Volume 31, Number 1

Water Resources for the Commonwealth of Massachusetts

Katherine Ronan[1] and Rebecca Weidman[1]

[1]Environmental and Regulatory Affairs, Massachusetts Water Resources Authority

E-mail: Katherine.Ronan@mwra.com and Rebecca.Weidman@mwra.com
Published August 15, 2023

Abstract

MWRA's water sources, the Quabbin and Wachusett Reservoirs, are the largest water bodies in the Commonwealth; together holding over 470 billion gallons of clean drinking water. MWRA currently delivers an average of 200 million gallons per day (mgd) of drinking water to the 54 communities it serves. Over the last 40 years, MWRA and its expanding list of member communities have taken major strides to reduce water consumption, which previously averaged well over the system safe yield of 300 mgd. By successfully shrinking daily demands by over 100 million gallons per day, MWRA has gained capacity to deliver water to additional communities throughout the Commonwealth. These water conservation efforts have also resulted in an even more resilient water supply system, able to withstand drought conditions and recover quickly following a drought. MWRA's high quality source water is a result of our highly protected, forested watersheds. These watersheds act as a buffer against many contaminants, both regulated and unregulated. While many other public water systems across the Commonwealth are detecting harmful per- and poly-fluoroalkyl substances (together known as PFAS) at concerning levels, MWRA has detected no more than trace amounts in its source water. As communities across the Commonwealth continue to contend with water quantity and quality issues, MWRA can be a resource, offering an opportunity to join a regional water supply system. A regional water system provides communities the assurance that a steady supply of clean and safe water will be available to those they serve and limits their responsibility for dealing with the next emerging contaminant. As our climate continues to change and new contaminants are identified and regulated, regional water systems that are well-resourced, such as the MWRA, are best positioned to deal with the uncertainties that public water systems continue to face.

Keywords: Quabbin Reservoir, Wachusett Reservoir, PFAS, regional water system, drinking water

1. Introduction

1.1 Quabbin Reservoir

The Quabbin Reservoir sits prominently in the center of the state and is prominent, even to those unfamiliar with its purpose, on most maps and imagery of Massachusetts. Former hill tops reach up from its vast waters creating islands that are over 150 feet above sea level. Remnants of old roadways mysteriously disappear into the water, a reminder of the four towns of Dana, Enfield, Greenwich and Prescott, whose residents were displaced from their homes and communities when the Swift River valley was flooded to create the reservoir in the 1930s and 40s. Today, the watershed land surrounding the reservoir remains vastly undeveloped and densely forested. The Quabbin Reservoir is a harbor of habitat biodiversity, a vast carbon sink and a resource for the Commonwealth (Figure 1).

1.2 MWRA Water System

MWRA's primary drinking water sources, the Quabbin and Wachusett Reservoirs, together can hold over 470 billion gallons of water. The larger of the two, the Quabbin Reservoir, impounds the Swift River and receives water from the surrounding Chicopee

River Basin. The Wachusett Reservoir impounds the Nashua River and receives water from the surrounding Nashua River Basin. Located 25 miles apart, the two reservoirs are hydraulically connected by a deep rock tunnel used to transfer water between them. The tunnel can also be used to divert water from the Ware River at certain times of year, supplementing flows into the reservoir system and further bolstering capacity. This robust reservoir system ensures an abundant source of drinking water to MWRA member communities that is resilient to dry periods and short- to medium-term droughts, even in the face of climate change.

Figure 1. Quabbin Reservoir (MWRA 2021)

Drinking water destined to the metropolitan Boston area is transported eight miles from the Wachusett Reservoir through another deep rock tunnel to MWRA's John J. Carroll Water Treatment Plant in Marlborough, Massachusetts. There, water receives ultraviolet and ozone disinfection treatment before continuing its journey east (Figure 2). In addition to the metropolitan system, MWRA also provides water directly from the Quabbin Reservoir to three communities in the Chicopee Valley. Water in the Chicopee Valley system is also treated with ultraviolet light at the Brutsch Water Treatment Facility.

