Washington Water Audit Pilot

Results and Recommendations

Final Report

April 2018

Washington State Department of Health

WSO

CAVANAUGH
Stewardship Through Innovation

Contents

Acknowledgments

This program was funded by the Washington State Department of Health Office of Drinking Water using State Revolving Funds disbursed by the Environmental Protection Agency.

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Executive Summary

Background

For more than ten years, the Washington Department of Health Office of Drinking Water has required that drinking water suppliers report distribution system leakage (DSL) annually and maintain DSL at less than 10% of the volume of supply (tracked as a three-year average). DSL is calculated as total water supplied minus authorized consumption, divided by total water supplied.

However, over the past ten years, drinking water system best practices have evolved and eclipsed Washington's DSL reporting requirements. This is acknowledged by the state of Washington's recent downgrading on the Alliance for Water Efficiency's 2017 State Scorecard for Efficiency and Conservation.[1] Washington now ranks eighth, a four-spot drop, behind states like California and Georgia that require industry best-practice methods for water loss monitoring. The American Water Works Association (AWWA) water audit methodology is now the industry standard for leakage tracking, and performance indicators that capture leakage in relative (percent) terms are now discouraged.

To evaluate the introduction and applicability of AWWA water audit methodology and performance indicators in Washington in a supported environment, the Washington Department of Health offered a pilot AWWA water audit program to ten utilities from late 2017 to early 2018.

Program Goals

The Washington pilot AWWA water audit program aimed to support four Office of Drinking Water goals:

1. Improved technical, financial, and managerial capacity
2. Water distribution infrastructure maintenance
3. Water conservation
4. Compliance with the 10% DSL requirement

Program Overview

The pilot program was designed to provide ten participating utilities with a foundational understanding of AWWA water audit and water loss control methodology. To accomplish this, participants were taught to use the AWWA Free Water Audit Software, engage with the level 1 water audit validation process, and improve data management practices and water loss control activities based on their specific audit results. The pilot program was divided into four phases to develop fluency in water audit terminology and support level 1 validation:

1. **Foundations** – utility recruitment, preparatory webinar
2. **Exposure, experience, and investigation** – guided data collection, water audit compilation, review
3. **Refinement and reinforcement** – workshop and level 1 validation
4. **Reflection and planning** – water audit results and next steps, reporting and recommendations

[1] http://www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=10296

Program Results

Utility water audit results after level 1 validation are displayed in Table 1 below. The DSL calculations use water audit data after validation to compare the results of each methodology when the same sources of data are used for each.

Table 1: Level 1 validated water audit results

Utility	**Apparent Losses** *gal / conn / day*	**Real Losses** *gal / conn / day*	**Total Water Loss Value** *annual*	**Data Validity Score**	**DSL Percent** *WAC method, with water audit data*	**Real Loss Percent** *real loss / water supplied*
City of Arlington	5.6	24.5	$126,210	55	12%	13%
City of Camas	6.6	66.7	$186,806	50	15%	13%
Clark Public Utilities	3.8	25.2	$179,416	56	9%	8%
Fruitland Mutual Water	7.9	35.4	$37,878	64	12%	10%
Liberty Lake Sewer and Water District	43.5	106.3	$56,711	49	16%	12%
Nob Hill Water	10.6	67.2	$176,259	60	20%	17%
Stevens Public Utility District	24.5	19.6	$22,099	55	4%	2%
Tacoma Water	6.7	16.8	$772,456	70	5%	4%
City of Walla Walla	34.7	141.4	$383,954	58	23%	18%
Yakima Water	6.0	92.6	$396,766	58	20%	19%
Average	**15.0**	**59.5**	**$177,838***	**57**	**14%**	**11%**

** Denotes a median value.*

The total volume of water loss experienced by pilot participants in a twelve-month period is $2.34 million. Some volume (and therefore value) of water loss is anticipated for all utilities. However, it is likely that all pilot participants could decrease a portion of their water loss volumes and corresponding financial loss. Informed by level 1 validated water audit results, the economic balance of intervention for each agency could be analyzed to determine the most appropriate and cost-effective water loss control strategies that would benefit each agency.

All ten utilities estimated less leakage when using the AWWA methodology, compared to the Washington DSL calculation. This is because the AWWA methodology distinguishes real loss from apparent loss, whereas the Washington DSL calculation typically captures both apparent loss and real loss as leakage. After validation through the Washington pilot program, the average calculated DSL was 14%, and the average real loss estimate was 11%.

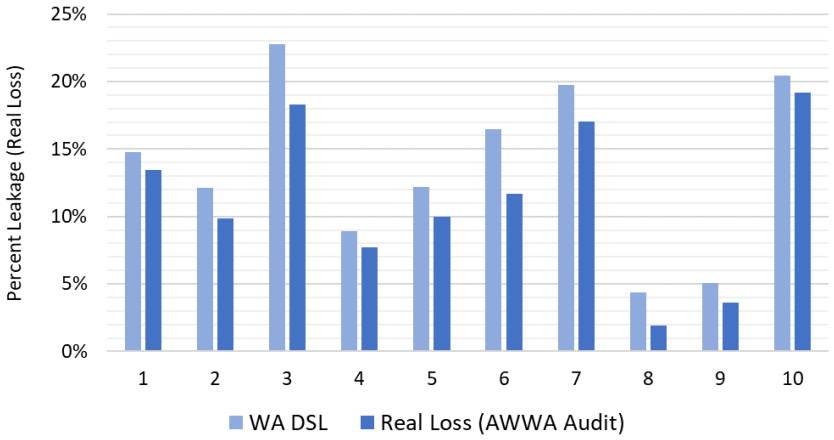


Figure 1: Washington DSL calculation (after validation) compared to AWWA-methodology real loss estimate (after validation)

Apparent loss (water that is delivered to a customer but not tracked due to customer meter inaccuracy, data handling issues, or theft) is distinct from real loss (leakage) in its location, its value, and the most appropriate remediation strategies. Without quantifying apparent loss and real loss distinctly, both forms of loss are difficult to effectively manage. As a result, the AWWA-methodology estimate of real loss provides more functional insight into leakage than the Washington DSL calculation. **And with increased knowledge of apparent losses, water utilities will have a better understanding of their real losses and more strategically address the public health consequences of failing infrastructure.**

Though self-reported AWWA water audits provide more actionable insight into leakage than the DSL calculation, **the accuracy of self-reported water audits can be improved through independent validation**. Figure 2 below displays the change in results produced by validation. In most cases, validation increased the estimate of apparent loss, often by allocating some apparent loss to customer metering inaccuracy rather than assuming perfect customer meter accuracy.

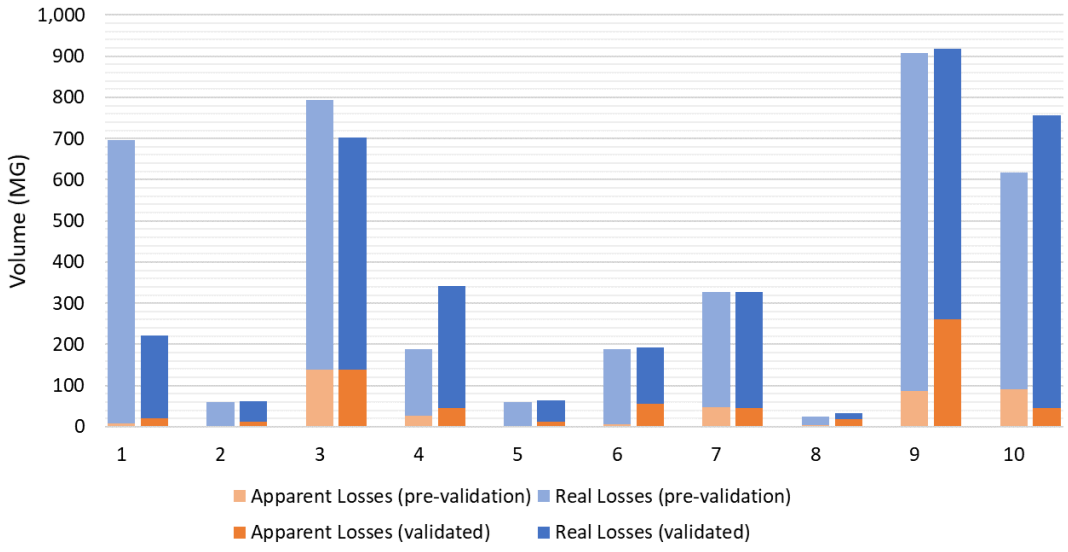


Figure 2: Self-reported water audit results compared to validated water audit results

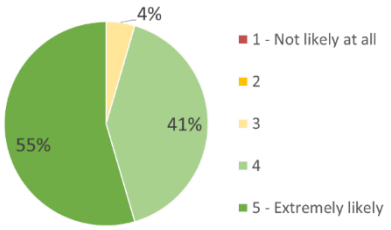
Four agencies saw the total volume of water loss change noticeably through validation. These changes are attributable to the acknowledgement of source meter inaccuracy diagnosed through source meter accuracy testing (thereby changing the volume of supply) or more accurate application of general methodology to calculate supply and sales volumes.

Feedback

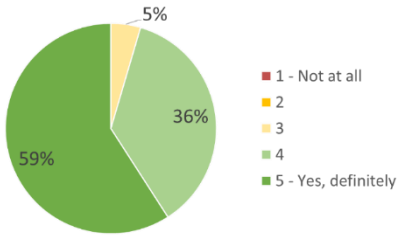
A survey was distributed at the end of the program to evaluate participants' experience and desire for additional support. Survey feedback was overwhelmingly positive, and most responses indicated that the AWWA methodology provides more insight into leakage management and data sources and should therefore be taught to utilities across the state.

Participants commented that "the water auditing process is **much more informative** than the traditional water use efficiency reporting." Two questions in particular addressed agencies' receptivity to the methodology and training program.

*How likely would you be to **recommend a similar program** to another utility looking for training on water auditing and the AWWA M36 methodology?*



*Was your training experience **worth the time and expense** with respect to learning the key elements of non-revenue water management and interdepartmental team building?*



Recommendations

The pilot program was successful and well-received by participating utilities. Most participants indicated that they prefer the AWWA methodology over the DSL calculation for leakage tracking and management. To extend program benefits to other drinking water utilities in Washington, the program team recommends four actions:

1. **Adopt AWWA methodology for leakage estimation:** adopt the AWWA water audit methodology for all drinking water utility annual reporting (as captured in the AWWA Free Water Audit Software) in order to distinguish between apparent loss and real loss. To estimate the DSL percentage using AWWA methodology, divide the volume of real loss by the volume of water supplied.
2. **Provide AWWA methodology training and technical assistance to all utilities:** offer webinars and workshops on AWWA water audit methodology and the AWWA Free Water Audit Software to all drinking water utilities. Workshops and webinars could be modeled after those provided during the Washington pilot program. Workshops and webinars are most effective when they are offered at no cost to the utility and as a progressive curriculum taught in more than one session to reinforce lessons learned. Additionally, water audit educational opportunities can support efforts to increase technical, managerial, and financial capacity.
3. **Validate all water audits prior to submission:** require that all AWWA water audits are level 1 validated independently to improve accuracy and methodological standardization. In the first years of validation, consistency of validation is particularly important. The Department of Health should consider providing verified validators to utilities through a centralized validation program.
4. **Migrate from leakage percent to leakage volume:** for the first few years of AWWA water audit reporting, collect both percent leakage and real loss volume (total volume as well as the real loss volume normalized to service connections and normalized to length of mains) to evaluate performance. Once multiple years of validated water loss data has been submitted, work with stakeholders and experts to establish a leakage standard in volumetric terms instead of leakage percent. Additional guidance from the AWWA water loss control committee on effective volumetric real loss performance indicators is expected to be published in the next few years and could be incorporated into Washington's volumetric standards.

To accomplish recommendations 1, 3, and 4, Washington could consider amending its administrative rules (WAC 246-290) to incorporate AWWA methodology, including level 1 validation.

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Introduction

For more than ten years, the Washington Department of Health Office of Drinking Water has required that drinking water suppliers report distribution system leakage (DSL) annually and maintain DSL at less than 10% of the volume of supply (tracked as a three-year average). DSL is calculated as total water supplied minus authorized consumption, divided by total water supplied:

$$DSL = [(TP - AC)/(TP)] \times 100$$

Where:

DSL = percent of distribution system leakage (%)
TP = total water produced and purchased
AC = authorized consumption

Additional information about the history of drinking water DSL regulation is provided in Appendix A on page 49.

However, over the past ten years, drinking water system best practices have evolved and eclipsed Washington's DSL reporting requirements. This is acknowledged by the state of Washington's recent downgrading on the Alliance for Water Efficiency's 2017 State Scorecard for Efficiency and Conservation. Washington now ranks eighth, a four-spot drop, behind states like California and Georgia that require industry best-practice methods for water loss monitoring. The American Water Works Association (AWWA) water audit methodology is now the industry standard for leakage tracking, and performance indicators that capture leakage in relative (percent) terms are now discouraged.

