California State Water Resources Control Board

Water Loss Performance Standards for Urban Water Suppliers

Standardized Regulatory Impact Assessment (SRIA)

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California Department of Finance
1001 I Street
Sacramento, California 95814

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Abbreviations

AWWA – American Water Works Association

BEA – Bureau of Economic Analysis

CPI – Consumer Price Index

DWR – Department of Water Resources

EBMUD – East Bay Municipal Utility District

EPA – Environmental Protection Agency

LADWP – Los Angeles Department of Water and Power

MWD – Metropolitan Water District

NAICS – North American Industry Classification System

RIMS – Regional Input-Output Modeling System

SRIA – Standardized Regulatory Impact Assessment

TAP – Technical Assistance Program

UWS – Urban Retail Water Suppliers

UWMP – Urban Water Management Plan

WLPS – Water Loss Performance Standards

PFAS – Per- and Polyfluoroalkyl substances

PFOA – Perfluorooctanoic acid

A. Introduction

It is important that California water resources are managed well and used efficiently. This will be of increasing importance over time, due to factors such as climate change, which will tend to put pressure on water supplies and make developing new water supplies increasingly costly. People, communities, governments at all levels, and all economic sectors have roles in our water use being efficient. One area the Legislature has focused on is urban water use, both on the "customer side of the water meter"—indoor and outdoor water use, addressed by Senate Bill (SB) 606 (2018) and Assembly Bill (AB) 1668 (2018)—, and on the "supplier side of the water meter"—water loss from leakage from water distribution systems, addressed by SB 555 (2015). See also Executive Orders (B-29-15, B-37-16, B-40-17, N-10-19, and N-10-21)[1] that directed parties to conserve water or reduce waste of water through leakage.

Both customer-side and supplier-side efficiency are important: the average urban water connection in California serves 356 gallons per day, and the average water loss through leakage for water suppliers in California is approximately 35 gallons per connection per day. This translates to annual statewide water losses of about 316,000 acre-feet (AF).[2] This regulation focuses on water loss, which is part of supplier-side water use efficiency.

Nationwide, water supply infrastructure has been inadequately maintained and rehabilitated over past decades, which has led to its deterioration and overall higher long-term operational costs (Sedlak, 2015). In California prior to the passage of SB 555, some suppliers monitored and addressed water loss, but there was no statewide standard or obligation regarding for the volume of water lost to leakage from distribution systems. SB 555 required the State Water Resources Control Board (State Water Board) to develop performance standards for the volume of water losses for urban water suppliers (UWS),[3] while considering lifecycle cost accounting of those standards. The volume of water losses is defined by the American Water Works Association (AWWA) as the sum of real losses (leaks) and apparent losses (theft and accounting errors) (AWWA, 2016). Both apparent losses and real losses are volumes of water that are lost, requiring them to be regulated with performance standards under SB 555.

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[1] https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/executive_orders.html.

[2] These figures are based on data from water loss auditing in California over 2016-17, 2017-18, 2018-19, and 2019-20.

[3] "Urban water supplier" or "supplier" means a water supplier that meets the definition set forth in Water Code section 10617, except it does not include suppliers when they are functioning solely in a wholesale capacity. A supplier can be publicly or privately owned and directly provides potable municipal water to more than 3,000 end users or supplies more than 3,000 acre-feet of potable water annually at retail for municipal purposes.

The proposed Water Loss Performance Standards (WLPS or regulation) will reduce water loss and reduce the energy and associated greenhouse gas emissions associated with supplying and treating water that is then lost to leakage.[4] The proposed regulation is designed to bring water losses to levels that are cost-effective and feasible for each UWS and the proposed regulation will support each UWS in planning and implementing water loss control in a cost-effective manner.[5] The intent of the proposed regulation is to provide each supplier the flexibility to choose any effective approach best suited for its system and budget that allows the supplier to reduce leakage to the level of its specific volumetric standard. Cost savings may be passed on to customers, and each UWS supplying water to disadvantaged communities that face burdensome upfront costs will have more time to comply.

Finally, more extensive monitoring for leaks can benefit suppliers through a reduction in the frequency and severity of breaks, which can cause property damage and compromise water quality. Each UWS will be required to comply with a maximum allowable water loss volume that is cost-effectively achievable, which will encourage improved distribution system monitoring through increased leak detection and repair, pressure management strategies, and asset management. These measures will result in prolonged asset life of the distribution system and a reduction in breaks, including the costs and damages associated with those breaks.

The proposed regulation has the following elements:

- Urban water suppliers will be required to comply with individual numeric volumetric standards for real water loss. Compliance will be required by 2028, or by 2031 for suppliers meeting certain criteria relating to serving disadvantaged communities/residents. These standards will be calculated using a model developed by the State Water Board that assesses the additional benefits and costs associated with reducing the leakage to the volumetric standard. The standard will require leakage reduction only if the net benefit is positive for the supplier, given the system and water resource conditions. If the net benefit is negative, the standard will be increased to the point at which the net benefit is positive, if possible. Otherwise, in cases where a positive net benefit is not possible, the standard will be a requirement to maintain current real water loss.
- Urban water suppliers will be required to comply with individual numeric volumetric standards for apparent water loss or report an inventory of their apparent losses

[4] California has a high energy consumption associated with water supply, accounting for 20% of total electricity use and 30% of total natural gas consumed in the state (PPIC Water Policy Center, 2016).
[5] Add note on benefit of fewer large leaks.

and any calculations and data used to determine apparent losses. Apparent loss standards will be assessed concurrently with real loss standards, with compliance demonstrated by 2028 and every third year after 2028 with three-year averages of reported apparent losses. The apparent loss standard for each UWS is equal to the average of the baseline (2017 through 2020) apparent losses with an allowed variation of 5 gallons per connection per day.

- Suppliers will be required to comply with data submission requirements in 2023, 2024, 2026, and 2027, unless they have existing low leakage levels and high-quality data. The data submissions will help the State Water Board:
    - Improve data quality of water loss estimates during the early implementation period (2023).
    - Better determine the operational and economic feasibility of reducing water loss through means that require larger capital investment, such as pressure management (2023, and updated in 2026) and asset management (2024, and updated in 2027), for individual water distribution systems.
- Suppliers will be required to annually submit their registry of breaks, repairs, and estimated water losses unless they have existing low leakage levels and high quality data. This data submission will help the State Water Board:
    - Understand the frequency and severity of breaks, repairs, and water losses specific to California suppliers.
    - Provide the public with information on breaks, repairs, and estimated water losses that that has not yet been available, which would have great value as a source for research, trend analysis, capital planning, and performance benchmarking for California suppliers.
- The proposed regulation also allows for the following:
    - Adjustments: UWS can provide the State Water Board with individualized data to replace the economic model defaults as each system improves its data accuracy and begins field implementation of water loss control approaches. This updated data leads to an adjustment to the supplier's real loss standard. Suppliers can request these adjustments until July 1, 2023.
    - Variances: In case of natural disasters or other unexpected adverse circumstances, suppliers can request variances at any time, which would provide the supplier with temporary relief regarding compliance with their real loss standard.
    - Variances: Suppliers can request a variance for their apparent loss standard if increases from the average baseline apparent loss level are attributable to improvements in data validity.
    - UWS with existing low losses: Suppliers with existing water losses lower than 16 gallons per service connection per day or the equivalent amount in gallons per mile per day that also meet data quality criteria will not be

required to reduce their water loss further or respond to questionnaires. Suppliers can qualify for this alternative compliance pathway until July 2023.

- Compliance Plan: Suppliers with standards that require a real loss reduction of more than 30% from baseline losses can request more time to meet their standard, given they show progress and meet other requirements.

A.1 Background of the Proposed Regulation

SB 555 (which added Water Code section 10608.34) sets statutory requirements for monitoring and reducing water losses through leaks in distribution systems. The State Water Board is required to develop performance standards for water loss by 2020 for urban water suppliers. Per statute, the State Water Board is required to evaluate a lifecycle cost accounting in the development of the performance standards.[6]

Urban water suppliers have been required to submit water loss audits since October 2017, pursuant to Water Code section 10608.34, subdivision (b) and regulations developed by Department of Water Resources. The water loss audits are required to be conducted per the M36 manual by the AWWA (AWWA, 2016). The accuracy of the water loss estimates from these audits depends on the quality of entered data. The process of assessing the quality of data entered in the audit is called validation. Water Code section 638.3, subdivision (a) requires the submitted audits be validated.

AB 1668 and SB 606, passed in 2018, require UWS to calculate their own individual urban water use objective beginning in 2024. The objectives are to be calculated based on efficient indoor residential use, outdoor residential use, and outdoor commercial, industrial, and institutional (CII) use associated with a dedicated irrigation meter, and an allowable water loss volume, based on standards adopted by the State Water Board (except that the standard for indoor water use was set by the legislature in Water Code section 10609.4). The objective may also include variances (allowances), for uncommon local uses (e.g., widespread use of evaporative coolers) and a bonus incentive (credit), for potable water reuse. The volumetric water loss standards to be adopted by the State Water Board pursuant to Water Code section 10608.34 will be used as the allowable water loss volume to calculate the urban water use objectives. Some water loss standards will be updated through July 1, 2023, as described by this regulation.

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[6] The lifecycle cost accounting will consider costs and benefits, projected to accrue while implementing interventions over their lifetime, including planning, installation, implementation, and operation of interventions that may be used to meet the WLPS.

The formal rulemaking process for setting water loss standards is expected to begin in Fall 2021 and is expected to conclude by Spring 2022.

A.2 Background on water loss reporting and control in California

The state has a partial understanding of water loss in California. Much of the data the State has are the results of water loss audits, which suppliers are currently required to report annually. These audits are spreadsheets which calculate the amount of leakage or real loss, based on the reported volumes of water that flow into the system and that are supplied.

The goal of the proposed regulation is to establish individual standards for each supplier, built on these industry-established concepts and an economic analysis of the benefits and costs associated with reducing leakage. Calculation of the standards depends on the accuracy of reported data. Inaccuracies in the reported volumes can introduce significant error into these audits. The accuracy of the reported volumes reflects the supplier's practices for water metering, testing meters for accuracy, and data handling. The data submission requirement regarding practices to improve data quality is intended to improve reliability of reported data, and to encourage data quality improvement during implementation and prior to compliance. The proposed regulation does not prescribe data improvement practices.

Intervention strategies to reduce leakage, also known as real loss, can vary depending on distribution system characteristics and the nature of real loss. Real loss can occur in several forms, including most commonly:

- Visible failures that are large and occur above the ground.
- Hidden leakage that is not visible above ground but detectable by surveying the distribution system through specialized equipment.
- Background leakage that is too small to be detected with specialized equipment, but that can be reduced by replacing or rehabilitating infrastructure or managing pressure.

