System Optimization Review Plan

Elsinore Valley Municipal Water District

2020

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1 Executive Summary

Between September 2019 and October 2020, Elsinore Valley Municipal Water District (EVMWD) worked with Water Systems Optimization (WSO) to develop the following System Optimization Review Plan (SOR Plan). After conducting an initial baseline assessment of EVMWD's operational practices and leakage profile, the project team evaluated and prioritized opportunities to better assess and reduce water loss in the potable system. The primary results of that work are synthesized in this executive summary, while specific details about each opportunity are discussed in the remaining sections.

Water Loss Control at EVMWD

EVMWD's current operations and data management practices support tracking and managing real and apparent water loss (see Box 1 for definitions of these terms). Examples include:

- **Annual water auditing**: To meet regulations outlined in California Senate Bill 555, EVMWD conducts annual water auditing using standard American Water Works Association (AWWA) M36 methodology. The water audit is validated by a third-party each year and provides a high-level indication of water loss performance.
- **Efficient response to reported breaks**: Field staff respond to work orders related to reported breaks quickly and repair breaks effectively, minimizing leakage.
- **Source meter testing**: EVMWD conducts accuracy testing on active source meters in order to verify they are capturing production volumes correctly. Accurate production volumes are critical to reliable water auditing.
- **Customer meter testing and replacement**: EVMWD conducts accuracy testing on several hundred customer meters per year in order to inform replacement policies and estimate metering error for the annual water audit.

BOX 1. A QUICK INTRODUCTION TO WATER LOSS TERMINOLOGY

Water Loss
The difference between the total volume of water supply and the total volume of authorized consumption. Water loss is typically divided into two categories, ***real loss*** and ***apparent loss.***

Non-Revenue Water
Water for which EVMWD does not receive payment. Non-revenue water is similar to ***water loss***, but it also includes unbilled authorized uses such as firefighting and routine flushing to meet water quality regulations.

Real Loss
Physical loss of water from the system as a result of leaks, breaks, or spillage that occurs prior to the point of customer consumption. Real losses can be further broken down into smaller categories: background, reported, unreported, and hidden. Different intervention strategies are effective at reducing each of these categories.

Apparent Loss
Nonphysical losses that occur when water is successfully delivered to the customer but is not measured or recorded accurately. This can result from metering inaccuracies, unauthorized consumption (theft), or systematic data handling error.

Recent water audit results indicate that there is minimal leakage in EVMWD's potable system. Table 1 shows selected performance indicators from reporting years 2016-2018.

Table 1: Selected Water Audit Performance Indicators 2016-2018

Water Audit Performance Indicator	2016	2017	2018
Total water losses (AF)	1,676.2	1,189.8	1,338.0
Real losses (AF)	1,365.3	865.1	827.8
Cost of real losses	$1,353,053	$840,918	$977,583
Real losses per connection per day (gal)	27.7	16.9	16.0
Apparent losses (AF)	310.9	324.6	510.2
Cost of apparent losses	$375,103	$419,987	$671,206
Apparent losses per connection per day (gal)	6.3	6.3	9.9
Infrastructure Leakage Index (ILI)	1.38	0.85	0.81

From 2016-2018, real loss averaged 20.1 gal/connection/day, which is substantially lower than the California state median over the same time period, approximately 25 gal/connection/day. Such low levels of loss are encouraging and reflect EVMWD's ongoing operational and data management practices to track and manage water loss.

However, the recent value of one performance indicator, the Infrastructure Leakage Index (ILI), indicates that EVMWD should take steps to verify its low loss audit results. The ILI is an indication of how well a utility is controlling leakage given its unique system characteristics (i.e. length of mains, number of service connections, and level of pressure). A lower value indicates less leakage and a higher value indicates more leakage. A value of 1.0 represents the "modeled technical minimum" achievable leakage, assuming best operational practices are maintained. Therefore, any value under 1.0 means that a utility is experiencing less leakage than is technically achievable according to an industry standard model. In 2017 and 2018, EVMWD's ILI fell below 1.0. While this is not impossible, it emphasizes the need to verify recent performance through continued auditing with increasingly accurate data.

The California State Water Resources Control Boards (SWRCB) is using the audit results presented in Table 1 to determine EVMWD's upcoming volumetric performance standard. The SWRCB is doing the same for all urban retail water suppliers in California with more than 3,000 service connections or that produce 3,000 AF of water annually. In other words, performance standards will be unique to each utility and based on their recent audit results. Although these standards are not finalized, at the time of writing (September 2020) EVMWD will be required to maintain its current level of loss (20.1 gal/connection/day) beginning in 2028. This makes it a critical time for EVMWD to keep focus on minimizing water loss in the distribution system.

System Optimization Review Plan

The SOR Plan is an important resource that will guide EVMWD's future water loss control efforts. The projects featured in the Plan have three primary goals:

1. **Increase confidence in water loss assessment**: The annual water audit requires complete, consistent, and accurate data sources to provide reliable assessments of water loss over time. With this in mind, many projects in the SOR Plan focus on improving data collection, management, and reporting practices.
2. **Determine efficiency of leakage reduction strategies through pilot programs**: Industry standard models such as real loss component analysis indicate that EVMWD does not have recoverable leakage (Section 2.2). This makes it challenging to project potential savings of specific intervention strategies. Despite this, the SOR Plan features several pilot projects that can help field validate EVMWD's low leakage while simultaneously determining which strategies are most efficient for EVMWD operations.
3. **Prepare for state regulatory requirements**: The current draft performance standards set by the state of California do not require EVMWD to reduce water losses—just maintain them at current levels. The SOR Plan will help ensure EVMWD does not lose ground before these standards take effect in 2028. In addition, it serves as documentation of existing and future efforts at EVMWD to minimize water losses.

Table 2 presents the final list of prioritized recommendations with a proposed timeline for implementation. Each recommendation represents a discrete project that EVMWD can implement to optimize operations and data management for water loss tracking and reduction. Each project is categorized into one of four areas: Water Audit Data Improvements, Source Meters, Customer Meters, or Leakage. Projects are color coded to indicate if they focus on water loss assessment or reduction. Both assessment and reduction are critical for controlling real and apparent water loss (Section 2.4).

The remainder of the SOR Plan is divided into six additional sections. The *Background* section describes the various phases of the project, the regulatory context in California, more information about EVMWD's past water loss performance, and a discussion about the importance of both assessment and reduction efforts. The next four sections describe specific optimization actions categorized by the major topic areas. Finally, the *Conclusion* section discusses the future of the SOR Plan and briefly discusses funding mechanisms.

Figure 1: Railroad Canyon Reservoir (Canyon Lake)

Table 2: EVMWD System Optimization Review Plan Implementation Timeline

Area	Optimization Project	Cost	Effort	2021	2022	2023	2024	2025	2026	2027	2028
Water Audit Data Improvements	Create single repository for source and customer meter testing and calibration results	*	**								
	Review AMI data handling process and procedure	*	*								
	Standardize audit compilation with written documentation	*	**								
	Improve cross-departmental communication related to water loss metrics and opportunities	*	**								
Source Meters	Reaffirm annual source meter accuracy testing policy	**	**								
	Reaffirm annual source meter calibration policy	**	**								
	Integrate source meters with AMI	****	****								
	Conduct source meter inventory and assessment	*	**								
	Install source meter at Temescal Valley Pipeline (TVP)	****	****								
Customer Meters	Shift to revenue-based large customer meter accuracy testing	*	**								
	Conduct flow profiling on large customer meters	**	**								
	Shift to random and representative small customer meter accuracy testing	***	**								
	Identify failing customer meters on closed accounts	*	*								
Leakage	Enhance work order data to support water loss analysis (adjust current system or implement new one)	* / ****	** / ****								
	Pilot satellite leak detection	**	***								
	Pilot transient monitoring	**	**								
	Pilot district metered areas (DMA) using booster stations	***	***								
	Look for opportunities to optimize pressure when operationally feasible	*	**								

Improved Assessment   Water Loss Reduction

**Lighter shade indicates reduced effort*

2 Background

2.1 Project Overview

In June 2018, Elsinore Valley Municipal Water District (EVMWD) completed a Water Conservation Business Plan that outlined a number of cost-effective water conservation projects. Among the recommendations was the development of a System Optimization Review Plan (SOR Plan) intended to investigate current water loss levels and identify opportunities for leakage reduction. Soon after publication of the Business Plan, EVMWD received funding to complete the proposed SOR Plan through the US Bureau of Reclamation's Water Conservation Field Services grant.

Between September 2019 and September 2020, EVMWD worked with Water Systems Optimization (WSO) to develop the SOR Plan, which is presented here. In addition to WSO, the core project team included staff from EVMWD's Operations and Water Resources Planning departments. Staff from other departments contributed significant time and effort to the project as it progressed through four distinct phases of work:

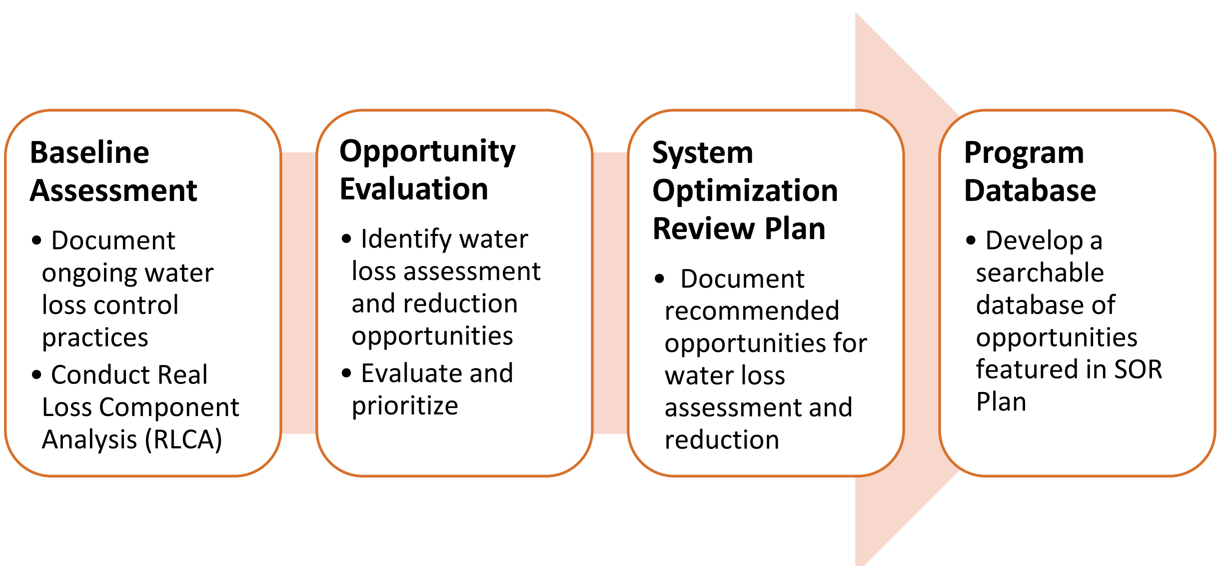

Figure 2: Summary of Project Elements

1.1.1 Baseline Assessment

To begin, the project team conducted a baseline assessment of the potable water system that focused on existing system characteristics, data management practices, and water loss control efforts. The assessment identified an initial set of opportunities to consider by comparing current operations with industry best practices and provided context for discussion during later stages of the SOR Plan development.

The team also completed a Real Loss Component Analysis (RLCA) during this phase, which is an analytical exercise that uses the results of the annual water audit, work order data, and proactive leak detection findings to establish a unique profile of real loss (leakage) in a system. The results of the RLCA are discussed in Section 2.3.

1.1.2 Opportunity Evaluation

Staff from many departments participated in a series of meetings led by the project team to evaluate opportunities for improved water loss assessment and reduction. First, participants gave their initial feedback on the list of opportunities created during the baseline assessment work. Opportunities were categorized in one of four topic areas: Water Audit Data Improvements, Source Meters, Customer Meters, and Leakage (Figure 3).

Water Audit Data Improvements
Projects related to improving processes and procedures used to ensure timely, consistent, and accurate water auditing each year.

Customer Meters
Projects related to verifying the accuracy of customer meters to reduce apparent loss.

Source Meters
Projects related to ensuring proper maintenance and performance of source meters.

Leakage
Projects related to work order data management and leakage identification and reduction.

Figure 3: Opportunity Topic Areas

In subsequent meetings, participants discussed the evaluation criteria presented in Table 3. The core project team used the group's assessment of these criteria to select the final opportunities and implementation timeline presented in this report.

