Water Loss Technical Assistance Program Final Report

Prepared by Water Systems Optimization, Inc.
Cavanaugh & Associates

Prepared for The California Nevada Section
of the American Water Works Association

Funded by The California State Water Resource Control Board
The Environmental Protection Agency

Project Management Team

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Sita Ramakrishnan, Director of Finance & Admin, California Nevada Section

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Water Loss Technical Assistance Program Final Report

Executive Summary

Program Goals

Signed into law in October 2015, California Senate Bill 555 (SB555) requires that all urban retail water suppliers annually submit validated level 1 water audit to the Department of Water Resources (DWR). The Water Loss Technical Assistance Program (WL TAP) – funded through the State Water Resources Control Board and part of the CA-NV AWWA's California Water Loss Collaborative – provided training and support for the first round of submission. The WL TAP started by teaching the foundations of water auditing and water loss control best practices, and it culminated in level 1 validation of water audits.

The WL TAP aimed to:

- Level 1 validate water audits for SB555 submission
- Provide a first-rate water audit training program
- Help suppliers discern data improvement opportunities
- Help suppliers identify priorities for better water loss management

Program Structure

To achieve these goals, the WL TAP started with a phase of recruitment and registration, followed by four touch points with participating suppliers. Each phase of the program – or "Wave" – built on the last to establish and reinforce fluency in water audit foundations and ultimately validate each supplier's water audit. Within the wave progression, two tracks accommodated the spread of suppliers' experiences in water auditing: the "New Learner" track for beginners and the "Early Adopter" track for the more experienced provided more customized curriculum.

Registration Outreach Campaign	Wave 1 *in-person workshop*	Wave 2 *remote conference call*	Wave 3 *in-person workshop*	Wave 4 *remote conference call*
• Email and phone recruitment campaigns • Introductory webcast • Stakeholder outreach	• Reviewed basics of water auditing • Introduced goals and process of validation	• 2 hour call to review a recent water audit • Practiced validation process, discussing data sources and data validity grade justification	• Reviewed Wave 2 lessons learned and common water audit improvements • Guided supporting documentation preparation	• 2 hour call to review either the Calendar 2016 or Fiscal Year 16-17 water audit • Completed a level 1 validation and provided all necessary documentation
New Learner Focus:	emphasized AWWA methodology introduction and audit software		reinforced water audit methodology and performance indicator interpretation	
Early Adopter Focus	emphasized data improvement opportunities		introduced water loss control best practices	

Program Results

The WL TAP's reach qualifies it as the biggest audit validation effort in the country to date. The WL TAP trained more than 1,500 water utility employees, hosted 72 workshops, and completed more than 400 Level 1 validated water audits.

For the official validation round in Wave 4, 404 water suppliers participated (including some wholesaler agencies and small systems). Of the 412 potable retail urban water suppliers[1] required to submit a level 1 validated water audit per SB555, 385 successfully participated in the WL TAP. For the first year of a new requirement, **the WL TAP provided the necessary water audit review for 93% of the legislatively mandated suppliers.**

The first year of SB555 validated water audit submissions provides the best snapshot currently available of water loss and utility operations for California Retail Urban Water Suppliers. Table ES 2 summarizes the key performance indicators for the *complete* dataset of level 1 validated audits.

It is not safe to assume each audit's leakage estimation is accurate! The level 1 validation process identifies areas of uncertainty and verifies that the water audit methodology is applied, but it does not guarantee accuracy of the results.

	All Audits - Key Performance Indicators Summary (N = 385)				
	Key Performance Indicator	**Median**	Mean	Min	Max
Volumetric	Water Losses per Service Connection per Day (gal)	**34.1**	42.7	-43.0	507.0
	Apparent Losses per Service Connection per Day (gal)	**8.1**	10.9	0.5	193.0
	Real Losses per Service Connection per Day (gal)	**24.9**	33.1	-49.5	505.3
	Real Losses per Service Connection per Day per PSI	**0.3**	0.5	-0.8	10.1
	Infrastructure Leakage Index (ILI)	**1.4**	2.1	-3.6	42.2
Financial	Annual Cost of Apparent Losses	**$148,968**	$450,012	$1,824	$21,609,190
	Annual Cost of Real Losses	**$152,432**	$520,918	- $165,244	$38,936,077
	Non-Revenue Water as a % of Total Operating Cost	**3.4%**	4.2%	-0.8%	68.2%
	Data Validity Score	**60**	61	36	89

Table ES 1: Key Performance Indicator Summary for All Audits

[1] Please note that all participants were potable water systems. Though recycled system inclusion was discussed in the rulemaking process, those systems are not subject to the final requirements.

Table ES 2 summarizes the key performance indicators for the 279 audits that pass a set of filters, as described in Section V. The filters applied aim to exclude audits with outlying results.

	Filtered Audits - Key Performance Indicators Summary (N = 279)				
	Key Performance Indicator	**Median**	Mean	Min	Max
Volumetric	Water Losses per Service Connection per Day (gal)	**40.5**	48.6	15.5	188.5
	Apparent Losses per Service Connection per Day (gal)	**8.6**	11.9	1.2	193.0
	Real Losses per Service Connection per Day (gal)	**31.0**	38.2	11.15	172.4
	Real Losses per Service Connection per Day per PSI	**0.4**	0.5	0.2	2.5
	Infrastructure Leakage Index (ILI)	**1.9**	2.4	1.0	10.7
Financial	Annual Cost of Apparent Losses	**$ 153,789**	$508,908	$3,423	$21,609,190
	Annual Cost of Real Losses	**$ 219,769**	$655,181	$5,562	$38,936,077
	Non-Revenue Water as a % of Total Operating Cost	**3.9%**	4.8%	0.4%	68.2%
	Data Validity Score	**60**	60	37	89

Table ES 2: Key Performance Indicator Summary for Audits that Passed Filters

Each key performance indicator reported varies widely, serving as an important reminder of the spread of experiences across systems throughout the state. **Especially given the diversity of infrastructure and financial parameters, it is critical to assess each supplier's water loss performance in the context of its unique operations and constraints.**

In its breadth of audit review, the WL TAP identified common opportunities to improve water loss assessment throughout the state. Though important for the accuracy of water audit results, the following practices are not commonly practiced:

- Testing and calibrating source meters
- Prorating consumption to align sales volumes with the audit period
- Testing customer meters to inform estimates of apparent loss

As utilities look to improve their understanding of water losses, more engagement with instrument inaccuracy and in-depth data review are good places to start.

Next Steps

Audit Validation Program

The WL TAP facilitated the biggest audit data collection effort in California to date. Across the trainings and validation sessions, the WL TAP instilled a new appreciation for the Audit Software tool and piqued interest in the benefits of water loss monitoring and management. To sustain attention and encourage water audit improvement, strengths of the WL TAP will be important to continue:

- **Consistency:** The first year of level 1 validations was unique because the WL TAP offered a streamlined and consistent process for all participants. Going forward, efforts to standardize and maintain clear expectations of level 1 validation across different validation providers will be essential (through checkpoints like the Water Audit Validator certificate program). It will also be critical that the State ensures quality control measures are in place.
- **Transparency:** The Project Management Team (PMT) emphasized the importance of transparency in the water audit process. For a water audit to be insightful and useful, the inputs must be as accurate as the data available allows and the Data Validity Grades (DVG) must reflect data collection and maintenance protocols in practice. The PMT successfully built trust over the course of the program to foster candid, comfortable conversations between the utility staff and the validator. Moving forward, maintaining these levels of transparency will be critical.
- **Learning:** Participants were especially appreciative that the reporting requirement was so well-supported by training. In addition to the final round of audit review, the WL TAP offered opportunities for utility employees to refine their water audit expertise, consider peers' experiences, and evaluate areas for improvement. Future training sessions would encourage continued attention and care to water auditing and water loss control while also allowing new staff to get up to speed. Moving forward, it is important that training continue for water suppliers in California.

Water Loss Programming Considerations

Now that water audit best practices are being adopted across the state and each utility has stepped up to assess its water loss starting point, practical discussions of where to improve data, how to empower proactive management, and how to cost-effectively reduce water losses can begin. As those discussions start, the WL TAP's experience with the first year of validations reveals some important considerations:

- **Uncertainty Remains:** The first year of level 1 validated data should serve as a starting point. An accurate audit requires constant refinement and ongoing study of data sources describing production, consumption, and meter inaccuracy. Many suppliers are now identifying potential sources of inaccuracy but data source improvement takes time. Ongoing training and technical assistance should include this in its focus.
- **Proactive Opportunities Exist:** In discussions with each supplier across the validation sessions, the PMT inquired about current water loss control activity. All suppliers

described programs of leak repair (responding to known failures) and many have active mains replacement programs. However, a minority of suppliers proactively survey or otherwise manage leakage. Only a quarter of the participating suppliers described any form of proactive leak detection work. Ongoing training and technical assistance should include this in its focus.

- **Context Matters:** Given the diversity of infrastructure and financial parameters across California water suppliers, it is critical to assess each utility's water loss performance in the context of its unique operations and constraints. This is especially important to consider as water loss target setting begins in upcoming years. SB555 outlines that performance benchmarking process will begin in 2019, and the Executive Order B-37-15 framework features water loss as a focus of its water waste reduction measures.

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I. WL TAP: Primary Program Goals

In 2015, the California-Nevada Section of the American Water Works Association ("the CA-NV Section") established the California Water Loss Control Collaborative[2] ("the Collaborative") to connect stakeholders on water loss work. The Collaborative included representatives from all perspectives on the issue. The State Water resourced Control Board ("SWRCB"), the Department of Water Resources ("DWR"), conservation advocacy organizations like the Natural Resources Defense Council, the United States Environmental Protection Agency ("EPA"), consultant experts, and water suppliers themselves were involved. Informed by the Water Loss Audit training and validation effort in Georgia[3] and an understanding of water audit engagement in California to date, the Collaborative recognized the first years of SB555 as a critical opportunity for training, data refinement and establishing a standard of review.

In early 2016, the SWRCB secured funding through the EPA to support the first year of training and level 1 validated water audit submissions. CA-NV AWWA was awarded the two-year contract and sub-contracted with Water Systems Optimization and Cavanaugh and Associates (together, the Project Management Team or "PM Team") to develop and implement the Water Loss Technical Assistance Program ("WL TAP").

The WL TAP set out to train and support Urban Water Suppliers through the first year of SB555 submission. To do this, the WL TAP:

- established a progressive learning training program that offered customized attention to each participating agency
- taught the fundamentals of non-revenue water assessment and use of the AWWA Water Audit Software
- taught Urban Water Suppliers how to prepare for level 1 validation
- completed a level 1 validation for each Urban Water Supplier
- provided the necessary documentation for final submission to DWR

The WL TAP served to satisfy regulatory reporting requirements, and the process delivered benefits well beyond compliance. The WL TAP accelerated Californian water suppliers' appreciation of the water audit as a valuable diagnostic. Across dozens of workshops and hundreds of validation conference calls, water agency employees grappled with their data sources, identified areas for improvement, and reflected on the significance of their audit results. Feedback from participants shows that the WL TAP not only helped with a new requirement; it equipped and motivated agencies to focus on water loss management going forward.

[2] The California Water Loss Control Collaborative's website is http://www.ca-nv-awwa.org/waterloss

3 Details on the Georgia program can be found here: https://gefa.georgia.gov/water-loss-technical-assistance

II. Background

The Water Audit

The water audit process has three objectives:

1. **Account for all volumetric inputs and outputs** in a potable water distribution system during an audit period to derive volumes of water loss.
2. **Study the audit data sources** to document the introduction of potential uncertainty and correct for known errors, where possible.
3. **Communicate system efficiency** with a suite of calculated performance indicators.

To estimate water loss volumes, it is best practice to complete a standard water balance as presented in Figure 1 below. Each column represents an equal volume. In a water balance, a volume of water introduced into a distribution system is broken down into component volumes based on how the water is consumed, or alternatively, lost. Water balancing permits all water to be quantified either by measurement or estimation.

<table>
<tr><td rowspan="12">Water from Own Sources

Water Imported</td><td rowspan="12">System Input Volume</td><td colspan="4">Water Exported</td><td rowspan="2">Revenue Water</td></tr>
<tr><td rowspan="12">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="10">Nonrevenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="4">Real Losses</td><td>Leakage on Mains</td></tr>
<tr><td>Leakage on Service Connections</td></tr>
<tr><td>Leakage on Appurtenances</td></tr>
<tr><td>Leakage and Overflow at Storage Tanks</td></tr>
</table>

Figure 1: Standard AWWA Water Balance

Completing a Water Audit results in an understanding of a supplier's water loss profile. Water losses can be divided into two distinct forms: Apparent Losses and Real Losses.

Apparent Losses are the volumes of water that are successfully delivered to customers but not measured or recorded accurately. Apparent Losses come in three distinct forms: customer metering inaccuracies, unauthorized consumption, and systematic data handling errors. Recovering Apparent Losses increases revenue but does not change the volume a utility must produce to meet demand.

Real Losses are physical losses like leaks, breaks, and overflows. Recovering Real Losses reduces the volume of water that a utility must produce. As a result, increasing system efficiency by reducing Real Losses can serve as an effective conservation measure. Furthermore, Real

Loss recovery often extends infrastructure life and enables a utility to more proactively manage its distribution system.

The AWWA's manual "M36 Water Audits and Loss Control Programs"[4] describes the industry best-practices for water auditing. Its companion tool, the AWWA Free Water Audit Software (version 5.0) ("the Audit Software"), is considered the industry's best standardized form for water auditing. The Audit Software requests inputs that capture audit-period volumes, describe infrastructure and cost parameters, and document data source management practices. The Audit Software then calculates standard performance indicators.

Data Validity Grades

The Audit Software requires that a user select data validity grades (DVG) to characterize the operational practices relevant to each water audit input. For example, a data validity grade must be assigned to each volume of authorized consumption (billed metered, billed unmetered, unbilled metered, and unbilled unmetered), resulting in four authorized consumption data validity grades. If data validity grades are not populated for all inputs, the Audit Software will not calculate performance indicators. The Audit Software also combines the individual data validity grades into an overall Data Validity Score, a weighted sum of all grades normalized to 100.

DVGs document the practices of instrument maintenance, data collection, and data review that a utility employed in the audit year. For a level 1 water audit validation, some documentation is necessary to substantiate the frequency and results of critical instrument maintenance. However, most data validity grades are verified in a level 1 water audit validation through utility staff interviews.

Each DVG is evaluated on a scale from one to ten. A grade of one for a given input aligns with specific criteria describing operational practices. The criteria are predominantly descriptive and qualitative, rather than quantitative. Each incremental grade above one aligns with a distinct and more proactive set of criteria. The maximum grade of ten stipulates the most aggressive and proactive set of practices relevant to an input.

Each grade captures a suite of practices, and all practices must be consistently employed for that grade to apply. Should any one practice in a given grade not be part of a utility's standard operations, a lower and more appropriate grade must be selected. Therefore, a utility may not achieve a specific grade for a variety of reasons. The reason that one utility was unable to achieve a grade of six for billed metered authorized consumption may be completely different from the reason that a neighboring agency also couldn't reach the same grade of six. As a result, the investment required for data validity improvement will vary from utility to utility, and it is impossible to determine from a data validity grade alone what specific practices a utility is not employing.

A utility may not achieve a specific grade for a variety of reasons, so investment requirement for data validity improvement will vary from utility to utility.

Lastly, DVGs do not document the accuracy of water audit inputs. Instead, they capture the frequency with which a utility may identify errors in data and instrumentation, given its methods of data collection and frequency of data review and instrument maintenance. Higher data validity

[4] AWWA (American Water Works Association). 2016. *M36 Water Audits and Loss Control Programs. Fourth Edition. Denver, Colo.: American Water Works Association.*

grades imply that a utility engages with information more often (e.g. daily instead of monthly, or with an automated system instead of a manual system). However, frequent engagement with data and instrumentation does not ensure accuracy. As a result, pursuing higher data validity grades may not directly improve the accuracy of a water audit or the insight that the audit provides. Instead, audit accuracy should be considered in tandem with data validity grades and include broader, more holistic considerations like the consistency of results year to year, missing information that the data validity grading system may not capture, and quantitative assessment of instrument accuracy and procedural reproducibility.