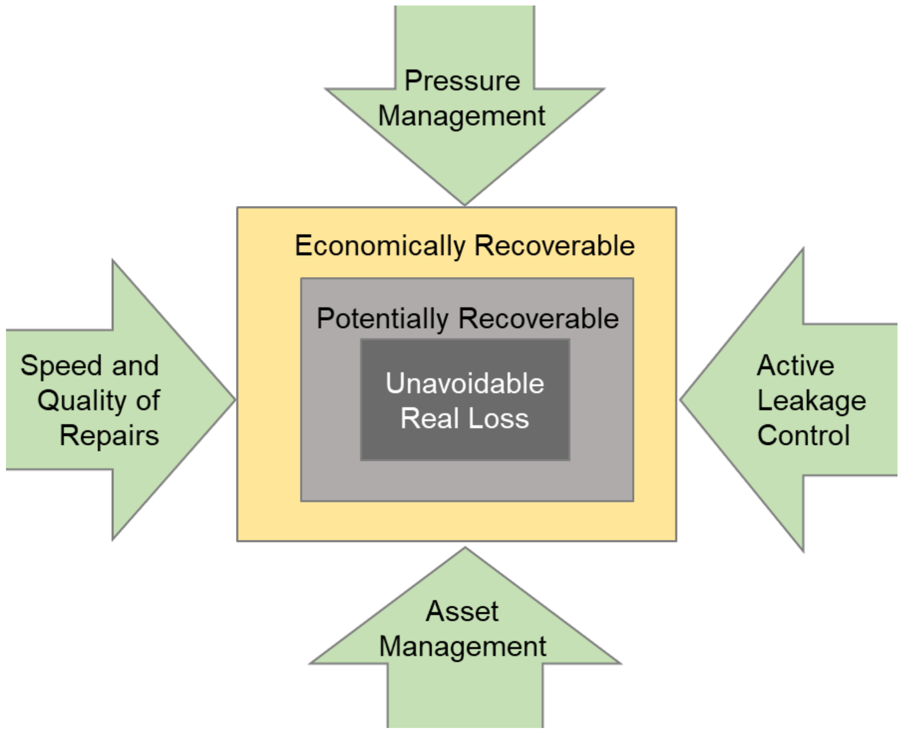

Figure 1. Foundational Approaches to Leak Detection

Per industry practice, real loss reduction has four key approaches that are suited for each form of leakage (Figure 1):

- Active leak detection and repair involves surveying the distribution system for leaks with specialized equipment and repairing those leaks. This method is typically used to reduce hidden detectable leakage.
- Reducing time between locating and repairing a leak minimizes the amount of water lost through visible or detectable leaks.
- Pressure management reduces strain on the distribution system infrastructure due to high water pressure or variations in water pressure (water hammer effect), and reduces the water leaking through cracks and defects in the system.
- Systematic asset management reduces leakage by prioritizing replacement of pipes and other appurtenances, usually those that are leakiest and have most failures and those located in areas of high consequence (e.g., hospitals, public transit infrastructure, and dense commercial centers).

Pressure and asset management are the only approaches that can be used to reduce background leakage that is too small to be detected through specialized equipment. These approaches, while also reducing repair time, can be used to reduce the occurrence of and loss of water through reported leaks. The feasibility of implementing pressure management, asset management, and the estimated volume of leakage reduction depends on operational characteristics for each distribution system. Estimating the amount of leakage that is recoverable through pressure management and asset management for UWS involves high amount of uncertainty and is dependent on the supplier's unique characteristics.

On the other hand, due to availability of data, the associated costs and benefits of implementing active leak detection and repair for each system can be determined to a much greater degree of accuracy. The amount of leakage that is recoverable can be determined from data on length of pipeline, number of service connections, and operational water pressure, as reported by suppliers.

Unreported or hidden leakage can be reduced by either of the standard approaches, in contrast to background or reported leakage. The intent of the proposed regulation is to provide each supplier the flexibility to choose any effective approach best suited for its system and budget that allows the supplier to reduce leakage to the level of its specific volumetric standard. The State Water Board developed its economic model to calculate the individual volumetric standards; the model focuses on unreported, hidden leakage, to ensure flexibility in suppliers' choice of approach.

A.3 Overview of proposed framework for performance standards

The State Water Board is required to adopt water loss performance standards for all urban water suppliers. Compliance with the proposed regulation will be in the form of volumetric water loss reduction based on economic and engineering feasibility, plus submission of data on practices influencing reported water loss data and efforts towards water loss control. The proposed regulation will require compliance with six requirements:

- Data submission on underlying data quality of water loss audits (2023).
- Data submission on feasibility of pressure management (2023, and updated in 2026) and asset management (2024, and updated 2027).
- Leakage reduction to comply with individual volumetric real loss standards in gallons per connection, or per mile, per day (by 2028) if assessed as economically feasible by the State Water Board's economic model, using the supplier's unique system data.
- Maintenance of leakage (real loss) at or below the volumetric real loss standard on a three-year average basis with an allowed variation of 5 gallons per connection per day (beyond 2028).
- Maintenance of apparent losses at or below the average baseline apparent loss level on a three-year average basis with an allowed variation of 5 gallons per

connection per day or submit a detailed inventory of apparent losses to the State Water Board.

- Annual reporting of breaks, repairs, and estimated water losses to the State Water Board.

Additional details on each requirement are provided in the next section. The proposed regulation will require compliance with a volumetric real loss performance standard by 2028. A supplier's individual standard will require the supplier to reduce real loss if the net benefit of reducing the real loss is positive. If the net benefit of reducing real loss for the supplier is not positive, the individual standard for the supplier will be increased to the point at which the net benefit is positive, if possible. When a positive net benefit is not possible, it is because the system's current real loss is slightly above what would have been their calculated standard; they are unable to save enough water to offset any costs. Therefore, if a positive net benefit is not possible, the individual standard will only require the supplier to maintain its system at its current level of real loss.

The proposed regulation will provide opportunities for adjustments to the volumetric standard in 2023 based on additional data from a supplier. The proposed regulation will have a process for UWS to request adjustments of their allowable water loss volume owing to improvements in data accuracy, and hence the reported real loss. Additionally, the framework includes a process to request a variance for the real loss standard in case of natural disasters or economically adverse circumstances, as well as a variance for the apparent loss standard if increases from the average baseline apparent loss level are attributable to improvements in data validity. A compliance plan is also available for those with standards requiring more than a 30% real loss reduction from the baseline.

The regulatory framework provides suppliers with existing low levels of water loss and high data quality an alternative compliance pathway where the suppliers would not be required to further reduce their real loss or submit additional data on data quality, pressure management, and asset management, or the registry of breaks, repairs, and estimated water losses. Suppliers that can demonstrate high underlying data quality by meeting data quality criteria developed by the State Water Board and that have existing losses lower than 16 gallons per connection per day, or the equivalent real loss in gallons per mile per day, will qualify for this alternative compliance pathway.

A.3.a Data submission on underlying data quality of water loss audits (by January 1, 2023)

The State Water Board provided $3.2 million in funding to the California-Nevada section of AWWA (CA-NV AWWA) to develop and execute a Technical Assistance Program (TAP) over a period of two years to facilitate the reporting of water loss volumes through

AWWA audits. The report on TAP (Water Systems Optimization and Cavanaugh, 2017) outlined gaps in collected data and monitoring practices that could impact the reliability of data from water loss audits. The gaps identified were uncertainty in estimating source and customer meter inaccuracy and average operating pressure and negative or technically implausible estimates for water loss.

To address these data gaps, the proposed regulation will require suppliers to submit data as responses to questionnaires on their metering and meter testing practices by January 1, 2023. The questions are aimed to gauge suppliers' current practices to assess the quality of underlying data for audits. The data submission does not require additional analysis or field work, but only reporting of current practices.

A.3.b Data submission on feasibility of pressure (by July 1, 2024, 2026) and asset management (by July 1, 2024, 2027)

Pressure management and asset management are crucial approaches to controlling water loss. These approaches are known to be highly effective in reducing real losses through small undetectable leaks and large visible leaks. Water loss control may require multiple approaches to be effective, in addition to active detection and repair. Due to supplier-specific needs and constraints that need to be considered for implementing these two approaches, it is proposed that suppliers submit data as responses to the pressure management and asset management questionnaires by July 1, 2023 and 2024, respectively, and update those responses by July 1, 2026 and 2027, respectively. The questions will assess suppliers' efforts towards systematic asset management and pressure management to reduce leakage in portions of the water distribution system that are highly prone to leakage. The data submission does not require additional analysis or field work, but only reporting of current practices.

A.3.c Leakage reduction to comply with individual volumetric standards by January 1, 2028

The calculation of real loss standards incorporates various unique characteristics of each water distribution system. The economic assessment used to calculate the standards evaluates the type of real loss occurring in each system and calculates the reduction of real loss that is economically feasible. Each supplier's standard is based on the volume of leakage reduction possible through standard approaches available to the supplier. The proposed regulation aims to provide every supplier the flexibility to select the appropriate approach for their own system's characteristics to reduce real losses to their volumetric standard. The economic model that calculates each UWS's individual volumetric standard focuses on unreported and hidden leakage, which can be reduced by all standard approaches, ensuring flexibility in chosen approaches. The economic model bases the economic feasibility on the costs and benefits associated with implementing active leak detection and repair. The proposed regulation does not require suppliers to use specific technologies; it bases the real loss standard only on the amount of reduction that is economically feasible during the implementation period. It is anticipated that suppliers will need time in the initial implementation period to select vendors and finalize contracts prior to implementation and achieving any real loss reduction. To accommodate this need, the model assumes that the period of actual reduction of real loss is 2022 through 2027, while compliance is first assessed based on the annual audits submitted for the year 2027. For calendar year audits, ‘year 2027’ means the period from January to December 2027. For fiscal year audits, ‘year 2027’ means the period from July 2026 to June 2027.

Apparent losses will also be evaluated using data from the years 2025, 2026, and 2027. If the average apparent losses are greater than the baseline apparent losses (with an allowed variation of 5 gallons per connection per day), then the supplier must submit an inventory of all apparent losses and any calculations and data used to determine those apparent losses.

A.3.d Ongoing Water Loss Control (2028 onwards)

Maintaining an appropriately low level of leakage efficiently requires continued infrastructure maintenance to control newly emerging leakage over time. These maintenance efforts involve regular monitoring of the distribution system, prioritizing infrastructure replacement and continued repair (and replacement as suitable) for system components. From 2028 onwards, UWS will be required to comply with their real and apparent water loss standards on a three-year average basis with an allowed deviation of 5 gallons per connection per day.

Per Water Code section 10608.34, the State Water Board is required to consider life-cycle costs accounting in its development of water loss performance standards. Once each supplier meets its individual standards in 2028, the economic model incorporates the costs and benefits associated with maintaining the real loss for the supplier for ongoing compliance. To incorporate the lifecycle of intervention strategies and the anticipated time for which suppliers may incur additional costs and benefits, the model considers a time horizon of 30 years.

The model is based on real loss reduction achievable through active leak detection and repair. The equipment used for active leak detection and repair has a typical lifecycle of 10 to 15 years. The duration between adoption and compliance is 7 years, with ongoing compliance beyond these 7 years. A lifecycle of 30 years accounts for the longer implementation, useful lifecycle of pipe material, and the compliance period, for the purpose of lifecycle cost accounting, as required by the statute.

A.3.e Annual report of breaks, repairs, and estimated water losses

California UWS have previously agreed to maintain a registry of breaks, repairs, and estimated water losses as part of the water loss Best Management Practices required under the Memorandum of Understanding Regarding Water Conservation in California (California Urban Water Conservation Council, 2011). Suppliers will be required to annually submit this registry to the State Water Board unless they are exempt from this requirement based on existing data quality and low loss levels. These combined registries would provide the Board with leakage data to better understand the frequency and severity of breaks, repairs, and water losses specific to California suppliers. Additionally, this data would have great value to the public as a source for research, trend analysis, capital planning, and performance benchmarking for California suppliers.

A.4 Economic model to calculate performance standards

For UWS, cost-effective water loss reduction requires a balance between the potential benefits and costs associated with reducing and maintaining losses at a lower level. For example, eliminating leakage completely from a water distribution system may not be economical, with the costs incurred being higher than the benefits achieved. The objective of the regulation is to determine the water loss volume that each system can cost-effectively achieve, with costs and benefits estimated over the lifetime of intervention strategies and compliance.

