4.2 Utility Water Audit & Water Loss

Applicability

This Best Management Practice (BMP) is intended for all utilities. This practice should be considered by a utility that

1. would like to analyze the benefits of reducing its water loss, unbilled authorized consumption, and other nonrevenue water,
2. does not conduct a water loss 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 BMP, a utility should use the information from its water loss 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 loss 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 a water loss audit annually. By adopting this practice, a utility may be conducting a more frequent water loss audit than required.

Description

Water loss audits and water loss programs are effective methods of accounting for all water usage by a utility. Performing a reliable water loss audit is the foundation of production-side water resource management and loss control in public drinking water systems. The structured approach of a water loss audit allows a utility to reliably track water uses and provides the information needed to address unnecessary water and revenue losses. The information resulting from a water loss audit is valuable in setting performance indicators and in setting goals and priorities to cost-effectively reduce water losses.

Compiling a water loss audit is a two-step process involving a top-down audit followed by a bottom-up audit. The first step, phase 1 of a total water loss control program and known as the top-down audit, is a desktop audit using existing records and some estimation to provide an overall picture of water losses. Records needed include but are not limited to: 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, phase 2 of a total water loss control program, is a bottom-up audit. This process involves a detailed investigation into actual policies and practices of the utility and can be phased in over several years. Several areas should 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. A utility may wish to adopt a water loss or nonrevenue water policy such as the one endorsed by the American Water Works Association.

The third step of the audit, phase 3 of the total water loss control program, is applying a reliable validation program including recordkeeping and best management practices.

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

(1) Real Loss

Real loss is water lost due to leakage and excess system pressure. With these losses, the water is not beneficially used by any party. Real losses can be reduced through more efficient leakage management; improved response time to repair leaks; improved pressure management and level control; improved system maintenance, replacement, and rehabilitation; and avoiding second- and third-party excavation damage. The cost of real losses is typically, but not always, estimated using variable production costs, such as the costs of energy and chemicals needed to treat and deliver the water (see Cost-Effectiveness Considerations section).

Real loss performance can be tracked using one of three technical performance indicators for real loss depending on the size of the utility. Infrastructure Leakage Index (see (4)) should be used by utilities with 3,000 or more connections and a connection density of 16 or more connections per mile. Utilities with a connection density of more than 32 connections per mile should use real loss per connection per day as a performance indicator, while utilities with a connection density of 32 or fewer connections per mile should use real loss per mile per day.

(2) Apparent Loss

Apparent loss includes losses due to retail customer meter accuracy error, data transfer errors between retail customer meters 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 price of water and the variable rate the customer pays for water use. Apparent loss performance is tracked using the same technical performance indicator for all utilities: apparent loss per connection per day.

(3) Unavoidable Annual Real Loss

Unavoidable Annual Real Loss (UARL) represents the lowest theoretical level of annual real losses in millions of gallons per day that could exist in a system if all possible leakage control efforts are exerted to reduce losses, without regard to cost effectiveness. UARL is based on data obtained from systems where effective leakage management was implemented. The calculation

of the UARL is based on the length of water mains in miles, the number of service connections, and the average annual water pressure. The UARL is only applicable to utilities with 3,000 or more connections and a connection density of 16 or more connections per mile.

(4) Infrastructure Leakage Index

The Infrastructure Leakage Index (ILI) is the ratio of annual real losses divided by UARL. The ILI provides a ratio of current leakage relative to the lowest level obtainable using current best management practices for leakage. A ratio of 1.0 indicates that the utility has reduced losses to the lowest level theoretically possible, given its annual average water pressure.

(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 4372 Water Audits and Real Loss Component Analysis.

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

- reducing repair time on leaks (long-running, small-to-medium-size leaks can be the greatest volume of annual leakage);
- conducting regular inspections and soundings of all water main fittings and connections;
- installing temporary or permanent leak noise detectors and loggers;
- conducting a large transmission main leak detection program;
- metering individual pressure zones;
- establishing district metering areas and measuring daily, weekly, or monthly flows with portable or permanently installed metering equipment;
- continuous or intermittent night-flow measurement;
- installing temporary or permanent pressure gauges throughout the distribution system to identify high- and low-pressure areas and pressure transients;
- controlling pressure just above the utility's standard-of-service level, taking into account fire requirements, outdoor seasonal demand, and requisite tank filling;
- operating pressure zones based on topography;
- limiting surges in pressure;
- reducing pressure seasonally and/or where feasible to reduce losses from background leaks;
- implementing a program to facilitate the location and marking of system distribution lines for contractors in the utility service area to reduce damage to system infrastructure during excavation and construction activities.