As best-practice methodology for water loss assessment has become more rigorous, states across the country have adopted more precise methods of water loss assessment and reporting. The most ambitious regulations to date have been established in California (2015), Georgia (2010), and Hawaii (2016), where an annual AWWA water audit must be compiled and level 1 validated by a third party prior to submission (see Figure 3). Additional information about water audit validation is provided in Appendix B on page 51.

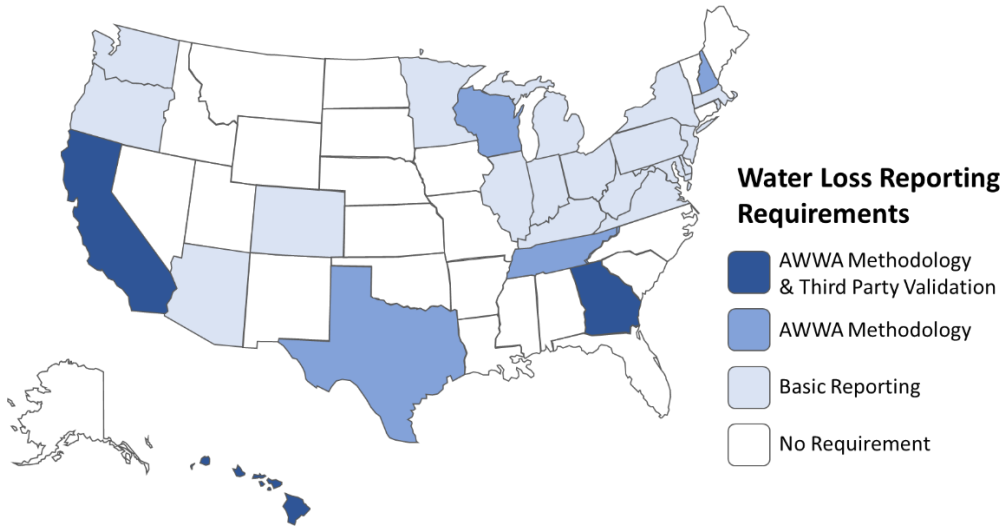


Figure 3: Water loss reporting requirements in the United States

Though Washington's DSL policies are no longer considered best practice, Washington utilities are accustomed to evaluating and reporting DSL using the percent-leakage methodology stipulated by the Washington Administrative Code. To evaluate the introduction and applicability of AWWA water audit methodology and performance indicators in a supported environment, the Washington Department of Health offered a pilot AWWA water audit program to ten utilities from late 2017 to early 2018.

Program Goals

The Washington pilot AWWA water audit program aimed to support four Office of Drinking Water goals:

1. Improved technical, financial, and managerial capacity
2. Water distribution infrastructure maintenance
3. Water conservation
4. Compliance with the 10% DSL requirement

To achieve these goals, the Washington pilot program used the AWWA water audit methodology, as captured in the AWWA Free Water Audit Software.

AWWA Water Audit Methodology

AWWA water audit methodology accounts for all water introduced into a distribution system and then withdrawn and used for authorized purposes in order to estimate water loss. Water loss is then divided into apparent loss and real loss and assigned a financial value. This top-down process of estimating apparent loss and real loss is illustrated with a water balance (see Figure 4) in which each column represents the same volume.

Apparent loss, water that reaches a customer but is not tracked or billed due to customer meter inaccuracy, theft, or data handling errors, is typically valued at retail rate.

Real loss, also referred to as leakage, is typically valued at variable production cost, though other costs of leakage can also be considered.

<table>
<tr><td rowspan="9">Water from Own Sources</td><td rowspan="10">System Input Volume</td><td colspan="4">Water Exported</td><td rowspan="3">Revenue Water</td></tr>
<tr><td rowspan="9">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="7">Nonrevenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Loss</td><td rowspan="3">Apparent Loss</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Loss</td><td>Background Leakage</td></tr>
<tr><td>Unreported Leakage</td></tr>
<tr><td>Reported Leakage</td></tr>
<tr><td>Water Imported</td></tr>
</table>

Figure 4: AWWA water balance, water losses highlighted

Based on the equation used to calculate DSL provided on page 9, Washington's DSL methodology calculates leakage as:

$$Leakage_{WA} = TP - AC$$

Notably, the Washington Administrative Code states that "any water that cannot be accounted for shall be considered distribution system leakage."

Conversely, using AWWA methodology, leakage is calculated as:

$$Leakage_{AWWA} = Real\ Loss = TP - AC - Apparent\ Loss$$

AWWA water audit methodology differs from Washington's DSL calculation by separating water loss into two categories: apparent loss and real loss (leakage). In AWWA methodology, the difference between water supplied and authorized consumption is the total volume of water loss, which contains both real and apparent loss. Viewed through this lens, Washington's DSL calculation conflates DSL by not incorporating an assessment of apparent loss in evaluations of distribution system performance. The AWWA water audit provides a standardized methodology to account for apparent losses, so it does not need to be considered distribution system leakage.

Program Overview

The pilot program was designed to provide participating utilities with a foundational understanding of AWWA water audit and water loss control methodology. To accomplish this, participants were taught to use the AWWA Free Water Audit Software, engage with the level 1 water audit validation process, and improve data management practices and water loss control activities based on their specific audit results.

The pilot program was divided into four phases:

1. Foundations
2. Exposure, experience, and investigation
3. Refinement and reinforcement
4. Reflection and planning

Each phase reinforced fluency in water audit terminology and supported the level 1 validation of each utility's water audit. Tasks and detailed descriptions of each phase are shown in Figure 5 and described below.

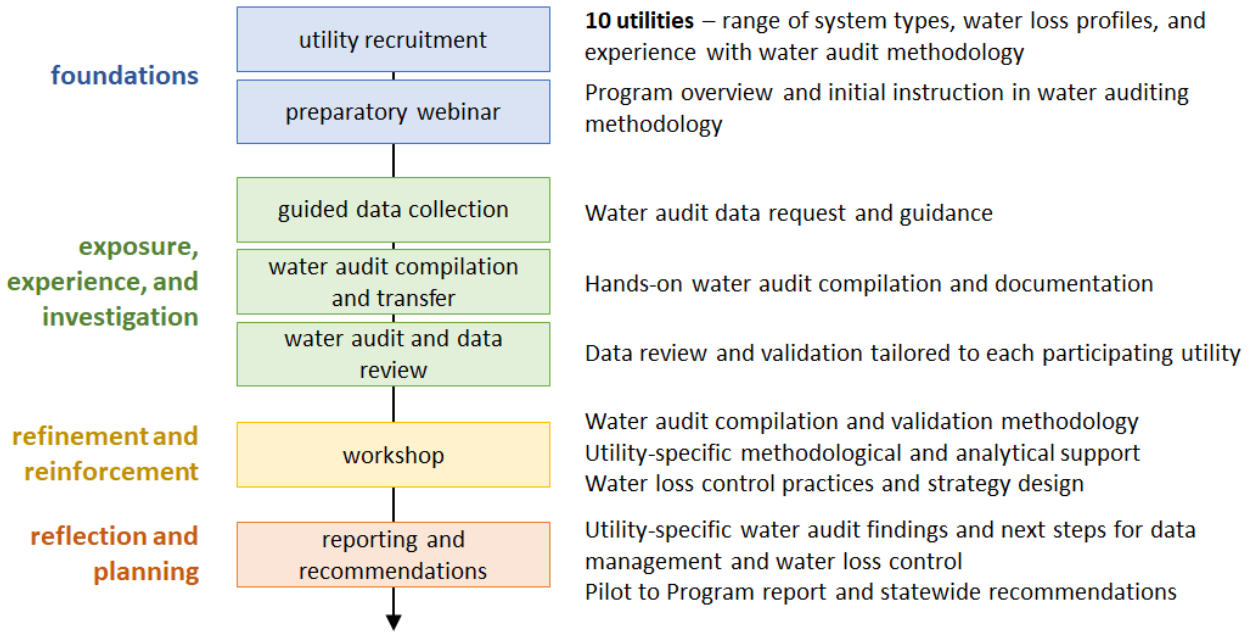


Figure 5: Pilot program overview

Phase 1: Foundations

Utility Recruitment

Mike Dexel, water resources policy lead at the Department of Health Office of Drinking Water, spearheaded utility recruitment and selection because he is familiar with the challenges that Washington utilities face and the water loss control priorities of utilities across the state. Mike Dexel distributed notice of the pilot program to regional managers, stakeholder groups and specific utilities. Seventeen utilities expressed interest in participating, and from this pool ten utilities were chosen to encompass a variety of locations, system sizes, water loss profiles, and water audit experience.

The selected utilities are described in further detail in the Participants section on page 15.

Preparatory Webinar

A 90-minute webinar was held to introduce program objectives, AWWA water audit methodology, and the AWWA Free Water Audit Software. The webinar explained water balance terms and concepts as well as the data needed to compile a water audit in preparation for level 1 validation. The end of the webinar outlined the next steps of data gathering and water audit compilation.

Phase 2: Exposure, Experience, and Investigation

Following the webinar, utilities were prompted to compile a water audit for calendar year 2016 on their own using the AWWA Free Water Audit Software. They were also asked to gather and provide specific supporting documents showing how inputs were derived (see Appendix C on page 52). For many pilot participants, this was their first exposure to the AWWA Free Water Audit Software.

If utilities were interested in providing data for deeper review, additional opportunities were offered for conducting further investigation into supply data, billing data, meter test data, and repair records.

Phase 3: Refinement and Reinforcement

Four full-day training and technical assistance workshops were held across the state to further reinforce water audit methodology through lectures, dialogue with peers, and one-on-one sessions with the Washington Pilot Program team. Workshops were hosted in Spanaway, Vancouver, Richland, and Liberty Lake.

Each full-day workshop included:

- Presentation on water audit methodology, including the water balance, AWWA Free Water Audit Software, and data validity grades
- Level 1 water audit validation of pilot utilities' water audits through one-on-one interviews with instructors
- Development of recommendations for improved data management practices
- Presentation on water loss control, supply meter testing, and customer meter testing
- Development of general recommendations for water loss control activities based on level 1 validated water audit results

After the workshop, each utility was given a follow-up document with notes from the validation process and a list of opportunities to improve the reliability of future water audit inputs and outputs. It was also recommended that each utility compile a water audit for calendar year 2017 using the follow-up document notes to maximize retention of knowledge gained from the workshop.

Phase 4: Reflection and Planning

Survey

A post-workshop survey was distributed to all participants to gain insight into each attendee's experience in the training program. Results from the survey are summarized in the Feedback section on page 42.

Survey feedback was overwhelmingly positive, and most responses indicated that the AWWA methodology provides more insight into leakage management and data sources and should therefore be taught to utilities across the state. For example, one participant commented that "the water auditing process is **much more informative** than the traditional water use efficiency reporting." For additional feedback, please visit that section of this report (page 42).

Participants

Ten utilities participated in the pilot program:

- City of Arlington
- City of Camas
- Clark Public Utilities District
- Fruitland Mutual Water Company
- Liberty Lake Sewer and Water District
- Nob Hill Water Association
- Stevens Public Utility District
- Tacoma Water
- City of Walla Walla
- City of Yakima

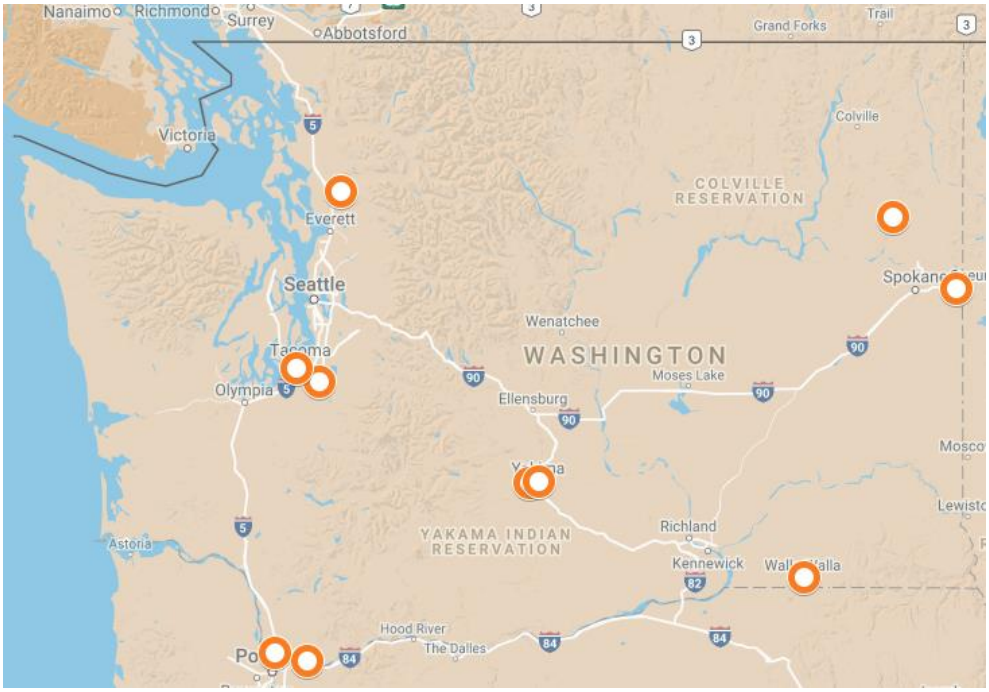


Figure 6: Pilot participant locations

Results and Recommendations

Each utility's results and recommendations are presented in the following pages. Additionally, a suite of common recommendations could benefit water loss analysis and management for all pilot participants.

