Colorado Water Loss Initiative

Final Report

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COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CAVANAUGH
Stewardship Through Innovation

WSO

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1 EXECUTIVE SUMMARY

The Colorado Water Conservation Board (CWCB) has been tasked to continue to provide funding, technical support, and training workshops to assist water providers in improving the management of their water systems. This includes several techniques, such as comprehensive water loss management programs. Water loss was identified in the Statewide Water Supply Initiative (SWSI) 2010 as a significant factor in the Municipal and Industrial water supply-demand gap[1]. For that purpose, the CWCB created the Colorado Water Loss Initiative (CWLI) - a 24-month program designed to teach water utilities and assist them with the implementation of best practices for the management of water losses.

The American Water Works Association (AWWA) water audit methodology, described in detail in the AWWA Manual of Water Supply Practices M36 Water Audits and Loss Control Programs, is a recommended best practice and is the North American industry standard approach for water loss management. This methodology allows for informed decision making for water loss control and management activities to reduce losses.

The scope of the CWLI comprises a comprehensive program of training and technical review and assistance for water systems across Colorado to attain a basic level of competency (Level one or Top Down Water Audit) with the AWWA water balance and audit concepts and the AWWA Free Water Audit Software (FWAS). This scope includes, at a minimum, Level 1 validation of the utility prepared water audits and includes multiple "touch points" for reinforced understanding, with the possibility of two tracks: "Early Adopters" (EA) and "New Learners" (NL).

This document is the final report for the program and documents the results achieved, including training activities and utility staff participation, summary and analysis of water audits completed by the participating utilities. It also presents a roadmap for the CWCB to continue assisting utilities with water loss best practices.

The scope of the CWLI included three main tasks that encompassed the five main stages of the program. The three main tasks include:

- Task 1: Development of the Colorado Water Loss Initiative, Program Administration, Management, and Communication
- Task 2: Collaborative Training and Technical Assistance Track for Early Adopters
- Task 3: Collaborative Training and Technical Assistance Track for New Learners

[1]Colorado Water Conservation Board, Statewide Water Supply Initiative 2010 (Denver, 2011).

The CWLI taught the best-management practices for water loss control following the methods established in the AWWA Manual of Water Supply Practices M36 Water Audits and Loss Control Programs, including the use of the AWWA Free Water Audit Software (FWAS) and conducting a water audit validation.

The CWLI kicked-off in August 2018 with an announcement to all target utilities encouraging them to register into the program and to explore the program webpage to learn more about the services being offered for free to the registered participants. The outreach network was also provided with content to spread the word among their networks and include in their digital platforms.

The program was implemented in five main stages over the course of a 24-month period. The Stages included:

- Stage 0: Program Development and Outreach
- Stage 1: Training Workshop
- Stage 2: Water Audit Review and Validation
- Stage 3: Training Workshop
- Stage 4: Water Audit Validation
- Advanced Validations
- Participant Survey

This 24-month program trained over 150 water utility professionals across Colorado on best management practices for water loss control based on the AWWA M36 Methodology.

A total of 120 entities registered for the CWLI (Figure 7), with 95% classified as New Learners, further demonstrating the need for water loss training. Initially, the program was targeted for the largest water providers in the state, 76% of all Covered Entities registered for the program, but there was an unexpected level of interest and participation from the smaller utilities – 46% of registered utilities supply less than 2,000 acre feet per year. It should be noted that registration into the program does not mean the utility participated in any stage, utilities had to register for each individual stage, but it showed the level of interest in this topic. After registering into the program, some registered utilities were not able to participate in any of the stages, mostly due to limitations in time and staffing resources (see Section 4.3).

Stage 2 and Stage 4 of the CWLI entailed a detailed review of each utility's water audit following Level 1 validation guidance set forth in WRF Project 4639. The purpose of the review is to confirm the correct application of the water audit methodology and make any necessary corrections. Fifty-two utilities and twenty nine utilities participated in a Stage 2 and Stage 4 water audit review, respectively (see Table 1). Over 70% of participants in both stages were Covered Entities. All Stage 4 participants participated in a Stage 2 session.

An analysis of the original and modified water audits was performed. For Stage 2, almost 50% of the original water audits were not complete. This improved for Stage 4, where about 30% of water audits were not complete. The review process allowed the utilities to discuss their questions or specific circumstances to be able to complete the water audit.

Two surveys were developed and approved by the CWCB. Those survey descriptions and participation stats are provided below. A participant survey was distributed to all utilities and respective staff members who registered for the program and attended one or more stages to gauge their experience. The survey responses demonstrate that most participants agree that:

- The amount of time spent in the program is reasonable and manageable,
- The extent of data requested was adequate and not burdensome,
- Most feel they have capacity to continue annual auditing,
- Most plan to complete their 2020 audit,
- The majority felt their successors would be unprepared to complete the audit if they (CWLI attendees) were to leave; and
- Most (as applicable) found this helpful to 1051 reporting.

A Non-Participant Survey was distributed to utilities and respective staff members who were included on all outreach and recruitment communications and either never registered for the program or registered, but did not participate in any of the four stages. The purpose of this survey was to gauge the challenges that some utilities faced with participating in the technical assistance program.

Based on the program feedback, continued water loss technical assistance is something most utilities are interested in. It is recommended for CWCB to offer a Phase II technical assistance program, to be made available for all Colorado water providers who are ready, willing, and able.

Phase II will build on the foundations established in Phase I, offering advanced assistance to Phase I participants and more foundation building for those who could not participate in Phase I. Structured as a 24-30 month program, Phase II is recommended to include multiple “touch points” for establishing principles & practice and reinforced understanding, culminating in direct technical assistance for data validation and water loss interventions based on the water provider’s needs.

While Phase II will likely include two training tracks with different starting points, the training tracks should follow similar approaches. The basic process is recommended to include the following:

Task 1: Development of Colorado Water Loss Initiative Phase II, Program Administration, Management and Communications

This task will be responsible for management and administration throughout the lifecycle of the program. Task 1 will also include communications; both internally with the project management team and CWCB staff, as well as outward facing in effort for outreach, recruitment, and retention in Phase II.

Task 2: Water Audit 101 Workshops and Level 1 Validation

This task will serve as a refresher for Phase 1 participants and any new employees they have. It will also introduce all necessary content for utilities that did not participate in Phase 1, including Level 1 validation. Additionally, it will introduce participants to the most updated AWWA software (v.6).

Task 3: 201 and 301 Workshops and Outreach

This task will focus on more advanced techniques and concepts beyond what was covered in Phase I. This task would include mostly participants from Phase I. These include input meter testing, customer meter testing, billing data analysis, real loss component analysis, and economic level of leakage.

Task 4: Ranking and Prioritization for Direct Technical Assistance

This task will identify and prioritize the best hands-on technical assistance area for each participating utility. This prioritization is based on audit results, data validity grades and validation documentation.

Task 5: Direct Technical Assistance

This task carries out the technical assistance identified in Task 4. Depending on the water provider, there could be technical assistance in the areas of input meter testing, billing data analysis and prorating, customer meter test design and result analysis, real loss component analysis, and leak detection.

Water loss control has been identified by the drinking water industry as a major topic of interest. With multiple states providing statewide water loss control training and having identified the AWWA M36 methodology in Colorado's Water Plan, the time is right to continue statewide training on the industry standard for water loss control and move onto prioritized interventions.

2 PROGRAM BACKGROUND

The Colorado Water Conservation Board (CWCB) has been tasked to continue to provide funding, technical support, and training workshops to assist water providers in improving the management of their water systems. This includes several techniques, such as comprehensive water loss management programs. Water loss was identified in the Statewide Water Supply Initiative (SWSI) 2010 as a significant factor in the Municipal and Industrial water supply-demand gap[2]. For that purpose, the CWCB created the Colorado Water Loss Initiative (CWLI) - a 24-month program designed to teach water utilities and assist them with the implementation of best practices for the management of water losses.

The American Water Works Association (AWWA) water audit methodology, described in detail in the AWWA Manual of Water Supply Practices M36 Water Audits and Loss Control Programs, is a recommended best practice and is the North American industry standard approach for water loss management. This methodology allows for informed decision making for water loss control and management activities to reduce losses.

The scope of the CWLI comprises a comprehensive program of training and technical review and assistance for water systems across Colorado to attain a basic level of competency (Level one or Top Down Water Audit) with the AWWA water balance and audit concepts and the AWWA Free Water Audit Software (FWAS). This scope includes, at a minimum, Level 1 validation of the utility prepared water audits and includes multiple "touch points" for reinforced understanding, with the possibility of two tracks: "Early Adopters" (EA) and "New Learners" (NL).

As part of the coordinated statewide water loss control training program, the CWCB convened an advisory group which included representation from water utilities, the Water Research Foundation, and the Colorado environmental community. This advisory group assisted in creating and reviewing the Request for Proposal (RFP) for the consultant team and assisted with the management and outreach of the program.

This document is the final report for the program and documents the results achieved, including training activities and utility staff participation, summary and analysis of water audits completed by the participating utilities. It also presents a roadmap for the CWCB to continue assisting utilities with water loss best practices.

[2]Colorado Water Conservation Board, Statewide Water Supply Initiative 2010 (Denver, 2011).

2.1 Scope

The scope of the CWLI included three main tasks that encompassed the five main stages of the program. Additional information on the stages is found in Section 3 Program Implementation. The three main tasks include:

Task 1: Development of the Colorado Water Loss Initiative, Program Administration, Management, and Communication – This task includes general management of the program, outreach and communication with the participants and the advisory committee, creation and maintenance of the program webpage, and program reporting.

Task 2: Collaborative Training and Technical Assistance Track for Early Adopters – This task includes the training and technical assistance, and advanced validation that was offered to participants considered to be early adopters of the water audit methodology. Early adopters were those utilities that had already gained substantial knowledge and proficiency in conducting AWWA water audits and Level 1 validations prior to the CWLI. Participants in this group were offered other advanced validation opportunities beyond the basic Level 1 validation offered to all participants of the program.

Task 3: Collaborative Training and Technical Assistance Track for New Learners – This task includes the training and technical assistance that was offered to the new learners of the program. It included Level 1 validations for most utilities and several advanced validation options for several participants.