2. Well Protected Watersheds

The Quabbin and Wachusett Reservoirs are naturally protected, with more than 85% of their watersheds covered with forests and wetlands. These environmental features filter rainwater and snow entering the reservoirs, both directly and through streams that flow into the reservoirs. As water comes into contact with soil, rock, plants and other material, it is cleaned as it flows on its path. Minimizing impervious area and development surrounding the reservoirs limits the opportunity for contaminated runoff and stormwater to enter the reservoirs directly.

Notably, MWRA is one of only a handful of large public water suppliers (PWSs) in the country that

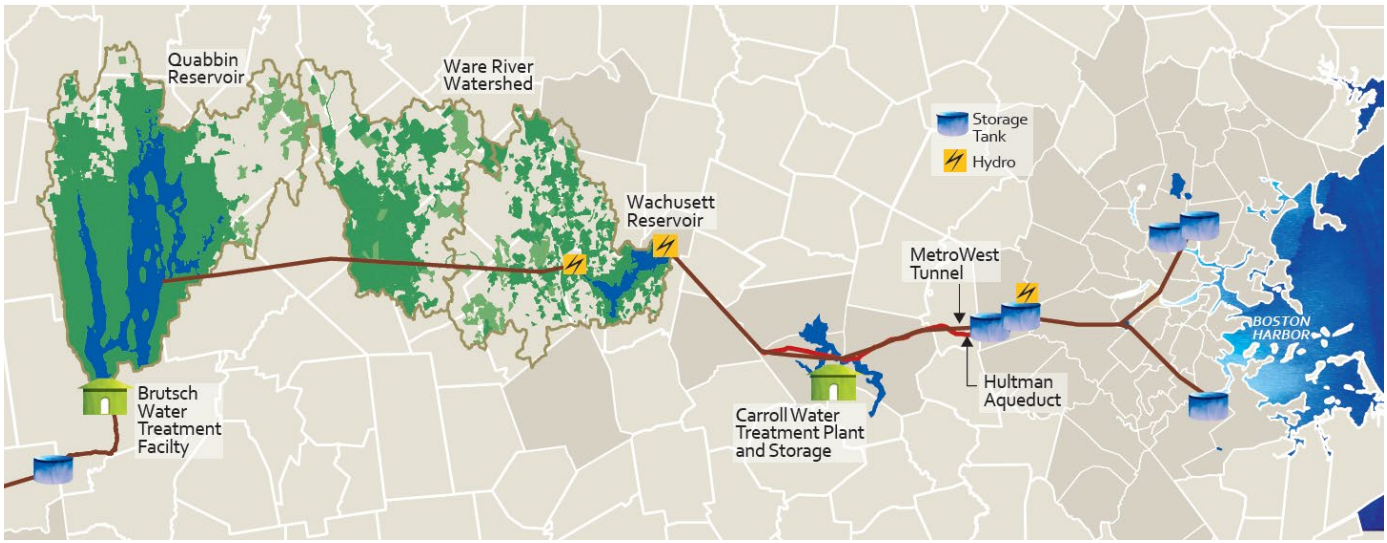


Figure 2. MWRA Water System (MWRA 2021)

does not require filtration treatment. Passed in 1974, the Safe Drinking Water Act (SDWA) is designed to protect public health by regulating the nation's public drinking water supplies. The SDWA also enables EPA to write subsequent rules regulating public drinking water as technology develops or as new threats to public health water supplies emerge. Written in 1989, The Surface Water Treatment Rule (SWTR) is one of these rules and was specifically designed to prevent against the newly identified contaminant threats of *Giardia* and *Cryptosporidium*. This rule requires all public water systems to filter water unless 11 filtration avoidance criteria are met. The criteria are all centered on watershed protection planning, source water quality, and post treatment water quality.

MWRA meets the filtration avoidance criteria largely due to the extensive watershed protection program, administered with our partners at the Massachusetts Department of Conservation and Recreation (DCR) Division of Water Supply Protection (DWSP). This comprehensive program involves a multi-barrier approach comprised of integrated programs that prevent contamination at all points of the water system, from source to tap. DCR's DWSP Rangers provide on the ground support by patrolling and protecting MWRA's watersheds (Figure 3).

