Comments to Advance Notice of Proposed Rulemaking of the Pennsylvania Public Utility Commission

Proposed Revisions to Water Audit Methodology; 52 Pa. Code § 65.20; Water Conservation Measures – Statement of Policy; Doc. No. L-2020-3021932

Comments provided by George Kunkel, David Sayers, Edward Osann, Steve Cavanaugh, Will Jernigan, and Drew Blackwell; all members of the AWWA Water Loss Control Committee. For questions contact George Kunkel at kunkelwaterefficiency@gmail.com.

Comments

I. Background/Interest of the Commenters

a. George Kunkel, P.E. is Principal of Kunkel Water Efficiency Consulting which provides engineering consulting services in water loss control to water utilities. Previously, Mr. Kunkel oversaw the successful water loss control program in the City of Philadelphia Water Department. Mr. Kunkel has chaired the Subcommittee that publishes the AWWA M36 Manual *Water Audits and Loss Control Programs* since 2003, is a co-author of the AWWA Free Water Audit Software (FWAS), and has been involved in numerous Non-Revenue Water (NRW) management projects administered by AWWA and the Water Research Foundation. Mr. Kunkel also serves as Public Services Institute Instructor for the Pennsylvania Department of Environmental Protection (DEP) in its Outreach Assistance Program (OAP), providing water audit training and validation for small water utilities. Mr. Kunkel assisted the PA Public Utility Commission (Commission) in its pilot project implementation of the AWWA Methodology in 2008 by providing training workshops to the Commission and water company staff. Mr. Kunkel can serve as a resource to the Commission on the AWWA Methodology in this rulemaking. He resides in Hershey, PA.

b. David Sayers has 20 years of experience in advancing the development of water system auditing and water loss control. He is the applications developer of the FWAS and Compiler tool. David led the development and implementation of a regulatory water audit reporting program at the Delaware River Basin Commission (DRBC) utilizing AWWA methods and tools, and now as a consultant helps clients across North America identify, manage, and reduce Non-Revenue Water. Mr. Sayers assisted the Commission in its pilot project implementation of the AWWA Methodology in 2008 by providing training workshops to the Commission and water company staff. He resides in Yardley, PA.

c. Edward R. Osann is Director of National Water Use Efficiency with the Natural Resources Defense Council. Ed is a member of the M36 Subcommittee and administered the *Report on the Evaluation of Water Audit Data for Pennsylvania Water Utilities* (2017). Mr. Osann has also been an active participant in the process to develop NRW performance standards in the

State of California, and is a member of the water loss committees of the Pennsylvania and California-Nevada Sections of AWWA.

d. Steve Cavanaugh is President and Chief Innovation Officer with Cavanaugh Solutions, and lead Cavanaugh's work to establish training, validation, and certified validator programs in the States of Georgia, California, and the Province of Quebec. Steve chairs the Outreach Subcommittee of the AWWA Water Loss Control Committee

e. Will Jernigan is Chief Financial Officer and Director of Water Efficiency with Cavanaugh Solutions. He is chair of AWWA's Water Audit Software Subcommittee and a member of the publishing Subcommittee of the AWWA M36 guidance manual. He has worked with over 1,000 water utilities in North America to conduct water audits, water loss analysis and loss reduction interventions Will has worked on the leading water audit programs in Georgia, California, other US states and the Province of Quebec.

f. Drew Blackwell is Non-Revenue Water Program Manager with Cavanaugh Solutions. Drew has worked on the leading water audit programs in Georgia, California, other US states and the Province of Quebec.

g. All commenters actively promote the use of the AWWA Methodology throughout North America as part of their work and volunteer efforts with the American Water Works Association. All see great opportunity and value for the Commission in adopting this methodology, which should promote better NRW reduction, improved cost-effectiveness for water companies, and equity of rates for customers.

II. Commission Rulemaking and the AWWA Water Audit Methodology

a. Rulemaking: The Commission is congratulated on its work since 2008 to advance effective water audits and NRW management in the Commonwealth's water companies and its proactive stance in undertaking this rulemaking.

b. Commission Mission: the mission of the Commission is to balance the needs of consumers and utilities; ensure safe and reliable utility service at reasonable rates; protect the public interest; educate consumers to make independent and informed utility choices; further economic development; and foster new technologies and competitive markets in an environmentally sound manner.

c. Purpose of the Rulemaking: to achieve many public interest benefits, including, preservation of water resources, limitation of water leakage, reduction of overall company risk, and enhanced customer service; and to more comprehensively address public utility water loss in the Commonwealth consistent with Pennsylvania Public Utility Commission regulations at 52 Pa. Code § 65.20, DEP regulations, and the guidance set forth by the Susquehanna River Basin Commission and Delaware River Basin Commission. Specifically, the Commission has requested comments regarding the replacement of current regulation with a Commission regulation to implement the International Water Association (IWA)/American Water Works

Association (AWWA) Water Audit Methodology (AWWA Methodology) as a best management practice in water loss control in Pennsylvania.

d. Commission history with the AWWA Methodology: The Commission was an early adopter of the AWWA Methodology, launching a pilot program in 2008, followed by the issuance of the 2011 Tentative Order wherein the Commission ordered all Class A water utilities to implement the AWWA Methodology. Since this time, the Commission reliably collects water audit data from these companies each year. This process has likely fostered a greater awareness within the water companies of the occurrence of NRW and need to control it. However, it is not believed that the Commission has fully leveraged the benefits available from this Methodology since data validation has not been conducted and follow-up actions with the companies on the data appear to be limited. Studies have shown that when validation – a data quality control process – has been employed, the reliability of the data has improved. It is also believed that the Commission has not fully tracked water company performance on a year-to-year basis. Finally, the Commission's continued use of a single percentage performance indicator inhibits it from motivating actual NRW reductions since a percentage does not measure water volumes or costs, the two most important aspects of NRW which must be measured to evaluated NRW management program success. The Commission has great opportunity – particularly due to recent advances by AWWA in the Methodology – to, through this rulemaking, motivate discernable and sustainable reductions in NRW in many of the water companies.

e. Benefits of the AWWA Methodology: The Water Audit Methodology advocated by the AWWA offers many benefits to water suppliers, and these align with the Commission's mission and goals in pursuing this Rulemaking. These include:

    1. The means exist to quantify NRW by volume, cost, and data quality using a standard water audit spreadsheet provided at no charge by AWWA. NRW is comprised of apparent (customer) losses, real (leakage) losses, and unbilled authorized consumption. Apparent losses inadvertently understate customer consumption, and this results in under-billing. Apparent losses mean companies fail to capture a portion of revenue which is needed to operate the water system, and inequity occurs among customers as some under-pay and the remaining population bears the burden of providing the company's revenue. In some instances, this might skew the rate-setting process since the costs of NRW are not typically included as a line item in the water company rate case documents. Real losses are system and customer service line leakage that wastes water resources and inflates energy and water treatment costs to produce water that leaks from the distribution systems without returning revenue to the company. Water resources are preserved by limiting leakage and good NRW management assists enhanced customer service, while optimizing cost management and value to customers. Excessive NRW wastes water and energy resources, compromises customer service, and creates cost-inefficiencies, resulting in NRW costs being passed on to paying customers as hidden components of water rate increases.

2. The capability to fully characterize NRW standing via an array of robust and reliable performance indicators that independently assess apparent losses, real losses, costs, and data validity.

3. Effective means for loss control target setting and measurable performance improvement, i.e. the AWWA Methodology is an *actionable* process.

f. Key points of these comments: The Commission is congratulated on its use of the AWWA Methodology in various forms since 2008 and its continued use of this approach is urged. However, the Commission is strongly urged to optimize its NRW program by including best practice functions that have been employed by water regulatory agencies in several US states and the Province of Quebec. These functions should include:

1. ***Training*** for water utility staff, Commission staff, and other stakeholders on the AWWA Method, data collection and self-assessment of water supply operations. Explanation of performance indicators, data grading, and general loss control methods should be included in the training.

2. ***Validation*** of assembled water audit data as an essential quality control check using an established process. Validation occurs after the company auditor compiles the water audit and before the water audit is formally submitted to the Commission. The water audit validator is a person who was not involved with the initial compilation of the water audit data. The validator may be an employee of the Company or a third-party person certified in the validation process.

3. ***Improved procedures*** for water audit submittal including FWAS submittal in its electronic MSExcel format (paper or .pdf submittals should not be permitted), water audits must be submitted for individual systems (based upon PWSID number), but allowing for some grouped water audit submittals in addition (for target monitoring purposes), and information on water company practices as needed.

4. ***Attestation*** of the submitted data by a senior executive of the water company to confirm the accuracy and completeness of the water audit submittal.

5. ***Transparency of water audit data:*** The Commission and companies should post annual water audit data and related information on NRW management progress on easily accessible and visually conspicuous web pages with data available in the public domain.

6. ***Discontinue use of percentage performance indicators***: AWWA recommends against the use of percentages for performance assessment and tracking, and target-setting because they misrepresent performance by not tracking loss volumes or costs. AWWA's forthcoming publications (M36, FWAS) will not include any percentage indicators. Arguably, the use of percentage indicators for over sixty years by US water regulatory agencies has rarely produced consistent discernable successes in NRW reduction.

7. ***Employ the AWWA performance indicators*** as defined in the AWWA Water Loss Control Committee's Committee Report (January 2020).

8. ***Target excessive losses***: rather than setting a single optimized low target for all water companies to achieve, the Commission should set individual company targets for loss volumes/rates and/or costs (apparent and real) for those companies that have NRW or costs at excessive levels. For example, water utilities with losses greater than the 90th percentile value of unit apparent losses (gallons per connection per day) should reduce apparent losses to the 90th percentile value within two years (or a specific period tailored to the particular water company situation). The target-setting process can be informed by the first 2-3 years of *validated* water audit data and updated every 3 years.

9. ***Compile summary analysis*** annually of the water audit data submitted by water companies. The Commission could perform such analysis in-house or via contracted service. Make the report publicly available.

Many of these functions are key components of leading state programs such as those in the States of Georgia and California and the Province of Quebec, Canada. Strong programs which feature the above functions now exist in these jurisdictions and they can serve as examples for the Commission to investigate.

III. NRW Management in Pennsylvania and North America:

a. Use of the AWWA Methodology in Pennsylvania: Within Pennsylvania, the Commission and the DRBC employ the AWWA Methodology and require submittal of annual water audit data in the FWAS for water utilities under their jurisdiction. Some water utilities/water companies report their annual data in the FWAS to both agencies. Unfortunately, DEP and SRBC require annual water audit reporting using agency-specific forms that do not specifically align with the FWAS, and both employ a volumetric percentage indicator (20% unaccounted-for water or UFW). Several investor-owned water companies operate numerous water systems in the Commonwealth and are required to submit annual water audit data in three different formats – FWAS to the Commission and DRBC, and individual forms to DEP and SRBC. This results in inconsistency of data and performance indicators and additional reporting burden on these water companies. It is recognized that the Commission cannot implement changes in reporting requirements in DEP and SRBC but the Commission's continued use of the AWWA Methodology provides the opportunity to align with the best practices being employed in leading state and provincial agencies in North America, and serve as a progressive model for DEP and SRBC.

b. PA DEP Outreach Assistance Program: While DEP's reporting structures do not align specially with the AWWA Methodology and the FWAS, DEP has informally piloted use of the AWWA Methodology and FWAS in its Outreach Assistance Program (OAP) which provides technical assistance to typically small water systems. OAP has assisted 25 water systems in compiling and validating the AWWA water audit and Mr. Kunkel has been the lead on 20 of these water audits. The work includes assisting utility staff in collecting and inputting data in the FWAS and reviewing and validating their processes to arrive at pointed recommendations for the system to better control NRW in their operations. Deliverables include the validated water audit in the FWAS and two reports, on validation and recommendations, respectively. This

level of validation activity is comprehensive and more extensive than the Level 1 validation process applied to systems in the States of Georgia and California. At least three of the systems audited under the OAP fail under the jurisdiction of the Commission and the deliverables for these systems might be available with permission from DEP and the systems. The Commission can contact the program coordinator – Dennis Harney – at dharney@pa.gov for information on the OAP water audits and the systems that fall under the jurisdiction of the Commission.

c. The Extent of NRW and Cost Impact in Pennsylvania Water Systems: Mr. Kunkel conducted research work for the Natural Resources Defense Council (NRDC) and authored the *Report on the Evaluation of Water Audit Data for Pennsylvania Water Utilities* (2017). Based upon water audit data collected in 2013 in the FWAS by the Commission and DRBC, the report states that NRW impacts – extrapolated for *all* water systems across Pennsylvania – total as much as $137 million in uncaptured revenue due to apparent losses and as much as $19.7 million in excessive production costs due to real (leakage) losses as highlighted in Tables 1 and 2 below:

Table 1 Summary of Findings: Evaluation of 2013 Water Audit Data

Reported to the PAPUC and DRBC by 155 Pennsylvania Water Utilities

Parameter	Value
Apparent losses reported	11,220 mg (30.7 mgd)
Estimated economical recoverable apparent losses	8,461 mg (23.2 mgd)
Estimated recoverable annual revenue from economically recoverable apparent losses	$67,033,000
Real losses reported	56,203 mg (154.1 mgd)
Estimated economical recoverable real losses	17,888 mg (49 mgd)
Estimated annual production cost savings from economically recoverable real losses	$10,713,000

Table 2 Estimates of Statewide Losses and Potential Savings

Parameter	Value
Apparent loss estimate – statewide	23,842 mg (65.3 mgd)
Estimated economical recoverable apparent losses – statewide	17,968 mg (49.2 mgd)
Estimated recoverable annual revenue from economically recoverable apparent losses - statewide	$137,637,000
Real losses estimate – statewide	119,313 mg (326.9 mgd)
Estimated economical recoverable real losses -- statewide	37,988 mg (104.1 mgd)
Estimated annual production cost savings from economically recoverable real losses - statewide	$19,754,000

Table 1 lists over $67 million of potentially recoverable revenue from the 155 water systems that reported AWWA water audits. Of these systems, 46 systems fall under the jurisdiction of the Commission and had potentially recoverable revenue totaling over $15 million, with the largest of these systems projected to have almost $6 million of potentially recoverable annual revenue. This suggests considerable revenue recovery potential for customers who are inadvertently being under-billed. Recovering apparent loss costs improves ratepayer equity and can temper the need for and frequency of water rate increases by companies. The new

rule implemented by the Commission will benefit greatly from the AWWA Methodology focus on revenue capture.

