

Journal



Our 140th Year

of The New England Water Works Association

Volume 135 No. 4 December 2021



Implementing Biological Filtration at the East Main Street Water Treatment Plant

Middleborough Water Department
Middleborough, Massachusetts



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NEWWA 2022 Meeting & Event Schedule

January 20, 2022

NEWWA/NHWWA Joint Membership Meeting
Birchwood Vineyards, Derry, New Hampshire

January 21, 2022

36th Annual Ski Classic
TBD, New Hampshire

NEWWA Annual Conferences

September 18-21, 2022

Marriott Hotel, Newport, Rhode Island

September 17-20, 2023

Hilton Burlington, Burlington, Vermont

September 15-18, 2024

Sea Crest Beach Hotel, Falmouth, Massachusetts

NEWWA Spring Conference & Exhibition

April 6-7, 2022

DCU Center, Worcester, Massachusetts

April 5-6, 2023

DCU Center, Worcester, Massachusetts

April 3-4, 2024

DCU Center, Worcester, Massachusetts

AWWA Annual Conferences

June 12-15, 2022

San Antonio, Texas

June 11-14, 2023

Sheraton Centre Toronto, Toronto, Ontario, Canada

June 10-13, 2024

Anaheim, California

Due to the ongoing uncertainty with the COVID-19 pandemic, any updates or changes to the above NEWWA events will be available on NEWWA's website at www.newwa.org.



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ON THE COVER

Implementing Biological Filtration at the East Main Street Water Treatment Plant Middleborough Water Department Middleborough, Massachusetts

The Town of Middleborough, Massachusetts experienced high levels of iron and manganese in their drinking water. A chronic issue in New England, this impacted the Town's water mains and storage tanks and caused discoloration of household fixtures and fouled in-home filters.

In 2006, the Town conducted pilot testing that evaluated both chemical filtration and biological filtration options to treat elevated levels of iron and manganese in the groundwater supply. The pilot study led to a recommendation of using the new technology of iron and manganese biological filtration. This technology harnesses the abilities of naturally occurring iron- and manganese-oxidizing bacteria in groundwater instead of using chemical oxidants to treat drinking water.

Tighe & Bond obtained the first MassDEP approval of a biological filtration water treatment plant in Massachusetts. A decade later, the Town contracted with Tighe & Bond again to finalize the design of the water treatment plant which would include biological filtration to treat the Town's East Main Street wells.

The sustainable design of the biological filtration treatment system enables the plant to treat up to 960 gallons of drinking water per minute (1.38 MGD). Online continuous analytical equipment was installed for the plant operators to monitor the plant's biological filters and disinfection system from the onsite lab. After the plant was complete, the Town implemented a solar panel array that rotates and tilts to follow the sun, ensuring optimal energy production for the plant.

After being brought online in December 2018, the Town has observed a significant reduction in iron and manganese concentrations (as well as customer complaints). Compared to other traditional iron and manganese treatment processes, the plant's filters operate longer between scheduled backwashes, they use less chemicals in the treatment process, waste less water and produce significantly less residuals.

Our project partners Blue Leaf, Inc. and Winston Builders Corporation conducted the projects pilot study and construction respectively.



Information and Photos Courtesy of:

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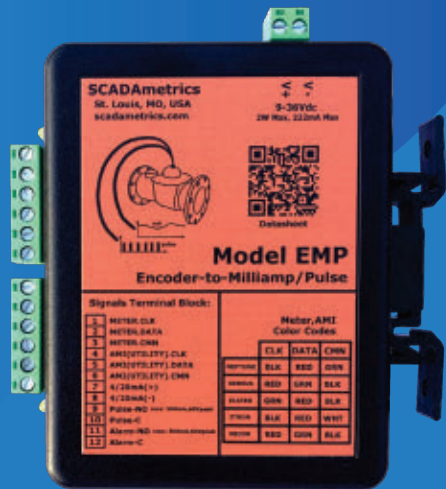
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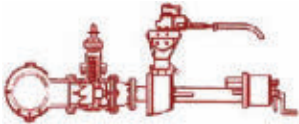
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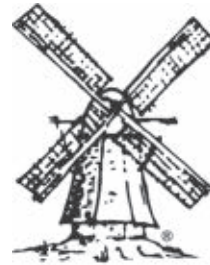
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Pictures for the Journal cover are also needed. Please submit a print of your facility or activity.

For guidelines on preparing a paper for the NEWWA Journal, please visit newwa.org.

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PFAS & Public Outreach: Risk Communication Best Practices & Lessons Learned

By Kirsten Ryan, PG, LEED AP*

Presented September 21, 2020

ABSTRACT

Many drinking water professionals have an abundance of training and expertise in engineering, science and possibly even management operations. Very few, however, received formal education in risk communication, which has become an increasingly important responsibility for water works professionals. At the same time, PFAS (per- and poly-fluoroalkyl substances) is a growing concern for both the water utilities that must address it, and the public that may not fully grasp what this contaminant is, how it gets into the water supply and what their water utility is doing about it. This paper outlines some best practices for risk communication drawn from subject experts, industry peers and the actual experiences of municipal water utilities. It illustrates how honesty, transparency and frequency of communication are critical in managing public perception. While this paper focuses on PFAS, much of its guidance can apply to any contaminant or controversy.

Introduction

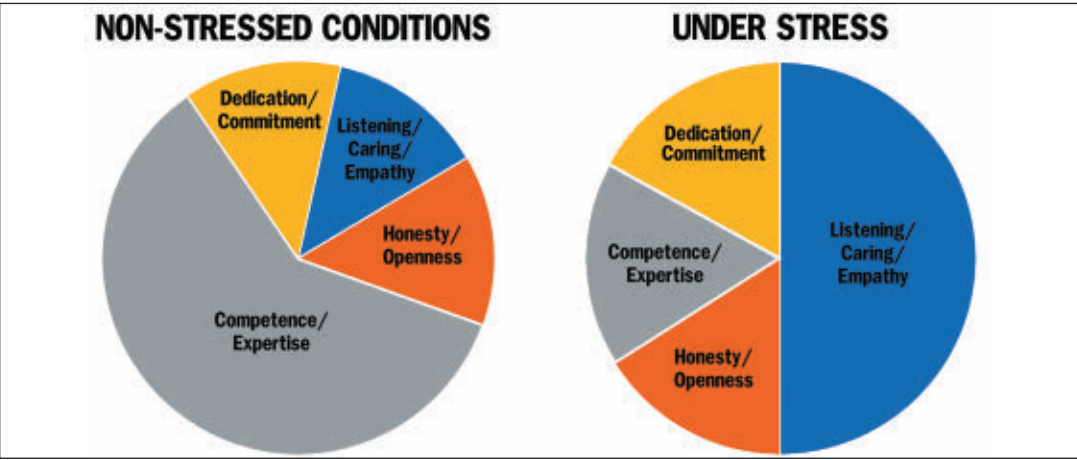
The 2019 film “Dark Waters” details the battle by lawyer Robert Bilott against DuPont Corporation over perfluorooctanoic acid (PFOA) contamination of the ground and water supply in a West Virginia town. It is based on a New York Times Magazine article from 2015, which followed a 2007 book by a reporter who covered the story at the time. These works, and many other recent examples in the traditional media exposing the potential health dangers posed by PFOA and other per- and polyfluoroalkyl substances (PFAS) perform an important public service. However, they may not tell the full story, and at times reach the level of hyperbole.

Complicating the issue further, regulatory agencies – specifically the U.S. Environmental

Protection Agency (USEPA) – have been slow to address PFAS. No federal Maximum Contaminant Level (MCL) currently exists for PFAS chemicals, though several states have moved ahead with MCLs and others have established less-stringent guidelines.

Water professionals know that PFAS can be treated, but the rhetoric around the issue and the inconsistent regulatory standards combine to create anxiety and anger among customers whose primary access to information on PFAS is from television, newspapers, social media and environmental advocacy groups. This is why it is critically important for a water utility to immediately get out in front of any situation involving PFAS in its drinking water system. The simple fact is that customers who are better informed by

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SOURCE: ADAPTED FROM CENTER FOR RISK COMMUNICATION

Trust factors for risk communication under stressed and non-stressed conditions.

their water system are less critical of the system, even in the event of a problem.

Proactive vs. Reactive Communications

Communicating effectively with customers during a crisis is a process that begins long before any crisis hits. Customers are much more likely to accept your guidance and believe what you’re telling them if a strong, open relationship is already established. This relationship is critical during a crisis, but it cannot be built when the crisis is underway.

This is why it is important to create a proactive, continuous and frequent communication program that informs your customers of all the good things their water system is doing for them. Well-informed customers are more inclined to perceive the relationship with their utility as a partnership.

Proactive communications can take many forms. Most customers don’t think about their water utility unless a pipe breaks or they’re paying their bill, neither of which is particularly pleasant for them. This is why it is important to engage with the community routinely. In this Information Age, communicating with a broad group is easier than ever. Update them on any new developments through your website and social media accounts, send newsletters and postcards with an overview of the system’s facts and figures, conduct user surveys, sponsor and participate in community events, and build a rapport with the local media to drive positive coverage. In this way, you control the message.

In the midst of a crisis, the biggest public relations mistake a water utility can make is to stay silent and hope the controversy blows over. A contaminant event creates public concern, even when it is not in your community. It won’t just go away, and if you are reactive, others control the message. You wind up fielding angry phone calls, being blindsided by TV news crews, and responding to and correcting misinformation. You’re on your heels and on the defensive.

Being proactive and spreading positive communications reduces stress for you and for your customers.

Communication, Stress and Trust

Behavioral scientists have discovered that stress in a crisis situation changes the way the human brain functions. People find it more difficult to process information, they become more distrustful and a negative information bias can kick in. Stressed people are upset, angry and fearful.

To paraphrase a quotation often attributed to Theodore Roosevelt, when people are stressed and upset, they want to “know how much you care before they care how much you know.” If your customers consider you a trusted source of reliable information, they are far more likely to accept what you say during a crisis situation. Under non-stressful circumstances, people base opinions regarding the trustworthiness of a spokesperson largely on competence and expertise. During a crisis, however, factors that most influence whether they trust the speaker rest primarily in their perceptions of that person’s empathy and caring attitude.



Build Trust and Credibility by Expressing:

- Empathy and caring.
- Competence and expertise.
- Honesty and openness.
- Commitment and dedication.

Top Tips:

- Consistent messages are vital.
- Don't over-reassure.
- Acknowledge uncertainty.
- Express wishes. ("I wish I had answers.")
- Explain the process in place to find answers.
- Acknowledge people's fear.
- Give people things to do.
- Ask more of people (share risk).

As a Spokesperson:

- Know your organization's policies.
- Stay within the scope of responsibilities.
- Tell the truth. Be transparent.
- Embody your agency's identity.

Stress also results in all parts of the brain becoming highly active, which can work to your advantage. The best communication is divided equally among the intellectual, emotional and visual forms, so tapping into these three aspects of the human condition can help a calming, reassuring message land in the minds of your stressed customers. It is also important to communicate in brief, clear language, as people under stress have trouble hearing and remembering information. Keep messages short and use plain language.

Risk Communication Tools & Best Practices

Clearly, effective risk communication involves building trust and credibility with your audience. It also improves their knowledge and understanding of the subject, encourages constructive dialogue, expresses appropriate levels of concern (illustrating empathy), and provides guidance on protective behavior and actions that they can take.

A colleague experienced in risk communication advises: "Practice fierce and fearless transparency," which is sound advice that more water systems could employ.

This point is underscored by the six easy-to-remember tenets of the Centers for Disease Control (CDC) Crisis & Emergency Risk Communication (CERC) Framework, which a May 2020 article in the AWWA Journal ("Talking to Customers and Communities About PFAS") astutely applied to the PFAS controversy.

Be first. The public's perception is shaped by the initial messages that they receive, regardless of the source, so it is critical to communicate early and often. This refers back to the concept of engaging with them proactively, and thus avoiding having the message controlled by others. Even if you don't have a proactive program in place, it is vital that you act swiftly and get your message out as soon as possible.

Be right. Accuracy is of paramount importance. Use precise, plain language. Don't be overly technical. Choose every word carefully, and be sure to provide as much context as necessary. When context is omitted, people manufacture their own, and it is often worse than the reality. Be clear about what is known and what isn't, and explain what is being done to fill in the gaps.

Be credible. Never compromise on honesty; it will surely come back to bite you if you do. To build trust in the proactive manner described above, articulate your values and prove to be a trusted source of reliable information and quality. Find partners who can help – including the local health agency, community groups, regulatory agencies, universities and consultants – to craft and deliver the message.

Prepare to Answer These Questions:

- Are my family and I safe?
- What can I do to protect myself and my family?
- Who is in charge here?
- What can we expect?
- Why did this happen?
- Were you forewarned?
- Why wasn't this prevented?
- What else can go wrong?
- When did you begin working on this?
- What does this information mean?

Stay on Message:

- "What's important is to remember..."
- "I can't answer that question, but I can tell you..."
- "Before I forget, I want to tell your viewers..."
- "Let me put that in perspective..."

Be First. Be Right. Be Credible.



Express empathy. People will only trust you if they believe you care about them, that you're listening to them and that you care what they think.

Acknowledge their concerns, no matter how right or wrong you think they are. Don't just hear them, listen actively and process what they say. Finally, tailor your messages as much as possible to different stakeholder groups (e.g., nursing mothers concerned about the effect on their baby) and using different modes of communication.

Promote action. The cliché that actions speak louder than words is never truer than in crisis communications. Explain the actions you've already taken and the actions that you have planned. Advise your customers what they can do, specifically, to protect themselves.

Show respect. Much of the discussion to this point can be summed up by simply ensuring that all communication and interaction illustrates the proper degree of respect for the people affected by the situation. When people feel vulnerable, they are more likely to be sensitive about feeling respected. This is another reason why honesty, transparency and acknowledging uncertainty are vital to defusing a potentially volatile situation with crisis communication.

A more thorough assessment of these and other communication techniques is available in the EPA document, "Effective Risk and Crisis Communication During Water Security Emergencies," by Dr. Vincent Covello of the Center for Risk Communication. While much of the 2007 guidebook offers similar recommendations to the CERC framework, it features a section on "Message Mapping." This is a systematic and proactive approach, stressing the importance of planning. This includes identifying the key stakeholders and the questions they may ask, developing your key concepts and supporting facts, and then delivering these messages through the appropriate information channels.

A final best practice is to avoid common pitfalls in risk communication, a caution that grows in significance as PFAS regulations take effect and concentrations of these chemicals continue to be found in public water supplies.

Two common pitfalls are 1) failing to answer customer questions effectively and 2) delivering mixed messages. Water utilities should identify and prepare a key spokesperson as the single point of contact. The spokesperson should be articulate, knowledgeable on the subject and capable of leading, staying on point and following the guidance presented previously in this paper.

Equally important is to ensure that everyone in the organization is prepared to provide a consistent message. This again involves open, honest communication with all stakeholders (e.g., municipal leaders, front- and back-office staff, etc.) to ensure that the situation is fully understood and the message is clear. To the extent possible, everyone should be informed of data and common talking points to address frequently asked questions.

Case Study – Millis, Massachusetts

The Town of Millis in Southeastern Massachusetts – population about 8,300 – is living through a PFAS risk communication story that many other communities may expect to experience in coming months and years. The Town is home to a former roofing factory and shoe manufacturer, industries potentially linked to PFAS chemicals. So when the Massachusetts Department of Environmental Protection (MADEP) offered to pay for testing in April of 2020, prior to the then-pending PFAS MCL of 20 ppt, the Town accepted.

The April test and follow-up testing over the summer found PFAS in all six of the town's wells, with levels in two sources barely exceeding the new Massachusetts standards. The water department shut down the two wells with the highest concentrations, and continues to monitor all active wells as required by the MADEP. Millis is also laying the groundwork to pursue a PFAS treatment plant at an estimated cost of approximately \$5 million.

Millis was already sharing its PFAS information publicly by discussing PFAS at regular Select Board meetings. After the promulgation of the MCL, Millis was the first system in the Commonwealth to be required to issue an official public notification under the new MCL. The Public Notification was issued using MADEP's required template. The official document opened with this passage (bolding as shown in the actual document):

This Public Education material contains important information about your drinking water and contaminants known as PFAS.

The Town of Millis is not in violation of the Massachusetts drinking water regulations.

However, the Town has confirmed elevated levels of PFAS6 – a set of six per- and polyfluoroalkyl substances (PFAS)* – in the drinking water



PFAS and Drinking Water Information and Frequently Asked Questions

The Town of Millis is committed to providing reliable, high-quality drinking water that meets all state and federal safety standards.

This document is intended to expand upon the information in the mailer sent October 8, 2020. There may be some differences between the two documents, as information and guidance we receive from MassDEP is subject to change.

Overview

During spring and summer 2020, Millis conducted voluntary, proactive water testing of all its wells for the presence of PFAS (per- and polyfluoroalkyl substances). One of Millis's water sources (the D'Angelis Water Treatment Plant, located at 7 Water St.) had slightly elevated levels of PFAS6 – a set of six PFAS compounds*. The detected level of 21.6 nanograms per liter (ng/L) was just above the newly published MassDEP drinking water standard (Maximum Contaminant Limit, or MCL) of 20 ng/L, but a regulatory violation was not triggered. **As a precaution, the Water Department removed the D'Angelis Water Treatment Plant from service immediately upon receiving the results. The D'Angelis Plant remains offline while Millis evaluates options. All of our other wells meet the standard, with test levels below the MCL, and we will continue to monitor them.**



What are PFAS?

PFAS are a group of numerous human-made chemicals used since the 1950s to manufacture stain-resistant, water-resistant, and non-stick products. Some examples include:

-  food packaging
-  non-stick cookware
-  waterproof clothing
-  personal care products
-  fire-fighting foam

Town of Millis PFAS Frequently Asked Questions.

https://www.millisma.gov/sites/g/files/vyhlf901/f/uploads/pfas_faqs_0.pdf

during voluntary monitoring. The level was above the MassDEP Drinking Water Maximum Contaminant Level (MCL) of 20 nanograms per liter (ng/L) but a regulatory violation has not been triggered at this time. The Water Department removed the sources with the highest levels from service immediately upon receiving the results on September 3, 2020. MassDEP requires us to provide you with these materials to make you aware of the elevated levels so that you can make informed decisions about your drinking water while we continue to monitor water quality.

The document goes on to offer seven “Steps you can take to reduce your intake of PFAS6,” most of which include using bottled water under certain conditions. What was the reaction among customers? “It scared the heck out of people,” says Millis Director of Public Works, Jim McKay. “It said we weren’t in violation right off the bat, but then it said to not drink the water.”

The Town worked with Kleinfelder to concurrently issue its own communication program, including a three-page Fact Sheet to supplement

the initial required notice. This follow-up document took a more conversational tone, with clear, instructive illustrations. The Fact Sheet defined PFAS, explained the levels in the water and how they related to the regulatory standards established, offered information on potential health effects and preventative measures, described the actions the town was taking in response to the test results, and listed PFAS information sources they could consult. The fact sheet began with this overview:

During spring and summer 2020, Millis conducted voluntary, proactive water testing of all its wells for the presence of PFAS (per- and polyfluoroalkyl substances). One of Millis's water sources (the D'Angelis Water Treatment Plant, located at 7 Water St.) had slightly elevated levels of PFAS6 – a set of six PFAS compounds. The detected level of 21.6 nanograms per liter (ng/L) was just above the newly published MassDEP drinking water standard (Maximum Contaminant Limit, or MCL) of 20 ng/L, but a regulatory violation was not triggered. As a precaution, the Water

Department removed the D'Angelis Water Treatment Plant from service immediately upon receiving the results. The D'Angelis Plant remains offline while Millis evaluates options. All our other wells meet the standard, with test levels below the MCL, and we will continue to monitor them.

The town also created a PFAS page on its website with chronological links to test results, meeting minutes, letters and notices, as well as helpful links for the public. "We wanted to put the information out there, and we wanted it to be readable and understandable for customers," says McKay. "A good majority read it. I think it helped because when we had a public hearing with the Select Board on Zoom, it was one of the biggest meetings we've ever had. People had great questions."

Having a more well-informed public is important, says McKay. "We still get calls from people asking if the water's safe to drink," he says. "I live in town and I tell them that I drink the water, and when my grandchildren want a glass of water, I get it from the tap. Yes, the water is safe to drink. We're telling people the truth, the good and the bad, and because of that I think, for the most part, they understand and believe us."

Millis and Kleinfelder are currently working together to design treatment upgrades to remove PFAS at the D'Angelis Facility, and to study the best way to address PFAS impacts to the other Town wells. By acting proactively, and practicing 'fearless transparency' during the process, the Town is working to build and maintain the public's trust, while improving public infrastructure.

Holding Polluters Accountable for the Cost of Contaminant Removal from Water Systems

By Ashley Campbell* and Nancy Mortvedt**

Presented September 9, 2021

ABSTRACT

Emerging contaminants of concern are on the rise and if detected in your water source, it is crucial to take action to comply with the law and protect your community from exposure to health risks. While the Environmental Protection Agency (EPA) sets national standards for drinking water purity, many states are putting in stricter regulations to protect residents against manmade contaminants. As a result, more water providers are discovering chemicals exceeding maximum contaminant levels (MCLs) and are being thrust into costly unplanned cleanup. Today, more than ever before, water providers are taking action against polluters to pay for the cleanup.

Many of the contaminants that exist in the environment have resulted from the use of defective commercial products near surface and groundwater sources, or from consumer products that release harmful chemicals into the water system through everyday use. Emerging contaminants of concern include per- and poly-fluoroalkyl substances (PFAS), Methyl Tertiary Butyl Ether (MTBE) and 1,2,3 trichloropropane (TCP).

For most contaminated systems, getting back into compliance will require costly treatment measures that could run as high as hundreds of thousands or millions of dollars to build and maintain. For some cash-strapped water systems, these costs could prove catastrophic unless outside funding is secured. Among the potential costs are:

- Design, construction, and operation of new wells and treatment facilities, including disposal costs of spent media over time
- Extension of service to impacted private wells
- Replacement water
- Property damage

Litigation Is a Viable Funding Option

Toxic manmade chemicals showing up in water systems is not new, but it has becoming more prevalent, as municipalities are now increasing mandatory testing due to new state and federal regulations. What is news, is that the public sentiment is shifting towards holding manufacturers accountable for the environmental damage and not leaving the cleanup bill with the rate payers.

Litigation is becoming a water provider's best line of defense. Some have seen success in receiving compensation from liable manufacturers, including over \$250 million for the State of New Hampshire, \$26.5 million for St. Louis MI, \$30 million for Clovis CA, and \$9 million for Livingston CA.

What to do when you find Chemicals in Your System

How and when you respond, can significantly impact your ability for a successful legal outcome. Here are some critical first steps:

Engage An Engineer to Assess Solutions

Once you have detected a contaminant in your water supply, the first step is to investigate

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possible solutions. There are many ways to address, mitigate, and respond to water contamination problems, including:

- Water treatment. Various media can remove certain contaminants from the water supply, and new adsorbents are being developed regularly. Treatment may need to be used in conjunction with other solutions.
- Purchasing alternative water sources. This can be a costly short-term option and may disrupt existing water treatment solutions, since the introduction of water from a new source may impact existing treatment.
- Abandoning or drilling new wells. This may be the costliest of choices due to the uncertainty of finding better water quality and potential losses in production.

The cost of additional water treatment is significant but often necessary. Although you will have to incur upfront costs to move quickly on remediation, you can then bring legal action to recover those costs.

Determine How the Contamination Occurred

In addition to reacting quickly on remediation, you will need to understand how the contamination occurred in the first place. This calls for an investigation of who was responsible and whether the impact is ongoing. This research can be time-consuming, but it is crucial for predicting whether levels may increase over time. The



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more you understand the reason for contamination, the more confident you can be in your chosen solution.

Naming the parties responsible for contamination can also help prepare you for pursuing compensation. This process is easier with the help of a team of experienced professionals in water contamination law, who can work with you to identify contamination sources even if you decide not to move forward with litigation to recover funds.

Determine How to Fund Your Treatment Solution

When faced with treatment costs, many water providers decide to pay for these expenses by



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either increasing water rates, issuing bonds, or finding applicable government grants. In instances when contamination occurs due to natural causes, these may be the best options available.

However, when a detected contaminant can be traced to the use of a commercial product or manufacturing process it may make sense to file a lawsuit. Across the country, water systems are placing the financial responsibility of treatment costs on the source of the problem, the commercial manufacturers whose defective products have resulted in the contamination of public drinking water.

Choose a Good Legal Team

A good law firm will work closely with expert witnesses, like hydrogeologists and engineers, that can help uncover the causes of contamination. This step is critical in determining a successful legal outcome and can speed up the time to recover funds for treatment or replacement water.

Seek out a firm with many years of experience in water law exclusively. Other firms can be too generalized to understand the nuanced approach it takes to move through the legal

process efficiently. The firm you choose should draw from experience working with water providers, state and local governments, hydrogeologists, and water treatment engineers. They should also be able to point to a long history of water law settlements and verdicts won by their team.

Pursuing litigation often requires a large investment of time and resources from the water provider with no guarantee of a favorable result. To move forward confidently, water providers must consider another important factor in assessing a law firm: their billing structure. Instead of an hourly billing method, where the client pays a set fee with expenses incurred by attorneys along the way, seek out a contingency fee arrangement that allows you to pay only when a settlement or trial verdict is won. These law firms will only take your case if they believe there is a high degree of success.

Act Sooner Than Later

If you are considering bringing legal action, you should be aware of the statute of limitations, the starting point for measuring contaminants,



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and other factors vary considerably from state to state, so water systems who are considering bringing a lawsuit against those responsible for the contamination should consult with legal counsel at the first opportunity, to ensure they are within the legal timeframe for filing a lawsuit.

It is important to both understand current regulations and have a sense of how they might change. Water quality standards are not static – they have the potential to become more stringent as new testing techniques are developed and health impacts are studied. For example, PFOA and PFOS are chemicals that are already regulated in many states and are being considered for regulation by others. However, there is a whole class of unregulated

PFAS chemicals that are currently undergoing scientific and regulatory scrutiny. The EPA has recently published a proposed 5th Unregulated Contaminant Monitoring Rule (UCMR 5). This would add a further 29 PFAS substances to be monitored in sample collections between 2023 and 2025.

In addition, the trend for lowering and setting low MCL's and the tightening of federal regulations means more municipalities will be stepping up, which can put pressure on the manufacturer's legal reserves, resulting in fewer funds for remediation. Being among the first to act may result in more generous settlements and ensure that your lawsuit is scheduled into busy court dockets as early as possible.

The NH Water Works Association's Strategy to Ensure Safe, Dependable, and Affordable Drinking Water

By Thomas S. Burack, Esq.,* and Susan S. Kaplan**

Presented January 21, 2021

ABSTRACT

In 2020, New Hampshire Water Works Association took a new, integrated approach to strategy, communications, and governance. The lessons it learned can provide a useful model and insights for other industry groups that recognize the challenges of tomorrow will be different from those of today and that the best way to prepare for uncertainty is to anticipate its effects and create strategies for dealing with them. This paper describes the purpose and development of the three major components and illustrates how these integrated strategies will increase NHWWA's impact on addressing NH's public drinking water supply needs far into the future.

Introduction: The Story of Drinking Water in New Hampshire

The story of public drinking water in New Hampshire might best be described as “essential but invisible.” However, thanks to a new, integrated approach to strategy development, communications, and governance, the New Hampshire Water Works Association (NHWWA) is writing a new story of drinking water that will make a big and continuing splash in the Granite State. The NHWWA's approach and the lessons it has learned can provide a useful model and insights for other drinking water industry groups that also recognize that the challenges of tomorrow will be different from those of today, and that the best way to prepare for uncertainty is to anticipate its effects and build strategies to deal with them. This paper describes the purpose and development of each of the three major components of this initiative and provides insights into how this integrated approach will increase the NHWWA's impact on addressing

the state's public drinking water supply needs far into the future.

A Brief History of the NHWWA and Recent Developments

The New Hampshire Waterworks Association, as it was initially known, was formed in 1939, with the purpose of “improvement of water supply service in New Hampshire.” The NHWWA is a New Hampshire nonprofit corporation and tax exempt under Section 501(c)(3) of the Internal Revenue Code.

In February 2020, the NHWWA Board of Directors (Board) hired a seasoned executive director, Boyd Smith, and charged him with various responsibilities, including refreshing the organization. This meant more than a new coat of paint. It meant developing a deep understanding of who the NHWWA's customers are and what those customers need from this state-level association in the face of current challenges and an uncertain future. Fortunately,

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the NHWWA secured a planning grant through the New Hampshire Community Development Finance Authority's (NH CDFA) tax credit program to help develop a new strategic plan, along with a fully aligned communications strategy and implementation plan. As a critical follow-on, the NHWWA also revised its governance documents, including its bylaws and policies, to ensure that the association is positioned to make a big splash for years to come on behalf of NH's drinking water experts and NH communities.

Strategy: Strategic Planning Based Upon Scenario Thinking

A strategic plan is a roadmap for where an organization wants to go and how it is going to get there – in short, what it is going to do in the future to serve its mission. Most strategic plans assume that the future world in which an organization will be operating will be basically the same as the world in which they are operating today. That is a fine assumption most of the time, but consider that you can wake up one day and your driveway is wiped out by a flood, or the world suddenly stops due to a global pandemic. The NHWWA Board was certain from the start that water suppliers will face unexpected challenges in the years ahead and the association will need to have its eyes on the horizon to help its members anticipate, prepare for, and meet those challenges. To figure these out, the first step in NHWWA's strategic planning process was to explore how the future worlds for drinking water could be different from the world of today.

