2026

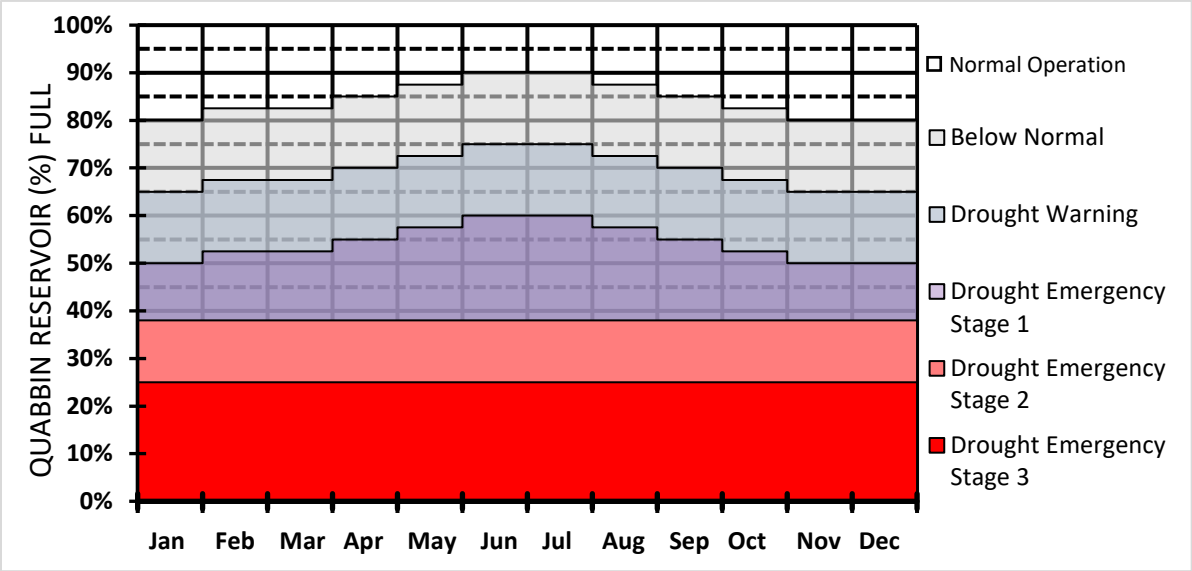
Massachusetts Water Resources Authority Drought Response Plan

July 2026

Executive Summary: The MWRA Drought Response Plan defines drought conditions and triggers response actions based on Quabbin Reservoir elevation, recognizing typical seasonal variations in reservoir levels due to normal fill and drawdown cycles. The plan establishes seasonally adjusted elevation triggers that dictate appropriate response measures to ensure continued water supply reliability.

The plan outlines *five drought trigger levels* based on Quabbin Reservoir Elevation:

1.	Below Normal	Reservoir Elevation	65-90%	510.1 - 524.6	ft.
2.	Drought Warning	Reservoir Elevation	50-75%	499.6 - 516.2	ft.
3.	Drought Emergency Stage 1	Reservoir Elevation	38-60%	490.0 - 499.6	ft.
4.	Drought Emergency Stage 2	Reservoir Elevation	25-38%	475.0 - 490.0	ft.
5.	Drought Emergency Stage 3	Reservoir Elevation	<25%	<475.0	ft.



Drought response actions, triggered within each drought stage, are organized into five categories:

1. Analysis & Planning – Assess drought conditions and potential impacts.
2. Coordination – Engage with stakeholders, agencies, and municipalities.
3. Public Outreach – Communicate water conservation measures and expectations.
4. Technical Assistance – Provide guidance and support to MWRA communities.
5. Operational Adjustments – Implement system-wide measures to optimize water use.

The **safe yield** of the Quabbin-Ware-Wachusett system is **300 million gallons per day (MGD)**, representing the volume of water that can be reliably supplied under prolonged drought conditions. MWRA holds Water Management Act registrations authorizing withdrawals of up to 312.82 MGD.

The MWRA reservoir system has a **drought storage capacity of 467 billion gallons (BG)**, providing an estimated **3.8 years of drought resilience** under critical conditions, and therefore meets the requirements for a multi-year drought storage system as specifically defined by 310CMR36.03

This framework ensures MWRA will **effectively monitor, manage, and respond** to drought conditions while maintaining long-term water supply reliability. In addition, MWRA's drought communication framework integrates coordinated State messaging, forward-looking guidance, and data-drive system indicators to provide clear, timely, and actionable information to communities throughout all stages of drought conditions.

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List of Acronyms & Definitions

BG	Billion gallons
MWRA	Massachusetts Water Resource Authority
MassDCR	Massachusetts Department of Conservation and Recreation
MassDEP	Massachusetts Department of Environmental Protection
MGD	Million gallons per day
NERFC	Northeast River Forecast Center
NIDIS	National Integrated Drought Information System
USGS	United States Geological Services

Drought- Abnormally dry (moisture-deficient) condition that is a shift away from average conditions for some prolonged period. Abnormally dry conditions may be due to a combination of precipitation deficit and increased evapotranspiration from heat stress.

Flash Drought- Periods of rapid drought intensification marked by high temperatures, decreased precipitation, strong winds, and significant reductions in drought levels within two to four weeks. Flash droughts can occur at the onset of a drought or within an ongoing drought, adding complexity to water resource management.

Months within Drought Status- The number of months with at different levels of demand and degrees of drought response. This “Demand-Supply Imbalance” value comes from modeling time series data with weather, water supply and demand to forecast system supply capacity. Emphasizing the relationship between demand and supply.

1 Introduction

This document provides the framework for MWRA's response to any drought affecting the MWRA water system. As a surface water supply system with multi-year storage capacity, defined in the Massachusetts Water Management Act regulations revised on January 20, 2023[1], MWRA has a site specific drought response plan triggered by system specific drought conditions – Quabbin Reservoir elevation. **The MWRA drought response framework integrates both the technical assessment and coordinated communication strategies, ensuring that operational decisions are supported by clear, consistent, and actionable guidance to member communities.**

The later sections of this document outline the Massachusetts Water Resources Authority (MWRA) water system and its capacity to reliably supply water to its customers by synthesizing several key factors: the large size and connectivity of the system reservoirs, management and operational strategies, long-term hydrologic records (including precipitation, temperature, runoff, yield and related factors), and the critical drought period. These elements form the analytical basis for drought stage determination, while also supporting data-driven communication of system conditions, trends, and anticipated changes.

Traditionally, water engineers have assessed a water supply system's capacity using a single measure known as safe yield—the maximum constant average annual demand that the system can reliably supply during a critical drought period. With safe yield as the guiding principle, MWRA has adopted a nuanced approach to measuring capacity. This approach evaluates yield, the impacts on the reservoirs themselves, and the effects on customers as system demand increases. These measures are modeled for varying demands and triggered drought stages, as seen in Table 4-1, and are used to inform internal operations as well as communicate system status with appropriate context, including storage levels, seasonal benchmarks, and rates of change.

The MWRA water system serves approximately 2.7 million users in Metropolitan Boston, Metro-West and the Chicopee Valley in Central Massachusetts. It employs a managerial, interventionist approach to drought planning, where proactive measures shape system operations to align with preferred goals, thus reducing reliance on costly reactionary practices. This approach extends to community communication, where forward-looking messaging is used to prepare communities for potential changes in drought stage, allowing for timely and coordinated implementation of response measures.

In compliance with the Massachusetts Department of Environmental Protection's (MassDEP) Water Management Act regulations of 2023, this document illustrates the MWRA's multi-year drought storage capability and how the MWRA operates that system. It highlights the processes developed to maintain a reliable, high-quality water supply during any droughts, including the most severe drought in historical record .

[1] Massachusetts Water Management Act, **310 CMR 36.03.** Massachusetts Water Resources Management Program, Massachusetts Department of Environmental Protection.

Due to its substantial multi-year storage capacity, the MWRA system responds slowly to hydrological conditions, and moves slowly between drought trigger stages. That inherent system stability provides valuable lead time between drought stages, which MWRA uses to review conditions, refine operational strategies; and, update, prepare and disseminate guidance to communities through our established communication infrastructure. Seasonally specific actions and communications would continue to be evaluated and adjusted to reflect real-time system conditions, evolving water quality and environmental factors, and community needs as drought conditions develop. Seasonally specific actions will likely need to be reviewed and adjusted for the current system and societal conditions as a severe multi-year drought event unfolds.

MWRA drought response plan framework emphasizes both operational adaptability and clear, coordinated messaging with Massachusetts State Drought Task Force through well-established MWRA communication platforms.

In addition, as MWRA is only withdrawing an annual average of around 200 MGD (as of 2024) from a watershed and reservoir system with a safe yield of 300 MGD, the likelihood of reaching severe drought conditions is currently low and expected to stay that way.

2 MWRA Drought Response Plan

The MWRA Drought Response Plan defines drought stages based on the percentage of Quabbin Reservoir storage volume percentage full (see Figure 2-1 and Table 2-1). Expected water levels vary by time of year, reflecting the reservoir's seasonal fill and drawdown cycles. **The Quabbin Reservoir's elevation is reviewed on the first of each month to determine the drought trigger stage.**

Figure 2-1: MWRA Drought Response Plan - Quabbin Reservoir Trigger Volumes

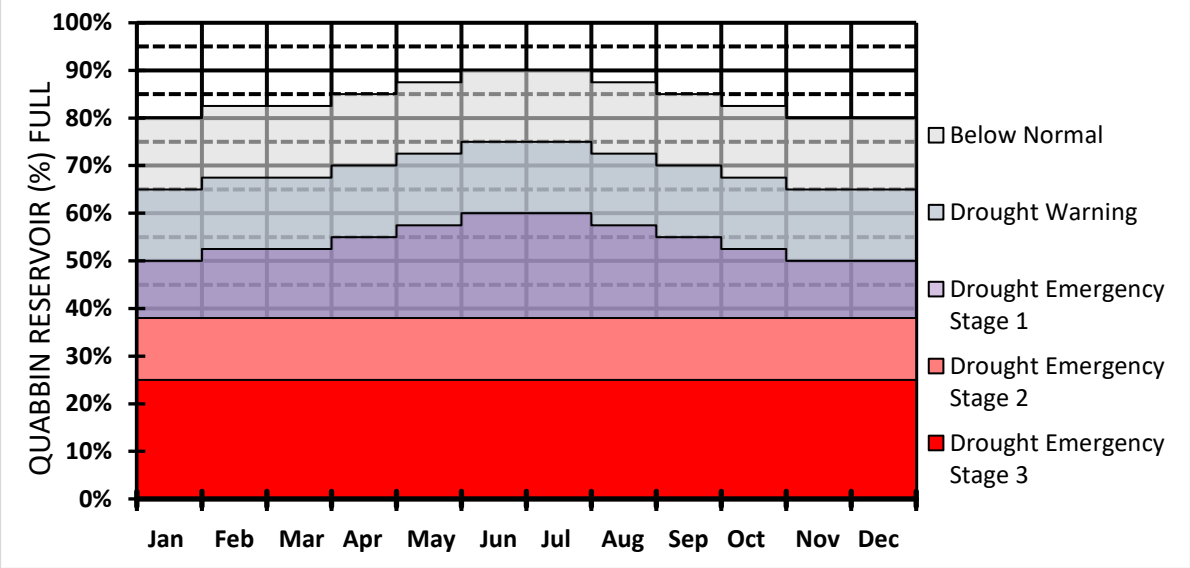


Table 2-1: MWRA Drought Response Plan - Monthly MWRA Drought Trigger for Quabbin Reservoir

