

## 4.2 System Water Audit and Water Loss

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### *Applicability*

This Best Management Practice is intended for all Municipal Water User Groups (“utilities”). This practice should be considered by a utility that:

1. would like to analyze the benefits of reducing its water loss and other nonrevenue water,
2. does not conduct a water audit on an annual basis,
3. wants to determine if under-registering meters are impacting its revenues, or
4. wants to reduce main breaks and leaks.

To maximize the benefits of this Best Management Practice, a utility would use the information from the water audit to revise meter testing and repair practices, reduce unauthorized water use, improve accounting for unbilled water, and implement effective water loss management strategies.

Texas Water Code Section 16.0121(b) requires retail public water utilities to conduct a water audit every five years, **unless they have an active financial obligation with the Texas Water Development Board or have more than 3,300 connections, in which case they must conduct an audit annually.** By adopting this practice, a utility may be conducting a more frequent implementation of water auditing and loss reduction techniques than required. Small utilities may want to use this Best Management Practice in part or its entirety.

### *Description*

Water loss 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 production-side water resource management and loss control in public drinking water systems. The structured approach of a water audit allows a utility to reliably track water uses and provides 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 to cost-effectively reduce 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 are required to gather information necessary to complete the Texas Water Developments Board’s Utility Profile (<http://www.twdb.texas.gov/conservation/municipal/plans/UP.asp>) or the Texas Commission on Environmental Quality’s Utility Profile (<http://www.tceq.texas.gov/assets/public/permitting/forms/10218.docx>), that information is the first step of a top-down audit. The records needed include quantity of water entering the system, customer billing summaries, leak repair summaries, average pressures, production and

customer meter accuracy percentages, permitted fire hydrant use, and other records that may be kept on water theft and unmetered uses such as street cleaning.

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 can be 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, metering of all authorized uses, and improved measurement of meter accuracies. Other tools to identify and isolate water loss include conducting a system-wide leak detection program, using night flow and zonal analysis to better estimate leakage, analyzing pressure throughout the system, and analyzing leakage repair records for length of time from reporting to repair of the leak.

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. With these losses the water is not beneficially used by any party. 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 costs of 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. These losses are experienced by the utility as forgone revenues, even though the water is still being beneficially used. The cost of apparent losses is estimated using the retail commodity rates.

#### (3) Unavoidable Annual Real Losses

This represents the theoretically low level of annual real losses in millions of gallons per day that could exist in a system if all loss control efforts are exerted to reduce losses, without regard to cost effectiveness. It is based on data obtained from systems where effective leakage management was implemented. The calculation of the Unavoidable Annual Real Losses is based on number of miles of water mains, number of service connections, and average water pressure. The Unavoidable Annual Real Losses is only applicable to utilities with 3,000 or more connections. The [Texas Water Development Board's Water Loss Audit Manual for Texas Utilities](#) provides details on how to calculate unavoidable annual real losses.

#### (4) Infrastructure Leakage Index

The Infrastructure Leakage Index is the ratio of annual real losses divided by Unavoidable Annual Real Losses. The Infrastructure Leakage Index 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

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. Further details on this measure can be found in the [Water Research Foundation report Evaluating Water Loss and Planning Loss Reduction Strategies](#).

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. reducing repair time on leaks since long-running small to medium size leaks can be the greatest percentage of annual leakage;
2. conducting regular inspections and soundings of all water main fittings and connections;
3. installing temporary or permanent leak noise detectors and loggers;
4. conducting a large/transmission main leak detection program;
5. metering individual pressure zones;
6. establishing district metering areas and measuring daily, weekly, or monthly flows with portable or permanently installed metering equipment;
7. continuous or intermittent night-flow measurement;
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 also 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; and
5. all forms of unauthorized consumption including meter or meter reading tampering, fire hydrant theft by contractors and others, unauthorized taps, and unauthorized restoration of water service cutoffs.

### *Implementation*

The Texas Water Development Board's Water Loss Audit Manual for Texas Utilities is a comprehensive guide to performing a water loss audit. It provides a framework for gathering data, calculating performance measures, and reporting requirements under Texas Water Code Section 16.0121(b). Utilities implementing this Best Management Practice should use the methodology from the Texas Water Development Board manual. The American Water Works Association also offers products that can assist performing a water audit. They have published the [M36 Manual](#), which can provide additional guidance on implementing this Best Management Practice, and offer free water loss audit software that allows utilities to quickly compile a preliminary water loss audit.

Utilities implementing this Best Management Practice 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 Best Management Practice. 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 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? Are they tested or just calibrated?
2. How often do we test commercial meters over 1 inch? Over 2 inches?
3. How often do we replace or repair  $\frac{5}{8}$  and  $\frac{3}{4}$  inch meters?
4. How inaccurate are the  $\frac{5}{8}$  and  $\frac{3}{4}$  inch meters on average when they are replaced?
5. 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?
6. How long does it take to repair leaks, itemized by size of leak?
7. Are customers encouraged to report leaks?