Table 3: Evaluation Criteria for Optimization Projects

Evaluation Criteria	Description
Potential Water Loss Impact	Each project is intended to either improve the assessment of water loss or reduce it directly. In some cases, both goals can be achieved simultaneously. o *Assessment:* These projects focus on improving data sources and processes used to estimate and track water loss over time. Accurate water loss assessment is critical for determining cost-effective intervention strategies and evaluating success. o *Reduction:* These projects focus on reducing apparent and real loss directly, such as through proactive leak detection or pressure optimization. For EVMWD, it is particularly difficult to evaluate potential leakage reduction because industry standard models indicate there is no leakage to recover (Section 2.2).
Roles and Responsibilities	The departments and staff who would help implement the project, as well as the short- and long-term responsibilities they would have.
Effort	A preliminary indication of the level of effort needed to implement the project, including planning, execution, and maintenance. Effort was assessed on a scale of 1-4 and is represented with asterisks (*) in this report. Projects with minimal anticipated effort were assigned a 1 (*) and projects with very high anticipated effort were assigned a 4 (****).
Costs	A preliminary indication of how much the project would cost to implement. Cost was assessed on a scale of 1-4 and is represented with asterisks (*) in this report. Projects with minimal anticipated cost were assigned a 1 (*) and projects with very high anticipated cost were assigned a 4 (****).
Obstacles for Implementation	Anything that would present a challenge to successful implementation (e.g. staff capacity issues, incompatible systems).
Ongoing Activity	Any ongoing activities at EVMWD related to the project that could be integrated or built on.

1.1.3 Optimization Review Plan

Following evaluation and prioritization, the project team formally documented each opportunity in this report. These opportunities are specific projects that EVMWD can implement to achieve accurate water loss assessment and reduction. The SOR Plan presents a prioritized timeline for these projects (Table 2) and includes relevant context and implementation guidance.

The projects featured in the SOR Plan have three primary goals:

4. **Increase confidence in water loss assessment**: The annual water audit requires complete, consistent, and accurate data sources to provide reliable assessments of water loss over time.
5. **Determine efficiency of leakage reduction strategies through pilot programs**: Industry standard models such as real loss component analysis indicate that EVMWD does not have recoverable leakage (see Section 2.2). This makes it challenging to project potential savings of specific intervention strategies. Despite this, the SOR Plan features several pilot projects that can help field validate EVMWD's low leakage while simultaneously determining which strategies are most efficient for EVMWD operations.
6. **Prepare for state regulatory requirements**: The current draft performance standards set by the state of California do not require EVMWD to reduce water losses—just maintain them at current levels. The SOR Plan will help ensure EVMWD does not lose ground before these standards take effect in 2028. In addition, it serves as documentation of existing and future efforts at EVMWD to minimize water losses.

1.1.4 Project Implementation Masterfile

In the last phase of work, the project team developed a Project Implementation Masterfile, which is a Microsoft Excel workbook that summarizes the recommendations described in the SOR Plan. It will serve as a "one-stop-shop" for information about EVMWD's water loss control projects and generally has four primary goals:

1. **Project inventory**: List all recommendations from the SOR Plan
2. **Water Loss Context**: Describe why each project is important for water loss control
3. **Implementation Guidance**: Points of emphasis for successfully implementing each project and managing related data
4. **Status**: Report the current status of each project (see Section 7 for more information)

2.2 Past EVMWD Water Loss Performance

EVMWD has submitted water audits every year since 2017 as required by California Senate Bill 555. A water audit is an accounting exercise used to systematically track all sources and uses of water in a distribution system. By comparing the volume of water produced to the volume of water consumed and adjusting for known errors, it provides a "top-down" evaluation of water loss, non-revenue water, and overall system efficiency.

Recent water audit results indicate that there is minimal leakage in EVMWD's potable system. From 2016-2018, real loss averaged 20.1 gal/connection/day, which is substantially lower than the California state median over the same time period, approximately 25 gal/connection/day (Figure 4).

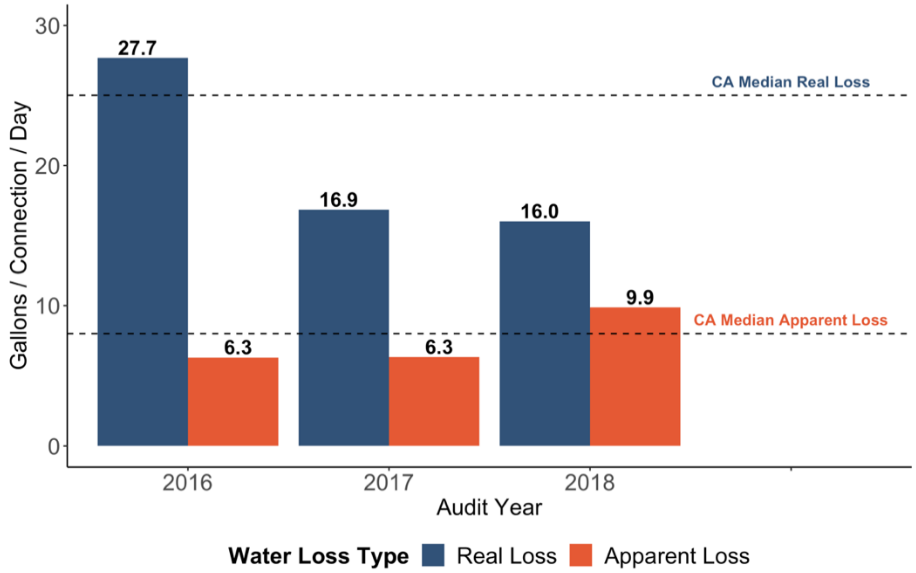

Figure 4: Real and Apparent Loss 2016-2018 Compared to California Median

Figure 4 also shows a substantial drop in real loss from 2016 to 2017-18. Although it is difficult to identify specific operational changes that would account for this change, the data shows that the volume of billed metered authorized consumption (BMAC) increased approximately 1,000 AF between 2016 and 2017, while water supply only increased half as much. During this time, EVMWD was completing its transition to advanced metering infrastructure (AMI), which may have improved its ability to accurately summarize annual BMAC.

In the two most recent audit years, the estimated volume of system leakage fell below the modeled technical minimum, as indicated by an infrastructure leakage index (ILI) less than 1 (Table 4). This modeled technical minimum, known as the Unavoidable Annual Real Loss (UARL), is calculated with equations published in AWWA M36 that assume a certain amount of leakage per mile of main and service connection. The UARL attempts to estimate the lowest achievable level of real losses for systems operated with “best practice” leakage management and with infrastructure in generally good condition.

Table 4: Selected Water Audit Performance Indicators 2016-2018

Water Audit Performance Indicator	2016	2017	2018
Total water losses (AF)	1,676.2	1,189.8	1,338.0
Real losses (AF)	1,365.3	865.1	827.8
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Apparent losses per connection per day (gal)	6.3	6.3	9.9
Infrastructure Leakage Index (ILI)	1.38	0.85	0.81

Part of the UARL is used in a real loss component analysis (RLCA), which is an analytical exercise that breaks down the total volume of real loss (as determined by the annual water audit) into four separate categories of leakage:

- **Background Leakage:** Leaks of low flow rates, continuously running, and not discoverable by leak detection. Typically composed of pinholes and minor leaks at pipe joints and fittings.
- **Reported Leakage:** Leaks reported by the public or utility staff. Generally high flow rate and of relatively short duration. This is volume of water is typically determined using work order data and the estimation technique described previously.
- **Unreported Leakage**: Leaks discovered through proactive leak detection.
- **Hidden Leakage:** Leaks that have not yet been discovered. Generally moderate flow with average runtimes dependent on the intervention practices of the respective utility.

The categories of background, reported, unreported and hidden leakage were defined to describe types of real loss that can be recovered using specific intervention strategies (Figure 5). For example, the principal recovery strategy for unreported and hidden leaks is proactive leak detection. Notably, all forms of real loss can be recovered through strategic pressure management because leak incidence and flow rate are highly related to pressure dynamics in water distribution systems. This leakage framework is a useful guide for planning future water loss reduction strategies.

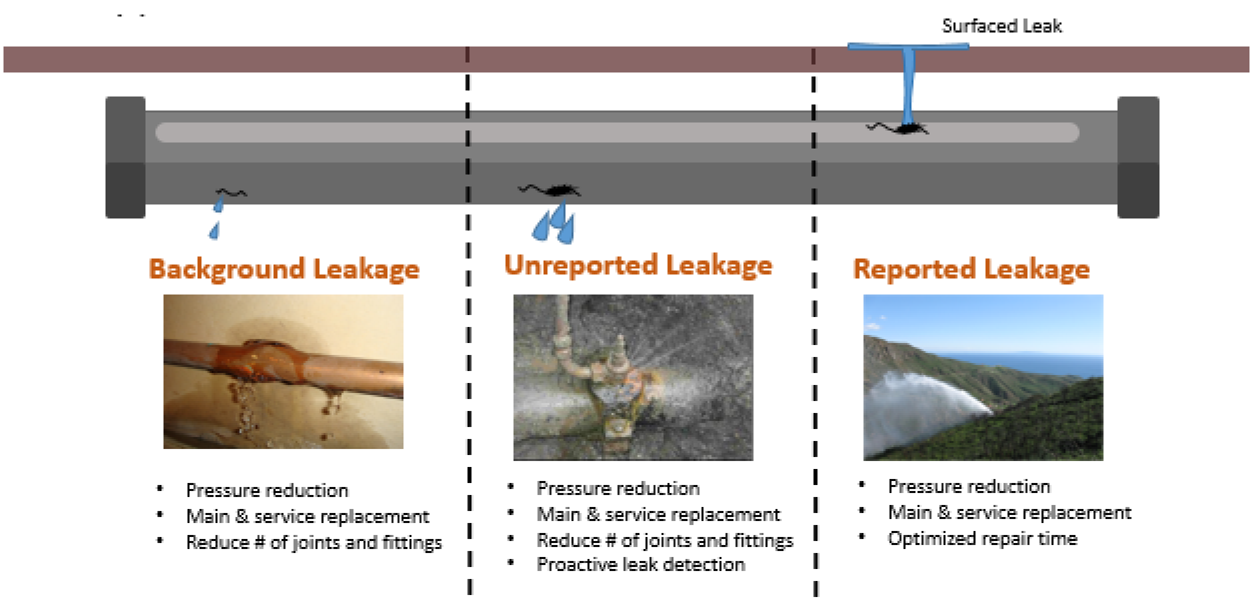

Figure 5: Types of real loss and their typical intervention strategies

The project team conducted a RLCA on EVMWD's CY2018 audit results during the baseline assessment phase. Table 5 presents the results of that analysis:

Table 5: CY 2018 Real Loss Component Analysis (RLCA) Results

	Category of Real Loss	*Data Source*	*Volume (AF)*
A	Reported loss	Work order records	256.0
B	Unreported loss	Proactive leak detection results[1]	0.0
C	Background loss	AWWA M36 UARL model	747.4
D	Hidden loss	E – (A + B + C)	-175.6
E	**Total volume of real loss**	CY2018 Audit	**827.8**

The volume of hidden loss in CY2018, which represents leakage that is potentially recoverable using active leakage control strategies, is a negative volume (Table 1). This is the unrealistic but expected result when the volume of background and reported leakage is higher than the total volume of real losses determined by the annual water audit.

There are two possible explanations for the low losses shown by recent water audits and negative losses shown by the 2018 RLCA:

- **Variable Data**: The annual water audit requires complete, consistent, and accurate data sources to provide reliable assessments of water loss. It is possible that inaccurate assessments of source meter and customer meter error, for example, are producing water audits that are under-estimating leakage.
- **Unique System Characteristics**: EVMWD may exhibit unique system characteristics that prevent the UARL model (and therefore, the RLCA results) from accurately estimating hidden leakage in the system.

Given these two possibilities, the SOR Plan features projects that focus on (1) better assessment of water loss and (2) leakage reduction pilots that will field validate EVMWD's low leakage while simultaneously determining which strategies are most efficient for EVMWD operations. This multi-faceted approach will improve EVMWD's understanding of system water loss and help ensure it meets upcoming state regulatory requirements.

[1] EVMWD did not conduct proactive leak detection in 2018

2.3 California Regulatory Context

The most recent draft proposal from the SWRCB for water loss performance standards set volumetric limits to real loss for each utility that they must meet beginning in 2028[2]. Limits are determined using an economic model that incorporates average audit results and other parameters between reporting years 2016-2018 (i.e. the values presented in Table 1). At the time of writing (September 2020), EVMWD will be required to maintain its current level of loss (20.1 gal/connection/day) beginning in 2028.

Although the standards do not prescribe specific intervention strategies to achieve compliance, the economic model does assume a default manual acoustic leak detection frequency when calculating each limit. If the 30-year net present value (NPV) of that strategy is positive, the utility's target is equal to the modeled level of leakage in 2026, assuming the assigned leak detection frequency. If the NPV is negative, the utility's target is equal to its 2016-2018 levels.

For the purposes of the SWRCB model, EVMWD's assumed survey frequency is 36 miles per year, given the length of mains in the system. At that frequency, the 30-year NPV is negative and therefore EVMWD has been assigned its current leakage level of 20.1 gal/connection/day.

Even though EVMWD is not required to lower its overall real losses, the SOR Plan will help ensure EVMWD does not lose ground before these standards take effect in 2028. In addition, it serves as documentation of the existing and future efforts at EVMWD to minimize water losses.

More specific information about upcoming regulations is included in subsequent sections, where relevant.