	Below Normal		Drought Warning		Drought Emergency Stage 1		Drought Emergency Stage 2		Drought Emergency Stage 3	
	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)
Jan	80.0%	519.1	65.0%	510.1	50.0%	499.6	38.0%	490.0	25.0%	475.0
Feb	82.5%	520.5	67.5%	511.7	52.5%	501.5	38.0%	490.0	25.0%	475.0
Mar	82.5%	520.5	67.5%	511.7	52.5%	501.5	38.0%	490.0	25.0%	475.0
Apr	85.0%	521.9	70.0%	513.2	55.0%	503.3	38.0%	490.0	25.0%	475.0
May	87.5%	523.2	72.5%	514.7	57.5%	505.0	38.0%	490.0	25.0%	475.0
Jun	90.0%	524.6	75.0%	516.2	60.0%	506.7	38.0%	490.0	25.0%	475.0
Jul	90.0%	524.6	75.0%	516.2	60.0%	506.7	38.0%	490.0	25.0%	475.0
Aug	87.5%	523.2	72.5%	514.7	57.5%	505.0	38.0%	490.0	25.0%	475.0
Sep	85.0%	521.9	70.0%	513.2	55.0%	503.3	38.0%	490.0	25.0%	475.0
Oct	82.5%	520.5	67.5%	511.7	52.5%	501.5	38.0%	490.0	25.0%	475.0
Nov	80.0%	519.1	65.0%	510.1	50.0%	499.6	38.0%	490.0	25.0%	475.0
Dec	80.0%	519.1	65.0%	510.1	50.0%	499.6	38.0%	490.0	25.0%	475.0

The MWRA Drought Response Plan objective is to optimize and conserve water consumption through five specific categories of response actions: Analysis & Planning, Coordination, Public Outreach, Technical Assistance, and Operational Adjustments. The elevation trigger levels indicated above initiate these conservation response actions. The MWRA Drought Response Plan

emphasizes timely forecasting of drought impacts, enabling timely and progressive public conservation actions to influence water withdrawal behavior.

The immense size of the reservoirs dampens the system's response to drought conditions. This includes delayed entry into drought stages as well as likely delayed recovery when compared to surrounding water systems. Consequently, other systems or regions may experience drought conditions before or after the MWRA does. This discrepancy is particularly common during rapidly developing, localized "flash droughts" that affect communities with smaller storage capacities in a short timeframe. The MWRA Drought Response Plan assumes coordination with the Massachusetts State Drought Task Force with voluntarily alignment of conservation messaging, even when MWRA and state drought conditions do not coincide. This ensures a degree of messaging consistency whether MWRA drought stages are more or less severe than the state-indicated drought levels.

The MWRA Drought Response Plan emphasizes timely forecasting of drought impacts, enabling public conservation actions to have widespread and lasting effects. MWRA's Enabling Act provides for MWRA to have the authority for "water use limitations in time of drought or other emergency."[2] The MWRA works with and provides technical support to the water system community managers within its service area to implement end-user water conservation and restrictions in response to drought conditions. The success of this approach relies on the already well-established patterns of coordination and cooperation between MWRA and its member communities, as well as ongoing public education and engagement campaigns to reduce water consumption.

2.1 MWRA Drought Response Plan – Technical Assessment Framework

The MWRA Drought Response Plan is founded on the principle of trigger planning, a project management technique designed to identify and prepare for potential risks or issues that may arise during a project. This approach involves developing a list of potential triggers—specific events or conditions that could signal a problem—and outlining corresponding response actions to address them. The MWRA's official drought declaration criterion relies on a critical key measurement to activate drought plan triggers: the elevation of the Quabbin Reservoir. This indicator serves as an effective and straightforward gauge, as it integrates many elements of typical drought indices, such as weather conditions, streamflow, soil moisture, evaporation, and reservoir yield. Reservoir elevation is a clearly understood measurement of a complex system.

The MWRA Drought Response Plan establishes five trigger elevations: Below Normal, Drought Warning, Drought Emergency Stage 1, Drought Emergency Stage 2, and Drought Emergency Stage 3. The "Below Normal" stage serves as a preemptive drought phase, representing the lower half of normal reservoir levels. This stage heightens awareness, prompts planning efforts and optimizes system output before conditions escalate to a "Drought Warning." By monitoring external conditions and issuing advanced notice during the "Below Normal" stage, MWRA ensures preparedness for a large system with multi-year storage capacity. Early voluntary reductions in water demand help bolster reservoir supply levels in subsequent years and mitigate consumption behaviors, providing a buffer against potential drought impacts. These early, incremental measures enhance the system's overall resilience.

[2] *Chapter 372 of the Act of 1984, Section 8(m).* 1984.

2.2 MWRA Drought Response Plan – Communication Framework

MWRA has well-practiced processes for communicating with our customer communities, as our partnership model of operation requires regular engagement with them, on daily operations, planned shutdowns and maintenance, water quality monitoring and troubleshooting, training, public communications – i.e. Annual Water Quality report, and, of course, any emergency. While a drought is classed as an emergency, it is a very slow moving one, allowing for more structured communication, feedback, and adjustments.

Initial communication on drought status would be to local water superintendents (and others within their departments on that list) shortly after the first of the month. This communication would include information of current MWRA drought status (as well as any appropriate reference to state drought status), projected changes in status over the next 1, 3, and 6 months, with requests for voluntary conservation measures, and any mandatory measures they are required to take (or may be required to take within the next few months). Operational requests would assist in managing water use and peak demand, as well as communicating the "shared response" to the public by highlighting these operational adjustments done by the municipality to reduce unnecessary use, such as changes in flushing practice or recreational field watering.

Direct communications with individual consumers would be both through the local communities and directly from MWRA as detailed in the response plan. Progression and communication outlines are discussed in detail in the following sections.

2.3 MWRA Drought Response Plan – Response Categories

For each trigger level within the MWRA Drought Response Plan, there are conservation response measures. Response measures are actions, policies, and programs that influence the consumption behavior of the system. These response measures can be direct or indirect influences on system managers or users. As with the official Massachusetts State Drought Management Plan[3], there are five categories of MWRA drought response:

1. Analysis & Planning
2. Coordination
3. Public outreach
4. Technical assistance
5. Operational Adjustments

Sections 2.3.1 – 2.3.5 describe an overview of the purpose, methodology, and progression of these five categories of drought responses with the specific drought response actions further described with each drought stage in Section 2.4.

[3] Massachusetts Executive Office of Energy and Environmental Affairs, Massachusetts Emergency Management Agency, & Drought Management Task Force. (2023). *Massachusetts Drought Management Plan*. https://www.mass.gov/doc/massachusetts-drought-management-plan/download

2.3.1 Analysis & Planning

Purpose: Establish a comprehensive understanding of current demand-supply trends and reservoir impacts to provide actionable insights.

Methodology: MWRA continuously monitors reservoir and watershed conditions through data provided by MWRA operations, Mass DCR, and USGS, while anticipating future trends using NERFC and NIDIS projections. Normal operations routinely review daily data on reservoir elevations and releases with in-depth analysis weekly, bi-weekly, or monthly. Reservoir system status reports are published with increasing report frequency - annually, monthly, and weekly - during drought conditions to ensure timely situational awareness and feedback on reservoir yields, storage remaining, and demand response to conservation response measures.

Drought status reports are produced on the first of the month when reservoir elevation and drought triggers are assessed. The STELLA Model of the MWRA reservoir system is used to evaluate supply outlooks and provide timeline projections. Drought status reports provide municipal leaders, served communities, and the public with performance metrics and trend analysis.

Combined with the work in “2.3.4 Technical Assistance”, infrastructure assessment assist in identifying vulnerabilities in municipal interconnections, focusing on the capacity, condition, and reliability of critical components such as valves, meters, and storage.

Progression: Data analysis and system status report frequency intensifies as drought conditions persist, shifting from monthly to weekly assessment when reservoir elevations reach critical drought triggers. This ensures real-time evaluation, feedback and adjustment of response strategies and strengthens system preparedness for escalating drought conditions. Drought status reports would be consistently reported on the first of the month to ensure consistent communication and measured interpretation of changing system conditions.

2.3.2 Coordination

Purpose: Foster collaboration among community leaders and drought task management force officials with up-to-date information and actionable guidance to support and achieve conservation goals to minimize conflicting messaging and reinforce public confidence in drought response actions.

Methodology: Coordination activities include MWRA’s active participation in the Massachusetts Drought Task Force and Drought Mission group, coordination with MassDCR, NERFC, NIDIS, and USGS on weather and reservoir status and operations, and coordination with MWRA communities on outreach and technical assistance. MWRA staff would provide regular updates to the MWRA Board of Directors, Advisory Board, and MassDEP.

Progression: As drought conditions intensify, coordination efforts increase in frequency and detail, ensuring that community leaders and officials remain aligned in conservation strategies.

Early-stage coordination includes routine check-ins and information sharing, progressing to more frequent strategy sessions and resource allocations as drought severity escalates. Forward-looking communication to community leaders and drought task management force officials prompts notice of potential stage transitions and expected actions

2.3.3 Public Outreach

Purpose: Promote public awareness and engagement with clear and actionable guidance to support conservation efforts and reduce water demand during drought conditions while ensuring messaging remains accurate, effective and retains public attention over extended drought periods.

Methodology: Composed of four steps – 1. Planning, 2. Targeting, 3. Medium, and 4. Focus.