Table 1 also lists over $10.73 million of potentially reduced production costs (treatment and pumping) from the 155 water systems that reported AWWA water audits. Of these systems, 14 systems fall under the jurisdiction of the Commission and had potentially reduced production costs of $2.16 million, with the largest of these systems projected to have almost $970,000 of potentially reduced production costs. This suggests a reasonable reduction of excessive costs for treatment of water that leaked from the distribution system and never reached a customer. Reducing leakage saves valuable water and energy resources, lowers operating costs, and potentially reduces liability (from water damage) for water companies. This optimizes the cost of providing drinking water service.

d. Growing use of the AWWA Methodology in North America: Required use of the AWWA Methodology and the FWAS is growing across North America. The States of Georgia and California are leaders in this progress by being early adopters but also by establishing comprehensive programs that feature training for water utility staff, Level 1 validation of collected data, a certified validator program, and public access to the water audit data. The Province of Quebec, Canada has also implemented a comprehensive program in this vein. Other US states with programs using these methods include Hawaii, Indiana, Tennessee, New Mexico, Arizona, Washington, Texas, and Colorado. Many other states are also investigating or launching pilot programs using the AWWA Methodology.

e. Emergence of considerable validated water audit data: As more programs have been established in North America, more data – particularly validated data – has emerged and is available in the public domain. The AWWA Water Loss Control Committee recently assembled a combined dataset of validated water audit data from Georgia, California, and Quebec: The Water Audit Reference Dataset or WARD. This dataset includes 1,124 water audits and represents the largest and most representative dataset of its kind. The data included in the WARD offers a good evaluation of the water efficiency status of North American water systems. By analyzing the range of water audit components and key performance indicators (KPI), high and low levels of these values are better appreciated and the boundaries of the extremes of these parameters are more clearly discerned. WARD data has been built into charts used in the forthcoming Version 6.0 FWAS as explained in Section V of these comments.

IV. Advancement in the AWWA Methodology

a. The AWWA Methodology continues to evolve: The Commission's proposed rulemaking notice document *Proposed Revisions to Water Audit Methodology; Water Conservation Measures – Statement of Policy; Advanced Notice of Proposed Rulemaking* gives the background the Commission's history with the water audit methodology and the purpose of the Order to move forward with an Advanced Notice of Proposed Rulemaking. The description of the Commission's early adoption of AWWA methods in the period of 2008-2012 is useful context that should allow new rulemaking to build on the success of the Commission in recent years.

However, since 2008, the AWWA Methodology has experienced considerable evolution and advancement. Notable recent developments include:

1. The AWWA Methodology is now a distinct methodology with several modest but notable modifications of the original International Water Association methodology. Hence the term "International Water Association (IWA)/American Water Works Association (AWWA) Water Audit Methodology" is now "American Water Works Association Water Audit Methodology" or more simply in these comments the "AWWA Methodology."

2. Language in the Advanced Notice document stated that the term "*unaccounted-for water"* was replaced with the term *"water audit,"* however, it is more accurate to not that the term "unaccounted-for water" was replaced with the term "Non-Revenue Water" in the AWWA Methodology. The water audit is a tool used to quantify annual volumes of water supply, customer consumption and losses, and related data.

3. The AWWA Water Loss Control Committee Report (*Journal AWWA*, January 2020) and companion research report offers new key performance indicators (KPI) and rejects use of any percentage indicators. This is discussed in Section V of these comments.

4. The current Version 5.0 of the FWAS dates from 2014. However, the forthcoming Version 6.0 FWAS includes an improved Data Grading capability and other refinements. This version is scheduled for release on December 4, 2020: World Water Loss Day. Since Version 6.0 has a number of new features and will require time to acclimate to, it is recommended that the Commission consider employing this version of the FWAS starting in early 2022 by collecting water company data from calendar year 2021.

5. The current 4th edition of the AWWA M36 guidance manual Water Audits and Loss Control Programs dates from 2016. The next (5th) edition is currently under development and is anticipated to be published in mid-2022

V. AWWA's updated position on Key Performance Indicators (KPI):

a. Abandoning use of Percentage Performance Indicators by the Commission:

1. The Advance Notice of the Proposed Rulemaking states:

> "The Commission has determined that, rather than revising its existing Policy Statement at § 65.20, a new regulation addressing water conservation is necessary and this Advanced Notice of Proposed Rulemaking reflects this change. The Commission has formally adopted the Water Audit Methodology and all Class A Water utilities have been filing the annual Water Audit summaries each year. Consistent with the proposed regulation, the DEP's regulations regarding water loss require certain reporting of system unaccounted for water loss (exceeding 20%). Establishing a water loss regulation is also consistent with the guidance set forth by the Susquehanna River Basin Commission and Delaware River Basin Commission."

2. The Commission's use of the AWWA Methodology since 2008 is applauded. However, using the AWWA Audit Methodology and continued use of percentage indicators/targets are incongruous since the AWWA Methodology no longer includes

or supports the use of any percentage indicators. The forthcoming Version 6.0 of the FWAS does not include percentages and percentage data will not be tracked in any AWWA assessments. Percentage indicators are imprecise metrics that misrepresent water system efficiency. It is strongly urged that the Commission abandon use of any percentage indicators and implement the use of the AWWA KPIs as detailed in these comments. The following sub-sections explain the deficiencies with percentage-based performance indicators and introduce the rationale for more meaningful and actionable performance indicators.

b. The problems with percentage performance indicators: The traditional use of volumetric percentage loss indicators, or an "unaccounted-for" water percentage, is an imprecise method which has brought more confusion than coherence to water loss assessments. This method is not a sound basis on which to motivate sustained, measurable loss reductions in North American water systems. Attempting to use a volumetric percentage - which hides the volumes of apparent losses and real losses – does not provide water utilities an ability to directly address specific losses for volume reduction. Because of this, percentage indicators are not *actionable* for water loss control; meaning a confirmed volume reduction in a utility's apparent or real losses may or may not move the percentage in an appropriate way. In some cases, the percentage may actually rise while NRW volumes are decreasing. Also, the volumetric percentage reveals nothing about cost impacts of losses and therefore places water companies at the great disadvantage of being pressed to undertake loss control actions without the cost-effectiveness of such actions being linked to the water loss standard employed by the regulatory agency. In some states, regulatory agencies using a percentage indicator have required water utilities to undertake loss control actions (and thereby incur expenditures) targeting loss reduction levels that are simply not achievable. This becomes an endeavor of wasted financial expenditures and runs counter to the mission of the Commission.

   Percentage indicators are flawed in several ways:

   - Volumetric percentages are unduly influenced and skewed by significant year-to-year change in the volume of customer consumption such as the shutdown of a large water using customer. In such a case, the percentage assigned to losses would likely increase even if actual water losses were to remain stable or decline. The volumetric percentage is heavily influenced by a parameter (total customer consumption) outside of the parameter that it attempts to measure (apparent and real loss volumes), making it highly unreliable.
   - Percentages do not reveal the distinction between the two primary losses occurring in water utilities: apparent and real (leakage) losses
   - Percentages reveal nothing about the costs of losses; thus, the cost-effectiveness of water company NRW management actions is inappropriately ignored

   With this rulemaking, the Commission has the important opportunity to advance the caliber of its regulatory practice in NRW management by eliminating the use of percentage indicators. This can serve as a model for the Commonwealth's other water regulatory

agencies: DEP, SRBC, and DRBC (DRBC requires annual AWWA water audit submittal but has not fully embraced the AWWA KPIs).

c. AWWA, through its Water Loss Control Committee, conducted important new research into performance indicators for NRW assessments and management, and released two reports in 2019. These reports, which recommend against the use of percentage indicators, are:

- "Committee Report: Key Performance Indicators for Nonrevenue Water—AWWA's 2020 Position" (*Journal AWWA*, January 2020)
- "Assessment of Performance Indicators for Non-Revenue Water Target Setting and Progress Tracking" (research report AWWA, September 2019)

d. AWWA's research report and Committee report established several new KPIs including the *Loss Cost Rate*, expressed in dollars per service connection per year, with separate indicators for apparent (customer) losses and real (leakage) losses. The forthcoming Version 6.0 FWAS includes these important new KPIs. The AWWA Methodology now includes a full array of robust KPIs that allow for rational and cost-effective assessments and NRW management planning. These KPIs are shown in Figure 1 which is a matrix which lists the KPIs and gives guidance on their appropriate use.

AWWA Recommended Water Loss Performance Indicators – Fit for Multiple Purposes and Users

Type	Indicator	Description	Suitable Purposes					Limitations Needing Further Data Collection and Assessment	Principal Users
			Assess-ment	Bench-marking	Target-Setting	Plan-ning	Track-ing		
Volume	Apparent losses (vol / conn / day)[1]	Strong and understandable indicator for multiple users	✓	✓	✓	✓	✓		Utilities Regulators
	Real losses (vol / conn / day)	Strong and understandable indicator for multiple users	✓	✓	✓	✓	✓		Utilities, Regulators, Policy Makers
	Real losses (vol / pipeline length / day)	Strong and understandable indicator for use by utilities with low connection density	✓	✓	✓	✓	✓	Data collection and assessment of the level of "low" connection density	Utilities, Regulators, Policy Makers
	Total Water losses (vol / conn / day)	Strong and understandable indicator; suitable for high-level performance measurement	✓	✓			✓		Utilities, Regulators, Policy Makers, Customers
	Real losses by pressure (vol / conn / day / pressure unit)	Robust but specialized indicator; technical rigor may be influenced by network materials.	✓	✓		✓	✓	Data collection and assessment of the use and applicable context(s) in NA	Utilities
	Infrastructure Leakage Index (ILI)	Robust but specialized ratio indicator, which can be influenced by pressure and connection density.	✓	✓			✓	Data collection and assessment for guidance on wide use in NA	Utilities
Value	Apparent Loss Cost Rate (value / conn / year)	Indicators with sufficient technical rigor. Provide the unit financial value of each type of loss, which is very useful for planning and assessment of cost efficiency of water loss reduction and control interventions and programs.	✓			✓	✓	Data collection and assessment on AWWA indicators or contextual parameters to use in conjunction with Loss Cost Rates	Utilities, Regulators, Customers
	Real Loss Cost Rate (value / conn / year)		✓			✓	✓		Utilities, Regulators, Customers
Validity	Data Validity Tier (DVT)[2]	Strong indicator of water loss audit data quality, if data has been validated. Tier provides guidance on priority areas of activity.	✓	✓		✓	✓		Regulators, Utilities

Notes: 1. Blue shading highlights real losses, green shading highlights apparent losses.
2. Data Validity Tier is a band-type grouping of Data Validity Scores: Tier I: DVS=0-25; Tier II: DVS=26-50; Tier III: DVS=51-70; Tier IV: DVS=71-90; Tier V: DVS=91-100

Figure 1 AWWA Recommended Key Performance Indicators and Appropriate Use (AWWA, 2019)

e. Analysis of the trends in these performance indicator values from the WARD has been undertaken and placed in the form of "speedometer" charts that are included in the forthcoming Version 6.0 FWAS to be released on December 4, 2020. These charts are shown

in Figure 2. The speedometers display the range of values from the WARD's 1,124 water audits by illustrating the 10th, 25th, 50th (median), 75th, and 90th percentile values for eight KPIs from these water audits.

The v6.0 FWAS was populated with example water system audit data and the calculated KPI values for this example system are shown by the black line on the speedometer charts in Figure 2. For any system being audited, their KPI values are compared with the range of values of the WARD data in the speedometer charts. As shown in Figure 2, two KPIs of the example water system – Apparent Loss Cost Rate and Unit Apparent Losses – exist above the median value of the WARD data. All other example system KPIs are well below the WARD median value. A cursory assessment of the water efficiency standing of the example system suggests that real (leakage) losses and total losses are low. However, apparent losses are moderately high, but not excessively high since they fall well below the 75th percentile level of the WARD data. This finding suggests that the example system should focus greater attention on reducing apparent losses, to bring these loss levels down to the median level of the WARD data as an achievable goal.