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[2] The latest information about these standards can be found here: www.waterboards.ca.gov/water_issues/programs/conservation_portal/water_loss_control.html

3 Water Audit Data Improvements

EVMWD conducts annual water auditing using the standard American Water Works Association (AWWA) M36 methodology. A water audit is an accounting exercise used to systematically track all sources and uses of water in a distribution system. By comparing the volume of water produced to the volume of water consumed and adjusting for known errors, it provides a high-level evaluation of water loss, non-revenue water, and overall system efficiency.

2020 marks the fourth consecutive year that EVMWD has submitted a validated water audit to the California Department of Water Resources. As EVMWD continues to build its record of audit results, there will be an ever-increasing opportunity to identify trends in real and apparent loss over time. However, high quality data and consistent methodology for calculating audit inputs are critical for reliable performance indicators. Without these, it is difficult to determine whether observed trends are the result of actual changes in water loss (e.g. due to intervention efforts) or the result of poor data or methodological changes.

The opportunities featured in this section are specific projects that EVMWD can pursue to improve data sources and increase its confidence in the annual water audit and advanced analysis such as a Real Loss Component Analysis (RLCA).

BOX 2. REGULATORY CONTEXT: WATER AUDIT DATA IMPROVEMENTS

EVMWD is currently required to submit a validated water audit each year to the state of California, as outlined in Senate Bill 555. Pending regulations will establish utility-specific performance standards that set volumetric standards to real loss beginning in 2028. The SWRCB has developed an economic model that uses average water audit results from 2016-2018 (as well as many other assumptions and parameters) to set these limits. Future water audit results will be used to determine compliance with standards.

Ahead of these new regulations, EVMWD should focus on improving water audit data as much as possible in order to accurately track trends in water loss. Reliable water audit results will allow EVMWD to identify changes in real loss and take steps to intervene.

3.1 Create single repository for source and customer meter testing and calibration results

CURRENT OPERATIONS

EVMWD oversees annual source meter accuracy testing and electronic calibration (see Sections 4.1 and 4.2), which is conducted by a third-party. After performing the test and/or calibration, the tester issues an accuracy report which is typically in portable document format (PDF). Reports are stored on EVMWD's network as stand-alone files and retrieved when necessary.

EVMWD also conducts annual customer meter accuracy testing (see Section 5.3) to determine overall population health and guide replacement efforts. Operations staff perform small meter tests using a modern test bench and a third-party performs large meter tests (3" and larger) in the field. EVMWD staff enter small meter results into CIS using mobile data collection software called Field Mapplet. Third-party testers issue large meter results which are compiled in a master spreadsheet.

For the annual water audit, EVMWD uses customer meter test results each year to calculate overall customer meter inaccuracy. However, source meter test results have only been used twice in the past four years to calculate master meter supply error adjustments (MMSEA).

OPTIMIZATION PROJECT

Create a single repository in CIS for accuracy and electronic calibration results for both source and customer meters. Table 6 outlines the departmental actions and other considerations for this project:

Cost	*
Effort	**
Impact type	Assessment

Table 6: Departmental involvement in project 3.1

	Customer Service (Billing)	Information Technology	Operations
Actions	Assign account number to each source meter in CIS, which will allow testing and calibration results to be associated with specific meters.	Update database structure to accommodate testing and calibration fields.	Input both internal and third-party testing and calibration results into CIS.
Considerations	This is also necessary for integrating source meters into AMI (Section 4.3)	Formatting of results (e.g. new contractor) may be different in the future.	Data collection templates may be provided to third parties

EVMWD should consider the different formats of tests and calibration documents when determining how to store results in the CIS. Although results should reside in a single database (i.e. CIS), that does not mean they need to be stored in the same table. Different table designs will allow for EVMWD to account for differences in testing and calibration protocols. For example, while large meter test results can feature an "as-left" value, small customer meters are scrapped after testing and therefore do not have such a value. Tables 7, 8, and 9 show example table formats for source, large customer, and small customer accuracy test results.

Table 7: Example of simplified test result table for source meters

Date	Nickname	Meter ID	Size (In)	Flow (gpm)	Accuracy	Make…
10/1/20	Back Basin WTP	BWTP16	16	7500	95.80%	…
10/1/20	Back Basin WTP	BWTP16	16	8000	97.86%	…
10/1/20	Back Basin WTP	BWTP16	16	8700	98.92%	…
10/1/20	Corydon Well	CW12	12	1600	100.05%	…

Table 8: Example of simplified test result table for large customer meters

Date	Meter ID	Size (In)	Flow (gpm)	Accuracy (As Found)	Accuracy (As Left)	Make…
10/1/20	HIJ123	3	40	95.80%	-	…
10/1/20	HIJ123	3	80	96.86%	99.73%	…
10/1/20	NOP345	6	75	99.12%	-	…
10/1/20	NOP345	8	125	99.62%	-	…

Table 9: Example of simplified test result table for small customer meters

Date	Meter ID	Size (In)	Low GPM	Mid GPM	High GPM	Low GPM Accuracy	Mid GPM Accuracy	High GPM Accuracy	Overall Accuracy	Make…
10/1/20	AB2	0.625	0.25	2	15	95.71%	98.54%	98.84%	98.16%	…
10/1/20	BC3	0.625	0.25	2	15	96.88%	98.56%	99.24%	98.41%	…
10/1/20	CE5	0.625	0.25	2	15	94.89%	97.65%	99.95%	97.58%	…
10/1/20	D46	0.75	0.25	2	15	96.34%	97.80%	99.11%	97.78%	…

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by consolidating the storage of meter accuracy and calibration results so they can readily be used in water loss auditing and analysis. Adjustments to water supply (via MMSEA inputs) and the estimate of customer meter inaccuracy can have substantial impacts on performance indicators and therefore it is critical that EVMWD pay particular attention to these entries. Dedicating a portion of the CIS database for this purpose is one way to encourage EVMWD to incorporate their test results each year.

Converting third-party PDF results to tabular form in a database will allow for clearer visualization of year to year trends and highlight which meters need greater attention. In addition, storage of results in a single database will make it simpler to run specific data queries for accurate calculation of source meter error and customer meter inaccuracy each year. Finally, it will simplify the process of providing data to third parties who can run additional analysis on test results.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

3.2 Review AMI data flow

CURRENT OPERATIONS

EVMWD meters all customers in its service area and bills them according to consumption. 100% of customer meters are equipped with advanced metering infrastructure (AMI), a technology that transmits consumption data to a central database using a cellular network. Figure 6 illustrates how data moves from the customer meter to a summary figure used in the annual water audit:

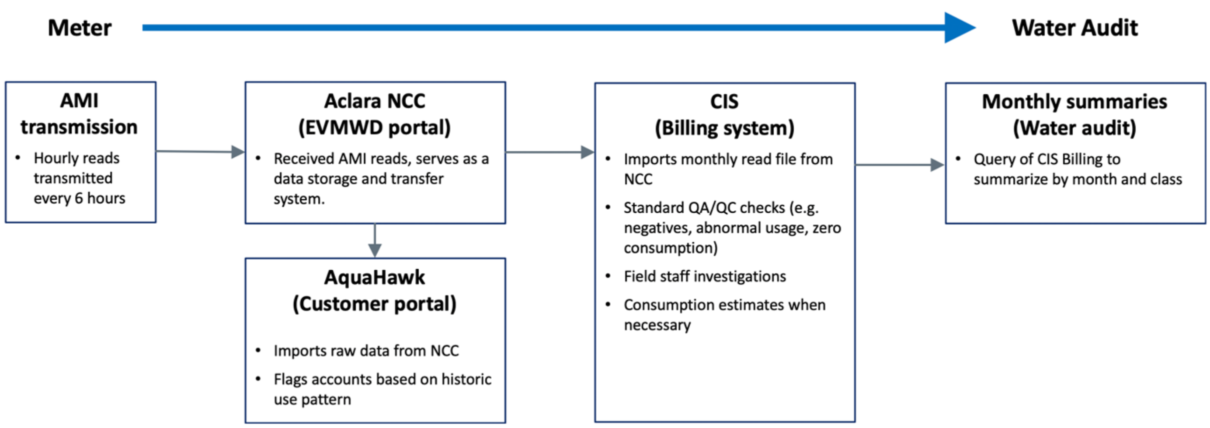


Figure 6: Customer meter data flow from meter to audit

EVMWD's CIS billing system is set up with standard quality assurance and control (QA/QC) checks to automatically flag problems such as negative consumption, abnormal usage, and consecutive zero reads. Although protocols exist for staff to handle these exceptions in a timely manner, there is no formal documentation of the steps.

OPTIMIZATION PROJECT

Cost	*
Effort	*
Impact type	Assessment

Review and document the processes and procedures related to how data is transferred from the customer meter to the annual water audit as well as how exceptions are handled. Table 10 outlines the departmental actions and other considerations for this project:

Table 10: Departmental involvement in project 3.2

	Customer Service (Billing)	Information Technology	Operations
Actions	Participate in periodic (e.g. bi-annual) meetings with representatives from key departments that interact with software in the data transfer process.		
Considerations	As source meters are integrated into AMI, it will be important to include them in the review process.		

One product that can simplify the data handling review is a process map. Process maps provide an excellent way to explicitly define the relationships between people, hardware, software, and the movement of data between them. The visual nature of process maps makes them particularly effective at highlighting potential data gaps and misunderstandings of procedure. The following list describes some specific issues the review team should consider when creating such a process map:

- **AMI endpoint connectivity**: Lapses in connectivity can prevent the AMI endpoint from successfully transmitting data to Aclara NCC. The review team should assess actual connectivity as compared to vendor specifications and verify that the proper usage is transmitted after communication is reestablished.
- **Estimation Protocols**: In cases when a faulty meter prevents tracking water use (e.g. stuck meter, cut wire), EVMWD staff estimate consumption and alter the read in CIS. The review team should assess this manual process of estimation and database editing to ensure it is consistency applied.
- **Meter Changeouts and Rollovers**: When a problematic meter is replaced or when a meter rollover occurs, Aclara NCC or CIS may record this in unexpected ways. For example, two reads might be recorded—one for the last read of the old meter, and one for the first read of the new meter—that over- or under-report actual consumption. EVMWD should carefully examine these situations to ensure that consumption is accurately recorded.
- **Farm Mutual Water Company:** Starting in 2018, EVMWD reclassified its single wholesale connection (Farm Mutual Water Company) as billed metered authorized consumption. The review team should make sure that this is accurately reported in the water audit (e.g. it is included the BMAC summary).

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by ensuring accurate reporting of billed metered authorized consumption. As one of the largest inputs in the water audit, any errors will have a relatively large impact on the accuracy of the water balance and the calculation of real losses. The relative complexity of EVMWD's data handling process makes it important to review on regular basis.

Process maps can be especially helpful for highlighting how water consumption data moves from the customer meter to the annual water audit. Water audits compare volumes of water supply and consumption to estimate water losses. However, the summary reports used to calculate volumes for the water audit are several steps removed from the original source of data—the meters themselves. Therefore, process maps can identify areas for investigation if there is reason to believe that summary reports are not capturing all volumes of production and consumption.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

Relevant staff should meet every other year to review and adjust AMI data transfer documentation. More regular reviews are probably necessary because most technologies and processes will not change very frequently.

3.3 Standardize annual audit compilation

CURRENT OPERATIONS

Each year, a single staff member leads the compilation of the water audit. Mostly, this involves calculating specific inputs or contacting other staff members directly for their assistance. Although EVMWD has successfully compiled its audit each year in a timely manner, there is no formal documentation of the steps.

OPTIMIZATION PROJECT

Standardize the compilation of EVMWD's annual water audit to ensure efficient and consistent analysis. Table 11 outlines the departmental actions and other considerations for this project:

Cost	*
Effort	**
Impact type	Assessment

Table 11: Departmental involvement in project 3.3

	Operations	Customer Service (Billing)	Information Technology	Engineering	Finance
Actions	Review inputs: • Supply and authorized consumption volumes • Testing and calibration adjustments	Review inputs: • Billing estimates and adjustments	Review inputs: • Length of mains and hydrants laterals (GIS) • Count of service connections	Review inputs: • Average operating pressure	Review inputs: • Variable production cost • Customer retail unit cost • Total annual operating cost
Considerations	No other considerations				

The following describes two ways that EVMWD can standardize the audit compilation process:

- **Standard Operating Procedures (SOP)**: EVMWD could outline the data and calculations required to derive each input in the water audit. This could take several forms:
    - *Bullet points*: The quickest way to explicitly document the most important elements
    - *Process map*: A visual description of the people, processes, and software involved
    - *"One-pagers"*: Reference sheets with narrative descriptions
- **Water Audit Handbook**: This is a single document that guides annual water auditing that may include the following elements:
    - *Roles and responsibilities*: Which people and/or departments are responsible for each input
    - *Data and calculations*: Location (e.g. internal network) of data and what specific calculations are needed to prepare the data for the audit. This section could include tips about how to do this efficiently or warnings about potential challenges.

- *Historic values*: Past performance indicators and input entries. Seeing previous input entries could be especially helpful for validating inputs and ensuring consistency year to year.
- *Regulatory context*: Any additional considerations for the audit related to current or upcoming state regulations.