Level 1 Validation

Water audit validation is the process of examining water audit inputs to 1) identify and appropriately correct for inaccuracies in water audit data and application of methodology and 2) evaluate and communicate the uncertainty inherent in water audit data.[5] Recent Water Research Foundation work developed definitions for distinct levels of validation. Level 1 validation is the starting point for water audit verification. The goals of level 1 validation are to:

- Confirm AWWA Water Audit methodology was correctly interpreted given the supplier's setup and data
- Identify evident inaccuracies, correcting where possible
- Verify that the DVG accurately reflect utility practices

To accomplish level 1 validation, a validator is equipped with a completed AWWA Water Audit Software file from the supplier, summary documentation of key production and consumption volumes, and discussions with utility personnel. Keep in mind that level 1 validation does not investigate raw data (as with level 2 validation) nor does it pursue new sources of information like test results or field studies of leakage (as with level 3 validation).

Level 1 validation does not guarantee a perfect calculation of water losses for each utility, but it does check that each utility is compiling the best audit possible given their current data sources.

After level 1 validation each audit is likely improved but still not perfect or completely accurate. An accurate audit requires constant refinement and ongoing study of data sources describing production, consumption, and meter inaccuracy. Level 1 validation doesn't guarantee a perfect calculation of water losses for each utility, but it does check that each utility is compiling the best audit possible given their current data sources.

California's History of Water Auditing

California water suppliers' experience with water auditing varies. Some were early adopters, starting when it was a voluntary best practice, and others have more recently started learning the methodology.

Water audits were first encouraged by the California Urban Water Conservation Council (CUWCC), now the California Water Efficiency Partnership (CalWEP). Their suite of Best Management Practices highlighted the importance of water loss attention. To comply with the

[5] Water Research Foundation Project 4639, available here: http://www.waterrf.org/Pages/Projects.aspx?PID=4639

Best Management Practice 1.2, a supplier quantified water system losses using the Audit Software, conducted a component analysis of real losses, and developed a water loss control program.

California State Senate Bill 1420 established water auditing as a required practice. Signed into law in September 2014, it requires that Urban Water Suppliers complete a water audit – in accordance with AWWA methodology – as part of their Urban Water Management Plan submission to the Department of Water Resources (DWR). In the last round of 2015 Urban Water Management Plan submissions (collected in 2016), 293 Urban Water Suppliers completed a water audit.

In October 2015 amidst mandatory water use reductions and a historic drought, California Governor Jerry Brown signed Senate Bill 555[6] into law to improve water auditing throughout the state. SB555 requires that all Retail Urban Water Suppliers[7] submit *level 1 validated*[8] water audits. With the California Water Loss Control Collaborative poised to support suppliers in this endeavor, the largest state program of water audit submission with third-party review was initiated.

Water Audit Reporting in California

Year Introduced	*Reporting Rule or Framework*	*Targeted Water Suppliers*	*Required?*	*Validation?*
2009	CUWCC Best Management Practice 1.2	Signatories of the CUWCC's Memorandum of Understanding	No	None
2014	Senate Bill 1420	All Urban Water Suppliers	Yes	None
2015	Senate Bill 555	Retail Urban Water Suppliers	Yes	level 1 validation required

Table 1: Water Audit Reporting in California

Water loss control promises to continue to play an import role in statewide water resource planning. Executive Order B-37-16[9], issued by the Governor on May 9, 2016, requires attention on eliminating water waste and features water loss control. The framework document, "Making Water Conservation a Way of Life, Implementing Executive Order B-37-16"[10] is clear that assessing and managing water losses will be a regular practice for water suppliers going forward.

[6] California Senate Bill 555 (2015) is available here: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB555

[7] Retail Urban Water Suppliers include water distribution systems that either serve more than 3,000 service connections or produce more than 3,000 acre-feet annually.

[8] Level 1 validation as defined by the Water Research Foundation Project 4639, available here: http://www.waterrf.org/Pages/Projects.aspx?PID=4639

[9] The Executive Order B-37-16 "Making Conservation a California Way of Life" is available here: https://www.gov.ca.gov/docs/5.9.16_Executive_Order.pdf

[10] The implementation final report on EO B-27-16 is available here: http://www.water.ca.gov/wateruseefficiency/conservation/docs/20170407_EO_B-37-16_Final_Report.pdf

III. Program Overview

Outreach & Recruitment

The first step of the WL TAP was a coordinated and persistent outreach and recruitment effort to drive participation. The campaign to get Urban Water Suppliers to register for the program began in two phases:

1) **Awareness Phase:** the first weeks of communication focused on the context of the program and what to expect from the WL TAP. This phase helped utilities appreciate why it's important they sign up and which staff should register and participate. A webinar was also produced to orient suppliers about what to expect.

2) **Recruitment Phase:** in early summer 2016, communications shifted to focus on encouraging registration. A deadline built a sense of urgency and gave the PM Team a milestone after which to switch outreach strategies.

The help of California water organizations (collectively, "stakeholders") was critical to the success of recruitment. The stakeholders involved in the initiation and outreach for the WL TAP were the:

- Association of California Water Agencies
- California Municipal Utilities Association
- California Water Association
- California Water Efficiency Partnership
- City of Sacramento
- Contra Costa Water District
- Department of Water Resources
- East Bay Municipal Utility District
- Environmental Protection Agency
- Irvine Ranch Water District
- Long Beach Water Department
- Los Angeles Department of Water and Power
- Metropolitan Water District of Southern California
- Municipal Water District of Orange County
- Natural Resources Defense Council
- San Diego County Water Authority
- Sonoma County Water Agency
- State Water Resources Control Board

Stakeholders reached out to their constituent water suppliers and encouraged participation in the WL TAP through email campaigns and personal contacts. Stakeholders were frequently updated with WL TAP progress, and every other month the stakeholders convened via conference call. Two trainings (one in Sacramento and another online) also provided stakeholders the program's context and detail.

The overall recruitment strategy relied on frequent, varied communication, summarized in Figure 4. The "x" indicates when each email was sent and is followed by two days of assumed interaction with the message. Two letters – one from the State Water Resources Control Board and another from the Department of Water Resources – were sent out to unresponsive utilities in mid-June and proved to be an important recruitment tool. Please see Appendix B for examples of these letters and email messages.

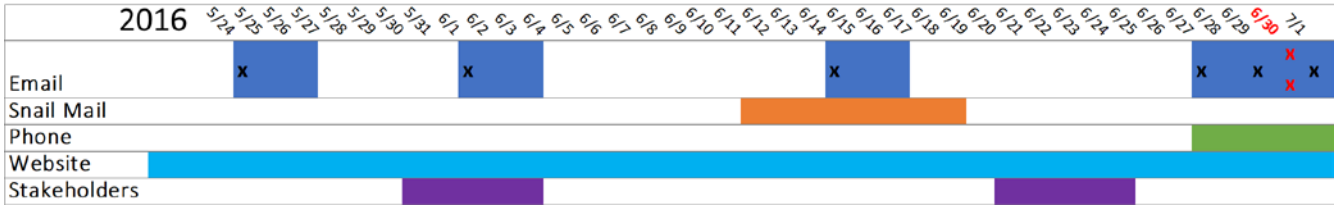


Figure 2: The WL TAP Outreach & Marketing Plan featured frequent multi-channel communications to encourage sign up.

The initial outreach campaign resulted in 234 Urban Water Suppliers registering by June 30, 2016. After this point, the outreach campaign shifted to individual phone calls and follow up emails from the PM Team and Section. A trend in varying responsiveness persisted across each wave. Approximately one third of Urban Water Suppliers were responsive and alert in their program engagement, another third required individualized outreach via phone or email, and the last third required repeated and persistent recruitment or were unresponsive.

Program Structure

Urban Water Suppliers engaged with the WL TAP through four distinct phases or "waves". The waves built on each other to establish and reinforce fluency in water audit foundations and ultimately validate each supplier's water audit. The waves included both in-person and remote touchpoints. Within the wave progression, two tracks accommodated the spread of suppliers' experiences in water auditing: the New Learner ("NL") track for beginners and the Early Adopter ("EA") track for the more experienced provided customized curriculum. The content of each phase of the program is detailed below:

Outreach Campaign

The WL TAP began with an outreach campaign to recruit water suppliers' participation. The campaign involved emails from different stakeholders, an introductory webinar, and a phone outreach effort. The outreach and recruitment effort is detailed below.

Wave 1: In-person work session

Day-long in-person work session (classroom) that covered the basics of water auditing and introduced water audit data validation, guided by the following questions:

- What is a water audit?
- How do you use the AWWA Water Audit Software?
- What are common mistakes or oversights when compiling a water audit?
- What is SB555 and how it is different than previous reporting requirements?

NL Focus: AWWA methodology and Audit Software guidance

EA Focus: opportunities for water audit data improvement

Wave 2: Remote practice validation call

A two-hour teleconference work session in which a member of the PM Team and each participant's water audit team examined the participant's most recent water audit. Resulted in detailed compilation of practice validation report including areas to improve audit inputs, guided by the following questions:

- Has this audit been compiled with the best available data?
- What are the practices and protocols that support the Data Validity Grades selected?
- What other information does the water supplier need to provide for successful validation in wave 4?

NL Focus: correct application of AWWA methodology and use of Audit Software

EA Focus: identification of data improvement opportunities and interpretation of results

Wave 3: In-person work session

A daylong in-person work session (classroom) that reinforced the water audit methodology before more deeply exploring water audit data validation and the connection between water auditing and water loss control, guided by the following questions:

- How do you best prepare for a successful level 1 validation session?

- What does complete supporting documentation look like?
- How can you improve water audit data sources?
- What water loss control actions should I consider after my water audit, and what industry resources are available for additional guidance?
- What have my peers discovered in compiling a water audit?

NL Focus: level 1 validation preparation

EA Focus: water loss control next steps

Wave 4: Remote final validation call

A teleconference session during which the level 1 validation of the FY or CY water audit to be submitted to DWR was completed. Resulted in detailed compilation of a validation report including areas to improve the audit inputs and resulting audit outputs, guided by the following questions:

- Has this audit been compiled with the best available data?
- What are the practices and protocols that support the Data Validity Grades selected?
- What insight can the supplier gain from its performance indicators?
- How has the supplier's participation in the WL TAP improved its assessment of distribution efficiency and data quality?

Customized Attention

The WL TAP acknowledged that each Urban Water Supplier in California is different. Their system characteristics and their experience with water loss assessment vary widely. As such, the WL TAP was tailored to meet each participant's distinct needs.

Upon registering for the WL TAP, participants selected an experience level that best described their familiarity with the water audit methodology. Their options were:

1. **Unfamiliar**: the AWWA Water Audit Software and Methodology are new
2. **Beginner**: beginning to use the AWWA Water Audit Software
3. **Intermediate**: regularly using the AWWA Water Audit Software
4. **Advanced**: regularly using the AWWA Water Audit Software, completing a Component Analysis of Real Losses, and pursuing customized water loss control activity

At the start of the WL TAP, experience with water auditing varied. 28% of the agencies had no experience with the Audit Software, while only a handful of utilities were well-practiced with the Audit Software and already implementing water loss control programs.

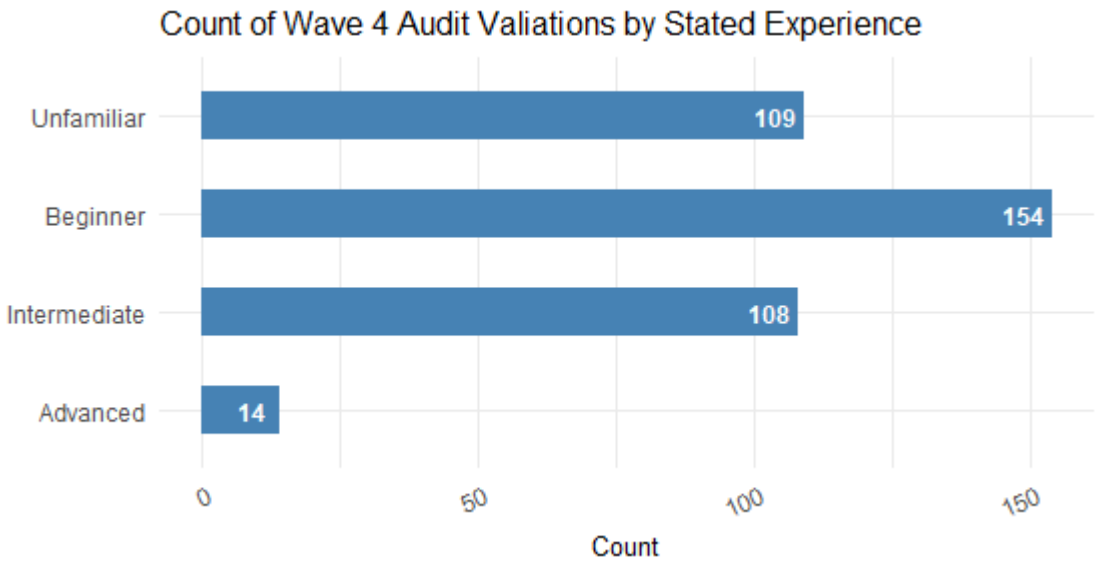


Figure 3: WL TAP Participants by Stated Experience

To address this spread of experience, the WL TAP offered separate curriculum tracks. The New Learner track was designed for the participant with little to no experience with water loss auditing (the "unfamiliar" or "beginner" groups). The Early Adopter track provided advanced instruction for those who were already familiar with water loss auditing (the "intermediate" or "advanced" groups). This distinction allowed instructors to modulate the level of detail in the curriculum and promoted sharing of questions and experiences in class among utilities with similar previous exposure.

In planning for the two tracks, the PM Team estimated that approximately one third of water suppliers would identify as either "intermediate" or "advanced" for the Early Adopter track, with the remaining two thirds opting for the New Learner track. The registrations reflected this

breakdown well: 32% (122 suppliers) self-selected for the New Learner track and 68% (263 suppliers) selected for the Early Adopters track.

Throughout the course of instruction, the PM Team appreciated that neat categorization of suppliers by experience was difficult. Describing an organization's practice of water auditing ("Example Water Utility conducts a water audit annually using the Audit Software") can be different from an individual employee's experience, and each supplier's water audit team often included individuals with varying experience. In the end, this resulted in adapting some of the Early Adopter curriculum to accommodate beginners in all workshops.

No matter what level of previous experience, each participating supplier got individualized attention in Wave 2. On this conference call, a water loss expert walked through each element of the audit. This practice round of review was a key piece of the training, since it provided a chance to ask system-specific questions and note necessary improvements *before* the official round of level 1 validation.

Resource Development

To supplement the in-person training and teleconference review, the PM Team developed a website to serve as a hub of updates and resource materials. These resources included introductory webcast recordings, review webcast recordings, reference slide decks, example calculations, and guidance documents. Participants entering the program in later waves used the website as a repository of catch-up resources, while participants who entered the program at its inception accessed website materials to refresh key concepts.

All resources were housed on the WL TAP website, www.californiawaterloss.org. This website also served as a tool for participants to sign up for sessions and upload supporting documents throughout the program.

Program Adjustments

The Water Loss TAP was continually refined to meet participant needs and evolve with ongoing rulemaking. The PM Team and Section staff accommodated those needs within the original scope and budget with the following adjustments:

Advanced to Wholesaler Track

The WL TAP's original scope allowed for advanced work with a handful of suppliers that demonstrated detailed past work with water loss assessment. The PM Team observed that the Early Adopter curriculum served both intermediate utilities and advanced utilities well, while wholesale agencies could benefit from additional support. Therefore, the Advanced program budget was reassigned to build a Wholesaler Track and better serve wholesale agencies in supporting their retail agency partners.

The Wholesaler Track featured 5 workshops across California on the applicability and non-applicability of the AWWA water audit methodology and Free Water Audit Software to wholesale systems, where to get water audit data, water audit validation steps and data validity scoring principles. Training wholesalers was especially important because they provide audit data for retail systems (a wholesaler's billed consumption is a retailer's imported supply volume). The Wholesaler Track highlighted best practices of documenting and communicating volumes and maintenance practices between agencies.

Sub-System Treatment

The rulemaking that dictates the specifics of SB555 water audit validation and submission was in the process of public comment and revision during the WL TAP. One of the rulemaking's clarifications particularly affected the validation work. Some Urban Retail Water Suppliers manage a collection of smaller systems that are hydraulically discrete. The rulemaking process clarified that the submission for these suppliers cannot combine these systems into one audit. Many large private suppliers were ready for this because they manage their sub-systems independently from one another. However, a handful of systems (eight in total) needed to disaggregate their data and recreate their audits for this requirement. The WL TAP guided suppliers through these changes and validated sub-system audits as necessary.