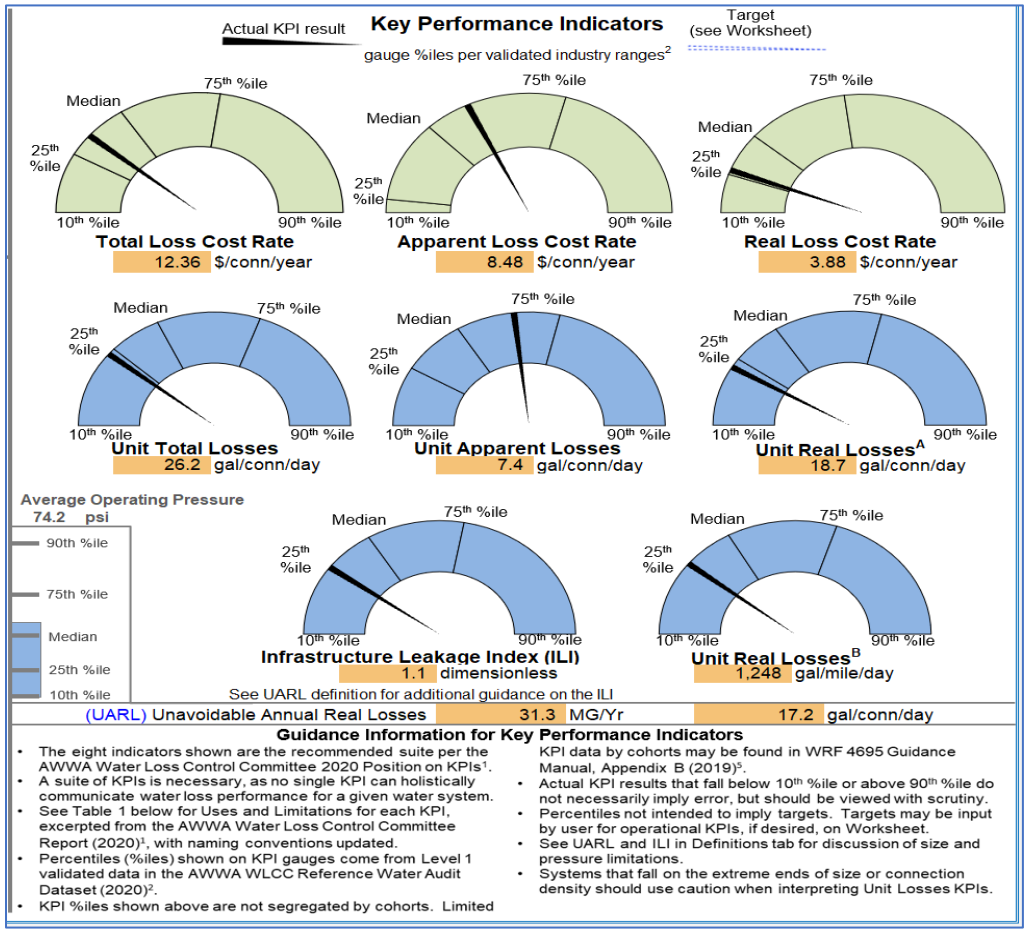

Figure 2 Excerpt of Dashboard Worksheet of Version 6.0 AWWA FWAS (2020) KPI values calculated from example data are shown

f. Mr. Kunkel also assembled a separate dataset of water audits from Pennsylvania systems. This dataset includes *unvalidated* data from the 2018 calendar year. The source of the data is mainly water audits submitted to DRBC, some water audits submitted to the Commission, and several systems not required to report to either agency. Data presentations from this Pennsylvania dataset are shown in Figures 3 through 8 give a representative range of the KPI values existing in Pennsylvania water systems. Figures 3-5 describe the range of unit apparent losses, Customer Retail Unit Charge (CRUC), and the Apparent Loss Cost Rate. These indicators represent the volume rate of apparent loss, the unit cost of apparent loss, and the indicator – Apparent Loss Cost Rate – that marries these two parameters. Figure 3 reveals a median value of 2.0 gallons/connection/day for this Pennsylvania data, a notably low value that may be understated since the data has not been validated. The WARD median value is much higher at 5.3 gallons/connection/day; but this value may be more representative since it comes from a much larger, *and validated*, dataset. This finding supports the importance of the validation process. Figure 4 displays a median CRUC value of $7.17 per 1,000 gallons for Pennsylvania water systems. The median CRUC value of the Georgia and California WARD is $4.40 per 1,000 gallons, notably lower than the Pennsylvania median value (Note: many Quebec system charge a flat rate for water service and this data was not referenced for the WARD CRUC median value). Figure 5 displays an Apparent Loss Cost Rate median value of $5.46/connection/year. This compares relatively closely to the WARD median value of $6.15/connection/year. It can also be valuable to compare the 75th and 90th percentile values of these KPIs from the Pennsylvania dataset and WARD to identify potential levels of excessive apparent loss volumes and excessive apparent loss costs that the Commission might consider as boundary values.

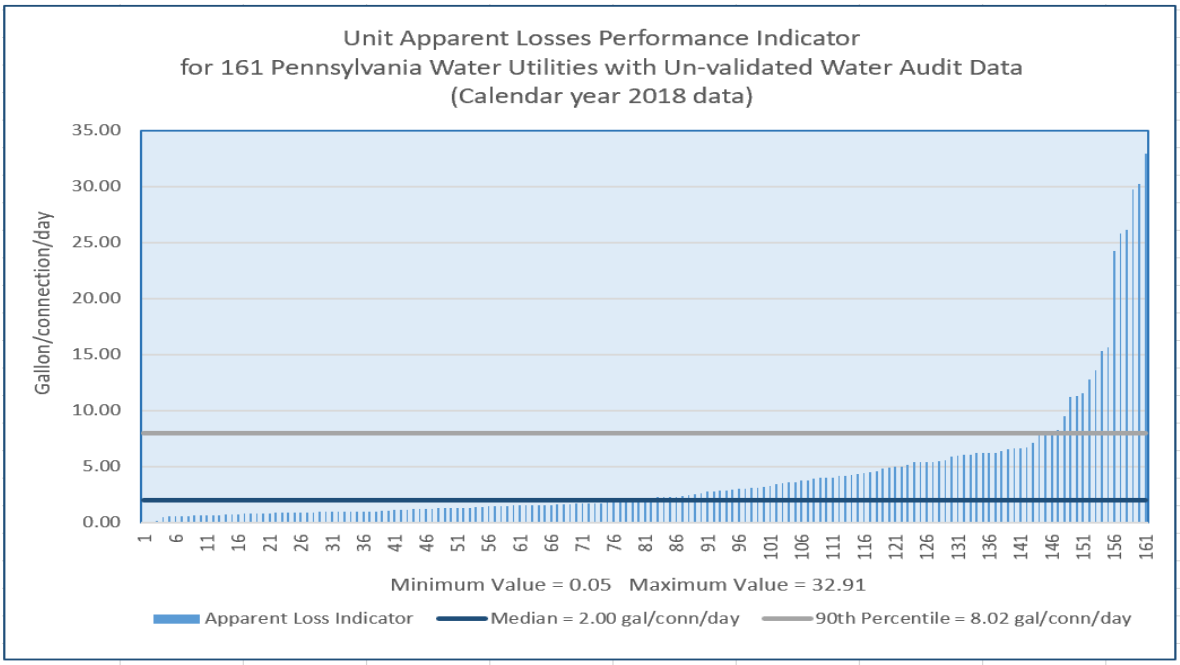

Figure 3 Unit Apparent Losses for 161 Pennsylvania Water Utilities, gal/service connection/day

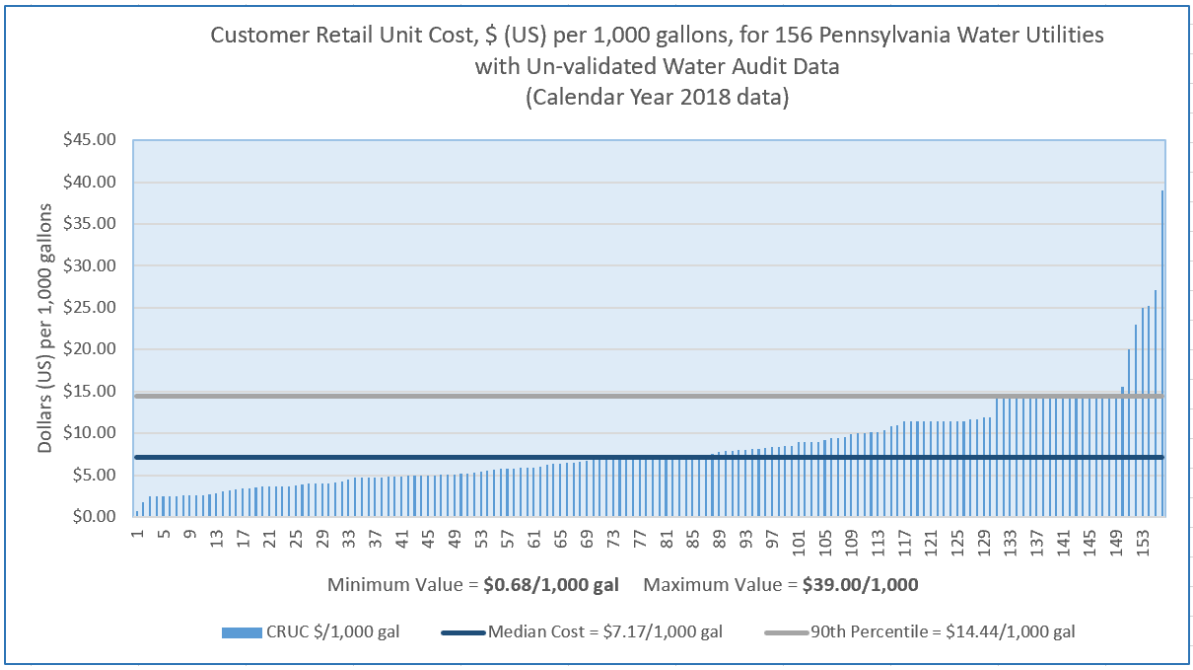

Figure 4 Customer Retail Unit Cost applied to Apparent Losses for 156 Pennsylvania Water Utilities, $ per 1,000 gallons

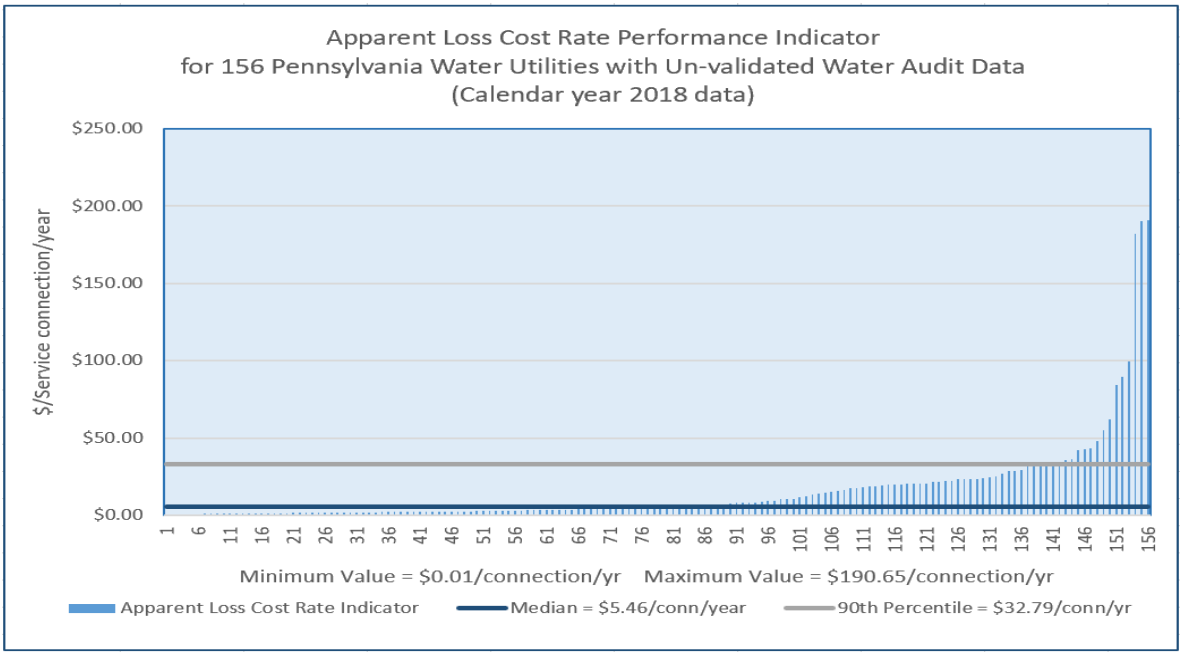

Figure 5 Apparent Loss Cost Rate for Pennsylvania Water Utilities, $/service connection/year

h. Figures 6-8 describe the range of unit real (leakage) losses, Variable Production Costs (VPC), and the Real Loss Cost Rate. These indicators represent the volume rate of real loss, the unit cost of real loss, and the indicator – Real Loss Cost Rate – that marries these two parameters. Figure 6 reveals a median value of 35.69 gallons/connection/day for the Pennsylvania data, a value very close to the WARD median of 36.78

gallons/connection/day. Figure 7 displays a median VPC value of $435.00 per million gallons for Pennsylvania systems. The median VPC value of the WARD is $529.07 per million gallons, notably higher than the Pennsylvania median value. Figure 8 displays a Real Loss Cost Rate median value of $8.87/connection/year for the Pennsylvania data. This compares relatively closely to the WARD median value of $7.95/connection/year. It can also be valuable to compare the 75th and 90th percentile values of these KPIs from the Pennsylvania Dataset and the WARD to identify potential levels of excessive real (leakage) loss volumes and excessive real loss costs that the Commission might consider as boundary values. See Table 3 in Section VII of these comments for these and additional values.

Figures 2-8 show several of the KPIs of the AWWA Methodology. These indicators are based in volumes of loss (apparent and real) and cost impact of these losses. They are effective in reliably characterizing the water efficiency standing of a water system and provide strong performance tracking and target-setting capabilities. If a water company assesses that a given water system has high apparent losses over the 75th or 90th percentile value of the WARD for instance, the company can determine what actions are cost effective to reduce apparent losses. By using the apparent loss KPIs the actual reduction in apparent losses achieved should be reflected by reduced levels of the apparent loss KPIs. In essence, the KPIs will trend in alignment with loss reduction, and are actionable indicators, unlike percentage indicators. In approaching target-setting the Commission can investigate the WARD and PA dataset to consider the range of values that exist in this data.