2.2 Methods

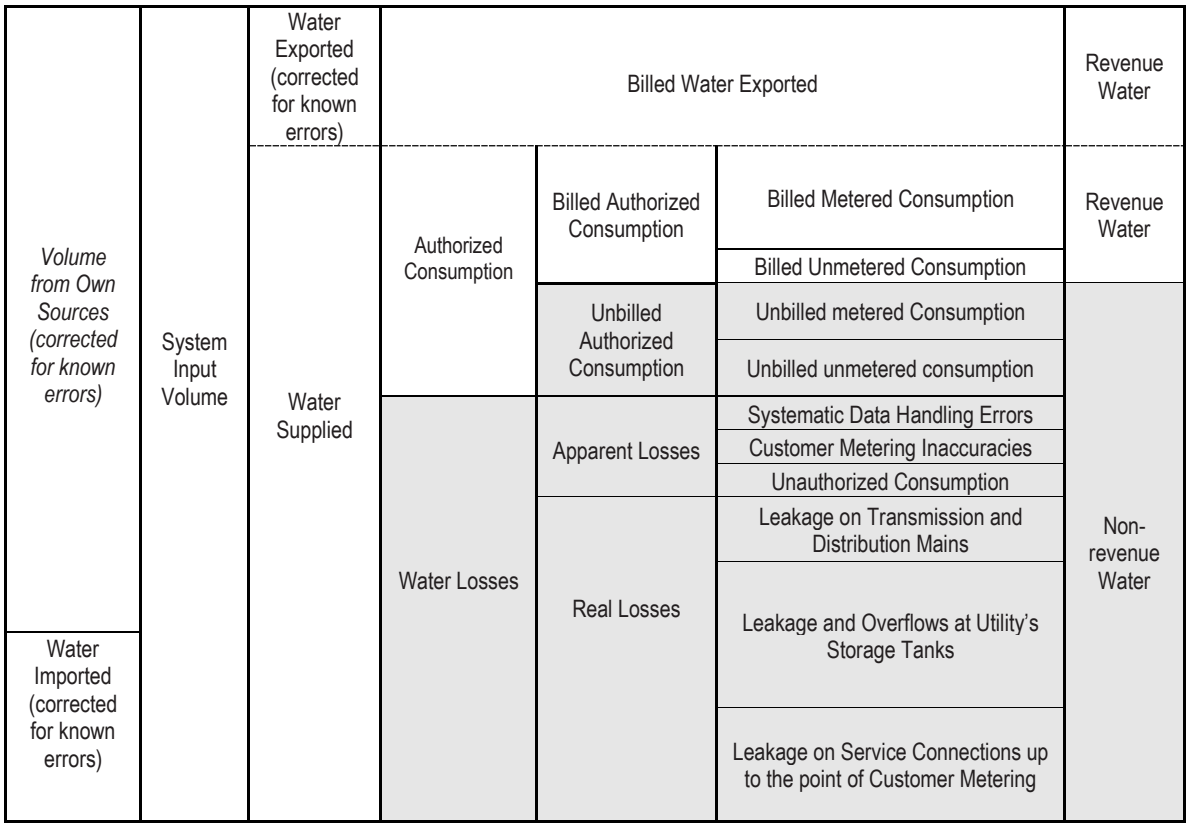
The CWLI taught the best-management practices for water loss control following the methods established in the AWWA Manual of Water Supply Practices M36 Water Audits and Loss Control Programs, including the use of the AWWA Free Water Audit Software (FWAS) and conducting a water audit validation.

M36 Water Audits and Loss Control Programs

The M36 Manual explains the water audit methodology and provides an overview of loss control techniques. The practices described in the M36 Manual provide water utilities effective tools and methods to promote accountability and efficiency in their operations.

The water audit is a technique that involves the review of records and data to trace the flow of water into a distribution system from its source to its final destination – whether that final destination is

consumption by a customer or a leak through a pipe. The water balance summarizes the components of the water audit providing accountability since, in theory, all water into the distribution system should equal all water out of the distribution system. Figure 1 shows the components of the standard water balance.



NOTE: All data in volume for the period of reference, typically one year.

Figure 1: M36 Methodology Water Balance
(Source: M36 Manual, Fourth Edition)

With the water balance calculation, all water that enters the distribution system is either *Authorized Consumption* or *Water Losses*. Therefore, no volume of water is assumed to be unaccounted. *Water Loses* is defined as the difference between *Water Supplied* and *Authorized Consumption*.

Additionally, *Water Losses* are subdivided into *Apparent Losses* and *Real Losses*. *Apparent Losses* are an estimated volume that represents the volume of water that reached a customer (or its intended end-user) but was not accounted and billed for properly. The main subcategories of *Apparent Losses* include

customer metering inaccuracies, unauthorized consumption, and systematic data handling errors. *Real Losses* are calculated with the water balance as the difference between *Water Losses* and *Apparent Losses*; and represents the physical losses of water from the distribution system. Leakage and tank overflows are the main causes of *Real Losses*.

AWWA Free Water Audit Software

The Free Water Audit Software (FWAS) is a spreadsheet-based water audit tool designed to help quantify and track water losses associated with water distribution systems and recognize areas for improved efficiency and cost recovery following the M36 Methodology. Utility specific data is entered into the FWAS to compute the water balance (see Figure 2).

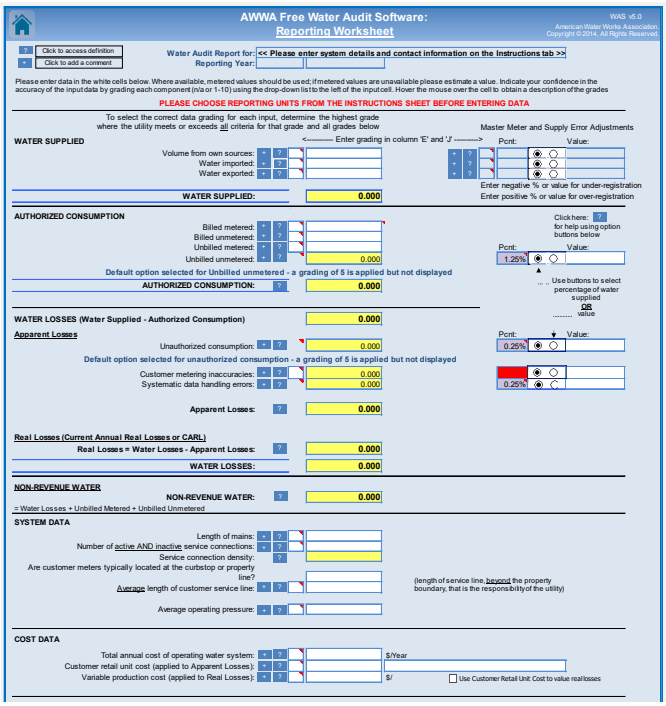


Figure 2: FWAS Reporting Worksheet

(Source: Free Water Audit Software v5)

The software also includes a method to assess the reliability of the data inputs and the results of the water audit through the concepts of Data Validity Grades (DVG) and Data Validity Score (DVS). DVG are a numerical grading (1 to 10) assigned to each data input intended to reflect the reliability of the data. The grades are assigned based on operational utility practices, following the descriptions set in the Grading Matrix – with lower grading indicating less certainty in the data input and higher grading indicating more certainty in the data. A DVS is then calculated for the water audit, based on the individual DVG.

The DVS can be a tool to assist in the development of water loss control measures, as shown in Figure 3: Water Loss Control Planning Guide. Depending on the score, utilities should focus their resources on different areas for water loss control. For example, a utility with a DVS in Level III (51-70) should focus on audit data collection, short and long-term loss control, target setting, and benchmarking. The most common DVS for water utilities in the US with Level 1 validated water audit data fall within Level III.

Water Loss Control Planning Guide					
	Water Audit Data Validity Level / Score				
Functional Focus Area	**Level I** (0-25)	**Level II** (26-50)	**Level III** (51-70)	**Level IV** (71-90)	**Level V** (91-100)
Audit Data Collection	Launch auditing and loss control team; address production metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs. Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)	Performance Benchmarking - ILI is meaningful in comparing real loss standing	Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service
For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.					

Figure 3: Water Loss Control Planning Guide

(Source: Free Water Audit Software v5)

Water Audit Validation

Research on water audit data has concluded that utilities often struggle to accurately and consistently assess the validity of their own data, and a substantial portion of audit submissions have reported suspect data that produce technically impossible water loss scenarios[3]. An inaccurate water audit may result in an incorrect assessment of water loss performance. Without an accurate understanding of the types and quantities of water loss or the practices contributing to these losses, it may not be possible to develop a cost-effective strategy to address the inefficiencies.

Water audit validation is the process of examining water audit inputs to improve the water audit's accuracy and document the uncertainty associated with the used data. The goals of the water audit validation are to:

- Identify and appropriately correct for inexactitudes in water audit data and application of methodology

[3] Water Research Foundation, Utility Water Audit Validation: Principles and Programs Project #4639B (Denver, 2017)

- Evaluate and communicate the uncertainty inherit in water audit data.

There are 3 levels of validation rigor:

- Self-Reported: Water audits have not been independently validated. This process does not confirm the accuracy of data validity grades and may contain subtle and/or egregious data errors.
- Level 1: Water audits are examined for inaccuracies evident in summary data and application of methodology.
- Level 2: Water audits have been corroborated with investigations of raw data and archived reports of instrument accuracy.
- Level 3: Water audits have been bolstered by field tests of instrument accuracy, such as source meter tests (see Section 3.6), and the water audit's estimate of Real Losses has been confirmed through other sources of field data, such as with a Component Analysis of Real Losses.

Water audit validation should be performed by a person proficient in current AWWA M36 and WRF #4639B Methodologies which codify best practices for water audit preparation and validation. In addition, the validator should not be the same person who compiled the water audit. Georgia, California, Indiana, and the province of Quebec require the submission of validated water audits to regulating agencies, recognize the importance of the validation and have created certification programs to certify qualified water audit validators.

Stage 2 and Stage 4 participants of the CWLI underwent a Level 1 validation of their water audits by professionals certified either (or both) in California's or Georgia's validator program. The Early Adopters and several New Learners were also able to undergo Level 2 or Level 3 validation of their data.

3 PROGRAM IMPLEMENTATION

The CWLI kicked-off in August 2018 with an announcement to all target utilities encouraging them to register into the program and to explore the program webpage to learn more about the services being offered for free to the registered participants. The outreach network was also provided with content to spread the word among their networks and include in their digital platforms.

The program was implemented in five main stages over the course of a 24-month period (see Figure 4).

	2018					2019												2020					
Stage	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Stage 0																							
Stage 1																							
Stage 2																							
Stage 3																							
Stage 4																							

Figure 4: General Program Schedule

3.1 Stage 0: Program Development and Outreach

Stage 0 of the CWLI included the tasks related to initial set up of the program, as well as other communication and management tasks throughout the entire program. The main elements of this stage included:

- Program Webpage
- Outreach, Recruitment and Retention
- Program Management and reporting

Program Webpage

The program webpage was launched on August 2018 and together with a formal email announcement from the CWCB marked the start of the recruitment of utilities into the CWLI. The program webpage (www.ColoradoWaterLoss.org – see Figure 5) was used for announcements, initial registration into the program and all stages, general communications, dissemination of program resources, administration of training workshops, scheduling, and as a data and document submission portal for the participants. Throughout the program the webpage was updated with the relevant resources for each stage.

Figure 5. Screenshot of Initial Program Webpage

Outreach Recruitment and Retention

Outreach, recruitment, and retention of participants was a continuous task throughout the whole program duration. Initially, a list of target utilities for the program was put together in collaboration with the CWCB. This target list contained the largest 165 water utilities in Colorado. Eventually, the program was opened to additional smaller utilities throughout the state.

Contacts from the target list were encouraged to visit the program webpage, register into the CWLI Program, and answer a short survey to gauge the utility's experience with the M36 water audit methodology. Results of the survey were used to determine which utilities would be considered Early Adopters. This registration step also provided us with current and relevant contact information to keep participants updated on the program's activities.

Outreach and recruitment were mainly done through email, although the program staff also posted on social media, conducted phone calls, and distributed mailed letters to those utilities that had not responded to emails or phone calls (see Figure 6). In order to increase the email read and response rates, electronic communications were sent both directly from the program's email address and also from CWCB staff. As part of the outreach effort, the program sent periodic emails – at a minimum monthly, but more frequently when critical milestones were approaching – over the program duration. Outreach efforts, either emails or phone calls, were typically increased prior to the commencement of a new stage to encourage registration and participation in that stage.

In addition to advertisement by the program staff and the CWCB, an Outreach Network was established to assist with advertising and recruitment. The Outreach Network consisted of a variety of organizations tied to the water industry throughout the state. Periodically, the program staff distributed content for the Outreach Network to distribute to their subscribers and blurbs for their own digital platforms.