Living in Today's World While Imagining and Preparing for the Worlds of Tomorrow: The Power of Asking, "What If?"

The Board and its new executive director were quite familiar with the classic list of concerns facing drinking water utilities, including everything from aging infrastructure to low funding levels, and from limited public awareness of the true cost and value of water to an aging workforce. At the same time, the Board sensed heightened concern about some big forces that could be in the offing, including a changing climate, shifting weather patterns, increasing population in New Hampshire, and the advent of new technologies.

Many "what if" inquiries can be good things. For example, when people see a sign for lottery

tickets, the question that often crosses their mind is, "what if I win the lottery?" Then they start imagining great futures for themselves and what they may have to do to adapt to those different futures.

To imagine the future creatively and think "outside the box," the Board and staff participated in a series of exercises based on "what if?" thinking. For starters, they were asked to imagine that they were driving to work on a dark morning after a storm left a coating of ice on the roads. Next, the scenario got more complicated as the car coming toward them started sliding in the direction of the center line of the road. They were asked what the first thing was that came to their mind. Some murmured an expletive, while others said they realized they had seen this situation before, so they imagined themselves next easing off the gas and steering out of harm's way. From this exercise, the participants learned that a person's response to danger typically involves two steps: first, the mind recognizes the danger, and second, the mind intuitively instructs our body in how to protect itself, based on its prior knowledge and experience.

Formal scenario thinking and planning with organizations use the same thought process that humans use subconsciously every day of our lives and adds structure to it. Through a defined process, the NHWWA's leaders used their imaginations to develop different alternative worlds or scenarios that the NHWWA's direct constituencies, especially public water utilities, could find themselves confronting. The process also identified the likely effects or implications of those worlds for their constituencies and then developed strategies that the NHWWA could implement to help those parties successfully address the implications of those new worlds.

For this process to be fruitful, the NHWWA Board did not have to predict exactly what the future would look like. After all, few if any of us would likely have predicted a pandemic that would simultaneously sicken millions of people and cripple economies worldwide in 2020 and beyond. If the NHWWA Board used scenario thinking prior to the pandemic, it could certainly have imagined one or more scenarios in which there would, for whatever reason, have been disruptions of transportation systems, logistics, markets, workforce, or other supply or demand forces. By exploring the implications of those



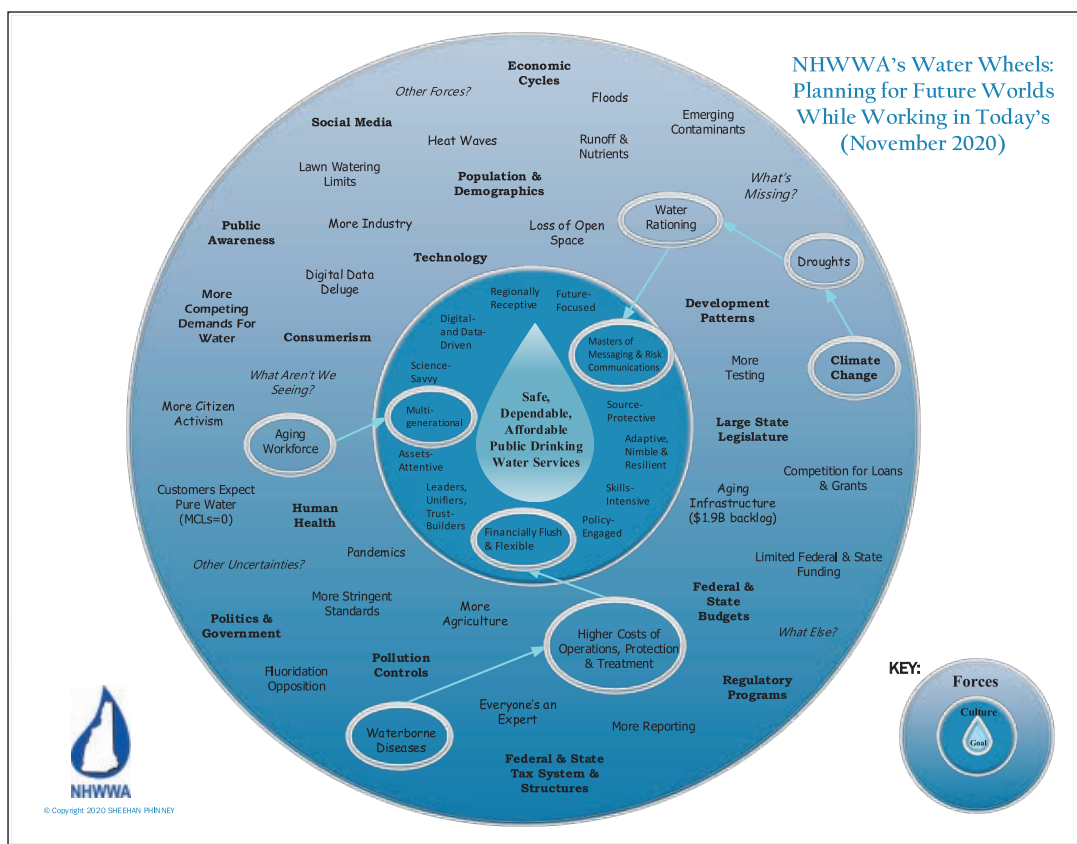
kinds of forces, the Board would have been positioned to develop and perhaps even test some strategies in case those kinds of disruptions actually occurred. The NHHWA would have had a new powerful tool for the pandemic by combining a problem and a potential solution, creating a “memory of the future.” As soon as the NHHWA saw the actual problem arise that it had only imagined, it would have instantly recalled the solution it had already developed and could then implement it rapidly.

Overview of the NHHWA’s Strategic Planning Process

The NHHWA’s planning process was dynamic and fast-paced. It involved a series of scenario thinking exercises in which each step informed and provided a foundation for the next one. Starting in April 2020, the executive director and one of the authors (Tom Burack) interviewed practically all of the members of the board, some industry leaders, and a number of elected officials. The goal was to gather multiple perspectives to identify major forces, drivers and trends that could shape future conditions impacting New Hampshire and

especially those that were having an impact on the state’s drinking water systems or might have such an impact in the future. Based upon the interviews, the consultant assembled a list of major drivers, which in turn helped to begin identifying some of the characteristics that water suppliers might need to address the challenges likely to be presented by these drivers. The Board then practiced asking “what if?” questions and imagining alternative futures for New Hampshire and its communities.

At a Board and staff retreat in August 2020, the participants imagined future New Hampshire communities through some fun, structured sessions and started to identify the challenges water suppliers in those communities might face due to the implications of the presumed forces at play in these towns and cities. In a follow-up session online, the Board and staff consulted some industry experts, and then developed a set of strategies that NHHWA could implement to help its primary customers – the state’s public water suppliers – succeed in the face of these alternative worlds. Those strategies were then “wind tunnel tested” against the various scenarios to see which ones would “fly” most



successfully in a range of different scenarios. If any potential strategies were considered to be of limited use, they were either modified or set aside. Those that appeared to be helpful across a broad range of alternative futures were retained for further refinement. In early November 2020, the Board adopted its new “living” strategic plan, which identified four key priorities. The NHWWA considers it to be “living” since it will not sit on a shelf but will instead be central to the Board’s operational work going forward. A summary of the adopted plan is available on the NHWWA’s website at <https://nhwwa.org/strategic-plan>.

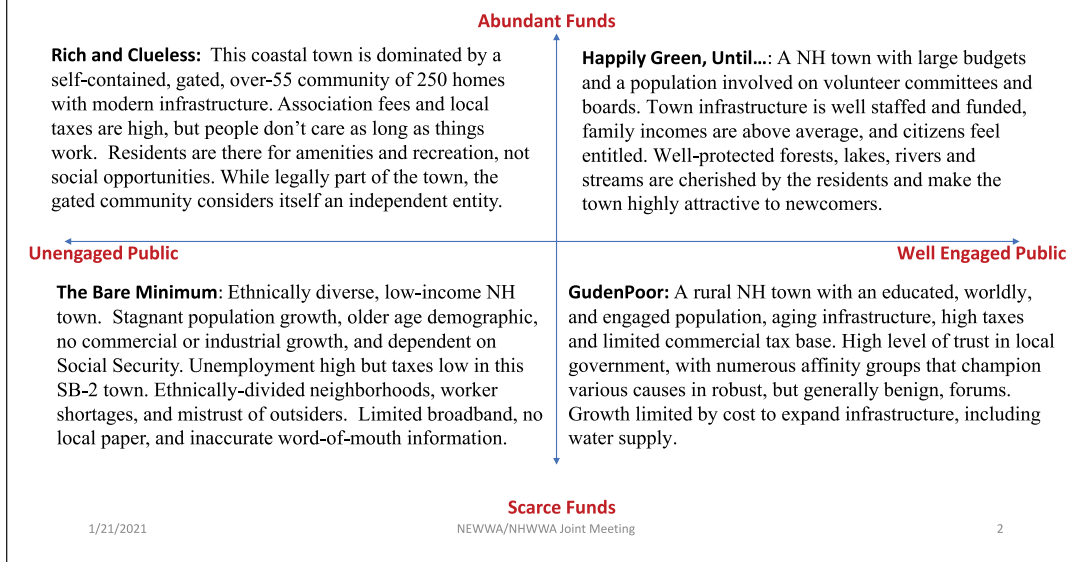
A Deeper Dive: Water Wheels as a Tool for Identifying Priorities

The information and ideas collected during the interviews was compiled into a “Water Wheel.” During the subsequent engagement with the Board, the conversations moved toward establishing a single, overall goal for the association’s work, which became “Safe, Dependable, Affordable Public Drinking Water Services” This goal statement appears in the center of the set

of concentric circles in Figure #1 as a constant reminder that, just as if this were a bullseye target, it is the NHWWA’s goal and NHWWA’s actions must aim to achieve that goal. In other words, if the NHWWA is spending its time and resources doing things that do not contribute directly, efficiently, and effectively to this overall goal, those activities will be either realigned with the goal or stopped. The outermost ring in the Water Wheel displays the various forces, drivers, and trends (collectively, the “drivers”) that are currently or possibly at play in the ecosystem. These drivers were largely distilled from interviews and from collective knowledge of the water supply industry and life generally. The inner wheel is all about culture; it is a distillation of key cultural attributes that will be helpful to accomplishing the water supply industry’s needs in the future.

These wheels helped the Board understand the cause-and-effect logic flow that identifies the implications of different drivers at work and comes from asking “what if?” questions. For example, climate change is expected to

Matrix of Condensed Scenarios for NH Communities in 2030



cause more droughts (see upper right portion of Figure #1), so water suppliers might respond by rationing water. But for this common strategy to be successful, water suppliers may need to become masters of messaging and risk communications. The strategy question for NHWWA became: what services can NHWWA provide to help its members achieve mastery of messaging?

Community Scenarios as a Platform for Imagining Alternative Futures

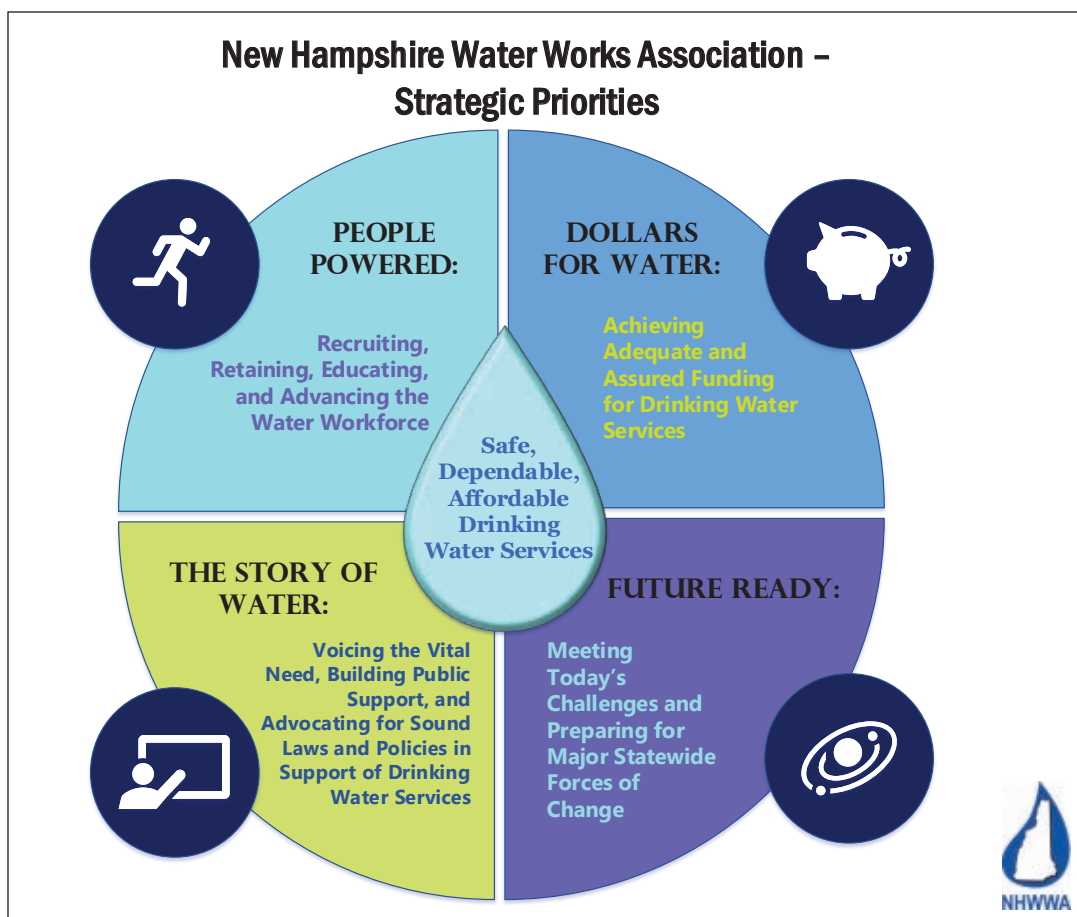
At the August 2020 retreat, the Board and staff chose to focus on two major, relevant forces: the availability of funding and the engagement of public understanding and support for water supply issues. These forces were arrayed against each other in four squares, from abundant to scarce funding and from unengaged to a well engaged public. (See Figure 2.)

The group was broken up into four teams, each assigned one quadrant and charged with imagining what a future NH community in that quadrant could look like at least 10 years in the future (i.e., in 2030 or later). Each group described their town, drew images of it, and gave their future community scenario a name. For example, "Happily Green, Until..." describes a community with abundant funding, a well engaged public, and a well-staffed and funded water supply system. In the lower left corner is "The Bare Minimum," a community with scarce funds, an unengaged

citizenry, and the economic challenges that come with this profile.

As much as the Board and staff thought they had expanded their thinking and been truly imaginative, they soon recognized that elements of all four of their imaginary communities already existed in various towns and cities in the Granite State. So, to get more creative and ask more challenging "what if?" questions about their new towns, they began to imagine unlikely but still plausible things that could happen. They dove deeper and thought about other major forces at play, like climate change, ever-more-powerful social media, cyber threats, and a potential resurgence in heavy manufacturing in the northeast due to an abundant water supply. They imagined another layer of possible events and trends that could make the scenarios faced by their four communities different from those of today but still plausible and supportable.

"Happily Green, Until..." suffered a major cyber-attack on its drinking water system. "The Bare Minimum" lost its 75-year-old drinking water treatment plant to a tornado, and suffered the ensuing outbreak of giardiasis. Then that community had to figure out how or whether it could afford to replace its treatment plant or whether it should instead join a regional water system. By digging deeper, the Board and staff created scenarios that pushed things beyond where most New Hampshire communities have found



themselves so far. This forced the Board and staff to be much more thoughtful in devising strategies that could be successful and prove useful in the longer term across a broader spectrum of future challenges. In short, this process broke the bonds of traditional, standard thinking, and put the organization on a path to imagining truly alternative new worlds of risk and opportunity.

Moving from Scenarios to Strategies

After looking at the scenarios and the presented needs, the Board and staff identified four overall thematic priorities. Three are largely outward focused, and one looks more inward. (See Figure 3.) All are intended to ensure that everything NHWWA does is designed to help its members deliver safe, dependable, and affordable drinking water. The strategic plan focuses on these four elements:

1. Centering on the people who power the drinking water industry and helping them to be the best they can be,

2. Advocating to rate payers, local boards, and state legislators for adequate funding for drinking water services,
3. Sharing the story of drinking water in a compelling and engaging way that draws public support for this critical service, and
4. Ensuring that the NHWWA is able to lead the industry as a strong and vibrant organization that establishes a culture of continuous learning and improvement through scenario thinking.

Achieving effective, ongoing communications within the NHWWA community itself and between the NHWWA and its external audiences is central to the success of all of these priorities, including elected officials, regulators, and the general public, along with equipping NHWWA's supporters to be knowledgeable and respected proponents of public drinking water supplies in their respective arenas. Fortunately, the seed grant that NHWWA received from the NH CDFA included funds to develop and implement a communications plan, which the association and one of the authors

(Sue Kaplan) structured to help implement the 2020 strategic plan in a fully integrated way.

Communications: Aligning Communications with the Strategic Plan

The NHHWA's leadership created an advantageous environment for the communications consultant to observe and participate in the scenario thinking at the Board and staff retreat in August 2020. This made it easier to align the communications strategy and implementation plan with that planning. Engaging in the discussions about the organizational drivers, cultural attributes, and the central goal was also an investment in ensuring that the intent and expectations were embedded when the new messaging foundation was developed.

While the Board, staff, and its strategy consultant moved toward completion of the strategic plan for 2021 and beyond, the communications consultant began the first phase of the communications project, assessing the current state of the association's messaging and its communication tools. The existing tools included the website, social media (LinkedIn, Facebook, and Twitter), publications, brand identity, and email marketing. The review showed absences and/or inconsistencies in the content: mission, tagline, key audiences, and basic description about the association. As an example, the tagline on the website banner was distinctly different than what was posted on LinkedIn:

- Website banner: Dedicated to improving municipal water supply in the state of New Hampshire,
- Website About page: Supporting NH Drinking Water Supply Industry Since 1939,
- LinkedIn: Providing advocacy and training for municipalities, operators, engineers and suppliers,
- Facebook: Your resource for improving municipal water supply service in the State of New Hampshire.

The review found that there were three LinkedIn pages, two Twitter feeds, and two Facebook pages with irregular postings. The overlaps and inconsistencies in content made it hard for those using social media to have a clear sense of what the NHHWA is and whether to engage with the platforms. The assessment phase revealed that there were significant opportunities to create clear, consistent, and compelling messaging for the NHHWA to mobilize its goal and help fulfill its four strategic priorities.

The second phase of the communications project began with a deep dive into the final strategic plan. Based on that work, the consultant drafted the NHHWA's new messaging foundation that aligned seamlessly with the plan's four strategic priorities.

The third phase, implementation, started with drafting the key institutional content in the messaging foundation, in collaboration with Boyd Smith and Tom Burack to get it to a final set of statements. A messaging foundation includes mission, vision, description, tagline, key audiences, value statements, and value propositions.

Vision, mission, and values are typically long-term foundational statements. A vision answers these questions: *why do you want to go where you envision going? and what is possible in the future?* Visions are vivid, inspirational, clear, memorable, and concise. Missions are simple statements about why the organization exists, with no buzz words. They address who you are and what you want to achieve.

Powerful vision, mission, and value statements make it possible for members and external constituencies to be clear about the NHHWA's purpose. They are reference points and tools, enabling the organization to recall why it does what it does, what it intends to achieve, and how it will maintain brand consistency. The importance of doing this work for all organizations cannot be overstated. Since nonprofits are inherently purpose-driven, their messaging must illustrate their purpose. Clear, consistent, and compelling communications can, as examples, help a nonprofit or a business recruit and retain employees and become more successful in developing new partners.

The NHHWA's messaging was inspired by and drawn from the strategy, general themes, and specific priorities in the strategic plan. The messaging, communications strategy and implementation plan all flow from the strategic priorities and the goal at the center of the water wheel (See Figure #1). The new messaging includes:

- Mission: To improve public water supply service in the State of New Hampshire
- Vision: Safe and sustainable public drinking water for New Hampshire communities
- Tagline: Working for New Hampshire's drinking water experts

This messaging foundation and the central goal of safe, dependable, and affordable public drinking water drove the communications tactics in the implementation plan.

The plan was driven by the four strategic priorities and structured to ensure each communication tactic is aligned to at least one priority, and has a purpose, a responsible party, target audience, description, and status. For example, to support the workforce development needs and highlight the story of drinking water in NH, the staff will talk with members to understand how the NHHWA's work is valuable to them. If they are willing to share their testimonial about the NHHWA along with a photo, it can be used with key audiences like public officials and potential employees to build the association's reputation. Tactics like these are outlined with specifics in a spreadsheet or table to ensure that the goals are fulfilled and shared with a variety of key audiences, as illustrated by the following examples.

- Strategic Priorities: #1 People Powered and #3 Story of Water
- Tactic: interview 4-6 individual members to gather perceptions on NHHWA and key information sources they use; ask for a photo and testimonial about NHHWA's impact and effectiveness
- Purpose: build reputation
- Target Audience: donors, students, public officials, prospective members, members, and industry partners
- Uses – Video, website, publications, social media, grant proposals.

With the strategic plan, messaging foundation, and annual plan for communication tactics in hand, the next step was to draft a Request for Proposal for a website developer. The executive director proposed a budget item to design a new website highlighting the strategic work done in 2021 and streamlining functional processes online. The Board approved that request.

The NHHWA's new website (<https://nhwwa.org/>) was brought online in June 2021. It is a refreshing illustration of the Board and staff's vision and the association's purpose and capabilities.

Governance: Foundational Framework for Continuous Learning and Improvement

For the third component of the NHHWA's new foundation, the Board recognized that its

governance system, primarily its bylaws and essential policies, was out-of-date and needed to be modernized to support greater nimbleness, agility, and responsiveness to the sometimes rapidly changing and evolving circumstances faced by the state's public water utilities.

As with many similar state-level organizations, the NHHWA is a charitable nonprofit that is tax exempt under Section 501(c)(3) of the Internal Revenue Code. This status puts NHHWA in the common position of needing to serve charitable, scientific, or educational purposes while at the same time striving to meet the needs of its "members." Various societal trends over the past half-century have tended to cause membership in nonprofit organizations to decline, resulting in less participation overall in the workings, programs, and volunteer boards of many such groups. NHHWA has not been immune to this societal trend, as it can be difficult now to attain a quorum of 30 dues-paying members at an annual meeting, which had been the required forum for electing the Board of Directors and amending the bylaws.

Beginning in January 2021, the executive director and the scenario planning consultant, Tom Burack, serving now in his attorney status, began to assess the type and form of bylaws that would most effectively promote continuous learning through the scenario planning process as a key to the Board's ongoing work. Ultimately, they decided not to use "traditional" bylaws as the basis for updating the governance processes. Instead, they deployed a governance approach generally based on the principles of "policy governance" in which an organization's board sets the goals or "ends" that the organization will strive to achieve and hires a chief executive officer to develop and implement strategies to achieve those goals, subject to certain limitations that the board may place on the CEO's actions or activities.

Largely guided by these general principles, the executive director and the attorney prepared a set of draft bylaws that was reviewed in detail by the Board at a series of meetings through the Spring of 2021. In May 2021, the Board voted to recommend that the membership approve a new set of bylaws that includes the following major elements:

- Constitute the Board of Directors as a self-perpetuating Board (so that the Board as a whole would be responsible for recruiting, nominating, and electing new Board members, all of whom would serve staggered terms), and as the “members” of the organization for purposes of compliance with state law;
- Simplify the membership structure by converting all categories of dues-paying “members” to “supporters”;
- Actively promote engagement of supporters in the work of the Board by encouraging all interested supporters, as individuals, to participate as volunteers on Board committees and sub-committees;
- Increase transparency and engagement by requiring an annual meeting for the supporters at which the Board presents an annual report on the organization’s accomplishments and actively engages supporters in the scenario thinking process by seeking their ideas, insights, and information;
- Establish a Governance and Nominating Committee whose roles include identifying and recruiting new members of the Board through active engagement with the NHWWA’s supporters, and;
- Articulate and clarify the respective roles of the Board and staff, including through provisions that specify the Board’s responsibility for strategic planning and policy-setting, and the staff’s responsibility for implementation and reporting.

At a special online meeting held on June 8, 2021, the NHWWA’s membership, with a quorum present, adopted the proposed new bylaws by unanimous vote. Following this vote, on June 16, the executive director, now operating under the title, “President and CEO,” sent an email to all of the NHWWA supporters who attended the online meeting, thanking them for participating in the process of adopting the new bylaws, expressing appreciation for “our Board’s willingness to embrace such important and sweeping changes that will directly impact their roles and responsibilities as volunteer Directors,” and pointing out that by requiring more of everyone involved in the NHWWA, “current and future Directors

will be even more motivated and empowered to serve...now that important duties with clear outcomes are codified in our foundational governance document.”

The Big Splash that Keeps on Splashing

The President and CEO in his June 16 message described the full scope of the organization’s modernization process as follows:

“The revised bylaws resulted from a ground-up analysis of Association mission and goals, crafted to clarify our organizational structure as well as build committees and positions to apply talent and resources to our shared priorities. Priorities were identified in our 2020 strategic plan, and include the critical challenges of workforce development, infrastructure development and communications. The June 8, 2021, bylaws will help us meet these and future priorities and challenges.”

The overall impact of the NHWWA’s modernization efforts are expected to strengthen the organization and ensure that it is well-positioned not only to help the state’s public water supply systems meet the challenges of today, but also to ensure that they are regularly imagining alternative future worlds, developing new strategies that could work in those future worlds, and ever-ready to implement them quickly and successfully, when and if the need arises. The combination of scenario-based continuous learning, effective and integrated communications, and a modern governance structure will help ensure that the NHWWA will be able to make a big splash for New Hampshire’s public drinking water supplies not only today but also far into the future.

About the authors: Tom Burack, Esq., Sheehan Phinney Bass + Green, PA, served both as the consultant to NHWWA on the scenario planning and the attorney on the governance system components of this project. Sue Kaplan, Sustainable Futures Consulting, served as the consultant on the communications strategy and implementation plan. The authors extend their gratitude to Boyd Smith, President and CEO of the NHWWA, for his invaluable assistance and support in the preparation of this article. Mr. Smith authored an article on the early phases of this process, “Scenario-based Strategic Planning,” Journal of the New Hampshire Water Works Association, Vol. 2, 2020, pp. 7-12.

Water Affordability and Policy Recommendations for Chelsea, MA

By Fidel Maltez*

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ABSTRACT

In this paper, I focus on water affordability, a growing crisis in the United States, that is disproportionately affecting low-income, communities of color. I will focus in Chelsea, MA where I live and work. Unlike electricity and gas, water charges are highly unregulated and there is little consistency of support programs to low-income residents. Nationally, operation of water systems, rate setting and revenue collection is the responsibility of each municipality. This has led to the creation of inconsistent, and highly localized water management policies that must be realigned, or low-income residents will lose access to clean drinking water, a basic human right.¹ Consumer Assistance Programs (CAP) can be used as a tool to address water affordability. I will explore several CAP initiatives and discuss their benefits and challenges.

Introduction

Chelsea is the smallest city in Massachusetts by land mass and the second most-densely populated, only behind Somerville. According to the United States Census Bureau, Chelsea has a population of 40,787, with 67% of its residents identifying as Latino.² Walking through Chelsea is a cultural experience and it is not uncommon to walk into a restaurant where English is not spoken. At the Chelsea Market Basket, a grocery chain, there is no “ethnic” lane, instead Latino, Asian and African products are intermingled throughout the store and Goya products hold a huge market share. Chelsea is a designated Environmental Justice community, with the majority of its neighborhoods meeting all three of the minimum criteria for poverty, proportion of minority residents and residents whose primary language is not English.³ Most recently, the pandemic has cast a spotlight on Chelsea as one of the communities in the Commonwealth most severely impacted by COVID-19.⁴ Leaders in Chelsea were not surprised by this: for years we have been raising awareness of the intersectionality between public health, poverty and resiliency, and the fact that Chelsea residents are carrying a disproportionate environmental burden at the

benefit of the region.⁵ Chelsea is the perfect place to implement an income based water and sewer subsidy, typically called a Consumer Assistance Program (CAP) (Mack et al. 2020).

Water Affordability in Chelsea

Section 30-4 of the City of Chelsea municipal code of ordinances states that the head of Public Works “shall set and collect reasonable charges for providing inspection of sewer, storm drain and waterworks covered under these regulations and applicable state and federal laws.”⁶ The rates for water and sewer are set annually in June, after the annual operating budgets for the water and sewer enterprises are approved. As the head of Public Works for the City of Chelsea it is my responsibility to set the rates every year for our residents. As required by ordinance, the Department of Public Works hosts a public hearing to announce the proposed rate increase for water and sewer, and every year a common plight ensues: our poorest and most disadvantaged residents cannot continue to bear the increases needed to sustain our rising costs of water and sewer. In 2019, the Chelsea Record, reported: “District 6 Councilor Giovanni Recupero, never

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MWRA Fully Served Water and Sewer Customers	Preliminary FY22 Combined Assessment	Dollar Change from FY21	Percent Change from FY21
Brookline	21,801,665	1,008,959	4.9%
Chelsea	14,531,827	787,705	5.7%
Newton	36,270,386	842,441	2.4%
Somerville	26,156,316	622,441	2.4%

Figure 1. Proposed Assessment from the MWRA in FY2022 for Chelsea.¹⁰

one to mince words, said homeowners and renters will end up getting shafted by the rate increases. ‘This is killing the poor people who live here,’ he said. ‘This is not only going to drive the homeowners out, this is going to drive the tenants out, too. This is a bad thing to go up this much. I like living here, I don’t want to be driven out.’”⁷ These public hearings are indicative of the nation-wide struggle to balance water affordability and the rising cost of water and sewer operations.

