BRIDGEWATER WATER DEPARTMENT
WATER SYSTEM MASTER PLAN

Prepared for:
Town of Bridgewater, Massachusetts

April 2024

ENVIRONMENTAL PARTNERS
— An Apex Company —

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AC	Asbestos Cement
ADD	Average-Day Demand
AFF	Available Fire Flow
ASR	Annual Statistical Report
AWWA	American Water Works Association
CEMU	Confidently Estimated Municipal Use
CCI	Construction Cost Index
CI	Cast Iron
CIP	Capital Improvements Program
Cu	Copper
DI	Ductile Iron
ENR	Engineering News Record
EP	Environmental Partners
EPS	Extended Period Simulation
GIS	Geographic Information Systems
gpd	Gallons per Day
gpm	Gallons per Minute
HGL	Hydraulic Grade Line
hp	Horsepower
ISO	Insurance Services Office
$KMnO_4$	Potassium Permanganate
KOH	Potassium Hydroxide
MAPC	Metropolitan Area Planning Council
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MCL	Maximum Contaminant Level
MDD	Maximum-Day Demand
MG	Million Gallons

MGD	Million Gallons per Day
MGY	Million Gallons per Year
NAVD88	North American Vertical Datum of 1988
NaOCl	Sodium Hypochlorite
NaOH	Sodium Hydroxide
ng/L	Nanograms per Liter
OPPC	Opinion of Probable Project Cost
OWR	Office of Water Resources
PFAS6	Per-and Polyfluoroalkyl Substances (group of 6)
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
RGPCD	Residential Gallons per Capita per Day
SCADA	Supervisory Control and Data Acquisition
TDH	Total Dynamic Head
UAW	Unaccounted-for Water
USEPA	United States Environmental Protection Agency
WMA	Water Management Act
WRC	Water Resources Commission
WSMP	Water System Master Plan
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

Environmental Partners Group, LLC (EP) contracted with the Town of Bridgewater Department of Public Works (Department) to prepare this Water System Master Plan (WSMP) as well as create and calibrate a Water Distribution System Hydraulic Model. The primary goal of this project is to identify capital improvements projects through the 2045 planning year that will assist the Department with providing high quality drinking water to all customers at adequate pressures and volumes.

EP's scope of services included the following tasks:

- Collect required data and information on the water supply and distribution system;
- Document and describe the existing water system;
- Evaluate current raw water supply and customer demands by usage category;
- Prepare average-day and maximum-day water demand projections and requirements through the year 2045;
- Determine historic and projected residential per-capita water use;
- Assess the ability of the Department's water supply sources, pumping facilities, and treatment facilities to meet current and future demands;
- Evaluate the potential for emergency interconnections with neighboring municipalities;
- Review and assess the Department's existing water storage facilities for the ability to provide suitable storage volumes and pressures for existing and projected water demands;
- Review and assess the Department's existing water storage facilities for the ability to meet fire flow requirements;
- Collect hydraulic data via field testing;
- Create and calibrate the hydraulic model;
- Using the hydraulic model, assess the ability of the distribution system to meet current and projected demands and fire flow requirements;
- Evaluate the hydraulic distribution system to identify hydraulic performance deficiencies;
- Develop a recommended improvements plan;
- Prepare a capital cost estimate for all recommended improvements;
- Categorize the recommended improvements in order of priority and prepare an implementation plan;

EP has provided a detailed explanation of our findings, conclusions, and recommendations in the following WSMP report.

REPORT CONTENTS

To document our work and address the project tasks and goals listed above, EP has prepared and organized the Department's WSMP report in sections as described below.

- Section 1 describes the Department's water system, including the raw water wells and piping, treatment facilities, storage facilities, finished water piping, emergency supply interconnections, and supervisory control and data acquisition (SCADA) system.

- Section 2 addresses supply and demand, including present water use, potential future development, projected demands, water conservation, and water supply availability.

- Section 3 assesses existing water storage and storage needs.

- Section 4 summarizes the water system hydraulic model creation and calibration process and presents the results of the field testing and calibration. A detailed preparation and calibration memo is included in Appendix C.

- Section 5 evaluates water distribution system hydraulics and the system's ability to meet service pressure and fire flow over the 2045 planning horizon.

- Section 6 recommends improvements and presents an implementation schedule and opinion of probable project cost (OPPC) for the recommended Capital Improvements Plan.

Existing System Description

The Department serves its 26,563 (2022) customers using 9 active groundwater wells. Water from the wells is treated at two WTPs, except for Wells 10A and 10B (the Plymouth Wells), which are treated locally. The Department's water system also includes approximately 131 miles of water mains and two above-ground water storage tanks providing 4.8 million gallons (MG) of total storage. Figure A-1 in Appendix A presents a map of the existing water system and key facilities.

The water system consists of one service zone, with all existing sources withdrawing raw water from the Taunton River Watershed. The Carver Pond WTP treats water from Wells No. 2, 4A, and 5A. The High Street WTP treats water from Wells No. 3, 6, 8, and 9. The Plymouth Wells (10A and 10B) are located off Plymouth Street and are treated locally. The Plymouth Wells are currently offline due to reported elevated levels of iron and manganese, detailed further in the following sections. The Department has also begun the process of establishing a new water source, the Vernon Street Wells, which is not yet approved.

The Department's water system includes an integrated Supervisory Control and Data Acquisition (SCADA) system. With this SCADA system, the Department can monitor the water levels in both the

Great Hill and Sprague Hill water storage tanks and use these water level elevations to control the operation of the Department's wells and WTPs.

The Department does not maintain any other remote facilities such as metered interconnections or booster pump stations. Although the Department has interconnections with neighboring communities, they have not assessed the feasibility of using the interconnections in an emergency or established formal operations protocols.

Water samples collected at Wells No. 2, 4A, and 5A on April 6, 2022, and May 9, 2022, were above the Massachusetts Maximum Contaminant Level (MCL) of 20 nanograms per liter (ng/L) for PFAS6. Given that the current levels of PFAS6 in the water system are proximate to the Massachusetts MCL and this MCL will potentially be revised by the United States Environmental Protection Agency (USEPA) in early 2024, EP proposed a building additions for PFAS removal at the Carver Pond and High Street water treatment plants to help the Department maintain levels within the new PFAS standards. This will be explained further in the Recommended Improvements Section of this report.

Based on the age, frequency of redevelopment needed (annually), and the results of recent redevelopment, Wells No. 9 and 5A are approaching the limit of their useful service life and require replacement.

Evaluation of Supply and Demand

Based on 2018 to 2022 data, the Department's average-day demand (ADD) is approximately 1.64 million gallons per day (MGD). Average unaccounted for water (UAW) is 9.31 percent, meeting the Water Management Act (WMA) performance standard of 10 percent. Historic residential gallons per capita per day (RGPCD) consumption has averaged 47.2. Bridgewater's annual average has been consistently below the performance standard of 65 prescribed by the Massachusetts Department of Environmental Protection (MassDEP). The 5-yr average maximum-day demand (MDD) is 2.56 MGD, resulting in a ratio of maximum-to-average of approximately 1.56.

The Department's Final Water Withdrawal Permit is effective January 5, 2021, and extends to February 28, 2025. The permit authorizes the Department to withdraw water from the Taunton River Basin at the annual rate of 1.86 MGD. The total may increase to 1.98 MGD through February 28, 2030 if Bridgewater continues to meet the MassDEP performance standards through 2024.

The Department's ADD is approaching the WMA permit limit and is likely to exceed the permit level if the known future developments are completed by 2025. The total supply capacity of the system is currently 2.57 MGD with Wells 10A and 10B offline for water quality concerns. With an average MDD of 2.56 MGD, the Department is also approaching their total supply capacity and are likely to exceed it if all proposed developments are completed in the near future. Additionally, the firm capacity with the largest source offline is 2.03 MGD. With an MDD of 2.56 MGD between 2018 and 2022, this indicates the Department is experiencing a firm capacity deficit and would not be able to safely meet maximum day demands if the Department loses a source during a high demand period.

The chart below compares the Department's historic demand and supply capacity.

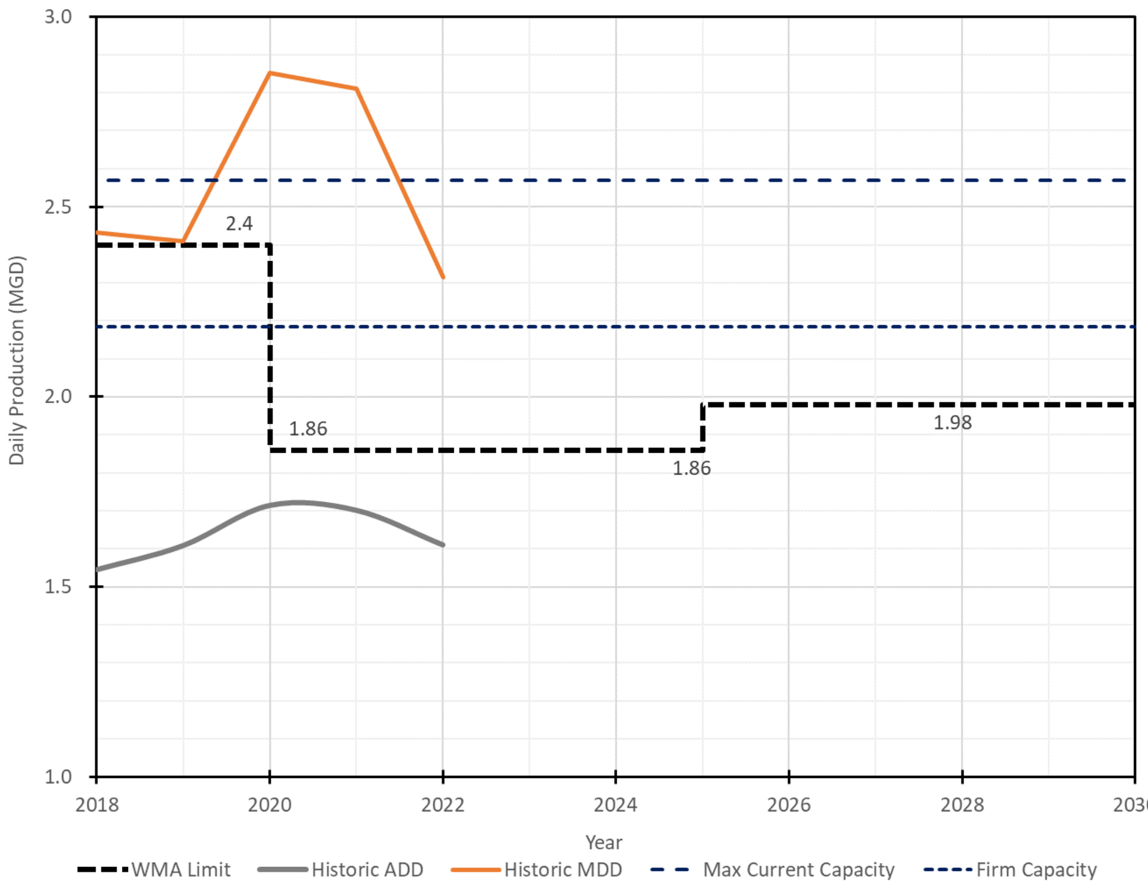

Chart ES-1: Bridgewater Historic Demand vs. Supply Capacity

The WRC forecasting methodology requires future residential demands to be calculated assuming 65 RGPCD and 10 percent UAW. The RGPCD for Bridgewater previously presented was estimated to be 47.2, which is below the WRC value of 65. EP has prepared the demand projections using both numbers to provide a range of potential outcomes. This approach adheres to the WRC's methodology while also depicting a potential future if the Department is able to maintain their current averages.

By 2045, average-day demand is projected to increase to between 2.02 MGD and 2.60 MGD depending on the RGPCD. With a maximum-to-average demand ratio of 1.56, the projected 2045 maximum-day demand is between 3.17 MGD and 4.06 MGD. Either scenario will result in a significant increase in the existing firm capacity deficit unless additional supply is secured, as discussed below. The resulting projections are shown in the chart below.

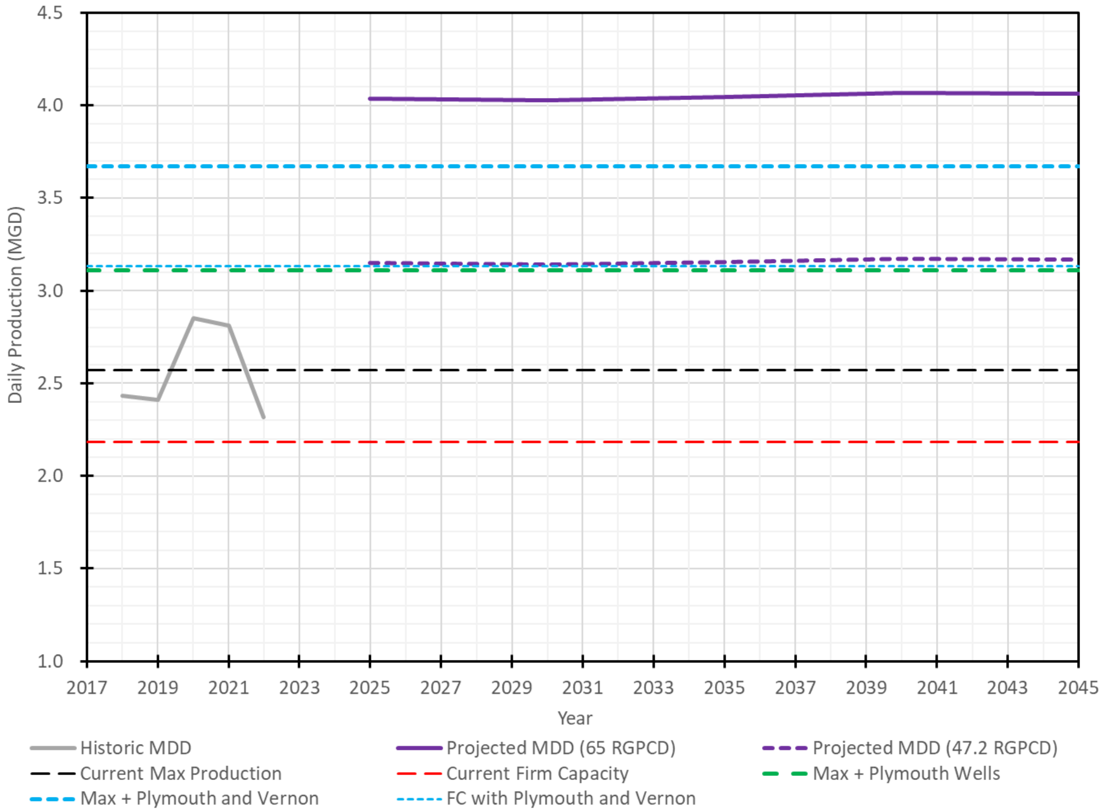

Chart ES-2: Bridgewater Projected Supply vs. Demand

As shown in the chart above, if the Department is able to maintain the historically low RGPCD of 47.2, they are projected to have sufficient supply capacity to meet MDD with all sources available, including the Plymouth Wells. If, however, demands climb to the WRC standard of 65 RGPDC, the Department will not be able to meet MDD even with the addition of both the Plymouth Wells and the Vernon Street Wells.

Notably, if the Department is able to recover capacity at the Plymouth Wells by routing them to the High Street WTP via a new raw water transmission main, and achieves the permitted capacity of 0.56 MGD at the Vernon Street Wells, the Department will have adequate firm capacity to meet future MDD with all sources available, provided RGPCD remains near the current value of 47.2.

To meet 2025 demands in a firm capacity scenario, the Department will either need to complete the Vernon Street Wells project or establish an emergency interconnection with a neighboring community (or multiple) totaling between 0.58 and 1.47 MGD (402 and 1,020 gpm).

EP recommends the Department begin the process of completing the Vernon Street Wells in the immediate future. In addition, the Department can recover function at the Plymouth Street Wells by completing a raw water transmission main to the High Street WTP, which was designed to accept approximately 0.58 MGD above the WMA permitted allowance for the High Street Wells. This is sufficient to incorporate the total permit allowance of 0.53 MGD at the Plymouth Wells.

To accommodate demands over the full 2045 planning horizon, the Department may need to locate additional water sources, establish permanent purchase agreements from neighboring communities, or purchase water from a regional supplier, such as the regional desalination plant. EP recommends the Department assess these alternatives to establish their viability, discussed further in Section 6.

Distribution System Storage Assessment

The Department currently has sufficient storage volume to meet typical residential fire requirements and ISO requirements, though the required flow rates are not available at all locations, as discussed below. The proposed developments may result in total demand exceeding pumping capacity, which would require a reassessment of available storage.

At present, the total bulk storage is approximately 4.8 MG, or 2.93 days of storage. This would result in turning over the total tank volumes in 2.93 days, or 34% daily turnover, which slightly exceeds the MassDEP guidelines of 20-33% per day. EP recommends the Department consider increasing its total volume of storage should a tank be added or replaced, which is included as part of the tank analysis discussed in Section 6.

Approximately 43% of the water in the Great Hill Tank and 40% of the water in the Sprague Hill Tank is considered unusable, located below an elevation associated with 35 psi for the highest elevation customer. The Great Hill Tank is 98 years old and at the end of its useful life. Recent inspection reports noted foundation degradation and exposed aggregate. As discussed further in Section 5, constructing a new tank at an alternate location may help address fire flow deficiencies in the western portion of the distribution system.

Water System Hydraulic Model Creation and Calibration

The Department assisted EP in performing 24 hydrant flow tests conducted on May 16 and 18, 2023, and provided supplementary SCADA data to accompany the tests. EP then simulated each of the field tests and adjusted the interior pipe roughness to simulate the headloss observed in the field. The Department reported a number of closed valves (either temporarily or permanently) during the time of field testing. EP simulated the closed valves in the model for calibration .

With this data and system information from the Department's SCADA system at the time of each test, EP simulated flow tests in the hydraulic model and compared the model results to the field results. EP then adjusted parameters in the hydraulic model until the simulation matched the field conditions. The chart below summarizes the result of the static pressure calibration.