Figure 6: Flyer for CWLI included in Outreach Mailer

3.2 Stage 1: Training Workshop

Stage 1 consisted of a brief webcast (posted March 28, 2019) to introduce participants to the CWLI and to help them prepare for the 1-day in-person workshop, also part of Stage 1. The Stage 1 in-person workshop covered the basics of AWWA M36 water auditing and introduced the concept of water audit validation. This session was offered to as many participants as the utility considered necessary and we encouraged the participation of personnel from supply and operations, metering, customer service, billings, finance, and management. After this work session, each utility was tasked with preparing an AWWA M36 water audit for calendar year 2018. This water audit was required documentation for participation in Stage 2 of the program.

A total of nine Stage 1 workshops were offered throughout the state between April and May 2019. All except one workshop was targeted to the New Learners. Workshop locations included Glenwood Springs, Montrose, Alamosa, Pueblo, and multiple offerings at Denver. A total of 127 participants from 74 water utilities participated in a Stage 1 workshop.

3.3 Stage 2: Water Audit Review and Validation

Stage 2 consisted of teleconference work sessions with individual utilities in which a water auditing expert and the utility's water audit team examined their specific AWWA M36 water audit in a 2-hour interview. Prior to the Stage 2 session, participating utilities submitted their compiled FWAS and supporting documentation through the program webpage. The program staff reviewed the submitted information and analyzed the data to assure the data was complete and applicable to the water audit. The individual Stage 2 meetings were conducted through a shared screen web application. During that meeting, the project team together with the utility conducted a Level 1 validation in accordance with the Water Research Foundation (WRF) Project #4639A Level 1 Water Audit Validation: Guidance Manual.

Participants of Stage 2 were provided a revised version of their water audit and a document summarizing the data sources for the water audit, relevant notes regarding the data collection process, and the rationale for the assignment of the Data Validity Grades for each input. This documentation serves as the basis for the completion of the following year's water audit and identifies areas for potential improvement either in the water audit or water loss management.

Stage 2 sessions, originally planned for a 3 to 4-month period, were offered between May 2019 and January 2020 to allow for more utility participation. A total of 52 Stage 2 sessions were completed. A summary of the Stage 2 water audit results is provided in Section 4.1.

3.4 Stage 3: Training Workshop

Stage 3 included a second round of 1-day in-person training session. During Stage 3, several of the early training sessions offered a Stage 1 "refresher" to allow for new participants to catch-up. However, most of the Stage 3 training sessions were more advanced and were aimed at reinforcing the water audit methodology before more deeply exploring water audit data validation and the connection between water auditing and water loss control.

Eight Stage 3 workshops were offered throughout the state between November 2019 and February 2020. Workshops were offered at Montrose, Glenwood Springs Berthoud, Alamosa, Pueblo, various offerings at Denver, and one Live Stream. A total of 74 participants from 44 utilities participated in the Stage 3 workshops.

3.5 Stage 4: Water Audit Validation

Similar to Stage 2, Stage 4 consisted of a second round of individual teleconference work sessions with each utility to conduct a Level 1 validation. Stage 4 sessions were offered between March and June 2020. For utilities that submit a 1051 report to CWCB by July 1st, this audit would provide them the supporting data required for that report.

However, this stage coincided with the general stay at home orders due to the COVID-19 pandemic. In order to encourage continued participation in the program, the PM team prepared a guidance document to identify potential impacts in logistics and schedule for the remainder of the program as well as a strategy to minimize disruption and maintain program continuity as much as possible.

The impacts due to the pandemic on Stage 4 participants was minimized for those utilities that had already signed up to conduct the session. We were not able to assess if the pandemic prevented some utilities from signing up. Most of the utilities that signed up for a Stage 4 session did complete the session. There was a significant amount of rescheduling, but most were able to participate. The cancellation on this stage was minimal. A total of 29 Stage 4 sessions were completed.

3.6 Advanced Validations

Levels of water audit validation are defined in the Water Research Foundation Report 4639B Utility Water Audit Validation: Principles and Programs. Validation efforts range from Level 1 – which examines summary data for evident errors and correct application of the M36 Methodology - to Level 3 – which includes field tests. All participants of the CWLI were offered, at a minimum, a Level 1 validation of their water audits.

Participants identified as Early Adopters were those utilities that had previous experience with the M36 Methodology and Level 1 validations. These utilities were given the opportunity to participate in more advanced validation (Level 2 or Level 3) of their water audit data. Advanced validations were originally planned for three Early Adopters. However, throughout the program, several New Learners expressed interest in advanced validation. Ultimately, a total of six utilities participated in an advanced validation, these were:

- Aurora Water
- City of Aspen
- City of Grand Junction
- City of Loveland
- Stratmoor Hills Water District
- Town of Telluride

The advanced validation activities included:

- Detailed billing data analysis: Analysis of raw data from the billing system that informs the total volume used to report the authorized consumption in the water audit. With this additional detailed scrutiny, any errors or anomalies in the raw data can be investigated and corrected if necessary.
- Source meter testing: Field test to determine the accuracy of the source meter used to report the supply volume in the water audit. The result of this test is used to understand or improve the estimate of water loss since any error in the reported supply volume will be passed on to the water loss estimated through the water audit.
- Customer meter test strategy development and analysis: Analysis of customer meter accuracy test data and development of strategy to select meters for testing. Accuracy testing of large and small customer meters improve the utility's estimate of apparent losses. An improved estimate of apparent losses will also improve the estimate of real losses.

3.7 Participant Survey

Upon completion of Stage 4, the PM team conducted a post-program survey of all registered system to assess and compile data on the satisfaction of participant experience in the program, program effectiveness, program improvements needed, and follow -up on training and technical assistance needs. There were two surveys distributed to all registered utilities: one survey for utilities that participated in at least one Stage of the program and another survey to those systems that registered with the CWLI but

were not able to participate in any of the states. The two surveys were drafted with feedback from the CWCB and distributed through SurveyMonkey.

CWLI Participant Survey. This survey was distributed to all utilities and respective staff members who registered for the program and attended one or more stages to gauge their experience.

Invitations:

- 217 individuals invited to participate
- 118 opened the invitation
- 90 unopened invitations
- 5 bounced invitations
- 57 responses with 100% completion

Invitation History:

- 06/25/20: Initial invitation sent
- 06/30/20: reminder
- 07/01/20: reminder
- 07/07/20: reminder
- 07/09/20: reminder
- 07/10/20: final reminder sent

CWLI Non-Participant Survey. This survey was distributed to utilities and respective staff members who were included on all outreach and recruitment communications and either never registered for the program or registered, but did not participate in any of the four stages. The purpose of this survey was to gauge the challenges that some utilities faced with participating in the technical assistance program.

Invitations:

- 270 individuals invited to participate
- 109 opened the invitation
- 132 unopened invitations
- 28 bounced invitations
- 41 responses
    - 75% completion
    - 25% partial

Invitation History:

- 06/30/20: Initial invitation sent
- 07/01/20: reminder
- 07/07/20: reminder
- 07/09/20: reminder
- 07/10/20: final reminder sent

4 PROGRAM RESULTS

The CWLI was developed by the CWCB to offer water providers technical support and training in comprehensive water loss management. This 24-month program trained over 150 water utility professionals across Colorado on best management practices for water loss control based on the AWWA M36 Methodology.

A total of 120 entities registered for the CWLI (Figure 7), with 95% classified as New Learners, further demonstrating the need for water loss training. Initially, the program was targeted for the largest water providers in the state, 76% of all Covered Entities registered for the program, but there was an unexpected level of interest and participation from the smaller utilities – 46% of registered utilities supply less than 2,000 acre feet per year. It should be noted that registration into the program does not mean the utility participated in any stage, utilities had to register for each individual stage, but it showed the level of interest in this topic. After registering into the program, some registered utilities were not able to participate in any of the stages, mostly due to limitations in time and staffing resources (see Section 4.3).

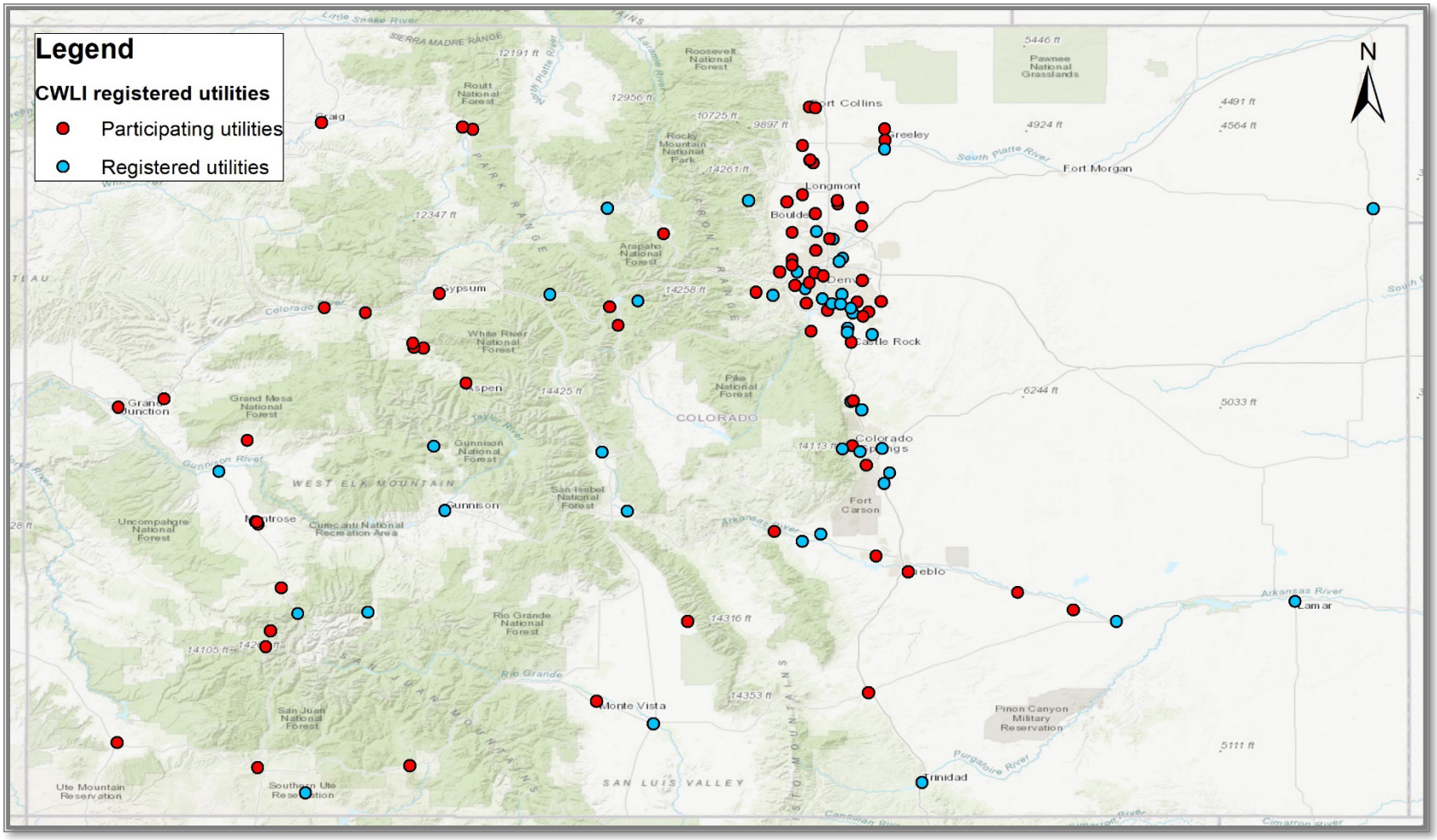


Figure 7: Map of Registered Utilities

4.1 Water Audit and Validation Results

Stage 2 and Stage 4 of the CWLI entailed a detailed review of each utility's water audit following Level 1 validation guidance set forth in WRF Project 4639. The purpose of the review is to confirm the correct application of the water audit methodology and make any necessary corrections. Fifty-two utilities and twenty nine utilities participated in a Stage 2 and Stage 4 water audit review, respectively (see Table 1). Over 70% of participants in both stages were Covered Entities. All Stage 4 participants participated in a Stage 2 session.