Aggressive land acquisition efforts are a key component of DCR's program and involve purchasing property to protect it from development and restore or maintain a stable vegetative cover. Deed restrictions on private properties known as 'Watershed Reservation Restrictions' are another tool which restrict future development and degradation of land surrounding the reservoirs. The watershed protection program involves a host of other efforts including land and wildlife management, invasive species management, water quality and hydraulic monitoring, infrastructure maintenance, watershed security, and public outreach and education.

The highly protected and well managed Quabbin and Wachusett watersheds provide a natural filter resulting in very clean, high quality source water even prior to treatment. In addition to negating the need for filtration, the watersheds act as a buffer against contaminants entering the water supply. The watersheds provide protection against known contaminants, such as pharmaceuticals and per- and poly- fluoroalkyl substances (PFAS), as well as other emerging containments that could be identified in the future.

Figure 3 On-duty DCR DWSP Ranger (DCR, 2023)

3. Declining Demand vs Safe Yield

In the 1980s, MWRA water communities regularly used much more water than could sustainably be supplied from the Quabbin and Wachusett Reservoir system. The system safe yield, or the amount of water that can be withdrawn on a daily basis without negative impacts even during a severe drought, is 300 million gallons per day (mgd). This safe yield is determined by modeling based on the multi-year drought of the 1960s, which is considered to be about a 1 in 400 year occurrence event. This modeling accounts for: system operations during various weather conditions, anticipated increases in use from existing partial MWRA water communities during drought conditions and expected impacts from climate change.

In 1984, the MWRA water system regularly exceeded safe yield, with an average daily demand of 331 mgd. This lead to investigations of ways to increase capacity, including evaluations of diverting water from the Connecticut River, which would have required costly infrastructure and had significant environmental impacts. In an effort to avoid more drastic and highly engineered solutions such as expanding the reservoir system, MWRA ultimately embraced an approach inspired by environmentalism and conservation. Investment in metering and improvements to MWRA's distribution system to detect and eliminate leaks was prioritized. A grant program for MWRA water communities was created to assist and incentivize communities to do the same — meter and detect and eliminated leaks, further reducing water loss. This focus on increasing efficiency and reducing water loss within the water system coincided with a consumer industry shift towards increasingly efficient household appliances and development, new plumbing codes and a transition away from water-intensive manufacturing in the regional economy. Last, but certainly not least, the rising cost of water made customers start to adopt less wasteful habits.