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by producing formal documentation of the data and calculations necessary to compile an accurate water audit each year. Documentation that is carefully developed and periodically reviewed will reduce the time necessary to complete the water audit, encourage a distribution of work so no one team member is held responsible, and protects against loss of knowledge due to staff turnover.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

Depending on the scale of implementation EVMWD chooses to pursue (e.g. bullet points vs water audit handbook), it may take several years to document the data and calculations required for all audit inputs. After this initial push, EVMWD should periodically review its documentation to ensure it is up to date.

3.4 Improve cross-departmental communication related to water loss

CURRENT OPERATIONS

Operations staff send monthly water loss totals throughout the organization. In addition, water loss related topics are sometimes discussed at the monthly "Regular Engineering and Operations Committee Meeting."

OPTIMIZATION PROJECT

Take additional steps to improve cross-departmental communication related to water loss. Table 12 outlines the departmental actions and other considerations for this project:

Cost	*
Effort	**
Impact type	Assessment

Table 12: Departmental involvement in project 3.4

	Coordinating Department	Other Departments
Actions	Coordinate water loss updates and/or meetings	Review, attend, or contribute to water loss updates
Considerations	For some departments, it may be difficult to find meaningful contributions each time. In these cases, the coordinating department should make a concerted effort to highlight how those departments are still connected to water loss and how their attention and contributions are important for the organization's success.	

The following describes two ways that EVMWD can improve its cross-departmental communication related to water loss:

- **Key performance indicator (KPI) updates:** Develop KPI goals, track progress towards meeting them, and regularly update the organization. Examples include real loss per connection per day, break response times, and source meter tests. These updates could be added to the existing monthly water loss report or discussed at dedicated meetings (see next bullet).
- **Regular meetings:** With representation from relevant departments, EVMWD could discuss water loss activities and updates

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by encouraging proactive thought, tracking, and coordination related to water loss activities. Possible outcomes of these efforts include:

- **Combating "brain drain":** Through regular information updates and discussion, water loss will remain in continuous focus for EVMWD staff. Rather than revisiting water loss concepts once a year during audit season, relevant staff will be prepared to gather data, generate new ideas, and implement water loss control projects without overlooking important details.

- **Shared vocabulary**: As staff become more accustomed to water loss terminology, it will become easier to discuss water loss topics. Ultimately, this will better prepare them to contribute to the annual water auditing effort.
- **New relationships and ideas**: By maintaining cross-departmental engagement, there will be more opportunities for staff to meet and interact when they typically would not during their day-to-day routines. This will cultivate new working relationships and stimulate new ideas for how to address water loss.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

EVMWD should encourage cross-departmental communication as a regular and continuous practice.

4 Source Meters

Source meters are some of EVMWD's most critical assets because they are responsible for tracking production volumes from wells and water treatment plants, purchased water at import connections, and wholesale water leaving the system. These volumes represent the foundation of the annual water audit—any error in this volume has a cascading effect that reduces the reliability of all performance indicators.

The opportunities featured in this section are specific projects that EVMWD can pursue to maintain accurate source meters and improve production data flows.

BOX 3. REGULATORY CONTEXT: SOURCE METERS

The most recent draft proposal for California state water loss performance standards requires suppliers to answer a short questionnaire related to apparent losses by 2024. Source meters are referenced in the following questions:

- How much of your agency's source water is metered?
- Does your agency have a program for regular flow testing of its production and source meters?
- On average, how frequently are source meters installed in your system flow tested, to determine accuracy?
- Does your agency have a program for regular electronic calibration of source meters?
- How frequently are source meters installed in your system electronically calibrated?

EVMWD will not be required to implement specific source meter maintenance practices.

As an alternative to answering questionnaires, suppliers can apply for an "off-ramp" that allows them to simply maintain their current levels of real loss rather than reduce them. With respect to source meter maintenance, qualification for the off-ramp requires that suppliers:

- Meter 100% of volume from own sources, imported, and exported water
- Perform annual testing of volume from own source meters that measure at least 95% of total production if this volume is greater than 5% of total water supply
- Perform annual calibration of import meters that measure at least 95% of total imports if this volume is greater than 5% of total water supply
- Perform annual testing of export meters that measure at least 95% of total exports if this volume is greater than 5% of total water supply

As the proposal stands, EVMWD cannot qualify for the off-ramp even if it met all requirements because its three-year average between reporting years 2016-2018 was above the threshold of 10 gal/connection/day.

4.1 Reaffirm annual source meter accuracy testing policy

CURRENT OPERATIONS

EVMWD oversees annual third-party source meter accuracy testing. Accuracy testing is distinct from electronic calibration (see Appendix B) and typically performed using either a comparative meter (e.g. Pitot tube) or a volumetric displacement method (a "drop test"). Meters are tested on site in order to replicate normal operations and verify proper piping conditions. EVMWD escorts the third-party tester to each meter site and coordinates with production staff to obtain proper flows for each meter. Once testing is finished, the tester issues an accuracy report with all test results across multiple flows and makes recommendations based on these findings.

In recent years, operational circumstances (e.g. wells shut down for maintenance) and contractor scheduling conflicts have prevented consistent testing for all source meters each year. Additionally, test results are stored in PDF format that is difficult to query.

OPTIMIZATION PROJECT

Cost	**
Effort	**
Impact type	Assessment

Reaffirm annual source meter accuracy testing policy to ensure that meters are accurately capturing production volumes. This includes both EVMWD maintained meters and meters at import connections. In addition to the standard documentation provider by the third-party tester with all available details (e.g. PDF of results), EVMWD should also request simplified results in tabular form to make it more convenient to archive in a database. See Table 7 in Section 3.1 for an example of what this table could look like. Table 13 outlines the departmental actions and other considerations for this project:

Table 13: Departmental involvement in project 4.1

	Operations
Actions	• Collect historic results to determine testing schedule for each source meter, including those at import connections (TVP and AVP) • Establish updated testing schedule for all source meters • Coordinate with third-party tester to setup and run tests • Identify alternative testing contractors to serve as backup
Considerations	Results from tests will ideally be stored in a newly establish repository managed in CIS (see Table 7 in Section 3.1)

Accuracy testing evaluates the primary instrumentation of the meter to determine if it is under or over-registering the volume of water flowing through it. The results from accuracy testing can be used to evaluate the performance of a source meter at different flow rates and to adjust input volumes for the annual Water Audit. Accuracy testing is necessary to confidently track production volumes.

Table 14 presents several methods available to perform accuracy testing. If possible, the volumetric displacement is preferred because it generally produces the most reliable and repeatable results, regardless of installation conditions. The general steps to complete a volumetric displacement test is provided here.

Table 14: Accuracy Testing Methods

Test Method	Advantages	Limitations
Clamp-on ultrasonic	No tap required. No interruption to operations.	Requires ideal installation conditions. Signal distortion can affect accuracy, depending on pipe material. No verification of flow condition or internal pipe diameter.
Portable test meter	More control over flow conditions.	Not practical for large meters.
Factory	Tested under ideal conditions.	Ideal conditions do not necessarily reflect field installation conditions. Meter is out of service during test.
Insertion meter	Verify the flow conditions inside the pipe. No interruption to operations.	Requires ideal installation conditions and a tap. Specialized equipment and expertise required.
Volumetric Displacement ("drop" or "fill" test)	Reliable and repeatable. Can be performed internally without extensive training.	Requires nearby reservoir, reliable verification of reservoir geometry, and reliable level measurement device. Interruption of operations.

If possible, EVMWD should conduct volumetric displacement tests, which tend to have reasonable margin or errors and do not require specialized equipment. Appendix B provides a standard approach to conducting a volumetric displacement test.

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by ensuring EVMWD is able to make the appropriate adjustments to supply volumes in the water audit. Accurate production volumes are critical to reliable water auditing because they are the first and largest inputs in the water audit. Any error in these volumes could have a substantial impact on performance indicators. For example, Figure 7 illustrates how a 2% under-estimate of water supply would result in a 50% increase in real loss when using EVMWD's approximate CY 2018 inputs.

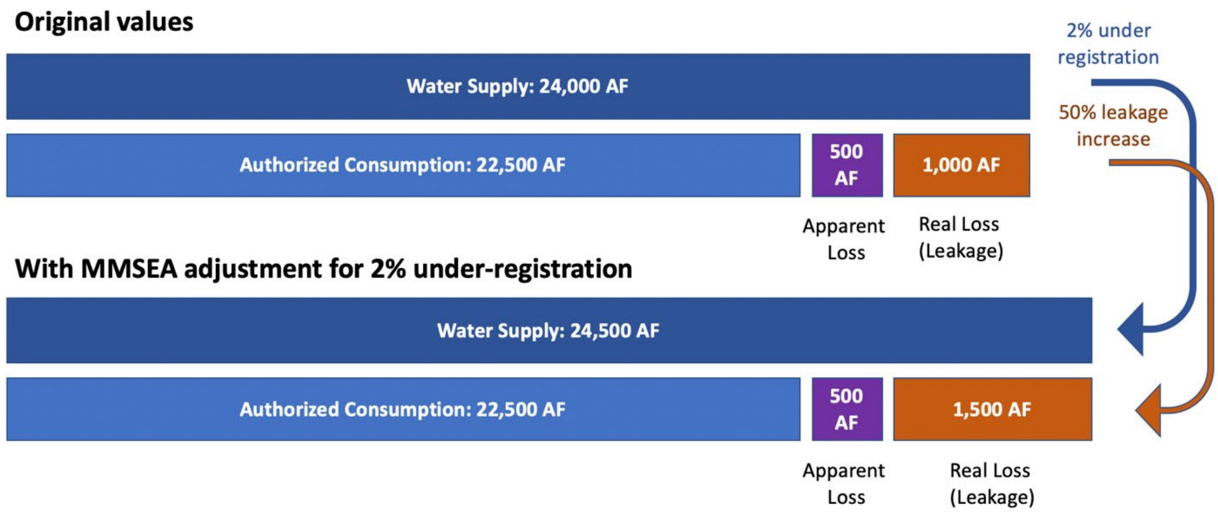


Figure 7: Example of how MMSEA adjustments affect performance indicators

As Figure 7 illustrates, even small adjustments to water supply can have an outsized impact on the results of the water audit.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

EVMWD should conduct accuracy testing on all of its source meters each year. Meters that register the largest volumes should be prioritized if resources and/or capacity is limited.

4.2 Reaffirm annual source meter electronic calibration

CURRENT OPERATIONS

EVMWD oversees third-party electronic calibration of its source meters when they are installed and annually during operation. Electronic calibration is distinct from accuracy testing (see Appendix B) and typically performed using a secondary device attached to the meter. Meters are calibrated on site in order to replicate normal operations and verify proper piping conditions. EVMWD escorts the third-party calibrator to each meter site and coordinates with production staff to obtain proper flows for each meter. Once calibration is finished, the calibrator issues a report with all calibration results across multiple flows and makes recommendations based on these findings. Each calibration report is stored in PDF format that is difficult to query.

OPTIMIZATION PROJECT

Cost	**
Effort	**
Impact type	Assessment

Reaffirm annual source electronic calibration policy to ensure that meters are accurately capturing production volumes. This includes both EVMWD maintained meters and meters at import connections. In addition, EVMWD should place an emphasis on obtaining and storing results from the third-party tester. Table 15 outlines the departmental actions and other considerations for this project:

Table 15: Departmental involvement in project 4.2

	Operations
Actions	• Collect historic results to determine calibration schedule for each source meter, including those at import connections (TVP and AVP) • Establish updated calibration schedule for all source meters • Coordinate with third-party calibrator to setup and run tests • Identify alternative testing contractors to serve as backup
Considerations	Results from tests will ideally be stored in a newly establish repository managed in CIS

Electronic calibration refers to evaluating and correcting errors in the conversion of an electronic signal into a flow rate. Calibration is typically performed with a secondary device attached to the meter. This is particularly important for meters that are integrated with a data archival system like SCADA because correct calibration ensures that the value of flow registered by the meter is the same value passed to that system.

While calibration of instrumentation is critical, it does not guarantee meter accuracy. For example, a meter could be calibrated properly but under-registering water by 5%. In this case, if 100 units of water actually flowed through the meter, it would register 95 units and pass that same value to SCADA. This meter is properly calibrated because it correctly passes the same value registered by the meter to SCADA, but it is inaccurate because it only registers 95% of the actual flow.

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by ensuring EVMWD's source meters are accurately reporting supply volumes in the water audit. As shown in Section 4.1, accurate production volumes are critical to reliable water auditing because they are the first and largest inputs in the water audit (Figure 7).

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

EVMWD should conduct electronic calibration on all of its source meters each year. Meters that register the largest volumes should be prioritized if resources and/or capacity is limited.

4.3 Integrate source meters with AMI system

CURRENT OPERATIONS

EVMWD's source meters are connected to a SCADA system that archives high frequency production volumes. However, there have been periods of unreliable recording in the past.

