the FWAS gives the option for the auditor to select a default value that can be used in lieu of otherwise using an unsupported utility estimate. The default provides a reasonable value that is based upon typical average values found in large water audit datasets. Once the auditor has entered all numeric inputs and answered all the associated questions in the Interactive Data Grading tab, the FWAS calculates a Data Validity Tier (DVT). Each DVT is based on a range of data validity scores – Tier I (1-25), Tier II (26-50), Tier III (51-70), Tier IV (71-90), and Tier (91-100).

The structure employed in the data grading and use of a DVT provide insight to the water audit by:

1. Providing a quantitative measure of the validity, or trustworthiness, of the individual data inputs;
2. Identifying the functional focus areas for each tier in the Loss Control Planning tab; and,
3. Giving insight into the extent that best practices are applied in the utility's operations for each component (data gradings), and for the system as a whole data validity score (DVS).

The third statement above reflects the process-based nature of the criteria used to assign gradings to the various data inputs. The criteria are included in the Interactive Data Grading Worksheet of the FWAS. Figure 3.1 gives the first of fifteen pages showing all the criteria questions, possible answers, and associated data grades for Volume from Own Sources. Figure 3.1 is from a pdf that can be downloaded for free from AWWA, and it is a static version of the Interactive Data Grading tab from the FWAS. As can be seen for Volume from Own Sources, the criteria corresponding to a particular grading reflect increasing rigor in the operations and procedures of the water utility as one moves up (left to right) on the Interactive Data Grading Worksheet.

In addition to the guidance provided to grade the input volumes, the Interactive Data Grading Worksheet also provides – for each component – guidance on the means to improve practices and procedures to qualify for the next highest grading. For each of the data grading criteria, the Interactive Data Grading tab of the FWAS will indicate what the limiting factor or factors are that are keeping the utility from earning a higher data validity grade. As mentioned above, the DVT also indicates overarching functional focus areas for each tier. These functional focus areas can be found in the Loss Control Planning Tab of the FWAS. These features of the FWAS give the utility valuable information on the means to improve both their processes and the validity of their water Audit data inputs.

Release Version
04-Dec-2020

AWWA Free Water Audit Software v6.0
Interactive Data Grading (IDG) Matrix

Volume from Own Sources (VOS)

vos.0: Did the water utility supply any water from its own sources during the audit year? (if no, both VOS and VOSEA data validity grades are assigned 'n/a' and subsequent questions are hidden)

Criteria ID	Criteria Theme	Criteria Question	1	2	3	4	5	6	7	8	9	10
vos.1	Percent of Flow Metered	What percent of own supply volume is metered?	<25%	25-50%	>50-75%	>75% - 90%		>90% - 95%		>95 - 99%		>99%
vos.2	Meter Electronic Calibration Frequency	What is the frequency of electronic calibration?			None, or Not within last 5 years		Less than annual but within last 5 years *(and vos.5 = Less than annual frequency)*		At least annually *(and vos.5 = Less than annual frequency)*		At least annually *(and vos.5 = Annual frequency or greater)*	At least semi-annually; OR Not applicable due to no electronic signal output (i.e. to SCADA)
vos.3	Scope of Electronic Calibration	What level of data transfer errors are checked as part of the electronic calibration process?				Data transfer errors are not checked, or not sure			Data transfer errors are checked at secondary device(s), but not to tertiary device(s)			Data transfer errors are checked at secondary device(s) AND tertiary device(s); OR Data transfer errors are checked at secondary device(s), but no tertiary device(s) exist
vos.4	Electronic Calibration documentation	Is the most recent electronic calibration documentation available for review?					No *(and vos.6 = No)*		No *(and vos.6 = Yes)*			Yes
vos.5	Meter Flow Accuracy Test Frequency	What is the frequency of in-situ flow accuracy testing?			None, or Not within last 5 years		Less than annual but within last 5 years *(and vos.2 = Less than annual frequency)*		At least annually *(and vos.2 = Less than annual frequency)*		At least annually *(and vos.2 = Annual frequency or greater)*	At least semi-annually
vos.6	Meter Flow Accuracy Test Documentation	Is the most recent in-situ flow accuracy testing documentation available for review?					No *(and vos.4 = No)*		No *(and vos.4 = Yes)*			Yes
vos.7	Meter Fow Accuracy Test Results	What are the total volume-weighted average results of in-situ flow accuracy testing (during or closest to audit year)?	Not sure						At ±6% or greater		Between ±3% to ±6%	At or within ±3%
vos.8	Rigor of Testing & Calibration Procedures	Have testing and calibration procedures been closely scrutinized for compliance with procedures described in the AWWA M36 and/or M33 Manual(s)?									No	Yes
vos.9	Frequency of Data Collection	Which best describes the frequency of finished water meter readings?				Less frequently than monthly		Once per month		More frequently than monthly, but not every day	Daily	Continuous
vos.10	Frequency of Data Review	Which best describes the frequency of data review for anomalies/errors? These can include numbers that are outside of typical patterns, and zero or 'null' values that may reflect a gap in data recording.	Regular review not conducted / Not sure			Less frequently than monthly		Once per month		More frequently than monthly, but not every day		Daily

Figure 3.1: Grading Matrix (Page 1) of the AWWA Free Water Audit Software, Version 6.0

3.3.3 Summary – the Value of Validation

Since North American state and regional water agencies started in 2005 to collect water Audit data using best practice approaches, it has become evident that strictly self-reported data often includes water Audits with incomplete or implausible numbers, and/or data that is not representative of the performance of their systems. The creation of the data grading capability and Data Validity Score in the AWWA FWAS provided water utilities with a standardized means to assess the validity of their water Audit data. The greatest value of the water Audit process to date, however, is the work – particularly in the State of Georgia – that validates water Audits by using a knowledgeable QWLA, either internal or external to the utility, to validate the results and produce a representative water Audit. Level 1 Validation is the most widespread validation work conducted to date for North American water utilities, and the appropriate starting point for utilities that have generated a Self-reported water Audit. Level 1 requires examination of Audit Data for inaccuracies in summary data and methodology for deriving inputs, as well as confirming all interactive data grading responses accurately reflect utility practices and supporting documentation. **<u>Level 1 validation is required in the State of Georgia</u>**. Level 1 Validation

Water utilities can then move to Level 2 and Level 3 Validation processes as deemed appropriate to improve their data validity and refine their NRW control efforts.

3.4 The FWAS Dashboard and KPIs

The FWAS calculates a variety of KPIs that are highly effective in the assessment of utility water loss performance. After data is input into the FWAS, the software calculates the volume of apparent losses, real losses, water losses, NRW, and the cost impacts of these quantities. Collectively these KPIs function as the "vital signs" of the utility operations. These KPIs also allow water stakeholders to objectively assess water efficiency performance of a single utility, or group of utilities. It is very important that utility and other water stakeholders have reliable KPIs for each of the major components of NRW and not attempt to assess performance via a single parameter. Since the water Audit requires data from many different operational areas within the water utility, it is not possible to reliably assess utility performance with a single output measure.

Figure 3.2 shows the KPIs of the Dashboard tab of the FWAS. It is important for the utility auditor to carefully review the KPIs after the data inputs are populated in the FWAS to ensure that they have reliably entered the data input. It is also important for the QWLA to scrutinize these values with respect to the utility performance, and in comparison, with industry peer datasets. **This is a necessary part of the Level 1 Validation process and should be conducted at the beginning of the process.**

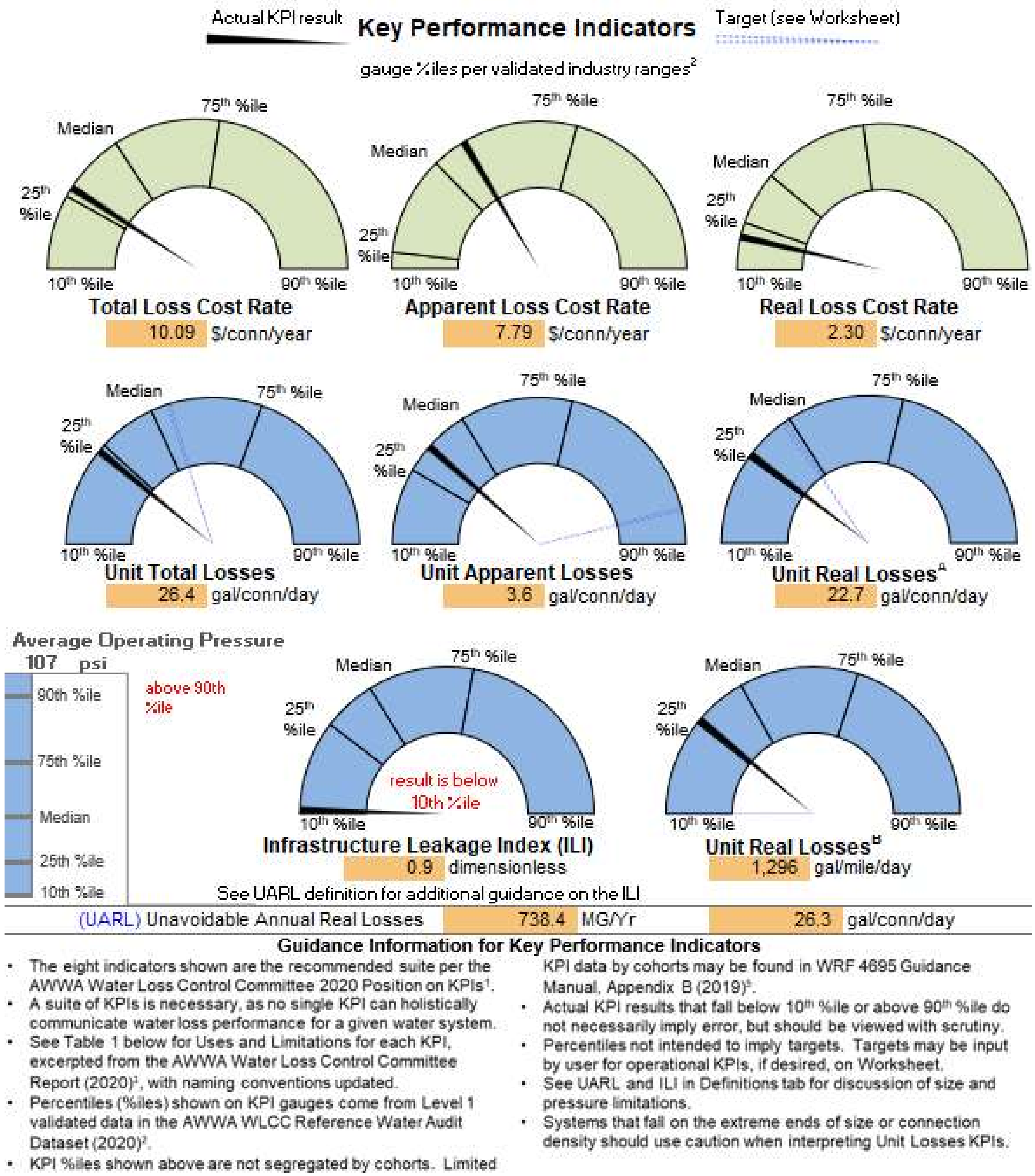

Figure 3.2: Key Performance Indicators from the Dashboard Tab of the AWWA Free Water Audit Software, Version 6.0

3.4.1 Assessing KPIs

The KPIs have the most relevance for the utility itself. There is some value in comparing the system attributes with the water audit data of other water utilities, but this is best done with systems of similar size or characteristics. As a starting point, the KPIs are benchmarked against validated industry ranges and a percentile is assigned to the audited utility based on where they fall within that range. While being above the 90th percentile or below the 10th percentile does not necessarily mean there is a data quality issue, it does suggest that additional scrutiny of the inputs would be a worthwhile effort. This can give the utility perspective on where their system stands among a larger group of utilities, even if systems of varying size are included.

