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Audit Report

Austin Water Utility:
Water Loss

April 28, 2009

Office of the City Auditor
Austin, Texas

Audit Team

Robert Elizondo, CIA, CGAP, Auditor-In-Charge
Joselito Cruz, Auditor
Robert Young, Audit Intern

Assistant City Auditors

C'Anne Daugherty, CPA, CIA
Russell Needler, CPA, CGAP

This audit was conducted in compliance with the Generally Accepted Government Auditing Standards.

Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives.

We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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Office of the City Auditor
301 W. 2nd Street, Suite 2130
P.O. Box 1088
Austin, Texas 78767-8808
(512) 974-2805, Fax: (512) 974-2078
email: oca_auditor@ci.austin.tx.us
website: http://www.ci.austin.tx.us/auditor

Date: April 28, 2009

To: Mayor and Council

From: Taylor Dudley, Acting City Auditor

Subject: AWU Water Loss Calculation Audit

I am pleased to present this audit report on the process for calculating water loss from the City's water distribution system. A calculation of water loss for FY07 was done by our staff in accordance with the most current methodology presented by the Texas Water Development Board (TWDB) with the assistance of Austin Water Utility (AWU)'s staff. Also included is our analysis of the Utility's preparedness to conduct detailed water loss calculations in the future.

Our objectives were:

- To review the process followed by Utility staff in performing *Water Loss* calculations to determine the Utility's preparedness to report system water loss according to current, more rigorous, TWDB guidelines.
- To provide a reliable baseline measurement of water loss within the AWU distribution system for FY07 that can be used to identify and track the success of efforts to minimize that loss.

We found that:

- The Austin Water Utility (AWU) has taken a utility-wide approach to measure and manage water loss, with some positive results.
- The Austin Water Utility has not yet fully implemented the new, best practice method recommended by the TWDB for measuring and managing water loss; however, they have begun taking steps to do so.
- Using the best practice approach recommended by the TWDB, we found that the City's water loss estimates for FY07 were within industry standards.

We have offered several recommendations that we believe will improve the accuracy, quality, and availability of information for the Utility to use in its planning processes. As of the date of this report, we believe that AWU staff has made good progress toward implementing many of the recommendations as they go forward in preparation for their next required report to the TWDB.

This audit was part the approved annual audit plan for FY 08 and is a product of the on-going audit initiative at AWU, which was initiated by Council in FY 2006.

We appreciate the cooperation and assistance we received from AWU personnel during this audit.

Taylor Dudley

Taylor Dudley, CIA, CGAP, CFE
Acting City Auditor

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COUNCIL SUMMARY

This report presents the results of our audit of the reliability of the water loss calculation process followed by the Austin Water Utility. Also included in this report is information on the Utility's preparedness to report more detailed calculations to the Texas Water Development Board (TWDB) and the calculation of water loss for FY 07.

According to the Texas Water Development Board (TWDB), utilities should measure water loss as an important part of their water conservation measures and activities. In 2003, the State began requiring retail public utilities to provide a water loss calculation to the TWDB once every five years. In response to this mandate, the TWDB published guidance for utilities in their *Water Conservation Best Management Practices Guide* (BMP Guide) and developed a water loss calculation methodology for utilities that measures efficiency, encourages water accountability, quantifies water losses, and standardizes water loss reporting across the State. TWDB has since updated their guidance to reflect more rigorous methods for estimating water losses.

Our audit objectives included reviewing the process followed by Utility staff in performing *Water Loss* calculations to determine the Utility's preparedness to report system water loss according to the current, more rigorous, TWDB guidelines. We also sought to provide a reliable baseline measurement of water loss within the AWU distribution system for FY 07 that can be used to identify and track the success of efforts to minimize that loss.

We found that the Austin Water Utility (AWU) has taken a utility-wide approach to measure and manage water loss, with some positive results. As a part of a broad, Utility-wide initiative focused on water conservation, AWU management created the Water Accountability Group (WAG) in 2006. The WAG was charged with addressing challenges to the measurement of water loss in the City. Using the prevailing methodology supported by TWDB at that time, the WAG performed a calculation to estimate the City's water loss for FY 05 which fell within acceptable industry standards. The WAG also offered several recommendations to better measure and to decrease the volume of water lost by the City. However, in 2007, progress toward this end stalled, and several of the WAG's strategies went unimplemented. The new AWU director, who was hired in 2008, revived the WAG, and AWU has moved forward with several of its suggested water loss control strategies.

We also found that AWU has not yet fully implemented the new, best practice method recommended by the TWDB for measuring and managing water loss; however, they have begun taking steps to do so. AWU needs to make additional process changes to fully implement the TWDB-recommended component reliability matrix. Making these changes will enable AWU management to calculate more reliable water loss estimates and take a best practice approach to manage water loss. We also noted improvement opportunities for AWU in terms of tracking and responding to known leaks, and increasing controls over privately owned hydrants.

Using the best practice approach recommended by the TWDB, we estimated that the City lost approximately 5.33 billion gallons or 11 percent of water that it treated in FY 07. This loss, when calculated against the size of the water infrastructure, results in an infrastructure leakage

index that is within acceptable industry standards, per American Water Works Association (AWWA) guidelines. The best practices approach we employed and the results we obtained during this audit can be used by AWU as a basis for future planning and benchmarking purposes.

We have offered recommendations that we believe will improve the accuracy, quality, and availability of information for the Utility to use in its planning processes. As of the date of this report, we believe that AWU staff has made good progress toward implementing many of the recommendations as they go forward in preparation for their next required report to the TWDB.

This audit was conducted in compliance with the Generally Accepted Government Auditing Standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

We would like to thank the staff at the Austin Water Utility for the cooperation and assistance that we received during this audit.

ACTION SUMMARY

AU08110 – AWU: WATER LOSS

Rec. #	Recommendation Text	Management Concurrence	Proposed Implementation Date
1	In order to improve the validity of data, develop more cost effective ways to further reduce actual water losses, and to continually address water loss issues, the AWU Department Director should produce an annual Water Loss Calculation and analyze the results in order to develop strategies aimed at reducing the level of unreported leaks.	CONCUR	Implemented
2	In order to improve the process followed to produce the Water Loss Calculation, the AWU Department Director should follow the updated guidelines provided by TWDB, and use the calculation component reliability matrix to ensure that its process and the data gathered are as detailed and accurate as possible.	CONCUR	Implemented
3	In order to ensure that the *System Input Volume* is as accurate as possible, the AWU Department Director should ensure that the meter testing program continues with annual testing and recalibration of production flow meters.	CONCUR	Implemented
4	In order to ensure that the *System Input Volume* is as accurate as possible, the AWU Department Director should first determine if using the SCADA system would yield reliable	CONCUR	05/01/2009

Rec. #	Recommendation Text	Management Concurrence	Proposed Implementation Date
	results, before fully automating the process of reporting the amount of water produced using the SCADA system.		
5	In order to ensure that all components of water loss calculations are accurate, the AWU Department Director should work with Austin Energy to ensure that the new Customer Billing System will provide consumption and billing reports that the Utility can rely upon to produce the calculation.	CONCUR	03/31/2011
6	In order to ensure that annual inspections are performed for each of the private fire hydrants within their jurisdiction, the AWU Department Director should coordinate with AFD to ensure that a process is created to properly identify responsible parties for all private fire hydrants, that the responsible parties are notified of the requirements for annual testing, and that water used during inspection and maintenance activities is properly accounted for.	CONCUR	09/30/2010
7	To ensure that AFD is aware of which hydrants have not been inspected recently so that they can properly protect the public, the AWU Department Director should ensure that annual testing reports are compiled into a central database and that the GIS system is properly updated with current data on the hydrant status.	CONCUR	09/30/2010

Rec. #	Recommendation Text	Management Concurrence	Proposed Implementation Date
8	To properly measure and analyze the water used by other City departments, the AWU Department Director should perform an analysis to ensure that water meters are installed at all sites from which other City departments draw water, and that accounts are set up on the CIS to ensure that the quantities are correctly accounted for.	CONCUR	09/30/2009
9	To ensure that as much of the unmetered water as possible is properly accounted for, the AWU Department Director should work with other City departments to standardize the procedures for estimating and reporting unmetered water, and ensure that personnel within other City departments are properly educated on those procedures.	CONCUR	12/31/2009
10	In order to conserve water used by City departments, the City Manager should establish an inter-departmental task force to monitor and analyze water use and create strategies for conserving as much water as possible.	CONCUR	09/20/2009
11	In order to quantify the amount of water lost through theft, the AWU Department Director should undertake a study to determine how prevalent theft from fire hydrants is throughout the distribution system, and start an education process for City employees and citizens to report suspicious activity.	CONCUR	09/30/2009 for implementation of the theft study; 06/30/2009 for implementation of education campaign

Rec. #	Recommendation Text	Management Concurrence	Proposed Implementation Date
12	In order to reduce the amount of theft from the distribution system, especially from fire hydrants in outlying areas, the AWU Department Director should ensure that the WAG works with APD to develop a program to respond to and investigate occurrences of water theft once a study has been undertaken to determine how prevalent theft from fire hydrants throughout the distribution system is.	CONCUR	To be determined based on results of theft study.
13	In order to ensure that all water used by contractors is accounted for, the AWU Department Director should ensure that policies governing the use of water from hydrants by non-City-owned vehicles are developed and implemented. Additionally, AWU should develop a program to educate contractors to ensure compliance with those policies.	CONCUR	To be determined based on results of theft study.
14	In order to ensure that as much of the water used by contractors from hydrants as possible is properly accounted for and billed, the AWU Department Director should ensure that an analysis is performed of the procedures in place and that research is performed to determine if new processes exist to meet this goal. One possible method would be the comparison of construction permits to temporary-use billings to determine if large amounts of water are being taken without metering and billing.	CONCUR	Ongoing as construction loop meters are set up as requested.

Rec. #	Recommendation Text	Management Concurrence	Proposed Implementation Date
15	In order to estimate the accuracy of small residential meters and establish a starting point for the small meter reliability rating, the AWU Department Director should direct that a reliability test be completed on a statistically valid random sample of small meters.	CONCUR	06/30/2009
16	In order to determine the extent to which there are any data discrepancies in the water billing data caused by data handling errors, AWU should partner with Austin Energy to perform an analysis of the processes followed within the CIS and throughout the customer billing program.	CONCUR	03/31/2011
17	In order to properly account for all water used, whether a customer is billed or not, the AUW Department Director should ensure that a standard conversion process for this data from dollars to gallons is added to the BAR production process.	CONCUR	04/30/2009
18	In order to reduce the amount of water lost through leaks and breaks, the AWU Department Director should ensure that maintenance and upkeep functions are a high-priority throughout the Utility.	CONCUR	Ongoing.
19	In order to reduce the amount of water lost through leaks and breaks, the AWU Department Director should ensure that strategies to reduce response and repair times are identified and implemented.	CONCUR	Ongoing, as new procedures are identified.

Rec. #	Recommendation Text	Management Concurrence	Proposed Implementation Date
20	In order to improve the response times for leak repair, the City Manager should appoint a task force with representatives from all involved departments to come up with solutions to the problems that AWU faces while coordinating with other City departments and outside entities when responding to water leaks.	CONCUR	09/30/2009
21	In order to properly estimate the amount of water lost at each break or leak, the AWU Department Director should ensure that a standard procedure for determining that the most accurate source of water pressure is at the point of a leak/break is identified, and that this methodology is used for all water loss calculations.	CONCUR	Implemented.
22	In order to properly account for as much of the water lost from overflows of reservoirs as possible, the AWU Department Director should ensure that the Pumping and Distribution division manager establishes procedures and a tracking process to properly account for all water lost through overflows.	CONCUR	05/01/2009
23	To facilitate a better Utility-wide approach to water loss reduction, identify as much of the *Unreported Loss* water as possible, and determine the cost to address all identified leaks, the AWU Department Director should ensure that leak detection programs are continued with the goal of testing the entire distribution system regularly.	CONCUR	Ongoing.

NOTE: Red boxes indicate links to page of the report where info can be found.

TABLE OF CONTENTS

BACKGROUND **1**

OBJECTIVES, SCOPE, AND METHODOLOGY **5**

AUDIT RESULTS

The Austin Water Utility (AWU) has taken a Utility-wide approach to measure and manage water loss with some positive results. 7

The Austin Water Utility (AWU) has not yet fully implemented the more rigorous best practice method for water loss control recommended by the TWDB for measuring and managing water loss; however, they have begun taking steps to do so 11

Using the approach recommended by the TWDB, we found that the City's water loss estimates for FY 07 were within industry standards 27

APPENDICES

Appendix A Management Response 31
Appendix B FY 05 AWU Water Audit Reporting Form as submitted by AWU to TWDB 49
Appendix C FY 07 AWU Water Loss Calculation performed by OCA 53
Appendix D Introduction to Water Loss (Excerpts from March 2008 TWDB *Water Loss Manual for Texas Utilities*) 57
Appendix E Copy of System Water Audit and Water Loss section from TWDB's Best Management Practices (BMP) Guide 85

EXHIBITS

Exhibit 1 Water Balance Table 2
Exhibit 2 AWU Water Loss for FY 05 8
Exhibit 3 AWWA Guidelines For Setting A Target Infrastructure Leakage Index 9
Exhibit 4 Water Loss Calculation Components 12
Exhibit 5 Prioritization of Water Line Break Repairs 23
Exhibit 6 AWU Water Loss for FY 07 28
Exhibit 7 AWWA Guidelines For Setting A Target Infrastructure Leakage Index 29
Exhibit 8 TWDB Assessment Score Guidance 30

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BACKGROUND

The Austin Water Utility (AWU or the Utility) is municipally-owned and charged with supplying water to customers within and outside the corporate city limits of Austin. Customers outside the Austin city limits include the communities of Rollingwood, Sunset Valley, Pflugerville, Round Rock, one water control and improvement district, five water supply corporations, seven municipal utility districts, and three private utilities. The Utility's 2007 Water Service Population was 834,984 (Retail 780,647 & Wholesale 54,337) through 198,895 service connections in a service area encompassing 538 square miles.

In 2006, the City Council set a goal to reduce the Austin's water use by 1 percent per year over the next 10 years. Council directed the Utility to implement additional conservation strategies aimed at achieving that goal and appointed a Water Conservation Task Force (WCTF) to assist Utility staff. On January 12, 2007, the WCTF issued a report which included reducing water loss as one of the strategies to achieve the water use reduction goal.

What is Water Loss? Simply stated, *Water Loss* is the amount of water that has not been "authorized" for consumption by a utility, yet does not remain in the distribution system. *Water Loss* can be classified as either:

- *Real Loss* - includes water lost through distribution system leakage and pipeline breaks; or,
- *Apparent Loss* - includes meter inaccuracies, unauthorized consumption (including water taken by theft), and/or systematic discrepancies within the billing system.

Water loss calculation is a conservation measure. According to the Texas Water Development Board (TWDB), water loss calculations and loss-control management are emerging as significant conservation measures. As utilities minimize water loss, they increase their efficiency and reduce the need to search for additional water sources.

The Texas Legislature enacted House Bill 3338 in 2003 to help conserve the State's water resources by reducing water loss occurring in the systems of drinking water utilities. This statute requires that retail public utilities providing water within Texas file a standardized system water loss "audit" [1] once every five years with the TWDB. In response to the mandates of HB 3338, the TWDB published guidance for a system water audit and water loss management in their *Water Conservation Best Management Practices Guide* (BMP Guide). See Appendix E for more information. The TWDB also developed a water loss calculation methodology for utilities that measures efficiency, encourages water accountability, quantifies water losses, and standardizes water loss reporting across the state. This methodology was developed based on guidance provided by the American Water Works Association (AWWA) and the International Water Association (IWA) and is presented in the TWDB's *Water Loss Audit Manual for Texas Utilities* (Manual). See excerpts from the manual in Appendix D.

The key to a successful water loss calculation is accounting for all water that enters a utility's distribution system. To assist water utilities in undertaking a water loss calculation, the Manual provides guidance on the specific data and information that should be gathered to assemble a realistic assessment of water loss. The water loss calculation methodology "assumes that all water

[1] The word "audit", as used by the TWDB does not denote an audit as recognized by the accounting and auditing professions, which require that auditing standards are followed throughout the audit. Therefore, for the purposes of this report, we will substitute the words "water loss calculation" when referring to the TWDB's water loss "audit."

can be accounted for and quantified as either a component of beneficial consumption or wasteful loss, by measuring or estimating water quantities," according to the Manual.

A standard water loss calculation is performed by estimating or quantifying how much water was placed into the water distribution system, known as Corrected System Input Volume (CSIV). Each known component of water usage within the water distribution system is then measured as precisely as feasible, and subsequently subtracted from the CSIV in order to identify the remaining quantity of water that had unknown uses (called Unreported Loss). The "Water Balance Table" shown in Exhibit 1 below provides the categories for classifying how water that enters the system is used and the terms used to discuss water loss.

EXHIBIT 1
Water Balance Table

CSIV	CONSUMPTION AND LOSS		CALCULATION COMPONENTS	KNOWN & UNKNOWN	REVENUE & NON REVENUE
Corrected System Input Volume All water that is treated by a Utility once it has been corrected for any error caused by production meter accuracy	**Authorized Consumption** Water that is authorized for use by the utility and its customers.	**Billed Authorized Consumption** Water that is authorized for use and is appropriately billed after either metering or estimating the quantity.	**Billed / Metered Consumption** Water that is appropriately metered and billed.	**Known Uses** Includes all components of water use that can be measured / estimated.	**Revenue Water** Billed wholesale water exported and Billed metered and un-metered water.
			Billed / Un-metered Consumption Estimated water that has been sold but not metered.		
		Unbilled Authorized Consumption Water that is authorized for use, but is not billed for after either metering or estimating the quantity.	**Unbilled / Metered Consumption** Water that is metered but not billed.		**Non-revenue Water** The sum of Apparent Loss, Real Loss, and Unbilled Authorized Consumption. This water is more clearly defined as all water for which no revenue is received.
			Unbilled / Un-metered Consumption Estimated water that is neither billed or metered.		
	Water Losses The difference between the Corrected System Input Volume and Authorized Consumption quantities.	**Apparent Losses** "Paper" losses that occur when water reaches a customer, but the volume is not accurately measured and/or recorded due to Customer Meter Inaccuracy, Systematic Data Handling Discrepancies, or Unauthorized Consumption.	**Unauthorized Consumption** Theft – water that is illegally taken from fire hydrants, as well as water loss at the customer service connection from tampering with meters to illegal taps and other similar occurrences.		
			Customer Meter Under-registering Water that is used, but not billed or accounted for because a meter is not properly calibrated.		
			Billing Adjustment and Waivers Water that is used, but not billed because of adjustments made to customer bills by the utility. This category includes water recorded by customer meters but distorted by meter reading or billing system error.		
		Real Losses Physical losses from the pressurized water distribution system, including water mains and appurtenances and customer service connection piping.	**Reported Leaks & Breaks** Breaks or leaks that are brought to the attention of the utility.		
			Unreported Loss This is a "catch all" volume, meaning that this is the quantity that remains after Authorized Consumption, Apparent Losses, and Reported Leakage quantities have been subtracted from the Corrected System Input Volume.	**Unknown Uses** Includes all components of water use that cannot be measured / estimated.	

SOURCE: TWDB's *Water Loss Audit Manual for Texas Utilities*, pg.5, adapted by OCA, March 2009

According to the TWDB, two methods can be used to produce a water loss calculation, one of which is currently considered the industry's best practice. The first method is referred to as a top-down approach and is largely a desktop exercise of gathering data and information from water consumption and loss reports already commonly compiled by many utilities. The second method is referred to as a bottom-up approach and involves a more detailed look at not only the components of the water loss calculation, but also other relevant aspects of the utility, such as: billing records, the distribution system, accounting principles, maintenance costs and productivity levels. See Appendix D for more information on the two approaches.

While bottom-up calculations are more costly due to the amount of time, staff hours, and detailed work that is required, such an approach can pinpoint more precisely where losses are occurring. This allows for a more valid, accurate water loss calculation, which can be used to guide a utility's loss control strategies. This bottom-up approach is considered the industry best practice.

The use of a more structured, rigorous, bottom-up approach to quantifying the components of a water loss calculation, combined with ongoing analysis of performance measures, will lead to improved system efficiency. Over time, ongoing analysis of the performance measures produced as part of the water loss calculation will allow a utility's management to create strategies that are specific to the components that make up the Water Balance Table. This ability to focus on individual water loss components will improve system efficiency and support conservation efforts. The goal is to reduce *Water Loss* and *Non-Revenue Water* by concentrating on each calculation component in the Water Balance Table.

Water loss calculations also provide an opportunity to assess system performance. The analysis and comparison of performance measures to industry standards is an integral part of a water loss calculation. By identifying and reducing *Water Loss* and *Non-Revenue Water* use, utilities can increase their efficiency, improve their financial status, minimize their need for additional water resources, and assist long-term water sustainability.