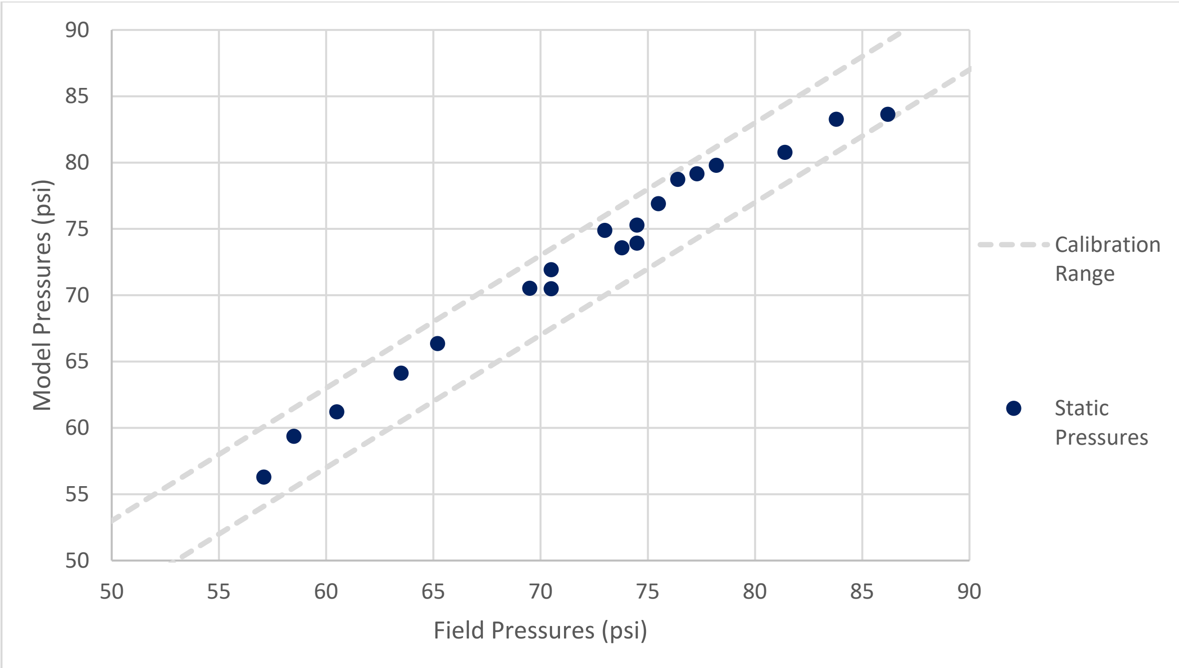

Chart ES-3: Static Pressure Calibration Results

EP produced comparable results during "dynamic" conditions, which is accomplished by inputting the hydrant flows measured during each test in the field into the model and comparing the pressure drop, or head losses, observed with those calculated by the model.

EP also performed an extended period simulation (EPS) calibration for an ADD period in early May 2023. EP received photos of the SCADA data from the Department for May 2023. EP processed the data to obtain 15-minute interval SCADA data and replicated the data in the hydraulic model by inputting pump controls that align with the SCADA data. The results of the EPS calibration are shown in the chart below.

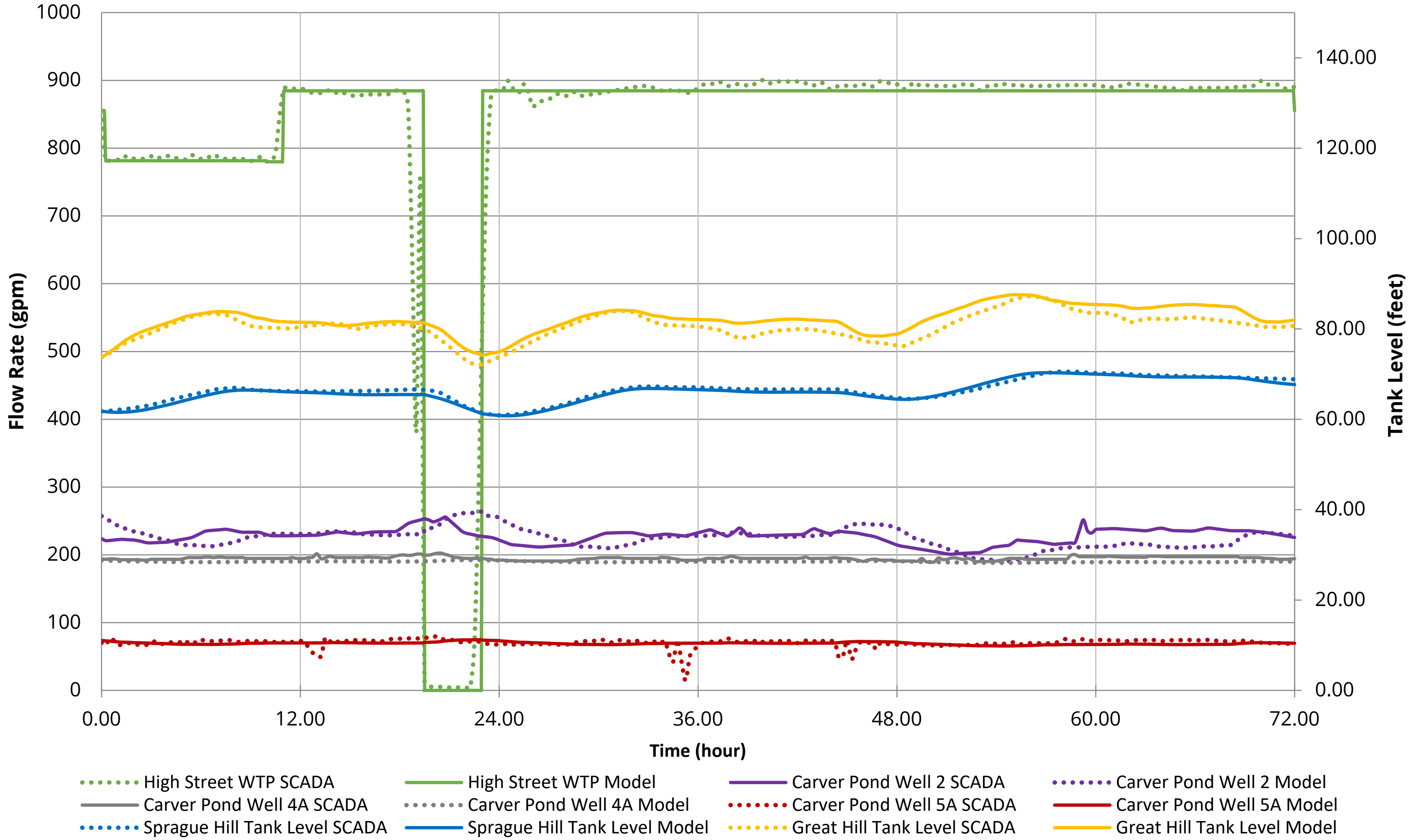

Chart ES-4: Bridgewater Water System ADD EPS Calibration

Overall, the calibrated model closely mimics actual water distribution system conditions represented by the field results. All static and residual pressures fell within the industry standard of precision. Four tests required higher than expected friction losses. It is likely one or more closed valves or pipe blockages are restricting flow in the system. It is also possible the GIS records reflect a pipe that does not exist. EP adjusted the C factors in these areas as required to replicate the losses observed in the field but recommends further investigation to confirm accuracy of these adjustments.

A comprehensive valve exercising program coupled with targeted flow tests will characterize any head loss discrepancies with higher precision. Should any blockages or closed valves be identified, these areas should be recalibrated with the data collected at that time. Further, these test locations would need to be reassessed for fire flow and other deficiencies described in the following section.

Water Distribution System Hydraulic Assessment

Using the calibrated hydraulic model, EP performed the analysis of the distribution system under the ADD, MDD and peak hour demand scenarios, for the current and 2045 projected demands. The results show that the majority of the system operates within the recommended pressure range (35 – 80 psi). However, during peak hour, 15 percent of the system experiences pressures exceeding 80 psi. EP recommends the Department work with these customers to verify the presence of pressure reducing devices, adding them where appropriate. In all scenarios, a small portion of the distribution system experiences pressures below 35 psi at the base of the Sprague Hill Tank.

EP also recommends the Department conduct a controls review to optimize system controls and distribution system pressures. Operating all pumps with the same "on" and "off" setpoints can contribute to higher pressures in the distribution system. EP recommends including this review as part of the design of future new source projects that will be required to supplement water supply.

During this analysis, EP found that 30 of the 176 Insurance Service Office (ISO) fire flow locations do not meet the required available fire flow at a residual pressure of 20 psi. The recommended improvements include water main upgrades to address these deficiencies.

It is important to note that both storage tanks are located in the northern, central region of the water system. The required water main improvements to address some deficiencies would be cost prohibitive and may create low velocities and higher water age during typical operations. EP recommends conducting a study to locate a new storage tank, which may address a large number of the fire flow deficiencies with a much smaller number of water main improvements, or in some cases, no water main improvements at all. This is discussed in more detail in Section 6.

Recommendations and Capital Improvements Plan

Recommendations are categorized into one of four phases spanning five years each, as well as an initial phase (Phase I) including projects already under way or which may be accomplishable within the Department's existing budget.

Some projects in the later years of the CIP are contingent on projects earlier projects. EP has included these contingent projects to help the Department prepare for a more aggressive expenditure projection. As discussed in Section 2, the Department is experiencing a firm capacity deficit and securing additional water supply is of the foremost importance. As such, Phase II includes projects affecting water supply capacity, as well as engineering studies that may result in revisions to later phases of the CIP. It is likely that the results of the engineering investigations included in Phase II will reduce the scope of required projects, as described below.

Phase III improvements include construction for larger water supply projects, as well as some water main replacement projects to address fire flow deficiencies. Phases IV and V include additional water main improvements projects, as well as an allowance to begin replacing some of the Department's aging cast iron (CI) water mains and asbestos cement (AC) water mains.

It is important to note that the Phase III and IV water main improvements may be significantly reduced if a new storage tank is constructed. EP strongly recommends the Department pursue a tank siting analysis and subsequently revise the CIP to reflect the impact on the Department's available fire flow. Additionally, EP has included recommendations for routine annual maintenance.

For each of the improvements, EP developed an opinion of probable project cost (OPPC) that includes the construction cost, engineering, and contingencies. These costs represent the current value of the project in 2023 dollars and should be compared to the Engineering News-Record (ENR) Construction Cost Index (CCI) from December 2023 of 13,514.8 when extrapolating to future value.

In the first quarter of 2023, there was slowdown in the rate of labor and materials cost increase as compared to 2022 overall increases. If this trend persists and material costs stabilize, the planning level estimates provided might be higher than the actual costs encountered at the time of implementation. Nevertheless, a contingency has been included to account for the possibility of ongoing labor and material price increase and challenges obtaining construction materials.

The table below summarizes the OPPCs associated with all five phases of the Department's CIP. These costs represent the current value of the project in 2023 dollars and should be compared to the Engineering News-Record (ENR) Construction Cost Index (CCI) from November 2023 of 13,510.6 when extrapolating to future value.

Table ES-1: Budgetary Cost Summary

Phase	Fiscal Years	Total Budgetary Cost ($)	Average Cost Per Year ($)
I	2024-2025	$3,804,000	$1,902,000
II	2026-2030	$63,027,000	$12,605,400
III	2031-2035	$44,919,000	$8,983,800
IV	2036-2040	$34,387,000	$6,877,400
V	2041-2045	$80,930,000	$16,186,000
	TOTAL	**$227,067,000**	

As discussed above, projects included in Phases III and IV will be potentially superseded by the results of the analyses in Phase II. EP recommends revising the CIP accordingly following the completion of the alternatives analyses.

SECTION 1 DESCRIPTION OF WATER SYSTEM

Section 1 of this Water System Master Plan (WSMP) summarizes the existing public water system for the Town of Bridgewater, including raw water supply sources and well stations, treatment facilities, water storage tanks, and distribution system piping.

SECTION 1.1 INTRODUCTION

EP met with the Department on May 16 and May 18, 2023, to conduct field flow tests at 24 locations throughout the water distribution system. As part of these site visits, EP collected information on the water storage tanks, water treatment plants, and Pump Stations. Additionally, EP requested information from the Department through three Request for Information (RFI) letters, sent on February 15, 2023, March 22, 2023, and July 31, 2023.

EP received and/or reviewed the following documents, as part of this project:

- Water Treatment Plant (WTP) and well station record drawings
- Distribution system mapping, databases, and shapefiles in Geographic Information Systems (GIS) software
- Annual Statistical Reports (ASRs) for the years 2018-2022
- Customer billing and consumption data
- Finished water pumping curves
- Roadway and water main planned improvements report
- Great Hill and Sprague Hill Storage Tank inspection reports
- Bridgewater Water Management Act (WMA) Permit
- Carver Pond, High Street, and Plymouth Street Wells redevelopment reports
- Insurance Services Office (ISO) reports
- 2021 Risk and Resilience Assessment

SECTION 1.2 WATER SYSTEM OVERVIEW

The Department serves 100% of the Town of Bridgewater's population (26,563 in 2022) via 7,868 water services (2022) using 9 active groundwater wells. The Carver Pond WTP treats water from Wells No. 2, 4A, and 5A. The High Street WTP treats water from Wells No. 3, 6, 8, and 9. The Plymouth Wells (10A and 10B) are located off Plymouth Street and are treated locally. However, they are currently offline due to elevated levels of iron and manganese and associated customer complaints as well as operational difficulties, detailed further in the following sections. Well No. 1 has been abandoned and Well No. 7 is inactive. The Department has begun the process of establishing a new water source, the Vernon Street Wells.

Finished water is stored in two above-ground storage tanks. The Great Hill tank is located off Great Hill Drive. It has a total capacity of approximately 1.0 million gallons (MG) and an overflow elevation of approximately 261.3 feet. The Sprague Hill tank is located off High Street and Broad Street near the northern border of town. It has a total capacity of approximately 3.8 MG and an overflow elevation of approximately 261.3 feet.

The water system consists of one pressure zone, with all existing sources drawing from the Taunton River Watershed. The Department's water system includes approximately 131 miles of water mains. Figure A-1 in Appendix A presents a map of the existing water system and key facilities.

The Department's water system includes an integrated Supervisory Control and Data Acquisition (SCADA) system. With this SCADA system, the Department monitors water levels in both the Great Hill and Sprague Hill water storage tanks and uses water level in the Sprague Hill tank to control operation of the Department's wells and WTPs.

The Department does not maintain any remote facilities such as metered interconnections or booster pump stations. Although the Department has interconnections with neighboring communities, they have not assessed the feasibility of using the interconnections in an emergency nor have they established formal operations protocols.

SECTION 1.3 WATER SUPPLY SOURCES

Table 1-1 below identifies the sources and their respective WMA authorized withdrawals from the Department's current WMA permit in million gallons per day (MGD). The treatment facilities chemically treat raw groundwater for iron and manganese removal, pH adjustment, disinfection, and corrosion control. These facilities are described further below. A copy of the Department's WMA permit can be found in Appendix B.

Table 1-1: Town of Bridgewater Sources and Water Management Act Authorizations

Source Name	Treatment/Controls/Notes	WMA Permit	
		Source Code	Maximum Daily Withdrawal Rate (MGD)
Total Wells Combined Permit No. 9P-4-25-042.01	Bridgewater currently has 12 groundwater withdrawal points permitted		
High Street Wells	On-site Iron and Manganese Treatment		
Well No. 3	Routed to High St WTP for treatment	4042000-02G	1.62
Well No. 6		4042000-05G	
Well No. 9		4042000-10G	
Well No. 8	Well house, routed to High St WTP for treatment	4042000-09G	
Carver's Pond Wells	On-site Iron and Manganese Treatment		
Well No. 7	Abandoned, not in use	4042000-08G	0.14
Well No. 2	Well house with controls	4042000-04G	0.58
Well No. 5A	Well house with controls; Running at reduced flow rate due to screen issue	4042000-13G	0.24
Well No. 4A	Well house with controls	4042000-14G	0.43
Plymouth Street Wells	One well house with chemical addition only		
Well No. 10A	Offline due to water quality concerns	4042000-11G	0.23
Well No. 10B	Offline due to water quality concerns	4042000-12G	0.31
Vernon Street Wells	Not yet developed		
Well No. 1		TBD	0.56
Well No. 3		TBD	
Total			4.11

Only Wells No. 2, 3, 4A, 5A, 6, 8, and 9 are currently in use. Based on the 2022 ASR, Carver's Pond Well No. 7 is currently inactive. Wells No. 10A and 10B are offline due to water quality concerns. Additionally, as mentioned above, the Department has started the process of establishing the Vernon Street Wells, which will provide the Department with an estimated additional 0.56 MGD. The seven wells currently in use account for a maximum daily withdrawal rate of 2.87 MGD (this excludes the Plymouth Street Wells).

Table 1-2 summarizes the data for the active groundwater source wells. The following sections discuss each source well in further detail. The abandoned Well No. 1 and inactive Well No. 7 are omitted from the table.

Table 1-2: Raw Water Source Wells Data

Source	Parameter						
	Address	Pump Type	Pump Horsepower (hp)	Well Type	Well Size	Well Depth (feet)	Screen Length (feet)
Carver Pond WTP Well No. 2	100 Wellfield Dr.	Vertical Turbine	60	Gravel packed	18"	58	10
Carver Pond WTP Well No. 4A	100 Wellfield Dr.	Submersible	20	Gravel packed	18"x12"	53.5	10
Carver Pond WTP Well No. 5A[1]	100 Wellfield Dr.	Submersible	20	Gravel packed	10"	70.4	10
High Street WTP Well No. 3	1420 High St.	Vertical Turbine	60	Gravel packed	24"	68	15
High Street WTP Well No. 6	1420 High St.	Vertical Turbine	50	Gravel packed	18"	61	10
High Street WTP Well No. 8	1420 High St.	Vertical Turbine	60	Gravel packed	12"	69.7	10
High Street WTP Well No. 9	1420 High St.	Submersible	40	Gravel packed	12"	68	10
Plymouth Street Well No. 10A[2]	1729 Plymouth St.	Submersible	25	Gravel packed	12"	60	8
Plymouth Street Well No. 10B[2]	1729 Plymouth St.	Submersible	25	Gravel packed	12"	62	10

1. Currently running at reduced capacity due to failing well screen.
2. Currently offline due to water quality concerns.

Section 1.3.1 Carver Pond WTP Wells

Carver Pond WTP Wells No. 2, 4A, and 5A are located off Wellfield Drive near the center of the Bridgewater water system and are surrounded by Bedford Street, Summer Street, and Conant Street. The wells are situated within the Taunton River Watershed.