The KPIs of the water utility include:

- Total Loss Cost Rate
- Apparent Loss Cost Rate
- Real Loss Cost Rate
- Unit Total Losses
- Unit Apparent Losses
- Unit Real Losses
- Infrastructure Leakage Index (ILI)
- Unit Real Losses
- Average Operating Pressure

The AWWA Water Loss Control Committee recommends against use of percentage indicators for operational assessments, such as total losses, apparent losses, and real losses, and as a result the KPIs in version of 6.0 of the FWAS do not include a percentage measurement of water loss from the utility.

Utilities benefit from tracking these values from year to year. Losses (both apparent and real) change from year to year, either in an increasing or decreasing manner. If the water utility does not have effective loss control interventions in place, the losses will tend to increase, particularly if aggravating factors (e.g., cold winter weather promoting leakage, a large water rate increase results in a backlash surge in unauthorized consumption) take place during the audit year. With effective loss control interventions in place, however, the utility will hopefully see a downward trend in these losses.

The impacts of apparent and real losses are reviewed below:

- Apparent Losses: by volume and by cost
  - Water reaches the customer but the utility doesn't (fully) recoup revenue
    - Revenue goes uncaptured
    - Billed authorized consumption is understated
    - Losses occur at the customer retail rate
    - Inequities among customers result
- Real Losses: by volume and by cost
  - Water is lost from the distribution system before reaching a user
    - Production costs are wasted (or potential sales to new customers is lost if the water is valued at the customer retail rate, which is appropriate where water resources are scarce)
    - Many other negative impacts due to leakage (damage and disruption in commerce from large water main breaks, icing on roadways in cold seasons, utility damage, other)

In addition to knowing its losses on an annual basis, it is also very important that the water utility calculate the cost of losses each year. Unfortunately, costs mostly tend to rise, so water utilities are usually working against upward cost pressures. It is not unusual for a water utility to see a decrease in losses (apparent and/or real) in a given year, but still see an increase in the cost impacts since cost rates rose during the audit year. Knowing the costs is also essential for the utility to calculate annual economic assessments including benefit/cost ratios, program payback periods, or other economic evaluations.

Water efficiency stakeholders should be mindful of the important cost relationships noted below:

- Apparent Losses: Valued at the customer retail rate
  - When customer billing rates are increased, the cost of apparent losses also increases
- Real Losses: Valued at the variable production cost (Unless water resources are scarce, then the customer retail rate should be applied to real losses)
  - When productions costs (electric power for pumping, treatment chemicals) increase, the cost of leakage increases

    _or_
  - When customer billing rates are increased, the cost of real losses also increases (if the customer retail rate is applied to leakage)

Because losses change each year and costs change most years, it is essential that the water Audit be compiled on an annual basis. Water utilities can observe their year-to-year performance by placing water audit data annually in the AWWA Compiler Software. This software includes useful worksheets that create charts of most of the input parameters, gradings, system attributes and performance indicators and is highly useful for water utility to trend its performance over time and identify effects of its loss control efforts.

The Infrastructure Leakage Index (ILI) is a unit-less indicator that is designed for benchmarking comparisons among utilities. It is the ratio of the level of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL). The UARL is a theoretical reference level of leakage that represents the technical lowest level of leakage that a utility could achieve if it employed all available leakage control technologies. Thus, the ILI is a ratio of the utility's current leakage level to its technically achievable lowest level of leakage. As theoretically derived, the lowest value of ILI that is achievable is 1.0; however, some utilities with very advanced leakage control are decreasing leakage to a level so low that their ILI is below 1.0. In this case, these systems may be proving that leakage levels can go below the levels commensurate with the leakage allowances devised in the UARL equation. Further research may be needed to update the UARL equation based upon the work by these utilities. Unfortunately, many utilities that have calculated values of ILIs below 1.0 do not have extensive leakage controls in place. For these systems, it is likely that their water audit data has embedded error - either the Water Supplied Volume is under-stated, or the Billed Authorized Consumption and/or Apparent Losses are over-stated (or some combination thereof). These systems should carefully review their water audit data for errors.

It should be noted that both the UARL and ILI are system-specific parameters. The UARL is calculated from an equation that includes as inputs the length of the water distribution system pipeline, the number of customer service connections, the average pressure, and the average length of customer service piping maintained by the customer. Since the UARL, and therefore the ILI, are influenced by the average pressure, these values can vary with changes in the average pressure value. For this reason, it is best if the ILI is used for comparisons only after the water utility has conducted work needed to optimize water pressure levels; otherwise, changes in the ILI may occur only because the average pressure has changed in a given year, and not necessarily because leakage levels have changed.

Since the variable production costs vary so widely, there is economic incentive for utilities with high costs to drive down their leakage level to the economic level, which is a value that should be determined by the utility and usually exists somewhere above the reference level of the

UARL. Water utilities can make use of the free software tool developed as part of the Water Research Foundation Project 4372a to determine economic leakage control activities (*Real Loss Component Analysis: A Tool for Economic Water Loss Control*). By inputting data on leakage occurrences in the utility, as well as various costs, the tool calculates the economically viable level of leakage management activities – including proactive leak detection and pressure management – to guide the water utility.

Particularly for utilities whose value of normalized real losses and variable production costs both fall above the median, consideration should be given to enhanced leakage management activities. It is very likely that notable leakage reduction potential exists in the utility. This can save water resources and reduce the production expenses incurred by the water utility.

3.4.2 Summary –Interpretation of KPIs

As part of the efforts to filter utility water audit data and to conduct Level 1 Validation, the QWLA should include a careful review of the KPIs values and percentile ranking within validated industry ranges that are calculated by the AWWA FWAS.

By comparing the utility audit data to the validated industry ranges, perspective can be gained on the meaning of the KPIs calculated for the water utility. If the utility has values that exist in the extreme ranges of the dataset, or certain combinations of values are in the extreme range of the dataset, then the QWLA should pursue a detailed line of questioning of the water utility in the particular area of the water Audit.

The close review of the KPIs by the QWLA is a very useful way to begin evaluating water Audit data as part of the Level 1 Validation process.

Section 4 – Validating a Water Audit

4.1 Approach to Validation

The responsibility of the QWLA is to review supporting data and ask questions with utility staff to validate the inputs and the data grades in the water loss audit. This is the essence of Level 1 Validation review described in this document. It's important to recognize that the QWLA may be reviewing the audit in one of three situations:

1) The QWLA is also the person who has prepared the audit
2) The QWLA did not prepare the audit, but works within the utility
3) The QWLA is third party to the utility

No matter the situation, the methodology described in this document applies. In each of the three situations described above, the gathering of data and interview questions with various utility staff is necessary. As such, the QWLA's techniques for gathering this information must be professional and guide any adjustments needed to inputs or grades as a consensus between the QWLA and utility staff. The QWLA should only certify an audit where all inputs and grades have been properly validated and documented per the Level 1 Validation methodology.

Below are the recommended techniques for the validation review of water utility data entered into the FWAS. There are two primary functions to the validation review: 1) affirming the data grades and 2) affirming the data inputs. Affirming the data grades is a function of matching up the utility's policies, practices, and records to the grading criteria in the Interactive Grading Worksheet of the FWAS – this largely comes from the Q&A with utility staff. Affirming the data inputs is a function of matching up the utility's data to the derivation of the input – this largely comes from review and understanding of the supporting documents. These are two independent functions that can simultaneously occur in the validation review.

It is most effective if the validation reviewer can review the utility's supporting documentation in advance of the validation review meeting. Parts of the validation checklist can be completed from the supporting documentation alone. If the submitted supporting documentation is sparse, the validation reviewer should work to obtain as much as possible before the validation review meeting. Items on the checklist that are not explained in the supporting documentation should be identified. In the meeting, the checklist may be completed by asking the utility representative(s) gently probing, open ended questions. For example, rather than "do you test your customer meters", the reviewer should ask "tell me about your customer meter testing"; or "how was the retail cost calculated" rather than "was the retail cost a weighted calculation from among all rate codes".

The responses and documentation provided should be used to assess the appropriate data grade for each input, which is the highest grade where all of the criteria are met or exceeded. If a grade adjustment (up or down) is made, this should be noted on the Comments worksheet of the FWAS in the final version of the audit. A general guideline is that documentation (as described in the subsequent section) should be provided to support data grades selected in the audit.

The reviewer should stay alert for common pitfalls in the derivation of the data inputs as well. If an input adjustment is needed, the reviewer and utility auditor should work together to come to agreement on the representative adjusted input during the meeting. This should be noted on the Comments worksheet in the final version of the audit.

4.2 Validation Documentation

The validation reviewer should document all checklist answers and any other pertinent information gained in the review in each respective cell of the Notes worksheet of the FWAS or comparable format. In the General Notes cell, the following minimum information should be documented: name, contact info, and QWLA certification number of validation reviewer; name and contact info of the utility audit preparer(s); reviewer's observations from initial screening of the audit metrics; and any general comments that are relevant.

4.2.1 Obtain Supporting Documentation

The documentation described in this section should be obtained where available from the auditor to facilitate the Level 1 Validation review. If some of the documents listed below are not available, the reviewer should note this in the validation form accordingly. A general guideline is that documentation should be provided to support interactive data grade question response. It should be noted that some documentation can be easily recorded in the Notes worksheet of the FWAS, and other documentation may need to be submitted as separate attachments. Relevant supporting documents are described below. It should also be noted that bolded documents are considered to be necessary for QWLA certification of the audit. Other documents, if not available for immediate review, should be identified for future development and inclusion.

4.2.2 Documents for Audit Metrics

- **(Required) Water Audit file in Excel and the basis of audit documentation available from all previous years.**
- Examples of key documented results and data including customer meter accuracy testing results, unauthorized consumption investigations, customer billing system data mining analysis, or other activities that demonstrate enhanced control of apparent losses.
- Real loss levels can be judged as representative by documented results or data supporting leak detection, pressure management and/or water main rehabilitation/replacement activities that demonstrate enhanced leakage management and control of real losses.

4.2.3 Documents for Water Supplied

- (Required) Monthly water supplied volume summary for the audit year, broken-down by source, pressure zones, or other major water supply configurations.
- (Required) Recent finished water (production flowmeter) meter accuracy test results. Accuracy test documentation should include numeric results, test data and indication of test methodology (comparative testing vs. signal verification, duration, etc.) – i.e. a statement that the flowmeter "passed" or "failed" is not sufficient.
- Derivation of master meter & supply error adjustment inputs. This can include numeric adjustments tabulated during the audit year to account for known flowmeter inaccuracy, as well as adjustments to account for disruptions in tank storage balances and corrected gaps in the supply data trail.
- (Required) If the water distribution system configuration is complex, a schematic of the system should be submitted to show the locations of production flowmeter sites, major supply transmission pipelines, and other significant features of the water supply system.

4.2.4 Documents for Authorized Consumption

- (Required) For Billed Authorized Consumption, volumes sold by rate code, by month. Include brief explanation of rate codes. Provide derivation of flat rate if the customer population is unmetered.
- For Unbilled Authorized Consumption, provide any available summary of tracking data such as flushing and fire department usage estimates.