According to the TWDB, the standardized approach to calculating water loss provides utilities with a reliable means by which to analyze water loss performance, track the utility's progress on a year-to-year basis, and set performance targets.

Key indicators of system performance are:

- *Unavoidable Annual Real Loss (UARL)* - a theoretical value of the level of leakage that a given water utility will experience based on characteristics of the system such as total length, water pressure, and the number of service connections; and
- *Infrastructure Leakage Index (ILI)* - an index that compares the calculated *Real Loss* to the UARL. See the AWWA Guidelines for Setting a Target Infrastructure Leakage Index Table in Exhibit 3 for more information.

Both UARL and ILI are industry standards that allow utilities to compare themselves with and benchmark performance against other utilities of similar size and characteristics.

The use of a rigorous approach to measuring and managing water loss should lead to reduced demand for system treatment capacity as well as long-term savings associated with the costs of obtaining water. Water that is lost obviously cannot be used for other legitimate, authorized consumption purposes. However, the demand for authorized consumption remains despite the volume of water that may be lost in the system. Thus, every gallon of water lost places additional pressure on the treatment capacity. Water loss cannot be completely reduced to zero. However, the more precise a utility's ability to pinpoint the sources of loss the better the utility will be able to reduce and manage them, thereby preserving treatment capacity.

In addition, an approach that significantly reduces water loss should reduce costs associated with acquiring water from the Lower Colorado River Authority (LCRA). The City of Austin has "run of the river" rights of 150,000 acre-feet per year (AFY) of water from the Colorado River. Beyond the first 150,000 AFY, Austin entered into a "Comprehensive Water Settlement Agreement" with LCRA in 1999 that locks in water at a fixed price until AWU draws more than 201,000 AFY for two consecutive years. At that time, the water rate will be re-calculated at prevailing market rates. In FY05, AWU drew 157,649 acre-feet from the river, in FY 07, that figure was 141,816. Based on current growth and consumption projections, the Utility is not expected to reach the 201,000 AFY level until after 2019. A water loss calculation and control process that leads to reduced water loss will extend the time it takes AWU to reach the 201,000 AFY plateau, keeping water acquisition costs lower for the Utility for an extended period of time.

OBJECTIVES, SCOPE AND METHODOLOGY

Audit Objectives:
The objectives of this project were:

- To review the process followed by Utility staff in performing water loss calculations to determine the Utility's preparedness to report system water loss according to current, more rigorous, TWDB guidelines; and
- To provide a reliable baseline measurement of water loss within the AWU distribution system for FY 07 that can be used to identify and track the success of efforts to minimize that loss.

Scope:
The scope of this audit includes the processes followed and the data provided to the TWDB in the Utility's FY 05 Water Loss Calculation Report; the processes and data gathered by the Utility's Conservation Division for use in our calculation of water loss for FY 07 (October 2006 thru September 2007); and, the readiness of the Utility to report water loss using the TWDB's more rigorous guidelines.

Methodology:
To address the audit objectives, we performed the following steps.

- Interviewed City staff to identify processes and individuals involved in the gathering of information necessary to calculate water used and lost.
- Analyzed the content of documents regarding water loss from both the State's Texas Water Development Board (TWDB) and the American Water Works Association (AWWA).
- Reviewed State water regulations and conservation best practices.
- Contacted other City departments to collect information related to water used in the operation of their daily duties, and we also tested data sources identified for content, sufficiency, and accuracy.
- Performed a water loss calculation for FY 07.

For the calculation of a water loss figure for FY 07, we reviewed the processes followed to calculate, gather data, and report quantities that make up the individual components of the water loss calculation. Also, we followed the updated methodology outlined in the 2008 version of the TWDB's *Water Loss Audit Manual for Texas Utilities*.

Because this audit required engineering expertise that the Office of the City Auditor (OCA) does not have on staff, we contracted with the consulting firm JCV Engineering (JCV) to provide expertise in water loss issues and calculations. JCV is based in Houston, Texas, and is in all ways independent of any ties to any City of Austin engineering or construction project contracts. The firm also has access to and is knowledgeable of pertinent industry standards.

This audit was conducted in compliance with the Generally Accepted Government Auditing Standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Those standards also speak to the reliance on work performed by consultants with specialized training and experience (specialists). The standards require that we perform procedures regarding the specific work to be relied on that provide a sufficient basis for that reliance. We have followed this requirement and have determined that we can rely on the work of JCV where that work serves as the basis for the findings and conclusions in this report.

AUDIT RESULTS

In recent years, the Austin Water Utility (AWU) management has taken a Utility-wide approach to measure and manage water loss by creating a Water Accountability Group (WAG) responsible for addressing challenges related to water loss measurement. The WAG initiated important water loss control steps including calculating a FY 05 water loss estimate and recommending strategies to reduce the volume of water lost. Despite this Utility-wide approach to water loss control, the Utility has not yet fully implemented the more rigorous best practice method for water loss measurement and control now recommended by the Texas Water Development Board. While important steps have been taken toward this end, AWU management needs to make additional process changes to achieve full implementation of the best practice approach. Using the more rigorous calculation methodology recommended by the TWDB, we found that the City's estimated water loss for FY 07 was within industry standards.

The Austin Water Utility (AWU) has taken a Utility-wide approach to measure and manage water loss, with some positive results.

As a part of a broad, Utility-wide initiative focused on water conservation, AWU management created the Water Accountability Group (WAG) in 2006. The WAG was charged with addressing challenges to the measurement of water loss in the City. Using the prevailing methodology supported by Texas Water Development Board (TWDB) at that time, the WAG performed a calculation to estimate the City's water loss for FY 05 which fell within acceptable industry standards. The WAG also offered several recommendations to better measure and to decrease the volume of water lost by the City. However, in 2007, progress toward this end stalled, and several of the WAG's strategies went unimplemented. The new AWU director, who was hired in 2008, revived the WAG, and AWU has moved forward with several of its suggested water loss control strategies.

In 2006, as a part of a broad initiative focused on water conservation, AWU management created the Water Accountability Group (WAG), which was charged with addressing challenges to the measurement of water loss in the City. Starting in late 2005, AWU managers decided to increase focus on water accountability with the goals of improving operations and reliably calculating the City's water loss using the methodology approved by the Texas Water Development Board (TWDB). Because water loss control is considered a conservation measure, AWU's Conservation Division was given responsibility for performing the Utility's water loss calculation and reporting the results to the TWDB. In 2006, the AWU Conservation Division Manager appointed personnel from throughout the Utility to serve as members of a Water Accountability Group (WAG). The WAG was tasked with gathering the information needed for the water loss calculation as well as addressing challenges to gathering that information. The WAG members include staff from divisions across the Utility.

In order to develop a comprehensive strategy to reduce *Non-Revenue Water* and the number of gallons that could not be accounted for in the service area, the committee focused on several initiatives including:

- improving large meter testing and repair;
- conducting a residential meter evaluation;
- enhancing the leak detection and repair program;

- reducing the backlog of leak repairs;
- tracking data systematically using database software;
- tracking all water used by other City departments; and
- reducing the theft of water.

The WAG calculated and reported an estimate of the City's water loss for FY 05; that estimate fell within acceptable industry standards. According to AWU management, the WAG performed the FY 05 water loss calculation in accordance with the top-down methodology approved by the TWDB at the time. This method, found in the TWDB's Water Loss Manual, is based largely on a desktop exercise of gathering information from water consumption and loss reports already commonly compiled by many utilities. As a result of the lack of detail used in a top-down approach, the ratios and performance measures associated with this type of calculation may not be as accurate as a bottom-up approach. In addition, we consider this data "unaudited" because the WAG did not maintain detailed records to support the calculation, and we did not independently replicate the calculation.

The WAG estimated the volume of water lost in FY 05 at 6.78 billion gallons, or 14.2 percent of water treated by the Utility. As previously noted, the total volume of water lost can be broken down into two major categories, *Apparent* and *Real* losses. As shown in Exhibit 2 below which summarizes the FY 05 water loss information reported by AWU to the TWDB, *Apparent Loss* was estimated at 2.314 billion gallons and the *Real Loss* amount at 4.462 million gallons. The Utility was able to account for all but 3.346 billion gallons, which amounts to approximately 7.02% of the Corrected System Input Volume (CSIV) for FY 05. See Appendix B for a copy of AWU's FY 05 Water Audit Reporting Form.

EXHIBIT 2
AWU WATER LOSS FOR FY 05

<table>
<tr><td rowspan="5">**Water Losses**
6,775,948,382 gals
14.22% of CSIV
18.56 MGD</td><td rowspan="3">**Apparent Losses**
2,313,910,526 gals
4.86% of CSIV
6.34 MGD</td><td>**Unauthorized Consumption**
142,000,000 gals
0.30% of CSIV
0.39 MGD</td></tr>
<tr><td>**Customer Meter Under-registering**
2,126,910,526 gals
4.46% of CSIV
5.83 MGD</td></tr>
<tr><td>**Billing Adjustments and Waivers**
45,000,000 gals
0.09% of CSIV
0.12 MGD</td></tr>
<tr><td rowspan="2">**Real Losses**
4,462,037,856 gals
9.36% of CSIV
12.23 MGD</td><td>**Reported Leaks**
1,116,259,464 gals
2.34% of CSIV
3.06 MGD</td></tr>
<tr><td>**Unreported Loss**
3,345,778,392 gals
7.02% of CSIV
9.17 MGD</td></tr>
</table>

SOURCE: AWU Water Accountability Group calculation of water loss for FY 05, unaudited.

According to the AWWA, a certain amount of leakage is unavoidable, even for a well-run water system. To determine whether the actual volume of water lost relative to the unavoidable losses is reasonable, the AWWA guidelines suggest using the Infrastructure Leakage Index (ILI). The AWWA methodology defines the ILI as the ratio of current actual losses to unavoidable losses. The WAG determined that AWU's *Unavoidable Annual Real Loss* (UARL) for FY 05 was 3.08 Million Gallons per Day (MGD), and the *Real Loss* for that year was 12.23 MGD. Using those numbers, the WAG calculated AWU's ILI for FY 05 to be 3.96. This figure is within the acceptable target range for Utilities with water resource, operational, and financial considerations similar to those of the Austin Water Utility, based on the AWWA's target ILI table (see Exhibit 3 below).

EXHIBIT 3
AWWA GUIDELINES FOR SETTING A TARGET INFRASTRUCTURE LEAKAGE INDEX

Target Infrastructure Leakage Index Range	Financial Considerations	Operational Considerations	Water Resources Considerations
1.0 – 3.0	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulation or low taxpayer affordability.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.
>3.0 – 5.0	Water resources can be developed or purchased at reasonable expense; periodic water rate increases can be feasibly imposed and are tolerated by the customer population.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management and water conservation) are included in the long-term plan.
>5.0 – 8.0	Cost to purchase or obtain/treat water is low, as are rates charged to customers.	Superior reliability, capacity, and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Water resources are plentiful, reliable, and easily extracted.
Greater than 8.0	Although operational and financial considerations may allow a long-term infrastructure leakage index greater than 8.0, such a level of leakage is not an effective use of water as a resource. Setting a target level greater than 8.0 other than as an incremental goal to a smaller long-term target is discouraged.		
Less than 1.0	If the value of the infrastructure leakage index for your system is 1.0 or less, two possibilities exist: 1) You are maintaining your leakage at low levels in a class with the top worldwide performers in leakage control; or 2) A portion of your data may be flawed, causing your losses to be greatly understated. This is likely if you calculate a low value but do not employ extensive leakage control practices in your operations. In such cases, it is beneficial to validate the data by performing field measurements to confirm the accuracy of production and customer meters or to identify any other potential sources of error in the data.		
Note: This table offers an approximate guideline for setting leakage reduction targets. The best means of setting such targets include performing economic assessments of various loss control methods. However, this table is useful if such assessments are not possible or a preliminary target is desired.			

SOURCE: TWDB Water Loss Manual, March 2008 revision, pg.36.

The WAG also offered recommendations to better measure and to decrease the volume of water lost; however, in 2007, the WAG stopped meeting and the Utility failed to implement several of the group's strategies. In the spring of 2006, the WAG offered several recommendations designed to improve AWU's ability to measure water loss and ultimately to reduce the number of gallons lost every year by the City. Specifically, the WAG recommended that the Utility:

- Continue holding regular WAG meetings;
- Perform an annual calculation of water loss;
- Track water loss data using current databases and correct existing inaccurate data;
- Implement a Utility-wide leak detection program; and
- Conduct regular meter calibrations.

Though the WAG's work initiated progress toward addressing challenges to measuring water loss in the City, AWU did not immediately implement many of the group's recommended strategies, and later the progress of the group stalled. In fact, we reviewed WAG meeting minutes and documentation and found that no meetings were held after the FY 05 water loss calculation was performed. Additionally, no annual water loss calculation was performed after FY 05.

In the past two years, AWU revised some processes identified by the WAG in order to enable better tracking of water loss. For example, AWU adopted the use of the Utility's work-order system of record, Hansen, to better track and report water used for system maintenance and water lost through identified breaks and leaks. Additionally, in late 2006 AWU implemented a leak detection program to cover one-third of their system. This program was later expanded as part of the work of the Water Conservation Task Force. At that time, they also started work towards implementing a large meter testing program. Also, in 2008, the City hired a new AWU Department Director who has recently reinstated the WAG meetings, which he attends. As a result, the new Director is moving the Utility forward with several of the WAG's previously recommended strategies. For example, AWU has begun annual testing of meters, starting with the Utility's larger meters, as part of an on-going Utility-wide revenue initiative.

Recommendation

01. In order to improve the validity of data, develop more cost effective ways to further reduce actual water losses, and routinely address water loss issues, the AWU Department Director should produce an annual Water Loss Calculation and analyze the results in order to develop strategies aimed at reducing the level of unreported leaks.

MANAGEMENT RESPONSE: CONCUR
The Water Accountability Group has been restructured into an executive-level Steering Committee and three subcommittees that meet more frequently to address specific areas of water accountability. The Water Audit Subcommittee will meet quarterly to supply and evaluate information gathered for annual water loss calculations, recommend ways to improve data collection, and summarize and report results to the Steering Committee. The Steering Committee will guide the Leak Detection and Response Subcommittee and the Metering and Billing Subcommittee in analyzing the results of these annual water loss calculations and developing strategies to reduce unaccounted-for water.

The Austin Water Utility (AWU) has not yet fully implemented the new, best practice method recommended by the TWDB for measuring and managing water loss; however, they have begun taking steps to do so.

As noted above, the TWDB recently published a more rigorous approach for water loss control, which they recommend that utilities in the State of Texas implement and report on beginning with loss data from FY 10. During the course of our work, we found that the Austin Water Utility (AWU) has not yet fully implemented the new, best practice method recommended by the TWDB for measuring and managing water loss. While AWU has made progress toward doing so, they need to make additional process changes to fully implement the TWDB-recommended component reliability matrix. Making these changes will enable AWU management to calculate more reliable water loss estimates and take a best practice approach to manage water loss.

Austin Water Utility has not yet fully implemented the more rigorous best practice method for water loss control recommended by the TWDB. The TWDB is trying to encourage utilities to analyze each water loss component and move towards a more accurate bottom-up calculation to better identify and control water loss. The TWDB has recommended that utilities adopt this approach in time to report 2010 water loss results. However, the Utility has not taken all the necessary steps needed to implement this best practice.

For example, the Utility is not yet using the component reliability matrix to calculate water loss estimates. The TWDB's Component Reliability Matrix (Matrix) provides "improvement" guidance for each component of water loss to help Utilities determine how to achieve a higher level of reliability for that component. The *Assessment Value* is a measure of reliability for each of the components of the water loss calculation. By following the guidance from the Matrix, a utility can achieve an *Assessment Score* (the total of the individual *Assessment Values*) that indicates that its calculation is reliable.

AWU has some practices in place to facilitate calculating water loss using the more rigorous method. For example, the Utility properly accounts for some components of water loss using existing internal reports and systems. Also, the Utility has begun testing and recalibrating meters and understands the methodology for calculating water loss under the new TWDB recommended methods.

In addition, work performed during this audit has led to an increased ability to account for water used or lost throughout the distribution system. In fact, after assisting us with the data collection for this audit, the Utility has begun taking steps to improve its data measurement, collection, and recordkeeping processes. For example, they are now using the *Assessment Values* portion of the water loss calculation to pinpoint the areas of the greatest water loss so that increase attention can be given to those components of the system.

Recommendation

02. In order to improve the process followed to produce the Water Loss Calculation, the AWU Department Director should follow the updated guidelines provided by TWDB, and use the calculation component reliability matrix to ensure that its process and the data gathered are as detailed and accurate as possible.

MANAGEMENT RESPONSE: CONCUR
AWU will continue to follow the most current TWDB methodology for future water loss calculations and will use the reliability matrix to identify and prioritize areas where data collection can be improved.

This section of the report (through page 26) details our findings related to AWU's progress toward and additional steps necessary for full implementation of the best practice water loss measurement and control approach. The detailed findings are grouped according to components of the TWDB Water Loss Calculation shown in columns A and D of the Water Loss Calculation Components Table (Exhibit 4).

NOTE: Red boxes indicate links to portion of the report.

Exhibit 4
Water Loss Calculation Components

A	Column B	Column C	Column D	Column E
Corrected System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed / Metered Consumption	Revenue Water
			Billed / Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled / Metered Consumption	Non-revenue Water
			Unbilled / Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Meter Under-registering	
			Billing Adjustment and Waivers	
		Real Losses	Reported Leaks & Breaks	
			Unreported Loss	

SOURCE: TWDB *Water Loss Manual for Texas Utilities*, March 2009

System Input Volume – This is the total amount of water that is treated and pumped into the distribution system. Having an accurate and reliable figure for this amount is important because the rest of the water loss calculation centers on accounting for all of the water that is pumped out of the treatment plants.

AWU has a meter testing and repair program focused on assessing large meter accuracy that helps ensure reliable figures for the volume of water entering the distribution system can be obtained. A reliable, accurate measure of the volume of water treated at AWU water treatment plants (*System Input Volume*) is essential to measuring water loss. The accuracy of water meters is vital to ensure accurate and reliable figures for water consumption and billing, which is critical to measuring water loss. Water that is treated and pumped out of the treatment plants into the distribution system should be properly metered in order to ensure that the *System Input Volume* is accurately measured. The water loss calculation calls for a correction to the *System Input Volume* based on production meter accuracy. The result is called the *Corrected System Input Volume* (CSIV) in the water loss calculation.

A meter testing program was one of the strategies recommended by the WAG in 2006 that did not immediately get adopted. However, with the arrival of the new department director in 2008, a revenue recovery initiative was instituted, and the meter testing program was adopted as an

integral part of that initiative. We found that currently, testing and repair is focused on larger meters which are used to measure production flow as well as wholesale and industrial usage. Accuracy of these meters ensures that production quantities and billing of wholesale and large accounts is accurate. Regular testing to ensure these meters are accurate is a critical component to AWU being prepared to reliably estimate water loss.

AWU's system for verifying flow data is manual and vulnerable to inaccurate reporting. Plant employees gather production volumes by manually reading mechanical production flow meters at each plant site. The employees then record the figure and enter the data into a spreadsheet, where monthly and annual totals are accumulated. This manual read and record process can result in data entry errors. Data entry errors could compromise the reliability of the system input measure currently used to calculate water loss. We did not find any evidence of a review for accuracy of the data.

Before relying on its automated control and data acquisition system, the Utility needs to conduct a full-scale validation study to ensure that the system provides accurate data. The volume of water produced at each of the three water treatment plants is also measured daily through the Supervisory Control and Data Acquisition (SCADA) system using sensors that track the flow of water. AWU uses the SCADA system to control and operate the Utility's distribution and collection system from a central location through the use of computers to automatically perform system management tasks based on software programs.

However, AWU has not validated the accuracy of the SCADA system. Both AWU personnel and the outside consultant that we used agree that mechanical meters are more accurate than automated systems. Therefore, readings from automated measurement systems such as SCADA should be calibrated against them to ensure that *System Input Volume* (SIV) data is as reliable as possible. Use of the SCADA system to measure the SIV is a relatively new process. Additionally, the SCADA system is not yet used to its full capacity; however, AWU has plans to upgrade the SCADA system and eventually replace the manual production meter reading with automated reads. The ability to provide accurate real-time information is predicated upon whether the SCADA system is found to be reliable and accurate enough to replace the current manual system.

Recommendations

03. In order to ensure that the *System Input Volume* is as accurate as possible, the AWU Department Director should ensure that the meter testing program continues with annual testing and recalibration of production flow meters.

MANAGEMENT RESPONSE: CONCUR
Current TCEQ rules and regulations for public water system require annual testing of meters; AWU is in compliance with that requirement. Meters are tested and recalibrated every 6 or 12 months, in accordance with the manufacturer's specifications for each meter, with additional testing in the event of a suspected discrepancy.