1) Outreach Planning: Define goals, establish budgets, and coordinate with external partners.
2) Target Messaging: Identify audiences to tailor message based on location and demographics.
3) Communication Mediums: Utilize traditional media (flyers, newspapers, signboards), digital platforms (websites, social media, videos), and interactive (webinars, press conferences).
4) Content Focus: Highlight indoor and outdoor water-saving tips, current water supply conditions, and the necessity of conservation. Ensuring seasonally appropriate and forward-thinking messaging.

Progression: Public outreach efforts escalate in response to drought severity. Initial messaging provides basic water conservation recommendations, progressing to regular press briefings and extensive multimedia campaigns as drought conditions persist. MWRA feedback on conservation measure impacts encourages public participation. Updates are provided with defined intent – either to inform, prepare, or prompt action - to ensure effective messaging and retain public attention over extended drought periods. Where appropriate, links to detailed analysis, including projected timelines and evaluations, are made available to support public engagement. In the most severe stages, outreach becomes more urgent, incorporating emergency notifications and widespread media engagement.

2.3.4 Technical Assistance

Purpose: Provide and support water departments and public officials with projected timelines to emphasize potential stage transitions and necessary goals to implement effective conservation measures and maintain supply stability.

Methodology: Meter data sharing to optimize and conserve water consumption at a local level. Development of infrastructure assessment protocols for critical connections and emergency connections to periphery communities.

- Early Stages: Introduce operational conservation measures, such as leak detection, adjusting flushing schedules and targeting outreach. Provide data necessary to identify and assess infrastructure vulnerabilities in municipal interconnections, focusing on the capacity, condition, and reliability of critical components such as valves, meters, and storage.
- Continual Support: Monitor and adapt responses to reduce consumer demand and address critical needs during worsening drought conditions. Expand data meter sharing to upscale and target leak detection effort and evaluate drought measure impacts. Evaluate and develop emergency connection procedures, where necessary.
- Emergency Stages: Provide more intensive and in-depth assistance to MWRA communities on restrictions, outreach, financial issues and enforcement. Provide inter-connection solutions, support emergency water requests, and assist neighboring communities with overburdened systems.

Progression: Technical assistance measures become increasingly proactive as drought conditions persist. Initially, guidance and recommendations are provided to optimize existing resources and reduce demands. The progression of communication and meter data sharing with community managers increases with frequency in order to measure the efficacy of leak detection efforts and other implemented conservation measures. In later drought stages, direct support, infrastructure assistance, and emergency interventions are implemented to ensure water supply.

2.3.5 Operational Adjustments

Purpose: Implement and support policy & regulatory measures to stabilize demand-supply ratios and mitigate drought impacts, signaling to communities that operational patterns are shifting to a more urgent, mutual goal of water demand management.

Methodology:

- Policy Development: Call for and support community policy, regulation, and restriction measures i.e. - voluntary/mandatory restrictions, changes to community distribution system management, increased leak detection, and adopting seasonal rate changes.
- Enforcement: As drought levels escalate, communities to transition from voluntary restrictions in "Drought Warning" to mandatory measures, including potential seasonal rationing and rate adjustments in "Drought Emergency Stage 3."
- Communication: Ensure clear, actionable, and appropriate messaging about policy changes to foster public understanding and compliance. Updates are issued with defined intent – either to inform, prepare, or prompt action.

Progression: Policy measures become progressively stricter as drought severity increases. Initial voluntary measures transition into more structured restrictions, culminating in regulatory enforcement and potential rationing during extreme drought conditions. MWRA coordinates with municipal water managers and officials to ensure the effective implementation and enforcement of conservation measures tailored to local drought conditions.

2.4 MWRA Drought Response Plan – Drought Stages

The MWRA Drought Response Plan is structured around progressive stages, each defined by Quabbin Reservoir elevation triggers and associated conservation response measures. These measures aim to ensure effective communication of shifting water management strategies that are supporting conservation efforts, and prepare for emergency provisions for neighboring communities experiencing drought conditions. Below, sections 2.4.1–2.4.6 outline the normal operating levels and drought stages, detailing the corresponding reservoir elevations, reduction goals, and conservation response actions.

Goal (%) Reduction - Water conservation targets are calculated using the five-year moving annual average of system use. These targets are realistic and adaptable for both MWRA and the public, and readily communicated.

Progression - Response measures escalate in stringency as drought severity increases from voluntary to mandatory. Continuance of response measures from previous stages unless otherwise stated. Response measures allocating resources to surrounding communities (i.e. - emergency connections) are contingent upon the drought levels and conditions of surrounding communities. The MWRA Drought Response Plan assumes surrounding areas are experiencing similar, if not worse drought conditions. Therefore, allocation of resources is based on local need and the ability of the MWRA.

2.4.1 Normal Operations

Trigger Elevation: 519.08 – 530 feet (80–100% full)

Goal (% Reduction): None

Table 2-2 MWRA Drought Plan - Response Measures – Normal Operations Monthly Volume & Elevation for Quabbin Reservoir		
Month	*Reservoir Volume (%)*	*Elevation (ft.)*
Jan	80.0 - 100%	519.08 - 530.0
Feb	82.5 - 100%	520.48 - 530.0
Mar	82.5 - 100%	520.48 - 530.0
Apr	85.0 - 100%	521.86 - 530.0
May	87.5 - 100%	523.24 - 530.0
Jun	90.0 - 100%	524.61 - 530.0
Jul	90.0 - 100%	524.61 - 530.0
Aug	87.5 - 100%	523.24 - 530.0
Sep	85.0 - 100%	521.86 - 530.0
Oct	82.5 - 100%	520.48 - 530.0
Nov	80.0 - 100%	519.08 - 530.0
Dec	80.0 - 100%	519.08 - 530.0

At this stage, the MWRA system operates under normal conditions, focusing on ensuring high-quality water supply while meeting required releases to the Swift, Nashua, and Ware Rivers. Secondary objectives include maintaining flood protection buffers and generating hydropower. Reservoir management prioritizes maintaining operational bands to address seasonal variations and maintenance needs.

Table 2-3 MWRA Drought Plan - Response Measures –Normal Operations		
Normal Operations	Goal (%) Reduction	Conservation Response Measures
Trigger Elevation **80-100%** **519.1 – 530ft.**	**---**	1. *Analysis & Planning* a. Provide routine system status updates b. Track demand patterns and long-term trends 2. *Public Outreach* a. Routine conservation messaging b. Routine provision of free conservation devices 3. *Technical Assistance to communities* a. Ongoing & on-call assistance b. Leak detection assistance *4. Drought Coordination* a. Participation on Massachusetts Drought Management Task Force (DMTF) meetings b. Voluntary alignment of conservation messaging with state drought messaging during state drought conditions *5. Operational Adjustment* a. Maintain high-quality supply, required releases, and flood protection b. Maintain operational bands to address seasonal variations and maintenance needs c. Maintain flood protection buffers and generate hydropower

2.4.2 Below Normal

Trigger Elevation: 510.1 – 524.6 feet (65–90% full)

Goal (% Reduction): None

Table 2-4 MWRA Drought Trigger (Volume & Elevation) - Below Normal Monthly Volume & Elevation for Quabbin Reservoir		
Month	Reservoir Volume (%)	Elevation (ft.)
Jan	65.0 - 80.0%	510.1 - 519.1
Feb	67.5 - 82.5%	511.7 - 520.5
Mar	67.5 - 82.5%	511.7 - 520.5
Apr	70.0 - 85.0%	513.2 - 521.9
May	72.5 - 87.5%	514.7 - 523.2
Jun	75.0 - 90.0%	516.2 - 524.6
Jul	75.0 - 90.0%	516.2 - 524.6
Aug	72.5 - 87.5%	514.7 - 523.2
Sep	70.0 - 85.0%	513.2 - 521.9
Oct	67.5 - 82.5%	511.7 - 520.5
Nov	65.0 - 80.0%	510.1 - 519.1
Dec	65.0 - 80.0%	510.1 - 519.1

The first trigger elevation, **65 - 90%**, indicates **"Below Normal"**. While still within normal operating limits, the "Below Normal" stage heightens monitoring and analysis of demand-supply trends. Higher frequency reviews of weather and model forecasts inform planning for current and future water supply conditions. Outreach to local officials and the public supports ongoing messaging aligned with Massachusetts state agencies drought guidelines.

Table 2-5 MWRA Drought Plan - Response Measures – Below Normal		
Below Normal	Goal (%) Reduction	Conservation Response Measures
<u>*Trigger Elevation*</u> ***65 - 90%*** ***510.1 – 524.6 ft.***	**---**	*1. Analysis & Planning* a. Conduct **monthly** reviews of weather and model forecasts of watershed input, reservoir elevations, and drawdown rates b. Periodic Drought Status Reports, as appropriate *2. Public Outreach* a. Seasonal messaging on conservation techniques via web and social media b. Monthly updates on water supply status and restrictions *3. Technical Assistance to communities* a. Support for municipal practices like flushing schedules, leak detection and customer outreach b. Preparation for potential escalation to the "Drought Warning" stage *4. Drought Coordination* a. Participation in Mass DMTF meetings b. Data collaboration with agencies: Mass DMTF, DCR & DEP; NERFC; NIDIS; USGS c. Messaging aligned (as appropriate) with state agencies messaging. d. Communicate and raise awareness of the timeline of reservoir drought impacts. e. Regular communication with likely emergency users *5. Operational Adjustment* a. Ongoing monitoring with no immediate mandatory changes b. Operate Ware River flow skimming transfer to Quabbin, when river flow conditions allow

2.4.3 Drought Warning

Trigger Elevation: 499.62 – 516.22 feet (50–75% full)

Goal (% Reduction): 5% (five-year annual average of system use)

Table 2-6 MWRA Drought Trigger (Volume & Elevation) - Drought Warning

Monthly Volume & Elevation for Quabbin Reservoir

Month	**Reservoir Volume (%)**	**Elevation (ft.)**
Jan	50.0 - 65.0%	499.6- 510.1
Feb	52.5 - 67.5%	501.5 - 511.7
Mar	52.5 - 67.5%	501.5 - 511.7
Apr	55.0 - 70.0%	503.3 - 513.2
May	57.2 - 72.5%	505.0 - 514.7
Jun	60.0 - 75.0%	506.7 - 516.2
Jul	60.0 - 75.0%	506.7 - 516.2
Aug	57.5 - 72.5%	505.0 - 514.7
Sep	55.0 - 70.0%	503.3 - 513.2
Oct	52.5 - 67.5%	501.5 - 511.7
Nov	50.0 - 65.0%	499.6 - 510.1
Dec	50.0 - 65.0%	499.6 - 510.1

The second trigger elevation, **50 - 75%**, indicates **"Drought Warning",** which indicates below-normal operating elevations and initiates additional proactive conservation response measures targeting a **5% reduction in consumption** from the Average System Use.