Administration Task Shift

Delays in rulemaking affected WL TAP administration. More outreach and recruitment was required without firm deadlines and rulemaking references pushing agencies to participate. Unanticipated rescheduling and delay from participants also required more administrative time per supplier than originally planned. Between May and September 2017, 265 scheduled Wave 4 validation sessions were canceled and required rescheduling.

Given delays in rulemaking, a handful of suppliers did not complete their audit compilation and validation before the October 1st deadline. As presented in Figure 3, the PM Team offered Wave 4 validation sessions through December 2017 to accommodate those suppliers. With unforeseen personnel changes at the Section, the PM Team tackled these additional program administration efforts and an amendment to the contract reflects that shift.

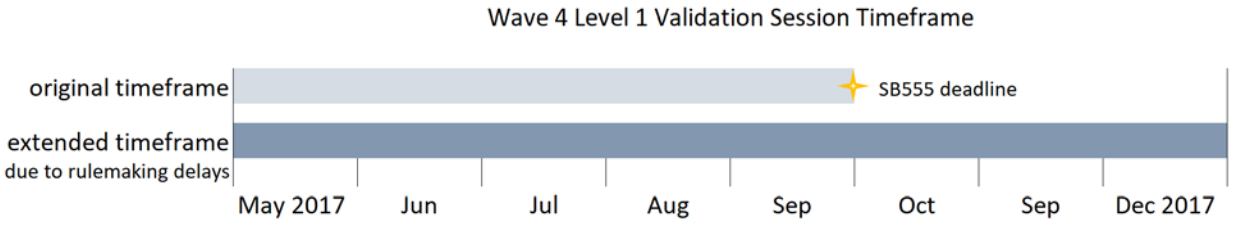
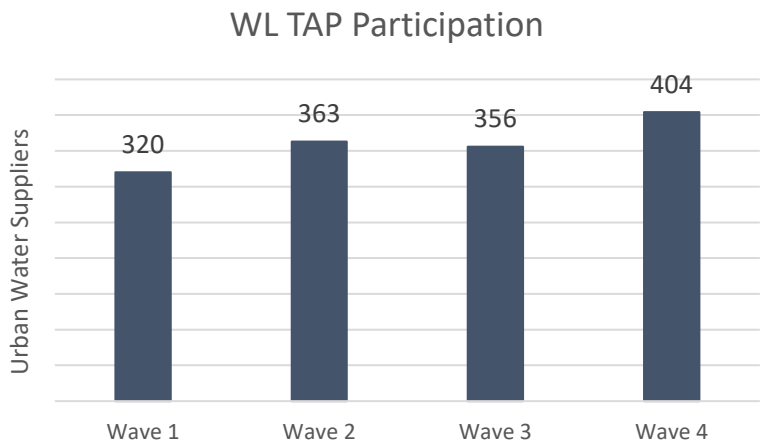


Figure 4: Timeframe Extension for Wave 4 Level 1 Validation Sessions

WL TAP Participation

Participation in the WL TAP was strong and sustained over the course of the year and half long program. The reach of this water audit training is unprecedented. Outreach and recruitment continued throughout, continuously folding in more agencies.



	WL TAP Participation			
Agency Type	*Wave 1*	*Wave 2*	*Wave 3*	*Wave 4*
Retailer[11]	306	349	338	392
Wholesaler	14	14	18	12
Total Participation	320	363	356	404
% Total[12]	70%	79%	78%	88%

Table 2: WL TAP Participation by Wave

The summary above shows total participation across all agency types. To isolate those legislatively mandated to submit validated audits, wholesaler agencies and smaller systems are excluded. 412 agencies qualify as Retail Urban Water Suppliers and are required to submit a level 1 validation water audit per SB555. Within that group, 384 successfully participated in the WL TAP. For the first year of a new requirement, **the WL TAP provided the necessary water audit review for 93% of the legislatively mandated suppliers.**

[11] Seven retailers participated in the WL TAP that are not of sufficient size to qualify as Urban Retail Water Suppliers. Six of these systems are part of a larger private water company so were previously lumped in as part of Urban Retail Water Supplier reporting requirements. One of these system's Urban Water Supplier status recently changed. Participation in the WL TAP helped clarify these designations.
[12] Percent total metric considers 458 agencies as the total, inclusive of wholesalers and small agencies that participated.

Program Overview Takeaways

- Suppliers began the WL TAP with varying experience in water auditing.
- The program was structured as a progressive learning module with training, application of concepts, and reinforcement.
- The WL TAP provided participants with customized attention: suppliers received training aligned with their audit experience in Waves 1 and 3, and each supplier received system specific attention in Waves 2 and 4.
- A wealth of water audit reference material was developed for participants to enhance learning and emphasize key points.
- Given the repository of references and program material on the WL TAP website, a utility could catch up and join the WL TAP at any point over the course of the program.
- Participation rates were high throughout the program, culminating with 93% of the regulated Retail Urban Water Suppliers completing the level 1 validation process.

IV. Urban Retail Water Supplier Audit Results

By the end of 2017, the WL TAP validated 404 water audits in Wave 4. Of those audits, 385 were completed by Retail Urban Water Suppliers for submission to DWR (the additional 19 validated audits were for small systems and wholesaler systems. The analyses presented below only includes the retail system audits, a total count of 385 water audits ("the final dataset").

Most reporting retail suppliers chose to submit audits describing the 2016 calendar year. The PM Team observed that many suppliers were affected by data availability constraints and as a result could not produce a fiscal year audit for the October 1 deadline.

Reporting Period	*Count of Audits*	*%*
Calendar Year 2016	311	80.8%
Fiscal Year 2016-17	74	19.2%

Table 3: Audit Period Selection

Summary of Audit Results: Key Performance Indicators

The first year of SB555 validated water audit submissions provides the best snapshot currently available of water loss and utility operations for California Retail Urban Water Suppliers. Table 4 summarizes the key performance indicators for the *complete* dataset of level 1 validated audits.

It is not safe to assume each audit's leakage estimation is accurate! The level 1 validation process identifies areas of uncertainty and verifies that the water audit methodology is applied, but it does not guarantee accuracy of the results.

	All Audits - Key Performance Indicators Summary (N = 385)				
	Key Performance Indicator	**Median**	Mean	Min	Max
Volumetric	Water Losses per Service Connection per Day (gal)	**34.1**	42.7	-43.0	507.0
	Apparent Losses per Service Connection per Day (gal)	**8.1**	10.9	0.5	193.0
	Real Losses per Service Connection per Day (gal)	**24.9**	33.1	-49.5	505.3
	Real Losses per Service Connection per Day per PSI	**0.3**	0.5	-0.8	10.1
	Infrastructure Leakage Index (ILI)	**1.4**	2.1	-3.6	42.2
Financial	Annual Cost of Apparent Losses	**$148,968**	$450,012	$1,824	$21,609,190
	Annual Cost of Real Losses	**$152,432**	$520,918	- $165,244	$38,936,077
	Non-Revenue Water as a % of Total Operating Cost	**3.4%**	4.2%	-0.8%	68.2%
	Data Validity Score	**60**	61	36	89

Table 4: Key Performance Indicator Summary for All Audits

Table 5 summarizes the key performance indicators for the 279 audits that pass a set of filters, as described in Section V. The filters applied aim to exclude audits with outlying results.

	Filtered Audits - Key Performance Indicators Summary (N = 279)				
	Key Performance Indicator	**Median**	Mean	Min	Max
Volumetric	Water Losses per Service Connection per Day (gal)	**40.5**	48.6	15.5	188.5
	Apparent Losses per Service Connection per Day (gal)	**8.6**	11.9	1.2	193.0
	Real Losses per Service Connection per Day (gal)	**31.0**	38.2	11.15	172.4
	Real Losses per Service Connection per Day per PSI	**0.4**	0.5	0.2	2.5
	Infrastructure Leakage Index (ILI)	**1.9**	2.4	1.0	10.7
Financial	Annual Cost of Apparent Losses	**$ 153,789**	$508,908	$3,423	$21,609,190
	Annual Cost of Real Losses	**$ 219,769**	$655,181	$5,562	$38,936,077
	Non-Revenue Water as a % of Total Operating Cost	**3.9%**	4.8%	0.4%	68.2%
	Data Validity Score	**60**	60	37	89

Table 5: Key Performance Indicator Summary for Audits that Passed Filters

Each KPI reported varies widely, serving as an important reminder of the spread of experiences across systems throughout the state. The distributions of select KPIs displayed below highlights the wide range of results.

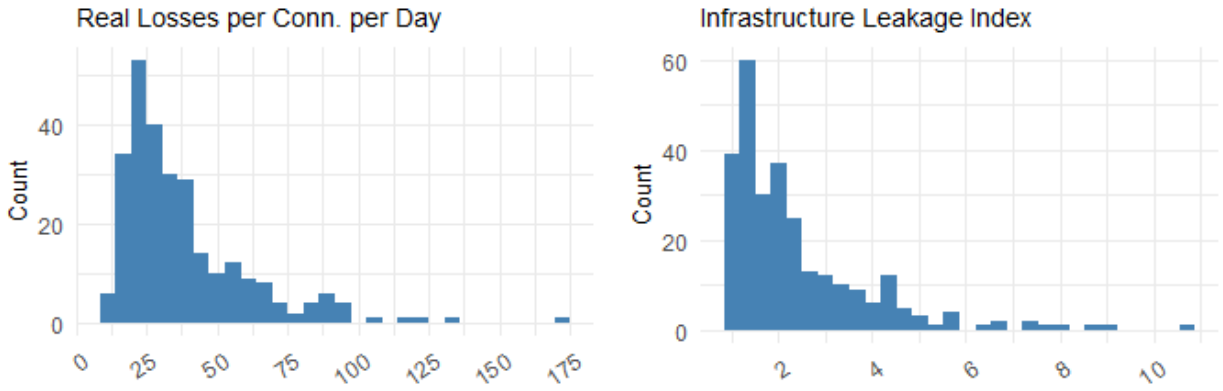


Figure 5: Distribution of Wave 4 Post-Validation Key Performance Indicators Show Results Vary Widely

Correlations

As expected, more infrastructure (longer length of main pipe, greater count of service connections) correlates with greater total real loss. The relationship between length of main pipe and the total volume of real loss is stronger than the relationship between the count of service connections and the total volume of real loss, though not markedly. However, the count of service connections and length of mains are related parameters (e.g. additional service connection installation corresponds with additional length of mains, and vice versa).

Higher reported variable production costs (i.e. more valuable real loss) correlates with lower real loss volumes, controlling for length of mains and count of connections.

When the length of mains and count of service connections are controlled for, no correlation can be observed between average operating pressure and real loss (whether total volume or normalized to the count of service connections). Pressure is not an explanatory variable for real loss in this dataset. Other factors not contained in average operating pressure like pressure variability and pipe characteristics may influence real loss but are not recorded in the Audit Software and so cannot be analyzed with this dataset. Additionally, for California utilities, the pressure input in the water audit tended to be informed anecdotally (with crude or limited field data) and as a result is bound by significant uncertainty for most audits in the dataset.

Key Takeaways: Retail Water Audit Results

- The magnitude and cost of water losses varies throughout the state.
- Total leakage is related to the price of producing water. The final dataset shows that more expensive water sources correspond to lower total leakage volumes.
- The data does not currently display a relationship between average operating pressure and leakage. However, average operating pressure data is bound by significant uncertainty.

V. Level 1 Validation Outcomes & Findings

Overall Dataset Quality: Applying Audit Filters

To evaluate the overall quality and consistency of the audit datasets collected over the course of the WL TAP, the PM Team used high-level filters to remove audits that may contain error. The filtering criteria flag audits that report physically impossible results (i.e. negative losses) or audits that present exceptionally low or high leakage. The filters applied here and described in Table 5 are consistent with industry standards developed in Water Research Foundation publication 4372B, *Water Audits in the United States: A Review of Water Losses and Data Validity*.

Excluding the filtered audits from database statistics (as presented in Table 5) is a conservative measure to avoid potentially erroneous audits. Consider the filter on the Infrastructure Leakage Index (ILI) that flags audits with an ILI below 1.0 or above 20.0. An audit presenting an ILI below 1.0 or above 20.0 – while physically possible – communicates exceptionally low or high leakage.

Level 1 validation cannot always discern between audits that rightly reflect exceptional performance and those that have embedded error, requiring advanced validation or correction. To be cautious in presenting the dataset's results, the audits that present outside of the ILI filter range are excluded from the filtered dataset analysis.

Water Research Foundation Water Audit Filters			
	Metric	Abbreviation	Criteria for Exclusion
Volumetric	Infrastructure Leakage Index*	ILI <1 | ILI >20	ILI less than 1 or greater than 20
	Real Losses	Real Loss < 0	Negative real losses
	Cost of Non-Revenue Water	NRW > Oper. Cost	The cost of Non-Revenue Water is greater than total operating costs
Financial	Variable Production Cost	VPC >< 2 Orders Magnitude	Variable Production Cost more than 100x or less than .01x the dataset median
	Customer Retail Unit Cost	CRUC >< 2 Orders Magnitude	Customer Retail Unit Cost more than 100x or less than .01x the dataset median
Usage	Incomplete Audit	[FIELD NAME] Blank	Reported value is either zero or blank in critical audit fields

* Not applicable to systems where the count of service connections + 32x miles of mains is less than 3,000

Table 6: Water Audit Dataset Filters

Applying these filters to each round of audit submission reveals that **the California water audit dataset steadily improved throughout the Water Loss TAP**, as detailed in Figure 7. Before the WL TAP, only 46% of California water audits submitted with 2015 Urban Water Management Plans passed these filter tests. After the WL TAP, 71% of water audits submitted for SB555 compliance passed.

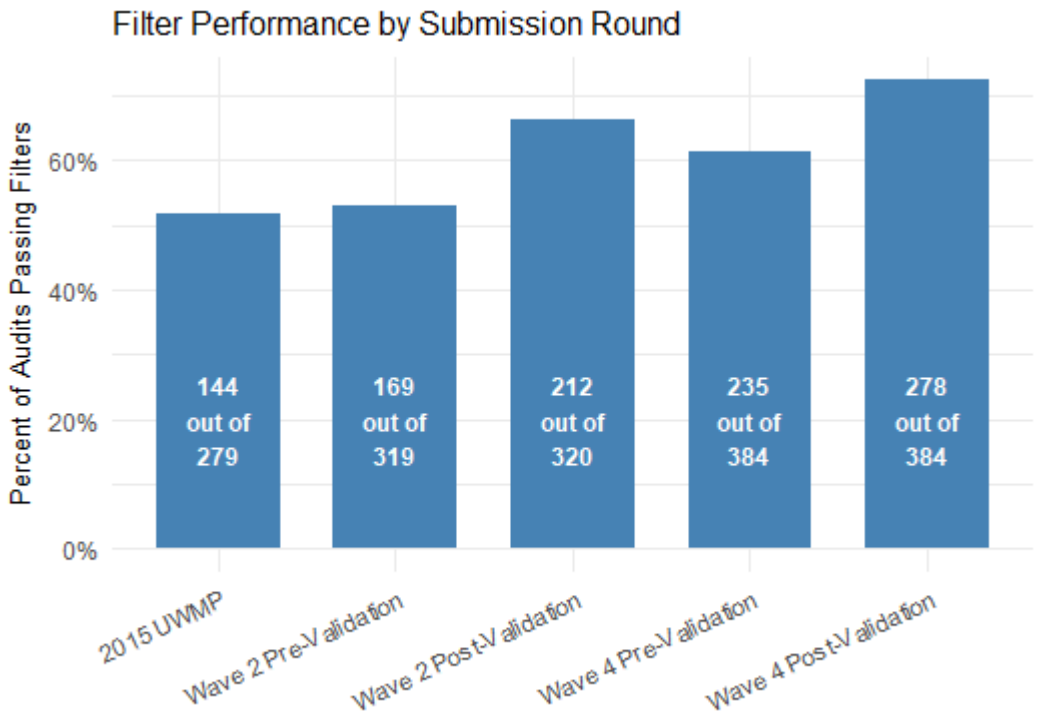


Figure 6: Audit Filter Results Improve as Submission Round Progress

The improvements result from the WL TAP's training on audit methodology and standardized third-party level 1 validation. In fact, the largest improvements are found between pre-validation audits and post-validation audits in both Wave 2 and Wave 4. By the end of the WL TAP, **the largest water audit dataset collected to date had the fewest instances of submissions with outlier performance to date.**

The specific filter results – presented in Table 6 and Figure 8 – highlight dataset differences before and after the WL TAP training and level 1 validation.