Common Recommendations

1. **Complete a calendar year 2017 water audit on your own.** It is recommended that you do this as soon as possible to cement what you learned in the pilot program.
    a. Gather 2017 calendar year water audit supporting data, follow the pilot program data request used to compile your 2016 water audit.
    b. Calculate the 2017 water audit inputs using the 2016 water audit and your pilot program follow-up documentation as a guide.
    c. Continue to conduct the AWWA water audit annually as a best practice to improve data reliability and track water loss.

2. **Begin investigating water loss control strategies for your system** while keeping in mind the strengths, shortcomings, and certainty of your water audit data and results.
    a. Conduct a component analysis of real loss to develop your leakage profile.
    b. Following the methodology enumerated in AWWA manual M36, conduct a cost-benefit analysis of water loss control strategies (e.g. proactive leak detection, pressure reduction, large meter maintenance) to determine the extent of cost-effective investment in water loss control.
    c. Design and implement a water loss control program that uses these cost-effective strategies to manage water loss.
    d. Evaluate water loss control results annually and refine your program as necessary to maintain cost-effectiveness.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	55 (Band III 51-70)
Service Connections:	5,577
Miles of Main:	98
Average Operating Pressure:	60 psi
Apparent Losses per service connection per day:	6 gal/conn/day
Real Losses per service connection per day:	25 gal/conn/day
Infrastructure Leakage Index:	1.7

Validity

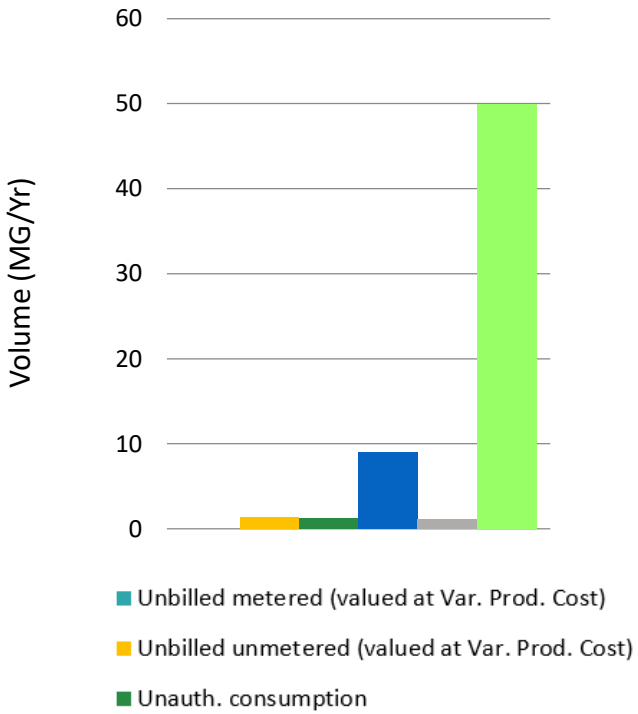
Level 1 validated DVS score of 55/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

- Volume from Own Sources
- Customer Metering Inaccuracies
- Average Operating Pressure

Detailed recommendations are presented on the following page.

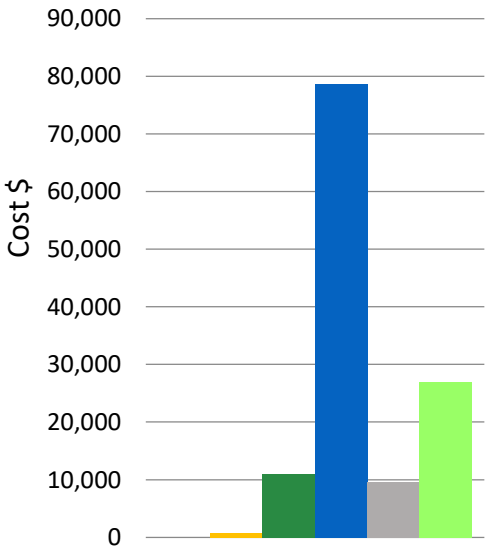
Volume

Total Volume of NRW = 63 MG/Yr



Value

Total Cost of NRW =$126,963



City of Arlington

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such a program, you should:
    - Inspect pipe configurations around the finished water meter to determine if adequate upstream and downstream straight pipe lengths are in place.
    - Annually conduct a multi-point span (4-20 mA) signal calibration on the electronic signal between the finished water meter and SCADA.
    - Conduct an annual volumetric meter accuracy test of the finished water meter using the clearwell.
    - Consider augmenting the clearwell volumetric accuracy test with a redundant insertion meter test if a suitable test location can be determined.
    - Investigate the feasibility of volumetrically testing the PUD intertie meter.

- **Improved estimation of customer meter inaccuracy**: consider a customer meter testing program that tests a sample of random meters whose stratification (by size, age, or other characteristics) represents the entire customer meter stock.
    - Develop small meter stratification parameters, then test a random sample to gauge small meter overall accuracy performance. The more meters you are able to test, the better.
    - Test large meters that see significant throughput to investigate their accuracy and revenue generation.

- **Pressure data**: analyze current real-time monitor data to determine what's available.
    - If there are any gaps in pressure data, identify additional logging locations to augment the average operating pressure calculation.
    - Update the average operating pressure calculation in future audits as additional data becomes available.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	50 (Band II 26-50)
Service Connections:	8,280
Miles of Main:	143
Average Operating Pressure:	85 psi
Apparent Losses per service connection per day:	7 gal/conn/day
Real Losses per service connection per day:	67 gal/conn/day
Infrastructure Leakage Index:	3.2

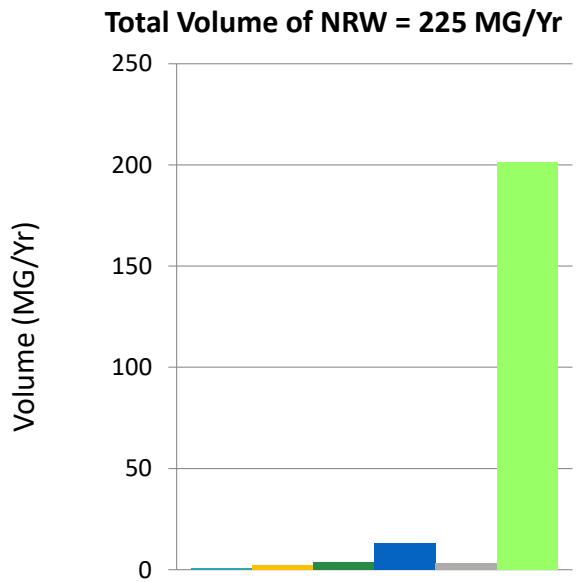
Validity

Level 1 validated DVS score of 50/100 suggests that next steps **should be generally focused on improving data reliability**. Priority areas for attention are:

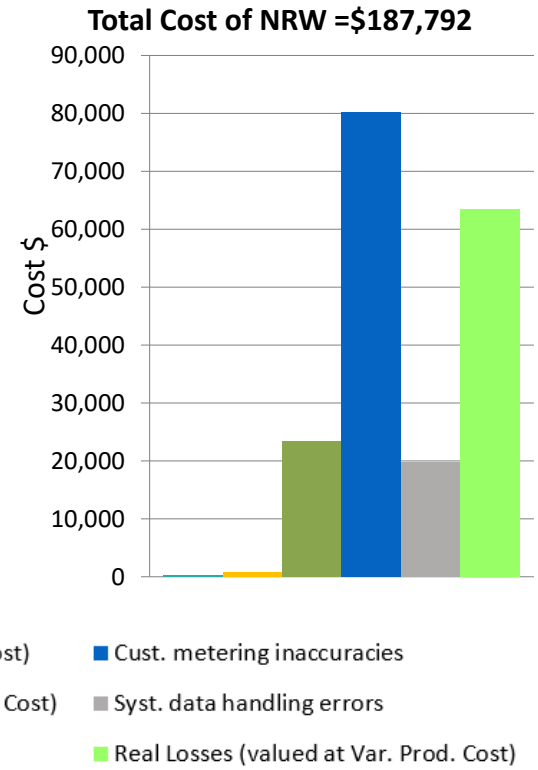
- Volume from Own Sources
- Customer Metering Inaccuracies
- Large meter testing policy

Detailed recommendations are presented on the following page.

Volume



Value



City of Camas

The data validity score falling within band II (26-50) indicates that next steps should be generally focused on improving data reliability. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such a program, you should:
    - Inspect pipe configurations around supply meters to determine if adequate upstream and downstream straight pipe lengths are in place.
    - Conduct an annual volumetric test of supply meters, using whatever methodology is most appropriate for the installation (e.g. reservoir drawn-down or fill-up test, insertion meter test, or pitot tube test).

- **Refined large meter testing policy:** Camas currently tests large meters based on size, account type, and accessibility. Consider changing the large meter testing policy and schedule to prioritize meters that see the most consumption, regardless of size or account type.

- **Improved estimation of customer meter inaccuracy**: consider a customer meter testing program that tests a sample of random meters whose stratification (by size, age, or other characteristics) represents the entire customer meter stock.
    - Priority should be given to remaining meters that have not been upgraded to AMR technology (about 2,500 meters) to inform the pace of future AMR conversion.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	55 (Band III 51-70)
Service Connections:	32,399
Miles of Main:	821
Average Operating Pressure:	78 psi
Apparent Losses per service connection per day:	4 gal/conn/day
Real Losses per service connection per day:	25 gal/conn/day
Infrastructure Leakage Index:	1.1

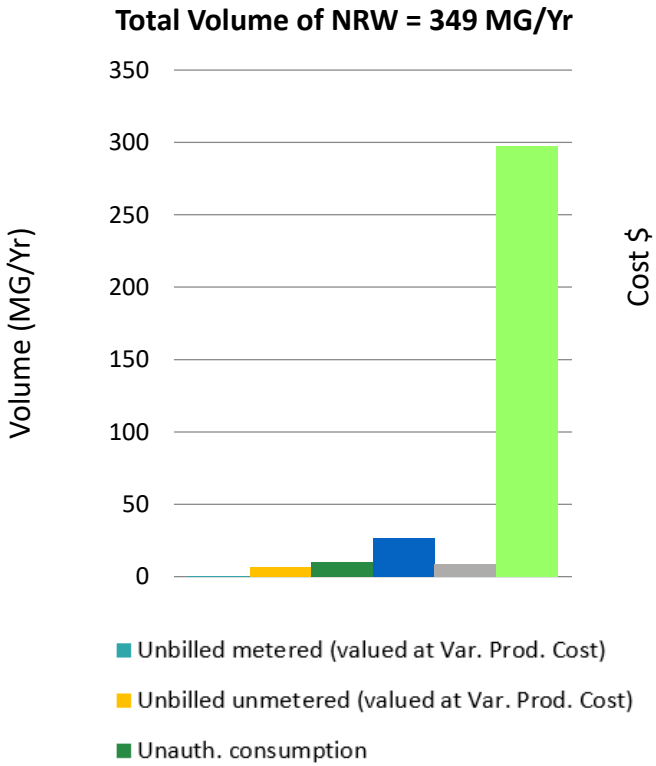
Validity

Level 1 validated DVS score of 55/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

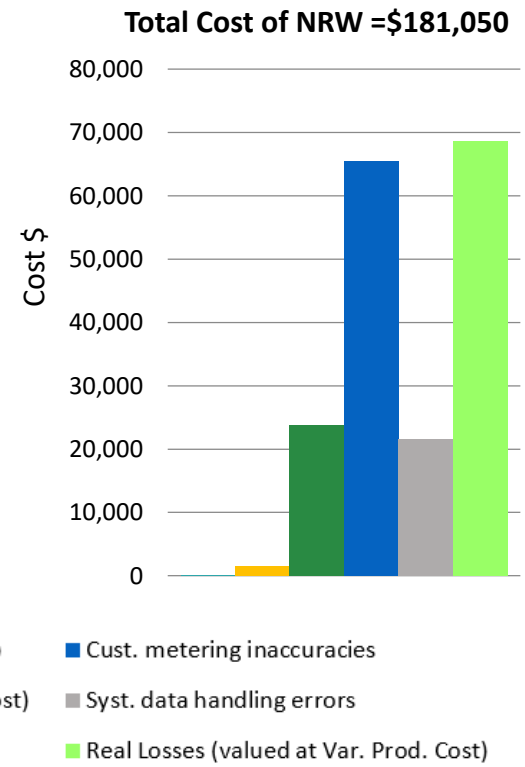
- Volume from Own Sources
- Average Operating Pressure
- Number of Service Connections
- Customer Retail Unit Cost

Detailed recommendations are presented on the following page.

Volume



Value



Clark Public Utilities District

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such a program, you should:
    - Transition to an annual test and calibration frequency for all supply meters.
    - Standardize documentation for supply meter accuracy testing and signal calibration.
    - Incorporate an adjustment to the volume of supply that accounts for the net change in stored volume over the audit period.