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04. In order to ensure that the *System Input Volume* is as accurate as possible, the AWU Department Director should first determine if using the SCADA system would yield reliable results, before fully automating the process of reporting the amount of water produced using the SCADA system.

MANAGEMENT RESPONSE: CONCUR
AWU has developed preliminary SCADA reporting tools that will be verified against field information. SCADA system upgrades will include a reporting system that minimizes data entry errors.

Billed and Metered Water – *This is water that is appropriately metered and billed. There are several categories of billed and metered water such as that which is sold to individuals, office complexes, warehouses, etc.*

The AWU Billed Consumption Report (BCR) is generated automatically based on data retrieved by the CIS billing system, but the accuracy and reliability of this report is unknown. Reliable measurements of water that is appropriately metered and billed must be known in order to accurately assess water losses from the distribution system. The Utility relies on the Billed Consumption report (BCR), which is produced by querying the Customer Information System (CIS) databases to show the amount of water sold by billing type (i.e., residential, industrial, wholesale, commercial, multifamily, and golf courses). Reports from databases should be reconciled and validated to ensure accuracy. Because the BCR is created from a query set up to gather data from the CIS billing system, it should be validated by reconciling the results to other known reports. Because this reconciliation is not performed, the accuracy and reliability of the billed consumption report is unknown. Austin Energy is currently in the planning stage of replacing the CIS system, scheduled to be implemented in 2011. This presents an opportunity to have a report created by the system developers that AWU can rely on to produce the water loss calculation.

AWU staff do perform annual tests to compare billed to expected consumption and revenues, which may help detect inaccuracies with consumption and billing measurements. As part of the annual external financial audit for the City, Utility employees perform predictive revenue tests to compare the revenue booked on the City's accounting system with computed expected revenues. Because the billing cycles are spread out throughout each month, the Utility employees use formulas to approximate the revenue for each month affected by each billing cycle. While this analysis is not a specific reconciliation of the billing system, it does give some assurance that the amounts billed are reasonable. This assurance is obtained through verification that the quantities of water and revenues from the billing system are within acceptable ranges when compared to pumping and distribution system records and revenue estimates.

Additionally, the predictive revenue tests also help determine the percentage of water pumped into the system that is not billed. This is done by comparing the amount of water captured through the water meter readings against the system pumpage reports. While unmetered water estimates must be factored into the calculation, this comparison provides a good basis from which to start the water loss calculation.

Austin Energy is currently in the planning stage of replacing the CIS system, scheduled to be implemented in 2011.

Recommendation

05. In order to ensure that all components of water loss calculations are accurate, the AWU Department Director should work with Austin Energy to ensure that the new Customer Billing System will provide consumption and billing reports that the Utility can rely upon to produce the calculation.

MANAGEMENT RESPONSE: CONCUR
AWU will work with AE to ensure reliable reports are incorporated into the new billing system.

Billed and Unmetered Water – This is water that is sold and billed, but not necessarily metered. Instead estimates of the amount of water are used. The main example is when a meter stops working. An estimate of the amount of water that was used must be made in order to bill the customer.

Most of the water that can be classified as *Billed and Unmetered*, including that which goes through a meter that has stopped working or is under-registering, is handled by the Utility as a billing adjustment. For this reason, the findings related to these issues are included in the Billing Adjustments and Waivers section later in this report.

Unbilled and Metered Water – This is water that is appropriately metered, but not billed. The main example is water used by the Austin Water Utility. Although there are meters at each of their buildings, the Utility does not bill itself for the water that they use. Other City departments are billed at commercial rates, and their use is included in the Billed and Metered Water component.

AWU appropriately accounts for water used by the Utility that is metered but not billed. Most of the water used by City departments at their buildings is properly metered and billed at commercial rates. One exception to this is that, like other water utilities, AWU does not bill itself for water used in its buildings and operations. However, the Utility does properly monitor and account for this water in the *Unbilled and Metered Water* component of the water loss calculation. This practice is in accordance with TWDB guidelines.

Unbilled and Unmetered Water – This is water that is used for firefighting and system maintenance activities.

Water used by the Utility for system maintenance, which is not billed or metered, is tracked by AWU and compiled into the Hansen database. Water used or lost throughout the treatment, pumping and distribution system should be should be tracked by the Utility on a regular basis in order to manage the amount of *Unreported Loss* water. AWU personnel estimate the amount of water used for system maintenance using their automated service and work order tracking system of record, the Hansen system. Utility employees historically used a report that totals the volume of water used for internal purposes, but that report did not distinguish between the volume of water used for maintenance from internal water loss due to leaks and breaks. During our audit, we pointed this out and suggested changes to the report and to the process so

that the two totals could be separately accounted for in order to ensure the reliability of the water loss calculations. Prior to the end of our audit, AWU had made the changes to the report that we suggested.

Water used for firefighting activities, which is not billed or metered, is properly accounted for through standard estimate calculations. In order to ensure that water used for firefighting activities is properly accounted for, the Austin Fire Department (AFD) estimates the amount of water used at each incident using the same formulas used by AWU personnel to estimate water lost from pipe breaks and leaks. The information is entered by AFD into an automated tracking system. AFD employees report annual usage to responsible AWU personnel when requested. Water used by AFD for maintenance and training activities is metered and billed; therefore, it is included in the Billed Consumption Report described above.

Water used for inspection and maintenance of firefighting infrastructure may be understated due to inaccurate estimation methods and incomplete reporting. Inspection and maintenance activities use water that must be accounted for in the water loss calculation. City ordinance # 20051215-105 requires that all fire hydrants, public and private, be inspected and maintained on an annual basis by a Utility-approved contractor. AFD tracks estimates of the volume of water used in the inspection and maintenance of City-owned fire hydrants and also for testing of private fire suppression systems. These estimates, however, are based on the assumption that AFD uses the same, minimum volume of water required for each inspection performed. Because some maintenance activities are likely to require more than the minimum volume of water to complete, the estimates provided by AFD may be understated. However, AWU management has agreed to work with AFD management to ensure that better estimates are produced.

Additionally, data for water used to inspect and maintain privately-owned fire hydrants is incomplete. Approximately 6,500 of the over 37,000 fire hydrants within the City of Austin's jurisdictional limits are privately-owned. According to City ordinance, private contractors are required to submit reports to AWU which include the amount of water used for any inspection or maintenance activity performed on private fire hydrants. The goals of the ordinance are to ensure that all private fire hydrants are inspected and maintained annually and also to capture the amount of water used during those inspections and maintenance repairs. These reports should be submitted to personnel in the AWU Special Services Division, which is responsible for the Utility's water protection program. However, our review of inspection and water use report records revealed that reports for only 25 to 29 percent of privately-owned hydrants are submitted annually. Therefore, AWU has no record and cannot be sure that the remaining 71 to 75 percent of privately-owned fire hydrants are inspected as required by ordinance.

Although it is possible to identify which private fire hydrants have not been inspected as required by ordinance, their owners are not notified when non-compliant. That is because neither AWU nor AFD have a standardized process to record ownership information for private fire hydrants along with inspection and maintenance data. While most private fire hydrants have been located using the City's Geographic Information System (GIS); neither AWU nor AFD has identified the owners of all of the private fire hydrants. As a result, neither AWU nor AFD has notified the responsible parties when proof of the annual inspection has not been submitted.

The calculation and reporting of unmetered water use by City departments is not as accurate as it should be; and departments are not billed for unmetered water that is reported, providing no incentive to conserve water. Water consumed by City departments that is unmetered should be estimated, compiled, and reported to AWU with the highest degree of certainty possible so that an accurate water loss measure can be calculated. The City has no systematic process to track unmetered water use across all City departments, and AWU has not requested this data on a regular basis from all departments in the past. City departments have different processes for identifying and reporting the amount of water they use. Some use scientific calculations based on estimates such as the size of a water tank used and how many times it was filled over the course of the year, while others put together estimates based on best-guesses when asked to provide them. Additionally, some departments are unaware if the water they use is actually metered. As a result, accurate and complete usage figures are not available.

Additionally, City departments are not billed for the water that they use that is not metered; therefore, they have no way of knowing how much they actually use. City departments should be aware of all of their water consumption and consider strategies to reduce the amount of unnecessary water use. At present, other City departments have accounts within the billing system to track their metered water use, and they are billed at commercial rates. However, they are not billed for water that they consume, if it is not metered.

Recommendations

06. In order to ensure that annual inspections are performed for each of the private fire hydrants within their jurisdiction, the AWU Department Director should coordinate with AFD to ensure that: a process is created to properly identify responsible parties for all private fire hydrants; the responsible parties are notified of the requirements for annual testing; and, water used during inspection and maintenance activities is properly accounted for.

MANAGEMENT RESPONSE: CONCUR
AWU will coordinate with AFD to better track and ensure compliance with the annual inspection requirements for private hydrants.

07. To ensure that AFD is aware of which hydrants have not been inspected recently so that they can properly protect the public, the AWU Department Director should ensure that annual testing reports are compiled in a central database and that the GIS system is properly updated with current data on the hydrant status.

MANAGEMENT RESPONSE: CONCUR
AWU will work with AFD to determine the best method of sharing testing data.

08. To properly measure and analyze the water used by other City departments, the AWU Department Director should perform an analysis to ensure that water meters are installed at all sites from which other City departments draw water, and that accounts are set up on the CIS to ensure that the quantities are correctly accounted for.

MANAGEMENT RESPONSE: CONCUR
AWU will work with other City departments to analyze water use and install meters where feasible. AWU Consumer Services Division will continue its process for monitoring CIS account setup.

09. To ensure that as much of the unmetered water as possible is properly accounted for, the AWU Department Director should work with other City departments to standardize the procedures for estimating and reporting unmetered water, and ensure that personnel within other City departments are properly educated on those procedures.

MANAGEMENT RESPONSE: CONCUR
The Water Audit Subcommittee will evaluate the data collected from each department and work with those departments to improve reporting methods and document standard procedures. The Metering and Billing subcommittee will assist in identifying situations where metering would be appropriate and cost-effective.

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10. In order to conserve water used by City departments, the City Manager should establish an inter-departmental task force to monitor and analyze water use and create strategies for conserving as much water as possible.

MANAGEMENT RESPONSE: CONCUR
Austin Water Utility will facilitate a quarterly meeting with representatives from City departments to monitor and analyze water use and create strategies for conserving water, as well as to address the coordination of responses to water leaks.

Unauthorized Consumption Water – This is water that is stolen from hydrants, through direct connections to the water distribution system, or by bypassing of meters.

AWU does not know the volume of water stolen from fire hydrants. According to the American Water Works Association (AWWA), most unauthorized water use occurs when individuals vandalize fire hydrants or open the hydrants to fill water trucks. To estimate the volume of water lost due to theft from the distribution system for the water loss calculation, the Utility currently uses the TWDB accepted rate of 0.25 percent of all water produced. However, the proximity of this estimate to the actual volume of water stolen is unknown. This is because the Utility has no procedures in place to detect water theft from fire hydrants; therefore, water lost due to theft cannot be reliably estimated and such instances go unreported and unpunished.

While the TWDB recommends a water theft monitoring and tracking program, they do not describe what one should include. AWU has personnel that investigate water theft, however their work is focused on theft by meter tampering and bypasses rather than fire hydrant theft. The water loss from meter tampering and bypasses is accounted for in the Billing Adjustments Report (see the *Billing Adjustments and Waivers* section below for more information).

One reason water theft may go unreported is that the public is not aware of water theft and its implications. According to the TWDB, when the public is educated about how water theft occurs and its implications, it is more likely that instances of water theft will be reported. When the public is not aware of what is considered water theft, reporting rates of such instances are often low.

Additionally, the *Unauthorized Consumption* component of the water loss calculation may be understated, and AWU may be losing revenue due to underreporting and theft of water by contractors. Water consumed by contractors drawing water from hydrants should be accurately reported and billed at the prevailing rate. Opportunities for theft exist because not all contractor trucks have water meters, and because AWU has no procedures in place to ensure that all water taken from hydrants by contractors gets billed. As such, the figures making up the *Unauthorized Consumption* component of the water loss calculation may not be accurately reported, and AWU may be losing revenue. One cause of this problem may be that contractors, especially those new to the City of Austin, are not educated about the requirements for metering and paying for water from fire hydrants.

Recommendations

11. In order to quantify the amount of water lost through theft, the AWU Department Director should undertake a study to determine how prevalent theft from fire hydrants is throughout the distribution system, and start an education process for city employees and citizens to report suspicious activity.

MANAGEMENT RESPONSE: CONCUR
Austin Water Utility will undertake a study to determine the prevalence of theft in the distribution system. Consumer Services Division has coordinated with Watershed Protection and Public Works inspectors to report instances of theft for the past few years. CSD will continue this effort and plans to expand awareness through preconstruction meetings, posters at the TAPS offices and the Water Conservation electronic newsletter.

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12. In order to reduce the amount of theft from the distribution system, especially from fire hydrants in outlying areas, the AWU Department Director should work with APD to develop a program to respond to and investigate occurrences of water theft once a study has been undertaken to determine how prevalent theft from fire hydrants is throughout the distribution system.

MANAGEMENT RESPONSE: CONCUR
AWU currently has a program to investigate water theft and has the authority to levee fines when deemed necessary. AWU had 830 instances of water theft in the previous fiscal year and levied $136,000 in fines. Prior discussions with APD have been complicated by the need to witness theft in progress in order to pursue charges. However, following the results of the water theft study AWU will revisit a possible partnership with APD.

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13. In order to ensure that as much of the water used by contractors as possible is accounted for, the AWU Department Director should ensure that policies governing the use of water from hydrants by non-City-owned vehicles are developed and implemented. Additionally, AWU should develop a program to educate contractors to ensure compliance with those policies.

MANAGEMENT RESPONSE: CONCUR
AWU will create a group of stakeholders from appropriate City departments and the private sector. The stakeholders group will review current policies and recommend improvements and additional requirements to ensure water use accountability. In addition, the group will work with AWU's Public Information Office to develop an education plan.

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14. In order to ensure that as much of the water used by contractors from hydrants as possible is properly accounted for and billed, the AWU Department Director should ensure that an analysis is performed of the procedures in place and that research is performed to determine if new processes exist to meet this goal. One possible method would be to compare construction permits to temporary-use billings to determine if large amounts of water are being taken without metering and billing.

MANAGEMENT RESPONSE: CONCUR
AWU will review current procedures for accounting for water drawn from hydrants and will research other methods of accounting for hydrant water use. AWU will analyze the correlation between electric construction loop meters and water metering at construction sites. Further analyses will be undertaken to the extent that they are cost-effective for the utility.

Customer Meter Under-Registered Water – This is the amount of water that is apparently lost due to inaccurate customer meters. The Water Loss Calculation allows for this amount to be estimated based on the accuracy of customer meters.

AWU has limited data available on the accuracy of most small meters, which measure the volume of water used by many residential customers. A determination of the average meter accuracy rating for small meters provides AWU with an overview of the amount of water not billed (lost) due to meter inaccuracy. At present, AWU does not have enough data on the accuracy of small meters because it only tests the accuracy of meters that have been replaced due to a reported problem. As such, it cannot determine the accuracy of a large part of its metered water since small meters account for approximately 35 percent of all water that is produced and metered. However, since 2008 when the Utility replaces small meters, it tests the reliability ratings of both the old and the new meters. The results are stored within the work order tracking system. Over time, this data should help to establish an average reliability rating for the small meters.

Recommendation

15. In order to estimate the accuracy of small residential meters and establish a starting point for the small meter reliability rating, the AWU Department Director should direct that a reliability test be completed on a statistically valid random sample of small meters.

MANAGEMENT RESPONSE: CONCUR
AWU is currently establishing a methodology for selecting meters and defining the scope of the accuracy testing to generate a baseline for system-wide small meter accuracy.

Systematic Data Handing Errors – This is water that is not billed because of errors in handling data at either the point that a meter is read, or when it is transferred into the billing system. Errors within the billing system are also accounted for in this component.

The volume of water loss due to systematic data handling discrepancies is unknown. Identification of systematic data handling discrepancies within the billing system is required by the TWDB water loss calculation process. Examples of possible discrepancies are transposition

errors when transferring data, miscalculation of billing amounts due to errors in formulas, and accounts set up under the wrong billing type. Meter reading and subsequent entry of the meter data are performed by contractors employed by Austin Energy (AE). Although meter edit reports exist and those reports are reviewed on a regular basis, neither AWU nor AE has audited or reviewed data handling within the billing system. Such a review might reveal whether discrepancies exist or could occur between the time that data is gathered by meter readers and amounts are billed to the customer.

As noted earlier, AWU does perform limited predictive revenue testing on an annual basis based on estimates of revenues and comparisons to the actual amounts billed through the CIS system. However, this review cannot take the place of a systematic data handling review.

Recommendation

16. In order to determine the extent to which there are any data discrepancies in the water billing data caused by data handling errors, AWU should partner with Austin Energy to perform an analysis of the processes followed within the CIS and throughout the customer billing program.

MANAGEMENT RESPONSE: CONCUR
Both utilities will be reviewing existing processes as part of the CIS replacement project, which is scheduled to be presented to Council in early summer 2009. The proposed web based system contains more checks and balances than CIS to reduce data handling errors.

Billing Adjustments and Waivers – This is water that is not billed for reasons such as inaccurate meters, customer line breaks that are deemed to be the result of reasons that cannot be directly attributable to the property owner, etc. Although customers are not billed, the water itself does leave the system.

AWU has standardized procedures in place for executing billing adjustments and waivers, but information on available system reports was insufficient to assess the volume of water adjusted. The ability to measure and account for the impact of billing adjustments and waivers is important to an accurate water loss calculation. The procedures in place at AWU call for standardized calculations to be used when billing adjustments are necessary. Billing adjustments may be necessary when water is not billed for some reason such as an inaccurate customer meter, a customer line break, or the identification of water theft by customers. Most billing adjustment calculations are based on standard calculations to ensure that customers are treated fairly and equitably. However, when Utility water theft investigators determine a customer has stolen water, they have the authority to levy fines up to $156 (not including the charge for the water itself), and their work is used to support billing this type of billing adjustment. While we did not perform testing in this area, we did review the information used in the calculation of billing adjustments and found that it was well documented.

Information regarding the volume of water associated with any billing adjustments is a required component of the water loss calculation. AWU has been using the system generated Billing Adjustment Report (BAR) to get this figure. However, because the BAR is a tool that was created for use by the AWU Customer Services Division to track credits and debits to customer accounts, it only contained data on the monetary value of adjustments. Therefore, we had to

request a special report in order to account for the volume of water consumed but not accounted for through the Billed Consumption Report. Following our work in this area, the AWU Customer Services Supervisor immediately requested that this special report become standard so that Utility staff would not have to perform an additional step to convert the data into volume-adjusted figures.

Recommendation

17. In order to properly account for all water used, whether a customer is billed or not, the AWU Department Director should ensure that a standard conversion process for billing adjustment data from dollars to gallons is added to the BAR production process.

MANAGEMENT RESPONSE: CONCUR
AWU will modify the existing BAS (billing adjustment system) report to include usage in gallons.

Reported Leaks and Breaks – This is water that is lost because of breaks or leaks in pipelines. The Utility calculates the amount of water lost on each work order based on the date the leak was discovered, the size of the break, and the water pressure at that point in the distribution system.

AWU tracks water loss due to leaks and breaks and compiles the information using the Hansen system. Water lost throughout the treatment, pumping and distribution system due to leaks and breaks should be tracked by the Utility in order to minimize the amount of *Unreported Losses*. AWU personnel estimate the amount of water lost due to a break or leak based on the level of water pressure at the point of the leak, the size of the break, and the length of time that the leak has been occurring. Then AWU personnel document the estimated volume of water lost in the appropriate Hansen system work order. Because AWU tracks this information, the Utility can easily compile the volume of water loss from maintenance, leaks, and breaks for use in the water loss calculation.

During the course of our audit, we made an additional suggestion to further improve the reliability of the information related to breaks and leaks. AWU supervisors review 80 percent of each day's work orders for quality assurance and control purposes, and we suggested that work orders that have a water loss amount documented be included in those work orders reviewed by supervisors. AWU managers agreed to incorporate the review process that we suggested immediately.

The backlog of work orders and the response times for stopping breaks and leaks leads to a larger amount of water loss than necessary. AWU's current system of prioritizing leaks and breaks does not ensure that the amount of water lost is minimized. According to the TWDB, all water utilities incur leakage losses, and the volume lost varies from one utility to the next. However, leakage only grows worse if left unchecked. Therefore, all water utilities should perform system maintenance and upkeep functions that include appropriate components of leakage management, active leakage control, timely quality repair, water main rehabilitation, and pressure management.

