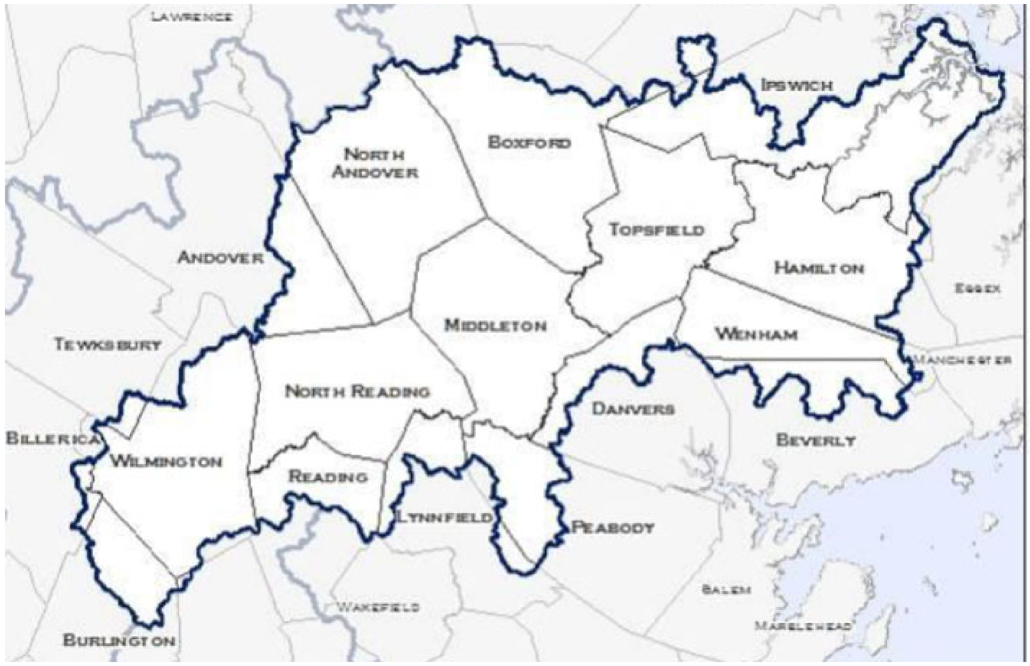

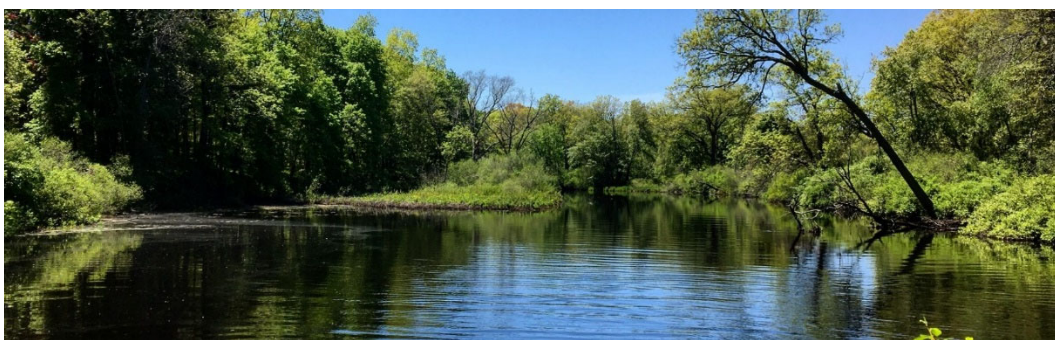

BWR 2022-01 Water Management Act (WMA) Grant - Regional Evaluation to Improve Water Supply Resiliency within the Lower Ipswich River Watershed

Task 6 – Final Report

Town of Hamilton, Massachusetts

June 30, 2022

SUBMITTED BY:

Dewberry Engineers Inc.
99 Summer Street
Boston, MA 02210

IN COLLABORATION WITH:

Ipswich River Watershed Association
143 County Road
Ipswich, MA 01938

SUBMITTED TO:

Town of Hamilton
Department of Public Works
577 Bay Road
Hamilton, MA 01982

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EXECUTIVE SUMMARY

The overall purpose for the subject WMA Grant is to conduct a regional evaluation of alternative sources to improve water supply resiliency within the lower Ipswich River Watershed for the Town of Hamilton and its neighboring communities of Topsfield, Manchester, Ipswich, Essex and Wenham. The WMA grant is divided into six (6) discrete tasks, each with its own required deliverable. Hamilton's existing water system borders all five (5) partnering communities and currently has interconnections with three of them including Ipswich, Essex and Wenham. This geographic condition places Hamilton in the best position to effectively convey and/or transfer alternate sources of supply between the partnering communities as well as sharing surplus supply available with the partnering communities to supplement and/or fulfill the water needs of the region.

For Task 1, we arranged for and conducted meetings with representatives from the Town of Hamilton, the partnering water system communities, Salem-Beverly Water Supply Board (SBWSB), MassDEP and other stake holders as necessary to discuss the project goals and scope, and review deliverables.

For Task 2, we coordinated and collected data from the partnering water system communities, Salem-Beverly Water Supply Board (SBWSB), and other resources as needed to perform the evaluations under Tasks 3, 4 and 5 for improving the supply resiliency of Hamilton and the partnering water systems.

For Task 3, we evaluated the feasibility of obtaining alternative water supply from the Salem-Beverly Water Supply Board (SBWSB) to supplement the water needs of Hamilton and the partnering communities on a regional/seasonal basis to reduce withdrawals from the Ipswich River Basin. We identified potential impacts to water quality, infrastructure, system hydraulics and operations, WMA withdrawals/regulations and permitting from augmenting Hamilton's existing well sources with SBWSB supply on a short-term basis, and fully supplying Hamilton on a permanent basis. We also identified similar impacts to sharing and/or transferring Hamilton and SBWSB's blended supply with the partnering water systems. Conceptual infrastructure upgrades with cost estimates were developed for **three (3) future pipeline routes** for connecting Hamilton's water system with the City of Beverly's water system for obtaining SBWSB supply. Hydraulic analyses were performed to determine the supply rates that could be effectively delivered into Hamilton from each future pipeline connection with the City of Beverly for obtaining additional supply to augment Hamilton's system only, or for fully supplying Hamilton's system. **Option A was recommended as the preferred pipeline route with Option B as the alternate.**

Similar hydraulic analyses were conducted to determine the supply rates that Hamilton could effectively deliver though the existing interconnections with the partnering water systems of Essex, Wenham and Ipswich. Upgrades to these existing interconnections such as the need for a pressure reducing valve or booster pump station were also identified. The Town of Manchester is not currently connected with Hamilton's water system and would require a new pipeline and interconnection to share and/or transfer supply. The feasibility of this new pipeline along with the needed infrastructure to connect Hamilton to Manchester for improving the supply resiliency of each system was evaluated under Task 4 of the WMA grant scope.

The Town of Topsfield is also not currently connected with Hamilton's water system and would require a new pipeline and interconnection to share and/or transfer supply as well. The evaluation of a new interconnection between Hamilton and Topsfield along with determining the ability of Hamilton and Topsfield to share supply was completed under Task 5 of the WMA grant scope. The results of the evaluation for obtaining SBWSB supply to improve the water supply resiliency of Hamilton and the partnering water systems was issued in the **Task 3 Technical Memorandum.**

For Task 4, we evaluated the feasibility of installing a new interconnection between Hamilton and Manchester to allow the ability to share water supply between the two systems, along with the other partnering water systems on a partially regional basis. Conceptual infrastructure upgrades with cost estimates were developed for a **future pipeline route along Chebacco Road** which was determined to be the only viable option to connect Hamilton's water system with Manchester's water system. Hydraulic analyses were performed to determine the supply rates that could be effectively delivered into Hamilton from this future pipeline connection with Manchester for obtaining additional supply to augment Hamilton's system only, or for fully supplying Hamilton's system. We identified potential impacts to water quality, infrastructure, system hydraulics and operations, WMA withdrawals/regulations and permitting from having Manchester augmenting Hamilton on a short-term basis, and fully supplying Hamilton on a permanent basis. We completed an assessment of Manchester's WMA authorized withdrawals versus pump capacity and future water needs to estimate the available supply surplus for augmenting Hamilton and the partnering water systems.

We identified potential impacts to water quality, infrastructure, system hydraulics and operations, and permitting from sharing and/or transferring Hamilton and Manchester's blended supply with the partnering water systems. Similar hydraulic analyses were also conducted to determine the supply rates that Hamilton could effectively deliver though the existing interconnections with the partnering water systems of Essex, Wenham and Ipswich. Upgrades to these existing interconnections such as the need for a pressure reducing valve or booster pump station were identified along with developing conceptual cost estimates.

As previously noted above, the Town of Topsfield is not currently connected with Hamilton's water system and would require a new pipeline and interconnection to share and/or transfer supply with Hamilton and the partnering water systems. The evaluation of a new interconnection between Hamilton and Topsfield along with determining the ability of Hamilton and Topsfield to share supply was completed under Task 5 of the WMA grant scope. The results of the evaluation for a new pipeline interconnection with Manchester to improve the water supply resiliency of Hamilton and the partnering water systems on a partially regional basis was issued in the **Task 4 Technical Memorandum.**

For Task 5, we evaluated the water systems of Ipswich, Essex, Wenham and Topsfield to determine the ability of sharing available supply between Hamilton and these systems to mitigate future short-term supply shortages on a Mutual Aid basis. Upon reviewing the existing system infrastructure of each individual water system, we assessed the adequacy of their water supply to meet future water needs while having surplus supply available under their current WMA authorized withdrawals to share amongst the partnering water systems. We then evaluated the possibility of sharing any identified surplus supply between the partnering communities under current WMA allocations and Interbasin Transfer Act (IBTA) regulations taking into consideration DCR Water Needs Forecast for the region.

We identified potential impacts to water quality, infrastructure, system hydraulics and operations, and permitting from sharing and/or transferring surplus supply between Hamilton and the partnering water systems. Hydraulic analyses were conducted to determine the supply rates that Hamilton could effectively deliver though the existing interconnections with the partnering water systems of Essex, Wenham and Ipswich. Upgrades to these existing interconnections such as the need for a pressure reducing valve or booster pump station were identified along with developing conceptual cost estimates. In addition, we evaluated a new pipeline and interconnection to connect the water systems of Hamilton and Topsfield along with determining the ability of Hamilton and Topsfield to share supply. We developed conceptual infrastructure upgrades with cost estimates for a **future pipeline along Asbury Street** which was determined to be the only viable option to connect Hamilton's water system with Topsfield's water system. Hydraulic analyses were performed to determine the supply rates that could be effectively delivered between Hamilton and Topsfield from this future pipeline connection.

We completed an assessment of the WMA authorized withdrawals versus pump capacity and future water needs for each partnering water system to estimate the available supply surplus that could possibly be shared between systems as needed. The results of the evaluation to determine the ability of Hamilton and the partnering water systems to mitigate future short-term supply shortages between systems on a Mutual Aid basis was issued in the **Task 5 Technical Memorandum.**

For Task 6, we prepared a summary of the work completed for Tasks 3, 4 and 5 including evaluations, analyses and results along with recommendations for Hamilton and the partnering communities to improve their water supply resiliency. The recommendations presented herein take into consideration the goal of Senator Tarr's North Shore Water Resiliency Task Force study which will be identifying a long-term regional solution to alleviate water resiliency issues and challenges faced by water systems located within the Ipswich River Watershed. Per the requirements of the WMA grant study, and to provide one comprehensive document that includes all narratives and supporting figures prepared for this project, **we have included the Task 3 through 5 Technical Memorandums in their entirety as attachments to this report.**

Given the order in which the Technical Memorandums were prepared, our approach to some of the evaluations and concepts presented initially in these documents changed during the completion of this study as a result of obtaining additional information or from applying a different perspective. As such, some of the narrative within these stand-alone documents has been revised and/or expanded on within the respective sections of this report.

1. Introduction

The overall purpose for the subject WMA Grant is to conduct a regional evaluation of alternative sources to improve water supply resiliency within the lower Ipswich River Watershed for the Town of Hamilton and its neighboring communities of Topsfield, Manchester, Ipswich, Essex and Wenham. This **Task 6 Final Report** presents a summary of methods and analyses employed to evaluate alternative supply sources and possible WMA withdrawals available to Hamilton and the partnering water systems along with recommendations for future infrastructure upgrades and additional analysis.

1.1 WMA Grant Study Overview

Hamilton's existing water system borders all five (5) partnering communities and currently has interconnections with three of them including Ipswich, Essex and Wenham. This geographic condition places Hamilton in the best position to effectively share alternate water supplies and/or available surplus water between the partnering communities to mitigate short-term and long-term water supply shortages. The WMA grant is divided into six (6) discrete tasks, each with its own required deliverable, as summarized below:

- **Task 1: Team Meetings and Project Management**
  - ➢ Conduct meetings and phone calls with representatives from the partnering water systems and other stakeholders including members of Senator Tarr's Task Force as applicable to kick-off project tasks, review draft deliverables, project status, schedule and issues related to the project.
- **Task 2: Data Collection**
  - ➢ Meet with and collate relevant data from the participating communities for determining existing system conditions, compatibility of water quality, hydraulic constraints, and costs of establishing regional water supply and management strategies.
- **Task 3: Assessment of Future Water Supply Connection with Salem-Beverly Water Supply Board (SBWSB)**
  - ➢ Evaluate the feasibility of obtaining alternative water supply from the SBWSB through a future pipeline connection to supplement the water needs of Hamilton and the participating communities on a regional/seasonal basis to reduce withdrawals from the Ipswich River Basin.
- **Task 4: Assessment of New Interconnection w/ Manchester (Partial Regionalization)**
  - ➢ Evaluate the feasibility of installing a new interconnection between Hamilton and Manchester to allow the ability to share water supply between the two systems, along with the other participating communities on a partially regional basis.
- **Task 5: Feasibility of Sharing Current/Future Water Supplies on a Mutual Aid Basis**
  - ➢ Evaluate the feasibility of sharing current and future water supplies between the partnering communities of Ipswich, Essex, Wenham and Topsfield on a Mutual Aid Basis.
- **Task 6: Final Report**
  - ➢ Prepare and submit a draft and final project report to MassDEP summarizing entire project, including methods, results, and conclusions.

2. Task 3 Summary and Conclusions

2.1 Introduction

For Task 3, we evaluated the feasibility of obtaining alternative water supply from the Salem-Beverly Water Supply Board (SBWSB) to supplement the water needs of Hamilton and the partnering communities on a regional/seasonal basis to reduce withdrawals from the Ipswich River Basin. As Hamilton has no direct connection with the SBWSB, a new pipeline will be required for the SBWSB to supply Hamilton's water system. Physically, the closest source of SBWSB supply to Hamilton is the City of Beverly's water system, which borders the southern side of Wenham with Hamilton bordering the northern side. Given the proximity of Hamilton to Beverly and Wenham, and the fact that a portion of Beverly's water system already extends into Wenham to supply Gordon College, connecting to Beverly for obtaining future SBWSB supply would be the most feasible approach to consider. Refer to attached **Figure 1 – Updated City of Beverly Water System Plan dated June 2022 included in Appendix D** as prepared from the Town's GIS data provided for the study.

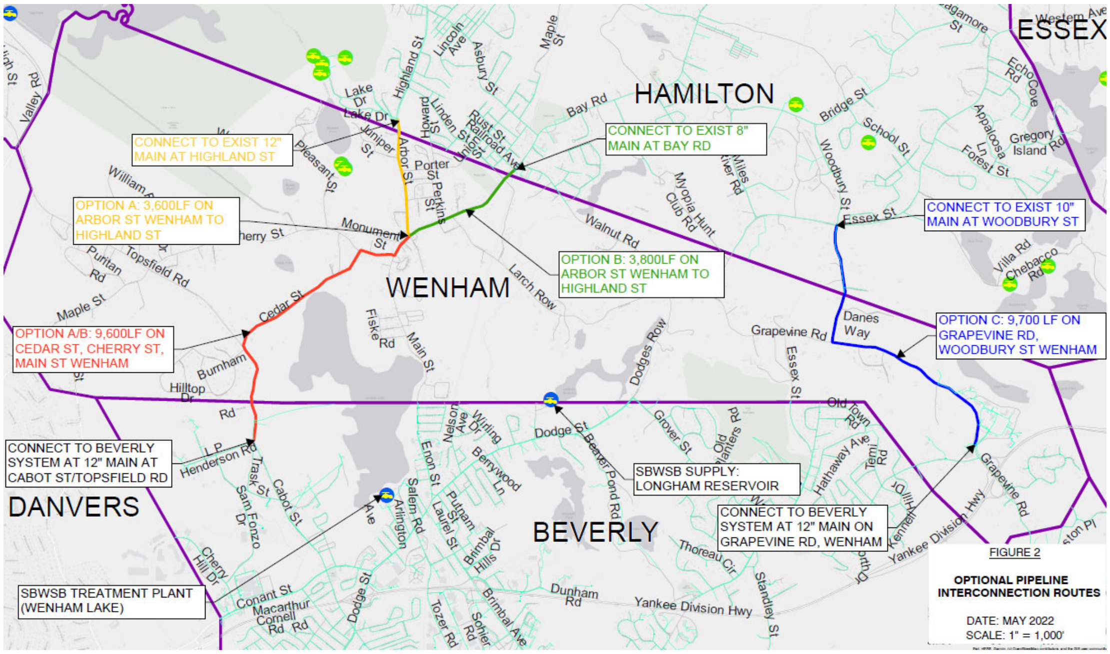
The Task 3 Technical Memorandum included in its entirety as **Appendix A** documents the evaluation and findings for this new water supply connection with the SBWSB including: review of SBWSB's supply system; review of Beverly's water system; analysis of the optional pipeline routes identified along with needed infrastructure upgrades and associated costs; review of water supply permitting considerations; review of water quality impacts from blending SBWSB finished water with Hamilton finished water and the partnering water systems' finished water; and needed infrastructure upgrades to supply the partnering water systems. Please refer to the **Task 3 Technical Memorandum** for full narratives of the specific topics evaluated as required per the WMA grant scope along with supporting tables and figures. The following provides an overview of the results related to the optional pipeline connection route assessment, water supply and permitting impacts, water quality review, and needed infrastructure upgrades for supplying Hamilton and the partnering water systems.

2.2 Pipeline Route Assessment for Future SBWSB Supply Connection

Based on existing system infrastructure, we identified three (3) options for a possible future interconnection with Beverly to supply Hamilton and the partnering communities on a seasonal and/or regional basis. These three options are as follows:

- Option A – Extending a new 12-inch water main from Cabot Street in Beverly up to Topsfield Road, Cedar Street, Cherry Street, Main Street and Arbor Street in Wenham to Highland Street in Hamilton ***(approx. 12,900 feet)***
- Option B – Extending a new 12-inch water main from Cabot Street in Beverly up to Topsfield Road, Cedar Street, Cherry Street and Main Street in Wenham to Bay Road in Hamilton ***(approx. 13,500 feet)***
- Option C - Extending a new 12-inch water main from Grapevine Road in Wenham up to Rubbly Road (Rte. 22) in Wenham to Woodbury Street in Hamilton ***(approx. 7,600 feet)***

Refer to **Figure No. 2 included in Appendix A of the Task 3 Technical Memorandum**. We have included a partial view of Figure 2 for reference on the following page. Each connection option will require a revenue meter chamber for measuring and totalizing flow along with a backflow prevention device for cross-connection control. As Beverly operates at a higher gradient than Hamilton (239 feet vs 210 feet), each option will require a pressure reducing valve (PRV) to control the supply gradient entering Hamilton's system when augmenting Hamilton's existing supplies.



Partial View of Figure 2-Optional Pipeline Interconnection Routes

We conducted hydraulic analyses of each pipeline option using the Town of Hamilton's existing computerized water system model to identify system impacts and the available supply that can be effectively delivered into Hamilton for the following operational scenarios:

- **Scenario #1:** Current System Conditions with Plant Finish Water Pumps On-line and Additional Supply from New Interconnection with New PRV and New Meter/Backflow Preventer Device
- **Scenario #2:** Plant Finish Water Pumps Off-line with Full Supply from New Interconnection without PRV and with New Meter/Backflow Preventer Device

For Scenario #1, we determined the optimal settings for the new PRV interconnection to supplement Hamilton's existing water system for each pipeline option. **For Scenario #2**, we determined the maximum flow that could be delivered through each new interconnection via gravity for fully supplying Hamilton. A summary of the results for the analyses completed is included in **Table 2.1** on the following page which was included in Section 3 of the attached Task 3 Technical Memorandum. Based on the results presented, **under Scenario #1**, both Options A and B would effectively augment Hamilton's existing water system with minimal impact to their current operations. As shown on **Table 2.1,** flow rates up to 300 gallons per minute (gpm) could be supplied with the new PRVs for Option A and B set to a downstream gradient of approximately 215 feet and 210 feet, respectively. Option C would only provide flow rates up to 200 gpm through the new PRV.

For Scenario #2, all three pipeline options could deliver flows up to approximately 600 gpm via gravity for fully supplying Hamilton. As Hamilton's finish water pumps operate at a flow rate of about 680 gpm to meet current system demands and maintain storage volumes, a new 1.5 million gallons per day (MGD) booster pump station would be needed for each option to replace the Town's current supply production and provide some surplus for the partnering water systems.

As noted in the Task 3 Technical Memorandum, although the Option C pipeline would deliver similar flow rates to the Option A and B pipelines for fully supplying Hamilton, it resulted in reducing available fire flows within Hamilton's existing water system. This is due primarily to the proximity of the Option C interconnection to Hamilton's existing Browns Hill Reservoir, which would have the new supply entering Hamilton's water system on the same side as the existing storage volumes. Ideally, it is more effective to have the supply and storage volumes on opposite side of the system to provide a more balanced approach for fire protection.

Table 2.1 Pipeline Interconnection Options Analyses Summary

Condition	Supply Rate	Comment
Option A, Scenario #1 – Additional SBWSB Supply, Current Existing Conditions w/ New PRV		
PRV set @ 220'	150 to 425 gpm	Ex. pumps & tank will be isolated from system
PRV set @ 215'	250 to 300 gpm	Ex. pumps & tank will operate, turnover reduced by about day
PRV set @ 210'	75 to 175 gpm	Ex. system not impacted, but minimal available supply
Option B, Scenario #1 – Additional SBWSB Supply, Current Existing Conditions w/ New PRV		
PRV set @ 215'	150 to 575 gpm	Ex. pumps & tank will be isolated from system
PRV set @ 210'	75 to 325 gpm	Ex. pumps & tank will operate, turnover reduced by about day
PRV set @ 208'	50 to 190 gpm	Ex. system not impacted, but minimal available supply
Option C, Scenario #1 – Additional SBWSB Supply, Current Existing Conditions w/ New PRV		
PRV set @ 225'	150 to 250 gpm	Ex. pumps & tank will operate, turnover reduced less than a day
PRV set @ 220'	155 to 210 gpm	Ex. pumps & tank will operate, turnover reduced by about day
PRV set @ 215'	50 to 160 gpm	Ex. system not impacted, but minimal available supply
Option A, Scenario #2 – Full SBWSB Supply, Finish Water Pumps Off-line, No PRV		
Maximum Supply	Up to 425 gpm	New 12" main up to existing interconnection at Town line
Maximum Supply	Up to 585 gpm	Extending New 12" main into Hamilton by 415 feet
Option B, Scenario #2 – Full SBWSB Supply, Finish Water Pumps Off-line, No PRV		
Maximum Supply	Up to 585 gpm	New 12" main up to existing interconnection at Town line
Maximum Supply	Up to 625 gpm	Extending New 12" main into Hamilton by 1,300 feet
Option C, Scenario #2 – Full SBWSB Supply, Finish Water Pumps Off-line, No PRV		
Maximum Supply	Up to 275 gpm	New 12" main up to existing interconnection at Town line
Maximum Supply	Up to 625 gpm	Extending New 12" main into Hamilton by 2,000 feet

Table 2.2 on the following page summarizes the total estimated costs for the three pipeline options as presented in the Task 3 Technical Memorandum to connect with Beverly and the SBWSB to supply Hamilton and the partnering communities under the two noted operational scenarios. The estimated total costs do not include land acquisition, right-of-way procurement and legal fees. Costs include 30% for engineering/permitting and a 25% contingency for planning purposes. All costs are presented in 2022 dollars and are based on the **May 2022 Boston ENR construction cost index of 17506.61.**

2.2.1 Conclusion

Based on the evaluation completed for each pipeline interconnection option, and considering the current and future supply needs of Hamilton and the partnering communities, **Option A is recommended as the preferred approach with Option B as an alternate** for obtaining SBWSB supply. Both of these options can effectively supplement Hamilton's existing water system as needed with minimal impact to system operations. Subsequently, these options would be best for fully supplying Hamilton and the partnering water sytsems on a more regional basis. For Option C, additional improvements to Hamilton's system such as a new storage tank along with larger water mains to support the new tank would be needed to maintain adequate fire protection for fully supplying Hamilton and the partnering communities.

Table 2.2 Cost Summary - Pipeline Interconnection Options

Item			Total Cost(1)
Option A – 12,900' of New 12" main w/ New Revenue Meter/Backflow Preventer			
Scenario #1: Additional SBWSB Supply, Current Existing Conditions w/ New PRV			$7,004,250
Scenario #2: Full SBWSB Supply, Finish Water Pumps Off-line, New 1.5 MGD Booster Pump Station			$7,637,500
Option B – 13,500' of New 12" main w/ New Revenue Meter/Backflow Preventer			
Scenario #1: Additional SBWSB Supply, Current Existing Conditions w/ New PRV			$7,296,250
Scenario #2: Full SBWSB Supply, Finish Water Pumps Off-line, New 1.5 MGD Booster Pump Station			$7,869,000
Option C – 9,600' of New 12" main w/ New Revenue Meter/Backflow Preventer(2)			
Scenario #1: Additional SBWSB Supply, Current Existing Conditions w/ New PRV			$5,395,000
Scenario #2: Full SBWSB Supply, Finish Water Pumps Off-line, New 1.5 MGD Booster Pump Station			$6,028,750

1. Costs do not include land acquisition, right-of-way procurement and legal fees.
2. Costs for Option C include the additional 2,000 feet of new 12" main as recommended in the Task 3 technical Memorandum.

It is also recommended that the preferred **Option A or alternate Option B be implemented in two phases** to account for the planned upgrades at the SBWSB's existing plant noted in the Task 3 Technical Memorandum. The initial phase would include the construction of the new 12-inch main, revenue meter/backflow preventer vault and PRV needed to connect Hamilton with the City of Beverly and the SBWSB. These initial upgrades will provide a supply rate of 275 gpm to 300 gpm to supplement Hamilton's existing well supplies when needed along with the other partnering communities. When the SBWSB's planned upgrades to increase the production capacity at their plant are completed as discussed further below, Hamilton can then consider completing the construction of the new booster pump station for being fully supplied from the SBWSB if desired and agreed to by the SBWSB. At a minimum, the station should be designed with a rated capacity of 1 MGD, or 700 gpm, to meet Hamilton's supply needs. For the purposes of this study, since we do not know at this time what the intent or additional supply needs of the partnering communities are, we have assumed a new 1.5 MGD booster pump station will be installedo.

2.3 SBWSB Water Supply/Permitting Impacts

As presented in **Section 4 of the Task 3 Technical Memorandum**, the SBWSB's existing Charter allows them to sell water to the Towns of Wenham and Hamilton along with Salem and Beverly. As such, new legislation would be needed to update the Charter to allow the SBWSB to supply the additional communities of Ipswich, Essex, Manchester and Topsfield. The passing of this new legislation is not viewed as a significant hurdle and should be attainable if needed.

With respect to available supply, the current total average day demand (ADD) for the cities of Salem and Beverly is 8.9 MGD with a WNF 2029 projected total ADD of 9.5 MGD. Based on SBWSB's existing registered withdrawal of 10.17 MGD, there is a current surplus of 1.27 MGD available to augment Hamilton and the other partnering water systems which will reduced to 0.67 MGD in the future. The SBWSB also has an additional permitted withdrawal of 2.27 MGD which if activated, would provide adequate surplus to fully supply Hamilton and other partnering water systems in the future.

From Table 4.1 in Section 4 of the Task 5 Technical Memorandum, we presented current and future average day demands (ADDs) for Salem-Beverly, Hamilton, Topsfield, Wenham, Essex, Ipswich and Manchester based on historical water usage, official DCR Water Needs Forecast and local studies. From this table, the total current ADD for the partnering communities listed above including Salem-Beverly is approximately **11.76 MGD,** with a 10-year projected ADD of **13.36 MGD.** Hamilton's current and projected ADDs are 0.55 MGD and 0.75 MGD, respectively.

With a projected ADD of 9.5 MGD for Salem-Beverly, the SBWSB could almost fully supply Hamilton and meet the future water needs of Salem-Beverly under their current registered withdrawal of 10.17 MGD **(9.5 MGD + 0.75 MGD = 10.25 MGD).** With activating their additional permitted withdrawal of 2.27 MGD, the SBWSB could supply Hamilton on a permanent basis along with a surplus of approximately 2.19 MGD to supply the other partnering systems **(12.44 MGD – 10.25 MGD = 2.19 MGD).** This surplus volume would be adequate to fully supply the combined future water needs of Wenham, Essex, Manchester and Topsfield with some surplus remaining to augment Ipswich as needed based on the DCR Water Need Forecast.

As noted in the Task 3 Technical Memorandum, MassDEP has never activated the permitted volume and that the SBWSB would need to demonstrate via an updated WNF that it needs the additional water. As such, the proposed needs of Hamilton and other partnering water systems would need to be included in an updated WNF for SBWSB to be able to activate its permit. Another consideration is that were the permit to be activated, a series of conditions such as mandatory water conservation requirements not currently required on the SBWSB registration would be imposed by MassDEP. Therefore, SBWSB would need to evaluate if these conditions are acceptable. It is assumed that if SBWSB wants to activate its permitted volume for the purpose of supplying the partnering water systems on a regional approach thereby reducing groundwater withdrawals within the Ipswich River Basin, MassDEP would be willing to ease some of those requirements.

With respect to production capacity, although the SBWSB's existing plant was originally designed to treat 24 MGD, changes to turbidity requirements limit the plant's peak capacity to only 16 MGD to achieve compliance. With peak daily flow rates of up to 16 MGD currently occurring within the systems of Salem and Beverly during high demand periods, the plant is required to operate at its maximum rate. During these periods of high demand, SBWSB would not have any surplus for supplying Hamilton and the partnering water systems due to the plant's limited production. As such, the SBWSB is not currently able to physically supply Hamilton and the other partnering water systems on a permanent and/or regional basis even with activating its permitted volume.

However, the SBWSB is planning to complete significant upgrades to its plant as part of their current Capital Sustainability Plan (CSP) for the next 10 years to increase production capacity. The CSP includes nine (9) phases of upgrades to the plant and related water supply system that have been estimated to cost upwards of $50 million to complete. Considering future increases in demands within Salem and

Beverly, SBWSB stated that they would need to complete the first five phases of their CSP which would return the plant back to its original 24 MGD capacity. This restored capacity should likely be enough to allow SBWSB to meet the future water needs of Salem-Beverly while fully supplying Hamilton along with Wenham, Essex, Manchester and Topsfield on a regional basis.

For Tasks 4 and 5, we collected and presented data related to future maximum day demands (MDDs) for Hamilton and the partnering water systems. Based on this data, the total future maximum day demand (MDD) for the water systems of Hamilton, Wenham, Essex, Manchester and Topsfield is approximately **4.78 MGD**. For Salem-Beverly, we do not have any data on future MDDs however, applying the current MDD/ADD ratio of 1.8 (16 MGD/8.9 MGD) to the projected ADD of 9.5 MGD results in an estimated future MDD of **17.1 MGD**. As such, the total future MDD that would need to be met by the SBWSB to supply Salem-Beverly, Hamilton, Wenham, Essex, Manchester and Topsfield on a regional basis would be approximately **21.88 MGD** which is below the increased capacity of 24 MGD anticipated for the plant.

Based on SBWSB's existing registered and permitted withdrawal volumes, and planned upgrades to its existing plant, the SBWSB will eventually have the supply and production capacity available to fully meet the water needs of Hamilton, Wenham, Essex, Manchester and Topsfield along with Salem-Beverly on a regional basis. Currently, SBWSB has the supply and production capacity available to meet the water needs of Salem-Beverly with some surplus to augment Hamilton's supply and possibly other partnering communities during normal demand periods. If Ipswich elects to be considered as part of this future regional approach, then discussions with MassDEP will be needed to allow the SBWSB to increase their permitted withdrawals which would likely require the partnering communities to forego utilization of their local WMA allocations. With most partnering communities in this WMA grant study relying on groundwater withdrawals from the Ipswich River Basin, transferring existing groundwater allocations to seasonal pump-storage water within the SBWSB reservoir system should be viewed as beneficial to improving the ecology of the Ipswich River.

2.4 Water Quality Review

Per Task 2 of the WMA grant study, we coordinated and requested various water quality and system infrastructure data from Hamilton, the SBWSB and partnering communities including Ipswich, Essex, Wenham and Topsfield as required to complete this task. **Table 2.3** below presents a summary of the finish water quality data collected from each of the communities and the SBWSB as it relates to this assessment.

Table 2.3 Finish Water Quality Summary

Parameter	SBWSB	Hamilton	Manchester	Essex	Ipswich	Topsfield	Wenham
pH	7.0 - 7.3	7.2 - 7.4	7.1 - 7.8	7.3 - 7.5	6.5 - 8.0	7.5	Unknown(2)
Chlorine (ppm)	0.57	0.50 - 0.75	0.80 - 1.40	0.53 - 0.59	0.25 - 0.89	0.22 - 0.34	0.3 - 0.88
Phosphate (ppm)	0.45 – 0.90	0.4 – 0.5	0.3 - 1.6	N/A(1)	0.5 - 0.80	Unknown(2)	Unknown(2)
TTHMs (ppb)	25 – 87	47 – 83	36 – 52	37 – 40	20 - 68	18 – 38	15.7
HAAs (ppb)	17 – 54	0 - 46	11 – 19	6 - 9	4.9 -35	ND - 4.5	4.4
PFAS6 (ppt)	2.4 - 4.9	4.9 – 13.0	7.3 - 18.9	<1.9	ND - 23.3	10-23	Unknown(2)

1. Essex does not add phosphate to their finished water.
2. Data was unable to be obtained from the partnering community.

Hamilton's primary source of supply is the **Idlewood wellfield** which consists of five (5) individual wells. These wells are pumped up to the Idlewood Water Treatment Plant (WTP) for treatment prior to being introduced into the distribution system which consists of pre-oxidation with sodium hypochlorite for iron and manganese removal through pressure filters containing a proprietary high rate catalyzed media. Post-filtration treatment includes sodium hypochlorite for disinfection, sodium fluoride for fluoridation, and a poly/orthophosphate blend for corrosion control. The Town's secondary source of supply is the **School Street well** which is chemically treated only before being delivered into the distribution system with sodium hypochlorite for disinfection, sodium fluoride for fluoridation, potassium hydroxide for pH adjustment, and a poly/orthophosphate blend for corrosion control.

SBWSB utilizes conventional treatment at their plant to treat their **3 surface water supplies** which includes flocculation, sedimentation, filtration via sand/anthracite media and post-treatment including disinfection with sodium hypochlorite, hydrofluorosilicic acid for fluoridation, quick lime for pH adjustment and an ortho/polyphosphate blend for corrosion control.

In comparing the finished water quality being produced by Hamilton and the SBWSB, they are compatible with respect to pH, free chlorine and total phosphate levels. Both use chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water. Additionally, since both use phosphate products for corrosion control and maintain similar pH levels within their system, there should be minimal impacts to Hamilton's system with respect to lead and copper. Levels of TTHMs, HAA5s and PFAS are also similar within the water systems of Hamilton and the SBWSB, with all being below their respective established MCLs. Recent sampling of Hamilton's School Street in 2021 showed a total sum of 13 ppt for the 6 regulated PFAS compounds which is still below the MCL of 20 ppt but over the 10 ppt threshold which requires monthly sampling of the source. Hamilton has limited the use of this well and is currently evaluating options for providing future on-site treatment for PFAS removal.

Based on the finished water quality maintained by the two water systems, Hamilton should be able to utilize a future interconnection with the SBWSB without any major water quality issues or impacts with meeting current drinking water standards. Given Hamilton's current upgrade of adding a new GAC treatment system at its plant and SBWSB's planned upgrades at their plant, the finish water quality of both systems should improve.

2.4.1 Supplying Partnering Water Systems

The **Town of Ipswich's** two surface water supplies are chemically treated and filtered at Ipswich's Water Treatment Plant (WTP) which includes rapid mixing, flocculation, sedimentation and filtration. The post-treatment of the filtered water includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid, pH adjustment with sodium hydroxide and an ortho/polyphosphate blend for corrosion control. Treatment at **Ipswich's five (5) wells** includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid and a poly/orthophosphate blend for corrosion control. corrosion control.

The **Town of Essex** has only wells for supplying their system which are chemically treated and filtered through its water treatment plant that includes disinfection with chlorine gas, and pH adjustment with potassium hydroxide. The **Town of Topsfield** has only wells for supplying their system which are chemically treated and filtered through its water treatment plant that includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride, pH adjustment with potassium hydroxide and an ortho/polyphosphate blend for corrosion control/sequestering. The **Town of Wenham** has only wells for supplying their system which are chemically treated only including disinfection with calcium hypochlorite, fluoridation with sodium fluoride and corrosion control with zinc orthophosphate.

In comparing the finished water quality of the partnering communities with the Town of Hamilton's current water quality and future water quality if blended with SBWSB supply, they are similar with respect to pH and free chlorine with exception of Ipswich which maintains a larger range of pH than the other systems. However, they do use an ortho/polyphosphate blend similar to Hamilton and the SBWSB for corrosion control so it is not anticipated that this larger pH range will be an issue. As shown in **Table 2-3** above, the Town of Essex does not use any phosphate addition for corrosion control which could be an issue with respect to lead and copper if supply from Hamilton and the SBWSB is delivered into their system. All the partnering communities rely on free chlorine for disinfection so **there is no concern of blending chlorinated water with chloraminated water between systems.**

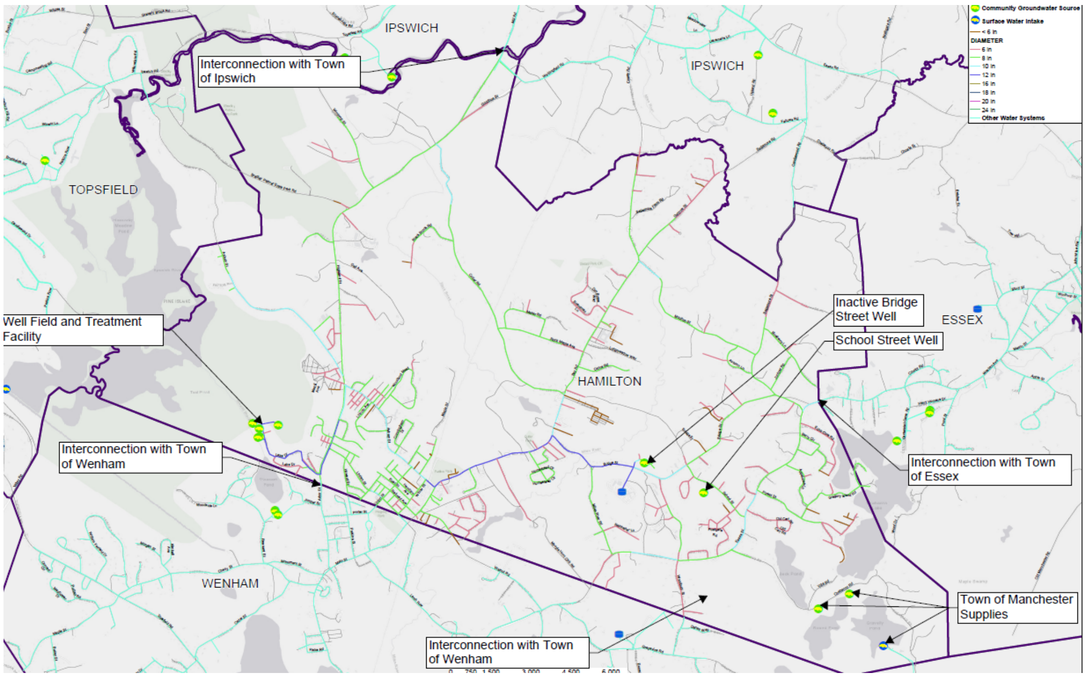
Two possible water quality issues were identified in the Task 3 Technical Memorandum about blending the water supplies between the partnering water systems including Essex's lack of using phosphate for corrosion control and the presence of PFAS within several individual supplies as shown in **Table 2-3.** The water systems of Manchester, Topsfield and Ipswich have had reported PFAS levels just at or above the 20 ppt MCL, however recent samplings have seen PFAS levels come down. These occasionally elevated levels could be problematic if introduced into another system with lower PFAS levels. This matter would likely have to be reviewed with MassDEP to determine what special requirements will need to be implemented before approving such a transfer. There are operational measures and treatment strategies that the systems can employ to mitigate their PFAS issues such as modifying the usage of the impacted supply similar to Hamilton or providing treatment for its removal. It is our understanding that Topsfield has already taken steps to address their PFAS levels and is in the process of adding granular activated carbon (GAC) at their treatment plant.

For Essex, the introduction of phosphate-treated water into their system could potentially disrupt the current chemistry that is providing the protective coating on the interior lead and copper surfaces. It will also increase the chlorine demand within the distribution system which will require adjusting the current chlorine dosages to avoid having coliform issues. Using the blended supply of Hamilton and the SBWSB on a short-term basis to alleviate a temporary loss of supply should not pose a significant issue. However, if Essex intends to obtain supply on a more regional/permanent basis, then they would likely need to adjust their current treatment practice for corrosion control to include phosphate.

2.5 Infrastructure Needs to Supply Partnering Communities

As previously noted herein, Hamilton has existing interconnections with the Towns of Ipswich, Essex and Wenham, ranging in size from 2-inches to 8-inches **(Refer to Figure No. 3 in Appendix A of the Task 3 Technical Memorandum).** We have included a view of Hamilton's water system showing the locations of the existing interconnections for reference on the following page. Hamilton currently has no interconnections in place with Topsfield or Manchester and as such, new interconnections and related pipelines will need to be constructed to connect these two systems with Hamilton. **These required pipeline improvements were evaluated under Tasks 4 and 5 of this WMA grant study and are reviewed in Sections 3 and 4 of this report.**

For Wenham, there are two existing interconnections including an 8-inch on Highland Street and a 6-inch on Woodbury Street. Based on Hamilton's existing system, the 8-inch interconnection on Highland Street would be more favorable for transferring future supply between Hamilton and Wenham. For Essex, there is an existing 4-inch and 2-inch interconnection at the end of Essex Street (Rte. 22) which is fed by Hamilton's 10-inch main. To effectively transfer future supply between the two systems, **it was recommended to replace this interconnection with a new single 8-inch connection.** For Ipswich, there is an existing 6-inch interconnection at the end of Waldingfield Road which is fed by Hamilton's 8-inch main. This interconnection should be adequate for transferring future supply between Hamilton and Ipswich.



View of Hamilton Water System w/ Existing Interconnections

Using Hamilton's computerized model, we conducted hydraulic analyses to estimate future supply rates that Hamilton's existing water system could deliver at each existing interconnection to augment the supplies of Wenham, Ipswich and Essex with a reduction in system pressure of no more than 3 psi. From the results of the analyses, a supply rate of up to 200 gpm can be provided at Wenham's interconnection, a supply rate of up to 300 gpm can be provided at Essex's interconnection, and a supply rate of up to 150 gpm can be provided at Ipswich's interconnection. **Table 2.4** on the following page shows the current operating gradient of Hamilton and the partnering water systems as determined from the Task 2 collected data and from correspondence with the partnering communities.

From **Table 2.4**, given that the existing system gradients for Wenham and Ipswich are about equal to Hamilton's gradient, supply between the systems can be delivered via gravity without the need for a PRV or a booster pump station. Depending on the demand and pressure fluctuations that occur within each of the systems over the course of a day, there will be times when the available gravity supply from Hamilton will be reduced. With Essex having a system gradient about 8 feet higher than Hamilton, a **booster pump station** will be needed at the interconnection to effectively supply Essex daily over an extended period. However, there could be times over a course of a day when the gradients between the two systems allow gravity flow.