Detection and marking of system distribution lines can be accomplished through a focused utility program such as an on-line location request tool with GIS capability. Participating in an existing location request program such as the 811 “Call before you dig” or “One Call” utility notification center is another option. Either option will require utility follow-up to field locate utility lines for contractors.

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 because

1. the first survey will uncover long-term leaks,
2. the second survey will uncover additional long-running leaks whose sounds were masked by larger nearby leaks,
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. Lost revenue can be made worse by the length of time and the number of occurrences of a customer service line leak.

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

- customer meter inaccuracy due to meter wear, malfunction, or inappropriate size or type of meter;
- data transfer error when transferring customer metered consumption data into the billing system;
- data analysis errors, including poor estimates of unmetered or unread accounts;
- inaccurate accounting resulting in some accounts not being billed for water use;
- 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, assessing data validity, and reporting requirements under Texas Water Code Section 16.0121(b). Utilities implementing this BMP should use the methodology from the Texas Water Development Board manual. The American Water Works Association also offers products that can assist with performing a water loss audit. They have published the M36 Manual, which provides additional guidance on implementing this Best Management Practice, and they offer free water loss audit software that allows utilities to quickly compile a preliminary water loss audit.

Gathering Data for the Audit

Utilities implementing this BMP 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 performing several of these functions; in these cases, 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 $^{5}/_{8}$ - and $^{3}/_{4}$ - inch meters?
4. How accurate are the $^{5}/_{8}$ - and $^{3}/_{4}$ - 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. How effective is our theft reduction program?
12. How do we track water used for flushing both new and existing lines?
13. Are excavation activities causing damage to pipes? Who is causing the damage, and how often? Are most excavation damage activities from a failure to communicate with the utility or from a failure to follow excavation guidelines provided?

Completing the Audit

Based on the data and information collected from the questions above, the utility should have enough information to complete a top-down audit. The water loss audit can be completed using the Texas Water Development Board's Water Loss, Use, and Conservation application. Completing the audit through the online application allows for the connection of data between the Water Use Survey and the Water Loss Audit reports submitted to the Texas Water Development Board and provides an easier approach for providing the data requested in the audit.

The data requested for completing the audit includes

- number of connections served,
- miles of main line length,

- average annual operating pressure,
- treated production volume and meter accuracy from the utility's own sources,
- treated purchased volume and meter accuracy from the utility's provider,
- treated volume of water sold to other water systems and the accuracy of these meters,
- the volume of authorized consumption,
- the average customer meter accuracy,
- the volume of systematic data handling discrepancy and unauthorized consumption,
- the volume of reported breaks and leaks,
- the retail price of water,
- the variable production cost of water,
- the annual operating cost.

The utility must then assess the validity of the data provided on the water loss audit. Data validity is critical for developing an accurate water loss picture. The Water Loss Manual for Texas Utilities provides an assessment scale for the data used in the water loss audit, allowing the utility to score 20 audit components on a scale from 0.5 to 5, with a maximum of 100. The assessment scale score represents the conditions present at the utility during the collection of the data used to complete each audit component. The Texas Water Development Board's Water Loss Audit Resources webpage provides a guidance document to assist the utility in completing its validity assessment.

Data Validation

Assessing the validity of the audit data components requires the utility to dive into its policies, procedures, and practices, as well as their effectiveness in the collection of accurate data. This detailed analysis requires the utility to take a hard look at itself. Completing the validity assessment is not intended to judge the utility but rather to provide an accurate assessment of the quality of its water loss audit data. The Water Research Foundation report 4639a Level 1 Water Audit Validation: Guidance Manual provides details to assist utilities in conducting an accurate assessment of the quality of water loss audit data.

The Water Research Foundation report 4639b Utility Water Audit Validation: Principles and Programs provides details on water loss audit data validation.

There are three levels of water loss audit data validation:

- Level 1 validation ensures the utility accurately applied the correct assessment scale scores
- Level 2 validation investigates and ensures the accuracy of some key data
- Level 3 validation confirms data through field verification

It is important to note that validation occurs as a separate process from the completion of the audit. A self-reported water loss audit, and the result of completing the audit, does not provide validation of the data.