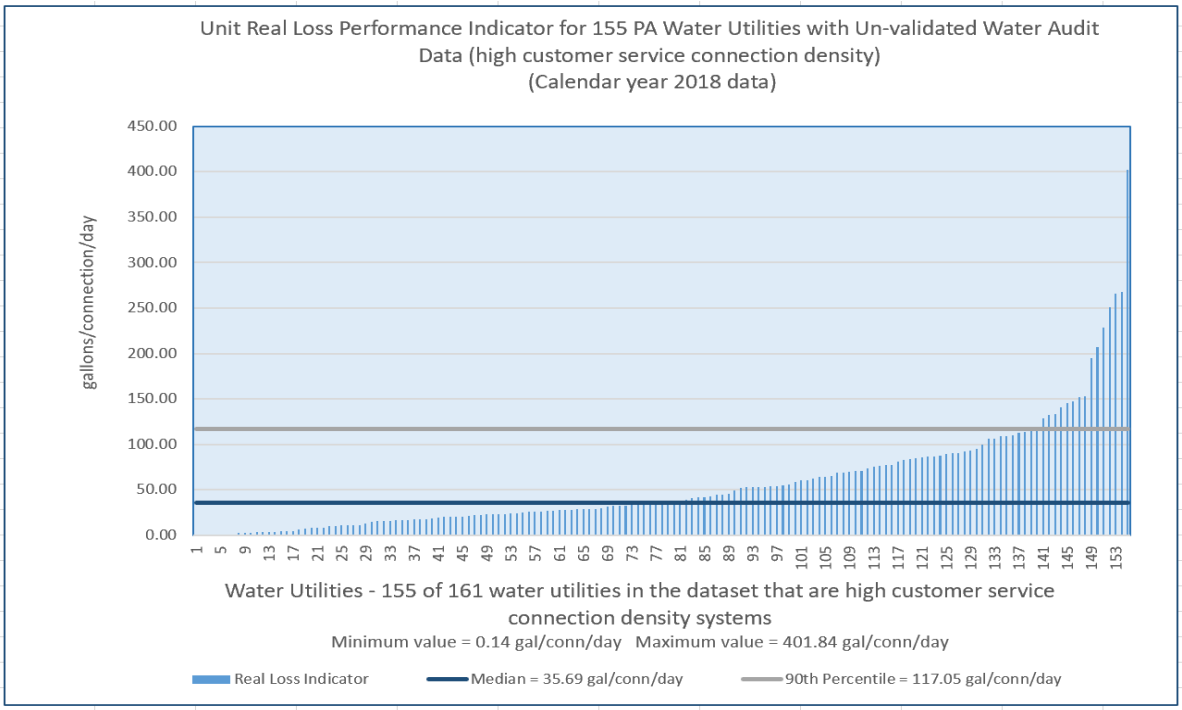

Figure 6 Unit Real (leakage) Losses for 155 Pennsylvania Water Utilities, gal/service connection/day

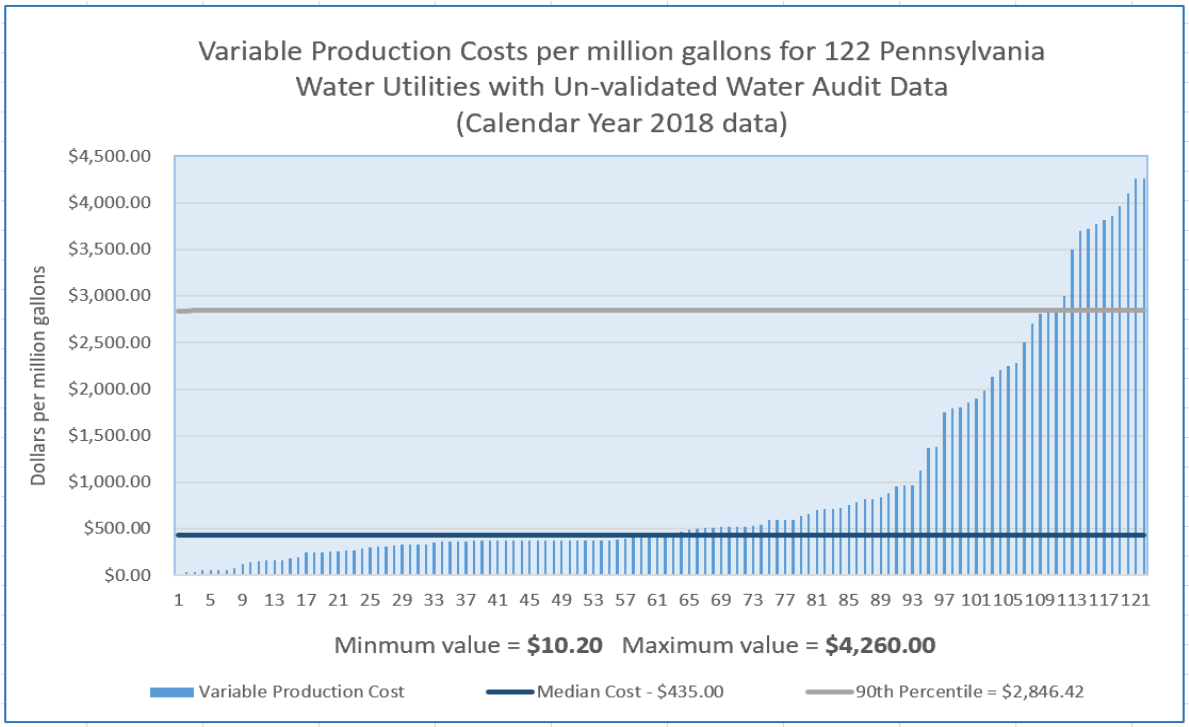

Figure 7 Variable Production Cost applied to Real (Leakage) Losses for 122 Pennsylvania Water Utilities, $ per million gallons

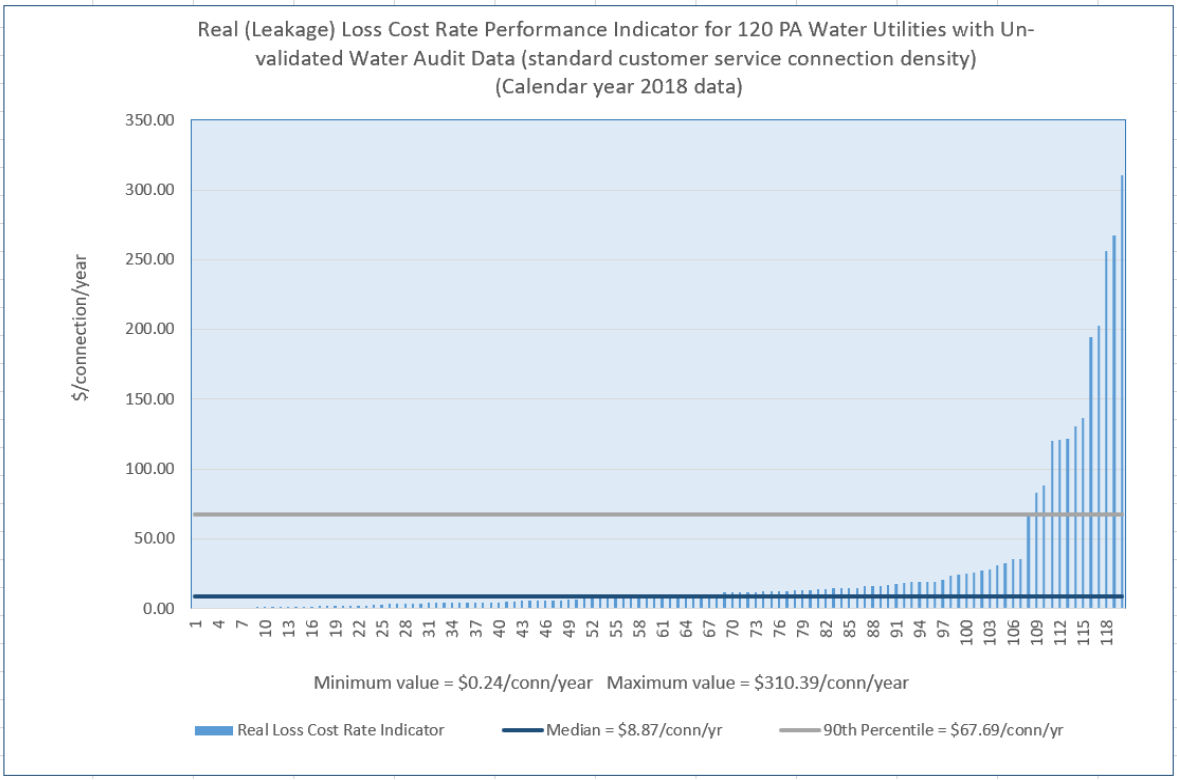

Figure 8 Real Loss Cost Rate for Pennsylvania Water Utilities, $/service connection/year

i. The KPIs of the AWWA Methodology are *output-based* measures of performance, meaning that they are based on data output measures of water volumes and costs primarily. The Commission might also consider the additional use of several *process-based* performance measures that are representative of the practices employed by the water companies. Examples include the extent of use of annual accuracy testing of production flowmeters and customer meters, customer meter reading success, leak detection activities, and other functions.

Many of these processes are characterized by the gradings assigned to the input components of the FWAS and calculated Data Validity Score (DVS). The State of Tennessee Comptroller of the Treasury oversees annual AWWA water audit data collection using the FWAS and has set goals based upon elevating the DVS incrementally over two-year periods. The intention is for water systems to improve their data collection processes over time to justify an increased DVS. Unfortunately, the State does not require validation of the water audits; and many water systems have submitted audits with increased DVS that may or may not be justified by improvement in practices. This reveals a program weakness from the absence of data validation.

It is recommended that the Commission consider two important processes in water company operations when establishing the new rule: regular production flowmeter accuracy testing and improved language for customer meter management and accuracy testing. These are elaborated upon below:

1. **Production Flowmeter Accuracy Testing and replacement**: production flowmeters are the meters that measure the bulk supply flows from the water sources or finished water effluent location as well as the custody transfer meters that measure the bulk flow of water that is imported or exported from one water system to another through interconnection piping. These flowmeters measure large flows of water and are usually the largest meters in the system. Even a small degree of inaccuracy in these meters can constitute a significant error in the volume of water believed to enter the distribution system. It is critical to the reliability of the water audit that these meters function adequately and it is proposed that:

    i. For each public water system operated by a water company, the production flowmeter(s) that continuously measure at least 5% of the annual water withdrawals/treated effluent be tested for accuracy on an annual basis. This testing process is known as flowmeter verification. For differential pressure-type flowmeters calibration of secondary devices such as differential pressure transmitters is also part of good flowmeter upkeep. However, calibration alone does not confirm the accuracy of the flowmeter and calibration alone does not meet this requirement. See the AWWA M36 manual, Appendix A for detailed guidance on flowmeter accuracy verification and calibration.

    ii. Language should be included requiring that water companies arrange for annual accuracy verification of export and import flowmeters to the extent possible.

Typically, a water company exporting (selling) water to another public water supplier owns the export flowmeter and is in a position to arrange for accuracy testing. However, when importing water from another public water supplier, the water company may need to arrange for the selling water supplier to conduct accuracy testing, which they may or may not be required in the contract of service between the two entities.

iii. Flowmeters that exist on emergency or standby supply pipelines or interconnections may be waived from the annual testing requirements if they were utilized for less than 30 days in a calendar year.

iv. Expected flowmeter life shall be 30 years and, at or before this time, flowmeters should be replaced in kind or with a new flowmeter of equal or improved capability on the same pipeline in-series to measure the same flowrate. Exceptions to this rule are for flowmeters where annual accuracy testing by the water company confirms accurate flowmeter function as defined by the accuracy limits listed in the AWWA M6 manual, "Water Meters – Selection, Installation, Testing, and Maintenance (2012), Table 5-3; or for flowmeter types not listed on this table refer to the in-situ test methods list on Table 6.1 in the AWWA M33 manual, Flowmeters in Water Supply (2018). Accuracy test reports must be submitted to the Commission and must clearly describe the test method steps employed and the detailed numeric results (merely listing pass or fail is insufficient) that confirm with M6. However, flowmeters remaining in service for over 30 years shall be tested for accuracy on a semi-annual basis and results must be within the accuracy limits of the M6 manual. Failure to achieve the M6 accuracy limits will require the flowmeter to be replaced. No flowmeters shall be permitted to remain in service for more than 40 years, and any such flowmeters shall be replaced before then reach this age.

2. **Customer Meter Management**: The Commission is urged to review its rule regarding customer meter management via accuracy testing and/or meter replacement, embodied in 052 Pa. Code § 65.8. Meters.

i. Figure 9 shows the Code's required meter accuracy testing requirement which calls for only a single accuracy test. AWWA's meter testing guidelines call for testing at three flowrates (low, intermediate, high) with the low flow test a critical measure of the meter function, particularly for 5/8-inch positive displacement meters, which are used commonly in single family residences and are the most common meter size/type used in Pennsylvania water systems. The AWWA M6 manual defines three flowrates for testing 5/8-inch meters which are ¼ gpm (low), 2 gpm (intermediate), and 15 gpm (high). The low-flow accuracy test is the most representative of meter accuracy function. AWWA requirements note acceptable flow registration from 95-101% accuracy at the low test flowrate of ¼ gpm. This heightened level meter accuracy is needed to reliably measure household toilet leaks, a low flow occurrence that is common and a considerable

source of unregistered water and under-billings by water utilities. The current Commission requirement falls short by requiring testing at only one flowrate, and at a flowrate (6 gpm) that is not included in the AWWA guidance and cannot evaluate the low-flow accuracy of the meter. A single test at a rate 6 gpm cannot provide a representative determination on the accuracy of a 5/8-inch positive displacement water meter and functions almost as "most-likely-to-pass" test flowrate. The same issue exists with meters of other sizes that are shown in Figure 9. The Commission is urged to revise its rule in this section regarding meters and allowable error to follow AWWA guidance as given in the M6 manual. It is recommended that the AWWA M6 accuracy test requirements for meters of all sizes be incorporated by the Commission in the new Rule as improvements in meter accuracy testing will directly improve the understanding and measurement of apparent losses.

§ 65.8. Meters.

(a) *Allowable error.* No water meter which has an error in registration of more than 2% may be placed in service, nor may a water meter which has an error in registration of more than 4% be allowed to remain in service, when water is passing through it at approximately the following rates of flow:

Meter size (inches)	*Gallons per minute*
5/8	6
3/4	10
1	20
1-1/2	30
2	50
3	90
4	180
6	300

Figure 9 Excerpt of 052 Pa. Code § 65.8. Meters – Allowable Error

i. Expected customer meter life is 25 years and, at or before this time, meters should be replaced with equivalent or improved metering technology. Exceptions to this rule are for meters where annual accuracy testing of a representative sample of meters by the water company confirms accurate flowmeter function as defined by the accuracy limits listed in the AWWA M6 manual, Table 5-3. Accuracy test reports must be submitted to the Commission and must clearly describe the test method steps employed and the detailed numeric results (merely listing pass or fail is insufficient) that confirm with M6. However, no meters are permitted to remain in service more than 30 years, and these shall be replaced before reaching this age.

VI. Improved water audit implementation by the Commission

It is believed that the Commission can better ensure high quality data from water company water audits by incorporating the below steps into its process as defined by the new Rule. Reliable data allows water companies to strategically plan NRW reduction activities and measure progress while giving the Commission the ability to monitor water company performance and value to customers.

a. Training: formal recurring training should be required for water utility staff and other stakeholders (Commission staff, others) involved in the AWWA Methodology, including training on the process to compile the water audit in the FWAS, use of the AWWA Compiler Software (water audit data-aggregating tool), and meaning and interpretation of the AWWA KPIs. Training should be provided by third party providers who are well versed in the AWWA Methodology and have prior experience in delivering training in a state-wide water audit program. Formal training on the AWWA Methodology helps to ensure water companies compiling the water audit in the FWAS reliably and with minimal errors. This helps to streamline the data collection and validation processes.

b. Water audit submittal requirements:

1. Water companies should submit annual data using the FWAS in its electronic (MSExcel) format. No .pdf files, paper, or other non-electronic/non-MSExcel formats are permitted for submittal.