- **Pressure calculation refinement**: calculate the average operating pressure using field data by first determining the average pressure in each zone and then weighting average zone pressures by the count of service connections in each zone to determine overall average pressure.

- **Count of service connections**: adjust the count in the audit to include connections at vacant properties.

- **Customer retail unit cost refinement**: recalculate the customer retail unit cost to reflect a weighted average of all classes and tiers. This can be accomplished by dividing the total commodity revenue by the total volume sold.

Level 1 Validated Water Audit Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	64 (Band III 51-70)
Service Connections:	3,997
Miles of Main:	81
Average Operating Pressure:	79 psi
Apparent Losses per service connection per day:	8 gal/conn/day
Real Losses per service connection per day:	35 gal/conn/day
Infrastructure Leakage Index:	1.5

Validity

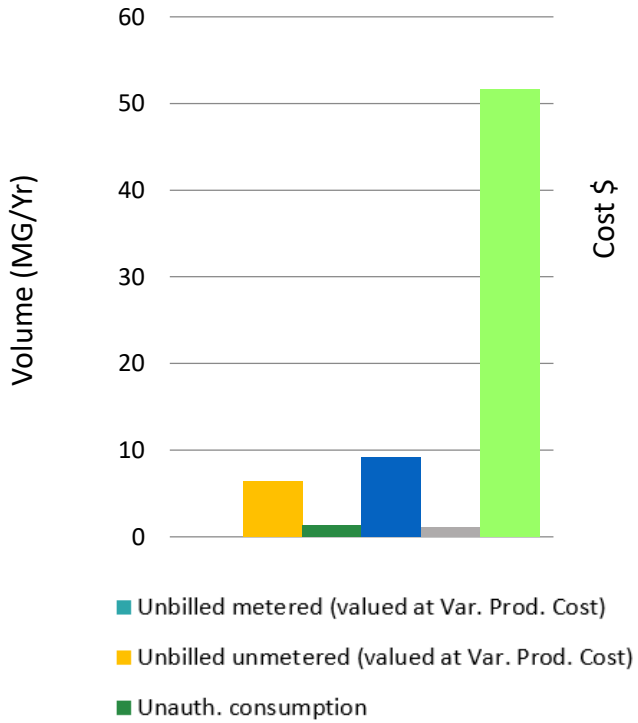
Level 1 validated DVS score of 64/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

- Volume from Own Sources
- Customer Metering Inaccuracies
- Unbilled Unmetered Authorized Consumption

Detailed recommendations are presented on the following page.

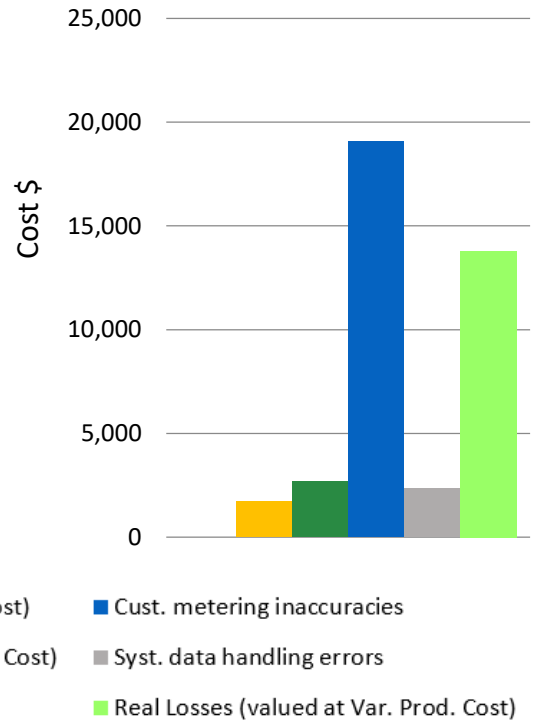
Volume

Total Volume of NRW = 70 MG/Yr



Value

Total Cost of NRW =$39,606



Fruitland Mutual Water Company

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such tests, you should evaluate the hydraulic conditions each meter experiences (e.g. laminar or turbulent flow, given installation configurations).

- **Improved estimation of customer meter inaccuracy**: consider a customer meter testing program that tests a sample of random meters whose stratification (by size, age, or other characteristics) represents the entire customer meter stock.
    - Develop small meter stratification parameters, then test a random sample to gauge small meter overall accuracy performance. The more meters you are able to test, the better.
    - Test large meters that see significant throughput to investigate their accuracy and revenue generation.

- **Customer retail unit cost refinement**: recalculate the customer retail unit cost to reflect a weighted average of all classes and tiers. This can be accomplished by dividing the total commodity revenue by the total volume sold.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	49 (Band II 26-50)
Service Connections:	3,541
Miles of Main:	76
Average Operating Pressure:	70 psi
Apparent Losses per service connection per day:	44 gal/conn/day
Real Losses per service connection per day:	106 gal/conn/day
Infrastructure Leakage Index:	5.7

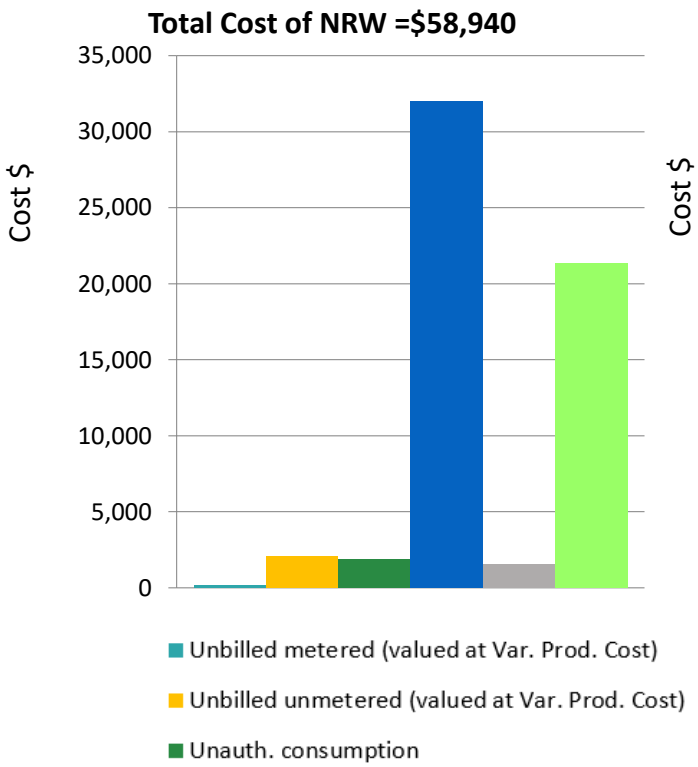
Validity

Level 1 validated DVS score of 49/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

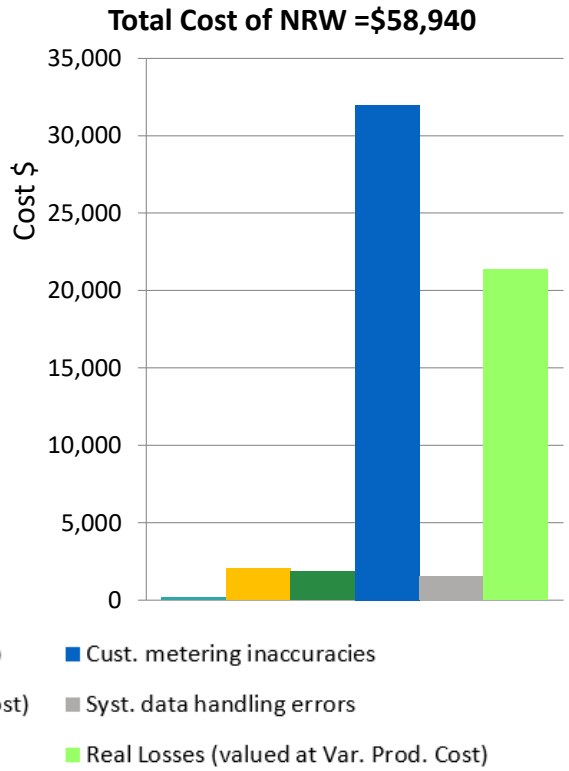
- Volume from Own Sources
- Customer Metering Inaccuracies
- Average Operating Pressure

Detailed recommendations are presented on the following page.

Volume



Value



Liberty Lake Sewer and Water District

The data validity score falling within band II (26-50) indicates that next steps should be generally focused on improving data reliability. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such tests, you should evaluate the hydraulic conditions each meter experiences (e.g. laminar or turbulent flow, given installation configurations) and ensure that test instruments are employed in laminar flow conditions.

- **Large customer meter testing**: Prioritize large customer meters registering the most consumption to study customer meter performance and assess revenue generation. Large meters should be tested on a regular schedule at flow rates that reflect the meter's standard operating conditions. Regular testing may be conducted with test ports, using a portable test rig, or by swapping out large meters (replace a large meter with a newly calibrated meter, test the removed meter, and install it at the next location).

- **Temporal alignment of supply and sales:** consider pro-rating the first and last months of the audit period consumption data to better align consumption with actual dates of use. If this cannot be performed, use read dates instead of bill dates as the basis for consumption volume reporting.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	62 (Band III 51-70)
Service Connections:	11,508
Miles of Main:	177
Average Operating Pressure:	93 psi
Apparent Losses per service connection per day:	11 gal/conn/day
Real Losses per service connection per day:	66 gal/conn/day
Infrastructure Leakage Index:	3.1

Validity

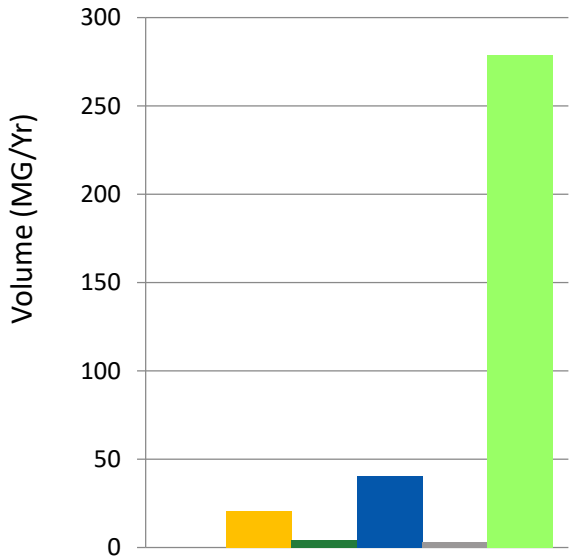
Level 1 validated DVS score of 62/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

- Volume from Own Sources
- Average Operating Pressure
- Number of Service Connections
- Customer Retail Unit Cost

Detailed recommendations are presented on the following page.

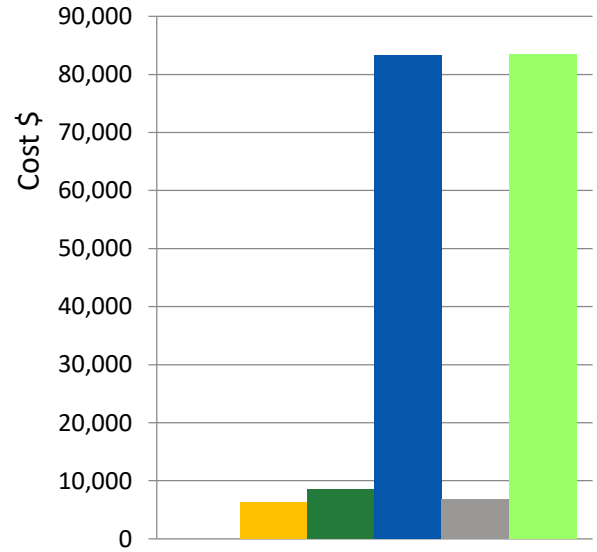
Volume

Total Volume of NRW = 347 MG/Yr



Value

Total Cost of NRW =$188,208



Unbilled metered (valued at Var. Prod. Cost)
Cust. metering inaccuracies
Unbilled unmetered (valued at Var. Prod. Cost)
Syst. data handling errors
Unauth. consumption
Real Losses (valued at Var. Prod. Cost)

Nob Hill Water Association

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such tests, you should evaluate the hydraulic conditions each meter experiences (e.g. laminar or turbulent flow, given installation configurations).