Well No. 5A has required frequent cleaning and redevelopment since 2016 to maintain its design capacity. A new pump was installed at the Carver Pond Well No. 5A in August of 2018, and a new motor was installed in November 2022. Well 5A has been offline since August 2023 due to a failing screen. Based on the age, frequency, and ineffectiveness of redevelopment, this well has reached the limit of its useful service life and requires replacement.

Water samples collected at Wells No. 2, 4A, and 5A on April 6, 2022, and May 9, 2022, were above the Massachusetts Maximum Contaminant Level limit of 20 nanograms per liter (ng/L) for PFAS6. Given this exceedance and the impending USEPA MCL for PFAS, EP proposes a building addition for PFAS removal at both Carver Pond and High Street WTPs to help the Department meet the new standards. This will be explained further in Section 6 of this report.

Section 1.3.2 High Street WTP Wells

High Street WTP Wells No. 3, 6, 8, and 9 are located off High Street in the northeast part of Bridgewater. The wells are situated within the Taunton River Watershed.

Well No. 9 was constructed in 1995 and has since been cleaned and redeveloped regularly by Maher Services. Maher conducted the most recent redevelopment in May 2023. Well No. 9 was originally a 12-inch diameter well and was lined with an 8-inch diameter lining in 2018. Specific capacity data post- May 2023 redevelopment showed little to no improvement after redevelopment. Based on the age and the inability of the well to rebound specific capacity via redevelopment, this well has reached the limit of its useful service life and requires replacement.

Section 1.3.3 Plymouth Street Wells

Plymouth Street Wells No. 10A and No. 10B are located in the northeast part of Bridgewater off Plymouth Street. The Department indicated these wells are currently offline due to elevated levels of iron and manganese and associated customer complaints. Since the introduction of the High Street WTP, the Department has also had difficulties running the wells and overcoming the increase in system head from the WTP operation. It is possible the pumps may be able to run if High Street WTP is running at reduced flow rates.

As part of the recommendations included within this report, EP has proposed pump replacements at these two wells and a new raw water transmission main from Plymouth Street to the High Street WTP. This is detailed further in Section 6 of this report.

Section 1.3.4 Vernon Wells No. 1 and 3

In July 2016, Bridgewater filed a WMA permit amendment to add two additional wells with a combined capacity of 0.56 MGD to its WMA permit (the Vernon Street wells). Currently these wells are included in the WMA permit but are not fully permitted with MassDEP and are not active.

SECTION 1.4 WATER TREATMENT FACILITIES

Section 1.4.1 Water Treatment Summary

Table 1-3 summarizes the chemicals used at each treatment facility and their purpose. Each facility is discussed in further detail in the following sections.

Table 1-3: Raw Water Treatment Summary

Treatment Process	Purpose	Carver Pond WTP	High Street WTP	Plymouth Street Wells
Sodium Hydroxide (NaOH)	pH adjustment & corrosion control		✓	✓
Potassium Hydroxide (KOH)	pH adjustment	✓		
Sodium Hypochlorite (NaOCl)	Disinfection	✓	✓	✓
Greensand Filtration	Iron & manganese removal	✓	✓	
Potassium Permanganate ($KMnO_4$)	Iron & manganese oxidation	✓[1]	✓[1]	
Ultraviolet (UV)	Disinfection		✓	

1. No longer in use since the addition of Greensand, but available as a backup oxidation method.

Section 1.4.2 High Street Treatment Plant

The High Street Water Treatment Plant was put into operation in 2023. This plant treats raw water from High Street Wells No. 3, 6, 8, and 9 using chemical addition, pressure filtration, and UV disinfection. The facility also serves as the central hub for SCADA communications.

The High Street WTP is designed to treat 1.62 MGD with the flexibility to increase capacity up to 2.2 MGD. Raw water from Wells No. 3, 6, 8, and 9 combine at the entrance of the treatment facility. The combined raw water is pre-treated with sodium hydroxide (NaOH) to increase pH and NaOCl and aeration for iron and manganese oxidation and maintenance of the media. Potassium permanganate ($KMnO_4$) is included for backup oxidation if needed but is not currently in use. The chemically treated raw water is then pumped through pressure filters for the removal of iron and manganese, receives chemical injection of NaOH for pH adjustment and corrosion control, is treated with sodium hypochlorite (NaOCl) and UV for disinfection, and proceeds to the distribution system.

The treatment plant also contains a SCADA control room in an adjacent room. This room, which serves as the central hub for SCADA communications, contains electrical panels, computers, and cabinet storage.

Section 1.4.3 Carver Pond Treatment Plant

The Carver Pond WTP was designed to treat water from three wells for the removal of iron and manganese at a maximum raw water flow of 1.8 MGD. Carver Pond Well No. 2 is located within a pump station and piped to the WTP. Carver Pond Well No. 4A has a submersible pump with pitless adapter that delivers raw water to the former Carver Pond Well No. 4 pump station for flow measurement before entering the WTP. Carver Pond Well No. 5A has a submersible pump with pitless adapter that delivers raw water to the former Carver Pond Well No. 5 pump station for flow measurement before entering the WTP.

The Carver Pond WTP treats raw water from the three active Carver Pond Wells with potassium hydroxide (KOH) for pH adjustment, $KMnO_4$ for iron and manganese oxidation, and NaOCl for disinfection. The oxidized water flows through six greensand pressure filters for removal of source water iron and manganese. The Department adds sodium hypochlorite and sodium hydroxide post-filtration for disinfection and final pH adjustment, respectively, before the finished water enters the distribution system.

The Carver Pond treatment plant also contains a separate control room. This room contains electrical panels, computers equipped to monitor SCADA information, and cabinet storage.

SECTION 1.5 DISTRIBUTION STORAGE FACILITIES

Water storage facilities serve several functions within the water distribution system including system pressure equalization, fire suppression volume, emergency storage, and operational flexibility. The volume of water within a storage tank is immediately available for fire protection and provides flexibility to the Department to perform routine maintenance on its pump stations, WTPs, groundwater wells, and distribution system. The Bridgewater water distribution system includes two water storage facilities totaling 4.8 million gallons (MG).

The Great Hill Tank is a riveted steel standpipe located near the central part of Bridgewater off Great Hill Drive. The tank has an overflow elevation of 261.3 feet and a total capacity of approximately 1.0 MG. The elevation of the ground at the tank is approximately 161.3 feet. The tank is 100 feet tall and has a diameter of 42 feet. The tank was constructed in 1925 and most recently rehabilitated in 2013. The most recent inspection report in November 2021 noted foundation degradation and exposed aggregate. The Great Hill Tank will need rehabilitation around 2035 but may be at the end of its useful life and in need of replacement.

The Sprague Hill Tank is a welded steel standpipe located in the northern part of Bridgewater off High Street and Broad Street. The tank has an overflow elevation of 261.3 feet. The tank was constructed in 1973 and was last rehabilitated in 2008. The elevation of the ground at the tank is approximately 178.8 feet. The tank is 82.5 feet tall, 90 feet in diameter, and has a total capacity of approximately 3.8 MG. The Sprague Hill Tank was last inspected in November 2021. The Sprague Hill Tank will need rehabilitation around 2030.

Table 1-4 provides a summary of the Department's storage tanks. The elevations are based on the North American Vertical Datum 1988 (NAVD88). The water storage tanks are well maintained and surrounded by locked access gates and adequate fencing to prevent vandalism and unauthorized access.

Table 1-4: Distribution Storage Tank Data

	Great Hill Tank	Sprague Hill Tank
Year Constructed/Rehabilitated	1925/2013	1973/2008
Address	160 Great Hill Drive	599 Broad Street
Ground Elevation (feet)	161.3	178.8
Type of Construction	Standpipe	Standpipe
Construction Material	Riveted Steel	Welded Steel
Tank Height *(feet)*	100	82.5
Tank Diameter *(feet)*	42	90
Overflow Elevation (feet)	261.3	261.3
Nominal Storage Volume *(gallons)*	900,000	3,900,000

SECTION 1.6 DISTRIBUTION SYSTEM PIPING

The Department operates and maintains the water distribution system piping network, which transports and delivers finished water from the water treatment facilities to its customers. The Department's finished water distribution system includes approximately 131 miles of water mains ranging in diameter from 2 inches to 16 inches. The majority of the system piping consists of 8-inch water mains. Table 1-5 summarizes the system's range of water main diameters.

Table 1-5: Distribution System Piping by Diameter

Diameter (inches)	Length (feet)	Length (miles)	Percent
2	1,434	0.3	0.2%
4	9,035	1.7	1.3%
6	154,091	29.2	22.2%
8	408,170	77.3	58.9%
10	33,299	6.3	4.8%
12	64,026	12.1	9.2%
14	1,271	0.2	0.2%
16	21,089	4.0	3.0%
Total	692,415	131	100%

The larger diameter finished water main materials are primarily asbestos cement (AC), polyvinyl chloride (PVC), and cast iron (CI). There is also a small percentage of ductile iron (DI) pipe (6.1%) and 3.6% are of unknown material. Table 1-6 summarizes the distribution of water main materials.

Table 1-6: Distribution System Piping by Material Type

Material	Length		Percent
	(feet)	(miles)	
AC	253,181	48.0	36.5%
CI	116,727	22.1	16.8%
DI	42,255	8.0	6.1%
PVC	255,193	48.3	36.8%
Unknown	25,059	4.7	3.6%
Total	692,415	131	100%

SECTION 1.7 SCADA

The Department utilizes the SCADA system to control and monitor all well supplies and storage tanks. The SCADA system has three main functions: data communication; data acquisition and presentation; and equipment automation. The Department can monitor all sources and tanks from hubs at the High Street and Carver WTPs. Each WTP can only control its own wells. The operators cannot monitor or operate the SCADA system remotely from any other devices. SCADA communications from the remote sites is via radio telemetry via the radio repeater located at the Sprague Hill Tank. The SCADA system alerts the on-call operator of an alarm condition via telephone telemetry at the High Street WTP. The Department has an on-call contractor, Electrical Installations, LLC, for equipment integration and control needs.

SECTION 1.8 BACK-UP POWER

Back-up power is critical for maintaining operations during strong storm events, malicious attacks, and other hazards. The Department has back-up power at both WTPs and the Sprague Hill Tank. Table 2 lists the Department's major assets and the presence of back-up power on site.

Table 1-7: Facility Back-Up Power Inventory

Facility	Back-Up Power	Automatic or Manual Transfer	Duration of Back-Up Power Available
Carver Pond WTP	Propane	Automatic	1 Week
Carver Pond Well No. 2			
Carver Pond Well No. 5A			
Carver Pond Well No. 4A	None	N/A	N/A
High Street WTP	Natural Gas	Automatic	Indefinite
High Street Well No. 3	Natural Gas at Well No. 8 Building	Automatic	Indefinite
High Street Well No. 6			
High Street Well No. 9			
High Street Well No. 8			
Plymouth Street Well No. 10A	Propane	Automatic	1 Week
Plymouth Street Well No. 10B			
Great Hill Tank	None	N/A	N/A
Sprague Hill Tank	Propane	Manual	3 Days

SECTION 2 EVALUATION OF SUPPLY AND DEMAND

Section 2 serves to review the ability of the Department's existing public water system to meet current and future water demands. EP compiled and analyzed current registered, permitted, and operational capacities of all water supply sources, historic average-day demand (ADD) and maximum-day demand (MDD), and future ADD and MDD projections to assess the ability of the water system to meet consumer needs through the 2045 planning period.

SECTION 2.1 WATER BALANCE

Currently, the Department does not have any water supply arrangements with neighboring towns to purchase or sell water.

The Department does not currently report the amount consumed during treatment processes (treatment losses). Finished water is consumed by the following demands: total metered use, confidently estimated municipal use (CEMU), and unaccounted-for water (UAW). Generally, CEMU includes estimated water usage for the following purposes: fire protection and training, hydrant or water main flushing and construction, flow testing, bleeders and blowoffs, tank overflow and drainage, sewer and stormwater system flushing, street cleaning, source meter calibration, and major water main breaks (not leaks). UAW is the volume of water that cannot be accounted for through either CEMU or metered use and is discussed later in this section.

SECTION 2.2 CURRENT DEMANDS

Section 2.2.1 Average-Day Demand

ADD is the average daily volume of water supplied to the distribution system in a given year, calculated by subtracting any water sold from water pumped and purchased, then dividing the result by the number of days in the same year. This metric is a baseline for determining the adequacy of water supply sources under normal conditions.

Table 2-1 below summarizes the Department's withdrawals from 2018 through 2022. Based on 2018 to 2022 data, the Department's ADD is approximately 1.64 MGD.

Table 2-1: Annual Average Water Demand

Year	Net Annual Finished Water Demand (MG)	Average-Day Demand (MGD)
2018	564.30	1.55
2019	587.50	1.61
2020	627.81	1.72
2021	621.37	1.70
2022	588.13	1.61
Average	**597.82**	**1.64**

The 2020 and 2021 production show a sizeable deviation from the surrounding years. As discussed in subsequent sections, the baseline consumption reported was comparable to surrounding years, but the UAW in 2020 and 2021 was higher, resulting in a larger total production volume.

Section 2.2.2 Maximum-Day Demand

MDD, the largest 24-hour demand during a calendar year, is essential in the evaluation of treatment and pumping facilities, storage tanks, and distribution piping. MDD is typically expressed as a ratio relative to ADD. This ratio varies based on the characteristics of the individual community. Table 2-2 below shows MDD relative to ADD for 2018 through 2022. The Department's average MDD is approximately 2.56 MGD and the average ratio of MDD to ADD is 1.56.

Table 2-2: MDD vs ADD, 2018-2022

Year	Maximum-Day Demand (MGD)	Average-Day Demand (MGD)	Ratio of Maximum-Day to Average Day
2018	2.43	1.55	1.57
2019	2.41	1.61	1.50
2020	2.85	1.72	1.66
2021	2.81	1.70	1.65
2022	2.32	1.61	1.44
Average	**2.56**	**1.64**	**1.56**

Section 2.2.3 Analysis of Metered Water Use

The Department's ASRs include reported annual metered water use. This total does not include UAW or CEMU. MassDEP requires that water use be reported in the following categories: Residential, Residential Institutions, Commercial/Business, Agricultural, Industrial, Municipal/Institutional/Non-Profits, and Other. Table 2-3 below summarizes the Department's total metered water consumption by customer classification from 2018 through 2022. The majority of the Department's average annual water use is residential and commercial consumption (approximately 94 percent).

Table 2-3: Annual Water Consumption by Customer Classification in MGY

Customer Classification	2018	2019	2020	2021	2022	Average	Percent Total Consumption[1]
Residential	425.05	511.19	475.58	437.08	441.00	457.98	86.89%
Residential Institutions	0.00	0.00	0.00	24.06	30.44	10.90	2.07%
Commercial	34.24	43.35	30.57	35.87	37.26	36.26	6.88%
Agricultural	0.00	0.00	0.00	0.00	0.00	0.00	0.00%
Industrial	5.27	5.94	7.77	7.36	3.61	5.99	1.14%
Municipal/Institution/Non-Profit (MGY)	8.14	10.48	8.99	0.18	17.94	9.15	1.74%
Other	17.37	7.33	0.00	6.72	2.68	6.82	1.29%
Total	490.06	578.29	522.91	511.26	532.92	**527.09**	**100%**

1. Percentage of all metered water does not include CEMU or UAW. Average of 2018-2022.

Section 2.2.4 Residential Per-Capita Finished Water Use

For public water systems permitted under the WMA, the residential gallons per capita per day (RGPCD) finished water use performance standard is 65 RGPCD or less. With predominantly residential demands, this value is especially important to the Department's operations.

According to the reported values in the ASRs, the Department has been below the WMA performance standard for per-capita water use each year, with an average of approximately 47 RGPCD. Table 2-4 below shows residential consumption from 2018 through 2022.

Table 2-4: Annual Residential Finished Water Use, 2018-2022

Year	Residential Metered Water Sales (MGY)	Percent	Residential Population Served[1]	Residential Per-Capita Water Use (RGPCD)
2018	425.05	86.7%	26,563	43.8
2019	511.19	88.4%	26,563	52.7
2020	475.58	90.9%	26,563	49.1
2021	437.08	85.5%	26,563	45.1
2022	441.00	82.7%	26,563	45.5
Average	457.98	86.9%	26,563	**47.2**[2]

1. Residential Population Served is based on Bridgewater's ASR data.
2. Water usage varies from month-to-month and residential populations vary slightly seasonally.

A breakdown of the Department's approximate average monthly RGPCD for 2018 through 2022 is shown below in Chart 2-1.