Table 1. Stage 2 and Stage 4 Participants

	Number of utilities	
Utility size (AF)	Stage 2	Stage 4
Covered Entities (>2,000)	36	23
1,500-1,999	1	1
1,000-1,499	3	1
500-999	5	2
<500	5	1
Other	3	1
Total	53	29

Prior to the review, the participating utility would submit a completed water audit and during the review, discuss with a water loss expert the data used to compile the water audit and operational practices behind the data. During this discussion, the submitted water audit may have been modified, as necessary.

An analysis of the original and modified water audits was performed. For Stage 2, almost 50% of the original water audits were not complete. This improved for Stage 4, where about 30% of water audits were not complete. The review process allowed the utilities to discuss their questions or specific circumstances to be able to complete the water audit.

The customer meter inaccuracies value was the most commonly corrected value during the review and in general increased. This value increased for more than 30% of utilities as a result of the validation. Several utilities left this value blank prior to the review. The result of increasing customer meter inaccuracies is an increase in apparent loss estimate which subsequently results in a decrease in the real loss estimate.

Several water utilities did not provide one or more of the of the cost data values of the water audit. The validation process allowed the participant to discuss the appropriate data that should be included for that portion of the audit. These cost values assist the utilities to assign a value to water losses to calculate

financial performance indicators and assist with the budget setting task to determine cost effective water loss management strategies.

The performance and frequency of several maintenance and operational practices are evaluated and scored according to the Grading Matrix. Therefore, looking at the scores can provide a general assessment of these practices at Stage 2 and 4 participants. Some of the most relevant practices are summarized here:

- Only 15% of participants perform annual calibration or accuracy testing of their production meters on an annual basis. Calibration and testing of production meters is the only way to know if the production volumes reported are accurate. All estimates related to water losses depend on the production volumes, therefore inaccuracies in this value will be carried through to inaccuracies in the estimation of water losses.
- 4 participants rely solely on imports for their water supply. Imported water typically has a higher cost, therefore these utilities usually have a stronger economic incentive to keep their water loss levels low.
- 19 participants export water to other entities but only 3 of these entities report performing annual calibration or testing of their export meters. Export meters may be a significant revenue generator for utilities, so assuring accurate readings directly impacts the utilities revenues.
- Half of the participants perform some form of proactive customer meter testing. This practice allows utilities to understand potential errors in their billed volumes due to meter inaccuracies.
- 12% of participants have some level of unmetered billed customers. Consumption estimates for these customers may be imprecise potentially impacting the estimate of water losses.
- Almost 70% of participants provided their estimate of unbilled unmetered authorized uses. This is a value that the FWAS provides a default value to use since it is not commonly tracked by utilities.
- Slightly more than 20% of the participants report having a well-covered pressure monitoring system throughout their distribution system. This tool allows utilities to gain a better understanding of pressure fluctuations in their system which is an important factor in leakage.

4.2 Performance indicators

The water audits provide several performance indicators related to reliability of the water loss estimates and water loss performance. These performance indicators are a tool to help utilities determine next steps towards improving water loss management and to track the progress with water loss management.

Data Validity Score

The water audit includes a method to assess the reliability of the data inputs and the results of the water audit through the concepts of Data Validity Grades (DVG) and Data Validity Score (DVS). DVG are a numerical grading (1 to 10) assigned to each data input intended to reflect the reliability of the data. A DVS is then calculated for the water audit, based on the individual DVG.

A key task of the Level 1 validation is to discuss the data collection and management practices within the utility to assess the correct DVG for each input. A utility might self-report a DVG for a particular data input, but the discussion with a qualified validator is the most reliable way to determine the appropriate DVG for the input. As a result, DVG and consequently, the total DVS for the water audits typically change after a Level 1 validation. As it is common during validations, most of the participants had a reduction in their DVS. Figure 8 and Figure 9 below show the DVS for all Stage 2 and Stage 4 participants (respectively) before and after the validation.

For Stage 4, the mean DVS before validation was 62 compared to 58 after validation. Close to 25% of participants had drops in DVS of 10 points or more. Two participants had post-validation DVS of 50 or less. Following the loss control planning guidance of the AWWA water audit software, any utility with a DVS less than 50 should focus on achieving more reliable data for their water audits instead of setting long term loss control measures.

A comparison of the DVG of validated water audits after Stage 2 and Stage 4 shows that the range of values is similar. Improvement in DVG usually requires changes in operational or maintenance practices and may sometimes require infrastructure improvements.

Table 2. Data Validity Score

Quartiles	Stage 2	Stage 4
Q1	52	54
Mean (Q2)	**55**	**58**
Q3	60	64
Number of utilities	52	29

