Introduction

There might have been a time when having a fair amount of lost or "unaccounted-for" water was pretty acceptable to water utilities. Finding and plugging leaks might not have seemed cost effective for a typical water system; that is, the perceived cost of detection and repair might have outweighed the perceived benefits of saving water. Many water systems also might not have metered or charged for certain kinds of uses.

Such practices are no longer accepted as the best management of water resources. Today, the commodity that water systems deliver has greater value than ever before. Extraction, treatment, storage, and pumping all add value to the water resource. Ignoring the value of water losses is no longer justifiable. Given growing constraints on water resources and mounting infrastructure costs, it is more imperative than ever that water managers endeavor to account for the water that travels from the source to end users.

While lacking a rational structure for quantifying water loss, numerous assessments in the literature suggest that water loss is a significant, and often overlooked, occurrence for many US water utilities. Many case studies have documented systems for which losses from leakage and poor accounting constitute substantial portions of total water deliveries.

A growing number of communities are faced with pressure to find additional supplies to serve expanding populations. Many of these exist in water-limited regions where the development of new supply sources and the allocation of existing sources are complex and sensitive issues. Yet rational assessment of water-loss performance and appropriate improvements often are not pursued as a resource management option or given appropriate priority.

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and the account is billed: *nonaccount water* is the sum of all water produced or purchased by a water utility that is not covered by the term "account water."  

This proposed nomenclature has not been widely internalized by U.S. water systems. For the most part, the industry and state agencies tend to use the term "unaccounted-for water" to mean leaks as well as other kinds of avoidable losses relative to total water production. However, the measurement of unaccounted-for water can be a source of confusion because the numerator and the denominator used to calculate the percentage are not obvious. Is the percentage amount supposed to represent all water not metered and sold or only water lost through leaks? How the percentage is calculated is obviously meaningful.

The confusion about terms exacerbates the confusion about standards. Any single standard (expressed in terms of volume or a percentage) for unaccounted-for water may not be valid, realistic, or appropriate for a particular water system. Many system characteristics—such as size, age, service population density, physical terrain, soil characteristics, and pipe materials—will affect leakage rates. Systems also have different production-cost profiles against which the cost-effectiveness of leak detection and control programs can be evaluated.

In 1996, AWWA’s Leak Detection and Accountability Committee recommended 10 percent as a benchmark for unaccounted-for water, supplanting a 15 percent standard that apparently was based more on folklore than rigid empirical analysis. But even this 10 percent recommendation in considered arbitrary in nature and the use of any percentage loss indicator is now viewed as suspect; particularly in light of emerging approaches that rest on more accurate water accounting.

The AWWA Committee concluded that, “Regardless of the water system’s size, water loss should be expressed in terms of actual volume, not as a percentage.” This volumetric measure, the committee points out, is essential for estimating the monetary value of losses. The volumetric measure of lost water can be multiplied by the unit cost of water production (or the retail rate) to estimate the value of the lost water. From an economics perspective, the true value of losses is the *marginal* or *incremental* unit cost of production (that is, the cost of producing the next increment of drinking water supply). Incremental or marginal costs more accurately reflect water’s resource value, which will increase as supply alternatives become scarcer. Reducing leakage and loss can help systems capture a supply resource and avoid costly supply-side operating and capital costs.

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8 Ibid., 110.
Although not entirely complete or representative, the results provide relatively good coverage of state water-loss policy development.

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6
Survey Design

The survey on state water loss policy, as well as the supplemental research, was designed to be very simple and straightforward in order to ensure a high rate of response. Ten issue areas, which emerged from the preliminary research phase of the project, were covered by the survey:

1. Water-loss policy. Does the state have a policy regarding the loss of water by water utility systems? If so, where is the policy stated (statute, regulation, directive, etc). Which agency or agencies are responsible for implementing the water loss policy?

2. Definition of water loss. Does the state or agency provide a definition of water loss or unaccounted-for water?

3. Accounting and reporting. Does the state or agency provide a method to account for and report water loss?

4. Standards and benchmarks. Does the state or agency identify a standard or benchmark for water losses, such as a specific percentage?

5. Goals and targets. Does the state or agency specify a goal or target for water-loss reduction?

6. Planning requirements. Does the state or agency address water-loss issues in the context of water resource, conservation, or other planning requirements?

7. Compilation and publication. Does the state or agency compile and/or publish data on water losses by water utility systems?