4.2.5 Documents for Apparent Loss

- Documented results and data from customer meter accuracy testing.
- Derivation of customer meter inaccuracy input

4.2.6 Documents for System Data

- Derivation of the number of active and inactive customer service connections input.
- Any available recent pressure data from permanently installed or temporarily installed pressure loggers, or hydraulic model results. Derivation of the average operating pressure input.

4.2.7 Documents for Cost Data

- (Required) Customer retail rate schedule for the audit year.
- (Required) Derivation of Customer Retail Unit Cost input.
- (Required) Derivation of Variable Production Cost input.

4.3 Initial Screening of Audit Metrics

The AWWA FWAS calculates a variety of KPIs that are highly effective in the assessment of utility water loss performance. Once appropriate documents are collected and examined as discussed above, the validation process should include a detailed review of KPIs as shown by the FWAS dashboard.

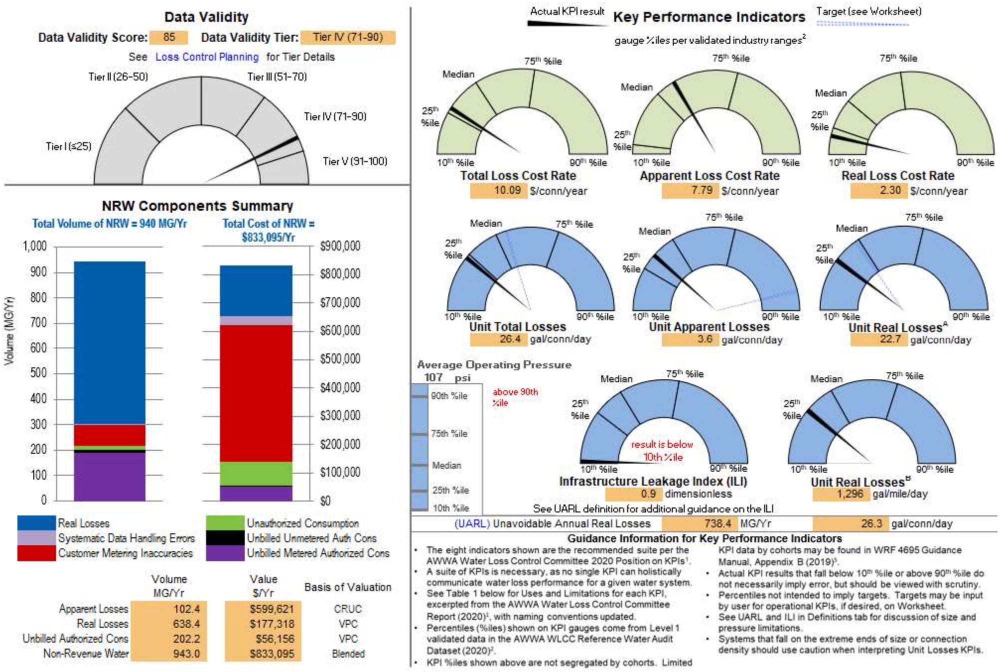

Figure 4.1: Data Validity Dashboard

4.3.1 Validation Checklist for Audit Metrics

1. The FWAS Dashboard should be reviewed by the auditor before submitting the Audit. Without reviewing and proofreading this worksheet, the auditor might overlook suspicious values which may result in the Audit being returned for review before Level 1 Validation takes place. Upon submittal of the water audit, the auditor should provide supporting documentation for various activities particularly if any of their KPI values fall within extreme ranges of validated summary datasets (below 10th percentile or above the 90th percentile). Also, the NRW Components Summary should be reviewed for any significant errors or anomalies. By not having good documentation available to support data inputs and gradings, the auditor risks extending the time needed to conduct the Level 1 Validation.

2. Be watchful for performance indicator values that appear to off by one or more orders of magnitude (i.e., 10, 100, or 1,000 times a number that you would expect). This can occur if the auditor misinterprets the units for the customer retail cost or misinterprets that the primary inputs of the water Audit are in MG/yr (the gallons units are used for most water audits submitted in the US). It may also occur simply because a number was not typed correctly into the water Audit, and the Audit was not sufficiently proofread before submittal.

3. Are the volumes for Real Losses and Apparent Losses very low? Perhaps the Water

Supplied Volume is under-stated, or the Billed Authorized Consumption is over-stated (watch out for double-counting of the Water Exported volume).

4. Review the activities in place to control Apparent Losses. Have the endeavors been successful because of a management motivation or another reason? If considerable Apparent Loss control activities have not been conducted, then low loss attributes and indicators may reflect data errors. Absent robust apparent loss controls, the grading of one or more Apparent Loss components may be too high. Perhaps the Water Supplied volume is under-stated, making the water losses – and quantities for Apparent Losses – appear erroneously low.
5. Are the Real Losses performance indicators, including the ILI and the Variable Production Cost, all very low relative to data from validated datasets? Note the nature and extent of leakage management activities that are employed. For a utility to truly have low leakage performance indicators, their leakage management practices must be extensive and/or their water distribution system is very young and robustly designed and constructed. If extensive leakage management controls are not being implemented, perhaps their volume of Apparent Losses in the water audit is over-stated, making the calculation of Real Losses erroneously low.
6. The AWWA Compiler can be used to trend/chart any data point from multiple years of audits. This can be a helpful tool throughout the validation process. The AWWA Compiler is a free download at: www.awwa.org/waterlosscontrol

4.4 Level 1 Validation of the Inputs that Calculate the Water Supplied Volume

The Water Supplied Volume is the annual quantity of treated drinking water that enters the water distribution system and has the opportunity to reach end-users. This volume is the largest volume in the water Audit and is of great importance since error in this quantity is carried through the entire Audit. It is very important that the quantity calculated for Water Supplied be as accurate as possible; therefore, the various inputs contributing to this volume should be as accurate as possible. Poorly managed flowmeters generally result in under-registration of flows and an under-stated Water Supplied Volume. In this case, the volume of losses can be erroneously understated also. There are many types of flowmeters that are effectively utilized in the determination of flow rates and volumes, as well as numerous means to ensure that reported flows are appropriate. This is perhaps the most technically challenging portion of any water Audit and should be considered carefully. While subsequent comments provide an overview of review considerations for the topic, a more detailed discussion of the nuances of this element is presented in Section 6 of this Manual.

As shown below and as calculated by the FWAS (see the Worksheet tab), the Water Supplied Volume is calculated as a composite volume from three primary components and the master meter error adjustment volume that exists for each of the three primary components. Thus, up to six quantities can contribute to the calculation of the Water Supplied Volume. These are:

Volume from Own Sources +/-Volume from Own Sources Error Adjustment *plus*

Water Imported +/- Water Imported Error Adjustment *minus*

Water Exported +/- Water Exported Error Adjustment

---

equals **Water Supplied**

As noted in the FWAS, the auditor can enter a percentage or a volume quantity when providing inputs for the master meter and supply error adjustments for each of the three components of Volume from own Sources, Water Imported, and Water Exported. Then the auditor selects whether the relevant meters are over or under registering volumes.

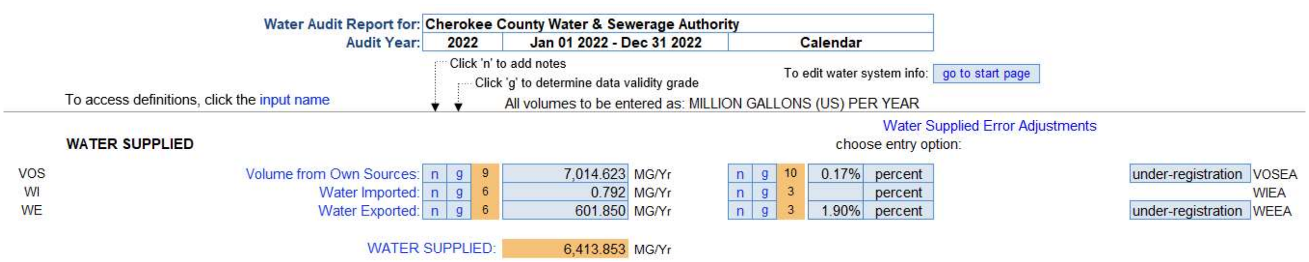

Figure 4.2: Water Supplied Components on the Reporting Worksheet for the AWWA Free Water Audit Software, Version 6.0

4.4.1 Validation Checklist for Water Supplied Data

1. For water utilities with multiple years of data, does the Water Supplied volume deviate significantly from the volume reported in the previous year, or prior several years? (The AWWA Compiler Software can reliably display these trends.) If so, is there a reasonable explanation for this difference, or could it suggest an error in this data for the current year's audit data?

2. Note the number of water sources providing supply, and the type, size, and age of each finished water meters (flowmeter) on these sources.
3. Note the flowmeter accuracy testing methods (if any) that are employed. Note if they include flowmeter accuracy verification in addition to secondary instrumentation calibration. Note frequency of these tests for each flowmeter, and the numeric results. Confirm that supporting documentation and input derivation aligns with input values for master meter and supply error adjustments.
4. Note how the flowmeter data is communicated from the field sites and channeled into a data repository. Does the utility use a SCADA system to provide this function? Is the data tabulated and reviewed on a regular and frequent basis? Does this occur daily, weekly, or monthly? Are corrections or adjustments implemented on a daily or weekly basis? Is the Water Supplied volume determined on a daily basis by taking into account water storage tank/reservoir elevation changes and the balancing of flows across pressure zones and District Metered Areas, as appropriate?
5. Confirm that the interactive data grading response and the assigned data grades align with the utility's practices and supporting documentation.

4.4.2 Grading the Water Supplied Volume Sub-components

The Interactive Data Grading includes process-based activities that define steps that produce data of high validity, and also operations of high performance. More information on data validity and the Interactive Data Grading process is provided in Section 3. The general processes include establishing and maintaining reliable flowmeters, regularly testing the flowmeters for accuracy and electronically calibrating their secondary devices, balancing flow data across the water distribution system, and providing ongoing data surveillance in order to quickly detect data gaps/disruptions and make data corrections.

Table 4.1: The Six Sub-components that are Inputs to the Calculation of the Annual Water Supplied Volume and the AWWA FWAS Interactive Data Grading Criteria

Sub-component	FWAS Grading Focus
Volume from Own Sources	Installing flowmeters on sources, conducting secondary device calibration, conducting meter accuracy testing, and obtaining test results within a tight degree of accuracy
Volume from Own Sources Master Meter and Supply Error Adjustment	Flowmeter output data is regularly monitored and inaccuracies are incorporated into regular data adjustments, flows are balanced across the distribution system with tank levels monitored regularly, and data gaps quickly identified and corrections to the data implemented
Water Imported	Installing flowmeters on sources, conducting secondary device calibration, conducting meter accuracy testing, and obtaining test results within a tight degree of accuracy
Water Imported Master Meter and Supply Error Adjustment	Flowmeters are installed and an explicit written agreement exists between the seller of the water and the utility. Flowmeter output data is regularly monitored and inaccuracies from data gaps or disruptions are incorporated into regular data adjustments which are quickly implemented.
Water Exported	Installing flowmeters on sources, conducting secondary device calibration, conducting meter accuracy testing, and obtaining test results within a tight degree of accuracy
Water Exported Master Meter and Supply Error Adjustment	Flowmeters are installed and an explicit written agreement exists between the utility and the utility purchasing the water. Flowmeter output data is regularly monitored and inaccuracies from data gaps or disruptions are incorporated into regular data adjustments which are quickly implemented.