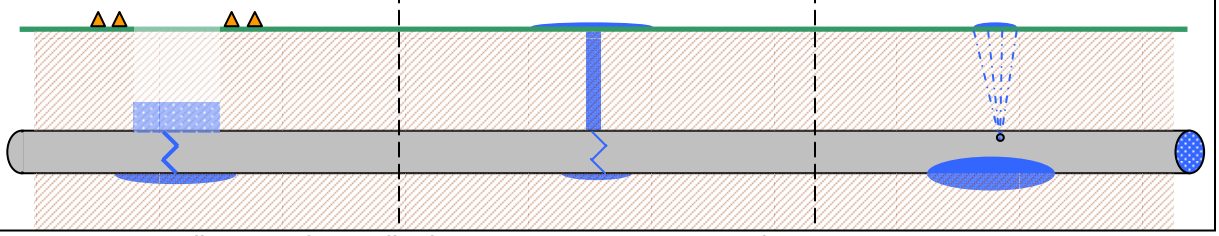
Hansen system work order data showed that the AWU has reduced the response time for identified breaks and leaks between FY 07 and FY 08. For FY 08, management has reported that 2 percent of leaks are not addressed within 30 days. However, that same data for FY07 shows

that 22 percent of leaks went unrepaired for over 30 days, including one leak that went unaddressed for 528 days due to a variety of reasons, as discussed below.

AWU prioritizes work orders to repair pipeline breaks according to State guidelines regarding health and safety, which do not consider water loss volume. State guidelines mandate that repairs of water line breaks be prioritized according to public health and safety risks. This three-level prioritization scheme, summarized in Exhibit 5 below, does not address the issue of water loss volume due to a leak or break. AWU reports that the prioritization of breaks and leaks is done by an investigator who assesses the problem according to those State guidelines. The AWU investigator does have some leeway to use professional judgment when prioritizing a leak with a high volume of water loss as long as State guidelines are considered and public health and safety is not at risk. However, because the prioritization of repairs is not always dictated by water loss volume, breaks involving a high volume of water loss may go unrepaired for over 30 days.

Exhibit 5
Prioritization of Water Line Break Repairs

Priority 1 Incident	Priority 2 Incident	Priority 3 Incident
• Loss of water service • Damage to private or public property • Public health or safety risk	• Incidents similar to Priority 1 without immediate risks • Occur during off-hours	• Incidents that do not pose an immediate risk to customer service, property, or public health. • Most leaks/ breaks are identified as Priority 3
Priority 1 Response • Within 5 hours • Repair crews on call 24/7	**Priority 2 Response** • Beginning of next business day	**Priority 3 Response** • Logistics teams prep sites (identify valves, mark utilities) ASAP • In FY 07, 60.3% repaired within one week and 20.1% within 60 days.



SOURCE: OCA diagram of unaudited AWU process as presented to us on January 2009.

Coordination with external agencies and other departments slows down AWU's response times to repair water line breaks. Most water and wastewater pipelines are buried under public streets and right-of-ways. This means that repair efforts must meet other City department guidelines for street closures and other logistic considerations. However, once a break is identified, water loss continues until the repair is made. Therefore, AWU and other departments should work to streamline communication and processes to allow for the most expeditious initiation of repairs possible.

Before any repair work is performed, AWU must coordinate with the Texas One Call system for utility line location and identification. The location of existing utilities in the area of the repair must be marked. Additionally, AWU must coordinate with other City departments to get approval on plans, including the Watershed Protection and Development Review Department (WPDR) for permitting and right-of-way management and the Public Works Department's (PWD) Street and Bridge Division for traffic control.

Although permitting, right-of-way, and traffic control management requirements may be waived for a Priority 1 response (enabling crews from other departments to be at the site within two hours to assist AWU) the development of these plans often delays response times for Priority 3 incidents. In the meantime, AWU logistics teams work on site preparation such as examining the grid maps to determine valve locations, and coordinating with WPDR, PWD, and Texas One Call as noted above. These processes could be streamlined and better coordinated to expedite initiation of Priority II and III repairs and minimize water loss.

Other field considerations and situations may also delay response times to incidents. AWU has repair crews in the field continuously working on scheduled maintenance and repairs. Often, these crews cannot be mobilized for an emergency response at a second site because the work they are performing at their first site involves open holes and cuts, which would pose a public safety hazard if not properly safeguarded. Also, valve location identification and access may delay a response. Access to valves is required to shut down water service at the repair site. Often, valves are not in working condition, or they have been paved over and are no longer accessible.

The Pipeline Operations Division plans to hold sessions with repair crews designed to cut Priority 1 response time in half (from 5 hours to 2.5 hours). Additionally, the AWU Department Director stated that he plans to bring on consultants to apply quality management practices to improve Utility-wide procedures.

AWU does not have a standard procedure for identifying the water pressure value at the point of a leak or break. The determination of water pressure at the point of a leak or break in the water distribution system is one component needed to determine the volume of water lost as a result of the problem. Some AWU personnel record the water pressure at the leak or break from GIS data, which takes into account the hydraulics of the system, while others record it from the nearest fire hydrant to the site of the problem, which may be affected by the leak itself. Because AWU does not have a standard procedure for identifying the water pressure value at the point of a leak or break, the figure recorded is not always reliable.

AWU does not track water lost from overflows from reservoirs and the actual volume of loss is unknown. Water used or lost throughout the treatment, pumping and distribution system should be should be tracked by the Utility on a regular basis in order to minimize the amount of water that cannot be accounted for. Water lost through overflows of reservoirs is not currently tracked, but is estimated at 1 million gallons per year by AWU personnel responsible for water loss calculations. If the volume of water lost as a result of these overflows were tracked, a more accurate, reliable water loss calculation could be obtained.

Recommendations

18. In order to reduce the amount of water lost through leaks and breaks, the AWU Department

Director should ensure that maintenance and upkeep functions are a high-priority throughout the Utility.

MANAGEMENT RESPONSE: CONCUR
AWU has prioritized the Field Operations Division in its Lean process improvement efforts and increased funding for proactive subsurface leak detection. Additionally, AWU has created a Distribution System Engineering Division responsible for coordinating system maintenance planning, leak detection, CIP project implementation, rehabilitation and replacement project implementation, and trenchless rehabilitation of the water distribution pipelines and transmission mains.

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19. In order to reduce the amount of water lost through leaks and breaks, the AWU Department Director should ensure that strategies to reduce response and repair times are identified and implemented.

MANAGEMENT RESPONSE: CONCUR
AWU has implemented or begun implementation of several strategies to reduce response and repair time for water leaks. These strategies include redirecting non-leak activities to other work groups, issuing field laptops to crew leaders, facilitating self-approval of right of way management permits, developing a service contract for non-core water distribution work orders, and developing trucking contracts for spoils disposal. In addition, the installation of automatic vehicle locators on all water distribution work vehicles will assist in redirecting the vehicles to active priority water leaks. AWU will continue to explore innovative methods to further reduce water lost to line leaks and breaks.

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20. In order to improve response times for leak repair, the City Manager should appoint a task force with representatives from all involved departments to come up with solutions to the problems that AWU faces while coordinating with other City departments and outside entities when responding to water leaks.

MANAGEMENT RESPONSE: CONCUR
Austin Water Utility will facilitate a quarterly meeting with representatives from City departments to monitor and analyze water use and create strategies for conserving water, as well as to address the coordination of responses to water leaks.

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21. In order to properly estimate the amount of water lost at each break or leak, the AWU Department Director should ensure that a standard procedure for determining what the most accurate source of water pressure is at the point of a leak/break is identified, and that this methodology is used for all water loss calculations.

MANAGEMENT RESPONSE: CONCUR
All field operations staff have been instructed to use the pressure calculated in the GIS Hotlinks system when calculating the amount of water lost due to breaks or leaks.

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22. In order to properly account for as much of the water lost from overflows of reservoirs as possible, the AWU Department Director should ensure that the Pumping and Distribution Division manager establishes procedures and a tracking process to properly account for all water lost through overflows.

MANAGEMENT RESPONSE: CONCUR

AWU has developed a process to track overflow events and is testing a methodology for calculating overflow volume using visual inspection and SCADA historical trending.

Unreported Loss – This is the "x" that is solved for in the Water Loss Calculation. After accounting for all other water, the remaining amount is what must be lost throughout the distribution system through leaks that have not been noticed, theft that is not taken into account, etc.

AWU has conducted a leak detection survey of one-third of the system, but a figure for leakage from the entire system is unknown. A leak detection program identifies leaks in the water distribution system and enables repairs to be made. Leak detection involves the use of sound, closed-circuit TV, and other technologies to identify the location of leaks in the system. In 2007, as part of the Utility's water conservation initiative, a contactor was hired to perform leak detection activities on some of the system's oldest pipes, which account for approximately one-third of the distribution system. Approximately 330 million gallons in leaks were identified. However, a figure for leakage from the entire system is unknown, as the rest of the system has not been studied. A more complete understanding of the extent of system leakage will enable AWU management to arrive at a cost to address all identified leaks and to initiate needed repairs as well as calculate a more accurate water loss figure. When combined with an analysis of the cost savings from reduced water loss through leaks and breaks, the Utility's Director should be able to determine the best Utility-wide approach to water loss reduction.

Recommendation

23. To facilitate a better Utility-wide approach to water loss reduction, identify as much of AWU's *Unreported Loss* water as possible, and determine the cost to address identified leaks, the AWU Director should ensure that leak detection programs are continued with the goal of testing the entire distribution system regularly.

MANAGEMENT RESPONSE: CONCUR
AWU is in the second phase of a small diameter leak detection program and plans to implement a condition assessment for large diameter transmission mains in FY10. AWU will evaluate the results of these leak detection efforts to determine goals for regular testing of the entire distribution system and determine a cost-effective, utility-wide approach to reduce water loss.

Using the best practice approach recommended by the TWDB, we found that the City's water loss estimates for FY 07 were within industry standards.

Although the AWU has taken a Utility-wide approach to control water loss, as noted above, the Utility is not yet fully prepared to use the more rigorous bottom-up methodology now recommended by the TWDB to calculate and report water loss. Using this new calculation methodology to estimate the City's water loss for FY 07, we found that the City lost approximately 5.33 billion gallons or 11 percent of water that it treated. This amount, when calculated against the size of the city's infrastructure, results in an Infrastructure Leakage Index that is within acceptable industry standards. The best practices approach we employed and the results we obtained during this audit can be used by AWU as a basis for future planning and benchmarking purposes.

Using the new, more rigorous calculation methodology recently adopted by the TWDB to estimate the City's water loss for FY 07, we found that water loss for that period was within industry standards. As noted in the previous section, the TWDB has recently adopted a new, more rigorous approach to the measurement of water loss for utilities to use as a basis for reporting beginning with FY 10 data. This bottom-up approach requires water loss estimates to be calculated by tracking and measuring *Assessment Values* for the individual components of water usage and loss as depicted in Column D of the Water Loss Table shown in a previous section of this report. As noted above, when contrasted with the previously-used top-down calculation methodology, the bottom-up approach provides a more precise estimate of total water loss and enables utilities to better pinpoint areas of excessive loss so that corrective action may be taken.

During the course of this audit, OCA performed this calculation to determine the Utility's estimated water loss for FY 07. Data for the calculation was obtained from the sources identified by the Conservation Division for the FY 05 calculation. However, to perform the FY 07 calculation, we followed the more rigorous, structured approach to quantifying the components of water use and loss as called for by the updated TWDB Water Loss Manual.

Results of our calculation indicated that in FY 07, the City lost approximately 5.33 billion gallons or 11 percent of water that it treated. For the water loss calculation, the volume of water treated by AWU is captured by the *Corrected System Input Volume (CSIV)* component. As noted above, the total volume of water lost can be broken down into two major categories, *Apparent* and *Real* losses. We calculated the Utility's *Apparent Loss* at 1.732 billion (3.70 percent of CSIV*)* and the *Real Loss* amount at 3.597 billion gallons (7.68 percent of CSIV). Further, *Real Losses* can be broken down into losses that are known and *reported*, or *unreported*, losses, which is the amount of water that cannot be accounted for. Using the TWDB methodology, we were able to account for all but 2.939 billion gallons. This "*Unreported Loss*" amount (previously referred to as "*Unaccounted for Water*") amounts to approximately 6.28 percent of the CSIV for FY 07. See Exhibit 6 below for a breakdown of water loss for FY 07.

EXHIBIT 6
AWU Water Loss for FY 07

<table>
<tr><td rowspan="5">**Water Losses**
5,328,258,952 gals
11.38% of CSIV
14.60 MGD</td><td rowspan="3">**Apparent Losses**
1,731,746,418 gals
3.70% of CSIV
4.74 MGD</td><td>**Unauthorized Consumption**
124,060,162 gals
0.26% of CSIV
0.34 MGD</td></tr>
<tr><td>**Customer Meter Under-registering**
1,553,939,113 gals
3.32% of CSIV
4.26 MGD</td></tr>
<tr><td>**Billing Adjustments and Waivers**
53,747,144 gals
0.11% of CSIV
0.15 MGD</td></tr>
<tr><td rowspan="2">**Real Losses**
3,596,512,534 gals
7.68% of CSIV
9.85 MGD</td><td>**Reported Leaks**
657,591,010 gals
1.40% of CSIV
1.80 MGD</td></tr>
<tr><td>**Unreported Loss**
2,938,921,524 gals
6.28% of CSIV
8.05 MGD</td></tr>
</table>

SOURCE: OCA Calculation of AWU Water Loss for FY 07.

We also determined that the Utility's *Unavoidable Annual Real Loss* (UARL), the amount of leakage that is unavoidable even for a well-run water system, was 3.762 Million Gallons per Day (MGD). This increase over the FY 05 figure of 3.08 MGD was due to an increase in the total miles of pipe and the number of connections that make up the Utility's distribution system. With a FY07 *Real Loss* figure of 9.853 MGD, we calculated the *Infrastructure Leakage Index* (ILI) to be 2.619. As was the case in FY 05, this figure is within the range for utilities with water resource, operational, and financial considerations similar to those of AWU. However, AWU has moved to the top tier of the table. (See Exhibit 7 below).

EXHIBIT 7
AWWA GUIDELINES FOR SETTING A TARGET INFRASTRUCTURE LEAKAGE INDEX

Target Infrastructure Leakage Index Range	Financial Considerations	Operational Considerations	Water Resources Considerations
1.0 – 3.0	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulation or low taxpayer affordability.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.
>3.0 – 5.0	Water resources can be developed or purchased at reasonable expense; periodic water rate increases can be feasibly imposed and are tolerated by the customer population.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management and water conservation) are included in the long-term plan.
>5.0 – 8.0	Cost to purchase or obtain/treat water is low, as are rates charged to customers.	Superior reliability, capacity, and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Water resources are plentiful, reliable, and easily extracted.
Greater than 8.0	Although operational and financial considerations may allow a long-term infrastructure leakage index greater than 8.0, such a level of leakage is not an effective use of water as a resource. Setting a target level greater than 8.0 other than as an incremental goal to a smaller long-term target is discouraged.		
Less than 1.0	If the value of the infrastructure leakage index for your system is 1.0 or less, two possibilities exist: 1) You are maintaining your leakage at low levels in a class with the top worldwide performers in leakage control; or 2) A portion of your data may be flawed, causing your losses to be greatly understated. This is likely if you calculate a low value but do not employ extensive leakage control practices in your operations. In such cases, it is beneficial to validate the data by performing field measurements to confirm the accuracy of production and customer meters or to identify any other potential sources of error in the data.		
Note: This table offers an approximate guideline for setting leakage reduction targets. The best means of setting such targets include performing economic assessments of various loss control methods. However, this table is useful if such assessments are not possible or a preliminary target is desired.			

SOURCE: TWDB Water Loss Manual, March 2008 revision, pg.36.

NOTE: Due to the use of different methodologies to calculate the FY 05 and FY 07 figures, it is not possible to compare the two. However, because the methodology we used yields more accurate results, the Utility can use our calculation as a baseline for future planning in order to focus its efforts on reducing water loss and non-revenue components, which are keys to achieving system efficiency.

The best practices approach that we employed and the results obtained during this audit can be used by AWU as a basis for future planning and benchmarking purposes. Our work on gathering data focused on achieving as high an *Assessment Value* for each component as possible. Summing the *Assessment Values* gives you an *Assessment Score* for the calculation.

For FY 07 that score is 59.5 out of a possible 85. According to the TWDB, this means that there is sufficient validity in the calculation so that the calculation can be used for planning and developing targeted loss control efforts by the Utility, along with comparison to similarly assessed data from other utilities, according to the TWDB scoring scale.

The TWDB provides guidance on whether a Utility can rely on its calculation based on *Assessment Score* ranges. Once a minimum score is attained, the Water Loss Calculation data is deemed to be of sufficient validity so that the data can be used to compare against data from other similarly assessed utilities. Exhibit 8 below shows the TWDB's guidance related to the level of validation. The TWDB, however, recommends that utilities concentrate on bringing each component's individual *Assessment Value* up as high as it can. Unlike previously, when the focus was on the percentage of treated water lost, the current focus is on the reliability and validity of the volume used or lost for each component.

EXHIBIT 8
TWDB ASSESSMENT SCORE GUIDANCE

Total Assessment Pts	TWDB Guidance
Below 40	Data considered Preliminary; do not benchmark to other utilities or use for planning.
40 to 70	Progressively greater validity of data; use for planning and developing targeted loss control efforts; sufficient validity to compare to similarly assessed data from other utilities.
Above 70	Mature programs of "auditing" and loss control; data is reliable in guiding and tracking advanced programs in apparent and real loss control; performance tracking and benchmarking to other utilities can be carried out in a reliable manner.

SOURCE: Compiled by OCA from TWDB Water Loss Manual, March 2008 revision, pgs 11-12.

APPENDIX A

MANAGEMENT RESPONSE

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MEMORANDUM

To: Taylor Dudley, Acting City Auditor

From: Rudy Garza, Assistant City Manager

Date: April 27, 2009

Subject: Response to Audit Recommendations

I have reviewed and approved the Austin Water Utility's response to the audit recommendations in OCA's draft report titled "Water Loss Calculation Process Audit" (AU08110). Attached is the Utility's response to the audit recommendations.

Rudy Garza, Assistant City Manager
City of Austin

cc: Greg Meszaros, Director, Austin Water Utility
Perwez Moheet, CPA, Deputy Director, Austin Water Utility
Daryl Slusher, Assistant Director, Environmental Affairs & Conservation

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MEMORANDUM

To: Rudy Garza, Assistant City Manager

From: Greg Meszaros, Director, Austin Water Utility

Date: April 27, 2009

Subject: Response to Audit Recommendations

I have reviewed and responded to the recommendations in the Office of the City Auditor's draft report titled "Water Loss Calculation Process Audit" (AU08110). Attached is the Utility's response to the audit recommendations.

Please let me know if you require additional information or if you have any questions.