	Wave 2 Pre-Validation		**Wave 4 Post-Validation**	
Filter	Count Filtered*	% Filtered (of 319 audits)	Count Filtered*	% Filtered (of 384 audits)
Leakage Index	128	40.1%	108	27.6%
Real Loss	10	3.1%	12	3.1%
Production Cost	17	5.3%	0	0.0%
Incomplete Audit	8	2.5%	0	0.0%
Non-Revenue Water	8	2.5%	0	0.0%
Apparent Loss	0	0.0%	0	0.0%
Retail Unit Cost	3	0.9%	0	0.0%
All Filters	**150**	**47.0%**	**108**	**27.6%**

*one audit can trigger more than one filter, so the total number of filtered audits is not a simple sum

Table 7: Audit Filter Results Before and After the WL TAP

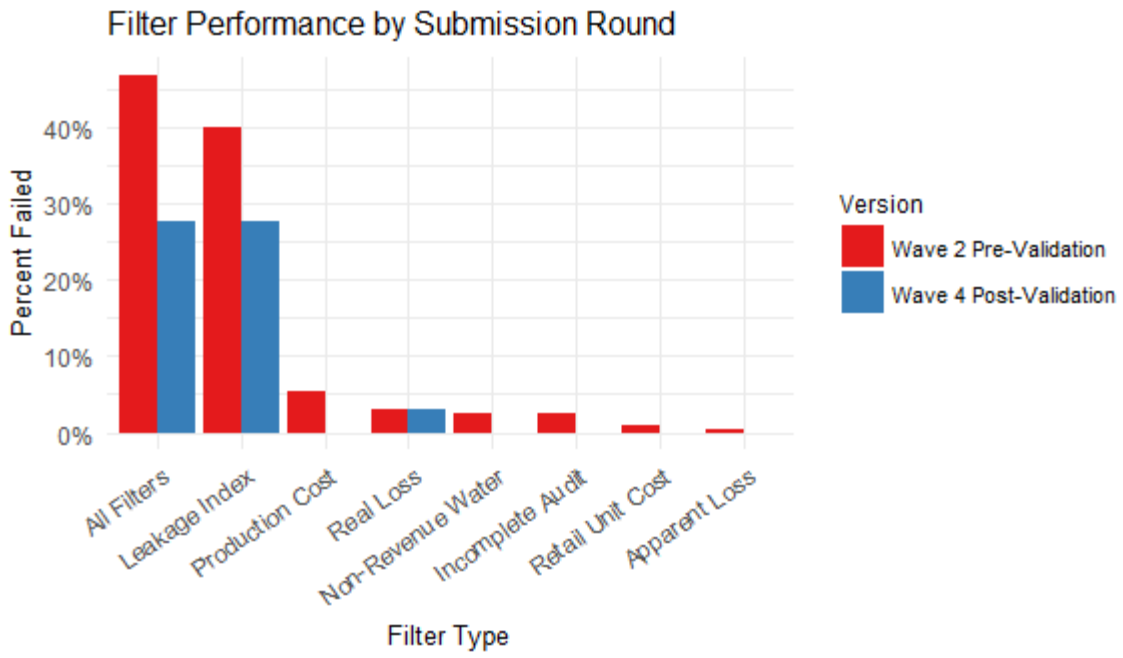


Figure 7: Audit Filter Results Before and After the WL TAP show improved use of the Audit Software.

This examination of specific filtering criteria reveals:

- **Many audit methodological errors were resolved after level 1 validation.** There were no cases of audits flagged by the Production Cost, Retail Unit Cost, Non-Revenue Water, Apparent Loss, or Incomplete Field criteria in the final dataset.

- The Infrastructure Leakage Index filter identified the greatest number of suspicious audits, as level 1 validation **did not** resolve all such cases. Please see "Section VI Audit Qualifications" for more discussion of ILIs below one.

- There were more instances of flagged audits from the Real Losses criteria after level 1 validation. This is likely an indirect impact of level 1 validation's insistence on AWWA audit methodology. In a handful of cases, shifting the Apparent Loss estimation to be more realistic (often by adjusting the Customer Meter Inaccuracy input) resulted in a negative Real Loss volume, thereby suggesting inaccuracies buried in instrumentation and database systems that the level 1 validation could not diagnose.

The WL TAP improved the consistent application of audit methodology, but it could not eliminate error across all water audits. Water utilities must work with the data available to them, and sometimes those data sources are limited or inaccurate. **Level 1 validation identifies sources of inaccuracy, but often those issues cannot be easily or quickly remedied for an improved estimation of leakage.**

Changes in Audit Entries

Level 1 validation confirms that the best data is used for the audit inputs because the quality of the water audit's leakage estimation relies on the quality of audit inputs. The process of third-party level 1 validation resulted in numerous edits to audit inputs, and certain common changes were observed.

Eliminating Arbitrary Adjustments

The Audit Software offers an opportunity to correct for known error in the System Input Volumes through the Master Meter Error Adjustment (MMEA) inputs. Adding an MMEA correction is warranted when test or calibration data supports adjustment. Level 1 validation confirmed that existing adjustments were warranted and supported by appropriate documentation. If documentation was not available or the adjustments were unwarranted, level 1 validation removed adjustments in favor of leaving the MMEA cells blank.

Unbilled Unmetered Authorized Consumption

The Unbilled Unmetered Authorized Consumption volume captures authorized operational uses in the audit. It typically includes uses like firefighting and mains flushing. A default value is provided in the Audit Software, calculated as 1.25% of Water Supplied. However, in most California utilities this calculation considerably overestimates unbilled unmetered use. For audits without tracking of unbilled unmetered use, a modified default of 0.25% of Water Supplied was used instead. Examining estimates of those utilities who do track unbilled unmetered use suggests that the modified default presents a better fit. For the 98 utilities that presented a customized value of Unbilled Unmetered Authorized Consumption, the median was 0.13% of Water Supplied.

Customer Meter Inaccuracy Estimations

Another frequently changed audit input was the customer meter inaccuracy estimate. Eighty-two audits presented zero (or below) for their estimation of customer meter inaccuracy before validation in Wave 2. These entries were discussed and corrected through validation. Insisting that customer meter inaccuracies exist is critical to make sure that not all water loss is mistaken as leakage.

Changes in Data Validity Scores

Level 1 validation confirms the appropriate selection of Data Validity Grades (DVGs). For each audit input, the water audit software requires an accompanying DVG that qualitatively captures operational practices. These grades are scaled between one and ten, and each specific grade is defined by a set of practices. To assign a grade, the utility's practices must meet or exceed all the grade's criteria. Individual DVGs are summarized by an overall Data Validity Score (DVS) that is a weighted sum normalized to 100.

The PM Team acknowledged the importance of consistency of DVG assignment and took extra care to standardize interpretation of the DVG criteria. After the Wave 2 practice validation calls, the PM Team developed an "Additional Guidance" document to clarify vague criteria language and establish consistent treatment of common scenarios in Wave 4.

As a result of more exacting application of the DVG criteria, nearly every DVS changed in the process of level 1 validation. The individual technical assistance offered with each level 1 validation call helped participants translate the water audit data grading criteria to their specific scenarios. This resulted in consistent application of DVGs in the final dataset.

Before the WL TAP, the median Data Validity Score in the Wave 2 pre-validation dataset was 73; after the final level 1 validation session in Wave 4, the median Data Validity Score was 60.

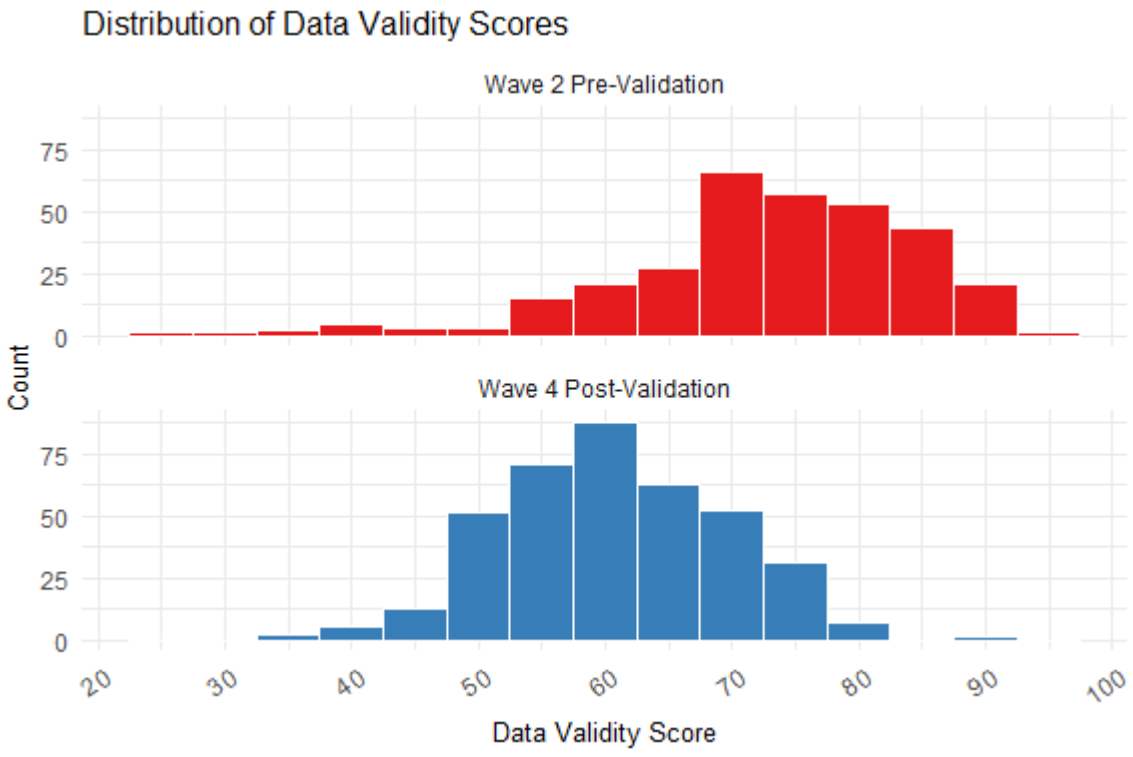


Figure 8: Distribution of Data Validity Scores Before and After Validation

Current Industry Practice Trends Revealed

The distributions of specific data validity grades reveal trends in industry practices that impact the water audit. The assignment of a specific Data Validity Grade requires that the Urban Water Supplier meet or exceed *all* the grade's criteria. When this grade assignment convention is consistently applied through level 1 validation, limiting factors and industry trends surface.

For example, before validation (considering the Wave 2 v1 audits), DVGs for Volume from Own Sources concentrated above six. In the process of level 1 validation, verification of the DVG criteria for this input often focused on the extent and frequency of meter testing. To receive a grade of six or higher for the Volume from Own Sources input, a supplier must volumetrically test or electronically calibrate its meters annually.

Figure 10 presents that after validation the most commonly assigned grade for the Volume for Own sources input is a five, revealing that most suppliers do not perform annual volumetric testing or electronic calibration on their source meters.

Another trend surfaces in the distribution of DVGs for the Customer Metering Inaccuracy input. To receive a grade of four or higher, a supplier must proactively conduct accuracy tests for a portion of its customer meter stock. After validation, most suppliers received a DVG of three, presented in Figure 10. These suppliers likely do not conduct any proactive customer meter tests and the Customer Meter Inaccuracy input is estimated.

The distribution of DVGs for the Average Operating Pressure input shows another operational practice trend. To receive a grade of six or higher, a supplier must collect pressure data within a zone, not just at the zone's boundaries, to calculate an average. This requires pressure logging throughout the distribution system. Most suppliers received a five or below after validation as shown in Figure 10, indicating that field pressure data collection is limited.

All three of these trends – lack of source meter calibration/testing, lack of customer meter testing and limited pressure data collection – directly impact water audits results. **These trends serve as important qualifications on data sources and the resulting certainty of the audit results.**

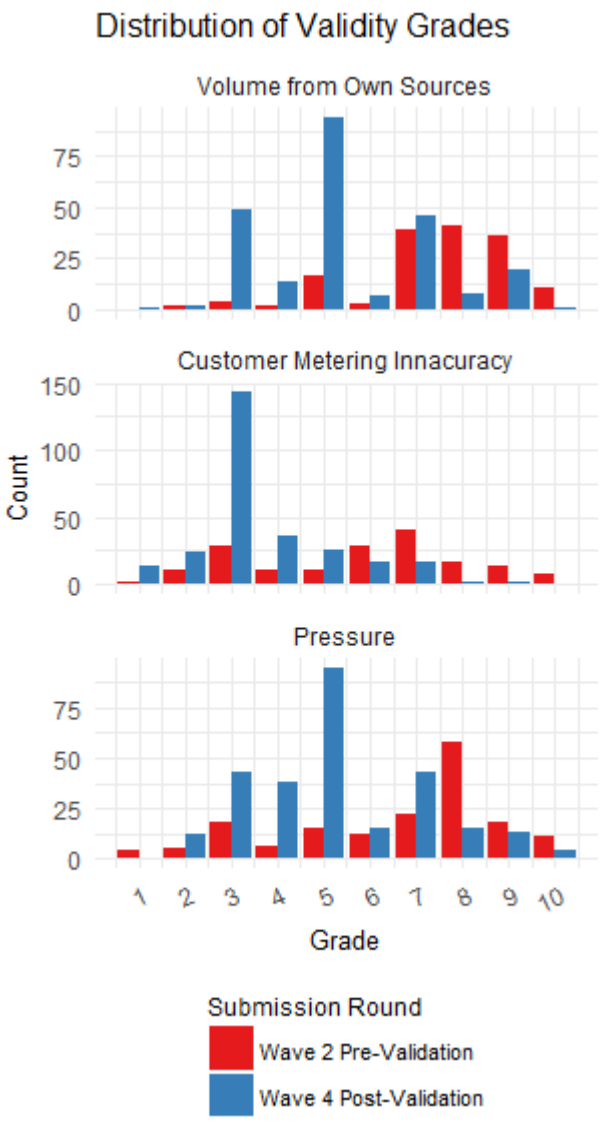


Figure 9: Distribution of Validity Grades that Show Industry Trends

Key Takeaways: Level 1 Validation Outcomes and Findings

- The WL TAP eliminated instances of incomplete audits and reduced the number of outlier audit results.
- The WL TAP provided consistent application of the DVG criteria.
- Common DVG assignments reveal common operational practices that directly impact water audit results (i.e. lack of proactive meter testing).
- Though the WL TAP improved many audits, level 1 validation often only identifies source of inaccuracy and cannot correct for all uncertainty in water audits.

VI. Water Audit Qualifications

Data Validity Score Significance

The process of assigning a DVG for each input in the audit is an important opportunity to discuss practices of data management and instrument accuracy. The conversation and the resulting grade assignment often unearthed areas for improvement for better data.

Though it is tempting to conclude that the higher composite DVS the better the audit data, the final dataset challenges that interpretation. Consider the twelve audits that show negative losses after level 1 validation. These audits results undoubtedly contain error that could not be resolved in the level 1 validation review. However, these audits show DVS ranging between 41 and 77.

The DVS communicates level of engagement in data review and instrument accuracy testing, but looking at the DVS alone as an indication of audit accuracy is not sufficient.

Consecutive Year Audit Results

The WL TAP often worked with two audits: one year's audit in the wave 2 practice validation and a more recent audit in the wave 4 formal validation. For those suppliers that participated in both rounds of review, the two audits provide insight into consistency of audit results from year to year, at least in the first few years of water audit compilation.

Variation in audit results is expected from year to year because water losses are dynamic. However, large swings in audit results from year to year rarely reflect true water loss changes. Instead, consecutive audits with a dramatic change in results indicates that the supplier is wrestling with data source error.

Of those 305 suppliers with two consecutive audits, 43 of them – 14% of the group – showed a change in the real losses performance indicator of greater than 15 gallons per connection day. **This serves as an important caution: it can take many years of audit compilation and refinement to develop a consistent and meaningful assessment of water losses.**

Persistence of ILIs Below One

An ILI below one suggests that the supplier's Current Annual Real Loss volume is less than the Unavoidable Annual Real Losses modeled for the system. In other words, the audit presents an exceptionally low leakage volume.