4.5 Level 1 Validation of the Inputs that Calculate Authorized Consumption

Authorized Consumption is the annual quantity of treated drinking water that is used by customers or other authorized end-users. This volume is usually the second largest volume in the water Audit and the difference between it and the Water Supplied is used to calculate Water Losses, so accurate data is very important. If there are inaccuracies that result in elevated Authorized Consumption, then Water Losses may be underestimated.

Authorized Consumption can be either metered or unmetered and billed or unbilled. These classifications create four input combinations shown in Figure 4.3 below: Billed Metered

(BMAC), Billed Unmetered (BUAC), Unbilled Metered (UMAC), and Unbilled Unmetered (UUAC). For the unmetered inputs, estimates are used to determine the volume to be entered into the water audit.

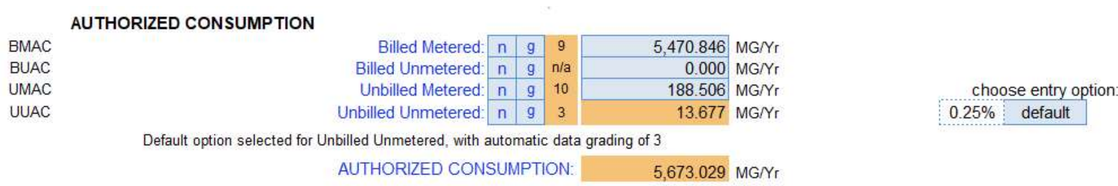

Figure 4.3: Authorized Consumption Components on the Reporting Worksheet for the AWWA Free Water Audit Software, Version 6.0

4.5.1 Validation Checklist for Authorized Consumption Data

1. For water utilities with multiple years of data, does the Authorized Consumption deviate significantly from the volume reported in the previous year, or prior several years? (The AWWA Compiler Software can reliably display these trends.) If so, is there a reasonable explanation for this difference, or could it suggest an error in this data for the current year's audit data?

2. Note percentage of customer population that is metered vs. billed on fixed (flat) basis. Note percent of estimated reads on average each billing cycle. Note average and range of customer meter ages. Note profile of meter read type (all manual, drive-by AMR, fixed network AMI, or indicate portions) and meter read frequency. Note if lag-time calculation is employed in the derivation of the BMAC input.

3. Note nature of customer meter testing policy – reactive (complaint driven) vs proactive (routine). Note frequency of customer meter testing – how many tested each year, and what is the basis for test: complaint or group selection (meters pulled for performance or replacement, random, other). Note differences in these practices between small customer meters and large customer meters. Verify documentation supports information noted.

4. Note policy for customer meter replacement – how many replaced each year, and what is the basis for replacement (upon failure only, age threshold, consumption threshold, test results, geography, other). Note differences in these practices between small customer meters and large customer meters.

5. Note nature, frequency and source of audits performed on the customer billing system (spot check by financial auditor, detailed data mining and analysis by staff or consultant, other).

6 Verify from supporting documentation that correct timeframe (12 months) has been utilized in the tally of consumption volumes. Verify by rate code summary volumes that non-potable volumes (sewer, raw, reuse, storm) have been excluded from the tally. Verify that summation of volumes by billed rate code matches total entered as the BMAC, with no double counting of unbilled volumes. If a volume is shown in the Water Exported input, verify that this same volume has been excluded from the BMAC input.

7 Note utility's policy indicating which customers are unmetered. Note percentage of accounts that are exempt from metering requirement. Note accounts included in this category for the utility. Note basis by which this input volume is derived.

8 Note utility's policy indicating which customers are unbilled. Note accounts included in this category for the utility. Note basis by which this input volume is derived. Note if these unbilled meters are read and managed the same or differently from billed meters. Verify that UMAC volumes are excluded from the BMAC input.

9 If default value is utilized, note types of uses that are in this category for the utility. If the default value is utilized, and many unbilled uses such as flushing are metered and included in the UMAC input, consider adjusting to a volume below the default. If non-default input utilized, review supporting documentation for reasonableness of magnitude of estimates and basis for estimates (categorical estimation, event-based formula approach, other). Verify that estimations of leakage volumes are excluded from this UUAC input. Be alert if a large emphasis is placed on UUAC, making it the majority component of NRW. For most utilities, this component is a very small portion of NRW.

10 For water utilities with multiple years of data, does the UUAC deviate significantly from the volume reported in the previous year, or prior several years? (The AWWA Compiler Software can reliably display these trends.) If so, is there a reasonable explanation for this difference, or could it suggest an error in this data for the current year's audit data?

4.5.2 Grading the Authorized Consumption Volume Sub-components

Grading of this element includes process-based activities that define steps that produce data of high validity, and also operations of high performance. See Section 3.1 for more information on data validity and the Interactive Data Grading process. The general processes include metering of authorized uses, good recordkeeping, and meter testing and replacement. For unmetered uses, the criteria also include clear written policies, procedures, and practices for estimating these uses, and tracking of all the different kinds of authorized uses.

Table 4.2: The Four Sub-components that are Inputs to the Calculation of the Authorized Consumption Volume and the AWWA Free Water Audit Software Grading Criteria

Sub-component	FWAS Grading Focus
Billed Metered	Metering of customers and billing based on volume, meter testing and replacement, good recordkeeping and auditing
Billed Unmetered	Written policies, minimizing unmetered accounts, reliable estimates of unmetered uses
Unbilled Metered	Written policies, meter reading and management, meter testing and replacement, good recordkeeping and auditing
Unbilled Unmetered	Written policies, minimizing unmetered accounts, reliable estimates of unmetered uses, tracking of all types of this use

4.6 Level 1 Validation of the Inputs that Calculate Apparent Losses

Apparent Loss is the annual quantity of treated drinking water that is used but not properly measured or paid for. These losses are also sometimes called paper or economic losses. Reducing these losses provides for better accounting and revenue recovery. There are three related inputs in the FWAS: Unauthorized Consumption (UC), Customer Metering Inaccuracies (CMI), and Systematic Data Handling Errors (SDHE). Data for these inputs may commonly be estimated, but there are practices listed in the Interactive Data Grading to improve the accuracy of these numbers.

4.6.1 Validation Checklist for Apparent Loss Data

1. Note the utility policy on theft documentation. Note the qualitative frequency (low, mid, high) of discovery of theft occurrences. Compare to default percentage as basis for adjustment if warranted.

2. Note the utility policy on theft enforcement and penalties.

3. Note nature of customer meter testing policy. Note detail on testing methodology – internal vs external, bench vs field, flow ranges utilized per AWWA M6 Manual. Confirm how multiple test flow ranges were reconciled to a single test result – arithmetic vs weighted average, and weightings used. Review derivation of CMI input, verify alignment with supporting meter test data. Watch for disconnect between detailed test data and generalized input. Note if procedures have been reviewed by a third party knowledgeable in M36 methodology.

4. Note nature of customer meter replacement policy. Note detail on relationship between meter testing and meter replacement to verify if one dictates the other.

5. Note policy on estimating consumption – scenarios in which this occurs, and for how long. Note policy to activate a new customer/meter and deactivate an old customer/meter. Note policy for billing adjustments and how this might impact integrity of archived consumption volumes.

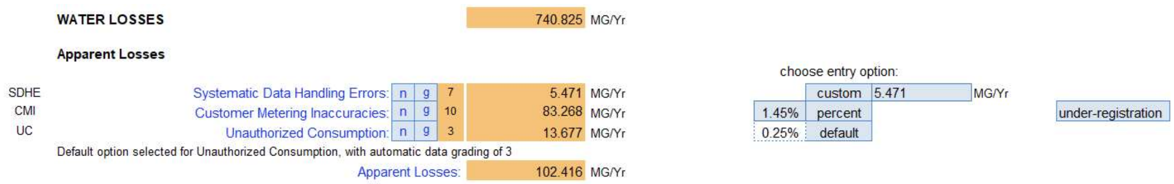

Figure 4.4 Apparent Losses Components on the Reporting Worksheet for the AWWA Free Water Audit Software, Version 6.0

4.6.2 Grading the Apparent Loss Volume Sub-Components

The Grading worksheet includes process-based activities that define steps that produce data of high validity, and operations of high performance. Table 4.3 lists the three sub-components and the process focus of each sub-component as included in the Grading worksheet. The general processes include establishing policies and procedures and implementing field activities for determination and management of subcomponents.

Table 4.3: The Three Sub-components that are Inputs to the Calculation of the Annual Apparent Loss Volume and the AWWA Free Water Audit Software Grading Criteria

Sub-component	FWAS Grading Focus
Unauthorized Consumption	Policies and procedures to document unauthorized consumption occurrences, policies exist to quantify, qualify and/or manage unauthorized consumption
Customer Metering Inaccuracies	Customer meters are used by the majority of customers, reliable recordkeeping system for customer meters, meter testing and replacement is customary, composite meter inaccuracy is determined from meter testing activities and is used in volume determination
Systematic Data Handling Errors	Policies and procedures to document and track activation and deactivation of billed accounts and meters, frequency of account review, robust computerized billing system with extensive reporting capabilities, examination of billing reports looking for lapses or misses in consumption

4.7 Level 1 Validation of the Inputs that Calculate the System Data

The System Data section of the water Audit includes utility-specific information for calculation of performance indicators and other metrics generated by the FWAS. There are four inputs shown in Figure 4.5 below: Length of Mains (Lm), Number of Active and Inactive Service Connections (Nc), Average Length of Customer Service Line (Lp), and Average Operating Pressure (AOP).

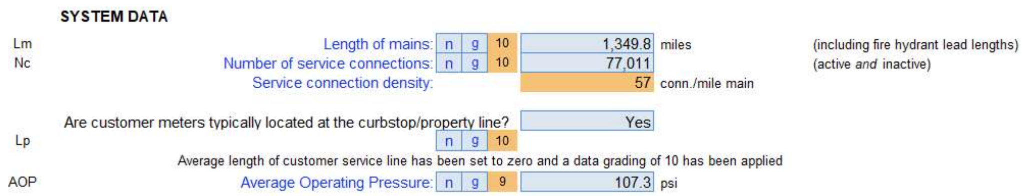

Figure 4.5: System Data Components on the Reporting Worksheet for the AWWA Free Water Audit Software, Version 6.0

4.7.1 Validation Checklist for System Data

1. For water utilities with multiple years of data, do each of the four System Data inputs deviate significantly from those reported in the previous year, or prior several years? (The AWWA Compiler Software can reliably display these trends.) If so, is there a reasonable explanation for this difference, or could it suggest an error in this data for the current year's audit data?

2. Note average and range of age and material composition of the pipe network. Note policy for updating and maintaining mapping database as mains are commissioned or decommissioned. Note coverage (full, partial) and nature (paper, GIS, asset management database, other) of mapping database. Note policy for field validation of mapped assets and verification between GIS and asset management databases.

3. Verify that hydrant leads are included in tabulation of Lm.

4. Verify whether derivation of the Lm input is from mapping database or an approximation.

5. Note policy for new account activations. Note policy for updating and maintaining accounts database as new connections are commissioned or decommissioned. Note policy for field validation of service connections and verification between GIS and customer account databases.

6. Note policy for service connections moving to inactive status. Verify if input derivation is from customer information database or an approximation. Verify whether input includes active and inactive connections.

7. Note policy for utility/customer separation of service line responsibility and placement of meter. Verify input of “0” utilized if customer meters are placed at property line.