- **Improved estimation of customer meter inaccuracy**: consider a customer meter testing program that tests a sample of random meters whose stratification (by size, age, or other characteristics) represents the entire customer meter stock.
    - Develop small meter stratification parameters, then test a random sample to gauge small meter overall accuracy performance. The more meters you are able to test, the better.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	55 (Band III 51-70)
Service Connections:	2,046
Miles of Main:	56
Average Operating Pressure:	58 psi
Apparent Losses per service connection per day:	24 gal/conn/day
Real Losses per service connection per day:	20 gal/conn/day
Infrastructure Leakage Index:	1.1

Validity

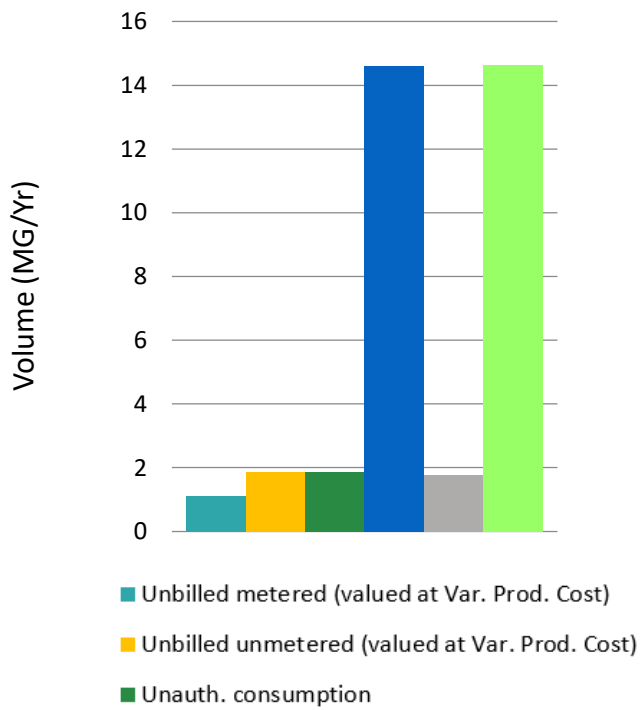
Level 1 validated DVS score of 55/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

- Volume from Own Sources
- Customer Metering Inaccuracies
- Unbilled Unmetered Authorized Consumption
- Average Operating Pressure

Detailed recommendations are presented on the following page.

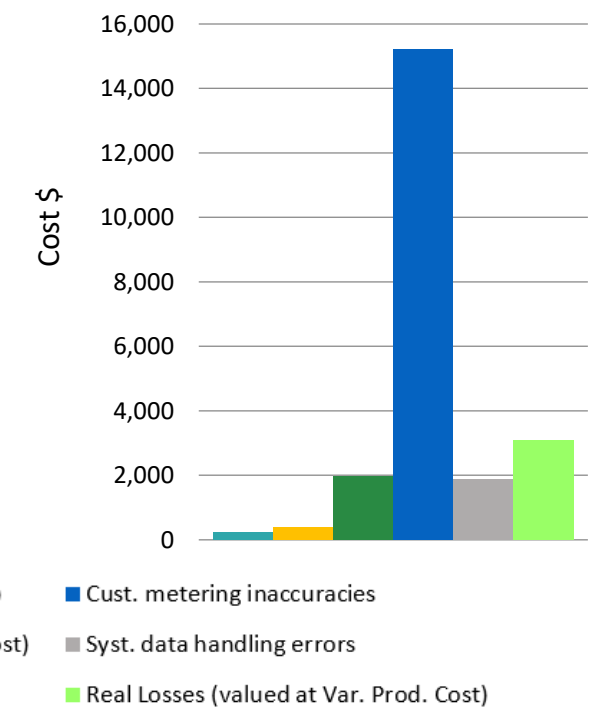
Volume

Total Volume of NRW = 36 MG/Yr



Value

Total Cost of NRW =$22,724



Stevens County Public Utilities District

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such a program, you should:
    - Transition to an annual test and calibration frequency for all supply meters.
    - Standardize documentation for supply meter accuracy testing and signal calibration.
    - Incorporate an adjustment to the volume of supply that accounts for the net change in stored volume over the audit period.

- **Improved estimation of customer meter inaccuracy**: consider a customer meter testing program that tests a sample of random meters whose stratification (by size, age, or other characteristics) represents the entire customer meter stock.
    - Develop small meter stratification parameters, then test a random sample to gauge small meter overall accuracy performance. The more meters you are able to test, the better.

- **Refined average operating pressure:** recalculate the average operating pressure to weight zonal pressures by the count of service connections in each zone.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	70 (Band III 51-70)
Service Connections:	107,170
Miles of Main:	1,373
Average Operating Pressure:	73 psi
Apparent Losses per service connection per day:	7 gal/conn/day
Real Losses per service connection per day:	17 gal/conn/day
Infrastructure Leakage Index:	1.1

Validity

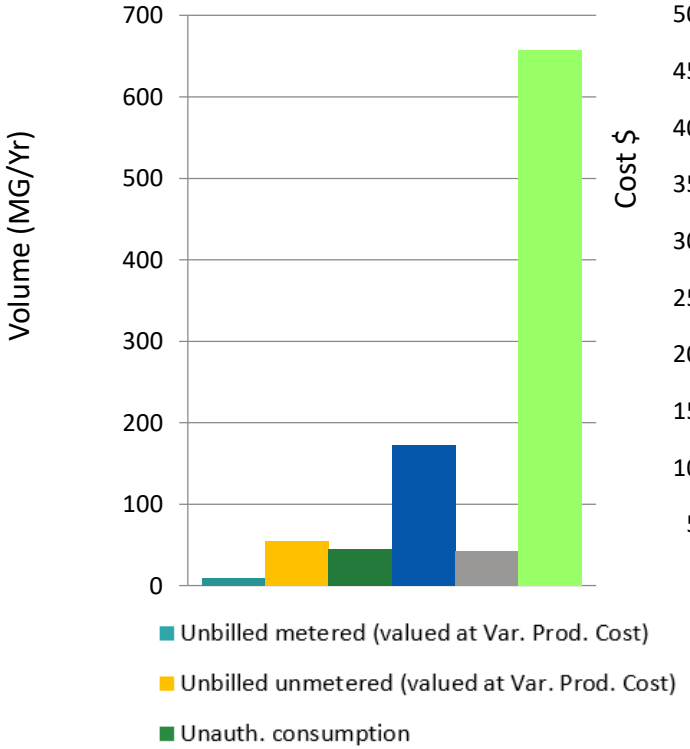
Level 1 validated DVS score of 70/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

- Volume from Own Sources
- Customer Metering Inaccuracies
- Unbilled Unmetered Authorized Consumption
- Average Operating Pressure

Detailed recommendations are presented on the following page.

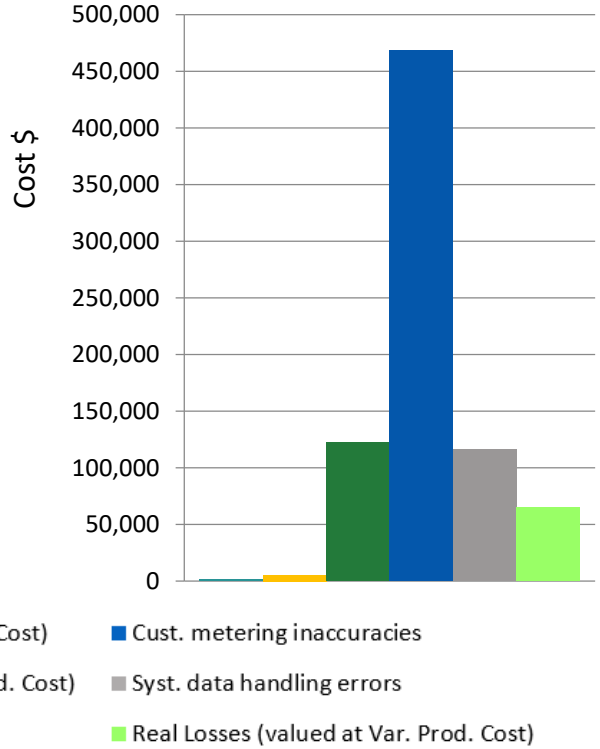
Volume

Total Volume of NRW = 983 MG/Yr



Value

Total Cost of NRW =$778,931



Tacoma Water

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A.
    - Tacoma staff acknowledged that leakage through Pipeline 1 is a known problem. Given the importance of Pipeline 1 and Pipeline 5, it is recommended that Tacoma conducts volumetric testing at these two finished water meters on an annual basis. Tacoma may need to volumetrically test their meters using an insertion meter instead of using a reference volume drawn from a tank due to the service disruptions this would cause.

- **Refined billed metered authorized consumption**: Tacoma's billed metered authorized consumption is based on billed volume, which could be a source of error. Ideally, this volume would be based on actual meter reads in case customers were issued any credits for water that passed through the customer meter. Currently, Tacoma staff do not believe they are able to obtain meter read data, but they will investigate if this is possible.

- **Refined average operating pressure:** recalculate the average operating pressure to weight zonal pressures by the count of service connections in each zone.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2016
Data Validity Score:	58 (Band III 51-70)
Service Connections:	10,949
Miles of Main:	186
Average Operating Pressure:	75 psi
Apparent Losses per service connection per day:	35 gal/conn/day
Real Losses per service connection per day:	141 gal/conn/day
Infrastructure Leakage Index:	7.8

Validity

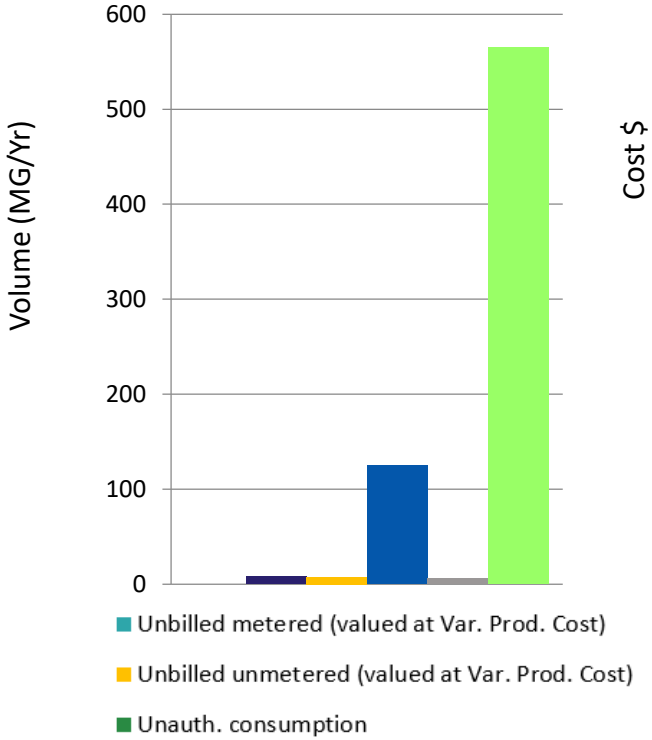
Level 1 validated DVS score of 58/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

- Volume from Own Sources
- Customer Metering Inaccuracies
- Unbilled Unmetered Authorized Consumption
- Average Operating Pressure

Detailed recommendations are presented on the following page.

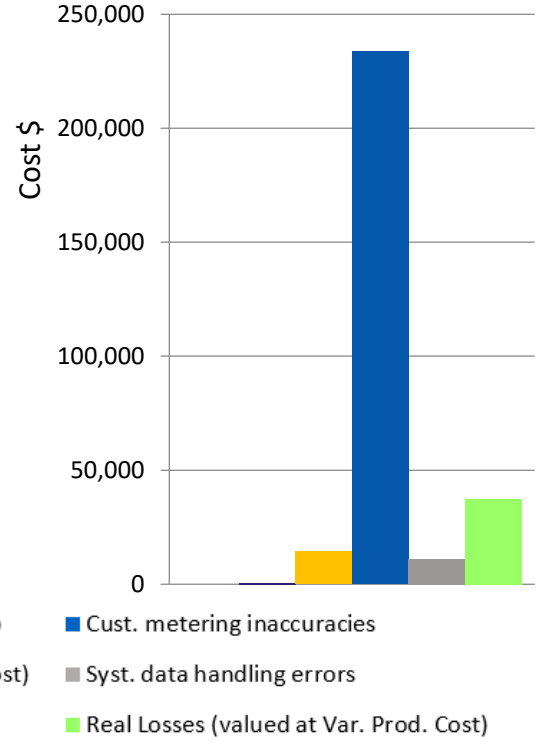
Volume

Total Volume of NRW = 711 MG/Yr



Value

Total Cost of NRW =$297,171



City of Walla Walla

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A. In such a program, you should:
    - Walla Walla's two 24" production meters typically record 100% of water supplied. It is recommended that Walla Walla annually conduct a draw-down test using their clearwells to volumetrically test these meters.

- **Large customer meter accuracy**: conduct customer meter testing on large meters that experience the highest volumes of consumption.

- **Temporal alignment of supply and sales:** consider pro-rating the first and last months of the audit period consumption data to better align consumption with actual dates of use. If this cannot be performed, use read dates instead of bill dates as the basis for consumption volume reporting.

- **Leak detection:** pursue savings through proactive leak detection. Two consecutive, comprehensive full-system surveys are recommended to remove the backlog of leakage.

- **Pressure transients**: use high-frequency pressure loggers to identify any transients, then mitigate any transients you discover.

- **PRVs**: maintain or rehabilitate PRVs to ensure that pressure is modulated as planned.

- **System pressure reduction**: investigate the possibility of lowering system pressure. During low demand periods in the winder, they may be room for pressure reduction, which could then be reversed when higher demand periods start.

- **Zonal management**: explore metering pressure zone inflows and outflows as a way to monitor leakage in each pressure zone and guide the deployment of leakage resources.