2. An individual water audit in the FWAS MSExcel format should be submitted for each distinct water system as identified by a distinct Public Water Supply ID (PWSID). It should be recognized that all water supply systems are unique: water supply is sourced, treated, and conveyed in treatment and piping infrastructure that is unique to each system and the communities that it serves. The water production costs of each system are also unique. Water companies shall be required to input in individual system water audits the unique Variable Production Cost (VPC) that exists for each system. Historically, some water companies have reported the same VPC for multiple systems that they manage, and this practice should not be permitted. Similarly, data input gradings should be assigned based upon the individual practices (such as production flowmeter accuracy verification) conducted at the individual water system. Historically, some water companies have reported the same data input gradings for multiple water systems and this practice should not be permitted.

3. Grouped water audits (a single AWWA water audit for multiple water systems of a company) shall be permitted for submittal to the Commission, but only in addition to all individual water audits. The Commission should include a formal provision allowing for group submittals and an authorization form that allows a water company to identify which of its systems will be included in a group water audit. The authorization form should be updated and submitted annually, at least three months in advance of the upcoming water audit submittal date.

c. Water Audit data validation: The Rule shall require a formal Level 1 validation process to ascertain that each water audit meets minimum data quality requirements, and that paths to improved quality are identified.

1. The Water Research Foundation Project 4639A "Level 1 Water Audit Validation – Guidance Manual" defines the water audit validation process with three levels of data scrutiny. The guidance manual focuses on the Level 1, or initial level, of data validation. Level 1 Validation is required in several US states and the Province of Quebec, Canada. Water Research Foundation Project 5057 "Update to Level 1 Water Audit Validation: Guidance Manual" is scheduled for publication in early 2021 and will provide an update based upon the use of the validation process in Georgia, California and other jurisdictions over the past decade.

2. The Level 1 data validation process has consistently proven instrumental in creating a reliable NRW management structure in regulatory agency programs. Water companies/utilities benefit from the guidance and assistance from experienced third-party providers in assessing their practices and data handling processes. The Commission will benefit from knowing that submitted water audit data has been scrutinized for data quality and is free of egregious errors. (Note: Level 1 validation does not ensure that the water audit is free of all errors; Level 2 and Level 3 validation processes get to imbedded errors that exist in the underlying source data that supplies data inputs to the water audit.) Invariably, the DVS for many water audits decreases after the data is validated to Level 1 since some water utility staff tend to grade their data in a favorable – but not always representative – way. The successful programs in the States of Georgia and California, and the Province of Quebec serve as strong examples of reliable water audit data collection and Level 1 data validation. The Commission can reference information on these programs to learn how they were implemented in various agencies.

3. Data validation (and training) are best provided by knowledgeable third-party experts during the initial phase of the program; the first 2-4 years. The program can then shift to the use of certified validators to provide a self-sustaining validation capability at the utility/industry stakeholder level. Certified validators can be a third-party provider or a certified staff person from the water company; however, the validator cannot be a person who participated in the compilation of the water audit.

4. Water Audit Validation costs: estimated cost ranges are given below and are approximated for work conducted on 80-160 water systems that would make up the estimated population of water systems falling under the new Commission Rule. The estimates will scale up or down depending on the *final number of water system audits* involved.

    i. In the first two program years water audit training and validation program comparable to the California Water Loss Technical Assistance

Program (Water Loss TAP), which includes third party water audit validation integrated into the training structure. Budget range: $750,000 - $1,000,000

ii. Third party water audit validation in year 3 and below (recurring validation services): $175,000 - $275,000 per year. The need for this service ends when the self-sustaining validation program initiates.

iii. Development and rollout of self-sustaining Validator Certification Program in year 4: $200,000 - $250,000

iv. The scope and structure of these three programs could be modeled on successful programs in other states but would need to be adapted to align with the goals of the Commission.

5. The Chief Executive Officer, Chief Financial Officer, or Chief Engineer of the water company shall attest to the completeness and accuracy of the submitted water audits in a formal validation statement that shall be required to be submitted to the Commission accompanying each system water audit.

d. Water Audit Program Transparency: The Commission should provide water audit data transparency and visibility to industry and general stakeholders by establishing a web-based directory for access to all water audit reports received by the Commission and reports regarding such issued by the Commission. Individual water system water audits in the MSExcel Format of the FWAS, compiled data of all annual water audits in the AWWA Compiler Tool or similar data-aggregating spreadsheet, and the attestation statements should all be posted for public access. Links to reference water audit datasets and reports (NRDC, AWWA WARD) can be included here as desired. Reports of review and analysis work should also be posted on the Commission website.

e. Awards and Recognition: The Commission may consider establishing a recognition program for water companies that routinely meet annual reporting requirements, achieve noteworthy and verifiable NRW reduction, demonstrate successful NRW management programs/projects, and/or achieve consistent year-by-year compliance with the Commission's NRW targets.

VII. Water Company Performance and NRW Management Targets

a. Background information: The Commission has historically employed a volumetric percentage indicator (unaccounted-for water percentage) as the sole metric to evaluate system efficiency standing. The Commission employs a value of 20% unaccounted-for water as the threshold between acceptable and unacceptable water efficiency performance. Due to the ineffectiveness and limitations of volumetric percentage indicators described above, the Commission should rescind current threshold for corrective action of "20% unaccounted-for water" and not employ any form of percentage performance indicator in the new Rule. For

reference, several improved target-setting approaches are described below with the recommended framework approach specified in Section VII.e.

b. State Target-setting structures: Two programs of note include:

1. **State of Tennessee Comptroller of the Treasury**: water audit submittal using the FWAS has occurred annually since 2013. The Comptroller established target values for the Data Validity Score (scale of 1-100) and the Percentage of Non-Revenue Water by Cost. Progressively stronger requirements were established in 2-year increments through December 31, 2020. While this program has been successful in providing extensive training to water utility staff and collection of annual water audit data, the program does not require validation, which confirms water audit data gradings and the Data Validity Score (DVS). It is a shortcoming that one of two targets (DVS) is not subject to the data quality control check offered in the data validation process. The other target is a percentage indicator that is no longer supported by AWWA and will not be included in the forthcoming Version 6.0 FWAS to be released in December 2020. Given these shortcomings, it is not recommended that the Commission follow the format employed in Tennessee. Information on this program can be found at:

https://comptroller.tn.gov/boards/utilities/utility-management-review-board/board-information-/water-loss-information.html

2. **California State Water Resources Control Board (SWRCB)**: Performance Standards for Non-Revenue Water management are being drafted and are expected to be finalized in 2021. The performance standards will emphasize real (leakage) loss control. The SWRCB is an environmental regulatory agency and is concerned in a foremost way with water availability and minimizing leakage. An economic model was developed and is run for each of the roughly 400 metropolitan water utilities, and a leakage target generated for each system. The targets identified in this pre-rulemaking exercise suggest that many systems have leakage levels close to their target and will not need to take enhanced action on leakage control. Dozens of water systems, however, have leakage levels well above their targets and would need to initiate further leakage control actions. The performance standard includes provisions and system actions to occur incrementally from 2021-2035. The SWRCB performance standards offer benefits of system-specific, economically justified leakage reduction targets for water utilities. This will allow for close tracking of systems that have leakage above their target levels. The performance standards may not include an emphasis on apparent losses, however. As a financial regulator, it is essential that the Commission include a focus on apparent losses in the new Rule. Finally, the economic model created by SWRCB required considerable effort and cost and will need to prove its reliability over time. Information on the SWRCB performance standards can be found at:

https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/water_loss_control.html

c. Recommended target-setting posture for the Commission Rule: many of Pennsylvania's water systems have buried infrastructure that is aged and leak prone. Leakage reduction methods

have advanced notably in recent years but controlling high leakage levels still requires years of concerted effort and investment for the many water systems owned by Pennsylvania water companies. Thus, it is not believed to be realistic or helpful for the Commission to set near-term targets based upon perceived optimized low levels ("floors") of NRW. Instead, it is recommended that the Commission approach target-setting by establishing realistic and achievable "ceiling" levels of apparent and real losses and/or costs. Water systems with losses and/or costs higher than the ceiling should be considered excessive with water company action needed to reduce losses. It is recommended that the Commission initially consider high percentile levels (75% or 90%) of the WARD and/or Pennsylvania water system data to guide establishment of Commission target levels (recalling that the current Pennsylvania dataset does not include validated data). For those systems that have excessive losses and/or costs, the Commission should work with the Company to establish a NRW reduction schedule that identifies incremental loss reduction targets over a reasonable period of years to meet the specified target value. This approach should motivate the relatively small number of out-of-compliance systems to take action to bring systems with high NRW volumes and/or costs down to acceptable threshold levels of performance. The approach provides the Commission with a manageable means to track the progress of specific water systems in moving toward their loss reduction target using performance indicators that are actionable and trend with the reductions of loss.

An example of a program that employed a version of the above approach is the Metropolitan Atlanta, GA region. Stemming from regional water resource management concerns, the Metropolitan North Georgia Water Planning District set a two-tiered leakage reduction target for participating water utilities to achieve by the year 2025. The program requirements were initiated in 2017 and include:

- Water utilities with real losses greater than 60 gallons/connection/day (2013 data) must adopt a 2025 goal to reduce to less than 60 gallons/connection/day and demonstrate progress in the interim years toward meeting this goal.
- Water utilities with real losses between 35 and 60 gallons/connection/day (2013 data) must adopt a 2025 goal to reduce to less than 35 gallons/connection/day and demonstrate progress in the interim years toward meeting this goal

These requirements apply to water utilities serving at least 3,300 individuals and with customer service connection density greater than 32 connections per mile of pipeline. Note that the levels of 60 gal/conn/day and 35 gal/conn/day were based upon several years of validated water audit data of the Metropolitan Atlanta area, and the range of values of the unit real (leakage) losses occurring in this data. This is a good example of one agency collecting validated water audit data and using the data to devise a tiered, incremental approach to motivate loss reduction in water utilities.

d. Water audit data serves as the basis of loss reduction targets: The Commission can reference the validated data of the AWWA WARD and the 2018 Pennsylvania Dataset. However, the most useful data to serve as reference will be *validated* data of the water companies

administered by the Commission. It is therefore recommended that the ultimate performance thresholds under the new Rule be based upon at least two consecutive years of ***validated*** water audit data. Target levels should then be reviewed and adjusted as needed every three years to keep current with KPI trends of Pennsylvania and North American water utilities. As NRW levels presumably decrease across the total of water company data, NRW targets could gradually be reduced. Eventually, long-term targets can be set.

e. KPIs for performance tracking and target-setting: The mission of the Commission is to help ensure safe and reliable utility service at reasonable rates. KPIs that evaluate water loss by volume and cost impact are the appropriate and useful indicators to promote strong system water efficiency, ensure good customer service, and set fair rates. The Loss Cost Rate indicators (apparent and real) were devised as a KPI that incorporates both volume and cost. Efforts by water companies to better manage NRW levels need to be evaluated on volumes of losses reduced. At the same time, the means to meet Commission targets should not be cost-inefficient. Water companies should not be expected to spend more on NRW reduction activities than can be recovered in NRW reduction savings, i.e. expected NRW reduction should be cost-effective. Recommended below are the fundamental steps to take to set targets based upon volumes and costs. Water systems with loss/cost values above the designated "ceilings" shall require water company action to reduce losses to at least the target level within a defined 2-4-year period. Water companies should be required to take specific NRW reduction actions when:

   i. the volume of water losses is wasteful, identified by being higher than the 75th percentile or 90th percentile values of Unit Apparent Loss Rate and Unit Real Loss Rate in gallons per service connection per day

   ii. the cost of water losses is high, identified by 75th percentile or 90th percentile values of Customer Retail Unit Charge (CRUC) in dollars per 1,000 gallons of customer consumption applied to apparent losses, and/or Variable Production Cost (VPC), in dollars per million gallons of water supplied applied to real losses.

   iii. High losses and expensive water exist, as identified by 75th percentile or 90th percentile values of the composite indicators Apparent Loss Cost Rate and Real Loss Cost Rate, in dollars per service connection per year

   Table 3 lists the median (or 50th), 75th, and 90th percentile values of the WARD and Pennsylvania dataset, including the four volume and cost KPIs and the CRUC and VPC values for reference.

   It is recommended that the Commission employ the four volume and cost rates, namely: Unit Apparent Losses, Apparent Loss Cost Rate, Unit Real Losses, and Real Loss Cost Rate, to track water company performance and use to set targets.

	WARD KPI Values			PA Dataset KPI Values		
Percentile Values - >	50th Perc.	75th Perc.	90th Perc.	50th Perc.	75th Perc.	90th Perc.
Unit Apparent Losses, gal/conn/day	5.30	6.85	12.52	2.00	4.98	8.02
Apparent Loss Cost Rate, $/conn/year	$6.15	$14.13	$24.23	$5.46	$20.10	$32.79
Customer Retail Unit Charge, $/1,000 gallons	$4.40	$5.21	$7.42	$7.17	$11.39	$14.44
Unit Real (Leakage) Losses, gal/conn/day	36.78	66.38	115.43	35.69	78.85	117.05
Real (Leakage) Loss Cost Rate, $/conn/year	$7.95	$16.29	$35.55	$8.87	$17.02	$67.69
Variable Production Cost, $/million gallons	$529.07	$1,079.09	$1,997.24	$435.00	$970.78	$2,846.42

Table 3 Volume and Cost-based Key Performance Indicators Values from Reference Datasets

The Commission could identify a provisional ceiling value for each of these KPIs and use the ceiling value to monitor incoming water audits over the first 2-4 years of validated water audit data collection. The provisional ceiling value can then be revised based on the multi-year pool of validated water audit data. As an example, for Unit Apparent Losses, Table 3 lists 90th percentile values at 12.52 and 8.02 gal/conn/day from the WARD and PA datasets. The Commission might select an intermediate value of 10 gal/conn/day as the provisional ceiling value for this KPI based upon these dataset values.