8. If all meters are not placed at property line, verify input derivation as a weighted calculation between portion of meters at property line (with Lp = 0) and portion of meters on premise (with average Lp >0).

9. Note configuration of pressure zones in the network, with estimated range and average pressure for each zone. Note estimated mileage and service connections by pressure zone, if available.

10. Note nature of pressure data (static readings, temporal pressure logs, continual telemetry logs, other).

11. Review average pressure supporting documentation. Note extent of field generated pressure data (plants, booster stations & tanks only, critical and average point monitoring, portion of hydrants, other). Note utilization of hydraulic model and policy for model calibration.

12. Verify if derivation of AOP input is from pressure database or an approximation. Make sure that the background data feeding the average pressure calculation is from the current audit year, and not dated data from a prior year.

4.7.2 Grading the System Data Sub-components

The Grading worksheet includes process-based activities that define steps that produce data of high validity, and also operations of high performance. Table 4.4 lists the four components and the process focus of each component as included in the Grading worksheet. The general processes include establishing and maintaining sound policies for permitting and activating new water mains and service connections, enacting pressure controls to separate and efficiently operate different pressure zones and field data collection of pressure data and validation of system appurtenances.

Table 4.4: The Six Sub-components that are Inputs for System Data and the AWWA Free Water Audit Software Grading Criteria

Sub-component	FWAS Grading Focus
Length of mains	Sound policies and procedures for permitting and commissioning new water mains, regular field validation of water mains, well-kept records and asset management system (GIS based)
Number of active AND inactive service connections	Activation policies and procedures for new service connections, well written billing policies and procedures, field validation of service connections, internal system auditing, connection count in error is less than 1%-2%
Average length of customer service line	Curb stop serves as delineation point between utility and customer ownership of service connection piping, clear written policy exists to define service connection piping responsibility, accurate recordkeeping
Average operating pressure	Pressure controls exist for the system and separate different pressure zones, telemetry monitoring of system pressure, pressure readings gathered by different sources, pressure zones are well delineated, SCADA system exists

4.8 Level 1 Validation of the Inputs that Calculate the Cost Data

The Cost Data section of the water Audit includes utility-specific cost information for calculation of performance indicators and other metrics generated by the water audit software. There are three inputs shown in Figure 4.6 below: Total Annual Cost of Operating the Water System, Customer Retail Unit Cost (CRUC), and Variable Production Cost (VPC).

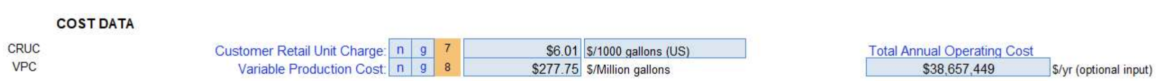

Figure 4.6: Cost Data Components on the Reporting Worksheet for the AWWA Free Water Audit Software, Version 6.0

4.8.1 Grading the Cost Data Sub-components

1. For water utilities with multiple years of data, do any of the below costs/cost rates deviate significantly from those reported in the previous year, or prior several years? (The AWWA Compiler Software can reliably display these trends.) If so, is there a reasonable

explanation for this difference, or could it suggest an error in the cost data? It is much more common for costs to increase from year-to-year. A decrease in any cost relative to the prior year – while plausible – should be understood and documented. Any inordinately large increases should also be explained.

2. Note frequency (annual, periodic, other) and source (internal, external CPA, other) of auditing of water accounting system. Note alignment of time period for costs reported and audit period.
3. Review supporting documentation. Note nature (uniform, class-based, tier-based) of customer retail rate structure. Note if derivation of input is an estimation, a selected rate, or a weighted average from all billing rates.
4. If derivation of CRUC input is from total volume sold divided by total water revenue, verify that base charges are excluded from total water revenue. Verify if any non-potable volumes (i.e. sewer) which are charged on the basis of water meter readings are included in the input derivation. Note if procedures are reviewed by third party knowledgeable in M36 methodology.
5. Verify that units are correct.
6. Review supporting documentation. Verify if derivation of input includes primary costs (power, chemicals, purchased water if applicable) only versus secondary costs (water treatment residuals, liability, pump depreciation, impending expansion of supply if applicable, other). Note the frequency (annual, periodic, other) and source (internal, third party CPA, third party knowledgeable in the M36 methodology, other) for auditing of these primary and secondary costs.
7. Verify derivation of input uses produced / purchased volumes that are corrected for error adjustments.

4.8.2 Grading the Cost Data Sub-components

The Grading worksheet includes process-based activities that define steps that produce data of high validity, and also operations of high performance. Table 4.5 lists the four sub-components and the process focus of each sub-component as included in the Grading worksheet. The general processes include a reliable electronic accounting system, including all pertinent costs, along with annual auditing. For customer retail and variable production costs, the criteria also include a clearly written up-to-date water rate structure that is based on customer classes and tracking of all variable production or purchase costs, both primary and secondary.

Table 4.5: The Three Sub-components that are Inputs to the Calculation of the Cost Data and the AWWA Free Water Audit Software Grading Criteria

Sub-component	FWAS Grading Focus
Total annual cost of operating water system	Using an electronic, industry standard, cost accounting system, including all pertinent water system costs, and annual auditing of financials (preferably by third-party CPA)
Customer retail unit cost	Current, up-to-date water rate structure based on customer classes, composite rate calculation reviewed by third party
Variable production cost	Using an electronic, industry standard, cost accounting system, including all pertinent water system variable operating costs (produced or purchased or both), and secondary costs, annual auditing of financials (preferably by third-party CPA), cost calculation reviewed by third party

4.9 Final Screening of Audit Metrics

This step repeats some of the review conducted in the initial screening of Audit metrics; however; by now gross errors or incomplete data should not be an issue with the water Audit. The Dashboard can now be reviewed again knowing that the input data has been validated and obvious data input errors should not be a factor.

1. For utilities that have multiple years of water Audit data, place the validated water Audit into the Compiler Software, and again review the year-to-year trend of data and performance indicators. Do any significant variations in values from year-to-year appear? If so, can the utility provide an explanation for the variance? Could a subtle data input error remain?
2. Does the volume of Water Losses and NRW remain very low? Is there still a possibility that the Water Supplied volume is under-stated, or the Authorized Consumption and/or Apparent Losses are over-stated? If any of these components/sub-components are of low validity, they might be contributing to the unusually low level of losses. It is also prudent to reconfirm that the Water Exported volume has not been double counted by including it also in BMAC.
3. Do the Unit Apparent Losses (gal/service connection/day) value and the CRUC remain very low relative to data from validated datasets? Are the gradings for the three Apparent Loss components validated to be at a high level (8 or above)? Conduct a further review of the activities in place to control apparent losses. If considerable Apparent Loss control activities have not been conducted, then low loss attributes and indicators may reflect data errors. Consider recommending cost-effective bottom-up apparent loss control activities that the utility might undertake in the upcoming year. Such activity might return uncaptured revenue and provide more robust data to better represent the apparent loss levels and performance indicators in the water audit.
4. Do any of the Real Losses KPIs, and/or the VPC remain very low, relative to data from validated datasets? Reconfirm the nature and extent of leakage management activities that are employed. For a utility to truly have a very low ILI, their leakage management practices must be extensive and/or their water distribution system is very young and robustly designed and constructed. If extensive leakage management controls are not being implemented, perhaps their volume of Apparent Losses in the water audit is over-stated, making the calculation of Real Losses erroneously low. Consider recommending cost-effective bottom-up Real Loss control activities that the utility might undertake in the

upcoming year. Such activity might provide more robust data to better represent the real loss levels and performance indicators in the water audit, while also producing additional, documented leakage reductions.

5. As a final step, the QWLA should document in the General Notes of the Notes tab regarding the KPIs and how they align with the utility's extent of water loss management. If a discrepancy is observed, such as a utility having a high levels of loss despite an aggressive loss management program - or low levels of loss in the absence of an aggressive loss management program - the QWLA should again review data inputs to identify if anything was missed in the review. If the root cause of the discrepancy is cannot be found through supporting documentation and utility staff interviews, the QWLA should include in the General Notes a description of the likely cause(s) and guidance on where deeper investigations (i.e. Level 2 validation data mining or Level 3 validation field testing) may be warranted.

4.10 Supporting Documents and Validation Form – Checklist

1. The QWLA should reconfirm all checklist answers and any other pertinent information gained in the review and proof-read all validation documentation now included in each cell of the Notes worksheet of the FWAS. It can be helpful to the validation process for future years' water Audits if system description information (additional system data, test procedures, billing protocols, etc.) are highlighted in this documentation. Much of this information does not change notably from year to year. It can be very helpful to next year's validation reviewer if this information stands out, and the reviewer does not need to question the utility on these practices repeatedly. Some of this information may also be included as separate attachments.

2. Be certain that the reasons for data grading selections are clearly documented. Discuss with the auditor the means to elevate certain gradings by improved activities in the upcoming audit year.

4.11 Water Loss Audit Certification Statement for EPD submittal

The QWLA should assemble the water Audit file with basis of audit documentation (Excel document including Worksheet and Notes tabs) and prepare it for submittal to EPD. If the validation reviewer has opted to record the basis of audit documentation on a comparable format, such as a separate Excel or MS Word file, that should be attached with the submittal to EPD. All supporting documentation (as described in Section 4.2) should be excluded from the submittal and kept on file by the QWLA and the auditor, to be made available if requested by EPD.

The QWLA should complete the water loss audit certification statement and provide this to the utility for inclusion in their EPD submittal. Version 4 of the Certification Statement is located on the next page.

4.12 QWLA Certification Form

Water Loss Audit Information:

Water System Name: ____

Water System No. (PWS ID #): _____________________________

Water Loss Audit Year: __________________________

Certified Data Validity Score: __________ Certified Real Loss (gal/conn/day): __________

Water System Primary Contact Information:

Name: __________________________

Email: __________________________ Phone: __________________________

Mailing Address:
________________________________City___________________State____ZIP______

Certification Statement:

I hereby certify that:

1. I HAVE CONDUCTED A LEVEL 1 VALIDATION REVIEW OF THE ABOVE REFERENCED WATER LOSS AUDIT AND THE RESULTS MEET THE REQUIREMENTS IN THE GEORGIA WATER SYSTEM AUDITS AND WATER LOSS CONTROL MANUAL AND THE AMERICAN WATER WORKS ASSOCIATION METHODOLOGY FOR WATER LOSS AUDITING.

2. THE BASIS OF AUDIT DOCUMENTATION FOR THE ABOVE REFERENCED WATER LOSS AUDIT IS INCLUDED EITHER IN THE COMMENTS TAB OF THE AUDIT FILE OR ATTACHED IN COMPARABLE FORMAT.

Qualified Water Loss Auditor (QWLA) Information:

First & Last Name (print): ____

Phone: __________________________ Email: ___________________________

QWLA Registration Number: __________________________

QWLA Signature: ____________________________________

Signature Date: __________________________

Supplemental information to be provided, if available, by Primary Contact listed above:

Total volume of residential water use for audit year (million gallons): _________________

Section 5 – Planning a Water Loss Control Program

5.1 Authority and Guidance

Beginning in 2016, water utilities in Georgia serving over 3,300 individuals have been required by the Georgia EPD to produce a Water Loss Control Program (WLCP).

The WLCP can be very basic, simply documenting the Priority Areas for Attention to Improve Data Validity (as identified by the FWAS or the utility) and how they will be addressed. The Georgia EPD website provides a template for this most simple level of WLCP. In that template, the Audit-defined Priority Areas are referred to as Audit Recommendation Areas. Additional utility-defined Priority Areas can also be documented in the template.