8. Technical assistance. Does the state or agency provide any form of direct technical assistance to water utility systems to help reduce water losses?

9. Performance incentives. Does the state or agency provide any form of performance incentive for water-loss reduction?

10. Auditing and enforcement. Does the state or agency implement any form of auditing or enforcement in relation to the water-loss policy?

Survey respondents were asked to provide additional information for affirmative responses to any of the survey questions. Follow-up contacts with some respondents helped provide additional information as needed.

Finally, in addition to the survey, case studies were developed for six jurisdictions in order to highlight various aspects of water-loss policy development:
example, the Georgia Environmental Protection Division defines unaccounted-for water as “the difference between the total amount of water pumped into the water system from the source(s) and the amount of metered water use by the customers of the water system expressed as a percentage of the total water pumped into the system” (Rules and Regulations of the State of Georgia Chapter 391-3-2-.02 Definitions, Amended).

The California Department of Water Resources distinguishes between authorized unmetered uses and water losses. Authorized unmetered uses may include water used for beneficial purposes, such as fire fighting and main flushing. Most definitions identify some of the potential sources of unaccounted-for water, including water for fire fighting and flushing, leaks and breaks, illegal connections, faulty meters, and other sources.

The Massachusetts Department of Environmental Protection uses a detailed definition provided by a sister agency, the Water Resources Commission, to define unaccounted-for water as: “the difference between water pumped or purchased and water that is metered or confidently estimated. Unaccounted for water should include, meter problems (i.e. master meter inaccuracies, domestic and non-domestic meter under-registration, etc.), unauthorized hydrant openings, unavoidable leakage, recoverable leakage, illegal connections, stand-pipe overflows and data processing errors.”

Three state agencies in the sample provide worksheets or formulas for calculating unaccounted-for water. The Missouri Department of Natural Resources defines water loss as a simple percentage: \( \frac{(\text{water pumped minus water used})}{(\text{water pumped})} \times 100 \). Total usage is the sum of customer meter readings, volume used for main flushing or fire hydrant testing, volume sold through water salesman or truck loads from fire hydrants, volume used to fill swimming pools not otherwise metered, etc.

The Texas Water Development Board provides a worksheet for systems to calculate unaccounted-for water, which can be summarized in three steps:

1. The volume of water produced or supplied to the distribution system, as measured by all master meters at wells and treatment facilities or points of purchase from other utilities, is totaled.
2. The volume of water sold and distributed as measured by sales meters and estimated un-metered uses.
3. Unaccounted-for water is obtained by subtracting water sales from total water produced supplied.

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its Annual Statistical Report for Community (COM) Public Water Systems and Non-Transient Non-Community (NTNC) Public Water Systems, the Massachusetts Department of Environmental Protection requires systems to identify the reasons for the unaccounted-for water, as well as the measures that will be implemented to correct the problem. According to the required form:

If your system has 15% or greater unaccounted water or uses 100,000 gallons per day or greater and has any % unaccounted for water, please indicate in the table below the possible reason(s) for your unaccounted for water and your plans to correct these problems. Please note that during or before your next Sanitary Survey DEP staff will evaluate your progress with the corrective actions plans as indicated.\textsuperscript{13}

In a like manner, the Ohio Public Utility Commission requires each waterworks company to annually report unaccounted-for water and also to propose remedial actions if unaccounted-for water exceeds 15 percent. The West Virginia Public Service Commission also requires a statement of remedial actions to be taken if the utility indicates unaccounted-for water greater than 15 percent in its annual report.

The New York Department of Health requires water suppliers to prepare an annual Drinking Water Quality Report that includes an accounting of the total amount of water withdrawn, delivered, and lost from the system. The Texas Water Board provides detailed worksheets for calculating unaccounted-for water in their Drought Planning Guide. Finally, the Public Service Commission of Wisconsin requires utilities to maintain a ongoing record that compares water pumpage with metered consumption.

\textbf{Standards and Benchmarks}

The imprecision of the definitions of water losses carries over to the establishment of standards and benchmarks. The survey confirmed the lack of clear consensus on standards. Twenty-eight agencies (representing twenty-three states and the three regional authorities) reported the use of some standard or benchmark for water losses. Table 2 presents standards for "unaccounted-for water" from a select number of jurisdictions. The reported standards range from 7.5 to 20 percent, with 15 percent being most common. The percentages refer generally, but rather vaguely, to water losses relative to production.