As the Commission requires out-of-compliance companies to take loss reduction actions, the KPIs will assist companies in setting their loss reduction strategy and monitoring progress. For example, consider a water system that has exceeded the target threshold for Unit Apparent Losses and has a High Apparent Loss Cost Rate, but with acceptable real loss levels, then the water company should strive to cut apparent losses. Actions to take might include billing system analysis, customer meter replacement, Advanced Metering Infrastructure (AMI) system installation, or unauthorized consumption detection. By implementing such actions as deemed necessary by the water company, apparent loss reduction is the likely result. The water company need not accelerate its leakage control efforts since its real loss KPIs exist below threshold levels. This approach is strategic and is superior to percentage indicators which don't reveal whether excessive NRW is due to excessive apparent loss or excessive real loss.

f. Several Pennsylvania water companies operate many systems of different sizes, but with many small systems. Some of these companies currently submit group water audits for clusters of systems. As stated earlier the Commission should require a separate and distinct water audit in the FWAS for each public water supply system. This is needed to identify the loss and cost levels of individual systems. But group water audits should be permitted in

addition to the individual water audits when systems serving less than 10,000 population exist. The Commission can reserve the option to apply loss control targets on the KPIs of the Group audit rather than individual water audits. This should be at the discretion of the Commission in communication with the water company.

VIII. Data Analytics – a high-level analysis of the water company data should be conducted by the Commission annually. Such analysis is done approximately every other year by the Delaware River Basin Commission and can be used as a model. The Commission might consider having analysis conducted by third party experts for the first 2-4 years of the new program, similar to the California Water Audit Technical Assistance Report, which describes trends in NRW levels and notes the number of water systems that have incurred exceedances of Commission ceilings for various AWWA KPI values. The report could also highlight general year-by-year trends in the occurrence and reduction of NRW in the water companies.

IX. Funding

a. Opportunities to create a funding pool contributed to by participating water companies should be reviewed. The pool's funds might be combined with available Commission funding, and directed to the launch costs of the new program, including training, validation, and data analysis in the first 2-4 years, after which the program becomes self-sustaining with the creation of a certified validator program.

X. PA Public Utility Commission Staffing and Funding

a. The Commission might consider assigning staff (one-half full-time-equivalent, or FTE, or greater) to oversee the NRW management program within the Commission. Funding to cover administrative costs should also be established.

XI. Appendix – Draft Regulatory Language

§ 65.1. Definitions.

Add the following new terms:

Level 1 validation – A review of the water loss audit that includes an examination of the data sources used for each unput and an evaluation of the data validity score assigned to each input of the audit, conducted in accordance with the Water research Foundation Level 1Water Audit Validation: Guidance Manual 4639A.

Non-Revenue Water – The components of water system input volume that are not billed and produce no revenue, consisting of unbilled authorized consumption, apparent losses, and real losses.

Water audit – a thorough examination of the accuracy of water utility data , records, accounts, policies, and practices regarding the volumes of water that are conveyed from water sources to treatment and then to distribution and customer consumption; ultimately distinguishing volumes reaching customers from volumes of loss.

Water audit report - the required materials to be submitted by water companies to the Commission annually, including the fully operational water audit spreadsheet (MSExcel format) generated from the AWWA Free Water Audit Software, signed attestation statement, and report of completed training activities.

§ 65.20. Water conservation measures—statement of policy.

Subsection (4) is revised as follows: -

~~(4) *Unaccounted-for water*. Levels of unaccounted-for water should be kept within reasonable amounts. Levels above 20% have been considered by the Commission to be excessive.~~

(4) *Non-Revenue Water*. Non-Revenue Water shall be calculated annually and transmitted to the Commission. Class A water companies shall incorporate their calculation of Non-Revenue Water in the annual water audit report pursuant to § 65. XX. Levels of Non-Revenue Water, or components thereof, shall comply with such performance standards and timetables as may be established by the Commission in this Chapter.

§ 65. XX. Water audits and water loss reporting.

(a) *Water audit reports*. Each Class A utility shall, on an annual basis, conduct a water audit on its water system and transmit such a water audit report to the Commission by April 30 immediately following the reporting year.
   1. Reports shall include a complete and fully operational water audit spreadsheet generated from the AWWA Free Water Audit Software (currently MSExcel format).
   2. Each report shall include system-specific data entered into each relevant field of the water audit worksheets.

3. In the case of utilities with two or more separate drinking water systems (unique PWSID number), the utility shall submit a separate water audit report for each system. A utility may request prior approval to additionally file a report covering more than one system upon a showing that similar geography, features, attributes, and cost profiles will result in a combined audit that is representative of each water system so covered.

(b) *Public posting*. Within five days of submission to the Commission, each water audit report shall be posted on the utility's internet web site.

(c) *Level 1 validation*. Each water audit report for calendar year 2022 and later shall undergo Level 1 validation prior to transmission to the Commission. A Level 1 validation shall include:

1. An interview between the water audit validator and the person or persons who prepared the water audit, and any member of the utility staff with information that the water audit validator believes is necessary to complete the Level 1 audit validation.
2. A review and evaluation of the following documentation:

   (i) The completed AWWA Free Water Audit spreadsheet.

   (ii) The reported water volume from its own sources, as documented by the supply meter(s) or other means, as applicable.

   (iii) The reported volume of water imported and exported each month by connection.

   (iv) The documentation of the customer meter and supply meter accuracy testing and calibration.

   (v) The reported volume of authorized consumption each month broken down by water rate if different rates are applied to water users.

   (vi) Support documentation on other input components of the water audit including system data and cost data

3. A review and evaluation of the accuracy of performance indicators included in the AWWA Free Audit Software.
4. A review of audit inputs and data grading values to confirm a correct application of methodology, and follow-up reviews (if indicated).
5. A summary of the validation, including:

   (i) Name and contact information of the water audit validator.

   (ii) A summary of the Level 1 validation utility staff interview, including the basis for the input derivations and the data validity score selections, noting the change in data validity score from the pre-validation to post-validation status.

   (iii) Any recommended changes to the water audit inputs by the water audit validator that were not accepted by the water utility, and the rationale for not accepting the recommendations.

   (iv) A summary of any follow-up performance indicator reviews.

   (v) Overall impressions, including the consistency of performance indicators with system conditions and water loss management practices.

   (vi) Any recommendations for further validation or water audit improvements.

(d) *Qualifications for a water audit validator*.

1. A Level 1 water audit validation shall be performed by a person with either of the following qualifications --

(i) An individual who can document having conducted water audits in accordance with the method specified in this Chapter, and having conducted a minimum of 10 Level 1 audit validations in accordance with the Water Research Foundation Level 1 Water Audit Validation: Guidance Manual 4639A (Water Audit Validation).

(ii) An individual certified by the American Water Works Association or any of its state sections as a water audit validator.

(iii) An individual designated as a certified validator in a program as may be established by the Commission at a time after the initial 2-4 years of activity of the water audit validation process.

2. A water audit validator may not conduct a Level 1 validation on any water audit for which that person participated in its compilation.

3. A utility may conduct a water audit validation for its own water audit, provided that the individual performing the validation meets the requirements of this section.

(e) *Accompanying documentation*. Each water audit report for calendar year 2022 shall be accompanied by –

1. A statement confirming the Level 1 validation of the submitted water audit, including the validation findings, and documentation of:
   (i) Identification of the water audit validator.
   (ii) Qualifications of the water audit validator.
   (iii) Date of the Level 1 validation review.
2. A description of the training offered and taken by water company staff compiling the water audit; and
3. A statement attesting that the water audit report meets the requirements of this section and has been prepared in accordance with the methods described herein, signed by the chief executive officer, chief financial officer, or chief engineer of the water company.

(f) *Public posting*. Within 30 days of final acceptance by the Commission, the Commission shall place Company water audit reports and all related documents on an easily accessible and visually conspicuous website with data and information available in the public domain.

(g) *Water loss performance requirements:* **RESERVED**

Draft Regulatory Language (cont'd)

§ 65.8. Meters.

Subsection (a) and (b) are revised as follows:

~~(a) *Allowable error.* No water meter which has an error in registration of more than 2% may be placed in service, nor may a water meter which has an error in registration of more than 4% be allowed to remain in service, when water is passing through it at approximately the following rates of flow:~~

~~*Meter size (inches)*~~	~~*Gallons per minute*~~
~~5/8~~	~~6~~
~~3/4~~	~~10~~
~~1~~	~~20~~
~~1-1/2~~	~~30~~
~~2~~	~~50~~
~~3~~	~~90~~
~~4~~	~~180~~
~~6~~	~~300~~

(a) *Allowable error – new and rebuilt meters.* No new or rebuilt customer service water meter which has an error in registration greater than that allowed by the test requirements identified in subsection (c) may be placed in service.

(b) *Allowable error – inservice meters.* No water meter which has an error in registration of more than 4% outside the accuracy limits specified by the test requirements identified in subsection (c) shall be allowed to remain in service.

(c) *Test requirements*. Test requirements applicable to this section shall be those contained in Table 5-3, Test requirements for new, rebuilt, and repaired cold-water meters, American Water Works Association Manual M6, Fifth Edition.

(~~b~~d) *Periodic tests.* No public utility furnishing metered water service may allow a water meter of 1 inch or less nor a water meter of more than 1 inch to remain in service for a period longer than 20 years and 8 years respectively without testing it for accuracy and readjusting it if it is found to be incorrect beyond the limits established in subsection (a). No customer service meter shall remain in service for more than 30 years. Upon a customer's request the public utilities shall also perform a meter test without charge if a meter has been in service, and has not been tested, for a period greater than that specified in the following table:

Inch Meter	*Years*
5/8	10
3/4	8
1	6
More than 1	4

[Remainder unchanged]

§ 65.14. Measurement.

(a) *Measuring devices.* Within 3 years after the effective date of this section, each utility shall install a suitable measuring device at each source of supply in order that a record may be maintained of the quantity of water produced by each source.

(b) *Records.* At least once each month, the quantity produced from each source of supply shall be determined. Twelve month totals by sources shall be recorded and transmitted to the Commission with the annual report of the utility to the Commission. The records shall further show actual annual metered consumption and any other properly estimated revenue-producing unmetered water.

(c) *Testing and reporting*. Each utility shall test all production, import, and export flow meters on an annual basis.

1. Test procedures and accuracy limits shall conform with Table 5-3, Test requirements for new, rebuilt, and repaired cold-water meters, American Water Works Association Manual M6, Fifth Edition, or for flowmeter types not listed on this table refer to the in-situ test methods list in Table 6.1 in the American Water Works Association Manual M33, Flowmeters in Water Supply (2018).

2. Any flowmeter which has an error in registration greater than that allowed by the test requirements identified in paragraph 1 shall be repaired or replaced.

3. The following flowmeters are exempt from this requirement:

(i) a flowmeter that measures less than 5 percent of the annual total of water supplied to customers.

(ii) a flowmeter located on an emergency or standby supply pipeline or interconnection if utilized for less than 30 days in a calendar year.

(iii) a flowmeter for which the utility provides documentation of the inability to test based on site conditions or other constraints specific to such flowmeter, and such documentation is approved by the Commission.

4. An annual accuracy verification report containing test results for all flowmeters tested shall be prepared and transmitted to the Commission.

5. No flowmeter shall remain in service for more than 40 years unless documentation of accuracy of such meter is transmitted to and approved by the Commission.

XII. References

1. AWWA (American Water Works Association). 2016. AWWA Manual of Water Supply Practices M36: Water Audits and Loss Control Programs, 4th Ed. Denver, CO: AWWA.

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3. *Report on the Evaluation of Water Audit Data for Pennsylvania Water Utilities*, Kunkel Water Efficiency Consulting for the Natural Resources Defense Council, 2017. https://www.nrdc.org/sites/default/files/pa-utilities-water-audit-data-evaluation-20170215.pdf

4. "Pennsylvania's Water Audit Technical Assistance to Small Water Utilities" presentation at the North American Water Loss Conference, G. Kunkel, December 6, 2020, Nashville, TN

5. Committee Report: Key Performance Indicators for Nonrevenue Water—AWWA's 2020 Position" AWWA Water Loss Control Committee (*Journal AWWA*, January 2020 abridged). Full report is available at: https://www.awwa.org/Portals/0/AWWA/ETS/Resources/WLCCKPIReport%202019.pdf?ver=2019-11-20-094638-933

6. Assessment of Performance Indicators for Non-Revenue Water Target Setting and Progress Tracking" (research report) AWWA, September 2019 https://www.awwa.org/Portals/0/AWWA/ETS/Resources/WLCCAssessmentReport2019.pdf?ver=2019-11-20-094731-123

7. AWWA (American Water Works Association). 2012. AWWA Manual of Water Supply Practices M6: Water Meters – Selection, Installation, Testing, and Maintenance, 5th Ed. Denver, CO: AWWA.

8. AWWA (American Water Works Association). 2018. AWWA Manual of Water Supply Practices M33: Flowmeters in Water Supply, 3rd Ed. Denver, CO: AWWA.

9. California Water Loss Technical Assistance Program Final Report, Water System Optimization, Inc and Cavanaugh & Associates (2018). Prepared for the California-Nevada Section of the American Water Works Association

10. Andrews, L., K. Gasner, R. Sturm, G. Kunkel, S. Cavanaugh, W. Jernigan, 2015. Level 1 Water Audit Validation – Guidance Manual. Project 4639A. Denver, Colo.: The Water Research Foundation.

11. Update to Level 1 Water Audit Validation: Guidance Manual. Project 5057. Denver, Colo.: The Water Research Foundation. Publication anticipated in 2021

12. Analysis of Calendar Year 2016 Water Audit Data from Public Water Supply Systems in the Delaware River Basin, Delaware River Basin Commission, February 2018.