The MWRA designates a drought coordinator to collaborate with the Massachusetts State Drought Task Force (MassDMTF) and Drought Mission Group, emphasizing enhanced conservation efforts. Public outreach expands to include requests for voluntary reductions from large users and visible users and restrictions on outdoor and municipal water use.

Table 2-7 MWRA Drought Plan - Response Measures - Drought Warning		
Drought Warning	Goal (%) Reduction	Conservation Response Measures
<u>*Trigger Elevation*</u> ***50 - 75%*** ***499.6 – 516.2 ft.***	**5%** From 5-year Annual Average	*1. Analysis & Planning* a. Conduct **monthly** reviews of reservoir yields, storage, weather and model forecasts b. Develop and publish **monthly** Drought Status Report c. Review and evaluate likelihood of emergency connections with typical emergency users *2. Public Outreach* a. Expanded efforts for seasonal messaging on conservation strategies and restrictions b. Weekly social media updates on drought status and restrictions c. *Press Releases to raise awareness* d. Publish FAQ webpage with MWRA regional messaging and links to state drought FAQs *3. Technical Assistance to communities* a. Optimize municipal flushing practices and provide customer outreach b. Additional outreach on and distribution of water saving devices c. Encourage and facilitate additional leak detection efforts d. Encourage and facilitate meter data sharing for local analysis *e.* Develop emergency connection procedures, as needed *4. Drought Coordination* a. Weekly participation in Mass DMTF meetings b. Continued data collaboration. c. Messaging aligned (as appropriate) with state messages. d. Communicate and raise awareness of the timeline of reservoir drought impacts. e. Regular communication with likely emergency users f. Inform MassDEP of imposed restrictions *5. Operational Adjustment* a. Communities to implement: ▪ **Restrictions** on non-essential outdoor water use (see Page 25) ▪ **Voluntary reductions** from large and visible users b. Evaluate reduction of water supply to McLaughlin Fish Hatchery c. Operate Ware River flow skimming transfer to Quabbin, when river flow conditions allow

2.4.4 Drought Emergency Stage 1

Trigger Elevation: 490 – 506.74 feet (38–60% full)

Goal (% Reduction): 10% (five-year annual average of system use)

Table 2-8 MWRA Drought Trigger (Volume & Elevation) Drought Emergency Stage 1

Monthly Volume & Elevation for Quabbin Reservoir

Month	Reservoir Volume (%)	Elevation (ft.)
Jan	38.0 - 50.0%	490.0 - 499.6
Feb	38.0 - 52.5%	490.0 - 501.5
Mar	38.0 - 52.5%	490.0 - 501.5
Apr	38.0 - 55.0%	490.0 - 503.3
May	38.0 - 57.5%	490.0 - 505.0
Jun	38.0 - 60.0%	490.0 - 506.7
Jul	38.0 - 60.0%	490.0 - 506.7
Aug	38.0 - 57.5%	490.0 - 505.0
Sep	38.0 - 55.0%	490.0 - 503.3
Oct	38.0 - 52.5%	490.0 - 501.5
Nov	38.0 - 50.0%	490.0 - 499.6
Dec	38.0 - 50.0%	490.0 - 499.6

The third trigger elevation, **(38-60%)**, indicates **"Drought Emergency Stage 1"**, which officially declares a drought emergency by MWRA standards. Entering an officially declared drought initiates more intensive conservation response measures targeting a **10% reduction in consumption** from the Average System Use.

Emergency Connections - Response measures allocating resources to surrounding communities (i.e. - emergency connections) are contingent upon the drought levels and conditions of surrounding communities. The MWRA Drought Response Plan assumes surrounding areas may be experiencing similar, if not worse drought conditions. Therefore, allocation of resources is based on local need and the ability of the MWRA.

Table 2-9 MWRA Drought Plan - Response Measures Drought Emergency Stage 1		
Drought Emergency Stage 1	Goal (%) Reduction	Conservation Response Measures
<u>Trigger Elevation</u> ***38-60%*** ***490 – 506.7 ft.***	**10%** From 5-year Annual Average	*1. Analysis & Planning* a. Conduct **bi-weekly** reviews of yield, storage, weather and model forecasts b. Develop & Publish Monthly Drought Status Report c. Prioritize, review and test necessary emergency connections with uncertain storage or connection condition d. Evaluate potential WQ concerns *e.* Evaluate further demand reduction in emergency community use *2. Public Outreach* a. Seasonal messaging via web and social media b. Weekly updated drought status and restrictions on "front" of web page c. Press Releases to raise awareness d. Update FAQ webpage with MWRA region messaging, with additional mandatory actions, and links to state drought FAQs *e.* Develop and print additional drought specific bill stuffers for community use *3. Technical Assistance to communities* a. Support for municipal practices like flushing schedules and customer outreach b. Encourage and assist additional leak detection efforts c. Expanded meter data sharing to allow communities to evaluate their use reductions in near real time d. Provide assistance in enforcement procedures e. Provide assistance in evaluating drought pricing f. Develop emergency connection procedures *4. Drought Coordination* a. Weekly participation in Mass DMTF meetings b. Continued data collaboration c. Messaging aligned (as appropriate) with state messages d. Communicate and raise awareness of the timeline of reservoir drought impacts e. Prepare and test emergency water supply connections to surrounding communities *5. Operational Adjustment* a. Communities to implement **Mandatory Restriction / Ban** for Nonessential outdoor and municipal use (As defined in WMA regulations) b. Evaluate further reduction/cutoff of water supply to McLaughlin Fish Hatchery c. Operate Ware River flow skimming transfer to Quabbin, when river flow conditions allow

2.4.5 Drought Emergency Stage 2

Trigger Elevation: 475–490 feet (25–38% full)

Goal (% Reduction): 15% (five-year annual average of system use)

Table 2-10 MWRA Drought Trigger (Volume & Elevation) Drought Emergency Stage 2

Monthly Volume & Elevation for Quabbin Reservoir

Month	Reservoir Volume (%)	Elevation (ft.)
Jan	25 - 38%	475 - 490
Feb	25 - 38%	475 - 490
Mar	25 - 38%	475 - 490
Apr	25 - 38%	475 - 490
May	25 - 38%	475 - 490
Jun	25 - 38%	475 - 490
Jul	25 - 38%	475 - 490
Aug	25 - 38%	475 - 490
Sep	25 - 38%	475 - 490
Oct	25 - 38%	475 - 490
Nov	25 - 38%	475 - 490
Dec	25 - 38%	475 - 490

The fourth trigger elevation, **25-38%**, indicates **"Drought Emergency Stage 2"**, requiring a **15% reduction in consumption** from the Average System Use. Enhanced conservation measures are implemented to sustain water supplies.

Response measures allocating resources to surrounding communities (i.e. - emergency connections) are contingent upon the drought levels and conditions of surrounding communities. The MWRA Drought Response Plan assumes surrounding areas are experiencing similar, if not worse drought conditions. Therefore, allocation of resources is based on local need and the ability of the MWRA.

Table 2-11 MWRA Drought Plan - Response Measures - Drought Emergency Stage 2		
Drought Emergency Stage 2	Goal (%) Reduction	Conservation Response Measures
Trigger Elevation ***25-38%*** ***475– 490 ft.***	**15%** From 5-year Annual Average	*1. Analysis & Planning* a. Conduct **weekly** reviews of weather and model forecasts b. Develop & publish Monthly Drought Status Report c. Evaluate impact of additional emergency connections to surrounding communities d. Monitor changes in Water Quality *2. Public Outreach* a. Seasonal messaging via social media, press events, and other mediums b. Weekly updates on drought status and restrictions on "front" of web page c. Update FAQ webpage with MWRA regional messaging, with additional mandatory actions, and links to state drought FAQs *3. Technical Assistance to communities* a. Support for municipal practices like flushing schedules and customer outreach b. Expand meter data sharing c. Provide assistance in enforcement procedures d. Provide assistance in evaluating drought pricing e. Develop rationing protocols f. Develop emergency connection procedures *4. Drought Coordination* a. Weekly participation in Mass DMTF meetings b. Continued data collaboration c. Communicate and raise awareness of the timeline of reservoir drought impacts. d. Review, evaluate, and prepare additional emergency connections to surrounding communities e. Review, evaluate, and prepare emergency backup water supply activation f. Collaboration with state drought management task force efforts. *5. Operational Adjustment* a. Communities to **Implement & Enforce Mandatory Ban** for Nonessential outdoor and municipal use b. Review, evaluate, and prepare emergency backup water supply activation c. Operate Ware River flow skimming transfer to Quabbin, when river flow conditions allow

2.4.6 Drought Emergency Stage 3

Trigger Elevation: <475 feet (25–38% full)

Goal (% Reduction): 30% (five-year annual average of system use)

Table 2-12 MWRA Drought Trigger (Volume & Elevation) Drought Emergency Stage 3

Monthly Volume & Elevation for Quabbin Reservoir

Month	Reservoir Volume (%)	Elevation (ft.)
Jan	25.0%	475.00
Feb	25.0%	475.00
Mar	25.0%	475.00
Apr	25.0%	475.00
May	25.0%	475.00
Jun	25.0%	475.00
Jul	25.0%	475.00
Aug	25.0%	475.00
Sep	25.0%	475.00
Oct	25.0%	475.00
Nov	25.0%	475.00
Dec	25.0%	475.00

The fifth trigger elevation, **below 475 feet (below 25%)**, indicates **"Drought Emergency Stage 3"**, targeting a **30% reduction in consumption** from the Average System Use. This stage intensifies previous conservation efforts.

Response measures allocating resources to surrounding communities (i.e. - emergency connections) are contingent upon the drought levels and conditions of surrounding communities. The MWRA Drought Response Plan assumes surrounding areas are experiencing similar, if not worse drought conditions. Therefore, allocation of resources is based on local need and the ability of the MWRA.