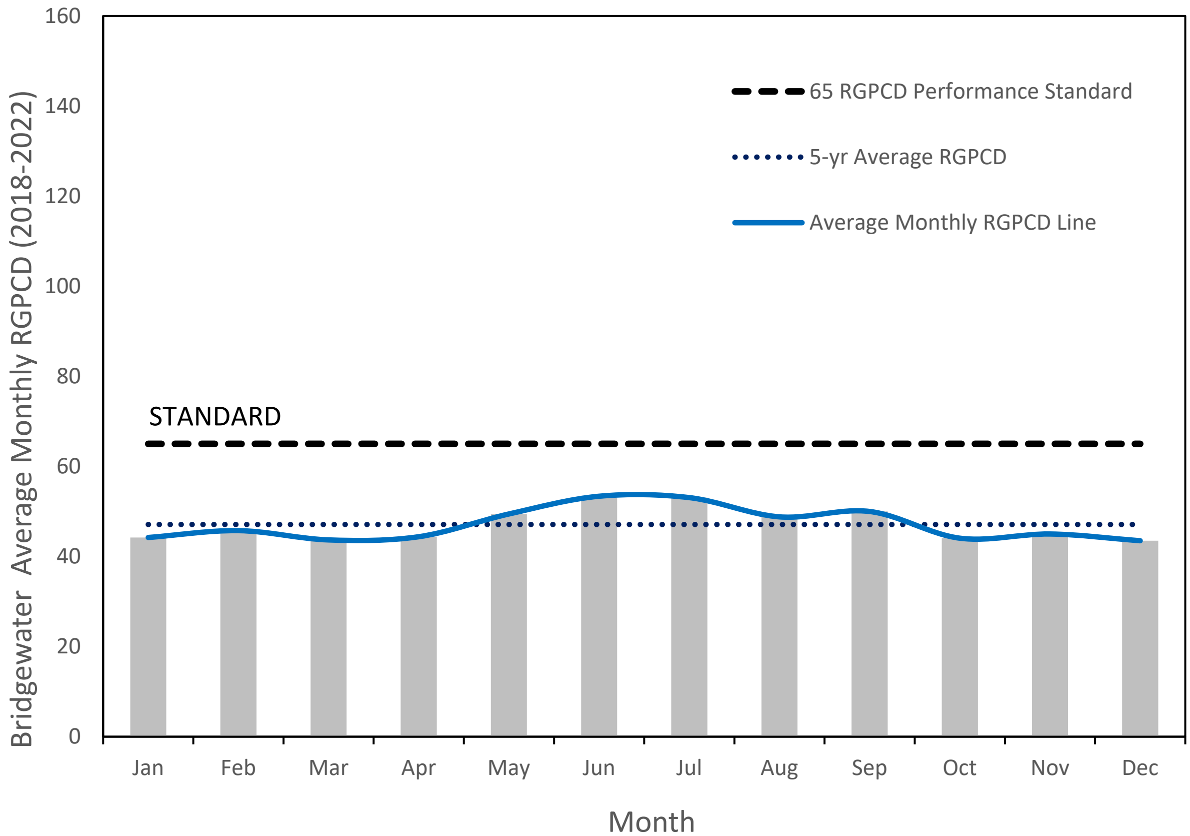

Chart 2-1: Average Monthly RGPCD, 2018 through 2022

Section 2.2.5 Monthly Finished Water Production

The monthly fluctuation in finished water production is demonstrated by comparing the total annual finished water production spread equally across all 12 months to the actual finished water production each month. Chart 2-2 below shows the average monthly finished water production based on data from 2018 through 2022.

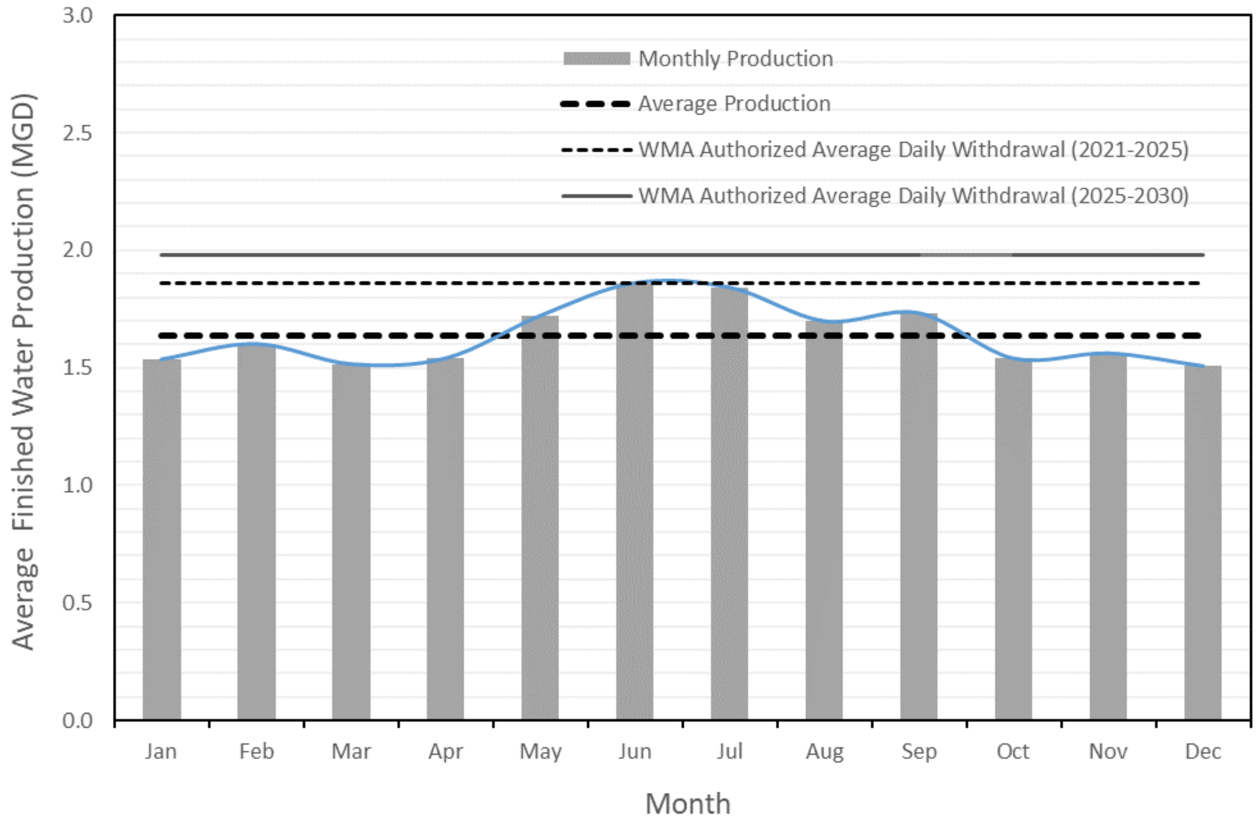

Chart 2-2: Average Finished Water Production by Month, 2018 through 2022

Section 2.2.6 Unaccounted-For Water

UAW is defined as any finished water which is produced or purchased but is not sold, metered, or included in CEMU. Common causes of UAW include leakage, metering inaccuracies, theft, and authorized uses omitted from CEMU totals. The performance standard for allowable UAW is 10 percent or less for water supplies permitted under the WMA. MassDEP will consider permittees that cannot meet the 10 percent UAW performance standard to still comply if they meet the Functional Equivalence requirements outlined in their WMA permit.

As shown below in Table 2-5, from 2018 through 2022, the Department had an average of 9.31 percent UAW with a peak UAW of 15.70 percent in 2021.

Table 2-5: Annual Unaccounted-for Water (UAW), 2018-2022

Year	Total Net Finished Water (MGY)	Total Metered Water Use (MGY)	Confidently Estimated Municipal Use (MGY)	Unaccounted-for Water Loss (MG)	Percent UAW
2018	564.30	490.06	35.24	39.00	6.91%
2019	587.50	578.29	3.52	5.69	0.97%
2020	627.81	522.91	6.56	98.34	15.66%
2021	621.37	511.26	12.54	97.57	15.70%
2022	588.13	532.92	12.19	43.01	7.31%
Average	597.82	527.09	14.01	**56.72**	**9.31%**

SECTION 2.3 CURRENT WATER SUPPLY

Section 2.3.1 Water Supply Sources

Table 2-6 below summarizes the 2022 total withdrawals for the Department's water supply sources. A review of the information presented in Table 2-6 shows that the Carver Pond Well No. 4A is the top producer for the Department, followed by the High Street Wells No. 8, and No. 3.

Table 2-6: Bridgewater Water Supply Sources

Source Name	2022 Total Withdrawal (MG)
Carver Pond Well No. 4A	208.72
High Street Well No. 8	107.05
High Street Well No. 3	105.59
High Street Well No. 6	85.53
Carver Pond Well No. 2	77.98
Carver Pond Well No. 5A	40.13
High Street Well No. 9	29.38
Plymouth Street Well No. 10B[1]	28.46
Plymouth Street Well No. 10A[1]	4.82
Total	**687.66**

1. Taken offline in 2023 due to water quality concerns.

Section 2.3.2 MassDEP Withdrawal Limits

MassDEP manages registrations and permits for all withdrawals of water for public water consumption greater than 100,000 gallons per day (gpd) under the requirements of the WMA. The Department's current WMA permit is effective as of January 5, 2021, and expires February 28, 2030.

Bridgewater's nine active wells are registered and permitted. The Department's current permit authorizes the Department to withdraw water from the Taunton River Basin at the rates described in Table 2-7. The permitted withdrawal rates are in addition to the 1.66 million gallons per day (MGD) authorized for Bridgewater. The total annual withdrawal volume is 678.90 MGY or 1.86 MGD for the current permit period from January 1, 2021, to February 28, 2025.

Table 2-7: WMA Permitted Maximum Annual Withdrawal Limits

Permit Periods	Permit #9P-4-25-042.01		Registration #425042.01		Total	
	Total Annual (MGY)	Daily Average (MGD)	Total Annual (MGY)	Daily Average (MGD)	Total Annual (MGY)	Daily Average (MGD)
1/5/21 to 2/28/25	73	0.2	605.90	1.66	678.90	1.86
3/1/25 to 2/28/30	116.8	0.32	605.90	1.66	722.70	1.98

Bridgewater may increase annual average daily withdrawals to the maximum authorized (1.98 MGD) if Bridgewater is meeting the following:

- RGPCD of 65 or less, or all RGPCD functional equivalence requirements in Special Condition 5 of their WMA permit;
- UAW of 10 percent or less, or all UAW functional equivalence requirements in Special Condition 6 of their WMA permit;
- Seasonal limits on nonessential outdoor water use in Special Condition 7 of their WMA permit; and
- Water conservation requirements in Special Condition 8 on their WMA permit.

As of the 2022 ASR, the Department's permitted average daily withdrawal limit was 1.86 MGD compared to the 2022 average water withdrawal of 1.61 MGD. Table 2-8 below summarizes the historic annual withdrawals from 2018 through 2022 versus their WMA authorized withdrawal volume.

Table 2-8: Town of Bridgewater Historic Water Withdrawals

Year	Total Water Withdrawal (MGY)	Average Water Withdrawal (MGD)	WMA Authorized Average Withdrawal (MGD)	Difference[1] (MGD)
2018	564.30	1.55	2.40	0.85
2019	587.50	1.61	2.40	0.79
2020	612.41	1.67	1.86	0.19
2021	621.37	1.70	1.86	0.16
2022	588.13	1.61	1.86	0.25

1. A negative difference indicates an exceedance of the WMA permit.

Table 2-8 shows that the Department has not exceeded their authorized withdrawal volume in the last 5 years (2018 – 2022).

In addition to the total annual average daily withdrawal limit, the Department's nine permitted wells are subject to maximum daily withdrawal limits. Table 2-9 summarizes the daily maximum withdrawal limits for those nine permitted wells.

Table 2-9: WMA Permitted Maximum Daily Withdrawal Limits

Source Name	Maximum Daily Rate	
	gpm	MGD
Carver Pond Well No. 2	403	0.58
Carver Pond Well No. 4A	299	0.43
Carver Pond Well No. 5A	167	0.24
High Street Well No. 3	1126	1.620[1]
High Street Well No. 6		
High Street Well No. 8		
High Street Well No. 9		
Plymouth Street Well No. 10A	160	0.23
Plymouth Street Well No. 10B	215	0.31

1. The WMA specifies a combined maximum daily withdrawal limit for High Street Wells.

Section 2.3.3 System-wide Maximum-Day Water Supply Assessment

EP utilized well evaluation data and rehabilitation reports, as well as historic pumping data and current reported operational settings to estimate each source's operational capacity. Table 2-10 below lists each source alongside its respective permitted or approved withdrawal limit, as well as its estimated operational capacity. Reported operational capacities reflect recent discussions with the Department's operations staff.

The supply capacities listed in Table 2-10 are the lesser of the estimated current operational capacity and the maximum daily withdrawal limit. In order to provide an adequate supply of water during periods of peak water usage, the firm capacity (the system capacity with the single largest source offline) should meet or exceed the MDD. Based on the supply capacities summarized within Table 2-10 below, the High Street Well No. 3 is the largest single source at 0.648 MGD of supply capacity.

Table 2-10: Water System Withdrawal Capacities

Source Name	Maximum Daily Withdrawal Limit (MGD)	Operational Capacity (MGD)	Supply Capacity (MGD)
Carver Pond Well No. 2	0.580	0.576	0.576
Carver Pond Well No. 4A	0.430	0.288	0.288
Carver Pond Well No. 5A	0.240	0.086[3]	0.086
High Street Well No. 3	1.620	0.648	1.620
High Street Well No. 6		0.396	
High Street Well No. 8		0.432	
High Street Well No. 9		0.252	
Plymouth Street Well No. 10A	0.230	0.288[2]	0[1]
Plymouth Street Well No. 10B	0.310	0.310[2]	0[1]
Total	**3.410**	**3.276**	**2.570**

1. Source currently offline, unable to achieve design flow rate while High Street WTP is operating.
2. Based on maximum aggregate capacity reported in the Department's ASR.
3. Capacity currently limited due to screen failure.

Following discussions with the Department operations staff, EP understands that the Department does not wish to operate the Plymouth Wells unless treatment is secured. As such, EP has excluded these wells from the current firm capacity calculations.

The resulting firm capacity is **2.030 MGD**. This assumes that High Street WTP continues to operate at 1.08 MGD with the other three wells at full capacity. An average MDD of 2.56 MGD between 2018 and 2022 (maximum MDD of 2.85 MGD in 2020) indicates that the Department is experiencing a firm capacity deficit and would not be able to safely meet maximum day demands if Well 3 is offline.

More notably, the difference between the total supply capacity of 2.570 MGD and the average MDD of 2.56 MGD is 0.01 MGD, which is the available supply margin. This margin is smaller than the capacity of all of the Department's sources, meaning the loss of any well during an MDD period would result in a supply deficit. The only exception is Well 9, as the four wells supplying the High Street WTP have more operational capacity than the maximum daily withdrawal limit of the four wells combined. Assuming Wells 3, 6, and 8 are operating at full operational capacity, the Department should be able to supply 2.58 MGD with Well 9 offline, which is marginally above the average MDD of 2.56. Chart 2-3 below compares the Department's historic demand and supply capacity.

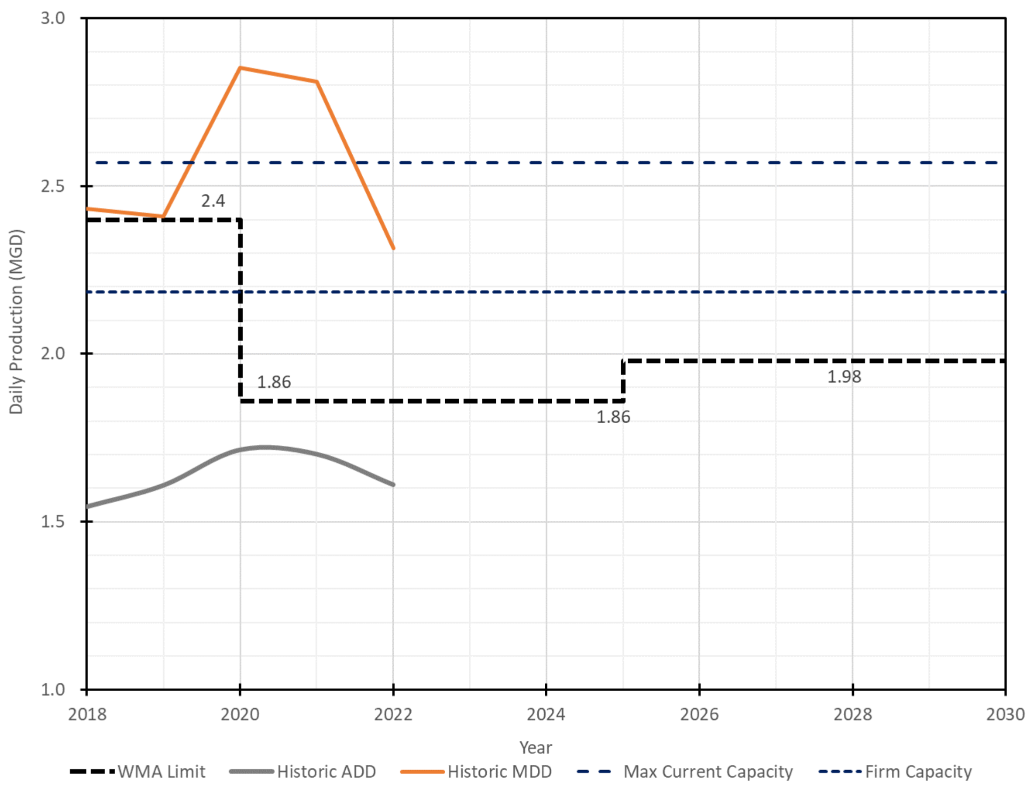

Chart 2-3: Bridgewater Historic Demand vs. Supply Capacity

As shown in the chart above, MDD has historically exceeded the current maximum supply capacity (with Plymouth Wells offline) and is above the current firm capacity on average. Historic ADD is also near the WMA limit and may exceed it following the addition of known proposed developments, as discussed later in this section.

Section 2.3.4 Additional Supply Considerations

The operational capacities of the wells are dependent on regular cleaning and redevelopment. Therefore, the Department should continue to complete this maintenance in order to efficiently produce water during peak summertime demand periods when the loss of a source could strain supplies.

Additionally, if an entire water treatment plant, raw water, or discharge piping were to experience a failure, the Department's water system could lose supply from multiple wells at once. This would result in a much larger supply deficit.