A.4.a Costs and benefits associated with real loss reduction[7]

The economic model uses data reported by suppliers through water loss audits, costs associated with active leak detection and repair based on quotes from vendors, literature review, and estimates from water suppliers to determine the costs and benefits associated with real loss reduction (Table 1). The benefits associated with water loss reductions are calculated based on the higher of variable production cost of water or the avoided cost of water. The reduction of embedded energy is included in the production or avoided cost of water. The volume of real loss reductions is calculated by assuming that all detected leaks are repaired. The model calculates the volume of real loss reductions through active leak detection and repair based on the volume and number of leaks typically detected and repaired for each distribution system as established by the AWWA (AWWA, 2016). The model assesses the present value of the net benefit associated with real loss reduction over the time horizon. The model calculates a volumetric leakage standard for each water distribution system based on system

[7] Please refer to the Appendix for detailed information on the costs and benefits.

characteristics and the specified four years of water loss audit data. Benefits and costs are discounted at the rate of 3.5% per year. A system will only be required to meet a lower standard if the net benefit of leakage control actions over 30 years is positive.

The structure, underlying assumptions, findings, and proposed default values of the model have been reviewed by experts through an independent, external peer review.

Table 1. Costs and Benefits associated with Real Loss Reduction

Associated Costs over time horizon of 30 years	**Associated Benefits over time horizon of 30 years**
Cost of surveying water distribution systems to detect and locate leaks. Cost of repairing leaks found while surveying. Costs associated with additional excavations, where equipment shows false positives while detecting leaks.	Marginal value of lost water valued at the avoided cost of water saved by reducing real loss or at the variable production cost of water, whichever is higher.*

* The default rise in the real price of water is 4.2% per year.

A.4.b Innovation in technology

Real loss reduction and leak detection and repair are emerging fields. It is assumed that the proposed regulation would not have a significant impact on leak detection and repair costs since the regulation could have two potentially opposite impacts on these costs. On the one hand, due to increase in the demand for leak detection and repair services, leak detection and repair service vendors or businesses might charge higher prices if no new businesses enter this sector. On the other hand, given the size of California's economy and the over 400 UWS subject to the regulation, higher demand will likely generate more competition among existing businesses and new firms may have incentives to enter the market, which could further increase competition. Competition would incentivize suppliers to innovate to decrease marginal cost and benefit from serving a larger market. This would drive down the price of leak detection and repair. Combining these two forces, it would be challenging to identify either the direction or the magnitude of the potential impact. The most likely outcome is some combination of both.

A.4.c Data used in the model

The model uses data reported on current real losses, the variable production cost of water, and other system-specific characteristics such as average operating pressure, length of distribution mains, and service connections from the water loss audits submitted by suppliers from 2017 through 2020. The reported data is averaged over a period of four years, and suppliers have the option to remove a year containing aberrant data.

Additionally, the proposed regulation will allow suppliers to provide individual system-specific information for most parameters used to evaluate the type of leakage occurring in the distribution system and the cost that they incur for detecting and repairing leaks. The suppliers can also provide values appropriate for their distribution systems for the marginal avoided cost of water. <u>For suppliers that are unable to provide values for these parameters</u>, the model provides default values. The <u>default</u> values for these parameters are below.

The model has two parameters that are fixed and cannot be changed by suppliers:

Time Horizon

The time horizon is 30 years to incorporate the costs and benefits associated with ongoing compliance beyond 2028 and the lifecycle of possible intervention strategies.

Discount Rate

The associated costs and benefits are discounted annually at the rate of 3.5%, per stakeholder recommendation. This is in line with the Guidelines for Preparing Economic Analysis (U.S. EPA, 2014), which suggests that the real discount rate should be in the range of 3% to 7%, depending on the time horizon and whether costs and benefits are incurred contingent on consumption flows or capital stocks. Consumption flows are associated with lower discount rates than capital stocks. In general, a lower discount rate could be adopted if the regulation impact is expected to last longer. The proposed regulation is intended to conserve water and it would have permanent impacts on water resources and the environment, with a time horizon of 30 years for economic analysis. Therefore, a relatively low discount rate is proposed.

The remaining parameters can be changed by suppliers if they provide appropriate supporting documentation:

Marginal Avoided Cost of Water

The marginal avoided cost of water is determined from the cost of alternative water sources available to the supplier. The most common alternative water sources are stormwater reuse, recycled water (indirect potable reuse), brackish water desalination, and imported water. The Pacific Institute has estimated the cost for each of these sources, which were averaged to calculate the default value of $1,275 per AF (Pacific Institute, 2016).

Average Unit Cost of Leak Detection

Costs for leak detection surveying are in metrics of dollars per mile surveyed. The State Water Board obtained estimates for cost incurred by a system both for leak detection programs that were conducted in-house and that were outsourced (see the economic model appendix at the end of this document for detailed cost data). While some suppliers have in-house leak detection programs, it is anticipated that most suppliers would opt for external consultants for leak detection.

The model uses the unit costs on the high end of the range ($595 per mile) as a conservative estimate for both surveying and pinpointing, to accommodate for the use of external technical consultants by suppliers and for different types of pipe (metal or plastic).

Leak Repair Costs

Typically, suppliers do not outsource leak repairs and instead use their own staff to repair leaks. The cost of repairing leaks varies significantly with pipe size, type of pipe, extent and size of leak, and depth of pipe. The State Water Board obtained a large range of leak repair costs from suppliers and from existing literature. Predicting the specifics of a pipe that could be identified to have a leak has high uncertainty associated with it. It was assumed in the model that there is equal probability to detect a leak in any type of pipe, and the average of all these estimates was used to value the cost of repairing each detected leak. The costs were averaged over two years to accommodate for changes in material vendors and cost of pipe material.

The average cost calculated from all these estimates is $5,946 per leak for repairing mains and $2,330 per leak for repairing laterals and service lines.

Infrastructure Condition Factor

The infrastructure condition factor (ICF) is a correction factor that considers the conditions of the infrastructure system being assessed as they relate to leakage. An ICF of 1 is the minimum value, and it represents a case of minimal water loss, where the system’s total leakage is equal to its background leakage. The current model default is 1.

Reported Leakage

The parameters to calculate reported leakage are different depending on if the leak is on a main or on a service connection (from the main to the curb stop). Table 2 shows the parameters and their two sets of default values: one set for leaks on mains, and one set for leaks on service connections. All default values are from AWWA (2016).

Table 2. Reported Leakage Parameters and their Default Values

Parameter Name	Defaults for Mains	Defaults for Connections
Average duration between reporting of and repair of reported leaks	3 days	8 days
Number of reported leaks per year	0.2 leaks per mile per year	2.3 leaks per 1,000 connections per year
Average flow rate for reported leaks	50 gallons per minute per leak	7 gallons per minute per leak

Unreported Leakage

The parameters used to calculate unreported leakage are the number of unreported leaks per year found on mains (default value of 0.01 leaks per 100 miles of mains) and found on service connections (default value of 0.75 leaks per 1,000 connections). These values are from AWWA (2016).

Efficiency of Leak Detection Equipment

This parameter represents the average number of actual leaks found on excavation as a percent of the total detected leaks, including false positives, expected to be pinpointed by leak detection equipment over the time horizon. This efficiency increases with higher training and experience as both vendor and water supplier knowledge increases based on field implementation. This parameter adds the cost of additional excavation associated with locating leaks pinpointed by false positives, without the benefits of water loss reductions, to the overall costs of leak detection and repair. The default value for the efficiency of leak detection equipment is 70%.

Average Leak Detection Survey Frequency

The leak detection survey frequency determines how quickly a system can be surveyed for leaks. The default average survey rate is based on communications with vendors and water suppliers, and differs based on the size of the system:

Table 3. Default Survey Rates by System Size

Miles of Main in System	Default Survey Rate
6,000 or more	130 miles per month
4,000 to 6,000	114 miles per month
1,000 to 4,000	One full survey every 3 years
500 to 1,000	One full survey every 2.5 years
500 or less	One full survey every 2 years

Rate of Rise of Leakage

This parameter is used to calculate how much additional unreported leakage a system experiences over time. The default value of 5 gallons per connection per day per year was chosen as representative of California water systems based on a combination of data (Sturm et al., 2014; European Union, 2015). The European Union (2015) provided a range of rate of rise values for many systems, though none in the United States, which show that very low and low rate of rise values are defined as up to 5 and 11 gallons per connection per day, respectively. Based on the field experience of technical experts, the rate of rise of leakage for California systems is expected to be very low (5 gallons per connection per day). To check the applicability of this value, the two case studies from Sturm et al. (2014) were evaluated, showing data from both a California and a Tennessee system. The values calculated for the rate of rise of leakage were 3.1 and 3.9 gallons per connection per day for the California and Tennessee systems respectively, verifying that the use of 5 gallons per connection per day is representative.

The model has three optional parameters that do not have suggested default values:

- Annual Background Leakage can be entered into the model instead of an ICF value, if the background leakage volume is known.
- Annual Reported Leakage can be entered into the model instead of the parameters to determine the reported leakage, if the reported leakage volume is known.
- Annual Unreported Leakage can be entered into the model instead of the number of unreported leaks per year on mains and service connections, if the unreported leakage volume is known.

Rise in Price of Water

California water systems have experienced various levels of water price growth in the past. The default value of the water price growth rate is based on the result from Gaur and Diagne (2017). The authors analyzed water bill data from multiple surveys for 14 counties in California, including seven counties from Northern California and seven from Southern California, from 2003 to 2015. The results suggest that the average *nominal* growth of water rate from 2003 to 2015 is about 6.3%, as can be seen in Figure 2.[8]

The average nominal water rate growth, 6.3%, is further adjusted by the average inflation rate in California during this period, 2.1%, to reach the inflation-adjusted *real* water rate growth, 4.2%, which is adopted as the default value in the model.[9] Staff notes a range of factors, such as climate change and water treatment (e.g., for per- and polyfluoroalkyl substances[10]) may make water more expensive in the future, relative to the general price level.

The State Water Board staff is aware of the potential concerns regarding use of the average water rate growth as the default value. For example, the water price reflects the average cost of producing water, including both fixed costs and variable costs. The staff believes this is a reasonable default value because the proposed regulation is a long-term effort, and over the longer-term, many costs are variable. Staff notes the model shows that the proposed standards would not be significantly affected by the choice of this number.