OPTIMIZATION PROJECT

Integrate all source meters with EVMWD's AMI infrastructure through retrofits and, if necessary, meter replacements. Table 16 outlines the departmental actions and other considerations for this project:

Cost	****
Effort	****
Impact type	Assessment

Table 16: Departmental involvement in project 4.3

	Customer Service	Operations	Engineering
Actions	Assign account number to each source meter in CIS, which will enable near real-time reporting of production volumes through normal reporting.	• Determine appropriate technology for each source meter • Prioritize meters for retrofit/replacement • Integrate new data source into current operations and reporting workflows	If necessary, facilitate retrofit or replacement of source meters with AMI-compliant technology.
Considerations	This is also necessary for establishing a testing and calibration repository (Section 3.1)		

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by ensuring complete and consistent tracking of production volumes. EVMWD expects AMI communication to be more reliable than the current SCADA system. In addition, having access to production volumes in CIS will allow for easier reporting. As shown in Section 4.1, accurate production volumes are critical to reliable water auditing because they are the first and largest inputs in the water audit (Figure 7).

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

This project is a key priority for EVMWD and will be implemented prior to other projects featured in the SOR Plan. Operations staff are currently determining appropriate technologies for source meters, but full integration will likely take several years.

4.4 Conduct source meter inventory and assessment

CURRENT OPERATIONS

EVMWD maintains a standard inventory of source meters that includes basic information such as make, model, and size. More detailed manufacturer specifications and operational manuals are also kept on hand so that EVMWD staff are able to properly maintain source meters. Some additional information about asset-specific maintenance history is also kept in a software program called "Water Tracks", but it does not have comprehensive data on all source meters.

OPTIMIZATION PROJECT

Cost	****
Effort	****
Impact type	Assessment

Conduct a source meter inventory and assessment with comprehensive and updated information about meter characteristics, technology, and testing options. Data gathered during this exercise should be stored in a secure database such as CIS. Table 17 outlines the departmental actions and other considerations for this project:

Table 17: Departmental involvement in project 4.4

	Operations	Information Technology	Engineering
Actions	• Conduct site visits, as necessary • Collect and consolidate information from other departments • Provide documentation of lube line usage, testing, and calibration • Establish policy for updating inventory and assessment	• Provide information related to SCADA and any other data transfer capabilities (e.g. AMI) • Set up table in CIS to store inventory and assessment • Update fields/data structure, if necessary	• Provide as-builts and other information related to installation conditions
Considerations	Could be performed in combination with AMI retrofits on source meters	Ideally, this dataset is integrated with the testing and calibration repository	

The following list describes some specific items that could be included in the source meter assessment:

- **Installation conditions**: The upstream and downstream lengths of straight pipe and nearby appurtenances (e.g. valves, fittings). This information will give some indication of the expected flow profile, which is critical for proper performance.
- **Pipe characteristics**: Age and material of pipe.
- **Metering technology**: What technology the meter uses to measure flow (e.g. electromagnetic, ultrasonic, propeller).
- **Data transfer capabilities**: The methods available to transfer flow data and their reliability. Typically, this is via manual reads, SCADA, or AMI.

- **Accuracy testing options**: The available options for accuracy meter testing. For example, is there a tap installed for insertion meter testing or an adjacent reservoir available for volumetric displacement tests.
- **Lube line usage**: Water usage associated with a lube line near the source meter, where in the configuration it occurs, and how it is tracked (e.g. with meter or estimated).

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by simplifying operational decision surrounding source meters and ensuring that they are maintained in the most appropriate manner given their unique characteristics. Regular documentation of installation conditions, data transfer capabilities, and accuracy testing options will enable EVMWD to prioritize meters for maintenance and retrofits. In addition, understanding more details about lube line usage will help determine if it should be incorporated in the water audit.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

4.5 Install source meter at Temescal Valley Pipeline (TVP)

CURRENT OPERATIONS

EVMWD purchases treated water from Western Municipal Water District (WMWD) through two import connections: Auld Valley Pipeline (AVP) and Temescal Valley Pipeline (TVP). While EVMWD maintains its own meter situated closely downstream of WMWD's meter at AVP, it does not maintain a similar meter at TVP. As a result, it cannot arrange independent reads, accuracy tests, or calibrations in the same way as its other source meters. Instead, WMWD provides EVMWD with annual calibration documents and monthly invoices with total purchased water.

OPTIMIZATION PROJECT

Cost	****
Effort	****
Impact type	Assessment

Install a new meter downstream of the TVP import connection with WMWD. This new meter will be fully owned and operated by EVMWD and maintained in a similar manner as other source meters. Table 18 outlines the departmental actions and other considerations for this project:

Table 18: Departmental involvement in project 4.5

	Customer Service	Operations	Operations
Actions	Assign account number to new import meter in CIS.	Integrate new data source into current operations and reporting workflows	Facilitate installation of new import meter at TVP.
Considerations			

Meters require a uniform flow profile in order to maintain adequate performance. EVMWD should consider the following guidelines when designing site plans and installing the new import meter:

- **Proper pipe configuration**: Some industry research suggests that 10 diameters upstream and 5 diameters downstream of straight length pipe are the minimum lengths required to ensure a proper flow profile for electromagnetic meters to maintain performance. These recommendations are a good rule of thumb but may change depending on meter type.
- **Proximity to appurtenances**: Meters should not be placed close to valves, control pumps, or fittings. These types of appurtenances can cause distortion to the flow profile.
- **Manufacturer specifications**: Meters may have certain specifications to maintain performance.
- **Insertion meter tap**: If possible, taps should be installed adjacent to meters to facilitate insertion meter accuracy testing.

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by ensuring that import volumes at TVP are tracked as accurately as possible. EVMWD will be able to independently accuracy test, calibrate, and take reads as it does for all of its other source meters. As shown in Section 4.1, accurate production volumes are critical to reliable water auditing because they are the first and largest inputs in the water audit (Figure 7).

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

5 Customer Meters

EVMWD maintains over 46,000 active customer meters in the potable system. These critical assets provide the revenue necessary to consistently deliver clean and reliable water for the public to use.

Metered volumes are a critical part of the annual water audit because they represent such a large input, similar to production volumes. Any error in these volumes have a substantial impact on the reliability of the performance indicators calculated in the water audit.

The opportunities featured in this section are specific projects that EVMWD can pursue to cost-effectively monitor the health of the customer meter population, gather the right data to adjust for metering inaccuracies, and ultimately recoup lost revenue from apparent loss.

BOX 4. REGULATORY CONTEXT: CUSTOMER METERS

The most recent draft proposal for California state water loss performance standards requires suppliers to answer a short questionnaire related to apparent losses by 2024. The questionnaire features a single question related to customer meter reading & management:

- Does your agency have a process for reducing and managing data handling and billing errors?

EVMWD will not be required to implement specific customer meter reading practices.

As an alternative to answering questionnaires, suppliers can apply for an “off-ramp” that allows them to simply maintain their current levels of real loss rather than reduce them. With respect to customer meter reading & management, qualification for the off-ramp requires that suppliers:

- Meter 100% of customer accounts (excluding fire services)
- Annually read unbilled metered accounts, if the reported volume is greater than 1% of water supplied

As the proposal stands, EVMWD cannot qualify for the off-ramp even if it met all requirements because its three-year average between reporting years 2016-2018 was above the threshold of 10 gal/connection/day.

5.1 Shift to a revenue-based large customer meter accuracy testing program

CURRENT OPERATIONS

In addition to its extensive small meter testing program (2” and smaller), EVMWD also coordinates a regular large meter (3” and larger) testing program. Each year, EVMWD oversees third-party accuracy testing of 25 large meters, which are on a rotating schedule. When a meter tests outside of AWWA accuracy standards it is replaced. Recently, operations staff have considered a consumption-based schedule that would prioritize high usage/high revenue meters.

OPTIMIZATION PROJECT

Shift from a time-based testing schedule to a revenue-based testing schedule for large customer meters using a “least-cost-of-ownership” economic model. Table 19 outlines the departmental actions and other considerations for this project:

Cost	*
Effort	**
Impact type	Assessment / Reduction

Table 19: Departmental involvement in project 5.1

	Operations	Information Technology
Actions	• Establish and maintain a revenue-based testing schedule for large customer meters • Coordinate with third-party tester to setup and run tests • Identify alternative testing contractors to serve as backup	Create list of large meters with consumption annual consumption data.
Considerations	Schedule may need to be revised every few years to reflect recent consumption patterns (e.g. if meter changes ownership and demand changes).	

The least-cost-of-ownership model attempts to minimize the total cost of maintaining each large by balancing two component costs:

- **Cost of Testing and Repair:** The cost of testing and repair consists of any expenses relating to testing the meter, including contractor fees, EVMWD field staff coordination time, and any costs for labor and materials to repair or replace the meter.
- **Cost of Inaccuracy (apparent loss)**: If a customer meter under-registers the volume of water delivered to the customer then that customer would also be under-billed and EVMWD would not receive full revenue.

To minimize the cost of potential inaccuracy, EVMWD staff could test and repair each meter every month. However, testing the meter every month would be very expensive, and perhaps more expensive than the lost revenue EVMWD would experience as a result of under-registration. Therefore, the key question is what is the optimum frequency of testing and repair that minimizes the combined total of these costs.

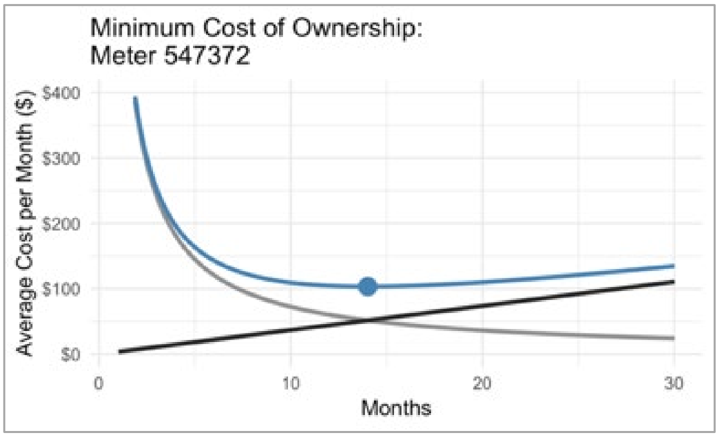


Figure 8: Least-cost-of-ownership model applied to an example large meter

Figure 8 shows the least cost of ownership model applied to an example large meter. The y-axis shows the average cost per month in dollars and the x-axis shows months. The grey line shows the average cost of testing and repair per month. For example, if EVMWD tested and repaired this meter six times per year, the cost would be about $400/month. If the meter was tested twice a year, the average cost would be $140/month and so on.

The black line shows the average cost of meter inaccuracy based on three factors: an expected rate of accuracy decline; the average volume recorded per month; and the customer retail unit cost. In this example, assuming an accuracy decline of 1% over 12 months, EVMWD would lose about $600 total in the year, or $50/month on average.

Finally, the blue line shows the sum of these two cost functions. For example, if EVMWD tested and repaired this meter once every 13 months, both (a) the average monthly cost of testing and repair, and (b) the average monthly cost of inaccuracy, would be about $50. Therefore, the total monthly cost of owning this meter would be $100/month as shown by the blue dot. This is the minimum point of the blue line and the optimum testing frequency for this meter because it minimizes the cost of ownership for EVMWD.

Four parameters are needed to calculate the optimum test and repair frequency for any large meter:

1. **The expected rate of accuracy degradation per year**. Unlike small meters, the least-cost of ownership model assumes that there is a linear relationship between large meter accuracy and age. Typically, a value of 1% per year is used as a starting point, however EVMWD may choose to adjust this based on actual large meter test results.
2. **The average volume recorded by the meter in any given month**. Used to calculate the cost of under-registration.
3. **The retail value of a unit of water sold**. Used to calculate the cost of under-registration.
4. **The cost of testing and repairing the meter**. Different costs can be used for specific groups, such as meter makes, models, and sizes.

The least-cost of ownership model is run for each large meter to determine the most cost-efficient frequency of testing and repair. Based on the results, meters can be prioritized and placed in a formal testing schedule. It is often simple to lump meters into general frequency categories such as annual, biannual, every three years, and so on.

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss, reduce apparent loss due to meter inaccuracy, and increase revenue generation. In terms of assessment, EVMWD can use test results to calculate a portion of the customer meter inaccuracy input in the annual water audit. Large meter test results should be applied on a meter-by-meter basis instead of generalized to all large meters. (This is in contrast to small meters, whose test results can be generalized if enough samples are available.) In terms of reduction, EVMWD will reduce apparent loss each time it repairs meters that fall outside of acceptable accuracy standards.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

The exact timeline of testing will depend on the results of the least-cost-of-ownership model. Typically, there are some meters that will be tested annually, some meters biannually, and other meters less frequently.

5.2 Conduct flow profiling on large customer meters

CURRENT OPERATIONS

EVMWD does not conduct flow profiling on large customer meters.