Greg Meszaros, Director
Austin Water Utility

cc: Perwez Moheet, CPA, Deputy Director, Austin Water Utility
Daryl Slusher, Assistant Director, Environmental Affairs & Conservation

ACTION PLAN
Water Loss Calculation Process Audit – AU08110

Rec. #	Recommendation Text	Proposed Strategies for Implementation	Status of Strategies	Responsible Person/Phone Number	Proposed Implementation Date
1	In order to improve the validity of data, develop more cost effective ways to further reduce actual water losses, and to continually address water loss issues, the AWU Department Director should produce an annual Water Loss Calculation and analyze the results in order to develop strategies aimed at reducing the level of unreported leaks.	Concur. The Water Accountability Group has been restructured into an executive-level Steering Committee and three subcommittees that meet more frequently to address specific areas of water accountability. The Water Audit Subcommittee will meet quarterly to supply and evaluate information gathered for annual water loss calculations, recommend ways to improve data collection, and summarize and report results to the Steering Committee. The Steering Committee will guide the Leak Detection and Response Subcommittee and the Metering and Billing Subcommittee in analyzing the results of	Implemented	Environmental Affairs and Conservation Assistant Director Daryl Slusher, 972-0218	Implemented

		these annual water loss calculations and developing strategies to reduce unaccounted-for water.			
2	In order to improve the process followed to produce the Water Loss Calculation, the AWU Department Director should follow the updated guidelines provided by TWDB, and use the calculation component reliability matrix to ensure that its process and the data gathered is as detailed and accurate as possible.	Concur. AWU will continue to follow the most current TWDB methodology for future water loss calculations and will use the reliability matrix to identify and prioritize areas where data collection can be improved.	Implemented	Environmental Affairs and Conservation Assistant Director Daryl Slusher, 972-0218	Implemented
3	In order to ensure that the *System Input Volume* is as accurate as possible, the AWU Department Director should ensure that the meter testing program continues with annual testing and recalibration of production flow meters.	Concur. Current TCEQ rules and regulations for public water system require annual testing of meters; AWU is in compliance with that requirement. Meters are tested and recalibrated every 6 or 12 months in accordance with the manufacturer's specifications for each meter, with additional	Implemented	Pumping and Treatment Division Manager, Rick Coronado 972-0510	Implemented

		testing in the event of a suspected discrepancy.			
4	In order to ensure that the *System Input Volume* is as accurate as possible, the AWU Department Director should first determine if using the SCADA system would yield reliable results, in the event that the Utility chooses to use the SCADA system before fully automating the process of reporting the amount of water produced.	Concur. AWU has developed preliminary SCADA reporting tools that will be verified against field information. SCADA system upgrades will include a reporting system that minimizes data entry errors.	Underway	Pumping and Treatment Division Manager, Rick Coronado 972-0510	5/1/2009
5	In order to ensure that all components of water loss calculations are accurate, the AWU Department Director should work with Austin Energy to ensure that the new Customer Billing System will provide consumption and billing reports that the Utility can rely upon to produce the calculation.	Concur. AWU will work with AE to ensure reliable reports are incorporated into the new billing system.	Planned	Consumer Services Division Manager Alice Flora, 972-0041 Austin Energy Project Manager David Orr, 322-6040	3/31/2011
6	In order to ensure that annual inspections are performed for each of the	Concur. AWU will coordinate with AFD to better track and ensure	Planned	Pipeline Operations Assistant	9/30/2010

	private fire hydrants within their jurisdiction, the AWU Department Director should coordinate with AFD to ensure that: a process is created to properly identify responsible parties for all private fire hydrants; the responsible parties are notified of the requirements for annual testing; and, water used during inspection and maintenance activities is properly accounted for.	compliance with the annual inspection requirements for private hydrants.		Director George Calhoun, 972-0256	
7	To ensure that AFD is aware of which hydrants have not been inspected recent so that they can properly protect the public, the AWU Department Director should ensure that annual testing reports are compiled in a central database and that the GIS system is properly updated with current data on the hydrant status.	Concur. AWU will work with AFD to determine the best method of sharing testing data.	Planned	Pipeline Operations Assistant Director George Calhoun, 972-0256	9/30/2010

8	To properly measure and analyze the water used by other City departments, the AWU Department Director should perform an analysis to ensure that water meters are installed at all sites from which other City departments draw water, and that accounts are set up on the CIS to ensure that the quantities are correctly accounted for.	Concur. AWU will work with other City departments to analyze water use and install meters where feasible. AWU Consumer Services Division will continue its process for monitoring CIS account setup.	Underway	Consumer Services Division Manager Alice Flora, 972-0041 Environmental Affairs and Conservation Assistant Director Daryl Slusher, 972-0218	9/30/2009
9	To ensure that as much of the unmetered water as possible is properly accounted for, the AWU Department Director should work with other City departments to standardize the procedures for estimated and reporting unmetered water, and that personnel within other City departments are properly educated in those procedures.	Concur. The Water Audit Subcommittee will evaluate the data collected from each department and work with those departments to improve reporting methods and document standard procedures. The Metering and Billing subcommittee will assist in identifying situations where metering would be appropriate and cost-effective.	Planned	Environmental Affairs and Conservation Assistant Director Daryl Slusher, 972-0218	12/31/2009
10	In order to conserve water used by City	The Austin Water Utility will facilitate a quarterly	Planned	City Manager	9/30/2009

	departments, the City Manager should establish an inter-departmental task force to monitor and analyze water use and create strategies for conserving as much water as possible.	meeting with the representatives from City departments to monitor and analyze water use and create strategies for conserving water as well as addressing the coordination of responses to water leaks.			
11	In order to quantify the amount of water lost through theft, the AWU Department Director should undertake a study to determine how prevalent theft is throughout the distribution system, and start an education process for city employees and citizens to report suspicious activity.	Concur. Austin Water Utility will undertake a study to determine the prevalence of theft in the distribution system. Consumer Services Division has coordinated with Watershed Protection and Public Works inspectors to report instances of theft for the past few years. CSD will continue this effort and plans to expand awareness through preconstruction meetings, posters at the TAPS offices and the Water Conservation electronic newsletter.	Planned	Consumer Services Division Manager Alice Flora, 972-0041	9/30/09 for implementation of the theft study; 6/30/09 for implementation of education campaign
12	In order to reduce the amount of theft from the distribution system, especially from fire hydrants in outlying	Concur. AWU currently has a program to investigate water theft and has the authority to levee fines when deemed	Underway	Pipeline Operations Assistant Director George	To be determined based on result of theft study.

	areas, the AWU Department Director should ensure that the WAG works with APD to develop a program to respond and investigate occurrences of water theft.	necessary. AWU had 830 instances of water theft in the previous fiscal year and levied $136,000 in fines. Prior discussions with APD have been complicated by the need to witness theft in progress in order to pursue charges. However, following the results of the water theft study AWU will revisit a possible partnership with APD.		Calhoun, 972-0256 Consumer Services Division Manager Alice Flora, 972-0041	
13	In order to ensure that as much of the water used by contractors as possible is accounted for, the AWU Department Director should ensure that policies governing the use of water from hydrants by non-City-owned vehicles are developed and implemented. Additionally, AWU should develop a program to educate contractors to ensure compliance with those	Concur. AWU will create a group of stakeholders from appropriate City departments and the private sector. The stakeholders group will review current policies and recommend improvements and additional requirements to ensure water use accountability. In addition, the group will work with AWU's Public Information Office to develop an education plan.	Planned	Pipeline Operations Assistant Director George Calhoun, 972-0256 Consumer Services Division Manager Alice Flora, 972-0041	To be determined based on result of theft study.

	policies.				
14	In order to ensure that as much of the water used by contractors from hydrants as possible is properly accounted for and billed, the AWU Department Director should ensure that an analysis is performed of the procedures in place and that research is performed to determine if new processes exist to meet this goal. One possible method would be to compare construction permits to temporary-use billings to determine if large amounts of water are being taken without metering and billing.	Concur. AWU will review current procedures for accounting for water drawn from hydrants and will research other methods of accounting for hydrant water use. AWU will analyze the correlation between electric construction loop meters and water metering at construction sites. Further analyses will be undertaken to the extent that they are cost-effective for the utility.	Planned	Consumer Services Division Manager Alice Flora, 972-0041	Ongoing, as construction loop meters are set up as requested.
15	In order to most reliably estimate the accuracy of small residential meters and establish a starting point for the small meter reliability rating, the AWU Department Director should direct a reliability test be completed on a	Concur. AWU is currently establishing a methodology for selecting meters and defining the scope of the accuracy testing to generate a baseline for system-wide small meter accuracy.	Underway	Asset Management and Business Processes Division Manager Donn Lorbieski, 972-1006	6/30/2009

	statistically valid random sample of small meters.				
16	In order to determine the extent to which there are any data discrepancies in the water billing data caused by data handling errors, AWU should partner with Austin Energy to perform an analysis of the processes followed within the CIS and throughout the customer billing program.	Concur. Both utilities will be reviewing existing processes as part of the CIS replacement project, which is scheduled to be presented to Council in early summer 2009. The proposed web based system contains more checks and balances than CIS to reduce data handling errors.	Underway	Consumer Services Division Manager Alice Flora, 972-0041 Austin Energy Project Manager David Orr, 322-6040	3/31/2011
17	In order to properly account for all water used, whether a customer is billed or not, the AWU Department Director should ensure that a standard conversion process for billing adjustment data from dollars to gallons is added to the BAR production process.	Concur. AWU will modify the existing BAS (billing adjustment system) report to include usage in gallons.	Planned	Consumer Services Division Manager Alice Flora, 972-0041	4/30/2009
18	In order to reduce the amount of water lost through leaks and breaks, the AWU Department Director	Concur. AWU has prioritized the Field Operations Division in its Lean process improvement efforts and	Underway	Field Operations Division Manager Robert	Ongoing

	should ensure that maintenance and upkeep functions are a high-priority throughout the Utility.	increased funding for proactive subsurface leak detection. Additionally, AWU has created a Distribution System Engineering Division responsible for coordinating system maintenance planning, leak detection, CIP project implementation, rehabilitation and replacement project implementation, and trenchless rehabilitation of the water distribution pipelines and transmission mains.		Hinojosa, 972-1112 Distribution System Engineering Division Manager, Mark Dollins 972-0171	
19	In order to reduce the amount of water lost through leaks and breaks, the AWU Department Director should ensure that strategies to reduce response and repair responses are identified and implemented.	Concur. AWU has implemented or begun implementation of several strategies to reduce response and repair time for water leaks. These strategies include redirecting non-leak activities to other work groups, issuing field laptops to crew leaders, facilitating self-approval of right of way management permits, developing a service	Underway	Field Operations Division Manager Robert Hinojosa, 972-1112	Ongoing, as new procedures are identified

		contract for non-core water distribution work orders, and developing trucking contracts for spoils disposal. In addition, the installation of automatic vehicle locators on all water distribution work vehicles will assist in redirecting the vehicles to active priority water leaks. AWU will continue to explore innovative methods to further reduce water lost to line leaks and breaks.			
20	In order to improve response times for leak repair, the City Manager should appoint a task force with representatives from all involved departments to come up with solutions to the problems that AWU faces while coordinating with other City departments and outside entities when responding to water leaks.	The Austin Water Utility will facilitate a quarterly meeting with representatives from all involved departments to better coordinate responses to water leaks.	Planned	City Manager	9/30/2009
21	In order to properly estimate the amount of	Concur. All field operations staff have been	Implemented	Field Operations	Implemented

	water lost at each break or leak, the AWU Department Director should ensure that a standard procedure for determining that the most accurate source of water pressure is at the point of a leak/break is identified, and that this methodology is used for all water loss calculations.	instructed to use the pressure calculated in the GIS Hotlinks system when calculating the amount of water lost due to breaks or leaks.		Division Manager Robert Hinojosa, 972-1112	
22	In order to properly account for as much of the water lost from overflows of reservoirs as possible, the AWU Department Director should ensure that the Pumping and Distribution Division manager establishes procedures and a tracking process to properly account for all water lost through overflows.	Concur. AWU has developed a process to track overflow events and is testing a methodology for calculating overflow volume using visual inspection and SCADA historical trending.	Underway	Pumping and Treatment Division Manager, Rick Coronado 972-0510	5/1/2009
23	To facilitate a better Utility-wide approach to water loss reduction, identify as much of the *Unreported Loss* water as	Concur. AWU is in the second phase of a small diameter leak detection program and plans to implement a condition	Underway	Distribution System Engineering Division Manager,	Ongoing

	possible, and determine cost to address all identified leaks, the AWU Department Director should ensure that leak detection programs are continued with the goal of testing the entire distribution system regularly.	assessment for large diameter transmission mains in FY10. AWU will evaluate the results of these leak detection efforts to determine goals for regular testing of the entire distribution system and determine a cost-effective, utility-wide approach to reduce water loss.		Mark Dollins 972-0171	

Status of strategies: planned, underway, or implemented.

APPENDIX B

FY 05 WATER LOSS CALCULATION

Prepared by the Austin Water Utility
and submitted to the
Texas Water Development Board

TEXAS WATER DEVELOPMENT BOARD
P.O. BOX 13231, CAPITOL STATION
AUSTIN, TX 78711-3231
WATER AUDIT REPORTING FORM

Texas Water Development Board

Mark Mathis, Conservation Division

P.O. Box 13231
Email: Mark.Mathis@twdb.state.tx.us

Utility Name: CITY OF AUSTIN WATER & WASTEWATER

Type of Utility: WSC MUD WCID SUD **CITY** Other

Regional Water Planning Group(s) in which this system operates: LOWER COLORADO
http://www.twdb.state.tx.us/mapping/maps/pdf/sb1_groups_8x11.pdf

Name of person competing form: AMANDA DEWEES

Phone number of person completing form: (512)-974-3514

Mailing address of Utility: PO BOX 1088
AUSTIN, TX 78767-1088

Reporting Period: From 10/01/2004 To 09/30/2005

Percentage of water used: Surface 100.00 % Groundwater 0.00 %
(must equal 100%)

Mean household income of population served: $67,300.00
http://factfinder.census.gov/servlet/SAFFPeople?

Population served: 734,519

Note: unit of measure (Acre-feet or Million gallons(MG) or Thousand gallons(KG) or gallons(G)/year) must stay consistent throughout report.

1. SYSTEM INPUT VOLUME ACRE-FT MG KG **G**

Water Delivery - Amount of water put into delivery system: 48,004,300,000.000

Production Meter Accuracy (enter percentage): 100.45 %

Production Meter Adjustment - Corrected Input Volume - Water Delivery: -215,051,617.720

Corrected Input Volume - Water delivery/Production Meter Accuracy: 47,789,248,382.280

2. AUTHORIZED CONSUMPTION

Billed Metered -	All water sold and metered:	40,411,300,000.000
Billed Unmetered -	All water sold but not metered:	142,000,000.000
Unbilled Metered -	City and local government use, metered line flushing:	85,000,000.000
Unbilled Unmetered -	Line flushing/fire dept use:	375,000,000.000
Authorized Consumption -	The Total of all authorized water:	41,013,300,000.000

3. WATER LOSS

Apparent Loss

Customer Meter Accuracy	(enter percentage)	95.00
Customer Meter Under Registering -	Total Water Sold / Customer Meter Accuracy	2,126,910,526.316 %
Billing Adjustment/Waivers	(Unbilled Consumption)	45,000,000.000
Unauthorized Consumption		142,000,000.000
Total of Apparent Loss		2,313,910,526.316

Real Loss

Main break/leaks	3,345,778,392.000
Customer service line leaks/breaks	1,115,259,464.000
Storage Tank Overflows	1,000,000.000
Total of Real Loss	4,462,037,856.000
Total of Water Loss (Apparent Loss + Real Loss)	6,775,948,382.316
Total of Water Loss + Authorized Consumption	47,789,248,382.316
Balancing Error (See 3B "Note" on instruction sheet)	-0.036

4. TECHNICAL PERFORMANCE INDICATORS

Performance Indicators for Real Losses

Your utility's number of service connections	188,441
Your utility's number of miles of main lines	2,790.00
Service connections per mile of main	67.54
Total Real Loss/Miles of Main/365 *(in gallons)*	4,381.635
Total Real Loss/No. of Service Connections/365 *(in gallons)*	64.873

4. TECHNICAL PERFORMANCE INDICATORS

Total Real Loss	4,462,037,856.00
Production cost of water *(make sure correct unit of measure is used to determine the cost)*	$0.00050
Total Real Loss multiplied by production cost of water	$2,231,018.93
Total Apparent Loss	2,313,910,526.32
Retail cost of water *(make sure correct unit of measure is used to determine the cost)*	$0.00290
Total Apparent Loss multiplied by retail cost of water	$6,710,340.53

APPENDIX C

FY 07 AWU WATER LOSS CALCULATION

As prepared by the Office of the City Auditor

AWU Water Loss Calculation

for: October 1, 2006 to September 30, 2007

Calculations performed by Office of the City Auditor on February 12, 2009 using data gathered from the Austin Water Utility.

Line #	Field Description (from TWDB Water Audit Reporting Form)	Value			Assessment Values: Score	Assessment Values: Max Points
A.	**WATER UTILITY GENERAL INFORMATION**					
1	Water Utility Name:	Austin Water Utility				
2	Contact:					
	Name	Drema Gross AWU Water Conservation Division				
	Telephone #					
	Email Address					
3	Reporting Period:	October 1, 2006 to September 30, 2007				
4	Source Water Utilization, percentage:					
	Surface Water %	100%				
	Groundwater %	0%				
5	Population Served:					
	a. Retail Population Served	780,647				
	b. Wholesale Population Served	54,000			System Data Points	
6	Utility's Length of Main Lines, miles	3,516			4.5	5
7	Number of Wholesale Connections Served	45				
8	Number of Retail Service Connections Served	198,895				
9	Service Connection Density (Number of retail service connections/Miles of main lines)	56.57	conn/ mile			
10	Average Yearly System Operating Pressure (psi)	77.0	psi		4.5	5
11	Volume Units of Measure (check one): acre-ft million gallons thousand gallons gallons	Gallons				
B.	**SYSTEM INPUT VOLUME**				Water Supplied Points	
12	Water Volume from own Sources	45,881,625,000.0	gals		4.5	5
13	Production Meter Accuracy (%)	98.00%	pct.		4.5	5
14	Corrected Input Volume	46,817,984,693.9	gals	100.00%		
15	Wholesale Water Imported	0.0	gals		5	5
16	Wholesale Water Exported	0.0	gals		5	5
17	**System Input Volume**	46,817,984,693.9	gals	100.00%		
C.	**AUTHORIZED CONSUMPTION**				Authorized Consumption Points	
18	Billed Metered	41,254,300,900.0	gals	88.12%	3.5	5
19	Billed Unmetered	0.0	gals	0.00%	1	5
20	Unbilled Metered (amount used at AWU buildings/facilities)	105,645,200.0	gals	0.23%	2	5
21	Unbilled Unmetered (amount used by other city Departments) *	129,779,642.0	gals	0.28%	3	5
22	**Total Authorized Consumption**	41,489,725,742.0	gals	88.62%		
	NOTE: * Most of the water used by other City Departments is included in line 18.					
D.	**WATER LOSSES**					
23	**Water Losses** (Line 17 minus Line 22)	5,328,258,951.9	gals	11.38%		
E.	**APPARENT LOSSES**				Apparent Losses Points	
24	Average Customer Meter Accuracy %	96.37%	pct.		3	5
25	Customer Meter Accuracy Loss	1,553,939,112.5	gals	3.32%		
26	Systematic Data Handling Discrepancy	53,747,144.0	gals	0.11%	4	5
27	Unauthorized Consumption	124,060,161.7	gals	0.26%	2	5
28	**Total Apparent Losses**	1,731,746,418.2	gals	3.70%		
F.	**REAL LOSSES**				Real Losses Points	
29	Reported Breaks/Leaks (Est. vol. of leaks/breaks repaired during report period)	657,591,010.0	gals	1.40%	3.5	5
30	Unreported Loss (Includes all unknown water loss) **	2,938,921,523.7	gals	6.28%	2.5	5
31	**Total Real Losses** (Line 29, plus Line 30)	3,596,512,533.7	gals	7.68%		
32	**Water (Apparent + Real) Losses** (Line 28 plus Line 31) should equal Line 23	5,328,258,951.9	gals	11.38%		
33	**Non-revenue Water** (Water Losses + Unbilled Authorized Consumption) (Line 32, plus Line 20, plus Line 21)	5,563,683,793.9	gals	11.88%		

NOTE:
** Calculated as Water Losses - Total Apparent Losses - Reported Breaks & Leaks

AWU Water Loss Calculation

for: October 1, 2006 to September 30, 2007

Calculations performed by Office of the City Auditor on February 12, 2009 using data gathered from the Austin Water Utility.

Line #	Field Description (from TWDB Water Audit Reporting Form)	Value			Assessment Values: Score	Assessment Values: Max Points
G.	**TECHNICAL PERFORMANCE INDICATOR FOR APPARENT LOSS**					
34	**Apparent Losses Normalized** (Apparent Loss Volume/# of Retail Service Connections/365)	23.854	gals/conn/day			
H.	**TECHNICAL PERFORMANCE INDICATORS FOR REAL LOSS**					
35	Real Loss Volume (Line 31) (shown as total gallons/year)	3,596,512,533.7	gals	7.68%		
36	**Unavoidable Annual Real Losses**, volume (calculated) in MGD	3,762,417.1	MGD	0.01%		
37	**Infrastructure Leakage Index** (calculated) (Equals real loss volume (div by 365) divided by unavoidable annual real losses)	2.619				
38	**Real Losses Normalized** (Real Loss Volume/# of Service Connections/365) (This indicator applies if service connection density is greater than 32/mile)	49.530	gals/conn/day		Austin's Serv Conn Density > 32/mile so this calc is used	
39	**Real Losses Normalized** (Real Loss Volume/Miles of Main Lines/365) (This indicator applies if service connection density is less than 32/mile)	9,853,458.996	gals/mile/day		This one not used (see note above)	
I.	**FINANCIAL PERFORMANCE INDICATORS**					
40	Total Apparent Losses (Line 28)	1,731,746,418.2	gals			Cost Data Points
41	Retail Price of Water	$2.99	per 1,000 gals		3	5
42	(Apparent loss volume multiplied by retail cost of water - Line 40 / 1000 x Line 41)	$5,177,921.79				
43	Total Real Losses (Line 31)	3,596,512,533.7	gals			
44	Variable Production Cost of Water***	$0.55	per 1,000 gals		4	5
45	(Real loss multiplied by variable production cost of water - Line 43 / 1000 x Line 44)	$1,960,351.09				
46	**Total Assessment Score**				59.5	85.0
47	**Total Cost Impact of Apparent and Real Losses**	$7,138,272.88				
						70.00%
						Percentage of points available

NOTE:

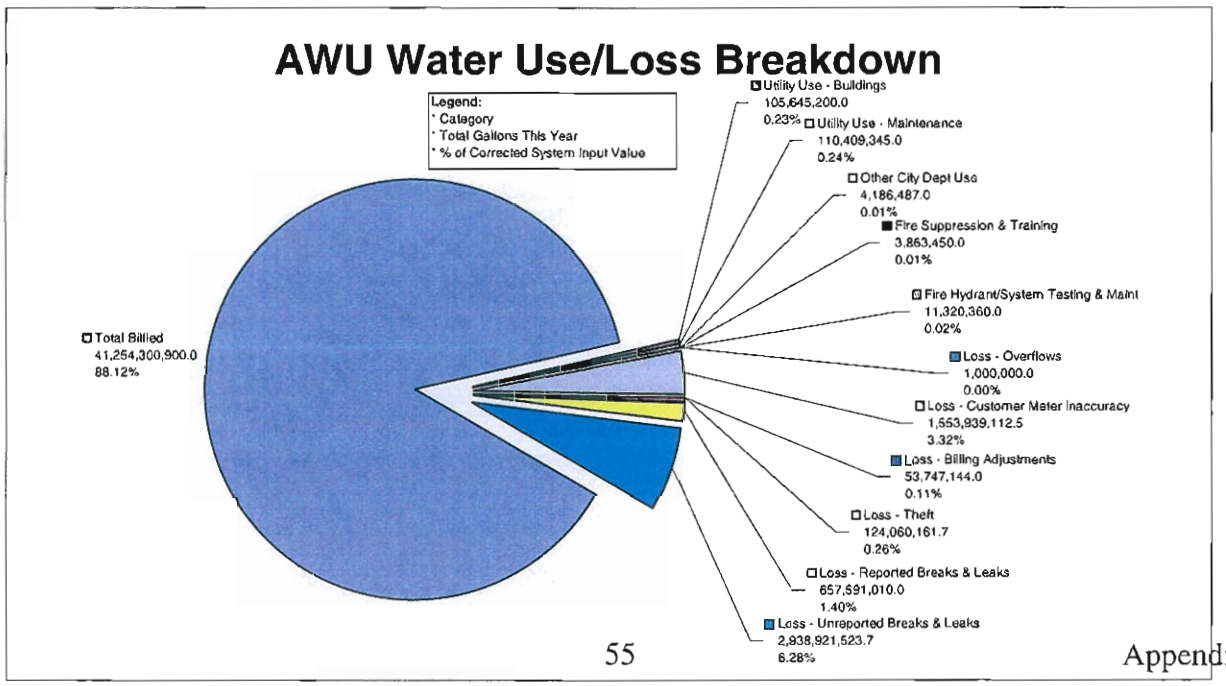
*** In case of water shortage, real losses might be valued at the retail price of water instead of the variable production cost.