As pointed out by one of the peer reviewers, it is reasonable to expect that water in the future will be at least as expensive as it is now, relative to the future general price level, since water is a scarce resource. <u>For this reason, the State Water Board staff requires that any supplier-submitted updates to the rise in price of water be at least as large as the discount rate</u>. A rate of rise in the cost of water *lower* than the discount rate would mean the real cost of water, in present value, was falling.[11]

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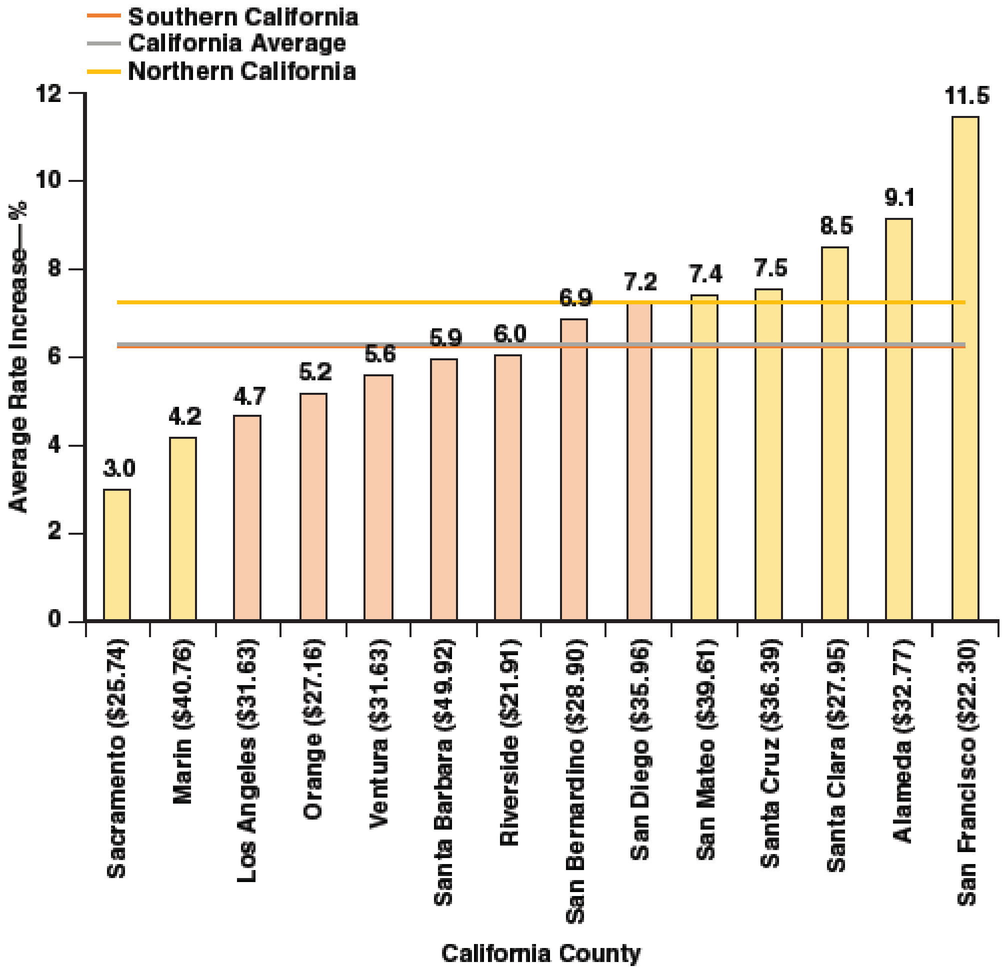
[8] This figure is corresponding to Figure 2 in Gaur and Diagne (2017).

[9] The staff also calculated the average water price growth rate for Metropolitan Water District (MWD), the largest water wholesaler in California serving almost half the population of California. The rise in water price is projected from the average annual rise in the cost of treated wholesale water that MWD sells to its member agencies that are urban water suppliers. The average real growth rate is about 4.6%.

[10] https://www.waterboards.ca.gov/publications_forms/publications/factsheets/docs/pfoa_pfos_guidelines_faq_factsheet.pdf

[11] See Sterner and Persson (2008).



[a]Average 2003 total bills for each county are shown in parentheses.

Yellow bars are Northern California counties; orange bars are Southern California counties.

Figure 2. Annualized rate increases of 14 counties from 2003 to 2015.

It should be emphasized that both the costs and benefits calculated from the model are real values since they have been either adjusted for inflation or using current prices. Costs are based on current cost information reported by the water suppliers. Benefits are calculated with a 4.2% annual growth in real water prices since all the prices are adjusted by CPI. Therefore, the costs and benefits are real present values after discounting from the future values with a real discount rate.

A.5 Provision for UWS to Request Adjustments or Variances

Suppliers will be able to request adjustments to their standards if there are significant changes to data used in the economic model for calculating standards that could impact their standard. These adjustments will be evaluated on a case-by-case basis, based on documentation supporting the adjustment. Suppliers will be able to request these adjustments on or before July 1, 2023.

Additionally, suppliers will be able to request a variance regarding compliance with their volumetric real loss standard if they can demonstrate unexpected adverse conditions which prevent the supplier from implementing established measures or strategies to achieve their standard. The request would need to be accompanied by supporting documentation of conditions pertaining to distribution system characteristics or administrative procedures warranting the variance. Thus, the real water loss standards for suppliers could change as a result of these variances. This could affect the associated benefits and costs. Predicting variations with these costs and benefits due to adjustments and variances involve a high amount of uncertainty, due to which the State Water Board has presented the analysis using default values used in the model. Because approved adjustments or variances are likely to lower costs, this approach is more conservative, i.e., it assumes greater impacts than may actually occur.

Suppliers are also able to request a variance to their apparent loss standard if increases from the average baseline apparent loss level are attributable to improvements in data validity. A variance may be approved after two consecutive years of the supplier's validated annual audits showing data grading values of 6 or higher for customer metering inaccuracies or all of the following: volume from own sources, master meter and supply error adjustment, water imported when more than 5% of total water supplied, and water exported when more than 5% of total water supplied. This variance is important because some suppliers may have artificially low apparent losses for the baseline period due to poor data validity, and improvements in data validity may show that apparent losses are likely to continually exceed the apparent loss standard. A variance for the apparent loss standard is in the form of a permanent adjustment to the standard.

Suppliers with real loss standards requiring water loss reductions of more than 30% from the baseline can request additional time to meet their standard. For the compliance plan to be approved, the UWS must meet several requirements, including demonstrating progress toward their standard of at least 30% of the difference between the baseline and the standard in their 2025, 2026, or 2027 water loss audits. The other requirements are to complete two full leak detection surveys and to demonstrate improving validity scores if not already at Level 3.

A.6 Major Regulation Determination

A major regulation is "any proposed rulemaking action adopting, amending or repealing a regulation subject to review by [the Office of Administrative Law (OAL)] that will have an economic impact on California business enterprises and individuals in an amount exceeding $50 million in any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through 12 months after the major regulation is estimated to be fully implemented (as estimated by the agency) computed without regard to any offsetting benefits or costs that might result directly or indirectly from that adoption, amendment, or repeal" (Budget letter 13-30, California Department of Finance).

The proposed regulation has been determined to be a major regulation because the annual macroeconomic impact would exceed $50 million in a 12-month period during the period of analysis, 2022 through 2051. As shown in section D.3, the impact on gross output in 2023 is projected to be approximately $52.34 million, which is higher than the threshold. In addition, the annual benefits from water loss reduction would be above $50 million dollars in 2023 and the years through 2051.

A.7 Baseline and Scope

The economic impact of the proposed regulation is evaluated against a baseline of current business as usual (BAU) practices for water loss control. In other words, in the absence of the proposed WLPS, the evaluation assumes suppliers would conduct leak detection surveys or repairs as needed to maintain leakage at current levels. Without regular maintenance, systems' leakage would rise naturally as time passes, so the assumption of a constant rate of water loss provides a conservative estimate for the amount of water saved.

The proposed regulation has the potential to directly affect each urban water supplier. Per Water Code § 10608.12(t), this "means a water supplier, either publicly or privately owned, that directly provides potable municipal water to more than 3,000 end users or that supplies more than 3,000 acre-feet of potable water annually at retail for municipal purposes." There are 366 urban water suppliers in California.

The unit of analysis used in this SRIA is the *system;* some urban water suppliers have more than one system. For example, the systems of two different towns might be owned or operated by one urban water supplier. There are currently 567 systems subject to the regulation.

Using the current model defaults to calculate water loss standards, approximately 265 systems would be required to reduce their water loss. The remaining systems already have their water loss controlled at levels that would not subject them to obligations under the proposed regulation. Among the 265 affected systems, 60 are privately-owned water companies and 205 are public water agencies. Among the impacted privately-owned water systems, 6 are small businesses. The remaining public water systems are all local agencies.[12]

The 265 impacted systems serve approximately 25.6 million people. As discussed in Section D.3.h, the State Water Board assumes that the direct impacts from the proposed regulation on the systems will be passed on to consumers. Therefore, about 25.6 million people would be indirectly affected by the proposed regulation. The 30-year lifetime, indirect per person impact is about a $178 net savings, in present value.

Of the 567 systems subject to the regulation, there are 109 UWS systems that have not yet submitted any water loss audits (as of July 8, 2021). These missing systems are not included in the analyses in this SRIA because the economic model relies on system-specific data from the water loss audits to generate a volumetric water loss standard. This lack of data does not substantially affect the results because most of these systems are small systems (less than 3,000 service connections) owned by larger suppliers. Only 20 of these systems have more than 3,000 service connections, and the missing systems represent only 4% of all households served by UWS. All missing systems will be evaluated and given water loss standards as soon as data from water loss audits is available.

A.8 Public Outreach and Input

As part of an extensive pre-rulemaking process for the proposed regulation, the State Water Board engaged with stakeholders, including water suppliers, industry experts, and environmental justice groups through public meetings and workshops and has received a significant amount of input from stakeholders. The stakeholder engagement covered topics such as data accuracy and variability, focus areas, program implementation, costs, feasibility and efficiency of interventions, the rulemaking framework, and the economic framework and analysis.

Prior formal stakeholder engagement was conducted on the following topics:[13]

- Data quality and performance indicators: March 2018
- Water loss control actions: June 2018
- Avoided cost of water, water loss control implementation in California (presented by water suppliers): September 2018
- Staff proposed framework: February 2019

[12] Section F includes detailed analysis on the fiscal impacts for the state agency and local agencies.
[13] https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/water_loss_control.html

- Assumptions, benefit-cost calculations behind economic framework: June 2019
- First draft of economic model to calculate standards: September 2019 (with 32-day written comment period)
- Data submission requirements: December 2019
- Second draft of economic model to calculate standard, data submission requirements and revised regulatory proposal: May 2020 (with 47-day written comment period)
- Overview of proposed water loss standards and regulatory framework: December 2020
- Overview of peer review and responses: March 2021

Additionally, the State Water Board conducted meetings and calls with individual suppliers and regional water supplier associations to address questions and issues related to the regulatory framework. The State Water Board has also participated in several conferences to present the regulatory proposal at various pre-rulemaking stages, organized by associations such as the American Water Works Association and the Alliance for Water Efficiency. The current proposed regulation and the current model reflect many of the comments provided.

B. Direct Benefits from the Regulation

The proposed regulation is intended to reduce water losses in the distribution systems of urban water suppliers through system-specific performance standards. The main direct benefits are from the value of water saved due to the proposed regulation. The saved water results in reduced costs associated with extracting or importing water and then treating and pumping it for distribution. Direct benefits have been quantified in the economic model as a function of system-specific variables (e.g., variable production costs). To evaluate the lifecycle benefit, future benefits are converted to present values through discounting.

B.1 Benefits to the Typical System

The benefits are calculated using the marginal avoided cost of future water, with the rising price of water incorporated at a real annual rate of 4.2%, as discussed in Section A.4.c. The future marginal avoided cost of water, $1,275 per AF, is based on an average of the costs of alternative sources - such as imported water, recycled water, brackish and sea water desalination (Pacific Institute, 2016). If a supplier’s current variable production cost, provided in audit data, was higher than this value, their current variable production cost was used instead. The real discount rate used in the economic model is 3.5%.

The calculation of direct benefits is based on the input values for each water system over a 30-year period and then aggregated to the state level.[14]

For analytical purposes, we define the *typical system* as an illustrative example system with characteristics set at the averages of the characteristics of all the systems subject to the regulation. For this hypothetical typical system, the proposed regulation would result in 12,655 AF of water loss reduction (water savings) and therefore would generate total benefits of $15.4 million dollars in present value, as shown in Table 3.