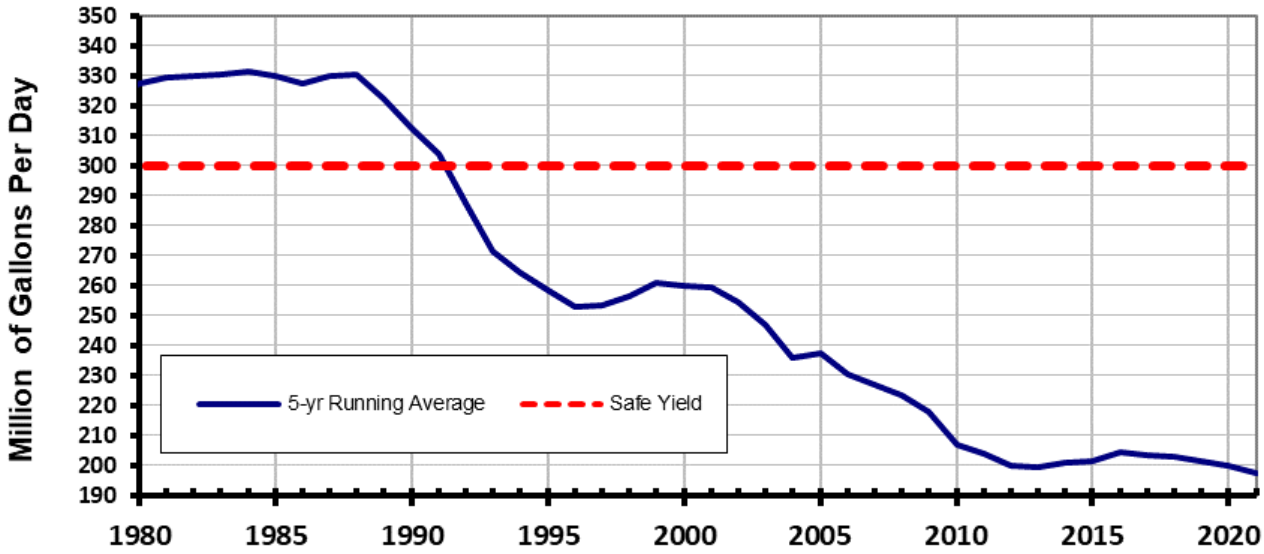


Figure 4 MWRA Average System Demand from 1980 through 2021 (MWRA, 2023)

Together, these factors have resulted in MWRA's average system demand dramatically declining over the past 30 years, despite growth in both the population and geography of MWRA's service area. Between 1980 and 2010, the total population within MWRA's original 1985 service area grew by approximately 163,000. Additionally, six new communities were admitted to the MWRA system with a population totalling approximately 135,000. Since then, two additional communities, Ashland and Burlington have also joined the MWRA water system. MWRA's current average system demand now hovers around approximately 200 mgd, 100 mgd below the system safe yield.

In addition to supplying drinking water to its member communities, MWRA regularly exceeds minimum release requirements to downstream rivers at both reservoirs (Figure 5). These releases ensure that stream flow is maintained in both the Swift and Nashua Rivers, supporting habitat, ecology, recreation and other uses. At the Quabbin Reservoir, discharges must be sufficient to maintain at least 20 mgd in the Swift River at the Village of Bondsville, downstream of the reservoir. Certain stream flow levels must also be met in the Connecticut River at Montague, further governing releases during the summer months. Additionally, MWRA provides six mgd to the Mass Wildlife McLaughlin Fish Hatchery directly from the Quabbin Reservoir. After water is circulated through the trout hatchery, it is discharged into the Swift River and further supplements flows. At Wachusett, at least 12 million gallons per week must be discharged into the South Branch of the Nashua River, downstream of the reservoir. MWRA regularly exceeds these required minimum discharges, helping to maintain downstream aquatic ecosystems.

Figure 5 The Quabbin Reservoir Spillway (Massachusetts 2023)

4. PFAS

PFAS include a suite of more than 9,000 man-made chemicals that have been used globally in a variety of industrial and commercial products since the 1940s (USEPA, 2023). PFAS is used in consumer and industrial products due to its desirable resistance to grease, oil, water and heat. PFAS can be found in stain and water-resistant fabrics and carpets, cleaning products, fabric softeners, polishes, waxes, paints, food packaging, adhesives, personal non-stick cookware, pesticides and herbicides, medical products and fire-fighting foams. Given its prevalence in products used daily, most people have been exposed to PFAS. This is concerning as certain studies have found that PFAS can accumulate and remain in the human body for long periods of

time, and that exposure can lead to adverse health outcomes in humans, including cancer and thyroid issues.

PFAS can be found throughout our environment, present in both soil and water. Historically, firefighting foams were a major source of PFAS contamination, entering the ground and water bodies through percolation and runoff. Unfortunately, PFAS has become widespread in our environment, raising concerns for public water suppliers and regulators (MassDEP, 2023).

In 2009, the U.S. Environmental Protection Agency (EPA) issued a provisional health advisory for two common PFAS compounds: perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). To gather information on PFAS occurrence in drinking water and aid regulatory decisions, large public water suppliers were monitored for six PFAS compounds as part of EPA's Third Unregulated Contaminant Monitoring Rule (UCMR3) between 2013 and 2015. Encouragingly, no PFAS was detected in any fully served MWRA community systems during this period (USEPA, 2023).