Alternatively, the WLCP can be more advanced, including information that would be helpful in succession planning at the utility and onboarding of new hires who will be involved in preparation and certification of the annual water Audit. The WLCP could include sections on authority, system description, data tracking methods for each item in the Audit, results and trends from annual water Audits, Real Loss Component Analysis results and trends, improvement strategies, and completed improvement strategies. All the required information for a robust WLCP should come from the most current water loss Audit. A WLCP is a living document and should be updated each year with the results from the most recently completed water audit.

Authority for water Audit and Water Loss Control Program requirements comes from Rules and Regulations of the State of Georgia 391-3-33 Rules for Public Water Systems to Improve Water Supply Efficiency.

5.2 Format

If a water utility chooses to create the most basic WLCP, the guidance provided on the EPD website may prove useful. The template available there contains fields that can be filled in according to the Priority Areas identified in the Audit. The cover letter introducing the template states that the WLCP "should reflect the results of the applicable annual water loss audits. Namely the program should address at least the 3 recommendations offered by the most recent annual water loss audit."

Space for additional, optional, utility-defined priority areas is also provided in the template, along with a section for notes.

It may be to the utility's advantage to develop a more robust WLCP, so that individual data collection and analysis methods can be documented. One possible way of organizing a detailed WLCP would be:

- Introduction and Authority
- Basic Data and Infrastructure
    - Production and/or Purchase Meters
    - Water Mains, Service Lines, and Valves
    - Fire hydrants
    - Customer Water Meters
    - Reservoir (if applicable)
- Water Supplied
    - Volume from Own Sources
    - Water Purchased
    - Water Exported
- Authorized Consumption
    - Billed Metered Use
    - Unbilled Metered Use
    - Billed Unmetered Use
    - Unbilled Unmetered Use
- Operational and Maintenance activities within the water distribution system
    - Continuous water system pressure readings
    - Maintenance activities related to water mains
    - Hydrant use or related maintenance activities
- Activities to reduce water loss
    - Real Loss
        - Distribution System Mapping
        - Material and Construction Standards
        - Maintaining Inventory of repair on all main breaks and leaks

        - GPS/GIS Mapping
        - Increased Surveillance in areas with aging infrastructure or reported leaks
        - Water main Rehabilitation and Replacement
        - Pressure Management
    - Apparent Loss
        - Metering of all input sources, Water Exports or Sales, Customer Accounts
        - Metering of Unbilled Uses
        - Accounting and Recordkeeping Practices
- Management Strategies to reduce water loss
    - Metering
    - Water Efficiency/Conservation
    - Speed and Quality of Repairs
- Functional Focus Areas

This more detailed WLCP is an excellent tool for presenting the utility's methods to anyone unfamiliar with the Water Audit process. It serves as a succession planning document and a guide for onboarding employees who will participate in the Water Audit data collection process, preparation of the Audit itself, and/or certification of the Audit as a QWLA.

In addition to the WLCP, it is very beneficial to maintain a companion workbook that stores all raw data used to develop the Water Audit inputs. Separate workbook tabs should be used for each Water Audit input.

5.3 Water Loss Control Program: Basic Data and Infrastructure Requirements

Whether you decide to use the basic or advanced version of a Water Loss Control Program, it is important to cover the basic data and infrastructure of your system. In the updated FWAS (V6.0) this should also be illustrated in the schematic that goes along with your audit document. For this section, an overview helps to capture the most essential parts of your system. It is not necessary to include very detailed information on infrastructure, but including more generalized information is very helpful. For example, it is not necessary to discuss all customer meters, but a general discussion of average age, manufacturer, overall accuracy, and replacement progress would be informative. The same is true for fire hydrants. It is not necessary to locate each one on the schematic, but in the WLCP a brief discussion of how many, manufacturer, age, and maintenance is helpful. For less numerous infrastructure items, it is advisable to be more detailed. Production and purchase meters, for example, should have a discussion of age, type, general location, average use, calibration, and flow verification information. This is also the proper place to give a brief explanation of how the system data is captured such as through a GPS/GIS system.

5.4 Water Loss Control Program: Water Supplied

In any WLCP there should be a detailed discussion of the water supplied. Attributes like production meters and purchase meters are very important to the calculations in the Water Audit software and should be discussed in detail in the WLCP. Detailed information about the meters themselves should be provided, and utilities should include information on how the data from these meters is captured, tracked, and utilized in the Water Audit. Information for the WLCP should include how often operators are reading production meters, how often corrections are done, whether tank level calculations are included, how estimations are used, the frequency of the data reported (ex. Monthly), and to whom the data is reported. Validation requires that all meters listed in the Water Supplied section report data by month and by meter.

The WLCP should also detail information for the Volume From Own Sources (VOS), Water Imported (WI), and Water Exported (WE) Master Meter Error Adjustments (MMEA). All of this information provides a clearer picture of how the inputs are derived and provides a clearer picture for someone new to the audit as well as the person validating the Audit.

5.5 Water Loss Control Program: Authorized Consumption

Authorized consumption should be discussed in the WLCP both for clarity and to provide any users that are new to the process of conducting a water audit information on what has been done in the past, and what could be done in the future. This section of the WLCP should include Billed Metered (BMAC), Unbilled Metered (UMAC), Unbilled Unmetered (UUAC), and Billed Unmetered consumptions (BUAC). For validation purposes, this should be reported by month and by classification (BMAC, UMAC, UUAC, BUAC). Detailed discussion about each classification is important and should contain as much information as needed. For example, Billed Metered Authorized Consumption (BMAC) often comes from a utility's billing system and may contain different types of billed metered water usage. Customer meters should be included, of course, but other sources may exist. For example, a utility may use rental hydrant boxes that are not part of the regular customer billing system, but are classified as billed metered water. It is also important to make sure that no wholesale accounts are included in this classification since those would already be captured in the Water Exported section. It is easy to overlook different classifications or to double count sources of authorized consumption, and having a detailed WLCP can help work through those potential mistakes. Furthermore, the information can provide additional details that will support later sections on management actions to reduce water loss.

For example, how adjustments in the billing system are handled can be of significance. A utility normally makes any adjustments to a customer's water bill in dollars, and not in volume. These volumes should be captured in the Water Loss Audit. It is also important to know how estimations are done, and how often estimations are used in the system. Additionally, if a utility uses flat-rate billing for any portion of the system, that should be noted in the WLCP. Specifically, flat-rate billing would be in the classification of Billed Unmetered Authorized Consumption (BUAC). Details to include in this classification would include how extensive is flat-rate billing, how many accounts are given this designation, why are accounts billed at a flat rate, and if there is a plan to migrate those accounts to metered use. Unbilled Metered use (UMAC) is typically reserved, through written policy, for the utility's own use and the use of a small number of other departments (i.e. fire department, roads and bridges, or construction and GADOT). Implementing a written policy that clearly defines how and who can be included in this category should be in the WLCP and it is a component of the interactive data grading for this entry.

There is one default option in the Authorized Consumption section of the water audit worksheet and it is associated with the Unbilled Unmetered Authorized Consumption (UUAC). One purpose of the WLCP should be to help guide a utility to use defaults less often and generate more custom data inputs. As a utility improves its ability to gather data, the use of defaults should be phased out. For the UUAC default, it is best to describe in the WLCP why the default is being used, as well as what steps are being implemented to move away from the default to a custom entry derived from actual data. This category is typically used to track firefighting use, line flushing without a hydrant box, or other uses by a specific and narrow group. It is also useful to have a written policy outlining which groups may fall into this category.

5.6 Water Loss Control Program: Operational and Maintenance Activities

This section of the WLCP deals with the "nuts and bolts" types of activities that correlate to other entries on the Water Audit. For any utility, it is paramount to know how accurately meters are reading. These devices are the cash registers of the utility and errors cost not only money but accuracy on the Water Audit. Before implementing projects to track and find water losses, it is important to know just how much the utility is actually looking for. This can be accomplished by implementing a customer meter testing program. Many utilities think that this is an insurmountable task and they simply cannot afford it. In reality, AWWA has stated that in some cases as few as 50 meters can be used to begin to evaluate the percent error for customer meters. Ideally, a utility should strive to reach a statistically valid sample set, which could be several hundred meters per year, but starting small is still a good idea. If a utility is using a customer meter testing program that should be explained in detail in the WLCP along with the most recent data from the tests.

Other O&M activities that need to be discussed in the WLCP are the construction department activities related to valves and hydrants, the GPS/GIS department's work to field verify the hydraulic model, and/or how hydrant flushing responsibilities are divided between the fire department and the water utility. Anything related to continuous pressure readings or pressure modeling and field verification activities should also be included in the WLCP.

Another default commonly used in the Water Loss Audit is SDHE or Systematic Data Handling Errors. These are errors occurring between the point of data input as meter readings and the data output in customer billing systems. Errors include billing system entry errors, account adjustments, invalid zero consumption readings, meter rollover, loss of data during meter change-out, or other oversights. Following are potential sources of Systematic Data Handling Errors:

- Manual adjustments to billing
- Meter reads of zero consumption that are unnoticed
- Crossed up meter data
- Estimated meter reads
- Errors upon meter replacement or final reads
- Improper programming of AMR or AMI
- Meter not read on time, or not read at all
- Erroneous multiplier
- Adjustments due to known leakages
- Adjustments that lose the original data
- Political or discretionary adjustments

Solutions to minimize errors include third-party audits of data and procedures, enhanced QA/QC on data entry, switching from manual to automated meter readings (AMR) or advanced metering infrastructure (AMI), enhanced software, and detailed comparisons of water production to water billed over time.

5.7 Water Loss Control Program: Activities to Reduce Water Loss

The FWAS breaks water loss into two main categories, Real Loss and Apparent Loss. Real loss refers to actual water lost from the system. Proactive leakage management is designed to control the Real Losses, which includes leaks on mains and service lines and overflows at storage facilities. Figure 5.1 illustrates the four components of controlling Real Losses.