OPTIMIZATION PROJECT

Conduct high-frequency flow profiling on a select number of high-consumption large customer meters. Table 20 outlines the departmental actions and other considerations for this project:

Cost	**
Effort	**
Impact type	Assessment

Table 20: Departmental involvement in project 5.2

	Operations	Information Technology	Customer Service
Actions	• Identify customers for profiling • Design profiling parameters (e.g. data capture frequency and duration) • Install and maintain equipment • Conduct analysis of results	• Support installation of necessary third-party software required for analysis of flow profiles • Facilitate data archival in CIS	Coordinate with customers
Considerations			

A flow profile, also called a demand profile, tracks the rate of water consumption at a service connection to create a customer-specific picture of water use. In particular, it identifies the percentage of volume registered at various flow rates over a fixed period of time. The data used to create a flow profile is captured with specialized equipment that attaches to a meter without interrupting normal operation. EVMWD can use the information from flow profiles in several applications:

- **Meter size assessment:** A properly sized ("right-sized") meter is one that minimizes cost of installation and maintenance while accurately recording consumption and ensuring adequate pressure and flow at peak demand. When a meter is under or oversized, it may see flows consistently outside of its technical specifications, risking inaccurate registration of volume. Undersized meters may also restrict the maximum flow to a customer, which can be especially problematic in cases of emergency. The assessment of flow profiles helps selecting the right size of a customer meter. If a meter is sized correctly and an appropriate metering technology is used, then all or the majority of flows will occur within the flow range the meter was designed for.

- **Meter accuracy test flow rate selection:** For a standard water audit, determining meter accuracy is critical to calculating the volume of apparent loss, which represents water that reaches customers but does not generate revenue. Results from accuracy tests are most useful when test flow rates align with typical consumption patterns. For example, given a meter that sees 80% of its registered volume at 50 gpm, test results derived from a 60 gpm flow rate are more useful than test results derived from a 200 gpm flow rate. By revealing how much volume a meter registers at low, medium, and high demand, profiles help determine appropriate flow rates for meter accuracy tests.

- **Other applications:** Flow profiles are also useful for other applications, including customer-side leak detection, conservation programs, hydraulic modeling, and cost of service studies. See AWWA manual M22 for more information about these topics.

A critical assumption of flow profile analysis is that the meters under investigation are accurate. Flow sensors cannot determine meter accuracy, meaning that if a meter is under-registering volume, the resulting flow profile will under-estimate flow. Despite this, profiling still provides a reasonable way to estimate the range of typical consumption patterns at a connection. When paired with regular meter testing (Section 5.1), it can be an effective tool for right-sizing and maintaining the accuracy of large customer meters.

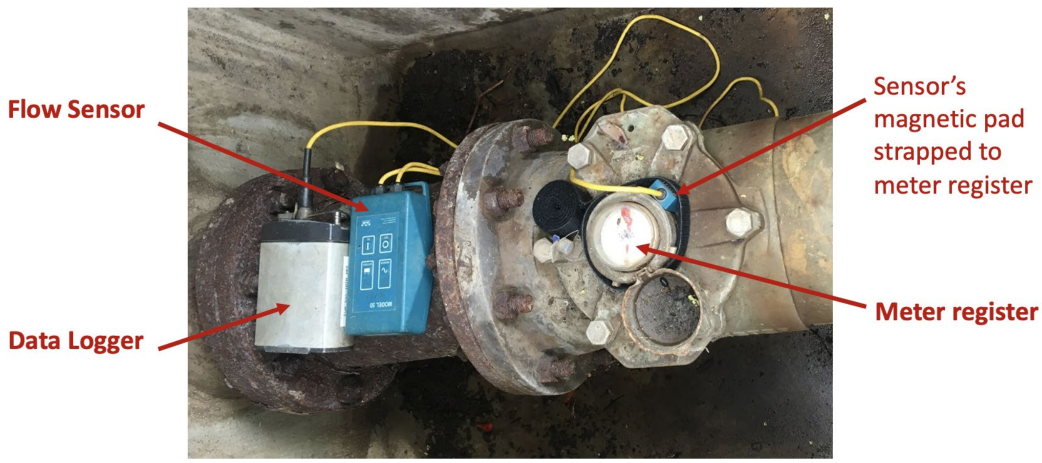


Figure 9: Flow profiling setup

Figure 9 shows what a typical flow profiling setup looks like: a flow sensor with magnetic pad and data logger attached to the meter. After downloading and analyzing the data, EVMWD could generate profiles as shown in Figure 10.

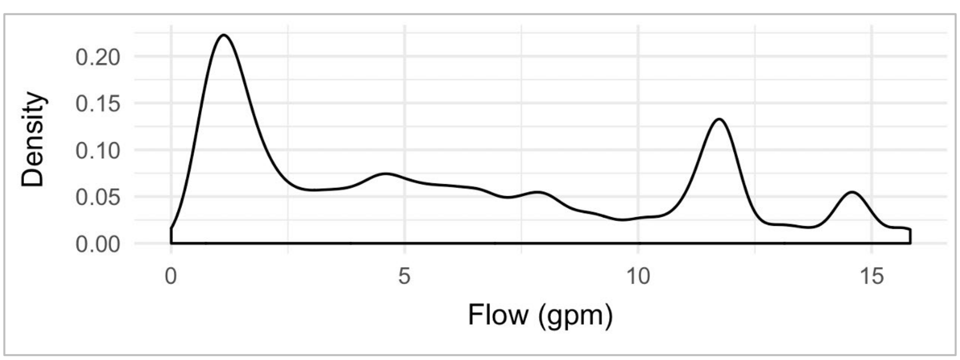


Figure 10: Example flow profile for a single customer meter

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by identifying meters that may be at risk of inaccurately reporting consumption. Flow profiling is particularly valuable when conducted on large customer meters because inaccurate registration of volumes at these connections can have considerable impact on revenue (i.e. apparent loss). Customers with large meters may also have unique consumption patterns that differ from what could normally be expected. With high resolution flow profiles for these customers, EVMWD will be well equipped to meet their demand while minimizing apparent loss.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

EVMWD can space out flow profiling efforts to complement its small meter testing program (Section 5.3). Operations staff can alternate years, focusing efforts on small meter testing in one year and flow profiling the next year. In this way, EVMWD can make the most of its existing staff time and budget.

5.3 Shift to a random and representative small customer meter accuracy testing program

CURRENT OPERATIONS

EVMWD maintains an extensive small customer meter (2” and smaller) testing program to track customer metering inaccuracy for the water audit and to guide replacement efforts. All meters are tested by EVMWD staff either in the field or using an on-site test bench installed and calibrated in 2020. Table 21 summarizes EVMWD’s testing policy by meter size.

Table 21: EVMWD small customer meter testing practices by size

Meter Size	Testing Practices
¾” and 1”	All meters flagged for replacement are tested on the EVMWD test bench. If the average accuracy of a year’s sample is 95% or higher, the throughput levels used for replacement are used again the next year. In addition, one meter from every new box is tested before being installed in the field.
1 ½" and 2	All 1 ½” and 2” meters are tested in the field by EVMWD staff at 30,000 CCF and 40,000 CCF of throughput, respectively. Past these thresholds, meters are tested every two years. In addition, one meter from every new box is tested before being installed in the field.

OPTIMIZATION PROJECT

Cost	***
Effort	**
Impact type	Assessment / Reduction

Shift from a small meter testing program based on throughput limits to one based on a random and representative sample. Previous studies[3,4] have not identified a significant relationship between age or throughput and meter accuracy. Therefore, EVMWD may be unnecessarily replacing meters that could perform well for many years when it pulls them for testing.

An alternate approach is to randomly sample and test 200-300 small customer meters from the entire system, which provides a high degree of confidence when calculating overall customer meter inaccuracy for the water audit. Sampling from the entire system ensures a representative sample that will not bias test results with any factor such as age, geography, or make. EVMWD can repeat this process ever 2-3 years in order to balance the cost of testing and meter replacement with the value of understanding the health of the meter population. Over time, by building a database of small meter test results, EVMWD may be able to distinguish differences between particular meter makes, which can help guide replacement efforts.

Table 22 outlines the departmental actions and other considerations for this project:

[3] Utah Water Research Laboratory at Utah State University (2011). Accuracy of In-Service Water Meters at Low and High Flow Rates. Water Research Foundation

[4] Williams, K. (2018). Small Meter Accuracy—Using Test Data for Better Decision-Making. Source CA-NV AWWA, 30–32.

Table 22: Departmental involvement in project 5.3

	Operations	Information Technology
Actions	• Pull, transport, and store meters for testing • Conduct testing and document results	• Create list of 200-300 random small meters from the entire customer base
Considerations	EVMWD should continue its other small meter testing practices as normal. This includes activities like testing a certain number of new meters from the manufacturer, responding to customer complaints, and investigating meters flagged by billing system integrity checks.	

EVMWD should consider the following guidelines related to pulling, transporting, and storing meters prior to testing:

- **Capping wet:** After a meter is pulled, both ends should be capped using the caps from the new replacement meter to keep the meter wet during transport. This will ensure that mechanical parts do not dry out prior to testing.
- **Packaging:** The meter should be packaged for minimal damage. For example, meters might be placed in the meter box that the replacement meter was packaged in.
- **Storage and Transport:** The meter should be stored neatly and systematically during and after transport. Previous experience has shown that storing meters unorganized in bins significantly affects test results.

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss and also reduce apparent loss due to meter inaccuracy. In terms of assessment, random and representative sampling is the best way to form an accurate understanding of overall customer meter inaccuracy, which is typically the biggest component of apparent losses. This will impact the results of the annual water audit because apparent losses have a direct relationship with real loss. Any under-estimation of apparent loss will result in an over-estimation of real loss, and vice versa (Figure 11).

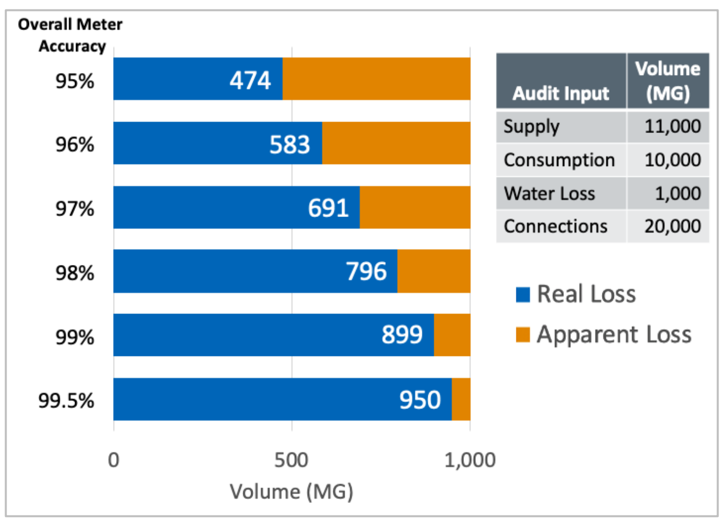


Figure 11: Relationship between apparent and real losses

In terms of reduction, EVMWD will potentially reduce apparent losses when it replaces meters pulled for testing with newer meters. Although age is not necessarily related to accuracy, it is possible that newer metering technology will show greater performance overall.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

EVMWD can space out its small meter testing program to complement its customer meter flow profiling efforts (Section 5.2). Operations staff can alternate years, focusing efforts on random and representative small meter testing in one year and flow profiling the next year. In this way, EVMWD can make the most of its existing staff time and budget. EVMWD can maintain its other testing activities as normal, including testing a certain number of new meters from the manufacturer, responding to customer complaints, and investigating meters flagged by billing system integrity checks. The shading in the timeline above reflects these waves of effort in the small meter testing program.

5.4 Identify failing customer meters on closed accounts

CURRENT OPERATIONS

EVMWD maintains records of inactive and closed accounts. In some cases, these meters will not function properly but still be seeing unauthorized usage.

OPTIMIZATION PROJECT

Identify failing customer meters on closed accounts and fix or remove them. Table 23 outlines the departmental actions and other considerations for this project:

Cost	*
Effort	*
Impact type	Assessment

Table 23: Departmental involvement in project 5.4

	Customer Service (Billing)	Information Technology	Operations
Actions	Create service order for inspecting meter	• Inspecting meters in field and determining if water is running even if the meter is non-functioning	• Adjust field in CIS to include flag for "inspected" to avoid duplicate efforts
Considerations			

POTENTIAL WATER LOSS IMPACT

This project is intended to reduce water loss by eliminating apparent loss generated by failing meters on closed accounts seeing unauthorized usage.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

This will be an ongoing practice for EVMWD.

6 Leakage

Tracking and controlling leakage is a key priority for EVMWD in its mission to deliver clean and affordable water to the public. Customers trust EVMWD to act as an effective steward of its water supply that takes reasonable and cost-effective steps to minimize physical water loss.

Reducing leakage can also save time and resources in the long-term. Less water lost is less water that needs to be energized and distributed to take its place. Additionally, proactive leak detection helps avoid costly and disruptive repair work needed after large infrastructure failures that go undetected.

The opportunities featured in this section are specific projects that EVMWD can pursue to improve data used for estimating leakage, field validate recent audit results, and prioritize areas for additional intervention.

BOX 5. REGULATORY CONTEXT: LEAKAGE

Although pending performance standards do not prescribe a specific intervention strategy to achieve compliance, the SWRCB's economic model does assume a default manual acoustic leak detection frequency when calculating each limit. EVMWD's assumed survey frequency is 36 miles per year, given the length of mains in the system. At that frequency, the 30-year NPV is negative and therefore EVMWD has been assigned its average 2016-2018 leakage level of 20.1 gal/connection/day.