Level 1 Validated Water Audit
Utility 3V Profile

Water Audit Reporting Year:	Calendar Year 2017
Data Validity Score:	58 (Band III 51-70)
Service Connections:	21,000
Miles of Main:	300
Average Operating Pressure:	60 psi
Apparent Losses per service connection per day:	6 gal/conn/day
Real Losses per service connection per day:	93 gal/conn/day
Infrastructure Leakage Index:	6.8

Validity

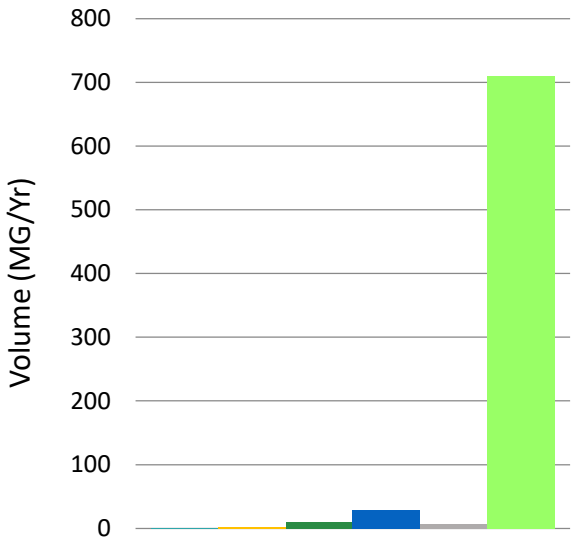
Level 1 validated DVS score of 58/100 suggests that next steps may be focused simultaneously on **improving data reliability and evaluating cost-effective interventions for water & revenue loss recovery**. Priority areas for attention are:

- Volume from Own Sources
- Customer Metering Inaccuracies
- Billed Metered Authorized Consumption
- Average Operating Pressure

Detailed recommendations are presented on the following page.

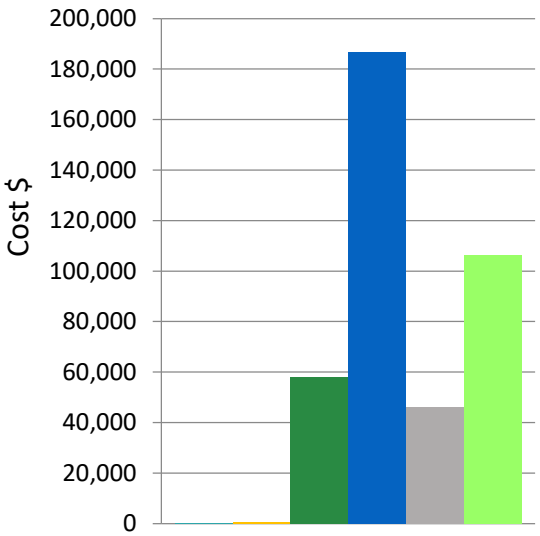
Volume

Total Volume of NRW = 759 MG/Yr



Value

Total Cost of NRW =$397,280



- Unbilled metered (valued at Var. Prod. Cost)
- Cust. metering inaccuracies
- Unbilled unmetered (valued at Var. Prod. Cost)
- Syst. data handling errors
- Unauth. consumption
- Real Losses (valued at Var. Prod. Cost)

City of Yakima

The data validity score falling within band III (51-70) suggests that next steps may be focused simultaneously on improving data reliability and evaluating cost-effective interventions for water and revenue loss recovery. Opportunities to improve the reliability of audit inputs and outputs include:

- **Improved understanding of supply meter error**: consider adopting or increasing the rigor of a source meter volumetric testing and calibration program, informed by the guidance provided in AWWA Manual M36 – Appendix A.
    - Evaluate whether SCADA can totalize well production.
    - Inspect each well site to determine the feasibility of volumetric accuracy testing.
    - Regularly compare well meter reads to SCADA reads.
    - Add a master meter before the Gleed Pump Station.

- **Improved estimation of customer meter inaccuracy**: consider a customer meter testing program that tests a sample of random meters whose stratification (by size, age, or other characteristics) represents the entire customer meter stock.
    - Develop small meter stratification parameters, then test a random sample to gauge small meter overall accuracy performance. The more meters you are able to test, the better.
    - Analyze large meter test results to understand accuracy.

- **Temporal alignment of supply and sales:** consider pro-rating the first and last months of the audit period consumption data to better align consumption with actual dates of use. If this cannot be performed, use read dates instead of bill dates as the basis for consumption volume reporting.
    - Develop a flow chart for the read to bill process to understand operations in which error could be introduced.

- **Refined average operating pressure:** recalculate the average operating pressure to weight zonal pressures by the count of service connections in each zone.

Program Results

The pilot program produced three progressive estimates of leakage for each utility: the standard DSL calculation, a self-reported AWWA water audit, and a level 1 validated AWWA water audit (see Figure 3).

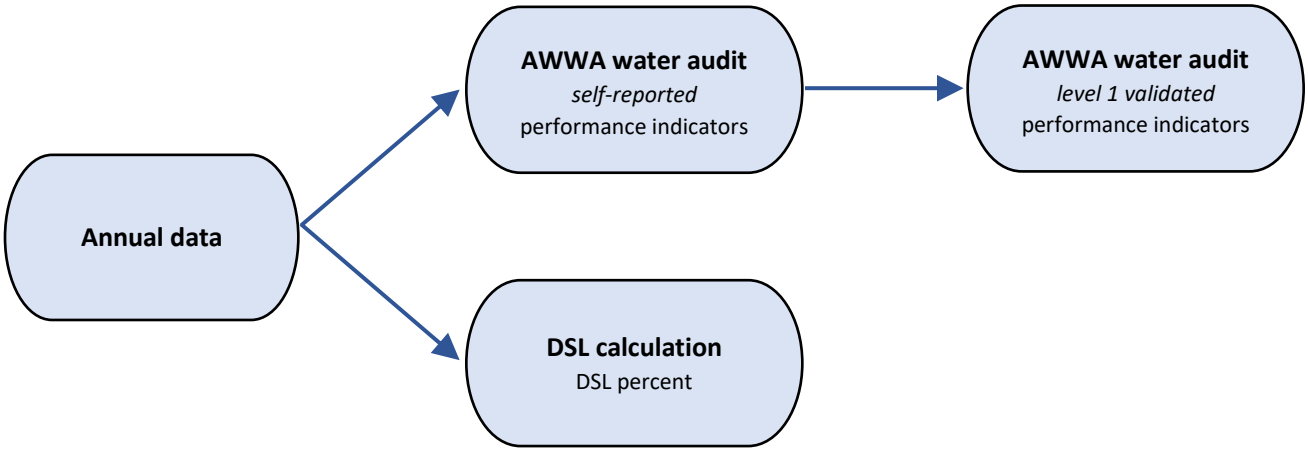


Figure 7: Leakage estimates produced by the Washington pilot program

By comparing DSL calculations to AWWA estimates of leakage, the differences in methodology can be highlighted. Furthermore, the additional value of validation can be considered by comparing self-reported and level 1 validated AWWA water audit results.

DSL Calculation Compared to AWWA Methodology

A comparison between the Washington DSL calculations and AWWA-methodology estimates of real loss for all pilot participants is presented in Figure 8 below. Volumes used to calculate real loss estimates are drawn from the water audits after validation.

All ten utilities estimated less leakage when using the AWWA methodology, compared to the Washington DSL calculation. This is because the AWWA methodology distinguishes real loss from apparent loss, whereas the Washington DSL calculation typically captures both apparent loss and real loss as leakage. After validation through the Washington pilot program, the average calculated DSL was 14%, and the average real loss estimate was 11%.

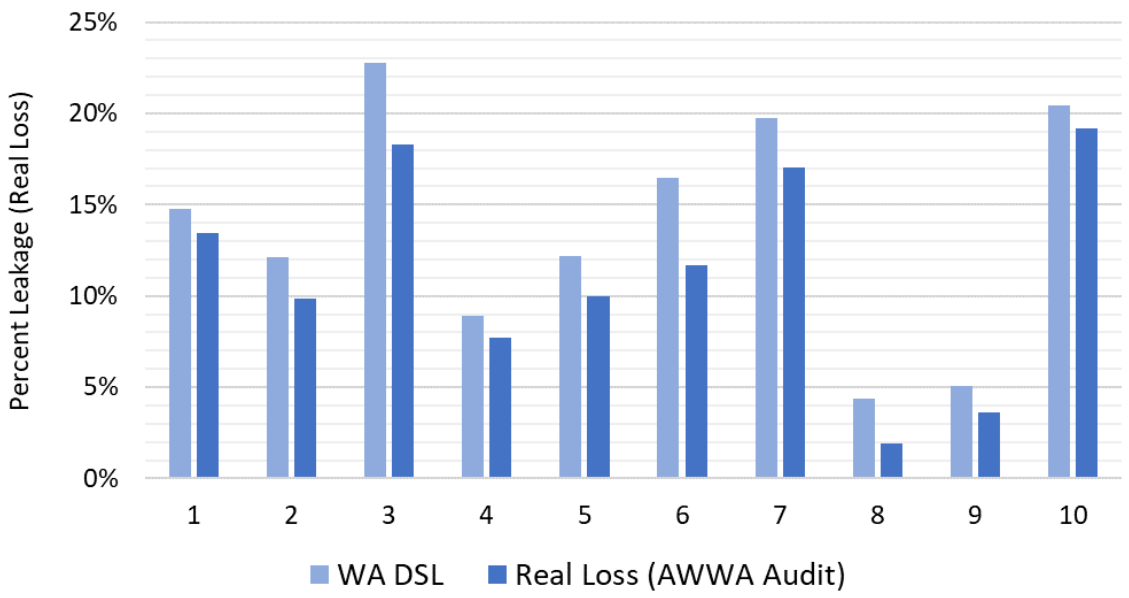


Figure 8: Washington DSL calculation (after validation) compared to AWWA-methodology real loss estimate (after validation)

Apparent loss (water that is delivered to a customer but not tracked due to customer meter inaccuracy, data handling issues, or theft) is distinct from real loss (leakage) in its location, its value, and the most appropriate remediation strategies. Without quantifying apparent loss and real loss distinctly, both forms of loss are difficult to effectively manage. As a result, the AWWA-methodology estimate of real loss provides more functional insight into leakage than the Washington DSL calculation.

Self-Reported Water Audits Compared to Validated Water Audits

Though self-reported AWWA water audits provide more actionable insight into leakage than the DSL calculation, **the accuracy of self-reported water audits can be improved through third-party validation**. Figure 9 below displays the change in results produced by validation. In most cases, validation increased the estimate of apparent loss, often by allocating some apparent loss to customer metering inaccuracy rather than assuming perfect customer meter accuracy.

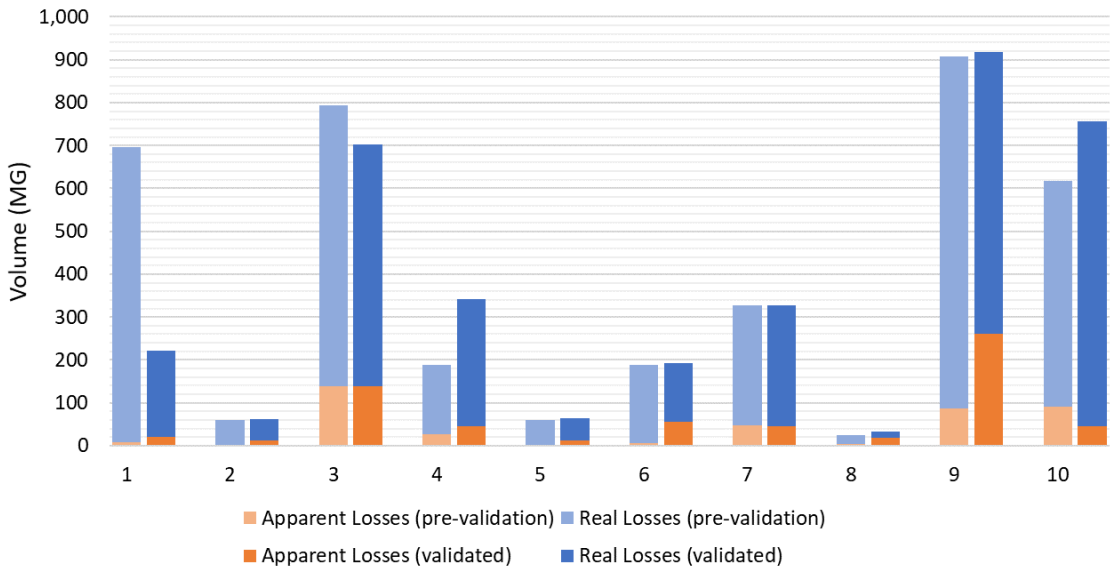


Figure 9: Self-reported water audit results compared to validated water audit results

Four agencies saw the total volume of water loss change noticeably through validation. These changes are attributable to the acknowledgement of source meter inaccuracy diagnosed through source meter accuracy testing (thereby changing the volume of supply) or more accurate application of general methodology to calculate supply and sales volumes.

Advanced Validation

The City of Arlington and Nob Hill Water Association requested level 2 validation of raw billing data to support their water audit results. Level 2 validation analyzes raw data supporting the water audit to determine whether the data is accurate and comprehensive.

Level 2 validation of raw billing data requires that raw billing data be extracted from a billing system and then passed through a series of integrity checks to identify and resolve anomalies (see Table 2 on the following page). Arlington and Nob Hill Water Association provided flat-file exports from their billing systems that documented all meter reads that occurred during the audit period. The file contained one row (record) per meter read. Additional fields like read date, meter totalizer, meter number, meter size, account number, and account type were also included.