After level 1 validation, 108 audits report an ILI below one. Figure 11 shows the distribution of ILI results below one before and after validation. For some agencies, review of summary documentation and double checking the audit methodology changed the audit inputs to show a more realistic volume of leakage. However, for many agencies reporting an ILI below one, the process of validation did not reveal any error in methodology or immediate corrections. In a handful of cases, application of the audit methodology (i.e. acknowledging customer meter under-registration or estimating some non-zero volume of operational use) shifted ILIs below one after level 1 validation.

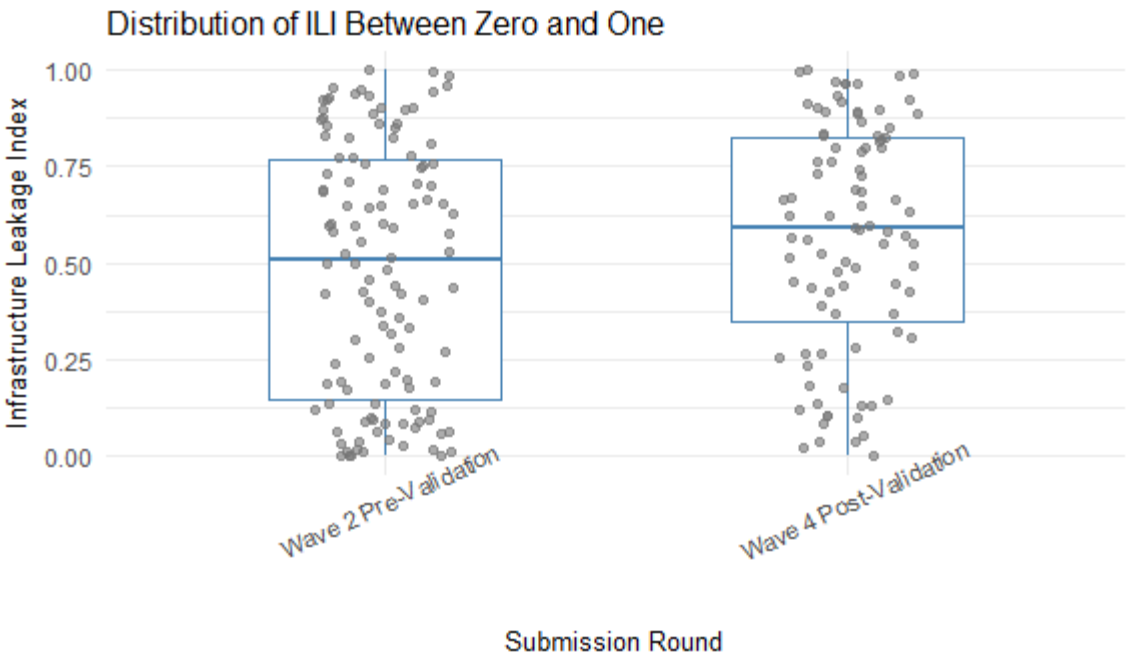


Figure 10: Distribution of ILIs Between Zero and One Before and After Validation

For the group that reports an ILI below one after validation, without advanced validation there is unfortunately no way to distinguish audits that accurately report an exceptionally low leakage volume from those that are erroneous. To be cautious, the filtering process flags audits that present an ILI below one to suggest potential error.

After multiple years of audit submissions and improved accuracy, the persistence of ILIs below one would warrant further examination and research.

VII. Wholesaler Audit Guidance

Wholesale agency can assess distribution system efficiency through a system mass balance, just like a retail agency can. However, the AWWA Free Water Audit Software was tailored for retail systems, and as a result the assumptions underlying default values, data validity grades, and performance indicator calculations do not always apply to wholesale systems. Nonetheless, when the limitations of the AWWA Free Water Audit Software's applicability to wholesale systems are understood, the tool can still be used to track volumes of water entering and leaving a wholesale network and account for the effects of meter inaccuracy on water loss assessment.

Wholesalers were introduced to the benefits and drawbacks of the Audit Software as it applies to their systems through wholesaler-specific curriculum and a written wholesaler guide to the Audit Software developed by the WL TAP program management team. Of the 39 Wholesaler Urban Water Suppliers, 18 of them participated at some point in the WL TAP.

The wholesaler Audit Software guide was published on the WL TAP website. Notably, the guide documented the applicability of traditional performance indicators to wholesale system, shown below in Table 7.

	APPLICABLE?	UNITS
FINANCIAL PERFORMANCE INDICATORS		
Non-Revenue as percent by volume of Water Supplied	NO	
Non-Revenue as percent by cost of operating system	NO	
annual cost of Apparent Losses	YES	*valued at customer retail unit cost*
annual cost of Real Losses	YES	*valued at variable production cost*
OPERATIONAL EFFICIENCY PERFORMANCE INDICATORS		
Apparent Losses per service connection per day	YES	gal / conn / day
Real Losses per service connection per day	NO	gal / conn / day
Real Losses per length of main per day	YES	gal / mile / day
Real Losses per service connection per day per PSI of pressure	NO	gal / conn / day / PSI
Unavoidable Annual Real Losses (UARL)	NO	AF / yr or MG / yr
Current Annual Real Losses (CARL)	YES	AF / yr or MG / yr
Infrastructure Leakage Index (CARL/UARL)	NO	
DATA VALIDITY PERFORMANCE INDICATOR		
Data Validity Score	NO	*weighted overall score out of 100*

Table 8: A select number of key performance indicators are applicable to wholesale agencies.

Wholesale Systems Supporting Retail Systems

Wholesaler participation in the WL TAP also enabled communication between retail agencies and wholesale agencies on the meter maintenance data that retail agencies needed for level 1 water audit validation. If a wholesaler performs any interconnection meter maintenance, the downstream retail agency benefits from documenting maintenance results in the water audit and correcting registered volumes for diagnosed inaccuracy. To empower wholesale agencies in meeting their retail systems' data request, communication throughout the program and the wholesaler-specific wave 3 track clarified the documentation retail agencies required from wholesalers to complete their validation.

The WL TAP provided guidance on better communication between retail and wholesale agencies.

Potential for Future Wholesale System Support

Wholesale systems may benefit from a unique tool designed to capture wholesale system performance, like the AWWA Free Water Audit Software does for retail systems. Until then, the Audit Software imperfectly assesses wholesale system performance, and many of the standard performance indicators do not apply to wholesale transmission infrastructure.

Furthermore, interconnection meters are critically important for accurate water loss assessment for both wholesale and retail agencies. Nonetheless, many meters have never been volumetrically (hydraulically) tested, and not all meters can be volumetrically tested to begin with, given their installation conditions. Therefore, wholesale systems could benefit from testing support, whether that support is technical or financial. Retail agencies would also benefit from engagement with wholesalers over critical metering assets, since wholesale agency practices typically determine the Water Imported data validity grades that a retail agency receives.

VIII. Program Feedback

The WL TAP conducted a post-program survey of its participants to profile three key aspects: participant experience with the training, the net impact of the training on water loss practices, and needs for future of water loss training & technical assistance. Full results of the survey are appended to this report. The survey was conducted October 31 – November 10, 2017, following the substantial completion of Wave 4. Out of 1,380 individuals invited to participate, 338 completed the survey yielding a response rate of 24%.

Conclusions based on the specific responses provided in the survey are shown below, regarding three key aspects:

Participant Experience

- ✓ The WL TAP is seen as a strong contributor to AWWA value by its members.
- ✓ Many participants rate WL TAP as better than other training.
- ✓ The WL TAP increased participants' interest, motivation, priority, and confidence in water auditing and the M36 methodology.
- ✓ Many participants found the training experience encouraging.
- ✓ Almost all participants rate the WL TAP as one of the best programs they have ever participated in.
- ✓ Participants are very likely to recommend the program to peers.
- ✓ Participants chose to invest many hours in the WL TAP training.

Program Impact

- ✓ The WL TAP provided key concepts of water auditing and has empowered utilities with the tools to address water losses.
- ✓ Many utility staff have seen the benefit of forming a dedicated water loss team with effective communications regarding water auditing.
- ✓ Water auditing and water losses are a higher priority because of the WL TAP.
- ✓ Utilities are beginning to think about cost-effective water loss intervention strategies.

Future Needs

Highlights of the TAP Survey Written Comments:

Please continue *to provide, and improve, the water loss assistance. Coaching on this subject matter is needed!*

Keep the program going next year*. This should be an ongoing training opportunity for water agencies to utilize going forward as staff turnover occurs.*

The program was ***excellent****. My only suggestion would be to offer these* ***same resources next year****, so agencies across the state don't lose their momentum on water loss auditing.*

Although it seems that we report the same information or similar information to various departments of the State in different formats, ***this process was exceptional*** *with the assistance of the program management team.*

I hope that we can continue *to have this support from the State so that we can have the assistance of this team to continue to assist with the reporting. I think the* ***data will be much more accurate and consistent with other agencies.***

I would suggest ***continuation of the training*** *based on program activity. For example, meter testing activities.*

Provide this opportunity annually*, we'd pay for the expertise that was received. Great job.*

Using a third party makes it about ***getting better data and putting it to use****. Not about getting fined or more reporting. This is a* ***good tool****.*

Thank you *for providing the valuable Water Loss TAP program. It was* ***extremely educational and helpful****. It would be great to have this resource* ***every year!***

- ✓ The vast majority of participants are interested in an extension of this WL TAP.
- ✓ The vast majority think their agency will invest in water loss training next year.
- ✓ Participants are interested in seeing the program continue and expanded to adjacent topics like meter testing and component analysis.

IX. Next Steps

Audit Validation Program

The WL TAP facilitated the biggest audit data collection effort in California to date. Across the trainings and validation sessions, the WL TAP instilled a new appreciation for the Audit Software tool and piqued interest in the benefits of water loss monitoring and management. To sustain attention and encourage water audit improvement, strengths of the WL TAP will be important to continue:

- **Consistency:** The first year of level 1 validations was unique because the WL TAP offered a streamlined and consistent process for all participants. Going forward, efforts to standardize and maintain clear expectations of level 1 validation across different validation providers will be essential (through checkpoints like the Water Audit Validator certificate program). It will also be critical that the State ensures quality control measures are in place.
- **Transparency:** The Project Management Team (PMT) emphasized the importance of transparency in the water audit process. For a water audit to be insightful and useful, the inputs must be as accurate as the data available allows and the Data Validity Grades (DVG) must reflect data collection and maintenance protocols in practice. The PMT successfully built trust over the course of the program to foster candid, comfortable conversations between the utility staff and the validator. Moving forward, maintaining these levels of transparency will be critical.
- **Learning:** Participants were especially appreciative that the reporting requirement was so well-supported by training. In addition to the final round of audit review, the WL TAP offered opportunities for utility employees to refine their water audit expertise, consider peers' experiences, and evaluate areas for improvement. Future training sessions would encourage continued attention and care to water auditing and water loss control while also allowing new staff to get up to speed. Moving forward, it is important that training continue for water suppliers in California.

Water Loss Programming Considerations

Now that water audit best practices are being adopted across the state and each utility has stepped up to assess its water loss starting point, practical discussions of where to improve data, how to empower proactive management, and how to cost-effectively reduce water losses can begin. As those discussions start, the WL TAP's experience with the first year of validations reveals some important considerations:

- **Uncertainty Remains:** The first year of level 1 validated data should serve as a starting point. An accurate audit requires constant refinement and ongoing study of data sources describing production, consumption, and meter inaccuracy. Many suppliers are now identifying potential sources of inaccuracy but data source improvement takes time. Ongoing training and technical assistance should include this in its focus.
- **Proactive Opportunities Exist:** In discussions with each supplier across the validation sessions, the PMT inquired about current water loss control activity. All suppliers

described programs of leak repair (responding to known failures) and many have active mains replacement programs. However, a minority of suppliers proactively survey or otherwise manage leakage. Only a quarter of the participating suppliers described any form of proactive leak detection work. Ongoing training and technical assistance should include this in its focus.

- **Context Matters:** Given the diversity of infrastructure and financial parameters across California water suppliers, it is critical to assess each utility's water loss performance in the context of its unique operations and constraints. This is especially important to consider as water loss target setting begins in upcoming years. SB555 outlines that performance benchmarking process will begin in 2019, and the Executive Order B-37-15 framework features water loss as a focus of its water waste reduction measures.

APPENDIX: Key Performance Indicators

	Key Performance Indicator Definitions and Interpretations[13]	
	Key Performance Indicator	Definition & Interpretation
Financial	Annual Cost of Apparent Losses	The total annual cost of Apparent Losses, the volume of water that reaches consumers but is not properly accounted for due to inaccurate metering, systematic data handling errors, and unauthorized consumption (theft). Apparent Losses are valued at Customer Retail Unit Cost (CRUC).
	Annual Cost of Real Losses	The annual cost of leakage from the distribution system. Real Losses are typically valued at Variable Production Cost (VPC). Not all of this loss is economically, or even technically, recoverable.
	Non-Revenue Water as a % of Total Operating Cost	The total value of Non-Revenue Water (NRW) as a percent of the total cost to operate the system during the audit period. NRW includes Unbilled Authorized Consumption in addition to Water Losses. This performance indicator must be interpreted carefully but generally provides an indication of the scale of NRW for a given system.
Volumetric	Apparent Losses per Service Connection per Day	A normalized indicator that facilitates comparison of Apparent Loss across different systems and audit periods.
	Real Losses per Service Connection per Day	A normalized indicator that facilitates comparison of Real Losses across different systems and audit periods.
	Real Losses per Service Connection per Day per PSI	A normalized indicator that acknowledges that pressure plays a significant role in the total volume of Real Losses. By normalizing to pressure, the confounding effects of pressure on leakage are reduced in comparisons among systems with different pressures.
	Infrastructure Leakage Index (ILI)	The ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL). An ILI of 1.0 indicates that a system lost a volume of leakage during the audit period equivalent to its modeled technical minimum.
	Data Validity Score	A weighted composite of the individual data validity grades assigned to audit inputs. Data Validity Grades describe the extent to which best practices for data collection and review are practiced.

Table 9: Key Performance Indicator Definitions & Interpretations

[13] Summarized from definitions as provided in AWWA (American Water Works Association). 2016. *M36 Water Audits and Loss Control Programs. Fourth Edition. Denver, Colo.: American Water Works Association.*

Appendix B: Example Communications for Recruitment

May 31, 2016

Dear California Urban Retail Water Supplier[1]:

California Senate Bill 555 (2015) requires urban retail water suppliers to submit a validated water loss audit annually to the California Department of Water Resources (DWR) beginning in October 2017. This requirement builds on SB 1420 (2014) which directs urban water suppliers to complete a water loss audit and include a quantification of water loss in their urban water management plans. In implementing SB 555, DWR is directed to develop rules and guidance on water loss audit validation by January 1, 2017. DWR will begin working with stakeholders in the next few weeks to develop the validation requirements and complete the rulemaking process.

To assist urban retail water suppliers in completing validated water loss audits, the California-Nevada Section of the American Water Works Association and the newly formed California Water Loss Collaborative, with funding from a State Revolving Fund grant administered by the State Water Resources Control Board, has developed a Water Loss Technical Assistance Program (Water Loss TAP).

The Water Loss TAP provides technical assistance by knowledgeable professionals to help urban retail water suppliers refine water audit practices. Specifically, the Water Loss TAP plans to assist urban retail water suppliers by reviewing the water loss water audits submitted with 2015 urban water management plans and offering assistance in the preparation and validation of 2016 water loss audits. These services are provided for free to California urban retail water suppliers. The Water Loss TAP will consist of a progressive series of in-person sessions with follow-up technical assistance phone conferences, as follows:

- In-person work session for audits (August-September 2016)
- Follow-up teleconference technical assistance work session (October 2016-February 2017)
- In-person work session for audits and validation (February-April 2017)
- Follow-up teleconference technical assistance work session (May-September 2017)

Participation in the Water Loss TAP requires a commitment to four work sessions over approximately 1.5 years.

[1] The Water Loss TAP is for urban retail water suppliers. If you are working with an urban retail water supplier please forward this letter to your contact there.

Registration

To register water agency staff to participate in the Water Loss TAP, go to: http://waterlosscontrolcollaborative.org

The Water Loss TAP is designed in a manner so an entire utility team can participate and benefit. At a minimum, urban retail water suppliers should designate one person familiar with your utility operations as the lead for this program. Active participation of production, operations, billing and engineering departments is also strongly encouraged. There is no cap on the number of individuals per agency on your audit team, but having three staff members participate in the technical assistance work session is suggested. All registered staff members are encouraged and expected to participate in all four work sessions leading up to the October 2017 audit submittal.