LEGEND:

= calculated item

= reliability assessment required

ASSESSMENT VALUE SCORING:	
Data considered Preliminary; Do not benchmark to other Utilities or use for planning	< 40
Progressively greater validity of data; use for planning & developing targeted loss control efforts; sufficient validity to compare to similarly assessed data from other utilities.	40 to 70
Mature programs of "auditing" & loss control, data is reliable in guiding and tracking advanced programs in apparent and real loss control; performance tracking and benchmarking to other utilities can be carried out in a reliable manner.	70 to 85



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APPENDIX D

INTRODUCTION TO WATER LOSS CALCULATIONS SELECTED SECTIONS FROM THE MARCH 2008 TWDB WATER LOSS MANUAL

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Texas Water Development Board
Report 367

Water Loss Audit Manual for Texas Utilities

by
Mark Mathis
Texas Water Development Board

George Kunkel, P.E.
American Water Works Association
Water Loss Control Committee, Active Member

Andrew Chastain Howley
American Water Works Association
Water Loss Control Committee, Active Member

March 2008

TABLE OF CONTENTS

Executive Summary 1

1 Introduction 2

2 Implementing Water Audits as the Foundation of the Water Loss Control Program 3

3 Understanding the Water Audit Method 5
- 3.1 How Much are Losses Costing the Utility? 5
- 3.2 Performance Indicators 7

4 Validating and Interpreting the Water Audit Data 10
- 4.1 Indicating the Level of Validation 11
- 4.2 Interpreting and Comparing Water Audit Data 11

5 Using Bottom-up Activities to Better Validate the Water Audit Data 13
- 5.1 System Input Volume and Consumption 13
- 5.2 Apparent Losses 13
- 5.3 Real Losses 15
- 5.4 Active Leakage Control 15

6 Conclusion 17

7 References 18

8 Acknowledgments 18

LIST OF FIGURES AND TABLES

Figure 3.1 Water Balance 5

Table 3-1 Standard Definitions of the Water Audit Method 6

Table 3-2 International Water Association and American Water Works Association Water Audit Method—Performance Indicators 9

Appendix 1

Appendix 1.1 Water Audit Worksheet 21

Appendix 1.2 Water Audit Worksheet Instructions 25

Appendix 1.3 Guidance Matrix for Assigning Scores to Components of the Water Audit 30

Appendix 1.4 General Guidelines for Setting a Target Infrastructure Leakage Index 36

Appendix 2

Form A Leak Detection and Repair Field Guide 39

Form B Leak Detection Survey Daily Log 41

Form C Leak Repair Summary Report 43

Form D Line Flushing Report 45

Form E Water for Fire Fighting and Training 47

Appendix 2.1 Leak Rates from Holes of Known Sizes 49

Brochures, Services, and Leak Detection Equipment 50

Executive Summary

In 2003, the 78th Texas Legislature, Regular Session, enacted House Bill 3338 to help conserve the state's water resources by reducing water loss occurring in the systems of drinking water utilities. This statute requires that retail public utilities providing water within Texas file a standardized water audit once every five years with the Texas Water Development Board (TWDB). In response to the mandates of House Bill 3338, TWDB developed a water audit methodology for utilities that measures efficiency, encourages water accountability, quantifies water losses, and standardizes water loss reporting across the state.

The water audit worksheet developed by TWDB is comprised of data typically required for a water supply utility to conduct an internal "top-down" water audit approach, which is largely a desktop exercise gathering data and information from water consumption and loss reports already commonly compiled by many water utilities. However, utilities seeking to gain further efficiencies can perform additional field auditing tasks in a more comprehensive "bottom-up" manner. Bottom-up practices can determine more precisely where losses are occurring, thus better validating the accuracy of the water audit and guiding the utilities' strategies for loss control efforts. To assist water utilities in undertaking their top-down water audit, this manual provides guidance on the specific data and information that should be gathered to assemble a realistic assessment of water loss. *The most important step in the auditing process is to begin.*

This standardized approach to auditing water loss provides utilities with a reliable means to analyze their water loss performance. By reducing water loss, utilities can increase their efficiency, improve their financial status, minimize their need for additional water resources, and assist long-term water sustainability.

1 *Introduction*

Water is one of our most precious resources, yet within North America only a few states have begun to implement proactive water accountability policies for their utilities. Water auditing and loss control are emerging as significant conservation measures because as utilities minimize water loss, they increase their efficiency and reduce the need to search for additional water sources. For utilities to effectively identify losses in their systems, they must first employ water auditing as a routine business practice, using a method that has clearly defined terms and meaningful performance indicators. In recognizing the need for such a reliable method, the Water Loss Control Committee of the American Water Works Association adopted (AWWA, 2003) the method published by the International Water Association's Water Loss Task Force (Alegre and others, 2000). This methodology not only assists utilities in identifying where their losses are occurring, but also expresses by volume how much is lost and associates a cost to those losses. It also standardizes the water audit reporting process for water utilities.

The Texas Water Development Board (TWDB) water audit program begins with an examination of the water utility's business practices and procedures. It uses the terms from the International Water Association and American Water Works Association Water Audit Method (hence referred to as the Water Audit Method)—system input volume, authorized consumption, real and apparent loss—as well as the performance indicators included in this method. Since all water is essentially accounted for in this approach, the term "unaccounted-for" water is discouraged. The Water Audit Worksheet (Appendix 1.1) is the audit form developed by TWDB, based on the Water Audit Method. The approach defined in this manual also asks water utilities to assess the validity of the data that they enter into the water audit. A scale is provided for all components of water consumption and loss, assigning low assessment scores to data that are mere approximations and high assessment scores for components that are derived from well-calibrated meters or other well-substantiated means.

2 *Implementing Water Audits as the Foundation of the Water Loss Control Program*

For utilities to operate efficiently, they should use recommended practices to monitor and control water and revenue losses. These include active leakage control, as well as metering production flows and customer consumption. Consumption data serve as the basis for billing and revenue collection for most water utilities, but the data are also critical to water demand management. Customer billing systems, which are commonly used to archive customer account and consumption data, should be configured so that consumption volumes are not distorted by billing adjustments or inconsistent procedures. By correcting deficiencies in archiving customer consumption in billing systems, utilities can often recover significant uncaptured revenue. Today's water utilities can also use other advanced technologies, such as automatic meter reading technologies, Advanced Metering Infrastructure, Supervisory Control and Data Acquisition (SCADA) Systems, Geographic Information Systems (GIS), hydraulic modeling, and sophisticated leak detection technologies, such as leak correlators and leak noise loggers. Many of these technologies help reduce real loss, which saves water resources.

By using the above technologies, water utilities can address a variety of losses; however, the foundation of the water loss control program is the compilation of the water audit on a routine basis as a standard business practice. Water utilities should compile a regular water audit in a fashion similar to how an accounting firm routinely examines the finances of a business: by tracking volumes of water supplied by the water utility from source to customer, just as accountants track a firm's finances throughout its business path. The water audit quantifies production flows, customer consumption, and a number of different loss volumes and assigns costs to these volumes. Throughout the audit process, utilities determine specific areas of water loss, examine deficiencies in their overall performance, review current practices and procedures for developing data, and calculate the costs of water loss. The Water Audit Worksheet (Appendix 1.1) uses a standard set of terms and definitions so that all utilities in the state are measuring water loss in the same way. Because many water utilities historically used water accounting practices that fell short in accurately determining where losses occurred and how to recover lost revenues, the water audit provides a tool for systematically evaluating those losses. The methods included in this manual follow a standard, best management practice approach advocated by the American Water Works Association, and TWDB encourages all water utilities to implement this method. Although House Bill 3338 requires that water utilities file a water audit only once every five years, TWDB recommends that water utilities compile a water audit annually on the same business year frequency as the financial audits that many water utilities perform.

Water loss programs should be planned based upon validated water audit data. The self-assessment feature described in this publication guides water utilities in taking steps to first obtain sufficiently validated data before making important loss control program decisions on the data produced by the water audit. An internal top-down water audit approach is largely a desktop exercise gathering data and information from water consumption and loss reports already commonly compiled by many utilities. Once a water utility produces this top-down water audit with

sufficiently validated data, it can begin bottom-up field auditing activities to better validate the initial data. Bottom-up activities are longer term in nature and can be implemented incrementally over periods of months or years. These activities typically involve some investment, but the projected costs of these activities can be objectively weighed against the inherent costs of the losses, as detailed in the validated top-down water audit. In the long run, investment in bottom-up activities will likely save the utility from costly, ineffective programs that may not provide a substantial return on investment. Bottom-up practices are discussed in Chapter 5.

Utilities should use the Water Audit Worksheet to compile the top-down water audit. To assist in this process, TWDB has provided a worksheet designed as a software application for utilities to download to their computers, so they can continue to use the methodology.

3 *Understanding the Water Audit Method*

The Water Audit Method takes the approach that all water is accounted for and quantified as either a component of beneficial consumption or wasteful loss by measuring (metering) or estimating water quantities. Under this approach, no water is "unaccounted for," and this flawed term and the flawed indicator "unaccounted-for-water percentage" should be avoided. Figure 3.1 shows the Water Balance of the Water Audit Method. All quantities of water fit into one of the boxes of the water balance. The sum of the quantities of each column in the water balance is the same; hence, all quantities balance.

Standard terms and definitions that accompany the components shown in Figure 3.1 are given in Table 3-1, and TWDB recommends reviewing these definitions before filling out the Water Audit Worksheet.

3.1 HOW MUCH ARE LOSSES COSTING THE UTILITY?

All losses impart a cost impact to the water utility and the communities they serve. By accurately assessing where and how much water is being lost, utilities can determine how much water loss is costing. These costs can then be compared to potential investments in loss control activities to determine cost-benefit ratios for effective loss reduction. When water utilities reduce losses, they may also improve their financial bottom line. All component volumes of

<table>
<tr><td rowspan="7">Corrected input volume</td><td rowspan="5">Authorized consumption</td><td rowspan="2">Billed authorized consumption</td><td>Billed metered consumption</td><td rowspan="2">Revenue water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled authorized consumption</td><td>Unbilled metered consumption</td><td rowspan="9">Non-revenue Water</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="5">Water losses</td><td rowspan="3">Apparent losses</td><td>Unauthorized consumption</td></tr>
<tr><td>Customer meter under-registering</td></tr>
<tr><td>Billing adjustment and waivers</td></tr>
<tr><td rowspan="2">Wholesale water imported</td><td rowspan="4">Real losses</td><td>Reported leaks</td></tr>
<tr><td>Unreported loss</td></tr>
</table>

Figure 3.1. Water Balance

Table 3-1. Standard Definitions of the Water Audit Method

Definitions
System Input Volume: The total water supplied to the water distribution system, corrected for any error in the production meters. It includes the sum total of purchased surface or groundwater, water obtained through the utility's own wells, water purchased through contracted interconnections with other water suppliers, or water obtained from other sources. This is the total of all production meter readings for the entire audit year from all sources. • **Production Meter Accuracy**—All production and bulk purchase volumes should be metered. Meters should be well maintained and calibrated to ensure a high degree of accuracy. For any given water utility, one or more production meters may incur a degree of inaccuracy due to wear, malfunction, or improper installation. • **Corrected System Input Volume**—The level of production meter accuracy is usually a percentage. To calculate corrected system input volume, divide the system input volume by the percentage of accuracy to achieve the corrected system input volume—the volume actually placed into the distribution system. Since inaccurate meters often under-register, this number will usually be larger than the reported system input volume.
Authorized Consumption: This category consists of all water that has been authorized for use by the utility and its customers. Authorized consumption includes, but is not limited to, water used for residential and commercial uses, fire fighting, public fountains, golf courses, municipal landscape watering, line flushing, city offices, water treatment facility use, dust control, and construction practices. Authorized consumption is all the water the utility gave permission to a business, individual, or itself to use. It may be billed or unbilled, metered or unmetered. • **Billed Metered**—Water that is appropriately metered and billed. • **Billed Unmetered**—Estimated water that has been sold but not metered; for example, dust-control trucks and types of businesses using authorized water drawn from fire hydrants or other unmetered uses. • **Unbilled Metered**—Water that is metered but not billed, such as city/government offices, city park irrigation, water treatment facility use, some fire department use, and line flushing. • **Unbilled Unmetered**— Estimated water that is not billed or metered, such as most line flushing (see Form D in Appendix 2). Estimations may also be entered for this category. Installing meters on any of the sources of significant unmetered water represents bottom-up activity to improve the accuracy of the top-down water audit and better manage these water uses.
Water Losses: This is derived by subtracting authorized consumption from corrected system input volume. Water losses exist in two major classifications: apparent losses and real losses. Both are considered types of water loss. Apparent loss is valued at the customer retail rate because it had the opportunity to be sold. Real loss, however, is calculated at the variable production cost of water. • **Apparent Losses**—These are "paper" losses that occur when water reaches a customer, but the volume is not accurately measured and/or recorded due to customer meter inaccuracy, systematic data handling discrepancies, or unauthorized consumption. Apparent loss is water that has been consumed but not paid for due to error in quantifying the volume of water. These losses cost water utilities revenue and understate the collective measure of customer consumption in the water utility's service area. Valued at the customer retail (revenue) rate, these losses are often very cost effective to recover. • **Real Losses**—These are the "physical" losses, largely leakage, from the infrastructure: mains, valves, service lines, and tank overflows. Leakage occurrences are categorized as "reported" (visible) events or "unreported" (nonvisible—found only by active leak detection) events. Real losses occur prior to reaching customers and effectively force the water utility to treat and deliver more water than its customer population actually requires. These losses are typically valued at the variable production rate (costs for water treatment, pumping, or bulk water purchase); however, if the utility is experiencing a water shortage, then real losses may be valued at the customer retail rate because recovered leakage could be viewed as water that can be sold to customers.
Revenue Water: Revenue water consists of billed wholesale water exported and billed metered and unmetered water. These are usually the primary categories through which the utility can generate revenue.
Non-revenue Water: This term is the sum of apparent loss, real loss, and unbilled authorized consumption. Non-revenue water is clearly defined as all water for which no revenue is received.

non-revenue water (unbilled authorized consumption, apparent loss, and real loss) should be assigned a cost value.[1]

Apparent losses differ from real losses in the manner in which they occur but, perhaps more dramatically, in the financial impact that they impart to the water utility. Apparent losses occur when water has reached the customer, but by not accurately recording the consumption, a portion of the revenue is not captured. Apparent losses are, therefore, valued at the customer retail rate. Water utilities often use rate structures with different rates for different customer classes, such as residential and industrial, and for different tiers of water consumption. For purposes of simplicity in compiling the water audit, utilities can use a single, composite rate for all customer classes to determine the cost impact of apparent losses.

Real losses cause a portion of the treated, pressurized water to be lost from the distribution system before customer use. In effect, the utility treats a greater volume than its customer base requires, hence incurring excess production costs. The cost for real losses is, therefore, typically valued at the variable production cost and/or the purchase cost of imported bulk water supply. The variable production cost is defined as the cost of raw water, electricity to treat and distribute water, and chemicals to treat the water for the year. One way to calculate the variable production cost is to divide the sum of the raw water, energy, and chemical costs by the corrected input volume. In cases of water shortage where any real loss reduction results in additional customer sales, then the real losses should be valued at the customer retail rate.

1 When compiling the water audit, utilities should use consistent volume units throughout the audit. Often water utilities measure their water supply in one unit (for example, gallons) and their customer consumption in another unit (for example, cubic feet). Typically, the customer consumption values must be converted to align with the units of measurement for the water supplied

3.2 PERFORMANCE INDICATORS

The water audit method features a number of performance indicators that allow water utilities to reliably assess their water loss standing and track their performance. The performance indicators are designed specifically to

- track the water utility's progress on a year-to-year basis,
- set performance targets, and
- benchmark performance with other water utilities.

The complete list of performance indicators is shown in Table 3-2. The indicators are categorized as operational or financial in nature. The level of detail they project is also identified as 1) basic level indicators, 2) intermediate indicators, and 3) detailed indicators. An array of operational performance indicators exists—one for apparent losses and four for real losses. The operational performance indicators are well suited to evaluate operational efficiency, track progress, and benchmark with other water utilities. Also shown are financial performance indicators included in the International Water Association and American Water Works Association Water Audit Method, including non-revenue water by volume and non-revenue water by cost.

Water utilities can track their performance in controlling apparent losses by using the apparent loss indicator (Op23), which reflects the volume of apparent losses quantified in the water audit, normalized by dividing this volume by the number of service connections per day.

For real losses, the water utility can likewise track performance using two normalized indicators of real losses (Op24). Dividing the quantity of real losses from the water audit by the number of service connections (or miles of pipe for low density systems) per day gives the Op24 indicator. A second variation of this indicator can also be calculated by dividing the result by the

average pressure across the system. These performance indicators are good for setting specific leakage reduction targets and tracking performance.

The unavoidable annual real losses are another performance indicator. These losses are a theoretical reference for low-level leakage that recognizes even the best maintained water distribution systems in the world have some leakage. Unavoidable annual real losses are calculated from the equation in Table 3-2 by using the most influential factors in system leakage: length of piping in the water distribution system, number of customer service connections, and average system pressure. Note that age of the piping is not an influential factor.

The primary performance indicator used for comparing performance with other water utilities (benchmarking) is the infrastructure leakage index. This index provides utility managers with the ability to weigh leakage efficiency relative to the ideal low level that might exist in the water utility (Appendix 1.4). The Water Loss Control Committee of the American Water Works Association also gives guidelines for using the infrastructure leakage index as a preliminary leakage reduction target-setting tool.

The index takes into account system-specific attributes, including the length of mains, number of customer service connections, and average pressure; therefore, leakage efficiency can be compared among water utilities in an objective manner. This avoids a "one size fits all" approach to target setting. The infrastructure leakage index is the ratio of the real loss volume from the water audit over the level of unavoidable annual real losses as calculated for each system using the equation shown in Table 3-2 (Op25). As a ratio, the lower the value of the infrastructure leakage index, the closer the actual level of real losses is to the unavoidable annual real losses. The index represents how efficiently the system's infrastructure upkeep, leakage management, and repair activities are operating at the current pressure, with a validated low infrastructure leakage index value implying that the utility is very efficient.