Table 2.4 Existing System Gradients

Community Water System	Hydraulic Gradient (feet)
Hamilton	210
Manchester	273
Ipswich	210(1)
Topsfield	260
Essex	217.7
Wenham	211

1. Main pressure zone gradient as maintained by Tower Hill Tank.

These existing interconnections will also need to be provided with new revenue meters for measuring and totalizing flow being supplied to the partnering water systems. If these interconnections are to be used on a temporary or short-term basis and would be normally closed otherwise, then it not expected that backflow prevention devices for cross-connection control will be needed. If, in the future, these existing interconnections are used on a more permanent basis and/or are left normally open, then the installation of a backflow prevention device may be necessary depending on applicable water system requirements and regulations. **The estimated costs for upgrading the existing interconnections as needed for sharing supply between Hamilton, Wenham, Ipswich and Essex are included in Section 4 of this report summarizing the Task 5 Technical Memorandum.**

The above analyses were completed to determine the available supply rates that Hamilton could possibly deliver to augment the supplies of Wenham, Ipswich and Essex based on existing infrastructure. We do not have working models of the other partnering water systems so we could not determine the available supply rates that could possibly be delivered into Hamilton from these systems. It is our understanding both Wenham and Ipswich do not have computerized models of their water system. However, based on the operating gradients maintained by the partnering systems as shown in **Table 2.4**, and the existing infrastructure of their systems as described in the **Task 5 Technical Memorandum**, it is reasonable to surmise that these systems should be able to deliver similar supply rates into Hamilton.

If the approach of having the SBWSB supplying the future water needs of Hamilton and the partnering water systems on a permanent/regional basis is considered, additional analyses will have to be completed to determine what other possible infrastructure upgrades may be needed for delivering the expected higher supply rates.

3. Task 4 Summary and Conclusions

3.1 Introduction

For Task 4, we evaluated the feasibility of installing a new interconnection between Hamilton and Manchester to allow the ability to share water supply between the two systems, along with the other partnering water systems on a partially regional basis. As Hamilton has no direct connection with Manchester, a new pipeline will be required for the two systems to share water supply. Refer to attached **Figure 2 – Updated Town of Manchester Water System Plan dated June 2022 included in Appendix D** as prepared from the Town's GIS data provided for the study.

The Task 4 Technical Memorandum included in its entirety as **Appendix B** documents the evaluation and findings for this new pipeline interconnection with Manchester including: review of Manchester's water supply system; analysis of the new pipeline route along with needed infrastructure upgrades and associated costs; review of water supply availability and permitting considerations; review of water quality impacts from blending Manchester finished water with Hamilton finished water and the partnering water systems' finished water; and needed infrastructure upgrades to supply the partnering water systems. Please refer to the **Task 4 Technical Memorandum** for full narratives of the specific topics evaluated as required per the WMA grant scope along with supporting tables and figures. The following provides an overview of the results related to the new pipeline interconnection assessment, water supply and permitting impacts, water quality review, and needed infrastructure upgrades for sharing supply between Hamilton, Manchester and the partnering water systems.

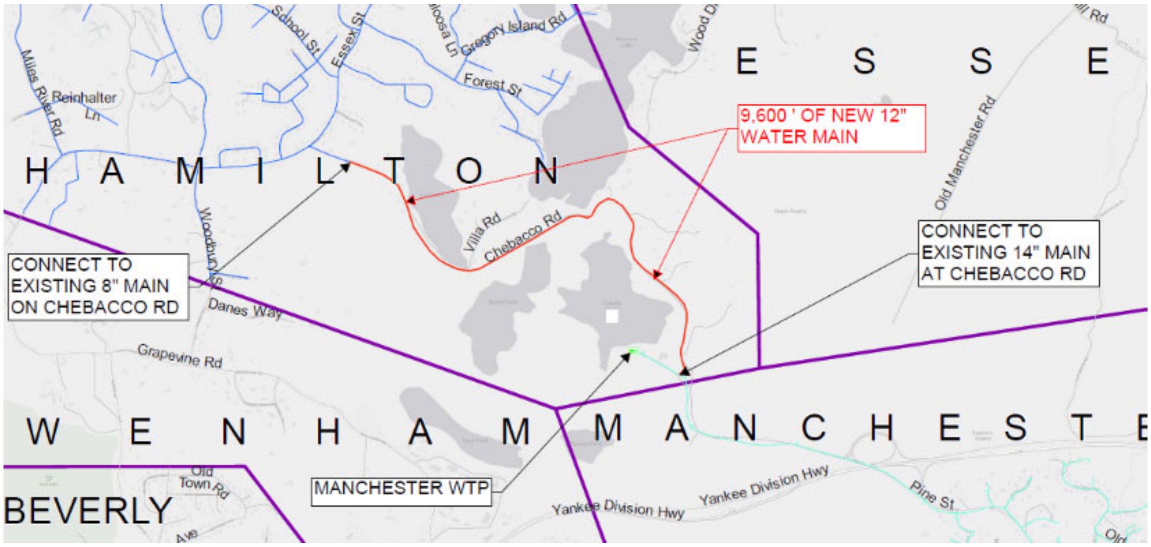
3.2 Pipeline Interconnection with Manchester

Based on existing infrastructure and previous discussions, the most preferable alignment for installing a new pipeline for connecting Hamilton to Manchester was determined to be along Chebacco Road which is located within Hamilton, MA. Refer to **Figure No. 1 included in Appendix A of the Task 4 Technical Memorandum**. We have included a partial view of Figure 1 for reference on the following page. A new 12-inch pipeline will initially connect to Hamilton's existing 8-inch main in Chebacco Road and extend westerly along Chebacco Road for approximately 9,600 feet terminating at Manchester's 14-inch transmission main leaving their WTF.

The new interconnection with Hamilton's existing 8-inch main will require a revenue meter chamber for measuring and totalizing flow along with a backflow prevention device for cross-connection control. As Manchester operates at a higher gradient than Hamilton **(273 feet vs 210 feet),** a pressure reducing valve (PRV) will be required to control the supply gradient entering Hamilton's system. Conversely, a new booster pump station will be needed to deliver supply into Manchester.

We conducted hydraulic analyses using the Town of Hamilton's existing computerized water system model to identify system impacts and the available supply that can be effectively delivered into Hamilton through the new pipeline and interconnection under the following operational scenarios:

- **Scenario #1:** Current System Conditions with Additional Supply from Manchester into Hamilton through New Interconnection with New PRV and New Meter/Backflow Preventer Device
- **Scenario #2:** Hamilton's Supplies Off-line with Full Supply from Manchester through New Interconnection with New PRV and New Meter/Backflow Preventer



Partial View of Figure 1- Pipeline Interconnection w/in Chebacco Rd.

For Scenario #1, we determined the optimal settings for the new PRV interconnection to supplement Hamilton's existing water system. **For Scenario #2**, we determined the maximum supply rate that could be hydraulically delivered through the new PRV interconnection to fully supply Hamilton. A summary of the results for the analyses completed is included in **Table 3.1** below which was included in Section 3 of the attached Task 4 Technical Memorandum.

Table 3.1 Chebacco Road Pipeline Interconnection Option Analyses Summary

Condition	Supply Rate	Comment
Scenario #1 – Additional Manchester Supply, Current Existing Conditions w/ New PRV		
PRV set @ 220'	150 to 525 gpm	Ex. pumps & tank will be isolated from system
PRV set @ 215'	150 to 385 gpm	Ex. pumps will not operate, tank turnover reduced to < half foot a day
PRV set @ 212'	100 to 325 gpm	Ex. pumps & tank operate, turnover reduced to ¾ foot a day
PRV set @ 210'	0 to 220 gpm	Ex. pumps & tank will operate, turnover reduced to 1-1/4 foot a day
PRV set @ 208'	0 to 100 gpm	Ex. system not impacted, but minimal available supply
Scenario #2 – Full Supply from Manchester, Finish Water Pumps & Reservoir Off-line, New PRV		
PRV set @ 230'	Up to 700 gpm(1)	Pressure increase by 9 psi, need to construct new tank in Hamilton
PRV set @ 235'	Up to 810 gpm(1)	Pressure increase by 11 psi, need to construct new tank in Hamilton

1. Manchester's current WMA Permit allows for a maximum authorized withdrawal of 0.72 MGD.

Based on results presented above for **Scenario #1**, the most favorable option is to set the new PRV to a downstream gradient somewhere between 210 feet and 212 feet which will supply flow rates up to 300 gpm to augment Hamilton's existing supplies with minimal impact to Hamilton's current operation. The final setting can be adjusted as needed based on actual system conditions when the new interconnection is installed and how much additional supply is needed. For **Scenario #2**, a maximum supply rate of about 800 gpm is predicted to be available for fully supplying Hamilton's system. This is based on the new PRV set at a downstream gradient of 235 feet which is the highest gradient that could be introduced into

Hamilton's system without causing significant pressure issues as their current system gradient is only 210 feet. **However, at this higher system gradient, Hamilton's existing Brown Hill Reservoir with a maximum water level elevation of 210 feet will no longer function as it will be hydraulically isolated from the system.**

For Scenario #2 to be feasible, Hamilton will need to construct a new taller storage tank at the appropriate height to replace the loss of the Browns Hill Reservoir for providing system equalization and fire protection. Also, based on Hamilton's current and future water needs, Manchester would need to have a supply surplus of about 1 MGD above their current supply needs along with the ability to withdraw this surplus from their existing sources to fully supply Hamilton, and provide some surplus for the partnering water systems. As noted in the **Task 4 Technical Memorandum**, Manchester's current WMA registration allows for a maximum authorized withdrawal of 0.72 MGD. This need for increased withdrawals to supply Hamilton and the partnering water system is discussed further in the following section.

Table 3.2 below summarizes the total estimated costs for the new pipeline within Chebacco Road as presented in the Task 4 Technical Memorandum to connect with Manchester to supply Hamilton and the partnering communities under the two noted operational scenarios. The estimated total costs do not include land acquisition, right-of-way procurement and legal fees. Costs include 30% for engineering/permitting and a 25% contingency for planning purposes. All costs are presented in 2022 dollars and are **based on the May 2022 Boston ENR construction cost index of 17506.61.**

Table 3.2 Cost Summary - Chebacco Road Pipeline Interconnection

Item			Total Cost(1)
Scenario #1: Additional Manchester Supply w/ New PRV, FW Pumps & Browns Hill Tank On-Line			
9,600' of new 12" Main w/ New PRV, Revenue Meter & Backflow Preventer			$5,565,625
Scenario #2: Full Manchester Supply w/ New PRV, FW Pumps & Browns Hill Tank Off-line			
9,600' of new 12" Main w/ New PRV, Revenue Meter & Backflow Preventer			$5,565,625
New 0.80 MG Storage Tank, Demolition of Ex. 0.80 MG Tank & Appurtenances			$4,021,875
Total - Scenario #2			**$9,587,500**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

3.2.1 Conclusion

Based on the assesment completed above, the option of constructing a new pipeline along Chebacco Road to connect Manchester with Hamilton would be effective for augmenting Hamilton's existing well supplies. There would be some system impacts with respect to a reduced turnover rate within the Browns Hill Reservoir, but on an temporary basis, this should not pose any significant operational or water quality issues. For fully supplying Hamilton on a more permanent basis, there would be signifiant impacts to Hamilton's system including the hydraulic loss of the Browns Hill Reservoir due to the increased gradient of the system. **Additional system improvements such as a new storage tank to replace the existing Browns Hill Reservoir along with larger water mains to support the new tank would be needed.**

Also, as noted above, Manchester would need to have a surplus of 1.0 MGD available within their existing supply capacity and allowable WMA withdrawal to be able to fully supply Hamilton along with supplementing the other partnering water systems while meeting their own water needs. An evaluation of Manchester's current supply capacity versus future water needs is presented in the following section.

3.3 Manchester Water Supply Availability/Permitting Impacts

3.3.1 Adequacy to Supply Hamilton and Partnering Water Systems

Manchester's current WMA registration allows for a total combined authorized daily withdrawal of 0.72 MGD from its three water supplies including the Gravelly Pond Reservoir, the Lincoln Street well and the Round Pond GP Well #1 which is pumped into the Gravelly Pond Reservoir to maintain storage volumes. A summary of Manchester's existing water supplies including approved daily withdrawals and maximum pump capacities is included in **Table 3.3** below which was included in Section 4 of the attached Task 4 Technical Memorandum.

Table 3.3 Town of Manchester - Existing Water Supplies

Supply	Maximum Pump Capacity (MGD)	Maximum Pump Capacity (gpm)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)
Gravelly Pond	4.30(2)	3,000	0.12	0.72(1)
Round Pond GP Well#1	N/A(3)	N/A(3)	0.43	
Lincoln Street Well	0.67	475	0.38	
Total	4.97	3,475	0.93	0.72

1. The WMA approved annual withdrawal from Manchester's combined supplies is 0.72 MGD.
2. This is the maximum pump capacity at the Gravelly Pond WTF which treats both Gravelly Pond and the Round Pond GP Well#1 supplies.
3. The Round Pond GP Well#1 has a rated well pump capacity of 300 gpm which is pumped into Gravelly Pond.

As shown in **Table 3.3**, Manchester has a maximum pump capacity of **4.97 MGD** with its existing supplies and infrastructure fully operational. From Hamilton's 2020 Water System Plan, Hamilton's projected average day demand (ADD) for 2035 is 0.671 MGD with a projected maximum day demand (MDD) of 1.01 MGD. From Manchester's **2018 Capital Efficiency Plan Report**, Manchester's projected ADD for 2035 is 0.620 MGD with a projected MDD of 2.03 MGD. From these projections, the total combined MDD for Hamilton and Manchester in 2035 would be approximately **3.04 MGD (1.01 MGD + 2.03 MGD),** which is below Manchester's current production capacity of 4.97 MGD. As such, Manchester has the infrastructure and pumping capacity to deliver enough supply to meet their future water needs, and the future water needs of Hamilton while having some surplus to share with the other partnering water systems. As noted in the Task 4 Technical Memorandum, Manchester's projected water needs included a 25% unaccounted-for water (UAW) which should be reduced in the coming years, thus resulting in a larger future surplus available to share.

With respect to available supply, as noted above, Manchester's projected ADD for 2035 is 0.620 MGD which is close to their recent ADD of 0.628 MGD as reported in their 2020 Annual Statistical Report (ASR). Based on Manchester's existing WMA registered withdrawal of 0.72 MGD as shown in **Table 3.3** above, there will be a future surplus volume of only 0.092 MGD available which is not enough volume to reliably augment Hamilton's supply as intended with the new future interconnection. However, as discussed in the Task 4 Technical Memorandum, this surplus could theoretically be increased up to 0.180

MGD if Manchester's current UAW percentage of 25% is reduced to 12% in the future which could possibly augment Hamilton enough to alleviate their current supply issue.

Based on the expected surplus volumes, there are several supply scenarios that could be considered for augmenting Hamilton's supplies through the new future interconnection while staying under their current registration. Some of which could allow Hamilton to reduce the use of its poorest raw water quality well, Idlewood Well #2, resulting in better finish water quality at its treatment plant as well as reducing withdrawals from the Ipswich River Basin. However, under these scenarios, there would not be any available surplus to supply the other partnering water systems.

For Manchester to fully supply Hamilton's future water needs of 0.671 MGD on a permanent basis along with their future water needs of 0.62 MGD as noted above, they would need to obtain MassDEP approval to increase their current WMA registered withdrawal of 0.72 MGD within the North Coastal Basin to **1.29 MGD (0.671 MGD + 0.620 MGD).** To achieve the goal of improving the supply resiliency of Hamilton and the other partnering water systems on a partial regional basis, then an additional increase to Manchester's current registered withdrawal volumes beyond the 1.29 MGD would be needed. The needed permitted volume would be dependent on how the partnering water systems intend to integrate this available supply into their system.

3.3.2 Water Supply Permitting Considerations

As presented in the Task 4 Technical Memorandum, Manchester can apply for a withdrawal permit from the DEP Water Management Program to increase its allowable withdrawal. However, Manchester's sources are within the North Coastal Watershed, which has a level 5 biological category and a level 4 Groundwater withdrawal category. This designation means the sub-basin is already depleted and suffering from significant environmental harm from water withdrawals. To obtain a new permit in this sub-basin, Manchester would first need to demonstrate it has a solid plan and program in place to get its UAW and gallons per capita day (gpcd) to below the State standards of 10% UAW and 65 gpcd. Second, Manchester would be required to *minimize* its existing withdrawals through a minimization program and *mitigate* the impacts of the new withdrawals on the sub-basin. While these steps are technically feasible, it is unclear if Manchester has enough options available to successfully meet the minimization and mitigation requirements. The permitting process would also require an extensive alternatives analysis to demonstrate that Hamilton has no other feasible and less-damaging water source alternative.

With Hamilton's existing water supplies within the Ipswich River Watershed, and Manchester's existing supplies within the North Coastal Watershed, an Inter-basin Transfer Act (IBT) permit will be needed to transfer water between the two systems and other affected partnering water systems. Depending on the volumes involved **(over 1 million gallons per day),** an IBT permit also requires that an Environmental Impact Statement assessment take place, which involves another layer of review. Several State agencies collectively participate in the IBT review and the permit is issued by the State Department of Conservation & Recreation under its role as support to the Massachusetts Water Resources Commission, which makes such regulatory decisions. The conditions of an IBT permit are contingent on overall environmental benefit, meaning a transfer from one basin can only be approved if it will have a neutral or net environmental benefit to the Commonwealth. Moreover, an IBT permit would require that both the donor and receiving permittees first comply with the principles of efficient water use as defined by the State Water Conservation Standards.

In the case of Manchester and Hamilton, the transfer of water between the two communities could theoretically be approved if both communities demonstrate efficient water use and a Comprehensive Water Resources Management Plan (CCMP) proves there is a neutral or net environmental benefit. The CCMP would analyze and demonstrate how the Towns would meet the Water Conservation Standards and reduced discretionary water use to the extent possible. For example, UAW would need to be 10% or below, and per capita water use below 65 gallons per day as previously noted for increasing registered withdrawals.

As the Town of Essex's sources within the North Coastal Basin are directly downstream of Manchester's water sources, the permitting process involved for both increasing existing WMA withdrawals and obtaining an IBT permit would require an analysis to determine the impact on Essex's sources. The Town of Essex, the local State legislative delegation and several stakeholders are currently involved in an extensive environmental assessment of the lower Essex River and Chebacco Lake Watersheds where the Manchester and Essex water sources are located. The study thus far has identified water withdrawals as a concern and potential source of water quality and flow impairments in the watershed. There is also a significant statewide effort amongst river advocates to prevent additional withdrawals in level 4 and 5 sub basins which may impact any decisions should Manchester request to increase its allocation. Any effort to increase Manchester's withdrawals would likely generate considerable involvement in downstream and other stakeholders, creating additional hurdles in the permitting process. To summarize, it is technically feasible for Manchester to increase its withdrawals, but the Towns would need to prove that overall environmental conditions will be improved through this effort.

3.3.3 Conclusions

Based on Manchester's existing registered withdrawals and future water needs, they should have the supply and production capacity available to augment the supply needs of Hamilton with a volume adequate to allow Hamilton to reduce the use of its Idlewood Well#2 source. This will result in an overall improvement of Hamilton's finish water quality, as well as reduce their withdrawals from the Ipswich River Basin and decrease the stress placed on their other's existing wells. However, under this supply scenario, there will be no surplus supply available to augment the other partnering water systems.

For Manchester to fully supply Hamilton and possibly other partnering water systems on a permanent or partial regional basis, they will need MassDEP approval to significantly increase their current registered withdrawals along with approval to transfer over 1 MGD of supply from one sub-basin to another. As noted above, although not impossible, the chances that Manchester can meet the withdrawal minimization and mitigation requirements for this approval is highly uncertain. In addition, given that Hamilton has another feasible and less-damaging source alternative with connecting to the SBWSB as discussed in Section 2, the likelihood of Manchester obtaining the noted permits to supply Hamilton and the partnering water systems on a regional basis would be even less. **As such, Hamilton should consider the new pipeline interconnection with Manchester as a short-term solution only to supplement their current supply needs.**

3.4 Water Quality Review

Per Task 2 of the WMA grant study, we coordinated and requested various water quality and system infrastructure data from Hamilton, Manchester and the partnering water systems of Ipswich, Essex, Wenham and Topsfield as required to complete this task. A summary of the finish water quality data collected from each of the water systems is presented in **Table 2.3** included in Section 2.4 of this report.

As previously noted in Section 2.4, **Hamilton's** five (5) Idlewood wells are post-treated at the Town's WTP after filtration for iron and manganese with sodium hypochlorite for disinfection, sodium fluoride for fluoridation, and a poly/orthophosphate blend for corrosion control. The Town's School Street well is chemically treated only before being delivered into the distribution system with sodium hypochlorite for disinfection, sodium fluoride for fluoridation, potassium hydroxide for pH adjustment, and a poly/orthophosphate blend for corrosion control.

From the Task 4 Technical Memorandum, **Manchester** utilizes the Trident/Microfloc package water treatment system at the Gravelly Pond WTF which includes oxidation, coagulation with aluminum sulfate, pH adjustment with sodium hydroxide, clarification, filtration, fluoridation with sodium fluoride, disinfection with sodium hypochlorite and corrosion control with zinc orthophosphate. This plant also treats raw water from the Round Pond GP Well#1 as this source is pumped directly into the Gravelly Pond reservoir. Treatment of Manchester's second source of supply, the Lincoln Street Well, is provided at the Lincoln Street Corrosion Control Facility which includes sodium hypochlorite for disinfection, sodium hydroxide for pH adjustment, a 70/30 percent non-sodium, non-zinc poly orthophosphate blend for corrosion control and prevention of colored water, and sodium fluoride for fluoridation.

As shown in **Table 2.3**, the finished water pH being maintained within Manchester's distribution system is in the range of 7.1 to 7.8 with a free chlorine residual in the range of 0.8 mg/l to 1.40 mg/l. The total phosphate residual maintained is in the range of 0.30 mg/l to 1.6 mg/l. In comparing the finished water quality being produced by Hamilton and Manchester, they are compatible with respect to pH, free chlorine and total phosphate levels. Both use chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water. Additionally, since both use phosphate products for corrosion control and maintain similar pH levels within their system, there should be minimal impacts to Hamilton's system with respect to lead and copper.

Levels of TTHMs and HAA5s within Manchester's system are less as compared to Hamilton's system, with both being below their respective established MCLs. However, Hamilton is currently constructing a new GAC treatment system that will reduce the levels of both TOCs and TTHMs at the plant which will improve finish water quality. PFAS levels at Manchester's Lincoln Street have had reported levels just at or above the 20 ppt MCL, however recent samplings have seen PFAS levels come down. These occasionally elevated levels could be problematic as they are higher than levels reported at Hamilton's Idlewood and School Street wells. However, sampling of Hamilton's School Street in 2021 showed a total sum of 13 ppt for the 6 regulated PFAS compounds which is still below the MCL of 20 ppt but is over the 10 ppt threshold which requires monthly sampling of the source. Hamilton has limited the use of this well and is currently evaluating options for providing future on-site treatment for PFAS removal.

There are operational measures and treatment strategies that Manchester can employ to mitigate their PFAS issues such as modifying the usage of the impacted supply similar to Hamilton or providing on-site treatment for its removal. **As such, Hamilton should be able to utilize a future interconnection with Manchester without any major water quality issues or impacts with meeting current drinking water standards, except for the noted PFAS.**

3.4.1 Supplying Partnering Water Systems

In Section 2.4, we presented and evaluated the finish water quality of the partnering water systems including Ipswich, Essex, Wenham and Topsfield, and possible water quality impacts with respect to Hamilton sharing its current and/or blended SBWSB supply with the partnering water systems. From

Table 2.3, given that Manchester's post-treatment practices and finish water quality closely match SBWSB, the blended supply of Hamilton and Manchester will have similar water quality impacts and issues related to supplying the partnering water systems as previously discussed in Section 2.4. With the partnering water systems of Ipswich, Wenham, Essex and Topsfield relying on free chlorine for disinfection as Hamilton and Manchester do, **there is no concern of blending chlorinated water with chloraminated water between systems.** The only two possible water quality issues identified in Section 2.4 which also apply here include Essex's lack of using phosphate for corrosion control and the presence of elevated PFAS levels within individual supplies for Manchester, Topsfield and Ipswich. As these same issues were already evaluated and discussed in Section 2.4, we did not feel it was necessary to repeat the same narrative. Please refer to Section 2.4 for the detailed discussion on these issues.

3.5 Infrastructure Needs to Supply Partnering Communities

As previously discussed in Section 2.5 of this report, Hamilton has existing interconnections with the Towns of Ipswich, Essex and Wenham, ranging in size from 2-inches to 8-inches **(Refer to Figure No. 2 in Appendix A of the Task 4 Technical Memorandum).** A view of Hamilton's water system showing the locations of the existing interconnections is included for reference in Section 2.5. Hamilton currently has no interconnection in place with Topsfield and as such, a new interconnection and related pipeline will need to be constructed to connect Topsfield with Hamilton. **This required pipeline improvement was evaluated under Task 5 of the WMA grant and is discussed in Section 4 of this report.**

The evaluation of these existing interconnections with Ipswich, Essex and Wenham related to the ability of Hamilton to hydraulically transfer supply into these systems based on current system gradients and infrastructure was previously presented in Section 2.5 of this report. The noted results from that evaluation are applicable here as well given that these same interconnections will be used to share the blended supply of Hamilton and Manchester with the partnering water systems under the same hydraulic conditions. Please refer to Section 2.5 for the detailed evaluation of these existing interconnections along with needed upgrades and considerations.

To summarize, it was recommended to replace Essex's existing 4-inch and 2-inch interconnection at the end of Essex Street (Rte. 22) **with a new single 8-inch connection.** For Ipswich, the existing 6-inch interconnection at the end of Waldingfield Road was noted to be adequate for transferring supply as was the existing 8-inch interconnection on Highland Street with Wenham. Additionally, it was estimated from hydraulic analyses that Hamilton's existing water system can deliver a supply rate of up to 200 gpm at Wenham's interconnection, up to 300 gpm at Essex's interconnection, and up to 150 gpm at Ipswich's interconnection.

As we do not have working models of the other partnering water systems, we could only determine what Hamilton could possibly deliver to augment the supplies of Wenham, Ipswich and Essex based on existing infrastructure. However, based on the operating gradients maintained by the partnering systems as shown in **Table 2.4**, and the existing infrastructure of their systems as described in the **Task 5 Technical Memorandum**, it is reasonable to surmise that these systems should be able to deliver similar supply rates into Hamilton.

Based on the existing system gradients of Hamilton and the partnering water systems as shown in **Table 2.4** in Section 2.5, Hamilton should be able to supply the systems of Wenham and Ipswich via gravity without the need for a PRV or a booster pump station. To effectively supply Essex, **a booster pump station** will be needed to overcome Essex's higher system gradient of 218 feet as compared to

Hamilton's gradient of 210 feet. The existing interconnections with Ipswich, Wenham and Essex will also need to be provided with new revenue meters for measuring the flows being supplied to the partnering water systems. The need for installing a backflow prevention device will be dependent on how the partnering water systems envision operating their interconnections, whether on a temporary/short-term basis or on a more permanent basis. **The estimated costs for upgrading the existing interconnections as needed for sharing supply between Hamilton, Wenham, Ipswich and Essex are included in Section 4 of this report summarizing the Task 5 Technical Memorandum.**

4. Task 5 Summary and Conclusions

4.1 Introduction

For Task 5, we evaluated the water systems of Ipswich, Essex, Wenham and Topsfield to determine the ability of sharing available supply between Hamilton and these systems to mitigate future short-term supply shortages on a Mutual Aid basis. As Hamilton has no direct connection with Topsfield, a new pipeline and interconnection will be required for the two systems to share water supply.

The Task 5 Technical Memorandum included in its entirety as **Appendix C** documents the evaluation of the partnering water systems along with the new pipeline for connecting Topsfield including: review of the existing water system infrastructure; review of water supply availability to meet future water needs within current WMA authorized withdrawals; identifying possible surplus supply to share amongst the partnering water systems; permitting considerations with sharing supply between different basins; review of water quality impacts from sharing and/or transferring finished water supply between Hamilton and the partnering water systems; needed infrastructure upgrades and associated costs to share supply between the partnering water systems; and analysis of the new pipeline route to connect Topsfield to Hamilton along with needed infrastructure and associated costs.

Please refer to the **Task 5 Technical Memorandum** for full narratives of the specific topics evaluated as required per the WMA grant scope along with supporting tables and figures. The following provides an overview of the results related to the assessment of existing water supply capacities and WMA registrations, review of system water needs, estimated supply surplus, water supply and permitting impacts, water quality review, and needed infrastructure upgrades for sharing supply between Hamilton and the partnering water systems.

4.2 Review of Existing Water System Supplies

4.2.1 Town of Ipswich

The Town of Ipswich's water system includes two (2) surface water supplies, five (5) groundwater supplies, one (1) conventional treatment facility, three (3) storage tanks and approximately 100 miles of water main. The distribution system includes three pressure zones or gradients as maintained by the Town Hill Tank (210 feet MSL), the Plover Hill Tank (216 feet MSL) and the Pinefield tank (269.5 feet MSL). The distribution system also includes approximately 4,764 service connections, and serves residential, commercial, business and institutional users. From the 2020 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately **1.008 million gallons per day (MGD).** The town has existing emergency interconnections with the neighboring communities of Hamilton and Rowley. The major components of Ipswich's current water system are shown on the attached **Figure 1 in Appendix A of the Task 5 Technical Memorandum.**

Ipswich's water supply includes several sources located within the Parker River Basin and Ipswich River Basin. The sources within the Parker River basin include two surface water sources, the Dow Brook and Bull Brook Reservoirs, the Mile Lane well and the Browns well. The two reservoirs are operated in series with the Bull Brook flowing via gravity into the Dow Brook where the combined sources are then treated and filtered at the Town's water treatment plant which has a reported production capacity of **2.5 MGD**. The Mill Lane and Browns wells are chemically treated only and have a combined reported maximum pump capacity of **0.42 MGD**. The Town's current WMA registration allows for a maximum authorized withdrawal of **0.98 MGD**, or 358 million gallons (MG) in a year, from all its combined sources located within the Parker River Basin.

The sources within the Ipswich River basin include the Fellows Road well, the Essex Road well and the Winthrop GD Well 2. The Town's current WMA Permit allows for a maximum authorized withdrawal of **0.20 MGD**, or 73 MG in a year, from all its combined sources located within the Ipswich River Basin. These three wells are chemically treated only and have a reported maximum pumping capacity of **0.75 MGD.** A summary of the Town's existing supplies and average annual withdrawals as taken from Table 2.1 included in Section 2.1 of the attached Task 5 Technical Memorandum is provided in **Table 4.1** on the following page. As noted in the Task 5 Technical Memorandum, Ipswich has taken Browns GP well off-line due to elevated levels of PFAS, and that new piping has already been installed up to the Town's WTP for purpose of blending the well water with the two surface water reservoirs for treatment.

4.2.2 Town of Essex

The Town of Essex's water system currently includes three (3) groundwater supplies, one (1) conventional treatment facility, one (1) storage tank and approximately 19 miles of water main. The distribution system includes approximately 1,135 service connections, and serves residential, commercial, business, industrial, agricultural and institutional users. The distribution system also includes one pressure zone which operates at a hydraulic gradient of 217.7 feet as maintained by the Town's only water storage tank, the Craft Hill tank. From the 2020 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately **0.201 MGD.** The Town has existing emergency interconnections with the neighboring communities of Hamilton and Gloucester. The major components of Essex's current water system are shown on the attached **Figure 2 in Appendix A of the Task 5 Technical Memorandum.**

Essex's water supply includes three (3) wells, the Harry Homan's Drive Well #1, the Harry Homan's Drive Well #2, and Centennial Grove Well #3, all located within the North Coastal Basin. The Town's current WMA registration allows for a maximum authorized withdrawal of **0.22 MGD**, or 80.3 MG in a year, from all three sources combined. The Town's maximum pumping capacity for its three sources combined is reported to be **1.21 MGD.** All three wells are chemically treated and filtered at Essex's Water Treatment Plant (WTP) which has reported production capacity of **1.0 MGD.** A summary of the Town's existing supplies and average annual withdrawals as taken from Table 2.3 included in Section 2.2 of the attached Task 5 Technical Memorandum is provided in **Table 4.1** on the following page.

4.2.3 Town of Wenham

The Town of Wenham's water system currently includes two (2) groundwater supplies, one (1) pump station, two (2) storage tanks and approximately 30 miles of water main. The distribution system includes approximately 1,220 service connections, and serves residential, commercial, business, industrial, agricultural and institutional users. The distribution system also includes one pressure zone which operates at a hydraulic gradient of 211 feet as maintained by the Town's Lords Hill Reservoir. The Town's second tank, the Iron Rail Pump storage facility, is pumped storage for fire protection only. From the 2021 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately **0.259 MGD.** The Town has existing emergency interconnections with the neighboring communities of Hamilton and Beverly. The major components of Wenham's current water system are shown on the attached **Figure 3 in Appendix A of the Task 5 Technical Memorandum.**

Table 4.1 Summary of Existing Supplies for Partnering Water Systems

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2020 Annual Average Withdrawal (MGD)(3)
Town of Ipswich:					
Dow Brook Reservoir	Parker	2.50	0.80(2)	0.98	0.642(1)
Bull Brook Reservoir	Parker				
Mile Lane GP Well	Parker	0.22	0.15		0.037
Browns GP Well(5)	Parker	0.20(4)	0.49		0.064
Subtotal		2.92	1.44	0.98	0.743
Fellows Road Well	Ipswich	0.31	0.31	0.20	0.102
Essex Road GP Well	Ipswich	0.21	0.21		0.089
Winthrop GD Well 2	Ipswich	0.23	0.23		0.075
Subtotal		0.75	0.75	0.20	0.266
Total – Town of Ipswich		3.67	2.19	1.18	1.009
Town of Essex:					
Harry Homan's Drive Well#1	North Coastal	0.36	0.22(6)	0.22	0.201
Harry Homan's Drive Well#2	North Coastal	0.49	0.48(6)		N/A
Centennial Grove Well#3	North Coastal	0.36	0.43(6)		N/A
Total – Town of Essex		1.21(8)	1.13	0.22	0.201(7)
Town of Wenham:					
GP Well 1	Ipswich	0.39	0.40(9)	0.29	
GP Well 2	Ipswich	1.07	1.08(9)		
Total -Town of Wenham		1.48	1.48	0.29	0.26(9)
Town of Topsfield:					
North Street Wellfield	Ipswich	1.14(9)	1.30(9)	0.43	0.314
Perkins Row Wellfield	Ipswich	0.43(9)	0.48(9)		0.079
Total - Town of Topsfield		1.57(10)	1.78	0.43	0.393(9)

1. Includes withdrawals from both Dow Brook and Bull Brook Reservoirs. Bull Brook transferred via gravity into Dow Brook for treatment.
2. Includes both the Dow Brook and Bull Brook Reservoirs as they are operated in series.
3. Estimated from Ipswich's 2020 Annual Statistical report (ASR).
4. This use of this source is limited due to water quality issues with manganese.
5. The Browns GP well is currently off-line due to elevated PFAS levels.
6. As reported in the Town's 2020 ASR.
7. This represents the supply being pumped into the water treatment plant from all 3 supplies.
8. The Town's water treatment plant that treats all 3 wells has a rated capacity of 1.0 MGD
9. As reported in the Town's 2021 ASR.
10. The Town's water treatment plant that treats both wells has a rated capacity of 1.4 MGD.

Wenham's water supply includes two (2) wells, GP Well 1 and GP Well 2, both located within the Ipswich River Basin. The Town's current WMA registration allows for a maximum authorized withdrawal of **0.29 MGD**, or 105.85 MG in a year, from both sources combined. These two wells are chemically treated only at the Town's Pleasant Street pump station only and have a reported maximum pumping capacity of **1.48 MGD.** A summary of the Town's existing supplies and average annual withdrawals as taken from Table

2.4 included in Section 2.3 of the attached Task 5 Technical Memorandum is provided in **Table 4.1** above.

4.2.4 Town of Topsfield

The Town of Topsfield's water system currently includes two (2) groundwater supplies, two (2) pump stations, one (1) greensand filtration plant, two (2) storage tanks and approximately 50 miles of water main. The system includes approximately 1,850 service connections, and serves residential, commercial, business, industrial, agricultural and institutional users. The distribution system also includes one pressure zone which operates at a hydraulic gradient of 260 feet as maintained by the Town's two water storage tanks including the Boston Street tank and the Garden Street tank. From the 2021 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately **0.393 MGD.** The Town has existing emergency interconnections with the neighboring community of Danvers. The major components of Wenham's current water system are shown on the attached **Figure 4 in Appendix A of the Task 5 Technical Memorandum.**

Topsfield's water supply includes two (2) well sources, the North Street wellfield and the Perkins Row wellfield, both located within the Ipswich River Basin. The Town's current WMA registration allows for a maximum authorized withdrawal of **0.43 MGD**, or 156.95 MG in a year, from both sources combined. The Town gave up its WMA permitted withdrawal of 0.17 MGD a few years ago. The Town's maximum pumping capacity for its two sources combined is reported to be **1.57 MGD.** All three wells are chemically treated and filtered at Topsfield's Boston Street Water Treatment Plant (WTP) which has reported production capacity of **1.4 MGD.** A summary of the Town's existing supplies and average annual withdrawals as taken from Table 2.6 included in Section 2.4 of the attached Task 5 Technical Memorandum is provided in **Table 4.1** above.

4.2.5 Town of Hamilton

The Town of Hamilton's water system currently includes five (5) groundwater supplies, one (1) storage tank, one (1) water treatment plant and approximately 54 miles of distribution piping. The distribution system includes approximately 2,563 service connections, and serves residential, commercial, industrial, and institutional users. The distribution system also includes one pressure zone which operates at a hydraulic gradient of 210 feet as maintained by the Town's only water storage tank, the Browns Hill Reservoir. From the 2020 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately **0.561 MGD**. The Town has emergency interconnections with the neighboring communities of Essex, Wenham and Ipswich. The major components of Hamilton's current water system are shown on the attached **Figure 5 in Appendix A of the Task 5 Technical Memorandum.**

Hamilton's water supply includes five (5) groundwater supplies including Idlewood #1, Idlewood #1 Satellite, Idlewood #2, Plateau and Caisson Satellite wells, all located within the Idlewood Wellfield, and the School Street Well. All well supplies are within the Ipswich River Basin and are registered except for the School Street well and Idlewood#1 well which are permitted. The Town's current WMA Permit allows for a maximum registered withdrawal of **0.92 MGD**, or 335.80 MG in a year, with a maximum permitted withdrawal of **0.11 MGD**, or 40.15 MG in a year, for a total authorized withdrawal of **1.03 MGD**, or 376 MG in a year, from all six sources within the Ipswich River Basin. Additionally, no more than 0.88 MGD can be withdrawn from the Idlewood Wellfield, and no more than 0.19 MGD can be withdrawn from School Street.

The Town's maximum pumping capacity for its five (5) Idlewood wells combined is reported to be **1.30 MGD.** All five wells are chemically treated and filtered at Town's Water Treatment Plant (WTP) which has reported maximum production capacity of **0.93 MGD.** The Town's School Street is chemically treated only and has a reported maximum pumping capacity of **0.16 MGD.** A summary of the Town's existing supplies and average annual withdrawals is provided in **Table 4.2** below which was included in Section 2.5 of the attached Task 5 Technical Memorandum. As noted in the Task 5 Technical Memorandum, Hamilton took Idlewood #2 well off-line in 2021 to mitigate water quality issues related to the formation of TTHMs at the plant and impacts to filter performance due to elevated levels of manganese. Also, Hamilton has taken the School Street well off-line due to elevated levels of PFAS.

Table 4.2 Town of Hamilton - Existing Water System Supplies

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2021 Annual Average Withdrawal (MGD)
Idlewood Wellfield[1]					
Caisson Satellite	Ipswich	0.21	0.22		0.096
Idlewood #1	Ipswich	0.31[3]	0.71[2]		0.323[2]
Idlewood Satellite #1	Ipswich	0.14		0.88	
Idlewood #2[4]	Ipswich	0.32[3]	0.57		0
Plateau	Ipswich	0.32[3]	0.51		0.126
Subtotal		1.30[6]	2.01	0.88	0.545
School Street[2]	Ipswich	0.16	0.19	0.19	0.020
Total – All Supplies		1.46	2.20	1.07[5]	0.565

1. The WMA permitted withdrawal for all combined wells within the Idlewood wellfield is 0.88 MGD.
2. Includes both Idlewood #1 and Idlewood Satellite #1 wells.
3. The maximum pump capacity of these sources is below the approved daily withdrawal due to water Quality issues with iron and manganese.
4. The Idlewood #2 well is currently off-line due to high TOCs and manganese.
5. The Town's WMA allows a total authorized withdrawal of 1.03 MGD from all five sources.
6. The Town's water treatment plant that treats the Idlewood wellfield has a maximum operating capacity of 0.93 MGD.
7. The School Street is currently off-line due to elevated PFAS levels.

4.3 Review of Future Water Supply Needs

4.3.1 Town of Ipswich

From the Town's **Final Water Demand and Supply Evaluation Report dated February 2019,** future average day demands for Ipswich were estimated to determine the future adequacy of the Town's supplies based on historical water usage, population projections and potential development. From this assessment, the Town's average day demand for 2040 was estimated to be **1.39 MGD** which is a 27% increase from its 2020 average day demand of **1.009 MGD** and exceeds its current total WMA registered withdrawal of 1.18 MGD as shown in **Table 4.1**. Additionally, as noted in the Task 5 Technical Memorandum, the safe yield of the Town's combined reservoirs of 0.80 MGD was re-evaluated in the February 2019 Report using supply data from the 2016 drought which resulted in a new established firm yield of **0.41 MGD**. This determination results in Ipswich having less supply available from these sources during a drought condition likely impacting the Town's ability to meet future water needs.

Based on the Town's current WMA registered withdrawal of 1.18 MGD from all its combined sources, Ipswich has a current surplus of **+0.171 MGD** available to share between the partnering communities on a short-term basis (1.180 MGD – 1.009 MGD). This equates to a total yearly volume of 62.4 MG. However, in 2040, the Town will have a supply deficit of **-0.210 MGD** based on its current WMA registered withdrawal (1.180 MGD – 1.390 MGD). Based on this future condition, it was recommended in the February 2019 report that the Town increase its water supply by 0.43 MGD along with requesting an increase in its current WMA withdrawal limits to meet future water demands.

As noted in the Task 5 Technical Memorandum, Ipswich is currently evaluating the development of the two new well sources within the Parker River Basin including one at the Town's existing Lynch site, and one to replace the existing Browns well. These new wells were noted in the February 2019 Report to have potential yields of up to 0.73 MGD and 0.58 MGD, respectively, which would address future supply deficits contingent on MassDEP approving an increase in the Town's current WMA withdrawal of 0.98 MGD for its Parker River basin sources.

In addition to average day demands, we also evaluated the impact to Ipswich's existing supply capacity in meeting future maximum day demands. From Ipswich's 2020 ASR, the maximum day demand within their system was reported to be **1.84 MGD** which equates to about 182% of the average day demand for the same year. From the Town's **Final Water Demand and Supply Evaluation Report dated February 2019,** the future maximum day demand for 2040 was estimated to be **4.17 MGD** which is about 300% of the future average day demand for the same year.

Based on the reported maximum supply capacity of **3.67 MGD** available from its combined Parker River and Ipswich River Basin sources as shown in **Table 4.1,** Ipswich will need to increase its existing supply capacity by at least **0.5 MGD (4.17 MGD – 3.67 MGD)** to meet its future maximum day demands. As MassDEP typically requires water systems to be capable of meeting their maximum day demand with their largest source or pump out of service, Ipswich may need more of an increase in capacity to meet this requirement. The future ratio of maximum day to average day demand used to estimate the Town's future maximum day demand seems high given the ratio noted for 2020, and the future water conservation measures that would likely be implemented. **Ipswich should consider re-evaluating this projection before moving ahead with significant investments to its existing infrastructure.**

Given that Ipswich's current maximum day demand noted above exceeds their current WMA daily registered withdrawal by 0.66 MGD, they would have to pump their sources at rates higher than the WMA daily withdrawal rate to meet this demand. These higher pump rates would likely be needed throughout the summer months when system demands tend to be consistently above the average day demands. As such, during these above average system demand periods, there would be minimal to no supply surplus available to share with the partnering water systems.

