Leak Mitigation

Introduction	
Purpose	This guide will help you understand: • The different causes of water loss in drinking water systems • The different approaches to controlling water loss in drinking water systems • How to implement a leak mitigation program. • Elements of a leak mitigation program
Target Audience	This guidance is intended for owners, managers, operators of drinking water systems, local officials, technical assistance providers and state personnel. The primary focus of this guidance is for Massachusetts water systems, but this guidance may also be applied outside of Massachusetts.

Leak Mitigation

A main responsibility of the water utility is to manage both the demand and supply of drinking water responsibly and efficiently. Water utilities establish local policies to conserve water. They also address state policies to reduce water losses from the distribution system. Water management can provide real benefits to a water utility. This guide addresses the reduction of water losses through a leak mitigation best practice.

Water system losses can be categorized as apparent losses (water lost through unauthorized use or from inaccurate flow measurements or data handling) and real losses. This document will touch upon apparent losses, but will focus more on the real losses attributed to a variety of different types of leaks in the system. The American Water Works Association (AWWA) defines real losses as physical water losses from the pressurized system (water mains and customer service connections) and the utility's storage tanks, up to the point of customer consumption. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows. Water suppliers are responsible for monitoring their systems to minimize water loss. Utilities have many resources that focus on water loss prevention.[1]

Water loss prevention and mitigation will benefit utilities not only with recovering some of the costs associated with treating and pumping the water, but also in addressing water needs that are regularly updated under the Water Management Act.

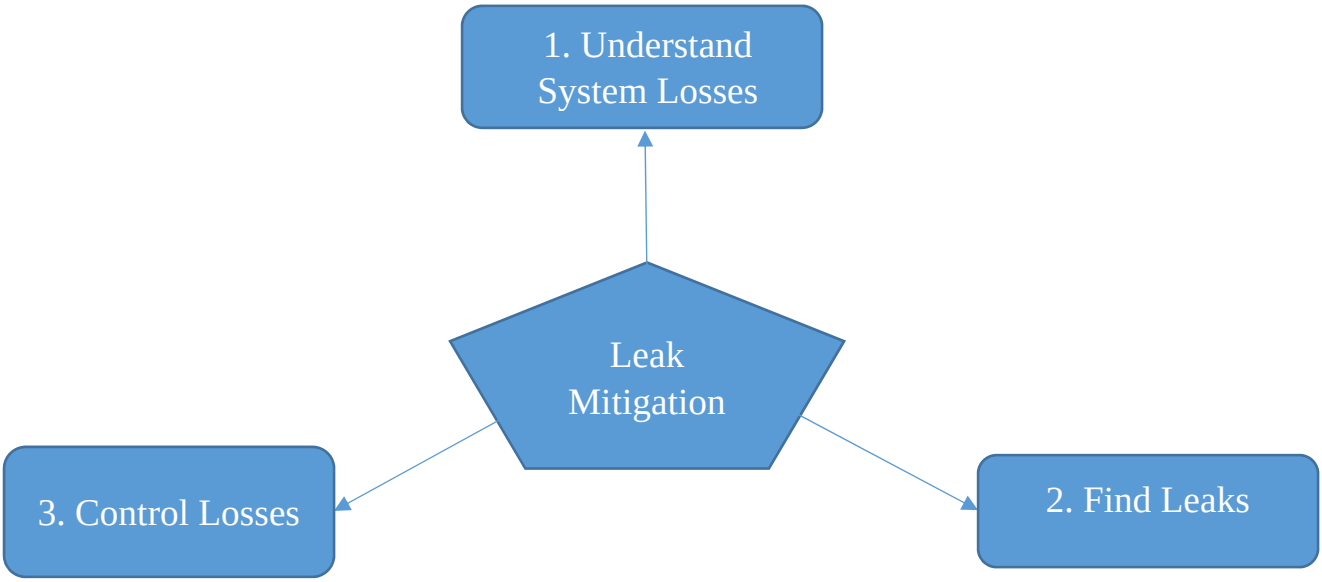
[1] A list of widely used references includes:

- The Massachusetts Department of Environmental Protection (MassDEP) Guidelines and Policies – Chapter 11.
- The Massachusetts Water Resource Commission's (MWRC) 2012 Water Conservation Standards
- The Environmental Protection Agency (EPA)'s Control and Mitigation of Drinking Water Losses in Distribution Systems
- AWWA's Water Audits and Loss Control Programs, Manual 36
- Massachusetts Water Resources Authority (MWRA)'s 360 CMR 12 Leak Detection Regulations

Challenges faced by Water Systems	Benefits of Leak Mitigation
• Decreasing revenues. • Increasing pressure to conserve water. • Encouraging the efficient use of water. • Aging infrastructure. • Regulated, limited withdrawals from underground aquifers and surface water bodies.	• Identifies and reduces water losses. • Increases available water. • Improves long-term water sustainability. • Reduces or postpones the need for additional sources of water supply. • Saves money.

Implementing Leak Mitigation: The Core Framework
The following framework should be followed to implement leak mitigation. This framework includes: (1) Understanding water system losses, (2) Finding leaks; and (3) Controlling loses.

Flow Chart: Leak Mitigation



1. Understanding Water System Losses: Types and Causes of Losses	
The first step in leak mitigation is to understand water system losses. This section outlines the types of apparent water losses with related possible causes for leaks, leakage events, and pressure effects.	
Types of Apparent Losses	Possible Causes
• Inaccuracies or failures in meters, and data handling errors	• All meters have a small amount of inaccuracy • Undersized and oversized meters can also cause inaccuracies • A broken meter may not register any water use at all • Illegible manual meter readings or readings that are incorrectly input into the electronic system • Aging meters
• Unauthorized use	• Theft, unauthorized hydrant openings, illegal connections, and meter tampering including bypassing the meter, are examples of water losses through unauthorized use

Types of Real Losses	Possible Causes
• Water main breaks	• Water mains break due to conditions such as corrosion, freezing, water hammer, and damage due to the construction of other utilities
• Water main leaks	• Water mains leak because of manufacturing defects, corrosion and improper installation
• Leaking services	• Services lines and service meters leak because of corrosion or improper installation
• Storage tank leaks	• Foundation or exterior wall cracks, vandalism
• Storage tank overflows	• Communication or instrumentation failure
• Estimated uses	• Water main flushing, hydraulic flow testing, fire emergencies, or fire exercises

Leakage Events	
Type	Loss
• Inaccuracies or failures in meters and data handling errors	• Although there is no actual loss, meter reading inaccuracies, data handling errors, and reader software issues can cost a water utility money if they are underestimating water use
• Unauthorized use	• There is no way to directly determine the amount of water lost to unauthorized use. 0.25 percent of water supplied can be used as a default value according to the AWWA reference
• Meter leaks o within meters pits, vaults, and in home	• Actual meter leaks are common and can vary in size from less than 1 gpm and higher; water loss is consistent and total losses add up quickly; in colder weather climate such as New England, meters are often placed inside the home and leaks are generally reported quickly
• Water main breaks	• Water losses during a main break can be significant, but depends on many factors such as the size of the main, size of break, pressure in the main, and time it takes to isolate the break
• Water main leaks (including services)	• Small water main leaks vary in size, for example, a hole or leak in a pipe has an expected leakage rate based on the size of the hole, shape of the hole, and the pressure • Water loss is constant and total losses add up quickly
• Storage tank leaks	• Water loss through foundation cracks and wall leaks located underground can go unnoticed and continue indefinitely; • Above ground leaks can be more easily located and attended to before losses add up
• Storage tank overflows	• Tank overflow losses are generally large volumes and noticed reasonably quickly so they can be stopped prior to significant losses occurring.
• Estimated uses	• Flushing mains is standard practice and calculating the water used for flushing has inherent errors • Unidirectional flushing programs are more effective than traditional flushing and therefore use less water, which may improve the calculation accuracy, but errors will still exist

Pressure Effects	
Pressure	Effects
• High pressure	• Higher system pressures increase the amount of water lost through all types of leaks and may also cause small leaks to increase over time
• Low Pressure	• Lower system pressures reduce the amount of water lost through all types of leaks categorized under real losses.