8. 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?
9. Are meter readers trained to look for and report leaks?
10. Do we adjust consumption records when billing records are adjusted?
11. Is backwash and other in-plant water use optimized?
12. How effective is our theft reduction program?
13. How do we track water used for flushing both new and existing lines?

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

A utility should set an Infrastructure Leakage Index goal based on its available and potential water supplies, its excess treatment capacity, its projected growth, and the Economic Level of Leakage. A guide for setting Infrastructure Leakage Index target ranges is available in the [Texas Water Development Board's Water Loss Audit Manual for Texas Utilities](#).

In conducting the bottom-up audit, the utility addresses the relevant issues identified during the top-down audit and further investigates any areas where the data may be lacking or incomplete. 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 Infrastructure Leakage Index is relatively high or low determines the number of years it may take to reduce the Index.

Each subsequent year, the utility completes another audit. Over time the utility should be able to gradually reduce its Infrastructure Leakage Index. If the utility finds the Infrastructure Leakage Index is increasing, then it should look to identify the causes using the annual audit results.

Data validity is critical for developing an accurate water loss picture. [The Water Loss Manual for Texas Utilities](#) provides an assessment scoring matrix for the data used in the water loss audit, scoring 17 categories on a scale from 1 to 5, with a maximum of 85. The scoring matrix also provides guidance on improving the assessment score. Utilities with a score below 40 should view that data as preliminary and should not use it to design long-term loss programs or to benchmark with other utilities. Utilities with scores between 40 and 70 can place greater faith in their data and can begin using the data to plan and develop water loss control reduction programs, as well as benchmarking the data with utilities with similar scores. Utilities with scores of 70 or more have mature water loss control and data collection efforts can have great confidence in the reliability of their water audit results.

Efforts to improve data validity include metering all water accounts and connections, including municipal connections; annually testing or calibrating all production meters; implementing district metering areas and automatic meter reading; tracking all unmetered water use, such as fire suppression and line flushing; conducting a theft identification and reduction program; tracking and quantifying all repaired leaks; and conducting a leak detection program.

### *Scope and Schedule*

To accomplish this Best Management Practice, the utility should:

1. Conduct a water loss audit annually following the methodology contained in the [Texas Water Development Board's Water Loss Manual for Texas Utilities](#) manual, yielding an Infrastructure Leakage Index and a data validity assessment score.
2. Develop and perform a proactive distribution system water loss program and repair identified leaks.
3. Implement a program to reduce apparent losses.
4. 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.
5. If the utility's Infrastructure Leakage Index is greater than 3:
  - a. Implement a program to reduce real losses, including a leak detection and repair program;
  - b. Implement a pressure reduction strategy if warranted; and
  - c. Take steps to account for and minimize all unmetered water, and
6. If the audit data validity assessment score is below 70, implement a plan to identify areas where data collection can be improved, using the matrix in the [Water Loss Manual for Texas Utilities manual](#).

### *Measuring Implementation and Determining Water Savings*

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

1. a copy of each annual water loss audit, the Infrastructure Leakage Index for each year, the audit data validity assessment scoring 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, actions taken to repair these leaks, and the average time to make repairs.
4. pressure reduction actions taken, if any; and
5. annual revenue lost to real and apparent losses.

Potential water savings are an integral part of the water loss audit process and can be tracked by comparing trends from the annual water loss audits. Based on the results of the audit, the utility should set goals for reducing its losses.

### *Cost-Effectiveness Considerations*

Direct costs that should be considered in implementing this Best Management Practice 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 system 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. 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.

### *References*

1. *Water Loss Manual for Texas Utilities*, Mark Mathis, George Kunkel, and Andrew Chastain-Howley, Texas Water Development Board, 2009.
2. *Water Audits and Loss Control Programs M36 Manual*, AWWA, 2009.
3. *Water Loss Control Manual*, Julian Thornton, McGraw-Hill 2002.
4. *Evaluating Water Loss and Planning Loss Reduction Strategies*, Water Research Foundation, 2007.
5. *AWWA Water Loss Audit software*,  
<http://www.awwa.org/publications/opflow/abstract.aspx?articleid=18141>.
6. *Validated Water Audit Data for Reliable Benchmarking*, AWWA Water Loss Committee, 2011.

### *Determination of the Impact on Other Resources*

Water loss impacts the supply side of water delivery. Therefore, any reductions carry not only the traditional conservation benefits of reducing demand, electricity and chemicals used in treatment and pumping, and water procurement costs, but also do so without reducing utility revenues. Reducing apparent losses by improving data management and meter accuracy can even increase utility revenues.

Reducing water loss can require a range of resources which vary depending on the age of the utility's distribution system, pipe materials, soil types, and system design. A responsive leak repair program is essential to reducing water loss. Leak detection and meter testing can be done by the utility or contracted out. Timely repairs and an ongoing preventative maintenance and replacement program will allow the utility to operate efficiently, minimizing operational losses.