Table 2-13 MWRA Drought Plan - Response Measures - Drought Emergency Stage 3		
Drought Emergency Stage 3	Goal (%) Reduction	Conservation Response Measures
Trigger Elevation **Below 25%** **< 475 ft.**	**30%** From 5-year Annual Average	*1. Analysis & Planning* a. Conduct **weekly** reviews of weather and model forecasts b. Develop & Publish Monthly Drought Status Report c. Evaluate transmission capacity and water quality issues from emergency supply activation *2. Public Outreach* a. All tools utilized for seasonal messaging on water conservation strategies b. Press Release to raise awareness c. Weekly updates on drought status and restrictions Publish FAQ webpage with directed links to state drought plan *3. Technical Assistance to communities* a. Optimize municipal usage and provide customer outreach b. Develop & implement ration protocols c. Implement drought pricing d. Implement emergency connections, as needed *5. Drought Coordination* a. Weekly participation in Mass DMTF meetings b. Continued data collaboration c. Communicate and raise awareness of the timeline of reservoir drought impacts. d. Implement emergency connections e. Implement MWRA emergency supply transmission to necessary areas *6. Operational Adjustment* a. Communities to evaluate, revise, and implement rationing b. Operate Ware River flow skimming transfer to Quabbin, when river flow conditions allow

Nonessential outdoor water use is defined as every use that is not required for essential purposes. The following is a list of outdoor water uses identified in the regulations that will not be restricted under the new condition:

a) *health or safety reasons, including public facilities used for cooling such as splash pads and swimming pools, and for washing of boats, engines, or marine equipment to prevent negative saltwater impacts or the transfer of invasive aquatic species;*

b) *by permit, license, statute or regulation;*

c) *production of food, including vegetable gardens, and fiber;*

d) *maintenance of livestock;*

e) *meet the core functions (those functions essential to the commercial operations) of a business, including but not limited to: 1. plant nurseries as necessary to maintain stock; 2. golf courses as necessary to maintain greens and tees, and limited fairway watering per 310 CMR 36.07(2)(c)2.a. through c.; 3. venues used for weddings or similar special events that limit watering to hand-held hose or drip irrigation as necessary to maintain gardens, flowers and ornamental plants; 4. professional washing of exterior building surfaces, parking lots, driveways and/or sidewalks as necessary to apply surface treatments such as paint, preservatives, stucco, pavement, or cement in the course of construction, reconstruction or renovation work;*

f) *irrigation of public parks before 9:00 A.M. and after 5:00 P.M.,*

g) *irrigation of public and private recreation fields, including those operated by schools, colleges, universities and athletic associations, before 9:00 A.M. and after 5:00 P.M.,*

h) *irrigation of publicly-funded shade trees and trees in the public right-of-way; or*

i) *establish a new lawn as necessary to stabilize soil in response to new construction or following the repair or replacement of a Title 5 system.*

Water Resources Management Program Regulations 310 CMR 36.00 January 20, 2023

https://www.mass.gov/doc/guidance-on-nonessential-outdoor-water-use-for-wma-registrants/download

3 Description of the MWRA Water System

The MWRA water system delivers wholesale potable water to approximately 2.7 million consumers across 53 communities, primarily in the Greater Boston area. This service accounts for about 45% of the population in the Commonwealth of Massachusetts. The system is operated in partnership with the Massachusetts Department of Conservation and Recreation (MassDCR), which manages the watersheds, while the MWRA manages and operates the reservoirs, treatment facilities, transmission, and distribution systems. This includes pumping and hydroelectric stations as well as distribution reservoirs. The individual communities served are responsible for operating and maintaining their local distribution systems.

The primary water supply originates from the Quabbin and Wachusett Reservoirs, located 65 and 32 miles west of Boston, respectively. Seasonal diversions from the Ware River supplement the supply, while the Sudbury Reservoir serves as an emergency source. The Quabbin Reservoir has a capacity of 412 billion gallons, and Wachusett Reservoir holds 65 billion gallons. Together, these reservoirs provide vast multi-year storage capacity relative to their drainage area, contribute to the system's ability to deliver high-quality water without filtration.

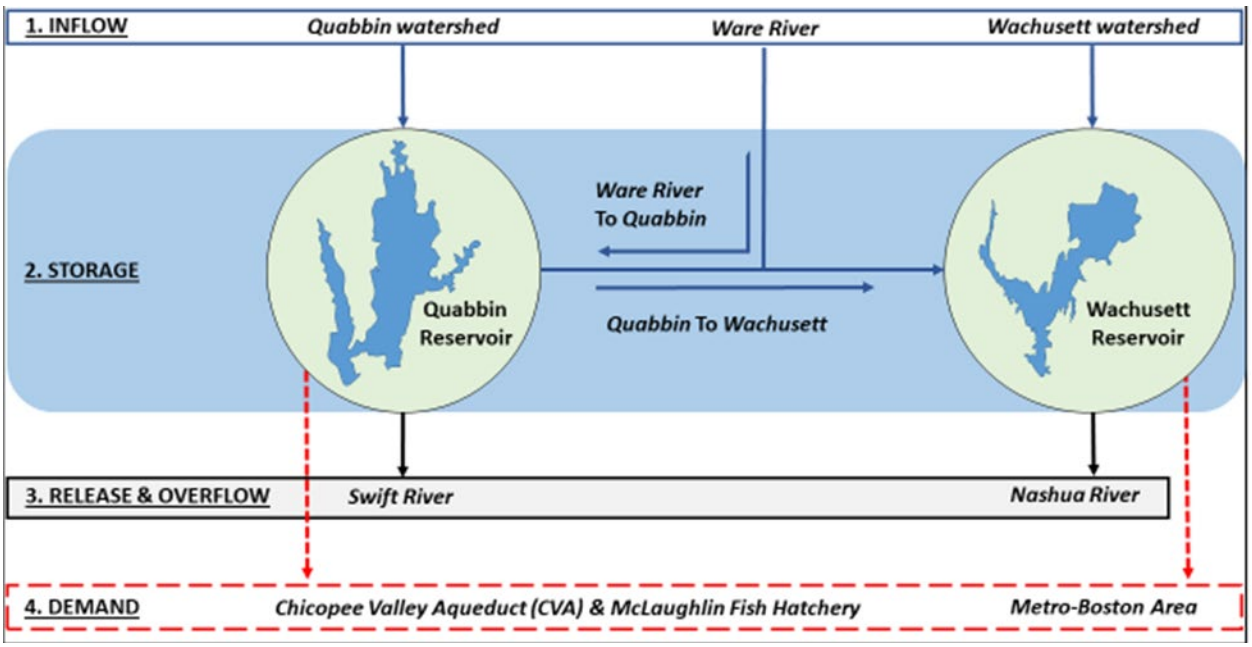
In compliance with the Safe Drinking Water Act, the MWRA and MassDCR have implemented an approved watershed resource protection plan for the Quabbin and Ware River watersheds. The Quabbin and Wachusett reservoirs' high water quality negates the need for filtration. MWRA operates the two-reservoir system to maximize delivered water quality, transferring water from the Quabbin Reservoir with its longer detention time and thus higher level of natural treatment, to Wachusett Reservoir as needed for quantity and quality management.

3.1 Overview of the MWRA Water System

The MWRA water system operates through four principal mechanisms: **Inflow**, **Storage**, **Release & Overflow**, and **Demand** (Figure 3-1) - *additional demand outlets not shown for simplification.*

1. **Inflow**: Water enters the reservoirs via watershed inflows, river diversions, and inter-basin transfers. The system's long-term inflow sources include the Quabbin watershed, Wachusett watershed, and the Ware River.
2. **Storage**: Water is stored primarily in the Quabbin and Wachusett Reservoirs. Transfers from Quabbin to Wachusett constitute a significant portion of the system's water quality and quantity management strategy.
3. **Release & Overflow**: Outflows consist of planned releases for seasonal storage adjustments, required releases, overflows when reservoirs reach capacity, and water withdrawals to meet demand. Planned releases are designed to anticipate seasonal storage needs and facilitate reservoir maintenance.
4. **Demand**: After treatment, water is withdrawn based on customer needs and distributed through a network of deep rock tunnels and ~284 miles of distribution pipes to MWRA communities.

Figure 3-1. Overview of Massachusetts Water Resources Authority (MWRA) water system



3.2 Operational Objectives of the MWRA Reservoir System

The MWRA reservoir system's **primary objective** is to ensure a high-quality, adequate water supply while maintaining the required minimum releases to the Swift, Nashua, and Ware Rivers under all conditions. This is facilitated by the system's immense usable storage capacity across the Quabbin and Wachusett Reservoirs. Managing these reservoirs involves balancing inflows and outflows—demand withdrawals, planned releases, and overflows—under varying regional weather conditions, including seasonal droughts and floods.

Secondary objectives of the MWRA reservoir system include:

1. Flood protection: Maintain adequate storage buffers to mitigate downstream flooding risks.
2. Hydropower generation: Hydropower produced at the Oakdale Station (Quabbin Aqueduct outlet), Cosgrove Intake, and additional locations within the transmission system, helps to offset the MWRA's greenhouse gas emissions.

3.3 Quabbin Reservoir

The Quabbin Reservoir has a capacity of 412 billion gallons, a surface area of ~39 square miles (100 km²), and a watershed area of 187 square miles (485 km²). Approximately 57% of the watershed land is owned by MassDCR, and 75% is protected from development and recreational impacts.

Water is transmitted by gravity from a maximum elevation of 530 feet (BCB) via the approximately 13-foot diameter, 24.6-mile Quabbin Aqueduct to the Wachusett Reservoir. During this transfer,

hydropower is generated at the Oakdale Station. Quabbin transfers typically account for over half of Wachusett Reservoir's average annual inflow. Additional withdrawals supply three communities west of Quabbin via the Chicopee Valley Aqueduct.

Regardless of drought status, MWRA will make these required releases from Quabbin Reservoir:

- Per Chapter 321 of the 1927 Massachusetts Acts, A minimum of 20 million gallons per day (MGD) must be released to the Swift River as measured at Bondsville.
- Per the 1929 War Department Requirement, additional releases from June 1 to November 30, depend on streamflow at Montague to maintain adequate flow in the Connecticut River during low-flow conditions. Additional releases range from 45 to 70 MGD based on daily average of Montague flow. Below 4900 cfs, release must be 45 MGD; Below 4650 cfs, release must be 70 MGD; Montague flows above 4900 cfs, the minimum flow of 20 MGD at Bondsville governs.

These regulated releases balance the water supply needs of the MWRA system with ecological and community requirements downstream. In addition, up to 6 MGD of high-quality water to the McLaughlin State Trout Hatchery is delivered via a 4,400-foot pipeline. This project, which includes a hydroelectric turbine, reduces pumping costs and greenhouse gas emissions at the hatchery while improving water quality for the Swift River. The Memorandum of Agreement (MOA) governing this supply indicates that the McLaughlin State Fish Hatchery flow is subject to reduction and cutoff during drought conditions in efforts to conserve water supply.