Table 3-2. International Water Association and American Water Works Association Water Audit Method—Performance Indicators

Function	Level*	Code*	Performance Indicator	Comments
Operational: Apparent losses	1 Basic	Op23	[gallons/service connection/day]	Basic but meaningful performance indicator for apparent losses. Easy to calculate once apparent losses are quantified.
Operational: Real losses	1 Basic	Op24	[gallons/service connection/day] or [gallons/mile of mains/day] (only if service connection density is less than 32/mile)	Best of the simple "traditional" performance indicators. Useful for target setting. Limited use for comparisons between systems.
Operational: Real losses	2 Intermediate	Op24	[gallons/service connection/day/pressure] or [gallons/mile of mains/day/pressure] (only if service connection density is < 32/mile)	Easy to calculate this indicator if the infrastructure leakage index is not yet known. Useful for comparisons between systems.
Operational: Unavoidable annual real losses	3 Detailed	UARL[a]	UARL (gallons) = (5.41Lm + 0.15Nc) x P, (Eq. 1) where Lm = length of water mains, miles Nc = number of service connections P = average pressure in the system	A theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. A key variable in calculating the infrastructure leakage index. The calculation for unavoidable annual real losses is not valid for systems with less than 3,000 service connections.
Operational: Real losses	3 Detailed	Op25	Infrastructure leakage index (dimensionless) = Real loss volume/UARL[a]	Ratio of real loss volume to unavoidable annual real losses). Best indicator for comparisons between systems.
Financial: Non-revenue water by volume	1 Basic	Fi36	Volume of non-revenue water as % of corrected system input volume	Easily calculated from the water balance. Has limited value in high-level, financial terms only. Misleading to use this as a measure of operational efficiency.
Financial: Non-revenue water by cost	3 Detailed	Fi37	Value of non-revenue water as a percentage of the annual cost of running the system	Incorporates different unit costs for non-revenue components. Good financial indicator. These costs include operations, maintenance, and any annually incurred costs for long-term upkeep of the system, such as repaying capital bonds 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. These costs should not include any costs to operate wastewater, biosolids, or other systems outside of drinking water.

* Descriptors assigned to the performance indicators from Alegre and others (2000).
[a]UARL=unavoidable annual real losses

4 *Validating and Interpreting the Water Audit Data*

Assembling a basic top-down water audit is the first step a water utility should take to establish accountability and manage water and revenue losses. The main advantage of the top-down approach is that it is relatively quick, using existing data from records routinely compiled by most water utilities and estimates for components where data do not exist. The top-down approach allows the water utility to get the process started.

The drawback to the top-down approach, particularly for the first time auditor, is that some of the data may be of suspect quality or estimates may be relatively crude. In such cases, utilities should interpret the validity of the water audit results cautiously. If many of the water audit quantities are derived from estimates, new data collection procedures and/or bottom-up field activities should ultimately be instituted over the course of time to generate more accurate and realistic data that better validate the water audit results and lead to better loss control program decisions.

Validation is defined as the process by which water audit data is confirmed to reflect the actual operating conditions of the water utility within a reasonable degree of accuracy. Water is indestructible; it can be neither created nor destroyed. Therefore, the quantities in the Water Balance (Figure 3.1) *must* balance, with each column adding to the same amount. All of the water managed by a utility can be assigned to the components shown in the balance, but it is frequently difficult to ascertain how accurate the quantities are in each of the boxes. Often some of the data, such as billed metered consumption, is very accurate because it is usually derived from customer meter data. However, other components, such as unauthorized consumption, may be much less valid if the water utility has not collected data from individual investigations of unauthorized consumption, instead merely entering an estimate or "best guess" for this quantity. For most utilities, some of the components of the water audit have data that are more accurate, or "valid," than other data. Since the sum of each column has to balance, overestimating one component means one or more of the other components are underestimated. But which components are over- or understated and by how much?

Another uncertainty in the top-down Water Audit Method is the unreported leaks. It is quantified as a "catch-all" component, meaning that the volume of real losses is the quantity that remains after authorized consumption, apparent losses, and reported leakage have been subtracted from the corrected input volume. Although this approach allows the top-down audit to be completed quickly, it results in assigning to unreported loss the collective inaccuracies in quantifying authorized consumption, apparent losses, and reported leakage. As a consequence

1) understating the quantity of authorized consumption, apparent losses, and reported leakage effectively overstates the volume of unreported loss; and

2) overstating the quantity of authorized consumption, apparent losses, and reported leakage effectively understates the volume of unreported loss.

Although the audit worksheet does not require a breakdown of leakage rates between leaks on water mains, leaks on customer services, or tank overflows, it is good practice if records are kept to this level of detail.

The reason that unreported loss is quantified in a "catch-all" method is that a true assessment of all leakage occurring in a distribution system often requires extensive bottom-up work to quan-

tify, which is beyond the scope of the top-down intentions expressed in this publication.

4.1 INDICATING THE LEVEL OF VALIDATION

Since this publication's Water Audit Method uses a top-down approach for expediency, it is important for utilities to not only obtain the results of the water audit, but also a sense of how reliable, or valid, their data are. In order to rate the degree of validity, a scale is included on the worksheet to allow water utilities to assess the various components of the water audit. A composite is then calculated to represent the relative degree of validity of the water audit results.

An assessment table (Appendix 1.3) has been developed using a 1-5 scale for the assignable components of the water audit. A score of 1 represents the lowest degree of certainty of a component. A purely arbitrary estimate of unauthorized consumption that amounts to a "rough guess" is an example of a component that should be assessed with a 1. Conversely, a score of 5 indicates a high degree of accuracy, an example of which might be system input volume derived from measured data gathered from current model, well-calibrated production meters and reliable data management. Assessments of 2, 3, and 4 represent incrementally greater levels of accuracy or validity of the data.

In the drinking water industry, a high level of data accuracy is achieved typically by

- metering water quantities to the greatest extent possible;
- accurately cataloging metered flow data in a billing system or other database; and
- conducting regular maintenance or auditing functions, such as meter testing and calibration, and audits of billing records to detect unauthorized consumption from meter tampering, or similar activities.

Water utilities that carry out all three levels of scrutiny for a given component should assign a high degree of validation to their quantities in the water audit. Systems that perform none of these activities for a given component have poor validity; hence, an assessment of 1 would apply.

Not all components of the water audit can be feasibly metered. Metering production flows and customer consumption is recommended as a minimum. In the absence of meters, estimates must be used.

Water utilities can improve the validity of their water audit data incrementally over time by instituting improvements that raise their scores. If production sources are unmetered, installing meters is a major step to move the utility from low validity to a higher validity. Improvements such as this can be identified from the recommendations listed in Appendix 1.3. A water audit should be compiled annually on the utility's business year frequency and improvements in data validity be incorporated incrementally over time.

4.2 INTERPRETING AND COMPARING WATER AUDIT DATA

The validity assessments on the Water Audit Worksheet are also used to calculate a composite for the entire water audit based on a scale of 85. This composite rates the level of validation for the water audit.

If a water utility is conducting a water audit for the first time and has a collective validation score of less than 40, then the results of the water audit should be viewed as preliminary, and the water utility should begin to carry out activities that improve the validation of the water audit. Improving the measured data from the system's production meters is the recommended starting point. Since

data from water audits with a composite at 40 or less are viewed as preliminary, this data should not be benchmarked with other utilities. Likewise, it would be premature to design long-term loss reduction programs and targets on such preliminary data. The water audit data can be best used for tracking performance within the water utility from year to year, until the validity of the water audit is upgraded.

A composite between 40 and 70 represents progressively greater validity in the water audit data. Utilities with assessments in this range can place greater faith in the water audit results, which can be reliably used for planning and developing targeted loss control efforts. Water audits in this range have sufficient validity so that their data can be compared with data from similarly assessed water audits of other water utilities. This also opens the door for performance benchmarking. The utility should continue to address lower assessments in any individual components of the water audit by upgrading procedures or practices in order to improve validation in these areas.

Water audits with an assessment between 70 and 85 reflect mature programs of auditing and loss control with a high level of confidence in the water audit results. Data from these water audits are highly reliable in guiding and tracking advanced programs in apparent and real loss control. Performance tracking within the water utility and benchmarking with similar water audits can be carried out in a reliable manner.

The validation of water audits is an important tool necessary for distinguishing data that are preliminary and approximate in nature versus data that are refined and accurate. The best actions for water utilities to take to improve their water accountability depend to a large degree on the level of validity of their water audit. Appendix 1.3 provides "improvement" guidance for each component in the water audit to allow water utilities to determine the next step to a higher level of validity.

5 *Using Bottom-up Activities to Better Validate the Water Audit Data*

Once water utilities have completed a preliminary, top-down water audit, they will have at least a general assessment of the level of apparent and real loss occurring. If the composite validation of the water audit is below 40, the utility should seek bottom-up activities in those specific audit components that have low scores of 2 or less. If the composite is higher, the utility can seek bottom-up activities that control the larger components of loss. Below are brief descriptions of the most important validation and bottom-up activities that utilities can undertake. (See Appendix 1.3 for additional information.)

5.1 SYSTEM INPUT VOLUME AND CONSUMPTION

5.1.1 Production and Wholesale Meters

Production and wholesale meters measure the large bulk supply volumes, such as source water or purchased water. The collective water from all such meters is entered into the Water Audit Worksheet as the first number under system input volume (line 12). Any notable degree of error in this quantity carries throughout the entire worksheet and can have an unduly negative influence on the accuracy of the water audit. Production and wholesale meters should be current, well calibrated, and continuously monitored, with measured data stored in a reliable billing system or database. Calibrating these meters is relatively inexpensive since they are typically few in number.

5.1.2 Customer Metering for Reliable Billed Consumption Data

The American Water Works Association recommends that water utilities meter all water withdrawn from their distribution system at the customer's point of service. Water utilities that do not meter their customers should seek to establish metering along with billing based upon consumed volumes of water. Billed metered and unbilled metered consumption can then be reliably derived.

5.1.3 Unmetered Consumption

Although utilities should strive to meter all customer consumption, some volume of water will always be withdrawn from the distribution system in unmetered fashion. Water used for fire fighting is a prime example, as well as water taken from fire hydrants for distribution system maintenance and testing. These uses can be metered to the extent possible; however, on an annual basis the total water used as unbilled authorized consumption is usually small. The utility should assign this component secondary priority for bottom-up assessments unless there is a very strong reason to believe that large, continuous uses of water are being consumed in unmetered fashion. In that case, the utility should launch a bottom-up investigation to confirm the existence and quantity of such use.

5.2 APPARENT LOSSES

5.2.1 Customer Meter Accuracy

Standard customer meters used in the United States are generally highly accurate and reliable, with long service lives, some over 20 years. Even with proper sizing and installation all meters will eventually lose accuracy and under-

register flow at a rate influenced by the amount of cumulative consumption passed through the meter. Chemically aggressive water may also shorten the lifespan of meter accuracy. Water utilities should monitor the demographics of their customer meter population (for example, age, size, and number) and perform testing on random and targeted samples of customer meters on a periodic basis to project when the limits of acceptable accuracy are expected to be reached. Irrigation meters and commercial meters should be tested first because these meters usually generate the majority of the revenue for the utility. In this way, a high level of accuracy will be ensured throughout the meter population.

5.2.2
Systematic Data Handling Error in Customer Billing Systems

Customer water meters generate readings that allow a water utility to measure the amount of water consumption occurring in a given period of time. However, the meter reading must be accurately transmitted and stored to a proper database, typically a customer billing system. Systematic and random errors can occur in the data transfer and archiving process. For example, when meters are read by humans, numbers can be transposed or viewed incorrectly. A fast-growing number of water utilities have installed automatic meter reading technologies to better allocate human resources, improve safety, and reduce data transfer error in the customer meter reading process. This progressive technology also improves customer service by reducing billing errors related to the above problems.

Most water utilities store customer consumption data in a customer billing system. Although such systems are designed for financial (billing) purposes, they have also become the de facto operational database for tracking customer usage patterns. Many billing systems have incorporated data adjustment and estimate procedures in order to address the variety of billing issues that occur. Unfortunately, sometimes these procedures unduly modify the consumption values in the process of making financial adjustments. An example is a billing routine that generates a credit to a customer by artificially reducing consumption. Although such a routine achieves the desired billing result, it distorts the measure of customer consumption. Utilities should analyze the information flow path in the billing system by flowcharting the process. Such an exercise can often reveal procedures that result in consumption values being understated. Fortunately, such issues are often easily corrected by relatively minor procedural and/or programming changes.

5.2.3
Unauthorized Consumption

There is a certain percentage of any population that will maliciously seek to obtain water service without paying for it. Typical examples include taking water illegally from fire hydrants, tampering with customer meters or meter reading equipment, and illegally tapping into service connections or fire service lines. There are limitless ways to take water in an unauthorized fashion, and every water utility should have in place at least minimal policies and safeguards to thwart, detect, and abate unauthorized consumption. For most systems, the total water lost to unauthorized consumption is small relative to the system input volume, and an approximate estimate should be used in the top-down water audit. Bottom-up activities should include examination of billing data for suspicious consumption patterns (successive periods of zero or lower than average consumption, for example) and follow-up investigation of individual customer properties to confirm evidence of tampering or similar illegal activity. Enforcement policies may need to be strengthened if pat-

terns of unauthorized consumption are chronic and widespread. Such policies could include service discontinuance and criminal judgments.

5.3
REAL LOSSES

All water utilities incur leakage losses; only the amount varies. Leaks and most visible main breaks occur for a variety of reasons, including poor installation workmanship or materials, corrosion, external forces, environmental extremes, and other causes. Leakage is always occurring, and only grows worse if left unchecked. Therefore, all water utilities should provide system maintenance and upkeep functions that include appropriate components of leakage management: active leakage control, timely quality repair, water main rehabilitation, and pressure management.

5.4
ACTIVE LEAKAGE CONTROL

Active leakage control is defined as any water utility program that proactively seeks nonvisible leakage. The most typical functions of active leakage control are routine leak detection surveys and the use of minimum hour flow measurement in District Metered Areas or pressure zones. District Metered Areas are zones or metered areas created within the distribution system to isolate flow to monitor water loss. Large meters are installed on the main lines, and with the aid of "radio read" or similar automated meter technology, the utility is able to compare customer usage to the actual main line flow meter. Although this effort will not pinpoint leaks, it will aid utilities in locating high loss sections so they can begin leak detection surveys with more accuracy.

Leaks and water main breaks that surface and are visible are defined as "reported' since they usually come to the water utility's attention by a report from a customer, police, or other citizen. Most water utilities are effective in addressing reported leaks since these events represent emergency or nuisance conditions. These leaks are addressed quickly so the duration of the leak event is short and volume of water lost is relatively small, even if the leak is spraying at a high rate of flow. Unfortunately, many water utilities respond only to reported leaks and operate no active leakage control programs to identify and control unreported leaks. Unreported leaks usually account for the majority of annual real loss volumes in most water utilities because they are numerous and run undetected for long periods of time. All water utilities should operate an active leakage control program, even if this involves conducting a leak detection survey once every several years. Utilities with extensive and/or aging water distribution systems should operate an ongoing program, with constant leak detection and possible use of District Metered Areas to monitor flows closely and respond to new leakage shortly after it arises. Even for systems that have a good active leakage control program, it is likely that a portion of the leakage will go undetected and, thus, unreported. This volume and the background leakage are collectively labeled "unreported loss" in the Water Audit Worksheet. The top-down Water Audit Method (Appendix 1.1) quantifies unreported loss as a "catch-all" component, meaning that this volume of real losses is the quantity that remains after authorized consumption, apparent losses, and reported leakage have been subtracted from the system input volume.

5.4.1
Timely, Quality Leak Repair Policies and Functions

This practice appears to be straightforward: once a leak or break is known to the water utility, respond quickly and make the repair. This function, however, can be more complicated than it seems. On some occasions, utilities use a "band-aid" repair approach that does not identify the underlying cause

of the failure and execute a repair that addresses that root cause. Unfortunately, many leaks occur at the site of previous repairs. Utility policy also plays a role in repair functions. When water utilities play a stronger role in customer service connection leak repairs, leak run time is usually reduced and quality repairs are implemented. Water utility managers should review their leak repair practices and look for ways to ensure that timely, quality repairs are implemented.

5.4.2
Water Main Rehabilitation and Replacement

All infrastructure eventually reaches the limits of its useful service life and must be renewed or replaced. This holds true for water infrastructure, such as pumps, pipelines, valves, hydrants, and appurtenances. In order to capture as much of the original investment in an asset as possible, most utilities want to ensure that the asset remains in service for its entire life. This is achieved by proper maintenance, such as that provided by active leakage control programs and timely repair efforts. At the time in which a water asset reaches the end of its useful life, a number of different options exist. Historically, water utilities relied upon outright replacement as the sole option once an asset reached this stage. Although replacement is the most comprehensive means of renewing an asset, it is also the most expensive option and often requires considerable disruption, such as full trench excavation to replace pipelines. More recently, "trenchless" technologies are providing means to renew pipeline assets without as much above-ground disruption and sometimes at lesser cost than full pipe replacement. All water utilities should have in place a capital program to renew water infrastructure as needed. This program should take into account the variety of options that can efficiently and economically maintain infrastructure integrity.

5.4.3
Pressure Management

Because more water is lost under high pressure conditions than low pressure, pressure management is a recent innovation that strives to reduce water loss. Where appropriate, it reduces excessive background leakage, inhibits the growth of new leakage, and limits the risk of breaks due to pressure transients. Evaluations of water distribution systems across the world have found that 1) many water utilities operate systems with very high pressure; and 2) in many systems, the condition of the piping makes the infrastructure very susceptible to high pressure, particularly poor infrastructure, plastic pipe, and poor service connection piping. Regarding the former, many water utilities have not set realistic upper limits for operating pressures. Additionally, in many distribution systems, pressure may rise during night or minimum consumption hours when customer demand drops. Conversely, when customer consumption is high during the day, pressure drops. Pressure management schemes now exist to regulate night or minimum consumption periods to reduce pressure and save water lost to leakage. During the high demand daytime periods, pressures rise to provide sufficient volume to meet demand. Not all water utilities operate with excessive pressure or have strong pressure management potential. However, all water utilities should understand the range of pressures within their water distribution system, including the occurrence of pressure transients, to judge the feasibility of pressure management to reduce leakage and sustain infrastructure.

6 *Conclusion*

As water utilities incorporate routine water audits as part of their standard business practices, they can expect to become more efficient by focusing on problem areas that were identified in the top-down audits. With decreasing water availability and rising costs for water treatment or purchase, auditing water supplies is essential for water utilities to ensure efficiency in their operations and preserve water resources.

The water audit method featured in this manual is designed to guide water utilities in identifying and quantifying components of water supply, customer consumption, and loss, so they can effectively focus their resources on priority areas of water loss. By implementing appropriate water management programs, these water utilities can extend existing supply resources and minimize the search for additional water resources to supply growing populations.

With routine water auditing and targeted loss control efforts, water utilities can anticipate incremental drops in water loss each year. As with any business plan, it may take several years for utilities to begin to see the effects of implementing this water loss management program. Therefore, goals can be long term but certainly achievable.