System Analysis	
Type	Recommendations
• Water Audits	• Performing a thorough audit helps to categorize system losses into apparent and real losses • Audits may need to be done annually until unaccounted for water (UAW) is at a level that is acceptable to the utility • Once unaccounted for water rates have been reduced to acceptable levels, plan to perform an audit every 5 to 10 years according to the MWRC reference, unless UAW on annual reports do not indicate an issue • Perform follow up audits to determine savings and efficiencies

You should:

- Understand how much water is being lost
- Understand the types and causes of leaks to determine why water is being lost
- Understand the types and losses of leakage events
- Understand the types and impacts of pressure events

Best practices include:

- Monitoring the system to minimize water losses
- Flushing the system periodically
- Routinely conducting water audits, beginning with a top-down/desktop approach (analysis of available data)
- Conducting bottom-up water audits that focus on and more closely analyze the components in the system that have been identified as significant sources of loss in the top-down approach

2. Find the Leaks
The second step in the establishment of a leak mitigation program is to find the leaks. After gaining an understanding of the types of leaks, it is up to the water supplier to locate and quantify these leaks. Unattended leaks can have severe consequences, can cause damage to infrastructure or private properties, and have economic impacts. Leakage can cause such things as contamination of the drinking water supply, degradation of underground soils causing sinkholes, an increase in water withdrawal and pumping, and an increase in chemical and electrical demands to distribute more water. This section outlines leak management programs for leak detection, water audits, leak detection options, and leak detection type analysis.

Leak Management Program	
Type	Recommendations
• Leak Detection	• The legal responsibility of leaks on private services and properties should be clearly defined in the by-laws, or the utilities rules and regulations • Perform annual leak detection surveys, according to the AWWA reference, in order to maintain control of losses • Perform system-wide leak detection at least every 3 years • Consider installing permanent leak detection equipment in your water system

Leak Detection Options Available	
Category	Type
• Tank Leak	• Close inlet and outlet valves and measure elevation drop over time and listen at valve
• Sonic / Acoustic leak detection options	• Geophones • Hydrophones • Listening rods • Leak noise loggers • Leak noise correlators • Streaming cable inline leak detectors • Free-floating inline leak detectors • Fiber optics • Electromagnetic field detection
• Other detection methods	• Thermography (Thermal detection) • Ground penetrating radar (Electromagnetic detection)

Leak Detection Type Analysis	
Type	Strengths and Weaknesses
• Geophones	• Strengths include: simple to use, no electronic parts, low capital cost, can be used with all pipe materials • Weaknesses include: difficult to master, needs to be placed directly above pipe, manual data collection, may not be able to hear leak deeper than 5 feet, used for leak detection and location only (does not quantify leak)
• Hydrophones	• Strengths include: locating leaks, can quantify leaks, can be used with all pipe materials • Weaknesses include: some operator training, manual data collection, may not be able to hear leak deeper than 5 feet
• Listening Rods	• Strengths include: simplicity, effective for any pipe material, no mechanical or electronic parts, no calibration required, low capital cost, can be used with all pipe materials • Weaknesses include: difficult to master, manual data collection, difficult to differentiate between normal leaks and system noises, difficult to pinpoint leak location, used for leak detection only (does not quantify leak)
• Leak noise loggers	• Strengths include: automatic data collection, can tie into automatic reading systems, can get several days of data, can combine with other loggers and correlators to quantify and locate leaks. • Weaknesses include: difficulty with plastic pipe material, leak detection only (does not quantify or precisely locate leak), subject to theft if place in the open, requires training to analyze noise recording
• Leak noise correlators	• Strengths include: automatic data collection, can be wireless, pinpoints leaks, works on all pipe materials and depths • Weaknesses include: difficulty finding large leaks as the equipment needs to be calibrated to find both low and high frequency breaks; this requires personnel to have factory training on equipment
• Streaming cable inline leak detectors	• Strengths include: flow rate estimation, highly accurate, works on all pipe materials, can obtain video of water main if requested