4.3.2 Town of Essex

From the Town's **Water System Plan dated September 2019,** future average day demands for Essex were estimated to determine the future adequacy of the Town's supplies based on historical water usage, population projections and potential development. From this assessment, the Town's average day demand for 2035 was estimated to be **0.260 MGD** which is a 30% increase from its 2020 average day demand of **0.201 MGD** and exceeds its current total WMA registered withdrawal of 0.22 MGD as shown in **Table 4.1**. However, Essex can withdraw an additional 0.10 MGD on top of its registered 0.22 MGD on an average daily basis without triggering additional permitting so they will still be able to operate under their current registration and meet their future water needs.

Based on the Town's current WMA registered withdrawal of 0.22 MGD from its combined sources, Essex has a current surplus of **+0.019 MGD** available to share between the partnering communities on a short-term basis (0.220 MGD – 0.201 MGD). This equates to a total yearly volume of 6.94 MG. However, in 2035, the Town will have a supply deficit of **-0.040 MGD** based on its current WMA registered withdrawal (0.220 MGD – 0.260 MGD). Taking into consideration the additional 0.10 MGD withdrawal available to Essex, there would be a current surplus of about **+0.12 MGD** available to share between the partnering communities on a short-term basis, which equates to a total yearly volume of 43.8 MG (0.320 MGD – 0.201 MGD). In 2035, this available surplus would be reduced to **0.06 MGD** (0.320 MGD – 0.260 MGD), which equates to a total yearly volume of 21.9 MG.

In addition to average day demands, we also evaluated the impact to Essex's existing supply capacity in meeting future maximum day demands. From Essex's 2020 ASR, the maximum day demand within their system was reported to be **0.435 MGD** which equates to about 216% of the average day demand for the same year. From the Town's **Water System Master Plan dated September 2019,** the future maximum day demand for 2035 was estimated to be **0.421 MGD** which is about 162% of the future average day demand for the same year.

Based on the reported maximum supply capacity of **1.0 MGD** available from its treatment plant which treats all its three (3) well sources within the North Coastal Basin as shown in **Table 4.1,** Essex has ample supply capacity to meet its future maximum day demands having a surplus of **0.58 MGD (1.0 MGD - 0.421)** with all sources in operation. Additionally, given the pump capacities of their individual wells as shown in **Table 4.1,** they should be able to meet future maximum day demands with their largest well out of service as required per MassDEP. As with Ipswich, given that Essex's current maximum day demand noted above exceeds their current WMA daily registered withdrawal by 0.215 MGD, they would have to pump their sources at rates higher than the WMA daily withdrawal rate to meet this demand. These higher pump rates would expect to be needed throughout the summer months when system demands tend to be consistently above the average day demands as noted for Ipswich.

As such, during these above average system demand periods, there would be minimal to no supply surplus available to share with the partnering water systems. As shown above, Essex has on average minimal surplus available to share unless they utilize their additional 0.10 MGD withdrawal available under their current WMA registration.

4.3.3 Town of Wenham

From the data collection conducted under Task 2, Wenham has not completed a recent Water System Master Plan and therefore has no future population projections and/or future water need forecasts available. Per discussions with Town staff, it is believed that future average day demands over the next 15 years should remain relatively constant with minimal increase in usage. Recent DCR Water Needs Forecast predicts a 9-percent increase to its average day water usage in 10 years. For the purposes of this assessment, we have assumed that the Town's average day demand for 2035 will increase to **0.280 MGD** which is a 9% increase from its 2021 average day demand of **0.260 MGD**. Based on this assumption, the Town will be operating just below its current WMA registered withdrawal of 0.29 MGD as shown in **Table 4.1** to meet their future water needs.

It should be noted that in the Task 5 Technical Memorandum, we had initially applied a 2% increase to Wenham's current average day demand to estimate their future water needs for 2035. However, upon further review of recent DCR projections and the estimated water needs by the other partnering water systems, we realized that the initial 2% increase was low and that applying a 9% increase was more representative of the region.

Based on the Town's current WMA registered withdrawal of 0.29 MGD from its combined sources, Wenham has a current surplus of **+0.030 MGD** available to share between the partnering communities on a short-term basis (0.290 MGD – 0.260 MGD). This equates to a total yearly volume of 10.95 MG. In 2035, this surplus will be reduced to **+0.010 MGD** (0.290 MGD – 0.280 MGD), which equates to a total yearly volume of 3.65 MG.

In addition to average day demands, we also evaluated the impact to Wenham's existing supply capacity in meeting future maximum day demands. From Wenham's 2021 ASR, the maximum day demand within their system was reported to be **0.466 MGD** which equates to about 179% of the average day demand for the same year. For Wenham, since they do not have future water demand projections available, we have estimated their future maximum day demand by applying the current maximum day/average day demand ratio calculated above of 179%. This approach results in a future maximum day demand of **0.500 MGD.**

Based on the reported maximum supply capacity of **1.48 MGD** available from the its two well sources within the Ipswich River Basin as shown in **Table 4.1,** Wenham has ample supply capacity to meet its future maximum day demands having a surplus of **0.98 MGD (1.48 MGD - 0.500)** with both sources in operation. However, given the pump capacities of their individual wells as shown in **Table 4.1,** they would not be able to meet future maximum day demands with their largest well out of service as required per MassDEP.

As with Ipswich and Essex, given that Wenham's current maximum day demand noted above exceeds their current WMA daily registered withdrawal by 0.180 MGD, they would have to pump their sources at rates higher than the WMA daily withdrawal rate to meet this demand. These higher pump rates would expect to be needed throughout the summer months when system demands tend to be consistently above the average day demands as noted for Ipswich and Essex. As such, during these above average system demand periods, there would be minimal to no supply surplus available to share with the partnering water systems.

4.3.4 Town of Topsfield

From the data collection conducted under Task 2, Topsfield has not completed a recent Water System Master Plan and therefore has no future population projections and/or future water need forecasts available. Recent DCR projections used by the Town for renewing a previous water permit shows a slight increase in population which was the basis for the requested 0.03 MGD of additional permitted withdrawal. This DCR forecast predicts a 10-percent increase to its average day water usage in 10 years. For the purposes of this assessment, we have assumed that the Town's average day demand for 2035 will be increase to **0.430 MGD** which is a 10% increase in demand from its 2021 average day demand of **0.393 MGD**. Based on this assumption, the Town will be operating at its current WMA registered withdrawal of 0.430 MGD as shown in **Table 4.1** to meet their future water needs.

It should be noted that in the Task 5 Technical Memorandum, we had initially applied a 3% increase to Topsfield's current average day demand to estimate their future water needs for 2035.

However, upon further review of recent DCR projections and the estimated water needs by the other partnering water systems, we realized that the initial 3% increase was low and that applying a 10% increase was more representative of the region.

Based on the Town's current WMA registered withdrawal of 0.430 MGD from its combined sources, Topsfield has a current surplus of **+0.037 MGD** available to share between the partnering communities on a short-term basis (0.430 MGD – 0.393 MGD). This equates to a total yearly volume of 13.50 MG. In 2035, this surplus will be reduced to zero (0.430 MGD – 0.430 MGD). As noted in the Task 5 Technical Memorandum, Topsfield operated their system in 2021 with a reported unaccounted-for water usage of 22% or approximately 31.6 MG for the year. This equates to a daily withdrawal rate of 0.087 MGD.

If the Town can eventually reduce their unaccounted-for water by half to a more reasonable 11%, this would conversely increase the current supply surplus by about 0.043 MGD (0.087 MGD x 0.5) to approximately **0.080 MGD**, which equates to a total yearly volume of 29.20 MG. In 2035, the Town could potentially have a supply surplus of **0.043 MGD,** which would allow Topsfield to continue operating under their current WMA registration with some additional surplus for sharing water with the partnering communities.

In addition to average day demands, we also evaluated the impact to Topsfield's existing supply capacity in meeting future maximum day demands. From Topsfield's 2021 ASR, the maximum day demand within their system was reported to be **0.823 MGD** which equates to about 209% of the average day demand for the same year. For Wenham, since they do not have future water demand projections available, we have estimated their future maximum day demand by applying the current maximum day/average day demand ratio calculated above of 209%. This approach results in a future maximum day demand of **0.900 MGD.**

Based on the reported maximum supply capacity of **1.40 MGD** available from its treatment plant which treats its two (2) well sources within the Ipswich River Basin as shown in **Table 4.1,** Topsfield has ample supply capacity to meet its future maximum day demands having a surplus of **0.50 MGD (1.40 MGD - 0.90)** with both sources in operation. However, given the pump capacities of their individual wells as shown in **Table 4.1,** they would not be able to meet future maximum day demands with their largest well out of service as required per MassDEP.

As with Ipswich, Essex and Wenham, given that Topsfield's current maximum day demand noted above exceeds their current WMA daily registered withdrawal by 0.470 MGD, they would have to pump their sources at rates higher than the WMA daily withdrawal rate to meet this demand. These higher pump rates would expect to be needed throughout the summer months when system demands tend to be consistently above the average day demands as noted for Ipswich, Essex and Wenham. As such, during these above average system demand periods, there would be minimal to no supply surplus available to share with the partnering water systems.

4.3.5 Town of Hamilton

From the Town's **Water System Master dated February 2020,** future average day demands for Hamilton were estimated to determine the future adequacy of the Town's supplies based on historical water usage, population projections and potential development. From this assessment, the Town's average day demand for 2035 was estimated to be **0.671 MGD** which is about an 18% increase from its 2021 average day demand of **0.565 MGD** but still below its current WMA authorized withdrawal of 1.03 MGD as shown in **Table 4.2**. As such, the Town will still be able to meet their future water needs with their current WMA authorized withdrawal.

Based on the Town's current WMA authorized withdrawal of 1.03 MGD from its combined registered and permitted sources, Hamilton would have a surplus of **+0.470 MGD** available to share between the partnering communities on a short-term basis (1.03 MGD – 0.565 MGD). However, as noted in the Task 5 Technical Memorandum, the Town has taken the School Street well off-line indefinitely due to elevated PFAS levels. As such, this only leaves the Idlewood wellfield available for the Town's use which has a WMA authorized withdrawal of 0.88 MGD as shown in **Table 4.2**. Based on this supply condition, Hamilton has a current surplus of **+0.315 MGD** available to share between the partnering communities on a short-term basis (0.880 MGD – 0.565 MGD). This equates to a total yearly volume of 114.98 MG. In 2035, this available surplus would be reduced to **+0.209 MGD** (0.880 MGD – 0.671 MGD), which equates to a total yearly volume of 76.29 MG.

In addition to average day demands, we also evaluated the impact to Hamilton's existing supply capacity in meeting future maximum day demands. From Hamilton's 2021 ASR, the maximum day demand within their system was reported to be **0.770 MGD** which equates to about 1.36% of the average day demand for the same year. From the Town's **Water System Master Plan dated February 2020,** the future maximum day demand for 2035 was estimated to be **1.006 MGD** which is 150% of the future average day demand for the same year.

Based on the current maximum production capacity of **0.93 MGD** at its treatment plant which treats all its five (5) Idlewood well sources as shown in **Table 4.2,** Hamilton will need to increase its existing supply capacity by at least **0.08 MGD (1.006 MGD – 0.937 MGD)** to meet its future maximum day demands. As MassDEP typically requires water systems to be capable of meeting their maximum day demand with their largest source or pump out of service, Hamilton may need more of an increase in capacity to meet this requirement. As noted in the Task 5 Technical Memorandum, the Town has taken its Idlewood #2 well which is its larger producer off-line for over a year due to elevated TOCs and manganese. This is significantly impacting the operation of the wellfield as other wells must be pumped more than they should to make up for the loss of the Idlewood #2 well in meeting system demands.

As noted in the Task 5 Technical Memorandum, this limited supply availability is further impacted by Hamilton having to routinely take one of the Idlewood wells off-line for redevelopment and maintenance due to excessive iron and manganese within the raw water. For example, taking one of the Idlewood wells off-line for maintenance with the Idlewood #2 well already off-line can potentially reduce Hamilton's available supply capacity to **0.67 MGD** which is less than the Town's higher summer demands which can approach 1.0 MGD at times. This places a great strain on the remaining wells and requires the plant to operate close to 24 hours a day during these higher demand periods to maintain adequate levels within their storage tank. The Town is currently completing the construction of a new GAC treatment facility to remove TOCs and TTHMs from the filtered water which will hopefully allow the Town to utilize Idlewood #2 well more often to help meet system demands. However, its use will always be limited due to its raw water quality which impacts the plant's filter performance and as such, would likely never be able to contribute enough to alleviate future supply deficits.

Unlike the other partnering water systems. Hamilton's current maximum day demand of 0.770 MGD is below its current WMA daily authorized withdrawal of 0.88 MGD for its Idlewood wellfield, which leaves some surplus to share. However, as noted above, given the current operation and water quality of the

Idlewood wells, this surplus is mostly unattainable, particularly during the summer months when Hamilton is struggling to meet system demands given their supply limitations.

4.3.6 Conclusion

For the assessment above, we first evaluated current and future average day demands of each partnering water system to identify supply surplus available under current WMA authorized withdrawals for sharing and which systems may be facing future supply deficits. We then evaluated the ability of each partnering water system's existing supply capacity to meet current and future maximum day demands and what impacts these higher demands will have on available surplus. **Table 4.3** below summarizes the results of the evaluations conducted under average day and maximum day demands for each partnering community water system.

Table 4.3 Available Surplus – Average Day & Maximum Day Demands

Year	Maximum Supply Capacity (MGD)	WMA Authorized Withdrawal (MGD)	Average Day Demand (MGD)	Surplus/ Deficit (MGD)	Maximum Day Demand (MGD)	Surplus/ Deficit (MGD)
Ipswich:						
2020	3.67	1.18	1.009	+0.171	1.837	-0.657
2040	3.67	1.18	1.390	-0.210	4.170	-2.99
Essex:						
2020	1.00	0.220	0.201	+0.019	0.435	-0.215
2035	1.00	0.220	0.260	-0.040	0.421	-0.201
Wenham:						
2021	1.48	0.290	0.260	+0.030	0.466	-0.176
2035	1.48	0.290	0.280	+0.010	0.500	-0.220
Topsfield:						
2021	1.40	0.430	0.393	+0.037	0.823	-0.393
2035	1.40	0.430	0.430	0.00	0.900	-0.470
Hamilton:						
2021	0.93	0.880	0.565	+0.315	0.770	+0.110
2035	0.93	0.880	0.671	+0.209	1.006	-0.126

As shown in **Table 4.3**, there is some surplus supply available within current WMA authorized withdrawals to share between the partnering water systems for mutual aid purposes based on current average day demands. However, based on future average day demands, all partnering water systems except Hamilton will have little to no surplus available to share for mutual aid purposes under current WMA authorized withdrawals. As shown in **Table 4.3**, both Ipswich and Essex are predicted to have supply deficits with Wenham and Topsfield predicted to be operating just at their WMA authorized withdrawals. Essex is permitted under their current WMA registration to withdraw an additional 0.10 MGD to meet their future water needs so they will be able to still operate under their current WMA authorized withdrawals.

Although Hamilton has surplus supply available within their current WMA authorized withdrawals, due to the poor water quality of its wells, Hamilton is limited to how much supply they can withdraw and treat which significantly diminishes the useable surplus available, particularly during high demand periods.

With respect to meeting future maximum day demands, from **Table 4.3**, Essex, Wenham and Topsfield will have ample supply capacity available as their maximum supply capacities exceed their future maximum water supply needs. However, based on the pump capacities for each individual source as shown in **Table 4.1**, both Wenham and Topsfield will not be able to meet these future demands fully with their largest well out of service.

With Ipswich's maximum supply capacity being less than their predicted future maximum day demand, they will need to improve their supply capacity either by increasing source pump rates, upgrading the production capacity of its treatment plant or developing a new source. As previously noted herein, the Town is evaluating the feasibility of installing a new well at its existing Lynch well site and a new replacement well for its Browns well which could potentially yield an additional combined capacity of 1.31 MGD. The future completion of these new wells, which are located within the Parker River basin, should alleviate the future supply and capacity deficits noted herein and improve Ipswich's ability to share supply with the partnering communities. **This is contingent on the Town being granted an increase in its current WMA authorized withdrawal for the Parker River Basin by MassDEP**

Like Ipswich, Hamilton's future maximum day demand exceeds their maximum supply capacity which as noted herein, is already reduced due to the water quality of their wells. The overall quality and performance of the Town's Idlewood wells have been gradually declining over the years with current production at about 60% of their approved capacity as shown in **Table 4.2**. This decline in water quality limits the production rate that the wellfield can yield, and the plant can treat providing little to no redundancy for the Town to rely on. The current condition of these wells makes it difficult to meet higher demand periods and as shown in **Table 4.3**, will not be adequate to future maximum day demands. This loss of production within their primary source of supply is the basis for Hamilton completing this study to identify alternative sources for improving its water supply resiliency to meet future water needs in the event future losses in production of these wells occur.

Although there is no apparent future surplus available to share during higher summer demand periods when most likely needed, some systems may have the capacity to pump their sources at higher rates to meet their water needs and still provide some surplus supply. As shown in **Table 4.3,** except for Ipswich, the maximum supply capacities for Essex, Wenham and Topsfield exceed their future maximum day demand so they may have the ability to meet their high demand periods and possibly share some supply on a mutual aid basis. **This would be contingent on the systems being able to over pump their wells during these high demand periods without having excessive drawdown issues due to long recovery periods as a result of low flow conditions within the subject river basins.**

Additionally, during the lower demand periods of the year when the partnering water systems typically pump their sources at or below the WMA daily authorized withdrawals, there would be surplus supply to share on an emergency or mutual aid basis. For most systems, this would be between the months of October and April.

4.3.7 Permitting Considerations for Sharing Surplus Supply

The water sources for the communities that are subject to this study are within 3 major river basins including the Ipswich, Parker and North Coastal. As noted in **Section 4.2**, Hamilton, Wenham and Topsfield are in the Ipswich Basin, Manchester and Essex are in the North Coastal basin and Ipswich has sources in both the Parker and Ipswich River Basins. As such, withdrawals made from the Ipswich Basin to share supply between Ipswich, Topsfield, Hamilton and Wenham would only be governed by the WMA requirements. However, withdrawals made from the North Coastal and Parker River Basins by Manchester, Essex and Ipswich to share supply with the Ipswich River Basin systems or vice versa would also need an **Interbasin Transfer Act (IBTA) permit.**

Based on conversations with WMA and IBTA staff conducted as part of this study, sharing water amongst the communities on an emergency or short-term basis should not be problematic so long as proper notifications and regulatory processes were followed. Regarding longer term or more permanent sharing of water scenarios, including on a regular mutual aid basis, more regulatory issues would come into play. **Because the updated Safe Yield (SY) for the Ipswich River is roughly equal to existing allocations, it would be nearly impossible to either increase withdrawals to serve communities within the basin or transfer water outside the basin to serve Manchester and Essex.**

Although it is theoretically possible to increase withdrawals in the North Coastal or Parker River watersheds because the SY for those river basins has not yet been exceeded, doing so would still be onerous as the sub-basins where Essex, Manchester and Ipswich withdraw are classified as **Level 4 or 5 Biological Category (BC) and Groundwater Category (GWC)** as explained in detail in the Task 4 Technical Memorandum with regard to Manchester supplying Hamilton. Regarding the WMA, sharing water amongst communities within the same river basin is allowable so long as the overall allocations for that basin is not exceeded. There are two scenarios where this could work. Under **Scenario One**, so long as an individual community does not exceed their authorized withdrawal volume, they would be free to share water to another community within a basin. Under **Scenario Two**, a community could exceed its withdrawals to share with another in-basin community so long as the receiving community reduced its withdrawal by a like amount.

Although some surplus supply for sharing amongst the partnering water systems was previously identified, there are additional regulatory considerations to consider as part of the new WMA and IBTA regulations in the Ipswich, Parker and North Coastal Basins. First, it is ***highly unlikely*** that increased water allocations would be allowed in the Ipswich, North Coastal or Parker River sub-basins where current withdrawals are being made to meet the needs of other communities because they are all currently located in a level 4 or 5 sub-basin. As such, any realistic water sharing scenarios would be limited to existing allocations. Second, although Hamilton appears to have a significant amount of surplus water within its permitted allocation, the State bases their allocations on ***actual*** need as determined by local use statistics and the official DCR Water Needs Forecast.

As such, it is possible that their allocation would be deemed unavailable by DEP to be shared with other towns. Additionally, based on the physical limitations of Hamilton's water supply documented earlier in Section 4.3, it is unlikely that surplus could ever be made available to other partnering water systems. Finally, the region has witnessed two severe droughts and one of the wettest summers on record just in the last 6 years making annual water use statistics difficult to use as a basis for confidently estimating the sustainability of the local water surpluses identified earlier in this memorandum in light of climate change.

To help provide for a broader range of scenarios given the extreme variability in weather and water use statistics in recent years, we compiled water use data for the last 6 full years (which encompassed two droughts, one wet year and three normal years) to provide a more representative picture. Also, we developed additional water savings estimates that could be implemented to examine if this were a means to provide additional water supply resiliency. **Table 4.4** below which was included in Section 4 of the attached Task 5 Technical Memorandum presents existing and projected water use that was developed to assess the feasibility of various water sharing scenarios amongst the communities in this study.

Table 4.4. Water Supply Needs by Community Under Various Scenarios

City or Town	Avg. Use: Current MGD(1)	Summer Use: High Month(2)	DEP Allocation MGD(3)	10-Year Need Projection(4)	Potential Water Savings(5)	Net Available Supply(6)	Net Available Supply(7)
Salem/Beverly	8.50	10.39	12.44	9.85	1.7 (20%)	2.59	4.29
Hamilton	0.55	0.65	1.02	0.75	0.8 (15%)	0	0.8
Ipswich	1.03	1.28	1.18	1.09	0.15 (15%)	0	0.15
Topsfield*	0.40	0.53	0.43	0.44	0.06 (15%)	0	0.05
Wenham	0.34	0.44	0.29	0.37	0.07 (20%)	0	-0.01
Essex	0.23	0.31	0.22	0.24	0.05 (20%)	0	-0
Manchester**	0.71	1.22	0.72	0.62	0.21 (30%)	0.10	0.31
Totals:	11.76	14.82	16.3	n/a	3.04	2.69	5.61

Notes:
1. Average daily use, 2016-2021
2. Average summer high use MGD, 2016-2021
3. Combination of registered and permitted volume
4. From official DCR Water Need Forecast (except Manchester and Essex: figures from local studies)
5. If enhanced water conservation program based on meeting Massachusetts Water Conservation Standards and Recommendations based on percentage of current use and individual town water conservation measures, UAW and summer use statistics. See publication: Recipe for Water Resiliency published by the Parker-Ipswich-Essex Rivers Resiliency Partnership, June 2022.
6. Amount of DEP allocation available to be shared with other communities based on current average use net of 10 year needs 5% protection buffer and that existing GW withdrawals in the Ipswich basin could not be shared due to regulation.
7. Amount of DEP allocation available to be shared with other communities based on average use net of implementation of enhanced water conservation program net of 10-year forecast needs and 5% protection buffer and that exiting GW withdrawals could not be shared due to regulation but water conservation savings could be.

* Based on finished water as raw water statistics unavailable for some years.
** Does not include 2017 data

Although there appears to be some surplus water available within existing WMA allocations to share on a mutual aid basis as identified in Section 4.3, sharing it to provide significant water supply resiliency benefits on a consistent basis and justify the capital costs over the long term would be challenging. This said, if communities were to implement an enhanced water conservation program, there should be enough water available to meet the needs of local communities for the short to medium term providing resiliency to both meet local growth needs and provide flexibility to address PFAS contamination. If the infrastructure investments analyzed herein to share water amongst the communities on a mutual aid basis were implemented, it would also allow for the importation and sharing of surplus water from future sources such as the SBWSB, thereby addressing the water supply resiliency needs of these communities for the long term.

4.4 Water Quality Review

Per Task 2 of the WMA grant study, we coordinated and requested various water quality and system infrastructure data from Hamilton and the partnering water systems of Ipswich, Essex, Wenham and Topsfield as required to complete this task. A summary of the finish water quality data collected from each of the water systems is presented in **Table 2.3** included in Section 2.4 of this report.

In comparing the finished water quality of the partnering water systems with the Town of Hamilton's current and future water quality, they are similar with respect to pH and free chlorine with exception of Ipswich which maintains a larger range of pH than the other systems. However, they do use an ortho/polyphosphate blend like Hamilton for corrosion control so it is not anticipated that this larger pH range will be an issue. As noted in Section 2.4, Essex does not use any phosphate addition for corrosion control which could be an issue with respect to lead and copper if supply from Hamilton and the other partnering water systems is delivered into their system. **All the partnering communities rely on free chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water between systems.**

From **Table 2.3**, levels of TTHMs and HAA5s within Hamilton's system are higher as compared to Ipswich, Wenham, Essex and Topsfield, but still below their respective established MCLs, so there is a potential for seeing an increase in these constituents within their systems. However, blending of the supplies between the partnering communities should minimize this issue to some extent and prevent any possible MCL exceedance. Additionally, Hamilton is currently constructing a new GAC treatment system that will reduce the levels of both TOCs and TTHMs at the plant which will improve finish water quality. As such, it appears that Hamilton and the partnering communities should be able to share supply utilizing existing and future interconnections without any major water quality issues or impacts with meeting current drinking water standards, except for the two noted below.

The only two possible water quality issues identified in Section 2.4 which also apply here include Essex's lack of using phosphate for corrosion control and the presence of elevated PFAS levels within individual supplies for Topsfield and Ipswich. As these same issues were already evaluated and discussed in Section 2.4, we did not feel it was necessary to repeat the same narrative. Please refer to Section 2.4 for the detailed discussion on these issues.

4.5 Infrastructure Needs to Supply Partnering Communities

As previously discussed in Section 2.5 of this report, Hamilton has existing interconnections with the Towns of Ipswich, Essex and Wenham, ranging in size from 2-inches to 8-inches **(Refer to Figure No. 5 in Appendix A of the Task 5 Technical Memorandum).** A view of Hamilton's water system showing the locations of the existing interconnections is included for reference in Section 2.5. Hamilton currently has no interconnection in place with Topsfield and as such, a new interconnection and related pipeline will need to be constructed to connect Topsfield with Hamilton. **The feasibility of a new interconnection with Topsfield is evaluated in the following section.**

The evaluation of these existing interconnections with Ipswich, Essex and Wenham related to the ability of Hamilton to hydraulically transfer supply into these systems based on current system gradients and infrastructure was previously presented in Section 2.5 of this report. The noted results from that evaluation are applicable here as well given that these same interconnections will be used to share surplus supply between Hamilton and the partnering water systems under the same hydraulic conditions. Please refer to Section 2.5 for the detailed evaluation of these existing interconnections along with needed upgrades and considerations.

To summarize, it was recommended to replace Essex's existing 4-inch and 2-inch interconnection at the end of Essex Street (Rte. 22) **with a new single 8-inch connection.** For Ipswich, the existing 6-inch interconnection at the end of Waldingfield Road was noted to be adequate for transferring supply as was the existing 8-inch interconnection on Highland Street with Wenham. Additionally, it was estimated from hydraulic analyses that Hamilton's existing water system can deliver a supply rate of up to 200 gpm at Wenham's interconnection, up to 300 gpm at Essex's interconnection, and up to 150 gpm at Ipswich's interconnection. The existing interconnections with Ipswich, Wenham and Essex will also need to be provided with new revenue meters for measuring the flows being supplied to the partnering water systems. The need for installing a backflow prevention device will be dependent on how the partnering water systems envision operating their interconnections, whether on a temporary/short-term basis or on a more permanent basis.

As we do not have working models of the other partnering water systems, we could only determine what Hamilton could possibly deliver to augment the supplies of Wenham, Ipswich and Essex based on existing infrastructure. However, based on the operating gradients maintained by the partnering systems as shown in **Table 2.4**, and the existing infrastructure of their systems as described in the **Task 5 Technical Memorandum**, it is reasonable to surmise that these systems should be able to deliver similar supply rates into Hamilton.

Based on the existing system gradients of Hamilton and the partnering water systems as shown in **Table 2.4** in Section 2.5, Hamilton should be able to supply the systems of Wenham and Ipswich via gravity without the need for a PRV or a booster pump station since their gradients are about equal. Since these interconnections will be used for sharing supply between both respective systems, we would recommend the use of an electromagnetic type flow meter as the revenue meter which can measure the gravity flow in either direction. Otherwise, two separate meters and pipe connections would be needed.

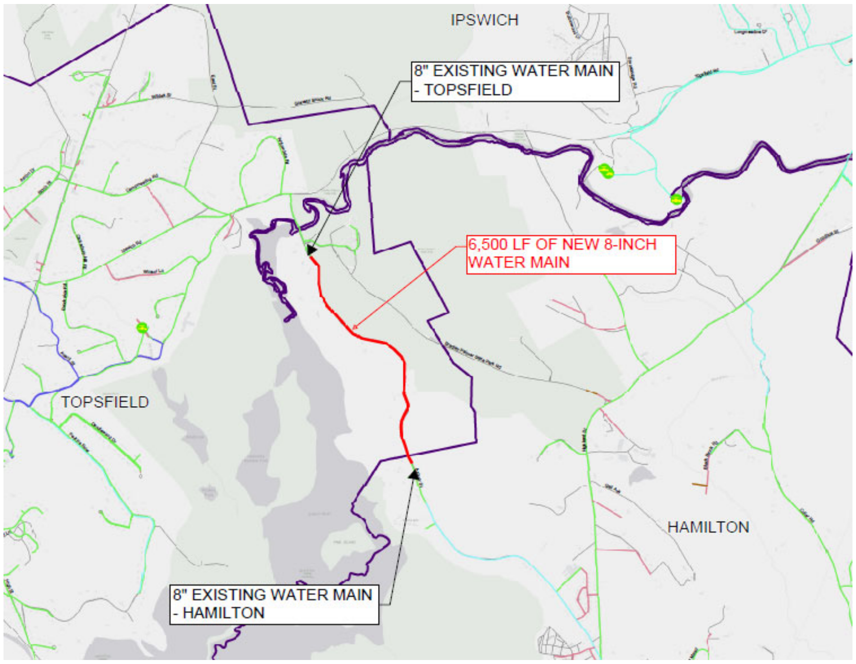
With Essex having a system gradient about 8 feet higher than Hamilton, **a booster pump station** will likely be needed at the interconnection to effectively supply Essex daily over an extended period. Based on the estimated supply rate of about 300 gpm that Hamilton can supply at the interconnection with Essex as noted above, we would recommend that a 350 gpm booster pump station be provided. Conversely, supply from Essex into Hamilton can likely be delivered via gravity since Essex maintains a higher gradient than Hamilton. To allow this gravity flow from Essex into Hamilton, the new interconnection with Essex would need to have a bypass around the booster pump station with a separate revenue meter. **The estimated costs for upgrading the existing interconnections as needed for sharing supply between Hamilton, Wenham, Ipswich and Essex are included in Section 4.5.2 of this report.**

For Topsfield, with an operating gradient of 260 feet, a booster pump station will be needed for Hamilton to supply Topsfield. Conversely, a pressure reducing valve (PRV) will be needed for Topsfield to supply Hamilton. Like Essex, a new interconnection with Topsfield would need to have a bypass around the booster pump station for the PRV along with a separate revenue meter. The following section evaluates the feasibility of installing a new pipeline to connect Hamilton and Topsfield for sharing surplus supply between their systems and the other partnering communities.

4.5.1 Future Pipeline Interconnection with Topsfield

In reviewing Topsfield's existing water distribution system as provided by the Town under Task 2, the best route for installing a new pipeline to connect the systems of Hamilton and Topsfield within an existing public road was identified in the Task Technical Memorandum to be along Asbury Street. The new pipeline would initially connect to Hamilton's existing 8-inch main in Asbury Street and extend westerly approximately 6,500 feet along Asbury Street terminating at Topsfield's existing 8-inch main in Asbury

Street. Refer to **Figure 6 – Hamilton-Topsfield Potential Interconnection included in Appendix A of the Task 5 Technical Memorandum.** We have included a partial view of Figure 1 for reference below.



Partial View of Figure 6- Hamilton/Topsfield Potential Interconnection

The new interconnection with Hamilton's existing 8-inch main will require a revenue meter chamber for measuring and totalizing flow. As this new interconnection will be normally closed and only manually opened when needed under a controlled operation, it is not expected that a backflow prevention device for cross-connection control will be needed. As such, we have not included the installation of this device in our assessment. If, in the future, this new interconnection is used on a more permanent basis and/or are left normally open, then the installation of a backflow prevention device may be necessary depending on applicable water system requirements and regulations.

As Topsfield operates at a higher gradient than Hamilton **(260 feet vs 210 feet),** a new booster pump station will be needed for Hamilton to share supply with Topsfield. Conversely, a new PRV station will be needed for Topsfield to share supply with Hamilton. Utilizing the Town of Hamilton's computerized water model, we conducted a hydraulic analysis to determine the design criteria for the new pipeline, PRV and booster pump station required to share supply between Hamilton and Topsfield.

From Hamilton's water system model, the hydraulic gradient at the proposed interconnection with Hamilton's existing 8-inch main on Asbury Street varies from **205 feet to 218 feet** over a 24-hour period depending on system demand, tank level and whether the Town's finish water pumps are operating. Upon including the new pipeline and new revenue meter into Hamilton's computerized water system model, we conducted extended period simulation (EPS) analyses for various PRV settings under average day demands computer simulations to determine the optimal PRV setting for augmenting Hamilton's existing water system from Topsfield. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps on-line and controlled off reservoir level.

From the results of the analyses, the most favorable option would be to set the new PRV to a downstream gradient somewhere between **208 feet and 212 feet.** This will hydraulically allow a predicted supply rate in the range of 200 gpm to 300 gpm, respectively, into Hamilton through the new interconnection with little impact to the current operation of Hamilton's system. The final setting can be adjusted as needed based on actual system conditions when the new interconnection is installed and how much supply is to be shared. As we don't have a working model of Topsfield's water system, we cannot determine the supply rates that Topsfield could possibly deliver into Hamilton. However, based on their higher operating gradient as shown in **Table 2.4**, and the noted infrastructure of their system in **Section 2**, it is reasonable to surmise that Topsfield should be able to deliver appropriate supply rates into Hamilton.

For the new pipeline, given the fact that Topsfield's gradient is 50 feet higher than Hamilton's gradient, an 8-inch diameter main should be enough to deliver flows up to 300 gpm. At this flow rate, the frictional head loss generated through 6,500 feet of 8-inch main would approximately 15 feet which, based on an operating gradient of 260 feet, would still provide an upstream gradient of about 245 feet at the new PRV. We do not have a model of Topsfield's water system and as such, we cannot determine the pressure fluctuations at the connection with Topsfield's existing 8-inch main. However, based on the higher operating gradient maintained by Topsfield, and the noted the infrastructure of their system in **Section 2 of the Task 5 Technical Memorandum**, we do not anticipate an issue.

For a new booster pump station, based on the predicted supply rates noted above, we would recommend that a **350 gpm booster pump station** be provided. The new booster station should be sized to overcome both the difference in static pressure and frictional losses to supply Topsfield from Hamilton. As noted above, the head loss through 6,500 feet of 8-inch main when supplying flow at a rate of 300 gpm would be approximately 15 feet. The gradient difference between Topsfield and Hamilton is 50 feet **(260 feet – 210 feet**). Allowing for station losses and having some additional head to effectively deliver water into Topsfield's system, the new pump station should be rated for 350 gpm at a total dynamic head (TDH) of about 80 feet.

4.5.2 Estimated System Infrastructure Costs for Sharing Supply

Tables 4.5 and 4.6 on the following pages present the estimated costs for the infrastructure upgrades for Hamilton to supply Ipswich, Essex and Wenham through their existing interconnections and Topsfield through a new interconnection and 8-inch pipeline based on the above assessment. These tables were previously included as Table 6.2 and Table 6.3 in Section 6 of the attached Task 5 Technical Memorandum. The estimated water main costs per foot included in the tables on the following page are weighted costs and include the cost for furnishing and installing the pipe, valves, fittings, bedding, backfill, traffic control, trench and site restoration. Costs were developed in part using recent construction cost data for new water mains, pumping stations, and appurtenances. The estimated costs do not include land acquisition, right-of-way procurement and legal fees. We have included 30% for engineering/ permitting and a 25% contingency for planning purposes. All costs are presented in 2022 dollars and are based on the **May 2022 Boston ENR construction cost index of 17506.61.**

Table 4.5 Infrastructure Upgrades to Existing System Interconnections

Item			Cost(1)
Interconnection with Wenham			
New Revenue Meter Vault and appurtenances(2)			$150,000
New Electrical/Control Systems & SCADA upgrades (for meter)			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$20,000
Subtotal			**$200,000**
Engineering and Permitting (30%)			**$60,000**
Subtotal – Engineering and Construction			**$260,000**
25% Contingency			**$65,000**
Total - Interconnection with Wenham			**$325,000**
Interconnection with Ipswich			
New Revenue Meter Vault and appurtenances(2)			$150,000
New Electrical/Control Systems & SCADA upgrades (for meter)			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$20,000
Subtotal			**$200,000**
Engineering and Permitting (30%)			**$60,000**
Subtotal – Engineering and Construction			**$260,000**
25% Contingency			**$65,000**
Total - Interconnection with Ipswich			**$325,000**
Interconnection with Essex			
New 350 gpm Booster Pump Station w/ Above-Grade Structure (incl. Revenue Meter)			$175,000
Site work & connections for new Booster Pump Station and Bypass			$75,000
New Revenue Meter Vault and appurtenances (for gravity flow)			$150,000
New Electrical/Control Systems & SCADA upgrades (for meter)			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$50,000
Subtotal			**$480,000**
Engineering and Permitting (30%)			**$144,000**
Subtotal – Engineering and Construction			**$624,000**
25% Contingency			**$156,000**
Total - Interconnection with Essex			**$780,000**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.
2. Based on using single electromagnetic flow meter for measuring bidirectional flow.

Table 4.6 New Hamilton-Topsfield Interconnection Costs

Item			Cost[1]
New Topsfield Interconnection w/ New Pipeline, PRV and Booster Pump Station			
6,500' of New 8" Main in Asbury Street from Ex. 8" Main to Ex. 8" Main @ $225/ft			$1,462,500
New Revenue Meter Vault and appurtenances			$150,000
New PRV Vault and appurtenances			$75,000
New electrical/control systems & SCADA upgrades (for meter & PRV)			$40,000
New 350 gpm Booster Pump Station w/ Above-Grade Structure (incl. Revenue Meter)			$175,0000
Site work & connections for new Booster Pump Station and Bypass			$75,000
Site work & connections to ex. 8" main on Asbury Street (Hamilton)			$25,000
Site work & connections to ex. 8" main on Asbury Street (Topsfield)			$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$225,000
Subtotal			**$2,252,500**
Engineering and Permitting (30%)			**$675,750**
Subtotal – Engineering and Construction			**$2,928,250**
25% Contingency			**$732,000**
Total - Interconnection with Topsfield			**$3,660,250**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

5. Future Water Supply Resiliency Summary/Recommendations

5.1 General

In the previous sections and attached Technical Memorandums, we evaluated alternatives for Hamilton to address its water supply limitations due to the deteriorating quality and capacity of its Idlewood wellfield for meeting future water needs. Two alternative sources of supply were identified for being evaluated as part of the WMA grant study including a new interconnection with SBWSB **per Task 3** and a new interconnection with Manchester **per Task 4.** Both alternatives were evaluated based on two supply scenarios including 1) supplementing Hamilton's existing water system on an as-needed basis and 2) fully supplying Hamilton on a permanent basis. For each alternative, we also determined the supply rates that could be delivered to the partnering water systems through existing interconnections with Hamilton and the associated infrastructure upgrades needed to augment their water systems. We identified possible issues with blending and sharing supply from the SBWSB, Manchester and the partnering water systems with respect to water quality and permitting impacts. Costs for system infrastructure required for the SBWSB and the Manchester to supply Hamilton were developed and presented in Sections 2 and 3 of this report.

Per **Task 5** of the WMA study, we also evaluated current and future water needs of the partnering water systems to determine available supply surplus for sharing when needed to mitigate future short-term supply shortages on a Mutual Aid basis. Similar to Tasks 3 and 4, we determined the supply rates that could be delivered through existing interconnections with Hamilton and the associated infrastructure upgrades needed to augment their water systems. This included a new pipeline and interconnection between Hamilton and Topsfield. We also identified possible issues with blending and sharing supply between the partnering water systems with respect to water quality and permitting impacts. Costs for system infrastructure required to share surplus supply between Hamilton and the partnering water systems were developed and presented in Section 4 of this report.

5.1.1 Permitting and Regulatory Considerations Summary

Public water supply is generally considered a utility for regulatory purposes. In Massachusetts, two laws and regulatory regimes govern drinking water: The Water Management Act (WMA) which governs the withdrawal of water from the environment and the Safe Water Drinking Water Act (SDWA) which governs the public health and safety-related aspects of water. This project reviewed the implications of the WMA as it relates to the ability to share and increase water withdrawals and the SDWA as it relates to the water quality implications of sharing different sources of water amongst the studied communities. A third law also comes into play in situations where water withdrawn from one watershed is discharged into another community in a different watershed, the Interbasin Transfer Act (IBTA).

This is the case for this study as the subject partnering communities are in three different river basins: The Ipswich, The Parker and the North Coastal. The regulatory implications of these three laws with respect to sharing supply between the partnering communities were examined in detail in the Task 3, 4 and 5 Technical Memorandums. **Table 4.4** included in Section 4.3.7 of this report and **Figure 5.1** included on the following page presents existing and projected water use, and withdrawal data that was developed and utilized to assess the various water sharing and resiliency scenarios examined under this project.

Groundwater Withdrawal Categories and Public Water Supplies

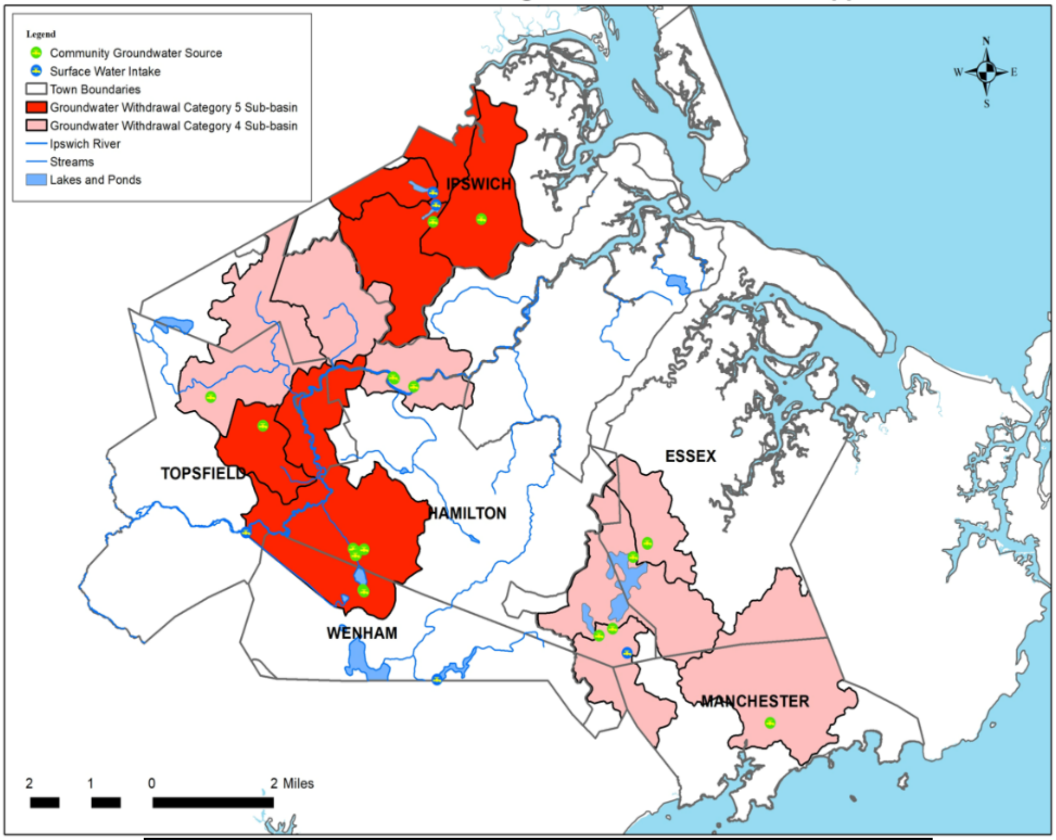


Figure 5.1 Groundwater Withdrawal Categories for Partnering Communities

Based on the data shown in **Table 4.4** and **Figure 5.1**, the following general summary and conclusions can be made regarding regulatory impacts from sharing supply from SBWSB, Manchester, and the partnering communities to meet future water needs.