DWR strongly encourages your participation in this program. The Water Loss TAP program will provide your agency access to water loss professionals who will train staff in completing accurate and useful audits. This will help your agency meet the new reporting requirements and gain a better understanding of how to improve your water loss control program.

If you need additional information, please call DWR's Water Loss Control Program Lead Todd Thompson at (916) 651-9255, or by email at Todd.Thompson@water.ca.gov.

Sincerely,

Peter Brostrom
Water Use Efficiency Program Manager
California Department of Water Resources
(916) 651-7034
Peter.Brostrom@water.ca.gov

Dear California Urban Water Supplier:

RE: Water Loss Technical Assistance Program – Wave 4 Validation Scheduling

California Senate Bill 555 (2015) requires urban retail water suppliers to submit a validated water loss audit annually to the California Department of Water Resources (DWR) beginning in October 2017. The CA/NV AWWA Water Loss Technical Assistance Program (Water Loss TAP) has been funded by a State Revolving Fund grant administered by State Water Resources Control Board. The Water Loss TAP is currently providing water utilities with the water loss audit validation review required by Senate Bill 555. There is no fee to Water suppliers to receive this service.

Our records indicate that presently your utility is not yet signed up for a Wave 4 Validation Work Session through the Water Loss TAP. The State Water Resources Control Board strongly encourages you to claim your Water Loss TAP Wave 4 Validation timeslot as soon as possible to ensure you secure the required validation review before the October 1, 2017 deadline for submission of validated water loss audits.

To sign up for the Water Loss TAP Wave 4 Validation Work Session, visit this address:

www.californiawaterloss.org/wave4

To catch up on the Water Loss TAP programming and information, visit this address:

http://www.californiawaterloss.org/resources

If you have questions regarding the Water Loss TAP or preparation for the Validation Work Session, please contact Will Jernigan at waterlosscontrolcollaborative@gmail.com.

Sincerely,

Max Gomberg
Climate and Conservation
Manager
State Water Board

American Water Works Association
California-Nevada Section

CALIFORNIA WATER LOSS CONTROL COLLABORATIVE

Water Loss Technical Assistance Program

May 2016

California Senate Bill 555, passed in October 2015, requires all urban retail water suppliers in the state to submit a validated water loss audit annually to the California Department of Water Resources (DWR) beginning October 2017. The CA-NV AWWA Section is pleased to announce the first phase of its Water Loss Technical Assistance Program (**Water Loss TAP**) – an approximately 1.5-year program that provides urban water suppliers with **free technical assistance** to comply with these new requirements.

The **Water Loss TAP** provides direct assistance including a free review of 2015 Urban Water Management Plan (UWMP) water audit, and preparation support and validation of the 2016 AWWA water loss audit at no charge to utilities. The first phase of the **Water Loss TAP** will commence in May 2016 and run through the end of 2017. The curriculum includes progressive events, including:

- In-person work session - late summer of 2016
- Teleconference work session - end of 2016
- In-person work session - early 2017
- Final teleconference work session - mid-2017
- Official Senate Bill 555 deadline for validated audit submittal - October 1, 2017

Participation in the **Water Loss TAP** will mean a time commitment of only four (4) work sessions over approximately 1.5 years.

One (1) person familiar with your utility operations should be designated as the lead for this program, and active participation of production, operations, billing and engineering departments is also strongly encouraged. A guideline of three (3) individuals is suggested. All individuals registered from each urban water supplier are encouraged and expected to participate in all four (4) work sessions between now and October 2017. To register individuals for the **Water Loss TAP**, go to:

http://waterlosscontrolcollaborative.org

The **Water Loss TAP** is part of a broader initiative known as the Water Loss Control Collaborative, which is led by CA-NV AWWA and includes stakeholders from utilities, industry organizations, non-profits and state entities.

Questions about the Water Loss TAP? Please contact:

Kate Gasner
Kate.Gasner@wsoglobal.com
415.533.0419

Will Jernigan
Will.Jernigan@cavanaughsolutions.com
828.255.7596

WSO | CAVANAUGH Stewardship Through Innovation

Sender: CANV AWWA Section
Subject: Deadline tomorrow
Audience: Non-Registrants
Send Date: 6/29/2016

Dear Urban Water Supplier,

Tomorrow is the deadline to **register for the Water Loss Control Technical Assistance Program**. **We strongly recommend that your utility participates in this program.** The Water Loss TAP is the only program offered at no cost to help utilities comply with SB 555.

Four work sessions over 1.5 years will ensure that your October 2017 water audit submission is validated in compliance with SB 555. **By completing the program, you'll have access to internationally recognized experts in Water Loss Control.**

Water Loss TAP activities include:

- In-person work session – Fall 2016
- Teleconference work session – Winter 2016
- Second In-person work session – Spring 2017
- Final teleconference work session – Summer 2017

Through these sessions you'll get important information about the water auditing methodology. Expert trainers will make sure your water audit is complete and help you ask the right questions about your data sources.

Be sure to register today. If you have any questions about this program, feel free to reach out to the project management team at waterlosscontrolcollaborative@gmail.com.

Sincerely,
Tim Worley
Executive Director CANV Section AWWA

Will Jernigan

From: Water Loss TAP Team <waterlosscontrolcollaborative=gmail.com@cmail20.com> on behalf of Water Loss TAP Team <waterlosscontrolcollaborative@gmail.com>
Sent: Thursday, September 1, 2016 01:00 PM
To: Will Jernigan
Subject: Water Loss TAP August Update

Dear Urban Water Supplier,

If you are reading this, you have not yet joined more than 350 utilities statewide who have registered for the Water Loss Technical Assistance Program (Water Loss TAP).

The Water Loss TAP provides water audit submission validation by October 2017, guarantees compliance with new statewide requirements, and is offered at no cost.

It is not too late. You can still join the Water Loss TAP here.

For a briefing on what has happened in the Water Loss TAP thus far see the August Update below and visit the Water Loss TAP **website.**

The Water Loss TAP

AUGUST UPDATE

After registering participants all summer, the Water Loss Technical Assistance Program (TAP) is off to a strong start! Are you new to the Water Loss TAP, or just curious what the Water Loss TAP has been up to and where the Water Loss TAP is going next? Then this update is for you!

What is the Water Loss Technical Assistance Program (TAP)?

The Water Loss Technical Assistance Program (TAP) connects urban water suppliers in California with the **training and support necessary to compile and level 1 validate water audits**. Level 1 validated water audits will be submitted by **October 1, 2017** to the California Department of Water Resources (DWR), as mandated by Senate Bill 555.

How is the Water Loss TAP structured?

The Water Loss TAP is composed of **four waves of interaction** between utilities and water auditing experts. The Water Loss TAP is provided at no cost to participants.

- ***Wave 1* is a day-long in-person work session** that covers the basics of water auditing and introduces water audit data validation.
- ***Wave 2* is a teleconference work session** in which water auditing experts and each utility's water audit team examine the utility's FY14-15 or CY15 water audit in a two-hour interview.
- ***Wave 3* is a day-long in-person work session** that refreshes attendees on water audit methodology before more deeply exploring water audit data validation and the connection between water auditing and water loss control.

- ***Wave 4*** ***is a teleconference validation session*** in which water auditing experts and each utility's water audit team perform a level 1 validation of the FY15-16 or CY16 water audit that will be submitted to DWR.

Additionally, the Water Loss TAP offers **two learning tracks** for the Wave 1 and Wave 3 in-person work sessions to recognize varying levels of familiarity with water auditing principles. Most urban water suppliers in California will follow the **New Learner** track in order to build a strong foundation in best-practice methodology. However, a subset of utilities that have pursued water auditing and water loss control in recent years will engage with the **Early Adopter** track to push their water auditing knowledge toward water audit data validation and advanced water loss analysis.

Who is participating in the Water Loss TAP?

So far, most California urban water suppliers are participating in the Water Loss TAP! As of August 9th, **350 utilities** had registered for the Water Loss TAP, and registration keeps ticking up. Utility representatives are currently attending Wave 1 in-person work sessions and assembling supporting documentation for Wave 2 validation of FY14-15 or CY15 water audits.

Where can I go for more information?

californiawaterloss.org

If you have any questions, please visit the Water Loss TAP **website**, or reach out to us at waterlosscontrolcollaborative@gmail.com.

Sincerely,
Kate Gasner and Will Jernigan
-The Water Loss TAP Team

Appendix C:
Learning from the California Water Loss TAP

Table of Contents

TAP Program Background

Between May 2016 and October 2017, the State of California Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) conducted the largest statewide water loss technical assistance program ever convened in the United States, with impact on 443 water systems and more than 1,500 individuals. This Water Loss TAP was conducted in four phases through the CA-NV Section of AWWA.

In addition to its large scale, the TAP also carried responsibility for four ambitious goals:

- *Executing a first-year program with high participation that sets the state up for a sustainable program in the future;*
- *Going beyond regulatory training just to satisfy compliance, but providing training that will last;*
- *Applying Level 1 validated water audits as a defensible basis for accountability for making resource allocation decisions; and*
- *Saving water, reducing costs, and enhancing the culture of stewardship; and many more.*

This unprecedented program presents the water management community across the country with a tremendous opportunity to assess the experience created by the program and the initial impact of the training on urban retail water systems.

Survey Methodology

A self-administered online survey was emailed to 1,380 individual program participants, yielding 338 completed questionnaires, for a respectable response rate of 24%. This provides margin of error of 5 percentage points at a 95% confidence level. The survey questions were vetted with the Section prior to release to program participants.

The survey was conducted between October 31 and November 10, 2017, shortly after the end of the program (Wave 4). The survey remained open for 10 days, with up to 3 reminders.

To encourage participation, prize incentives were offered for responders:

- 1 - $100 VISA Gift Card and ten $10 Starbucks Gift Cards
- 1 free registration and 1 half-price registration to the North American Water Loss 2017 Conference and
- 3 copies of the AWWA M36 Water Audits and Loss Control Programs, 4th Edition.

Prize winners were randomly selected and contacted by the PM Team to confirm mailing addresses for delivery. Survey respondents were afforded the opportunity to submit responses anonymously. Note that all responses were confidential and no responses are attributed to individual participants. Survey completion generally took less than 10 minutes.

EXECUTIVE SUMMARY

The Water Loss TAP conducted a post-program survey of its participants to profile three key aspects: participant experience with the training, the net impact of the training on water loss practices, and needs for future of water loss training & technical assistance.

Participant experience

The Water Loss TAP had a strong effect on how participants feel about water auditing. They report that it increased their interest in and motivation to conduct water audits. In addition, it encouraged them to increase the priority they give to water audits, and increased their confidence in water auditing and the M36 methodology.

It should be noted that many participants chose to invest many hours in the Water Loss TAP training, beyond the programmed class hours. In addition, participants volunteer many enthusiastic statements about the content, process, and people of the Water Loss TAP.

Almost all participants rate the Water Loss TAP as one of the best programs they have participated in. Accordingly, the Water Loss TAP is seen as a strong contributor to AWWA value by its members.

Program Impact

Training should be relevant and leave a participant equipped to successfully perform specific job duties. The vast majority indicated the program had a positive impact on their job duties regarding water loss by providing resources, a baseline to track water losses, and equipping with the industry standard methodology of water auditing.

Communication among all utility staff involved with addressing water losses is important for a successful water loss program. Survey responses strongly show that the training has increased participants' comfort in discussing water losses with local and state entities as well as its prioritization in their own role in addressing water losses at their utility.

Most participants indicate a heightened priority when it comes to reducing water losses and conserving water and revenue as a result of this program. Over half indicated that this program has been a strong driver in considering implementation strategies.

Future Needs

The vast majority of participants are interested in an extension of this water loss TAP.

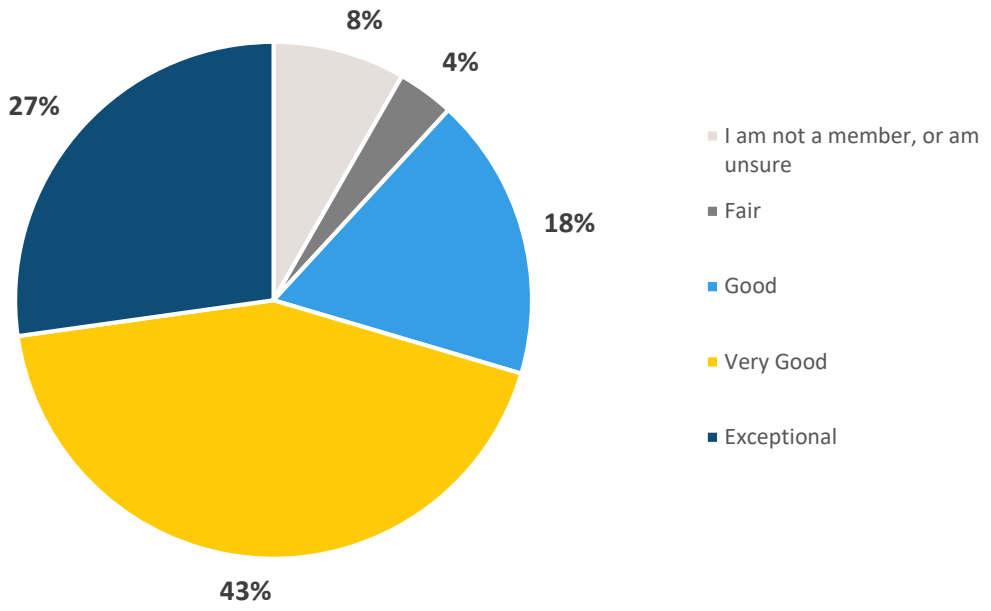
Similarly, the vast majority think their agency will invest in water loss training next year. Participants are interested in seeing the program continue and some suggest expanding it to adjacent topics like meter testing and component analysis.

LEARNING PART 1: PARTICIPANT EXPERIENCE

Contribution of Program to AWWA Membership Value

<u>The Water Loss TAP is seen as a strong contributor to AWWA value by its members.</u>

A plurality (43%) believe the Water Loss TAP is a very good reflection on AWWA and fully one-quarter (27%) say it is “exceptional”.

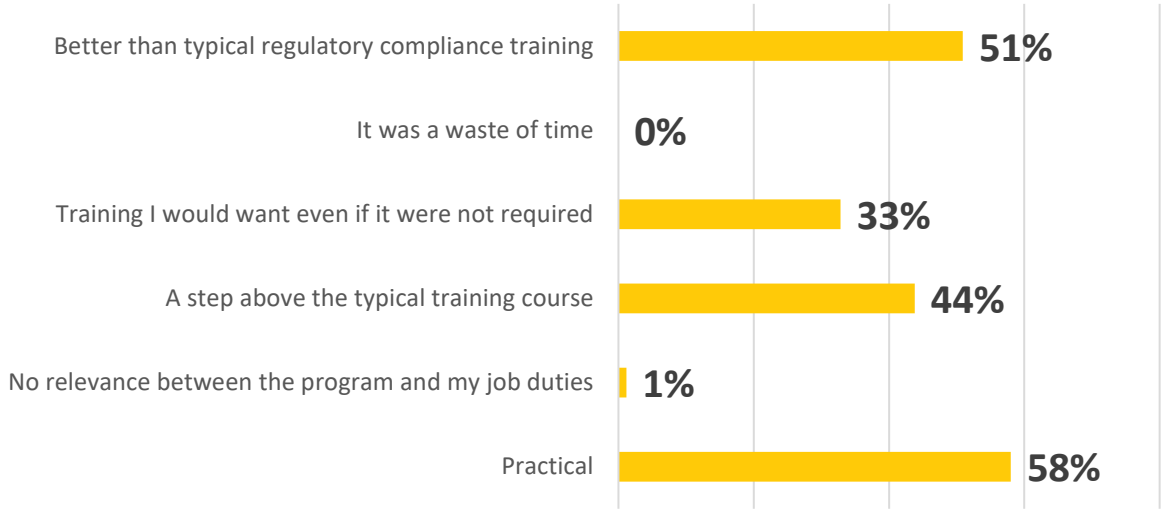


Q10: With funding from US Environmental Protection Agency and the State Water Resources Control Board, the Water Loss TAP was brought to you by the California-Nevada Section of AWWA. How does offering this program contribute to your view of being a member (individual or agency) of AWWA?

Assessment of TAP Training Experience by Participants

Many participants rate TAP as better than other training.

In addition to finding the Water Loss TAP to be practical (58%), large proportions rate is better than typical regulatory training (51%), a step above the typical training course (44%), and training they would want even if it were not required (33%). Nearly no one considers the program irrelevant (1%) or a waste of time (0%).