3.4 Wachusett Reservoir

The Wachusett Reservoir has a capacity of 65 billion gallons, a surface area around 6.5 square miles (17 km²), and a watershed area of 108 square miles (280 km²). MassDCR owns ~29% of the watershed, and 53% of the land is protected. Water is delivered through a network of aqueducts and tunnels (10-14 feet in diameter) to 14 distribution reservoirs or directly to community systems. *Regardless of drought status*, MWRA will make the required releases from Wachusett Reservoir. A minimum of 12 million gallons per week is released to the Nashua River, per Chapter 488 of the 1895 Massachusetts Acts, with typical releases exceeding this requirement to maintain reservoir elevation and mitigate flooding risks.

Wachusett Reservoir operation objectives:

1. Operate within elevation bands: Wachusett Reservoir elevation is maintained within a specific range to balance supply, prevent shoreline erosion, minimize downstream flooding, and improve water quality by submerging gull roosting areas.
2. Water quality: Quabbin water is mixed with Wachusett water to maintain quality. Transfers are particularly beneficial during reservoir stratification (May–October), where cooler Quabbin water forms an interflow, improving intake water quality.

3.5 Ware River

The MWRA enhances system safe yield by diverting water from the Ware River watershed to the Quabbin Reservoir when the reservoir is in Below Normal or lower drought status. Seasonal inflows from the Ware River typically flow by gravity for mixing and detention into the Quabbin Reservoir. When the system is within Normal Operating range, transfers are typically only made for flood prevention in the Ware River basin as well as annual facility exercise and training.

Ware River diversion requirements and conditions[4]:

Continuous requirement of flow conditions - Diversions are permitted when the Ware River's flow exceeds 85 million gallons per day (mgd).

a) *Dec 1 to Jun 1*: Diversions can occur, as needed, provided the flow condition is met.

b) *Jun 1 to Jun 15* & *Dec 1 to Dec 15*: Diversions require notification to the Massachusetts Department of Environmental Protection (MassDEP).

c) *Jun 15 to Oct 15*: Diversions are not permitted during this period.

These guidelines ensure that water transfers are conducted responsibly, balancing the needs of the MWRA water system with environmental considerations. Typical operations limit diversions when the Quabbin Reservoir is within its normal operating elevation band and prioritize reducing the risk of transferring invasive species.

3.6 Safe Yield

The safe yield is the amount of water that can be reliably supplied during extended periods of system stress, such as a critical drought[5]. For the Quabbin-Ware-Wachusett system, the safe yield is an annual average of 300 million gallons per day (MGD). This value has remained consistent since the design of the Wachusett Aqueduct in 1895 and has been validated through multiple studies, including those conducted in 1922, 1950, the 1980s and 1990s, and 2011. The 300 MGD designation is a conservative estimate based on the historical drought of the 1960s. Detailed calculations and a review of the safe yield value are provided in 4.1 Safe Yield & Climate Change Impacts.

3.7 Storage Capacity

The reliability of the MWRA water system is supported by the large storage capacities of the Quabbin and Wachusett Reservoirs. The Quabbin Reservoir has a total capacity of 412 billion

[4] Acts of Massachusetts State Legislature Chapter 375, Acts of 1926
[5] National Study of Water Management During Drought; US Army Corps of Engineers; 1994

gallons, and the Wachusett Reservoir holds 65 billion gallons, providing a combined total capacity of 477 billion gallons.

3.7.1 Multi-Year Drought Storage Capacity

The MWRA's multi-year drought storage capacity significantly exceeds the requirements set by the Massachusetts Department of Environmental Protection (MassDEP) under the Water Management Act regulations. These regulations define multi-year drought storage as a reservoir capacity of at least two times the sum of authorized withdrawal and required reservoir releases:

> "*Multi-Year Drought Storage means a registrant's reservoir capacity, as determined by the Department, of not less than two times the sum of a registrant's authorized withdrawal and any required reservoir release established by statute, regulation, permit or other approval issued by a state or federal agency. Multi-Year Drought Storage does not include the volume of water below intake elevations*."[6]

For the MWRA, the authorized withdrawal is 312.82 MGD, and required releases average a total of 28.4 MGD, resulting in a total system demand plus releases of 341 MGD or approximately 124 billion gallons (BG) annually. The MWRA system provides 467 billion gallons of drought storage capacity, easily meeting MassDEP's two-year supply requirement of 248 BG (see Table 3-1).

Table 3-1 MWRA Multi-Year Drought Storage based on Mass DEP Requirements

Quabbin Reservoir	402,000[7]	MG	402	BG
Wachusett Reservoir	65,000	MG	65	BG
Total System Capacity	467,000	MG	467	BG
Total Demand & Releases[8]	124,545	MG	125	BG
Multi-Year Drought Capacity	3.7	Years		

[6] Massachusetts Water Management Act, **310 CMR 36.03.** Massachusetts Water Resources Management Program, Massachusetts Department of Environmental Protection. https://www.mass.gov/doc/310-CMR-360-the-water-management-actregulations/download

[7] Adjusted for intake levels, the Quabbin Reservoir's effective usable capacity is reduced from 412 BG to 402 BG. Wachusett capacity based on usable storage above intake.

[8] Total Demand and Releases is the total allowed withdrawal permitted (312.22 MGD) plus the minimal downstream release requirements for the Swift and Nashua River (29 MGD) for a total of 341.22 MGD.

3.8 Overview of Drought in Massachusetts

Drought is characterized by prolonged periods of abnormally dry conditions resulting from precipitation deficits and increased evapotranspiration due to heat stress. Recent years have seen the emergence of "flash droughts," periods of rapid drought intensification marked by high temperatures, decreased precipitation, strong winds, and significant reductions in drought levels within two to four weeks. Flash droughts can occur at the onset of a drought or within an ongoing drought, adding complexity to water resource management.

3.8.1 Flash Droughts

Droughts traditionally develop slowly and may persist for extended periods, with cumulative impacts on natural and human systems. However, recent droughts, including those in 2015–2017 and 2024, featured rapid intensification—defining characteristics of flash droughts. These events lead to increased evapotranspiration, reduced soil moisture, and rapidly worsening local conditions.

MWRA models drought based on Quabbin Reservoir elevation. This approach may seem to delay response to flash droughts, but correctly accounts for the dampening effect of the system's large storage volume. The state drought plan and drought task force may recommend the declaration of drought conditions even when MWRA reservoir levels remain above "Normal" levels, as other indices—such as precipitation, streamflow, and groundwater—may reflect severe conditions for systems with less storage. Although the resilience of MWRA's water supply buffers against immediate impacts, continuous monitoring of all drought conditions in MWRA's approach and response plan is crucial to avoid missing the transition into a prolonged drought.

3.8.2 Historical Drought

Although data on some drought impacts remain limited, research continues to improve understanding of these effects. Historical climate data, including tree-ring analyses, provide valuable insights into long-term precipitation patterns. Despite being a relatively water-rich state, Massachusetts has experienced several severe droughts, including those from 1879–1883, 1908–1912, 1929–1932, 1939–1944, 1961–1969, 1980–1983, and 2016–2017. Less severe but still impactful droughts occurred in 1999, 2001, 2002, 2007, 2008, 2010, 2014, 2019, 2020–2021 and 2024.

Among these, the 1961–1969 drought is considered the most significant, with far-reaching consequences for water supplies. Thirty-seven communities faced emergency declarations, and the Quabbin Reservoir dropped to 45% of capacity in May of 1967. During this period, water restrictions were issued, and annual water demand in 1965 reached 278 MGD. Historical drought

analysis suggests the **1960s drought event** was an estimated **1-in-400-year occurrence**[9]. This severe drought event defines the safe yield for drought modeling and planning purposes.

In 1989, below-normal precipitation and declining watershed yield over four years led to water stress at Quabbin Reservoir, with water use exceeding the system's safe yield. At its peak in 1988, demand was 323 MGD, prompting water emergencies in several communities and the development of MWRA drought management plans.

The 2016–2017 drought was the most significant event since the 1960s. Rainfall in 2016 totaled 37 inches—comparable to levels experienced over several years during the 1960s drought. Streamflow and groundwater levels hit record lows, with 15 gages and 41 wells recording all-time low levels in September 2016. Given MWRA's substantially reduced demand, the MWRA system only dropped to 79.1% (January 2017), which was just within the beginning stage of "Below Normal."

Figure 3-2 illustrates the performance of the system using the actual historical demand (black line) and conditions on the system from 1948–2024, and the drought response plan triggers from this plan.

Figure 3-3 is a box plot analysis to illustrate the impacts of drought on Quabbin Reservoir volume percentage with real, historical demand. The box plots show the mean value of each month over the 1948-2024 calendar years with boxes illustrating the upper 75% and lower 25% percentile marks. The whiskers show max and minimum values excluding outliers. The outliers (represented by circle markers) represent the extreme drought event of the 1960's and illustrate the lower 8% of historical trends. These outliers enter the "Drought Warning" stage with the lower 2.5% entering "Drought Emergency: Stage 1".

[9] WSCAC (08/05/1985) comments on 7/24/85 MWRA MDC-WFA Presentation. quoting W. Nechamen, June 1983, Diagnosing Water System Problems in New York…. Pipe Dreams or Planning? Report to the New York State Research Service Task on Critical Problems