Summary:

- It is generally feasible to share and move water amongst all the communites in the study provided the identified infrastructure improvements were made, the relatively minor water mixing chemistry issues addressed and legislation passed to amend the charter of the Salem Beverly Water Supply Board (SBWSB) to serve additional communites.
- Although some of the communities have some surplus water available under their existing allocations to share with other communities on a mutual aid basis, it would likely be restricted to the low demand months (due to high summer demand in most communities already pushing their withdrawal and production capacity limits) such that it would make the infrastructure investments necessary to do so difficult to justify economically.
- Because every groundwater-dependent community in the study withdraws from a level 4 or 5 sub-basin, it would be extremely difficult for the communities to increase their local withdrawal allocations in the future.
- Considering current and future water needs, it appears that Essex and Wenham do not have enough water availble under their existing allocations such that alternative sources will be needed by those communities in the near future.

- Although the SBWSB appears to have some surplus water available under its current registration, it would be difficult to share that water on a long term basis considering the future growth needs of Salem and Beverly.
- If the SBWSB were to activate their unused WMA permit allocation of 2.27 MGD, enough water could be made available to supply several or all of the communities with supplemental water and/or serve the entire needs of one to three addional communites completely depending on which ones.
- If the communities implemented an enhanced water conservation program as developed by the Greenscapes Coalition, which all the communities are members of, there appears to be enough water available to meet the water needs of the communities for the forseeable future (assuming water were to be shared with Essex and Wenham).
- Ideally, an alternative water source (currently being studied by the North Shore Water Supply Resileincy Task Force) would be identified to provide long term water resileincy and security for the communities studied which would also aleviate the environmental impact on the three stressed river basins which currently supply the regions water.

Conclusions:

1. It appears to be more feasible for Hamilton to obtain its water from the SBWSB as opposed to Manchester. If the necessary infrastructure improvements were made to connect Hamilton to SBWSB, this would also help meet the additional water supply needs of Essex and Wenham since Hamilton already has interconnections with those communities.
2. If SBWSB were to activate its permit, it could serve Hamilton and provide supplemental water to each of the other communities to provide additional water supply resileicny for the foreseeable future. Implementing enhanced water conservation programs in each of the communities would provide for additional water supply resiliency.
3. Ideally, an alternative source of water would be identified to provide both permanent water supply resilency and increase ecosystem health for the regions water resources.

5.1.2 Water Supply Recommendations

Based on the results of the analyses presented in Sections 2 and 3 of this report, and the regulatory considerations noted above, a new interconnection and pipeline with the SBWSB would be the most feasible approach for meeting the future water supply needs of Hamilton and conversely the partnering water systems. From the three optional pipeline routes evaluated as presented in Section 2, **we recommended Option A which includes installing approximately 12,900’ of new 12” water main from the existing 12” main in Cabot Street up to the existing 8” main in Highland Street. The new interconnection will also need to be provided with a new PRV, revenue meter and backflow preventer device to supplement Hamilton’s existing water system**.

The SBWSB has the existing supply capacity under their existing registered withdrawals to augment Hamilton’s supply and possibly the partnering water systems on a short-term basis. Upon completing the planned upgrades to their existing plant and activating their permitted withdrawal volumes, SBWSB could fully meet the supply needs of Hamilton, Salem-Beverly and most of the partnering water systems on a long-term regional basis. Additionally, as both supplies for Hamilton and the SBWSB are within the Ipswich River Basin, no IBTA permit would be needed. **To fully supply the future water needs of**

Hamilton and other partnering water systems, a new 1.5 MGD booster pump station will be needed at the interconnection with SBWSB as indicated in Section 2.

Although Manchester has the existing supply capacity and registered withdrawals to augment Hamilton's future supply needs, there would be no surplus supply available to augment the other partnering water systems. For Manchester to fully supply Hamilton and possibly other partnering water systems on a permanent or partial regional basis, they will need a significant increase int their current registered withdrawals along with approval to transfer over 1 MGD of supply from one sub-basin to another. As noted in Section 2, this would be challenging and likely not realistic given that Manchester's supplies are located within a level 4 or 5 sub-basin. Additionally, significant upgrades to Hamilton's water system would be needed to accommodate the higher-pressure gradient from being supplied by Manchester including a new taller water storage tank and associated mains.

Given these limitations, and the fact that this future connection would not provide any benefit to the partnering water systems, this approach does not meet the overall goal of improving water supply resiliency on a more regional basis as the future connection with the SBWSB would. Additionally, the recommended SBWSB future connection could be considered the initial step in meeting the goal of Senator Tarr's North Shore Water Resiliency Task Force study to implement a long-term regional solution to alleviate water resiliency issues within the Ipswich River Watershed. As such, we recommend that Hamilton not consider a future pipeline and interconnection with Manchester. **It should be noted that Manchester is already connected to the SBWSB through the City of Beverly, and has the infrastructure in place to be part of a long-term regional approach with SBWSB as the source of supply**

In addition to the new pipeline and interconnection with SBWSB, in Section 4, we also recommended several infrastructure upgrades to Hamilton's existing interconnections with Wenham, Ipswich and Essex for sharing future supply between the partnering water systems on a mutual aid basis. **These included the addition of revenue meters at each interconnection along with the installation of a new booster pump station and pipe upgrades to the interconnection with Essex.**

We also evaluated the feasibility of installing a future pipeline for connecting the systems of Hamilton and Topsfield to provide the ability of the two systems to share surplus supply as needed. From the analyses conducted, it was proposed to **install approximately 6,500 feet of new 8-inch main along Asbury Street, from Hamilton's existing 8-inch main to Topsfield's existing 8-inch main.** Given Topsfield's higher gradient as compared to Hamilton (260 feet versus 210 feet), it was also proposed to install a **new 350 gpm booster pump station** for Hamilton to supply Topsfield and a bypass with a PRV for Topsfield to supply Hamilton.

Based on Topsfield's future water needs as presented in Section 4 of this report, there will be minimal to no surplus supply available within their current WMA registration to share with Hamilton or the other partnering water systems. Given that this future pipeline interconnection with Topsfield will not address Hamilton's future supply issues or be able to aid the other partnering water systems, **we have not recommended it for consideration in this report.** However, as noted in the Task 5 Technical Memorandum, Topsfield has previously evaluated a proposed interconnection with the City of Beverly to obtain alternate supply directly from the SBWSB. This evaluation proposed to install approximately 3.2 miles of pipeline along Route 97 to connect Topsfield's system to Beverly's system at an estimated cost of $11,500,000.

Given the recommendation above to connect Hamilton with the SBWSB, this possible future pipeline and connection with Hamilton along Asbury Street could prove to be a more economical option for Topsfield to consider. Additionally, this future pipeline would certainly be an option that Senator Tarr's North Shore Water Resiliency Task Force can consider as part of their long-term regional study. **As such, we have included it in the following implementation plan for this purpose only.**

5.1.3 Phased Implementation Plan

To assist Hamilton and the partnering water systems in implementing the recommendations to improve overall water supply resiliency, we have prioritized the recommended water supply infrastructure improvements into the following categories based on Hamilton's current and future water needs, and benefit to the partnering water systems.

- **Initial Water Supply Infrastructure Improvements**
- **Short-Term Water Supply Infrastructure Improvements**
- **Long-Term Water Supply Infrastructure Improvements**

The initial water supply infrastructure improvements are based on supplementing Hamilton's existing water system with SBWSB supply to address current and future supply deficiencies with respect to capacity, operations and water quality. These improvements should be implemented preferably over the **next 3 years.** The short-term water supply infrastructure improvements are based on improving the ability to share surplus supply between Hamilton and the partnering water system of Ipswich, Essex, Wenham and Topsfield. These improvements should be implemented preferably over the **next 3 to 5 years.** The long-term water supply infrastructure improvements are based on fully supplying Hamilton's future water needs along with other interested partnering water systems. These improvements should be implemented preferably within the **next 5 to 15 years** in parallel with SBWSB's plant upgrades which will increase its production capacity as needed to fully supply Hamilton.

The recommended water supply infrastructure improvements presented herein are shown on **Figure 3 included in Appendix D.** Based on the categories noted above, we have prioritized the recommended infrastructure improvements presented in this report as follows:

Initial Water Supply Infrastructure Improvements (0-3 Years):

- Design and construction of 12,900' of new 12" DI main with new PRV, revenue meter, backflow preventer and related appurtenances to connect with SBWSB

Short-Term Water Supply Infrastructure Improvements (3-5 Years):

- Design and construction of a new interconnection with Wenham including new revenue meter and related appurtenances
- Design and construction of a new interconnection with Ipswich including new revenue meter and related appurtenances
- Design and construction of a new interconnection with Essex including new 350 gpm booster pump station and bypass, revenue meters (2) and related appurtenances

Long-Term Water Supply Infrastructure Improvements (5-15 Years):

- Design and construction of a new 1.5 MGD booster pump station at the interconnection with SBWSB

- Design and construction of 6,500 feet of new 8-inch DI main on Asbury Street with new PRV, 350 gpm booster pump station and bypass, revenue meters (2) and related appurtenances to connect with Topsfield.

Table 5.1 below presents the estimated costs associated with the recommended water supply infrastructure improvements for the Town of Hamilton to consider based on the categories listed above. Estimated costs are total project costs and include construction, 30% engineering/permititng and 25% contingency for planning purposes as developed from the Task 3, Task 4 and Task 5 Technical Memorandums. The estimated water main costs per foot included in the table are weighted costs and include the cost for furnishing and installing the pipe, valves, fittings, bedding, backfill, traffic control, trench and site restoration. Costs were developed in part using recent construction cost data for new water mains, pumping stations, and appurtenances. The estimated costs do not include land acquisition, right-of-way procurement and legal fees.All costs are presented in 2022 dollars and are based on the **May 2022 Boston ENR construction cost index of 17506.61.** For the short-term and long-term improvements, we applied an inflation adjustment of ten-percent and fifteen-percent, respectively.

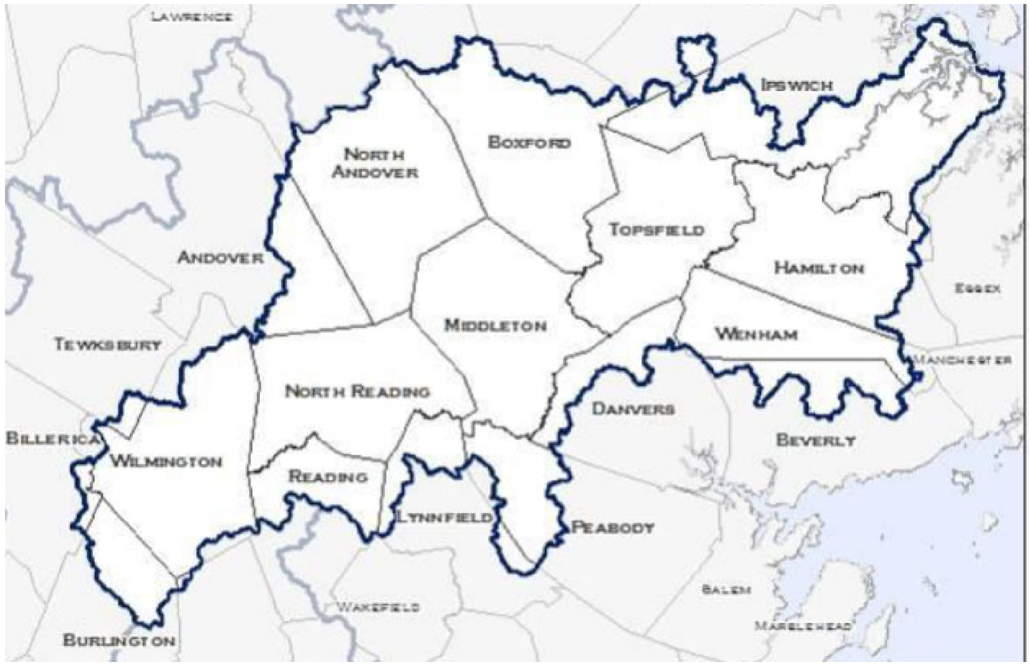
Table 5.1 Water Supply Infrastructure Implementation Plan

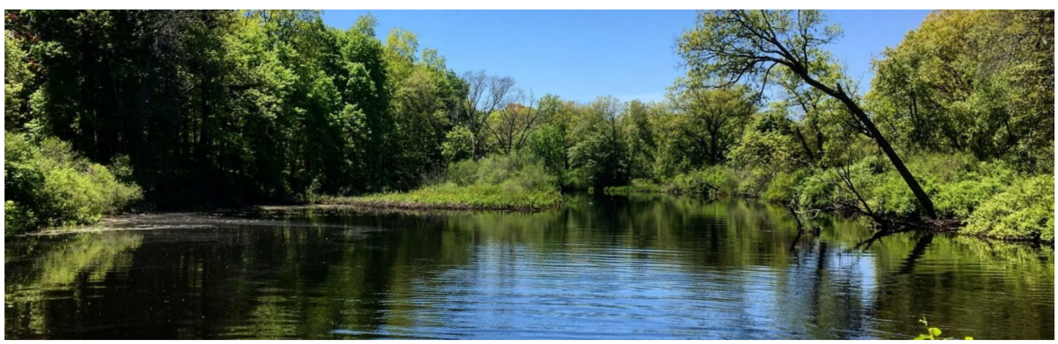
ITEM			COST[5]
Initial Water Supply Infrastructure Improvements (0 to 3 Years)			
12,900' of new 12" DI main with new PRV, revenue meter, backflow preventer & related appurtenances			**$7,004,250**
Total – Initial Water Supply Infrastructure Improvements			**$7,004,250**
Short-Term Water Supply Infrastructure Improvements (2 to 5 Years)			
New interconnection with Wenham including new revenue meter & related appurtenances			**$325,000**
New interconnection with Ipswich including new revenue meter & related appurtenances			**$325,000**
New interconnection with Essex including new 350 gpm booster station w/ bypass, revenue meters(2) & related appurtenances			**$780,000**
Subtotal – Short -Term Water Supply Infrastructure Improvements			**$1,430,000**
Inflation Adjustment (10%)			$143,000
Total – Short-Term Water Supply Infrastructure Improvements			**$1,573,000**
Long-Term Water Supply Infrastructure Improvements (5 to 15 Years)			
New 1.5 MGD booster station & appurtenances at SBWSB interconnection			**$772,000**
6,500 feet of new 8" DI main with new PRV, 350 gpm booster station & bypass, revenue meters(2) & related appurtenances			**$3,660,250**
Subtotal – Long-Term Water Supply Infrastructure Improvements			**$4,432,250**
Inflation Adjustment (15%)			$664,840
Total – Long-Term Water Supply Infrastructure Improvements			**$4,325,090**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

APPENDIX A

Task 3 Technical Memorandum w/ Attachments





BWR 2022-01 Water Management Act (WMA) Grant - Regional Evaluation to Improve Water Supply Resiliency within the Lower Ipswich River Watershed

Task 3 – Technical Memorandum

Town of Hamilton, Massachusetts

May 30, 2022 **(Revised June 3, 2022)**

SUBMITTED BY:

Dewberry Engineers Inc.
99 Summer Street
Boston, MA 02210

IN COLLABORATION WITH:

Ipswich River Watershed Association
143 County Road
Ipswich, MA 01938

SUBMITTED TO:

Town of Hamilton
Department of Public Works
577 Bay Road
Hamilton, MA 01982

TABLE OF CONTENTS

Attachments

1. Introduction

The overall purpose for the subject WMA Grant is to conduct a regional evaluation of alternative sources to improve water supply resiliency within the lower Ipswich River Watershed for the Town of Hamilton and its neighboring communities of Topsfield, Manchester, Ipswich, Essex and Wenham. The WMA grant is divided into six (6) discrete tasks, each with its own required deliverable. The following Memorandum documents the evaluation and findings for the assessment of a future water supply connection with the Salem-Beverly Water Supply Board (SBWSB) as defined under Task 3 of the WMA grant.

1.1 Task Overview

Hamilton's existing water system borders all five (5) partnering communities and currently has interconnections with three of them including Ipswich, Essex and Wenham. This geographic condition places Hamilton in the best position to effectively convey and/or transfer alternate water supplies between the noted communities including a future interconnection with the SBWSB. For Task 3, the main objective is to evaluate the feasibility of obtaining alternative water supply from the SBWSB to supplement the water needs of Hamilton and the participating communities on a regional/seasonal basis to reduce withdrawals from the Ipswich River Basin. This task includes the following major scope items:

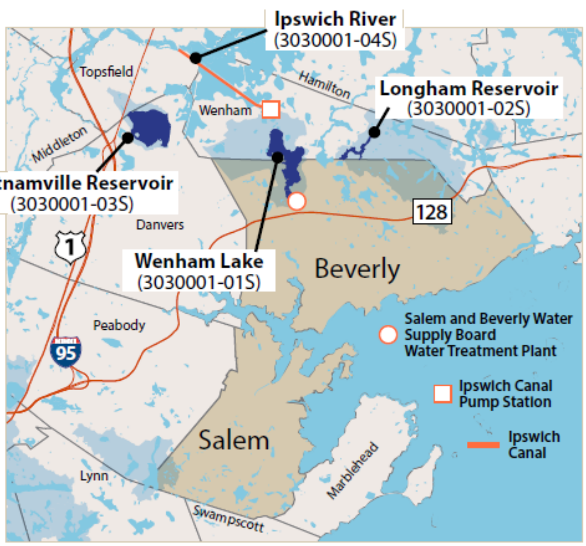
- Confirm the **current and future supply capacity** available with SBWSB to supplement Hamilton and the partnering communities on a seasonal basis and/or on a permanent basis if Hamilton and the partnering communities want to consider having all their supply needs met by SBWSB.
- Review **possible routes** for installing new pipelines and appurtenances and where a future interconnection could be made between Hamilton and SBWSB.
    - Evaluate the operational and supply impacts on Hamilton's water system from a new interconnection with SBWSB through **hydraulic analyses**.
    - Identify **infrastructure/permitting requirements** necessary to interconnect the water systems of Hamilton and the partnering communities with SBWSB including the need for pumping stations, pressure reducing valves and other appurtenances.
    - Prepare **cost estimates** associated with the needed permitting, infrastructure, and operational improvements to install a new interconnection between Hamilton and the SBWSB, and subsequent interconnections with the partnering communities.
- Identify **potential water quality impacts** from the mixing groundwater supplies of the participating water systems with the Salem-Beverly Water District. Parameters to be considered include finish water quality (pH, color, turbidity, iron, manganese), post-disinfection practices (free chlorine, chloramines), corrosion control methods (pH adjustment, phosphate addition) and distribution water quality (chlorine residual, TTHMs, HAAs and PFAS). This task will also consider future water quality as it relates to the proposed upgrade of the SBWSB Treatment Plant.
- Evaluate the **impact of supplying the partnering communities** through existing and future system interconnections with Hamilton. Estimate the available supply capacity that can be hydraulically conveyed through existing and future system interconnections of each water system to augment their water supply needs.
    - Evaluate **infrastructure improvements** to alleviate hydraulic limitations and allow the adequate delivery of water supply between the partnering communities including larger diameter water mains, booster pump stations and pressure-reducing valves.

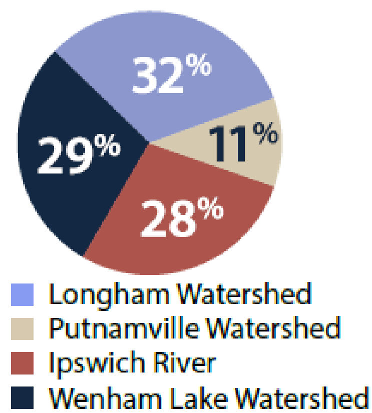
2. Description of Salem-Beverly Water Supply System

The Salem-Beverly Water Supply Board (SBWSB) operates and maintains the supply system for the cities of Salem and Beverly including the watersheds, reservoirs and water treatment plant. Finished water produced at the SBWSB's treatment the plant is fed into Salem and Beverly's distribution systems via pump stations and piping maintained by the municipalities. Both Salem and Beverly are responsible for operating and maintaining all distribution infrastructure. The SBWSB administers the Water Management Act (WMA) registrations and permits for the Board's supplies, and is responsible for meeting water quality standards, but they do not have the authority to institute water bans in times of drought.

2.1 Supply

As noted above, the water supply that serves the residents of Salem and Beverly is managed and operated by the SBWSB and includes the following three (3) surface water sources, all within the Ipswich River Watershed: the Longham Reservoir, the Putnamville Reservoir, and the Wenham Lake Reservoir. Water from the Longham and Putnamville Reservoirs is directed into the Wenham Lake Reservoir where it is then pumped up to the Arlington Avenue Water Treatment Plant for treatment. In addition, SBWSB is permitted to withdraw water from the Ipswich River between December 1st and May 31st. This water is diverted into the Putnamville and Wenham Lake Reservoirs for storage and use via the Ipswich Canal and Pump Station. The two figures below as taken from SBWSB's 2020 Drinking Water Report show the supply and treatment locations, and percentages withdrawn from each source.





SBWSB has a registration to withdraw up to 10.17 MGD from their supply reservoirs and are permitted (with restrictions) for an additional withdrawal of 2.27 MGD. There has not been a recent study to determine the safe yield for the three reservoirs, however, the average daily demand has been below the Water Management Act (WMA) authorized withdrawal by at least 3 MGD for the last 4 years. If a regional approach with SBWSB as the main supplier of water is further explored, a study of these water sources would need to be performed to determine the firm yield of each reservoir. Table 2.1 on the following page shows the average pumping rate for each water source, as reported in SBWSB's Annual Statistical Reports (ASR) from 2017-2020, and as discussed with SBWSB staff

Table 2.1 Salem Beverly Water Supply Board Average Pumping Rates

Reported Pumping Rates		
SOURCE	PUMPING RATE (GPM)	TIME PERIOD
Ipswich River	7,000-35,000	December-May
Longham Reservoir	3,800	December-May
Putnamville Reservoir	8,500	August-November
Wenham Lake	6,300	Year-Round

The SBWSB treats over 3 billion gallons of source water per year through its water treatment plant to meet the supply needs for the cities of Salem and Beverly. The average production rate at the SBWSB's plant to supply Salem and Beverly is reported to be approximately 8.9 MGD with peak daily flow rates of up to 16 MGD during high demand periods, which requires the plant to operate at its maximum rate. The plant was originally designed to treat 24 MGD, but changes to turbidity requirements limit the plant's peak capacity to only 16 MGD to achieve compliance. The plant was designed with provisions to increase its capacity to 32 MGD, however significant upgrades are needed to achieve this expansion. The plant was constructed to provide conventional treatment and includes pretreatment (flocculation, sedimentation), filtration via sand/anthracite media, disinfection with chlorine and post-treatment including fluoride, lime for pH adjustment and phosphate addition. The filtered/post-treated water flow is conveyed to the plant's filtered water reservoir where it is then delivered as needed to supply Salem's and Beverly's distribution systems.

From discussions with SBWSB staff, their current Capital Sustainability Plan (CSP) for the next 10 years includes nine (9) phases of upgrades to the plant and related water supply system that have been estimated to cost upwards of $50 million to complete. Considering future increases in demands within Salem and Beverly, SBWSB stated that they would likely need to complete the first five phases of their CSP which would return the plant back to its original 24 MGD capacity to supply Hamilton and the partnering communities with water on a regional/permanent basis. They would likely be able to augment Hamilton's supply on a seasonal/temporary basis if needed.

2.2 Distribution

As noted above, each City owns and operates an individual pump station, as well as all distribution piping, tanks, and booster stations required to serve their customers. Beverly's water system has interconnections with Salem, Wenham, Danvers, and Manchester. Salem's water system has interconnections with Beverly, Marblehead, and Peabody. **Figure No. 1 included in Appendix A** shows the location of Hamilton's water system relative to Beverly, Salem, the SBWSB's supplies and the partnering communities. Given the proximity of Hamilton to Beverly, and the fact that a portion of Beverly's distribution system already extends into Wenham to supply Gordon College, connecting to Beverly for obtaining future SBWSB supply would be the most feasible approach to consider.

Additionally, as shown in **Figure No. 1 included in Appendix A**, the SBWSB's supply system including Wenham Lake Reservoir and the treatment plant are located within the same area of Beverly's system which would provide a strong hydraulic connection for supplying Hamilton and the partnering communities. As Salem and Beverly operate normally as two separate and independent systems, we only evaluated impacts to Beverly's system for the purposes of this memorandum since we are proposing to connect directly to Beverly.

Beverly's water distribution system includes approximately 212 miles of water main ranging in size from 4-inch diameter up to 24-inch diameter along with two water storage tanks including the Brimbal Avenue Standpipe and the Folly Hill Water Tank. The system has one pressure zone and operates at a hydraulic gradient between 228 feet and 239 feet (NGVD29) as maintained by the two storage tanks. To effectively deliver flow into Hamilton and the other partnering communities, it would beneficial to connect to the largest available sized transmission main. This would allow the most flow to be supplied hydraulically while minimizing system impacts to Beverly and the SBWSB. In reviewing Beverly's water distribution system map, the two largest mains available within the proposed area include a 12-inch main on Cabot Street near the SBWSB's treatment plant and a 12-inch main on Grapevine Road located in Wenham near Gordon College **(see Figure No. 2 in Appendix A).**

Based on Hamilton's existing infrastructure, the most favorable points of connection hydraulically along the Wenham Town line would be at the ends of Highland Street and Bay Road since both these locations are close to Hamilton's larger transmission mains. As shown in **Figure No. 3 included in Appendix A**, Hamilton has an existing 8-inch interconnection with Wenham on Highland Street which could possibly be adequate to serve as a future supply connection. With these two locations serving as possible connections, extending a new main from Beverly's existing 12-inch main in Cabot Street through Wenham would be the most direct alignment to consider.

Another available connection point is Hamilton's existing 6-inch interconnection with Wenham at the end of Woodbury Street. Although this connection point is not as close to Hamilton's larger transmission mains, as shown in **Figure No. 2**, it is closer to Beverly's 12-inch main within Grapevine Road in Wenham and would require less piping to connect the two systems. This option may require additional pipe to be installed in Hamilton as compared to the other locations to effectively distribute supply given its current size.

It should be noted that during discussions held with the Town of Hamilton and the SBWSB, it was agreed that having a new direct connection between Beverly and Hamilton as opposed to relying on Wenham's system to deliver supply into Hamilton would be preferred. This approach would minimize possible hydraulic losses by utilizing existing undersized mains within Wenham and provide a much stronger and reliable future supply connection for Hamilton and the partnering communities. As such, the assessment and analyses presented in the following section are based on extending new piping from Beverly's water system to Hamilton's water system.

3. Optional Pipeline Routes for Future Interconnection

Based on existing infrastructure, we have identified several options for a possible future interconnection with Beverly to supply Hamilton and the partnering communities on a seasonal and/or regional basis. Two options involve extending a new pipeline from the end of Cabot Street in Beverly through Wenham and into Hamilton, with one option connecting at Highland Street and the other connecting at Bay Road. A third option includes extending a new pipeline from Grapevine Road in Wenham up to Woodbury Street in Hamilton. These options have been evaluated as follows:

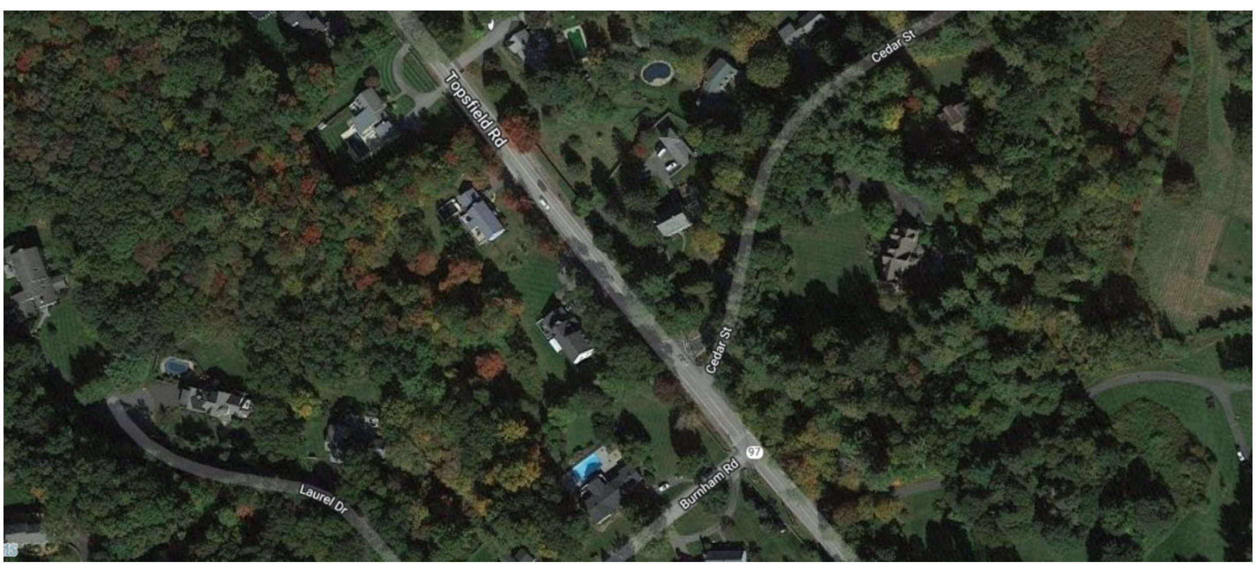
- Option A – Extending a new 12-inch water main from Cabot Street in Beverly up to Topsfield Road, Cedar Street, Cherry Street, Main Street and Arbor Street in Wenham to Highland Street in Hamilton ***(approx. 12,900 feet)***

- Option B – Extending a new 12-inch water main from Cabot Street in Beverly up to Topsfield Road, Cedar Street, Cherry Street and Main Street in Wenham to Bay Road in Hamilton ***(approx. 13,500 feet)***
- Option C - Extending a new 12-inch water main from Grapevine Road in Wenham up to Rubbly Road (Rte. 22) in Wenham to Woodbury Street in Hamilton ***(approx. 7,600 feet)***

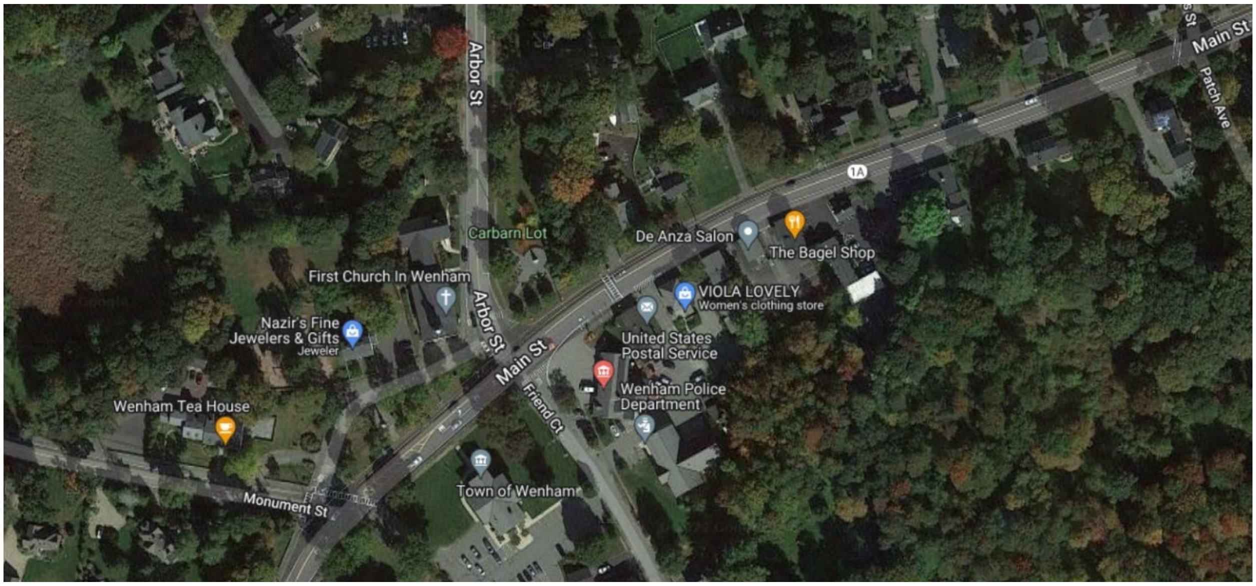
These options are highlighted on **Figure No. 2 included in Appendix A**. As shown on **Figure No. 2**, Options A and B share a common section of pipeline along Topsfield Road, Cedar Street, Cherry Street and Main Street. Each option will require a revenue meter chamber for measuring and totalizing flow along with a backflow prevention device for cross-connection control. As Beverly operates at a higher gradient than Hamilton (239 feet vs 210 feet), each option will also require a pressure reducing valve (PRV) to control the supply gradient entering Hamilton's system. Depending on the future supply rates needed and the system losses to overcome, some options may require the addition of a booster pump station as well. We have conducted an analysis of each option below to determine this need along with other infrastructure upgrades.

3.1 Option A Pipeline Interconnection

This option includes approximately 12,900 feet of new 12-inch main beginning at the existing 12-inch main within Cabot St in Beverly, then following Topsfield Road, Cedar Street, Cherry Street, Main Street and Arbor Street in Wenham and finally connecting to the existing 8-inch main within Highland Street in Hamilton. Topsfield Road in Wenham follows State Route 97 and is a well-travelled rural roadway with wide shoulders and intermittent asphalt sidewalks. Cedar Street, Cherry Street and Arbor Street are wide, 2-lane residential streets with intermittent asphalt sidewalks and not heavily travelled. Cherry Street does get busier towards Main Street/Rte. 1A, with more dense housing. Main Street/Rte. 1A is a heavily travelled roadway, particularly during commuting hours as it connects Hamilton, Wenham and Beverly to Route 128 **(see views below).**



View of Topsfield Road Intersection w/ Cedar Street



View of Intersection of Arbor Street and Main Street (Rte. 1A)

View of Cherry Street from Cedar Street to Main Street (Rte. 1A)

In review of the Town of Wenham's available data, there are existing water mains located within the noted roadways. It is unknown at this time how many other underground utilities exist within these roadways, however, given the rural nature of the town, it is likely that enough room is available to install a new 12-inch pipeline. Additionally, there appears to be enough space within the roadways to maintain vehicular and pedestrian access during future pipeline construction.

From a supply standpoint, this option would be advantageous in supplying the Town of Hamilton and its partnering communities since it is close to Hamilton's existing wells and treatment plant and would utilize the same transmission mains for conveying water into Hamilton. In addition, this connection to Hamilton under Option A would feed into the most densely populated area of the town, thus providing additional supply where mostly needed. Utilizing the Town of Hamilton's computerized water model, we conducted a hydraulic analysis to determine the amount of supply that can be delivered through this connection with the SBWSB under current conditions and possible infrastructure upgrades for supplying future needs.

3.1.1 Hydraulic Analysis – Option A

Hamilton's existing primary water supply includes the Idlewood wellfield and treatment plant which currently operates at a production capacity of approximately 650 gallons per minute (gpm), although it was originally designed for a rated capacity of about 900 gpm. The finish water pumps at the plant, which draw from the plant's clearwell, operate at a rate of about 685 gpm. The Town's secondary supply is the School Street well which is operated intermittently at a rate of about 110 gpm. Both the plant's finish water pumps and the School Street well are controlled off the water level within the Town's only water storage tank, the Browns Hill Reservoir, which is a 12-foot tall buried concrete tank. The pumps and well are set to turn on at a level of 209 feet and turn off at a level of 210 feet. Refer to **Figure No. 3 in Appendix A** for the location of Hamilton's water supplies and storage tank.

From Hamilton's water system model, the hydraulic gradient at the proposed interconnection with the existing 8-inch main on Highland Street varies from 205 feet to 220 feet over a 24-hour period depending on system demand, tank level and whether the Town's finish water pumps are operating. As previously noted, given that Beverly operates their system at a higher hydraulic gradient of 228 feet to 239 feet, a new pressure reducing valve (PRV) will be needed at the new interconnection to allow Hamilton to continue operating their current system. This scenario is based on the approach of utilizing the new interconnection with the SBWSB to only augment the supply of Hamilton and the other partnering communities as needed during high demand periods or when existing wells may be out of service for maintenance or repair. For the approach of utilizing the new interconnection to fully supply Hamilton and the other partenering communities on a more permanent basis, a PRV will not be needed. However, other infrastructure upgrades may be required including the installation of a new booster pump station.

Upon including the new pipeline, new revenue meter and backflow preventer into the Town's computerized water system model, we conducted computer simulations to identify system impacts and the available supply that can be effectively delivered through the new interconnection under the following operational scenarios:

- **Scenario #1:** Current System Conditions with Plant Finish Water Pumps On-line and Additional Supply from New Interconnection with New PRV and New Meter/Backflow Preventer Device
- **Scenario #2:** Plant Finish Water Pumps Off-line with Full Supply from New Interconnection without PRV and with New Meter/Backflow Preventer Device

For **Scenario #1**, to determine the optimal PRV setting for augmenting Hamilton's existing water system, we conducted extended period simulation (EPS) analyses for various PRV settings under average day demands. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps on-line and controlled off reservoir level. From the results of the analyses, setting the new PRV to a downstream gradient of 220 feet or more will hydraulically allow the most flow from SBWSB into Hamilton with a predicted range of 150 gpm to 425 gpm, respectively. However, at this setting, the finish water pumps will not operate since the Browns Hill Reservoir is never allowed to empty enough to call the pumps to start. In addition, the current daily fluctuation of 2 feet within the Browns Hill Reservoir will be reduced to about a half a foot per day, significantly increasing water age within the tank.

Lowering the new PRV setting down to 210 feet will allow the finish water pumps and Browns Hill Reservoir to operate similarly as they currently do while maintaining the 2 feet per day fluctuation within the tank. However, the available supply through the new interconnection is reduced to a range of only 75 gpm to 175 gpm, respectively. Having the new PRV set to a downstream gradient of 215 feet increases the available supply through the interconnection to a range of 250 gpm to 300 gpm, with the finish water pumps operating about six hours a day mainly to fill the Browns Hill Reservoir. Additionally, the daily fluctuation within the Browns Hill Reservoir will be reduced to about 1 foot.

From the results presented above for **Scenario #1**, the most favorable option would be to set the new PRV to a downstream gradient somewhere between 210 feet and 215 feet to maximize the available supply while minimizing overall system impacts. The final setting can be adjusted as needed based on actual system conditions when the new interconnection is installed. As an alternative to using a PRV, the Town could consider using a flow control valve (FCV) which maintains a downstream flow setpoint as opposed to a hydraulic gradient if that is preferable. For a FCV, the most favorable flow setting would be somewhere between 200 gpm and 250 gpm, respectively. This flow range will have similar system impacts to those identified above for the PRV gradient setting of 210 to 215 feet.

For **Scenario #2**, we conducted extended period simulation (EPS) analyses under average day demands to determine the maximum supply that could be delivered via gravity through the new interconnection to fully meet the Town's water needs. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps off-line and no PRV at the interconnection. From the results of the analyses, the maximum gravity flow that can be supplied through the new interconnection is predicted to be approximately 425 gpm, which is less than what the Town currently relies on for meeting system demands. At this flow rate, it would take approximately 30 hours to fill the Browns Hill Reservoir by one foot. Additionally, once full, the reservoir will never drop below an elevation of 209.75 feet as the incoming supply from the interconnection would basically isolate the tank hydraulically from the system. Controls and valving could be put in place to automatically close the interconnection intermittently to allow the Browns Hill Reservoir to fluctuate as needed, but the available gravity supply is inadequate for Hamilton to rely on solely.

To improve the system hydraulics and possibly increase the available gravity supply through the new interconnection, the Town could consider extending the new 12-inch main in Highland Street up to the existing 12-inch main at the intersection with Lake Drive. This would require an additional 415 feet of new 12-inch main to be installed. The results of additional analyses conducted using this approach shows that the maximum gravity flow supplied through the new interconnection would increase to about 585 gpm, which is an improvement but still less than what the Town would need to fully supply their water system.

Based on the results of the modeling, a new booster pump station will be needed at the new interconnection to fully supply Hamilton's water system along with sharing supply with the other partnering communities. At a minimum, the station should be designed with a rated capacity of 1 MGD, or 700 gpm, to meet Hamilton's supply needs. For the purposes of this memorandum, since we do not know at this time what the intent or additional supply needs of the partnering communities are, we have assumed that a new 1.5 MGD booster pump station will be installed for this scenario. This will meet Hamilton's supply needs while providing excess supply for sharing with the partnering communities on a temporary or mutual aid basis. Adjustments to the station capacity will be made once the intended supply volumes for each community is determined upon completing Task 5 of the WMA grant.

To identify any possible impacts to Hamilton's water system in delivering fire flows at adequate pressures for fire protection when being fully supplied from this interconnection with the SBWSB, we conducted steady-state analyses imposing fire flows at the following two hydrant locations:

- Hydrant #33: Highland Street near the Pingree School
- Hydrant #164: Intersection of Asbury Street and Spring Avenue

This hydrant locations are shown on attached **Figure No. 3**. Computer simulations were first conducted under maximum day demands and existing system conditions to determine the available fire flow that can be provided at the noted hydrant locations. Per ISO guidelines, available fire flows are defined as the maximum flow rate at a point in the distribution system while maintaining a minimum pressure of 20 psi at all points in the distribution system. We then conducted simulations under maximum day demand using Scenario #2 system conditions with Hamilton's finish water pumps off-line and the system being fully supplied via gravity through the interconnection.

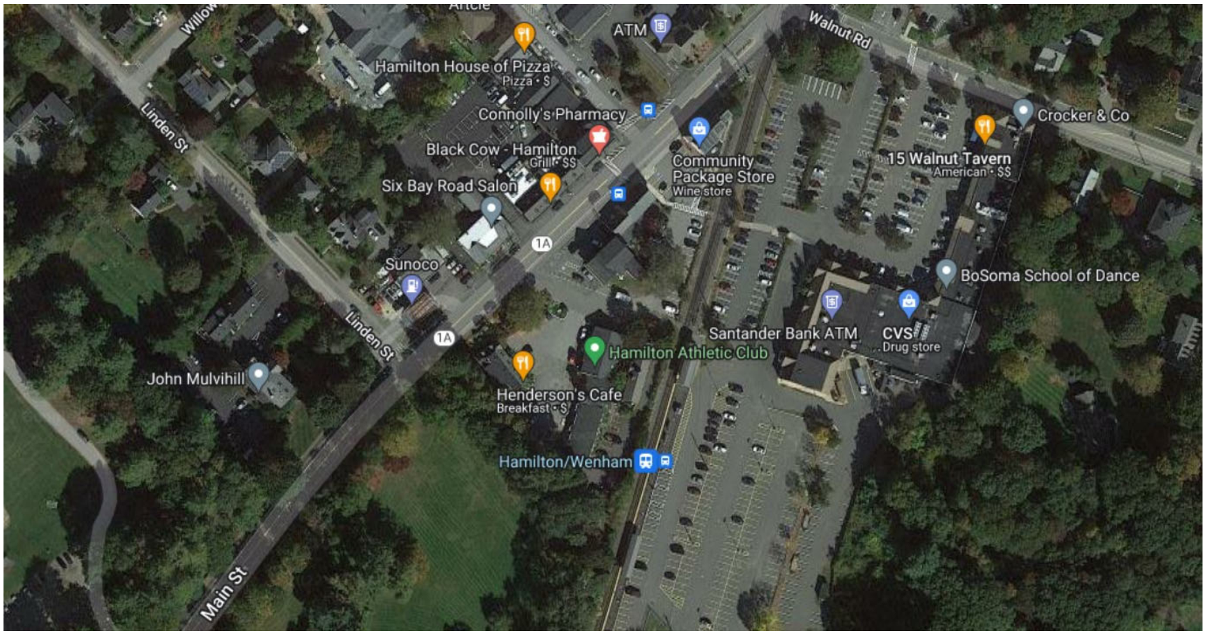
Under existing system conditions, the available fire flows at Hydrant #164 and Hydrant #33 as predicted in the model are 2,100 gpm and 1,400 gpm, respectively. Under Scenario #2 system conditions, the available fire flows at Hydrant #164 and Hydrant #33 as predicted in the model are 2,200 gpm and 1,400 gpm, respectively, which are equivalent to the existing system flows.