Chelsea is part of a network of municipalities served by the Massachusetts Water Resources Authority (MWRA).⁸ Chelsea is responsible for maintenance, capital improvements, and operations of the water and sewer pipe networks within city limits, while the MWRA is responsible for water supply and treatment of sewage. The MWRA publishes the water and sewer assessment annually. This assessment does not take into account the differences between communities, and wealthy communities like Newton and Brookline, often receive increases lower increases than low-income communities like Chelsea.⁹ Figure 1 shows the increases proposed by the MWRA in FY2022.

For Chelsea, the MWRA assessment accounts for 60% of our water enterprise budget and 66% of our sewer enterprise budget. Other fixed costs, such as debt and interest payments, capital projects and general fund obligations, make up for another 29% of the water enterprise budget and 26% of the sewer enterprise budget. This means that over 90% of the water and sewer enterprise costs are outside of our control and cannot be quickly reduced to address affordability of water to our residents. Figure 2 below shows a summary of expenses for our water and sewer enterprise budgets.

Water Affordability Across the Region and the United States

Cities like Detroit, Philadelphia, Atlanta and Baltimore have publicly struggled with water affordability for its residents. In Detroit, over 50,000 households have experienced water shut-offs since 2014. In Philadelphia, 4 out of 10 water accounts are past due. In Atlanta, a family of 4 is estimated to pay \$325.52 per month for water and sewer (Mack et al 2017). The Wall Street Journal reports that “over the past decade, increases have averaged 5.5% a

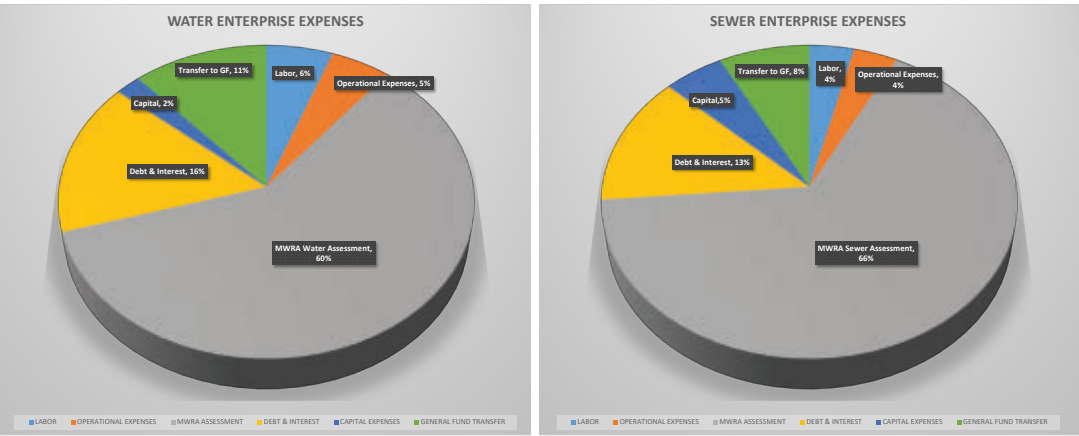


Figure 2. FY2022 Operating Budget for Chelsea’s Water & Sewer Enterprises.¹¹

Chelsea (W/S)				Revere (W/S)				Somerville (W/S)			
Annual Cost AWWA Standard for Historical Comparison (120 HCF = 90,000 gals.)				Annual Cost AWWA Standard for Historical Comparison (120 HCF = 90,000 gals.)				Annual Cost AWWA Standard for Historical Comparison (120 HCF = 90,000 gals.)			
Utility	Rate	Change from 2019		Utility	Rate	Change from 2019		Utility	Rate	Change from 2019	
Water	\$656.40	0.00%		Water	\$469.20	0.00%		Water	\$723.12	7.49%	
Sewer	\$1,136.40	0.00%		Sewer	\$1,414.80	0.00%		Sewer	\$1,368.84	2.30%	
Combined	\$1,792.80	0.00%		Combined	\$1,884.00	0.00%		Combined	\$2,091.96	4.03%	
Malden (W/S)				Winthrop (W/S)				Everett (W/S)			
Annual Cost AWWA Standard for Historical Comparison (120 HCF = 90,000 gals.)				Annual Cost AWWA Standard for Historical Comparison (120 HCF = 90,000 gals.)				Annual Cost AWWA Standard for Historical Comparison (120 HCF = 90,000 gals.)			
Utility	Rate	Change from 2019		Utility	Rate	Change from 2019		Utility	Rate	Change from 2019	
Water	\$682.08	0.00%		Water	\$1,374.00	0.00%		Water	\$291.60	0.00%	
Sewer	\$797.76	0.00%		Sewer	\$1,374.00	0.00%		Sewer	\$793.20	0.00%	
Combined	\$1,479.84	0.00%		Combined	\$2,748.00	0.00%		Combined	\$1,084.80	0.00%	

Figure 3. Annual Water and Sewer Costs for 120 hundred cubic feet of water.¹⁴

year, more than three times the rate of inflation.” The same Wall Street Journal story noted that a national survey by the American Water Works Association showed that the median household bill rose 75% in the period between 2006 and 2016 nationally.¹² A study that analyzed water increases for twelve cities found that in 2018 the average annual water bill was \$476, but saw a big swing, with Fresno charging \$196 per year and Austin charging \$869 per year for the same quantity of water.¹³ Figure 3 shows this same fluctuation in communities in the Metro Boston region.

Figure 3 above shows the large swing between water costs among neighboring communities. These costs are calculated, using the American Water Works Association standard usage for a family of 120 hundred cubic feet (HCF) per year. For 120 HCF the City of Everett charges \$1,084 per year while Winthrop charges \$2,748 per year.¹⁵ This means that family in Winthrop pays 250% more than a family in Everett, even though these communities are less than 3 miles away from each other.

We know that wages have not increased at the same pace as water costs, particularly for people of color. The Economic Policy Institute found

that between 2006 and 2016, wages increased by roughly 14%.¹⁶ The institute also noted that 2019 was the first year that wages for African Americans exceeded their 2000 and 2007 levels, showing the unequal distribution of the recovery from the Great Recession. The institute noted that 2019 also saw the largest wage gap between people of color and their white counterparts since the year 2000.¹⁷

Customer Assistance Programs (CAPs)

In a 2016 report, the Environmental Protection Agency (EPA) noted that a number of municipalities “have developed Customer Assistance Programs (CAPs) to help financially constrained customer maintain access to drinking water.”¹⁸ The EPA surveyed 795 municipalities and found that 228 (28.7%) offered at least one type of CAPs, most frequently serving low-income residents, seniors, veterans, residents with disabilities, and residents experiencing temporary hardship. The report points out several benefits of instituting CAPs.¹⁹

Water and sewer rate setting is not regulated at the state or federal levels, in fact, there is limited guiding principles or framework from the federal government on this issue (Mack et al 2020). This is entirely different from other utilities

Social Responsibility	Taking care of the less fortunate in our communities is the right thing to do. CAPs give municipalities an opportunity to help residents in need.
Improves Public Relations	CAPs improves public health and environmental quality; improves the municipality’s standing in the community; bolsters the municipality’s reputation with key stake holders.
Improves Financial Health	Municipalities can save on administrative and legal costs associated with collecting debts, disconnection of water services, mailers, etc.

such as electricity and natural gas. In Chelsea, Eversource and National Grid are required to set aside a portion of their annual revenue to subsidize low income residents. These utility companies participate in the Low Income Home Energy Assistance Program (LIHEAP), which is partially funded from the federal government and provides assistance to low-income residents to help them meet their energy needs (Mack et al 2020). In Chelsea, Eversource, through its Community Action Program (CAP), partners with CAPIC, a local non-profit, to provide support to low-income residents.²⁰

The World Bank states, “subsidies to utility customers are widely popular among policy makers, utility managers, and residential customers alike” (Komives et al 2005). The World Bank argues that targeting subsidies to the poor has three potential benefits: it limits the amount of subsidy needed and thus limits the impact to revenue; it maximizes the potential benefit of the subsidy to those that need it most; and it has the potential to cause fewer distortions in consumption decisions that might affect long term policy (Komives et al 2005).

The EPA report on Customer Assistance Programs (CAPs) notes that subsidies can take several forms. The table below summarizes the forms CAPs usually take across the United States.²¹

The most common CAPs are bill discount (42%), followed by flexible term (26%) and temporary assistance (23%). CAPs vary in structure and size, but they often address only short-term needs such as household financial emergencies. CAPs also suffer from uneven outreach efforts, and typically lack sustainable funding sources to finance them.²²

NYC’s Home Water Assistance Program

In 2015 New York City’s Mayor Bill de Blasio announced a new program to help residents

with the rising cost of water bills. The Mayor’s program is simple: the Home Water Assistance Program provides an annual credit of \$115.89 to homeowners who live in one-to-four unit homes and qualify for other low-income benefits, such as senior citizen homeowner tax exemption, heating/fuel assistance, disabled homeowner tax exemption, and/or enhanced school tax relief.²³ There is no application process and residents simply “receive” the discount if they are enrolled in other programs. The Mayor estimates that this discount is given to 53,000 low-income homeowners in New York City.²⁴ The program is not designed for tenants, even though 62% of homes in NYC are renter-occupied.²⁵ This simplistic, no-barriers-to-entry approach has its benefits, especially for those residents who are not technologically savvy or do not have the time to complete applications.

Philadelphia’s Tiered Assistance Program (TAP)

The City of Philadelphia launched its Tiered Assistance Program (TAP) in 2017 to subsidize water and sewer costs for low-income residents. From 2012 to 2017, more than 40% of the households in Philadelphia had experienced at least one shut-off.²⁶ Philadelphia is a majority minority city, with over 67% of its residents identifying as African American, Latino or Asian.²⁷ It has a median family income of \$43,744, and 24% of residents live in poverty. A large quantity of neighborhoods in Philadelphia have an environmental justice designation.²⁸ The TAP program has “the goal to help low-income households that are between 0% and 150% of the federal poverty levels” (Mack et al 2020). The program also provides temporary assistance to households who face financial hardship due to a death, prolonged unemployment, lasting illness, or increase in household size due to domestic violence (Mack et al 2020). Philadelphia’s

Bill Discount	Provides direct discounts to each bill and are typically long term
Flexible Terms	These can take the form of payment plans, even billing, forgiveness of previous balances or interest, etc.
Lifeline Rate	Sets a lower rate for a fixed amount of water that is expected to meet resident’s basic water needs
Temporary Assistance	Provides short-term support in the case of unexpected hardship, such as death, job loss, divorce, domestic violence, etc.
Water Efficiency	Subsidizes water efficiency measures for providing leak repairs, installing low-usage fixtures, toilers, shower heads, etc.

program was the first in the country to include a subsidy structure based on each participant's income. TAP uses EPA guidelines on water affordability, which sets a maximum water and sewer cost of 4.5% of the household's income. If accepted into the program, water bills are capped between 2% and 3% for households earning less than 150% of the federal poverty level and 4% for those earning less than 250% of the federal poverty level.²⁹ The program gives residents a way to eliminate past due amounts, so long as they pay the TAP agreed amount for 24 months. Finally, the program gives residents consistent and predictable bills and eliminates the fear of a water shut-off (Mack et al 2020). Enrollment numbers and program costs have increased steadily: as of 2021 Philadelphia has 26,397 enrollees at an annual cost of \$17 million.³⁰

Baltimore's Water-For-All Program

In 2019 the Baltimore City Council passed the Water Accountability and Equity Act.³¹ This legislation established the "Water-for-All-Baltimore" program which provides robust assistance to low-income residents against water affordability. It is important to note that this legislation was passed as a response of the Baltimore City Council approving a 9% annual rate increase for the next 3 years.³² It appears that the Council was cognizant that these large increases would disproportionately impact low-income residents. Water-For-All is an income-based discount program that closely resembles Philadelphia's Tiered Assistance Program. The legislation has a "purpose of increasing the availability or affordability of basic water and wastewater service to low-income consumers and assuring a fair process for all consumers."³³ The legislation sets the requirement for a billing credit, a process for resolving disputes, establishes the Office of Water-Customer Advocacy and Appeals, and requires that the Department of Public Works offer installment payments to residents before implementing service shut-offs. The Water-For-All program benefits residents and tenants making less than 200% of the federal poverty level. Specifically, the program caps water bills to 1% of annual income to residents making less than 50% of the federal poverty level. Residents making between 50%-100% of the federal poverty level pay 2% of their annual income. Residents making between 100%-200% will have their water

bills capped at 3% of their annual income.³⁴ In addition, Section 2-6 (B) allows undocumented residents to participate in the program: "Water utility customers are not required to be citizens or permanent residents of the United States to be eligible for the water-for-all discount program."³⁵

The most exciting part about the Baltimore legislation is that it specifically addresses renter occupied units and establishes a vehicle to get assistance to tenants. The legislation defines tenants as "a customer who is a tenant and who can verify that he or she pays a landlord, separate from the fixed periodic rent, an amount for water or wastewater provided to his or her principal residents."³⁶ The legislation does not require units to be individually metered, but requires that the landlord clearly separate water costs from rent amounts, and requires that arrangement be incorporated into a written lease. The tenant is still responsible for paying the landlord for the water charge. For property owners who qualify, the credit is incorporated into their water bill. For tenants, the Department of Public Works issues a check to the tenant for the amount of the credit; the tenant has the option of receiving the credit annually or monthly. The legislation also clearly outlines the requirements of all parties, and can be easily mirrored in other municipalities.

Policy Recommendation for Chelsea – What Won't Work

The model developed by Mayor de Blasio in New York City is attractive because of the low administrative burden and since it is given automatically without residents having to apply. Chelsea currently has a senior discount that is easy to administer and provides significant benefits. Any senior who is a homeowner completes an application with the Department of Public Works; the senior provides proof of age, and the senior is given 20% off the total water bill. This discount is approved administratively every year and is factored into the water rates. For FY2022 water rates, we estimate that the senior discount would cost the water and sewer enterprise \$120,000, or roughly 0.53% of the total budget. The cost of this discount is shared by the rest of the rate payers. A similar discount can be implemented for low-income homeowners. Households making less than 50% of the federal poverty level can receive a 30% discount; households making between 50% and 100% of the federal poverty level can receive a 20% discount;

City	% Residents of Color	% Renters of Color	Median HH Income
Chelsea	79%	70%	\$53,280
Belmont	26%	20%	\$120,208
Newton	26%	20%	\$139,696

households making between 150% and 200% of the federal poverty level can receive 10% discount. The additional costs of this discount should be modest, similar to the senior discount and could be approved administratively when rates are set annually. This would be the easiest vehicle to get a low-income discount implemented, specially, if it promoted as a pilot program in response to the global pandemic.

According to the US Census, Chelsea has 25.9% owner occupied units.³⁷ Furthermore, the 2018 5-Year American Community Survey, shows that for the State of Massachusetts, 87% of owner occupied units are owned by non-Hispanic Whites.³⁸ Given these two figures, it is clear to see that a policy on water affordability cannot exclude tenants. The table above shows that excluding tenants in Chelsea would have a disproportionate impact on people of color, especially in comparison to neighboring wealthier and whiter communities.³⁹

Policy Recommendation for Chelsea – Chelsea’s Water for All

A policy recommendation must prioritize tenants to be effective in Chelsea, this program would be called Water-For-All-Chelsea. To reduce the administrative burden, Chelsea’s program would follow a tiered percentage discount based on the residents’ income level. Residents making less than 50% of the federal poverty level would get a 30% discount on the bill; Residents making between 50% and 100% of the federal poverty level would get a 20% discount on the bill; Residents making between 100% and 200% of the federal poverty level would get a 10% discount on their water bill. This progressive discount rate will ensure that the residents that need help most get it, while balancing revenue impacts to the water and sewer enterprises. Residents would be required to provide income verification annually.

Administratively, this program would roll-out slowly and would be opened in phases. We would mirror the process administrated recently in Chelsea for our food assistance cards, called Chelsea Eats, or our recent rental assistance

programs.⁴⁰ Low-income residents would apply with the Department of Public Works who would review their applications. Once the applications are certified, the Department of Public Works would hold a lottery for the first 300 households in the program. 300 households are the same number selected for each phase of our rental assistance program. As a team, we discovered that this number of residents was manageable from an administrative standpoint. On the next phase of the roll-out, an additional 300 homes would be selected. The phases would continue until all homes that apply are verified and are properly processed. This phased roll-out limits employee burn-out and decreases the possibility of frustration from residents, as we work out the kinks of a new and complicated assistance program.

Process for Gaining Public Support: LIHWAP

A key requirement for any legislation is to garner public support. The Biden-Harris administration has acknowledged that water affordability is a growing public health crisis for our country. In the press release for the Low-Income Household Water Assistance Program (LIHWAP), the Secretary of the Department of Health and Human Services affirms that “having access to affordable, clean, and safe drinking water is essential to everybody’s health and well-being. No family or child should go without access to water because of challenges paying the bills. Access to a healthy environment – including drinking water – is a key determinant of health.”⁴¹ The recognition at the federal level should be our call to action. The federal funding provided by the LIHWAP should give us the building blocks to create an effective low-income program that prioritizes communities of colors and tenants. The arguments are simple: (1) low-income residents need support against inevitable rising costs; (2) CAPs have been in place for electricity and gas for many years; and (3) CAPs make financial sense for water and sewer enterprises and the city.

There are many who will be against this program. These folks claim to believe in free market, and continually oppose programs to help low-income residents. Their arguments are tired and are always the same: (1) why should rate payers help people who can't help themselves; (2) it is not fair for the rest of the rate payers to "subsidize" low-income people; and (3) we can't afford to provide this help. The extensive research in this policy recommendation should provide enough facts to answer these questions: The World Bank, the United Nations, the EPA, the American Water Works Association all recommend support program for low-income residents.

Furthermore, close to 30% of cities already have a low-income CAPs in place. I am confident that we can overcome the objections by groups who would be against this proposal. Chelsea has provided remarkable support to our low-income residents throughout the global pandemic. We have provided financial assistance through the Chelsea Eats direct payment program;⁴² we have staffed food lines for over a year to ensure that no resident is hungry;⁴³ and we have distributed millions of dollars in rental assistance to ensure our low-income residents are not put out on the streets.⁴⁴ Everyone in our city is better off with this support.

Who Benefits from LIHWAP

LIHWAP should specifically targets low-income residents, whether they are homeowners or tenants. Implementing a low-income assistance program will increase equity by affirming that uncompromised access to clean drinking water is a basic human right. This program will ensure that all Chelsea residents have access to clean drinking water, regardless of their income level.

Who Is Injured from This Policy Recommendation

Groups that oppose LIHWAP make the argument that it is not fair for ratepayers to subsidize low-income residents. The global pandemic has exposed the harsh realities of our community:

I believe that it is the city's responsibility to provide a safety net and support system for our low-income residents. Letting residents go hungry is not an option; allowing residents to be evicted is not an option; having residents without access to clean drinking water is simply not an option. We also know that homeowners and wealthier residents get other benefits that are subsidized by tenants and low-income residents. The City of Chelsea offers a 35% residential exemption on property taxes for owner-occupied units.⁴⁵ This means that as a homeowner in Chelsea, I receive a tax savings of \$2,144.79 per year through this residential exemption.⁴⁶ This subsidy to homeowners is spread throughout the rest of the tax base, which includes a significant number of tenants. Renters therefore cover the cost of this property tax subsidy to homeowners.

Conclusion

Rising water costs and water affordability is a nationwide crisis. I am confident that we will do the right thing and we will provide direct support to our low-income residents. Water is a human right and must be guaranteed to our residents: Water-for-All-Chelsea!

References

- Komives, Kristin, & World Bank. (2005). Water, Electricity, and the Poor : Who Benefits from Utility Subsidies?. World Bank.
- Kayaga, Sam, & Franceys, Richard. (2007). Costs of urban utility water connections: Excessive burden to the poor. *Utilities Policy*, 15(4), 270–277. <https://doi.org/10.1016/j.jup.2007.06.002>
- Mack, Elizabeth A, Wrase, Sarah, Dahme, Joanne, Crosby, Susan M, Davis, Martha, Wright, Melody, & Muhammad, Ravonne. (2020). An Experiment in Making Water Affordable: Philadelphia's Tiered Assistance Program (TAP). *Journal of the American Water Resources Association*, 56(3), 431–449. <https://doi.org/10.1111/1752-1688.12830>
- Mack, Elizabeth A, & Wrase, Sarah. (2017). A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States. *PloS One*, 12(1), e0169488–e0169488. <https://doi.org/10.1371/journal.pone.0169488>

Kayaga, Sam, & Franceys, Richard. (2007). Costs of urban utility water connections: Excessive burden to the poor. *Utilities Policy*, 15(4), 270–277. <https://doi.org/10.1016/j.jup.2007.06.002>

Rita Martins, Carlota Quintal, Luís Cruz, Eduardo Barata. (2016). Water affordability issues in developed countries – The relevance of micro approaches. *Utilities Policy*, Volume 43, Part A, Pages 117-123, ISSN 0957-1787, <https://doi.org/10.1016/j.jup.2016.04.012>. (<http://www.sciencedirect.com/science/article/pii/S0957178715301119>)

Footnotes

- 1 https://www.un.org/waterforlifedecade/pdf/human_right_to_water_and_sanitation_media_brief.pdf
- 2 <https://www.census.gov/quickfacts/chelseacity-massachusetts>
- 3 <https://www.mass.gov/info-details/environmental-justice-populations-in-massachusetts#what-is-an-environmental-justice-population?>
- 4 <https://www.wbur.org/earthwhile/2020/05/12/massachusetts-coronavirus-environment>
- 5 <https://www.bostonglobe.com/2020/04/29/metro/pollution-might-affect-states-covid-19-hotspots-harvard-study-shows/>
- 6 https://library.municode.com/ma/chelsea/codes/code_of_ordinances?nodeId=PTIIICOR_CH30WASESY
- 7 <https://chelsearecord.com/2019/06/21/councillors-say-its-time-to-put-the-brakes-on-water-sewer-increases/>
- 8 https://en.wikipedia.org/wiki/Massachusetts_Water_Resources_Authority
- 9 https://www.mwra.com/finance/rates/fy2021/fy2021preliminary_r1.pdf
- 10 <https://www.mwra.com/finance/rates/fy2022/fy2022preliminary.pdf>
- 11 https://www.chelseama.gov/sites/g/files/vyhlf396/f/pages/chelsea_fy2022_annual_budget_report_1.pdf
- 12 <https://www.wsj.com/articles/who-is-paying-to-fix-outdated-water-and-sewer-systems-you-are-1521106201>
- 13 <https://www.sciencedirect.com/science/article/abs/pii/S0957178707000550?via%3Dihub>
- 14 <https://mwraadvisoryboard.com/2020ratesurvey/>
- 15 <https://mwraadvisoryboard.com/2020ratesurvey/>
- 16 <https://www.epi.org/publication/swa-wages-2019/>
- 17 <https://www.epi.org/publication/swa-wages-2019/>
- 18 https://www.epa.gov/sites/production/files/2016-04/documents/dw-ww_utilities_cap_combined_508.pdf
- 19 https://www.epa.gov/sites/production/files/2016-04/documents/dw-ww_utilities_cap_combined_508.pdf
- 20 <https://www.masscap.org/>
- 21 https://www.epa.gov/sites/production/files/2016-04/documents/dw-ww_utilities_cap_combined_508.pdf
- 22 https://www.epa.gov/sites/production/files/2016-04/documents/dw-ww_utilities_cap_combined_508.pdf

- 23 <https://www1.nyc.gov/site/dep/pay-my-bills/home-water-assistance-program.page>
- 24 <https://qns.com/2017/07/low-income-homeowners-to-receive-115-credit-on-water-and-sewer-bill/>
- 25 <https://www1.nyc.gov/content/tenantprotection/pages/fast-facts-about-housing-in-nyc>
- 26 http://bcpiac.com/wp-content/uploads/2016/06/Colton_Water_Affordability_Philadelphia_October-2015.pdf
- 27 <https://www.census.gov/quickfacts/philadelphiacountypennsylvania>
- 28 <https://www.census.gov/quickfacts/philadelphiacountypennsylvania>
- 29 <https://www.awwa.org/Portals/0/AWWA/Government/ImprovingtheEvaluationofHouseholdLevelAffordabilityinSDWARulemakingNewApproaches.pdf>
- 30 <https://www.awwa.org/Portals/0/AWWA/Government/ImprovingtheEvaluationofHouseholdLevelAffordabilityinSDWARulemakingNewApproaches.pdf>
- 31 <https://ca.baltimorecity.gov/codes/Art%2024%20-%20Water.pdf>
- 32 <https://www.circleofblue.org/2019/world/baltimore-council-approves-income-based-water-bills/>
- 33 <https://baltimore.legistar.com/LegislationDetail.aspx?ID=3769175&GUID=4A3F24AF-7CC7-442B-86C5-B01AF0A148F7&Options=&Search=&FullText=1>
- 34 <https://www.circleofblue.org/2019/world/baltimore-council-approves-income-based-water-bills/>
- 35 <https://ca.baltimorecity.gov/codes/Art%2024%20-%20Water.pdf>
- 36 <https://ca.baltimorecity.gov/codes/Art%2024%20-%20Water.pdf>
- 37 <https://www.census.gov/quickfacts/chelseacitymassachusetts>
- 38 US Census Bureau, 2014-2018 American Community Survey 5-Year Estimates, Table S2502
- 39 <https://www.usccr.gov/files/2021-01-27-MA-SAC-Water-Affordability-Report.pdf>
- 40 <https://www.chelseama.gov/Rental-Assistance>
- 41 <https://www.hhs.gov/about/news/2021/06/02/biden-harris-administration-launches-relief-program-to-improve-access-to-affordable-water-services.html>
- 42 <https://www.bostonglobe.com/2020/10/17/business/chelsea-is-about-become-countrys-biggest-experiment-giving-out-no-strings-attached-checks/>
- 43 <https://www.bostonglobe.com/2020/11/18/business/tackling-pandemic-chelsea-finds-new-strength/>
- 44 <https://chelsearecord.com/2020/04/29/city-of-chelsea-emergency-rental-assistance-program-now-available/>
- 45 <http://chelsearecord.com/2016/08/29/gov-baker-signs-higher-residential-exemption-for-chelsea-homeowners/>
- 46 <https://www.chelseama.gov/assessor/files/fy-2021-residential-exemption-application>

Insights from Isotopic Tracers on the Sources and Processes by which Water is Transported to Streams and Groundwater in Southern New England

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ABSTRACT

Understanding the mechanisms by which water is transported to streams has been a long focus of hydrologists. This paper presents the use of stable isotopic tracers to understand sources of water to streams and groundwater aquifers. Five brief case studies relevant to water managers and watershed stakeholders are presented that assess the use of stable isotopes as tracers in New England. We show the value of these tools to conceptualizing hydrologic systems and provide new insight into the source of water to streams/aquifers. These science-based insights should be considered when assessing water management decisions and frameworks.

Introduction

The movement of water within and through the terrestrial hydrologic cycle (e.g. soils, groundwater, streams, lakes, ponds, and wetlands) is key important to understand for many reasons. The terrestrial water cycle supports distinct ecosystems, provides drinking water, and are the main transport mechanism for nutrients and contaminants (Schmadel et al., 2021). In addition to knowing how much water is in these reservoirs, tracking the changes in the storage and volume and fluxes through these systems is critical for making decisions on sustainable use and environmental impacts of extraction and disturbances. Assessing storage and flux changes is often accomplished using in-place physical measurements of water level, discharge, and precipitation rates and amounts. These physical measures only tell water scientists part of the full picture of their hydrologic systems (Beven, 2002; McDonnell, 2017). The 'inventory' of the different water masses and the time spent transiting the hydrologic system (i.e. residence time) can be equally important in many cases (McDonnell, 2017; Van Meter et al.,

2018; Zell et al., 2018, Sprenger et al., 2019). The pathways and time it takes water gets to a pumping well, stream, or pond controls the chemical composition of that water, the likelihood of interacting with different contaminants, and source area. A prime example of this is the water that appears in a stream after rainfall is not the same water as the precipitation that fell out of the sky but is a complex mixture of stored water in the watershed. This implies that the time it takes for water to fall as precipitation to the stream is significantly delayed in time and space. Therefore, there are differences between the speed (or time) that a hydrologic disturbance (such as a rainfall event) will take to propagate through a watershed (termed the celerity) compared to the time it takes for individual water molecules to transit the same distance (velocity). One way hydrologists have begun to address the travel time distribution (i.e. velocity distribution) in watershed science is through the use of tracers of fluid movement. One such tracer commonly used are stable isotopes of the water molecule.