Reference 5 is included below. Other references can be provided by G. Kunkel, AWWA or WRF


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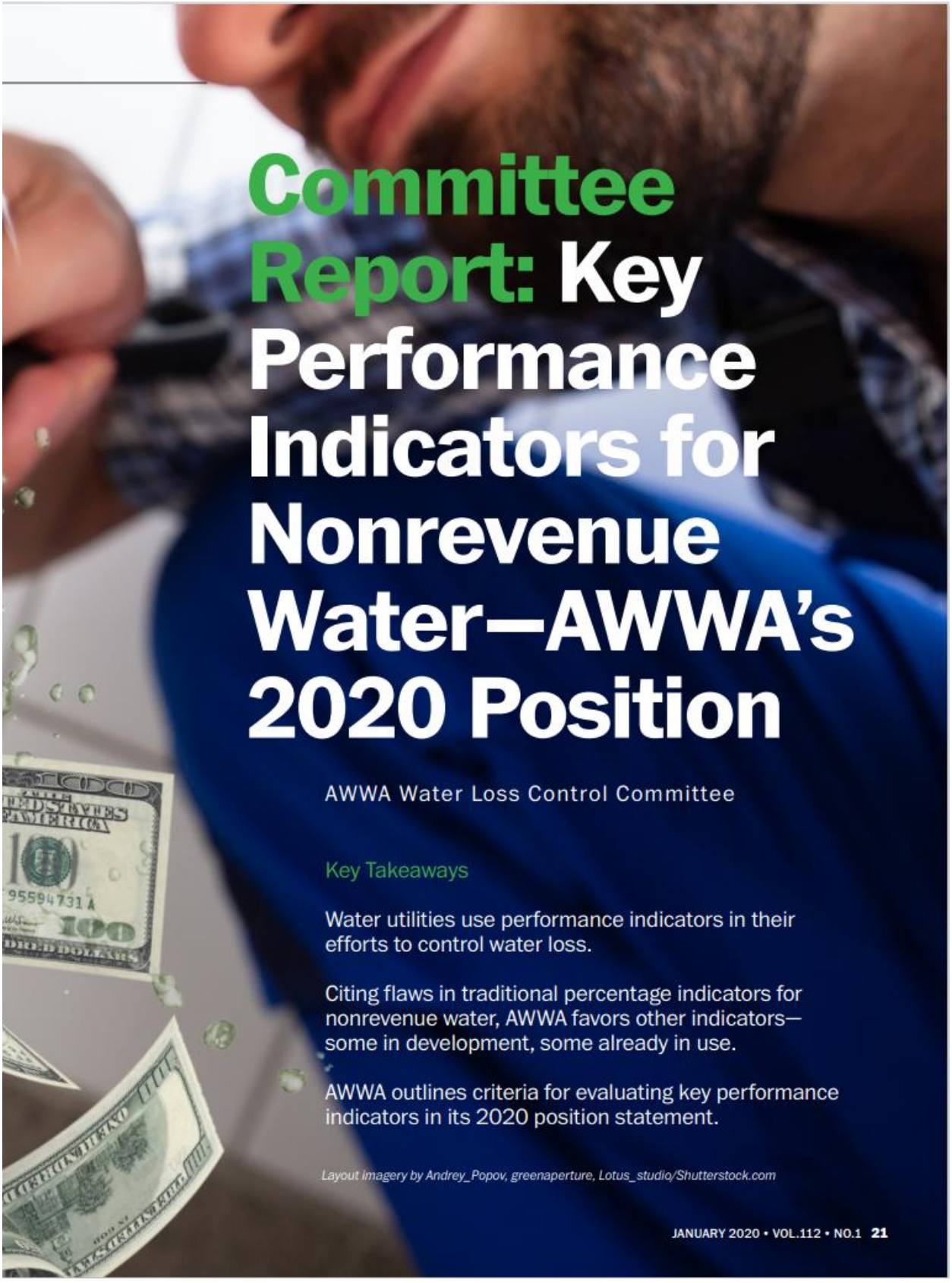

Committee Report: Key Performance Indicators for Nonrevenue Water—AWWA's 2020 Position

AWWA Water Loss Control Committee

Key Takeaways

Water utilities use performance indicators in their efforts to control water loss.

Citing flaws in traditional percentage indicators for nonrevenue water, AWWA favors other indicators—some in development, some already in use.

AWWA outlines criteria for evaluating key performance indicators in its 2020 position statement.

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Since 2003, AWWA's Water Loss Control Committee (WLCC) has encouraged utilities and other stakeholders to assess and control water loss using the nonrevenue water (NRW) key performance indicators (KPIs) outlined in AWWA Manual of Water Supply Practices M36, *Water Audits and Loss Control Programs* (4th edition, 2016) and the associated Free Water Audit Software (FWAS; version 5.0, 2014).

However, on the basis of potential new indicators and a growing concern about the use of percentage indicators, the WLCC recently reviewed these KPIs, ultimately concluding that AWWA would no longer support NRW percentage indicators and would instead support adding two new KPIs—the loss cost rate and normalized water losses indicator—to AWWA's existing array of KPIs.

The process used to reach these conclusions and how they should be interpreted and used by utilities and other stakeholders is outlined in this report.

Background

Drinking water utilities are challenged by deteriorating infrastructure, growing customer expectations, new regulatory requirements, and a changing climate. Recognizing that "what gets measured gets managed," water utilities rely on performance indicators that are "actionable" to drive improvements in their operations.

Water loss control includes the efforts of water utilities to minimize NRW, which consists of real (physical) losses, largely leakage; apparent (nonphysical) losses that result in customer underbilling; and unbilled, authorized consumption. AWWA recommends that water utilities use a best-practice water audit method described in M36. AWWA's FWAS spreadsheet can be used to apply this method and a forthcoming version (6.0), is planned for release in 2020. AWWA also supports the use of annual water audits by water utilities in its Metering and Accountability Policy Statement (available at www.awwa.org). These tools and policies guide water utilities in quantifying water losses; evaluating cost-effective loss control actions; and demonstrating to regulators, customers, and other stakeholders that utilities are responsible stewards of the valuable water resources and money they manage.

A large body of reliable water audit data has been collected from water utilities, and analysis of the data provides evidence of the types, extent, and costs of losses occurring in North America.

Thousands of water utilities have used AWWA tools to compile a reliable water audit and implement effective loss control practices; this approach is now required in several US states and at least one Canadian province. A large body of reliable water audit data has been collected from water utilities, and analysis of the data provides evidence of the types, extent, and costs of losses occurring in North America.

The traditional use of a single NRW percentage loss indicator, or "unaccounted-for" water percentage—which is imprecise—continues to bring more confusion than coherence to water loss assessments. This method arguably has never been successful in motivating sustained, measurable loss reductions. The AWWA water audit method includes an array of KPIs that represent both traditional and new, more insightful ways to evaluate NRW. While the current FWAS includes effective KPIs, it still uses two percentage indicators, although this is now considered to be a weakness by the WLCC.

With the development of version 6.0 of the FWAS, the WLCC determined that it was time to reevaluate its position on NRW KPIs. The committee believed that new KPIs were superior to percentages for water loss management and, in 2015, launched the Performance Indicators Task Force (PITF) to evaluate the acceptability of historically used KPIs and recommend the appropriate set of NRW KPIs to use going forward—i.e., AWWA's 2020 position.

The PITF included WLCC leadership and members representing a broad spectrum of water industry professionals and affiliations. It conducted research and evaluated traditional and contemporary NRW KPIs, which served as the basis of the 2020 position. The newly recommended slate of KPIs will appear in version 6.0 of the FWAS, the 2020 AWWA Benchmarking Survey, and the next edition of M36.

The decisions formulated by the PITF in guiding the new WLCC position include three recommendations (refined as position statements in the section titled "AWWA's 2020 Position"):

- Discontinue support for any percentage performance indicator, including the volumetric percentage performance indicator (VPPI), often expressed as an "unaccounted-for" water percentage, the financial percentage performance indicator (FPPI), and others structured as a percentage.
- Promote certain existing and two new KPIs—the loss cost rate (LCR) and normalized water losses—to use specifically in place of percentage indicators.

Nonrevenue water management has been historically hindered by the longstanding misconception that assessments can be reliably conducted using a single key performance indicator.

- Guide water utilities, regulatory agencies, and other stakeholders in using and interpreting AWWA's entire array of NRW KPIs in a manner that meets their situational needs.

The process leading to these recommendations is described next, along with guidance for implementing them. The WLCC's 2020 position is seen as the important next step in the evolution of water loss control advancement for the North American drinking water industry.

The Task Force Establishes KPI Criteria

The PITF established four criteria for the NRW KPIs advocated in AWWA's 2020 position. The KPIs should be

- technically rigorous, reflecting field observations and theoretical principles, without significant bias or influence from situational parameters;
- easily understood by a wide range of stakeholders, including water utilities, regulatory agencies, customers, elected officials, and the media;
- suitable for target-setting and monitoring of progress in loss reduction activities—i.e., they must be actionable; and
- suitable for the state of readiness of North American water utilities and regulatory agencies, recognizing that some water utilities will be new to water loss control and that regulatory agencies need straightforward ways to collect water audit data and loss control monitoring that can be readily implemented.

No KPI in the recommended suite is expected to satisfy all four of these criteria; however, they are all technically rigorous and suitable for the preparedness of North American water utilities and regulatory agencies. Some KPIs are specifically suited for setting loss reduction targets, while others are fit for benchmarking comparison, operational efficiency, or financial efficiency. Certain KPIs are expected to resonate with nontechnical stakeholders, while others have strong appeal for regulatory agencies. Most importantly, the AWWA water audit method features a full array of KPIs that, when applied collectively, provide a better understanding of the occurrence of NRW and its costs in utility operations than what has been previously available. Loss control activities are reliably planned and conducted when using the full suite of NRW KPIs in the AWWA water audit method. This is significant because NRW management has been historically hindered by the longstanding misconception that assessments can be reliably conducted using a single KPI (percentage or otherwise).

The PITF knew the KPIs needed to be both technically astute and understood by a range of stakeholders. The task force began with an understanding that percentage indicators are technically weak because they are distorted by changing customer consumption levels, causing percentages to be easily misunderstood. Additionally, percentages are not actionable, so setting goals involving lower percentages does not easily translate into saving water, reducing production costs, or gaining revenue. Certain NRW KPIs must be actionable or able to be used for translating loss reduction efforts to measurable savings in water and money. In moving beyond percentage indicators, the drinking water industry will also move beyond the misconception that a utility's loss standing can be assessed using any single KPI. Like financial performance and drinking water quality, comprehensively assessing a utility's water loss requires multiple parameters and KPIs to objectively provide direction.

NRW KPIs must be applicable to the current state of readiness of water utilities and North American regulatory agencies to implement. However, because many water utilities are unfamiliar with AWWA methods and tools, KPIs and their implementation must be easily grasped by staffs at water utilities of all sizes, albeit with moderate training to understand the methods.

The features of the 2020 position will be included in version 6.0 of the FWAS and the next (fifth) edition of M36 (targeted for 2021). Incorporating the 2020 position into AWWA's key water loss control publications will support the drinking water industry for the next five years or so, but additional improvements in the water audit process and data collection software platforms are already being planned.

AWWA-Funded Research on NRW Performance Indicators

Current and new NRW KPIs were examined using the PITF's four criteria as described here and in the Technical and Educational Council (TEC) 2019 project report, *Assessment of Performance Indicators for Nonrevenue Water Target Setting and Progress Tracking.* Three tasks were requested of this research:

- Explore a list of KPIs to evaluate and control NRW, including those suited for setting water loss control targets.

- Analyze prospective KPIs using validated water audit data, including data from California and Georgia and an enhanced version of the AWWA Water Audit Data Initiative, known as the WADI Plus data set (see the Water Research Foundation's 2019 project 4695, *Guidance on Implementing an Effective Water Loss Control Plan*).
- Survey several US state and Canadian provincial regulatory entities that have implemented water loss control regulations and that document the key characteristics of their programs, including how they use NRW KPIs.

The core methodology of the research assessed each indicator for the four criteria, using a mix of quantitative and qualitative scoring. Technical rigor was assessed using the frontier analysis method, which predicts relative performance for utilities in a similar mathematical situation. For example, if an indicator measuring real losses is well correlated with real loss performance from the frontier analysis, that indicator is considered technically rigorous.

The final TEC project report presented a recommended set of NRW KPIs and a rationale for phasing in, or out,

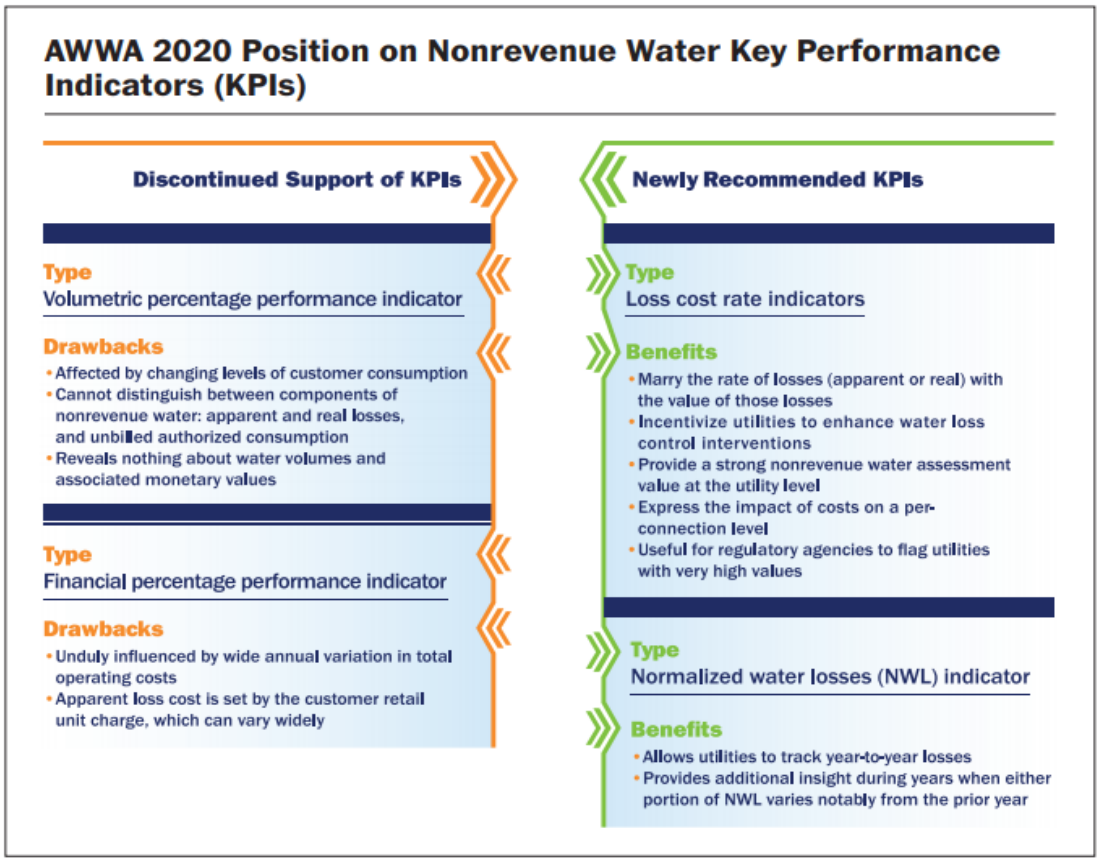

Figure 1

certain indicators. The research provided objective assessments of NRW KPIs and provided the foundation of the WLCC's new position.