It does not appear that having Hamilton supplied from a new interconnection on Highland Street will reduce the system's ability to provide fire protection. This would be expected given that the incoming supply from the new interconnection is close to the Town's current supply point and simulates how supply from the plant and the Browns Hill Reservoir is currently delivered for fire protection.

3.2 Option B Pipeline Interconnection

This option includes approximately 13,500 feet of new 12-inch main beginning at the existing 12-inch main within Cabot Street in Beverly, then following Topsfield Road, Cedar Street, Cherry Street and Main Street in Wenham finally connecting to the existing 8-inch main within Bay Road in Hamilton. This option follows the same alignment as discussed for Option A from Cabot Street in Beverly up to Main Street in Wenham and as such will encounter the same existing conditions and issues described above. For Option B, the pipeline will continue along Main Street (Rte. 1A) after passing Arbor Street and enter Hamilton on Bay Road near the intersection with Railroad Avenue. As previously noted, Main Street/Rte. 1A is a heavily travelled roadway, particularly during commuting hours as it connects Hamilton, Wenham and Beverly to Route 128. Bay Road (Rte. 1A) in Hamilton is also heavily travelled as it enters the downtown area **(see view on following page).**

As previously noted, the Town of Wenham does have existing water mains located within the respective roadways. It is unknown at this time how many other underground utilities exist within the roadways, however, given the rural nature of the town, it is likely that enough room is available to install a new 12-inch pipeline. Additionally, there appears to be enough space within the roadways to maintain vehicular and pedestrian access during future pipeline construction. There will be a significant traffic design for completing the pipeline work along the end of Main Street and into Bay Road with the possibility of having to perform the work at night, however, there is only about 400 feet or so of new main within this stretch needed to connect to the existing 8-inch main.



View of Main Street/Bay Road (Rte. 1A) Entering Hamilton

From a supply standpoint, this option would be advantageous in supplying Hamilton and its partnering communities since it is centrally located within the system and will connect to Hamilton's 12-inch transmission main that extends up Bay Road and down Bridge Street to the Browns Hill Reservoir. In addition, this connection to Hamilton under Option B would directly feed into the most densely populated area of the town, thus providing additional supply where mostly needed, similar to Option A. Utilizing the Town of Hamilton's computerized water model, we conducted a hydraulic analysis to determine the amount of supply that can be delivered through this connection with the SBWSB under current conditions and possible infrastructure upgrades for supplying future needs.

3.2.1 Hydraulic Analysis – Option B

From Hamilton's water system model, the hydraulic gradient at the proposed interconnection with the existing 8-inch main on Bay Road varies from 205 feet to 218 feet over a 24-hour period depending on system demand, tank level and whether the Town's finish water pumps are operating. As with Option A, given the higher gradient of Beverly's system, a new pressure reducing valve (PRV) will be needed at the new interconnection to allow Hamilton to continue operating their current system. Upon including the new pipeline, new revenue meter and backflow preventer into the Town's computerized model, we conducted computer simulations to identify system impacts and the available supply that can be effectively delivered through the new interconnection under the following operational scenarios as modeled for Option A:

- **Scenario #1:** Current System Conditions with Plant Finish Water Pumps On-line and Additional Supply from New Interconnection with New PRV and New Meter/Backflow Preventer Device
- **Scenario #2:** Plant Finish Water Pumps Off-line with Full Supply from New Interconnection without PRV and with New Meter/Backflow Preventer Device

For **Scenario #1**, to determine the optimal PRV setting for augmenting Hamilton's existing water system, we conducted extended period simulation (EPS) analyses for various PRV settings under average day demands. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps on-line and controlled off reservoir level. From the results of the analyses, setting the new PRV to a downstream gradient of 215 feet or more will hydraulically allow the most flow from SBWSB into Hamilton with a predicted range of 150 gpm to 575 gpm, respectively. However, at this setting, the finish water pumps will not operate since the Browns Hill Reservoir is never allowed to empty as it will always remain full.

Lowering the new PRV setting down to 210 feet will reduce the available supply through the new interconnection to a range of 75 gpm to 325 gpm, with the finish water pumps operating about 6 hours per day. Additionally, the daily fluctuation within the Browns Hill Reservoir will be reduced to about a 1 foot per day. Lowering the new PRV setting down to 208 feet will allow the finish water pumps and Browns Hill Reservoir to operate similarly as they currently do while maintaining the 2 feet per day fluctuation within the tank. However, the available supply through the new interconnection is reduced to a maximum flow rate of 190 gpm. From the results presented above for Scenario #1, the most favorable option would be to set the new PRV to a downstream gradient somewhere between 208 feet and 210 feet to maximize the available supply while minimizing overall system impacts. The final setting can be adjusted as needed based on actual system conditions when the new interconnection is installed.

As an alternative to using a PRV, the Town could consider using a flow control valve (FCV) as was modeled for Option A. For a FCV, the most favorable downstream flow setting would be somewhere between 200 gpm and 225 gpm, respectively. This flow range will have similar system impacts to those identified above for the PRV gradient setting of 208 to 210 feet.

For **Scenario #2**, we conducted extended period simulation (EPS) analyses under average day demands to determine the maximum supply that could be delivered via gravity through the new interconnection to fully meet the Town's water needs. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps off-line and no PRV. From the results of the analyses, the maximum gravity flow that can be supplied through the new interconnection is approximately 585 gpm, which although greater than what was predicted for Option A, is still less than what the Town currently relies on for meeting system demands. At this flow rate, it would take less than 8 hours to fill the Browns Hill Reservoir by one foot however, once full, the reservoir will never drop as the incoming supply from the interconnection would basically isolate the tank hydraulically from the system. Controls and valving could be put in place to automatically close the interconnection intermittently to allow the Browns Hill Reservoir to fluctuate as needed, but the available gravity supply is inadequate for Hamilton to rely on solely.

To improve the system hydraulics and possibly increase the available gravity supply through the new interconnection, the Town could consider extending the new 12-inch main in Bay Road up to the existing 12-inch main at the intersection with Asbury Street. This would require an additional 1,300 feet of new 12-inch main to be installed. The results of additional analyses conducted using this approach shows that the maximum gravity flow supplied through the new interconnection would increase to about 625 gpm, which is an improvement and very close to what the Town would need to fully supply their water system. However, there will be no surplus supply available for the other partnering communities if needed.

Based on the results of the modeling, a new booster pump station will be needed at the new interconnection to fully supply Hamilton's water system along with sharing supply with the other partnering communities. As noted for Option A, for the purposes of this memorandum, since we do not know at this time what the intent or additional supply needs of the partnering communities are, we have assumed that a new 1.5 MGD booster pump station will be installed for this scenario. This will meet Hamilton's supply needs while providing excess supply for sharing with the partnering communities on a temporary or mutual aid basis. Adjustments to the station capacity will be made once the intended supply volumes for each community is determined upon completing Task 5 of the WMA grant.

To identify any possible impacts to Hamilton's water system in delivering fire flows at adequate pressures for fire protection when being fully supplied from this interconnection with the SBWSB, we conducted steady-state analyses similar to Option A, imposing fire flows at the following two hydrant locations:

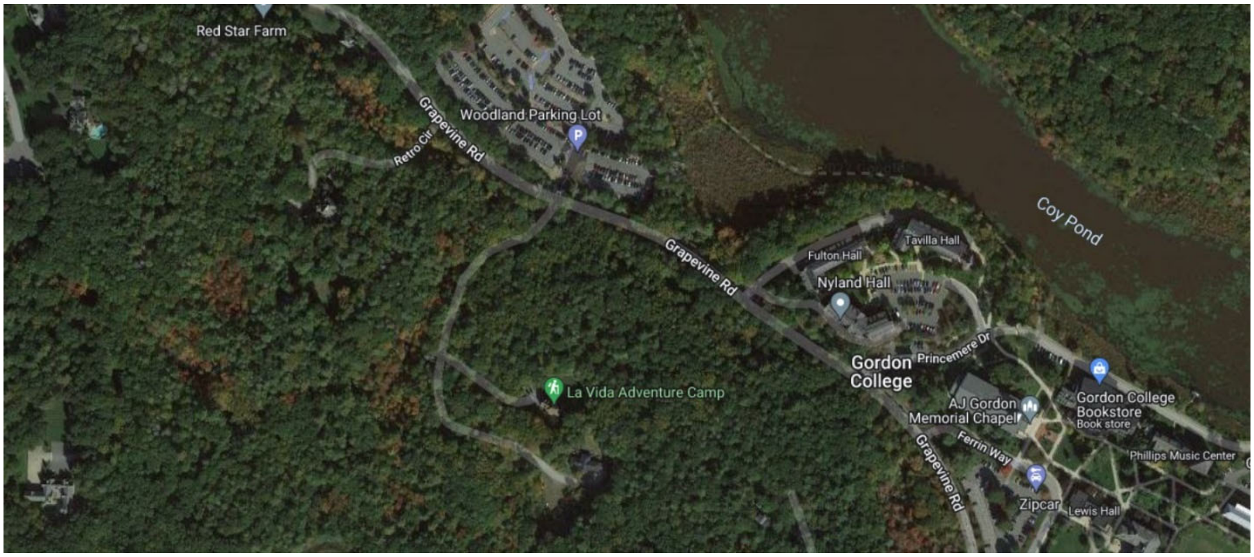
- Hydrant #33: Highland Street near the Pingree School
- Hydrant #164: Intersection of Asbury Street and Spring Avenue

This hydrant locations are shown on attached **Figure No. 3**. From the Option A analyses, under existing system conditions, the available fire flows at Hydrant #164 and Hydrant #33 as predicted in the model are 2,100 gpm and 1,400 gpm, respectively. Under Scenario #2 system conditions, the available fire flows at Hydrant #164 and Hydrant #33 as predicted in the model are 2,300 gpm and 1,400 gpm, respectively, which are equivalent and/or slightly improved to the existing system flows. It does not appear that having Hamilton supplied from a new interconnection on Bay Road will reduce the system's ability to provide fire protection. This would be expected given that the incoming supply from the new interconnection is close to the Town's current supply point and simulates how supply from the plant and the Browns Hill Reservoir is currently delivered for fire protection, similar to Option A.

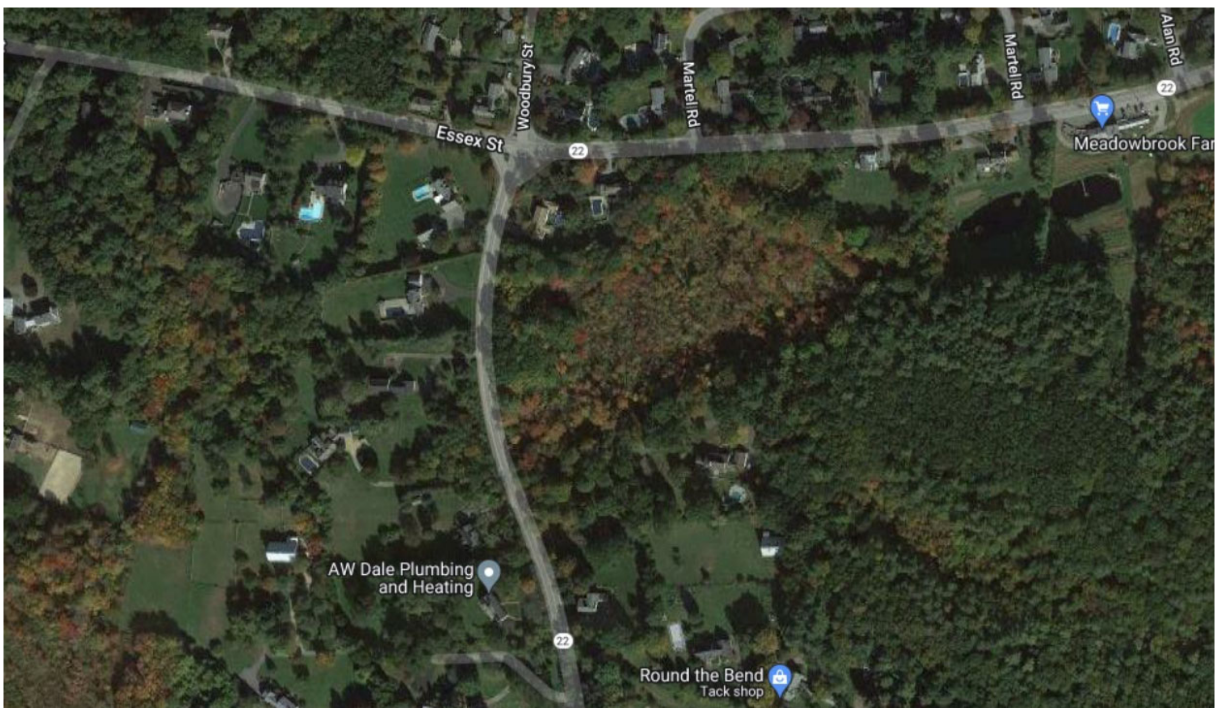
3.3 **Option C Pipeline Interconnection**

This option includes approximately 7,600 feet of new 12-inch main beginning at the existing 12-inch main on Grapevine Road in Wenham, then following Rubbly Road (Rte. 22) finally connecting to the existing 6-inch main within Woodbury Street in Hamilton. This proposed alignment follows State Route 22 and is a well-travelled rural roadway with wide shoulders and a few stream crossings. As with Options A and B, it is unknown at this time how many underground utilities exist within the roadway. The Town of Wenham does have existing water mains located within the respective roadways. Given the rural nature of the town, it is likely that enough room is available to install a new 12-inch pipeline. Additionally, there appears to be enough space within the roadways to maintain vehicular and pedestrian access during future pipeline construction **(see views on following page).**

This option is a much shorter route, with less traffic and less disruption anticipated from construction. However, from a supply standpoint, this option is not that advantageous since it will rely on approximately 2,000 feet of existing 6-inch main to convey supply from the interconnection to the Town's 8-inch and 10-inch mains located in Essex Street. It is possible that this section of 6-inch main will need to be replaced with new 12-inch main to improve the hydraulics and effectiveness of the new interconnection to supply Hamilton and the partnering communities. Additionally, it is not located near the more densely populated areas where the most supply is needed. Utilizing the Town of Hamilton's computerized water model, we conducted a hydraulic analysis to determine the amount of supply that can be delivered through this connection with the SBWSB under current conditions and possible infrastructure upgrades for supplying future needs.



View of Grapevine Road in Wenham



View of Rubbly Road (Rte. 22) Entering Hamilton at Woodbury Street

3.3.1 Hydraulic Analysis – Option C

From Hamilton's hydraulic model, the gradient at the proposed interconnection with the existing 6-inch main on Woodbury Street varies from 207 feet to 211 feet over a 24-hour period depending on system demand, tank level and whether the Town's finish water pumps are operating. As with Options A and B, given the higher gradient of Beverly's system, a new pressure reducing valve (PRV) will be needed at the new interconnection to allow Hamilton to continue operating their current system. Upon including the new pipeline, new revenue meter and backflow preventer into the Town's computerized model, we conducted computer simulations to identify system impacts and the available supply that can be effectively delivered through the new interconnection under the following operational scenarios as modeled for Options A and B:

- **Scenario #1:** Current System Conditions with Plant Finish Water Pumps On-line and Additional Supply from New Interconnection with New PRV and New Meter/Backflow Preventer Device
- **Scenario #2:** Plant Finish Water Pumps Off-line with Full Supply from New Interconnection without PRV and with New Meter/Backflow Preventer Device

For **Scenario #1**, to determine the optimal PRV setting for augmenting Hamilton's existing water system, we conducted extended period simulation (EPS) analyses for various PRV settings under average day demands. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps on-line and controlled off reservoir level. From the results of the analyses, setting the new PRV to a downstream gradient of 220 feet will hydraulically allow a predicted supply in the range of 155 gpm 210 gpm through the new interconnection. At this setting, the finish water pumps will operate about 6 hours per day with an expected daily fluctuation of 1 foot within the Browns Hill Reservoir.

Increasing the new PRV setting to 225 feet will increase the available supply through the new interconnection to a range of 150 gpm to 250 gpm, with the finish water pumps operating about 5 hours per day. Additionally, the daily fluctuation within the Browns Hill Reservoir will be reduced to just below 1 foot. Lowering the new PRV setting down to 215 feet will allow the finish water pumps and Browns Hill Reservoir to operate similarly as they currently do while maintaining close to a 2 feet per day fluctuation within the tank. However, the available supply through the new interconnection is reduced to a maximum flow rate of only 160 gpm. From the results presented above for Scenario #1, the most favorable option would be to set the new PRV to a downstream gradient somewhere between 215 feet and 220 feet to maximize the available supply while minimizing overall system impacts. The final setting can be adjusted as needed based on actual system conditions when the new interconnection is utilized.

As an alternative to using a PRV, the Town could consider using a flow control valve (FCV) as was modeled for Option A and B. For a FCV, the most favorable downstream flow setting would be somewhere between 200 gpm and 225 gpm, respectively. This flow range will have similar system impacts to those identified above for the PRV gradient setting of 215 to 220 feet.

For **Scenario #2,** we conducted extended period simulation (EPS) analyses under average day demands to determine the maximum supply that could be delivered via gravity through the new interconnection to fully meet the Town's water needs. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps off-line and no PRV. From the results of the analyses, the maximum gravity flow that can be supplied through the new interconnection is only approximately 275 gpm, which is significantly less than what the Town currently relies on for meeting system demands. At this flow rate, levels within the Browns Hill Reservoir cannot be maintained and the tank will eventually empty.

As noted above, an enhancement to this option would be to consider extending the new 12-inch main some 2,000 feet up Woodbury Street to the intersection with Essex Street for connecting to the Town's 10-inch and 8-inch mains. The results of additional analyses conducted using this approach shows that the maximum gravity flow supplied through the new interconnection would increase to 625 gpm, which is a significant improvement and very close to what the Town would need to fully supply their water system, similar to Option B. At this flow rate, it would take less than 8 hours to fill the Browns Hill Reservoir by one foot however, once full, the reservoir will never drop as the incoming supply from the interconnection would basically isolate the tank hydraulically from the system. As with Options A and B, controls and valving could be put in place to automatically close the interconnection intermittently to allow the Browns Hill Reservoir to fluctuate as needed. However, there will be no surplus supply available for the other partnering communities if needed.

Based on the results of the modeling, a new booster pump station will be needed at the new interconnection to fully supply Hamilton's water system along with sharing supply with the other partnering communities. As noted for Options A and B, for the purposes of this memorandum, since we do not know at this time what the intent or additional supply needs of the partnering communities are, we have assumed that a new 1.5 MGD booster pump station will be installed for this scenario. This will meet Hamilton's supply needs while providing excess supply for sharing with the partnering communities on a temporary or mutual aid basis. Adjustments to the station capacity will be made once the intended supply volumes for each community is determined upon completing Task 5 of the WMA grant.

In addition, we would also recommend replacing the existing 2,000 feet of 6-inch main within Woodbury Street with new 12-inch main up to the intersection with Essex Street as evaluated above to improve the system hydraulics and delivery of supply into Hamilton and to the partnering communities through this interconnection.

To identify any possible impacts to Hamilton's water system in delivering fire flows at adequate pressures for fire protection when being fully supplied from this interconnection with the SBWSB, we conducted steady-state analyses similar to Options A and B, imposing fire flows at the following two hydrant locations:

- Hydrant #33: Highland Street near the Pingree School
- Hydrant #164: Intersection of Asbury Street and Spring Avenue

This hydrant locations are shown on attached **Figure No. 3**. From the previous analyses, under current system conditions, the available fire flows at Hydrant #164 and Hydrant #33 as predicted in the model are 2,100 gpm and 1,400 gpm, respectively. Under Scenario #2 system conditions, the available fire flows at Hydrant #164 and Hydrant #33 as predicted in the model are 1,600 gpm and 1,300 gpm, respectively, which are lower than existing system flows. This reduction in fire flow would be expected given that the supply from this new interconnection on Woodbury Street is on the other side of Hamilton's system, closer to the Browns Hill Reservoir. Option C is not hydraulically effective as compared to Options A and B which have the supply entering Hamilton's system on the same side as the Town's existing well supplies. Ideally, it is more effective to have the supply and storage volumes on opposite side of the system to provide a more balanced approach for fire protection.

3.4 Hydraulic Analyses Summary

Table 3.1 on the following page presents a summary of the analyses conducted above on the three (3) pipeline interconnection options for each scenario evaluated. As shown in **Table 3.1**, for Scenario #1, Options A and B are predicted to supply upwards of 300 gpm to augment Hamilton's existing supplies with minimal impact to the Town's current operation as compared to only about 200 gpm predicted for Option C. For Scenario #2, Option B is predicted to supply the highest gravity flow of 585 gpm based on the initial approach of installing new 12-inch water main up to the existing interconnection at Bay Road.

However, as noted above and in **Table 3.1**, extending the new pipeline for each option further into Hamilton to connect to the nearest large transmission main results in a maximum supply rate of 625 gpm for both Options B and C. Although the additional length of water main for each option does increase the supply rate available from the proposed interconnections with SBWSB, the available gravity flow is still inadequate to meet the full supply needs of Hamilton and the partnering communities. As such, a new booster pump station will be needed to implement Scenario #2 in the future.

Table 3.1 Pipeline Interconnection Options Analyses Summary

Condition	Supply Rate	Comment
Option A, Scenario #1 – Additional SBWSB Supply, Current Existing Conditions w/ New PRV		
PRV set @ 220'	150 to 425 gpm	Ex. pumps & tank will be isolated from system
PRV set @ 215'	250 to 300 gpm	Ex. pumps & tank will operate, turnover reduced by about day
PRV set @ 210'	75 to 175 gpm	Ex. system not impacted, but minimal available supply
Option B, Scenario #1 – Additional SBWSB Supply, Current Existing Conditions w/ New PRV		
PRV set @ 215'	150 to 575 gpm	Ex. pumps & tank will be isolated from system
PRV set @ 210'	75 to 325 gpm	Ex. pumps & tank will operate, turnover reduced by about day
PRV set @ 208'	50 to 190 gpm	Ex. system not impacted, but minimal available supply
Option C, Scenario #1 – Additional SBWSB Supply, Current Existing Conditions w/ New PRV		
PRV set @ 225'	150 to 250 gpm	Ex. pumps & tank will operate, turnover reduced less than a day
PRV set @ 220'	155 to 210 gpm	Ex. pumps & tank will operate, turnover reduced by about day
PRV set @ 215'	50 to 160 gpm	Ex. system not impacted, but minimal available supply
Option A, Scenario #2 – Full SBWSB Supply, Finish Water Pumps Off-line, No PRV		
Maximum Supply	Up to 425 gpm	New 12" main up to existing interconnection at Town line
Maximum Supply	Up to 585 gpm	Extending New 12" main into Hamilton by 415 feet
Option B, Scenario #2 – Full SBWSB Supply, Finish Water Pumps Off-line, No PRV		
Maximum Supply	Up to 585 gpm	New 12" main up to existing interconnection at Town line
Maximum Supply	Up to 625 gpm	Extending New 12" main into Hamilton by 1,300 feet
Option C, Scenario #2 – Full SBWSB Supply, Finish Water Pumps Off-line, No PRV		
Maximum Supply	Up to 275 gpm	New 12" main up to existing interconnection at Town line
Maximum Supply	Up to 625 gpm	Extending New 12" main into Hamilton by 2,000 feet

3.5 Estimated Costs for Pipeline Interconnection Options

Tables 3.2, 3.3 and 3.4 on the following pages present the estimated costs for the three options evaluated to interconnect with Beverly and the SBWSB to supply Hamilton and the partnering communities both on a seasonal/ temporary basis and on a more permanent/regional basis. To assist in determining the most cost-effective approach to implement based on future water supply needs, we have included estimated costs for the infrastructure upgrades associated with each operational scenario evaluated.

Table 3.2 Option A Pipeline Interconnection Costs

Item			Cost[(1)]
Scenario #1: Additional Supply from New Interconnection w/ New PRV			
12,900' of New 12" Main from Cabot Street to Highland Street @ $300/ft			$3,870,000
New Revenue Meter/Backflow Preventer Vault and appurtenances			$175,000
New PRV Vault and appurtenances			$75,000
New electrical/control systems & SCADA upgrades (for meter & PRV)			$40,000
Site work & connections to ex. 12" main on Cabot Street			$25,000
Site work & connections to ex. 8" main on Highland Street			$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$100,000
Subtotal			**$4,310,000**
Engineering and Permitting (30%)			**$1,293,000**
Subtotal – Engineering and Construction			**$5,603,500**
25% Contingency			**$1,400,750**
Total - Scenario #1			**$7,004,250**
Scenario #2: Full Supply from New Interconnection w/o PRV, FW Pumps Off-line			
12,900' of New 12" Main from Cabot Street to Highland Street @ $300/ft			$3,870,000
New Revenue Meter/Backflow Preventer Vault and appurtenances			$175,000
New 1.5 MGD Booster Pump Station w/in Above-Ground Structure			$350,000
Site work & connections for new booster pump station			$75,000
New electrical/control systems & SCADA upgrades (for meter)			$30,000
Site work & connections to ex. 12" main on Cabot Street			$25,000
Site work & connections to ex. 8" main on Highland Street			$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$150,000
Subtotal			**$4,700,000**
Engineering and Permitting (30%)			**$1,410,000**
Subtotal – Engineering and Construction			**$6,110,000**
25% Contingency			**$1,527,500**
Total - Scenario #2			**$7,637,500**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

Table 3.3 Option B Pipeline Interconnection Costs

Item	Cost[1]
Scenario #1: Additional Supply from New Interconnection w/ New PRV	
13,500' of New 12" Main from Cabot Street to Bay Road @ $300/ft	$4,050,000
New Revenue Meter/Backflow Preventer Vault and appurtenances	$175,000
New PRV Vault and appurtenances	$75,000
New electrical/control systems & SCADA upgrades (for meter & PRV)	$40,000
Site work & connections to ex. 12" main on Cabot Street	$25,000
Site work & connections to ex. 8" main on Highland Street	$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)	$100,000
Subtotal	**$4,490,000**
Engineering and Permitting (30%)	**$1,347,000**
Subtotal – Engineering and Construction	**$5,837,000**
25% Contingency	**$1,459,250**
Total - Scenario #1	**$7,296,250**
Scenario #2: Full Supply from New Interconnection w/o PRV, FW Pumps Off-line	
13,500' of New 12" Main from Cabot Street to Bay Road @ $300/ft	$4,050,000
New Revenue Meter/Backflow Preventer Vault and appurtenances	$175,000
New 1.5 MGD Booster Pump Station w/in Above-Ground Structure	$350,000
Site work & connections for new booster pump station	$75,000
New electrical/control systems & SCADA upgrades (for meter)	$30,000
Site work & connections to ex. 12" main on Cabot Street	$25,000
Site work & connections to ex. 8" main on Highland Street	$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)	$150,000
Subtotal	**$4,880,000**
Engineering and Permitting (30%)	**$1,464,000**
Subtotal – Engineering and Construction	**$6,344,000**
25% Contingency	**$1,525,000**
Total - Scenario #2	**$7,869,000**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

Table 3.4 Option C Pipeline Interconnection Costs

Item			Cost[1]
Scenario #1: Additional Supply from New Interconnection w/ New PRV			
7,600' of New 12" Main from Grapevine Road to Woodbury Street @ $300/ft			$2,280,000
2,000' of New 12" Main along Woodbury Street to Essex Street @ $300/ft			$600,000
New Revenue Meter/Backflow Preventer Vault and appurtenances			$175,000
New PRV Vault and appurtenances			$75,000
New electrical/control systems & SCADA upgrades (for meter & PRV)			$40,000
Site work & connections to ex. 12" main on Cabot Street			$25,000
Site work & connections to ex. 8" main on Highland Street			$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$100,000
Subtotal			**$3,320,000**
Engineering and Permitting (30%)			**$996,000**
Subtotal – Engineering and Construction			**$4,316,000**
25% Contingency			**$1,079,000**
Total - Scenario #1			**$5,395,000**
Scenario #2: Full Supply from New Interconnection w/o PRV, FW Pumps Off-line			
7,600' of New 12" Main from Grapevine Road to Woodbury Street @ $300/ft			$2,280,000
2,000' of New 12" Main along Woodbury Street to Essex Street @ $300/ft			$600,000
New Revenue Meter/Backflow Preventer Vault and appurtenances			$175,000
New 1.5 MGD Booster Pump Station w/in Above-Ground Structure			$350,000
Site work & connections for new booster pump station			$75,000
New electrical/control systems & SCADA upgrades (for meter)			$30,000
Site work & connections to ex. 12" main on Cabot Street			$25,000
Site work & connections to ex. 8" main on Highland Street			$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$150,000
Subtotal			**$3,710,000**
Engineering and Permitting (30%)			**$1,113,000**
Subtotal – Engineering and Construction			**$4,823,000**
25% Contingency			**$1,205,750**
Total - Scenario #2			**$6,028,750**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

The estimated water main costs per foot included in the above tables are weighted costs and include the cost for furnishing and installing the pipe, valves, fittings, bedding, backfill, traffic control, trench and site restoration. Costs were developed in part using recent construction cost data for new water mains, pumping stations, and appurtenances. The estimated costs do not include land acquisition, right-of-way procurement and legal fees. We have included 30% for engineering/permitting and a 25% contingency for planning purposes. All costs are presented in 2022 dollars and are based on the May 2022 Boston ENR construction cost index of 17506.61.

3.6 Conclusion

Based on the assessments completed for each pipeline interconnection option, and considering the current and future supply needs of Hamilton and the partnering communities, **Option A would be the preferred approach with Option B as an alternate for obtaining SBWSB supply.** These options are similar in cost and are equally effective for augmenting Hamilton's existing well supplies or for fully supplying Hamilton on a more permanent basis, with minimal system impacts. Subsequently, these options would be best for sharing future supply with the partnering communities on a more regional basis. Although Option C is the least costly, as shown from the analyses, it can only effectively deliver supply for augmenting Hamilton's existing supplies. Under the scenario of fully supplying Hamilton on a more permanent basis, available fire flows within the Town's existing water system are reduced due to the supply interconnection being located close to the Town's storage tank which is hydraulically ineffective. Additional system improvements such as a new storage tank located on the other side of the system along with larger water mains to support the new tank would be needed for this option to be considered for supplying Hamilton and the partnering communities.

As the SBWSB can only commit to augmenting Hamilton's supply on an interim/seasonal basis until the planned upgrades to their plant are completed, it is recommended that the preferred Option A or alternate Option B be implemented in two phases. The initial phase would include the construction of the new 12-inch main, revenue meter/backflow preventer vault and PRV as noted in **Tables 3.2 and 3.3** under Scenario #1. This would provide a supply rate of 275 gpm to 300 gpm at the interconnections to supplement Hamilton's existing well supplies when needed along with the other partnering communities. When the SBWSB's planned upgrades to increase the production capacity at their plant are completed, Hamilton can then consider completing the construction of the new booster pump station for being fully supplied from the SBWSB if desired and agreed to by the SBWSB. The final station capacity should be designed to meet Hamilton's future water demands along with any future supply arrangements made with the other partnering communities.

From the analyses conducted, both Options A and B would benefit from extending the new 12-inch main further into Hamilton connecting to the larger existing mains within Highland Street and Bay Road. For example, under Option B, extending the 12-inch main another 1,300 feet increased the available gravity supply through the interconnection from 585 gpm to 625 gpm, respectively. However, to achieve the main goal of the WMA grant scope which is improve water supply resiliency within the Lower Ipswich River Basin region, and reduce overall basins withdrawals, a new booster pump station would still be needed. **To determine the most cost-effective option and related infrastructure upgrades to be implemented, a more thorough investigation of the pipeline alignments will be needed beyond the scope of this task along with finalizing the future supply expectations for Hamilton, the partnering communities and the SBWSB.**

3.7 **Water Supply Permitting Considerations**

3.7.1 SBWSB Authority

The SBWSB was established by the Massachusetts legislature as a Water Authority under the Acts of 1913, Chapter 700 on May 26, 1913. In addition to Salem and Beverly, its existing charter states that they can sell water to the Towns of Wenham and Hamilton. Should additional communities desire to connect to the system, there would need to be new legislation to update the Charter allowing the SBWSB to serve additional communities. Should this be deemed desirable by the existing Board and communities served, passing this enabling legislation is not seen as a significant hurdle.

3.7.2 Water Supply Permitting

Public water supply is generally considered a utility for regulatory purposes. As such, most federal, state and local environmental regulations generally exempt utilities from their purview. In Massachusetts, only one law governs the withdrawal of water from the environment, the Water Management Act (WMA). The WMA was passed in 1986 as a result of the multi-year drought in the mid to late 1960's which is considered the drought of record for the area. During this drought, the combination of unusually dry conditions coupled with societies increasing need for water due to residential and commercial growth throughout the Commonwealth indicated a mismatch between water supply and demand such that the legislature felt the need to enact a new law. The law requires a balance between competing uses and states that the combination of all withdrawals must remain within the Safe Yield of a water source which in Massachusetts is determined on a major river basin basis.

For the Ipswich River, the safe yield is 28.3 Million Gallons per Day (MGD). The WMA is administered by the Massachusetts Department of Environmental Protection (DEP) and is implemented based on the most recent WMA regulations promulgated in 2014. The WMA exempted existing withdrawals at the time of its passage from certain requirements known as registrations. Permits are required for any new or increased volumes requested over the registration value which are conditioned according to the regulations. Requests for increases in withdrawals must be justified and in accordance with a **Water Needs Forecast (WNF)** which is prepared by a sister agency, the MA Department of Conservation & Recreation (DCR). The WMA only regulates withdrawals in excess of 100,000 GPD which generally consists of municipal water suppliers and large commercial uses such as golf courses and industry.

Based on a meeting held with WMA staff of the DEP specifically to inform this project, sharing and supplementing water amongst the communities is theoretically possible so long as the overall Safe Yield for the Ipswich River is not exceeded. Because existing WMA allocations for the basin exceed its Safe Yield, such water sharing would need to come out of existing WMA allocations. **There are two scenarios through which the SBWSB could agree to serve adjacent communities with supplemental water**. One, water could be supplied within SBWSB's existing combined registered and permitted allocation. Two, other communities could (permanently or temporarily) agree to transfer their existing allocations to SBWSB in order to allow them to provide water to those communities (as opposed to making it themselves).

Under **Scenario 1**, SBWSB would need to first determine if they had enough surplus water within their existing allocations to meet their existing demand plus future growth projections. In May 2022, DCR met with the SBWSB to update the WNF for the system. The WNF for the two cities served by the SBWSB are as follows:

DCR Salem and Beverly Water Needs Forecast as of 5/20/22

Year	2025	2029	2040
Water Demand (MGD)	8.7	9.5	9.5

Based on the current annual average demand of 8.9 MGD and the WNF 2029 demand of 9.5 MGD, it appears that SBWSB could meet its current and projected needs within its existing registered volume of 10.17 MGD but with little surplus to supply additional communities in the future. Therefore, if SBWSB desired to supply additional communities under Scenario 1, it would need to do so under its permitted volume of 2.27 MGD. However, it should be noted that the SBWSB permit exists only on paper and has not been activated by DEP and that SBWSB would need to demonstrate via an updated WNF that it needs the additional water. As such, the proposed needs of the other communities would need to be included in an updated WNF for SBWSB to be able to activate its permit. Another consideration is that were the permit to be activated, a series of conditions such as mandatory water conservation requirements not currently required on the SBWSB registration would be imposed by DEP. Therefore, SBWSB would need to evaluate if these conditions are acceptable.

Since there are currently no WMA-imposed conditions placed upon registered-only water, implementation of the standard water conservation conditions on WMA permits would likely save additional water thereby freeing up existing water that could be made available to other communities. Based on a 2022 study conducted by the Ipswich River Watershed Association, it is estimated that communities such as Beverly & Salem could save approximately 25% on average of current demand through the implementation of an enhanced water conservation program which goes above and beyond the standard conditions in the permit. Therefore, based on current use, approximately 2.20 MGD of existing water use could be made available through the implementation of such a program. If these water savings were realized, when coupled with SBWSB's permitted volume of 2.27, an additional 4.47 MGD on average could be available to share with other communities***. (Note that this analysis is based on average daily use and does not consider the maximum daily demand in Salem and Beverly which can be up to 16MGD in the summer. Therefore, an assessment of the system's ability to meet the peak daily demand in combination with the other communities' peak demand would need to occur.)***

Under **Scenario 2**, the partnering communities would need to forego utilization of their local allocations in order to allow SBWSB to exceed theirs. All the partnering communities in this WMA grant study rely on groundwater withdrawals and according to the USGS, groundwater withdrawals particularly in summer are the primary driver of the low flow issues in the Ipswich River. Therefore, transferring existing groundwater allocations to seasonal pump-storage water within the SBWSB reservoir system would also have the beneficial effect of improving the ecology of the Ipswich River. Moreover, since groundwater is the primary source of elevated PFAS contamination that has been found to date throughout the Ipswich Basin, such a transfer would help mitigate the groundwater-dependent communities' exposure to PFAS contamination. Also, if Scenario 2 were implemented seasonally, resting municipal groundwater wells could have added benefits of reducing iron, manganese and sodium contamination, as well as lowering operating costs for local municipalities. Finally, if other communities implement an enhanced water conservation program according to the IRWA study, additional water savings could be realized lowering overall water demand thereby increasing the ability of SBWSB's "surplus" water to meet and/or supplement the needs of local communities. **Under Task 5, we will explore the water needs of other participating communities and analyze various scenarios on how SBWSB could meet those needs.**

4. Water Quality Evaluation

4.1 Hamilton

The primary source of supply for the Town of Hamilton's water system is the **Idlewood wellfield** which consists of five (5) individual wells. These wells are pumped up to the Idlewood Water Treatment Plant (WTP) for treatment prior to being introduced into the distribution system. The WTP was constructed to remove elevated levels of iron and manganese from the raw water wells, and includes the following processes:

- Pre-oxidation of the incoming raw water with 15% sodium hypochlorite
- Filtration through four (4) horizontal pressure filters containing 36-inches of high rate catalyzed media
- Post-filtered disinfection with 15% sodium hypochlorite as needed prior to entering the clearwell
- Fluoridation with sodium fluoride and corrosion control with a poly/orthophosphate after the clearwell

The Town's secondary source of supply is the **School Street well** which is chemically treated only before being delivered into the distribution system with sodium hypochlorite for disinfection, sodium fluoride for fluoridation, potassium hydroxide for pH adjustment, and a poly/orthophosphate blend for corrosion control. The location of these sources is shown on **Figure No. 3 in Appendix A**.

The finished water pH being maintained at these two sources is in the range of 7.2 to 7.4 with a free chlorine residual in the range of 0.5 mg/l to 0.7 mg/l, and a total phosphate residual of about 0.4 to 0.5 mg/l. Total trihalomethanes (TTHMs) as measured within the distribution system at the Town's two Stage 2 Disinfection Byproducts Rule sites for the last two years have ranged from 47 ppb to 83 ppb, respectively, with the calculated Locational Running Annual Average (LRAA) below the maximum containment level (MCL) of 80 ppb. Haloacetic Acids (HAA5) as measured within the distribution system at the Town's two Stage 2 Disinfection Byproducts Rule sites for the last two years have ranged from 0 ppb to 46 ppb, respectively, with the calculated Locational Running Annual Averages (LRAA) below the maximum containment level (MCL) of 60 ppb **(see Figure No. 3 in Appendix A).**

TTHMs within the Town's system tend to be on the higher side for a system that has well supplies, primarily due to several wells within the Idlewood wellfield that have moderate levels of total organic carbon (TOC). As water from these wells is oxidized with sodium hypochlorite for iron and manganese removal, TTHMs are formed at the plant and carried through the system. The Town is currently constructing a new GAC treatment system that will reduce the levels of both TOCs and TTHMs at the plant which will improve finish water quality.

Per the recently promulgated MassDEP regulation pertaining to PFAS monitoring under CMR 310 22.07G, the Town sampled its raw water sources to determine if PFAS was present at the detection levels that would trigger the need for treatment. The results of this initial sampling showed that the Town's Idlewood well supplies had a total sum of 3 ppt for the 6 regulated PFAS compounds in 2020, with 4.9 ppt in 2021, well below the established total PFAS MCL of 20 ppt. Sampling of the School Street well in 2021 showed a total sum of 13 ppt for the 6 regulated PFAS compounds which is still below the MCL of 20 ppt but is over the 10 ppt threshold which requires monthly sampling of the source. The Town has limited the use of this well and is currently evaluating options for providing future on-site treatment for PFAS removal.

4.2 Salem-Beverly Water Supply Board

As previously noted, the SBWSB utilizes conventional treatment at their plant which includes flocculation, sedimentation, filtration via sand/anthracite media and post-treatment including disinfection with sodium hypochlorite, hydrofluorosilicic acid for fluoridation, quick lime for pH adjustment and an ortho/polyphosphate blend for corrosion control. From the data collected per Task 2, the finished water pH being maintained at the plant is in the range of 7.0 to 7.3 with a free chlorine residual about 0.57 mg/l. The total phosphate residual maintained by the SBWSB ranges from 0.45 mg/l to 0.90 mg/l.

Total trihalomethanes (TTHMs) as measured within the distribution systems for Salem and Beverly at their Stage 2 Disinfection Byproducts Rule sites are reported to be in the range of 25 ppb to 87 ppb, respectively, with the calculated Locational Running Annual Average (LRAA) below the maximum containment level (MCL) of 80 ppb. Haloacetic Acids (HAA5) as measured within the distribution system for Salem and Beverly at their Stage 2 Disinfection Byproducts Rule sites are reported to be in the range of 17 ppb to 54 ppb, respectively, with the calculated Locational Running Annual Averages (LRAA) below the maximum containment level (MCL) of 60 ppb. The total sum of the 6 regulated PFAS compounds is reported to be in the range of 2.4 to 4.9 ppt, which is well below the established total PFAS MCL of 20 ppt.

In comparing the finished water quality being produced by Hamilton and the SBWSB, they are very similar with respect to pH, free chlorine and total phosphate levels. Both use chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water. Additionally, since both use phosphate products for corrosion control and maintain similar pH levels within their system, there should be minimal impacts to Hamilton's system with respect to lead and copper. Levels of TTHMs, HAA5s and PFAS are also similar within the water systems of Hamilton and the SBWSB, with all being below their respective established MCLs. **As such, it appears that Hamilton should be able to utilize a future interconnection with the SBWSB without any major water quality issues or impacts with meeting current drinking water standards.**

4.3 Partnering Communities

Per Task 2 of the WMA grant study, we coordinated and requested various water quality and system infrastructure data from the partnering communities including Ipswich, Essex, Manchester, Wenham and Topsfield as required to complete this task. **Table 4.1** on the following page presents a summary of the finish water quality data collected from each of the communities as it relates to this assessment.

Both the Towns of Manchester and Ipswich have a combination of surface water and wells that supply their water systems. The surface water sources for each Town are chemically treated and filtered through water treatment plants. The post-treatment of the filtered water at the Manchester's plant includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride, pH adjustment with sodium hydroxide and zinc orthophosphate addition for corrosion control. The post-treatment of the filtered water at the Ipswich's plant includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid, pH adjustment with sodium hydroxide and an ortho/polyphosphate blend for corrosion control. Treatment at Manchester's single well includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride, pH adjustment with sodium hydroxide and a poly/orthophosphate blend for corrosion control. Treatment at Ipswich's wells includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid and a poly/orthophosphate blend for corrosion control.