Figure 3-2 Quabbin Reservoir Volume (1948 -2024) and MWRA Drought Triggers

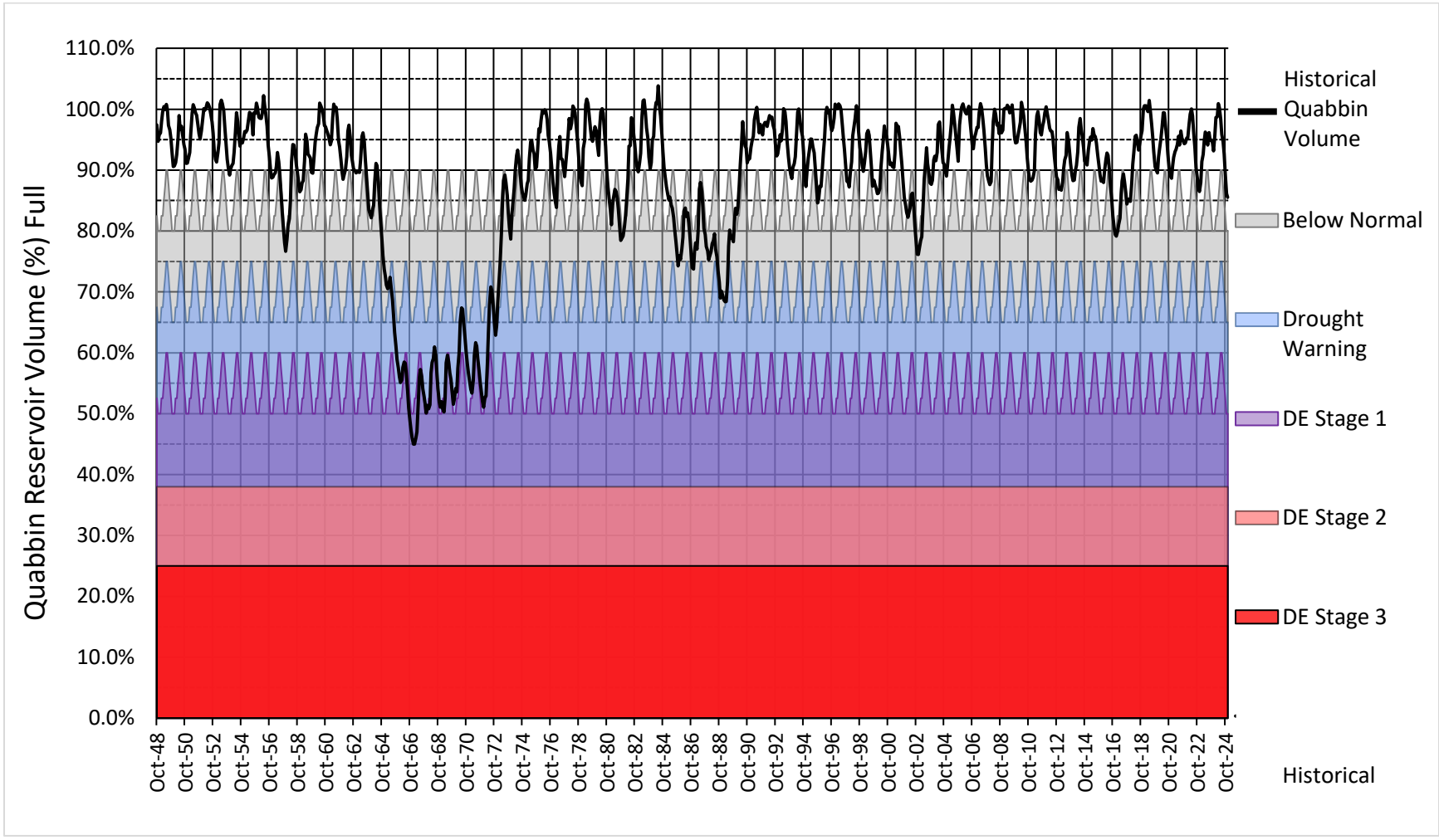
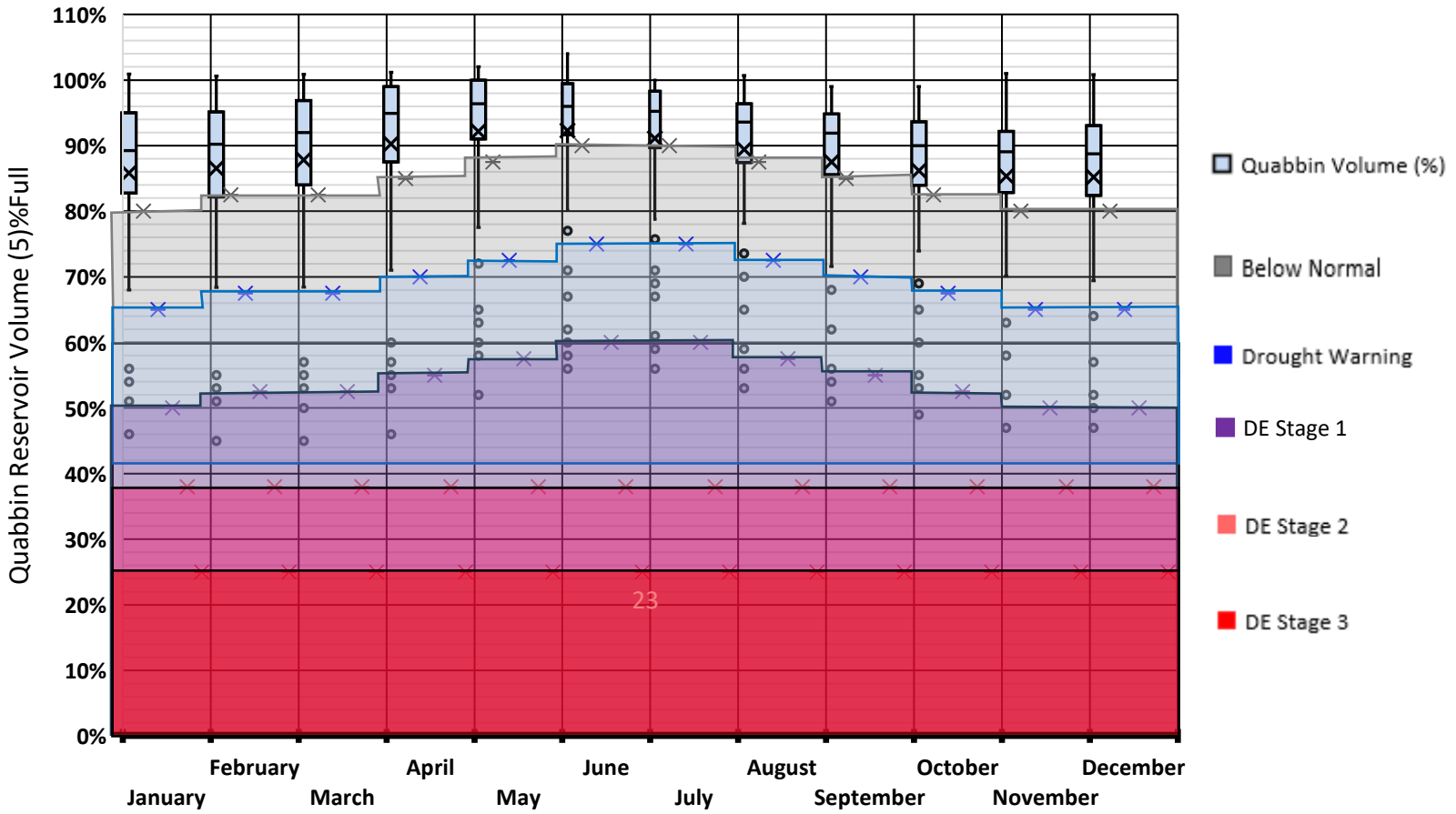


Figure 3-3: Box Plot Analysis of Quabbin Reservoir Volume (1948 - 2024) & MWRA Drought Triggers



The "Below Normal" drought trigger follows the curve on the lower end of the box plots (25th percentile) with 2.5% volume steps between months for ease of transition between months. Drought Emergency Stage 3 is not triggered (25% Volume) by historical data.

4 Performance Evaluation of Response Measures

STELLA[10] software was selected during the Trigger Planning Study[11] as the modeling platform for updating the original safe yield model. This interactive modeling environment simulates MWRA system operations under various conditions, allowing for scenario-based assessments of reservoir performance. The model incorporates hydrological data spanning 1948–2024, including USGS streamflow records for the Connecticut River at Montague and the Ware River at the Intake Works. MWRA and MassDCR operational data, including reservoir releases, transfers, elevations, and yields, supplement the dataset.

STELLA Model performance is assessed with the foundation of the Safe Yield – estimated 300 MGD. MWRA has collaborated with research institutions to evaluate the potential impacts of climate change on system performance. These efforts integrate MWRA's expertise with advanced modeling tools to support regional water management planning. The safe yield marks the limits of water consumption and allows an analysis of demand-supply imbalance. The duration (months or percentage of time) that Quabbin Reservoir remains in each drought stage under different demand conditions at set annual average demand (MGD), as seen in Table 4-1.

Table 4-1. MWRA Drought Response Plan - Months within Each Drought Stage[12]
Based on Modeled Annual Average System Demand - LIMITED Ware River Transfer[13]

913 Months; October 1948 - November 2024

Annual Average of Demand (MGD)	Below Normal		Drought Warning		Drought Emergency				Max Descent
					Stage 1		Stage 2	Stage 3	
190	20	2%	0	0%	0	0%	0	0	11.17
200	24	3%	0	0%	0	0%	0	0	12.75
210	34	4%	0	0%	0	0%	0	0	14.51
220	41	4%	1	0%	0	0%	0	0	16.5
230	49	5%	8	1%	0	0%	0	0	18.52
240	56	6%	18	2%	0	0%	0	0	20.98
250	66	7%	44	5%	0	0%	0	0	24.45
260	73	8%	50	5%	5	1%	0	0	27.93
270	67	7%	60	7%	19	2%	0	0	31.78
280	91	10%	43	5%	46	5%	0	0	35.89
290	155	17%	22	2%	71	8%	0	0	39.44
300	226	25%	18	2%	71	8%	13	0	42.77
Historical Data	120	13%	64	7%	41	4%	0	0	

[10] High Performance Systems Inc. of Hanover, NH developed the software. Its application to water resources modeling was the brainchild of Prof. Richard Palmer, then at the University of Washington, Seattle.
[11] National Study of Water Management During Drought; US Army Corps of Engineers; 1994
[12] Note: Historical Data reflect actual use, while projected values are modeled at specific average demand.
[13] Under Limited Ware operation, the Ware River Diversion is used only during Below Normal or lower stages.

4.1 Safe Yield & Climate Change Impacts

Climate projections for the New England region indicate an overall increase in both temperature and precipitation, accompanied by shifts in seasonal precipitation patterns. These shifts include periods of both drier and wetter conditions, with a potential for more extreme weather events. Trends in precipitation patterns suggest a transition from snowmelt-driven (nival) to rainfall-driven (pluvial) hydrology, largely due to decreasing snowfall and, to a lesser extent, increasing non-winter rainfall. While some climate models suggest warming could lead to increased precipitation and snowfall in certain northern temperate regions, historical snowfall data from 21 USHCN sites in New England indicate a decline in snowfall over the latter half of the 20th century.

To assess the potential impacts of climate change on safe yield, MWRA collaborated with climate specialists at the National Center for Atmospheric Research (NCAR) using a probabilistic modeling approach. This approach, detailed in a 2011 Water Research Foundation report[14], applies results from multiple General Circulation Models (GCMs) to develop regional probability distributions for temperature and precipitation changes. Unlike earlier studies that relied on single-point estimates from a specific climate model and greenhouse gas scenario, this method uses statistical techniques to generate climate ensembles at the 10th percentile, median, and 90th percentile.

The results indicate a projected increase in safe yield to 324 MGD, an estimated 8% increase over the historical 300 MGD designation under a moderate emissions scenario. This analysis incorporated geographically refined rainfall projections, using localized rainfall data adjusted for climate projections at weekly time steps, rather than relying solely on generalized regional data at monthly intervals. The K-NN method applied in the most recent modeling effort produced results that align with previous studies while offering a more detailed and robust assessment.