According to the review, only Arizona, Texas, and Wisconsin established different standards for water systems based on their type or size. The Texas Water Development Board, for example, has found that "unaccounted for water rates above 15 percent for municipal systems and slightly higher (15% to 18%) for widespread rural systems indicate the need for immediate actions."\(^\text{14}\)

**Goals and Targets**

Eighteen (18) state agencies and the two Florida water management districts mentioned a goal or target for water-loss reduction. In most cases the goal or target is for the utility to meet the standard or benchmark for unaccounted-for water discussed in the previous section. Goals often are stated in relatively vague terms.

For example, the Florida Department of Environmental Protection, Water Resource Implementation Rule declares that, "The overall water conservation goal of the state shall be to prevent and reduce wasteful, uneconomical, impractical, or unreasonable use of water resources..."Districts shall further accomplish this water conservation goal by:...3. Minimizing unaccounted for water losses..."\(^\text{15}\)

The Minnesota Department of Natural Resources provides a time period target of three years for a water supplier to reduce unaccounted-for water:

> If unaccounted-for water exceeds 20% of total water appropriations the public water supplier's water appropriation permit is amended to require the implementation of measures to reduce unaccounted-for water volumes within 3 years. The generous targets of 20% and 3 years are intended to provide sufficient time and resources for small systems...\(^\text{16}\)

The Kansas Water Office is the only agency in the sample to specify a particular target year. The agency plans to reduce the number of public water suppliers with excessive unaccounted-for water by the year 2010.

**Planning Requirements**

For twenty-seven (27) of the agencies in the sample, water-loss issues are addressed in the context of planning requirements. In almost every case, the planning requirement is for water conservation, supply, or emergency planning. For example, the Connecticut Department of Health requires water suppliers to

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\(^{14}\) Texas Water Development Board, 2.
\(^{16}\) Jim Japs, Supervisor, Water Permit Programs, MN Department of Natural Resources, Division of Waters, survey information.
online. The office currently lists sixty-one (61) systems with unaccounted-for water amounting to 30 percent or more.

Technical Assistance

Eighteen (18) state agencies and one Florida water management district in the sample provide some amount of technical assistance to water utility systems to help reduce water losses. In Kansas, technical assistance is provided to any public water supplier upon request. The Kansas Rural Water Association provides on-site technical assistance at no charge. In Texas, technical assistance, classes, and training are available from a number of providers, including the Texas Natural Resources Conservation Commission, Texas Water Development Board, Texas Water Utilities Association, the Texas Engineering Extension Service, and the Community Resource Group.

The Kentucky Infrastructure Authority implements a program to assist systems in detecting water losses from distribution lines. The program includes both audits and low-interest loans:

The authority shall establish a program to assist governmental agencies in detecting water loss from distribution lines. The program may include contracting with third parties to conduct water loss audits and leak detection. The program may include giving low interest loans, on a priority basis established by the authority consistent with the findings and purposes set out in section 1 of this act, for the repair or replacement of distribution facilities, deemed reasonable by the authority, undertaken as a result of the water loss audit.\(^\text{20}\)

Performance Incentives

Only eleven (11) state agencies and one Florida water management district in the sample indicated the use of performance incentives for water loss reduction, broadly defined for the purpose of this study. Minnesota and Rhode Island consider the approval of a conservation plan or permit as a performance incentive. The Rhode Island Water Resources Board, for example, requires attention to water-loss reduction for approval of Water System Supply Management Plans. The Vermont Department of Environmental Conservation reported that fees might be slightly lowered as incentive for water-loss reduction. The Texas Natural Resources Conservation Commission, a price regulator for some systems, reports that a system's rate of return may be affected by excessive line losses.

The Minnesota Department of Natural Resources audits annual reports and also requires an audit of unaccounted-for water when reviewing each permit request. Public water suppliers with losses exceeding 20 percent must provide an annual report of actions being implemented to reduce unaccounted-for water. The Kansas Rural Water Association closely audits all public water suppliers with 30 percent or more unaccounted-for water. Quarterly monitoring is required until two consecutive quarterly reports show 20 percent or less unaccounted-for water.

As an example of potential enforcement, the Ohio Public Utility Commission requires a water company to notify the Commission if it cannot comply with water-loss requirements. The company is given thirty days to take corrective actions and submit a report to the Commission. “The compliance division of the commission shall, after reviewing the report, notify the company of any further necessary actions.”