Table 4.1 Finish Water Quality Summary

Parameter	Manchester	Essex	Ipswich	Topsfield	Wenham
pH	7.1 - 7.8	7.3 - 7.5	6.5 - 8.0	7.5	Unknown(2)
Chlorine (ppm)	0.80 - 1.40	0.53 - 0.59	0.25 - 0.89	0.22 - 0.34	0.3 - 0.88
Phosphate (ppm)	0.3 - 1.6	N/A(1)	0.5 - 0.80	Unknown(2)	Unknown(2)
TTHMs (ppb)	17 – 57	37 – 40	20 - 68	18 – 38	15.7
HAAs (ppb)	8.1 – 12	6 to 9	4.9 -35	ND - 4.5	4.4
PFAS6 (ppt)	0 - 19.8	<1.9	ND - 23.3	10-23	Unknown(2)

1. Essex does not add phosphate to their finished water.
2. Data was unable to be obtained from the partnering community.

The Town of Essex has only wells for supplying their system which are chemically treated and filtered through a water treatment plant that includes disinfection with chlorine gas, and pH adjustment with potassium hydroxide. The Town of Topsfield also has only wells for supplying their system which are chemically treated and filtered through a water treatment plant that includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride, pH adjustment with potassium hydroxide and an ortho/polyphosphate blend for corrosion control/sequestering. The Town of Wenham has only wells for supplying their system which are chemically treated only including disinfection with calcium hypochlorite, fluoridation with sodium fluoride and corrosion control with zinc orthophosphate.

In comparing the finished water quality of the partnering communities with the Town of Hamilton's current water quality and future water quality if blended with SBWSB supply, they are similar with respect to pH and free chlorine with exception of Ipswich which maintains a larger range of pH than the other systems. However, they do use an ortho/polyphosphate blend similar to Hamilton and the SBWSB for corrosion control so it is not anticipated that this larger pH range will be an issue. As shown in **Table 4-1** above, the Town of Essex does not use any phosphate addition for corrosion control which could be an issue with respect to lead and copper if supply from Hamilton and the SBWSB is delivered into their system. **All the partnering communities rely on free chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water between systems.**

4.4 Possible Issues

As previously noted above, based on comparing the finished water quality being maintained by Hamilton and the SBWSB, we do not envision any issues in meeting current drinking water standards with blending the two water supplies. Subsequently, upon the SBWSB completing their planned upgrades to their plant, the finish water quality to be delivered into Hamilton will only improve. **With respect to Hamilton sharing its current and/or blended SBWSB supply with the partnering communities, there may be some potential water quality issues that need to be addressed.**

As noted above, Essex does not currently add phosphate at their plant for corrosion control within their distribution system. They only provide pH adjustment. The introduction of phosphate-treated water into their system could potentially disrupt the current chemistry that is providing the protective coating on the interior lead and copper surfaces. It will also increase the chlorine demand within the distribution system which will require adjusting the current chlorine dosages to avoid having coliform issues. For emergency measures, using their interconnection with Hamilton on a short-term basis should not pose a significant issue. However, if Essex intends to utilize their interconnection with Hamilton to obtain supply on a more permanent basis, then consideration to adjusting their current treatment practice for corrosion control to include phosphate should be made.

With respect to transferring and/or sharing supply from Essex into Hamilton and the partnering communities, the lack of phosphate within Essex's finish water could pose an issue depending on how much volume of water is being delivered as compared to what Hamilton is supplying. Any prolonged use of an interconnection with Essex should be further evaluated and likely will require Essex to commence adding phosphate as part of the corrosion control practice.

From the noted water quality data, both the SBSWB's and Hamilton's water system have higher TTHMs and HAA5s as compared to the partnering communities so there is a potential for seeing an increase in these constituents within their systems. However, blending of the supplies should minimize this issue to some extent and prevent any possible MCL exceedance. It should be noted that both Hamilton and the SBWSB will be improving their current treatment processes at their plants which is expected to reduce current TTHMs and HAA5s within their systems in the future.

A major water quality impact with transferring and/or sharing supply from the partnering communities into and through Hamilton is **the presence of PFAS** within the individual supplies. As shown from **Table 4-1**, the Towns of Manchester, Topsfield and Ipswich have noted PFAS levels just at or above the 20 ppt MCL. As Hamilton's primary well supply has current PFAS levels below 5 ppt, it may not be prudent to allow water with PFAS levels above the MCL into their system. This matter would likely have to be reviewed with MassDEP to determine what special requirements will need to be implemented before approving such a transfer.

5. Supplying Partnering Communities

5.1 Infrastructure Improvements Required

As previously noted herein, and as shown on **Figure No. 3 in Appendix A**, Hamilton has existing interconnections with the Towns of Ipswich, Essex and Wenham, ranging in size from 2-inches to 8-inches. There are currently no interconnections in place with Topsfield or Manchester and as such, new interconnections and related pipelines will need to be constructed to connect these two systems with Hamilton. In addition to having a physical connection between systems, there may also be the need for a pressure reducing valve (PRV) or booster pump station depending on the hydraulic gradient of the systems being supplied. **Table 5.1** on the following page shows the operating gradient of Hamilton and the partnering community systems.

For Wenham, there are two existing interconnections including an 8-inch on Highland Street and a 6-inch on Woodbury Street. Based on Hamilton's existing system, the 8-inch interconnection on Highland Street would be more favorable for transferring supplying between Hamilton and Wenham. For Essex, there is an existing 4-inch and 2-inch interconnection at the end of Essex Street (Rte. 22) which is fed by Hamilton's 10-inch main. To effectively transfer future supply between the two systems, these two existing interconnections should be replaced with a new single 8-inch connection. For Ipswich, there is an existing 6-inch interconnection at the end of Waldingfield Road which is fed by Hamilton's 8-inch main. This interconnection should be adequate for transferring supply between Hamilton and Ipswich.

Table 5.1 Existing System Gradients

Community Water System	Hydraulic Gradient (feet)
Hamilton	210
Manchester	273
Ipswich	210(1)
Topsfield	Unknown(2)
Essex	217.7
Wenham	211

1. Main pressure zone gradient as maintained by Tower Hill Tank.
2. Data was unable to be obtained from the partnering community.

Using Hamilton's computerized model, we conducted steady state simulations under maximum day demands to estimate the available future supply that Hamilton's existing system infrastructure could effectively deliver at each of the existing interconnections. From the results of the analyses, a supply rate of about 200 gpm could be provided at Wenham's 8-inch interconnection with a reduction in system pressure less than 3 psi. At Essex's 4-inch and 2-inch interconnection, a supply rate of about 300 gpm could be provided with a reduction in system pressure less than 3 psi. At Ipswich's 6-inch interconnection, a supply rate of about 150 gpm could be provided with a reduction in system pressure less than 3 psi.

From **Table 5.1**, given that the existing system gradients for Wenham and Ipswich are about equal to Hamilton's gradient, supply between the systems can be delivered via gravity without the need for a PRV or a booster pump station. Depending on the demand and pressure fluctuations that occur within each of the systems over the course of a day, there will be times when the available gravity supply from Hamilton will be slightly reduced. With Essex having a system gradient about 8 feet higher than Hamilton, a booster pump station may be needed at the interconnection to effectively supply Essex daily over an extended period. We do not currently have a model of Essex's water system and as such, we cannot determine the actual gradient on the Essex side of the interconnection. There could be times over a course of a day when the gradients between the two systems allow gravity flow.

Additionally, for the analyses above, we only determined the available supply that Hamilton could possibly deliver into Wenham, Ipswich and Essex. Since we do not have working models of the other partnering systems at this time, we cannot determine the available supply that could possibly be delivered into Hamilton from these systems. **The ability and capacity of the partnering systems to supply Hamilton in the future along with possible infrastructure improvements such as booster pump stations will be evaluated under Task 5 of the WMA grant scope.**

As noted above, Hamilton's system does not currently have any interconnections with Topsfield or Manchester. From collected data and discussions with Hamilton and Manchester staff, it is our understanding that the only physical way to connect these two systems is to construct approximately 9,000 feet of new pipeline along Chebacco Road. This pipeline would extend from Hamilton's existing 8-inch main down to Manchester's existing 14-inch main near the Gravelly Pond Water Treatment Plant. Additionally, given Manchester's operating gradient of 273 feet, a booster pump station will be needed to supply Manchester from Hamilton and conversely, a PRV will be needed to supply Hamilton from

Manchester. **The feasibility of this new pipeline along with the needed infrastructure to connect Hamilton to Manchester for improving the supply resiliency of each system will be further evaluated under Task 4 of the WMA grant scope.**

For Topsfield, we have no yet received any water system data that was requested under Task 2, nor have we spoken with Topsfield staff since that activity is to be completed under Task 5 of the WMA grant scope. We did find some data on-line related to their water treatment plant along with water quality reports for the last four years, However, we have no distribution system data with respect to pipeline locations and operating gradients to appropriately identify options for interconnecting Hamilton to Topsfield. We also cannot determine at this time the available supply that Hamilton can deliver to Topsfield in the future. **As such, the evaluation of a new interconnection to connect Hamilton with Topsfield along with determining the ability of Hamilton and Topsfield to share supply will be completed under Task 5 of the WMA grant scope.**

APPENDIX A

FIGURE 1

REGIONAL COMMUNITY WATER SYSTEM PLAN

DATE: MAY 2022
SCALE: 1" = 3,000'

Dewberry

FIGURE 2

OPTIONAL PIPELINE INTERCONNECTION ROUTES

DATE: MAY 2022
SCALE: 1" = 1,000'

Dewberry

FIGURE 3

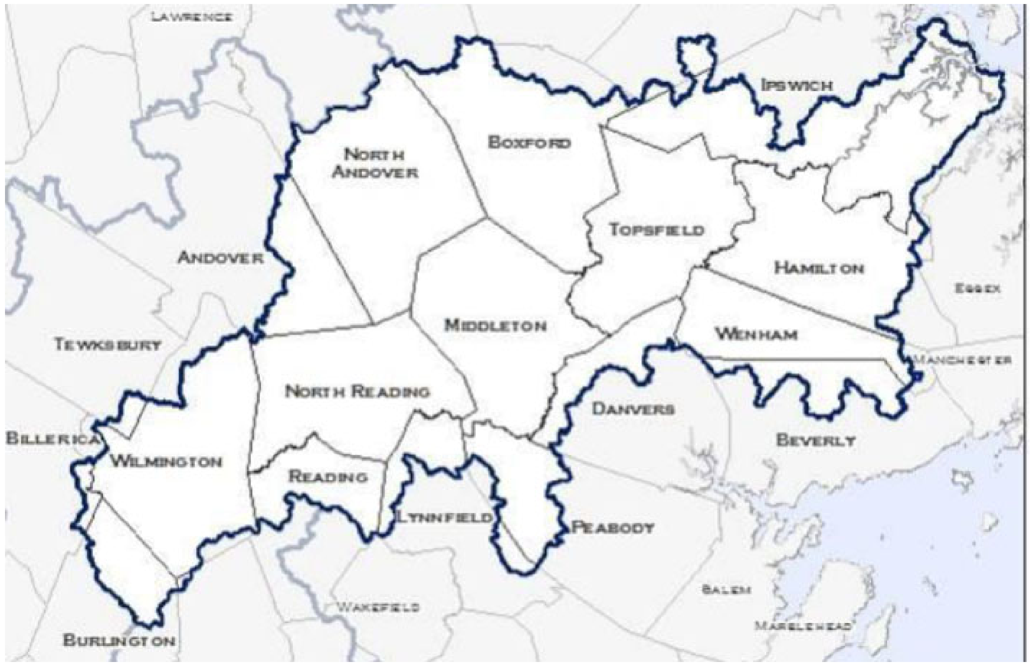
TOWN OF HAMILTON, MA
WATER SYSTEM PLAN

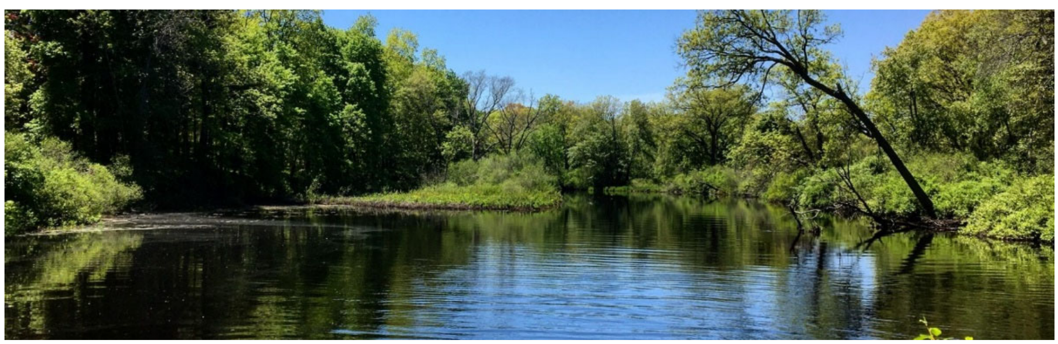
DATE: MAY 2022
SCALE: 1" = 1,500'

Dewberry
99 Summer Street
Boston, MA 02110
617 695-3400
617 695 3310
www.dewberry.com

APPENDIX B

Task 4 Technical Memorandum w/ Attachments





BWR 2022-01 Water Management Act (WMA) Grant - Regional Evaluation to Improve Water Supply Resiliency within the Lower Ipswich River Watershed

Task 4 – Technical Memorandum

Town of Hamilton, Massachusetts

June 22, 2022

SUBMITTED BY:

Dewberry Engineers Inc.
99 Summer Street
Boston, MA 02210

IN COLLABORATION WITH:

Ipswich River Watershed Association
143 County Road
Ipswich, MA 01938

SUBMITTED TO:

Town of Hamilton
Department of Public Works
577 Bay Road
Hamilton, MA 01982

TABLE OF CONTENTS

Attachments

1. Introduction

The overall purpose for the subject WMA Grant is to conduct a regional evaluation of alternative sources to improve water supply resiliency within the lower Ipswich River Watershed for the Town of Hamilton and its neighboring communities of Topsfield, Manchester, Ipswich, Essex and Wenham. The WMA grant is divided into six (6) discrete tasks, each with its own required deliverable. The following Memorandum documents the evaluation and findings for the assessment of a future water supply connection with the Town of Manchester as defined under Task 4 of the WMA grant.

1.1 Task Overview

Hamilton's existing water system borders all five (5) partnering communities and currently has interconnections with three of them including Ipswich, Essex and Wenham. This geographic condition places Hamilton in the best position to effectively convey and/or transfer alternate water supplies between the noted communities including a future interconnection with the Town of Manchester. For Task 4, the main objective is to evaluate the feasibility of installing a new interconnection between Hamilton and Manchester to allow the ability to share water supply between the two systems, along with the other participating communities on a partially regional basis. This task includes the following major scope items:

- Confirm the **capacity and permitted safe yields available** with Manchester's supplies to supplement Hamilton and other interested communities on a regional basis to reduce withdrawals from the Ipswich River Basin.
- Evaluate the operational and supply impacts on Hamilton's water system from a new interconnection with Manchester through **hydraulic analyses**.
- Identify **infrastructure/permitting requirements** necessary to interconnect the water systems of Hamilton and Manchester including the need for pumping stations, pressure reducing valves, Interbasin Transfer Act (ITA) and other appurtenances.
- Evaluate the **impact of supplying the partnering communities** through existing and future system interconnections with Hamilton. Estimate the available supply capacity that can be hydraulically conveyed through existing and future system interconnections of each water system to augment their water supply needs.
- Evaluate **infrastructure improvements** to alleviate hydraulic limitations and allow the adequate delivery of water supply between the partnering communities including larger diameter water mains, booster pump stations and pressure-reducing valves.
- Prepare **cost estimates** associated with the needed permitting, infrastructure, and operational improvements to install a new interconnection between Hamilton and Manchester, and subsequent interconnections with the partnering communities.
- Identify **potential water quality impacts** from mixing groundwater and surface water supplies of Hamilton, Manchester and the participating water systems. Parameters to be considered include finish water quality (pH, color, turbidity, iron, manganese), post-disinfection practices (free chlorine, chloramines), corrosion control methods (pH adjustment, phosphate addition) and distribution water quality (chlorine residual, TTHMs, HAAs and PFAS).

2. Description of Manchester's Water System

The Town of Manchester's water system currently includes one (1) surface water supply, two (2) groundwater supplies, two (2) water treatment facilities, one (1) storage tank and approximately 44 miles of water main. The system includes approximately 2,533 service connections, and serves residential, commercial, industrial, and institutional users. From the 2020 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately 0.628 million gallons per day (MGD), with approximately 69% attributed to residential usage, 3% attributed to commercial, 1% attributed to municipal/institutional usage, 25% attributed to unaccounted for usage, and the remaining 2% attributed to industrial and miscellaneous usages. The Town has existing emergency interconnections with the neighboring communities of Beverly and Gloucester, which operate at a lower pressure and would require the use of pumps to supply Manchester. The major components of Manchester's current water system are shown on the Town's **Water Distribution System Plan dated February 2017 included in Appendix A** as taken from the Town's Capital Efficiency Plan completed in February 2018.

2.1 Supply and Treatment

The water supply that serves the residents of Manchester includes two primary sources, the Gravelly Pond Reservoir and the Lincoln Street Well. The Gravelly Pond Reservoir is also supplemented by Round Pond Well#1 which is pumped into a series of ponds that flow via gravity into Gravelly Pond. All three Town sources are registered supplies, having been in operation prior to the Water Management Act (WMA), which came into effect in 1986. The Town's current WMA Permit allows for a maximum authorized withdrawal of 0.72 MGD, or 262 MG in a year, from all three sources which are located within the North Coastal Basin. For 2020, the total raw water pumped from the Town's sources was reported to be approximately 231.38 MG, which equates to an average daily withdrawal of 0.634 MGD.

The first source, Gravelly Pond, is a surface water reservoir, which is located off Chebacco Road in Hamilton **(see Water Distribution Plan in Appendix A).** In 2020, Gravelly Pond provided approximately 62 percent of Manchester's drinking water or 144.38 million gallons. The reservoir has a surface area of 49 acres and a capacity of over 360 million gallons when full. The pond is fed by rainfall, runoff from the surrounding area, and groundwater springs. The pond's watershed, or area that drains into the pond, is relatively small and the ability of the pond to recharge or fill back up is limited. According to the Town's ASR, the reported safe yield of Gravelly Pond is 0.12 MGD. However, it is our understanding that the Town is currently evaluating its safe yield under another study. As the 2020 average daily pump rate of this source calculates to be **0.396 MGD (144.38 MG/365 days),** it appears that the reported safe yield is less than what the source can adequately supply.

To supplement the Gravelly Pond supply and to aid with watershed recharge, the Town pumps raw water from the Round Pond Well #1, which is located along Chebacco Road in Hamilton, into Gravelly Pond. A total of **37.583 million gallons** of water were transferred from this source into the Gravelly Pond in 2020.

The second source is the Lincoln Street Well, which is a 58-foot-deep, 500 GPM, gravel packed well located next to the Manchester/Essex Regional Junior/ Senior High School on Lincoln Street in Manchester **(see Water Distribution Plan in Appendix A).** In 2020, the Lincoln Street Well provided approximately 38 percent of Manchester's drinking water or 87.01 million gallons. The approved withdrawal rate from this source as reported in the Town's Capital Efficiency Plan dated February 2018 is **0.38 MGD.** A summary of the Town's existing supplies and average annual withdrawals is provided in **Table 2-1** on the following page.

Table 2.1 Town of Manchester - Existing Water Supplies

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2020 Annual Average Withdrawal (MGD)
Gravelly Pond Reservoir	North Coastal	4.32	0.12(2)	0.72(3)	0.393(1)
Round Pond Well#1	North Coastal	0.43	0.43		(4)
Lincoln Street Well	North Coastal	0.68	0.38		0.238
Total			1.44	0.98	0.631

1. Includes withdrawals from both Gravelly Pond Reservoir and Round Pond Well#1 as they operate in series with water from Round Pond Well#1 transferred in Gravelly Pond for treatment.
2. Town is evaluating the reported safe yield as the use of this source suggests a higher yield is available.
3. The total authorized annual withdrawal for the combined supplies is 0.72 MGD.
4. The total volume of 37.583 million gallons of raw water was transferred from Round Pond Well#1 to Gravelly Pond Reservoir in 2020.

Treatment of the raw water from the Gravelly Pond and the Round Pond Well #1 is provided by the Gravelly Pond Water Treatment Facility (WTF) located at the end of Chebacco Road in Hamilton, MA **(see Water Distribution Plan in Appendix A).** The WTF was constructed in 1997 and has a reported maximum production capacity of 4.32 MGD. The facility was designed based on the Trident/Microfloc package treatment system which provide a combination of upflow clarification followed by dual media filtration. Treatment processes include oxidation, coagulation with aluminum sulfate, pH adjustment with sodium hydroxide, clarification, filtration, fluoridation with sodium fluoride, disinfection with sodium hypochlorite and corrosion control with zinc orthophosphate. The facility also contains a clearwell which has a volume of approximately 0.48 million gallons.

Treatment of the Lincoln Street Well is provided by the Lincoln Street Corrosion Control Facility which was constructed in 1997. The facility treats the raw water from the well with sodium hypochlorite for disinfection, sodium hydroxide for pH adjustment, a 70/30 percent non-sodium, non-zinc poly orthophosphate blend for corrosion control and prevention of colored water, and sodium fluoride for fluoridation.

The operation of Manchester's water treatment facilities is performed by Woodard & Curran Inc., who has been the town's contract operator since 2000. The Town's Department of Public Works operates the distribution system described below.

In addition to the three active sources described above, the Town also owns the Round Pond Well No. 2 which is located along Chebacco Road in Hamilton and according to Town records, has been inactive since 2009. This well was constructed as a tubular wellfield consisting of seven 2-1/2-inch diameter wells, pumped with a centrifugal pump. The previously approved MassDEP maximum daily withdrawal rate for the Round Pond Well No. 2 was 0.36 MGD or 250 gpm as stated in the WMA permit issued February 15, 1991. As the well has been off-line for several years, it would need to go through the Drinking Water New Source Approval process before it could be re-activated.

2.2 Distribution

Manchester's water distribution system includes approximately 44 miles of water main ranging in size from 4-inch diameter up to 16-inch diameter with most of the mains being over 50 years old. The system has one pressure zone and operates at a hydraulic gradient of 273 feet as maintained by the Moses Hill

Standpipe **(see Water Distribution Plan in Appendix A).** The Moses Hill Standpipe is located off Pine Street and is a prestressed concrete tank that was constructed in 2001. The standpipe is approximately 78 feet tall and 60 feet in diameter with a storage capacity of approximately 1.7 MG. The overflow elevation of the tank is approximately 273 feet Mean Sea Level (MSL).

As noted above, Manchester currently has emergency interconnections with the City of Beverly and Gloucester only. As such, a new pipeline and interconnection will need to be installed between Hamilton and Manchester. Based on Hamilton's and Manchester's existing infrastructure, the most feasible point of connection would be at the end of Chebacco Road near the Gravelly Pond WTF. This is the closest area of Manchester's system to Hamilton's as the Gravelly Pond WTF is in Hamilton, and given the proximity of the WTF, this connection should be able to effectively supply flows into Hamilton with minimal system impacts to Manchester. **Figure No. 1 included in Appendix A** shows the location of Hamilton's system to Manchester's WTF along with the proposed connection points and pipeline along Chebacco Road.

It should be noted that from previous discussions between representatives of both towns, it has been determined that extending a new pipeline along Chebacco Road to connect with Manchester's system is the only viable and preferred approach to sharing supply between the two systems. As such, the assessment and analyses presented in the following section are based on this future supply approach.

3. Pipeline Route for Future Interconnection

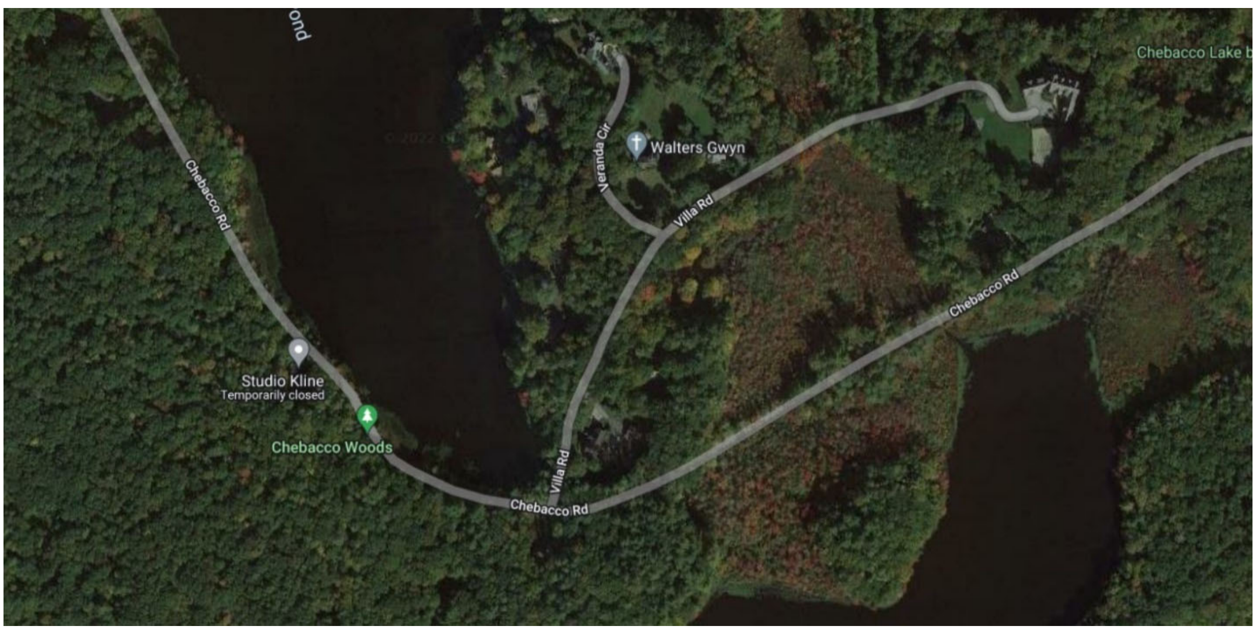
Based on existing infrastructure and previous discussions, the most preferable alignment for installing a new pipeline for connecting with Manchester to share supply with Hamilton and the partnering communities on an as needed or regional basis is along Chebacco Road. From **Figure No. 1 included in Appendix A,** a new 12-inch pipeline will connect to Hamilton's existing 8-inch main in Chebacco Road and extend westerly along Chebacco Road for approximately 9,600 feet terminating at Manchester's 14-inch transmission main leaving the WTF.

The new interconnection will require a revenue meter chamber for measuring and totalizing flow along with a backflow prevention device for cross-connection control. As Manchester operates at a higher gradient than Hamilton **(273 feet vs 210 feet),** a pressure reducing valve (PRV) will be required to control the supply gradient entering Hamilton's system. Conversely, a new booster pump station will be needed to deliver supply into Manchester.

3.1 **Chebacco Road Alignment**

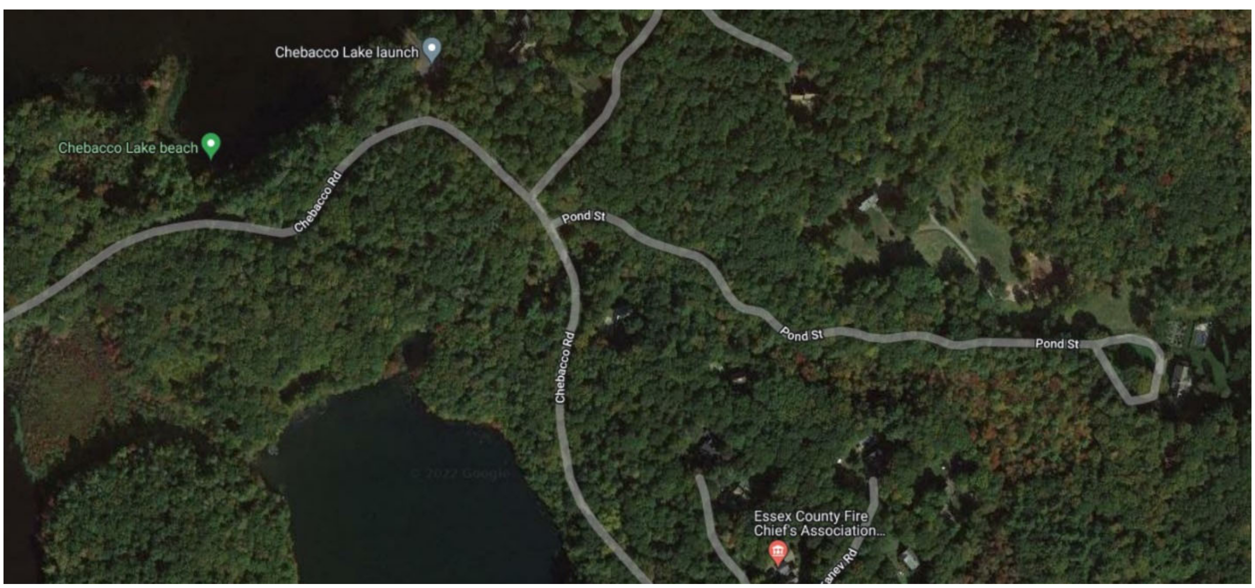
Chebacco Road in Hamilton is a rural roadway that is partially paved from Essex Street up to Pond Street just passed Chebacco Road. The remainder of the roadway into Manchester is comprised of a gravel base and top course. During heavy rain falls, the gravel sections of the road become inundated with ruts that make it difficult for cars to travel. Hamilton is considering paving the gravel portion of the roadway this year to address this issue. It is not a particularly heavily travelled roadway given its condition and is only mainly used by the residents that live along and off Chebacco Road. There are several residences along Chebacco Road and along the two intersecting roads off Chebacco Road including Villa Road and Pond Street **(see views on the following pages).**

View of Chebacco Road near Hamilton's 8-inch Water Main



View of Chebacco Road at Intersection with Villa Road

View of Chebacco Road at Intersection with Pond Street



View of Chebacco Road at Gravelly Pond WTF & Manchester's 14" Main

As Chebacco Road passes through Manchester's protected Watershed District and is closely bordered by several water bodies including Beck Pond, Round Pond and Gravelly Pond, a Notice of Intent will need to be filed with Hamilton's and Manchester's conservation commissions. Additionally, the filing of an Environmental Notification Form (ENF) may be needed depending on the amount of supply to be shared between the two towns since they are located within different river basins, which will trigger an Interbasin Transfer permit. One of the thresholds for filing an ENF is a **"new interbasin transfer of water of 1,000,000 or more gpd or any amount determined significant by the Water Resources Commission."**

Except for the existing water mains that will be connected to the new pipeline, there are no other underground utilities that exist within the roadway. As such, there should be ample room available to install a new 12-inch pipeline. Additionally, there appears to be enough space within the roadway to maintain vehicular and pedestrian access during future pipeline construction.

Utilizing the Town of Hamilton's computerized water model, we conducted a hydraulic analysis to determine the amount of supply that can be delivered through this new interconnection with Manchester's water system under current conditions and possible infrastructure upgrades for supplying the future needs of Hamilton.

3.1.1 Hydraulic Analysis

Hamilton's existing primary water supply includes the Idlewood wellfield and treatement plant which currnently operates at a production capacity of approximately 650 gallons per minute (gpm), or 0.93 MGD, although it was originally designed for a rated capacity of about 900 gpm or 1.3 MGD. The finish water pumps at the plant, which draw from the plant's clearwell, have a rated capacity of about 900 gpm but are operated at a rate of about 685 gpm. The Town's secondary supply is the School Street well which is operated intermittenly at a rate of about 110 gpm. Both the plant's finish water pumps and the School Street well are controlled off the water level within the Town's only water storage tank, the Browns Hill Reservoir, which is a 12-foot tall buried concrete tank. The pumps and well are set to turn on at a level of 209 feet MSL and turn off at a level of 210 feet MSL. Refer to **Figure No. 2 in Appendix A** for the location of Hamilton's water supplies and storage tank.

From Hamilton's water system model, the hydraulic gradient at the proposed interconnection with the existing 8-inch main on Chebacco Road varies from 207 feet to 211 feet over a 24-hour period depending on system demand, tank level and whether the Town's finish water pumps are operating. As previously noted, given that Manchester operates their system at a higher hydraulic gradient of 273 feet, **a new pressure reducing valve (PRV)** will be needed at the new interconnection to allow Hamilton to continue operating their current system. This scenario is based on the approach of utilizing the new interconnection with Manchester to augment the supply of Hamilton and the other partnering communities as needed during high demand periods or when existing wells may be out of service for maintenance or repair. This same scenario of having a new PRV would also be needed for utilizing the new interconnection to fully supply Hamilton on a more permanent basis.

Upon including the new pipeline, new revenue meter and backflow preventer into Hamilton's computerized water system model, we conducted computer simulations to identify system impacts and the available supply that can be effectively delivered into Hamilton through the new interconnection under the following operational scenarios:

- **Scenario #1:** Current System Conditions with Additional Supply from Manchester into Hamilton through New Interconnection with New PRV and New Meter/Backflow Preventer Device
- **Scenario #2:** Hamilton's Supplies Off-line with Full Supply from Manchester through New Interconnection with New PRV and New Meter/Backflow Preventer

For **Scenario #1**, to determine the optimal PRV setting for augmenting Hamilton's existing water system, we conducted extended period simulation (EPS) analyses for various PRV settings under average day demands. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps on-line and controlled off reservoir level. From the results of the analyses, setting the new PRV to a downstream gradient of 215 feet will hydraulically allow a predicted supply in the range of 150 gpm to 385 gpm, respectively, into Hamilton through the new interconnection. However, at this setting, the finish water pumps will not operate since the Browns Hill Reservoir is never allowed to empty enough to call the pumps to start. In addition, the current daily fluctuation of 2 feet within the Browns Hill Reservoir will be reduced to about a half a foot per day, significantly increasing water age within the tank.

Lowering the new PRV setting down to 212 feet will hydraulically allow a predicted supply in the range of 100 gpm to 325 gpm, respectively, into Hamilton through the new interconnection with the finish water pumps operating every 30 hours and the Browns Hill Reservoir fluctuating about ¾ of foot per day, respectively. Lowering the new PRV setting down further to 210 feet will reduce the available supply through the interconnection to a predicted range of 50 to 220 gpm, with the finish water pumps operating about every 14 hours and a daily fluctuation within the Browns Hill Reservoir of about 1-1/2 feet. Lowering the PRV setting below 208 feet will allow the finish water pumps and Browns Hill Reservoir to operate as they currently do, but the available supply through the new interconnection will be less than 100 gpm.

From the results presented above for **Scenario #1**, the most favorable option would be to set the new PRV to a downstream gradient somewhere between 210 feet and 212 feet to maximize the available supply while minimizing overall system impacts. The final setting can be adjusted as needed based on actual system conditions when the new interconnection is installed and how much additional supply is needed.

For **Scenario #2**, we conducted extended period simulation (EPS) analyses under average day demands to determine the maximum supply that could be hydraulically delivered through the new PRV and interconnection to fully meet Hamilton's water needs. Based on Hamilton's current operating gradient of 210 feet, the highest gradient that we could increase Hamilton's system to without causing significant pressure issues would be about 230 feet or so. This would be equivalent to an increase in system pressure of approximately 9 psi ((230 feet – 210 feet) x 1 psi/2.31foot H_20). **It should be noted that at this gradient, the Town's Brown Hill Reservoir will no longer function as it will be hydraulically isolated from the system.**

For this analysis, both the Browns Hill Reservoir and the plant's finish water pumps were taken off-line, and the new PRV was set initially to maintain a downstream gradient of 230 feet. From the results of the analyses, the maximum flow that can be supplied through the new interconnection is predicted to be approximately 700 gpm, or 1 MGD, which is about equivalent to what Hamilton currently relies on for meeting system demands. At a new PRV setting of 235 feet, which would increase system pressures by about 11 psi, the maximum flow through the new interconnection is increased to about 815 gpm, or 1.16 MGD, which is more than adequate to meet Hamilton's supply needs.

Table 3.1 below presents a summary of the analyses conducted above on the Chebacco Road pipeline interconnection option for each scenario evaluated. As shown in **Table 3.1**, for Scenario #1, a supply rate upwards of 300 gpm to augment Hamilton's existing supplies with some impact to the Town's current operation is predicted to be available. For Scenario #2, a maximum supply rate of about 800 gpm is predicted to be available for fully supplying Hamilton's system. However, for this scenario to be feasible, Hamilton would need to construct **a new taller storage tank at the appropriate height to replace the loss of the Browns Hill Reservoir** for providing system equalization and fire protection. Also, Manchester would need to have a supply surplus of 1 MGD along with the ability to withdraw this surplus from their existing sources. As previously noted, Manchester's current WMA Permit allows for a maximum authorized withdrawal of 0.72 MGD. This issue is discussed further in a following section of this memorandum.

Table 3.1 Chebacco Road Pipeline Interconnection Option Analyses Summary

Condition	Supply Rate	Comment
Scenario #1 – Additional Manchester Supply, Current Existing Conditions w/ New PRV		
PRV set @ 220'	150 to 525 gpm	Ex. pumps & tank will be isolated from system
PRV set @ 215'	150 to 385 gpm	Ex. pumps will not operate, tank turnover reduced to < half foot a day
PRV set @ 212'	100 to 325 gpm	Ex. pumps & tank operate, turnover reduced to ¾ foot a day
PRV set @ 210'	0 to 220 gpm	Ex. pumps & tank will operate, turnover reduced to 1-1/4 foot a day
PRV set @ 208'	0 to 100 gpm	Ex. system not impacted, but minimal available supply
Scenario #2 – Full Supply from Manchester, Finish Water Pumps & Reservoir Off-line, New PRV		
PRV set @ 230'	Up to 700 gpm(1)	Pressure increase by 9 psi, need to construct new tank in Hamilton
PRV set @ 235'	Up to 810 gpm(1)	Pressure increase by 11 psi, need to construct new tank in Hamilton

1. Manchester's current WMA Permit allows for a maximum authorized withdrawal of 0.72 MGD.

3.2 Estimated Cost for New Pipeline Interconnection

Table 3.2 on the following page presents the estimated cost for installing the new pipeline along Chebacco Road to interconnect with Manchester to supply Hamilton both on a seasonal/ temporary basis and on a more permanent/regional basis. To assist in determining the most cost-effective approach to implement based on future water supply needs, we have included estimated costs for the infrastructure upgrades associated with each operational scenario evaluated.

The estimated water main costs per foot included in the table on the following page are weighted costs and include the cost for furnishing and installing the pipe, valves, fittings, bedding, backfill, traffic control, trench and site restoration. Costs were developed in part using recent construction cost data for new water mains, pumping stations, and appurtenances. The estimated costs do not include land acquisition, right-of-way procurement and legal fees. We have included 30% for engineering/permitting and a 25% contingency for planning purposes. All costs are presented in 2022 dollars and are based on the **May 2022 Boston ENR construction cost index of 17506.61.**

Table 3.2 Chebacco Road Pipeline Interconnection Costs

Item			Cost[1]
Scenario #1: Additional Manchester Supply w/ New PRV, FW Pumps & Browns Hill Tank On-Line			
9,600' of New 12" Main in Chebacco Road from Ex. 8" Main to Ex. 14" Main @ $300/ft			$2,880,000
New Revenue Meter/Backflow Preventer Vault and appurtenances			$175,000
New PRV Vault and appurtenances			$75,000
New electrical/control systems & SCADA upgrades (for meter & PRV)			$40,000
Site work & connections to ex. 8" main on Chebacco Road			$25,000
Site work & connections to ex. 14" main on Chebacco Road			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$200,000
Subtotal			**$3,425,000**
Engineering and Permitting (30%)			**$1,027,500**
Subtotal – Engineering and Construction			**$4,452,500**
25% Contingency			**$1,113,125**
Total - Scenario #1			**$5,565,625**
Scenario #2: Full Manchester Supply w/ New PRV, FW Pumps & Browns Hill Tank Off-line			
9,600' of New 12" Main in Chebacco Road from Ex. 8" Main to Ex. 14" Main @ $300/ft			$2,880,000
New Revenue Meter/Backflow Preventer Vault and appurtenances			$175,000
New PRV Vault and appurtenances			$75,000
New 0.80 MG Storage Tank including access road, site work, controls & appurtenances			$2,250,000
Demolition of Ex. 0.8 MG Browns Hill Reservoir			$75,000
New electrical/control systems & SCADA upgrades (for meter & PRV)			$40,000
Site work & connections to ex. 8" main on Chebacco Road			$25,000
Site work & connections to ex. 14" main on Chebacco Road			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$350,000
Subtotal			**$5,900,000**
Engineering and Permitting (30%)			**$1,770,000**
Subtotal – Engineering and Construction			**$7,670,000**
25% Contingency			**$1,917,500**
Total - Scenario #2			**$9,587,500**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

3.3 Conclusion

Based on the assesment completed above, the option of constructing a new pipeline along Chebacco Road to connect Manchester with Hamilton would be effective for augmenting Hamilton's existing well supplies. There would be some system impacts with respect to a reduced turnover rate within the Browns Hill Reservoir, but on an temporary basis, this should not pose any significant operational or water quality issues. For fully supplying Hamilton on a more permanent basis, there would be signifiant impacts to Hamilton's system including the hydraulic loss of the Browns Hill Reservoir due to the increased gradient of the system. **Additional system improvements such as a new storage tank to replace the existing Browns Hill Reservoir along with larger water mains to support the new tank would be needed.**

Before considering the approach of constructing a new pipeline to Manchester for supplying Hamilton, the capacity and permitted safe yields available with Manchester's sources need to be confirmed to ensure that there is adequate supply to meet both Manchester's and Hamilton's system needs. An evaluation of Manchester's current supply capacity versus system demands is presented in the following section.

4. Assessment of Manchester's Water Supply Availability

As previously noted, Manchester's WMA permit allows a total combined authorized daily withdrawal of 0.72 MGD from its supplies with a daily approved withdrawal of 0.43 MGD from the Round Pond GP Well #1 and 0.38 MGD from the Lincoln Street Well. The Gravelly Pond Reservoir, which is the Town's primary source, has a reported safe yield of only 0.12 MGD, however, the Round Pond GP Well#1 is pumped into the Gravelly Pond to maintain storage volumes, thus allowing the Town to pump more than its safe yield. For example, in 2020, Manchester pumped an average of 0.39 MGD out of this source to meet system demands which equated to about 62% of the yearly finish water usage.

Table 4.1 below presents a summary of Manchester's supplies including approved safe yields and withdrawals per the WMA permit issued by the MassDEP along with maximum pump capacities at each supply. From **Table 4.1**, the total combined approved daily withdrawals for the Town's existing three (3) supplies is 0.93 MGD which exceeds the maximum registered withdrawal of 0.72 MGD. Given that the water supplies of Gravelly Pond and the Round Pond GP Well#1 are combined prior to treatment, MassDEP may consider a single approved withdrawal of only 0.43 MGD for both supplies which would reduce the total combined source withdrawals to 0.81 MGD. The WMA approved withdrawal of 0.72 MGD would still rule in this case, however it is important to note the approved pumping capacities of individual sources, should future demand conditions warrant an increase in the registered withdrawal.

Table 4.1 Town of Manchester - Existing Water Supplies

Supply	Maximum Pump Capacity (MGD)	Maximum Pump Capacity (gpm)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)
Gravelly Pond	4.30(2)	3,000	0.12	0.72(1)
Round Pond GP Well#1	N/A(3)	N/A(3)	0.43	
Lincoln Street Well	0.67	475	0.38	
Total	4.97	3,475	0.93	0.72

1. The WMA approved annual withdrawal from Manchester's combined supplies is 0.72 MGD.
2. This is the maximum pump capacity at the Gravelly Pond WTF which treats both Gravelly Pond and the Round Pond GP Well#1 supplies.
3. The Round Pond GP Well#1 has a rated well pump capacity of 300 gpm which is pumped into Gravelly Pond.

From **Table 4.1,** the maximum pump capacity for the Town's two individual supply facilities including the Gravelly Pond WTF and the Lincoln Street well is 4.97 MGD which far exceeds the maximum registered withdrawal of 0.72 MGD. As such, it appears that Manchester has the existing infrastructure in place to supply Hamilton and the partnering communities with supplemental water assuming enough surplus remains after Manchester meets their system needs, subject to WMA limitations discussed in **Section 4.3.**

4.1 Supply Versus Usage

Table 4.2 below summarizes Manchester's historical water supply usage as reported in the Town's Annual Statistical Reports (ASRs) from 2017 to 2020. As shown in the table, the Town has never exceeded its WMA authorized withdrawal of 0.72 MGD and has consistently been operating with a surplus on average of about 0.1 MGD per year. From **Table 4.2**, Manchester has been operating their system with a significantly high unaccounted-for water usage ranging from 20% to 30% of the total metered water usage with 25% in 2020. Unaccounted-for water (UAW) within the system typically consists of water theft, leak detection, and meter losses. In review of the **Town's 2018 Capital Efficiency Plan Report**, and recent ASRs, most of the unaccounted-for usage can be contributed to faulty meters and the Town has been working to reduce this percentage by conducting water audits, leak detection surveys and meter replacement.