Table 2: Level 2 billing validation integrity checks

Integrity Check	Purpose
Count of accounts per bill cycle	The number of accounts billed per billing cycle should not vary significantly. If significant variation is observed, some data may be missing from or duplicated in the export.
Exclusion of non-potable volumes	The water audit deals strictly with potable water volumes. Any raw, recycled, or reclaimed water should be excluded.
Duplicate records	Each water meter read and subsequent bill should only be counted a single time in the water audit. Duplicate records may be introduced by meter reading and billing procedures and must be resolved into a single consumed volume for the accuracy of the water audit.
Negative consumption	Negative consumption may indicate a meter rollover, a billing correction, or an errant read. The reason for each negative consumption record must be determined to verify that it represents a legitimate record.
Consumption outliers	Unusually high or low consumption values for an account could indicate misreads or other data inaccuracies. However, some outlying consumption values may represent legitimate use, so the reason for significant outlying consumption must be ascertained to determine whether the consumption volume should be used in the water audit.
Accounts with no audit-period consumption	If an active account does not have recorded consumption during the audit period, it is worth investigating whether the account is truly active or if the meter is malfunctioning.
Consecutive zero consumption	Consecutive zero reads are repeated meter readings that indicate that no consumption is occurring on an active meter. Consecutive zero readings can indicate a stuck meter or other data handling issues.
Summary report verification	Raw billing data is used to reconstruct summary reports of audit period consumption. If misalignment is observed between raw data and summary reports, it may be that the summary query does not correctly capture audit period sales.

Level 2 billing data validation highlighted inconsistencies in each agency's billing data that could be explored and resolved to improve the accuracy of the water audit. Notable findings include:

- **Variation in monthly location records**: one utility's raw billing data contained a varying number of unique locations (designated by location identification numbers) that are recorded each month. This variation suggests missed reads or billing cycles that do not neatly overlap with month boundaries. If billing cycles do not align well with the audit-period boundary months, pro-rating billing data to align consumption with the date of use becomes critical.

Table 3: Monthly location identification number variation

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Distinct Count of Location ID	2,929	4,142	5,308	4,768	5,219	5,315	5,255	4,531	5,388	5,255	4,041	5,403	5,407	3,198

- **Significant negative consumption volumes**: one utility's raw billing data included significant negative consumption volumes that, if included, would decrease the water audit's reported volume of billed metered authorized consumption by 23%. Negative consumption volumes appear to have been excluded from the summary reporting used to determine billed metered authorized consumption in the water audit. Examples of negative consumption volumes are presented in Table 4 below.

Table 4: Examples of negative billed metered authorized consumption records contained in raw billing data

Location ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10-08100	-61993	330		679	254	308	342	336	392		675	290
10-14500	891	526		825	275	600	529	-179518	610		1404	548
10-18200	837	532		637	1039	1245	-49666	1633	-1575		504	698
10-18300	1276	799		994	706	804	768	1448	-70580		1818	863
10-46600		479	3052		3095	-130689	1826	1839	1893		2868	1857
10-53700	1308	669		723	574	946	797	1858	-3482		1759	393
10-54700	2333	1273		-64135	1176	1799	1563	1629	1789		3390	1924
10-55000	6950	1685		-892605	1287	1681	1493	1417	1652		3074	1409
10-55200	6819	4074		-361555	2801	3758	3031	3081	4226		7799	3440

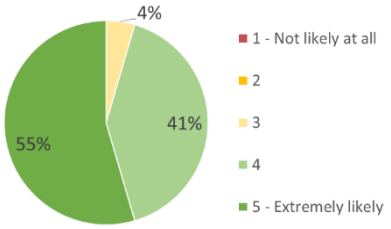
Feedback

A survey was distributed at the end of the program to evaluate participants' experience and desire for additional support. Survey feedback was overwhelmingly positive, and most responses indicated that the AWWA methodology provides more insight into leakage management and data sources than the DSL calculation method and should therefore before taught to utilities across the state.

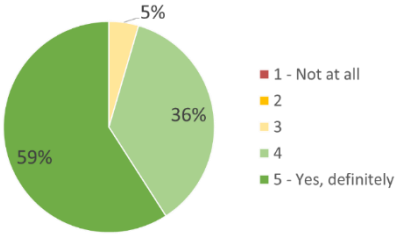
Participants commented that "the water auditing process is **much more informative** than the traditional water use efficiency reporting." Feedback received through the survey is captured below.

Key Questions

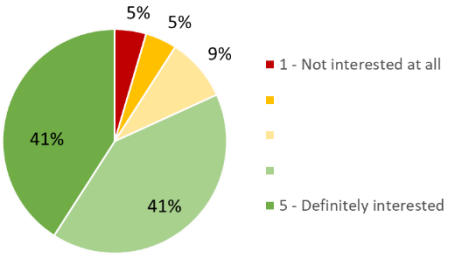
*How likely would you be to **recommend a similar program** to another utility looking for training on water auditing and the AWWA M36 methodology?*



*Was your training experience **worth the time and expense** with respect to learning the key elements of non-revenue water management and interdepartmental team building?*



*How interested would you be in **participating in a statewide program** involving validation of water audits in future years (beyond what was offered in the pilot program) if it were offered?*



Quoted Feedback

Excerpts from survey feedback are presented below. These comments highlight the value of both training and the AWWA water audit methodology in utility water loss management.

It was extremely helpful to have an expert to guide us through the water audit process and explain the various components and how our data fit into each one. I'm not sure we would have been able to accurately complete the audit without them.

Two major reasons [I would recommend a similar program to colleagues]: the water auditing process is much more informative than the traditional WUE reporting. The second is that the audit also provides focused suggestions where money and effort can be most effectively leveraged.

This training was excellent! The process was fairly easy to understand, while being incredibly useful and hugely informative about loss in the system.

It was very good training for me and I picked up some new ideas I hadn't thought about, the customer metering topics were very insightful and I have already started the process on how we record that info and understand it, also I thought a lot about the pressure management topic as this also pertains to specifically to what I do also maintaining ARVs and PRVs, I thought everyone was friendly and very knowledgeable.

I've never focused on apparent and even real losses like I did here. Very thorough with regard to metadata and evaluating data quality (DVG). Introduces new metrics to evaluate water efficiency. My previous water balance process was ratcheted up several clicks through this program.

The detail that we went into with this framework, really illuminated different aspects of the unaccounted-for water in our system. Those figures help us to really focus in on the areas where the cost-benefit ratio makes the most sense to improve the integrity of our water system.

Capacity Development

A series of survey questions evaluated the efficacy of the workshop in developing water loss analysis and management capacity, one of the primary program goals. Capacity development feedback is collected in Figure 10 on the following page.

How has the Washington Water Audit Pilot Program helped you in your job?

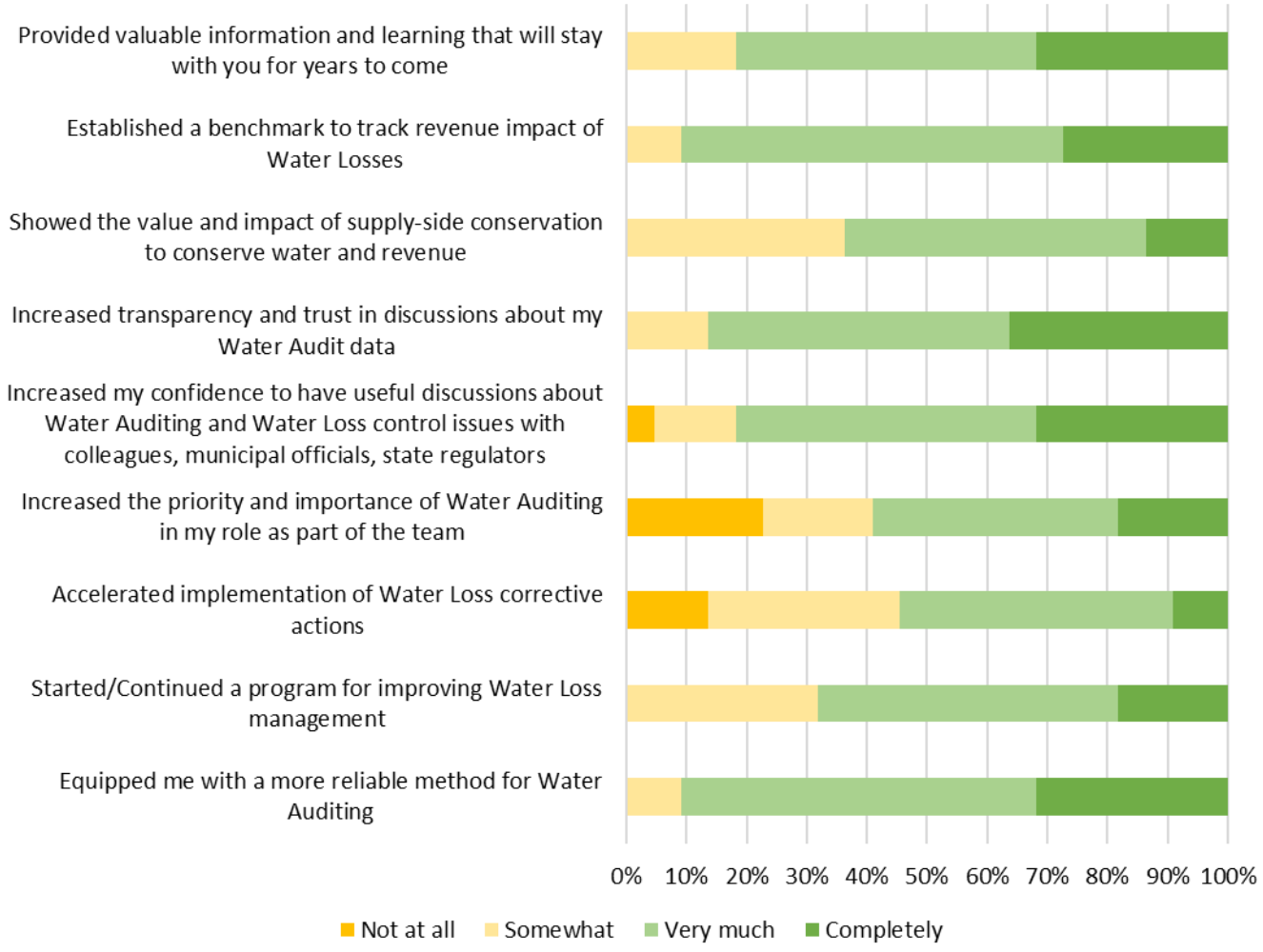


Figure 10: Capacity development feedback

Management and Next Steps

Participants were also asked about any insights they discovered during pilot program involvement that would affect water loss management in the future.

Upon reflecting on your experience using the audit and discussions with your team and consultants, which of the following topic areas did you discover where you could improve water loss techniques?

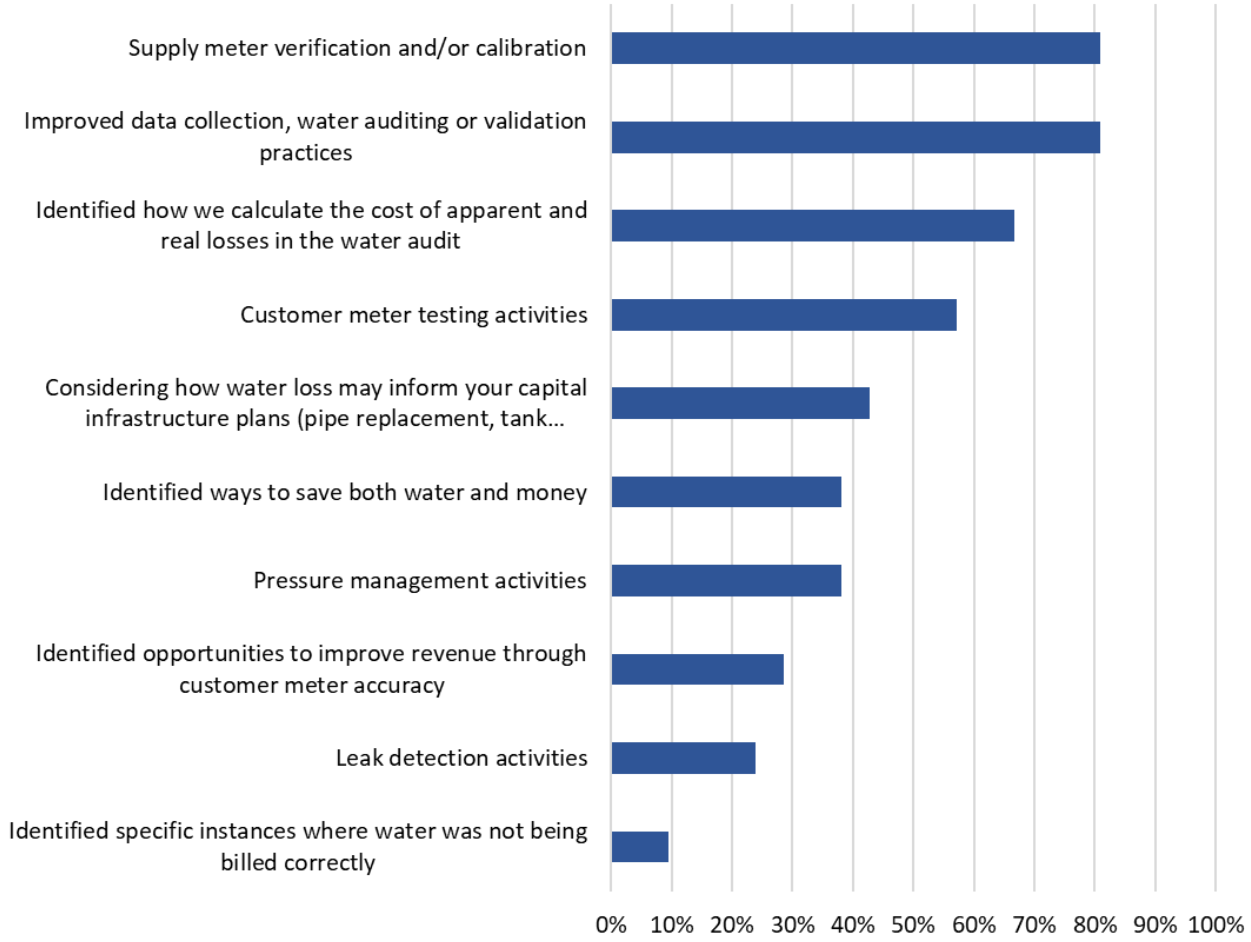


Figure 11: Insight from pilot program participation

Recommendations

The Washington water audit pilot program improved each participating utility's insight into system management, data source reliability, and water loss. These improvements manifested in more accurate leakage estimates determined using AWWA water audit methodology and validation. Pilot participants also offered consistently positive feedback communicating appreciation for the methodology and third-party support. Participant feedback additionally encouraged the adoption of the water audit in future reporting requirements with continued training and validation.