Case Studies

Six cases are highlighted here because they represent significant water-loss policy developments at the state and regional levels.

Arizona Department of Water Resources

Most water-loss requirements in Arizona are implemented through the states five Active Management Areas (AMA). Each AMA must submit a yearly Management Plan, which requires all municipal suppliers to report their unaccounted-for water.

Arizona applies a relatively specific working definition of unaccounted-for water:

Lost and unaccounted for water is defined as the total water from any source, except direct use effluent, withdrawn, diverted, or received in a year minus the total amount of authorized deliveries made by the municipal provider in that year.

Lost and unaccounted-for water includes leaks (from distribution lines, sewer lines, storage tanks, storage ponds, hydrants), breaks (from distribution lines, sewer lines, mains, hydrants), measurement errors (meter under/over-registration, source meter errors, flumes/weirs errors), evaporation, illegal connections/water theft, and phreatophyte uses.

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23 Ohio Administrative Rule 4901:1-15-22 OAC.
25 Ibid.
The Kansas Water Office defines unaccounted for water as... the amount of water that a public water supplier pumped and/or purchased from other entities; minus all metered amounts (either sold or distributed free). Metered amounts include sales to other public water suppliers; large industrial, bulk or livestock water users; and residential and commercial customers; as well as metered free water (such as swimming pools, golf courses, community buildings, water treatment process, etc).  

One of the two primary objectives of the Kansas Water Plan is to, “By 2010, reduce the number of public water suppliers with excessive ‘unaccounted for’ water by first targeting those with 30 percent or more ‘unaccounted for’ water.” In addition to the focus on systems with very high losses, the plan also targets systems with losses exceeding 15 percent because “15% was the average percent of unaccounted for water for public water suppliers in 1997, and is a reasonable amount for unfinished water.”

Water suppliers are required to report their unaccounted-for water in an annual water report. Failure to submit an annual report is subject to a fine and providing false information is considered a class C misdemeanor. Furthermore, most water suppliers are also required to submit a water-conservation plan. One of the long-term water-use efficiency practices required of water utilities is the implementation of:

... a water management review, which will result in a specified change in water management practices or implementation of a leak detection and repair program or plan, whenever the amount of unsold water (amount of water provided free for public service, used for treatment purposes, water loss, etc.) exceeds 20 percent of the total raw water intake for a four month time period.

The Kansas Municipal Water Use Report keeps a current compilation of all water losses in the state of Kansas. The annual and average percent of unaccounted-for water for all public water suppliers in the state is compiled and published by the Kansas Water Office.

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30 ibid.
32 This report is available online at http://www.kwo.org/reports/1999_mwur/index.htm.
Minnesota has set a standard for water losses at less than 10 percent. According to the state’s water appropriation permit program:

Cities should establish a goal for unaccounted-for water (the AWWA recommends less than 10 percent) and monitor unaccounted-for water volumes each month or billing period. Water audit, leak detection, and repair programs should be implemented when unaccounted-for water is higher than the goal.\(^{36}\)

However, Minnesota has set a more lenient target for public water suppliers with high rates of water loss. “If unaccounted-for water exceeds 20% of total water appropriations the public water supplier’s water appropriation permit is amended to require the implementation of measures to reduce unaccounted-for water volumes within 3 years.”\(^{37}\) It is believed that this more lenient goal will give small systems a reasonable amount of time and resources to reduce water loss.

The Minnesota DNR audits all annual water-report forms. Furthermore, an audit and evaluation of unaccounted-for water is conducted in connection with each permit request. If a public water supplier exceeds 20 percent unaccounted-for water, the system must provide an annual report of actions being implemented to reduce unaccounted-for water.