SECTION 2.4 WATER SYSTEM DEMANDS FORECAST

A water needs forecast estimates the volume of water a public water supplier will need to provide to meet the needs of its customers in the future. EP reviewed historic water use patterns along with the Department's anticipated population and employment projections. The Massachusetts Water Resources Commission (WRC) published the "Policy for Developing Water Needs Forecasts for Public Water Suppliers and Communities and Methodology for Implementation" (last revised March 9, 2017), which outlines their methodology for demand forecasting. EP utilized this methodology to forecast the Department's customer water demands through the 2045 planning period.

Section 2.4.1 Population Served Forecast

As the Department's customers are primarily residential (87 percent), population changes will be the most significant factor in accurately forecasting future water needs. The Massachusetts Department of Transportation (MassDOT) released population forecasts in September 2018. Table 2-11 below presents a summary of Bridgewater's historic population according to the United States (US) Census Bureau, the town census, and the projected populations according to the MassDOT forecasts, Metropolitan Area Planning Council, and UMass Donahue Institute.

Table 2-11: Historic and Forecasted Population

US Census Data		Bridgewater Census Data			MassDOT Projections	
2010	2020	2020	2021	2022	2030	2040
26,563	28,633	28,509	28,888	28,780	28,333	28,689

The MassDOT projections for 2020 underestimated the Bridgewater census population by 2.5%. EP shifted the MassDOT projected population growth rate to the actual 2020 population as indicated by the US census Data. Chart 2-4 below shows how the MassDOT population projections and the EP adjusted population projections compare to the historic population.

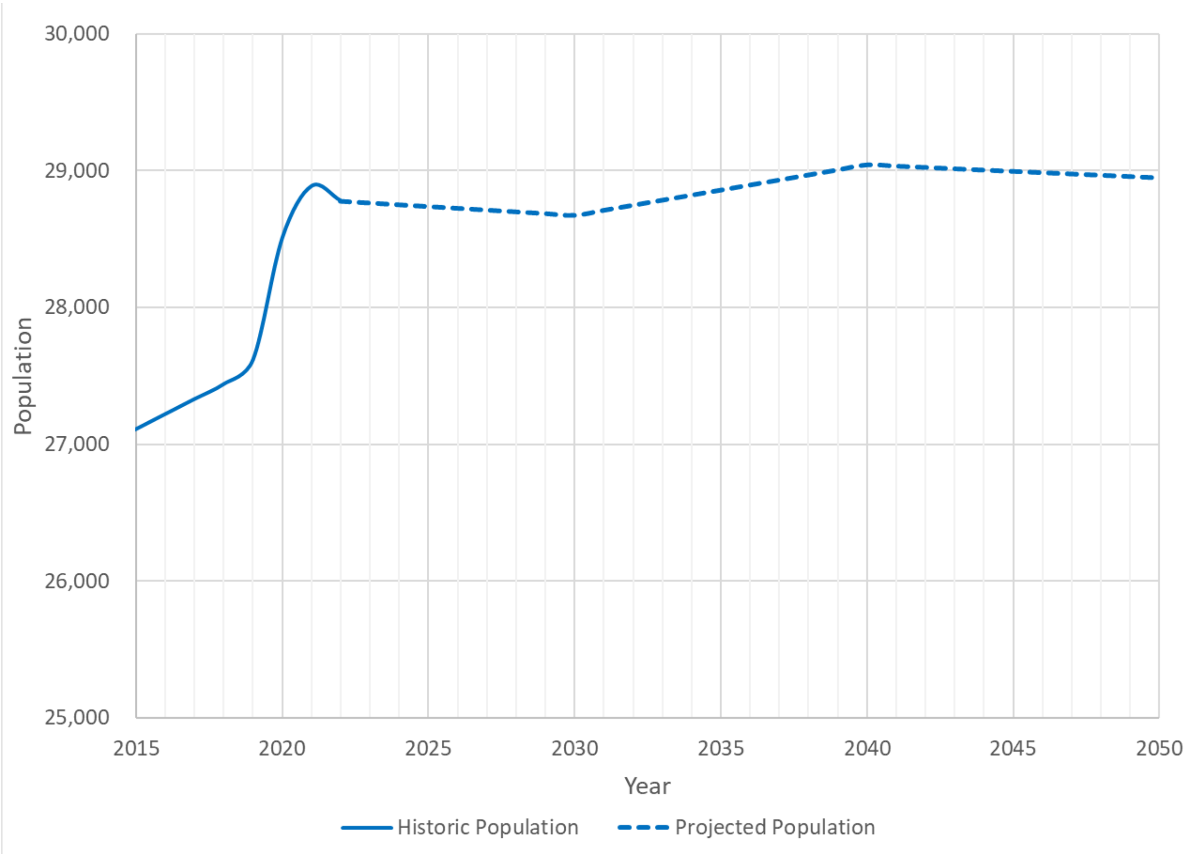

Chart 2-4: **Bridgewater Historic and Projected Population**

Section 2.4.2 Employment Forecast

Commercial use is the second largest classification in Bridgewater. Table 2-12 below summarizes the MassDOT employment forecasts through 2040.

Table 2-12: MassDOT Employment Projections

MassDOT Projections				
2010	**2020**	**2030**	**2040**	**2050**
8,025	8,791	8,536	8,585	8,624

As shown in Table 2-12 MassDOT projections suggest employment growth in Bridgewater will remain stable from 2020 to 2050.

Section 2.4.3 Known Future Developments

EP received a list of known future developments from the Bridgewater Water Department, including full build-out sewer needs. EP used these as approximations of the required water provisions, totaling 360,723 gpd.

It is important to note that the demand for the known future developments is higher than the margin between ADD for the last three years and the currently authorized WMA permit. Therefore, if these developments are completed, the authorized WMA permit will likely be exceeded, unless the demands across the system can be reduced.

Section 2.4.4 Demand Forecasts

The WRC forecasting methodology requires future residential demands to be calculated assuming 65 RGPCD and 10 percent UAW. The 5-year average RGPCD for Bridgewater is 47.2, which is below the WRC value of 65. EP has prepared the demand projections using both numbers to provide a range of potential outcomes. This approach adheres to the WRC's methodology while also depicting a potential future if the Department is able to maintain their current averages. This demonstrates the importance of continuing to encourage efficient water use.

Table 2-15 below summarizes the average historic demands used as the basis for the WRC forecasts presented below.

Table 2-13: Average Historic Demands in Gallons per Day, (2018 – 2022)

Residential ADD[1]	Non-Residential ADD	UAW[2]	Average-Day Demand
1,254,023	189,274	194,573	1,637,870

1. 47.2 RGPCD
2. 11.6% UAW

Table 2-16 below provides a summary of the demand forecast for the years 2025 to 2045 in five-year increments using the standard WRC forecasting methodology of 65 RGPCD and 10% UAW.

Table 2-14: Projected Demands in GPD (WRC Methodology, 65 RGPCD)

Year	Projected Residential ADD[1]	Projected Non-Residential ADD	Projected UAW[2]	Known Development ADD[1]	Projected Average-Day Demand
2025	1,868,189	131,257	219,939	360,723	2,580,108
2030	1,864,005	129,325	219,266	360,723	2,573,319
2035	1,875,998	129,696	220,626	360,723	2,587,043
2040	1,887,990	130,067	221,986	360,723	2,600,766
2045	1,884,903	130,363	221,679	360,723	2,597,667

[1]65 RGPCD
[2]10% UAW

Table 2-17 below provides a summary of the demand forecast using the 2018 – 2022 average RGCPD of 47.2. This demonstrates a potential outcome if the Department is able to maintain low average residential demands.

Table 2-15: Projected Demands in GPD (WRC Methodology with 47.2 RGPCD)

Year	Projected Residential ADD[1]	Projected Non-Residential ADD	Projected UAW[2]	Known Development ADD[1]	Projected Average-Day Demand
2025	1,356,863	131,257	163,693	360,723	2,012,536
2030	1,353,824	129,325	163,146	360,723	2,007,018
2035	1,362,534	129,696	164,145	360,723	2,017,098
2040	1,371,244	130,067	165,144	360,723	2,027,179
2045	1,369,002	130,363	164,930	360,723	2,025,017

[1]47.2 RGPCD
[2]10% UAW

As shown in the above tables, by 2045, average-day demand is projected to increase to between 2.02 MGD and 2.60 MGD depending on the RGPCD. With a maximum-to-average demand ratio of 1.56, the projected 2045 maximum-day demand is between 3.17 MGD and 4.06 MGD. Either scenario will result in a significant increase in the existing firm capacity deficit unless additional supply is secured, as discussed below.

Section 2.4.5 Supply and Demand Analysis

Chart 2-5 below compares the maximum supply capacity with the projected maximum day demands under multiple supply scenarios.

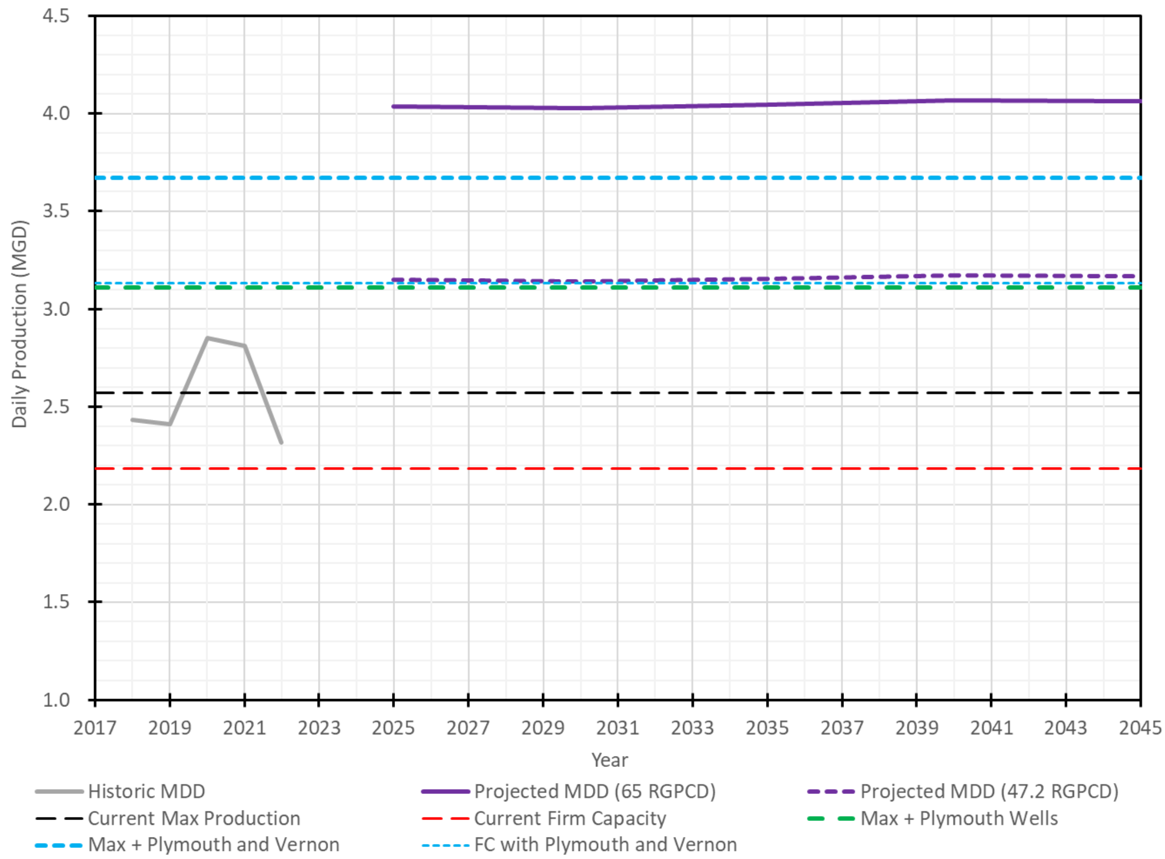

Chart 2-5: Bridgewater Projected Supply vs. Demand

As shown in the chart above, if the Department is able to maintain the historically low RGPCD of 47.2, they are projected to have sufficient supply capacity to meet MDD with all sources available, including the Plymouth Wells. If, however, demands climb to the WRC standard of 65 RGPDC, the Department will not be able to meet MDD even with the addition of both the Plymouth Wells and the Vernon Street Wells.

Notably, if the Department is able to recover capacity at the Plymouth Wells by routing them to the High Street WTP via a new raw water transmission main and achieves the permitted capacity of 0.56 MGD at the Vernon Street Wells, the Department will have adequate firm capacity to meet future MDD provided RGPCD remains near the current value of 47.2.

Interconnections

One means of increasing firm capacity and bolstering supply in the short term is to establish an emergency interconnection with a neighboring municipality. The Vernon Street Well project may take several years to complete and may not be finished before the anticipated developments are constructed. 2025 projected MDD ranges between 3.15 and 4.04 MGD. The resulting firm capacity if the Plymouth Wells are recovered would be 2.57 MGD.

An interconnection (or multiple) would therefore need to supply between 0.58 and 1.47 MGD to provide the Department with sufficient capacity, depending on the actual RGPCD in 2025. This amounts to between 402 and 1,020 gpm. EP recommends the Department assess the short-term supply capacity of neighboring communities to offset the risk of a firm capacity deficit prior to activation of Vernon Street.

SECTION 2.5 CONCLUSIONS AND RECOMMENDATIONS

The Department presently lacks the necessary firm capacity to meet the current and projected 2045 maximum-day demand, regardless of whether the projections are calculated using the historic average RGPCD of 47.2 or the WRC value of 65.

If the Department is able to maintain its low RGPCD of 47.2, recovering the capacity of the Plymouth Street Wells via a raw water transmission main to the High Street WTP would provide sufficient capacity to meet MDD when all sources are available. To meet 2025 demands in a firm capacity scenario, the Department will either need to complete the Vernon Street Wells project or establish an emergency interconnection with a neighboring community (or multiple) totaling between 0.43 and 1.32 MGD (300 and 925 gpm). EP understands the Department has begun pursuing the Plymouth Street Wells project.

Additionally, the 5-yr ADD is near the WMA permit limit. If the proposed future developments are completed, the WMA permit allowance will likely be exceeded unless demands can be maintained at low levels.

EP recommends the Department begin the process of completing the Vernon Street Wells as soon as possible, as the project may take several years to complete. In addition, the Department can recover function at the Plymouth Street Wells by completing a raw water transmission main to the High Street WTP, which was designed to accept approximately 0.58 MGD above the WMA permitted allowance for the High Street Wells. This is sufficient to incorporate the total permit allowance of 0.53 MGD at the Plymouth Wells.

To accommodate demands over the full 2045 planning horizon, the Department may need to locate additional water sources, establish permanent purchase agreements from neighboring communities, or purchase water from a regional supplier, such as the regional desalination plant. EP recommends the Department assess these alternatives to establish their viability, discussed further in Section 6.

Further, EP strongly recommends the Department continue to encourage efficient consumption and closely monitor the RGPCD annually. The Department has historically been well below the RGPCD standard of 65. Increasing per capita demands will accelerate the need for additional water sources and the risk of experiencing a water shortage during the loss of individual water sources.

Environmental Partners recommends continuing regular well maintenance and redevelopment to maximize the operational capacity of the wells. Section 6 of this report presents a series of recommended projects to recover lost capacity, including replacement of High Street Well No. 9, Carver Pond Well No. 5A, pump upgrades at Plymouth Wells 10A, and 10B, as well as new supply sources such as the Vernon Street Wells and possible connection to Aquaria Regional Desalinization Plant.

SECTION 3 DISTRIBUTION STORAGE ASSESSMENT

Section 3 serves to assess the Department's existing distribution system storage facilities, determine whether the Department's current storage volumes are adequate for existing and future needs, and identify any volumetric deficiencies to be addressed with system improvements. An assessment of fire flow rates is included in Section 5.

SECTION 3.1 DISTRIBUTION STORAGE OVERVIEW

Water storage tanks provide water for peak demands of short duration, minimize pressure fluctuations during periods of demand changes in the distribution system, and furnish reserve storage volumes for fire protection. Storage may also serve to provide an emergency short-term supply in case water sources become temporarily unavailable.

The tank water level is just as important as the volume of water in the Department's storage tanks. Under MassDEP regulations, water suppliers must maintain adequate pressures within their distribution systems during normal operating conditions and fire flow conditions. MassDEP provides guidelines for minimum distribution system pressures, which are dictated by peak-hour-demand and fire-flow storage volumes within the Department's storage tanks. Water levels in the storage facilities must be maintained above the minimum elevations to ensure adequate pressures and hydraulic gradient throughout the system.

Provided within the top portion of the tank, the peak hour demand storage volume maintains a minimum pressure of 35 pounds per square inch (psi) in the distribution system. Beneath this, the fire protection storage volume typically supports a minimum pressure of 20 psi throughout the distribution system during maximum day demands with a coincident fire flow.

As discussed in Section 1, the Department has two storage tanks within its distribution system. The tanks each have an overflow level of 261.3 feet. The table below provides a summary of pertinent engineering data associated with the Department's water distribution storage tanks.

Table 3-1: Summary of Distribution Storage Facilities

Tank Name	Great Hill Tank	Sprague Hill Tank
Material	Steel	Steel
Year Built/Rehabilitated	1925/2013	1973/2008
Base of Tank/Storage	161.3	178.8
Height (feet)	100	82.5
Overflow Elevation (feet)	261.3	261.3
Diameter (feet)	42	90
Nominal Volume (gallons)	900,000	3,900,000

The total bulk storage is approximately 4.8 MG, or 2.93 days of storage. This volume theoretically results in turning over the total tank volumes in 2.93 days, or 34% daily turnover, which slightly exceeds the MassDEP guidelines of 20-33% per day. EP recommends the Department consider increasing its total volume of storage should a tank be added or replaced, which is included as part of the tank analysis discussed in Section 6.

SECTION 3.2 USABLE STORAGE

EP determined the highest customer in the system to be at elevation 131 feet, located in the southwest of the system, near the intersection of Pine Street and Fairway Drive. The following analysis uses this benchmark to evaluate the amount of usable storage within each of the storage tanks as well as the volume of peak hour demand and fire-flow storage under current and future demand conditions.