Q3: Which words and phrases describe your experience with the Water Loss TAP program? Check all that apply.

It was the most detailed water auditing course I have ever taken on the M36 methodology. **I have taken other training on water auditing, but this course covered the important details that I have not received anywhere else.** It was very helpful and I felt more confident in the process and the numbers at the end.
- Sarah Fleury, Castaic Lake Water Agency

Very comprehensive and surprising **high level of person-to-person communication** given the volume of systems they were administering.
- Justin Shobe, Discovery Bay Community Services District

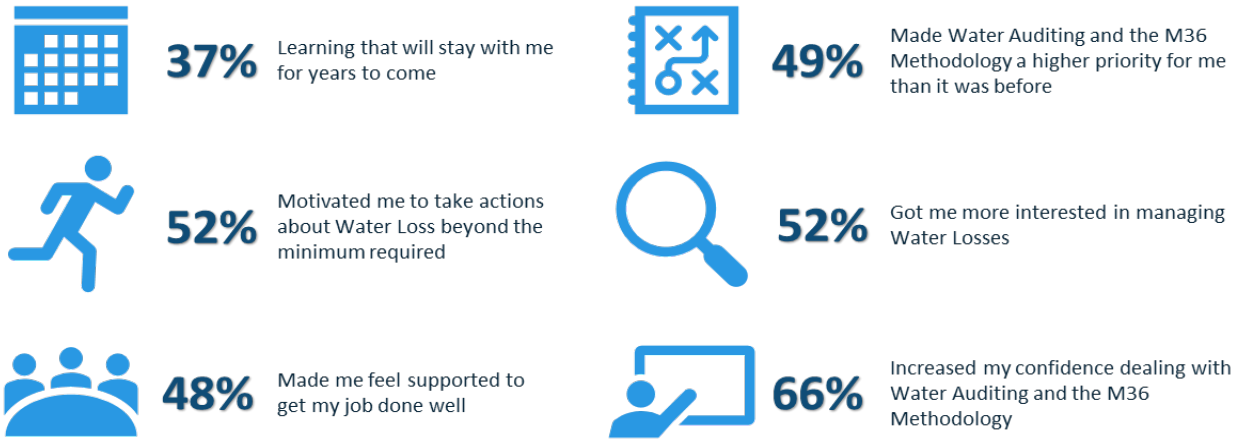
The training was relevant, well-presented and executed in stages. This training schedule provided a realistic timeline with realistic milestones for project completion. **The Water Loss Facilitators were extremely knowledgeable yet presented their material and the methodology in a manner that was understandable to all levels** - even me, a non- operations team member (I am Customer Service Mgr.)
- Kathleen Willson, Valencia Water Company

The Water Loss TAP program was instrumental for our agency for providing clarification to the water audit procedures that we needed to improve our water audit and to be confident that the data produced is a true reflection of our water system. It also gave us the ability to interpret our results for meaningful change in our system.
- Rachel Hernandez, City of Arcata

Influence of TAP Training on Participant Orientation to Water Auditing

The Water Loss TAP increased participants' interest, motivation, priority, and confidence in water auditing and the M36 methodology.

At least half the participants say the program had a variety of positive influences and more than a third (37%) say the learning will stay with them for years.

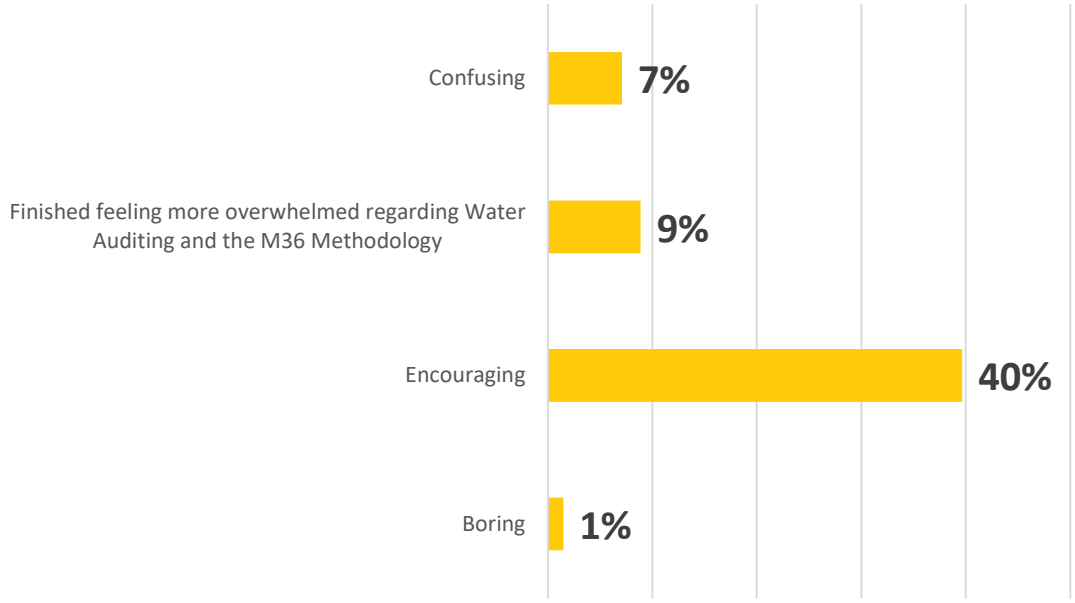


Q3: Which words and phrases describe your experience with the Water Loss TAP program? Check all that apply.

Participant Experience of TAP Training

Many participants found the training experience encouraging.

When asked how they would describe their experience of the training, many (40%) describe it as "encouraging" and very few rate it negatively.



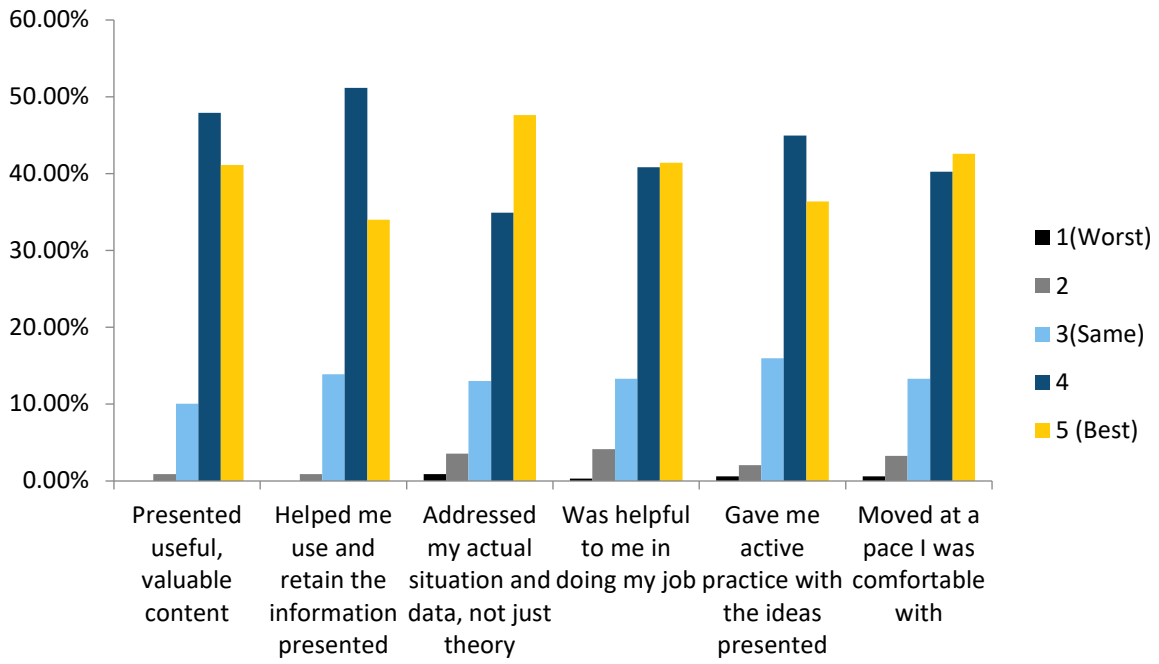
Q3: Which words and phrases describe your experience with the Water Loss TAP program? Check all that apply.

Comparison of TAP vs. Other Training Programs

<u>Almost all participants rate the Water Loss TAP as one of the best programs they have ever participated in.</u>

Nearly half give the Water Loss TAP the top rating on a 5-point scale when compared with other training programs they have taken. Most of the remainder give it the next-highest rating (4).

In particular, they give high ratings for addressing their actual situation and providing active practice, being helpful in their job, and presenting useful content at a comfortable pace that they will be able to retain. Nearly none rate it less favorably than other programs.



Q2: Compared with other training programs you have taken, how would you rate the Water Loss TAP program in the following areas? With 1 being one of the worst and 5 being one of the best.

Participant Recommendations for TAP

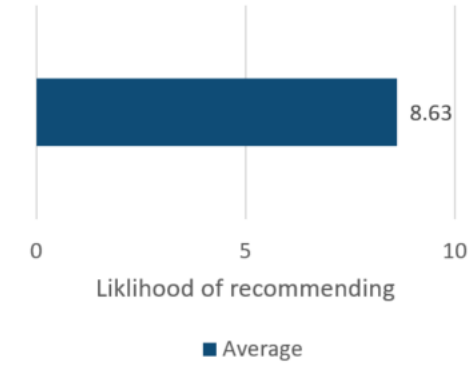
Participants are very likely to recommend the program to peers.

Using the industry-standard Net Promoter Score (NPS) methodology, participants were asked how likely they would be to recommend the program to a colleague, using a ten-point scale.

- A clear majority (61%) use a 9 or 10 on the 10-point scale to depict how likely they would be to recommend the program. These are considered "promoters".
- One-eighth (12%) rate their experience as a 6 or lower, who are generally considered "detractors" in the NPS methodology.
- Finally, roughly one-quarter (28%) are in the middle as "neutrals" (rating 7-8).

This yields a NPS rating of 49, making the program comparable with consumer ratings for [see prior notes]. As an average, recommendation ratings average 8.63 on a 10-point scale.

	Percentage
Promoters (9-10)	61%
Neutrals (7-8)	28%
Detractors (0-6)	12%
Total Responses	100%



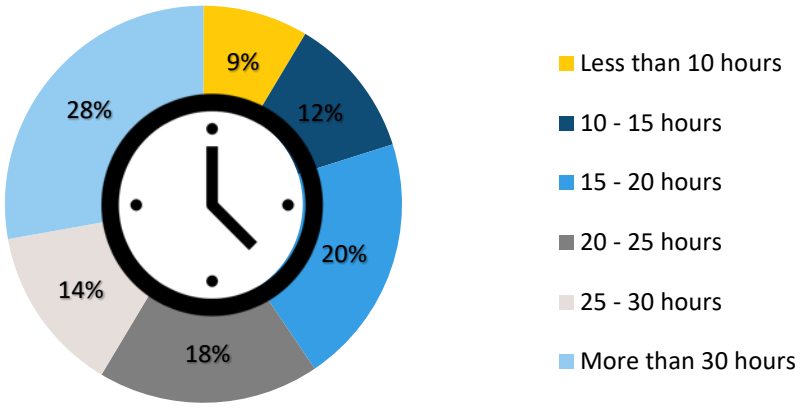
"The team members who worked with us were professional in all aspects of our training, and they really knew their stuff. We not only achieved our goal of completing a water audit, we learned a lot along the way and the experience was enjoyable. Top notch program."
- Peter Martin, Calaveras County Water District

Q1: Based on your experience with the Water Loss TAP, how likely would you be to recommend a similar program to a colleague looking for training on Water Auditing and the M36 Methodology? 1- Not Likely At All, 10-Extremely Likely

Participant Time Invested in TAP Training

Participants chose to invest many hours in the Water Loss TAP training.

The program itself required 17 hours of direct interaction during all four waves. Waves 1 and 3 were approximately 6.5 hours each, and Waves 2 and 4 were approximately 2 hours each. Most invested more than 20 hours in the training experience, in and out of class.



Q8: How much time did you personally spend preparing for and participating in the Water Loss TAP wave sessions?

Participant Comments about their TAP Experience

Participants shared many enthusiastic statements about the content, process, and people of the Water Loss TAP.

Finally, participants were asked to volunteer comments anonymously about their experience in the program and suggestions for the future. Listed here are representative comments about their personal experiences.

***Not really any improvements needed**. The Water Loss TAP provided **all the tools** and they were **easy to use!** If anyone didn't benefit from the TAP, then they weren't putting enough effort into it, because the TAP was very well planned out and thorough.*

*I thought the Water Loss TAP program was **excellent overall** and that the **instructors were great.***

*Provide this opportunity annually, we'd **pay for the expertise** that was received. **Great job**.*

***Keep the program going next year**. This should be an **ongoing training** opportunity for water agencies to utilize going forward as staff turnover occurs.*

Thank you** for providing the valuable Water Loss TAP program. It was **extremely educational and helpful**. It would be great to have this resource **every year!

***Continue** to provide training.*

*I **thoroughly enjoyed** each wave and working with the presenters. **Very entertaining and valuable.***

*It would be great if this program **continues into the next water audit season.***

The only area I thought that needed improvement was specific to DWR's reporting requirements, and the timing that those requirements were made available.

***Keep the third-party format**. The EPA is too heavy handed. Drinking water was done correctly under AWWA standards for a long time without the EPA. Using a third party makes it about **getting better data and putting it to use**. Not about getting fined or more reporting. This is a **good tool**.*

***Please continue** to provide, and improve, the water loss assistance. Coaching on this subject matter is needed!*

*Although it seems that we report the same information or similar information to various departments of the State in different formats, **this process was exceptional** with the assistance of the program management team.*

*The resources available on this website have been **incredibly useful**. They provided **updated information** on regulations and provided extra clarifications on new rules. The website was **much more helpful** than the M36 manual due to the timeliness of the updates versus the static nature of the manual.*

I hope that we can continue *to have this support from the State so that we can have the assistance of this team to continue to assist with the reporting. I think the* ***data will be much more accurate and consistent*** *with other agencies.*

Continue *the training program and possibly* ***expand on it.***

I don't feel this program could have been improved, *the staff was* ***educated*** *and delivered the message well. They were also* ***available*** *when needed. Kate is* ***top notch****!*

Continue to provide ***excellent*** *Technical Assistance Staff.*

The program was ***excellent****. My only suggestion would be to offer these* ***same resources next year****, so agencies across the state don't lose their momentum on water loss auditing.*

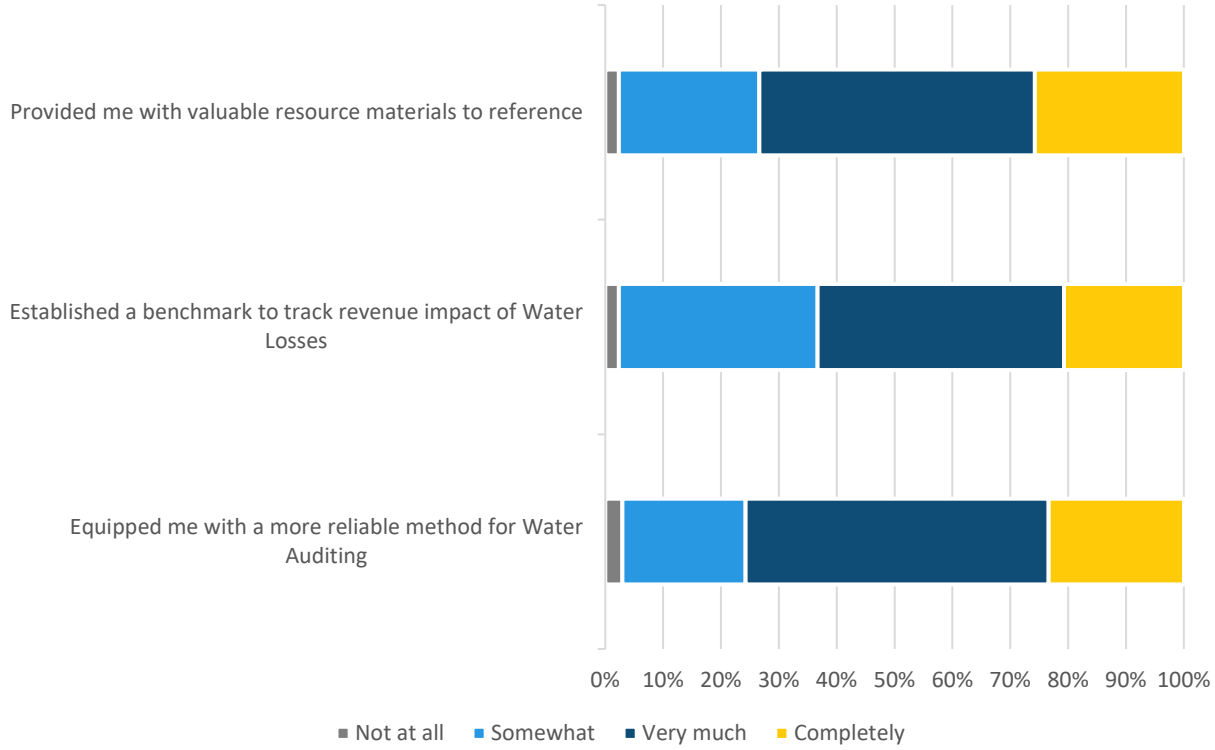
Keep offering it!