Even though EVMWD is not required to lower its overall real losses and it is not specifically required to conduct manual acoustic surveys, it is still advisable to pilot leakage reduction strategies. In the case that leakage increases or new data changes EVMWD's understanding of system leakage in future years, it will have the tools and knowledge to react accordingly.

6.1 Enhance work order data to support water loss analysis

CURRENT OPERATIONS

EVMWD creates and archives work orders in an industry-standard software package called Maximo. Field crews receive work orders on mobile devices with an accompanying software package called Field Mapplet. After performing work, crews enter specific data (e.g. nature of work, infrastructure type) back into Field Mapplet, which communicates with Maximo to update the work order record.

EVMWD is currently planning to implement a new enterprise asset management system (EAMS) / computerized maintenance management system (CMMS) in the coming years. The project elements outlined here should be implemented in the design of this new system.

OPTIMIZATION PROJECT

Cost	*/****
Effort	**/****
Impact type	Assessment

Enhance work order data to support advanced water loss analysis. The current structure of work order data can be improved to allow for additional water loss analysis (see bulleted list below). Additionally, the upcoming plans for a new EAMS/MMS present a good opportunity to incorporate the recommendations provided here. Table 24 outlines the departmental actions and other considerations for this project:

Table 24: Departmental involvement in project 6.1

	Information Technology	Operations
Actions	• Update database structure in Maximo and Field Mapplet to accommodate additional columns • Coordinate with third-party tester to setup and run tests	Field staff input data into new columns during work order completion
Considerations	• Could add data constraints to only allow entry of pre-determined values for certain columns • Columns should be incorporated into design of new EAMS/CMMS	

More details about EVMWD's work order data and recommended improvements are included in a separate document (Technical Memorandum #2) which was developed during the baseline phase of this project. The recommendations from that document are summarized in the following list:

- **Authorized Use vs. Leakage:** Maximo does not distinguish between authorized uses (e.g. flushing, regular maintenance) and unauthorized leakage from break. EVMWD should implement a column that field staff can use to indicate between work orders related to authorized uses and those related to leakage.
- **Query-Ready Columns**: Field staff capture lots of information that can be used for water loss analysis such as repair completion times and local pressure. However, much of this information is stored together in an unstructured format that cannot be easily queried. EVMWD should

separate information into dedicated columns to facilitate easy data querying. Table 25 outlines columns particularly important for water loss analysis.

Table 25: Columns important for water loss analysis

Data Column	*Priority*	*Available in Maximo*	*Relevant Field Name in Maximo*
Work Order ID	High	Yes	WO #
Reported Time	High	Few entries	Failure Long Description
Repaired Time	High	Few entries	Failure Long Description
Infrastructure Type	High	Inconsistent	Failure Long Description
Infrastructure Size	High	Inconsistent	Description
Activity (e.g. flushing)	High	Inconsistent	Description
Estimated Flow (gpm)	Medium	Inconsistent	Failure Long Description
Pressure at Break (PSI)	Medium	Inconsistent	Failure Long Description
Geographic Location	Low	No	-
Infrastructure Material	Low	Few entries	Failure Long Description

- **Timestamps for Estimated Leakage Calculation**: Work orders have limited data related to exact timestamps of when a break was first reported and when leakage was stopped (repaired time). EVMWD should add explicit columns that indicate the reported time and repaired time of the break. Figure 12 shows how these are used to calculate a response duration.

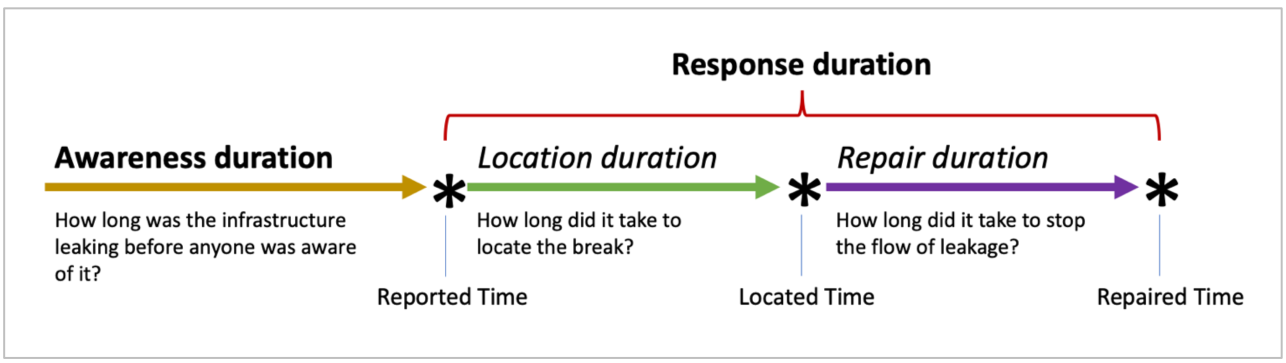


Figure 12: Leakage duration components

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss by ensuring EVMWD has work order data that supports confident estimation of leakage from reported breaks. With an accurate water audit and complete work order data, EVMWD can conduct real loss component analysis (RLCA), which is an analytical exercise that separates the total volume of real losses into distinct categories of leakage: background, reported, unreported, and hidden. These categories were defined to describe types of loss that can be recovered using specific intervention strategies and EVMWD can use them to guide its leakage management strategy. See Technical Memo #2 for additional information about RLCA.

One specific savings projection that EVMWD can conduct given complete and consistent work order data with timestamps is related to response times. By tracking actual response times to breaks and comparing them to specific goals, EVMWD can model how much leakage would be avoided due to reduced runtimes. For example, Table 26 is an excerpt from Technical Memo #2 that projects savings due to modest improvements in responds times to breaks.

Table 26: Modeled Savings from Response Time Reduction Based on CY 2018 Work Orders

Type	Count	Estimated Response Time (Days)	Ideal Response Time (Days)	Estimated Flow Rate at 84 PSI (gpm)	Modeled Savings from Reduced Runtime (AF)
Main	47	2.80	2	123	55.4
Service	176	11.75	5	14	7.4
Totals	**223**				**62.8**

To perform this analysis, breaks were grouped by type (main or service) and the volume of leakage was calculated based on EVMWD's best current understanding of response times. Next, the volume of leakage produced by each group was calculated using optimized response times and the same flow rates. Based on the difference in those volumes and a variable production cost of approximately $1,200/AF, the potential for savings is approximately 62.8 AF/year valued at approximately $75,000.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

This project could be completed in 1-2 years in the current system because adjusting the structure of data in Maximo and Field Mapplet is relatively straight forward. However, incorporating the recommendations presented here into a new EAMS/CMMS will take several years to complete because of the budgeting, procurement, and implementation time of a system that integral to EVMWD's operations.

6.2 Pilot satellite leak detection

CURRENT OPERATIONS

EVMWD does not conduct regular proactive leak detection but it is currently considering satellite leak detection. EVMWD has experimented with acoustic loggers on at least two separate occasions but were not satisfied with the results. Most of the distribution system is composed of plastic piping, which makes acoustic leak detection difficult.

OPTIMIZATION PROJECT

Cost	**
Effort	***
Impact type	Reduction

Pilot satellite leak detection to locate and prioritize leaks. This technology works by taking satellite images of the distribution system to create maps with prioritized "points of interest" (POI) that represent small areas with a suspected leak. Table 27 outlines the departmental actions and other considerations for this project:

Table 27: Departmental involvement in project 6.2

	Customer Service	Operations	Information Technology
Actions	• Identify pilot areas for image capture • Establish workflow for responding to points of interest	• Work with vendor to share data (e.g. GIS, work orders) • Support data archival and integration with service order generation	• Help design workflow for investigating points of interest and generating necessary service orders
Considerations	Analysis of data will require training on how to use a third-party "software as a service" (SaaS), which is an online web dashboard.		

EVMWD should consider the following when designing a satellite leak detection pilot:

- **Costs:** Total cost of satellite leak detection depend on several factors:
  - *Image Coverage*: EVMWD does not need to analyze imagery for the entire distribution system for its pilot. Instead, it can choose to analyze a smaller portion of the system.
  - *Image Capture Frequency*: If EVMWD extends its pilot to capture another snapshot of the system, or if it pursues regular imagery analysis, it needs to decide how much time to wait between image capture.
  - *POI Investigation*: Each POI identified on a map does not necessarily represent a leak, therefore EVMWD must investigate them as an additional cost.
- **Snapshot in Time**: Each map produced by the satellite leak detection vendor only represents a single snapshot in time. If satellite leak detection reveals previously hidden leakage, EVMWD may need to repeat these efforts periodically to maintain lower leakage levels.

- **Repair Crew Capacity**: EVMWD should be prepared for a sudden increase in service orders to investigate the potentially large number of POIs generated by imagery analysis. It may be advisable to dedicate a specific field crew to solely investigate these POIs to avoid conflicts with normal maintenance and repair duties.
- **Coordination of Processes:** EVMWD should be prepared to coordinate processes that generate normal work orders and those that generate investigations of POIs. For example, if a customer reports a surfaced leak that was also tagged as a POI, EVMWD needs to ensure that two work orders are not created. In this situation, it is possible that crews investigating the POI are unaware that the leak was previously repaired.

POTENTIAL WATER LOSS IMPACT

This project is intended to directly reduce water loss by accelerating the process of locating and repairing leaks. As noted, standard water loss models such as real loss component analysis indicate that EVMWD does not have recoverable leakage (Section 2.2), which makes it challenging to project potential savings for satellite leak detection. However, piloting this technology will help field validate EVMWD's audit results and establish best practices for incorporating service orders generated by proactive leak detection into day-to-day operations. In case satellite leak detection reveals previously hidden leakage, EVMWD will know to revisit water audit data and be prepared in time to meet state performance standards.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

6.3 Pilot pressure transient monitoring

CURRENT OPERATIONS

EVMWD has access to real-time pressure data at the zonal boundaries of its distribution system—at booster stations, groundwater wells, import connections, and storage tanks. In addition, field staff take static pressure reads as part of routine flushing activity. EVMWD does not continuously log data or monitor for transients from within its pressure zones.

OPTIMIZATION PROJECT

Cost	**
Effort	**
Impact type	Reduction

Pilot pressure transient monitoring in selected sites within the distribution system. Pressure transients occur when there is a sudden and substantial deviation from the steady state pressure at a given location. Typically, they are triggered by pump starting/stopping or valves opening/closing, and they are suspected to contribute to infrastructure failures. Continuous monitoring in susceptible locations can help identify when and how they occur so they can be addressed. Table 28 outlines the departmental actions and other considerations for this project:

Table 28: Departmental involvement in project 6.3

	Operations	**Information Technology**
Actions	• Identify areas of focus • Install equipment • May need to assign field staff to collect data • Conduct analysis of results • Establish workflow for responding to flags/alerts	• Support installation and usage of any necessary third-party software • Support data archival
Considerations	Analysis of data may require knowledge of data processing or usage of specialized software.	

POTENTIAL WATER LOSS IMPACT

This project is intended to directly reduce water loss by identifying and mitigating pressure transients in susceptible locations within the network before they contribute to breaks. More generally, addressing transients early will prolong the overall life of the pipes in the distribution system and help avoid costly infrastructure replacement.

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028
	■	■					

6.4 Pilot district metered areas (DMA) using booster stations

CURRENT OPERATIONS

EVMWD's service territory is divided into 41 pressure zones that are maintained with a mix of gravity and booster pumps. Many of these booster stations represent the only inlet to contained areas with several thousand service connections. Due to this arrangement, they are naturally situated to facilitate the implementation of district metered areas (DMA).

OPTIMIZATION PROJECT

Cost	***
Effort	***
Impact type	Reduction

Pilot DMAs in the selected areas of the potable water system by installing AMI-integrated meters at booster stations. EVMWD should prioritize booster stations that serve approximately 3,500-6,000 service connections, which is an ideal starting point for DMA management. Table 29 outlines the departmental actions and other considerations for this project:

Table 29: Departmental involvement in project 6.4

	Customer Service (Billing)	**Information Technology**	**Operations**
Actions	• Assign account number to each new inlet meter in CIS • Help design workflow for investigating events or alerts and generating necessary service orders	• Support installation and usage of any necessary third-party software	• Prioritize zones for pilot • Installation of necessary equipment • Monitor zones • Establish workflow for responding to events or alerts
Considerations		Additional software may help to automate monitoring of zones	Need capacity to monitor zones once established

A DMA is a hydraulically discrete zone consisting of known points of inflows and outflows. In EVMWD's case, each pilot DMA would have one inflow (at the booster station) and no outflows. By tracking volume at the inflow and comparing it to total consumption of all service connections within the DMA, it is possible to assess water losses in a smaller and more manageable portion of the distribution system. This is particularly important for EVMWD because most of the distribution system is composed of non-metallic piping, which makes acoustic leak detection over the entire system extremely difficult.