In accordance with MassDEP Guidelines for Public Water Systems (Chapter 8.4.1.3), water systems are required to provide a minimum service pressure of 35 psi (81.2 feet) to the highest customer under static conditions. EP calculated usable storage based on the overflow elevation of each tank and the elevation of the highest customer in the system (131 feet). Based on the highest customer elevation of 131 feet, the required water elevation to provide 35 psi would be 211.9 feet.

Table 3-2: Volume of Usable Storage

Tank Name	Great Hill Tank	Sprague Hill Tank
Base elevation	161.3	178.8
Overflow elevation (feet)	261.3	261.3
Diameter (feet)	42	90
Volume per foot (gal/ft)	10,364	47,589
Vertical feet of usable storage	49.4	49.4
Volume of usable storage (gal)	512,491	2,355,259
Percent of Volume Usable	57%	60%

SECTION 3.3 PEAK HOUR DEMAND STORAGE

The amount of distribution storage required to meet peak hour demands is a function of both the MDD and the available pumping capacity. In accordance with the American Water Works Association (AWWA) Manual of Water Supply Practices, if pumping capacity is equal to or greater than the MDD, the storage required to meet peak hourly demands is estimated to be 30 percent of the MDD. This is presently the case for the Bridgewater water system.

Section 3.3.1 Peak Hour Storage Assessment

The Department's ASRs data from 2018 to 2022 show an average MDD of 2.56 MGD. As presented in the previous section, the available pumping capacity is 2.724 MGD. Because this is larger than the current maximum day demand, the required peak hour demand storage is 30 percent of MDD or

0.77 MGD. As referenced in Section 2, EP developed water demand projections in accordance with WRC methodology and estimated a 2045 MDD of 4.06 MGD (assuming an RGPCD of 65). At 30 percent of this MDD, the anticipated peak hour demand will climb to 1.22 MGD in 2045.

Under existing MDD conditions, the system requires 768,600 gallons of peak hour storage. In 2045, with increased demands, the need for peak hour storage will increase to 1,287,400 gallons. The table below shows the comparison between available usable storage and peak hour demand under current and future demands.

Table 3-2: Peak Hour Storage Analysis

Year	Usable Storage (Gallons)	Peak Hour Storage Required (Gallons)	Peak Hour Storage Surplus or (Deficit) (Gallons)
2023	2,867,751	768,600	2,099,151
2045	2,867,751	1,219,000	1,648,751

As shown in the table above, the Department has sufficient peak hour storage under current and future demands. This analysis assumes no changes are made to the Department's storage tanks, and that the Department locates sufficient supply to exceed MDD.

SECTION 3.4 FIRE PROTECTION

The volume of distribution storage necessary for fire protection is based in part on the fire flow requirements established by the ISO. The ISO establishes fire protection criteria, which are used by insurance companies to set insurance rates. According to ISO standards, the maximum residential fire flow required is 3,500 gpm for 3 hours. When determining system adequacy, ISO requires the water system to provide fire flow up to 3,500 gpm, while any property owners with higher fire flow requirements are responsible for the remainder of the flow. However, a water system may elect to provide additional fire flow to areas with elevated requirements.

As a part of the reports published by the ISO, 176 locations throughout the Town of Bridgewater were tested and evaluated for adequacy. The highest required fire flow in the system is 6,000 gpm for 4 hours at two locations: a storage facility at 31 Perkins Street, and a recycling facility at 1 Depot Street. For this analysis, EP evaluated system storage based on this maximum ISO fire flow requirement as well as the maximum residential requirement.

Section 3.4.1 Fire Flow Storage

During a fire event, water suppliers are required to maintain 20 psi (46 feet) of service pressure throughout the distribution system while providing adequate fire flow. Under this condition, usable fire flow storage is calculated as the amount of water that will provide a pressure of 20 psi to the customer at the highest elevation.

In order to supply 20 psi of water pressure to the highest customer elevation of 131 feet, the water level elevation in the tanks need to be at least 177.2 feet. Below is a summary of available fire flow storage in the Department's water tanks.

Table 3-3: Fire Flow Storage

Tank Name	Great Hill Tank	Sprague Hill Tank
Base elevation (ft)	161.3	178.8
Fire Flow Storage (gal)	871,598	3,928,076
Total of Fire Flow Storage (gal)	4,799,674	

Section 3.4.2 Existing Demands – Fire Flow Storage Assessment

EP first evaluated fire flow storage for the maximum residential ISO requirement of 3,500 gpm for 3 hours, or 630,000 gallons of water. Next, EP looked at the maximum ISO requirement in the system. To be conservative, both analyses assumed the worst-case scenario with current MDD demands occurring during the fire-fighting event.

The maximum ISO requirement for the system is 6,000 gpm for 4 hours, or 1,440,000 gallons of water. Table 3-4 below shows the comparison between available and required fire flow storage for both the maximum residential and maximum overall requirements.

Table 3-4: Fire Flow Storage Analysis – Existing Demands

ISO Requirement	Fire Flow Required (GPM)	Hours	Fire Storage Required (Gallons)	Usable Fire Flow Storage (Gallons)	System MDD during Fire Event (Gallons)	Fire Flow Storage Surplus or *(Deficit)* (Gallons)
Residential Maximum	3,500	3	630,000	4,799,674	320,240	**3,849,434**
Overall Maximum	6,000	4	1,440,000	4,799,674	426,990	**2,932,684**

As shown in Table 3-4, the system has a surplus of fire flow storage available to meet all residential fire flow requirements and the maximum zonal ISO requirement.

Section 3.4.3 Future Demands – Fire Flow Storage Assessment

EP also assessed fire flow storage under the worst-case scenario with future MDD demands occurring during the firefighting period. As mentioned above, EP developed water demand projections and estimated a 2045 MDD of 4.06 MGD.

Table 3-5 below shows the comparison between available and required fire flow storage for both the maximum residential and maximum zonal requirements in 2045.

Table 3-5: Fire Flow Storage Analysis – Future Demands

ISO Requirement	Fire Flow Required (GPM)	Hours	Fire Storage Required (Gallons)	Usable Fire Flow Storage (Gallons)	System MDD during Fire Event (Gallons)	Fire Flow Storage Surplus or *(Deficit)* (Gallons)
Residential Maximum	3,500	3	630,000	4,799,674	507,910	**3,661,764**
Zone Maximum	6,000	4	1,440,000	4,799,674	677,210	**2,682,464**

As shown in Table 3-5, the system will continue to have sufficient fire storage to meet all residential fire flow requirements and the maximum zonal ISO requirement even as demands increase in the future.

SECTION 3.5 CONCLUSIONS AND RECOMMENDATIONS

The Department currently has a surplus of usable storage and a sufficient volume of fire storage to meet all residential fire requirements and zonal ISO requirements. As noted in the previous section, the proposed developments may result in total demand exceeding pumping capacity, which would require a reassessment of available storage.

At present, the total bulk storage is approximately 4.8 MG, or 2.93 days of storage. This would result in turning over the total tank volumes in 2.93 days, or 34% daily turnover, which slightly exceeds the MassDEP guidelines of 20-33% per day. EP recommends the Department consider increasing its total volume of storage should a tank be added or replaced, which is included as part of the tank analysis discussed in Section 6.

Approximately 43% of the water in the Great Hill Tank and 40% of the water in the Sprague Hill Tank is considered unusable, located below an elevation associated with 35 psi for the highest elevation customer. Recent inspection reports noted foundation degradation. The tank may be at the end of its useful life and in need of replacement. As discussed further in Section 5, constructing a new tank at an alternate location may help address fire flow deficiencies in the western portion of the distribution system.

The Sprague Hill Tank will likely need rehabilitation around the year 2030. The Great Hill Tank will likely need rehabilitation around the year 2035 or replacement sooner, pending the results of a tank analysis. This is discussed further in Section 6.

SECTION 4 WATER SYSTEM HYDRAULIC MODEL CREATION AND CALIBRATION

Section 4 serves to summarize the process and methods used to create and calibrate the hydraulic model for the Department's water distribution system. A technical memorandum detailing the hydraulic model creation and calibration is included in Appendix C. A brief summary of the creation and calibration is presented below.

SECTION 4.1 BACKGROUND

A calibrated hydraulic model is a powerful tool for every water distribution system. It enables the Department to complete distribution system assessments, prioritize capital improvements, develop and optimize flushing programs, and estimate future impacts to the water system. In addition, a calibrated model can predict available fire flow (AFF) at locations throughout the water system under varying system conditions. With additional calibration effort, a hydraulic model can even simulate water quality (e.g., chlorine residual) throughout the distribution system.

The Department provided EP with shapefiles of the water system distribution mains dated February 15, 2023. The Department provided EP with shapefiles of the system isolation valves and hydrants dated August 31, 2021 as part of previous efforts. EP referenced record drawings and engineering reports to add the treatment and pumping facilities and storage tanks to the model.

EP incorporated the demands for the year 2022 into the model. To account for UAW in the model, EP took the annual consumption volume and scaled it to match the annual production volume reported. Using the address of each customer, EP geographically located the scaled demands, assigned them to the nearest pipe, and then distributed them proportionally to the nearest nodes in the model. This approach yields a spatially weighted representation of recent demands.

SECTION 4.2 STEADY-STATE CALIBRATION

The Department assisted EP in performing 24 hydrant flow tests in the field on May 16 and 18, 2023, and provided supplementary SCADA data to accompany the tests. Once the model was built, EP simulated each of the field tests and adjusted the interior pipe roughness coefficients to approximate the headloss observed in the field. EP also closed several isolation valves the Department reported were closed (either temporarily or permanently) during the time of field testing.

EP targeted three psi accuracy for all static pressure readings. EP used the same 3 psi accuracy standard for the calculated headloss during a flowing event. This is compatible with the accuracy of the pressure gauges and falls within the industry standard of 2.2-4.3 psi per the fourth edition of the American Water Works Association's (AWWA's) M32 Manual: Computer Modeling of Water Distribution Systems.

The chart below summarizes the static pressure calibration results. Three results were ultimately excluded from the calibration as detailed in Appendix C.

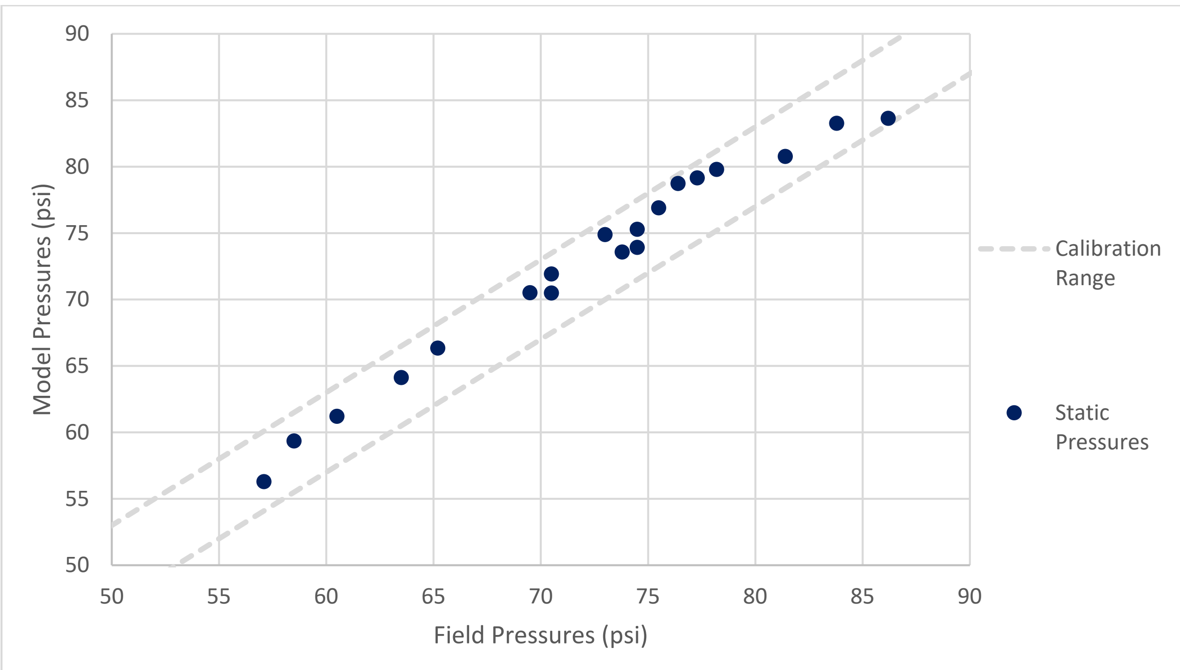

Chart 4-1: Static Pressure Calibration Results

The next step in the calibration process is to input the hydrant flows measured during each field test into the model and compare the headlosses observed. EP targeted the industry standard of three psi accuracy for dynamic head losses.

The results of the dynamic calibration are summarized below.

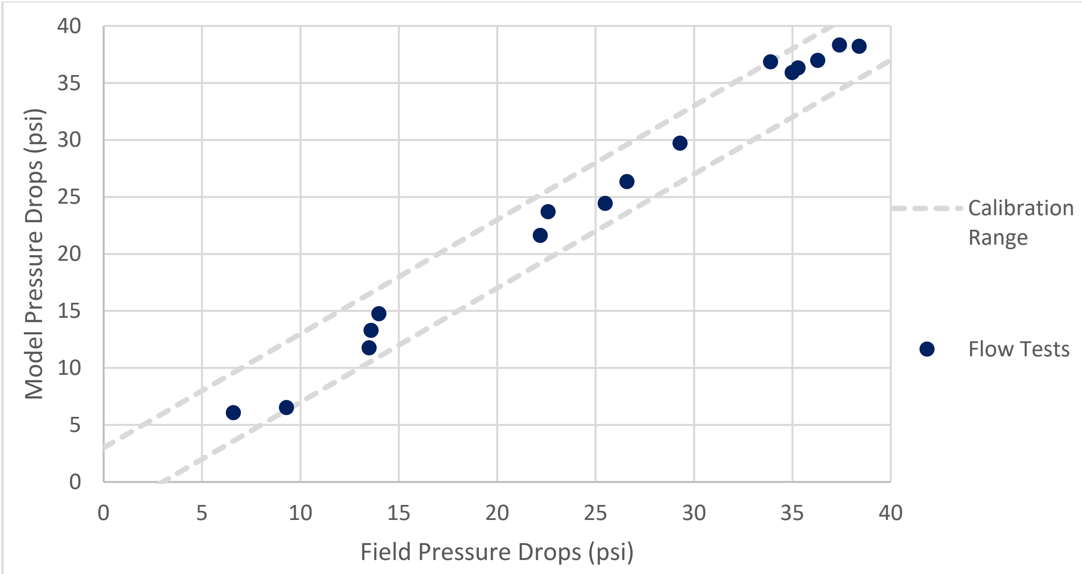

Chart 4-2: Dynamic Calibration Results

SECTION 4.3 EXTENDED PERIOD SIMULATION (EPS) CALIBRATION

The EPS calibration aims to replicate the dynamic conditions of the system. EP simulated operating conditions in the model with the goal of replicating the following:

- Changes in tank levels as a result of demand over a 72-hour calibration period, and
- Pumped flow under varying head conditions over a 72-hour calibration period

EP performed EPS calibration for an ADD period in early May 2023. EP received photos of the SCADA data from the Department for May 2023. EP processed the data to obtain SCADA data in 15-minute intervals and replicated the data in the hydraulic model by inputting pump controls that align with the SCADA data.

The AWWA manual does not prescribe standards for matching source flows. However, they do provide comparable guidance from the Water Authorities Association in the United Kingdom. These standards state that model flows should be within 5 percent of recorded flows when the flow is greater than 10 percent of total demand, and within 10 percent of recorded flows when the flow is less than 10 percent of recorded flows.

The results of the extended period calibration are presented below.

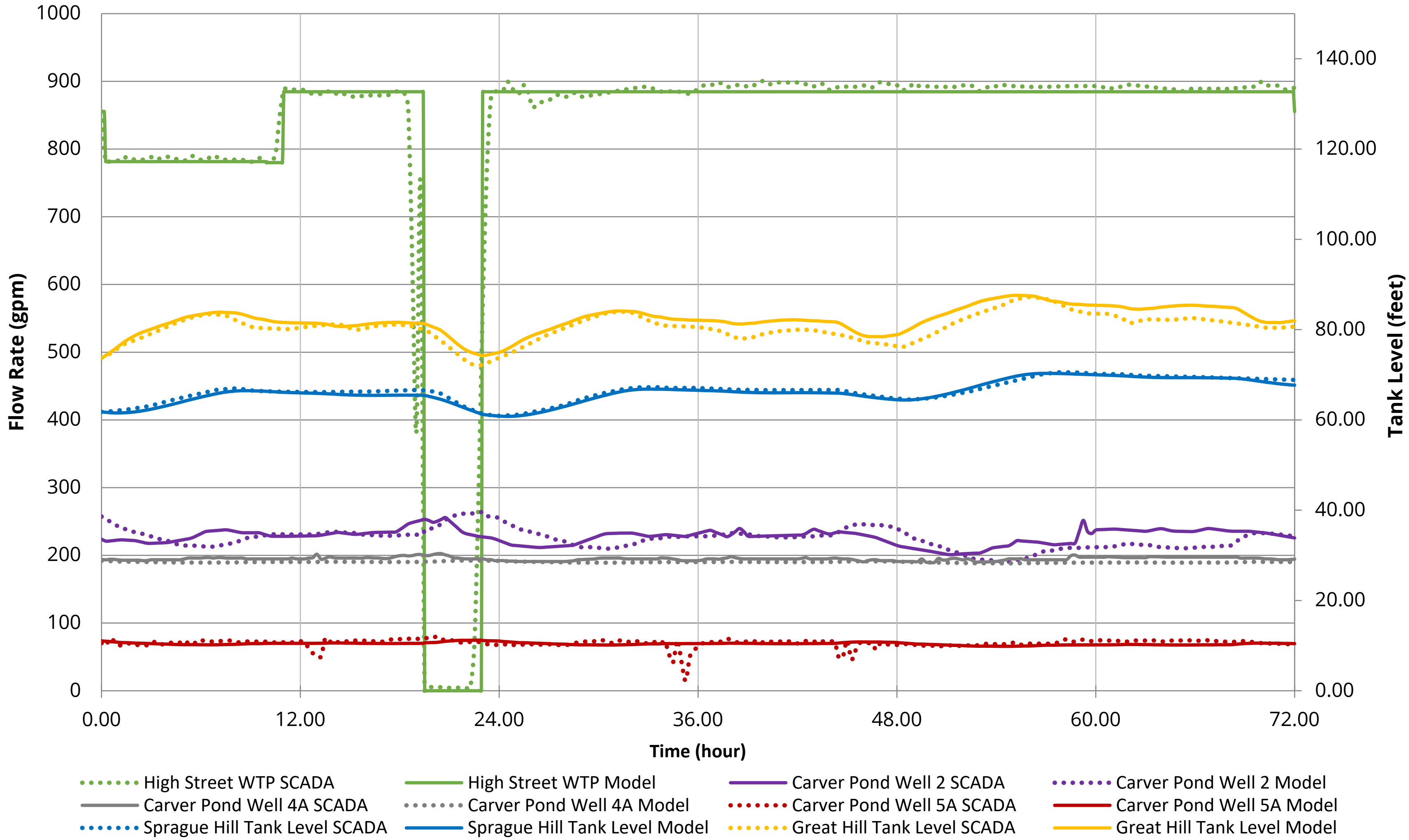

Chart 4-3: Bridgewater Water System ADD EPS Calibration

EP was able to calibrate the water system hydraulic model successfully. Modeled flows and storage tank levels match the SCADA data to a greater degree of accuracy than those described above.