Table 4. Direct Benefits for Systems

	Typical System	Small Businesses
Water loss reduction (AF)	12,655	3,786
Total Benefits ($)	15,455,201	4,589,987

Importantly, the model does not incorporate additional benefits from leak reduction approaches other than leak detection and repair, such as preventative pipe replacement or pressure management. Additional benefits may include the prevention or reduction of:

- Strain on and early deterioration of distribution systems.
- Unexpected main breaks that can cause property damage.
- Water outages.
- Traffic caused by repairs.
- Contamination of water due to defects in infrastructure.
- Carbon emissions associated with water treatment and pumping activities.

Quantifying these benefits involves a high amount of uncertainty, and thus these likely additional benefits are not included in the model.

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[14] As the regulation is targeting system-level water loss control, the analysis in this SRIA is based on system-level information. For suppliers with multiple systems, the costs and benefits could be summed up to the supplier level if needed.

B.2 Benefits to Small Businesses

The benefits to small businesses are examined separately. According to Government Code section 11346.3, subdivision (b)(4)(B), a small business is a business that satisfies three criteria: (a) is independently owned and operated; (b) is not dominant in its field of operation; and (c) has fewer than 100 employees. Among the 265 water systems that could be impacted by the proposed regulation, 60 are privately owned water systems. Six of these meet the criteria that define a small business. On average, the regulation would generate 3,786 AF water loss reduction in the 30-year lifetime at the system level for small businesses, with total benefits amounting to 4.6 million dollars. Both are much lower than the benefits to a typical system because smaller systems generally have smaller water systems with a smaller length of pipe and a corresponding lower volume of total leakage that could occur.

B.3 Statewide Benefits

Given that the State Water Board's model is system-specific, benefits must be aggregated to give an estimate of the direct benefits to the State. There are currently 460 systems that have reported data as UWS. The total benefit to the State is composed of the total values of water loss reduction for all these systems.

The benefits are estimated based on the amount of water saved through real loss reduction. The model compares the amount of real loss that a distribution system would have under two scenarios: *No intervention* (business as usual) while maintaining existing real loss levels; and *With intervention* (with reduced leakage based on a reasonable average leak detection frequency).

As shown in Table 4, the total amount of water saved at the state level in response to the proposed regulation is approximately 3.4 million AF and the associated total benefit is $4.1 billion (in 2020 dollars). Annual benefits are reported in the table for several critical years: anticipated beginning of implementation (2022), primary year of initial compliance (2028), and the end of the assumed lifecycle period (2051). The water saved in the initial year (2022) is estimated to be 17,854 AF, due primarily to new leak detection and repair. This number would increase to 117,368 AF after 2028 when nearly all the systems complete the initial survey of their whole water system and would continue until the end of the assumed lifetime (2051). The associated benefit would increase from about 23 million dollars in 2022 to about 155 million dollars in 2028 and then decrease to 122 million dollars in 2051. From 2022 to 2028, water saved would increase as more leakages would be detected and repaired. The annual water saved would be constant after the backlog of leaks are fixed. The total benefit would then decline over time as further future values are discounted into the present values.

Table 5. Statewide Direct Benefits

	30-year lifetime	2022	2028	2029	2051
Water Saved (AF)	3,353,549	17,854	117,368	117,368	117,368
Total Benefit ($)	4,092,978,354	23,252,863	154,574,188	154,197,226	121,769,982

C. Direct Costs of Regulation

The proposed regulation will result in direct costs to urban water suppliers, which will have spillover effects to individuals and businesses (indirect costs). No other group of individuals or businesses are anticipated to face direct costs from this regulation. Individuals are not expected to modify any home infrastructure or plumbing and thus do not face any direct costs due to this regulation; rather they will indirectly incur costs to the degree that UWS raise rates (or surcharges) to pay for increased maintenance of supplier-owned water distribution systems. Indirect costs are discussed in Section D.3.h.

The direct costs calculated are based on costs associated with regular leak detection and repair of detected leaks, for suppliers that can reduce leakage effectively, over the time horizon of 30 years. Direct costs have been quantified in the economic model as a function of current real loss and system characteristics, such as length of mains, number of service connections, operational parameters, and the set of default parameters. The default parameters may be changed by suppliers to better represent their systems. This analysis includes only default parameters to calculate the standards, and parameters updated by suppliers are likely to lead to lower standards and lower costs. Therefore, the costs presented here are conservative estimates. The economic model also contains a detailed description of the variables and equations used to calculate direct costs. Please refer to Section A.5 for details.

C.1 Costs to the Typical System

The direct costs of conducting leak detection and repair are calculated based on a unit cost for surveying and repairing detected leaks for each mile of the distribution system. The calculation of the direct costs is based on input values for each system over a 30-year period (the time horizon of the economic assessment) and then aggregated up to the state level. The *typical system* is defined as a system with the average cost and benefit among all the impacted systems.

As discussed in Section A.5, three components are considered in the total costs: leakage detection cost, leak repair cost, and monitoring and reporting costs associated with complying with the proposed regulation. Table 5 reports the direct costs over the 30-year lifetime. For the hypothetical typical system, the highest direct cost would be from leak detection, which is approximately $1.21 million. The repair cost is $431,369. In addition, it is assumed that each impacted system would need to dedicate 1/24 of an engineer's personnel-year (about 7.2 hours per month) to monitor the leak detection and repair progress and report to the State Water Board, including preparing data and paperwork. These tasks could be absorbed by urban water suppliers' existing employees. The cost of this position is assumed to be $200,000 per year in 2020 with an annual real growth rate of 3.5%.[15] This results in a total of monitoring and reporting cost of $250,000 in present value.

Table 6. Direct Costs for Systems

	Typical System	Small businesses
Leakage Detection ($)	1,206,531	553,517
Repair Costs ($)	431,369	171,846
Monitoring and Reporting Costs ($)	250,000	250,000
Total Costs per System ($)	1,887,900	975,363

C.2 Costs to Small Businesses

The costs imposed on small businesses are examined separately. According to Government Code section 11346.3, subdivision (b)(4)(B), a small business is a business that satisfies three criteria: (a) is independently owned and operated; (b) is not dominant in its field of operation; and (c) has fewer than 100 employees. Among the 265 water systems potentially impacted by the proposed regulation, 6 are identified as small businesses according to these criteria. On average, the total cost is about $975,363 for small businesses, less than half of the cost for the typical system. This is mainly because small businesses have smaller water supply systems with shorter pipes and fewer total leaks to repair, which leads to both lower leak detection and repair costs. For simplicity,

[15] If an alternative growth rate is adopted, the monitoring and reporting cost could be higher or lower, but would be still in line with the magnitude estimated here.

monitoring and reporting costs are assumed to be independent of system size since the proposed regulation involves a similar amount of paperwork and monitoring efforts regardless of the size of the supplier.

C.3 Statewide Costs

Given that the State Water Board's economic model is system-specific, costs were aggregated to give an estimate of the direct costs to the state. The total cost to the State is composed of the total leak detection costs, leak repair costs, and monitoring/reporting costs for all affected suppliers.

As shown in Table 6, the total costs for all the impacted urban water suppliers at the state level would be approximately $500 million over the 30-year lifetime. The cost of leak detection is approximately $320 million for the lifetime considered, which accounts for about 67% of the total cost. Leak repair costs account for another 21% of the total cost, and the rest is monitoring and reporting costs. The average annual cost would be approximately 17 million dollars, and the actual annual costs vary from year to year. Table 5 reports the annual costs in the years 2022, 2028, 2029 and 2051. In 2022, the total cost is about 26 million dollars. It declines to about 20 million dollars in 2028 and further down to about 10 million dollars in 2051. The savings are mainly due to regular detection in the later years.

Table 7. Statewide Direct Costs

	30-year lifetime	2022	2028	2029	2051
Leak detection costs ($)	319,730,743	17,530,287	13,480,821	13,017,817	6,034,178
Repair costs ($)	114,312,704	6,159,290	4,736,505	4,573,827	2,120,117
Monitoring and Reporting costs ($)	66,250,000	2,208,333	2,208,333	2,208,333	2,208,333
Total Costs ($)	500,293,447	25,897,910	20,425,659	19,799,977	10,362,628

D. Macroeconomic Impacts

D.1 Methodology

Direct costs are translated into inputs of a general equilibrium economic model to assess the macroeconomic, indirect, and spillover effects of the regulation. The statewide impacts of the proposed regulation on the California economy will depend on the results from the general equilibrium model. For estimating these costs, the State Water Board adopts the regional economic model developed by the U.S. Bureau of Economic Analysis (BEA): the Regional Input-Output Modeling System (RIMS II). The RIMS II model provides multipliers that allow the Board to estimate the effect of the regulation on the industries in California.

RIMS II is produced by the U.S. BEA using its 2012 national I-O table, which shows the input and output structure of 372 U.S. industries, which have then been adjusted by their 2017 regional economic accounts to reflect California-specific industrial structure and trading patterns.[16] Each industry is associated with a set of multipliers that represent how final demand changes would be translated into regional outputs, earnings, and employment.

The RIMS II model depends on a few important modeling assumptions that can be considered as limitations to this approach. First, only backward linkages are modeled in RIMS II. In other words, only the impacts on the upstream industries are included in the model. Second, businesses in the affected industries have no supply constraints and can satisfy additional demand with an increase in inputs and labor from within the State. Third, it assumes businesses have fixed patterns of purchases, or no potential technological changes are allowed in the model. Fourth, the model assumes businesses use local inputs if they are available.

Regarding the first assumption, one concern is that water is a key input for various industries. If the UWS pass the costs of complying with the proposed regulation to consumers, and this results in a significant consumer price increase, then the downstream industries that use water as an input would be affected. Based on our later analysis on water price, the potential change in water price is negligible (below 0.01% increase in household water bill as a share of disposable income for the first year). This justifies the adoption of RIMS II model for this analysis.

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[16] Please see https://apps.bea.gov/regional/rims/rimsii/ for detailed information.

Regarding the second assumption, it would be violated if there is a capacity limit for detection, repair and pressure management equipment and services. Given that the total demand changes for these industries are not extremely large and the UWS will split the changes across time, effects are unlikely to reach any supply capacity.

Regarding the third assumption, technology has become more efficient for leak detection and leak repair in the last decades. For example, since 2016, some leak detection companies have started using continuous acoustic monitoring systems, which have decreased the use of equipment and labor efficiently by automating leak detection and location.[17] Additionally, consistent use of leak detection over time increases efficiency of the equipment due to increased training and technical knowledge. This applies not only to the service contractors, but also to the operators who may find more cost-effective solutions to satisfy the requirements of the proposed regulation. Therefore, the results of the assessment represent the impact's upper bound.

Regarding the fourth assumption, since a majority share of the changes in final demand are services which are mostly provided by local firms, this assumption is reasonable. In the case that some of these services and equipment are not provided by the local companies, the Board's estimates based on RIMS II multipliers tend to overestimate the impacts.

D.2 Inputs to the Assessment

Translating the direct costs for RIMS II inputs begins with identifying industries that produce water loss control equipment or provide related services, including but not limited to leak detection and leak repair. To generate RIMS II input values, we first categorize all the industries by NAICS name and code that make up the capital costs used in the economic model. Table 6 lists the industries that are directly related to leak detection and repair. Costs reported in Table 6 have been separated into NAICS categories with the matched NAICS codes listed in Table 7.