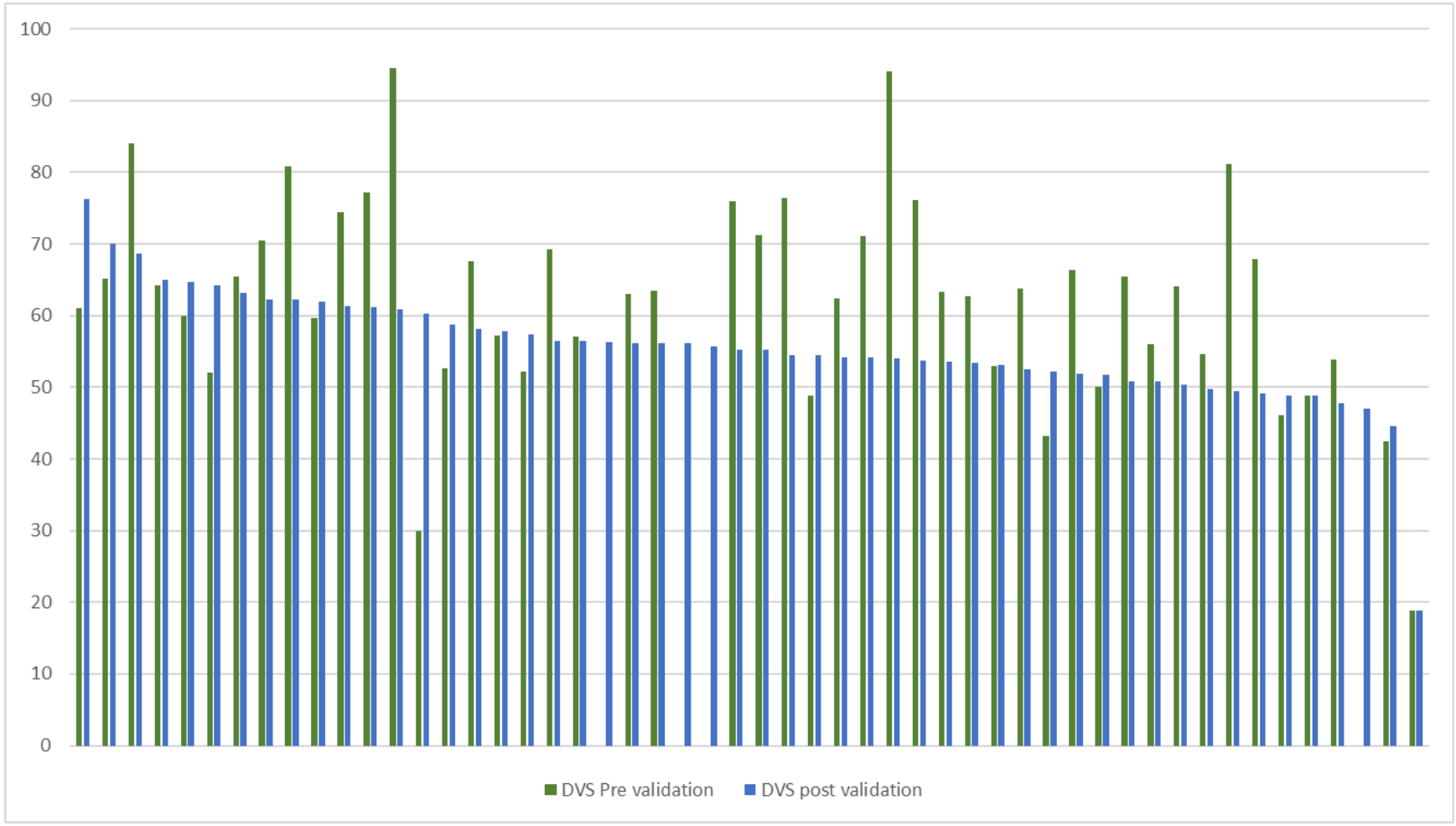


Figure 8. Stage 2 Data Validity Scores Pre and Post Validation

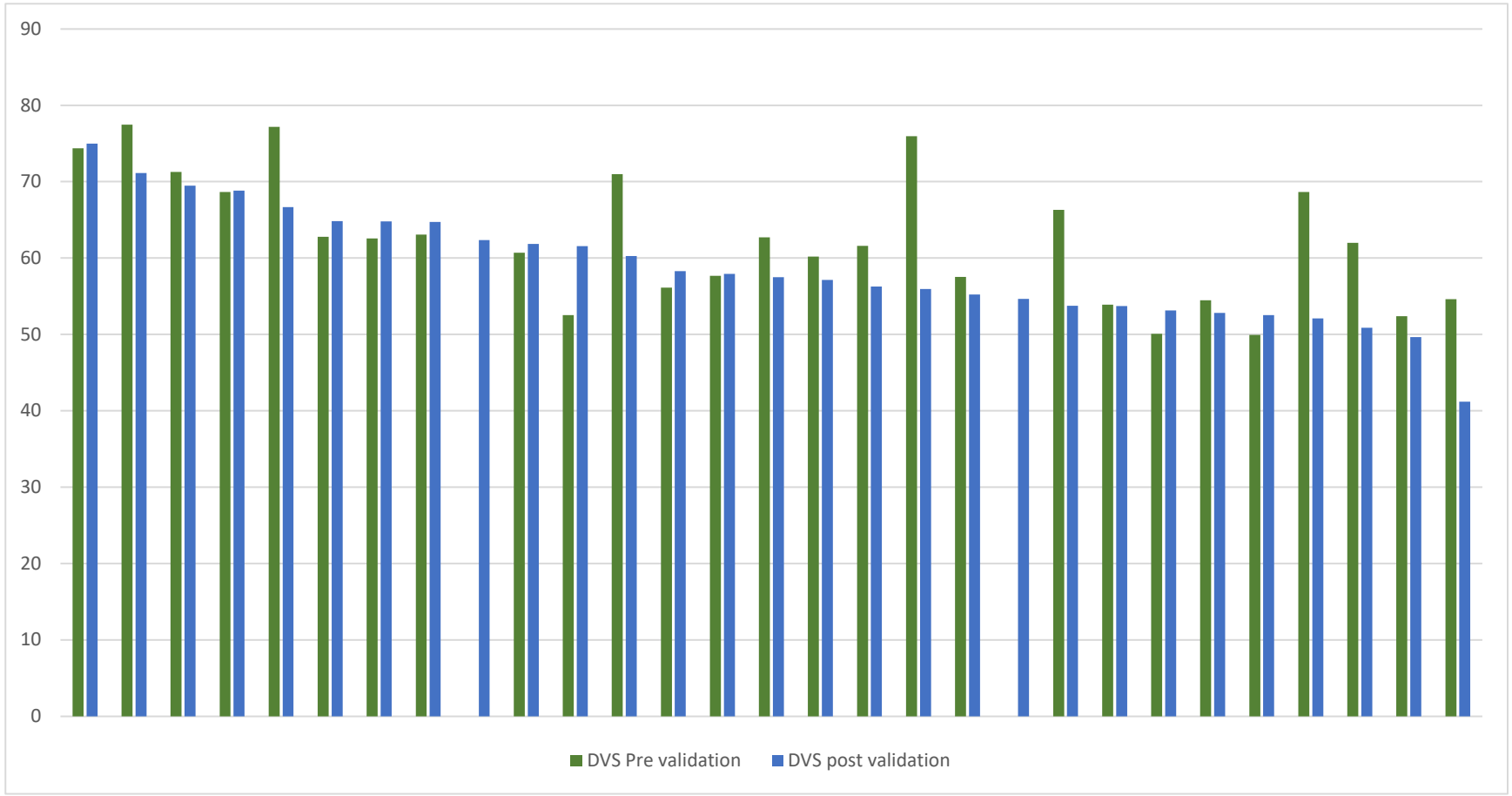


Figure 9. Stage 4 Data Validity Scores Pre and Post Validation

Water Losses

Water losses include water that is lost to leakage (Real Losses) or meter error and other unauthorized uses (Apparent Losses). Apparent losses are usually estimated with results of customer meter accuracy tests and a combination of other assumptions. However, if customer meter tests results are not available – then looking at the total Water Loss volume might be more informative than the segregated values.

The total annual volume of these indicators may vary greatly depending on utility size and other operational conditions. One way to be able to compare and benchmark performance with these indicators is to normalize the value by day and number of service connections or miles of main. In cases were the utility has a low density of connections the normalization of real loses is volume of losses per mile of main per day. Table 3 and Table 4 show the unit water loss performance indicators after validation for Stage 2 and Stage 4 respectively. Changes before and post validation values respond primarily to a higher allocation to apparent losses components and other system data corrections.

These performance indicators did not vary significantly between both stages. This is to be expected if general practices remain and if no proactive activities to reduce losses are undertaken.

Table 3. Stage 2 Volume Key Performance indicator post validation

Quartile	Unit Total Water Losses (gallons /connection/day	Unit Apparent losses (gallons /connection/ day)	Unit Real losses (gallons /connection/day	Unit Real Losses (gallons /miles/day
Q1	19.6	5.7	11.3	724.5
Q2	**32.9**	**7.9**	**28.3**	**1,079.2**
Q3	73.1	12.3	65.1	1,624.2
Utilities considered	41	52	41	11

Table 4. Stage 4 Volume Key Performance indicator post validation

Quartile	Unit Total Water Losses (gallons /connection/day	Unit Apparent losses (gallons /connection/ day)	Unit Real losses (gallons /connection/day	Unit Real Losses (gallons /miles/day
Q1	21.1	5.4	13.3	631.9
Q2	**30.4**	**7.5**	**23.9**	**1,042.8**
Q3	53.6	10.2	43.9	2,412.6
Utilities considered	24	29	24	5

Infrastructure Leakage Index

Every system is expected to experience a certain level of leakage that is unavoidable. The leakage levels above that unavoidable volume is what is considered recoverable, also considering other economic factors. The Infrastructure Leakage Index (ILI) is an indicator that measures the utility's real loss performance compared to that unavoidable level estimated for each utility based on that utility's individual characteristics. It is the ratio of current level of leakage over the unavoidable level of leakage. An ILI of 1 means the utility is operating at leakage levels considered the minimum technically feasible. ILIs lower than one – may be observed at well performing utilities – but typically indicate there might be other data issues that should be corrected.

The mean ILI for the participating utilities in Stage 2 was 1.01 and in Stage 4 was 0.95. Table 5 shows the distribution of ILI for Stage 2 and Stage 4 participants. Approximately 24% of utilities in both stages have ILI values higher than 2.0. On the other hand, 30% of Stage 2 participants and 24% of Stage 4 participants had ILI of less than 0.5. Incorrect data or other system information may be resulting in these low ILI values. It should also be noted that the ILI cannot be computed for very small systems due to limits on the assumptions of the unavoidable leakage.

Table 5. Infrastructure Leakage Index

Quartile	Stage 2	Stage 4
Q1	0.44	0.59
Q2	**1.01**	**0.95**
Q3	1.91	1.69
Utilities considered	42	25

New Performance Indicators

The Water Loss Control Committee of the AWWA (responsible for developing and updating the M36 Manual and the FWAS), has recently reviewed existing and new water loss performance indicators due to the growing concern that percentage indicators are not useful for tracking and benchmarking water loss performance. Based on this review, the AWWA concluded that they would no longer support NRW percentage indicators and would instead support adding two new KPIs—the loss cost rate and normalized water losses indicator—to AWWA's existing array of KPIs.

- Loss cost rate (LCR) indicator is expressed in value ($) per service connection per year, with one expression for apparent losses and one for real losses. These KPIs measure the negative impact of losses on a utility's finances. It has public relations value by expressing annualized loss costs (operating cost and revenue) on a per-connection basis.
- Normalized Water Losses (NWL) is expressed in volume per connection per day. NWL is a high-level KPI that represents the combined volume of apparent and real losses occurring in the water utility on a per-connection basis. The NWL metric allows utilities to track their year-to-year losses and provides additional insight during years when either portion of NWL (apparent or real normalized loss rate) varies notably from the prior year.

Although these indicators are not included in the current version of the FWAS, they will be included in the next version of the FWAS. These performance indicators have been calculated for the CWLI Stage 2 and Stage 4 participants. The NWL indicator were included in Table 3 and Table 4. The LCR are included in the table below.

Table 6. Loss Cost Rate Indicators

	Stage 2		Stage 4	
	Apparent Loss Cost Rate	Real Loss Cost Rate	Apparent Loss Cost Rate	Real Loss Cost Rate
Quartile	($/connection/ year	($/connection/ year)	($/connection/ year	($/connection/ year
Q1	7.54	0	6.83	1.36
Q2	**11.10**	**4.37**	**13.01**	**7.54**
Q3	21.19	11.05	25.06	16.95
Utilities considered	51	41	29	23

As it is typically the case, although real loss might be larger volumetrically, when considering the economic value of losses, apparent losses have a higher value. However, before establishing strategies for loss recovery, utilities should have a thorough understanding of the economic benefit of these strategies through additional field testing of the established assumptions.

4.3 Post-Program Survey

Two surveys were developed and approved by the CWCB. Those survey descriptions and participation stats are provided below.

CWLI Participant Survey

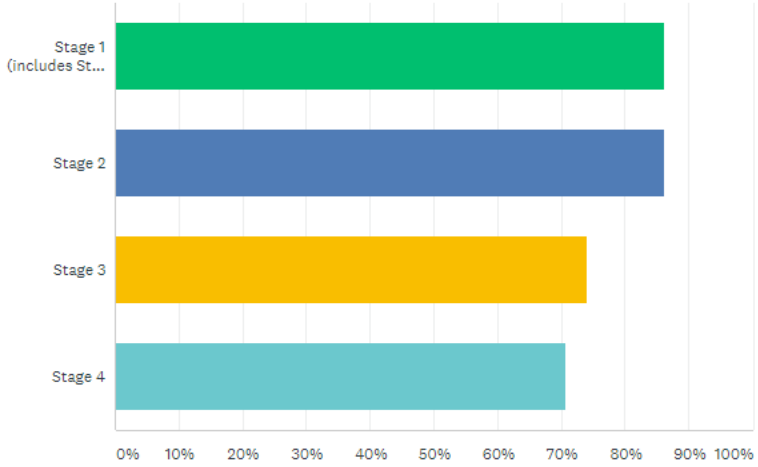
This survey was distributed to all utilities and respective staff members who registered for the program and attended one or more stages to gauge their experience. The survey responses demonstrate that most participants agree that:

- The amount of time spent in the program is reasonable and manageable,
- The extent of data requested was adequate and not burdensome,
- Most feel they have capacity to continue annual auditing,
- Most plan to complete their 2020 audit,
- The majority felt their successors would be unprepared to complete the audit if they (CWLI attendees) were to leave; and
- Most (as applicable) found this helpful to 1051 reporting.

Each survey question and summary responses are provided below:

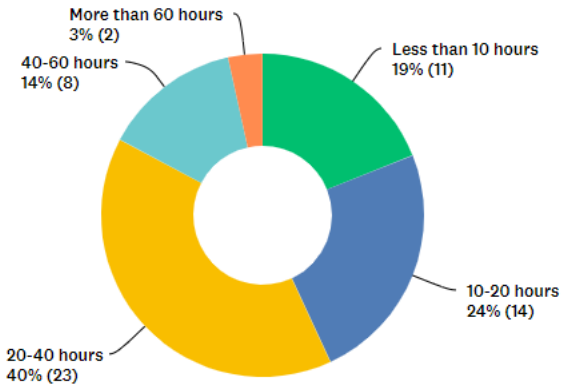
Please indicate your participation in the Colorado Water Loss Initiative (Choose all that apply)

Answered: 58 Skipped: 0



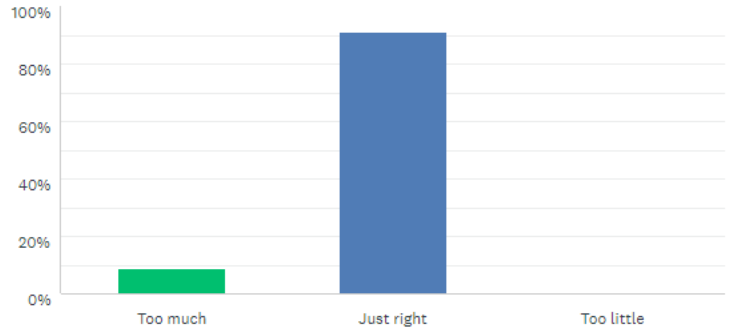
How much interactive time (example: internal meetings, data collection, follow up time with internal teams, etc.) did you invest in the overall Colorado Water Loss Initiative to meet the goals and outcomes of the program (Reminder: Stages 1 and 3 were approximately 6.5 hrs each and Stages 2 and 4 approximately 2 hrs each)?