In 2016, the EPA replaced the provisional health advisory for PFOA and PFOS with a combined lifetime health advisory of 70 parts per trillion (ppt). Subsequently, in 2019, at the request of MassDEP, MWRA conducted voluntary testing of raw and treated water from the Quabbin and Wachusett Reservoirs. Only trace amounts of a few PFAS compounds were detected, and the levels were too low to be quantified.

In 2020, the Massachusetts Department of Environmental Protection (MassDEP) developed drinking water regulations and promulgated a new PFAS maximum contaminant level (MCL) of 20 ppt for six common PFAS compounds (PFAS6). All PWSs in Massachusetts were required to complete at least one round of testing by the end of 2021. While the results of MWRA's sampling for PFAS6 were 0 ppt, many other PWSs in the Commonwealth have detected PFAS in in excess of the limit. This has left these communities scrambling to implement short term solutions and evaluate long term options for removing PFAS6 from their drinking water supplies (Mass DEP 2023) .

In the short term, some communities detecting PFAS6 in excess of the MCL, have turned off certain water sources (i.e., wells or surface water) with the highest concentrations of PFAS6 and increased reliance on other sources with lower concentrations or no PFAS, blending water to reduce concentrations. This presents challenges related to water quantity and the ability to meet local demand for these communities, a matter complicated further by regular drought conditions across the region. Some communities have installed temporary treatment at local sources to reduce PFAS levels below the MCL. Treatments used to remove PFAS from drinking water, such as granular activated carbon (GAC), are in high demand and in some cases have long lead times. For some communities with limited options, bottled water is provided to vulnerable populations within the communities, such as those who are immunocompromised, pregnant or breast-feeding, while long-term solutions are evaluated and implemented.

In March 2023, EPA issued proposed National Primary Drinking Water Regulations for six PFAS compounds (four of those PFAS compounds are currently regulated by MassDEP). MWRA meets the proposed federal PFAS drinking water regulations, but, if promulgated, these standards will likely result in additional community drinking water sources throughout the Commonwealth requiring treatment for PFAS.

Presently, long-term solutions such as treatment for PFAS include granular activated carbon, ion exchange resins and high pressure membranes. Unfortunately, these treatments are costly and may be difficult to obtain given supply chain issues and high demand. Additionally, there is significant regulatory uncertainty around PFAS given that EPA is in the process of developing a MCL for PFOS and PFOA and recently revised the Health Advisory for PFOS and PFOA to levels below current analytical detection limits. Furthermore, there are challenges and costs associated with disposal of treatment byproducts. For these reasons, it is prudent for communities to evaluate all options for addressing PFAS, including seeking new supplies. For many communities in the Commonwealth, MWRA may be an option.

5. Stressed Basins

In addition to water quality issues, water quantity is a concern for many communities. Communities located in stressed river basins sometimes struggle meeting local demand with their sources, particularly during drought conditions. This may be due to variety of factors including increasing development and density, decreasing impervious area, and limited access to additional sources. Additionally, climate change continues to exacerbate impacts of drought and increase extreme weather conditions. Of particular concern is the Ipswich River Basin, where 14 communities (both within and outside the basin) rely on the Ipswich River as a water source, from PWSs and private ground water wells. The Ipswich River increasingly runs low or dry, even in non-drought years (Figure 6). Concern for maintaining this resource is constant for communities and residents who rely on this river not only for drinking water, but also for fire protection, recreation, tourism, and biodiversity. The river has garnered attention from state leaders and legislators looking for solutions, including obtaining water from sources outside the basin.

Figure 6: The Stressed Ipswich River in August 2016 (IRWA, 2023).

6. MWRA as a Resource to the Commonwealth

After years of relatively limited new drinking water regulations, allowing PWSs throughout the Commonwealth the ability to focus primarily on the operation and maintenance of their infrastructure, several new concerns for community public water suppliers across the Commonwealth are now arising. PFAS is a growing issue for many systems, MassDEP already set an MCL for PFAS6 and EPA recently proposed National Primary Drinking Water Regulations for six PFAS compounds. These emerging contaminants and subsequent regulations have left many communities with difficult and costly decisions to make. Additionally, many communities are facing increasing water quality challenges and difficulty meeting local demand. For many PWSs these impacts will undoubtedly be exacerbated by climate change in the coming years.