Appendix 1.3

Guidance Matrix for Assigning Scores to Components of the Water Audit

COMPONENT	ASSESSMENT TABLE				
SYSTEM DATA	1	2	3	4	5
Length of mains	Estimates only	Paper records in poor condition (no totals from year to year)	Good annual paper records	Electronic records and asset management system in good condition; includes system backup	GIS data and asset management database in agreement; random field checks validate databases
Improvements in quantifying the length of mains	Research and collect paper records for a number of years prior to audit year	Improve to include all totals for at least five years prior to audit year	Convert to electronic databases with backup	Link GIS and asset management databases; conduct field verification of data	Continue with standardization and random field validation to improve knowledge of system
Average operating pressure	Estimates only	Random pressure testing and averaging	Pressure testing through system standardized on annual basis	Combine pressure testing to calibrate hydraulic model to develop average system pressure	District testing and averaging matching data from hydraulic model
Improvements in quantifying the average operating pressure	Develop total system pressure by averaging known pressure from hydrant and random pressure tests	Improve standardization of pressure testing and recording	Analyze SCADA pressure data and assess average system pressure through hydraulic network modeling	Conduct standardized pressure testing as part of calibration process for developing hydraulic model	Continue with standardization and random field validation to improve knowledge of system; refine hydraulic model
System Data					**10**
WATER SUPPLIED	1	2	3	4	5
Volume from own sources	No meters; volume quantified by estimates only	Partially metered; several supply sources metered but not all	Fully metered; no regular testing or calibration of meters	Fully metered; partial testing or electronic calibration; no meters greater than 15 years old	Fully metered; annual electronic calibration and flow testing; no meters greater than 15 years old
Improvements in quantifying volume from own sources	Install meters	Complete 100% metering	Initiate testing of meters	Reduce age of meters unless able to prove accuracy of all old meters through flow testing	No new work; standardize calibration, testing, and replacement to ensure this high level of service continues

Appendix 1.3 continued

Production meter accuracy	No testing of production meters; estimated adjustment used only as needed	Testing of production meters only where problems suspected	Systematic testing of meters; underperforming meters not always replaced	Systematic testing of all meters within at least a five-year cycle; all meters over standards replaced or repaired and retested	Testing of all production meters conducted in year of audit; replacement of all meters outside standard accuracy range
Improvements to master meter error adjustment	Start testing program	Develop systematic testing program	Replace or repair all non-standard meters	Test all production meters annually; repair or replace all underperforming meters	No new work; standardize calibration, testing, and replacement to ensure this high level of service continues
Water imported	No meters; volume quantified by estimates only	Partially metered; several supply sources metered but not all	Fully metered; no regular testing or calibration of meters	Fully metered; partial testing or electronic calibration; no meters greater than 15 years old	Fully metered; annual electronic calibration and flow testing; no meters greater than 15 years old
Improvements in quantifying volume of water imported	Install meters	Complete 100% metering	Initiate testing of meters	Reduce age of meters unless able to prove accuracy of all old meters through flow testing	No new work; standardize calibration, testing, and replacement to maintain this high level of service
Water exported	No meters; volume quantified by estimates only	Partially metered; several interconnections metered but not all	Fully metered; no regular testing or calibration	Fully metered; partial testing or electronic calibration; no meters greater than 15 years old	Fully metered; annual electronic calibration and flow testing; no meters greater than 15 years old
Improvements in quantifying volume of water exported	Install meters	Complete 100% metering	Initiate testing of meters	Reduce age of meters unless able to prove accuracy of all old meters through flow testing	No new work; standardize calibration, testing, and replacement to ensure this high level of service continues
Water Supplied					**20**
AUTHORIZED CONSUMPTION	**1**	**2**	**3**	**4**	**5**
Billed metered	No consumption data gathered; flat or fixed rate in use only	Manual meter reads and billings; no regular audits of customer billing data	Automated billing system; no annual checks of data	Automated meter reading and billing system; internally checked or checked by third party on less than annual basis	Automated meter reading and billing system audited by third party on annual basis
Improvements in quantifying volume of billed metered consumption	Start meter reading and volume-based billing; plan computerized billing system	Develop computerized billing system; consider automatic meter reading	Conduct internal checks of billing data; install automatic meter reading	Conduct third-party audit of billed data	Continue and standardize program

Appendix 1.3 continued

Billed unmetered	Estimates of consumption used	Production meters used to determine consumption; all areas not monitored	Production meters used to determine consumption; all areas monitored	District meters (each 3,000 or fewer connections) used to determine consumption; No total coverage; rest use production meters	District meters (each covers 3,000 connections or less) throughout system used to determine consumption
Improvements in quantifying volume of billed unmetered consumption	Develop methods to meter at a higher level (production or district level)	Improve level of monitoring to all areas or consider metering any unmetered accounts	Reduce size of monitored areas or meter unmetered accounts	Reduce size of monitored areas and standardize system analysis, or meter unmetered accounts	Continue and standardize program; all customers who can feasibly be metered are metered
Unbilled metered	No testing; estimates only	Testing only where problems suspected	Systematic testing of all meters; underperforming meters not always replaced	Systematic testing of all meters within at least a five-year cycle; all meters over standards replaced or repaired and retested	Testing of all production meters conducted in year of audit; replacement of all meters outside standard accuracy range
Improvements in quantifying volume of unbilled metered consumption	Start testing program and regular meter readings	Develop systematic testing program; consider automatic meter reading	Replace or repair all non-standard meters; install automatic meter reading	Test all meters annually; repair or replace all underperforming meters	No new work; standardize calibration, testing, and replacement to ensure this high level of service continues
Unbilled unmetered	Overall estimates throughout system	Partial estimates for some of variables; basic estimates for others	Estimates using formulae (for example, time x gallons per flush) for known events	Partial estimates using test data; other estimates using formulae from known number of events	Estimates using previous metered testing to determine overall estimated values
Improvements in quantifying volume of unbilled unmetered consumption	Develop estimates for various unbilled metered events; use default of 1.25% of input volume; change to metered values	Record number of events and develop standard formula for calculating volume, or change to metered values	Conduct test studies of defined duration to determine actual versus estimated volumes, or change to metered values	Conduct test studies on all variables to determine actual versus estimated volumes, or change to metered values	Change to metered values; use of diffuser to accurately determine flushing volume
Authorized Consumption					**20**

Appendix 1.3 continued

APPARENT LOSSES	1	2	3	4	5
Average customer meter accuracy	No testing or replacement; estimates only	Testing or replacement of 1 to 5% of meters in year of audit	Analysis of test data finds meters meeting specs, or testing or replacement of 5 to 10% of meters per year	Previous test data analyzed and all meters in specifications, or testing or replacement of 10 to 50% of meters in year of audit	Previous test data analyzed and all meters in specifications, or testing or replacement of over 50% of meters in year of audit
Improvements in quantifying loss due to customer meter inaccuracies	Conduct testing regime on small number of meters targeted to suspected problem areas such as meter age or type	Standardize testing and test or replace 5 to 10% of meters; consider increasing number of meters tested or replaced after review of test data	Consider increasing number of meters tested or replaced after review of test data	Consider increasing number of meters tested or replaced after review of test data	Consider increasing number of meters tested or replaced after review of test data
Systematic data handling discrepancy	No review of billing system	Automated system but no checks of data validity	Automated system; less than annual checks of data	Automated system; internally checked on at least annual basis	Assessment of data handling errors conducted internally and audited by third party on annual basis
Improvements in quantifying losses due to systematic data handling error	Conduct internal review of meter reading and billing systems	Conduct internal checks on data validity and meter reading procedures	Conduct annual internal checks of billing data	Conduct third party audit of billed data with specific review of possible data handling and meter reading errors	Continue and standardize program
Unauthorized consumption	Arbitrary volume estimates	Default of 0.25% of input volume	Number of events of each type evaluated; multiply by estimated gallons lost per event	Number of occurrences evaluated; monitoring and enforcement program started	Monitoring and enforcement program well established with analyzed losses less than 0.25% and declining from previous years
Improvements in quantifying volume of unauthorized consumption	Develop estimates for likely major incidents of unauthorized consumption; use default of 0.25% of input volume	Evaluate number of occurrences of each of major incidents of unauthorized consumption	Identify losses and aim to reduce; audit areas of suspected losses; examine policy and procedures for gaps allowing fraud	Put in place a monitoring and enforcement plan to show reductions in water lost; implement improved policy and procedures for better policing	Continue with monitoring and enforcement program; review at least annually; consider new regulations to thwart specific incidents of unauthorized consumption
Apparent Losses					**15**

Appendix 1.3 continued

REAL LOSSES	1	2	3	4	5
Reported leaks	Arbitrary estimates; repairs of reported leaks and breaks not documented	Only visual leaks and breaks from customer calls fixed; no known duration before fixing; cursory records	Visual leaks and breaks reported by customers and city staff; call-to-repair times known (greater than one week average); good records	Visual leaks and breaks reported by customers and city staff; call-to-repair times average less than one week; computerized maintenance management system used to document leak repair trends	Visual leaks and breaks reported by customers and city staff; call-to-repair times average less than two days; outstanding computer maintenance records track system deficiencies and repair crew performance
Improvements in quantifying reported leaks	Report leaks and breaks and develop standards to find, repair, and document leaks and breaks	Standardize recording of leak location and repair data	Continue to standardize recordkeeping process; plan computerized maintenance management system; cut average leak run time to less than one week	Implement computerized maintenance management system to document repairs; reduce leak run time average to less than two days; plan proactive leak detection	Use capabilities of computerized maintenance management system to track failure trends in distribution system and repair crew activity costs; conduct proactive leak detection
Unreported loss	If no active leakage control activities exist, unreported leaks are undetected and quantity is zero	Limited leak detection using basic sounding performed for a portion of the distribution system; no detailed records/ database	Proactive leak detection using basic sounding, correlation, and detailed leak detection records; one or more District Metered Areas in use	Proactive leak detection using basic sounding, correlation, flow monitoring, and detailed leak detection and asset condition records; detailed component analysis results	Fully integrated flow monitoring and leak detection program with continuous reporting and analysis of system leakage; integration with asset management, GIS, and economic level of leakage
Improvements in quantifying unreported loss	Plan proactive leak detection, and/or evaluate the feasibility of continuous flow monitoring in one or more District Metered Areas	Upgrade leak detection capabilities using electronic correlation; set structured leak survey schedule; improve detail of records/database	Improve sonic leak detection and flow monitoring capabilities; improve records to include analysis of asset condition; conduct a component analysis by estimating leak run times and repair times	Fully integrate all leak detection and asset management functions; continue to install District Metered Areas as economically feasible; start to analyze economic level of leakage	Continue to standardize and audit on regular basis
Real Losses					**10**

Appendix 1.3 continued

COST DATA	1	2	3	4	5
Customer retail unit cost (applied to apparent losses)	Estimates only	Residential rate only	Weighted average residential rate using volumes in each rate block	Weighted average combination usage rate (includes residential, commercial, and industrial)	Third-party reviewed; weighted average combination usage rate (includes residential, commercial, and industrial)
Improvements in quantifying the annual retail unit costs	Conduct structured audit	Evaluate volume of water used in each usage block by residential users; multiply volumes by full rate structure	Evaluate volume of water used in each usage block by all classifications of users; multiply volumes by full rate structure	Conduct a third-party audit of water used in each usage block by all classifications of users; multiply volumes by full rate structure	Continue with this program
Variable production cost (applied to real losses)	Estimates only	Extrapolated from evaluation of partial system electric and chemicals costs	Non-audited evaluation of total system electric and chemical costs	Internally audited wholesale, electric, and chemical costs	Third party audited wholesale, electric, chemical, and detailed support costs annually
Improvements in quantifying the variable production costs	Conduct structured audit	Conduct cost evaluation of total system electric and chemical costs	Conduct an annual internal audit	Conduct a third-party audit	Continue with this program
Cost Data					**10**
				Total Score	**85**

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APPENDIX E

SYSTEM WATER AUDIT AND WATER LOSS SECTION FROM TWDB BEST MANAGEMENT PRACTICES (BMP) GUIDE

2.1 System Water Audit and Water Loss

A. Applicability

This BMP is intended for all Municipal Water User Groups ("utility"). This BMP should be considered by a utility that:

1) would like to analyze the benefits of reducing its unaccounted for water,
2) has not conducted a periodic water audit,
3) wants to determine if under-registering meters is impacting its revenues, or
4) has not implemented a leak reduction program.

To maximize the benefits of this BMP, the utility uses the information from the water audit to revise meter testing and repair practices, reduce unauthorized water use, improve accounting for authorized but unbilled water and implement effective water loss management strategies. HB 3338 only requires a water utility to conduct a water audit every five years. By adopting this BMP, a utility will be implementing a more frequent implementation of water auditing and loss reduction techniques than required by HB 3338. Small utilities may want to use parts of this BMP, without following every step.

B. Description

System water audits and water loss programs are effective methods of accounting for all water usage by a utility within its service area. Performing a reliable water audit is the foundation of proper water resource management and loss control in public drinking water systems. There has been much recent interest in revising and developing water audit procedures to move away from simply considering "unaccounted for water" to a systematic methodology of accounting for all water uses. The structured approach of a water audit allows a utility to reliably track water uses and provide the information to address unnecessary water and revenue losses. The resulting information from a water audit will be valuable in setting performance indicators and in setting goals and priorities for cost-effectively reducing water losses.

Compiling a water audit is a two-step approach, a top-down audit followed by a bottom-up audit. The first step, the top-down audit, is a desktop audit using existing records and some estimation to provide an overall picture of water losses. For those utilities that gather the information necessary to fill in the Texas Commission on Environmental Quality's Utility Profile, (http://www.tnrcc.state.tx.us/permitting/forms/10218.pdf) that information is the first step of a top-down audit. If a utility has been conducting a water audit using the American Water Works Association ("AWWA") M36 Manual, the utility will already have the data needed to complete the first step of this audit. The records that will be needed include quantity of water entering the system, customer billing summaries, leak repair summaries, average pressures, meter accuracy test, meter change-out summary, permitted fire hydrant use, and other records that may be kept on water theft and unmetered uses such as street cleaning. AWWA is currently revising the M36 Manual, which will provide additional guidance on implementing this BMP. TWDB will also be

publishing a report on HB 3338, which will have information that will assist in implementing this BMP.

The second step of the audit, the bottom-up approach, involves a detailed investigation into actual policies and practices of the utility. This part of the audit is phased in over several years. There are several areas to be addressed including development of better estimates of water use by the fire department, water used in line flushing and street cleaning, and metering of all authorized uses. The procedures of the detailed water audit also include using night flow and zonal analysis to better estimate leakage; analysis of leakage repair records for length of time from reporting to repair of the leak; and analyzing pressure throughout the system.

Several indicators from the analyses in a water audit should be considered by utilities in order to improve water loss control procedures. These include:

1) Real Losses
Losses due to leakage and excess system pressure. Real losses can be reduced by more efficient leakage management, improved response time to repair leaks, improved pressure management and level control, and improved system maintenance, replacement, and rehabilitation. The cost of real losses is estimated using the marginal production costs, such as energy and chemicals needed to treat and deliver the water.

2) Apparent Losses
Losses due to meter accuracy error, data transfer errors between meter and archives, data analysis errors between archived data and data used for billing/water balance, and unauthorized consumption including theft. The cost of apparent losses is estimated using the retail commodity rates.

3) Unavoidable Annual Real Losses ("UARL")
This represents the theoretically low level of annual real losses in millions of gallons daily ("MGD") that could exist in a system if the current best management practices for leak management are successfully implemented. It is based on data obtained from systems where effective leakage management was implemented. The calculation of the UARL is based on number of miles of water mains, number of service connections, average water pressure, and length of service connections. The UARL is allocated to service lines and water mains. The revised AWWA M36 Manual will provide details on how to calculate unavoidable annual real losses.

4) Infrastructure Leakage Index ("ILI")
Ratio of annual real losses divided by UARL. The ILI provides a ratio of current leakage relative to the best level obtainable with current best management practices for leakage. A ratio of 1.0 would indicate that the utility has reduced losses to the theoretically lowest level possible.

5) Economic Level of Leakage ("ELL")
This is a calculation based on the cost of reducing leakage. It is the theoretical level at which the cost of leakage reduction meets the cost of the water saved through leakage reduction. These costs include not only the cost of producing water but also the avoided cost of replacing the water.

In order to reduce water losses due to leakage, a utility should maintain a proactive water loss program. A structured approach to leakage management has proven to be successful in limiting losses. Potential elements of an active water loss program include:

1) Conducting regular inspections and soundings of all water main fittings and connections;
2) Using a water loss modeling program. A model can range from the AWWA M36 Manual Water Audit Spreadsheet to a commercially available statistical model;
3) Metering individual pressure zones;
4) Establishing district metering areas ("DMA") and measuring daily, weekly or monthly flows with portable or permanently installed metering equipment;
5) Continuous or intermittent night-flow measurement;
6) Installing temporary or permanent leak noise detectors and loggers;
7) Reducing repair time on leaks since long-running small to medium size leaks can be the greatest volume of annual leakage;
8) Controlling pressure just above the utility's standard-of-service level taking into account fire requirements, outdoor seasonal demand and requisite tank filling;
9) Operating pressure zones based on topography;
10) Limiting surges in pressure; and
11) Reducing pressure seasonally and/or where feasible to reduce losses from background leaks.

If a utility has not had regular leak surveys performed it will probably need at least three leak surveys performed in consecutive years or every other year for these reasons:

1) The first survey will uncover leaks that have been running for a long time;
2) The second survey will uncover additional long-running leaks whose sounds were masked by larger nearby leaks; and
3) By the third survey, the level of new leaks should start to approximate the level of new reported leaks.

The utility should make every effort to inform customers when leaks exist on the customer side of the meter. If customer service line leaks are significant, a utility might consider the option of making the repairs itself.

The utility should reduce apparent losses since reducing these losses will increase utility revenue. Some of the areas that should be examined are:

1) Customer meter inaccuracy due to meter wear, malfunction or inappropriate size or type of meter;
2) Data transfer error when transferring customer metered consumption data into the billing system;
3) Data analysis errors including poor estimates of unmetered or unread accounts;
4) Inaccurate accounting resulting in some accounts not being billed for water use;
5) All forms of unauthorized consumption including meter or meter reading tampering, fire hydrant theft by contractors, unauthorized taps, and unauthorized restoration of water service cutoffs; and
6) Unmetered municipal connections (every effort should be made to meter municipal connections in order to better account for water use).

C. Implementation

To successfully implement this BMP, the utility should start by forming a working group from the following work areas: management, distribution, operations, production, customer service, finance, and conservation. Each of these work areas has an essential role to play in implementing this BMP. Smaller utilities may have the same person doing several of these functions and therefore the working group may just be one or two individuals. The utility should also consider a public involvement process to solicit outside input as well as to enhance public relations.

Initially the working group should focus on gathering relevant data and identifying current practices listed above in Section B that form the basis for the top-down audit. Some of the questions that should be addressed during the top-down audit are:

1) How often do we test production meters? Commercial meters over 1 inch? Over 2 inches?
2) How often do we replace or repair ⅝ and ¾-inch meters?
3) How inaccurate are the ⅝ and ¾ inch meters on average when they are replaced?
4) Do we estimate total leakage from each leak based on the leakage flow rate and length of leakage from time reported when we fix leaks?
5) How long does it take to repair leaks, itemized by size of leak?
6) Are customers encouraged to report leaks?
7) Do we have a system for tracking location of leaks and a method to calculate when it is cost-effective to replace mains and service lines?
8) Are meter readers trained to look for and report leaks?
9) Do we adjust consumption records when billing records are adjusted?
10) Is backwash and other in-plant water use optimized?
11) How effective is our theft reduction program?

Based on the data collected and information from the questions above, the utility should have enough information to complete a top-down audit.

An ILI of 3 should be used as an example of an achievable target. If the ILI is 3 or below, then further implementation of the BMP is not required until the following year. This would indicate that the utility already has an effective water audit and water loss program. If the ILI is above 3,

then the utility should implement a more effective water audit and water loss program. The utility then proceeds to conduct a bottom-up audit.

In conducting the bottom-up audit, the utility addresses the relevant issues identified during the top-down audit and further investigates those issues discussed in Section B. The utility uses the results of the audit to focus on the best approaches to reduce both real and apparent losses. Depending on whether the ILI is relatively high or low determines the number of years it may take to reduce the ILI to 3.

Each subsequent year, the utility completes another top-down audit. Over time the utility should be able to gradually reduce its ILI to 3. If the utility finds the ILI is increasing, then it should perform a bottom up audit.

D. Schedule

To accomplish this BMP, the utility should:

1) Gather the necessary information for conducting the top-down audit, develop the procedures and complete the audit within the first twelve (12) months of implementing this BMP.
2) The bottom-up refinements should start to be implemented in the twelve (12) months immediately following the completion of the top-down audit if the ILI exceeds 3.
3) Based on the goal of achieving an ILI target of 3, the utility continues to implement bottom-up refinements to reduce real and apparent losses each subsequent year until the utility achieves an ILI of 3.
4) The utility's ILI should be calculated each year.

E. Scope

To accomplish this BMP, the utility should:

1) Conduct a periodic system audit following the methodology contained in the revised AWWA M36 Manual and the report that TWDB is preparing as part of implementing HB 3338.
2) Develop and perform a proactive distribution system water loss program and repair identified leaks.
3) If the utility's ILI is greater than 3:
   a. Implement a pressure reduction strategy if warranted;
   b. Implement a program to reduce real losses, including a leak detection and repair program;
   c. Implement a program to reduce apparent losses; and
   d. Advise customers when it appears that leaks exist on the customer's side of the meter and evaluate a program to repair leaks on the customer's service line.

F. Documentation

To track the progress of this BMP, the utility should gather and have available the following documentation:

1) A copy of each annual system audit, the ILI for each year, and a list of actions taken in response to audit recommendations.
2) Annual leak detection and repair survey, including number and sizes of leaks repaired.
3) Number of customer service line leaks identified and actions taken to repair these leaks.
4) Pressure reduction actions taken, if any; and
5) Annual revenue increased through reducing apparent losses.

G. Determination of Water Savings

Potential water savings are an integral part of the system water audit process and should be contained in the audit report. Based on the results of the audit, the utility should set goals for reducing its losses.

H. Cost-Effectiveness Considerations

Direct costs that should be considered in implementing this BMP include the initial and ongoing costs for performing and updating the water audits and capital costs for items such as leak detection equipment and billing software upgrades. Utilities may wish to do the work in house with technical staff or by using outside consultants and contractors.

A recommended method to make cost effectiveness decisions is based on the economic value of real losses and apparent losses. (*See* Section I. References for Additional Information, 4.) Real losses are losses due to leaks and are valued at actual costs to produce and deliver the water. Apparent losses, sometimes called paper losses, are those attributable to meter and billing inaccuracies and are valued at the retail rates charged by the utility. The amount of lost revenue due to real losses, based on the utility's marginal production cost, and apparent losses, valued at the retail rate charged to customers, can be compared to the costs of reducing the sources of loss.

I. References

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