Stable isotopes of water (H_2O , δH and ^{18}O) have a long history in lake, rain and watershed

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studies (see Kendall et al., 2014 and Kendall and McDonnell, 1998 for a review). Water isotopes are added to watersheds as both rain and snow-melt, and the isotopic values of rain and snow-melt can vary by season and source (Ingraham, 1998; Cooper 1998). In general, when water (or snow) undergoes a change in state (from gas to liquid or solid) the different isotopologues (e.g., $^1\text{H}_2^{16}\text{O}$, $^1\text{H}^2\text{H}^{16}\text{O}$, H_2^{18}O) that are present will be distributed with the heavier molecules (e.g., $\text{H}^2\text{H}^{16}\text{O}$, $^1\text{H}_2^{18}\text{O}$) being present in the condensed phase (snow > rain > water vapor). The ^2H and ^{18}O content of water vapor (and its products) will depend on the values of the source ocean vapor and its evaporation (Clark and Fritz, 1997; Cooper, 1988; Ingraham, 1998; Sharp, 2007; McGuire and McDonnell, 2007). The storm track (e.g., off the ocean, up a valley, over a mountain, in from a landward source) as well as how fast it is evaporating, raining (or snowing) contribute to its isotopic signature. Stable isotopes of water (^{18}O and ^2H) are popular tools to trace streamflow, examine soil water dynamics, and characterize rainfall-runoff patterns (Kendall and McDonnell, 1998; Kendall and Doctor, 2004). The measurement of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ is an ideal tracer because it is a constituent of the water molecule and sampled easily in precipitation, soil water, surface water, and ground water (Winograd et al 1988; Reddy et al, 2006). The technique of tracing ^{18}O in precipitation to processes in catchment hydrology is well established (Dincer, 1968; Gat, 1981; Gonfiantini, 1986; Kendall and McDonnell, 1998; Cook and Bohlke, 2000; Kendall and Doctor, 2004). One important insight that isotopic and other tracers in ground water have provided is the paradox that long residence time ground water (i.e. old water) seems to dominate stream run-off response to a precipitation event (McDonnell, 1990; Kirchner, 2003) despite strong temporal relationships between stream hydrographs and rainfall events. This paradox suggests that regardless of a particular hydrogeologic environment old water dominates streamflow and that streams source water from flow paths of many lengths and residence times. Stable isotope tracers also suggest that shallow soil water used by vegetation is distinct from that of recharge or stream water (Brooks et al., 2009).

In this paper we present case studies across southern New England (Massachusetts) that

documents the insight gained from using stable isotopes to better understand hydrologic systems. We first provide an overview of the analytical and foundation of the approach followed by a review of recent work. Five different case studies are presented with an eye towards applied applications of stable isotopes for watershed managers, regulators, and stakeholders. Finally, we recommend approaches to integrating stable isotopes into future investigations.

1. Stable Isotopic Methods and Approach

Understanding the stable isotopes of water relies heavily on accurate and high precision measurements of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ (Brand et al 2009; Wassenaar et al 2012). Isotope ratios are considered ideal tracers as they are part of the water molecule and can be easily sampled and preserved in groundwater, surface water, precipitation. Most importantly hydrogen and oxygen can preserve vital historical information (location, time, phase of precipitation) thus becoming a primary tool for hydrological, atmospheric, and meteorological studies (Timsic and Patterson, 2014; Bowen et al., 2007; Reddy et al., 2006). The stable isotopes of water are presented in the δ notation and represent the difference in heavy to light isotopes of water relative to the Vienna Standard Mean Ocean Water (VSMOW) (Sprenger et al., 2016; Craig, 1961; Gonfiantini et al., 1995). Although the delta notation is a dimensionless quantity the values are in per mil because of the low variation in the natural abundance of water stable isotopes (Coplen, 2011; Sprenger et al., 2016). High δ values indicate a higher $^{18}\text{O}/^{16}\text{O}$ and $^2\text{H}/^1\text{H}$ ratio relative to the Vienna Standard Mean Ocean Water. Low δ values indicate a lower $^{18}\text{O}/^{16}\text{O}$ and $^2\text{H}/^1\text{H}$ ratio relative to the Vienna Standard Mean Ocean Water. For the purposes of this paper, the term “enriched” will be used to describe water samples that have a high amount of heavy isotopes and “depleted” will be used to describe water samples that have a low amount of heavy isotopes. To determine the $\delta^{18}\text{O}$ and $\delta^2\text{H}$ of a water sample equation 1 is used:

$$\delta = \left(\frac{R_{\text{Sample}}}{R_{\text{Standard}}} - 1 \right) \times 1000 \quad (1)$$

where R is the abundance ratio of the heavy and light isotopes (e.g., $^{18}\text{O}/^{16}\text{O}$ and $^2\text{H}/^1\text{H}$) and R_{standard} is the VSMOW.

1.1. Analytical Methods

Stable isotope compositions discussed in this paper are measured by a wavelength scanned cavity ring-down spectrometry on un-acidified samples by a Picarro Cavity Ring Down Spectrometer (L2120-I) analyzer (Berden et al. 2000) in the Stable Isotope Laboratory at UMass-Amherst. Cavity ring-down spectroscopy is a direct absorbing technique which is conducted with eight pulse or continuous light sources which is significantly more sensitivity than the conventional absorption spectroscopy. The Picarro is equipped with a high precision vaporizer (A0211) and fitted with a CTC PAL auto-sampler. International reference standards (IAEA, Vienna, Austria) were used to calibrate the instrument to the VSMOW scale. To remove possible memory effect between samples, each sample was analyzed six times and the results of the first three injections were discarded. To further reduce memory effect, we adopted a modified version of a technique by Penna et al. (2012) where samples are grouped by water source and location. Three reference waters that isotopically bracket the sample values were run alternately with the water samples: Boulder, Colorado, Tallahassee, Florida and Amherst, Massachusetts, were used for a total of nine times each in every sample tray. The average values for these standards are -16.5‰, -2.6‰, and -7.5‰ respectively. These standards were calibrated with the Greenland Ice Sheet Precipitation (GISP), Standard Light Antarctic Precipitation (SLAP) and Vienna Standard Mean Ocean Water (VSMOW) from the IAEA (Kendall and Coplen, 2001). The results were calculated based on a rolling calibration so that each sample is determined by the three standards closest in time to that of the sample.

1.2. Data Analysis and Interpreting Stable Isotopic Data

Once the isotopic ratios of Hydrogen and Oxygen relative to the VSMOW standard are acquired the first step of exploring the data is plotting on a dual isotope plot as shown in the example in Figure 1. This plot shows the distribution of the ratios of the H and O isotopes to one another compared to VSMOW (0,0 on this plot). Raleigh distillation theory predicts that all precipitation will fall along lines of consistent slope and intercept, such that a predictable relationship between the two ratios exists. In a dual isotope

plot, $\delta^{18}\text{O}$ - $\delta^2\text{H}$, the relationship between $\delta^{18}\text{O}$ and $\delta^2\text{H}$ is defined as the global meteoric water line (GMWL) (Craig, 1961) and is described by the following equation:

$$\delta^2\text{H} = 8 \delta^{18}\text{O} + 10 \quad (2)$$

This equation represents the relationship of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ of surface waters globally and is an approximation of the mean world annual amount-weighted precipitation (Timsic and Patterson, 2014). Though local precipitation lines vary based on moisture recycling and moisture transport trajectories, precipitation isotope ratios at a given region though should follow on a trend line of fairly constant slope with the values becoming more positive (enriched in heavy isotopes) under warmer atmospheric conditions and more negative (depleted in heavy isotopes) under cooler atmospheric conditions.

2. Hydrological Insights from the Application of Stable Isotope Tracers in Massachusetts

As introduced above isotopic tracing of water using the stable isotopes of O and H has led to exciting new discoveries in the hydrologic sciences. A recent MS thesis (Cole, 2019) and subsequent paper (Cole and Boutt, 2021) has applied some of the new tools and calculations to a large isotope dataset for the Commonwealth of Massachusetts. While serving to document fundamental aspects of isotope compositions of surface and groundwater across the state, it also presents key data on precipitation isotopes for the region from 10 precipitation collection stations. With this information Cole and Boutt (2021) documented new insights into hydrological processes and characteristics from temporal comparisons of isotopic compositions. These are:

- Groundwater and stream water are biased slightly towards cold-season precipitation
- On average and at any given time 78% of water in Massachusetts older than 2-3 months
- On average 98% of ground water older than 2-3 months

Each of these results have important implications for how stakeholders conceptualize and manage water resources. Cole and Boutt (2021) documented that groundwater isotopic composition ($n=409$ sites) ranges from $\delta^{18}\text{O}$ -11 to -4 ‰ surface water ranges ($n=516$ sites) from $\delta^{18}\text{O}$ -13 to -3.84 ‰ and precipitation ranges ($n=14$ sites) from $\delta^{18}\text{O}$ -17.88 to -2.89 ‰. It was found that most

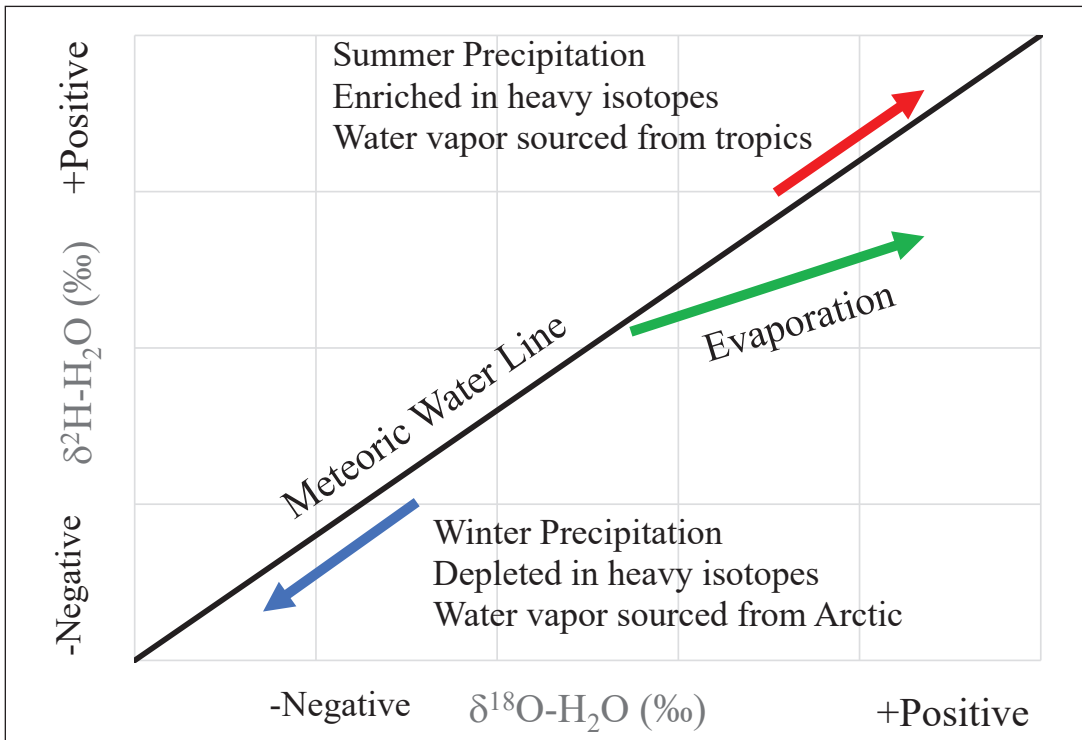


Figure 1. Example dual isotope plot of $\delta^2\text{H}$ vs $\delta^{18}\text{O}$ showing major processes impacting the stable isotopic composition of waters.

water in streams are influenced by groundwater inputs with isotopic compositions and timing of groundwater infiltration during the non-growing season. On a first order, the small bias of mean groundwater (-8.7‰) and surface water (-8.0‰) isotopes compared to precipitation $\delta^{18}\text{O}$ (-7.6‰) supports that groundwater recharge and surface water are slightly more impacted by cold season precipitation. While this is significant, it is not as extreme of a bias compared to other mid-latitude locations within the US and the world (Jascheko et al., 2014). This result supports the inclusion of some summer (growing-season) precipitation into streams and groundwaters.

The bias and amplitude difference in the seasonal cycles of isotope behavior allow the assessment of differences between the composition of the precipitation input and the response observed in surface and groundwater (von Freyberg et al., 2018). We calculate that approximately 22% of the water in streams is less than 2-3 months old and the majority of the water have recharge ages greater than 1-2 yrs. As will be elaborated below, even during storm events which causes observable increases in

stream discharge, waters discharged to streams are dominated by water stored in the subsurface for periods of months to years.

The combined use of environmental tracers and physical hydrologic measures (precipitation amounts, streamflow, groundwater levels) can reduce uncertainty in system conceptualization also allow the constraint of unknown processes. Work documented in Boutt et al. (2019) provides a good example of this using data collected after Tropical Storm Irene impacted western New England. Using 5 years of isotopic data this work documented the long-lasting impact of the precipitation from Irene (and likely TS Lee as well) on the groundwater storage and streamflow. Streamflow isotopic composition of small and large streams (e.g. Deerfield and Westfield) show anomalous isotopic compositions after the extreme precipitation events of August and September 2011, the two wettest consecutive months on record. While the physical hydrologic recession lasted almost over a year, the time it took for isotopic composition of stream water to come to a new level took almost 4-5 years. In the same study (Boutt et al., 2019) showed too that the groundwater isotopes

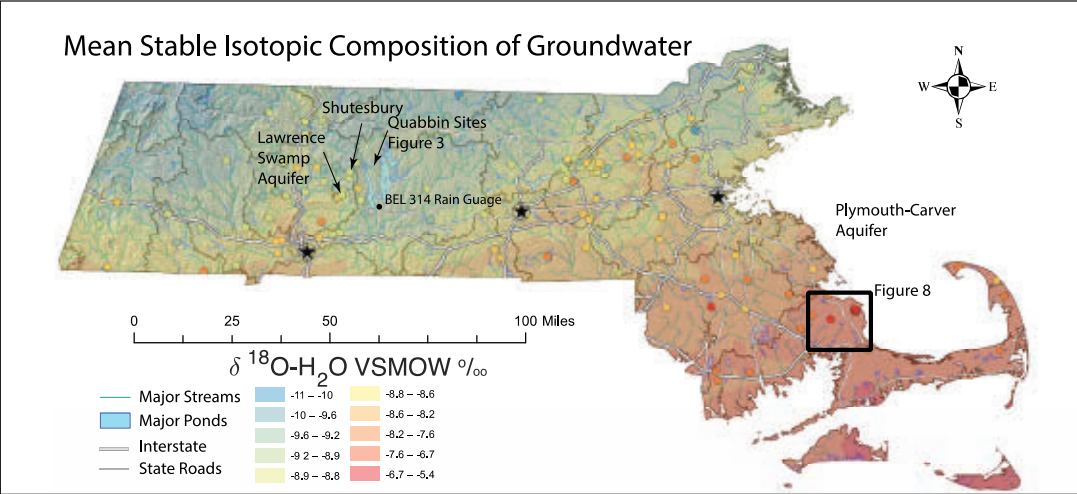


Figure 2. Composite Site map showing locations of study sites, precipitation network on shaded relief. Stars represent major cities in the state.

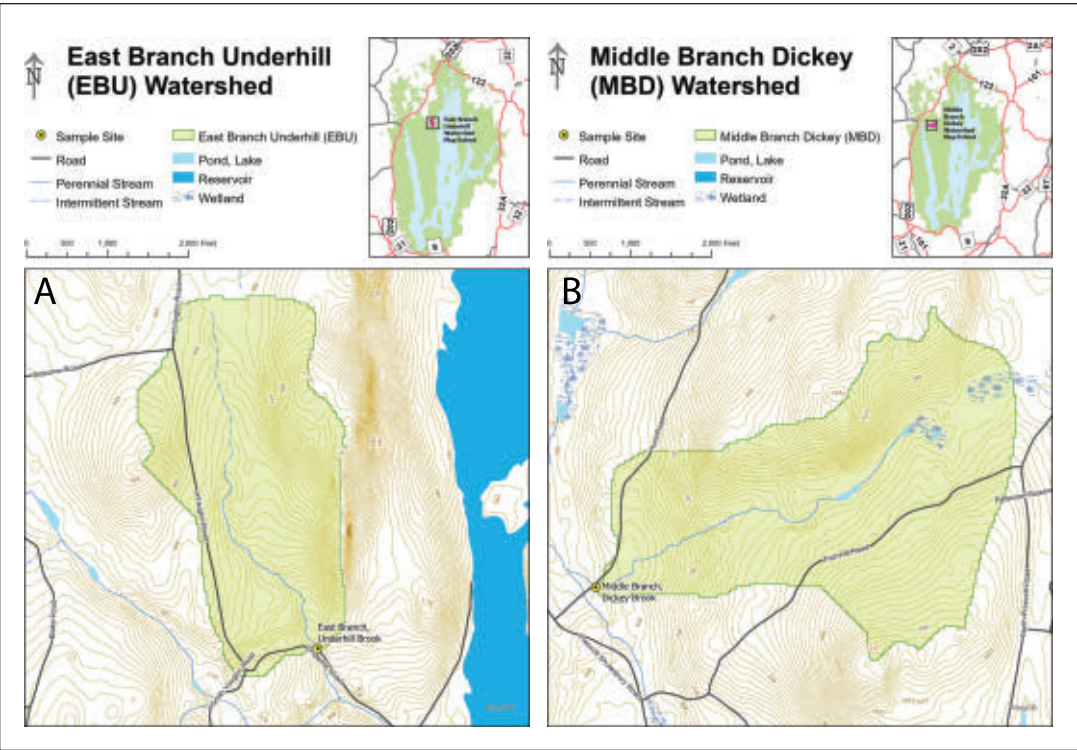


Figure 3. Site map showing locations of Quabbin watersheds East Branch Underhill (EBU) and Middle Branch Dickey (MBD) with topography and water features.

also were impacted by enhanced recharge from precipitation during the late summer of 2011. The spatial distribution of isotopic compositions of surface and groundwaters is also important to discuss and distinguish as it can be an important indicator of inter-basin water transfers and within

watershed variability. Cole (2019) documented a strong regional gradient in isotopic composition of groundwater (and surface water across the state). This distribution is presented as contoured map of the groundwater oxygen isotopic composition (Figure 2). The most distinct groundwaters are in

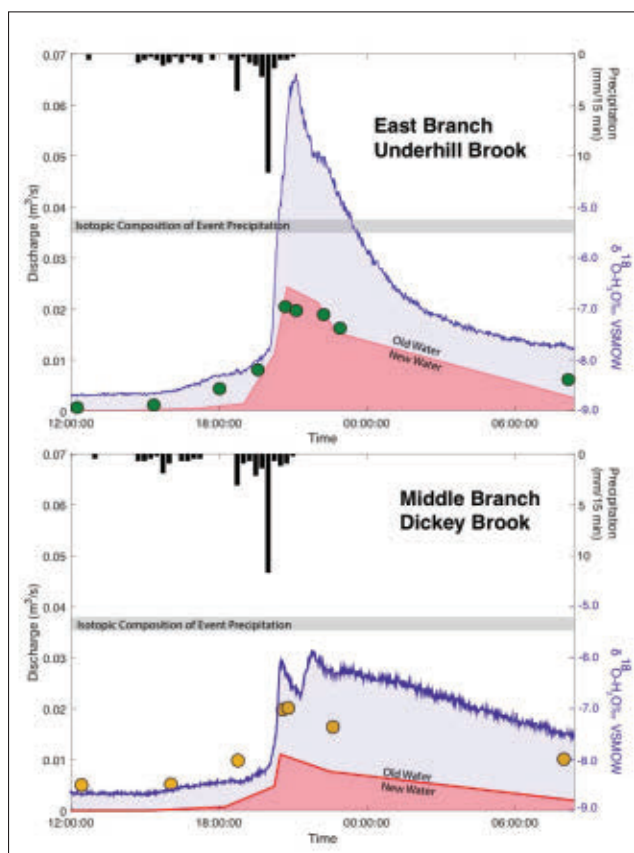


Figure 4. Event Hydrographs for Dickey and Underhill brooks.

the western and northern part of the state. The southeast, Cape Cod, and Islands have the most isotopically enriched composition due to storm tracks and direct coastal influences. Also present here is the topographic effect on the isotopic composition of groundwater water in Connecticut River Valley and general north-south trend is compositions. Here the isotopic composition is more positive in value consistent with warmer conditions.

3. Case Studies

Five distinct case studies showing the application of stable isotopes to understanding the hydrology and hydrogeology of streams and groundwater systems are presented below. Approximate locations of study sites are presented in Figure 2 and represent studies ranging across diverse temporal and spatial scales. While each case study is its own distinct project, the overall use and applicability of stable isotopes show that they are important tools to refine conceptualization of hydrologic behavior. Thus, in each case

we focus on the new understanding of hydrologic processes operating in southern New England.

3.1. Storm Event Analysis at Prescott Peninsula

The Massachusetts Department of Conservation and Recreation (MA-DCR) has established long-term hydrologic monitoring sites within the Quabbin Reservoir watershed to monitor land-management effects on stream water quality (Shanley et al., 1995). Two storm event streamflow monitoring sites located at East Branch Underhill (EBU) and Middle Branch Dickey (MBD) have installed weirs for stream discharge. Water samples are collected at both sites by MA-DCR staff during precipitation events to characterize watershed exports. The location, topography and surface water features are shown in Figure 3. Based on statistics acquired from USGS StreamStats (<https://streamstats.usgs.gov/ss/>) EBU has a watershed area of 0.5 km², is 98% forested, has 0.8 % wetland cover and sediments on top of bedrock is thin till. MBD has a watershed area of 0.7 km², is 88% forested, has 2.8% wetland cover and is

also dominated by thin till surficial deposits. The EBU watershed has slightly more mapped sand and gravel deposits (4% compared to 0% for MBD). Both watersheds have similar areas and topography with MBD having more wetland and surface water features by area.

We present data here for a storm event in May of 2016. Hydrologic conditions in the region were dry following a below average snowfall and reached the height of a moderate drought later in the summer of 2016 (Boutt et al., 2019). Full leaf out had been established by this time of year in the forest with evapotranspiration rates approaching the maximum of the year. Weirs set up with pressure transducers measure stream discharge at yellow dots in Figure 3 using a 15-minute interval recording of stage. Composite precipitation samples were collected using a through-fall rain gauge at the site of each weir. Grab sample of stream water were taken prior to the initiation of precipitation and continued throughout the recessional limbs of the hydrograph Figure 4. Nine (9) and 7 stream

Time of Sample	$\delta^2\text{H}$ (‰)	$\delta^{18}\text{O}$ (‰)	Isotope Fraction of Precipitation (%)	Steam Discharge (m ³ /s)	New Water (m ³ /s)	Old Water (m ³ /s)
Middle Branch Dickey Brook (Total Event New Water - 18%)						
6/5/16 11:15 AM	-8.35	-49.98	0%	3.68E-03	0.00E+00	3.68E-03
6/5/16 3:15 PM	-8.34	-49.72	0%	3.40E-03	1.03E-05	3.39E-03
6/5/16 6:15 PM	-8.00	-46.32	12%	6.00E-03	7.23E-04	5.28E-03
6/5/16 8:15 PM	-7.27	-40.97	37%	1.31E-02	4.84E-03	8.27E-03
6/5/16 8:30 PM	-7.25	-40.26	38%	3.00E-02	1.13E-02	1.87E-02
6/5/16 10:30 PM	-7.52	-41.99	28%	2.77E-02	7.83E-03	1.98E-02
6/6/16 8:50 AM	-7.98	-46.87	13%	1.41E-02	1.79E-03	1.23E-02
East Branch Underhill (Total Event New Water - 26%)						
6/5/16 10:45 AM	-8.84	-51.84	0%	3.28E-03	0.00E+00	3.28E-03
6/5/16 2:15 PM	-8.80	-51.99	1%	3.51E-03	4.53E-05	3.46E-03
6/5/16 5:15 PM	-8.55	-50.31	9%	5.80E-03	4.98E-04	5.30E-03
6/5/16 7:00 PM	-8.26	-48.64	17%	8.15E-03	1.40E-03	6.75E-03
6/5/16 8:15 PM	-7.29	-41.04	46%	2.50E-02	1.14E-02	1.36E-02
6/5/16 8:45 PM	-7.35	-42.13	44%	5.67E-02	2.47E-02	3.19E-02
6/5/16 10:00 PM	-7.41	-42.81	42%	5.16E-02	2.17E-02	2.99E-02
6/5/16 10:45 PM	-7.62	-44.04	36%	4.37E-02	1.57E-02	2.81E-02
6/6/16 9:10 AM	-8.41	-49.96	13%	1.21E-02	1.53E-03	1.05E-02
Composite Precipitation						
6/5/16 10:30 PM	-5.44	-29.51	N/A	N/A	N/A	N/A

Table 1. Event water isotope compositions and mixing model calculations for the May 2016 Dickey and Underhill brook. Top italicized row indicates the value of the old water isotopic composition used for the end-member mixing model.

water samples were analyzed for the stable isotopic composition respectively for EBU and MBD including the precipitation composite sample (Table 1). Event hydrographs for MBD and EBU Brooks for the May 2016 event are presented in Figure 4. Precipitation started around mid-day and picked up in the evening with the largest rainfall approaching 2 mm/hr. Hydrograph response from both brooks peaked after the highest intensity rainfall and recessed well into the next day. The hydrograph response of MBD and EBU are very distinct despite similar precipitation conditions. This is likely due to the more extensive wetland storage at the MBD site.

Figure 5 presents stable water isotope results for the stream water and composite precipitation

during the event. Pre-event stream water is indicated by arrows and represent the most heavily depleted (most negative) isotopes. The isotopic composition of Underhill is more depleted than that of MBD, perhaps to the differing watershed conditions. This may be an indication of EBU brook being more dominated by groundwater baseflow pre-storm. Both brooks record that during the precipitation event the isotopic composition of the stream water evolves towards (but never reaches) the isotopic composition of composite precipitation water. A time evolution of the of $\delta^{18}\text{O}$ composition is plotted in along with the precipitation composite value. From this plot the temporal evolution indicates that the most isotopically enriched (most positive)

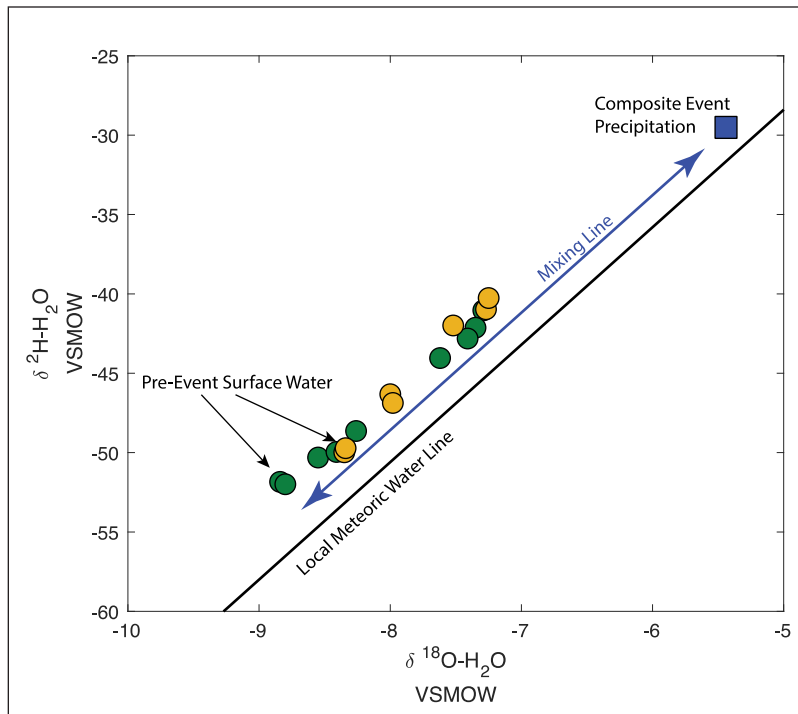


Figure 5. Dual Isotope plot for Precipitation and Event stream water samples for Dickey and Underhill brooks.

values in the stream water coincide closely with discharge. The rise and fall in the isotopic composition roughly corresponds with the discharge pattern. The recessional behavior of the isotopes mimics that of the stream water almost reaching the pre-storm value with last samples taken.

The combined discharge and isotopic measurements allow the portioning of the stream water volume into event water (new) and pre-event water (old). As described above this is accomplished by using a two-component mixing model (Kendall et al., 2014) with distinct end-members defined by 1) the pre-storm stream water which is assumed to be groundwater baseflow, and 2) the composite precipitation isotope composition. End members and mixing line are graphically shown on Figure 5. The intermediate compositions collected at different discharge rates are used to determine the percentage of water in the stream that is 'new' vs 'old' at the time of isotope sample collection. Using standard 2-end member mixing model equation, $\% \text{ New} = \frac{I_0 - I_t}{I_0 - I_N}$, where $\% \text{ New}$ is the percentage of new water in the stream at any time (I_t), I_0 is the isotopic composition of the old water (defined here as the isotopic composition of water in the stream prior to precipitation, and I_N is the composite

isotopic composition of the precipitation. We estimate that at peak discharge the maximum percentage of new water in MBD is 38% and EBU brook is 46% (Table 1). This calculation reflects an instantaneous assessment of the amount of event water at peak discharge. We also calculate that the percentage of new water at MBD Brook to be 18% and EBU Brook 26% over the total event. This means that the majority of water being mobilized from the watershed to the stream is comprised of older stored water. The finding that old water dominates stream water in forested catchments is not a new concept and is consistent with a rich literature in the field hydrology (REF). We now discuss some specific inferences from this study.