Answered: 58 Skipped: 0



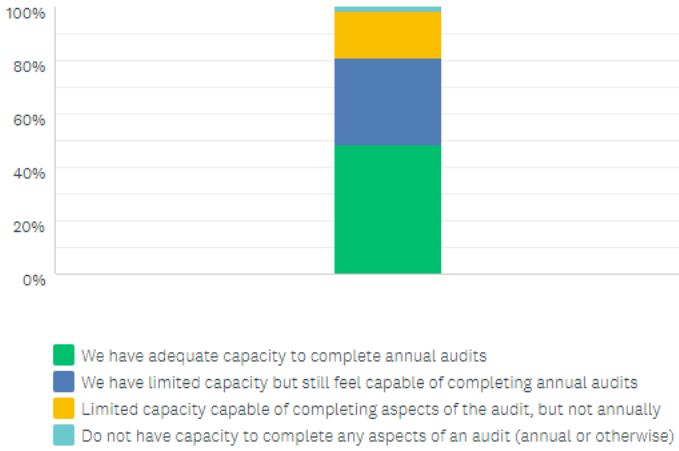
Thinking back to the supporting data you were asked to gather, please select the best answer that describes the extent of data items requested:

Answered: 58 Skipped: 0



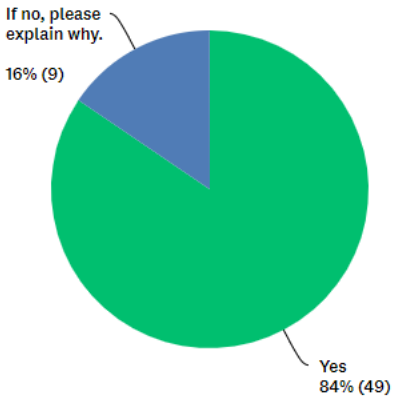
After completing the Colorado Water Loss Initiative, what is the level of capacity (e.g. staff, time, expertise, other resources) in your utility to complete water audits using the AWWA M-36 methodology?

Answered: 58 Skipped: 0



Do you plan to complete your 2020 water audit, and if not, what factors (if any) may limit the ability or likelihood of your utility to carry out future water audits using the AWWA M-36 methodology?

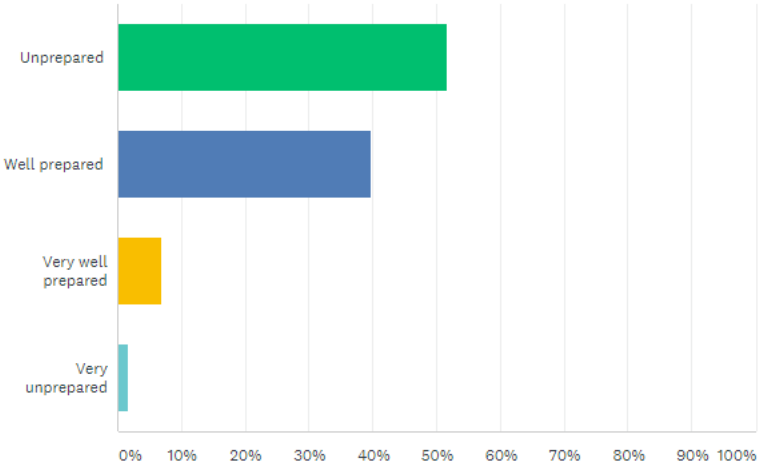
Answered: 58 Skipped: 0



- Limited staff time.
- Not enough time this year.
- It will depend on staff and time with the 2 other programs I handle.
- I will not personally. However, someone from the organization will.
- Having the time set aside as a team to compile all of the proper data. Luckily CWLI representatives were able to get us on the right track when we were not providing the correct data.
- We have many other projects going on and know where we are in need of improvement. We will work on these aspects before re-auditing.
- Our district does not yet have the data required by CWLI. We track water loss internally, however.
- Need more review.

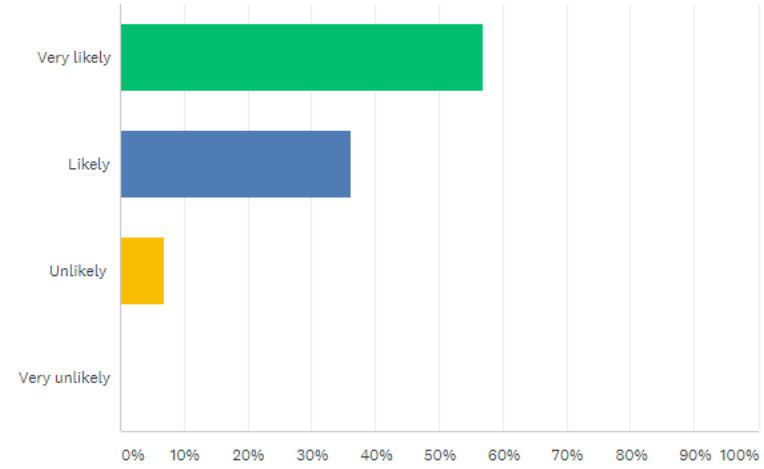
If you or your team members who participated in the Colorado Water Loss Initiative were to leave your position, how prepared would your successors, other team members and your utility be to continue with the auditing efforts that began as part of this program?

Answered: 58 Skipped: 0



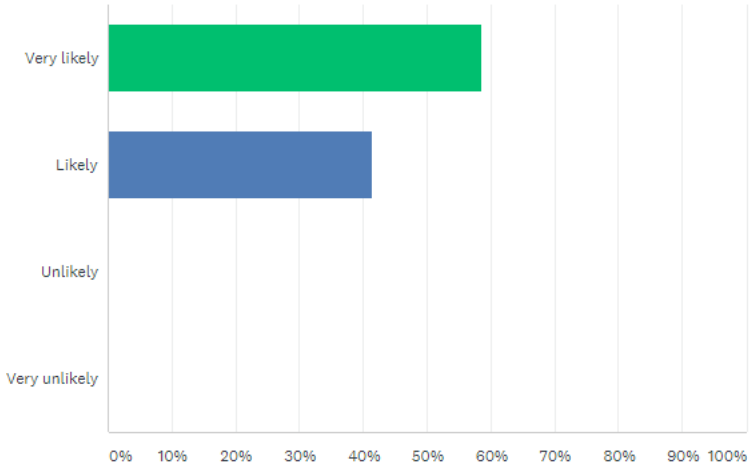
Based on your experience with the Colorado Water Loss Initiative, how likely are you to continue conducting annual water loss audits on your system using the AWWA M-36 methodology?

Answered: 58 Skipped: 0



Based on your experience with the Colorado Water Loss Initiative, how likely would you be to recommend a similar program to another utility who is looking to effectively manage water loss in their system.

Answered: 58 Skipped: 0



In what ways has the Colorado Water Loss Initiative helped you in your job? Please select all that apply.

Answered: 58 Skipped: 0

ANSWER CHOICES		RESPONSES	
Equipped me with a more reliable method for water auditing		71%	41
Increased my confidence in effectively discussing water auditing and water loss control issues with colleagues, municipal officials, and/or state regulators		71%	41
Started a dialogue about practices and policies related to water loss data		67%	39
Provided valuable information and learning that will stay with me for years to come		59%	34
Increased the priority and importance of water auditing in my role		36%	21
Started program for improving water loss management		34%	20
Accelerated implementation of water loss corrective actions		26%	15
Other (please specify)	Responses	10%	6

> The Water Loss Initiative provided a tool for us to get a more accurate and clear picture of our system and to gain more confidence in what we were doing to minimize the preventable water loss in our system.

> Helped me to understand the complexity of our distribution system and the way we manage data

> I participated in the first outline of how to fill out the reporting document for understanding. This is not part of my role. We do have a representative from the utility that participates with all workshops and reporting.

- Ignited a passion for targeting water loss and making conscious efforts to improve our numbers.
- Great feedback on how to improve which meters to test, how to apply meter test results and how frequently to test our 1.5" meters and larger based on the revenue impact if under-registering vs. the cost of testing/replacing.
- Bring discussion regarding production flow meter verifications, where our organizations has many

Based on your experience in the Colorado Water Loss Initiative, in which of the following areas did you discover opportunities for improving your system's water loss control practices? (Choose all that apply)

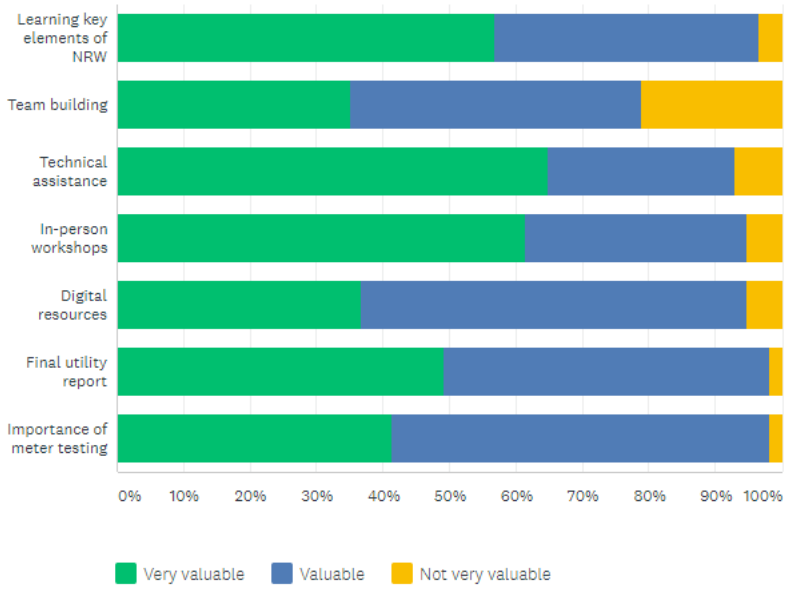
Answered: 46 Skipped: 12

ANSWER CHOICES	RESPONSES	
Improved validation practices	80%	37
Supply meter verification and/or calibration	74%	34
Improved data collection	70%	32
Identified how to appropriately value apparent and real losses in the water audit	54%	25
Customer meter testing activities	43%	20
Established a benchmark to track revenue impact of water losses	41%	19
Showed the value and impact of supply-side conservation to conserve water and revenue	30%	14
Identified opportunities to improve revenue through customer meter accuracy	26%	12
Considering how water loss may inform your capital infrastructure plans (pipe replacement, tank replacement, plant expansion, etc)	26%	12
Leak detection activities	17%	8
Pressure management activities	17%	8
Identified specific instances where water was not being billed correctly	17%	8

- Valuable to share with board members for future improvements.

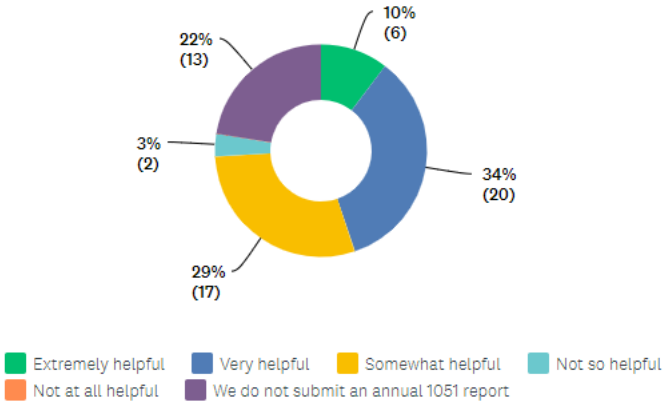
Please rate the value of the following components of the Colorado Water Loss Initiative

Answered: 58 Skipped: 0



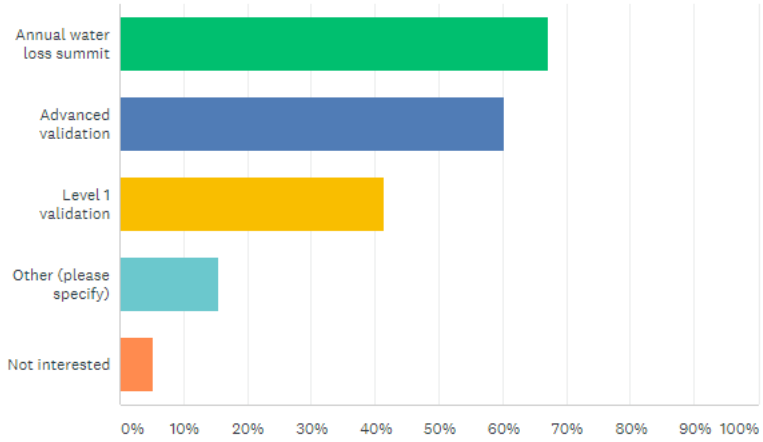
If you submit an annual 1051 report, has this program helped you prepare?