SECTION 4.4 CONCLUSIONS AND RECOMMENDATIONS

Overall, the calibrated model closely mimics actual water distribution system conditions represented by the field-testing results. All static and residual pressures fell within the industry standard of precision. Four tests required higher than expected friction losses. It is likely one or more closed valves or pipe blockages are restricting flow in the system. It is also possible the GIS records reflect a pipe that does not exist. EP adjusted the C factors in these areas as required to replicate the losses observed in the field but recommends further investigation to confirm accuracy of these adjustments.

A comprehensive valve exercising program coupled with targeted flow tests will characterize any head loss discrepancies with higher precision. Should any blockages or closed valves be identified, these areas should be recalibrated with the data collected at that time. Further, these test locations would need to be reassessed for fire flow and other deficiencies described in the following section.

SECTION 5 WATER DISTRIBUTION SYSTEM HYDRAULIC ASSESSMENT

Section 5 assesses the current condition of the water distribution system using the hydraulic model. EP assessed the hydraulic performance of the distribution system during both ADD and MDD conditions and evaluated the ability of the Department's water supply system to provide adequate system pressures and fire flows, as outlined in the MassDEP Guidelines for Public Water Systems and the ISO. The analysis was completed utilizing the calibrated hydraulic model as described briefly in Section 4 and in detail in Appendix C.

SECTION 5.1 DISTRIBUTION SYSTEM PRESSURE ANALYSIS

According to MassDEP Guidelines for Public Water Systems Chapter 9: Distribution System Piping & Appurtenances, the ideal pressure range for the distribution system is 60-80 psi and not less than 35 psi under normal operation conditions.

Section 5.1.1 Typical Pressure Ranges

Using the calibrated hydraulic model, EP performed the analysis of the distribution system under the ADD, MDD and peak hour scenarios, for the current and 2045 projected demands. For all scenarios, the valves that are currently closed/broken were assumed repaired and open. All sources were assumed online. Table 5-1 below shows the comparison of these results.

Table 5-1: System Pressures under Current and Projected Demand Conditions

Condition	System Pressures under Current Demand			System Pressures under Projected Demand		
	Less than 35 psi	Between 35 and 80 psi	Above 80 psi	Less than 35 psi	Between 35 and 80 psi	Above 80 psi
Average Day Demand	0.2%	79.3%	20.6%	0.2%	82.4%	17.4%
Maximum Day Demand	0.2%	82.3%	17.5%	0.2%	86.5%	13.3%
Peak Hour	0.2%	84.6%	15.2%	0.2%	91.0%	8.8%

In the table above, the results show that the majority of the system operates within the recommended pressure range (35 – 80 psi). However, during peak hour, 15 percent of the system experiences pressures exceeding 80 psi. In all scenarios, a small portion of the distribution system experiences pressures below 35 psi at the base of the Sprague Hill Tank. Figures A-3 through A-8 in Appendix A provide the model results for the ADD, MDD, and Peak Hour conditions under current and future demands.

Section 5.1.2 Maximum Pressures

Maximum system pressures are typically experienced when demands are low and tank levels are at their highest. EP repeated the ADD analysis with storage tanks full to approximate the maximum service pressures experienced outside of surge or transient events. Figure A-9 in Appendix A shows the modeled maximum pressures in the system under ADD existing conditions. As shown in the figure, the regions experiencing high pressures are constant, but expand slightly.

Several of these high pressures are due strictly to the low elevation of the customers in relation to the tanks; even when tank levels are low, pressures at this location will still be above 80 psi. Where reducing system pressures below 80 psi is not feasible, it is important that those customers are equipped with necessary pressure reducing valves to prevent potential damage to appliances per the Massachusetts Plumbing Code.

Approximately 1 percent of customers across the distribution system experience maximum pressures above 100 psi. These are concentrated in the northernmost part of the system, along High Street and Plymouth Street. A closer analysis of the hydraulic model calibration and the HGL during the above model scenarios revealed these elevated pressures are due largely to a capacity restriction in the cast iron main on High Street, exacerbated when valves are left in the closed position following flushing. The Department noted that these pressures have been slightly lower since High Street has been running at a lower flowrate due to loss of capacity at Well 9.

When valves are left closed following system flushing, water from the High Street WTP is forced to travel through the High Street water main, which creates additional headlosses and puts backpressure on the WTP and Plymouth Wells. While it may be possible to reduce these peak pressures by replacing a long stretch of water main on High Street, the effect of this water main on the distribution system is minor when the valves are opened. The reduced pumping capacity at the Plymouth Wells will also be mitigated once those wells are routed to the High Street WTP. For these reasons, EP did not include this water main project as a priority replacement in Section 6, but recommends the Department re-evaluate the need for this water main improvement during the design of the above project, as the headlosses may become more impactful with increased flow rates at the High Street WTP. If not part of the above project, this water main should be replaced in the future as part of the system-wide CI replacement program.

Section 5.1.3 Minimum Pressures

Minimum system pressures are typically experienced during the highest demand periods. Figure A-10 in Appendix A shows the modeled minimum pressures in the system under existing MDD conditions. Sources were assumed to be offline (High Street WTP), and tanks were at the lower end of their typical operating range, just before the sources turn on.

Under these conditions, approximately 90 percent of the distribution system experiences minimum pressure within the acceptable 35 – 80 psi range. Approximately 10 percent of the distribution system experiences minimum pressures above the maximum recommended 80 psi.

As shown in the figure, the only area of low minimum pressure is immediately downstream of the Sprague Hill Tank. There are no apparent customers in the immediate vicinity of the Sprague Hill Tank that are impacted by these low pressures.

SECTION 5.2 FIRE FLOW ANALYSIS

Section 5.2.1 ISO Fire Flow Sites

In addition to publishing guidelines on fire flow requirements, ISO routinely visits cities and towns to perform field testing of fire flow availability at a group of predetermined locations, typically non-residential areas. Following testing, they compare the field data to the required fire flow at each location and the city/town receives a Public Protection Classification rating. Appendix D contains the Department's most recent ISO data. EP utilized the hydraulic model to establish the available fire flow at each these sites with 20 psi of residual pressure at any point in the distribution system. Table 5-2 below shows the needed fire flow and modeled available fire flow at the deficient sites.

Table 5-2: ISO Fire Flow Deficient Sites Summary

Test No.	Location	Fire Flow Needed[1] (GPM)	Modeled Available Fire Flow (GPM)[2]
1	31 Perkins St	3,500	2,120
3	1453 Pleasant St	3,500	1,405
5	100 1st St	3,500	1,428
9	755 Bedford St	3,500	2,313
10	75 Main St	3,000	1,971
12	20 Bedford Park	3,000	1,453
16	792 Plymouth St	2,500	2,469
17	1000 Main St	2,500	344
18	110 Elm St	2,250	1,428
20	45 1st St	2,250	1,428
22	98 Bedford St	2,250	1,179
25	70 1st St	2,250	1,428
29	1199 Auburn St	2,000	1,413
32	300 Elm St	2,000	1,428
35	1108 Vernon St	2,000	1,059
37	571 Elm St	2,000	1,428
42	30 1st St	1,750	1,428
43	85 1st St	1,750	1,428
44	95 1st St	1,750	1,428
47	60 1st St	1,750	1,428
50	1355 Pleasant St	1,750	1,419
60	90 1st St	1,500	1,428
80	1925 Old Plymouth St	1,250	702
107	1912 South St	1,000	420
109	48 Bedford St	1,000	360
112	10 Cranmore Dr	1,000	681
130	2105 Plymouth St	1,000	681
133	1893 Old Plymouth St	1,000	702
155	32 Douglas Dr	750	428
165	567 Main St	750	432

1. Needed fire flow is the rate of flow for a specific duration for a full credit by ISO. Needed fire flows greater than 3,500 gpm are not considered in determining the classification of the city when using ISO's fire suppression rating system.

2. Modeled available fire flows assume existing closed/broken valves as repaired and open. Projected 2045 maximum day demand (MDD) conditions with low tank levels were assumed and the single largest source was assumed offline (High Street WTP). Additionally, modeled available fire flows are limited by a minimum residual pressure of 20 psi within the system.

As shown the Table above, EP found that 30 of the 176 ISO locations do not meet the required available fire flow at a residual pressure of 20 psi. The recommended improvements in Section 6 include water main upgrades to address these deficiencies.

Section 5.2.2 Residential Fire Flow

Fire flow requirements for standard residential dwellings can be approximated by house spacing. In Bridgewater, most houses are single family dwellings spaced at least 30 feet apart. These houses require at least 500 gpm of fire protection available at 20 psi according to the ISO. In some locations, particularly near the residential developments on Michael Road and off Plain Street and Pond Street, house spacing requires a minimum of 1,000 gpm of fire protection at 20 psi, as shown in Table 5-3.

Table 5-3: ISO Needed Fire Flow for 1- and 2-Family Dwellings

Distance Between Buildings	Needed Fire Flow
More than 30 feet	500 gpm
21 to 30 feet	750 gpm
11 to 20 feet	1,000 gpm
0 to 10 feet	1,500 gpm

Based on the hydraulic modeling results, EP determined that 95 percent of the system receives at least 500 gpm of available fire flow, and 85 percent receives at least 750 gpm. The majority of the Department's water system has sufficient fire protection to meet residential requirements, with 72 percent having the maximum residential requirement of 1,000 gpm available. Figure A-11 in Appendix A shows the locations with deficient fire flow.

The deficient areas are primarily limited by small diameter mains, cast iron piping, and/or dead ends. EP recommends the Department prioritize pipe replacement or looping in these areas to improve hydraulic conditions and increase fire flow availability. A full list of recommended improvements is included in Section 6, and these recommendations are shown on Figures A-12 and A-14 in Appendix A.

SECTION 5.3 CONCLUSIONS AND RECOMMNDATIONS

A significant portion of the Bridgewater water system experiences maximum pressures above the recommended 80 psi during ADD existing conditions. EP recommends the Department work with these customers to verify the presence of pressure reducing devices, adding them where appropriate. As the Department continues to replace AC and CI pipe across the distribution system, areas that typically experience maximum pressures above 80 psi should be prioritized, as they are typically at an elevated risk for leaks and breaks.

EP also recommends the Department conduct a controls review to optimize system controls and distribution system pressures. Operating all pumps with the same "on" and "off" setpoints can contribute to higher pressures in the distribution system. EP recommends including this review as part of the design of future new source projects that will be required to supplement water supply.

EP identified several areas across the distribution system with fire flow deficiencies that should be addressed with water main upgrade projects. The list of water main upgrade projects is included in Section 6, and these recommendations are shown on Figures A-12 through A-14 in Appendix A.

It is important to note that both storage tanks are located in the northern, central region of the water system. The required water main improvements to address some deficiencies would be cost prohibitive and may create low velocities and higher water age during typical operations. EP recommends conducting a study to locate a new storage tank in Section 6, which may address a large number of the fire flow deficiencies with a much smaller number of water main improvements, or in some cases, no water main improvements at all.

SECTION 6 RECOMMENDATIONS AND CAPITAL IMPROVEMENTS PLAN

In Section 6, EP presents the recommended Capital Improvements Program (CIP) through the 2045 planning horizon.

SECTION 6.1 GENERAL

Recommendations are categorized into one of four phases spanning five years each, as well as an initial phase (Phase I) including projects already under way or which may be accomplishable within the Department's existing budget.

The phases include contingent projects to help the Department prepare for a more aggressive expenditure projection. As discussed in Section 2, the Department is experiencing a firm capacity deficit and securing additional water supply is of the foremost importance. As such, Phase II includes projects affecting water supply capacity, as well as engineering studies that may result in revisions to later phases of the CIP. It is likely that the results of the engineering investigations included in Phase II will reduce the scope of required projects in subsequent phases, as described below.

Phase III improvements include construction for larger water supply projects, as well as some water main replacement projects to address fire flow deficiencies. Phases IV and V include additional water main improvements projects, as well as an allowance to begin replacing some of the Department's aging cast iron (CI) water mains and asbestos cement (AC) water mains.

It is important to note that the Phase III and IV water main improvements may be significantly reduced if a new storage tank is completed. EP strongly recommends the Department pursue a tank siting analysis and subsequently revise the CIP to reflect the impact on the Department's available fire flow.

Additionally, EP has included recommendations for routine annual maintenance.

SECTION 6.2 CAPITAL COSTS

For each of the recommended improvements, EP developed an opinion of probable project cost (OPPC) that includes engineering services, construction cost, engineering fee, and contingencies. These costs represent the current value of the project in 2023 dollars and should be compared to the Engineering News-Record (ENR) Construction Cost Index (CCI) from December 2023 of 13,514.8 when extrapolating to future value.

The probable project costs were compiled based on available data from projects of similar scope for public water suppliers of comparable size in the area. All provided costs are planning level and preliminary estimates with appropriate contingency. Project costs are likely to vary based on changes to scope, design intent, and regional and local economic conditions during project implementation.

The estimated capital costs presented represent costs for the construction and/or implementation of each project unless otherwise noted, including a 25 percent allowance for engineering services. Engineering services include activities such as preliminary study, design, permitting, bidding assistance, construction administration, and record drawings services. An additional 10 percent is included for resident project representation, and an additional 2 percent is included for police details. The OPPC also includes a 30 percent planning contingency to account for planning level estimates and unforeseeable factors that may affect cost such as inflation and market conditions. For projects which do not involve construction (engineering studies or evaluations), EP reduced the total contingency to 25 percent.

EP estimated water main improvement projects based on recent bid results for water main projects from Bridgewater and other communities in eastern Massachusetts. Presented water main costs include the cost for materials (pipe, valves, hydrants, etc.), as well as installation. The provided estimates include costs for 3-inch depth trench paving only. Table 6-1 presents the unit costs used for budgeting water main replacement projects before contingencies and engineering fees. While these costs are based on ductile iron water mains, recent changes in market conditions and material availability have resulted in prices of DI and PVC converging. EP has carried DI pipe in the recommended projects based on durability and local contractor level of experience with this material but anticipates PVC project costs to be comparable.

Table 6-1: Unit Costs for Water Main Projects

Diameter (inches)	Material	$/L.F.
6-inch	Ductile Iron	$ 275
8-inch	Ductile Iron	$ 325
12-inch	Ductile Iron	$ 375
16-inch	Ductile Iron	$ 450
20-inch	Ductile Iron	$ 650
24-inch	Ductile Iron	$ 900

SECTION 6.3 WELL REDEVELOPMENT

In addition to finding new water sources, it is imperative the Department maintain its existing sources to protect against potential supply shortages. Continuing regular well maintenance and redevelopment will be critical to maintaining maximum water supply during peak summer-time demand periods. Environmental Partners recommends the Department continue to maintain existing water supply sources with annual well rehabilitation at a rate of one well per year minimum. EP has included this in all phases presented below.

SECTION 6.4 PHASE I (FY 2024-2025)

Section 6.4.1 Unidirectional Flushing Program (UDF)

An optimized unidirectional flushing (UDF) program can minimize customer complaints, improve water quality, and restore hydraulic capacity of the distribution system by cleaning sediment and buildup from water mains. If a flushing program is not properly designed, the hydrant flushing may simply stir up and move deposits from one area of the system to another and exacerbate aesthetic water quality issues for customers. EP understands the Department does not currently have a documented and engineered flushing program.

Final deliverables for a UDF program include flushing zone maps, written directions for each zone, and field spreadsheets to record results and approximate water volumes. The program would also include training Department personnel on the program. Additional scope could be included to incorporate the UDF program into GIS/asset management software.

Section 6.4.2 Well No. 9 Replacement

Well No. 9 was constructed in 1995 and has since been cleaned and redeveloped regularly by Maher Services. Maher conducted the most recent redevelopment in May 2023. Well No. 9 was originally a 12-inch diameter well and was lined with an 8-inch diameter lining in 2018. Specific capacity data post- May 2023 redevelopment showed little to no improvement after redevelopment. Based on the age and the inability of the well to rebound specific capacity via redevelopment, this well has reached the limit of its useful service life and requires replacement.

The Department has contracted EP to assist with the completion of this project, including exploration for a replacement well location, installation of a replacement production well for Well No. 9, conducting a 48-hour prolonged pump test, water quality analyses, and reporting the prolonged test results to MassDEP for approval. The Scope of Services also includes a second phase of work for design, permitting, bidding and construction administration of the well pumping system.

EP anticipates DEP approval around September 2024, with completion of construction around nine months after, in summer of 2025.