The source of water to two streams with fairly different catchment responses to precipitation inputs show similar amounts of new components to streamflow. EBU has higher maximum new water percentage and higher event total percentage of stream flow. Its hydrograph response is also much more abrupt with a quick rise to peak discharge followed by a quick recession. This manifests itself in a larger mobilization of new water into the stream supporting fast pathways and shorter residence times of water in the

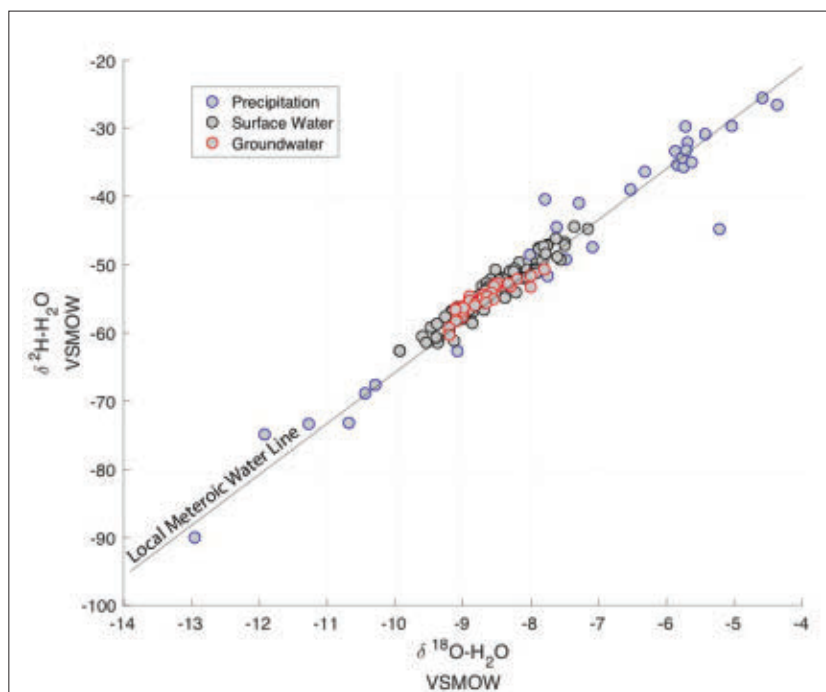


Figure 6. Dual Isotope plot of long-term monthly samples of precipitation (blue), surface water (black), and groundwater (red).

catchment. On the other hand, MBD has less new water in stream and a smaller peak discharge followed by a long recessional limb of the hydrograph. This suggest water being mobilized along slightly slower pathways. Interestingly, despite the distinct hydrograph responses the new water percentages are fairly similar. This suggest that despite the different time-scales of storage and release of water to the stream, that stored water has similar new/old water composition. In the case of the greater wetland percentages in MBD, this seems to suggest a role of surface water storage that delays the streamflow response but perhaps the surface water storage has similar new/old water compositions. One other interesting observation this dataset allows that the largest percentage of new water is close to the peak discharge and is roughly timed with the peak in precipitation intensity. This suggests that near stream sources of new water are contributing to that streamflow. An additional peculiarity in this dataset is that despite having distinct pre-event baseflow isotope compositions, both brooks have similar maximum isotopic compositions. Finally, the small amount of event water in both brooks does not appear to reside long in the watershed. The peak of the new water in the streams decays

quickly reaching baseline isotopic compositions reflecting the short residence time of that mixed water in the system.

3.2. Seasonal Analysis of Source of Water to Streams and Groundwater in Central Massachusetts

Use of monthly analyses of stable water isotopes can provide insight into longer term sources and residence time of water in streams and groundwater (Cole and Boutt, 2021). While the above storm event sampling provides insight on daily sources of water to streams and the dynamics associated with runoff events, there are additional processes generating streamflow and groundwater recharge at the annual scales, such as snow-melt infiltration and changes in soil saturation state. To investigate the dynamics of precipitation, streamflow and groundwater isotopes at the annual scale we present data collected from the years 2016 to 2020. Precipitation samples were collected as described in Cole and Boutt (2021) from the MA-DCR Quabbin rain gauge in Belchertown, Massachusetts (BEL314). Daily precipitation was collected and composited in bottles every 2 weeks and the total amount

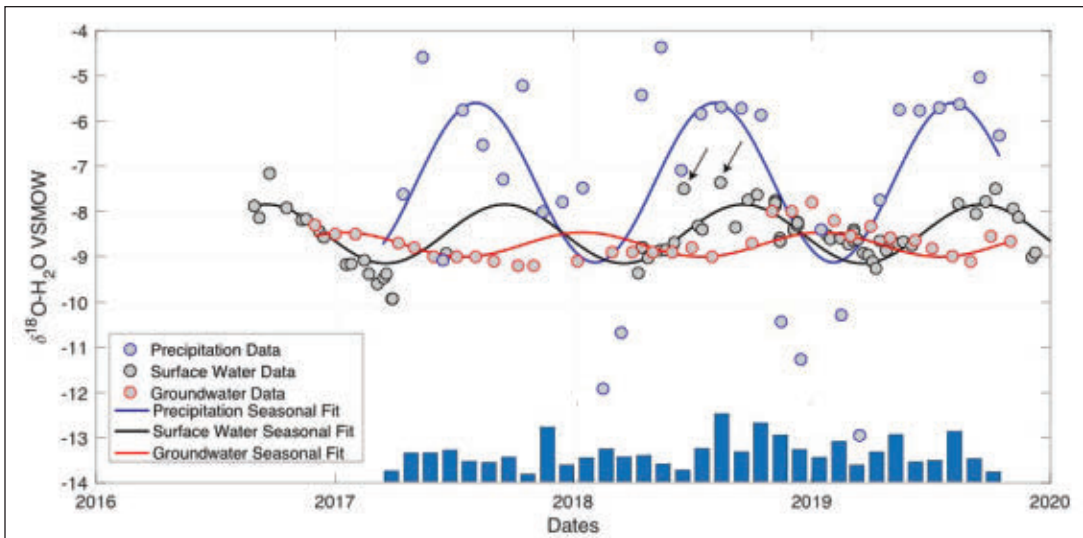


Figure 7. Times Series of long-term monthly samples of precipitation (blue), surface water (black), and groundwater (red) along with seasonal fits.

of precipitation that fell was recorded. Monthly amount-weighted isotopic compositions were calculated by weighting value by amount per month. Stream-water isotope data were downloaded in March of 2021 from the NEON Hop Brook sampling station in the Quabbin reservoir watershed (NEON, 2021). Hop Brook has similar watershed characteristics to MBD and EBU. Groundwater samples were monthly grab samples collected from a nearby bedrock well in Belchertown, MA (N 42.309252°, E -72.394310°) which sits close to the watershed divide between the Fort River watershed and the Swift River watershed (which drains into the Quabbin reservoir).

We present samples of precipitation, surface water and bedrock groundwater collected in the general region of the Quabbin reservoir. Data from 2016–2020 is plotted in a dual isotope plot in Figure 6. All data plot close and to the left of the LMWL consistent with water isotopes of the region (Cole and Boutt, 2021). Precipitation stable isotopes are more variable and have a larger range (-13 to -4 in $\delta^{18}\text{O}$ ‰) compared to surface water and groundwater samples. Surface water samples form a slightly compact flattened ellipse to the left of the LMWL with a range of -10 to -7 in $\delta^{18}\text{O}$ ‰. The bedrock groundwater samples plot in a similar region and are also variable with an even smaller range (-9 to -7.5 in $\delta^{18}\text{O}$ ‰). All samples plot close to one another and have median values that progress from precipitation waters

having most enriched to groundwater having least (precipitation [-6.8 $\delta^{18}\text{O}$ ‰], surface water [-8.6 $\delta^{18}\text{O}$ ‰], groundwater [-8.8 $\delta^{18}\text{O}$ ‰]). This trend is consistent with the differences documented by Cole and Boutt (2021) and reflects a winter bias in surface water and groundwater recharge processes. Interestingly, the differences in mean and median values of surface water and groundwater are almost identical and reflect a strong source of groundwater to surface water. There is strong consistency between the precipitation surface water and groundwater samples, despite these being samples of opportunity and not within a single instrumented watershed. This shows the power and utility of using the isotopes to track hydrological connections.

Temporal analysis of the isotope data shows important patterns and relationships between the datasets (Figure 7). Precipitation seasonal patterns of $\delta^{18}\text{O}$ ‰ show most enriched values in summer and least enriched in late winter. As described in Cole (2019) and Cole and Boutt (2021) these patterns are predominantly driven by seasonal air temperature with a secondary control on moisture transport into the region (Punstag et al, 2016). The surface water also follows this seasonal signal but is much damped in the magnitude of amplitude. Close inspection of the data in the summer of 2018 shows individual months (highlighted with arrows) with increases in isotopic composition due to intense summer

$\delta^{18}\text{O}$	a	b	c	Amplitude (per mil)	Older than 2 months
Precipitation	1.6	-	-	1.8	-
Surface Water	0.6	0.2	8.5	0.7	63%
Groundwater	-0.2	0.2	8.7	0.3	85%

Table 2. Fit parameters for seasonal isotope fit and of data and lines presented in Figure 7. The older than 2 months percentages are based on the amplitude ration of surface and groundwater to precipitation.

precipitation events that fall back to baseflow conditions. Bedrock groundwater shows much less variability but still changes seasonally and perhaps due to periods of enhanced groundwater recharge.

To aid in the quantification of seasonal trends and illuminate the differences in amplitudes and phase shifts seasonal sine wave fits to each dataset (von Freyberg et al., 2018) are presented as solid lines in Figure 7. The general fit of this line is described by the equation.

$$y(t) = a \cos 2\pi \frac{1}{365} x - b \sin 2\pi \frac{1}{365} x + c.$$

The parameters a, b, and c are fit using a LOWESS non-linear regression in MATLAB. The fits are intended to capture the broad patterns with the most simplistic set of assumptions, a periodic trend defined by a cosine-sine function and constant parameters over the whole length of the dataset. The parameters of the fits and resulting amplitude of the signal are presented in Table 2. All 3 fits have amplitudes that are non-zero. The precipitation amplitude is largest followed by surface water and groundwater. This is due to surface water having a more rapid response to the seasonal input of precipitation isotopes compared to groundwater. Another important aspect of the fits are the phase shifts (offsets in peaks) in the different waters. The amplitude of the precipitation signal leads in time by the surface water and groundwater by 3 and 6 months respectively. This qualitative observation gives some insight into the storage/response time of the watershed hydrologic system. The amplitudes can be quantitatively expressed as an amplitude ratio between the precipitation and surface and groundwater respectively. Kirchner (2016) showed that this ratio expressed a percentage is proportional to the new/old water in

the stream with lower percentages having less new water. The percentages (Table 2) for surface water was 63% (1-minus amplitude ratio) older than 2 months and groundwater 85% older than 2 months water. The surface water percentage is broadly similar to the new/old water component from the event analysis. Clearly the precipitation fits do not capture the full range of seasonal behavior – especially the winter samples with least enriched in heavy isotope. Therefore, these values are too low because the amplitude of precipitation would be higher if those winter precipitation events depleted in heavy isotope were weighted more. Based on the surface water isotope trends in the winter/spring months it is likely that some of that water is indeed making it to the stream. As will be further evaluated below the bedrock groundwater response is not fit well by the seasonal signal and is more controlled by larger temporal-scale wet and dry periods.

3.3. Aquifer-Pond Interactions in South-East Massachusetts

To investigate the source of water to private wells in an outwash-kettle pond aquifer system we worked with local citizens to collect well water, stream and spring water samples and pond waters over a period of approximately a year. Prior work in this aquifer system (Hare et al., 2015) documented the impact of pond evaporation and subsequent re-infiltration of that water on groundwater isotopic composition. That study showed that some groundwater wells had compositions that were significantly impacted by evaporative enrichment in heavy stable isotopes of water. The intent of this study was to examine the temporal and spatial variability of the isotopic composition of the different waters in the sole-source aquifer system with a focus on establishing the magnitude of pond re-infiltration on groundwater composition. The aquifer of study is the Plymouth-Carver aquifer system which consists of glacial outwash deposits up to 100m thick with deep kettle ponds and pitted outwash plain deposits. The ponds themselves are outcrops of the water table where water moves through the ponds and often times undergoes different amounts of evaporation enrichment (Lapham and Hanson, 1982; Masterson et al, 2009). Numerous springs feed different ponds and often are the source of small streams that either connect ponds or drain

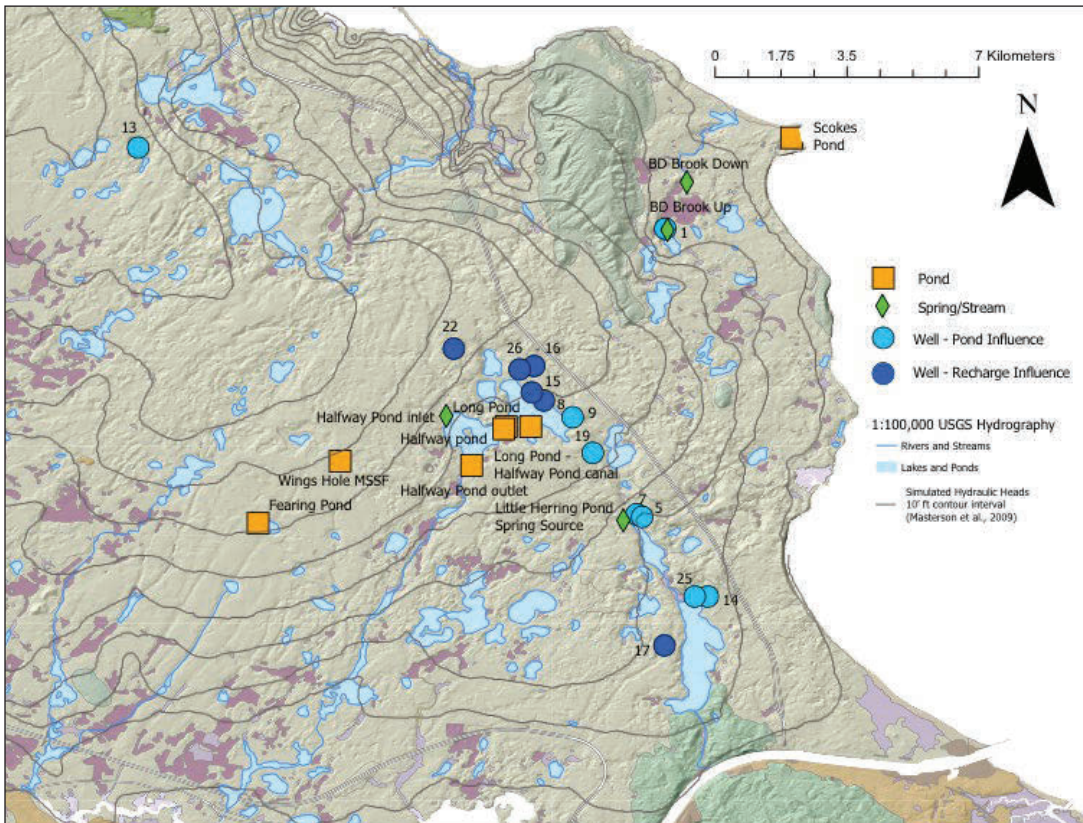


Figure 8. Site map showing location of wells (blue circles), spring/stream (green triangles) and ponds (yellow squares) sampled for isotopic composition. Wells are identified that have little to no pond influence are in dark blue circles compared to those that do are in light blue. Numbers (wells) and names (pond and spring/streams) are labeled and correspond to tabulated data. Simulated hydraulic heads from Masterson et al. (2009) are shown in light black lines.

the regional aquifer system. Therefore, streams here tend to be fed entirely by groundwater discharge rather than direct rainfall sources.

We report here a data set consisting of 77 (14 distinct sites) total groundwater analyses, 44 (7 distinct sites) pond water analyses, and 33 (4 distinct sites) springs and stream water analyses. Locations of sample sites are shown on Figure 8 with local town boundaries, aquifer boundaries, water table contours, surface water features and sample sites. Sample sites are clustered along flow lines from the main recharge area of the aquifer system towards the coast and ponds. Isotope data is presented as a dual isotope plot in Figure 9A and a violin plot in Figure 9B. All sample types fall across almost the complete range of isotopic compositions analyzed. Six of the sampled wells fall in a cluster of the most depleted in heavy isotopes, likely reflecting the mean-mixed recharge composition

of the Plymouth-Carver aquifer. This composition is distinct from the rest of the waters sampled and represents an end-member composition for the aquifer system. There are wells that do not fall into that group and fall off a line tangent to the meteoric water line, which represents the mixing of recharge water composition with water that has undergone evaporative enrichment. The ponds sampled also fall along this line (arrow). This line defines the local open-water evaporative enrichment line for the region which is sensitive to humidity and seasonal air temperatures. The springs and streams fall along this line consistent with them being sourced from discharge from a mixture of the regional groundwater system. The springs and streams have the smallest mean of all sites and the smallest range (Figure 9B). The 7 pond sites that were sampled fall into 3 clusters. These clusters represent some fraction of what the pond water might look like in the

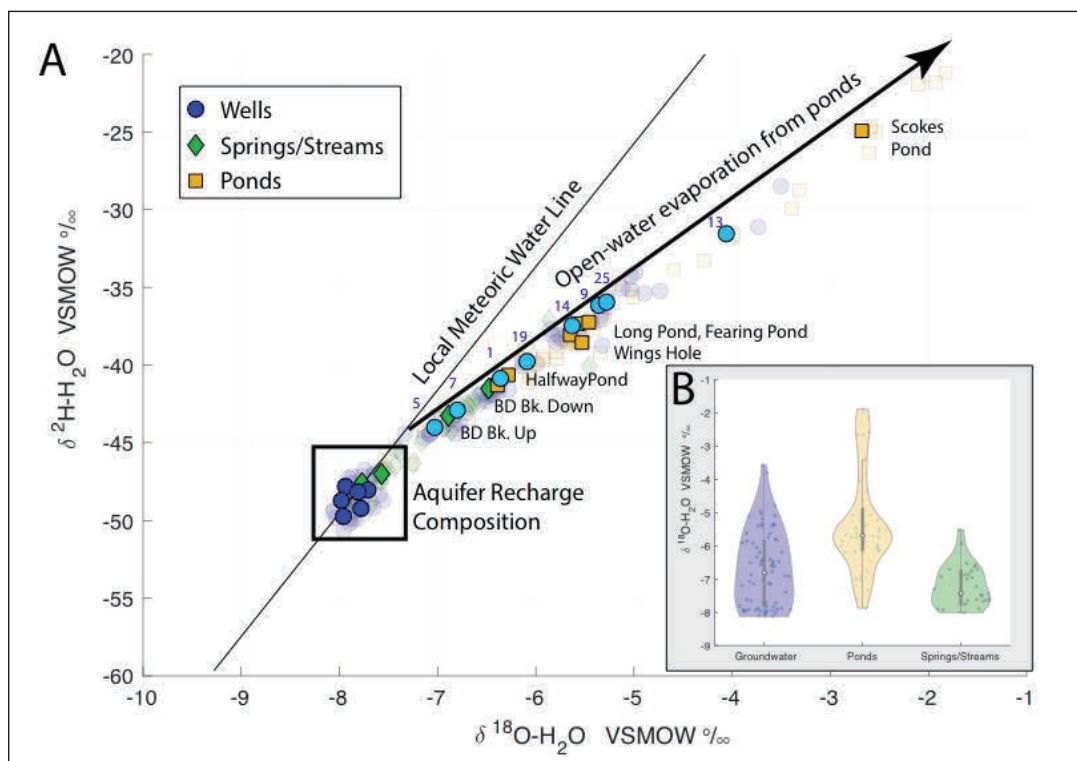


Figure 9. A) Dual-isotope plot from samples from the Plymouth-Carver aquifer system. Dark symbols represent average composition of waters over the period of sampling while the transparent symbols represent all samples analyzed. Individual pond groupings are labeled. B) Violin plot showing the distribution of $\delta^{18}\text{O}$ of all samples analyzed.

region. The most significantly distinct pond is Skokes pond which is a small coastal pond that has a wide range of isotopic composition with a mean value between -2 to -3 per mil in $\delta^{18}\text{O}$. This composition suggests that this pond has a short residence time and volume and is likely disconnected from the regional groundwater flow system. The samples from Halfway pond fall towards the other end of the open-water evaporation line and must be primarily source from groundwater recharge that has undergone some evaporation.

The wells that fall along the open-water evaporation line must have some dominant composition of water that spent time in different ponds. They fall remarkably along a wide range of isotopic composition. This suggests that these wells must intercept discrete flow paths and are sourcing water from the aquifer in locations directly down hydraulic gradient from ponds or pond-groundwater mixtures. A map of sample sites (Figure 8) provides some insight into possible mechanistic explanations for the isotopic

composition. Wells with recharge dominated compositions (dark blue circles) almost exclusively plot near the recharge of the aquifer and up-hydraulic gradient from ponds. The wells with pond influences either plot directly down hydraulic gradient from a pond or at elevations of lower hydraulic head. There is no systematic trend in this (i.e. groundwaters don't necessarily become more pond enriched along a flowline) but they do fall in spatial clusters of similar pond-influenced compositions. This supports nested flowlines of local recharge influencing where and when the groundwaters intercept direct recharge or pond re-infiltration. Another factor not explored here is the impact of well screen depth on the isotopic composition. Unpublished data from a piezometer nest in the region suggest that the aquifer might be isotopically stratified with depth. This is supported by comparing the 'BD Bk. Up' sample (green triangle in Figure 9), which is a spring fed stream to a co-located groundwater sample '1' that has a screen depth of ~20m. The stream sample is more isotopically depleted than

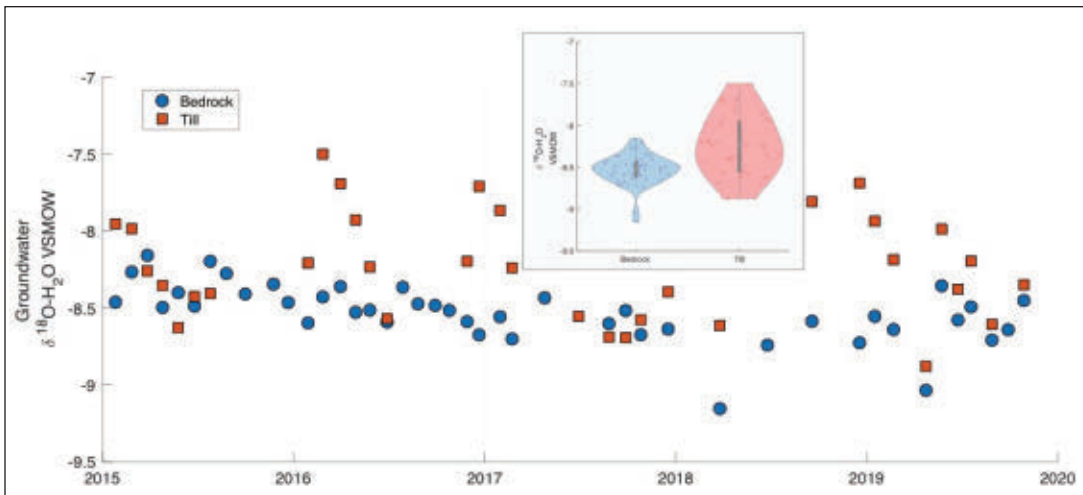


Figure 10. A) Time series of shallow till (red) aquifer and bedrock (blue) $\delta^2\text{H}$ isotopic composition in Shutesbury, Massachusetts. B) Inset shows dual isotope plot for same data shown in A. Isotopic composition of till water is much quicker to respond to precipitation events than the bedrock.

the “deep” groundwater at this site suggesting a nested flow path of pond re-infiltrated water being captured by the drinking water well at this site (Hare et al., 2015).

3.4. Till-Bedrock Recharge Processes in Shutesbury, Massachusetts

The movement of precipitation to subsurface soils, sediments, and rocks (e.g. groundwater recharge) is an important process to understand for groundwater quality and aquifer sustainability (REF). In the New England region where with the majority of the area is covered with thin soils over shallow bedrock, recharge into bedrock aquifers must transit the shallow or thick glacial sediments. In many upland areas these sediments consist of poorly sorted silt, sand, and gravel with a genetic descriptor used for them as till. Recent work (Boutt, 2016) using physical data has shown that till deposits in Massachusetts for example store and release a significant amount of water throughout the hydrologic year that feeds headwater streams and may pass some of that water to underlying bedrock. We present a 5-year time series of stable water isotope analyses from a well located in a till-bedrock nest to understand the isotopic composition of possible recharge water and underlying bedrock aquifer isotopic response.

Isotope samples come from two wells in Shutesbury, Massachusetts at the very top of

the watershed divide (~400m asl) between the Swift River watershed to the east and Connecticut River watershed to the west. There are two wells at the location (within 1 m² region), a shallow well installed in till with a 1m screen at 3m depth and a 100m deep bedrock well with an open hole from 20-100m. Depth of bedrock at the site is approximately 4m. The bedrock well is part of the USGS climate response monitoring well network with ID 422703072243401. Mean depth to water over the course of sampling for the shallow well was 2m and for bedrock well was 27m, with annual water level fluctuations for the shallow well on the order of 0.5-1m and the bedrock well 2m. Plots of hydraulic head of both wells (not shown) have no offset in time and seem to be seasonally synced. At the peak of the 2016 drought, the water table in the shallow till well dropped below the well screen. Given the depth of the wells and their hydraulic heads its clear that the till aquifer is perched on top of the bedrock aquifer. There is a potential for downward flow but without other data it is unclear if till aquifer feeds the bedrock aquifer.

Wells were sampled using a 0.5 inch bailer and represent discrete grab samples. Figure 10A presents an almost monthly time series of $\delta^{18}\text{O}$ VSMOW ‰ for the till and bedrock well. The mean bedrock water isotopic composition is statistically distinct from that of the till water (Figure 10B). There is a range of overlap between

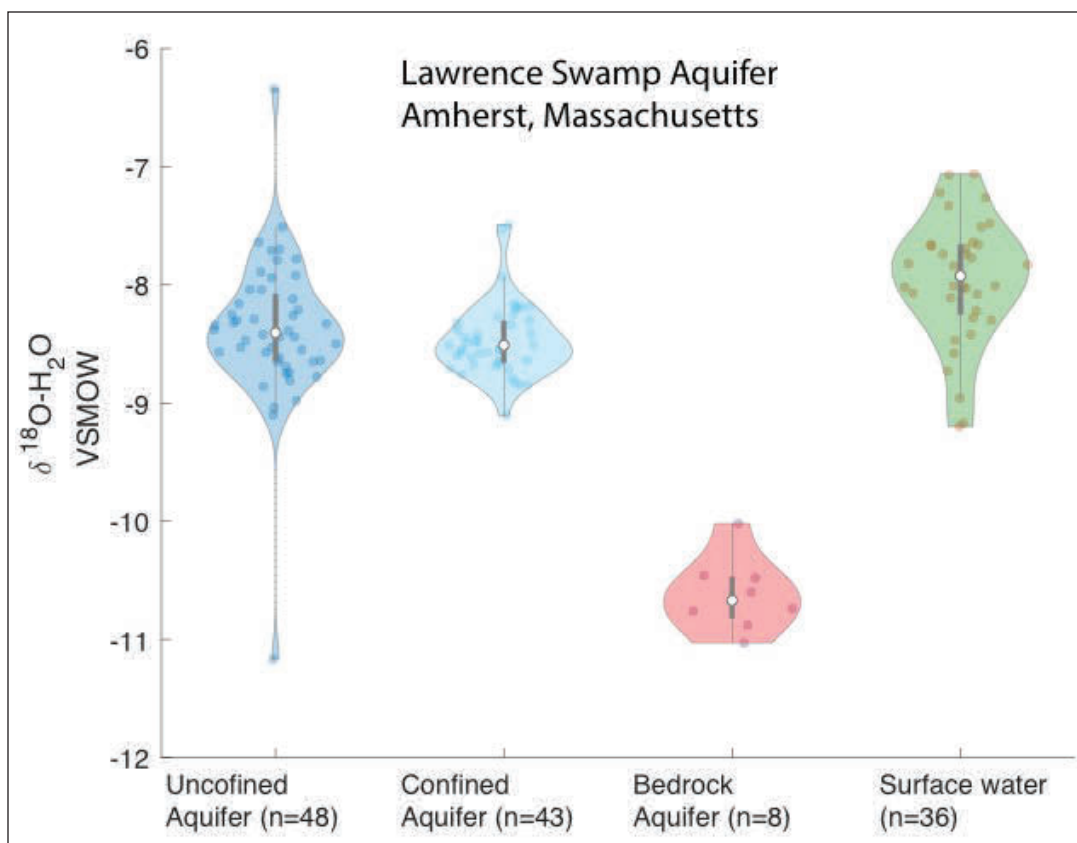


Figure 11. Violin plot of aggregated data from water samples collected at the Lawrence Swamp Aquifer system in Massachusetts. Data is from 6 unconfined aquifer wells, 5 confined aquifer wells, 1 bedrock well, and 4 surface water locations.

the two compositions at around -8.5 ‰ that is likely the mean average recharge and aquifer composition. There are distinct periods of increased (more positive) isotopic composition in the winter of 2016, 2017, and 2019 where it appears more isotopically enriched waters are moving into the till deposit consistent with the timing of recharge in these aquifers (non-growing season). These waters are isotopically enriched for the time of year (see precipitation data in Figure 7) and must be late-summer/fall precipitation mobilized by winter recharge pulses of water. The general trend for both till and bedrock water compositions are towards more depleted isotopic compositions consistent with observations presented in Boutt et al., 2019 that documented region wide multi-year isotopic depletion trends in groundwater and surface water. An interesting observation made here is that the till water never seems to become more isotopically depleted (more negative) than the

bedrock water. There are two possible explanations for this. First, the only water that percolates to the bedrock aquifer is water of an isotopic composition that exists in the till during mid-late summer times. Second, the bedrock aquifer is not fed directly from vertical recharge through the till but sourced from another source laterally. The position of these wells at the top of the divide does potentially rule out this second explanation, but given the water level of 20m below the land surface does leave open the possibility of some lateral source. The occurrence of similar isotopic compositions at times, it does suggest a distinct connection between the two systems. An additional constraint that the isotopic data allow us to conclude is that of the storage volumes and residence time of the aquifer. Since the till aquifer isotopic composition responds quickly to recharge events it suggests that the volume of water in the thin deposit is small and that water moves in/out

quickly. On the other hand, the bedrock aquifer isotopic composition hardly changes ($\sim 0.5\text{‰}$), suggesting that the volume of water is quite large. This is furthermore the case with 3m hydraulic head changes seasonally.