Figure 4-1 illustrates the expected increase in safe yield under climate change scenarios. The first column represents the 10th percentile of projections, the second column reflects the median estimate, and the third column represents the 90th percentile. The red line indicates the weighted average of the three modeled deciles, representing the projected safe yield increase due to climate change. The green line marks the current safe yield of 300 MGD. In more than 90% of the simulations, safe yield increased, though a small number of cases projected potential decreases. These findings have been reinforced by research at UMass Amherst, which has examined a broader range of climate scenarios.[15]

[14] David Yates and Kathleen Miller; University Corporation for Atmospheric Research; "Climate Change in Water Utility Planning: Decision Analytic Approaches"; Prepared for: National Center for Atmospheric Research, 2011

[15] Casey Brown, Yonas Ghile, Mikaela Laverty, Ke Li (2012), Decision scaling: Linking bottom-up vulnerability analysis with climate projections in the water sector, Water Resources Research (Volume 48, Issue 9).

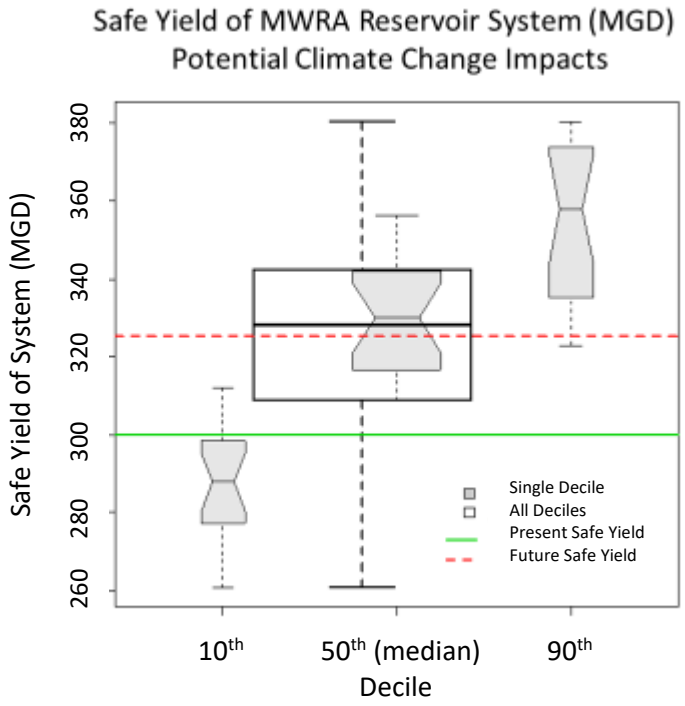


Figure 4-1 Potential Increase in Safe Yield with Climate Change.

5 Resilience of the MWRA System

The Massachusetts Water Resource Authority is blessed by the foresight of our predecessors with an incredibly resilient water system. The immense multi-year storage capacity of the reservoir system along with dramatic reductions in water use since the 1980's, proactive management & redundancy planning, and support of conservation programs have all lead to the MWRA's reliable supply of excellent quality water, which supports the vitality of the region, and provides an option for communities struggling with water availability.

A review of climate change research for New England suggests an ongoing trend of greater seasonal variability, with more frequent shifts between intense wet and dry periods. The reliability of snowmelt as a seasonal water source is expected to diminish as winter seasons shorten and temperatures rise. The shift from snowmelt-driven (nival) to rainfall-driven (pluvial) hydrology will result in increased reliance on direct precipitation rather than stored snowpack. The expected impacts of climate change in the New England region is not about less or more water – it is the shifting pattern of water availability. The massive, protected watershed of the MWRA system has the ability capture these shifting patterns from snow melt to intense rainfall periods, with the forest and wetland areas within the watershed helping to protect the water quality by slowing down intense storm runoff.

The projected increase in safe yield is largely attributed to the Quabbin Reservoir's multi-year storage capacity. By contrast, systems with smaller reservoirs (or those relying on snow pack storage)—both within Massachusetts and in other parts of the country—may experience overflows during wet periods but lack sufficient storage to sustain supply through dry periods, reducing their overall reliability. Communities on the periphery of the MWRA service area, particularly those with limited or no over-year storage, may face increased vulnerability and could require emergency water supplies from MWRA during drought conditions. MWRA Drought Response Plan and long-term MWRA Master Plan account for these periodic increases in demand to provide resilience for the surrounding region through drought events.

The challenge is not just supplying high quality water – it is managing with clarity, consistency and foresight. The MWRA Drought Response Plan works to integrate data-driven assessment of the reservoir system's quality and quantity of water with the effective, clear and concise communication of conservation goals and expectations to our communities.

6 Citations

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- Derivation of Quabbin Reservoir & US Army Corp of Engineers, PR-88b August 2013
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- MassDEP - Water Management Act Registrant Statement #10830901 for 2023-2033

Figure 6-1 MWRA Drought Response Plan - Quabbin Reservoir Trigger Volumes

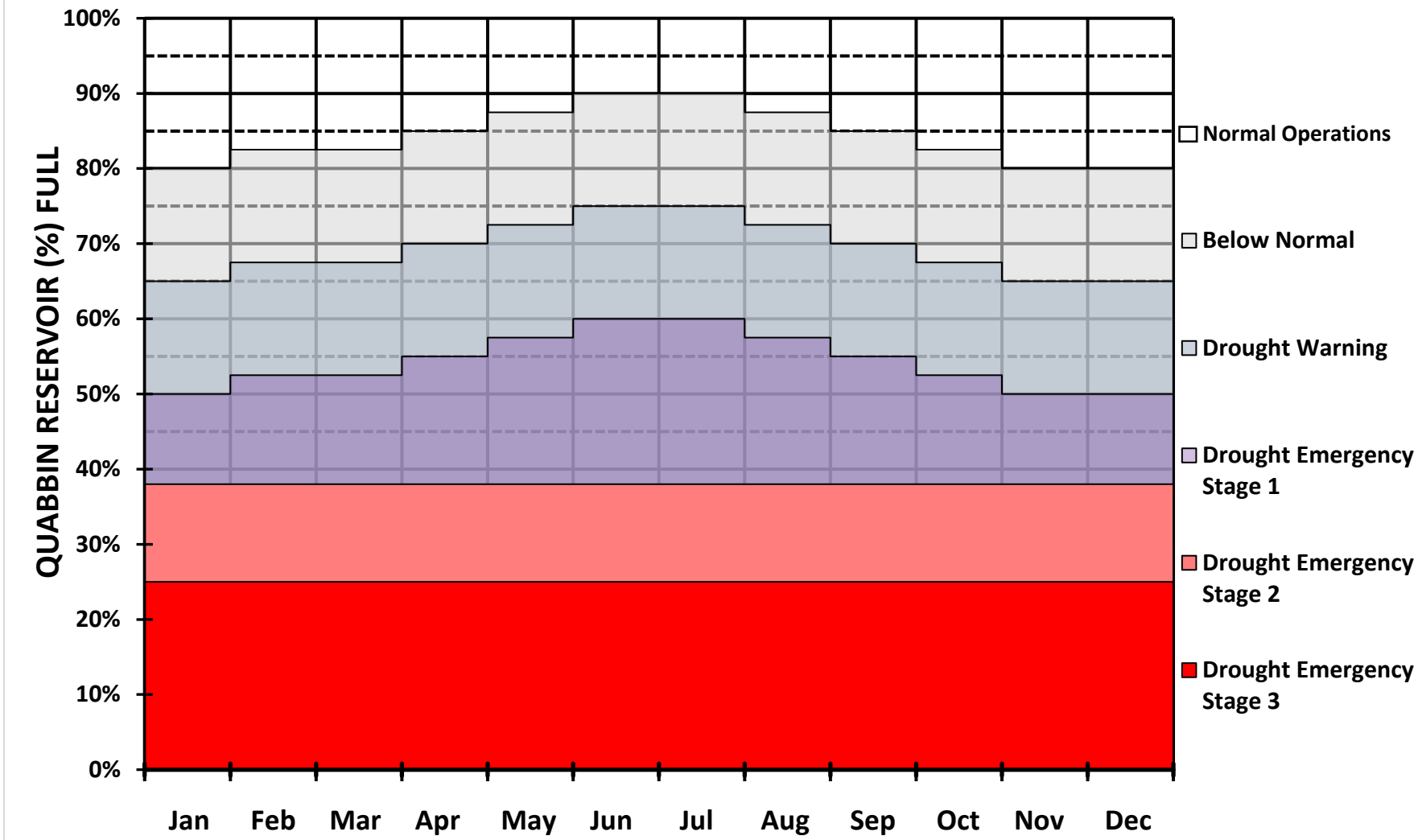

Table 6-1 Monthly MWRA Drought Trigger for Quabbin Reservoir

Monthly MWRA Drought Trigger for Quabbin Reservoir – Volume (%) & Elevation (ft)										
	Below Normal		Drought Warning		Drought Emergency Stage 1		Drought Emergency Stage 2		Drought Emergency Stage 3	
	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)	Volume (%)	Elevation (ft)
Jan	80.0%	519.1	65.0%	510.1	50.0%	499.6	38.0%	490.0	25.0%	475.0
Feb	82.5%	520.5	67.5%	511.7	52.5%	501.5	38.0%	490.0	25.0%	475.0
Mar	82.5%	520.5	67.5%	511.7	52.5%	501.5	38.0%	490.0	25.0%	475.0
Apr	85.0%	521.9	70.0%	513.2	55.0%	503.3	38.0%	490.0	25.0%	475.0
May	87.5%	523.2	72.5%	514.7	57.5%	505.0	38.0%	490.0	25.0%	475.0
Jun	90.0%	524.6	75.0%	516.2	60.0%	506.7	38.0%	490.0	25.0%	475.0
Jul	90.0%	524.6	75.0%	516.2	60.0%	506.7	38.0%	490.0	25.0%	475.0
Aug	87.5%	523.2	72.5%	514.7	57.5%	505.0	38.0%	490.0	25.0%	475.0
Sep	85.0%	521.9	70.0%	513.2	55.0%	503.3	38.0%	490.0	25.0%	475.0
Oct	82.5%	520.5	67.5%	511.7	52.5%	501.5	38.0%	490.0	25.0%	475.0
Nov	80.0%	519.1	65.0%	510.1	50.0%	499.6	38.0%	490.0	25.0%	475.0
Dec	80.0%	519.1	65.0%	510.1	50.0%	499.6	38.0%	490.0	25.0%	475.0