Many utilities have found a benefit to the operations and management of their systems after undertaking a water loss audit validation process. Data validation can be performed by a third-party or another individual trained in this method. Preferably, the individual performing the data validation is different from the individual or group that completed the audit, thus providing an independent perspective on the quality of the data. Data validation may or may not improve the assessment score, and in many cases, it may lower the score. Validation provides an understanding of how effective the utility's data collection and management activities are.

The assessment scale also provides guidance on improving the assessment score. 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. A utility should ensure the validity of its water loss audit data prior to using the audit to set targets and plan water loss control projects and programs.

Using the Audit to Set Targets and Plan the Total Water Loss Control Program

Ensuring the validity of the water loss audit data helps the utility identify cost-effective steps in controlling water loss. The Water Loss Control Planning Guide (adapted from the American Water Works Association) can help a utility identify steps to take in setting targets and controlling water loss. The guide uses the total assessment score, which represents the utility's confidence in the overall water loss audit data, to guide the utility in identifying potential areas of planning and control.

Utilities with low confidence in their data should view the overall water loss audit data as preliminary. Utilities with a score below 25 should not use the audit data to design targets, long-term loss programs, or benchmarks with other utilities due to the unreliability of the data. Processes to improve data quality provided in the assessment scale should be implemented. Utilities with scores between 26 and 50 should feel comfortable beginning investigations of portions of their system and assessing long-term needs but should not use the audit to set targets or benchmark with other utilities. Improvements to data quality should be implemented first.

Utilities with greater confidence in their data should view the overall water loss audit data as a tool to inform more detailed water loss mitigation strategies. Utilities with scores between 51 and 70 should feel comfortable establishing or revising policies, procedures, and practices, and beginning to establish long-range targets. Utilities with scores between 71 and 90 have many water loss tracking measures in place and can place greater faith in their data. They can use their data to guide their water loss control mitigation programs, set mid-range targets, and track and benchmark the data with utilities with similar scores. Utilities with scores of 90 or more have taken steps to maximize their validity scores through implementation of mature water loss control and data collection efforts. They have greater confidence in the reliability of their water loss audit results and should continue to

perform and confirm these efforts.

A utility with high confidence in its water loss audit data should set a water loss mitigation goal using industry performance indicators. Utilities with an Infrastructure Leakage Index can set a goal based on their available and potential water supplies, excess treatment capacity, projected growth, and economic considerations. 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. Utilities can also set a goal using other technical performance indicators listed in the Description section above.

Controlling Water Losses

In conducting a 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. Whether the technical performance indicators for water loss are relatively high or low determines the number of years it may take to reduce the indices.

Each subsequent year, as the utility completes another audit, the utility should be able to gradually reduce its technical performance indicators for water loss. If the utility has performed bottom-up auditing to improve data collection, it may find that its technical performance indicators for water loss increase due to better data.

Scope and Schedule

To accomplish this BMP, the utility should undertake the steps listed below.

1. Conduct a water loss audit annually following the methodology contained in the Texas Water Development Board's Water Loss Manual for Texas Utilities, yielding technical performance indicators and a total assessment score.
2. Develop and implement 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 real loss volume is high
    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.
6. If the audit data validity assessment score is below 90, implement a plan to identify areas where data collection can be improved, using the assessment scale table on the Texas Water Development Board's Water Loss Webpage.

Measuring Implementation and Determining Water Savings

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

1. a copy of each annual water loss audit, the technical performance indicators for water loss for each year, the audit data validity assessment score for each field and the total for the 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, if repaired by the utility or through a program;
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 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 BMP include the initial and ongoing costs of performing and updating the water loss 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. According to the M36 Manual, however, leakage should be valued at retail cost if the utility operates in a context of water resource limitations and is implementing water conservation measures in response. 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 variable production or retail cost, and apparent losses, valued at the retail rate charged to customers, can be compared to the costs of reducing the sources of loss.

Determination of the Impact on Other Resources

Reduction of real water loss increases the available water supply in addition to the traditional conservation benefits of reducing water demand, electricity and chemicals used in treatment and pumping, and water procurement costs. These benefits can be achieved 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.

References for Additional Information

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