3.5. Aquifer System Interaction in Lawrence Swamp Aquifer, Massachusetts

We investigated the differences in the isotopic composition of surface and groundwater in the Town of Amherst, Massachusetts groundwater aquifer system. This aquifer system sits in a topographic depression called the Lawrence Swamp basin (low point elevation of 49m asl) and provides water year-round to the Amherst water supply through 5 permitted wells. The sediments of the basin were deposited in a glacial lake environment under the influence of melt-water discharge that deposited coarse-to-fine sand with the center of the basin composed of up to 30m thick fine-grained silt unit that serves as a local aquitard. Wells are screened along the margins of the depression (unconfined conditions) and through the thickest part of the basin in a confined aquifer. Wells sampled for isotopic compositions of the waters, at land surface elevations of 49 to 67m asl, ranged in depths from 3-6m ($n=6$, unconfined) to 46m ($n=5$, confined aquifer) and a single 40m bedrock well that is screened below the glacial sediment package. Additional samples ($n=4$) were collected through a shallow slow-moving stream (Hop Brook) that discharges into the Fort River. Monthly samples were collected from approximately October 2012 to September 2013. The 2013 hydrologic year was a typical year with average precipitation (Boutt et al., 2019).

Results of isotopic analyses for all groundwaters and surface waters are presented as a violin plot in Figure 11. Data is aggregated across aquifer type to investigate general patterns. The unconfined aquifer shows the largest range of isotopic compositions from -11 to -7.5 in $\delta^{18}\text{O}$ VSMOW ‰. The confined aquifer shows a much smaller range but a similar median composition than the unconfined aquifer. The mean recharge composition here seems to be about -8.5 $\delta^{18}\text{O}$ VSMOW ‰, which supports a significant bias in winter recharge compared to the precipitation of -6.8 $\delta^{18}\text{O}$ VSMOW ‰. Consistent with Cole and Boutt (2021) the surface water is more

enriched in heavy isotopes (more positive values) than the groundwater. This is related to the preferential inclusion of more enriched summer precipitation events. The coincidence of similar median isotopic compositions between the glacial aquifer units and surface water suggests a local recharge source and strong connections between the aquifers. This is consistent with prior work in the basin for managing the towns water supply (Geraghty and Miller, 1987).

The bedrock aquifer has an extremely distinct set of compositions. In fact, this water is the most isotopically distinct groundwater (see Cole and Boutt (2021) that has been analyzed or reported. There are few mechanisms to explain such a negative value. The only times of year precipitation becomes this negative is in the winter (see Figure 7). If this water is modern groundwater, the bedrock would have to be solely recharged from the most depleted (negative) precipitation events. This is extremely unlikely as one would expect to see this signature in other observation wells or aquifers. No other wells in the Cole and Boutt (2021) database show ranges of similar composition. Another possible explanation is that this bedrock groundwater is sourced from high elevation recharge (which tends to be more isotopically depleted (negative). This is not supported by the data presented in the case above (Figure 10) where samples in a similar recharge area at the local maximum elevation of 400m asl have minimum compositions around -8.5 - -9 $\delta^{18}\text{O}$ VSMOW ‰. The most plausible explanation of the isotopic composition of this water is that it is relic groundwater of a past colder climate where the mean recharge composition was significantly more negative (by about 2 ‰ in $\delta^{18}\text{O}$). The bedrock aquifer composition suggests 1) that it has little connection to above unconfined/confined aquifers and 2) the bedrock water here essentially no modern hydrologic connections to the surface. This is an important finding for 2 reasons. First, prior work in the basin had suggested possible inflow to the glacial aquifer through bedrock pathways (Geraghty and Miller, 1987). Second, concerns of possible connections between the bedrock aquifer and a local landfill have been raised. The data presented here suggest that both scenarios are unlikely based on the isotopic composition.

4. Concluding Remarks and Recommendations

The case studies presented here represent a range of investigations into the sources, pathways, and residence times of water transiting the terrestrial hydrologic cycle. A key theme and conclusion from these studies is that the response of the hydrologic system is not instantaneous and water storage on and below the surface is key to deciphering pathways and velocity distributions. A key point of emphasis emerges from considering the conclusions of each of these cases. Constraining the residence time of water in these systems is of critical importance to watershed managers and stakeholders and there are two main reasons for this. First, the time water spends on the surface or in subsurface has first order controls on the chemical composition, contamination risk, and water quality. This residence time effect is not always observable based on physical hydrologic assessment. Second, by integrating knowledge gleaned from isotopic tracers (such as pathways and water source) one can reduce conceptual uncertainty in their hydrologic system. For example, sources of chloride to streams and reservoirs during spring runoff might be implicated to snowmelt and near-surface sources based on chloride concentrations and hydrograph response. However, stable isotope data suggest that stored groundwater dominates discharge during these times. Understanding those sources is key to managing solute loads to streams.

A number of the case studies presented here focused on the quantification of new/old water in streams and groundwater. Physically these quantifications are associated with the physical mechanisms by which water is transported to streams, the water table, and drinking water wells. Oftentimes conceptual models of stream flow generation simplify the rainfall-runoff process. Under different land-use conditions (e.g. agriculture, forest, and urban) these processes can be drastically different. Understanding hydrograph response based on the physical and isotopic response can be critical to conceptualizing how these systems behave and can be managed for storm water quantity and quality purposes. Ultimately the fraction of new/old water in streams is a measure of the relative residence time of the water in the watershed to that drainage point. Smaller fractions of old water

in streams indicate that the reservoir is turned over quickly and might be subjected to times of water deficits. Small old water fractions can also suggest that contaminants or solutes can move quickly to streams and less diluted by other water in the system.

These case studies demonstrate the maturity of isotopic tools as tracers in hydrologic and watershed science. This affords the incorporation of these methods into typical water, wastewater, and environmental monitoring and consulting. The collection of the water samples for stable isotopes is very simple and have essentially infinite hold times if the bottle is sealed tight with small head space. The low cost of analysis (~\$10-20) per sample and many labs around the region allow easy incorporation into projects. Depending on the nature of project objectives/goals, we suggest frequent sampling of surface water (as allowed) to establish seasonal patterns. For projects investigating sources of water to streams (for example from CSOs or impervious surfaces), event sample is critical. Collection of pre-event, event, and post-event is ideal and allows the most robust interpretation. For projects investigating contaminant transport or source water to wells, spatial sampling of monitoring wells is often more important than temporal (as compositions don't tend to vary much and spatial variability dominates – see Cole and Boutt (2021)). Finally, we encourage interested parties to pilot the use of these tools and develop frameworks and mechanisms to incorporate them into their existing work plans. For example, Cole and Boutt (2021) worked with local watershed monitoring programs to collect additional samples of stream water through a project funded by the Massachusetts Environmental Trust. We believe the use of that data and the insights have yet to be fully used to their potential.

While the application of isotopic tracers for water resource and water quality problems in the region has matured significantly there are still basic research needs and investments in instrumentation and monitoring. These investments will broaden applications, reduce uncertainty in interpretation and provide valuable data of the regions water resources. Isotopic tracing requires a robust understanding of the input signals into the hydrologic system (i.e. precipitation). Cole (2019) established 14 stations

(of which 10 are still collecting data) by working with volunteers to sample and composite precipitation. Effort and resources should be spent in maintaining the existing distribution of precipitation collection stations and fund analyses. Baseline sampling of surface water and groundwater should be continued and collected on a quarterly basis for surface water and annual basis for groundwater. Ideally co-location stable isotopes samples with stream discharge locations would enable extended analysis and interpretation capabilities. Finally, academic hydrologists in the region should continue to develop understanding of isotope systematics in watersheds across the region. It would be useful to develop an increased understanding of the impacts of soil and tree water use on water isotopes, especially in the context of understanding water transport through soils to streams and groundwater. The improved understanding of isotopic enrichment in heavy isotopes due to surface water storage (in wetlands, ponds, etc) should be investigated in a systematic way. Together these analyses could provide novel insights applicable to water resource management in New England and beyond.

5. Acknowledgements

The work reported here is the result of a greater than 10-year commitment of the Hydrogeology Lab at UMass-Amherst to establish the use of stable isotopes in understanding regional hydrologic systems of New England. None of the work reported here would have been possible without the countless people and entities that have collected samples or allowed us to collect samples at their sites including: Massachusetts Department Conservation and Recreation (especially Yuehlin Lee, Brett Boisjolie and Drew Forest), Town of Amherst DPW (Guilford Mooring and Amy Rusieki), Office of the Massachusetts State Geologist (Stephen Mabee), Al Werner, Jim Holden, Living Observatory (Glorianna Davenport) and Plymouth MA Isoscape volunteers. Thanks to Phil Lamothe for generating the site maps for the Quabbin study sites in Figure 3. Thanks to all the undergraduate and graduate students in the Hydrogeology group that contributed to sample collection and analysis over the years. Thanks to Brett Boisjolie (MA-DCR) for a detailed review and comments on an earlier version of the manuscript.

References

- Berden, G., Peeters, R., and Meijer, G., 2000, Cavity ring-down spectroscopy: Experimental schemes and applications: *Int. Reviews in Physical Chemistry*, Vol. 19, No. 4. 565–607.
- Beven K. (2002). Toward a coherent philosophy for modelling the environment *Proc. R. Soc. A* 458 1–20
- Boutt D.F., Assessing hydrogeologic controls on dynamic groundwater storage using long-term instrumental records of water table levels, *Hydrological Processes*, 2017; 31 (7): 1479 doi: 10.1002/hyp.11119.
- Boutt, D. F., Mabee, S. B., & Yu, Q. (2019). Multiyear increase in the stable isotopic composition of stream water from groundwater recharge due to extreme precipitation. *Geophysical Research Letters*, 46. <https://doi.org/10.1029/2019GL082828>
- Bowen, G. J., J. R. Ehleringer, L. A. Chesson, E. Stange, T. E. Cerling, (2007), Stable isotope ratios of tap water in the contiguous United States, *Water Resources Research*, 43, W03419, doi:10.1029/2006WR005186.
- Brand, W.A., and 3 others, 2009, Cavity ring-down spectroscopy versus high-temperature conversion isotope ratio mass spectrometry; a case study on $\delta^2\text{H}$ and $\delta^{18}\text{O}$ of pure water samples and alcohol/water mixtures: *Rapid Commun. Mass Spectrom.* 2009; 23: 1879–1884.
- Brooks, JR, Barnard, HR, Coulombe, R., McDonnell, JJ. 2009. Ecohydrologic separation of water between trees and streams in a Mediterranean climate. *Nature Geoscience*. DOI: 10.1038/NGEO722
- Clark, I., and Fritz, P., 1997, *Environmental Isotopes in Hydrogeology*: CRC Press LLC, Boca Raton, FL.
- Cole, Alison (2019) Spatial and Temporal Mapping of Distributed Precipitation, Surface and Groundwater Stable Isotopes Enables Insights into Hydrologic Processes Operating at a Catchment Scale. Masters Theses. 823. https://scholarworks.umass.edu/masters_theses_2/823
- Cole, A. and Boutt, D.F. (2021) Spatially-Resolved Integrated Precipitation-Surface-Groundwater Water Isotope Mapping From Crowd Sourcing: Toward Understanding Water Cycling Across a Post-glacial Landscape. *Front. Water* 3:645634. doi: 10.3389/frwa.2021.645634
- Cook PG and Bohlke J-K. 2000. Determining timescales for groundwater flow and solute transport. In *Environmental Tracers in Subsurface Hydrology*, Cook PG, Herczeg AL (eds). Kluwer Academic Publishers: Norwell, MA; 1–30.
- Cooper, L.W., 1988, Isotopic fractionation in snow cover: in, Kendall C., and McDonnell, J.J. (eds), *Isotope Tracers in Catchment Hydrology*, Elsevier, Amsterdam.
- Coplen TB (2011) Guidelines and recommended terms for expression of stable isotope-ratio and gas-ratio measurement results. *Rapid Communications in Mass Spectrometry* 25: 2538–2560.
- Craig, H. (1961). Isotopic variations in meteoric waters. *Science*, 133(3465), 1702–1703. <https://doi.org/10.1126/science.133.3465.1702>
- Dincer T. 1968. The use of oxygen-18 and deuterium concentrations in the water balance of lakes. *Water Resources Research* 4: 289–1306.
- Gat JR. 1981. Lakes. In *Stable Isotope Hydrology*, Gat JR, Gonfiantini R (eds). Technical Report Series No. 210. International Atomic Energy Agency: Vienna; 203–222.
- Geraghty and Miller, Inc. 1987. Ground-water Management Plan for the Hop Brook Drainage Basin, Volume II, Prepared for the Town of Amherst, January 1987.

- Gonfiantini R. 1986. Environmental isotopes in lake studies. In *Handbook of Environmental Isotope Geochemistry*, Fritz P, Fontes J (eds). Elsevier Scientific: Amsterdam, Netherlands; 113–167.
- Hansen, B.P., and Lapham, W.W., 1992, *Geohydrology and simulated groundwater flow, Plymouth-Carver aquifer, southeastern Massachusetts*: U.S. Geological Survey Water-Resources Investigations Report 90–4204, 69 p.
- Hare, D. K., Boutt, D. F., Clement, W. P., Hatch, C. E., Davenport, G., and Hackman, A.: Hydrogeological controls on spatial patterns of groundwater discharge in peatlands, *Hydrol. Earth Syst. Sci.*, 21, 6031–6048, <https://doi.org/10.5194/hess-21-6031-2017>, 2017.
- Ingraham, N.L., 1998, Isotopic Variation in Precipitation: in, Kendall C., and McDonnell, J.J. (eds), *Isotope Tracers in Catchment Hydrology*, Elsevier, Amsterdam.
- Jasechko, S., S. Birks, T. Gleeson, et al., (2014), The pronounced seasonality of global groundwater recharge, *Water Resources Research*, 50: 8845–8867, doi: 10.1002/2014WR015809
- Kendall C, Doctor DH. 2004. Stable isotope applications in hydrologic studies. In *Treatise on Geochemistry, Surface and Ground Water, Weathering, and Soils*, vol. 5, Drever JJ (ed.). Elsevier: 319–364.
- Kendall C, McDonnell JJ (eds). 1998. *Isotope Tracers in Catchment Hydrology*. Elsevier: Amsterdam.
- Kendall, C., T. B. Coplen, (2001), Distribution of oxygen-18 and deuterium in river waters across the United States, *Hydrological processes.*, 15: 1363–1393, doi:10.1002/hyp.217.
- Kendall, C., Doctor, D.H and M.B. Young, 7.9 – Environmental Isotope Applications in Hydrologic Studies, Editor(s): Heinrich D. Holland, Karl K. Turekian, *Treatise on Geochemistry (Second Edition)*, Elsevier, 2014, Pages 273–327, <https://doi.org/10.1016/B978-0-08-095975-7.00510-6>.
- Kirchner JW. 2003. A double paradox in catchment hydrology and geochemistry. *Hydrological Processes* 17: 871–874.
- Kirchner, J. W. 2016. Aggregation in environmental systems – Part 1: Seasonal tracer cycles quantify young water fractions, but not mean transit times, in spatially heterogeneous catchments, *Hydrol. Earth Syst. Sci.*, 20, 279–297, <https://doi.org/10.5194/hess-20-279-2016>, 2016a.
- Masterson, J. P., Carlson, C. S., and Walter, D. A.: Hydrogeology and simulation of groundwater flow in the Plymouth-Carver-Kingston-Duxbury aquifer system, southeastern Massachusetts, *Scientific Investigations Report* 2009–5063, 110 pp., 2009.
- McGuire, K., and McDonnell, J., 2007, *Stable isotope tracers in watershed hydrology*: in, Michener, R., and Lajtha, K., eds., *Stable Isotopes in Ecology and Environmental Science*, Blackwell Publishing, Malden, MA.
- McDonnell, J.J. 1990. A rationale of old water discharge through macropores in a steep, humid catchment. *Water Resources Research* 26(1): 2821–2832.
- McDonnell, J. 2017. Beyond the water balance. *Nature Geosci* 10, 396. <https://doi.org/10.1038/ngeo2964>
- National Ecological Observatory Network (2021). Data Product DP1.20206.001, Stable isotopes in surface water. Provisional data downloaded from <http://data.neonscience.org> on March 9, 2021. Battelle, Boulder, CO, USA NEON. 2021.
- Penna, D., et al., (2012), Technical Note: Evaluation of between-sample memory effects in the analysis of $\delta^2\text{H}$ and $\delta^{18}\text{O}$ of water samples measured by laser spectroscopes, *Hydrol. Earth Syst. Sci.*, 16, 3925–3933, doi: 10.5194/hess-16-392.
- Puntsag, T., M. J. Myron, J. L. Campbell, E. S. Klein, G. E. Likens, W.M. Welker, (2016), Arctic Vortex changes alter the sources and isotopic values of precipitation in northeastern US, *Scientific Report*, 6:22647 doi:10.1038/srep22647.
- Reddy, M. M., P. Schuster, C. Kendall, M. B. Reddy, (2006), Characterization of surface and ground water $\delta^{18}\text{O}$ seasonal variation and its use for estimating ground water residence times, *Hydrological Processes*, 20: 1753–1772, doi: 10.1002/hpy.5953.
- Schmadel, N.M, Harvey, J.W., & G.E. Schwarz (2021) Seasonally dynamic nutrient modeling quantifies storage lags and time-varying reactivity across large river basins, *Environ. Res. Lett.* 16 095004
- Shanley, J. B., Strause, J. L., & Risley, J. C. (1995). Effects of selective forest clearing fertilization, and liming on the hydrology and water quality of a small tributary to the Quabbin Reservoir, central Massachusetts. In *Water-Resources Investigations Report*. <https://doi.org/10.3133/wri954124>
- Sharp, Z., 2009, *Principles of Stable Isotope Geochemistry*: Pearson, Education, Inc., Upper Saddle River, NJ.
- Sprenger, M., D. Tetzlaff, J. Buttle, et al., (2016), Measuring and Modeling Stable Isotopes of Mobile and Bulk Soil Water, *Vadose Zone Journal*, 17(1): 0, doi: <https://dl.sciencesocieties.org/publications/vzj/abstracts/17/1/170149>.
- Sprenger, M., Stumpp, C., Weiler, M., Aeschbach, W., Allen, S. T., Benettin, P., et al. (2019). The demographics of water: A review of water ages in the critical zone. *Reviews of Geophysics*, 57. <https://doi.org/10.1029/2018RG000633>
- Van Meter K J, Van Cappellen P and Basu N B 2018 Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico *Science* 360 427 LP–430
- von Freyberg, J., S.T. Allen, S. Seeger, M. Weiler, J.W. Kirchner (2018), Sensitivity of young water fractions to hydro-climatic forcing and landscape properties across 22 Swiss catchments, *Hydrol. Earth Syst. Sci.*, 22, 3841–3861, <https://doi.org/10.5194/hess-22-3841-2018>.
- Timsic, S., W. P. Patterson, (2014), Spatial variability in stable isotope values of surface waters of Eastern Canada and New England, *Journal of Hydrology*, 511: 594–604, doi: 10.1016/j.jhydrol.2014.02.
- Wassenaar L.I., and 6 others, 2012, Worldwide proficiency test for routine analysis of $\delta^2\text{H}$ and $\delta^{18}\text{O}$ in water by isotope-ratio mass spectrometry and laser absorption spectroscopy: *Rapid Commun. Mass Spectrom.* 2012, 26, 1641–1648 ([wileyonlinelibrary.com](http://www.wileyonlinelibrary.com)) DOI: 10.1002/rcm.6270
- Winograd IJ, Riggs AC, Coplen TB. 1998. The relative contributions of summer and cool-season precipitation to groundwater recharge, Spring Mountains, Nevada, USA. *Hydrogeology Journal* 6: 77–93.
- Zell WO, Culver TB and Sanford WE. 2018 Prediction uncertainty and data worth assessment for groundwater transport times in an agricultural catchment *J. Hydrol.* 561 1019–36

WATER SYSTEM PROFILE

Middleborough Water Department Middleborough, Massachusetts

System Overview

Town of Middleborough Water Department customers receive their water from groundwater sources. The East Grove Street, Rock #1 and #2, East Main Street #1, #1A, #1B and #2, Tispaquin #1 (offline) and #2, Cross Street, Plympton Street, Miller Street and Spruce Street wells are located within the Taunton River basin. The Town has received high susceptibility ratings for 8 of 11 wells and moderate for the remaining 3 wells in town. These ratings are due to the absence of natural barriers to contamination in the aquifers that supply these wells, which makes them vulnerable. The two new East Main Street Satellite Wells were installed after the SWAP Report was completed; their susceptibility is high, similar to that of the original East Main Street Wells #1 and #2.

The main focus of this article is the construction of the East Main Street treatment facility. The East Main Street treatment facility utilizes Well #1, Satellite Wells #1A and #1B and #2 Well. The wells are filtered through a biological filtration process for iron and manganese removal. Note all the well supplies are treated for pH adjustment with potassium hydroxide, and sodium hypochlorite is added for disinfection purposes. Additionally, the East Grove Street Well is filtered through a slow sand filter. Also, a new distribution elevated storage tank was built replacing the Fire Tower elevated tank.

Water System Information	
System Name	East Main Street Water Treatment Plant, Middleborough, Massachusetts
Date of Origin	1885
Population served	16,839
Service Connections	6,244
Miles of pipe	130
Average Daily Demand	1.7 MGD
Maximum Daily Use	2.64 MGD
Storage Facilities	2
Wells	11
Treatment Plants	8
Fire Hydrants	800
Average Monthly Water Bill	Median price is \$47.44 for 7,500 gallons

Searching for a Sustainable Solution for a Long-Term Water Quality Issue

The Town of Middleborough began searching for a solution in the early 2000's after residents were experiencing high concentrations of iron and manganese in their water supply. Iron and manganese are abundant elements found in soil that can dissolve into groundwater used in community drinking water sources. Being common elements in New England groundwater, they impacted the Town's wells, water distribution piping and storage tanks. Residents experienced discolored water, stained household fixtures, and fouled in-home filters.



At the time the project began, there was no regulatory requirement to remove iron and manganese from groundwater, but the Town wanted to move forward with a solution because it was proving to be problematic for residents. The Town was regularly testing the groundwater and discovered that the water supply contained levels that exceeded the Secondary Maximum Contaminant Levels established at that time by the Massachusetts Department of Environmental Protection (MassDEP). Today, the Massachusetts Office of Research and Standards Guidelines has set up regulations and set a limit of 0.3 mg/L.

In 2005, the Town of Middleborough requested a pilot study be conducted to establish the best type of water treatment for the East Main Street well site. This study was conducted at a neighboring wellfield and compared biological iron and manganese filtration to the chemically enhanced option of GreensandPlus™ filtration.

Exploring Cutting-Edge Technology for Water Treatment in Middleborough

Based on the study, the Town ultimately viewed biological filtration as the best treatment option. At the time, biological filtration was a relatively new water treatment technology in New England as no Massachusetts public water supplier was using this type of treatment.

The biological filtration process is a unique and relatively new water treatment technology in the United States that does not use chemicals to achieve oxidation. The process works in two stages, with the iron filter first removing dissolved iron, followed by the manganese filter removing dissolved manganese.

Microorganisms that oxidize iron and manganese are naturally occurring and can be found in groundwater sources throughout the world. Biological filtration harnesses the abilities of these naturally occurring bacteria to oxidize iron and manganese in groundwater. Biological iron and manganese oxidation are typically accomplished by striking a delicate balance with pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) in the groundwater to create the proper environment for the naturally occurring iron- and manganese-oxidizing bacteria. The bacteria will then attach itself to the filters and cause the iron and manganese to precipitate through oxidation. The oxidized iron and manganese are filtered out in the media, reducing the iron and manganese levels in the treated water.

Tighe & Bond used the data collected during the pilot study to prepare an application for New Technology Approval to MassDEP. This regulatory permit protects the public's health and welfare through the control of any product or operation that comes into contact with public drinking water.



New Technology Approval was granted by MassDEP in August 2006. The approval allowed the Town of Middleborough and Tighe & Bond to proceed with the design and construction of a new treatment facility using this new technology. This approval had a ripple effect on the industry, allowing other public water suppliers the ability to consider the use of this new technology as a solution for their treatment needs.

In 2007, Tighe & Bond proceeded with the design of the biological water treatment plant that would remove the iron and manganese from the East Main Street wellfield. The original wellfield contained two gravel packed wells known as Well No.1 and Well No.2. The wells had a combined pumping capacity of approximately 500 gallons per minute (gpm), which was well below their total permitted capacity of 640 gpm.

In December 2008, Tighe & Bond submitted design plans and received MassDEP approval to construct a full-scale biological iron and manganese facility to treat the East Main Street wells using the cutting-edge biological filtration. The treatment plant was designed to treat up to 960 gallons per minute (1.38 million gallons per day).

Due to political and economic factors, the Town of Middleborough decided to postpone the construction of the water treatment plant. The project did not resume until 2014 when the Town reached out to Tighe & Bond to begin the process of completing the design and construc-

tion of the treatment plant project. Meanwhile, the issue with Middleborough's water quality at the East Main Street wells persisted.

Creating a Sustainable Water Treatment Plant Design

As part of the restart of the project, the biological treatment manufacturer Infilco Degremont (currently owned by SUEZ) partnered with Blueleaf Inc. to complete another pilot study at the East Main Street wells. The purpose of this study was to verify there were no significant changes in water quality from the previous 2005 pilot study and because the study was conducted at a different wellfield, the team needed to confirm that no changes were needed in the filtration system design. This study confirmed the design parameters were appropriate for proper performance and operation of the proposed biological system.

Tighe & Bond submitted the Pilot Study for MassDEP approval and then began updating the eight-year-old treatment facility design to bring it up to current building codes and design standards.

The biological filtration water treatment plant design took into account a plethora of sustainable, economic and social implications. Winston Builders Corporation of Westborough, MA was awarded a contract in December 2016 to construct the East Main Street Water Treatment Plant. They were required to purchase and install the Infilco Degremont Filter system that was specifically pilot tested in 2006 and 2014 for this project. Infilco Degremont is now owned by Suez North America. The filters for this biological system are more sustainable because of the denser and more

crystalline metal precipitates formed by bacterial oxidation. This allows the filters to hold more precipitated material and operate longer between backwashes. Fewer backwashes also yield less backwash water which provides the Town of Middleborough with a more sustainable system and less operational and maintenance costs.

During the studies from the pilot program, it was found that choosing a traditional chemically enhanced filtration system would produce approximately 20,000 gallons of backwash wastewater per day. With biological filtration, the system was estimated to produce only 3,500 gallons per day or 1/5th the amount of wasted water. Less wasted water was an important factor in the technology selection process at this site as all residuals need to be hauled away for disposal. The limited available area of the treatment plant site did not allow for on-site disposal of the backwash water and the closest municipal sewer was located over one mile from the site. With less backwash wastewater to be hauled away, the biological system reduced disposal costs for the Town.

The design also included improvements to the East Main Street wells in order to maximize production capacity. Two new satellite wells were permitted and installed at Well No. 1 in order to increase the pumping capacity of this source. These three wells along with Well No. 2 can now pump a maximum of 960 gallons per minute (1.38 MGD) to the water treatment plant. The two new satellite wells are equipped with glass bead packing. This is a new technology that allows for a more efficient development procedure for the well construction, and a more efficient flow through the well. The beads are a byproduct of other production processes (which makes them environmentally friendly) and are National Sanitation Foundation certified for drinking water. The glass beads reduce operation and maintenance costs by increasing well efficiency and enhancing a longer lifetime cycle for the wells. All four wells were outfitted with Variable Frequency Drives (VFD). VFDs control the frequency of the electrical power supplied to a pump and provide significant power savings for the Town.

The size of the water treatment plant's recycling system was taken into careful consideration during the design for installation at this constrained site. The size of recycle tanks was able to be minimized due to the reduced volume of waste backwash water produced by the biological filtration system as compared to chemically enhanced adsorptive pressure filtration. With a limited amount of available area left at the site, the Town was also able to install a solar panel array that was constructed on a pedestal adjacent to the plant. This solar panel array is a smart system that rotates and tilts to follow the sun and maximize energy production.

Completing a Successful Alternative to Traditional Water Treatment

The Town of Middleborough received MassDEP approval for the completed construction of the \$6.75M East Main Street Treatment Plant on December 18, 2018. This complex project required the teamwork of multiple entities over a decade of communication and advocacy for sustainable water treatment technology. Since the plant has been on-line, the Town has observed that the plant's filters operate longer between scheduled backwashes, use less chemicals in the treatment process, and significantly reduce the amount of wasted water when compared to other traditional treatment options. There has also been a significant decline in water quality complaints and residents have commented on the noticeable improvement in their drinking water.