Table 8. Macroeconomic Inputs by Industry in 30 Years

Direct Cost Category	NAICS	Industry Description	RIMS II Code	Direct Cost ($)

Leak detection service	334519	Other Measuring and Controlling Device Manufacturing	33451A	319,730,743
Leak repairing equipment	334513	Industrial process variable instruments manufacturing	334513	35,436,938
Leak repairing service	541990	All Other Professional, Scientific, and Technical Services	5419A0	78,875,766
Monitoring and reporting	541990	All Other Professional, Scientific, and Technical Services	5419A0	66,250,000

Table 9. RIMS II Multiplier (Type II) Associated with the Affected Industries

Direct Cost Category	Type II RIMS II multipliers			
	Gross Output (per dollar)	Earnings (per dollar)	Jobs (per million $)	Value Added (per dollar)
Leak detection service	1.6625	0.4638	7.1558	1.1391
Leak repairing equipment	2.1849	0.9085	13.9868	1.3288
Leak repairing service	1.9837	0.6604	11.2098	1.2524
Monitoring and reporting	1.9837	0.6604	11.2098	1.2524

Data Source: BEA, *California RIMS II multipliers (Type II), 2007/2015,* 2017.

The industries were then matched with the RIMS II industry codes. Table 7 reports the RIMS II code corresponding to each cost category and industry description. The next step is to identify the multipliers for each industry.[18] The industry multipliers are reported in Table 8, which include multipliers for gross outputs, earnings, employment, and value added.

[18] Department of Finance, California, provided the RIMS II type II multipliers.

D.3 Results

D.3.a Overall Impacts by Industries

The resultant macroeconomic impacts are shown in Table 9 for gross output, earnings, jobs, and value added. The total impacts are separated into the contribution from changes in final demand for each direct cost category.[19] As there is no timeline in the RIMS II model, all these results should be interpreted as the overall final outcomes to the new equilibrium due to the proposed regulation in a 30-year lifetime.

Gross output

Gross output represents the total value of goods or services produced in a region within a given time period. It is used as a measure for the overall size of the economy. As demand increases, output is expected to expand, holding all other factors constant. As discussed in the above sections, the proposed regulation increases the final demand in leak detection and repair related services and equipment. Thus, it is expected to increase the total output in the whole California economy.

As can be seen from the first column of Table 9, the total impact on gross output is approximately 897 million dollars over the 30 years. The largest contributor is leak detection, which results in an increase of approximately 532 million dollars in gross output, or about 62% of the total impacts. The contribution from extra demand in repair equipment and service to comply with the proposed regulation is approximately 156 million dollars, which accounts for about 24% of the total impacts. The rest is from the monitoring and reporting category. The average annual impact is approximately 30 million dollars in present value. Overall, the impact is relatively small compared to the size of the California economy, which was about 3 trillion dollars in 2019.[20]

Earnings

The proposed regulation will impose no direct costs on individuals in California. However, the costs incurred by affected businesses and the public sector will cascade through the economy and affect individuals.

One measure of this impact is the change in real personal income. Table 9 shows annual change in real personal income (*Earnings* column) across all individuals in California.

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[19] The industry specific and statewide economic impact depend on the proportion of regulation related spending that remains in the state. Hydraulic models, leak repairs, and leak detection surveys performed by companies located within the state will likely result in positive economic indicators.
[20] This information is from the U.S .Bureau of Economic Analysis: https://www.bea.gov/sites/default/files/2020-10/qgdpstate1020_0.pdf

Total personal income growth increases by about 276 million dollars as a result of the proposed regulation over the assumed lifetime. The change in personal income estimated here can also be divided by the California population to show the average or per capita impact on personal income. The increase in personal income is estimated to be about $7 per capita over the proposed regulation's assumed lifetime.

Table 10. Macroeconomic Impacts by Industries over 30 Years

Direct Cost Category	Gross Output (dollar)	Earnings (dollar)	Jobs (number)	Value Added (dollar)
Leak detection service	531,552,361	148,291,119	2,288	364,205,290
Leak repairing equipment	77,426,166	32,194,458	496	47,088,604
Leak repairing service	156,465,857	52,089,556	884	98,784,009
Monitoring and reporting	131,420,125	43,751,500	743	82,971,500
Total Macro Impacts	896,864,509	276,326,633	4,410	593,049,402

Employment

The *Jobs* column in Table 9 presents the impact of the proposed regulation on total employment in California. The employment impacts represent the net change in employment, which consist of positive impacts for some industries and negative impacts for others. The proposed regulation is estimated to result in a slightly positive job impact of 4,410 jobs in total over the assumed lifetime. These changes in employment represent less than 0.03 percent of baseline California employment.

Value Added

Value added includes all the extra value contributed by all the factors of production. It excludes the values of direct inputs and intermediate inputs, either domestically produced or imported from other regions/countries. As reported in the last column of Table 9, the total impact on value added is approximately 593 million dollars, less than 0.02 percent of the total Gross Domestic Product (GDP) in California.

Impacts in Certain Years

The annual impacts are examined for some critical years and reported in Table 10.[21] The overall impact on gross output is estimated to be approximately 47 million dollars for 2022, and 52 million dollars in 2023, which qualifies the regulation as a major regulation. The earning impact varies from about 14 million dollars in 2022 to 6 million dollars in 2051. The annual impact on jobs varies from 229 jobs in the initial year to 95 jobs in 2051, and would peak at 258 jobs in 2023. These impacts reflect the increase in economic activity to fix backlogs of leaks followed by reaching a steady state of water savings that decline in value with future discounting. The impact on value added is about 60% of that on gross output, as expected. There is a decreasing trend in macroeconomic impact over time due to lower leak detection and repair costs, and positive real discounting. Overall, the annual economic impacts are relatively small compared to the size of California economy.

Table 11. Macroeconomic Impacts by Year

Economic Impact	2022	2023	2028	2029	2051
Gross Output ($)	46,534,596	52,381,470	36,797,112	35,683,757	18,890,661
Earnings ($)	14,443,971	16,245,111	11,444,323	11,101,352	5,928,210
Jobs	229	258	182	177	95
Value Added ($)	30,758,280	34,640,931	24,292,046	23,552,716	12,401,162

D.3.b How many firms are impacted by the WLPS?

The proposed regulation directly affects all the urban water suppliers that will be required to conduct water loss control for purposes of complying with the proposed regulation. There are currently 460 UWS systems in this analysis, out of which 265 would be affected by the proposed regulation. The rest of the 195 systems already have their water loss controlled at levels that would not subject them to additional obligations under the proposed regulation and thus they would not be affected by the regulation. Among the 265 affected systems, 60 are privately-owned water systems and 205 are public water

[21] Annual impacts for other years are available upon request.

agencies. The 60 privately-owned water systems belong to 14 water companies, out of which six are identified as small businesses.

As shown in the analysis above, firms providing services including leak analysis, detection, and repair services will be affected indirectly. In addition, manufacturing firms producing leak detection equipment will experience higher demand as well. There are, in total, seven large businesses in California for water distribution system leak detection among urban water suppliers. There are 29 water consulting firms in California, providing consulting services related to water loss control that would be also affected. All of them are counted as small businesses. The numbers of equipment producers are from the US Census.[22] It reports the number of businesses in California at the NAICS six-digit level. According to the data, there were 107 businesses in this industry in California in 2017. Among them, 90 are counted as small businesses, with the number of employees below 100.[23] As not all these firms are leak detection or repair equipment producers, this approach tends to overestimate the number of firms affected.

The results are listed in Table 11.[24] The second column reports the share of number of firms for each category. The privately-owned urban water suppliers account for 8.92% of the total impacted firms. Leak-related service and detection equipment businesses account for approximately 4.46% and 68.15% of the total, respectively. The number of small businesses is reported in the next column. According to the definition of small businesses from the Government Code, six out of the 14 privately owned water systems are counted as small businesses. The total number of small businesses impacted is 125, including six privately owned water systems, 29 water consulting companies, and 90 leak detection equipment producers.

The State Water Board considers the above numbers as the lower bound of the potential overall impacted firms. As discussed in Section D.2 on the macroeconomic impacts, other industries can be affected indirectly due to production chains and networks. Due to data limitations, it is infeasible to estimate impacts for firms or industries beyond the ones directly tied to water loss control. Also, given that the overall impact of the proposed regulation is not substantial compared to the overall size of manufacturing in California,

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[22] https://www.census.gov/data/datasets.html

[23] According to the definition of small businesses from the Government Code for the State of California, a manufacturing enterprise exceeding 100 employees is not "small business."

[24] An alternative approach that was considered involved counting the numbers of firms for leak detection, repair and equipment producers. According to the information from https://www.directindustry.com/, there are 18 and 14 firms producing leak detectors and pressure sensors, respectively. It's possible that not all the firms list their products there. This approach is likely to underestimate the number of firms affected.

the potential impacts on those indirectly affected manufacturing firms are anticipated to be negligible.

Table 12. The Number of Firms Impacted

Firm Category	Total firms	Share of firms	Small firms	Share of small firms
Urban water suppliers	14	8.92%	6	43%
Leak detection and repair service	7	4.46%	0	0%
Water consulting service	29	18.47%	29	100%
Leak detection equipment	107	68.15%	90	84.11%
Total number of firms	157	100%	125	-

D.3.c Business Creation and Elimination

The RIMS II model cannot directly estimate the creation or elimination of businesses. The overall increase in jobs represents the net impact, which can be associated with both creation and elimination. The direct increase occurs in the form of demand for leak detection, repair, and consulting services; this may promote creation of new business to advise UWS on compliance with the proposed regulation. At the same time, new businesses generally promote competition among existing firms, which can result in exiting of less-competitive firms.

In addition, water rates are likely to increase in the short term to cover initial capital investment. Although the potential increase in water rates on average is not large based on State Water Board calculations, suppliers in various regions may react differently depending on their ability to finance the initial capital costs. Thus, in certain regions with high water use, there could be a relatively higher increase in water rates than the baseline estimate, which may theoretically lead to a possibility of exit or entry of businesses that use water intensively.[25] However, businesses have absorbed increases in water rates over the years, and are anticipated to do so for future increases as well.

The increase in gross output will not only affect the industries that provide the contracted services, but also all the related equipment manufacturers, maintenance operators, equipment suppliers, and other businesses that provide intermediate services or goods to those leak detection contractors. Therefore, leak detection service contractors and their various suppliers will likely see an increase in demand for their services as a result of the proposed regulation. However, barriers to entry, such as the cost of equipment or innovation needed to provide goods and services for leak detection and repair work, is likely to limit the number of new indirectly impacted service contractor businesses.

The cost of compliance could be a financial burden on smaller businesses. However, there are four mechanisms in the proposed regulation that will help suppliers manage costs: variances are allowed in cases of unexpected adverse economic conditions, which could prevent exiting of such smaller businesses; adjustments to the volumetric standard can be made if default parameter estimations by the urban water suppliers are different from the State's default values; more time is provided to suppliers struggling to meet their standard if that standard requires a large (more than 30%) reduction in real loss; and flexibility is provided for suppliers serving disadvantaged communities.

D.3.d Job Creation and Elimination

The proposed regulation is expected to create a demand for services from consultants and system employees to aid in developing hydraulic models, conducting leak detection surveys and repairs, and assessing and implementing asset management and other approaches for real loss reduction. Table 9 displays the expected job growth from the final demand change, ranging from 95 to 258 jobs per year for the assumed lifetime of the proposed regulation, primarily for work related to leak detection, repair, and pressure management. Employment will consist of full- and part-time jobs, though the RIMS II data does not capture the difference.