Answered: 58 Skipped: 0



If offered in the future, which follow on training and technical assistance activities would you be interested in participating in (choose all that apply):

Answered: 58 Skipped: 0



What suggestions do you have for ways we could improve this program in the future?

Answered: 58 Skipped: 0

- This was a great program. I won't lie, it was a little overwhelming at first, but you do a great job at explaining the audit.
- Great job, we will continue this program into the future!
- maybe more support for smaller utilities
- none - the program was really helpful and well done by implementation team
- It was a great program I enjoyed a lot. It fostered a lot of conversation about how to do our jobs better and track our water supply and demands in a more careful way. The program explained both the importance and the methodology in a clear way that helped everyone from our line level distribution staff, to our water treatment operators, our billing specialists and the Assistant Director to understand the process, data and outcomes that are possible. Thank you - I wish COVID hadn't disrupted our ability to finish this year's Stage 4.
- We were very pleased with what we gained from the program.
- I really liked everything about the program. The instructors were clear and provided a lot on insight during the in-person classes.
- The program was very good. More live class sessions would be nice. I found the in-person class sessions very valuable. Gave us a chance to hear voices on issues other districts have and how they deal with them. THANK YOU VERY MUCH FOR THIS OPPORTUNITY!

- I know that in order for me to continue I may need some assistance.
- This program was incredibly helpful - the folks from Cavanaugh were extremely knowledgeable and were able to diplomatically lead the sessions with diverse teammates. I don't have many suggestions on the program side, but some on the auditing software itself. I think future programs that helped turn the audit results into intervention strategies would be very beneficial.
- Thank you. Very good program
- I feel my feedback is not warranted as I did not fully participate. I went to one course during the onset to gain understanding for the document requirements and validation of data. I did not participate fully. However, our Conservation and Sustainability program manager did fully participate and will continue to do so.
- This isn't an improvement, but I suspect this kind of program my need to continue in a more streamlined fashion to keep many utilities on the right track.
- Provide overview of statewide information such as: water audit results, expectations (ie what grade is good), and information that would help with determining and implementing next steps.
- Refreshers for water districts that keep the CWLI on the radar and not pushed aside until the meetings.
- Show how to do electronic calibrations
- The validation this year seemed a bit arbitrary. There were items that we felt we met the criteria listed, but the validator interpreted the same words differently, which is kind of frustrating to try to figure out our scores.
- I think the program was incredibly educational and supporting of utilities that participated. The depth of knowledge of the consultants was very comprehensive and allowed for intricate conversations around the different elements of the water audit.
- Difficult to say since I was unable to attend some of the program due to work commitments/projects.
- More time for question and answers and discussions at the end of the in-person stages. Felt like it was always rushed and there always seemed to be good questions and discussion.
- The entire process was extremely well designed. The instructors were knowledgeable and well prepared.
- This was a great program with knowledgeable personnel. Since we aren't required to perform, we may not do it again. But this is a reflection of our small staff and limited time, not a reflection of the program.
- Suggestions on how to implement a program development
- Reduce the timing between in person meetings (Covid may have impacted this)

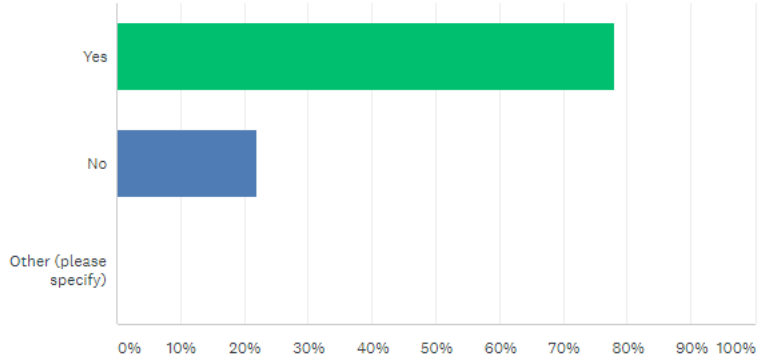
- Provide summary document of why this is important to a busy organization with a pretty good result, "why prioritize the (perceived) effort? We're doing ok."- may become required by regulation, grant funding requirement, identify revenue losses, etc.
- I don't think doing meter testing at different age intervals every year is needed when a utility has years of test records. It is a waste of resources in my opinion.
- Keep doing it; team up utilities with commonalities on the "buddy system" to help keep program going. Plus, we all would like a Certificate of Participation, even if we finished last.
- Establish local teams for water loss programs
- I think your approach is perfect. No need to change anything.
- I thought it was great. No other suggestions at this time.
- Excellent job to all staff.
- Not so much this program but the software itself needs to be modified and updated.
- continue to educate the water community. I imagine this will someday be a requirement (or something similar) of the State as water availability becomes tighter. Even if it doesn't, I see minimizing water loss as both an fiduciary responsibility and moral obligation for systems, owners, and operators. Thank you
- It is a very good program that seems geared to the larger suppliers. I do not have anything to add to your program.
- Better differentiation of scoring on the spreadsheet. Way too much grey area in numbers and language. Way to open to different interpretations.
- Clean up the 1-10 criteria
- An ongoing resource/contact for utility employees when odd questions come up about the audit.
- Additional Analysis of interpreting the data and specific examples of how to implement the data to improve water loss and make the most cost-effective choices.

CWLI Non-Participant Survey

This survey was distributed to utilities and respective staff members who were included on all outreach and recruitment communications and either never registered for the program or registered, but did not participate in any of the four stages. The purpose of this survey was to gauge the challenges that some utilities faced with participating in the technical assistance program.

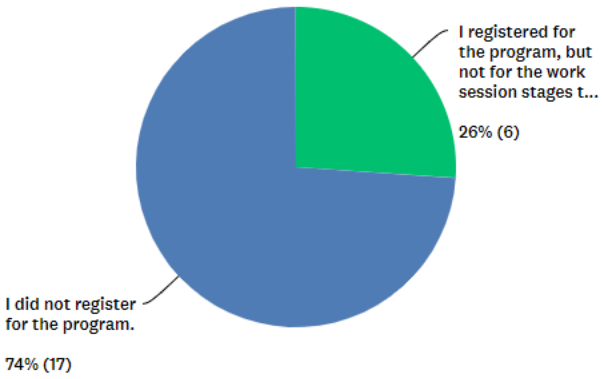
Did you receive outreach communications (email, phone, conference, webinar, word of mouth) regarding the opportunity to participate in the Colorado Water Loss Initiative?

Answered: 41 Skipped: 0



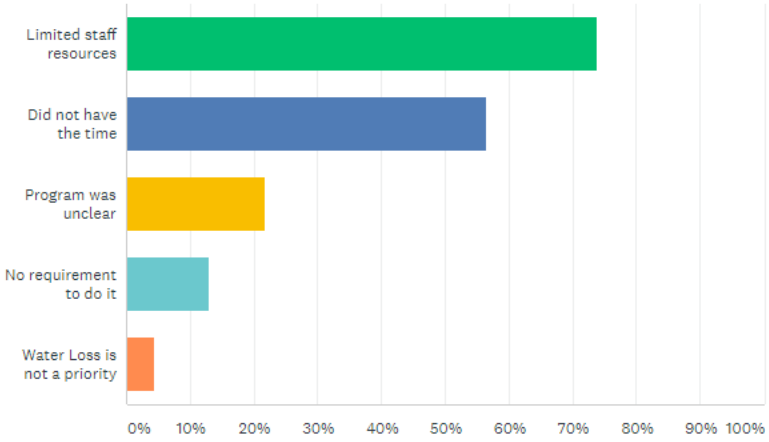
Please select the following that best describes your reaction to Colorado Water Loss Initiative opportunity:

Answered: 23 Skipped: 18



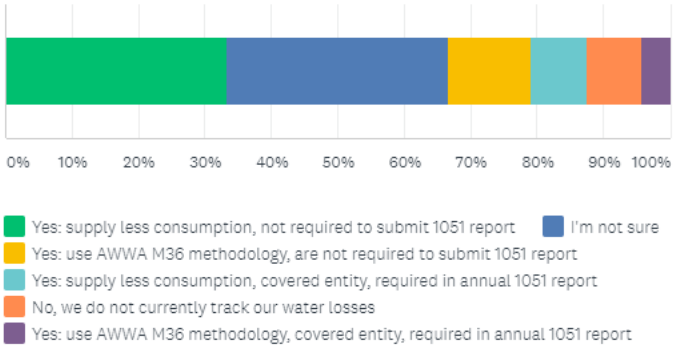
Please select the factors that went into deciding to not participate in the program (Choose all that apply):

Answered: 23 Skipped: 18



Do you currently track/report your water losses?

Answered: 24 Skipped: 17



Lessons Learned from Phase I

With every water loss program conducted comes the opportunity to learn from and improve upon the next program. The Colorado Water Loss Initiative brings a unique perspective to this opportunity as the largest voluntary water loss program in the United States to date.

Perhaps the biggest challenge in a voluntary environment is achieving a high registration rate and low attrition rate throughout the program. The post-program survey results show the top reasons for utilities deciding not to take part in the program were limited staff resources (74%) and not enough time (57%). In the future, communicating a clearer level of effort and time commitments may have resulted in more participants. A small number of utilities registered for the program, but no other subsequent stages. These utilities were continually followed up with during the program, encouraging them to participate, regardless of the current stage. Any feedback received from these utilities cited the same reasons of limited staff and time as an obstacle to participating; however, utilities that did participate in the program mid-stream responded in the survey that the time and effort was reasonable and not burdensome.

The program was designed to usher participating utilities through a multiple stages described in Section 3 – Program Implementation. This structure was carried out as planned, but with notable challenges in participation numbers lower than expected. There was interest in the program and that can be seen from the diversity of utilities that registered in both size and geography. A higher participation from larger utilities and less participation from the smaller ones was anticipated. Actual participation indicated more participation from smaller ones than expected. In the future, more workshop dates and locations closer participating utilities may be considered.

One online session was offered in Stage 3. This session was a hybrid in-person workshop that was offered as a live-stream learning opportunity. In the future, additional online opportunities should be developed to maximize participation, but a hybrid approach may not be the best fit. A stand-alone online opportunity may be developed for a different duration, but using the same materials.

Clear and effective communication is critical to participation. While Outreach Channels were identified during the Outreach and Recruitment phase, these channels could and should be used more for more frequent communication at a broader reach.

All these lessons learned can be applied to subsequent phases of the Colorado Water Loss Initiative.

5 RECOMMENDATIONS

Based on the program feedback, continued water loss technical assistance is something most utilities are interested in. It is recommended for CWCB to offer a Phase II technical assistance program, to be made available for all Colorado water providers who are ready, willing, and able.