To extend the benefits that AWWA methodology, validation, and training offer to other drinking water utilities in Washington, the Washington pilot program management team propose the following recommendations. **To accomplish these recommendations, Washington could consider amending its administrative rules (WAC 246-290) to incorporate AWWA methodology, including level 1 validation.**

Adopt AWWA Methodology for Leakage Estimation

Challenge: the Washington distribution system leakage (DSL) calculation does not distinguish between apparent loss and real loss (leakage), thereby making leakage quantification and management difficult.

Recommendation: adopt the AWWA water audit methodology for all drinking water utility annual reporting (as captured in the AWWA Free Water Audit Software) in order to distinguish between apparent loss and real loss. To estimate the DSL percentage using AWWA methodology, divide the volume of real loss by the volume of water supplied.

Support: the AWWA water audit methodology is considered industry best practice for leakage tracking. The current DSL methodology results in a single value that is used to communicate leakage in the distribution system, providing no guidance on potential strategies for managing or addressing leakage. Additionally, the majority of pilot participants indicated that they prefer the AWWA methodology to the standard DSL calculation for the refined insight into leakage, apparent loss, and data sources that it provides.

Provide AWWA Methodology Training to All Utilities

Challenge: the AWWA methodology isn't familiar to many drinking water utilities in Washington, even though the structure it provides empowers utilities to engage with data reliability, distinct water loss volumes, and the financial impacts of water loss.

Recommendation: offer webinars and workshops on AWWA water audit methodology and the AWWA Free Water Audit Software to all drinking water utilities. Workshops and webinars could be modeled after those provided during the Washington pilot program. Workshops and webinars are most effective when they are offered at no cost to the utility and as a progressive curriculum taught in more than one session to reinforce lessons learned. Additionally, water audit educational opportunities can support efforts to increase technical, managerial, and financial capacity.

To move toward a statewide program of AWWA methodology training and technical assistance, Washington could consider the following steps:

1. Conduct a phase 2 pilot program that expands the training and level 1 validation opportunity to other regions and systems to continue to study the applicability of AWWA methodology to Washington utilities.
2. Informed by the phase 1 and phase 2 pilots, offer a statewide training and technical assistance program to utilities surpassing a defined size to teach AWWA water audit methodology and conduct standardized level 1 water audit validation.
3. Refine future education and technical assistance opportunities using lessons learned from the phase 1 pilot, phase 2 pilot, and statewide program.

Ultimately, a statewide technical assistance and reporting program could:

- Establish a distribution efficiency baseline for Washington using AWWA methodology and validated data
- Build technical, financial, and managerial capacity for all utilities
- Enhance utilities' understanding of their data sources, system performance, and cost-justified opportunities for water loss reduction
- Equip utility and state managers with the information necessary to adopt a proactive stance toward supply management and capital investment

Support: all pilot participants indicated that the workshops were a good use of their time and energy and were essential for learning to adopt a more rigorous leakage accounting methodology. Additionally, such training programs have proven successful in other states. For an example, visit www.californiawaterloss.org to learn more about the California Water Loss Technical Assistance Program that was funded using State Revolving Funds.

Validate All Water Audits Prior to Submission

Challenge: self-reported water audits are not always accurate, especially when a utility uses the AWWA methodology for the first time, and so the results may not truly capture utility performance.

Recommendation: require that all AWWA water audits are level 1 validated independently to improve accuracy and methodological standardization. In the first years of validation, consistency of validation is particularly important. The Department of Health should consider providing verified validators to utilities through a centralized validation program.

Support: pilot participants indicated that the validation interaction was beneficial. Additionally, the quality of the water audit inputs and outputs improved, since the basis for all audit inputs and data validity grades was discussed and documented.

Migrate from Leakage Percent to Leakage Volume

Challenge: leakage measured as a percentage has been deemed obsolete by industry leadership (e.g. the AWWA Water Loss Control Committee). Additionally, the percent leakage is unduly influenced by changes in customer

demand, since demand changes drive supply changes and therefore influence leakage percent when compared to supply.

Recommendation: for the first few years of AWWA water audit reporting, collect both percent leakage and real loss volume (total volume as well as the real loss volume normalized to service connections and normalized to length of mains) to evaluate performance. Once multiple years of validated water loss data has been submitted, work with stakeholders and experts to establish a leakage standard in volumetric terms instead of leakage percent. Additional guidance from the AWWA water loss control committee on effective volumetric real loss performance indicators is expected to be published in the next few years and could be incorporated into Washington's volumetric standards.

Support: tracking leakage in absolute (volumetric) terms enables more effective and cost-effective management. Additionally, pilot program participants indicated that the connection between the volume of leakage and its financial value that absolute metrics provide gave them necessary information for economically-optimized leakage management.

Appendix A: DSL Regulation in Washington

History

The Office of Drinking Water at the Washington Department of Health is tasked with protecting the health of the people of Washington state by ensuring safe and reliable drinking water. Water efficiency, including distribution system efficiency, contributes to drinking water reliability and therefore aligns with the Department of Health's goal. To this end, the Washington state legislature directed the Department of Health to adopt an enforceable water use efficiency program.

The Washington water use efficiency program, enacted in January 2007, consists of three annual tasks designed to develop long-term water supply and infrastructure stewardship:

1. Planning, including supply and consumption data collection, demand forecasting, and efficiency program design.
2. Distribution system leakage tracking and standards achievement
3. Goal setting and reporting

Requirements

To support planning, leakage management, and reporting, the Office of Drinking Water established a progressive implementation timeline lasting ten years. For municipal water systems serving 1,000 or more connections, the requirements included production meter and service meter installation, as outlined in () below.

Table 5: Water use efficiency plan requirements

Requirement	Deadline
Install production meters	January 2007
Include a water use efficiency program in planning documents	January 2008
Submit the first annual water use efficiency report	July 2008
Submit a service meter installation schedule	July 2008
Set system water use efficiency goals	July 2009
Meet the DSL standard *(calculated as a three-year rolling average)*	July 2010 *or three years after service meter installation*
Complete service meter installation	January 2017

The DSL standard for systems with more than 500 service connection is 10% or less. DSL is calculated as the difference between water supplied and authorized consumption divided by water supplied, though alternative methodologies of calculation can be approved. If a municipal water agency does not meet the DSL standard, penalties and/or required remediation may take effect.

Compliance

If a municipal water agency exceeds the DSL standard, the agency must develop and implement a water loss control action plan, including a water audit that accords with the methodology prescribed by the International Water Association and AWWA. The greater a utility's DSL, the more aggressive and prompt water loss control planning and implementation must be. At minimum, an agency's water loss control plan must include:

- Water loss control methods to be implemented
- An estimate of the time necessary to achieve DSL standard compliance
- A budget for water loss control activities
- Any technical or economic concerns that prevent compliance with the DSL standard

Appendix B: Water Audit Validation

According to Water Research Foundation(WRF) report 4639, "water audit validation is the process of examining water audit inputs to improve the water audit's accuracy and document the uncertainty associated with water audit data."

Water audit validation can be conducted at one of three levels. Each level corresponds with defined goals, methods, and effort. As WRF 4639 also points out,

- **Level 1 validated water audits** have been examined for inaccuracies evident in summary data and application of methodology. The data validity grades assigned to inputs accurately reflect utility practices.
- **Level 2 validated water audits** have been corroborated with investigations of raw data and archived reports of instrument accuracy. The best sources of data to inform the water audit have been identified
- **Level 3 validated water audits** have been bolstered by field tests of instrument accuracy. The water audit's estimate of Real Losses has been confirmed through pilot leak detection, Component Analysis of Real Losses, and/or minimum night flow analysis.

Water audits compiled by pilot program participants received level 1 validation. Level 1 validation aims to:

- Confirm the accurate application of American Water Works Association (AWWA) M36 water audit methodology and terminology to the utility-specific situation
- Identify evident inaccuracies and correct inaccuracies, where realistic
- Verify the selection of correct data validity grades

In meeting these goals, the level 1 validation process results in:

- Data validity grades that reflect utility practices
- Identification of macroscopic inaccuracies
- Recommendations for advanced validation activities

Level 1 water audit validation *does not*:

- Correct inaccuracies in raw data that may affect summary data and audit inputs
- Investigate data processing and handling to identify and correct inaccuracies
- Study instrument accuracy through field tests to improve the certainty of the water audit
- Corroborate the volume of real losses with bottom-up or field investigations of leakage

Level 1 water audit validation is accomplished through five steps:

1. Receive and review the water audit and supporting documentation listed at the bottom of this page.
2. Review performance indicators for evidence of inaccuracy.
3. Review audit inputs and data validity grades and confirm correct application of methodology in a level 1 validation interview. Adjust inputs and data validity grades if necessary.
4. Review performance indicators again for evidence of persisting inaccuracy.
5. Document results.

Appendix C: Pre-Workshop Data Request

Before the workshop, participants were asked to compile a water audit and specific supporting documentation. This data request is included below for reference.

- Timeframe for the data requested unless noted otherwise: **calendar year 2016** (January 2016 – December 2016).
- If something we ask for is not available – that's ok, just do your best!
- Format for the data requested: **Excel preferred**, scan or PDF if Excel format is not available.
- **Deadline** to provide the requested data: **Monday, February 12, 2018.**

1. Calendar year 2016 water audit, in AWWA Free Water Audit Software format (v5.0).
    - If you aren't already using the AWWA format, just do your best to complete the worksheet including inputs and data grades. The webcast, program team, and workshop will all incorporate software guidance.
    - If you also are tracking water loss in your own format, please provide that as well.
2. Water Supplied
    - Basic schematic showing where supply meters are located relative to distribution system, including any export or import meters, and pressure zones if applicable.
    - Inventory of your finished water meters, import water meters, and export water meters – size, type, and age.
    - Provide your current policy for flow testing and/or signal calibration of these meters, if you have one.
    - Provide all available records/reports/data from testing and/or calibration activities for each finished water and/or purchase meter.
    - Table of volume produced from own sources, by month, by finished water meter (if applicable)
    - Table of volume imported from another system(s), by month, by import water meter (if applicable)
    - Table of volume exported to another system(s), by month, by import water meter (if applicable)
3. Authorized Consumption
    - For billed water, provide volumes sold by charge code or account type, by month. Include key for charge codes or account types, if relevant.
    - For unbilled water, provide any available summary of tracking data such as flushing and fire estimates.
4. Apparent Loss
    - Any available customer meter testing results.
    - Provide your policy/practice for testing of customer meters, if you have one. Note if you have a different testing policy for large vs small meters.
    - Provide your policy/practice for customer meter replacement.
5. System data – as of today
    - Total miles of distribution main, including hydrant laterals
    - Number of active and inactive service connections.
    - General description of operating pressure – how many pressure zones and what are the ranges of pressure in each zone. Provide any available pressure data.
6. Cost data – for audit year only
    - Total annual operating cost for the water system, including admin (billing, management) and water debt service, excluding any costs associated with non-potable water (sewer, storm, etc).
    - Total *commodity* revenue (excluding base charges, consumption only) from water sales and sewer sales.
    - Total cost for power (supply and distribution), treatment chemicals, residuals management (if applicable).
    - Total cost for water purchases, if applicable.
    - Total cost for damages paid on claims resulting from main or service line breaks for the past 5 years.
    - Itemized depreciation schedule for water system pumping and treatment assets, if available.