It should be noted that while the I-O model captures job growth in companies that perform support activities on a contract or fee basis for leak detection and repair, it's possible that water suppliers themselves may downsize the number of in-house employees if they shift these activities from in-house to outsourcing. Also, for the leak detection and repair service companies, competition could be tougher due to new firms entering. This could drive some small firms out of markets. All these examples would lead to limited job losses

[25] In order to quantify these disparate impacts, information on individuals and businesses served by each water system is required. Due to data limitation, these analyses are not feasible at this stage.

not captured by the RIMS II model. However, it should be emphasized that these negative impacts would be outweighed by the positive effects on job creation. The net impact would be positive, as shown in Table 9.

D.3.e Increase or Decrease in Investment in California

From the results shown in Table 6, the direct cost impacts mostly consist of increased leak detection and repair services or equipment to meet the requirements of the proposed regulation. The total increase in purchases from these two directly affected industries is approximately $500 million over the assumed lifetime. The indirect economic effect of this spending is expected to create about $897 million of gross outputs over the lifetime and $593 million in value added (see Table 9). This increase in outputs would be associated with higher investment spending. However, this impact of the proposed regulation will be insubstantial compared to California's roughly $3 trillion annual economy.[26]

D.3.f Incentives for Innovation

The proposed regulation would potentially increase incentives for innovation through two channels: First, increased use of leak detection and repair equipment will promote competition and innovation in this sector. Higher demand could increase the competition among equipment producers. If the market is large enough, some producers could have incentives to invest in developing new technologies in order to improve their productivity and obtain a larger market share. Second, the proposed regulation could increase the incentives for innovation in water-saving appliances related industries. As can be seen in Table 13, the proposed regulation could increase water price in the short run if water suppliers pass some of the compliance costs to the consumers. This could further increase the demand for water-saving appliances, such as high efficiency shower heads, toilets, dishwashers, and washing machines and therefore promote innovation in the related industries.

D.3.g Competitive Advantage or Disadvantage

Water service is provided locally and consumers generally don't have a choice of their water service supplier. As we have discussed, water prices will not change significantly due to this regulation. Water loss control services are labor-intensive and will likely be provided by California-based businesses. The other inputs needed for water loss control, such as trucks or pipes, tend to be provided by sectors that compete across state lines.

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[26] California Department of Finance, *Gross State Product*.
<http://www.dof.ca.gov/Forecasting/Economics/Indicators/Gross_State_Product/>

The regulation will not materially affect the relative competitiveness of California as a place these suppliers decide to locate.

D.3.h Impacts on Households

In addition to the projected income impacts identified through the RIMS II model, the potential effects of the proposed regulation on household water bills and disposable income are analyzed under a number of assumptions. The impacts of the proposed regulation on water bills per connection and household disposable income are presented in Table 13. The main finding is that the proposed regulation will have minimal impacts on water bills and disposable income. In the first year of the regulation, water bills will increase slightly by about $ 0.20 per household. For all other years presented in the table, the actual water supply costs will decrease by roughly $8 to 11 per year, due to the benefits from saved water, which could delay any rise in water prices for individual households.

These estimated impacts rely on a number of important assumptions. First, it is assumed that all capital costs are spread equally across years with a fixed portion of equipment cost in the total repair costs. Second, it is assumed that leak detection and repair are constantly efficient over the assumed lifetime and, as the suppliers finish the first round of detection, the later costs of leak detection decrease due to positive discounting. In addition, the same technologies have been applied through the assumed regulation lifetime, which tends to overestimate costs because technological development is expected to make leak detection and repair more efficient and less costly. Finally, it is assumed the net costs and benefits that occur to comply with the proposed regulation will be passed onto all households. Water suppliers, however, might absorb these costs and benefits rather than increase their water rates.

The proposed regulation will have very small impacts on disposable income. In 2022, the proposed regulation will increase annual average household income slightly, by $1.17. In later years, consumers will experience a net increase in disposable income due to avoided increases in water prices as water supply costs decrease. The total net impacts on disposable income per household will be positive each year, up to approximately $13 per year. It accounts for less than 0.02% of the annual median income in California.[27] The net impact of the proposed regulation on household disposable income will be positive and fluctuate by approximately $1 per month in most years, which is less than 0.02% of median income.

[27] The median income and number of households in California are from https://www.census.gov/quickfacts/CA.

Table 13. Household Impacts or Water Loss Reductions

Economic Impact	2022	2028	2029	2035	2040	2051
Earnings per household ($)	1.17	0.90	0.87	0.73	0.63	0.46
Water bill change per household ($)	0.20	-10.35	-10.37	-10.22	-9.85	-8.59
Net Impact per Household ($)	0.97	11.25	11.24	10.95	10.48	9.05

D.3.i Other Benefits

Other benefits of the proposed regulation include beneficial impacts to the state's environment and the quality of life, health, safety, and welfare of California residents, among many others potential benefits.

First, reduction in water losses can promote energy conservation by reducing the need to pump, treat, and distribute water. This will reduce associated greenhouse gas emissions and provide environmental benefits. There could be a slight increase in carbon emissions due to increased activity to reduce real losses, such as repair trucks, excavations, or increased demand in water infrastructure material, however that is expected to be at least offset by reductions in energy used to pump and treat water that is currently lost to leaks.

In addition, the proposed regulation could improve water quality or reduce the cost of treating contaminated water due to pipe breaks. In compliance with the proposed regulation, urban water suppliers are encouraged to prioritize infrastructure monitoring and maintenance to reduce leakage. This could effectively decrease the risk of water outages resulted from aged and deteriorating water distribution systems, and therefore reduce the risk of contaminant intrusion through broke pipes, which would contribute to better access to safe and affordable water supply. Improved water quality would further bring health benefits to California residents.

Finally, the proposed regulation would reduce property damages and traffic jams caused by main water pipe breaks.

D.4 Summary and Interpretation of the Economic Impact Assessment

California urban water suppliers will face higher operating costs during the implementation of the proposed regulation but will see reduced operational spending as water losses are reduced. As suppliers implement these changes, demand for goods and services in supporting industries will benefit the State.

Overall, the proposed regulation is unlikely to have a significant impact on the California economy. The results show that purchases made by urban water suppliers have a positive impact on many industries, and that the transition from uncontrolled or under-controlled water loss to reduced water loss will bring many indirect and induced economic benefits to California. Additional economic benefits include benefits to the environment and households due to reduced energy usage, water quality improvement, and lower risk of main water breaks.

E. Alternatives

The State Water Board considers two alternatives to the water loss performance standards based on stakeholder comments. The two alternatives are evaluated for costs and benefits, economic impacts, and cost-effectiveness relative to the proposed regulation.

E.1 Alternative 1

The first alternative proposes using a more stringent leak detection survey frequency to calculate the standards, which would lead to quicker reduction in leakage as compared to the proposed regulation. The assumed leak detection survey rates from the proposed regulation were halved for this alternative, meaning that suppliers would be expected to take double the time to survey their systems for this alternative.

Under Alternative 1, 302 UWS systems would be required to conduct leak detection and repair to achieve the water loss levels.

E.1.a Costs and Benefits

Table 13 reports the costs and benefits for Alternative 1 over the 30-year assumed lifetime of the regulation. For a typical system, the total cost to comply with Alternative 1 is 3.08 million dollars in present value. The statewide total cost is about 931 million dollars. As compared to the proposed regulation, Alternative 1 would incur about 86.19% higher costs. This is consistent with the fact that Alternative 1 would require more frequent leak surveying, which is associated with higher costs. The lifetime benefit from water loss reduction for a typical system is about 18.9 million dollars in present value, which results in a total of 5.7 billion dollars statewide benefit. This is about 39.12% higher than the proposed regulation. As more frequent leak detection surveying would be able to identify and repair more leaks in time, it would reduce the total water loss further and lead to a higher total benefit. The net benefit is about 34.67% higher than the proposed regulation as well. It should be noted that even though Alternative 1 would generate a larger net benefit, the percentage increase in cost is much higher than the percentage increase in benefit. This implies that the extra benefit is associated with a much larger cost increase.

Table 14. Direct Costs for Alternative 1

	Typical System	Statewide	Comparing to Proposed Regulation, Statewide
Total Cost ($)	3,084,423	931,495,835	86.19%
Total Benefit ($)	18,855,178	5,694,263,636	39.12%
Total Water Loss Reduction (AF)	15,377	4,643,821	38.47%
Net Impact ($)	16,020,754	4,838,267,801	34.67%
Cost-effectiveness ($/AF)	201	201	34.46%

E.1.b Economic Impacts

Macroeconomic impacts are also evaluated for Alternative 1. The same approach is adopted using the RIMSII model as for the proposed regulation. The industry multipliers in Table 7 are used to account for the amplified impacts for the whole California economy. Results on gross outputs, earnings, employment and value added are reported in Table 14. In addition to the 30-year assumed lifetime impact, the annual impacts for the critical years are also reported. Both the lifetime impacts and annual impacts are about 86% higher than for the proposed regulation as reported in Table 9, which is consistent with the fact that the direct cost is about 86% higher and the same RIMS-II multipliers are adopted.

Table 15. Macroeconomic Impacts for Alternative 1

Economic Impact	30-year Lifetime	2022	2028	2051
Gross Output ($)	1,657,530,916	100,175,789	68,821,799	33,279,189

Earnings ($)	510,605,204	30,859,321	21,200,672	10,251,710
Jobs	8,048	486	334	162
Value Added ($)	1,100,693,216	66,522,326	45,701,523	22,099,242

E.1.c Cost-Effectiveness

Cost-effectiveness is measured by the average cost to achieve one AF of water loss reduction. As shown in the last row of Table 13, the cost-effectiveness is approximately $201 per acre feet of water saved, which is about 34% higher than the cost-effectiveness for the proposed regulation. Alternative 1 would achieve higher water loss reduction, but the total cost is much higher than the proposed regulation. Alternative 1 is a less cost-effective alternative compared to the proposed regulation.

E.1.d Reason for Rejection

Though Alternative 1 could lead to a rapid reduction in leakage, it would increase the annual costs to approximately $31 million per year. The initial cost per system would increase by about 112% as compared to the proposed regulation. Even though the long-run benefits are relatively higher than the proposed regulation, the higher initial costs would impose a much larger burden on the suppliers. In addition, the cost effectiveness analysis shows that even though the total water loss reduction is higher for Alternative 1, the average cost of reducing water loss is higher than for the proposed regulation by about 34%, as can be seen in the last column of Table 13. Therefore, Alternative 1 is rejected.

E.2 Alternative 2

Alternative 2 is based on a proposal provided by stakeholders. This proposal would require a decrease in leakage to a volume equal to the 85th percentile of overall leakage for California averaged over three years instead of individual standards.

Under Alternative 2, 68 UWS systems would be required to reduce their leakage. This is as expected since Alternative 2 would require systems to reduce their leakage less, compared to the proposed regulation, to a much higher level of loss (85th percentile of average losses in California). A majority of systems report leakage that is lower than the threshold for additional water loss requirements proposed through Alternative 2.

E.2.a Costs and Benefits

Table 15 reports the costs and benefits for Alternative 2 over the 30-year assumed lifetime of the regulation. For a typical system, the total cost to comply with Alternative 2 is 516 thousand dollars in present value. The total cost on a statewide basis is approximately 35.1 million dollars. Costs incurred pursuant to this alternative would be about 93% lower than those for the proposed regulation. This is consistent with the fact that Alternative 2 would result in less frequent leak surveying and repair, which results in lower costs.