Years of strategic planning and the amazing foresight of our predecessors has uniquely positioned the MWRA to be a resource to the Commonwealth and to assist communities at these environmental and regulatory crossroads (Figure 7). MWRA's holistic approach to water system management has successfully maintained very high quality source water and efficiently reduced water use despite its growing service area. Because of this, MWRA has sufficient excess capacity to supply water to additional communities that are not presently part of the MWRA water system, while continuing to reliably supply its existing member communities. As noted, MWRA's average system demand is presently approximately 100 mgd below its system safe yield. This is water that could be utilized by communities struggling with water quality and/or quantity concerns.

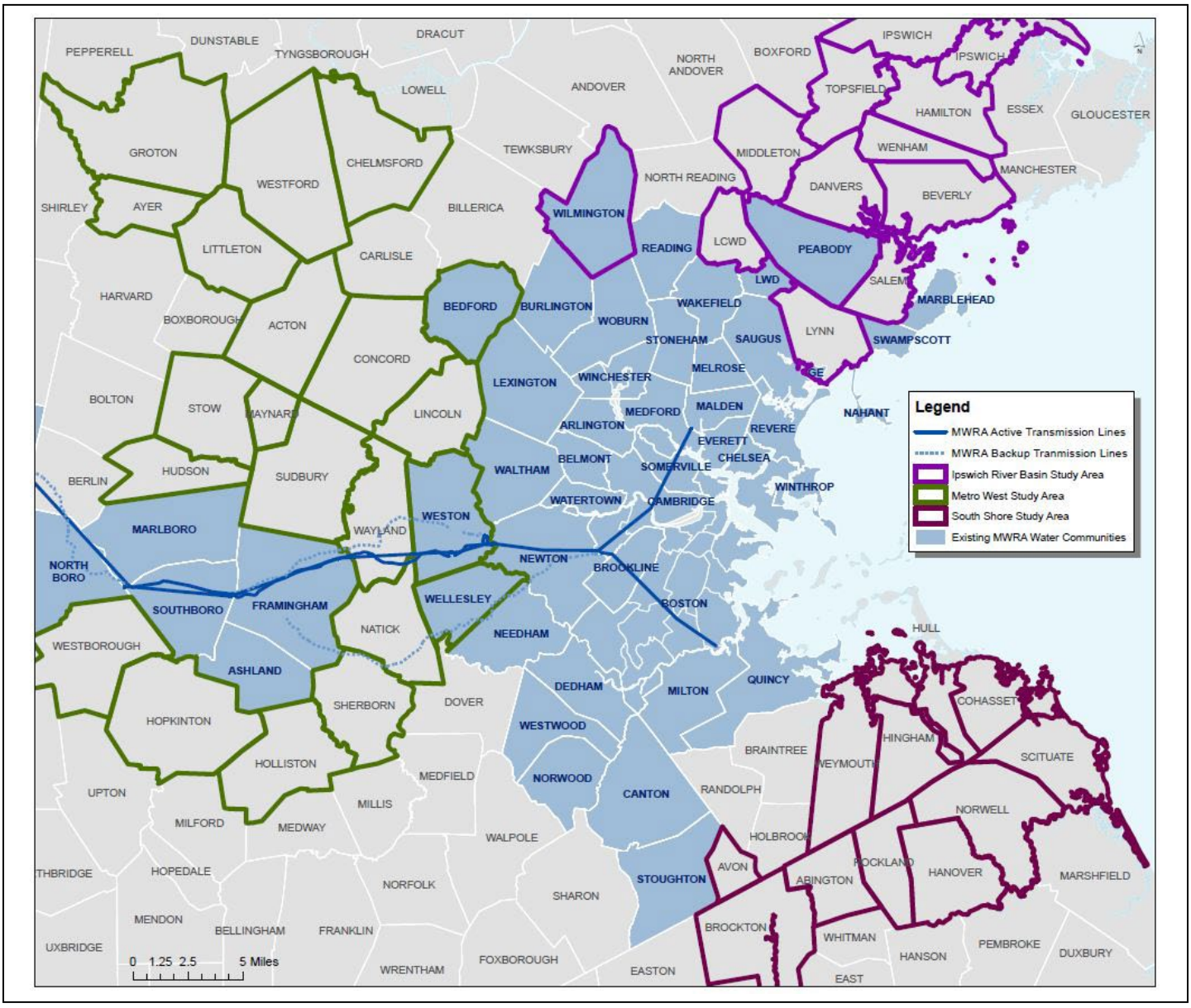
While capacity to supply water to new communities is not a concern, geography and infrastructure are logistical barriers for new communities interested in joining the MWRA water system. MWRA maintains extensive infrastructure; however, it is only feasibly accessible to certain communities based on geographic location and the costs of connection. Typically, communities can receive water from MWRA in one of two ways; directly from a connection to an MWRA pipeline, or indirectly via an existing MWRA water community. For this reason, communities near existing MWRA infrastructure or member communities are typically in a better position to connect with minimal additional infrastructure needed.