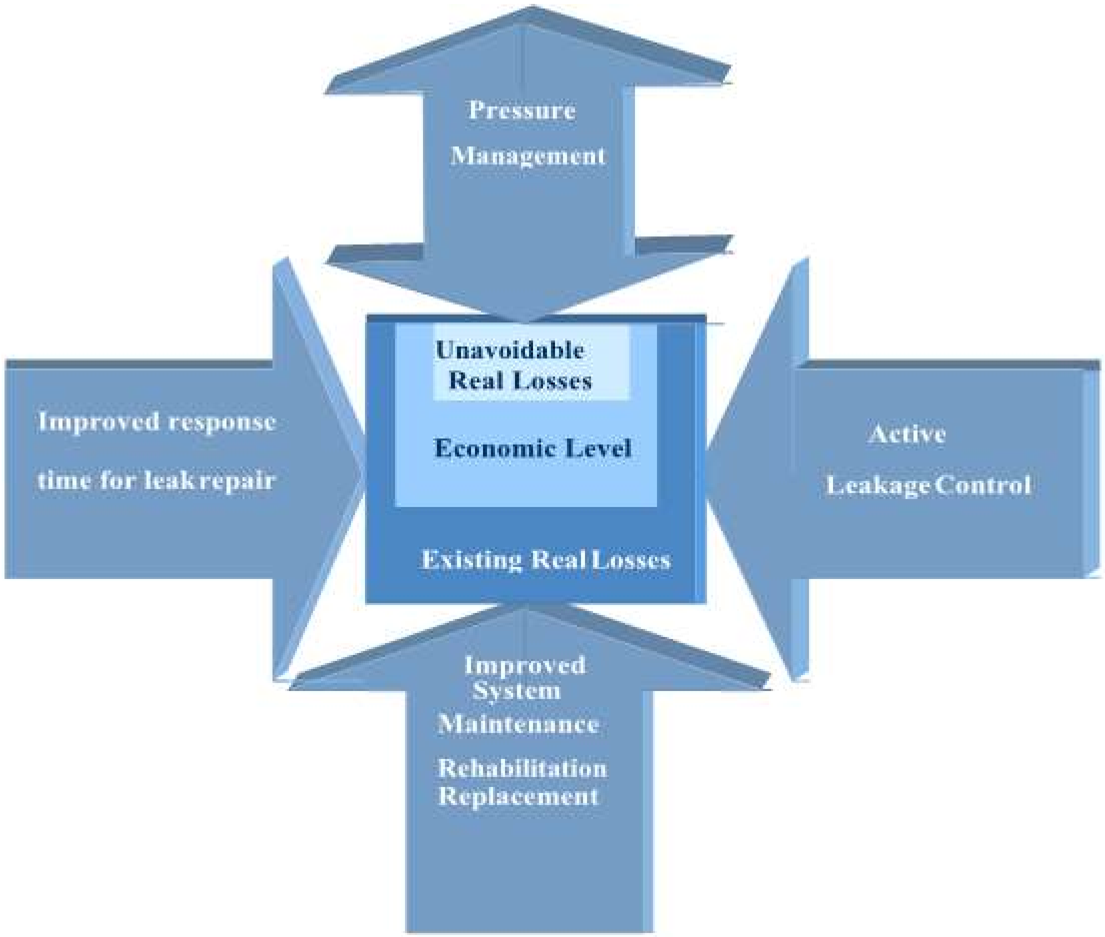

Figure 5.1: The Four-Pillar Approach to the Control of Real Losses

5.7.1 Active Leakage Control and Timely Leak Repair Programs

As noted previously, physical losses in the distribution system are referred to as Real Losses. Real Losses 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 Leakage (ELL) as appropriate for each water distribution system.

ELL is defined as a systematic way for a water utility to estimate the optimum leakage level below which the costs of further reducing leakage exceed the benefits of saving water. AWWA publishes the free Real Loss Component Analysis (RLCA) tool for utilities to use in arriving at their ELL. The RLCA tool estimates the amount of Real Losses in each of three components – Background Leakage, Unreported Leakage, and Reported Leakage. Opportunities to control losses in each of these three components are discussed in the Real Loss Component Analysis

(RLCA) tool, and the Economic Level of Leakage (ELL) specific to a utility can be estimated. ELL is also used in demonstrating the progress of water loss control, as described in Section 5.7.6 below.

If the RCLA tool or other analysis reveals that it may be beneficial to employ proactive leak detection, there are various options available to utilities. Most leak detection uses acoustic "listening" technology to provide evidence of leakage and its location. Data loggers can be placed on hydrants, at specific intermediate locations, or incorporated into customer AMI meters themselves using proprietary devices. There are also satellite imagery technologies and even leak-sniffing dogs that can help narrow down leaks that have not surfaced. Pilot programs for leak detection are described in Section 5.7.2.

5.7.2 Implementing Pilot Programs for Leakage Management

Recommendations in this category include investment in additional leak detection resources and strategies such as in-house crews, equipment, contractors, and operational changes including 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.

Specialized, stationary, proprietary leak detection devices are also available for use. These devices are co-located in customer meter boxes and can create a dense network of acoustic leak detection. This type of leak detection may be more effective than portable loggers since it provides continuous service, rather than a periodic leak survey.

Leak noise loggers may also be used in conjunction within District Metered Areas (DMAs). In creating a DMA, a portion of the distribution system is temporarily or permanently re-configured to measure all inflows at one or more entry points to an isolated area on a continuous basis. The inflows are then 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 DMAs to ensure that acceptable water quality and adequate domestic service and fire protection capability are maintained.

The frequency of leak detection system surveys varies within the industry, with some large utilities targeting a cycle time of one year. For some systems, 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.

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. To effectively manage Real Losses, the system will need to determine an appropriate level of investment in repair crews and equipment to maintain its desired response goal.

5.7.3 Pressure Management

The average system pressure is a very important parameter in calculating the 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, topographic variations, demand patterns, level of service, 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. More detailed guidance on this topic is available in the AWWA M36 Manual.

5.7.4 Storage Tank Overflows and Leakage

As noted previously, leakage and overflows from storage tanks increase a water system's avoidable Real Losses. The proper design, operation, maintenance, and inspection of storage tanks are important components of a WLCP. Recommendations for controlling Real Losses from storage include:

- Storage tanks should be designed and operated to prevent overfilling (use the correct overflow elevation, install level control sensors, and use altitude valves to prevent overflows)
- Level-control sensors and altitude valves should be inspected regularly (weekly if

possible) and maintained to ensure proper operation

- Tanks should be inspected for leaks, overflows, vandalism, and visible damage by water system personnel frequently (weekly if possible) and after all natural disasters and extreme weather events
- A professional tank company should perform a comprehensive inspection of each storage tank every 3 to 5 years

The information provided in Table 5.1 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 5.1: 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 5.1 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. 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 benefit. Real Loss reduction not only reduces day-to-day operational costs by reducing the amount of water needed to be produced and distributed (usually through pumping), it can also reduce overall system demand and defer costly capital improvements in production and distribution infrastructure and/or source water expansion. Initiatives to reduce Real Losses might 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.

The AWWA Water Audit Software (Version 6.0) does not account for sewer revenue losses, but utilities are encouraged to consider these impacts when developing a water loss program. In some cases, sewer revenue losses will be greater than water revenue losses.

5.7.5 Water Loss Control Program: Apparent Loss

Apparent Loss reduction will directly increase income to the water system; Apparent Losses are valued at the retail water rate. Activities to reduce unauthorized consumption can include GIS mapping of water meters to detect customers that may not be metered, installation of detector checks or meters on customer fire lines to prevent cross connection, fire hydrant locks, and better enforcement of unauthorized fire hydrant use.

Apparent Loss also encompasses 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, consideration of 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. A third-party audit of these business practices can be performed to determine if Apparent Losses can be reduced.

5.7.6 Water Loss Control Program: Demonstrable Progress

The 2015 Georgia Rules for Public Water Systems to Improve Water Supply Efficiency (Chapter 391-3-33) sets forth the requirement for systems serving over 3,300 individuals that a water system be able to document progress towards improved water supply efficiency in its system when it applies for a water withdrawal permit or an increase in permitted water service connections. The demonstration of progress may be evaluated by EPD as part of the review of a permit application to 1) renew or 2) modify an existing water withdrawal permit to increase the permitted water supply, or 3) increase the number of permitted service connections. The Rules specify four areas through which progress may be documented. These are Data Validity Score improvement (to the extent practicable for a given system), developing and implementing a WLCP, improvement in the performance measures of Operational Basic Real Losses and Operational Basic Apparent Losses once a reliable level of validity score has been reached, and demonstration that the system has achieved and is maintaining its Economic Level of Leakage.

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.

5.7.7 Water Loss Control Program: Economic Level of Leakage

The Economic Level of Leakage (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 water savings. ELL 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. ELL is used for leakage reduction target setting and setting the frequency of leak survey investigations.

Much more information and a more formal software model for determining a system's ELL can be found in the free Water Research Foundation publication "Real Loss Component Analysis: A Tool for Economic Water Loss Control" (Web Report #4372a). Access this report through the Water Loss Control Committee page on the AWWA website.

5.8 Water Loss Control Program: Functional Focus Areas

The most important section of any WLCP is the functional focus area. This is where a utility should discuss the three priority areas of concern identified by the FWAS, as well as the Infrastructure Leakage Index, and the Data Validity grade and tier that are generated from the most current Water Audit. Functional focus areas are listed under the Loss Control tab in the FWAS. There are five functional focus areas: Audit Data Collection, Short-term Loss Control, Long-term Loss Control, Target Setting, and Benchmarking. The tasks recommended in this tab are based on the data validity grade and tier for a utility, and they create a foundational approach to making program and policy improvements within the utility. For example, if a utility has a data validity grade of 35 (which is Tier II), target setting and benchmarking are not appropriate activities at this point. It would be better to improve data collection methods and focus on short-term loss control measures until such time as the data validity grade is in Tier III.

5.9 Water Loss Control Program: Conclusions

While there are many versions of how a WLCP can look, the one important feature is that the WLCP should be reflective of the specific utility and its current practices. Additionally, a WLCP should be a living document that is updated each year with the submission of a new Water Audit. It is best to update annually so that changes in procedure, updates to data validity grades, and improvements to a utility's ability to capture better data are tracked and reflected in one document. It is best to always have the most current version so that new or newly promoted individuals have a reference for how calculations and scoring have been handled in the past. It is also helpful to have a current WLCP available if the auditor has questions.

Section 6 – Supplemental Information

6.1 Definitions

Note: The following are standardized definitions used in the IWA/AWWA water audit methodology. Some definitions may vary slightly among 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:** 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 (Lp):** Distance beyond the customer property line that the utility is responsible for maintaining, typically zero in Georgia.
- **Average Operating Pressure (AOP):** Average distribution system pressure during the Water Audit period 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, elevation changes, demand patterns, and other local considerations.
- **Billed Metered Authorized Consumption (BMAC):** 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 Authorized Consumption (BUAC):** 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.
- **Community Water System:** A public water system that supplies water to the same population year-round.
- **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 of operating wastewater and other non-potable water operations should not be included.

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

- **Customer Retail Unit Cost (CRUC)**: Overall charge that customers pay for water service per unit of water and is applied to apparent losses.

- **Data Validity Score***:* 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):** 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)**: 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 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 (Lm)**: Total length of water distribution pipelines, including fire hydrant leads. This length does not include customer service connection lines.

- **Non-revenue Water (NRW)**: 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 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 (Nc)**: 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.

- **Public Water System (PWS)**: A public water system is one that provides water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year.

- **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 (SDHE)**: 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. It is important to note that the UARL calculation has not yet been proven fully effective for very small (length of mains+ number of connections <3000) or very low pressure water systems (average system pressure < 35 psi). In these cases 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 (UMAC)**: 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 (UUAC)**: This includes unmetered water that is unbilled for authorized uses such as; firefighting, flushing of mains or sewers, street cleaning, etc.

- **Unauthorized Consumption (Uc)**: 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 (VPC)**: 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 (VOS)**: The amount of finished water leaving the water treatment plant, entering the distribution network and recorded by the production master meter(s).

- **VOS Master Meter and Supply Error Adjustment (VOSEA)**: 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.

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

- **Water Exported Master Meter and Supply Error Adjustment (WEEA):** 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.
- **Water Imported (WI)**: Water purchased from a neighboring utility or regional water authority.

- **Water Imported Master Meter and Supply Error Adjustment (WIEA):** 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.

- **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.

6.2 Sources of Data for Authorized Consumption

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.

6.3 Sources of Data for Apparent Losses

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	

6.4 Metering Discussion

6.4.1 Production/Supply Metering and Data Management in Water Utilities

Water utilities employ a variety of meter types to measure the bulk flows that convey water supplied from own sources, water imported, and water exported. Certain meter types are generally applied for higher flow applications vs. medium- and low-flow applications, as shown in Table 6.4. All meter types have specific characteristics in measuring flows, with varying performance strengths and certain limitations. Proper sizing of the meter for the expected flow range is also important. Thus, having an improper size or type of meter can result in inaccuracy of the flow measured by the flowmeter.