LEARNING PART 2: PROGRAM IMPACT

Contribution of TAP to Water Auditing Knowledge

<u>The TAP provided key concepts of water auditing and has empowered utilities with the tools to address water losses.</u>

More than 97% of program participants indicated the program had a positive impact on their job duties regarding water loss by providing resources, a baseline to track water losses, and equipping with the industry standard methodology of water auditing. The majority of those reporting a positive impact on their job duties indicated to the degree of 'very much' or 'completely'.

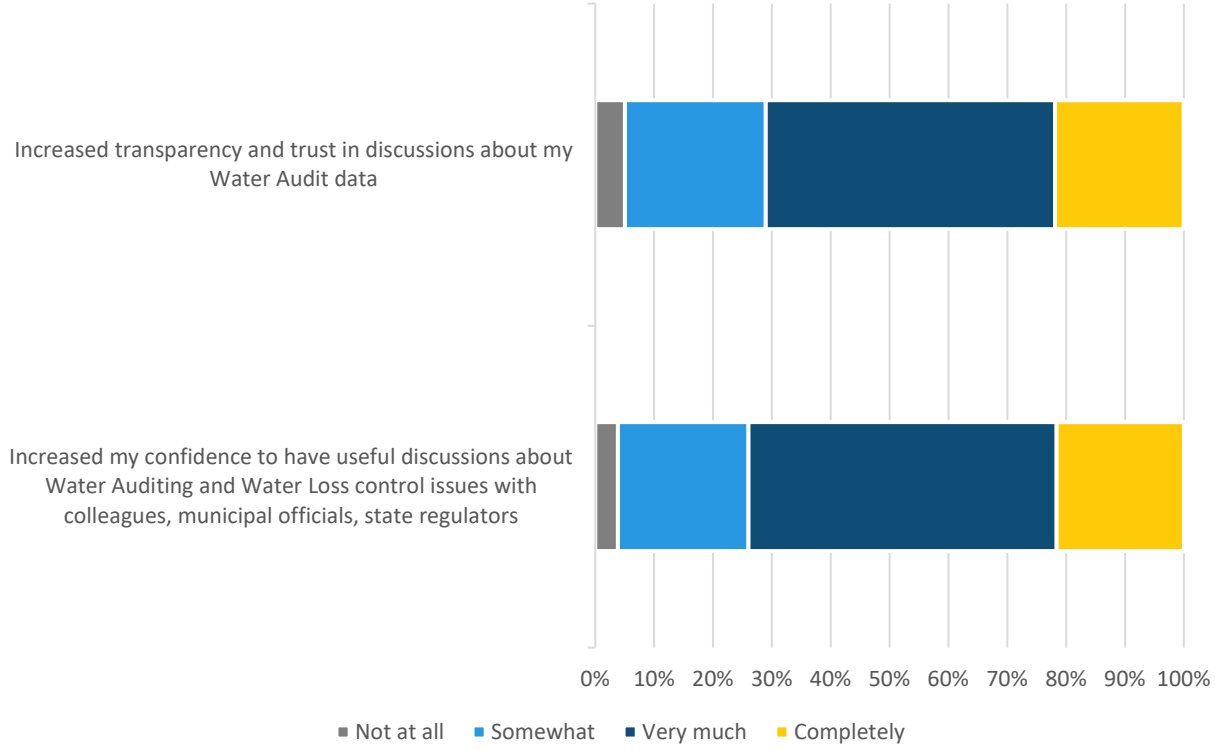


Q6: How has the Water Loss TAP training helped you in your job?

Contribution of TAP to Water Loss Communications

<u>Many utility staff have seen the benefit of forming a dedicated water loss team with effective communications regarding water auditing.</u>

The ability to effectively communicate inter-departmentally and to state regulators regarding water auditing and loss control is an important part of a water loss control program. Most indicate they have an increased transparency and trust in discussions about their water audit data, which facilitates more than 95% of participants who said they feel more confident in their ability to communicate in this capacity and see their role in addressing water losses with a higher priority within their team.

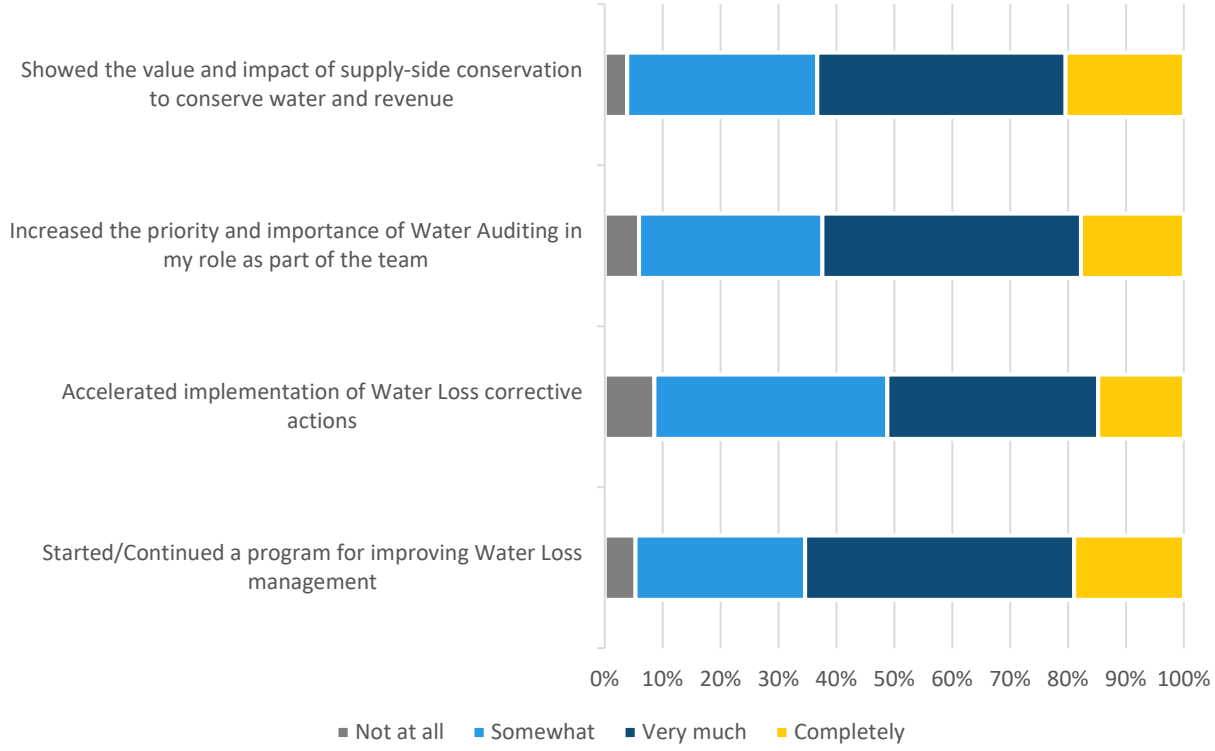


Q6: How has the Water Loss TAP training helped you in your job?

Contribution of TAP on Priority of Water Loss Measures

Water auditing and water losses are a higher priority as a result of the Water Loss TAP.

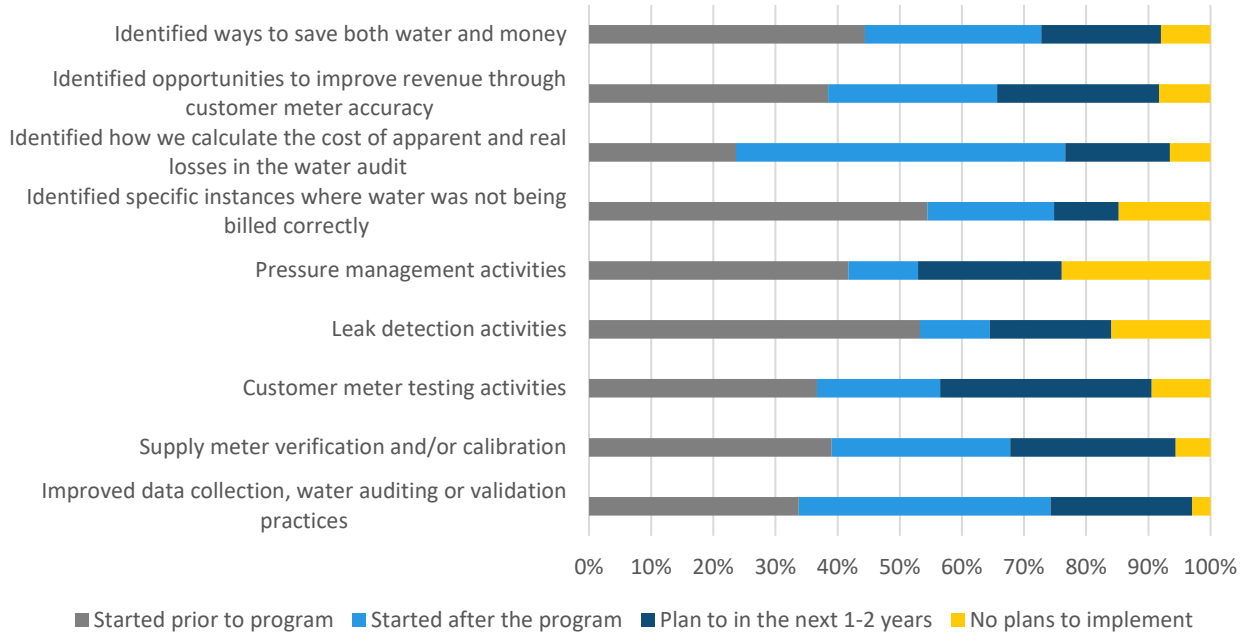
Most participants indicate a heightened priority when it comes to reducing water losses and conserving water and revenue as a result of this program. Over half indicated that this program has been a strong driver in considering implementation strategies.



Q6: How has the Water Loss TAP training helped you in your job?

Impact on Water Loss Activities

Utilities are beginning to think about cost-effective water loss intervention strategies.



Q7: Have you implemented, started or plan to start any of the following activities? We're interested to know how these activities aligned with your participation in the Water Loss TAP.

This whole process brought to light the areas in which our District could improve and how the interaction between the departments affects the water loss analysis; i.e. not just the field staff. Creation of databases has occurred, with QAQC processes, to enable one source for all data. Communication between the District departments has increased greatly resulting in more efficient work flows. A meter accuracy program has been put into place. The need to proceed with additional SCADA monitoring for system pressures. These are just a few of the improvements that are in progress.

– Cindy Kecskes, Phelan Piñon Hills Community Services District

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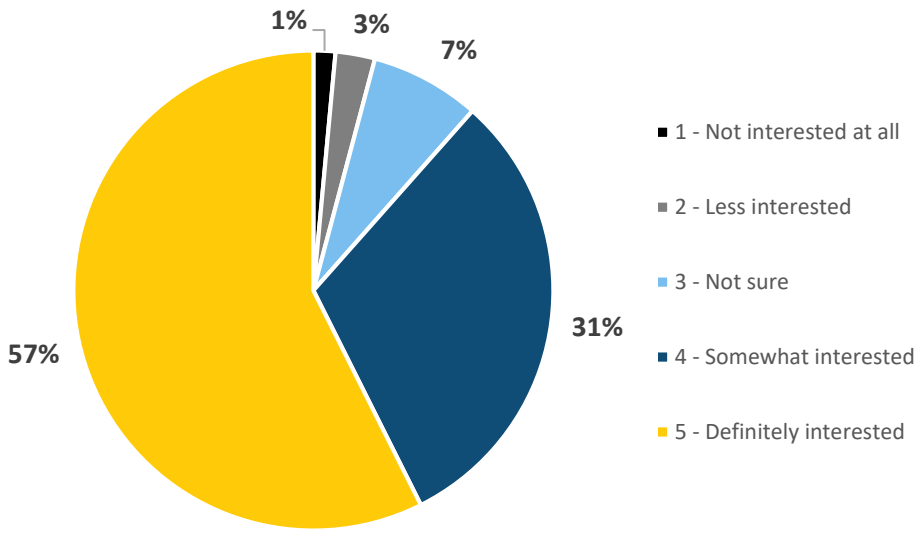
LEARNING PART 3: LOOKING AHEAD

Interest in Future TAP Program Extension

<u>The vast majority of participants are interested in an extension of this water loss TAP.</u>

A clear majority of participants (57%) are “definitely” or “somewhat” (31%) interested in a possible future extension of the program.

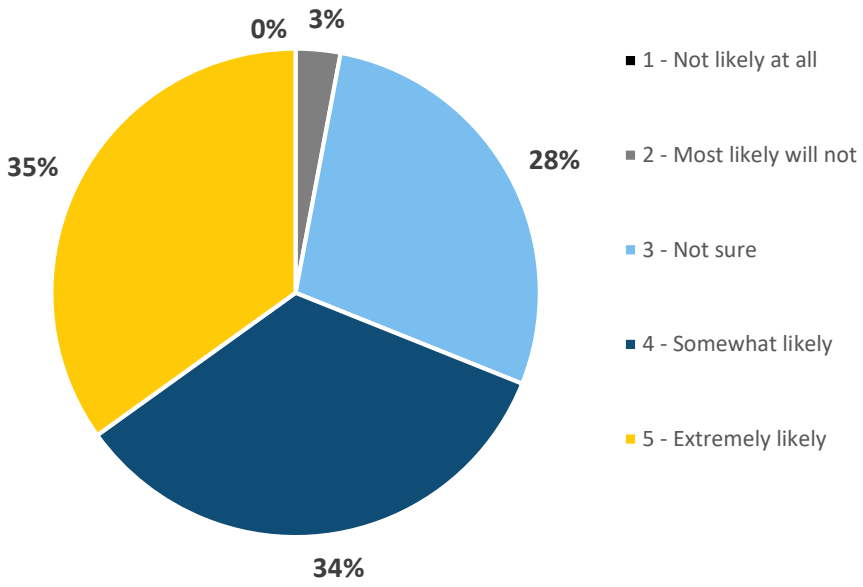


Q4: How interested would you be in participating in an extension of the Water Loss TAP program in future years if it were offered?

Likelihood of Future Agency Investment in TAP

Similarly, the vast majority think their agency will invest in water loss training next year.

Despite their personal interest, about one-quarter (28%) say they are unsure whether their agency will invest in water training next year.



Q5: How likely is your agency planning to invest in Water Loss Training next year?

Participant Suggestions for Next Year

Participants are interested in seeing the program continue and expanded to adjacent topics like meter testing and component analysis.

Finally, participants were asked to volunteer comments anonymously about their experience in the program and suggestions for the future. Listed here are representative comments.

*I would suggest **continuation of the training** based on program activity. For example, meter testing activities. Interested utilities would self-select for additional training similar to the water loss training. Utilities would gather their data and upload to discuss with a mentor and then be given "homework" on establishing the framework for a **meter testing program** based on # of meters and funding necessary to implement a successful program. This would help **defend budget requests** to fully implement this one component of water loss. Perhaps two topics annually.*

***Provide this opportunity annually**, we'd pay for the expertise that was received. Great job.*

***I would like to see the next step** build on the water audit and work off the **4372 Component Analysis Model** (in a few years, let's master the water audit first).*

***Keep the program going next year**. This should be an ongoing training opportunity for water agencies to utilize going forward as staff turnover occurs.*

*It would be great if this program continues into the **next water audit season.***

*I hope that we can **continue to have this support** from the State so that we can have the assistance of this team to continue to assist with the reporting. I think the data will be much more accurate and consistent with other agencies.*

*The program was excellent. My only suggestion would be to **offer these same resources next year**, so agencies across the state don't lose their momentum on water loss auditing.*