All new connections to the MWRA water system require infrastructure and planning to determine if and how much water MWRA could provide to a given community. MWRA is currently undertaking feasibility studies evaluating the potential to provide water to new communities in specific regions (Figure 8). One study focuses on the Ipswich River Basin, including the communities of Beverly, Danvers, Hamilton, Ipswich, Lynn, Lynnfield, Middleton, Peabody, Wenham and Wilmington. Another study focuses on the South Shore including the communities of Abington, Avon, Brockton, Cohasset, Hanover, Hingham, Norwell, Rockland Scituate and Weymouth. MWRA also recently commissioned a third study focusing on the MetroWest region including the communities of Acton, Ayer, Bedford, Chelmsford, Concord, Groton, Holliston, Hopkinton, Hudson, Lincoln, Littleton, Maynard, Natick, Sherborn, Stow, Sudbury, Wayland Wellesley, Westborough, Westford, and Weston. These studies aim to help communities in these regions better understand available water supply options. The studies will evaluate potential connection options to the existing MWRA water system, the cost for communities to connect and other issues that would need to be addressed for a community to be supplied by MWRA.

Figure 7: The Shores of Quabbin Reservoir (Massachusetts 2023)

7. Regional Solutions

Historically, many communities in Massachusetts have preferred to maintain individual, locally owned and operated public water supply systems. While this approach has been cost-effective and provided sufficient water supplies in the past, we are entering a new regulatory and climatic period, where it may be



appropriate for communities to consider other options, particularly evaluating the benefits of being part of a regional system like MWRA. While the logistics of constructing a new connection to the MWRA water system may not be feasible for an individual community due to costs, geography and infrastructure, a collaborative approach may change that outlook. Regional approaches to connecting to the MWRA water system may make the prospect of a large pipeline and construction project possible. Cost sharing of resources related to engineering, environmental permitting and construction, make finances more manageable for individual communities. A regional approach allows for a consolidation of resources to address a common problem.

Public water suppliers throughout the country will continue to face regulatory uncertainty in the years to come. MassDEP and EPA are currently focused on PFAS; there is good reason to believe that additional PFAS compounds will be regulated and that regulatory standards will become even more stringent. In 2023, the fifth Unregulated Contaminant Monitoring Rule (UCMR5) will include sampling for 29 PFAS compounds. Results from UCMR5 may result in additional PFAS compounds begin regulated at the federal and/or state level.

There is significant regulatory uncertainty around PFAS right now. Unfortunately for public water systems, there will always be other emerging contaminants of concern after PFAS to contend with. Connecting to the regional MWRA water system shifts the burden of complying with new regulations from many PWSs to one. In addition, the Commonwealth continues to face unpredictable weather patterns that may further impact communities' ability to provide clean drinking water. Given all of this uncertainty, joining a large, regional system like MWRA may prove to be an efficient and cost-effective decision for public water suppliers and communities throughout the Commonwealth.

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