Special recognition: In December of 2020, the Middleborough Water Department received a Public Water System Award for outstanding performance and achievement in the medium and large Community Systems Category and another Public Water System Award for energy conservation in 2019 from MassDEP.

Information and photos courtesy of:

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Correction of Information in the September 2021 issue of the *Journal*

In the Water System Profile of the Rochester, NH, Water Department in the section, Information Courtesy of, the name of Karl Duffield was inadvertently omitted. At the time he was an engineer with Wright-Pierce of Portsmouth, NH.

Proceedings

2019-2020 Committee Reports Standards Council

S263 Polyolefin Pressure Pipe & Fittings Committee

Committee Mission: Track and summarize revisions to ANSI/AWWA Standards C901, C903, C904, C906 and AWWA M55

Committee Goals:

- Maintain a constant link with AWWA staff in Denver and with AWWA 263 Committee members worldwide
- Provide input from NE AWWA members regarding issues related to standards, design and installation of PE piping systems.
- Communicate revisions to NE AWWA members.

Committee Meetings:

- AWWA 263 Committee: Due to COVID-19, AWWA cancelled ACE20 in Denver; the committee is chaired by John Fishburne, PE, previously with Charlotte Water and currently with consulting firm, Freeze & Nichols.
- AWWA 263 Subcommittees: AWWA M55, AWWA C901, C903, C904, C906

Committee Members: Chair (M55, C901 and C906 Subcommittees)- Camille George Rubeiz, PE, F. ASCE

Updated and Published Standards:

- This AWWA Standards Committee has been busy updating the AWWA M55 (2006), PE Pipe- Design and Installation. Design engineers and utilities should refer to this Manual when designing and specifying HDPE (PE4710) piping systems using open cut and trenchless (HDD, Pipe Bursting and Sliplining). The Manual is expected to be published by December 2020.
- Similarly, the AWWA 263 committee updated C901. The Committee reached consensus and AWWA Standards Council approved it. The ANSI and AWWA Public Review will close on 8/24/2020. C901 is expected to be published by January 2021.
- The complete and detailed AWWA HDPE Standards and Manual (including C901, C906, and M55) are available from the AWWA website, www.awwa.org

Future Plans:

- AWWA C903, C904 and C906: Revisions to these Standards will be initiated by 2021
Respectfully submitted,
Camille George Rubeiz, PE, F. ASCE, Chair, NEWWA 263 CMT and Secretary, AWWA 263 CMT.

Scale and Corrosion Control Chemicals Committee

Committee Mission: To develop and maintain standards and related materials for chemicals and other substances used in the control of scale and internal corrosion in water distribution systems, including: B404, B502, B503, B504, B505, B506, B50A (Phosphoric Acid), B50X (Calcium Carbonate), and B50Y (Blended Orthopolyphosphate).

Accomplishments/Activities and New Initiatives During the Past Year (Sept. 2019-2020):

- Standard B404 Liquid Sodium Silicate was reviewed, and changes balloted.

Plans for 2021:

- Ensure AWWA standards and recommendations for corrosion control chemicals are reviewed and up-to-date.
- B50A – Limestone Contactor Material – New Standard Draft review

2019-2020 Committee Meeting Dates/Locations: None

Committee Member Roster:

R.A. Ryder – Chair N.J. Edman E.H. Leung N.E. McTigue D. Orozco	R.D. Vaidya H.T. Belcher Jr. C.P. Principi H. Stiefel D.M. LaFalam	J.D. Musinski R.M. Powell Y. Zhang
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Other Committee Related Efforts: N/A

Succession Planning – Incoming Committee Chair & Anticipated Appointment Date: N/A

Respectfully submitted, Darin LaFalam, Chair

Sluice Gates Committee

As an Active Member of the AWWA Gate Standards team; I am happy to report that we are close to a final vote on the 4-Gate Standards, that include: the Cast Iron Slide Gates C560; the Stainless Steel Slide Gates C561; the Aluminum Slide Gates C562 and the Non-Metallic Slide Gates C563.

The final vote is expected by our group by the end of August 2020. Once these Standards each have a majority vote; then it moves on to the next step where the Standards Council will take a separate vote.

Assuming that this final step is completed by the end of 2020; it will then be sent to the printers.

Four updated Gate Standards should all be completed by the Spring of 2021; at which time they will be available, and they will be in compliance with the protocol of being reviewed every 5 years.

I hope that this short update report is of help to the NEWWA Committees.

Respectfully submitted by:

Paul Brunelle, Chair, Rodney Hunt Inc.

S287 Steel Pipe Committee

Committee Meetings: The AWWA Steel Pipe Standards Committee did not meet for the Annual Conference and Exposition (ACE20), scheduled for June 14-17, 2020, in Orlando. It was canceled due to the COVID-19 pandemic.

Committee Members:

John H. Bambei, Jr – Chair	Wayne Geyer	Kaushal Parbhoo
Bob Card – Vice Chair	Rusty Gibson	Tao Peng
John Luka – Secretary	Mike Gossett	Andy Romer
Liz Ralph – SEL, AWWA	Shelly Hattan	George Ruchti
Martin Garcia – SCL	Mike Horsley	V. Scutelnicu
Lucas Adams	Rami Issa	Brett Simpson
George Anderson	Brent Keil	Russ Snow
Sam Arnaout	Christine Kirby	Andrew Stanton
Henry Bardakjian	Raz Konyalian	Chris Sundberg
Bob Cheng	Ray Kufaas	Matt Turney
Roger Coffey	Martin Lobik	Bill Whidden
Dennis Dechant	Jeff Mattson	John Wise
Darren Dunker	Rich Mielke	Ricky Wu
Brent Fountain	Adam Murdock	
Javier Garcia	Rafael Ortega	

SEL, Standards Engineer Liaison; nonvoting | SCL, Standards Council Liaison; nonvoting

Accomplishments/Activities and New Initiatives during the Past Year (2019-2020): The following AWWA Standard(s) and/or Manual(s) were reviewed, approved and published (unless noted) this past year:

- C-203 – Coal-Tar Protective Coatings and Linings for Steel Water; Revision Approved by Steel Committee & sent to the Standards Council for balloting
- C-209-19 – Tape Coatings for Steel Water Pipe and Fittings; Effective 12/1/2019
- C-210 – Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings; Addendum Approved by Steel Committee & sent to the Standards Council for balloting
- C-214 – Machine-Applied Polyolefin Tape Coatings for Steel Water Pipe; In Recirculation balloting
- C-225-20 – Fused Polyolefin Coatings for Steel Water Pipe; Effective 7/1/2020
- C-229-20 – Fusion-Bonded Polyethylene Coatings for Steel Water Pipe and Fittings; Effective 8/1/2020
- M11 – Steel Pipe; 5th ed. Addendum

Future Plans: The Steel Pipe Committee is responsible for (26) Standards and (1) Manual. The goal is to review and update the Standards every (5) years or earlier as needed.

Respectfully submitted,

Martin J. Lobik, P.E., Chair, Springfield Water and Sewer Commission

S334 Taste & Odor Control Chemicals Committee

Committee Mission: To develop and maintain standards and related manuals, reports, etc., for the chemicals and other substances used in the control of taste and odor in water supplies, including AWWA B512, B601, B602, B603, and B2HO (Hydrogen Peroxide).

Committee Goals:

- To assist in maintaining AWWA Standards and communicate developments to the NEWWA members.
- Maintain a constant link and presence with AWWA Staff, Shareholders, and other members of the AWWA Committee.

Committee Meetings:

- AWWA Committee did not meet this year.

Accomplishments/Activities and New Initiatives During the Past Year (2019-2020):

- No Standards were published or updated.

Future Plans:

- Next Standard up for Revision is B512-15 Sulfur Dioxide in 2020.
- To develop and publish a new Standard for Hydrogen Peroxide, collecting from new member expertise.

Other Committee Related Efforts:

- Focus on recruitment of new members for the AWWA Committee.

Respectfully submitted, Bradley E. Perron, Chair, NEWWA S334 Committee

S510 Water Main Rehabilitation Committee

Committee Mission: The committee is liaison to AWWA through both the Standards Council and the Technical & Education Council, for water main rehabilitation standards and manuals of practice.

Committee Goals: AWWA M28 is under the purview of the TEC. Educational outreach at ACE and other conferences is also included in the TEC council goals.

Development and updates to ANSI accredited standards on pipe rehabilitation are included under the standards council, such as C620 spray in place liners (2019 revision issued), upcoming C621 (2018) on internal joint seals, and additional draft standards anticipated to be finalized over the next two years on cured in place pipe (CIPP), pipe bursting, and sliplining.

Committee Meetings: The national committee meets at least annually at ACE and ASCE Pipelines. No local committee meetings were held. Additional monthly calls have been held throughout the pandemic.

Committee Members:

Ian Mead, Tighe & Bond, Worcester, MA – Committee Chair
Chris Dzidek, Boston Water & Sewer Commission, Boston, MA
Colleen Heath, CDM Smith, Boston, MA

Accomplishments/Activities and New Initiatives During the Past Year (Sept. 2019 – Aug. 2020): Updates of M28 are ongoing. The committee has split up chapters for revision and review. National committees met at ASCE Pipelines 2019 and remotely to review potential educational initiatives, plans for additional outreach and potential 2020 webinars.

The committee also worked with AWWA to develop a new manual of practice, M81, targeted at rehabilitation of larger diameter water mains requiring pipe entry. This initiative has been kicked off, membership is expanding, and a preliminary table of contents, draft chapters, and work groups are being established.

Future Plans: The workgroup will continue holding monthly conference calls to review the revised M28 manual sections and progress. A separate workgroup is working on a draft standard for CIPP. Another committee is continuing development of the first version of new manual M81 for large diameter mains. Follow up on workshops, potential in-person meetings as the pandemic continues, and additional manuals/standards will continue.

Respectfully submitted,
Ian W. Mead, PE, BCEE, Chair

S404 Water Service Line Fittings Committee

Committee Mission: To assure interchangeability of fittings with corporation stop inlet threads and copper tubing threads; and to provide performance standards and materials specifications for underground service line fittings, including C800.

Committee Goals:

- To assist in maintaining AWWA Standards and communicate developments to the NEWWA members.
- Maintain a constant link and presence with AWWA Staff, Shareholders, and other members of the AWWA Committee.

Committee Meetings:

- AWWA Committee met at remotely in 2020, in lieu of ACE20 cancelation.
- Most communication occurs by email, with occasional conference calls.

Accomplishments/Activities and New Initiatives During the Past Year (2019-2020): Continuing its work from last year, the Committee has been working extensively to develop approval methodologies and testing requirements to control and permit new alloy materials into the C800 Standard. There is a concern in the industry that all current alloys are Bismuth-based, with most Bismuth isolated to certain geological areas. This is ongoing and approval has affected the next revision.

Future Plans:

- Standard C800 was up for Revision in 2019. Revision was balloted and received significant negative comments, due to inclusion of different untested alloys. Further discussion is warranted, based on voting on a new Silicon-based alloy.

Other Committee Related Efforts:

- Finalizing C800 revision with committee comments.
- Respectfully submitted,
Bradley E. Perron, Chair, NEWWA S404 Committee

Wire Wound Prestressed Concrete Water Tanks Committee

Committee Mission: Track areas in Standard being considered for revisions.

Committee Goals:

- Interact with the National AWWA Committee.
- Communicate potential AWWA D-110 Standard revisions.

Committee Meetings: None held this year.

Committee Members: Chair – William Powers

Accomplishments/Activities and New Initiatives During the Past Year (2019-2020):

- National Committee continues to discuss, and solicit input from AWWA membership, ways to revise the current ANSI-AWWA D110-13 Standard. AWWA strives for the release of new standards every 5 years. Current standard remains D110-13(R18) issued in 2018.
- National Committee has leaders assigned to all chapters in the standard. At this time no definitive changes have been identified.

Future Plans: Continue to monitor potential revisions to AWWA standard.

Other Committee Related Efforts: Nothing further to report.

Recommendation for Committee Chair: No change

Respectfully submitted, William Powers, Chair

Water Quality/Treatment Council Report

5 Committees:

- Filtration Committee: (Mike Caso Chair)
 - ♦ Well over 100 attendees for WQ Symposium May 2019 in Milford MA focusing on PFAS/PFOA with an excellent group of speakers.
 - ♦ Filter Surveillance Workshops to continue with one at Worchester Plant and one elsewhere in New England.
 - ♦ Welcomes several new members this year.
 - ♦ In process of finalizing the May 6, 2020 Symposium topics and obtaining speakers
- Water Treatment Plant Residuals: (Eric Kelley & Marc Moran Co-chairs)
 - ♦ Have met over past year
 - ♦ Online survey type and practices in NE complete
 - ♦ Water Treatment Plant Residuals class content updated
 - ♦ Class not held in 2019 due to low numbers
 - ♦ Residuals based presentation at the Spring Conference in 2019.
 - ♦ Plan to offer class in late spring or fall of 2020
- Disinfection Committee: (James Collins Chair)
 - ♦ Historically offered 2 Courses (Disinfectant and Drinking Water Distribution Quality AND Using Chloramines as a Drinking Water Disinfectant)
 - ♦ Developed a draft policy document regarding handling and storage of sodium hypochlorite as it pertains to chlorite, chlorate, and perchlorate formation.
 - ♦ The Chloramines course was offered at Manchester NH in 2019 was not run due to low numbers.
- Corrosion Control Committee: (Cathy DiPietro Chair)
 - ♦ Recruiting of new members continues with goal of course offering in 2021.
- Fluorides Committee (Without a Chair)
 - ♦ No Chair since retirement of previous Chair
 - ♦ Staff plans to restructure 2010 course to keep pace with CDC recommendations
 - ♦ Recruiting members with a goal of course offering in 2021.

Disinfection Committee

Committee Mission: To review all current reports and literature relating to water disinfection practices. To survey and report on technology and all aspects of disinfection required to produce high quality, palatable water to meet quality goals.

Accomplishments/Activities and New Initiatives During the Past Year (Sept. 2019-2020):

- Had plans to hold an in-person meeting at the April conference to plan out activities for the remainder of the year. Meetings have been postponed due to COVID.
- Meeting being scheduled for Sept/Oct to determine future plans.

- Identify co-chair or secretary (David Miller, Kyle Hay and Michaela Bogosh have expressed interest).

Plans for 2021:

- Hold at least two in person or virtual trainings
- Integrate others into leadership roles

2019-2020 Committee Meeting Dates/Locations:

- Spring meeting cancelled due to COVID
- Planned meeting for Sept/Oct

Committee Member Roster:	
Christopher Jacobs – United Water New Jersey Dave Miller – Manchester Water Works Andrea Traviglia – US EPA Gregg Giasson – Providence Water Supply Board James Collins – Tighe and Bond Paul Riendeau – NEWWA John Cordaro – Wright-Pierce Bob Stoops – Springfield Wtr & Swr Commission	Thomas Cutler – Norwich Public Utilities Soni Pradhanang – University of Rhode Island Kyle Hay – Weston and Sampson Chris Astephen – White Water Hichem Hadjeres – Canopus Water Maria Franko – Kleinfelder Rebecca Paustian – Woodard & Curran Michaela Bogosh – CDM Smith

Other Committee Related Efforts/Notes: N/A

Succession Planning – Incoming Leaders & Anticipated Appointment Date: David Miller, Kyle Hay and Michaela Bogosh have expressed interest in leadership roles
Respectfully submitted,
James Collins, Chair

Filtration Committee

The Filtration Committee continues to look at how best to serve the Water Professionals in New England. As with every sector of business, Covid has required adjustments and creative alternatives to provide information and services to those in need. The in person 2020 WQS scheduled for May in Milford, MA was not able to take place. The online WQS is presently scheduled for December 2020. Committee members have finalized the conference schedule to put forth a shorter, but just as informative, online version of the originally planned seminar. We have retained many of the speakers and look forward to this new format.

The Filter Surveillance Workshop series has been postponed until we can safely hold it at a municipal facility. The Committee is hopeful this will be in early 2021.

We have added several new younger members and look forward to their contribution, especially in this new era of communicating. With the New Normal still an unknown, the Filtration Committee looks to be flexible and creative to continue the many years of being a resource to our industry.

Respectfully submitted,
Michael J. Caso, Chair

Water Treatment Plant Residuals Committee

Committee Mission: To study and report on areas related to drinking water treatment plant (WTP) residuals management. To make recommendations to the NEWWA board on processing, disposal, and beneficial reuse of WTP residuals, related water works practice issues/technology, regulatory permitting requirements, and technology transfer.

Accomplishments/Activities and New Initiatives During the Past Year (2019-2020): The committee planned for another annual WTP Residuals Management operator training class for the fall of 2019, which unfortunately could not be held due to limited registrations. Plans are underway to host a future the training class at Pennichuck's Water Treatment Plant in Nashua, NH.

The Committee continues to track several regulatory issues related to drinking water residuals including NPDES General Permit discharges from Water Treatment Plants and considerations for emerging

contaminants such as PFAS in residuals. Committee members are currently scheduled to speak at the future Water Quality Symposium on the topic of PFAS and water treatment residuals management.

Recently EPA Region 1 invited the Committee Chair to attend an academic presentation on research being undertaken by the University of Vermont regarding application of residuals for phosphorous control in stormwater treatment structures. The results of the study are pending publication in a peer reviewed journal.

Committee Members:

Patrick Burke, Holland Company Christopher Countie, Pennichuck Water Works James Cray, Wright-Pierce James Finegan, Lynnfield Water District Sean Griffin, MADEP Eric Kelley, Environmental Partners Group, Inc.	Anthony Drouin, NHDES Robert Little, Woodard & Curran, Inc. Todd Melanson, Chelmsford Water District David G. Miller, Manchester Water Works Marc Morin, Hazen and Sawyer Don Bunker, NEWWA
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Respectfully submitted, Marc Morin and Eric Kelley, Co-Chairs, Water Treatment Plant Residuals Committee

New England Water Works Association
Annual Executive Director and Staff Report
Year Ending June 30, 2021
September 7, 2021 – Omni Mt. Washington Resort –
Bretton Woods, NH

Foreword:

I look forward to the year I can address the membership without having to say: “well, that was an interesting one.” But yet again, NEWWA’s 2020-2021 fiscal year proved to be just that, combined with a lot of evolution and coming together of so many of our members, volunteers, students, and staff.

When reading through this year’s Annual Executive Director and Staff Report you will notice a theme, and that is of our people. While the pandemic had a lot of dark days, the people involved with NEWWA proved to be a shining light that kept us moving forward to help us reach the other side changed, but once again whole.

OUR PEOPLE



While the pandemic had a lot of dark days, the people involved with NEWWA proved to be a shining light that kept us moving forward to help us reach the other side changed, but once again whole.

So many committees and members did yeoman’s work to ensure NEWWA could continue to provide valuable service even though we physically could not be together. Many committees are featured throughout the below pages, which are a highlight of the additional work undertaken by so many more. This year once again proved what an amazing group of peers we all have as water works professionals.

In addition to our fantastic volunteers, NEWWA’s staff worked (and con-

tinues to work) so hard to keep all of the behind-the-scenes work flowing. From initiating a computer software upgrade to applying for Payroll Protection Program monies, to facilitating hundreds of Zoom calls, it was a “different” year but also an incredibly productive one.

And finally, I would like to highlight our first fully “virtual” President, Lisa Gove, who established, worked on, and executed several presidential goals, all while behind a computer screen. The dedication and grace at which Lisa faced an unprecedented year must be noted and commended. All of us thank her for her dedication and look forward to finally celebrating with her, in person, at our Annual Conference in September 2021.

Thank you all again for staying with us through yet another difficult year. We truly enjoy the camaraderie and fun you continue to bring and look forward to even more.

Sincerely,

Kirsten King, Executive Director

1. Membership

The association experienced a 4.02% decrease in total membership from FY2020 to the end of FY2021. NEWWA, Inc. membership decreased from 482 to 424 total members, while New England Section membership decreased from 1,834 to 1,799 total members.

During FY2020, NEWWA, Inc. membership saw a 12.03% decrease in membership overall, driven by losses in the individual member category, which fell from 190 to 150 members. NEWWA, Inc. organizational membership decreased by about 10%. New England Section membership decreased by about 2%.

The Membership Committee hosted its second webinar on November 10, 2020. This webinar provides a general overview of the benefits of a NEWWA membership and presentation highlights active members in the association from different regions throughout New England. The webinar recording is available on NEWWA's YouTube channel and a link is provided to all new members in their welcome materials.

The Membership Committee participated in the 2020 Membership Challenge but did not meet the goal of increasing section membership by 2% or retaining 65% of first year members (the section retained 47,

the goal was 57 members.) The committee is participating in the 2021 Membership Challenge, which ends December 2021. The plan includes reviving the Ambassador Program for in person events and a phone outreach campaign to lapsed members. To date, 23 first year members have renewed – the goal is for at least 39 members to renew to meet the 62% retention rate goal.

The Membership Committee continues to support the Mentoring Program, which pairs a newer NEWWA member with an established member from a different area of the water works community. 3 mentees graduated from the program in Spring 2021, 2 mentees are awaiting an opportunity to graduate at a NEWWA event, and there are 10 active mentee/mentor pairs. While the program typically last 6-12 months, pairs have been granted as much time as they need to complete the program due to the ongoing pandemic and its affect on in person events. Two Mentoring Program coordinators and the Membership & Volunteer Coordinator work throughout the year to identify prospective mentees and mentors and support the pairs with resources and ideas for their meetings.

FY2020 MEMBERSHIP STATISTICS				
NEWWA, INC.	Member Category	Member Type	FY20 Ending 6/30/20	FY21 Ending 6/30/21
	Individual	Individual	190	150
		Honorary	8	8
		Life	28	27
		Retired	18	16
		Utility Representative	96	97
		Junior	1	0
		Total Individual Members	341	298
	Organization	Utility	115	104
		Service Provider	26	22
		Total Organization Members	141	126
NEWWA, INC. TOTAL		482	424	
NE SECTION AWWA	Individual	Individual	975	971
		International Individual	0	0
		Honorary	4	4
		Life	83	82
		Main Utility Contact	232	224
		Operations	155	152
		Retired	56	59
		Student	58	42
		Total Individual Members	1,563	1,534
	Organization	Utility	215	208
		Partner Agency	6	8
		Service Provider	50	49
		Total Organization Members	271	265
	NE SECTION AWWA TOTAL		1,834	1,799
NEWWA, INC. AND NE SECTION AWWA TOTAL MEMBERSHIP		2,316	2,223	

With their budget for FY21, the Members Committee designed and sent current members a membership appreciation gift, which was a sticker to put on a water bottle, laptop cover, banjo case, etc. The membership breakdown by category follows:

2. Education and Training Report

Fiscal year 2021 saw the association's Education and Training Program conduct a total of 135 sessions with a total attendance of 3,132 participants a 3% increase from FY 2020.

Training Formats, Online vs In-Person Learning

Following the successful conversion to online learning during FY 2020, NEWWA offered a blend of online and in-person training programs. Starting in September 2020, NEWWA offered its multi-week classes for preparation of taking the Massachusetts Operator Certification exams in a hybrid format. Under this format all lectures were presented via Zoom with in-person students present in the classroom. The two labs were split so that one was completed online while the second required in-person participation. The classes included:

- Technical Training and Drinking Operator Exam Preparation, Grade D1, 6 weeks
- Technical Training and Drinking Operator Exam Preparation, Grade T1, 6 weeks
- Concept and Practices of Advanced Drinking Water Treatment, Grade T3/T4, 12 weeks
- Concept and Practices of Basic Drinking Water Treatment, Grade T2, 12 weeks
- Concept and Practices of Drinking Water Distribution, Grade D2-4, 12 weeks

The vast majority participated via Zoom, as a result the offering of these classes in the Spring of 2021 were offered online only. All students were required to participate in the one in-person lab.

In addition to the multi-week classes, NEWWA offered operations, basic science, and management programs both online and in-person. Because of limitations in technology at the training center and the high level of effort required no additional programs were offered in a hybrid format. During FY 2021 NEWWA offered 135 in-person programs and 76 online programs.

Training Partnerships:

In FY2021 the New Hampshire Department of Environmental Services (NHDES), in conjunction NEWWA delivered a wide range of programs to operators and water systems in the state. NEWWA presented 17 unique programs to a total of 160 New Hampshire operators and managers. All courses were offered online via Zoom.

NEWWA worked with the Rhode Island Department of Health to offer training to RI water suppliers free of charge. Two programs were offered in person at the Pawtucket Water Supply Boards T&D facility. The remainder were offered in an online format. A total of 9 programs were offered to 212 students.

Partnerships in training also remained an important component of the General Education Program. CT Section, AWWA and NEWWA continued to work closely in a collaborative relationship, which has spanned over 30 years. This unique joint effort continued in FY21 in response to operator re-certification requirements and has allowed the two AWWA sections to complement each other's training efforts. A total of 13 programs were offered to 745 students presented in FY21 through this partnership. All programs were offered in an online format.

Staff presented five small system education programs as part of the grant program with AWWA and RCAP Solutions, Inc. During FY2021 programs were offered online for RI, MA, ME, NH, and VT. This is the seventh year NEWWA has worked with AWWA and RCAP on this grant, and another contract was awarded to continue through 2022. In addition, NEWWA assisted with the marketing of training events under the USDA/WWA grant program, with one online learning event presented in RI, MA, ME, NH, and VT throughout the fiscal year. This is also as part of a subcontract with AWWA.

During the Spring and Fall of FY 2021 NEWWA Staff worked with the New Hampshire Water Works Association to offer a 3-day (12 hour) Fundamentals of Water Works Math. The course was offered online. The course was presented in preparation for the NH Operator Certification Exams. NEWWA will continue to offer this course in the Fall of FY 2022.

Contract Training:

During FY21, the association conducted on-site, specialized training programs for public and private organizations throughout New England including: the Boston Water and Sewer Commission, Aquarion

Water Co. of Connecticut, Pawtucket Water Supply Board, Springfield Water and Sewer Commission, CT Section AWWA, NH Department of Environmental Service, and the RI Department of Health. A total of 93 contract training sessions were presented to a total of 1,515 students.

Cross Connection Control Training Program:

The Cross-Connection Control Program remained active with 78 offerings of courses around New England and out of region in Pennsylvania, New York, and New Jersey to a total of 780 students. Most training continued to be in person so that practical examinations could be offered. A new 3-hour recertification review class was developed and offered online.

IACET Authorized Provider Re-Authorization:

The association 5-year IACET authorization expired on May 1, 2021. NEWWA staff worked with IACET staff and commission to reapply for IACET authorization in February 2021. The final site visit occurred on July 16, 2021. NEWWA received its reauthorization on July 19, 2021, retroactive to May 1, 2021. NEWWA's reauthorization is valid for 5 years and will expire on May 1, 2026.

Section Education Award:

Each year, AWWA recognizes sections for initiatives that educate water industry personnel, the public, students, or other groups about water and to disseminate guidelines that will enable other AWWA sections to conduct comparable education activities. NEWWA's 2020 submission focused on NEWWA's transition to online learning – within just 2 weeks of closing the doors to its training facility – as well as how it developed a new course that focused on the pandemic. Specifically:

- From zero to Zoom – NEWWA's lightning speed transition to online learning, and
- The development of the course "Pandemic Problem Solving and Planning."

For these efforts, NEWWA was awarded its 31st AWWA Section Education Award.



FY 2021 Training Report Summary Period July 1, 2020, to June 30, 2021

Topic Area	In Person Programs	Online Programs	Total Attendance
Distribution Operations	10	16	650
Safety	43	0	247
Treatment	3	20	435
Management Development	0	5	102
Water Management	5	15	458
Computer	0	1	38
Science	5	5	124
Specialty Topics	0	5	298
Cross Connection Control and Related Courses	69	9	780
Total	135	76	3,132

Three Year Comparison

	Fiscal Year		
	2021	2020	2019
Total Students	3,132	3,038	4,262
Total Backflow Students	780	560	1,161
Total Programs Scheduled	211	311	299
Total Backflow Programs Scheduled	78	90	81
Total Programs Cancelled (includes backflow)	25	116	44
% of Programs Cancelled	12%	37%	15%
Total Contract training sessions	93 (1,515)	91 (806)	83 (1,283)

3. Conferences and Membership Meetings

The Annual Conference was held virtually September 2- 23, 2020, via Zoom and the Map Dynamics platform. Final attendance reached 162 attendees and 9 exhibiting companies. Overall, attendees were pleased with the first virtual conference experience. The technical sessions ran smoothly and efficiently, without any technical glitches. Robert Bilott, Environmental Attorney, Partner, at Taft Stettinius & Hollister LLP, Cincinnati, OH, and the inspiration behind the Critically Acclaimed Film Dark Waters, was a captivating keynote speaker and drew much positive feedback in the survey results. Awards were mailed to the recipients in advance, and the winners were announced during the conference. See the full list below.