Table 4.2 Town of Manchester - Historical Water Supply Usage

Year	Average Day Metered Usage (MGD) (1)	Confidently Estimated Municipal Usage (MGD)	Unaccounted-For Water (MGD)	Total Average Daily Usage (MGD)	WMA Approved Annual Withdrawal (MGD)	Surplus/ Deficit (MGD)
2017	0.411	0.013	0.218	0.642	0.72	+0.078
2018	0.472	0.010	0.127	0.610	0.72	+0.110
2019	0.426	0.009	0.136	0.571	0.72	+0.149
2020	0.457	0.013	0.157	0.627	0.72	+0.093

1. Includes metered usage for Residential, Commercial/Business and Municipal/Institutional use categories.

Assuming the Town's unaccounted-for water will be eventually reduced to a more reasonable percentage of 10% to 15%, this would increase the supply surplus available to augment Hamilton and the partnering communities. For example, if the unaccounted-for water percentage of 25% was reduced to 12% in 2020, the available surplus for that year would double from 0.093 MGD to 0.180 MGD. This would depend if the reported losses are not a result of meter calibration, faulty calculations, etc. (known as "paper" losses).

From the **Town's 2018 Capital Efficiency Plan Report**, future population and demand projections were made up to the year 2035 to determine the future adequacy of the Town's supplies. From these projections, the Town's average day demand for 2035 was estimated to be 0.620 MGD which is about equal to the average day demand in 2020. This future estimate also included a 25% unaccounted-for water which as noted above, should be reduced in the coming years. Applying a 10% to 15% unaccounted-for water to the future demand projection of 0.620 MGD, the Town should see a future surplus close to the 0.180 MGD calculated above for 2020 since the average day demand for both years are about the same. **(Note that due to the high and uncertain UAW described above, the State has not been able to conduct a Water Needs Forecast (WNF) for Manchester which would be the governing analysis required to evaluate alternatives under the IBT and WMA).**

4.2 Possible Supply Scenarios

Based on the estimated surplus noted above for 2020, Manchester could theoretically supply flows up to 125 gpm for 24 hours a day, 365 days per year to augment Hamilton's supply and comply with their current WMA registered withdrawals, if the current UAW is reduced from 25% to 12%. Manchester could also supply flows up to 250 gpm for 24 hours a day over 6 months to augment Hamilton's supply and stay in compliance with their current WMA registration. Based on these supply scenarios, Hamilton could use this future interconnection with Manchester to significantly reduce, or fully replace the use of the Idlewood Well #2, which has the poorest raw water quality of all Hamilton's water sources. Reducing its usage would result in overall improvement of the finish water quality, as well as reduce the Town's withdrawals from the Ipswich River Basin and decrease the stress placed on Hamilton's existing wells.

It should be noted that the estimated surplus supply for the above flow scenarios are based on average daily demands which represents the total volume of finished water pumped over 365 days. During periods of higher seasonal demands or maximum day demand where Towns would be pumping their supplies at higher rates to meet system water needs, less surplus supply will likely be available. For example, in 2020, for the months of June, July and August, the average daily water usage for Manchester was calculated to be approximately **1.045 MGD,** which is 165% of the average day demand for that year. Additionally, the maximum day demand for 2020 which occurred on July 20th was **1.403 MGD,** 220% of the average day demand. Given that Manchester would be over pumping their supplies to meet these seasonal demands, it is expected that there would be less surplus available to supply Hamilton during this time without increasing stress on the existing sources. As Hamilton experiences similar peaks in demand during the summer months, they would likely be relying on this future interconnection with Manchester to augment their supplies during the same time when Manchester's supplies are limited. As such, this future supply connection with Manchester may not benefit Hamilton when needed most.

To supply Hamilton during the summer months to account for peak water usage, Manchester may need to alter the operation of Round Pond GP Well#1 and recharge of Gravelly Pond. The **Gravelly Pond Study** being conducted should produce a more realistic safe yield for the reservoir and provide a better estimate of achievable summer yield. Moreover, if Manchester were to implement an enhanced water conservation program to get their seasonal usage and gallons per capita to well below State standards, additional water could theoretically be available to supply Hamilton with some amount of water during peak demand periods. However, as shown in **Table 4.1**, the maximum supply capacity for Manchester of 4.97 MGD is over three times greater than maximum day demand recorded for 2020. This suggests that Manchester could likely meet their high demand periods while still being able to augment Hamilton as needed, assuming all their sources are available to their fullest and in operation.

With respect to Manchester fully supplying Hamilton from this future interconnection, Manchester has the infrastructure in place to meet Hamilton's existing and future water needs and their own based on a maximum production capacity of 4.97 MGD as shown in **Table 4.1** above. From Hamilton's Water System Plan completed in February 2020, Hamilton's projected average day demand for 2035 is 0.671 MGD with a projected maximum day demand of 1.01 MGD. For 2035, the total combined average day demand for both Hamilton and Manchester would be approximately **1.29 MGD (0.671 MGD + 0.620 MGD)** which is approximately 25% of Manchester's full pumping capacity. However, Manchester would need to obtain approval from MassDEP to increase their current WMA registered withdrawal of 0.72 MGD within the North Coastal Basin to 1.29 MGD which could be challenging to achieve. **The feasibility and requirements for Manchester to increase its current WMA registered withdrawals is discussed in the following section.**

4.3 **Water Supply Permitting Considerations**

Public water supply is generally considered a utility for regulatory purposes. As such, most federal, state, and local environmental regulations generally exempt utilities from their purview. In Massachusetts, only one law governs the withdrawal of water from the environment, the Water Management Act (WMA). The WMA was passed in 1986 because of the multi-year drought in the mid to late 1960's which is considered the drought of record for the area. During this drought, the combination of unusually dry conditions coupled with society's increasing need for water due to residential and commercial growth throughout the Commonwealth indicated a mismatch between water supply and demand such that the legislature felt the need to enact a new law. The law requires a balance between competing uses and states that the combination of all withdrawals must remain within the Safe Yield of each individual major river basin in Massachusetts. Under the law, two types of withdrawals were created: registered withdrawals and permitted withdrawals. Registered withdrawals equate to the existing withdrawals at the time the law was passed and are largely unrestrictive. Permitted withdrawals are new withdrawals over the registered amount or any amount of water associated with a new source.

4.3.1 Supplying Water to Hamilton

There are two scenarios under which Manchester could supply water to Hamilton. One, Manchester could provide surplus water under its current registration as described in the previous section. Second, Manchester could apply for a permit to increase their withdrawals and transfer that water to Hamilton. Under **Scenario One**, no approval under the Water Management Act would be needed if Manchester stayed under its current registered volume. This would however require approval form the DEP Drinking Water Program regarding water chemistry and disinfection-related standards, which will be discussed in the next section.

Manchester would need to significantly lower its unaccounted-for water (UAW) as described in the prior section to make enough water available to justify the effort. If Manchester were to lower its relatively high Gallons Per Capita Per Day (gpcd) figure in addition to lowering its UAW, a considerable amount of surplus water could be made available within its registered volume. Adoption of an enhanced water conservation program that implements the standards and recommendations in the Massachusetts Water Conservation Standards would lower existing usage by approximately 30% creating an additional 0.184 MGD that could be provided to Hamilton. Given that Manchester is a member of the Greenscapes Coalition, which assists cities and Towns in implementing such programs, these savings could be realized at little to no cost to the community.

Under **Scenario Two**, to increase available supply, Manchester could apply for a withdrawal permit from the DEP Water Management Program to increase its allowable withdrawal. However, the Town's withdrawal sources are within the North Coastal Watershed, in a sub-basin with a level 5 biological category and a level 4 Groundwater withdrawal category. This designation means the sub-basin is already depleted and suffering from significant environmental harm from water withdrawals. A new permit in this sub-basin is unlikely without following several steps. First, Manchester would need to demonstrate it has a solid plan and program in place to get its UAW and gpcd to below the State standards of 10% UAW and 65 gpcd. Second, the WMA permitting regulations in level 4 & 5 sub-basins require that Manchester *minimize* its existing withdrawals through a minimization program and *mitigate* the impacts of the new withdrawals on the sub-basin. While this is technically feasible, it is unclear if Manchester has enough options available to successfully meet the minimization and mitigation requirements. The permitting process would also require an extensive alternatives analysis to demonstrate that Hamilton has no other feasible and less-damaging water source alternative.

4.3.2 Inter-Basin Transfer and Watershed Impacts

Hamilton's existing water supply comes from the Ipswich River Watershed, while Manchester's supply is sourced from the North Coastal Watershed. When transferring water from one river sub-basin to another, the Inter-basin Transfer Act (IBT) must be followed. The law requires an analysis and permit for any amount of water transferred form one of the 28 major river basins in Massachusetts to another. Depending on the volumes involved (over 1 million gallons per day), an IBT permit also requires that an Environmental Impact Statement assessment take place, which involves another layer of review. Several State agencies collectively participate in the IBT review and the permit is issued by the State Department of Conservation & Recreation under its role as support to the Massachusetts Water Resources Commission, which makes such regulatory decisions.

Massachusetts water policy promotes that water resources should be managed within watersheds and discourages transfer of water outside the source watershed. The conditions of an IBT permit are contingent on overall environmental benefit, meaning a transfer from one basin can only be approved if it will have a neutral or net environmental benefit to the Commonwealth. Moreover, an IBT permit would require that both the donor and receiving permittees first comply with the principles of efficient water use as defined by the State Water Conservation Standards.

In the case of Manchester and Hamilton, the transfer of water between the two communities could theoretically be approved if both communities demonstrate efficient water use and a Comprehensive Water Resources Management Plan (CCMP) proves there is a neutral or net environmental benefit. The CCMP would analyze and demonstrate how the Towns would meet the Water Conservation Standards and reduced discretionary water use to the extent possible. For example, UAW would need to be 10% or below, and per capita water use below 65 gallons per day.

The Town of Manchester's water sources are upstream of the Town of Essex's in the same sub-basin. Both the WMA and IBT permitting process would require that the impact of increased withdrawals on Essex be thoroughly analyzed. The Town of Essex, the local State legislative delegation and several stakeholders are currently involved in an extensive environmental assessment of the lower Essex River and Chebacco Lake Watersheds where the Manchester and Essex water sources are located. The study thus far has identified water withdrawals as a concern and potential source of water quality and flow impairments in the watershed. There is also a significant statewide effort amongst river advocates to prevent additional withdrawals in level 4 and 5 sub basins which may impact any decisions should Manchester request to increase its allocation. Any effort to increase Manchester's withdrawals would likely generate considerable involvement in downstream and other stakeholders, creating additional hurdles in the permitting process. To summarize, it is technically feasible for Manchester to increase its withdrawals, but the Towns would need to prove that overall environmental conditions will be improved through this effort.

5. Water Quality Evaluation

5.1 **Hamilton**

The primary source of supply for the Town of Hamilton's water system is the **Idlewood wellfield** which consists of five (5) individual wells. These wells are pumped up to the Idlewood Water Treatment Plant

(WTP) for treatment prior to being introduced into the distribution system. The WTP was constructed to remove elevated levels of iron and manganese from the raw water wells, and includes the following processes:

- Pre-oxidation of the incoming raw water with 15% sodium hypochlorite
- Filtration through four (4) horizontal pressure filters containing 36-inches of high rate catalyzed media
- Post-filtered disinfection with 15% sodium hypochlorite as needed prior to entering the clearwell
- Fluoridation with sodium fluoride and corrosion control with a poly/orthophosphate after the clearwell

The Town's secondary source of supply is the **School Street well** which is chemically treated only before being delivered into the distribution system with sodium hypochlorite for disinfection, sodium fluoride for fluoridation, potassium hydroxide for pH adjustment, and a poly/orthophosphate blend for corrosion control. The location of these sources is shown on **Figure No. 2 in Appendix A**.

The finished water pH being maintained at these two sources is in the range of 7.2 to 7.4 with a free chlorine residual in the range of 0.50 mg/l to 0.75 mg/l, and a total phosphate residual of about 0.4 to 0.5 mg/l. Total trihalomethanes (TTHMs) as measured within the distribution system at the Town's two Stage 2 Disinfection Byproducts Rule sites for the last two years have ranged from 47 ppb to 83 ppb, respectively, with the calculated Locational Running Annual Average (LRAA) below the maximum containment level (MCL) of 80 ppb. Haloacetic Acids (HAA5) as measured within the distribution system at the Town's two Stage 2 Disinfection Byproducts Rule sites for the last two years have ranged from 0 ppb to 46 ppb, respectively, with the calculated Locational Running Annual Averages (LRAA) below the maximum containment level (MCL) of 60 ppb **(see Figure No. 2 in Appendix A).**

TTHMs within the Town's system tend to be on the higher side for a system that has well supplies, primarily due to several wells within the Idlewood wellfield that have moderate levels of total organic carbon (TOC). As water from these wells is oxidized with sodium hypochlorite for iron and manganese removal, TTHMs are formed at the plant and carried through the system. **The Town is currently constructing a new GAC treatment system that will reduce the levels of both TOCs and TTHMs at the plant which will improve finish water quality.**

Per the recently promulgated MassDEP regulation pertaining to PFAS monitoring under CMR 310 22.07G, the Town sampled its raw water sources to determine if PFAS was present at the detection levels that would trigger the need for treatment. The results of this initial sampling showed that the Town's Idlewood well supplies had a total sum of 3 ppt for the 6 regulated PFAS compounds in 2020, with 4.9 ppt in 2021, well below the established total PFAS MCL of 20 ppt. Sampling of the School Street well in 2021 showed a total sum of 13 ppt for the 6 regulated PFAS compounds which is still below the MCL of 20 ppt but is over the 10 ppt threshold which requires monthly sampling of the source. **The Town has limited the use of this well and is currently evaluating options for providing future on-site treatment for PFAS removal.**

5.2 Manchester

As previously noted, Manchester utilizes the Trident/Microfloc package water treatment system at the Gravelly Pond WTF which includes oxidation, coagulation with aluminum sulfate, pH adjustment with sodium hydroxide, clarification, filtration, fluoridation with sodium fluoride, disinfection with sodium hypochlorite and corrosion control with zinc orthophosphate. Treatment at the Lincoln Street Well is provided by the Lincoln Street Corrosion Control Facility which includes sodium hypochlorite for disinfection, sodium hydroxide for pH adjustment, a 70/30 percent non-sodium, non-zinc poly orthophosphate blend for corrosion control and prevention of colored water, and sodium fluoride for fluoridation. From the data collected per Task 2, the finished water pH being maintained within Manchester's distribution system is in the range of 7.1 to 7.8 with a free chlorine residual in the range of 0.8 mg/l to 1.40 mg/l. The total phosphate residual maintained is in the range of 0.30 mg/l to 1.6 mg/l.

Total trihalomethanes (TTHMs) as measured within the distribution system at their two Stage 2 Disinfection Byproducts Rule sites are reported to be in the range of 36 ppb to 52 ppb, respectively, with the calculated Locational Running Annual Average (LRAA) below the maximum containment level (MCL) of 80 ppb. Haloacetic Acids (HAA5) as measured within the distribution system at their two Stage 2 Disinfection Byproducts Rule sites are reported to be in the range of 11 ppb to 19 ppb, respectively, with the calculated Locational Running Annual Averages (LRAA) below the maximum containment level (MCL) of 60 ppb. The total sum of the 6 regulated PFAS compounds is reported to be approximately 7.35 ppt at the Gravelly Pond WTF and approximately 18.9 ppt at the Lincoln Street well, which are below the established total PFAS MCL of 20 ppt. **Table 5.1** below presents a summary of the finish water quality presented above for both Hamilton and Manchester.

Table 5.1 Finish Water Quality Summary - Hamilton and Manchester

Parameter	Hamilton	Manchester
pH	7.2 - 7.4	7.1 - 7.8
Chlorine (ppm)	0.50 - 0.75	0.80 - 1.40
Phosphate (ppm)	0.4 – 0.5	0.3 - 1.6
TTHMs (ppb)	47 – 83	36 – 52
HAAs (ppb)	0 - 46	11 – 19
PFAS6 (ppt)	4.9 – 13.0	7.35 to 18.9

In comparing the finished water quality being produced by Hamilton and the Manchester in **Table 5.1**, they are similar with respect to pH and free chlorine, and total phosphate. Both use chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water. Additionally, since both use phosphate products for corrosion control and maintain similar pH levels within their system, there should be minimal impacts to Hamilton's system with respect to lead and copper. Levels of TTHMs and HAA5s within Manchester's system are less as compared to Hamilton's system, with both being below their respective established MCLs. However, PFAS levels at Manchester's Lincoln Street are higher than levels reported at Hamilton's Idlewood and School Street wells. **As such, it appears that Hamilton should be able to utilize a future interconnection with Manchester without any major water quality issues or impacts with meeting current drinking water standards, except for PFAS.** If levels at the Lincoln Street well begin to exceed the MCL, then Manchester would need to take action to alleviate the issue since this a major source within their system.

5.3 Partnering Communities to be Supplied

Per Task 2 of the WMA grant study, we coordinated and requested various water quality and system infrastructure data from the partnering communities including Ipswich, Essex, Wenham and Topsfield as required to complete this task. **Table 5.2** below presents a summary of the finish water quality data collected from each of the communities as it relates to this assessment.

Table 5.2 Partnering Communities - Finish Water Quality Summary

Parameter	Essex	Ipswich	Topsfield	Wenham
pH	7.3 - 7.5	6.5 - 8.0	7.5	Unknown(2)
Chlorine (ppm)	0.53 - 0.59	0.25 - 0.89	0.22 - 0.34	0.3 - 0.88
Phosphate (ppm)	N/A(1)	0.5 - 0.80	Unknown(2)	Unknown(2)
TTHMs (ppb)	37 – 40	20 – 68	18 – 38	15.7
HAAs (ppb)	6 to 9	4.9 -35	ND - 4.5	4.4
PFAS6 (ppt)	<1.9	ND - 23.3	10-23	Unknown(2)

1. Essex does not add phosphate to their finished water.
2. Data was unable to be obtained from the partnering community

The **Town of Ipswich** has a combination of surface water and wells that supply their water system. The surface water source is chemically treated and filtered through a water treatment plant. The post-treatment of the filtered water at the Ipswich's plant includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid, pH adjustment with sodium hydroxide and an ortho/polyphosphate blend for corrosion control. Treatment at Ipswich's wells includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid and a poly/orthophosphate blend for corrosion control.

The **Town of Essex** has only wells for supplying their system which are chemically treated and filtered through a water treatment plant that includes disinfection with chlorine gas, and pH adjustment with potassium hydroxide. The **Town of Topsfield** has only wells for supplying their system which are chemically treated and filtered through a water treatment plant that includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride, pH adjustment with potassium hydroxide and an ortho/polyphosphate blend for corrosion control/sequestering. The **Town of Wenham** has only wells for supplying their system which are chemically treated only including disinfection with calcium hypochlorite, fluoridation with sodium fluoride and corrosion control with zinc orthophosphate.

In comparing the finished water quality of the partnering communities in **Table 5.2** with the Town of Hamilton's current water quality and future water quality if blended with Manchester's supply in **Table 5.1**, they are similar with respect to pH and free chlorine. Although Ipswich does maintain a slightly larger range of pH than the other systems, they do use an ortho/polyphosphate blend like Hamilton and Manchester for corrosion control so it is not anticipated that this higher pH range will be an issue. As shown in **Table 5-2** above, the Town of Essex does not use any phosphate addition for corrosion control which could be an issue with respect to lead and copper if supply from Hamilton and Manchester is delivered into their system. **All the partnering communities rely on free chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water between systems.**

5.4 Possible Water Quality Issues

As previously noted above, based on comparing the finished water quality being maintained by Hamilton and Manchester, we do not envision any issues in meeting current drinking water standards with blending these two water supplies, except for PFAS. However, as noted above, if PFAS levels at Manchester's Lincoln Street well continue to exceed the MCL, then they would need to implement a treatment strategy or modify the current usage of the well to comply with drinking water standards. With respect to Hamilton sharing its current and/or blended Manchester supply with the partnering communities, there may be some potential water quality issues that need to be addressed.

As noted above, Essex does not currently add phosphate at their plant for corrosion control within their distribution system. They only provide pH adjustment. The introduction of phosphate-treated water into their system could potentially disrupt the current chemistry that is providing the protective coating on the interior lead and copper surfaces. It will also increase the chlorine demand within the distribution system which will require adjusting the current chlorine dosages to avoid having coliform issues. For emergency measures, using their interconnection with Hamilton on a short-term basis should not pose a significant issue. However, if Essex intends to rely on their interconnection with Hamilton to obtain supply on a more permanent basis in the future, then consideration to adjusting their current treatment practice for corrosion control to include phosphate should be made.

With respect to transferring and/or sharing supply from Essex into Hamilton and the partnering communities, the lack of phosphate within Essex's finish water could pose an issue depending on how much volume of water is being delivered as compared to what Hamilton is supplying. Any prolonged use of an interconnection with Essex should be further evaluated and likely will require Essex to commence adding phosphate as part of the corrosion control practice.

From the noted water quality data, Hamilton's water system has higher TTHMs and HAA5s as compared to the partnering communities so there is a potential for seeing an increase in these constituents within their systems. However, blending of the supplies between Hamilton and Manchester should minimize this issue to some extent and prevent any possible MCL exceedance. **It should be noted that Hamilton will be improving their current treatment processes at their existing plant which is expected to reduce current TTHMs and HAA5s within their systems in the future.**

A major water quality impact with transferring and/or sharing supply from the partnering communities into Hamilton is **the presence of PFAS** within the individual supplies. As shown from **Table 5-2** the towns of Topsfield and Ipswich have noted PFAS levels just at or above the 20 ppt MCL, similar to Manchester's Lincoln Street well. As Hamilton's primary well supply has current PFAS levels below 5 ppt, introducing water with PFAS levels above the MCL into their system could be problematic. This matter would likely have to be reviewed with MassDEP to determine what special requirements will need to be implemented before approving such a transfer. **But as noted above for Manchester, if PFAS levels within Topsfield and Ipswich continue to exceed the MCL, then they would need to implement a treatment strategy or modify the current usage of their supply to comply with drinking water standards.** It is our understanding that Topsfield has already taken steps to address their PFAS levels and is in the process of adding granular activated carbon (GAC) at their treatment plant.

6. Supplying Partnering Communities

6.1 Infrastructure Improvements Required

As previously noted herein, and as shown on **Figure No. 2 in Appendix A**, Hamilton has existing interconnections with the Towns of Ipswich, Essex and Wenham, ranging in size from 2-inches to 8-inches. There are currently no interconnections in place with Topsfield and as such, a new interconnection and related pipeline will need to be constructed to connect Topsfield with Hamilton. In addition to having a physical connection between systems, there may also be the need for a pressure reducing valve (PRV) or booster pump station depending on the hydraulic gradient of the systems being supplied and the flow rate to be delivered. **Table 6.1** below shows the operating gradient of Hamilton and the partnering community systems.

Table 6.1 Existing System Gradients

Community Water System	Hydraulic Gradient (feet MSL)
Hamilton	210
Manchester	273
Ipswich	210[(1)]
Topsfield	260
Essex	217.7
Wenham	211

1. Main pressure zone gradient as maintained by Tower Hill Tank.

For Wenham, there are two existing interconnections with Hamilton including an 8-inch on Highland Street and a 6-inch on Woodbury Street. Based on Hamilton's existing system, the 8-inch interconnection on Highland Street would be more favorable for sharing supply between Hamilton and Wenham. For Essex, there is an existing 4-inch and 2-inch interconnection with Hamilton at the end of Essex Street (Rte. 22) which is fed by Hamilton's 10-inch main. **To effectively share future supply between the two systems, these two existing interconnections should be replaced with a new single 6-inch connection.** For Ipswich, there is an existing 6-inch interconnection with Hamilton at the end of Waldingfield Road which is fed by Hamilton's 8-inch main. This interconnection should be adequate for sharing supply between Hamilton and Ipswich.

It is our understanding that the existing interconnection with Essex is currently metered, and the other interconnections with Wenham and Ipswich are not metered. However, given the age of the existing meter, we recommend that new revenue meters be installed at all three existing interconnections. As these interconnections will be normally closed and only manually opened when needed under a controlled operation, it is not expected that backflow prevention devices for cross-connection control will be needed. As such, we have not included the installation of these devices in our assessment. If, in the future, these existing interconnections are used on a more permanent basis and/or are left normally open, then the installation of a backflow prevention device may be necessary depending on applicable water system requirements and regulations.

Using Hamilton's computerized model, we conducted steady state simulations under maximum day demands to estimate the available future supply that Hamilton's existing system infrastructure could effectively deliver at each of the existing interconnections. From the results of the analyses, a supply rate of about 200 gpm could be provided at Wenham's existing interconnection location with a reduction in system pressure less than 3 psi. At Essex's existing interconnection location, a supply rate of about 300 gpm could be provided with a reduction in system pressure less than 3 psi. At Ipswich's existing interconnection location, a supply rate of about 150 gpm could be provided with a reduction in system pressure less than 3 psi. Depending on the final design and operational parameters utilized for the new interconnection with Manchester and subsequent upgrades made to Hamilton's system, these supply rates could likely improve.

From **Table 6.1**, given that the existing system gradients for Wenham and Ipswich are about equal to Hamilton's gradient, supply between the systems can likely be delivered via gravity without the need for a PRV or a booster pump station. Depending on the demand and pressure fluctuations that occur within each of the systems over the course of a day, there will be times when the available gravity supply from Hamilton will be slightly reduced. Since these interconnections will be used for sharing supply between both respective systems, we would recommend the use of an electromagnetic type flow meter as the revenue meter which can measure the gravity flow in either direction. Otherwise, two separate meters and pipe connections would be needed.

With Essex having a system gradient about 8 feet higher than Hamilton, **a booster pump station** will likely be needed at the interconnection to effectively supply Essex daily over an extended period. We do not currently have a model of Essex's water system and as such, we cannot determine the actual gradient on the Essex side of the interconnection. There could be times over a course of a day when the gradients between the two systems allow for gravity flow from Hamilton into Essex without the need for pumping. Conversely, supply from Essex into Hamilton can likely be delivered via gravity since Essex maintains a higher gradient than Hamilton. To allow this gravity flow from Essex into Hamilton, the new interconnection with Essex would need to have a bypass around the booster pump station with a separate revenue meter.

For the analyses above, we can only determine the supply rates that Hamilton could possibly deliver into Wenham, Ipswich and Essex, since we do not have working models of the other partnering systems at this time. It is our understanding both Wenham and Ipswich do not have computerized models of their water system. However, based on the operating gradients maintained by the partnering systems as shown in **Table 6.1**, and the noted infrastructure of their systems in **Section 2**, it is reasonable to surmise that these systems should be able to deliver similar supply rates into Hamilton.

For Topsfield, we have no distribution system data at this time with respect to pipeline locations and sizes to appropriately identify options for interconnecting Hamilton to Topsfield. We also cannot determine at this time the supply rate that Hamilton can deliver to Topsfield in the future since we don't know the location of the new interconnection. Based on Topsfield's operating gradient of 260 feet as noted in **Table 6.1**, a booster pump station will be needed for Hamilton to supply Topsfield. Conversely, a pressure reducing valve (PRV) will be needed for Topsfield to supply Hamilton. **We intend to complete the evaluation of a new interconnection to connect Hamilton with Topsfield including pipeline routes and sizes under Task 5 of the WMA grant scope upon obtaining the necessary system data from Topsfield.**

6.2 Estimated Infrastructure Costs

Table 6.2 on the following page presents the estimated costs for the infrastructure upgrades for Hamilton to supply the Towns of Ipswich, Essex and Wenham through the existing interconnections based on the above assessment. **The estimated costs associated with a new interconnection between Topsfield and Hamilton will be included as part of the Task 5 Technical Memorandum along with the evaluation to be completed.**

The estimated water main costs per foot included in the table on the following page are weighted costs and include the cost for furnishing and installing the pipe, valves, fittings, bedding, backfill, traffic control, trench and site restoration. Costs were developed in part using recent construction cost data for new water mains, pumping stations, and appurtenances. The estimated costs do not include land acquisition, right-of-way procurement and legal fees. We have included 30% for engineering/permitting and a 25% contingency for planning purposes. All costs are presented in 2022 dollars and are based on the **May 2022 Boston ENR construction cost index of 17506.61.**

Table 6.2 Infrastructure Upgrades to Existing System Interconnections

Item			Cost[1]
Interconnection with Wenham			
New Revenue Meter Vault and appurtenances[2]			$150,000
New Electrical/Control Systems & SCADA upgrades (for meter)			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$20,000
Subtotal			**$200,000**
Engineering and Permitting (30%)			**$60,000**
Subtotal – Engineering and Construction			**$260,000**
25% Contingency			**$65,000**
Total - Interconnection with Wenham			**$325,000**
Interconnection with Ipswich			
New Revenue Meter Vault and appurtenances[2]			$150,000
New Electrical/Control Systems & SCADA upgrades (for meter)			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$20,000
Subtotal			**$200,000**
Engineering and Permitting (30%)			**$60,000**
Subtotal – Engineering and Construction			**$260,000**
25% Contingency			**$65,000**
Total - Interconnection with Ipswich			**$325,000**
Interconnection with Essex			
New 350 gpm Booster Pump Station w/ Above-Grade Structure (incl. Revenue Meter)			$175,0000
Site work & connections for new Booster Pump Station and Bypass			$75,000
New Revenue Meter Vault and appurtenances (for gravity flow)			$150,0000
New Electrical/Control Systems & SCADA upgrades (for meter)			$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$50,000
Subtotal			**$480,000**
Engineering and Permitting (30%)			**$144,000**
Subtotal – Engineering and Construction			**$624,000**
25% Contingency			**$156,000**
Total - Interconnection with Essex			**$780,000**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.
2. Based on using single electromagnetic flow meter for measuring bidirectional flow.

APPENDIX A

Town of Manchester Water Distribution System Plan dated February 2017

Figure 1 - Pipeline Interconnection Route with Manchester

Figure 2 - Town of Hamilton Water System Plan

Water Distribution System Capital Efficiency Plan™ Manchester by the Sea, MA

TATA & HOWARD

Approximate Scale: 1" = 750'

February 2017

FIGURE 1

PIPELINE INTERCONNECTION ROUTE

DATE: JUNE 2022
SCALE: 1" = 1,000'

Dewberry

FIGURE 2

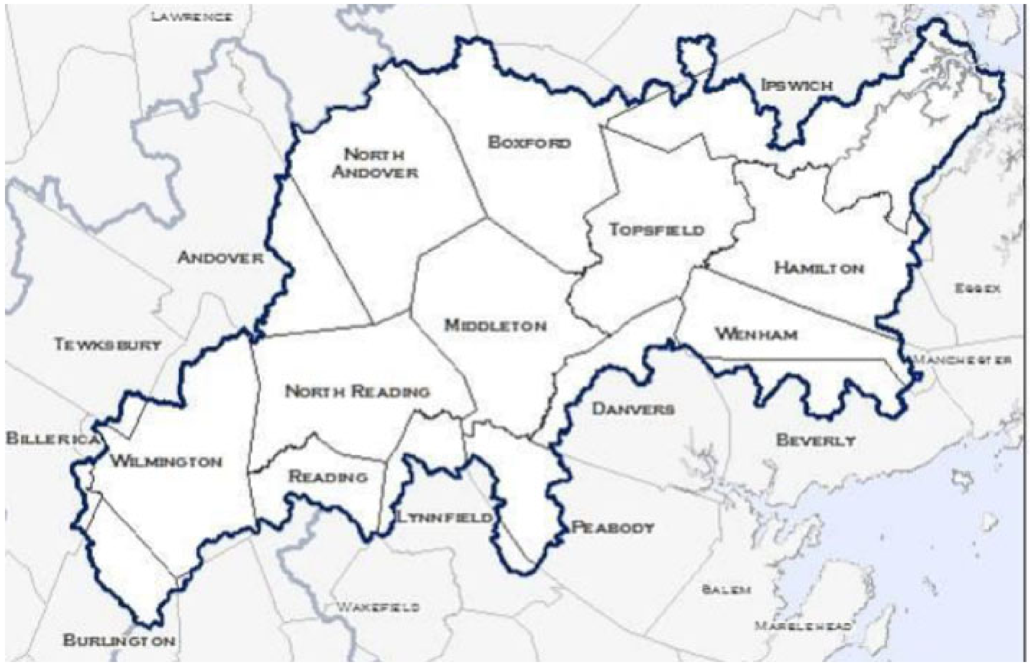
TOWN OF HAMILTON, MA
WATER SYSTEM PLAN

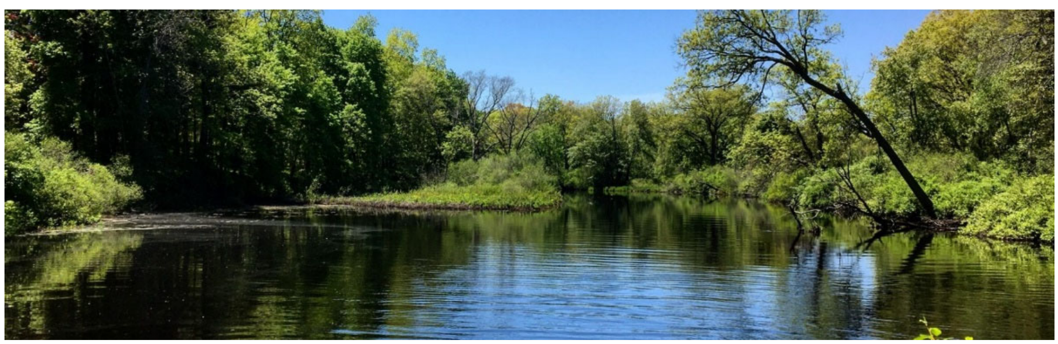
DATE: JUNE 2022
SCALE: 1" = 1,500'

Dewberry
99 Summer Street
Boston, MA 02210
617 695-3400
617 695 3310
www.dewberry.com

APPENDIX C

Task 5 Technical Memorandum w/ Attachments





BWR 2022-01 Water Management Act (WMA) Grant - Regional Evaluation to Improve Water Supply Resiliency within the Lower Ipswich River Watershed

Task 5 – Technical Memorandum

Town of Hamilton, Massachusetts

June 27, 2022

SUBMITTED BY:

Dewberry Engineers Inc.
99 Summer Street
Boston, MA 02210

IN COLLABORATION WITH:

Ipswich River Watershed Association
143 County Road
Ipswich, MA 01938

SUBMITTED TO:

Town of Hamilton
Department of Public Works
577 Bay Road
Hamilton, MA 01982

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Attachments

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Figure 2 - Town of Essex Water System Plan dated June 2022

Figure 3 - Town of Wenham Water System Plan dated June 2022

Figure 4 - Town of Topsfield Water System Plan dated June 2022

Figure 5 - Town of Hamilton Water System Plan dated June 2022

Figure 6 – Hamilton-Topsfield Potential Interconnection dated June 2022

1. Introduction

The overall purpose for the subject WMA Grant is to conduct a regional evaluation of alternative sources to improve water supply resiliency within the lower Ipswich River Watershed for the Town of Hamilton and its neighboring communities of Topsfield, Manchester, Ipswich, Essex and Wenham. The WMA grant is divided into six (6) discrete tasks, each with its own required deliverable. The following Memorandum documents the evaluation and findings to determine the ability of sharing available supply between the **water systems of Ipswich, Essex, Wenham and Topsfield** to mitigate future short-term supply shortages as defined under Task 5 of this WMA grant. An assessment for a future water supply connection with the Town of Manchester has been previously completed under Task 4 of this WMA grant.

1.1 Task Overview

Hamilton's existing water system borders all five (5) partnering communities and currently has interconnections with three of them including Ipswich, Essex and Wenham. This geographic condition places Hamilton in the best position to effectively convey and/or transfer surplus water between the partnering communities to mitigate short-term water supply shortages. For Task 5, the main objective is to evaluate the feasibility of sharing current and future water supplies between the partnering communities of Ipswich, Essex, Wenham and Topsfield on a Mutual Aid Basis. This task includes the following major scope items:

- Review current **WMA registrations and permits** for Hamilton and the adjacent communities to identify where additional withdrawals may be available based on system demands and permitted safe yields to augment supply shortages for the participating communities.
- Review regulatory and legislative issues associated with **establishing a Mutual Aid approach** to sharing groundwater supplies within and out of the basin.
- Identity issues related to **transferring and sharing water on a Mutual Aid basis** through existing and future interconnections with respect to system infrastructure, hydraulics, compatibility of water quality, supply and storage capacity.
- Conduct **computer simulations** using available models to evaluate the impact of sharing and/or transferring supplies between Hamilton and the adjacent water systems through existing and future system interconnections. Analyses will be performed to estimate the available supply capacity that can be hydraulically conveyed through existing and future system interconnections of each water system to augment their water supply needs.
- Evaluate **infrastructure improvements** to alleviate hydraulic limitations and allow the adequate delivery of water supply between the partnering communities including larger diameter water mains, booster pump stations and pressure-reducing valves.
- Identify **potential water quality impacts** as a result of mixing and sharing supplies between the partnering water systems on a Mutual Aid basis. Parameters to be considered include: finish water quality (pH, color, turbidity, iron, manganese), post-disinfection practices (free chlorine, chloramines), corrosion control methods (pH adjustment, phosphate addition) and distribution water quality (chlorine residual, TTHMs, HAAs & PFAS).
- Prepare **cost estimates** associated with the needed permitting, infrastructure and operational improvements to establish new interconnections between Hamilton and the partnering communities to augment supply shortages on a Mutual Aid basis.

2. Description of Community Water Systems

The following presents a summary of the water systems for each of the partnering communities being evaluated under Task 5 including current supply, treatment, distribution and usage based on data collected per Task 2 and from discussions held with town representatives.

2.1 Town of Ipswich

The Town of Ipswich's water system currently includes two (2) surface water supplies, five (5) groundwater supplies, one (1) conventional treatment facility, three (3) storage tanks and approximately 100 miles of water main. The system includes approximately 4,764 service connections, and serves residential, commercial, business and institutional users. From the 2020 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately 1.008 million gallons per day (MGD), with approximately 62% attributed to residential usage, 16% attributed to business/commercial, 1% attributed to municipal/institutional usage, 14% attributed to unaccounted for usage, and the remaining 7% attributed to estimated municipal and miscellaneous usages. The Town has existing emergency interconnections with the neighboring communities of Hamilton and Rowley. The major components of Ipswich's current water system are shown on the attached **Figure 1 – Town of Ipswich Water System Plan dated June 2022 included in Appendix A** as prepared from the Town's GIS data provided for the study.

2.1.1 Supply and Treatment

The water supply that serves the residents of Ipswich includes several sources located within the Parker River Basin and Ipswich River Basin. The sources within the Parker River basin include two surface water sources, the Dow Brook and Bull Brook Reservoirs, the Mile Lane well and the Browns well. The two reservoirs are operated in series with the Bull Brook flowing via gravity into the Dow Brook where the combined sources are then treated. The Town's current WMA authorization allows for a maximum withdrawal of **0.98 MGD**, or 358 million gallons (MG) in a year, from all its combined sources located within the Parker River Basin. For 2020, the total raw water pumped from these sources was reported to be approximately **271.29 MG,** which equates to an average daily withdrawal of **0.743 MGD.**

The sources within the Ipswich River basin include the Fellows Road well, the Essex Road well and the Winthrop GD Well 2. The Town's current WMA authorization allows for a maximum withdrawal of **0.20 MGD**, or 73 MG in a year, from all its combined sources located within the Ipswich River Basin. For 2020, the total raw water pumped from these sources was reported to be approximately **97.19 MG**, which equates to an average daily withdrawal of **0.266 MGD**. A summary of the Town's existing supplies and average annual withdrawals is provided in **Table 2-1** on the following page.

As shown in **Table 2.1**, the Town's two reservoirs provided a majority of Ipswich's drinking water in 2020 totaling approximately 0.642 million gallons or 64 percent. According to the Town's ASR, the reported safe yield of the combined reservoirs is **0.8 MGD**, which is also the annual average withdrawal stated for these two sources in the Town's WMA permit. However, from the February 2019 Water Supply and Demand Evaluation Report commissioned by the Town, the safe yield of the combined reservoirs was recalculated using the 2016 drought as a basis which resulted in a new established firm yield of **0.41 MGD**. The two wells within the Parker River basin including the Mile Lane and Browns well only contributed approximately 0.101 million gallons, or 10 percent, of Ipswich's drinking water in 2020. The approved withdrawal rates for these sources as shown in **Table 2.1** is 0.15 MGD and 0.49 MGD, respectively. As noted in **Table 2.1,** the three (3) well supplies within the Ipswich River basin provided approximately 0.266 million gallons, or 26 percent, of Ipswich's drinking water in 2020, with Fellows Road contributing the most at 0.102 million gallons.

Table 2.1 Town of Ipswich - Existing Water Supplies

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2020 Annual Average Withdrawal (MGD)(5)
Dow Brook Reservoir	Parker	2.50	0.80(2)	0.98(3)	0.642(1)
Bull Brook Reservoir	Parker				
Mile Lane GP Well	Parker	0.22	0.15		0.037
Browns GP Well(7)	Parker	0.20(6)	0.49		0.064
Subtotal		2.92	1.44	0.98	0.743
Fellows Road Well	Ipswich	0.31	0.31	0.20(4)	0.102
Essex Road GP Well	Ipswich	0.21	0.21		0.089
Winthrop GD Well 2	Ipswich	0.23	0.23		0.075
Subtotal		0.75	0.75	0.20	0.266
Total – All Supplies		3.67	2.19	1.18	1.009

1. Includes withdrawals from both Dow Brook and Bull Brook Reservoirs. Bull Brook transferred via gravity into Dow Brook for treatment.
2. Includes both the Dow Brook and Bull Brook Reservoirs as they are operated in series.
3. The total authorized annual withdrawal for the supplies within the Parker River Basin is 0.98 MGD.
4. The total authorized annual withdrawal for the supplies within the Ipswich River Basin is 0.20 MGD.
5. Estimated from Ipswich's 2020 Annual Statistical report (ASR).
6. This use of this source is limited due to water quality issues with manganese.
7. The Browns GP well is currently off-line due to elevated PFAS levels.

The Town's two surface water supplies are chemically treated and filtered at Ipswich's Water Treatment Plant (WTP) located at 277 High Street in Ipswich, MA **(see attached Figure 1 – Town of Ipswich Water System Plan in Appendix A).** The WTF was constructed in 1988 and has a reported maximum production capacity of 2.5 million gallons per day (MGD). Treatment processes at the plant include rapid mixing, flocculation, sedimentation and filtration. The post-treatment of the filtered water includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid, pH adjustment with sodium hydroxide and an ortho/polyphosphate blend for corrosion control. Treatment at Ipswich's five (5) wells includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid and a poly/orthophosphate blend for corrosion control. It is our understanding that the **Browns GP well is currently off-line** due to elevated levels of PFAS, and that new piping has already been installed up to the Town's WTP for purpose of blending the well water with the two surface water reservoirs for treatment. The Town is awaiting MassDEP approval for this approach.

2.1.2 Distribution

Ipswich's water distribution system includes approximately 100 miles of water main ranging in size from 6-inch diameter up to 12-inch diameter, approximately 40,000 feet of larger transmission mains, two (2) booster pump stations and three (3) water storage tanks. The system includes three separate pressure zones including: the Main Service which operates at a hydraulic gradient of 210 feet; the Plover Hill area which operates at a hydraulic gradient of 216 feet; and the Pinefield area which operates at a hydraulic gradient of 269.5 feet.

The Town has three water storage tanks within their distribution system including: the Town Hill tank located off the end of Spring Street within Daniel Boone Park; the Plover Hill tank located off Plover Hill Road and the Pinefield tank located off Dix Road (**see attached Figure 1 – Town of Ipswich Water System Plan in Appendix A). Table 2.2 below** presents the storage volume, dimensions and overflow elevation for each of the tanks. It is our understanding that the Town will be replacing the existing welded steel Town Hill tank with a new 3.0 MG prestressed concrete tank soon.