Phase II will build on the foundations established in Phase I, offering advanced assistance to Phase I participants and more foundation building for those who could not participate in Phase I. Structured as a 24-30 month program, Phase II is recommended to include multiple "touch points" for establishing principles & practice and reinforced understanding, culminating in direct technical assistance for data validation and water loss interventions based on the water provider's needs.

The AWWA methodology is considered the industry standard for water loss control and management. The goal for the Colorado Water Loss Control Initiative is for participating water utilities to learn how to apply the methodology to their water system and to achieve a complete and transparent (as measured by Level 1 validated Data Validity Scores) water loss audit. This phase goes beyond audits and assists the water providers in targeting interventions. Water loss was identified in the Water Plan technical update as a significant factor in the M&I gap and, as outlined in Colorado's Water Plan, the CWCB will:

Support water management activities for all water providers: *The CWCB will continue to provide funding, technical support, and training workshops to assist water providers in improving the management of their water systems. This will include the use of techniques such as water budgets, smart-metering, comprehensive water loss management programs, savings tracking and estimating tools, and improved data collection on customer water uses. For example, in the next year, the CWCB will fund several regional training workshops about using the American Water Works Association M36 Methodology for Water Audits and Loss Control.*

As part of the coordinated statewide water loss control training program Phase II, the CWCB would reconvene a steering committee which should include (but not be limited to) representation from water utility personnel, AWWA, and the Water Research Foundation (WRF). This steering committee will assist in creating and reviewing the RFP for the project and assist with the management of the training process as it moves forward. The steering committee for Phase I has been indispensable with recruitment and review and the members will be asked to continue into Phase II. Phase II should also focus additional efforts on smaller, more rural water providers, in order to bring more of those providers up to speed on this methodology.

While Phase II will likely include two training tracks with different starting points, the training tracks should follow similar approaches. The basic process is recommended to include the following:

Task 1: Development of Colorado Water Loss Initiative Phase II, Program Administration, Management and Communications

This task will be responsible for management and administration throughout the lifecycle of the program. Task 1 will also include communications; both internally with the project management team and CWCB staff, as well as outward facing in effort for outreach, recruitment, and retention in Phase II.

Process management

Consultant, CWCB staff and advisory committee will provide on-going management of the Initiative, including the development of a program management plan and associated schedule, marketing and outreach plan, regular team coordination calls for program management and documentation, internal progress tracking, internal task assignments and accountability, program management plan amendments, and course corrections as warranted.

Deliverables:

- Program management plan
- Marketing and outreach plan. This will include maintaining existing CWLI website
- Program schedule
- Approximately one call per month

Assessment

CWCB staff and Consultant will assess the level of M36 Water Loss Control methodology implementation in Colorado.

Deliverables:

- Examine current 1051 web portal database, Phase I participation, other sources (possibly Basin Implementation Plans) to identify 101 & 201-301 participants
- Analysis of results to determine tracks of training program

Outreach, Recruitment, and Retention

Consultant, with CWCB staff and advisory committee assistance, will manage water system recruitment and retention for the Initiative. The objective of recruitment and retention will be the registration of approximately 100 target water systems and as complete as possible participation in the Initiative. This will include development of a recruitment and retention plan, development of all communication materials in support of the recruitment plan, conducting regular coordination calls with the CWCB and the advisory committee to manage execution of the outreach plan, and conducting direct outreach to approximately 100 target water systems. A major effort will be made to recruit smaller, more rural water providers, in order to bring more of those providers up to speed on this methodology.

Deliverables:

- Recruitment plan
- Recruitment and retention communications materials
- Monthly recruitment and retention statistics
- Monthly recruitment coordination calls with key Initiative stakeholders

Post-Program Survey

Consultant will conduct a post-program survey to each of the participant systems, to assess and compile data on the satisfaction of participant experience in the program, program effectiveness, program improvements needed, and follow -up on training and technical assistance needs.

Deliverables:

- Survey tool
- Conduct and complete survey
- Summary of survey results

Final Report

Consultant will develop a final report for the Initiative, to include program genesis and overview, profile of program stakeholders and participants, program design and execution methodology, and a summary of program technical materials. The report will also include the marketing and outreach plan and materials referenced in Task 1.1, the program recruitment and retention plan and materials referenced in Task 1.2, and a summary of survey results from Task 1.3 and program outcomes including water audit analyses from Tasks 2 and 3.

Deliverables:

- Final report

Task 2: Water Audit 101 Workshops and Level 1 Validation

This task will serve as a refresher for Phase 1 participants and any new employees they have. It will also introduce all necessary content for utilities that did not participate in Phase 1, including Level 1 validation. Additionally, it will introduce participants to the most updated AWWA software (v.6).

Water Audit and Validation Webcast and 101 Workshops

The Technical Assistance (TA) for "101" and refresher for Phase I participants will begin with a three-hour webcast or live webinar providing introductions to the program, the team and the program objectives. The webcast will discuss the water audit methodology and terminology, data needs for compiling a water audit, water audit data validation steps and data validity scoring principles. The webcast will also establish homework assignments for the utilities for gathering necessary data for the first round of workshops. The webcast will be recorded and will be available online for participants to view at a later stage if the webinar could not be attended.

Consultant, with CWCB staff assistance, will provide webcast and workshop administration including venue selection and coordination, registration setup and management, materials printing, food arrangements, and Contact Hours (CH) coordination.

Consultant will provide all associated technical materials development including curriculum development, webinar content, workshop presentation content, practical exercises content, and participant workbook content.

Consultant will conduct up to six (6) in-person workshops across Colorado or the same equivalent in a virtual setting. Consultant will provide training sessions in the following formats as directed by the State of Colorado; in-person trainings, if allowed by the State of Colorado, and/or by virtual platform. These workshops will teach foundational water audit concepts and tools, provide a review of the AWWA Free Water Audit Software and its functions, and review data validity scoring. These workshops are geared towards providing the new utilities with a basic understanding of the water audit process and the AWWA Free Water Audit Software. Common mistakes in water audit preparation will be discussed with the workshop participants and tips and guidance will be provided for the preparation of their own water audits. After the webinar and workshop, each participant is expected to attempt a completion of their own water audit.

Deliverables:

- One (1) webcast/webinar
- Webcast/webinar and workshop materials
- Webcast/webinar and workshop administration
- Six (6) workshops

Audit Basics Technical Review for "101" Participants

Following the participant preparation and submission of their water audits to the Consultant, Consultant will conduct an hour long individual call with each participating utility to provide a one on one Question and Answer session, where Consultant evaluates and confirms the participant's understanding and proficiency in preparing their water audit, and provides feedback to questions/problems/issues that they encountered during their water audit preparation.

Consultant will provide all associated technical materials including technical review documentation.

Deliverables:

- Documentation of technical review meeting for each participant

Data Validation Level 1 for "101" Participants

Consultant will make contact with each "101" participant to achieve the following:

- Confirm scheduling for an online meeting
- Discuss preparation for the online meeting, including:
    - Background discussion on the participant's structure and involvement in the water audit preparation.
    - Identification of the optimal team members to have present for the online meeting.
    - Baseline supporting data and records to provide in advance of meeting.

Consultant will conduct a 60-90 minute online meeting for each participating utility to achieve the following:

- Follow up on recommendations provided during the validation workshop.
- Review and gauge successful completion of the data gathering and population of their water audit.
- Review grades, data validity scores, identify obvious errors and anomalies in the metrics through interview with the audit preparation team. The methodology used during those interviews/online meetings will be built on an input-by-input approach, where every audit data point has a checklist of data grading questions that integrate seamlessly with the AWWA Free Water Audit Software Data Grading Matrix. The methodology will cover a range of analysis from initial screening of common input errors to deeper levels of revealing hidden errors to accurate assignment of input data grades. Most importantly, the methodology will be the same for each participating utility.
- Identify data quality issues and data grading amendments.
- Provide recommendations for improved data validation, data collection and validity scoring.
- Consultant will provide all associated technical materials including validation review documentation.

Deliverables:

- Documentation of validation review meeting for each participant

Analysis of Final Water Audit Submissions and Report

Consultant will review the final water audit submissions and prepare a summary report to:

- Summarize the work performed and results achieved related to:
    - Training: Including providing summary statistics on utility participation in each phase of the project
    - Learning progression: By reviewing and analyzing the final water audit submissions of the "101" group and comparing to where the "101" group began the process in terms of knowledge base and awareness of the M36 methodology
    - Analyze the validated water audits submitted and summarize at several scales such as by the entire group or by river basin or by utility size
    - Identify where the greatest need/opportunity for real and apparent loss control was observed and suggest some recommended next steps utilities could implement to reduce losses as described in AWWA's M36.

Deliverables:

- Summary documentation of the analysis to be included in Task 1.6 final report

Task 3: 201 and 301 Workshops and Outreach

This task will focus on more advanced techniques and concepts beyond what was covered in Phase I. This task would include mostly participants from Phase I. These include input meter testing, customer meter testing, billing data analysis, real loss component analysis, and economic level of leakage.

Consultant will create and execute a three-hour webinar for "201 & 301" participants providing introductions to the program, the team and the program objectives. The webinar will discuss M36 Water Audit Manual concepts as well as other advanced techniques. The webinar will also establish homework assignments for the utilities for gathering necessary data for the first round of workshops. The webinar will be recorded and shall be available online for participants to view at a later stage if the webinar could not be attended.

Consultant with assistance from CWCB staff will provide webcast and workshop administration including venue selection and coordination, registration setup and management, materials printing, food arrangements, and Contact Hours (CH) coordination.

Consultant will provide all associated technical materials development, including curriculum development, webinar content, workshop presentation content, practical exercises content, and participant workbook content.

Consultant will conduct a minimum of ten (10) workshops across Colorado or the same equivalent in a virtual setting. Consultant will provide training sessions in the following formats as directed by the State of Colorado; in-person trainings, if allowed by the State of Colorado, and/or by virtual platform. The number of workshops and locations will be determined by how many 201 and 301 participants exist. These full day workshops will cover a detailed review of input meter testing, customer meter testing,

billing data analysis, real loss component analysis, and economic level of leakage among other advanced techniques.

Deliverables:

- One (1) webcast
- Webcast and workshop materials
- Webcast and workshop administration
- Ten (10) workshops

Task 4: Ranking and Prioritization for Direct Technical Assistance

This task will identify and prioritize the best hands-on technical assistance area for each participating utility. This prioritization is based on audit results, data validity grades and validation documentation.

- Review of all Level 1 validated audits
- Sort all participants by technical assistance
- Level 1 audits and participation in 201 and 301 workshops will be used to sort participants into TA categories
- Create short report for each participant on what areas they should focus on

Deliverables:

- Summary of findings from each review level 1 validated audit
- Summary of participants and their technical assistance needs
- Documentation of follow up review meeting for each participant

Task 5: Direct Technical Assistance

This task carries out the technical assistance identified in Task 4. Depending on the water provider, there could be technical assistance in the areas of input meter testing, billing data analysis and prorating, customer meter test design and result analysis, real loss component analysis, and leak detection.

- Contact identified participants, approximately 50.
- Meet with TA participants either in person or virtually approximately 2-3 times
- Consultant will produce a report for each participant summarizing topics covered and recommendations that go beyond what was discussed

Deliverables:

- Documentation of TA meeting for each participant.
- Summary report of TA discussions and recommended next steps

Water loss control has been identified by the drinking water industry as a major topic of interest. With multiple states providing statewide water loss control training and having identified the AWWA M36 methodology in Colorado's Water Plan, the time is right to continue statewide training on the industry standard for water loss control and move onto prioritized interventions.