Table 6.4 Common Types of Meters used as Flowmeters to Measure Supplied, Imported, and Export Bulk Water Supplies in Water Utilities

Meters used in High Flowrate Applications	Meters used in Medium, Low Flowrate Applications
Venturi	Turbine
Orifice Plate	Propeller
Electro-Magnetic	Positive Displacement
Ultrasonic	

Many thousands of flowmeter installations exist throughout the United States. Unfortunately, many flowmeters installations are:

- Improperly typed
- Poorly sited
- Rarely have maintenance conducted on the meter
- Seldom tested for accuracy
- Producing data taken verbatim as accurate by utility personnel

Figure 6.4 - 36-inch Venturi Meter

The Water Supplied Volume is the most important quantity in the water audit; yet flowmeter installations are often neglected or poorly managed assets. Hence the measured flows that are produced by flowmeters may suffer compromised accuracy. Since these meters produce the largest quantities in the water audit, even a very small degree of error can represent a significant amount of water volume that is erroneous. Water utilities should assess their flowmeter installations and give these assets a high level of focus in their maintenance and operations activities.

Water utilities should have a good handle on their flowmeter demographics, or the information on the existence and characteristics of the flowmeters in the system. Utilities should maintain detailed information on these assets, including: their locations, piping configurations, size, type, and manufacture of the flowmeter and its secondary instrumentation. Good meter accuracy and instrument calibration records should be maintained. If utility personnel don't have good information on their production meters, the first step should be to conduct a physical inventory of the meter sites. Visit the sites and inspect the flowmeters, take photographs, record the information found on nameplates, observe electronic or hydraulic connecting lines and instrumentation. Check files in the main office for purchase or maintenance records. Assemble all possible information in a file and begin activities for accuracy testing, repair and/or replacement of various flowmeters.

The measured volumes produced by flowmeters can have notable inaccuracies. Additionally, the collective data produced by multiple flowmeters in the system is not always reliably tracked and balanced across the distribution system to produce an accurate Water Supplied volume. On a daily basis, the Water Supplied Volume is not only a function of the volumes produced by the treated water flowmeters, but also the net flow impacts of supply to tanks and storages, and, possibly, supplies into and out of pressure zones and District Metered Areas (DMA), all of which depend upon the configuration of the water distribution system and number of bulk metering points throughout the system. Utilities should be familiar with their detailed water distribution system configuration and maintain operational reports that can tally the daily Water Supplied Volume for the system. These daily values should be reviewed and corrected as needed on a regular basis so that monthly and annual reporting of supplied volumes is accurate.

6.4.2 Flowmeter Accuracy Testing: Verification and Calibration

Since the Water Supplied Volume is such an important quantity to the accuracy of the utility water audit, the flowmeters that generate the measured flow data should be maintained and regularly tested for accuracy. As discussed later in this section, rigorous and routine flowmeter accuracy testing is necessary in order to justify high data gradings in the WAS. Use of meter accuracy test results is needed to quantify the error adjustment components of the water audit. Good data management of the supply data across the system and making adjustments for data gaps and flow balancing errors should also be included in the error adjustment (VOSEA) component for Volume for Own Sources. Several reliable methods exist to test flowmeters in water utilities (M36). The primary methods include:

- Take the flowmeter out of service and send it to a meter testing facility
- Test the flowmeter in-situ by running flow through a calibrated test meter in an outfitted

truck (Figure 2).

- Install a portable meter in series with the existing meter and obtain two sets of measurements over a minimum 24-hour period (Figure 3).
- Conduct a reservoir or tank drop test if the flowmeter exist adjacent to a water storage facility and the pipe configuration is acceptable (Figure 4)
- Use the Mass Balance Technique (although this is more of a process control check than an actual meter accuracy test method).

Methods listed as 1 and 2 (Fig 2) apply to medium- and small-sized meters of approximately 20-inch and smaller. For Method 1, a brief pipeline shutdown is executed to remove the flowmeter and replace it with a meter of the same type. The meter to be tested is then sent to a meter test facility. A downside to this approach is that the meter is tested in laboratory conditions and any disturbances existing in the field location of the meter will not exist during the accuracy test. Removing and transporting meters larger than 20-inch to test facilities is usually not practical.

Method 3 (Fig 8) is virtually the only means to test large flowmeters sized 24-inch and above.

Accurate results can be achieved in conducting a reservoir drop test (Method 4), which is a volumetric test in which inflow to a reservoir, tank, or storage basin (Fig 9) is halted and only outflow exists for a period of several hours. The entire outflow must pass through the meter being tested. The drawdown in the storage facility over the period of the test is converted to a volume and average flowrate that can be compared to the measured volume recorded by the meter over the same period. Unfortunately, this test can only be conducted by utilities that have an acceptable configuration of storage, piping, and flowmeter to allow this procedure.

The Mass Balance technique (Method 5) compares flows from two or more flowmeters in series. Usually, the relative difference in flows shows a steady pattern. When this difference begins to change notably, it could mean that one of the meters is beginning to lose its typical accuracy level.

Figure 2 Meter testing via truck mounted apparatus

(Courtesy of Louisville Water Company)

Figure 3 Pitot rod inserted into large pipeline

Figure 4 Reservoir or clearwell adjacent to a water treatment plant

6.4.3 Flowmeter Accuracy Test vs. Secondary Instrumentation Electronic Calibration

Flowmeter installations typically consist of a primary measuring element (the flowmeter) and a secondary device, which may be a differential pressure cell, chart recorder, or other device which receives the input from the flowmeter. Figure 5 shows a cross section of a typical water flowmeter installation.

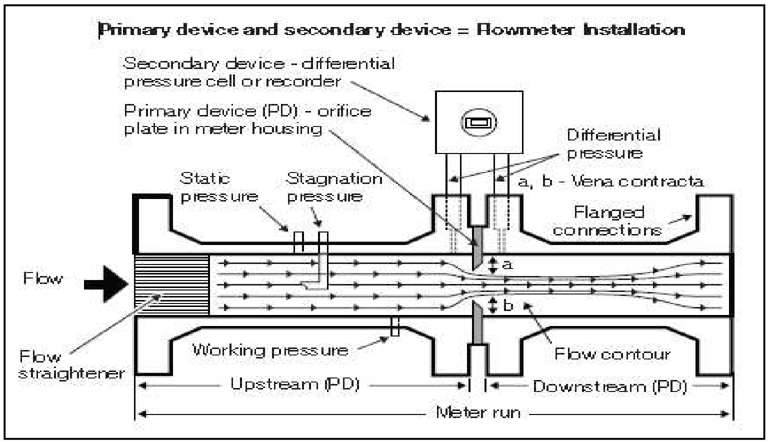

Figure 5 Orifice Plate Flowmeter components

Figure 6 shows a bank of differential pressure (DP) cells connected to several venturi flowmeters. These DP cells are connected to water sensing lines from the venturi. The cell senses the differential pressure generated by the venturi flowmeter and converts this value to a flow and equivalent electronic signal.

DP cells should undergo regular electronic calibration to make sure that their capability to create an output signal from the input is accurate. However, this calibration function does nothing to test the accuracy of the water pressure being generated by the venturi flowmeter. Electronic calibration merely confirms the secondary device, not the primary – metering – device.

Fig 6 Bank of Differential Pressure Cells connected to flowmeters

Many water utilities reliably electronically calibrate secondary devices like DP cells and assume that this has confirmed the accuracy of the flowmeter. Unfortunately, this is not the case. Utilities should verify the flow measuring capability of the primary device (flowmeter) on a regular basis through a meter flow accuracy test. This is one of the most fundamental and important activities of a good water loss control program.

In compiling the AWWA standard water audit, many utilities seem to interpret secondary device electronic calibration as a meter flow accuracy test function, which it is not. This is a common misconception. These utilities often select a high data grading for the Volume from Own Sources, Water Imported, and Water Exported based upon regular calibration of secondary devices.

6.4.4 After the Flowmeter – Maintaining Integrity in the Data Trail throughout the SCADA System to Final Reporting

Meter accuracy testing confirms the degree of inaccuracy of the various flowmeters in a utility water supply system. Many utilities include a number of flowmeter installations with a variety of flowmeter sizes and types, each with a different level of accuracy. The degree of inaccuracy should be taken into account by the utility when reporting the annual Water Supplied Volume. Adjustments to the flow data – ideally on a business-daily basis – should be employed to account for these inaccuracies.

In addition to the inaccuracies of the flowmeters, additional data errors can occur in the data trail that leads from the flowmeters to the secondary devices, to the SCADA System, and final reporting. Error in the data can be introduced in a variety of manners. In addition to the summation of the flowmeter data, the annual Water Supplied should include flows moved into- and out of- storage facilities like tanks and treated water reservoirs, in a manner tabulated on a daily basis. While tank flows tend to trend in a regular daily pattern and the net inflows/outflow tend to cancel each other, disruptions to the data occur regularly in water systems. Such disruptions can occur when SCADA communications are compromised and data transmission is halted, flowmeters or related instrumentation fail, and SCADA computer equipment interruptions occur. Additionally, events such as storage tank overflows occasionally occur inadvertently, and drinking water is supplied to tank overflows as waste rather than supplied to the water distribution system. All of these events can compromise the daily Water Supplied Volume; hence it is best for the utility to monitor and correct data on a business-daily basis.

The data adjustment method described above can be carried out throughout the water audit year on a regular basis in order to correct data gaps and other data disruptions as they occur. It is recommended to review SCADA system output reports to confirm supply data and detect data gaps and disruptions; and make corrections and data adjustments as soon as possible. Delaying data review (or not conducting this function) creates the opportunity for such disruptions to go undetected and to introduce an uncertain degree of error into the ultimate Water Supplied calculation.

Activities to maintain integrity of the data throughout the entire data trial are included as criteria in the Interactive Data Grading of the WAS. These are included in the error adjustment components.

6.4.5 Validation Checklist for Water Supplied Data

- For water utilities with multiple years of data, does the Water Supplied volume deviate significantly from the volume reported in the previous year, or prior several years? (The AWWA Compiler Software can reliably display these trends.) If so, is there a reasonable explanation for this difference, or could it suggest an error in this data for the current year's audit data?
- Note the number of water sources providing supply, and the type, size, and age of each finished water meters (flowmeter) on these sources.
- Note the flowmeter accuracy testing methods (if any) that are employed. Note if they include flowmeter accuracy verification in addition to secondary instrumentation calibration.
- Note frequency of these tests for each flowmeter, and the numeric results. Confirm supporting documentation and input derivation aligns with input values for master meter and supply error adjustments.
- Note how the flowmeter data is communicated from the field sites and channeled into a data repository. Does the utility use a SCADA system to provide this function? Is the data tabulated and reviewed on a regular and frequent basis? Does this occur daily, weekly, or monthly? Are corrections or adjustments implemented on a daily or weekly basis?
- Is the Water Supplied volume determined on a daily basis by taking into account water storage tank/reservoir elevation changes and the balancing of flows across pressure zones and District Metered Areas, as appropriate?
- Confirm the interactive data grading response and the assigned data grades align with the utility's practices and supporting documentation.

Section 7 - 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 2014, 4th 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

- *Real Loss Component Analysis: A Tool for Economic Water Loss Control*, Water Research Foundation, Project 4372a, 2014.