Monitoring losses within a DMA is typically conducted in two ways:

1. **High Frequency Water Balances:** As described previously, a water balance is a technique for estimating water losses that compares the total volume of water entering a distribution system to all the known volumes of consumption. In the case of DMAs, water balances are conducted with more frequency (e.g. once a month) on a specific area that is much smaller and more manageable than the entire distribution system.

2. **Minimum Night Flow (MNF):** By analyzing daily trends in supply, EVMWD can identify periods of lowest flow into the zone, typically late at night. A change in the minimum night flow rate that is not attributed to authorized nighttime use can indicate an increase or decrease in water losses.

These analyses require high-frequency monitoring of both input volumes and consumption volumes. With customer meters fully integrated with AMI, EVMWD is well suited to implement DMAs as long as meters can also be installed at selected booster stations. These meters would ideally be integrated with AMI as well to facilitate analysis. EVMWD may also consider specialized software that is designed to automate DMA management. These software packages can help perform monthly water balances and minimum night flow analysis, as well as set up alerts for investigation when breaks are suspected.

POTENTIAL WATER LOSS IMPACT

This project is intended to improve the assessment of water loss and also reduce water loss directly. In terms of assessment, a DMA (or set of DMAs) would allow EVMWD to monitor current levels of leakage in a specific service area on a regular basis, using that knowledge to prioritize proactive leak detection and repair activities there.

In terms of leakage reduction, closely monitoring flows in a DMA will make it possible to quickly identify and address significant infrastructure failures. Figure 13 shows a theoretical example of what this might look like in practice. In this example, the rolling average of water loss is generally consistent week to week, but there are sudden spikes in the beginning of March and October, which might alert EVMWD to new system conditions driving loss, such as a new break.

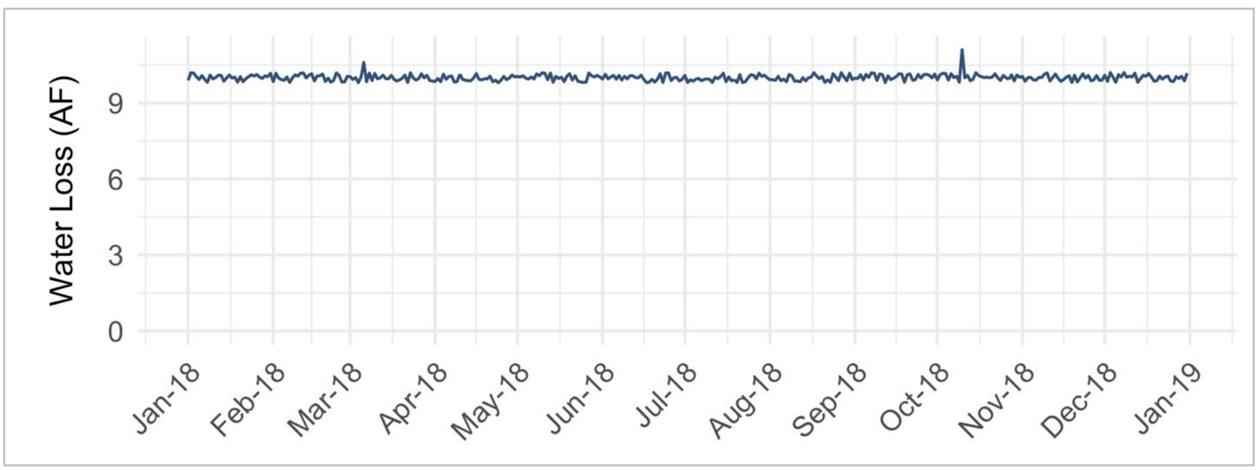


Figure 13: Theoretical example of high-frequency water balances for monitoring water loss in a DMA

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

6.5 Look for opportunities to optimize pressure when operationally feasible

CURRENT OPERATIONS

EVMWD's service territory is divided into 41 pressure zones that are maintained with a mix of gravity and booster pumps. Average operating pressure is approximately 84 PSI, although this varies substantially throughout the distribution system due to varied terrain. To manage pressure, EVMWD maintains 44 pressure reduction valves (PRV) and keeps storage tanks low in winter months when demand is lower.

OPTIMIZATION PROJECT

Cost	*
Effort	**
Impact type	Reduction

Look for opportunities to optimize pressure when operationally feasible in order to reduce leakage. Even incremental optimizations of water pressure can provide measurable benefits for EVMWD. There are four fundamental strategies for pressure optimization:

1. **Transient Mitigation:** Transients are high frequency pressure waves traveling through the pipe network. They can be caused by valves shutting too quickly or even hydrant operation. These pressure events can directly cause leaks and breaks. Arguably the larger cost of transients is the increased wear and tear on infrastructure. See Section 6.3 for a specific project recommendation to identify transients.
2. **Pressure Increase:** Areas with low pressure can be identified and pressure can be increased. This is especially important to meet fire suppression requirements.
3. **Flow Modulated Pressure Management:** During periods of low demand, such as at night, the pressure can be strategically reduced or maintained to prevent unnecessary high night-time or low-demand pressures.
4. **Pressure Reduction:** Areas with excessively high pressure can be reduced by installing or adjusting Pressure Regulating Valves (PRVs).

POTENTIAL WATER LOSS IMPACT

This project is intended to directly reduce water loss by lowering leakage flow rates and the frequency of breaks (Table 30).

Table 30: Benefits of pressure optimization

Conservation Benefits		*Water Utility Benefits*			*Customer Benefits*	
Reduced Leakage Flow Rates		Reduced Frequency of Breaks				
Reduced Flow Rates of Leaks and Bursts	Reduced Consumption	Reduced Repair Costs, Mains & Services	Deferred Renewals and Extended Asset Life	Reduced Cost of Active Leakage Control	Fewer Customer Complaints	Fewer Problems on Customer Plumbing & Appliances

A simplified analysis to project the water loss savings of pressure reduction is to assume a 1:1 relationship between pressure and leakage. Table 31 uses this assumption to model leakage savings of EVMWD's total volume of real losses from the CY 2018 water audit given a 1-10 PSI reduction and a variable production cost of approximately $1,200/AF.

Table 31: Modeled savings from pressure reduction

Reduction in System Average Pressure (PSI)	System Average Pressure (PSI)	Volume Saved/Year (AF)	Value of Savings/Year
1	83	10	$12,000
2	82	20	$24,000
3	81	30	$36,000
4	80	40	$48,000
5	79	50	$60,000
6	78	60	$72,000
7	77	70	$84,000
8	76	80	$96,000
9	75	90	$108,000
10	74	100	$120,000

TIMELINE

2021	2022	2023	2024	2025	2026	2027	2028

EVMWD should continue to look for opportunities to optimize system pressure as a standard operational practice.

7 Conclusion

7.1 Project Life Cycle

The SOR Plan outlines 18 discrete optimization projects that EVMWD can implement to increase confidence in water loss assessment, reduce leakage, and prepare for upcoming state regulations. However, EVMWD should consider these projects as a single effort, or water loss control program, to achieve these goals. Projects may be implemented at different times or with varying degrees of effort, but the progress and effectiveness of each should be tracked using the same framework and documented in same place. Day-to-day, this may take the form of a regularly updated word document, spreadsheet, or collection of related materials. EVMWD should also consider using the Project Implementation Masterfile as the primary location to store project life cycle updates. Figure 14 illustrates one possible framework for standardizing the life cycle of individual projects.

Figure 14: Possible life cycle framework for individual projects

PROJECT LIFE CYCLE

Project Review: Meet to discuss the current project status. Initially, this will involve familiarizing relevant staff to the project and general brainstorming. Following a complete life cycle, this will involve reviewing recommendations from the Evaluation phase.

Work Plan: Develop a detailed work plan that specifies departments and/or individuals and what actions they will take and determine key performance metrics to track. This may also include determining an appropriate budget.

Implementation: Execute the work plan and document key performance metrics.

Evaluation: Using key performance indicators and staff feedback, recommend continuation, adjustment, or termination of the project.

7.2 Periodic Updates

In addition to regularly tracking the life cycle of individual projects, EVMWD should also plan for periodic updates to the SOR Plan. Updates to the SOR Plan should include the most recent water audit results as well as a synthesis of recommendations developed during project life cycle analyses (see previous section). EVMWD should plan to update the SOR Plan every five years, which is a long enough time to see the effects of optimization projects and short enough to incorporate lessons learned from recent optimization projects.

7.3 Funding Opportunities

Due to the nature of optimization projects identified in the SOR Plan, external funding opportunities may be limited. Most likely, EVMWD will need to cover project costs with internal operational and capital expense budgets. However, there may be opportunities to receive free or discounted services and equipment for the leakage reduction pilots by sharing data and results with some vendors. For example, satellite leak detection vendors may offer EVMWD a free prioritization map so they can further calibrate their novel analytical model.

Appendix A: All Program Options Considered

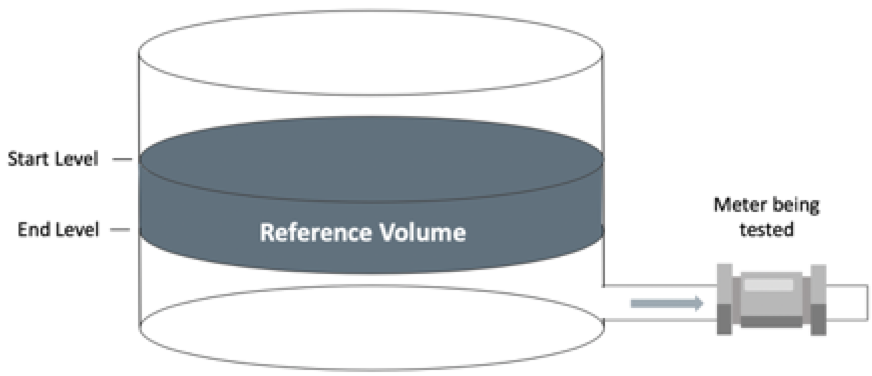
Table 32: All Program Options Considered

Category	Optimization Project	Cost	Effort	Notes
Water Audit Improvements	Create single repository for source and customer meter testing and calibration results	*	**	
Water Audit Improvements	Review AMI data handling process and procedure	*	*	
Water Audit Improvements	Standardize audit compilation with written documentation	*	**	
Water Audit Improvements	Improve cross-departmental communication related to water loss metrics and opportunities	*	**	
Source Meters	Reaffirm annual source meter accuracy testing policy	**	**	
Source Meters	Reaffirm annual source meter calibration policy	**	**	
Source Meters	Integrate source meters with AMI	****	****	
Source Meters	Conduct source meter inventory and assessment	*	**	
Source Meters	Install source meter at Temescal Valley Pipeline (TVP)	****	****	
Source Meters	Shift to revenue-based large customer meter accuracy testing	*	**	
Customer Meters	Conduct flow profiling on large customer meters	**	**	
Customer Meters	Shift to random and representative small customer meter accuracy testing	***	**	
Customer Meters	Identify failing customer meters on closed accounts	*	*	
Customer Meters	Enhance work order data to support water loss analysis (adjust current system or implement new one)	* / ****	** / ****	
Leakage	Pilot satellite leak detection	**	***	
Leakage	Pilot transient monitoring	**	**	
Leakage	Pilot district metered areas (DMA) using booster stations	***	***	
Leakage	Look for opportunities to optimize pressure when operationally feasible	*	**	
Leakage	*Pilot infrastructure assessment tools (e.g. consequence of failure)*	***	**	*Asset management plan already in place*
Leakage	*Pilot manual acoustic leak detection*	**	**	*Majority of system is plastic, making acoustic leak detection difficult*
Leakage	*Pilot acoustic noise loggers*	***	**	*Previous pilots not successful*
Leakage	*Improve response and repair time to breaks*	***	***	*Not cost effective*
Leakage	*Increased rate of infrastructure replacement*	****	****	*Not cost effective*

**Projects in red italics not included in final plan*

Appendix B: Source Meter Accuracy Testing Additional Guidance

General Steps for Completing a Volumetric Displacement Test



$$Accuracy = \frac{Meter\ end\ read - Meter\ start\ read}{Reference\ volume}$$

Figure 15: Diagram of volumetric displacement accuracy test ("drop test")

PROCEDURE CHECKLIST

- ☐ Ensure the system has enough water to meet demand for the duration of the test.
- ☐ Ensure the reservoir can accommodate the desired level change for the test.
- ☐ Isolate the reservoir and the test meter and monitor the tank level for 15 minutes. Collect level reading once every few minutes to ensure that the system is isolated. Any water that does not move through the meter will affect the results.
- ☐ Collect initial totalizer readings for the test meter and from SCADA when possible.
- ☐ Collect initial tank readings from SCADA and via physical apparatus (e.g. sounder) when possible.
- ☐ Start pumps at desired flow rate and let water run through meter for the pre-determined test time.
- ☐ Stop pumps and/or close valves to end flow of water.
- ☐ Collect final totalizer readings for the test meter and from SCADA when possible.
- ☐ Collect final tank readings from SCADA and via physical apparatus (e.g. sounder) when possible.
- ☐ Calculate accuracy of the meter by dividing the volume registered by the meter by the reference volume calculated for the reservoir.