Section 6.4.3 Well No. 5A Replacement

Well No. 5A has required frequent cleaning and redevelopment since 2016 to maintain its design capacity. A new pump was installed at the Carver Pond Well No. 5A in August of 2018, and a new motor was installed in November 2022. Well 5A has been offline since August 2023 due to a failing screen. Based on the age, frequency, and ineffectiveness of redevelopment, and failure of the screen, this well has reached the limit of its useful service life and requires replacement. The Department has contracted EP to assist with the completion of this project, including exploration for a replacement well location, installation of a replacement production well for Well #5A, conducting a 48-hour prolonged pump test, water quality analyses, and reporting the prolonged test results to MassDEP for approval. The Scope of Services also includes a second phase of work for design, permitting, and construction administration of the well pumping system.

EP anticipates DEP approval around October 2024, with completion of construction around nine months after, in summer of 2025.

Section 6.4.4 Other Small Scope Projects

EP has included a small number of lower cost and easily implementable projects in this phase. This includes repairing several broken isolation valves across the system that are impeding proper flow. Additionally, EP understands a water main replacement is planned on Main Street. EP has also included a recommendation to abandon the smaller, parallel main in that area with additional cut and caps and service transfers. These recommendations are shown on Figure A-12 in Appendix A.

Section 6.4.5 Opinion of Probable Project Cost

For the projects listed above as part of Phase I, EP has come to the following opinion on probable project costs:

Table 6-2: Phase I Improvements Opinion of Probable Project Costs

Phase I Improvements (FY 2024-2025)		Opinion of Probable Cost
1	Annual Well Redevelopment (One well per year)	$40,000
2	Unidirectional Flushing Program	$90,000
3	Well No. 9 Replacement, Investigation, Design and Construction	$1,671,000
4	Well No. 5A Replacement, Investigation, Design and Construction	$1,671,000
5[1]	Open/Repair 4 Closed/Broken Valves on Pleasant Street, Old Pleasant Street, Cross Street, and Vernon Street	$81,000
6	Abandon 6" CI Water Main along Main Street from Center St to Central Square	$251,000
	Phase I Improvements Total	**$3,804,000**

1. Project improves available fire flow (AFF) in the ISO deficient areas.

SECTION 6.5 PHASE II (FY 2026-2030)

EP recommends the Department address the current and future supply deficits before commencing the water main replacements aimed to address insufficient fire flows. EP anticipates a small supply increase will need to be secured by the end of Phase 2, but any major construction efforts related to supply are unlikely to be completed in this phase.

This phase includes improvements to current supplies to promote continued operation and recover lost capacity. Additionally, this phase recommends an engineering study which aims to evaluate water supply alternatives and the installation of a new storage tank. EP has included a range of potential supply projects as an expected upper limit for budgeting purposes. The result of these evaluations may supersede some future projects in the CIP.

In addition, some of the water main projects recommended in Phases III - V may be superseded if a new tank is installed, depending on the design and location of that tank. Similarly, changes to source supply capacity and/or locations may impact the need for water main improvements. EP recommends updating the CIP accordingly upon completion of engineering studies that affect system storage or supply.

Section 6.5.1 Tank Analysis and Water Supply Strategy Alternatives

The Great Hill Tank is 98 years old and at the end of its useful life. Constructing a new tank at an alternate location may help address fire flow deficiencies in the western portion of the distribution system.

EP recommends a new storage tank analysis and site assessment be performed. Installing a new water storage tank near the west or southwest of the system extents may reduce the extent of water main upgrades required to mitigate insufficient fire flows. EP recommends this tank analysis/site assessment be completed ahead of the proposed water main improvements. If the Department is able to secure a new tank site, some water main improvements recommended in Phases III – V to meet fire flow requirements may not be required.

Section 6.5.2 Vernon St. Wells and Treatment Facility

Maintaining an adequate and resilient water supply is critical to providing high-quality water in sufficient volumes. As previously mentioned, some of the Department's sources have experienced degradation in capacity and water quality over time. To improve the resiliency of system supply, EP recommends the Department continue to pursue new supply sources.

As discussed previously, a potential source includes the Vernon Street wells and new treatment facility. It is recommended that the Department complete an engineering evaluation and begin the new source process by installing test wells and performing a short-term pump test to gauge water quality and pumping capacity.

Section 6.5.3 Pump Upgrades and New Raw Water Transmission Main from Plymouth Street Wells to the High Street WTP

The Department has been experiencing elevated levels of iron in the groundwater at Wells 10A and 10B. In June 2023, the Department began receiving significant customer complaints regarding the water color and staining. Since the introduction of the High Street WTP, the Department has also had difficulties running the wells and overcoming the increase in system head from the WTP operation.

In discussion with the Department, EP proposes replacing the pumps for wells 10A and 10B, and installing a new raw water transmission main that connects these two wells with the High Street water treatment plant. This will recover lost supply capacity and will allow for an easier accommodation of the upcoming USEPA MCL for PFAS without needing to add separate treatment at the Plymouth Well site.

Section 6.5.4 Carver Pond and High Street WTPs Building Addition for PFAS Removal – OPM, Pilot, Engineering and Construction

In 2022, the Bridgewater water system surpassed the Massachusetts MCL for PFAS6. While working towards a long-term solution, the Department has made some operational adjustments such as blending and mixing sources with increased PFAS6 levels with other sources to reduce the overall PFAS6 levels.

Given the current levels of PFAS6 in the water system and the pending USEPA MCL, EP proposes a building addition for PFAS removal at both Carver Pond and High Street WTPs to meet the new standards.

Section 6.5.5 Sprague Hill Tank Rehabilitation

The Sprague Hill Tank was last rehabilitated in 2008. EP anticipates the tank will need interior and exterior rehabilitation at the end of Phase II.

Section 6.5.6 Connection to Regional Desalinization Plant – Phase 1

As stated previously, the Department presently lacks the necessary firm capacity to meet the anticipated maximum-day demand. While Vernon Street Wells will help in the short term, additional sources will need to be secured to meet future demands including known future developments. EP recommends beginning an engineering evaluation to review the feasibility of an interconnection with Aquaria Regional Desalinization Plant. Preliminary consideration of this alternative will be included in the previously recommended engineering study. This evaluation would serve as a continuation of that effort should the Water Supply Strategy Alternatives study indicate the alternative is viable.

The feasibility study will include hydraulics review (hydraulic grade line comparison), water quality (blending of Aquaria with Bridgewater water), potential regulatory hurdles, and cost estimates of the mechanical work necessary to facilitate an interconnection.

Based on our experiences with performing water system feasibility studies. The following tasks would need to be performed as part of this evaluation:

- Collect and review existing available water quality data from Aquaria and Bridgewater.
- Identify any potential water quality issues that may occur if blending of Aquaria and Bridgewater's water occurs.
- Identify if supplemental sampling is required to assess water quality issues associated with blending.
- Identify potential regulatory hurdles or permitting requirements for the proposed interconnection with Aquaria.
- Review Aquaria's water treatment process and high-lift pump operation to determine the hydraulic grade line of Aquaria's water transmission main. Compare with Bridgewater's hydraulic grade line.
- Prepare a breakdown estimate of capital costs required for any water system infrastructure improvements necessary to complete the proposed interconnection.
- Engineering design of required water system infrastructure to facilitate the interconnection.

Section 6.5.7 Opinion of Probable Project Cost

For the projects listed above as part of Phase II, EP has come to the following opinion on probable project costs:

Table 6-3: Phase II Opinion of Probable Project Costs

Phase II Improvements – FY 2026-2030		**Opinion of Probable Cost**
1	Annual Well Redevelopment (One well per year)	$100,000
2	Tank Analysis and Water Supply Strategy Alternatives	$75,000
3	Vernon St. New Well and Treatment Facility - OPM, Pilot, Design, Bidding and Construction	$38,427,000
4	Pump Upgrades and New Raw Water Transmission Main from Plymouth St. Wells to the High St. WTP	$3,915,000
5	Carver Pond WTP Building Addition for PFAS Removal - OPM, Pilot, Engineering & Construction	$7,351,000
6	High St. WTP Building Addition for PFAS Removal - OPM, Pilot Design and Bidding	$7,351,000
7	Sprague Hill Tank Rehabilitation	$4,558,000
8	Connection to Aquaria Regional Desalinization Plant (if required) - Phase 1 Engineering and Evaluation	$1,250,000
	Phase II Improvements Total	**$63,027,000**

SECTION 6.6 PHASE III (FY 2031-2035)

This phase includes significant construction efforts related to long term supply improvements. This includes water main replacement along Vernon Street, which will help provide fire flow, but has been prioritized because it may also be required to transmit water from the new Vernon Street source and/or storage tank. This phase also includes the connection to Aquaria Regional Desalinization Plant if deemed feasible. The results of the engineering study and evaluation may result in revisions to the scope of this phase.

Section 6.6.1 Vernon Street Water Main Replacement

As discussed above, EP recommends a water main replacement along Vernon Street, which will not only address fire flow deficiencies in that area but may also be required to transport water from the new Vernon Street Wells, once implemented. Additionally, if a new the new storage tank is adopted as a feasible alternative, this road may become an important route to transmit water from the tank to the southwest part of the system.

Section 6.6.2 Great Hill Tank Rehabilitation

The Great Hill Tank was last rehabilitated in 2013. EP anticipates the tank will need interior and exterior rehabilitation at the end of Phase III. This project may be superseded, pending the results of the Tank Analysis and Water Supply Strategy Alternatives project.

Section 6.6.3 Connection to Regional Desalinization Plant – Phase 2

Pending the findings from the engineering study and evaluation suggested in Phase II, this project includes the construction of the infrastructure necessary to connect the Bridgewater water distribution system to Aquaria Regional Desalinization Plant.

Section 6.6.4 Opinion of Probable Project Cost

For the projects listed above as part of Phase III, EP has come to the following opinion on probable project costs:

Table 6-4: Phase III Opinion of Probable Project Costs

Phase III Improvements – FY 2031-2035		Opinion of Probable Cost
1	Annual Well Redevelopment (one well per year)	$100,000
2	Replace existing 6" and 8" AC, CI Water Main along Vernon Street with 6", 8", and 12" DI Water Main	$7,620,000
3	Great Hill Tank Rehabilitation	$2,117,000
4	Connection to Aquaria Regional Desalinization Plant (if required) - Phase 2 Construction	$35,082,00
	Phase III Improvements Total	**$44,919,000**

SECTION 6.7 PHASE IV (FY 2036-2040)

As discussed in Section 5, there are several water main improvements identified that will increase deficient fire flow availability. Phase IV consists of high priority water main replacements, primarily driven by fire flow deficiencies and water mains already in the Department's planning horizon. These recommendations are shown on Figure A-13 in Appendix A. As mentioned, the scope of these recommended improvements may change considerably if the supply landscape changes or if a new tank is introduced to the system. EP anticipates the costs associated with a new tank would be offset by reduction in required water main improvements for fire flow, but further analysis is needed.

EP recommends these water main improvements be addressed in Phase IV, after the water supply deficit concerns have been addressed, as proposed on the previous phases. Table 6-5 below shows a list of these water main improvements.

Table 6-5: Recommended Water Main Improvements

Phase IV Improvements – FY 2036-2040		Length (ft)	Proposed Size and Material
2[1]	Replace existing 6" - 16" Water Main along Plymouth St., School St., South St., Pleasant St., and Birch St. with 24" DI Water Main, and Install 12" DI Water Main Loop on Swift Avenue	5,525	12" and 24" DI
3[1]	Replace 4" and 10" CI Parallel Water Mains on Bedford St. from School St. to Maple St. with 16" DI Water Main	1,080	16" DI
4[1]	Replace 10" - 12" AC, CI Water Main on Bedford S.t, with 16" DI Water Main, and abandon Parallel Water Mains along Bedford St.	2,615	16" DI
5[1]	Replace 10"-12" AC, PVC along Bedford St. with 16" DI Water Main	9,860	16" DI
6[1]	Replace 8" AC Water Main along Cross St., and part of South St. with 12" DI Water Main	7,216	12" DI
7[1]	Replace 6" AC Water Main along Plain St. from High St. to W Pond St. with 8" DI Water Main	4,800	8" DI
8[1]	Replace 6" - 8" AC Water Main along Pond St. and part of Old Plymouth St. with 12" DI Water Main	5,500	12" DI
9[1,2]	Replace 6" - 10" AC, CI Water Main along Flagg St., and part of Auburn St. from Summer St. to Laurel St. with 12" and 16" DI Water Main	6,430	12" and 16" DI
10[1]	Replace 6" CI Water Main along Main St. from Ash St. to Center St. with 8" and 12" DI Water Main	2,095	8" and 12" DI
11[1]	Replace 6" CI Water Main on Perkins St. from Pearl St. to Broad St. with 8" DI Water Main	700	8" DI

1. Project potentially superseded by the new storage tank.

Section 6.7.1 Opinion of Probable Project Cost

For the projects listed above as part of Phase IV, EP has come to the following opinion on probable project costs:

Table 6-6: Phase IV Opinion of Probable Project Costs

Phase IV Improvements – FY 2036-2040		**Opinion of Probable Cost**
1	Annual Well Redevelopment (one well per year)	$100,000
2[1]	Replace existing 6" - 16" Water Main along Plymouth St., School St., South St., Pleasant St., and Birch St. with 24" DI Water Main, and Install 12" DI Water Main Loop on Swift Avenue	$7,020,000
3[1]	Replace 4" and 10" CI Parallel Water Mains on Bedford St. from School St. to Maple St. with 16" DI Water Main	$820,000
4[1]	Replace 10" - 12" AC, CI Water Main on Bedford St, with 16" DI Water Main, and abandon Parallel Water Mains along Bedford Street	$1,980,000
5[1]	Replace 10"-12" AC, PVC along Bedford St. with 16" DI Water Main	$7,420,000
6[1]	Replace 8" AC Water Main along Cross St, and part of South St. with 12" DI Water Main	$4,530,000
7[1]	Replace 6" AC Water Main along Plain St. from High St to W Pond St. with 8" DI Water Main	$2,630,000
8[1]	Replace 6" - 8" AC Water Main along Pond Street and part of Old Plymouth Street with 12" DI Water Main	$3,460,000
9[1,2]	Replace 6" - 10" AC, CI Water Main along Flagg Street, and part of Auburn St. from Summer Street to Laurel Street with 12" and 16" DI Water Main	$4,727,000
10[1]	Replace 6" CI Water Main along Main St. from Ash St. to Center St. with 8" and 12" DI Water Main	$1,310,000
11[1]	Replace 6" CI Water Main on Perkins St. from Pearl St. to Broad St. with 8" DI Water Main	$390,000
	Phase IV Improvements Total	**$34,387,000**

1. Project potentially superseded by the new storage tank.

SECTION 6.8 PHASE V (FY 2041-2045)

Section 6.8.1 Water Distribution System Improvements

Phase V consists of water main replacements that are lower priority than those in Phase IV based on anticipated age, interior and exterior condition, and internal and external risk factors. These recommendations are shown on Figure A-14 in Appendix A. As with Phase IV, these projects may change depending on the results of previously phased projects. This phase also includes the replacement of some of the Department's aging CI water mains.

EP recommends the Department continue to replace aging AC and CI pipe. In the absence of installation dates, EP recommends starting with the 4 miles of CI pipe that the hydraulic model calibration suggests are in the worst condition. These mains are reaching or are already at the end of their service life. The Department should target approximately one mile of CI water main replacement each year during this phase of improvements. Table 6-7 below includes a list of CI water mains EP identified for replacement.

Additional CI water main replacements will need to be performed beyond the duration of this phase to complete the total replacement of CI pipe in the system. EP recommends minimum 8-inch diameter DI replacement pipe unless hydraulic modeling can confirm adequate fire flow availability.

Table 6-7: Recommended Cast Iron Water Main Replacements

Street Name	Length (feet)	Current Size and Material
Summer Street	2,730	6" CI
Dean Street	370	2" CI
Cottage Street	1,520	4" CI
Central Square	770	4" CI
Latham Terrace	260	2" CI
Deport Street	250	4" CI
Pearl Street	1,410	4" / 6" CI
Oak Street	3,410	8" CI
Crapo Street	1,320	8" CI
Ball Avenue	810	6" CI
High Street	7,440	8" / 12" CI

Section 6.8.2 Opinion of Probable Project Cost

For the projects listed above as part of Phase V, EP has come to the following opinion on probable project costs:

Table 6-8: Phase V Opinion of Probable Project Costs

Phase V Improvements – FY 2041-2045		Opinion of Probable Cost
1	Annual Well Redevelopment (One well per year)	$100,000
2[1,2]	Replace 8" - 16" PVC, DI, AC Water Main along Pleasant St, part of Elm St. and 1st St. with 24" DI Water Main	$17,570,000
3	Replace approximately 114,600 linear feet of 4" - 10" AC, CI, PVC Water Mains with 8" and 12" DI Water Mains	$63,260,000
	Phase V Improvements Total	**$80,930,000**

1. Project improves available fire flow in ISO deficient areas.
2. Project potentially superseded by the new storage tank.

Following the completion of these CI replacements, approximately 83,000 linear feet of CI replacements would remain for future phases. EP estimates the cost of these replacements to be approximately $41,490,000 but has not included this cost in the CIP for the 2045 planning period.

SECTION 6.9 CAPITAL IMPROVEMENTS PLAN SUMMARY

Table 6-9 below summarizes the OPPCs associated with all five phases of the Department's CIP. These costs represent the current value of the project in 2023 dollars and should be compared to the Engineering News-Record (ENR) Construction Cost Index (CCI) from November 2023 of 13,510.6 when extrapolating to future value.

Table 6-9: Budgetary Cost Summary

Phase	Fiscal Years	Total Budgetary Cost ($)	Average Cost Per Year ($)
I	2024-2025	$3,804,000	$1,902,000
II	2026-2030	$63,027,000	$12,605,400
III	2031-2035	$44,919,000	$8,983,800
IV	2036-2040	$34,387,000	$6,877,400
V	2041-2045	$80,930,000	$16,186,000
	TOTAL	**$227,067,000**	

As discussed above, projects included in Phases III and IV will be potentially superseded by the results of the analyses recommended in Phase II. EP recommends revising the CIP accordingly following the completion of the alternatives analyses.

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