AWWA's 2020 Position

Since 2003, AWWA has advocated using the NRW KPIs included in M36 and FWAS for water loss assessments and loss control planning. Informed by the TEC report and its member deliberations, the PITF recommended a new position on NRW KPIs, along with specific guidance on their use. Three primary changes to the KPIs were recommended (summarized in Figure 1):

- AWWA no longer supports any form of NRW percentage KPIs, including volumetric indicators such as water loss percentage indicators, "unaccounted-for" water percentages, and financial percentage indicators.
- AWWA supports the use of the LCR indicator, a new KPI expressed in value per service connection per year, with one expression for apparent losses and one for real (leakage) losses. These KPIs measure the negative impact of losses on a utility's finances.
- AWWA supports the use of the normalized water losses indicator, a new KPI expressed in volume per service connection per day. *Water losses* is the sum of apparent losses and real losses. It is meant to be used only as a high-level indicator and in tandem with the disaggregated normalized KPIs: normalized apparent loss (volume per service connection per day) and normalized real loss (volume per service connection per day).

Each of these changes is discussed further in the following sections.

AWWA's Discontinued Support of NRW Percentage Indicators

Percentages are problematic because their fractional components (numerator and denominator) can be unduly influenced by factors unrelated to water loss control activities. The basis for discontinuing support for them is twofold.

First, the KPI known as the volumetric percentage performance indicator (VPPI), often expressed as the "unaccounted-for" water percentage, is a misleading and unreliable measure of utility performance for three reasons: (1) VPPI is greatly affected by changing levels of customer consumption, (2) VPPI cannot distinguish the components of NRW (apparent and real losses, and unbilled authorized consumption), and (3) VPPI reveals nothing about water volumes and associated monetary values—the two most important factors in assessing a utility's water efficiency. Furthermore, percentage indicators like VPPI are not technically rigorous because they can be significantly influenced by parameters unrelated to NRW.

It is important to note that AWWA recommends that water utilities, regulatory agencies, and other industry stakeholders discontinue use of a VPPI or "unaccounted-for" water percentage indicator.

Second is the financial percentage performance indicator (FPPI). This indicator has limitations as a result of similar undue influences on the numerator and denominator—in particular, wide annual variation in total operating costs (denominator), which are common for some water utilities as reported in AWWA's 2019 *Assessment of Performance Indicators for Nonrevenue Water Target Setting and Progress Tracking.* Also, the apparent loss cost—a component of the FPPI—is set by the customer retail unit charge (CRUC), which can vary widely because while some water utilities include sewer charges in the CRUC, many do not.

This KPI has been used formally in a regulatory context in a single US state (the only such use of this KPI known to the PITF), which uses it as both a performance tracking indicator and a target-setting indicator. By removing its support for the FPPI, AWWA recognizes that an alternative financial indicator is needed; the LCR KPI is offered for consideration by regulatory agencies because, as a KPI, it's superior to the FPPI. AWWA believes that water utilities should not employ the FPPI or any percentage KPIs in water loss assessments.

To this end, AWWA is removing all percentage indicators from its water loss publications and tools, including the next (fifth) edition of M36 and the next version (6.0) of its FWAS. AWWA instead recommends adding two alternative KPIs, which are described in the next sections (and summarized in Figure 2).

AWWA's Support of LCR

An alternative KPI is the LCR, mentioned earlier. Expressed in dollars per service connection per year, the LCR is a financial KPI, with one expression for apparent losses and one for real losses. The LCR indicates the financial impact of the respective losses to the utility and has public relations value by expressing annualized loss costs (operating cost and revenue) on a per-connection basis. It is derived from each corresponding normalized volumetric loss indicator expressed in volume per connection per day, by converting the volume unit to its value of loss, expressed on a yearly basis. This KPI marries the rate of losses (apparent or real) with the value of those losses as a cost rate of losses. Utilities with a high LCR incur high losses and/or high costs. On a broad level, high LCR values give a water utility good incentive to enhance their water loss control interventions.

Following are some positive attributes of an LCR:

- It has strong NRW assessment value at the utility level by revealing the impact of changing loss and cost values year to year.
- It helps public relations by expressing the impact of costs on a per-connection level for easier comparison with other systems.
- It is useful for regulatory agencies when it's used as an out-of-bounds KPI to flag utilities with very high values. However, it is not appropriate to employ the LCR to set optimally low loss targets in water utilities.

PITF members have piloted and analyzed the LCR in several efforts, including the 2018 TEC project and independent work on water audit data from Pennsylvania (https://on.nrdc.org/2VxXwew) and New Jersey (https://on.nrdc.org/2pnWSoc). The Water Research Foundation's Project 4695 includes a downloadable spreadsheet of LCR values from North America in the form of percentiles for the range of values across utilities. LCR should further help water utilities and other stakeholders assess and manage water loss.

While the LCR has many strengths, it is a high-level KPI and stakeholders are advised not to employ the LCR as a singular KPI for water loss assessments. Because it's influenced by the volume of losses and their monetary value, the LCR could change notably as a result of a significant change in a single component. For instance, an annual reduction in loss volumes (apparent or real) may be masked by a large monetary increase that year, either because of a large water rate increase (CRUC) or increase in the variable production cost. In this way the LCR is not directly actionable as a target setting or benchmarking KPI. It is appropriate to assess the LCR in combination with the other KPIs in the AWWA water audit method.

AWWA's Support of Normalized Water Losses Indicator

A second alternative KPI is normalized water losses (NWL).

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Figure 2

Expressed in volume per connection per day, NWL is a high-level KPI that represents the combined volume of apparent and real losses occurring in the water utility on a per-connection basis. The NWL metric allows utilities to track their year-to-year losses and provides additional insight during years when either portion of

AWWA recommends that water utilities, regulatory agencies, and other industry stakeholders discontinue use of a VPPI or "unaccounted-for" water percentage indicator.

NWL (apparent or real normalized loss rate) varies notably from the prior year. NWL should not be used as a stand-alone KPI, but in combination with the apparent and real loss normalized indicators. Also, as a high-level indicator, NWL is not actionable because its components include water that is physically lost (real losses) and water that is not physically lost but under-recorded (apparent losses). Thus, NWL should not be used for target-setting. Instead, targets can be set using the normalized apparent and real loss indicators. NWL is best used in the data validation process by helping broadly explain year-to-year changes in apparent and real loss volumes and provide a buffer against inordinate uncertainty in either of these volumes.

NWL is new and has not yet been employed extensively. As a combined version of the normalized apparent losses and normalized real losses indicators, NWL is subject to the same influencing factors as those KPIs. AWWA believes that NWL—used for high-level trending in combination with other KPIs—adds value to water loss assessments.

Incorporating the New KPIs in the Free Water Audit Software

Concurrent with the PITF's efforts to update its position on NRW KPIs, the WLCC Software Subcommittee worked to develop version 6.0 of the FWAS. The PITF coordinated with the subcommittee to include LCR (apparent and real forms) and NWL in version 6.0 of the FWAS. Version 6.0 will include many additional improvements.

Guidance for NRW KPI Implementation

Since the launch of the FWAS in 2006, Georgia, California, Hawaii, and the province of Quebec have required utilities to use the AWWA water audit method and the FWAS as the data collection tool. These initiatives have formal programs that include training for water utilities in the water audit process, including data collection, validation, and analysis. The data quality of these programs is distinctly higher than programs that accept self-reported data from water utilities. Regulatory agencies requiring water audit data collection are urged to employ the AWWA FWAS and provide training for utility auditors and formal validation of the reported water audits. Several states have leveraged set-aside funds from their state revolving fund programs to pay for training and validation.

The FWAS is used with lesser requirements in many other states and agencies, including Tennessee, New Mexico, Colorado, and the Delaware River Basin Commission, with pilot projects occurring in at least another six states. Data from thousands of water audits that were compiled using the FWAS are now available, and analysis of the data has provided deeper understanding of utility water efficiency than historic approaches using only a single percentage indicator. Additional water regulatory agencies are expected to adopt requirements for the AWWA water audit method because it enables more rational assessments, improved NRW reduction tracking, and benchmarking among water utilities. With a suite of effective KPIs available in the AWWA tools, agencies can use appropriate combinations to meet their water efficiency objectives. Table 1 describes the KPIs of the 2020 position, along with their suitability for specific purposes and their limitations.

Benefits for the Water Industry

The water industry's approaches of the past 60 years that have relied on imprecise, "unaccounted-for" water percentages have not been successful in motivating measurable loss reductions. Consequently, losses have been increasing in some systems as a result of deteriorating infrastructure (distribution system piping and customer water meters), increasing costs, and other factors. AWWA has advanced water auditing and loss control technologies considerably over the past 20 years, and it believes that these newer approaches are improving water utilities' ability to assess their water loss control standing, plan and execute effective loss reductions, and communicate this progress to stakeholders and customers. The improved outcomes for society include improved

management of water resources; improved utility operations and finances; consistent reporting and workable planning for loss control activities; and better understanding of water utility performance by customers, the media, elected officials, funding agencies, and other stakeholders.

Multiple benefits are available to drinking water utilities via effective water loss control. It's time for

2020 AWWA Water Audit Method Outputs and Key Performance Indicators: Uses and Limitations

Indicator	Description	Suitable Purposes	
		Assessment	Benchmarking
Attribute			
Apparent loss volume	Calculated by FWAS	✓	
Apparent loss cost	Calculated by FWAS	✓	
Real loss volume	Calculated by FWAS	✓	
Real loss cost	Calculated by FWAS	✓	
Unavoidable annual real loss	Calculated by FWAS	✓	
Volume			
Normalized apparent Losses (volume/connection/day)	Strong and understandable indicator for multiple users	✓	✓
Normalized real losses (volume/ connection/day)	Strong and understandable indicator for multiple users	✓	✓
Real losses (volume/ pipeline length/day)	Strong and understandable indicator for use by utilities with low connection density	✓	✓
Normalized water losses (volume/ connection/day). **New KPI**	Strong and understandable indicator, suitable for high-level performance measurement	✓	
Real losses by pressure (volume/ connection /day/pressure unit)	Robust, specialized indicator; technical rigor may be influenced by network materials	✓	✓
Infrastructure leakage index	Robust, specialized ratio KPI; can be influenced by pressure and connection density	✓	✓
Value			
Apparent loss cost rate (value/ connection/year). **New KPI**	Indicators with sufficient technical rigor; provide the unit financial value of each type of loss, which is very useful for planning and assessment of cost efficiency of water loss reduction and control interventions and programs	✓	
Real loss cost rate (value/ connection/year). **New KPI**		✓	
Validity			
Data validity tier[a]	Strong indicator of water loss audit data quality if data have been validated; tier provides guidance on priority areas of activity	✓	✓

FWAS—AWWA Free Water Audit Software

[a]*Data validity tier* is a new term that will appear in Version 6.0 of the FWAS (2020 release) and is a band-type grouping of data validity scores (DVS): of audit reliability.

DVS should not be used to quantitatively indicate accuracy for the audit outputs.

Table 1

additional water utilities and regulatory agencies to follow the example of the water utilities and state/provincial regulatory agencies that have embraced AWWA's water audit method.

Improved Water Loss Monitoring

AWWA has carefully investigated existing and new NRW key performance indicators and has recommended an updated set of KPIs for water utilities, regulatory agencies, and

Target-Setting	Planning	Tracking	Uses and Limitations	Principal Users
		✓	Assess loss level	Utilities, regulators
		✓	Assess loss cost level	Utilities, regulators
		✓	Assess loss level	Utilities, regulators
		✓	Assess loss cost level	Utilities, regulators
		✓	Reveal theoretical technical low level of leakage	Utilities, regulators
✓	✓	✓	Used for performance tracking and target-setting	Utilities, regulators, policy makers
✓	✓	✓	Used for performance tracking and target-setting	Utilities, regulators, policy makers
✓	✓	✓	Data collection and assessment of systems with low connection density	Utilities, regulators, policy makers
		✓	High-level indicator for trending analysis; not appropriate for target-setting or benchmarking	Utilities, customers
	✓	✓	Data collection and assessment of pressure level	Utilities
		✓	Benchmarking after pressure management is implemented	Utilities
	✓	✓	Data collection and assessment on AWWA indicators or contextual parameters to use in conjunction with loss cost rates	Utilities, regulators, customers
	✓	✓		Utilities, regulators, customers
	✓	✓	Assess caliber of data inputs of the water audit	Utilities, regulators

Tier I: DVS = 0–25; Tier II: DVS = 26–50; Tier III: DVS = 51–70; Tier IV: DVS = 71–90; Tier V: DVS = 91–100. The data validity tier is a broad indicator

Multiple benefits are available to drinking water utilities via effective water loss control.

other water industry stakeholders. Of particular note is the recommendation to discontinue support for percentage indicators, which are known to be imprecise and misleading. AWWA advises water industry stakeholders to stop using percentage indicators and embrace those existing and new performance indicators recommended by AWWA. This development will greatly improve the ability of drinking water utilities to identify, quantify, and value water losses, as well as to target actions to advance the efficiency of water supply operations and management of water resources.

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https://doi.org/10.1002/awwa.1428

AWWA Resources

- Water Loss Control: Actionable Accountability Has Evolved Over the Decades. Trachtman, G.B. & Kunkel, G., 2019. *Journal AWWA,* 111:8:79. https://doi.org/10.1002/awwa.1347.
- Detecting and Resolving Apparent Loss With Data Science. Mohanakrishnan, J.; Boyle, C.; & Poff, J.G., 2019. *Journal AWWA,* 111:2:13. https://doi.org/10.1002/awwa.1230.
- Make Water Loss Control a Priority. Mosburg, S. & Jernigan, W., 2017. *Opflow,* 43:8:6. https://doi.org/10.5991/OPF.2017.43.0052.

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