	• Weaknesses include: for large pipe only (greater than 12-inch diameter), trained contractor required
• Free-floating inline leak detectors	• Strengths include: automatic procedure once detector is inserted into water main, works with any pipe material, high leak location accuracy • Weaknesses include: ball can get stuck or lost in system, requires factory training on data reading equipment
• Fiber optics	• Strengths include: can do condition assessment, highly accurate • Weaknesses include: primarily for large diameter concrete pipe, requires unidirectional flow, can get false positive and negative readings
• Electromagnetic field detection	• Strengths include: generates record of water main integrity • Weaknesses include: primarily for large diameter concrete pipe, must first dewater water main
• Thermography	• Strengths include: simple, can narrow in on general area of leak • Weaknesses include: temperature variations may not be present in Spring or Fall, no indication of size of leak, interference with ground water, for detection only (does not quantify leak)
• Ground penetrating radar	• Strengths include: can be used with all pipe materials, can detect leaks greater than 1-inch • Weaknesses include: moderate training required, definition dependent on bedding material and groundwater conditions, manual data collection

You should:

- Develop a leak detection program to locate and quantify leaks
- Develop a program for water audits
- Select appropriate leak detection options based on leak detection type analyses

Best practices include:

- Performing annual leak detection surveys in order to obtain complete system wide surveys
- Installing permanent leak detection equipment in the water system
- Developing a leak detection program based on the system needs in order to reduce losses and improve the performance of the water system

3. Controlling Loses
The third step in leak mitigation is to control loses. Once the leak detection method has been researched, chosen, and applied, the water supplier is ready to begin the task of repairing the system and controlling losses. This section outlines formulating goals and developing a schedule to control losses.

Formulate Goals	
Goals	Recommendations
• Funding	• Obtain budget quotes and set up an annual budget to repair and control system losses which requires portions of the budget for locating and repairing existing leaks and for unforeseen leaks, as well as for public outreach programs to communicate successes and guard against unauthorized use
• Repair Schedule	• Set up a schedule that helps to meet regulatory requirements and also meets the budget

Develop a Schedule	
Goals	Recommendations
• Meter Replacement	• Set up a large meter testing calibration program to identify which meters need replacement (calibration procedures are offered in the AWWA and EPA references) • Set up residential meter testing program using a select few that can be used as a representative sample of the whole • Replace oversized meters to help avoid inaccuracies • Replace all service meters based on referenced guidelines (every 10-12 years) (MassDEP, 2014, 11-11) or based on professional financial analysis
• Unauthorized use	• Conduct public outreach and edit by-laws or regulations to discourage water theft, by placing heavy fines on theft, and take enforcement action when necessary • Relay positive messages about water and cost savings through leak detection programs • Update by-laws and regulations as needed
• Water main breaks	• Repair as necessary • Set up annual water main replacement and strengthen and enforce the program using professional analysis such as an Asset Management Program, Capital Improvement Plan, or Master Plan • Have updated mapping to understand where

	valves are located for immediate isolation of a water main break • Incorporate valve exercising programs to maintain preparedness for breaks
• Water main leaks	• Repair as necessary • Determine annual repair rate for leaks on private property that fits your schedule and your budget, unless private property owner is responsible under the written by-laws or regulations • Include resident responsibility in by-laws
• Estimated uses	• Continually monitor and calculate usage

You should:

- Formulate goals to eliminate water losses
- Develop a repair schedule

Best practices include:

- Continually monitor and calculate usage
- Repairing leaks as necessary
- Using leak detection surveys to maintain system wide monitoring
- Installing permanent leak detection equipment
- Seeking water audit grants and loans as they become available
- Seeking asset management grants and loans as they become available, which can help in the planning stage of upgrading infrastructure
- Using funding to replace aging infrastructure to reduce costs for continual repairs
- Assessing current water rates and budget accordingly for repairing and/or maintaining the system
- Promoting the value of reliable water supply to the community
- Developing a plan to maintain the prevention of system water losses