Award of Merit	Mr. Lindle D. Willnow, P.E.
David M. Erickson Groundwater Award	Ms. Sarah Pillsbury
Dexter Brackett Award	Ms. Kristen M. Berger, P.E., ENV S
Diversity Award	Ms. Rachel Gilbert, P.E.
Past Presidents Award	Mr. Robert W. Kortmann
Past Presidents Award	Ms. Elizabeth Cummins
Utility of the Year Award (small size utility)	West Groton Water Supply District
Utility of the Year Award (medium size utility)	Hyannis Water System
Utility of the Year Award (large size utility)	Champlain Water District
Utility Service Award	Salem & Beverly Water Supply Board
Jerome Healey Award	Mr. Richard C. Skarinka
John H. Chafee Distinguished Public Servant Award	Mr. Mark H. Johnson, P.E.
K.O. Hodgson Distinguished Service Award	Mr. Savas C. Danos
Young Professional Employer Support Award	CDM Smith
Sponsor of the Year Award	Putnam Pipe Corp.
Fuller Award	Ms. Sarah Pillsbury
Operator Meritorious Service Award	Mr. Mario Tricomi
Younger Member of the Year Award	Mr. Nathan H. Little
NEWWA Honorary Member Award	Mr. James W. Fay
Lifetime Achievement	Mr. Peter Prescott

As almost all events in 2020, the **Water Resources & Sustainability Symposium** was held virtually October 28, via Zoom. 45 attendees enjoyed technical presentations and a regulatory panel discussion during the half day symposium. This was about 50% attendance compared to the 2019 in-person event.

The NEWWA/NEWEA IT & Asset Management Fair was also held virtually November 4 & 5 via Zoom. There were 41 participants, including presenters. The committee will debrief and determine whether they intend to continue the collaboration with NEWEA again next year.

The December Meeting was held virtually on December 17 via Zoom. For the first time, 2.0 TCHs were available for attending the technical sessions. In lieu of the traditional Water For People raffle, the committee promoted an optional donation with the meeting registration fee in support of Water For People. A total of \$640.00 was raised. 32 folks registered by the early registration deadline and received recipes for Johnny Bourbon's signature cocktail and Farmor Bunker (Bergström's) authentic Swedish Meatballs. In total, the December Meeting had 73 registrants.

The January Meeting held jointly with NHWWA was held virtually on January 21 via Zoom. Once again, this meeting offered a speed networking activity (virtual this year) and a student rate. A new feature to increase virtual participation was a mystery word contest. Presenters included a mystery word in each of their presentations. Attendees listened intently to figure out the five mystery words during the technical presentations and the first person to identify the word won NEWWA swag. Overall, the meeting had strong virtual attendance with 74 water professionals logged in remotely and the group enjoyed the networking breakout rooms at the end of the meeting.

The 35th Annual Ski Classic was held at Gunstock on January 22 with approximately 26 participants. It was a beautiful day on the mountain and the group truly enjoyed the chance to have some socially-distance fun. Special thanks to David Polcari and the Sponsor Services Committee for coordinating this great tradition.

Due to the COVID19 pandemic, NEWWA's Spring Conference shifted to a fully virtual format for 2021, using the Map Dynamics platform. The traditional in-person, two-day conference, was held virtually March 29 – April 1, 2021, and was called **NEWWA Spring Learnapalooza**. The Program Committee developed 18 technical sessions were presented over the course of three days. Attendees could earn up to 12 TCH credits at this event, which is the most we have ever offered at this conference. NEWWA hit a new record for virtual event attendance with 1,122 attendees. Technical sessions saw strong attendance ranging between 100-300+ attendees in each session. The Distribution & Storage session topped the charts with 355 attendees, while the trivia event was the most-popular of the networking opportunities with a group of about 35 participants. The Organization Diversity panel discussion on recruitment and hiring strategies to assist with diversity in the water profession was well-attended with just under 100 folks. In total, 734 participants were eligible for technical credit totaling over 5,350 hours combined.

The conference kicked-off with a virtual hydrant hysteria competition with four teams competing virtually. Bristol County Water Authority was once again crowned the winner. Networking events were held on Tuesday and Wednesday evening. The Young Professionals hosted their traditional meet & greet breakfast, and the Student Activities Committee coordinated ten virtual student presentations.

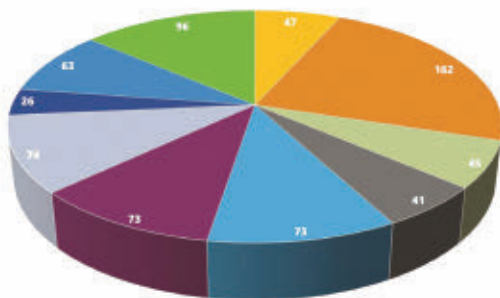
Exhibiting in the virtual world is much different than in-person and participation was significantly lighter than due to the virtual format. NEWWA staff developed sponsorship options that provide more value to the standard virtual "booth" and in an effort to manage expectations, this area of the conference platform was also referred to as the Marketplace rather than exhibit hall.

Preparation with the speakers, moderators, vendors, and students proved to be an integral part in ensuring a smooth presentation. No technological glitches were experienced and only a handful of folks struggled logging into the virtual platform. A big thanks to all the volunteers and staff who made this conference so successful.

The **23rd Annual Water Quality Symposium** was held Wednesday, May 5, 2021 with 63 participants. The Filtration Committee once again developed a robust agenda, this year focusing on recent revisions to the Lead & Copper Rule and the challenges utilities may face because of the detection of and/or treatment of PFAS contamination. With the virtual format, this event was able to include speakers from across the country.

The **28th Annual Golf Classic** was held Monday, May 17, 2021, at the Sterling National Country Club in Sterling, MA, with 96 registered players and 20 sponsoring companies, two of which were new

EVENTS STATISTICS



- Joint NEWWA/NHWWA Membership Meeting | July 14, 2020 | Virtual
- 130th Annual Conference | September 21 – 23, 2020 | Virtual
- Water Resources & Sustainability Symposium | October 28, 2020 | Virtual
- NEWWA/NEWEA IT & Asset Management Fair | November 4 - 5, 2020 | Virtual
- 22nd Annual Water Quality Symposium | December 2, 2020 | Virtual
- December Monthly Membership Meeting | December 17, 2020 | Virtual
- Joint NEWWA/NHWWA Membership Meeting | January 21, 2021 | Virtual
- 35th Annual Ski Classic | January 22, 2021 | Gunstock, NH
- 23rd Annual Water Quality Symposium | May 5, 2021 | Virtual
- 28th Annual Golf Classic | May 17, 2021 | Sterling, MA

Spring Learnapalooza – Virtual – 1,122

sponsors of this event. The tournament raised \$9,000.00 and was well-enjoyed by all participants. Special thanks to the NEWWA Golf-Sub Committee for coordinating this stand-out event.

ACE21 shifted to a fully virtual event, so no in-person luncheon with CTAWWA was coordinated.

The 2021 **NEWWA & RIWWA Joint Membership Meeting** was held virtually on Wednesday, July 14, 2021, with 33 registered attendees including speakers. Attendance was lighter than anticipated, particularly for a virtual event. Many folks had stored up vacation time due to the pandemic and zoom fatigue could also have been a contributing factor for the light attendance.

4. Membership Communications

The E-Source continues to be sent to approximately 2,800 members and non-members on a biweekly basis. The open rate averages between 26 and 30, which is well above the non-profit average of just 20 percent. This low-cost method of membership communications has proven to be highly successful. The E-Source software has also been used for special membership communications, specifically conference follow-up surveys, cross connection control and backflow prevention notifications, state-specific notifications, training-specific marketing, and vendor communications. The E-source continues to be a critical communications tool for NEWWA's membership and stakeholders during the COVID-19 pandemic. In addition, NEWWA's 2021 election was sent via Constant Contact (the E-Source software), with success as well. As a result of the pandemic, NEWWA is moving to shifting most marketing efforts for its events and courses to the electronic format.

NEWWA remains strong on social networking sites, specifically Facebook, Twitter, and Instagram, which has helped broaden communication tools for the members. NEWWA's social media stats are as follows:

- Facebook now has 1,270 fans (an increase of 41 from last year) and 1,523 followers (an increase of 68 from last year).
- Twitter now has 1,510 followers (an increase of 44 from last year).
- Instagram has 897 followers (an increase of 202 over last year).
- The Young Professionals Facebook page has 251 fans (an increase of 30 over last year) and 278 followers (an increase of 38 from last year).
- LinkedIn has 543 followers (an increase of 186 from last year) and 400 group members (a decrease of five from last year).

The traditional form of print communication continues to serve the members in the form of seven memberships mailings each year; four issues of the *Journal*; and seven issues of *Currents*, all of which were published and mailed on time, despite the pandemic. With the continuation of the pandemic, NEWWA halted training mailings and are only marketing events online for the foreseeable future. Membership mailings continue to be sent via mail.

For the *Journal*, NEWWA continues to contract all advertising sales, publishing, printing, and mailing to Naylor Association Solutions. In addition, NEWWA continues to utilize NEWWA member, Jerry Guerra, to ghost write articles based on presentations given at conferences. The Publications Committee also maintained its editorial calendar from the previous year to assist authors and advertisers with better planning what issue of the *Journal* they may want to target for ads or an article. The Publications Committee as well as staff also developed official publication guidelines and missions, which were approved by the board of directors to be placed in NEWWA's policy document. In addition, the advertisement and solicitation of a new *Journal* editor was initiated, with a new editor to be officially named at the 2021 (next fiscal) Annual Conference.

The 2021 Membership Roster was mailed to the members in December 2020. NEWWA has shifted the schedule of the member roster to a calendar year for ease of marketing as well as being in line with the September election results. NEWWA continued its distribution and use of a digital version as well. Naylor Association Solutions manages the advertising sales, design, layout, printing, and mailing of this product. This publication is a member-only benefit and will not be given out at future NEWWA events.

Unfortunately, the Massachusetts Drinking Water Day awards program was held virtually in May 2021 and recognized award winners from across the state. NEWWA partners annually with MWWA and MassDEP on this event.

NEWWA remains involved in the MA Water and Wastewater Agency Response Network (WARN) with staff acting as secretary and maintaining the MAWARN Web site. Due to the pandemic, the MAWARN saw a significant increase in membership, with 113 utilities in Massachusetts now signed on to the

agreement. Staff assisted with multiple MAWARN requests throughout the year, including staffing issues and chemical supply shortages. In addition, NEWWA continues to maintain the RIWARN Web site.

5. Governmental Affairs

The Legislative and Regulatory Affairs Committee, chaired by Steve Estes-Smargiassi of the Massachusetts Water Resources Authority, also saw significant growth during the pandemic. Again, with online committee meetings becoming more of a reality, NEWWA was able to engage members from all New England states. As a result, NEWWA sent a record number of delegates to AWWA's virtual Washington, D.C., Fly-in in the Spring of 2021. In addition, the committee is closely monitoring legislative and regulatory efforts at the federal level, specifically the Lead and Copper Rule, PFAS, and infrastructure funding, communicating with states and coordinating region-wide meetings on these issues, and also writing articles for NEWWA's e-newsletter and member newsletter.

6. Association Development

The 2020 Planning Session, led by Vice President Erica Lotz, was held virtually on Monday July 27, 2020, with the theme of "diversity and inclusion." Despite the pandemic, and this being one of our first large-scale virtual events with almost 50 in attendance, the session went extremely well and received multiple accolades by all who attended. The day included quizzing the attendees via a "privilege walk," breakout sessions to discuss how NEWWA and the water works profession as a whole can embrace diversity and inclusion better, and then a robust panel discussion lead by members of NEWWA and AWWA's Organizational Diversity Committee members. Ideas presented will be the basis for Erica's goal planning as she prepares for her presidential year, which will begin in September 2021.

7. Administrative/Facilities Facility Upgrades

Staff purchased three Arlo security cameras and placed them at the front door, back door, and in the back of the building to add an extra layer of security for the facility as well as staff. Staff receives motion alerts and can monitor these cameras on their smartphones 24/7. This was due to increased vehicular traffic in our parking lot as well as behind the building near the dumpster. In addition, after suspecting others were utilizing NEWWA's dumpster for personal use, NEWWA has installed a padlock on the dumpster that is only accessible by NEWWA staff and the sanitation company. Finally, "private parking" signs have been installed in both the front and back lots and a "security cameras in use" sign placed on the back of the building near the dumpster. This has resulted in much less "outside" traffic around our facility and provides peace of mind.

As part of the MassSAVE program, all lighting in the building has been converted to LED. This should save costs on the annual electric bill. Through a pandemic program with MassSAVE, this changeout did not cost the association any funds.

Technological Upgrades

All data from the legacy Association Management System (AMS) has been transitioned into the new AMS, and staff is now conducting extensive testing in the sample environment before going live. The entire system was shut down on close of business, June 25, to complete the full final data migration and go live. The go live date was moved to coincide with the fiscal year for accounting and auditing purposes. Upon completion of the new AMS, staff will begin the process of securing a Learning Management System.

The new AMS also means that licenses and hosting for both the Great Plains accounting software and website were also transitioned. Staff secured a vendor and all transitions for this piece of the project were completed.

Fundraising

In coordination with the Fundraising Committee, staff developed a "wish list" of items to help enhance its online learning efforts. This includes a Learning Management System, and

ADMINISTRATION

- Board Policy Document Update
- Paycheck Protection Program
- Association Management System Upgrade
- Virtual Technology Campaign 2021



hardware to upgrade classrooms at headquarters. A webpage announcing the program was created, hard-copy collateral printed, and donation solicitations began in early summer 2021 with the goal to raise \$150,000 by December 31, 2021.

COVID-19

NEWWA continues to monitor the pandemic and has kept most of its staff working remotely. In-person as well as online courses are being scheduled for winter 2021 both at NEWWA's headquarters and at satellite locations. Protocols for staff, students, off-site courses and events, backflow laboratory, and building reopening have all been established per the government's guidelines and are being followed. NEWWA will continue to offer in-person as well as online offerings to meet the needs of students across the region. All staff have also transitioned to working in the office at least one day a week to ensure business continuity. In addition, limited off-site courses are being offered at facilities across the northeast, primarily for our backflow prevention courses.

Staff

There were no staffing changes throughout the fiscal year. Two loans under the CARES Act program (Payroll Protection Program) in addition to outstanding work by all staff to maintain finances at a manageable and sustainable level resulted in NEWWA not needing to furlough or lay off staff during the lowest days of the pandemic.

Conclusion

I would formally like to thank all NEWWA staff for their hard work, unwavering dedication, and resilience throughout the pandemic and beyond. NEWWA would not have been able to weather the worst of the pandemic storm without any of them. In addition, I would like to thank the board of directors and President Lisa Gove for putting in extra efforts and providing the oversight needed to ensure NEWWA remained strong and relevant during this time. Finally, I want to thank all members as well as our talented and incredibly loyal volunteers who stepped up and increased involvement, keeping NEWWA viable and full of life. It is truly an honor and privilege to serve such an amazing group of individuals in this capacity.

Respectfully submitted,

Kirsten King, Executive Director

With support from:

Don Bunker, Deputy Executive Director; Pam Amalfi, Accounting Manager; Katelyn Todesco, Event and Marketing Manager; Mary Keating, Registrar; and Mary Quigley, Membership and Volunteer Coordinator

New England Water Works Association Treasurer's Report

Year Ending June 30, 2021

September 7, 2021 – Omni Mt. Washington Resort –
Bretton Woods, NH

NEWWA FINANCIALS

Gregory Leighton, Treasurer

FINANCIALS

- Virtual courses developed and continued successfully.
- AMS software upgrade is underway.
- NEWWA received two CARES Act PPP Loans (\$148,200 each).
- Eligible for up to \$194,000 in payroll tax credit from the Employee Retention Credit portion of the CARES Act.
- Investment dividend, interest, and principal returns net of fees totaled \$367,715.

FINANCIALS

Statement of Activities for the Year Ended June 30, 2021
Money we earned in the past 12 months offset by costs incurred.

	Income	Expenses	
Training	\$940,689	\$1,100,092	\$(159,403)
Conferences	184,105	92,916	91,189
Membership	239,080	17,815	221,265
Publications	59,364	59,048	316
Fundraising	127,367	50,218	77,149
Meetings	36,755	22,939	13,816
Other (Administrative)	19,367	505,349	(485,982)
Total Operating	\$1,606,727	\$1,848,377	\$(241,650)
Investment Income			\$711,940
Net Income (Increase in Net Assets)			\$470,290

FINANCIALS – BALANCE SHEET

Assets – What we Own

Cash & Investment	\$2,861,779
Property & Equipment	\$1,828,934
Other Assets	\$626,314
Total Assets	\$5,317,027

Liabilities – What we Owe

Building Loan	\$427,647
Other Liabilities	<u>\$596,459</u>
Total Liabilities	\$1,024,106
Net Assets	<u>\$4,292,921</u>
Total Liabilities & Net Assets	\$5,317,027

Annual Report of the Editor

September 2021

The annual report of the Editor of the *Journal of the New England Water Works Association* covers the period from July 1, 2020, to June 30, 2021. The *Journal* has been published continuously since 1886 and we are now in our 135th year of the *Journal* and 140th year of the association. This report covers the period from July 1, 2020, to June 30, 2021. During that period, the normal 4 issues of the *Journal* were published which include September and December of 2020 and March and June of 2021 in both hard copy and digitally on the NEWWA website.

The *Journal* featured the following cover photos and pages of text during the past year.

Issue	Photo	Pages of Text
September 2020	Sunrise on the Twin 600,000 Gallon Leicester Street Tanks, Auburn Water District, Auburn, Massachusetts NEWWA 2019 Photo Contest First Place Winner	83
December 2020	Caribou Utilities District, Caribou, Maine	67
March 2021	Water and Energy Technology (WET) Center, University of Massachusetts, Amherst, Massachusetts	76
June 2021	Foxborough Water and Sewer Department, Foxborough, Massachusetts	77

These four issues included 19 papers and 4 water system profiles as well as obituaries, conference proceedings, speaker abstracts, executive summaries, and council and committee reports. The average number of copies that were printed and reported to the U.S. Postal Service as of October 2020 was 2,486.

The mission of NEWWA of “protecting public health through the dissemination of knowledge” cannot be successfully attained without a vibrant and complete reporting of the new information being presented at our meetings. The editor urges all presenters at NEWWA conferences to prepare a written paper as well as an in-depth abstract of their paper that captures the major findings which will then be published in the *Journal*.

For those unable to prepare a written paper the ghostwriting process that was approved by the Board of Directors has proved to be successful in preparing papers for the *Journal*. Papers that have been rated highly by members who have attended the spring conference are normally the ones selected for ghostwriting.

There are 9 papers pending publication, an uptick from the previous years. While this is favorable, I again ask the Board of Directors to request committees that produce technical sessions to redouble their efforts to encourage presenters to write a paper suitable for publication.

Currently, only a portion of past issues of the Journal are available online. I urge NEWWA to place all past issues online which would enable access by anyone which I believe is consistent with one of the missions of the association which is to protect public health by the dissemination of knowledge and information.

Thanks to everyone involved in producing the Journal including Jacqui Campana who does a fabulous job, Chuck Larson and Kevin Reilly, assistant editors, Jerry Guerra, ghostwriter, Kirsten King, executive director, the publications committee chaired by Tom LeCourt, and Robin Lamerson at our publisher, Naylor Association Solutions.

The contract with Naylor Association Solutions to solicit advertising, print, publish, and mail the *Journal* has proved to be successful. Their effort to improve the appearance of the *Journal*, particularly the cover, is appreciated. In addition, one of the immediate beneficial effects of this new contract is that NEWWA members receive an email with links to the latest issue of the *Journal* which can be viewed online immediately upon publication. NEWWA should place the entire *Journal*, including all back issues, on the NEWWA website at newwa.org as soon as possible. Volumes 1 through 47 are available in digital format at an independent website named archive.org.

As always, the editor salutes the authors without whom there would be no *Journal*.

This year I informed the Publications Committee that I would not seek reappointment as the editor for the coming year and will finish my duties as editor with the December 2021 issue. That will complete a total of 30 years as Journal editor. Jacqui Campana, publications coordinator, will also be retiring this year as well. Jacqui joined the NEWWA staff in 1989 and began working on the Journal in 2008. She will be missed.

I am pleased to note that Michelle Clements of the Portland Water District has been recommended by the Publication Committee to the Board of Directors as the incoming editor. I will work with her both now and in the future to ensure a smooth transition and to assist in any way I can in preparing and publishing the Journal.

As we look to the future, I do have two recommendations for the Board of Directors. The first is that the Board urge all committees that produce technical programs to increase their efforts to encourage more written papers that would be available for publication in the Journal.

The second is to place all past issues of the Journal on the NEWWA website so that they are available for our members, students, researchers, historians, and anyone interested in drinking water and public health.

It has been an honor and a privilege to have served the Association as editor and I plan to continue as an active member of NEWWA which has the highest calling and mission of any organization namely the protection of public health.

Respectfully submitted,
Peter C. Karalekas, Jr., P.E., Editor

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Robin Lamerson 5650 NW 1st Place Gainesville, FL 32607

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☒ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months (Publisher must submit explanation of change with this statement)

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13. Publication Title: *Journal of the New England Water Works Association*

14. Issue Date for Circulation Data Below: *December 2020*

15. Extent and Nature of Circulation

		Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies (Net press run)			
		2247	2367
b. Paid Circulation (By Mail and Outside the Mail)	(1) Mailed Outside-County Paid Subscriptions Stated on PS Form 3841 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	X	8
	(2) Mailed In-County Paid Subscriptions Stated on PS Form 3841 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	2273	2352
	(3) Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS® (e.g., First-Class Mail®)	X	8
	(4) Paid Distribution by Other Classes of Mail Through the USPS	X	8
c. Total Paid Distribution (Sum of 1b (1), (2), (3), and (4))		2273	2352
d. Free or Nominal Rate Distribution (By Mail and Outside the Mail)	(1) Free or Nominal Rate Outside-County Copies Included on PS Form 3841	X	8
	(2) Free or Nominal Rate In-County Copies Included on PS Form 3841	X	8
	(3) Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail)	X	8
	(4) Free or Nominal Rate Distribution Outside the Mail (Carriers or other means)	58	50
e. Total Free or Nominal Rate Distribution (Sum of 1d (1), (2), (3), and (4))		58	50
f. Total Distribution (Sum of 1c and 1e)		2331	2342
g. Copies not Distributed (See Instructions to Publishers #4 page 6)		18	15
h. Total (Sum of 1f and g)		2347	2357
i. Percent Paid (1c divided by 1h times 100)		100	100

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16. Electronic Copy Verification

	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Paid Electronic Copies	2273	2352
b. Total Paid Print Copies (Line 15c) + Paid Electronic Copies (Line 16a)	2331	2342
c. Total Paid Distribution (Line 15c) + Paid Electronic Copies (Line 16a)	2331	2342
d. Percent Paid (Both Paid Print & Electronic Copies) (15c divided by 15h x 100)	58	50

☐ I certify that 50% of all my distributed copies (electronic and print) are paid above a nominal price.

17. Publication of Statement of Ownership:
☒ If the publication is a general publication, publication of this statement is required. Will be printed in the *December 2021* issue of this publication.
☐ Publication not required.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner: *Robin Lamerson* Date: *November 18, 2021*

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- Item 17 must be signed.

Failure to file or publish a statement of ownership may lead to suspension of periodicals authorization.

PS Form 3526, July 2014 (Page 4 of 4)

140th Annual Conference Membership Gala Invocation

By Stephen C. Olson

September 9, 2021

**Omni Mount Washington Resort,
Bretton Woods, New Hampshire**

Under the circumstances of this past year and a half, I think we've all come to really appreciate this assembly and this association which is filled with many old and fast friends, acquaintances, and colleagues.

I invite you all to please bow your heads with me for the invocation:

God our Father, we give you special thanks for the opportunity to meet here tonight, and for the opportunity to become reacquainted and better acquainted with our fellow water works professionals and associates. May we listen to one another intently, with the purpose of bettering ourselves, our profession, and our relationships with one another.

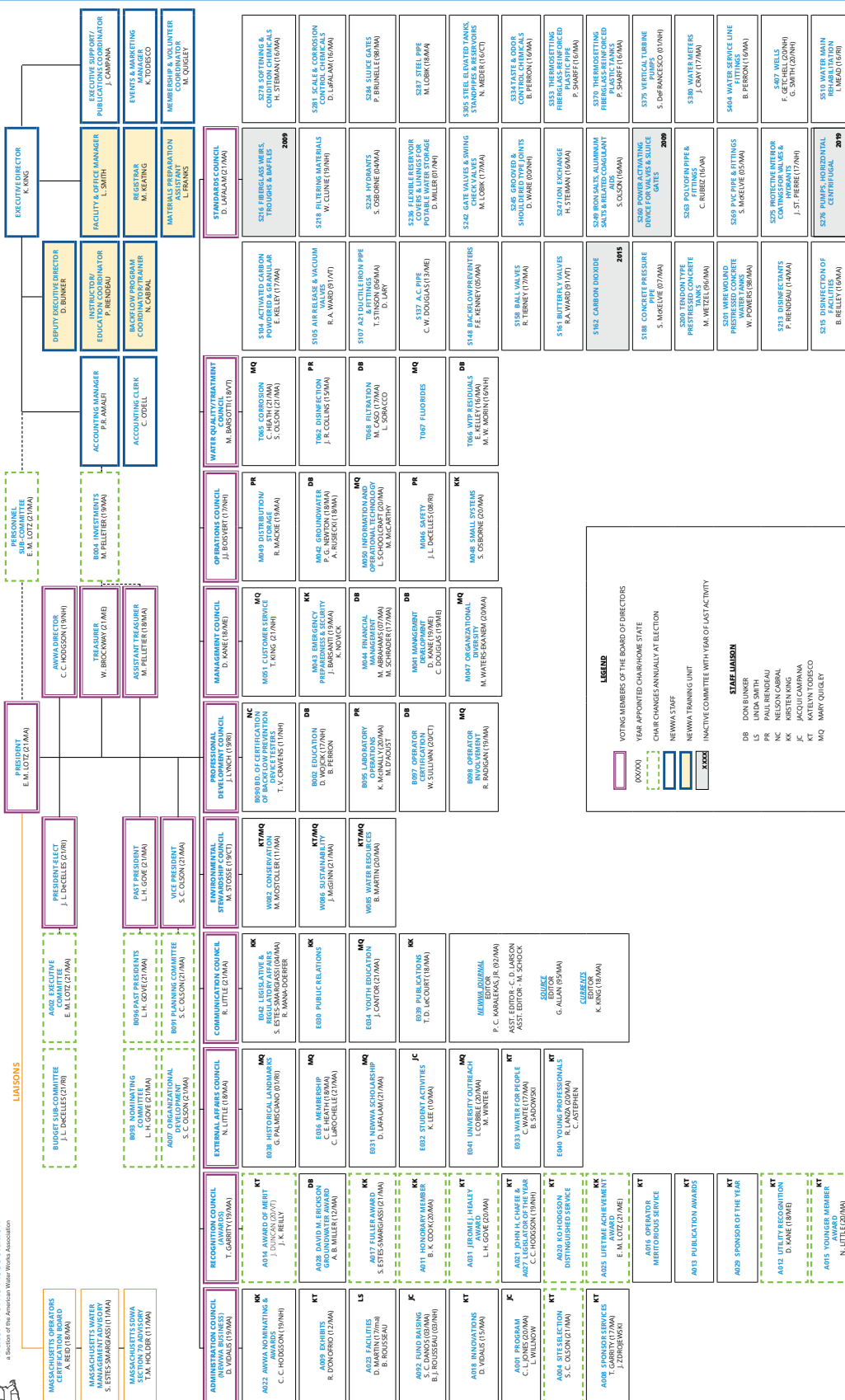
As we enjoy each other's fellowship tonight, help us to remember how fortunate we are to be able to serve one another and the general populations of our New England Communities through our unique and diverse professions within the field of drinking water and this great organization.

God our father, we offer our prayers to families, friends, co-workers, and strangers affected by the recent hurricane events this summer. Please watch over and help those that are in need.

Let us also pray silently together for a moment and remember those in our profession and our personal lives that we have lost this past year.

Dear Lord, for all of your many blessings, we give you thanks, and we ask you to keep us all safe from harm, bless this food, and all those who have contributed to this wonderful event, and our evening together.

Amen.



New England Water Works Association

Teller's Report Year Ending June 30, 2021

8/18/21

2021 REPORT OF THE TELLERS OF THE ELECTION

Candidate	# Online Votes	# Paper Votes	# Total Votes Cast
For President-Elect - Term Expires 2022			
James L. DeCelles, Pawtucket, RI	184	HH	189

For Vice President - Term Expires 2022	# Online Votes	# Paper Votes	# Total Votes Cast
Stephen C. Olson, Lakeville, MA	175	HH	180
Bruce Borge	1		1
David Miller	1		1

For AWWA Director - Term June 2021-2024	# Online Votes	# Paper Votes	# Total Votes Cast
Craig Douglas, Topsham, ME	181	HH	186
Mickey Morse	1		1

For Treasurer - Term Expires 2024	# Online Votes	# Paper Votes	# Total Votes Cast
Wayne Brockway, Kennebunk, ME	184	HH	189

Continued on reverse side

For State Director, MA #1 - Term Expires 2024	# Online Votes	# Paper Votes	# Total Votes Cast
Darin LaFalam, Lincoln, MA	173	HH	178

For State Director, MA #2 - Term Expires 2024	# Online Votes	# Paper Votes	# Total Votes Cast
Rob Little, Andover, MA	91	11	93
Blake Martin, Reading, MA	81	111	84
	1		1

For Director-at-Large - Term Expires 2024	# Online Votes	# Paper Votes	# Total Votes Cast
Nathan Little, Chelsea, MA	182	HH	187

Respectfully submitted,
(Teller names & date)

Matthew
J. E. R.
David Brockway

Total paper ballots received:
Total electronic ballots received:

JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION

**VOLUME CXXXV
2021**

**PUBLISHED BY
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Executive Director: Kirsten King

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Journal

of The New England Water Works Association

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