Pennsylvania Public Utility Commission and Pennsylvania Bureau of Water Supply and Wastewater Management

In Pennsylvania, both the Public Utility Commission and the Bureau of Water Supply and Wastewater Management implement policies that address the issue of water loss. The Public Utility Commission, an economic regulatory agency, requires evidence of the reasonableness of unaccounted-for water claims greater than 20 percent. This policy was adopted in a general waterworks rate-case order. According to the order:

In the future, water companies with experienced unaccounted-for water of more than 20%, should be prepared to demonstrate by way of substantial evidence that their experience is both normal and reasonable. Such evidence may be a combination of engineering, operations or historical testimony and data, but

\(^{36}\) Minnesota Water Appropriation Permit Program - “Conservation Measures for Water Supply Systems”
http://www.dnr.state.mn.us/waters/programs/water_mgt_section/appropriations/pwsconserve.html

\(^{37}\) James Japs, Minnesota DNR Water, survey response.
The Pennsylvania DEP recommends the AWWA standard of 10-15 percent for unaccounted-for water. However, the department also notes the relevance of a number of systems-specific considerations:

1. The age and condition of the system... A range of 35 to 40 percent may be acceptable until funds for replacement of mains is available;
2. The pressure in the system can affect the rate of leakage. Thus high pressure systems may have a higher percentage of unaccounted-for water;
3. The number of customers per mile of main can affect the unaccounted-for water. Therefore, if a system has a high ratio of miles of pipeline to the number of customers, the percentage of unaccounted-for water will increase;
4. Under-registration of customer meters or unauthorized uses can increase the percentage of unaccounted-for water.\(^{40}\)

Pennsylvania policy also expressly considers the economic value of water losses. The state recommends that systems “Calculate the cost of producing a thousand gallons or one hundred cubic feet of water and then calculate the amount of money which is being ‘lost’ as unaccounted-for water each month. By identifying this cost, you can justify the cost of the programs to correct the problem.”\(^{41}\) Suggested programs include meter testing, leakage control program that focuses on detection, and record keeping to support a main-replacement program.

These requirements and recommendations are incorporated in the review and evaluation of the Operations and Maintenance Plans that public water suppliers must prepare in accordance with the DEP’s drinking water management programs.

The DEP’s Water Allocation Permit system also requires systems to implement a continuous water conservation program, which must include an ongoing leakage and loss control program. Permit holders must initiate a study to develop a plan to reduce unaccounted-for water within one year of the date of the permit and reduce losses to 20 percent or less within five years of the date of the permit.

Finally, the DEP provides free leak-detection services to water suppliers that agree to follow program requirements, including a yearly water audit through a partnership agreement with the Pennsylvania Rural Water Association.

**Delaware River Basin Commission**

The Delaware River Basin Compact was enacted in 1961 to address water-resource issues on a regional basis. The member states include Delaware, New Jersey, New York, and Pennsylvania. The governing commission is composed of

\(^{40}\) Ibid.
\(^{41}\) Ibid.
Consumptive Uses of Water rule. All applicants for a consumptive-use permit must complete a thorough water audit. The water audit requires identification of water losses in the treatment process and in the distribution system. Applicants must identify all water uses, as well as total unaccounted-for water and the percentage of unaccounted-for water.

Conservation is required as part of all consumptive-use permits. In order to obtain a consumptive-use permit (CUP) from the SJRWMD, "all available water conservation measures must be implemented unless the applicant demonstrates that implementation is not economically, technically, and environmentally feasible." Water-loss reduction is a recognized water conservation measure. Permit applicants must also conduct a meter survey to account for and correct meter error if unaccounted-for water is 10 percent or greater based on the initial water audit.

SJRWMD has one of the strictest requirements for leak detection. According to one handbook:

An applicant whose water audit...shows greater than 10% unaccounted for water use, must complete the leak detection evaluation portion of Form 40C-22-0590-3. Based upon this evaluation, an applicant may choose to implement a leak detection program immediately or develop an alternative plan of corrective action to address water use accountability and submit a new water audit to the District within two years. If the subsequent audit show greater than 10% unaccounted for water, the applicant must implement a leak detection and repair program within one year unless the applicant demonstrates that implementation is not economically feasible. In all cases, this evaluation and repair program may be designed by the applicant to first address the areas which are most suspect for major leaks. The evaluation and repair program may be terminated when the permittee demonstrates that its unaccounted for water loss no longer exceeds 10%.

The leakage evaluation must include the following items:

- Potential water system leakage
- Annual potential system leakage
- Recoverable leakage (assumes 50%)
- Production cost per million gallons
- Recoverable savings
- Estimated cost of leak detection survey
- Estimated recovery period

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43 Florida Administrative Code, Chapter 40C-2.
44 Florida Administrative Code, Chapter 40C-2.301 (4).
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<td>AZ, GA, HI, KS, MD, MN, NH, OH, OR, PA, SC, TX, WI, SWFWMD, SRJRBM</td>
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Bibliography