The lifetime benefit from water loss reduction for a typical system is about 14 million dollars in present value under Alternative 2, which results in a total of 963 million dollars in statewide benefit. The total benefit is 76% lower than that for the proposed regulation. As less frequent leak detection surveying would identify and repair fewer leaks in time, Alternative 2 would reduce the total water loss reduction and lead to a lower total benefit. The net benefit is about 74% lower than for the proposed regulation.

Table 16. Direct Costs and Benefits for Alternative 2

	Typical System	Statewide	Comparing to Proposed Regulation, Statewide
Total Costs ($)	515,617	35,061,948	-92.99%
Total Benefits ($)	14,170,376	963,585,558	-76.46%
Total Water Loss Reduction (AF)	11,837	804,882	-76.00%
Net Impact ($)	13,904,759	945,523,610	-73.68%
Cost-effectiveness ($/AF)	44	44	-70.80%

E.2.b Economic Impacts

Macroeconomic impacts have been evaluated for Alternative 2 using the RIMS II model *in the same way as* the proposed regulation and Alternative 1. The industry multipliers in Table 7 are used to account for the amplified impacts to the statewide economy. Results on gross outputs, earnings, employment, and value added are shown in Table 16. In addition to the 30-year assumed lifetime impact, the table also shows the annual impacts for critical years. Both the lifetime impacts and annual impacts are less than one-tenth of those for the proposed regulation as shown in Table 15. This is consistent with the fact that the direct cost for Alternative 2 is about 93% lower than for the proposed regulation with the same RIMS II multipliers.

Table 17. Macroeconomic Impacts for Alternative 2

Economic Impact	30-year Lifetime	2022	2028	2051
Gross Output ($)	62,390,256	2,577,802	2,559,130	1,587,934
Earnings ($)	19,219,424	794,096	788,344	489,166
Jobs	303	13	12	8
Value Added ($)	41,430,619	1,711,805	1,699,405	1,054,477

E.2.c Cost-Effectiveness

Cost-effectiveness is measured by the cost to achieve an AF of water loss reduction. For Alternative 2, though the total cost is lower than the proposed regulation, it would achieve significantly lower overall water loss reductions. The cost-effectiveness is much lower than for the proposed regulation. This means that the average cost of saving one AF of water loss is lower than that for the proposed regulation.

E.2.d Reason for Rejection

Alternative 2 is rejected because it would not reduce statewide water loss to the level we calculate is economic. The current median leakage for the state is 26 gallons per connection per day, while the average is 35 gallons per connection per day. The proposed threshold per Alternative 2, i.e., the 85th percentile of statewide leakage, would result in a standard of 57.1 gallons per connection per day for all suppliers regardless of their system-specific characteristics, potential for reducing water loss, or water resilience. The proposed threshold would be twice that of the current median, which would not adequately improve statewide water loss control, reduce potential leakage, or improve maintenance of water infrastructure, and could result in a lapse in ongoing or future water loss control efforts.

Alternative 2 would impose lower costs on urban water suppliers, but the amount of total water loss reduction would be 76% lower than under the proposed regulation.

Additionally, with inadequate water loss monitoring and maintenance of water supply infrastructure, suppliers and businesses would likely face higher costs in terms of unexpected leaks, water outages, and property damage. Water supply infrastructure has been inadequately maintained and rehabilitated over past decades, which has led to its deterioration and overall higher long-term operational costs, which suggests efforts towards water loss control would be beneficial (Sedlak, 2015). Thus, Alternative 2 would not achieve the goals of adequate water loss control as effectively as the proposed regulation. Therefore, Alternative 2 is rejected.

F. Fiscal Impacts

F.1 Local Government

The proposed regulation directly impacts urban water suppliers that are public agencies. Among the 265 systems potentially impacted by the proposed regulation, 205 are local public water systems and one is a state or federal water agency. The public water systems are typically operated by cities or local water authorities. The revenues of water agencies come from different sources, including local grants, local taxes, and operating revenues.

The overall fiscal impact to local governments is positive. In the short term, expenditure on leakage detection and repair services, capital investments towards replacing old water pipes and infrastructure could lead to increased annual budgets for public water agencies. In the longer term, the total direct costs to water systems due to the proposed regulation result in annual savings due to water loss reduction and reduced operating costs and increased available resources. The annual total direct costs and benefits of the proposed regulation to public water agencies relative to the baseline are summarized in Table 18.

Table 18. Fiscal Impact on Local Government

Year	Total direct Costs	Total Value of Water Loss Reduction	Net Impact
2022	21,883,002	19,956,596	-1,926,406
2028	17,229,131	133,582,340	116,353,209
2035	13,860,865	128,784,118	114,923,253
2040	11,912,460	122,645,380	110,732,919

2051	8,655,630	105,233,088	96,577,458

As the change in water price caused by the proposed regulation is not expected to be significant, the burden from this on local governments will be minimal. It is likely that local governments will experience some fiscal benefits from economic activity induced by the regulatory requirements. They will also benefit from reduced environmental liabilities associated with water loss in their communities.

F.2 State Government

F.2.a The State Water Board

The proposed regulation would have a minor impact on staffing resources and would require one and one-half personnel-years assisting urban water suppliers with compliance and modifications to their standards, reviewing supplemental documentation, and enforcement including audits of reported information. The cost of the position is estimated to be $200,000 annually in 2020 dollars. The total estimated annual cost due to additionally required staff hours would be $300,000. Currently, this additional workload is expected to be absorbed by current staff.

F.2.b Other State Agencies

The proposed regulation would affect public water agencies and is not expected to have adverse impacts on other state agencies.

G. References

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H. Economic Model Appendix

This appendix contains additional background information on the water loss economic model developed by the State Water Board.

Distribution system condition, typical leak flow rates and number of leaks for different types of leakage: Based on the American Water Works Association Water Audits and Loss Control Programs M36 Manual (American Water Works Association, 2016).

Marginal avoided cost of water: The marginal avoided cost of water is determined from the cost of alternative water sources available to the supplier. The most common alternative water sources are stormwater reuse, recycled water (indirect potable reuse), brackish water desalination and imported water. The Pacific Institute estimated costs for each of these sources (Pacific Institute, 2016), and the model uses the average cost for all these sources as the marginal avoided cost.

H.1 Leak detection

Leak detection involves surveying pipes and other infrastructure with specialized equipment that can alert the supplier if a leak exists on that part of the infrastructure. This is followed by leak pinpointing, which involves determining the exact location of the leak with the appropriate equipment. The costs in Table 19 show ranges of leak detection costs from different sources. The costs vary by type of pipe material and logistical issues, and values on the higher end of the range are associated with outsourcing.

Table 19. Unit leak detection costs and sources.

Source of Data	Range of Costs (per mile)
Kunkel Water Efficiency Consulting	\$177 - \$400
Water Systems Optimization	\$250 - \$400
M.E. Simpson	\$295 - \$595
Municipal Water District of Orange County (2019-2020)	\$278 - \$350
Los Angeles Water Action Plan (2015)	\$255 (average)

The leak detection efficiency denotes the number of actual leaks located out of the ones detected, indicating false positives. Table 20 shows the range of leak detection efficiencies for both surveying and pinpointing, which were developed with the help of highly trained experts.

Table 20. Leak detection efficiency by type.

Detection Type	Efficiency Range	Average Efficiency
Leak Survey	98 - 99%	98.5
Leak Pinpoint	50 - 92%[a]	71
		70%[b]

a. Expected Efficiency of a new program (variable).
b. Product of average efficiencies for surveying and pinpointing.

The State Water Board also collected estimates of the number of miles of system infrastructure that can be surveyed realistically from consultants offering leak detection services. Estimates from suppliers on their current and future leak detection programs were also used to inform this parameter. The following estimates for current leak detection frequencies were collected and used to inform leak detection frequencies in the model.

Table 21. Typical number of miles surveyed each year to detect leaks (all methods).

Supplier	Total length of mains (miles)	Anticipated or typical annual survey frequency (miles/year)	Years taken to survey system
M.E. Simpson (Vendor)	N/A	1200	N/A
Irvine Ranch Water District	1886.1	840	2.24
East Bay Municipal System District (EBMUD)	4205.9	1236	3.4
City of Seal Beach	75	75	1.0
Trabuco Canyon Water District	66	66.5	1.0
City of La Habra	165	83	2.0
City of Tustin	172	102	1.7

East Orange County Water District	23.7	48	0.5
City of Huntington Beach	607.2	18	33.7
Mesa Water District	328.4	32	10.3
City of Orange	462	30	15.4
City of San Clemente	212.6	30	7.1
Yorba Linda Water District	367.1	110	3.3

The data in Table 21 was used to determine a reasonable range for surveying frequencies, and it was concluded based on these estimates and information from suppliers that most systems can survey their entire system once in two to three years. Two exceptions are the two largest systems in California, Los Angeles Department of Water and Power (LADWP) and EBMUD, which have 7,385 miles and 4,206 miles of distribution system mains, respectively. EBMUD surveys its system in just over three years. It was assumed that LADWP would be able to survey its distribution system once in the five years between 2022 and 2028. As LADWP's operating budget is 3.5 higher than EBMUD, it was assumed that LADWP would be able to survey an additional 15 miles per month as compared to EBMUD.

H.2 Leak repair costs

The following three tables (22, 23, 24, and 25) show the data collected for leak repair costs from different sources.

Table 22. Cost of repairs per leak for different types of pipe (provided by Irvine Ranch Water District).

Type of pipe	2017 costs ($)	2018 costs ($)	Average costs ($)
2 to 3 inch Polyvinyl Chloride	3000 - 5000	2000 - 6000	4000
4 inch Polyvinyl Chloride	3000 - 6000	4000 - 9000	5500
6 inch Polyvinyl Chloride	4000 - 6000	4000 - 9000	5750
6 inch Asbestos Cement	3000 -12000	4000 - 5000	6000
C-900 Asbestos Cement	3000 - 9000	4000 - 6000	5500

8 inch Ductile Iron	6000	12000	9000
10 inch Asbestos Cement	4000 - 6000	7000	5667
12 inch Cement mortar lined/ Asbestos Cement Pipe	6000 - 15000	15,000	12000
16 inch Cement mortar lined/ Asbestos Cement Pipe	4000 – 31650	6000 - 12000	13413

Table 23. Cost of repairs per leak (from PG&E Report[28].

	Tehama County Water system	Kings County Water System	Alpine County Water System	Madera County System
Estimate #1	$2,745.00	$2,500.00	$2,500	$1,500
Estimate #2			$6,000.00	$1,500
Estimate #3			$7,900.00	
Estimate #4			$4,100.00	
Estimate #5			$8,600.00	
Estimate #6			$7,500.00	
Estimate #7			$6,800.00	
Estimate #8			$1,950.00	

Table 24. Repair costs per leak for laterals and service lines (provided by Kunkel Water Efficiency Consulting).

Type of Leak	Repair Cost per Leak
Service lines	$108
Abandoned services	$1,100
Hydrants	$215
Valves	$215
Average	**$410**

[28] Pacific Gas and Electric's Report ET13PGE1451: Water System Leak Identification and Control Field Evaluation (2015)

Table 25. Repair costs per leak for laterals and service lines (provided by Water Systems Optimization, Inc.).

Cost Type	Repair Cost per Leak
Typical Cost	\$3,500 - \$5,000
Average Cost	\$4,250