Table 2.2 Town of Ipswich - Existing Water Storage Tanks

Storage Tank	Year Built	Tank Material	Tank Type	Overflow Elevation (feet MSL)	Height (feet)	Diameter (feet)	Storage Volume (MG)
Town Hill	Unknown	Welded Steel	Reservoir	210.0	40.0	110.0	3.0
Plover Hill	Unknown	Welded Steel	Elevated	216.0	96.0	50.0	0.5
Pinefield	Unknown	Welded Steel	Standpipe	269.5	80.0	46.0	1.0

2.2 Town of Essex

The Town of Essex's water system currently includes three (3) groundwater supplies, one (1) conventional treatment facility, one (1) storage tank and approximately 19 miles of water main. The system includes approximately 1,135 service connections, and serves residential, commercial, business, industrial, agricultural and institutional users. From the 2020 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately 0.201 million gallons per day (MGD), with approximately 64% attributed to residential usage, 11% attributed to residential institutions, 8% attributed to business/commercial, 1% attributed to agricultural and industrial, 2% attributed to municipal/institutional usage, 5.5% attributed to unaccounted for usage, and the remaining 8% attributed to estimated municipal and miscellaneous usages. The Town has existing emergency interconnections with the neighboring communities of Hamilton and Gloucester. The major components of Essex's current water system are shown on the attached **Figure 2 – Town of Essex Water System Plan dated June 2022 included in Appendix A** as prepared from the Town's GIS data provided for the study.

2.2.1 Supply and Treatment

The water supply that serves the residents of Essex includes three (3) wells, the Harry Homan's Drive Well #1, the Harry Homan's Drive Well #2, and Centennial Grove Well #3, all located within the North Coastal Basin. All three well sources are registered supplies, having been in operation prior to the Water Management Act (WMA), which came into effect in 1986. The Town's current WMA registration allows for a maximum authorized withdrawal of **0.22 MGD**, or 80.3 MG in a year, from all three sources combined. For 2020, the total raw water pumped from these sources was reported to be approximately **73.228 MG,** which equates to an average daily withdrawal of **0.201 MGD.** A summary of the Town's existing supplies and average annual withdrawals is provided in **Table 2.3** on the following page.

The Town's three well supplies are chemically treated and filtered at Essex's Water Treatment Plant (WTP) located at 44 Centennial Grove Road in Essex, MA **(see attached Figure 2 – Town of Essex Water System Plan in Appendix A).** The WTP was constructed in 1982 and has a reported maximum production capacity of 1.0 million gallons per day (MGD). Treatment processes at the plant include coagulation, flocculation, sedimentation and filtration. The post-treatment of the filtered water includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid and pH adjustment with potassium hydroxide.

Table 2.3 Town of Essex - Existing Water Supplies

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2020 Annual Average Withdrawal (MGD)(3)
Harry Homan's Drive Well#1	North Coastal	0.36	0.22(1)	0.22(2)	0.201
Harry Homan's Drive Well#2	North Coastal	0.49	0.48(1)		N/A
Centennial Grove Well#3	North Coastal	0.36	0.43(1)		N/A
Total		1.21(4)	1.13	0.22	0.201(3)

1. As reported in the Town's 2020 ASR.
2. The total authorized annual withdrawal for the combined supplies is 0.22 MGD.
3. This represents the supply being pumped into the water treatment plant from all 3 supplies.
4. The Town's water treatment plant that treats all 3 wells has a rated capacity of 1.0 MGD.

2.2.2 Distribution

Essex's water distribution system includes approximately 19 miles of water main ranging in size from 2-inch diameter up to 12-inch diameter, with 70% asbestos-cement, 19% PVC and the remaining percentage cement-lined ductile iron. The system includes one pressure zone which operates at a hydraulic gradient of 217.7 feet as maintained by the Town's only water storage tank, the Craft Hill tank. This tank is located off Story Street and is a glass-fused bolted steel tank that was constructed in 1991. The tank is approximately 27 feet tall and 70 feet in diameter with a storage capacity of approximately 0.8 MG. The overflow elevation of the tank is approximately 217.7 feet MSL.

2.3 Town of Wenham

The Town of Wenham's water system currently includes two (2) groundwater supplies, one (1) pump station, two (2) storage tanks and approximately 30 miles of water main. The system includes approximately 1,220 service connections, and serves residential, commercial, business, industrial, agricultural and institutional users. From the 2021 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately 0.259 million gallons per day (MGD), with approximately 83% attributed to residential usage, 2% attributed to residential institutions, 1.5% attributed to business/commercial, 0.5% attributed to agricultural, 0.7% attributed to municipal/institutional usage, 11% attributed to unaccounted for usage, and the remaining percentage attributed to estimated municipal and miscellaneous usages. The Town has existing emergency interconnections with the neighboring communities of Hamilton and Beverly. The major components of Wenham's current water system are shown on the Town's attached **Figure 3 – Town of Wenham Water System Plan dated June 2022 included in Appendix A** as prepared from the Town's GIS data provided for the study.

2.3.1 Supply and Treatment

The water supply that serves the residents of Wenham includes two (2) gravel pack wells, GP Well 1 and GP Well 2, both located on Pleasant Street within the Ipswich River Basin **(see attached Figure 3 – Town of Wenham Water System Plan in Appendix A)**. Both well sources are registered supplies, having been in operation prior to the Water Management Act (WMA), which came into effect in 1986. The Town's current WMA registration allows for a maximum authorized withdrawal of **0.29 MGD**, or 105.85

MG in a year, from both sources combined. For 2021, the total raw water pumped from these sources was reported to be approximately **94.415 MG,** which equates to an average daily withdrawal of **0.259 MGD** with 73 percent supplied by GP Well 1 and 27 percent supplied by GP Well 2. A summary of the Town's existing supplies and average annual withdrawals is provided in **Table 2.4** below.

Table 2.4 Town of Wenham - Existing Water Supplies

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2021 Annual Average Withdrawal (MGD)
GP Well 1	Ipswich	0.39	0.40(1)	0.29(2)	0.19
GP Well 2	Ipswich	1.07	1.08(1)		0.07
Total		1.48	1.48	0.29	0.26

1. As reported in the Town's 2021 ASR.
2. The total authorized annual withdrawal for the combined supplies is 0.29 MGD.

Treatment of the Town's two well supplies are provided at the Pleasant Street Pump Station. Raw water from both wells are combined within the station and treated with calcium hypochlorite for disinfection, zinc orthophosphate for corrosion control and sodium fluoride for fluoridation.

2.3.2 Distribution

Wenham's water distribution system includes approximately 30 miles of water main ranging in size from 6-inch diameter up to 12-inch diameter, with 80% asbestos-cement and 20% cement-lined ductile iron. The system includes one pressure zone which operates at a hydraulic gradient of 211 feet as maintained by the Town's Lords Hill reservoir which is a welded steel tank located off Burnham Road that was constructed in 1958. This tank is approximately 35 feet tall and 60 feet in diameter with a storage capacity of approximately 0.74 MG. The Town also operates the Iron Rail Pump Storage facility located off Grapevine Road which is a ground level tank constructed in 2002 and equipped with a 2,000 gpm pump system that draws water from the tank as needed to supply additional fire protection. This tank is constructed of concrete and has a storage capacity of 0.60 MG. **Table 2.5 below** presents the storage volume, dimensions and overflow elevation for each of the tanks.

Table 2.5 Town of Wenham - Existing Water Storage Tanks

Storage Tank	Year Built	Tank Material	Tank Type	Overflow Elevation (feet MSL)	Height (feet)	Diameter (feet)	Storage Volume (MG)
Lords Hill	1958	Welded Steel	Reservoir	211	35	60	0.74
Iron Rail	2002	Concrete	Reservoir	77	26	62	0.6

2.4 Town of Topsfield

The Town of Topsfield's water system currently includes two (2) groundwater supplies, two (2) pump stations, one (1) greensand filtration plant, two (2) storage tanks and approximately 50 miles of water main. The system includes approximately 1,850 service connections, and serves residential, commercial, business, industrial, agricultural and institutional users. From the 2021 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately 0.393 million gallons per day (MGD), with approximately 69% attributed to residential usage, 1.4% attributed to residential institutions, 4% attributed to business/commercial, 1% attributed to agricultural and industrial, 22% attributed to unaccounted for usage, and the remaining percentage attributed to estimated municipal and miscellaneous usages. The Town has existing emergency interconnection with the neighboring community of Danvers, which operates at a higher pressure and can supply Topsfield via gravity flow. The major components of Topsfield's current water system are shown on the Town's attached **Figure 4 – Town of Topsfield Water System Plan dated June 2022 included in Appendix A** as prepared from the Town's GIS data provided for the study.

2.4.1 Supply and Treatment

The water supply that serves the residents of Topsfield includes two (2) well supplies, the North Street wellfield and the Perkins Row wellfield, both located within the Ipswich River Basin. Both well sources are registered supplies, having been in operation prior to the Water Management Act (WMA), which came into effect in 1986. The Town's current WMA registration allows for a maximum withdrawal of **0.43 MGD**, or 156.95 MG in a year, and maximum permitted withdrawal of **0.17 MGD**, or 62.05 MG in a year, from the two sources combined. It is our understanding that Topsfield gave up their WMA permitted withdrawal several years ago and therefore is no longer available for consideration. For 2021, the total raw water pumped from these sources was reported to be approximately **143.617 MG,** which equates to an average daily withdrawal of **0.393 MGD.** A summary of the Town's existing supplies and average annual withdrawals is provided in **Table 2.6** below.

Table 2.6 Town of Topsfield - Existing Water Supplies

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2021 Annual Average Withdrawal (MGD)
North Street Wellfield	Ipswich	1.14(1)	1.30(1)	0.43(2)	0.314
Perkins Row Wellfield	Ipswich	0.43(1)	0.48(1)		0.079
Total		1.57(3)	1.78	0.43	0.393

1. As reported in the Town's 2021 ASR.
2. The total authorized annual withdrawal for the combined supplies is 0.43 MGD. The Town has recently given up its permitted annual withdrawal of 0.17 MGD.
3. The Town's water treatment plant that treats both wells has a rated capacity of 1.4 MGD.

The Town's two wellfield supplies are chemically treated and filtered at the Boston Street Water Treatment Plant located at 279 Boston Street in Topsfield, MA **(see attached Figure 4 – Town of Topsfield Water System Plan in Appendix A).** The WTF is a greensand filtration plant constructed in 2019 and has a reported maximum production capacity of approximately 1.4 million gallons per day (MGD). Treatment processes at the plant include aeration, corrosion control, disinfection, iron & manganese removal with greensand filtration, sequestration, and fluoridation. The post-treatment of the filtered water includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride, pH adjustment with potassium hydroxide and an ortho/polyphosphate blend for corrosion control.

2.4.2 Distribution

Topsfield's water distribution system includes approximately 50 miles of water main ranging in size from 4-inch diameter up to 12-inch diameter, with 50% asbestos-cement, 45% cement-lined ductile iron and the remaining percentage cast-iron and HDPE. The system includes one pressure zone which operates at a hydraulic gradient of 260 feet as maintained by the Town's two water storage tanks including the

Boston Street tank and the Garden Street tank (**see attached Figure 4 – Town of Topsfield Water System Plan in Appendix A). Table 2.7** below presents the storage volume, dimensions and overflow elevation for each of the tanks. It is our understanding that the Town is evaluating the replacement of the Boston Street tank.

Table 2.7 Town of Topsfield - Existing Water Storage Tanks

Storage Tank	Year Built	Tank Material	Tank Type	Overflow Elevation (feet MSL)	Height (feet)	Diameter (feet)	Storage Volume (MG)
Garden Street	1972	Concrete	Reservoir	260	24	60	0.5
Boston Street	1948	Concrete	Reservoir	260	25	55	0.5

1. The Town will be replacing the existing Boston Street tank.

2.5 Town of Hamilton

The Town of Hamilton's water system currently includes five (5) groundwater supplies, one (1) storage tank, one (1) water treatment plant and approximately 54 miles of distribution piping. The system includes approximately 2,563 service connections, and serves residential, commercial, industrial, and institutional users. From the 2021 Annual Statistical Report (ASR), the average daily water consumption for the system was reported to be approximately 0.561 million gallons per day (MGD), with approximately 63% attributed to residential usage, 3% attributed to commercial/business, 7% attributed to municipal/institutional usage, 11% attributed to unaccounted for usage, and the remaining 16% attributed to industrial and miscellaneous usages. The Town has emergency interconnections with the neighboring communities of Essex, Wenham and Ipswich. The major components of Hamilton's current water system are shown on the Town's **Water System Plan dated June 2022 included as Figure 5 in Appendix A.**

2.5.1 Supply and Treatment

The water supply that serves the residents of Hamilton includes five (5) groundwater supplies including Idlewood #1, Idlewood #1 Satellite, Idlewood #2, Plateau and Caisson Satellite wells, all located within the Idlewood Wellfield, and the School Street Well. All Town's well supplies are located within the Ipswich River Basin. The School Street well and Idlewood#1 well are registered supplies, having been in operation prior to the Water Management Act (WMA), which came into effect in 1986. The Idlewood #2, Idlewood #1 Satellite, Caisson Satellite and Plateau wells were added to the Town's Water Management Act (WMA) Permit as permitted supplies back in 1989, 2000 and 2003, respectively.

The Town's current WMA authorization allows for a maximum registered withdrawal of **0.92 MGD**, or 335.80 MG in a year, and maximum permitted withdrawal of **0.11 MGD**, or 40.15 MG in a year, for a total authorized withdrawal of **1.03 MGD**, or 376 MG in a year, from all five sources within the Ipswich River Basin. Additionally, no more than 0.88 MGD can be withdrawn from the Idlewood Wellfield, and no more than 0.19 MGD can be withdrawn from School Street. For 2021, the total raw water pumped from the Town's sources was reported to be approximately **204.77 MG**, which equates to an average daily withdrawal of **0.561 MGD.** A summary of the Town's existing supplies and average annual withdrawals is provided in **Table 2.8** on the following page.

As shown in **Table 2.8**, the Idlewood well supplies provided a majority of Hamilton's drinking water in 2021 totaling approximately 0.545 million gallons or 96 percent. The Town's School Street well only contributed approximately 0.020 MGD, or 4%, which is typical as Hamilton can only utilize this well sparingly due to its minimal drawdown and recovery time. Also, **from Table 2.8**, the Town did not pump the Idlewood #2 well at all during 2021. This well has been off-line to mitigate water quality issues related to the formation of TTHMs at the plant and impacts to filter performance due to elevated levels of manganese.

Table 2.8 Town of Hamilton - Existing Water Supplies

Supply	River Basin	Maximum Pump Capacity (MGD)	Approved Daily Withdrawal (MGD)	WMA Approved Annual Withdrawal (MGD)	2021 Annual Average Withdrawal (MGD)
Idlewood Wellfield[1]					
Caisson Satellite	Ipswich	0.21	0.22		0.096
Idlewood #1	Ipswich	0.31[3]	0.71[2]		0.323[2]
Idlewood Satellite #1	Ipswich	0.14		0.88	
Idlewood #2[4]	Ipswich	0.32[3]	0.57		0
Plateau	Ipswich	0.32[3]	0.51		0.126
Subtotal		1.30[6]	2.01	0.88	0.545
School Street[2]	Ipswich	0.16	0.19	0.19	0.020
Total – All Supplies		1.46	2.20	1.07[5]	0.565

1. The WMA authorized withdrawal for all combined wells within the Idlewood wellfield is 0.88 MGD.
2. Includes both Idlewood #1 and Idlewood Satellite #1 wells.
3. The maximum pump capacity of these sources is below the approved daily withdrawal due to water Quality issues with iron and manganese.
4. The Idlewood #2 well is currently off-line due to high TOCs and manganese.
5. The Town's WMA allows a total authorized withdrawal of 1.03 MGD from all five sources.
6. The Town's water treatment plant that treats the Idlewood wellfield has a maximum operating capacity of 0.93 MGD.
7. The School Street is currently off-line due to elevated PFAS levels.

The Town's 4 wells within the Idlewood wellfield are chemically treated and filtered at the Idlewood Water Treatment Plant (WTP) located at 67 Pine Tree Drive in Hamilton, MA **(see attached Figure 5 – Town of Hamilton Water System Plan in Appendix A).** The WTP was constructed in 2000 and has a reported maximum production capacity of 1.3 million gallons per day (MGD). Prior to 2018, the WTP was operating at a reduced capacity due to filter performance, which limited the finished water production rate to about 0.642 MGD. Since the completion of recent upgrades including the rehabilitation of the filters, the WTP is now operating at an average rate of about 0.93 MGD. Treatment processes at the plant include oxidation followed by filtration through iron and manganese pressure filters. The post-treatment of the filtered water includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride and an ortho/polyphosphate blend for corrosion control.

Treatment at the Town's School Street well includes the addition of sodium hypochlorite for disinfection, sodium fluoride for fluoridation, potassium hydroxide for pH adjustment and a poly/orthophosphate blend for corrosion control.

2.5.2 Distribution

Hamilton's water distribution system includes approximately 54 miles of water main ranging in size from 2-inch diameter up to 12-inch diameter, composed of cement-lined ductile iron, unlined cast iron and asbestos cement. The Town has had an on-going program in place over the last few years to replace several sections of asbestos cement pipe with cement-lined ductile iron. To date, the Town has replaced approximately 30,000 feet of asbestos cement pipe. The system includes one pressure zone which operates at a hydraulic gradient of 210 feet as maintained by the Town's only water storage tank, the Browns Hill Reservoir. This tank is located on the Gordon Conwell Theological Seminary property off Essex Street (**see attached Figure 5 – Town of Hamilton Water System Plan in Appendix A).** The existing reservoir is a buried concrete structure consisting of four individual cells, approximately 11 feet deep, which are connected by internal piping and can be isolated as needed. The first cell was constructed in 1935, with the last cell constructed some time before 1972. The reservoir has a storage volume of 0.85 MG and operates at a hydraulic gradient of approximately 210 feet (MSL).

3. Adequacy of Community Water Supplies

The following is an assessment to determine the available supply surplus that each partnering community may have to share under their current WMA authorized withdrawals for alleviating current and future short-term supply shortages while meeting their system's future water supply needs. The likelihood of being able to share any identified surplus supply between the partnering communities under current WMA allocations and Interbasin Transfer Act (IBTA) regulations is discussed in Section 4.

3.1 Town of Ipswich

As shown in **Table 2.1**, Ipswich's average daily withdrawal and/or demand in 2020 was reported to be 1.009 MGD with 0.743 MGD supplied by its sources within the Parker River Basin and 0.266 MGD supplied by its sources within the Ipswich River Basin. From **Table 2.1**, the Town's current WMA authorized withdrawal for its Parker River Basin sources is 0.98 MGD and 0.20 MGD for its Ipswich River Basin supplies, respectively. Based on the reported 2020 water usage, the Town was below its current WMA authorized withdrawal of 0.98 MGD from the Parker River basin but exceeded its current WMA authorized withdrawal of 0.20 MGD from the Ipswich River basin. From the Town's 2020 ASR, the unaccounted-for water usage was calculated to be 14% which is above the 10% goal established by MassDEP but is reasonable given the size and age of Ipswich's water system.

From the Town's **Final Water Demand and Supply Evaluation Report dated February 2019,** future average day demands for Ipswich were estimated to determine the future adequacy of the Town's supplies based on historical water usage, population projections and potential development. From this assessment, the Town's average day demand for 2040 was estimated to be **1.39 MGD** which is a 27% increase from 2020 and exceeds its current total WMA authorized withdrawal of 1.18 MGD. Additionally, as noted in Section 2.1, the safe yield of the Town's combined reservoirs of 0.80 MGD was re-evaluated in the February 2019 Report using supply data from the 2016 drought which resulted in a new established firm yield of **0.41 MGD**. This determination results in having less supply available from these sources during a drought condition likely impacting the Town's ability to meet future water needs. Although Ipswich is allowed under the current WMA registration to withdraw an additional 0.10 MGD of water from its two well supplies within the Ipswich River Basin, this is not being considered for this assessment since the goal of this study is to reduce withdrawals within the basin.

From **Table 2.1,** the total maximum pump capacity for Ipswich's Parker River basin sources is 2.92 MGD with the water treatment plant serving the two reservoirs having a reported rated production capacity of 2.5 MGD. The total maximum capacity for the Town's Ipswich River basin sources is reported to be 0.75 MGD. Based on the these reported capacities, it appears that Ipswich has the existing infrastructure in place to deliver its future water supply needs assuming the Town can obtain an increase in its current WMA authorized withdrawal limits. **Table 3.1** on the following page compares the Town's existing supply capacity to its current and future water usage as presented above with all sources available and in operation. Although the Town's **Browns GP well is currently off-line** due to elevated levels of PFAS, it is our understanding that the Town is in the process of completing system upgrades to allow the well to be blended with its two surface reservoirs for treatment at its WTP.

Table 3.1.Town of Ipswich – Supply Versus Usage

Year	Maximum Supply Capacity (MGD)	Average Day Demand (MGD)	WMA Authorized Withdrawal (MGD)[2]	Surplus/ Deficit (MGD)	Existing Restricted Withdrawal (MGD)[3]	Surplus/ Deficit (MGD)
2020	3.67[1]	1.009	1.18	+0.171	0.96	-0.050
2040	3.67[1]	1.390	1.18	-0.210	0.96	-0.430

1. This includes all sources pumped from both the Parker River and Ipswich River basins.
2. This is the total combined authorized daily withdrawal from both the Parker River and Ipswich River basins.
3. As estimated in the February 2019 Final Water Demand and Supply Evaluation Report.

As shown in **Table 3.1,** Ipswich has a current surplus of 0.171 MGD available within their authorized withdrawal to share between the partnering communities on a short-term basis, which equates to a total yearly volume of 62.4 MG. However, from **Table 3.1**, in 2040, the Town will face a supply deficit of 0.210 MGD based on its current WMA authorized withdrawal of 1.18 MGD. When considering the restricted use of the two reservoirs during drought conditions to the established firm yield of 0.41 MGD, the maximum withdrawal rate for the Town's sources as reported in the February 2019 Water Supply and Demand Evaluation Report will be **0.96 MGD.** This will result in a future supply deficit of 0.43 MGD as shown in **Table 3.1**. Based on this condition, it was recommended in the February 2019 report that the Town increase its water supply by 0.43 MGD along with requesting an increase in its current WMA withdrawal limits to meet future water demands.

The Town is undertaking a number of actions to address the noted supply issues including: the development, design and approval of a new well source at the Town's existing Lynch site: the development, design and approval of a new well to replace the existing Browns well along with new piping to treat the new well at the Town's water treatment plant; and upgrades to the existing plant to improve treatment performance and capacity. From the February 2019 Report, the new Lynch well could produce a potential capacity up to **0.73 MGD** and the new Browns replacement well could produce up to **0.58 MGD**. These two proposed wells which are located within the Parker River basin would likely alleviate the Town's future supply deficits assuming MassDEP approves an increase in the Town's current WMA withdrawal of 0.98 MGD for its Parker River basin sources. Depending on the actual yields of the new wells and approved WMA withdrawal limits, Ipswich may have future surplus available to share with the partnering communities. This regulatory impact is further discussed in Section 4.

3.2 Town of Essex

As shown in **Table 2.3,** Essex's average daily withdrawal and/or demand in 2020 was reported to be 0.201 MGD which is below its current WMA registered withdrawal of 0.22 MGD from the North Coastal Basin. From the Town's 2020 ASR, the unaccounted-for water usage was calculated to be only 5.5% which is very low and means that the Town is maximizing the use of its available supply. From the Town's **Water System Plan dated September 2019**, future average day demands for Essex were estimated to determine the future adequacy of the Town's supplies based on historical water usage, population projections and potential development. From this assessment, the Town's average day demand for 2035 was estimated to be **0.26 MGD** which is almost a 30% increase from 2020 and exceeds its current WMA registered withdrawal of 0.22 MGD. However, Essex can withdraw an additional 0.10 MGD on top of its registered 0.22 MGD on an average daily basis without triggering additional permitting so they will still be able to operate under their current registration and meet their future water needs.

From **Table 2.3,** the total maximum pump capacity for Essex's 3 wells is 1.21 MGD with the water treatment plant having a reported rated production capacity of 1.0 MGD. As all three wells are pumped up the plant for treatment, the maximum pump capacity of Essex's supply system is 1.0 MGD which is adequate to meet its future water needs and possibly supplement other partnering communities. **Table 3.2** below compares the Town's existing supply capacity to its current and future water usage as presented above with all its wells available and in operation. As shown in **Table 3.2,** Essex will eventually exceed its WMA registered withdrawal of 0.2 MGD and will have to rely on the additional 0.1 MGD withdrawal allowable under its current registration to meet future water needs.

Table 3.2.Town of Essex – Supply Versus Usage

Year	Maximum Supply Capacity (MGD)	Average Day Demand (MGD)	WMA Authorized Withdrawal (MGD)(2)	Surplus/ Deficit (MGD)	WMA Allowable Withdrawal (MGD)(3)	Surplus/ Deficit (MGD)
2020	1.0(1)	0.201	0.220	+0.019	0.320	+0.119
2035	1.0(1)	0.260	0.220	-0.040	0.320	+0.060

1. This is the rated capacity of Essex's water treatment plant which treats all 3 supplies.
2. This is the registered daily withdrawal for Essex's system.
3. This represents the additional 0.1 MGD that the Town can withdraw under their current registration.

From **Table 3.2**, there is a current surplus of about 0.12 MGD available with Essex utilizing its full 0.32 MGD allowable withdrawal to share between the partnering communities on a short-term basis, which equates to a total yearly volume of 43.8 MG. In 2035, this available surplus will be reduced to 0.06 MGD, which equates to a total yearly volume of 21.9 MG. However, this identified surplus is assuming MassDEP would allow Essex to consistently pump over its registered withdrawal of 0.22 MGD which may not be the case. This regulatory impact is further discussed in Section 4.

3.3 Town of Wenham

As shown in **Table 2.4,** Wenham's average daily withdrawal and/or demand in 2021 was reported to be 0.260 MGD which is below its current WMA registered withdrawal of 0.29 MGD from the Ipswich River Basin. From the Town's 2021 ASR, the unaccounted-for water usage was calculated to be 11% which is just above the 10% goal established by MassDEP. From the data collection conducted under Task 2, it was noted that Wenham has not completed a recent Water System Master Plan and therefore does have any future population projections and/or future water need forecasts available. Per discussions with Town staff, it is believed that future average day demands over the next 15 years should remain relatively constant with minimal increase in usage. For the purposes of this report, we have assumed that the Town's average day demand for 2035 will be increase to **0.265 MGD** which is roughly a 2% increase in demand from 2021. Based on this assumption, the Town will still be able to operate below its current WMA registered withdrawal of 0.29 MGD and meet their future water needs.

From **Table 2.4,** the total maximum pump capacity for Wenham's two wells which are combined within the Pleasant Street Pump Station for chemical treatment is 1.48 MGD which is adequate to meet its future water needs and possibly supplement other partnering communities. **Table 3.3** on the following page compares the Town's existing supply capacity to its current and future water usage as presented above with both its wells available and in operation.

Table 3.3. Town of Wenham – Supply Versus Usage

Year	Maximum Supply Capacity (MGD)	Average Day Demand (MGD)	WMA Authorized Withdrawal (MGD)(2)	Surplus/ Deficit (MGD)
2021	1.48(1)	0.260	0.290	+0.030
2035	1.48(1)	0.265(3)	0.290	+0.025

1. This is the rated capacity of Wenham's two existing well supplies.
2. This is the authorized daily withdrawal for Wenham's system.
3. This demand was estimated for the purposes of this report and not based on actual future water need forecasts.

As shown in **Table 3.3,** Wenham has a current surplus of 0.030 MGD available within their authorized withdrawals to share between the partnering communities on a short-term basis, which equates to a total yearly volume of 10.95 MG. In 2035, this surplus will be reduced to 0.025 MGD, or a total yearly volume of 9.13 MG.

3.4 Town of Topsfield

As shown in **Table 2.6,** Topsfield's average daily withdrawal and/or demand in 2021 was reported to be 0.393 MGD which is below its current WMA registered withdrawal of 0.430 MGD from the Ipswich River Basin. From the Town's 2021 ASR, the unaccounted-for water usage was calculated to be 22% which is high compared the 10% goal established by MassDEP. From the data collection conducted under Task 2, it was noted that Topsfield does not have a recent water system master plan or report that projects future water needs. However, recent DCR projections used by the Town for renewing a previous water permit shows a slight increase in population which was the basis for the requested 0.03 MGD of additional permitted withdrawal. The Town is not expecting a great deal of growth as both available land and supply is limited. For the purposes of this report, we have assumed that the Town's average day demand for 2035 will be increase to **0.405 MGD** which is roughly a 3% increase in demand from 2021. Based on this assumption, the Town will still be able to operate below its current WMA registered withdrawal of 0.430 MGD and meet their future water needs.

From **Table 2.6,** the total maximum pump capacity for Topsfield's two wellfields is 1.57 MGD with the water treatment plant having a reported rated production capacity of 1.40 MGD. As both well fields are pumped up the plant for treatment, the maximum pump capacity of Topsfield's supply system is 1.4 MGD which is adequate to meet the estimated future water needs and possibly supplement other partnering communities. **Table 3.4** below compares the Town's existing supply capacity to its current and future water usage as presented above with both its wells available and in operation.

Table 3.4.Town of Topsfield – Supply Versus Usage

Year	Maximum Supply Capacity (MGD)	Average Day Demand (MGD)	WMA Authorized Withdrawal (MGD)(2)	Surplus/ Deficit (MGD)
2021	1.40(1)	0.393	0.430	+0.037
2035	1.40(1)	0.405(3)	0.430	+0.025

1. This is the rated capacity of Topsfield's existing water treatment plant.
2. This is the registered daily withdrawal for Topsfield's system.
3. This demand was estimated for the purposes of this report and is not based on actual future water need forecasts.

As shown in **Table 3.4,** Topsfield has a current surplus of 0.037 MGD available within their authorized withdrawals to share between the partnering communities on a short-term basis, which equates to a total yearly volume of 13.50 MG. In 2035, this surplus will be reduced to 0.025 MGD, or a total yearly volume of 9.13 MG. As noted above, Topsfield operated their system in 2021 with a reported unaccounted-for water usage of 22% or approximately 31.6 MG for the year. This equates to a daily withdrawal rate of 0.087 MGD. If the Town can eventually reduce their unaccounted-for water by half to a more reasonable 11%, this would conversely increase the supply surplus by about 0.043 MGD (0.087 MGD x 0.5) to approximately 0.068 MGD, which equates to a total yearly volume of 24.82 MG. This is a significant reduction in water usage which if achieved, would allow the Town to continue operating under their current WMA registration while providing additional surplus for sharing water with the partnering communities.

3.5 Town of Hamilton

As shown in **Table 2.8,** Hamilton's average daily withdrawal and/or demand in 2021 was reported to be 0.565 MGD which is below its current WMA authorized withdrawal of 1.03 MGD from the Ipswich River Basin. From the Town's 2021 ASR, the unaccounted-for water usage was calculated to be 11% which is just above the 10% goal established by MassDEP. From the Town's **Water System Master dated February 2020,** future average day demands for Hamilton were estimated to determine the future adequacy of the Town's supplies based on historical water usage, population projections and potential development. From this assessment, the Town's average day demand for 2035 was estimated to be **0.671 MGD** which is about an 18% increase from 2020 but still below its current WMA authorized withdrawal of 1.03 MGD. As such, the Town will be able to meet their future water needs with their current WMA authorized withdrawal.

From **Table 2.8,** the total maximum pump capacity for the Town's Idlewood wells is 1.30 MGD with the water treatment plant having a current production capacity of 0.93 MGD. As all wells are pumped up to the plant for treatment, the maximum pump capacity of the Idlewood wells is 0.93 MGD which is adequate to meet its future water needs and possibly supplement other partnering communities. Additionally, as shown in **Table 2.8,** the Town also has 0.16 MGD of available withdrawal from its School Street well however, as evident from the 2021 ASR, this well has not historically been pumped consistently at this rate. As previously noted, the Town's Idlewood #2 well which is one of the larger producers has been off-line for over a year due to elevated TOCs and manganese. The Town has also recently taken the School Street well off-line due to elevated PFAS levels. With these wells off-line, the Town's total maximum pump capacity of 1.46 MGD has been currently reduced to **0.98 MGD**.

Table 3.5 on the following page compares the Town's existing supply capacity to its current and future water usage as presented above with all its wells available and in operation excluding the Idlewood #2 well and School Street well which will likely be off-line indefinitely. As shown in **Table 3.5,** under current conditions with the Idlewood #2 well and School Street well off-line, Hamilton has a current surplus of 0.315 MGD available within their authorized withdrawal to possibly share between the partnering communities on a short-term basis, which equates to a total yearly volume of 114.98 MG. In 2035, this surplus will be reduced to 0.209 MGD or a total yearly volume of 76.29 MG, respectively.

Table 3.5.Town of Hamilton – Supply Versus Usage

Year	Maximum Supply Capacity (MGD)	Average Day Demand (MGD)	WMA Authorized Withdrawal (MGD)(2)	Surplus/ Deficit (MGD)
2021	0.93(1)	0.565	0.880	+0.315
2035	0.931)	0.671	0.880	+0.209

1. This is the maximum production capacity of Hamilton's water treatment plant which treats the Idlewood wells.
2. This is the authorized daily withdrawal for the Town's Idlewood wellfield only as the School Street well is off-line.

Although the Town's authorized withdrawal meets their current and future average day demands, the available supply capacity of the Idlewood wells is limited by having to routinely take one of the wells off-line for redevelopment and maintenance due to excessive iron and manganese within the raw water. Some of these wells require redevelopment on annual basis which depending on the time of year, places a great strain on the remaining wells and requires the plant to operate close to 24 hours a day to maintain adequate levels within their storage tank. For example, having one well off-line can reduce the Town's available supply capacity to **0.67 MGD** at times which is less than the Town's higher summer demands which approach 1.0 MGD. Even with having Idlewood #2 well on-line, because of its poor water quality, its use is limited due to impacts to the plant's filter performance and as such, does not contribute enough to alleviate this supply inadequacy.

The overall quality and performance of the Town's Idlewood wells have been gradually declining over the years with current production at about 60% of their approved capacity. This reduction is due to the raw water quality of these wells which limits the production rate that the wellfield can yield and provides little to no redundancy for the Town to rely on. In addition, as noted above, the raw water quality of these wells put a significant strain on the water treatment plant, limiting its production capacity which makes it difficult to meet higher demand periods. This loss of production within their primary source of supply is the basis for Hamilton completing this study to identify alternative sources to improve its water supply resiliency to meet future water needs in the event future losses in production of these wells occur.

The Town has taken steps to address the raw water quality and production issues including the construction of a new GAC treatment facility to remove TOCs and TTHMs from the filtered water which will hopefully allow the Town to utilize the wells at a higher production rate. They are also performing maintenance on the plant's pressure filters to improve their performance and production capacity as well. Upon completion of these improvements, the Town should be able to use Idlewood #2 well when needed to help meet system demands however, its use will always be limited due to its raw water quality.

3.6 **Summary**

From the water supply assessment completed herein, all partnering communities have some surplus supply available to be shared on a short-term basis under their current WMA authorized withdrawals based on current average day conditions. Under future average day conditions, only the Towns of Hamilton, Topsfield and Wenham will have surplus supply available to share under their current WMA authorized withdrawals. However, as noted above, Hamilton's supply capacity is limited due to the water quality of its wells which significantly diminishes the surplus available, particularly during high demand periods. Both Ipswich and Essex will face future supply deficits under their current WMA authorized withdrawals and thus will not be able to share supply. They will likely need to request an increase in their

WMA authorized withdrawal in the future or identify alternate sources of supply. As previously noted, Ipswich is currently evaluating two possible well sites to address their future water needs. For Essex, although they will exceed their WMA registered withdrawal, they are allowed under their current registration to withdraw an additional 0.1 MGD over their registered 0.22 MGD on an average daily basis which will meet their future water needs but will not provide any surplus.

Another element to consider with respect to sharing surplus supply between the partnering communities is when the actual surplus will be available. The estimated supply surplus presented herein is based on average daily demands which represents the total volume of finished water pumped over 365 days. During periods of higher seasonal demands or maximum day demand where Towns would be pumping their supplies at higher rates to meet system water needs, less surplus supply would be available as previously discussed above with respect to Hamilton's system. To illustrate this, we prepared **Table 3.6** below which compares available supply surplus under average day and maximum day demands for each of the partnering community water systems.

Table 3.6. Available Surplus – Average Day & Maximum Day Demands

Year	Maximum Supply Capacity (MGD)	WMA Authorized Withdrawal (MGD)	Average Day Demand (MGD)	Surplus/ Deficit (MGD)	Maximum Day Demand (MGD)	Surplus/ Deficit (MGD)
Ipswich:						
2020	3.67	1.18	1.009	+0.171	1.837	-0.657
2040	3.67	1.18	1.390	-0.210	4.170	-2.99
Essex:						
2020	1.00	0.220	0.201	+0.019	0.435	-0.215
2035	1.00	0.220	0.260	-0.040	0.421	-0.201
Wenham:						
2021	1.48	0.290	0.260	+0.030	0.466	-0.176
2035	1.48	0.290	0.265	+0.025	0.477	-0.187
Topsfield:						
2021	1.40	0.430	0.393	+0.037	0.823	-0.393
2035	1.40	0.430	0.405	+0.025	0.848	-0.418
Hamilton:						
2021	0.93	0.880	0.565	+0.315	0.770	+0.110
2035	0.93	0.880	0.671	+0.209	1.006	-0.126

Current maximum day demands presented in **Table 3.6** for each water system were obtained from available Annual Statistical Reports (ASRs). Future maximum day demands for the Towns of Ipswich, Essex and Hamilton were taken from recent water system and supply evaluation reports collected under Task 2 of this study. For the Towns of Wenham and Topsfield, future maximum day demands were estimated based on applying the current maximum day/average day demand ratio as calculated from the ASRs.

As shown in **Table 3.6**, under both current and future maximum day demands, all towns are pumping over their WMA authorized withdrawal rates except for Hamilton which has a surplus of 0.110 MGD in 2021. Given that these systems would be over pumping their supplies to meet high demand/maximum day demand conditions, it is expected that there would be less surplus available during these times to share between systems which would primarily be between June and August. Some systems experience significant increases in demand as early as May and as late as September. The capacity of these systems to provide surplus supply would be further limited during these high demand conditions with having one of their supply sources off-line for maintenance or repair. However, as shown in **Table 3.6**, except for Hamilton, the maximum supply capacities for the towns of Ipswich, Essex, Wenham and Topsfield are close to double their current maximum day demand. This suggests that these towns could have capacity to meet high demand periods and still share some available surplus even with a source off-line assuming their systems can hydraulically deliver supply through existing and future interconnections during these periods.

From **Table 3.6**, the Town most capable to share supply on a short-term basis currently would be Ipswich, which has the largest supply capacity and authorized withdrawal of all the towns. Additionally, as a larger percentage of Ipswich's source withdrawals are from the Parker River basin, having Ipswich augmenting Hamilton, Wenham and Topsfield would reduce the need for these towns to over pump their wells which are located within the Ipswich River basin. However, as shown in **Table 3.6**, Ipswich will be facing a supply deficit as their projected average day demand for 2040 will exceed its current WMA authorized withdrawals. As noted herein, the Town is evaluating the feasibility of installing a new well at its existing Lynch well site and a new replacement well for its Browns well which could potentially yield an additional combined capacity of 1.31 MGD. The future completion of these new wells, which are located within the Parker River basin, could alleviate future supply deficits and restore Ipswich's ability to share supply with the partnering communities. **This is contingent on the Town being granted an increase in its current WMA authorized withdrawal for the Parker River Basin by MassDEP.** This regulatory impact is discussed further in Section 4.

As shown in **Table 3.6**, Hamilton's current maximum supply capacity is only approximately 20 percent above its maximum day demand and only 5 percent over its WMA authorized withdrawal for its Idlewood wellfield. These percentages are much lower when compared to the other partnering communities which limits Hamilton's ability to over pump its sources when needed to meet high demand periods. This is evident by the fact that even though Hamilton has a current surplus when considering its WMA authorized withdrawal, it still has difficulty meeting system demands, particularly during the summer months. This condition is due to the raw water quality of the Town's wells which limits the production rate that the wellfield can yield, and that the plant can treat. Although the plant was originally designed for a capacity of **1.3 MGD**, given the raw water quality of the wells, the plant can only treat up to **0.93 MGD** while meeting drinking water standards. This limited production is further impacted when one of Hamilton's wells is off-line for redevelopment which is an annual occurrence.

As such, although Hamilton does have a greater supply surplus that the other systems, most of it is not available to be shared when likely needed during high demand periods. Given the current operations of the Town's wells and treatment plant, Hamilton would only be able to share supply during the lower demand periods between October and March when other partnering communities would likely have adequate capacity to meet demands. This circumstance may change once the new GAC adsorption facility is completed along with the planned filter cleaning.

4. Water Supply Permitting/Regulatory Issues for Mutual Aid Basis

As was described in detail in the Task 3 Technical Memorandum, the **Massachusetts Water Management Act (WMA)** is the primary law that regulates the withdrawal of water supply from the environment. Under the WMA, there are two categories of withdrawal: registered withdrawals which were in place at the time the law was originally passed in 1986 and permitted withdrawals which are requests for additional water over the registered volume, or for new sources of water developed since 1986. Generally, registered withdrawals are exempt from being conditioned under the Act so long as one does not exceed the registered volume whereas permitted water is usually conditioned for compliance with the MA Water Conservation Standards and require that benchmarks in terms of water use efficiency are achieved. If a water supplier has both a registration and permit, the entirety of the withdrawal amount is conditioned. **Currently, the Towns of Ipswich and Hamilton have permits and Essex, Manchester, Wenham and Topsfield are registered-only.**

Under the latest WMA regulatory update promulgated in 2014, a new scheme was implemented to provide more clarity and predictability on the original WMA requirements that water withdrawals be balanced between human and ecological needs. As such, each of the roughly 1,440 of river sub-basins in Massachusetts were classified in terms of the impacts of water withdrawals on the environment based on biological considerations and the level to which the withdrawal depletes the groundwater. These are known as **Biological Category (BC) and Groundwater Category (GWC)** and are ranked into 5 levels 1-5 based on the impact (with 5 being the highest). The regulations require that permitted withdrawals minimize their impact and further, in groundwater depleted sub-basins which are those classified as Level 4 or 5, the impact of the withdrawals must be mitigated to offset the withdrawal. The regulations also established updated Safe Yield (SY) figures for each of the 28 major river basins in the State as the law requires that overall withdrawals cannot exceed the SY. If water is transferred between major river basins, another State law comes into play, **the Interbasin Transfer Act (IBTA)** which require a permit and a regulatory review to mitigate the impacts of transferring water outside a river basin to another.

4.1 Sharing Supply between Partnering Communities

The water sources for the communities that are subject to this study are within 3 major river basins including the Ipswich, Parker and North Coastal. As noted in Section 2, Hamilton, Wenham and Topsfield are in the Ipswich Basin, Manchester and Essex are in the North Coastal basin and Ipswich has sources in both the Parker and Ipswich River Basins. As such, withdrawals made from the Ipswich Basin and used within Ipswich, Topsfield, Hamilton and Wenham would only be governed by the WMA but withdrawals made within Manchester or Essex from the North Coastal and within Ipswich from the Parker River Basins that are imported into the Ipswich Basin (or vice versa) would also need an IBTA permit to share with other towns. Based on conversations with WMA and IBTA staff conducted as part of this study, sharing water amongst the communities on an emergency or short-term basis should not be problematic so long as proper notifications and regulatory processes were followed. Regarding longer term or more permanent sharing of water scenarios, including on a regular mutual aid basis, more regulatory issues would come into play. **Because the SY for the Ipswich River is roughly equal to existing allocations, it would be nearly impossible to either increase withdrawals to serve communities within the basin or transfer water outside the basin to serve Manchester and Essex.**

Although it is theoretically possible to increase withdrawals in the North Coastal or Parker River watersheds because the SY for those river basins has not yet been exceeded, doing so would still be onerous as the sub-basins where Essex, Manchester and Ipswich withdraw are classified as level 4 or 5

BC and GWC as explained in detail in the Task 4 Technical Memorandum with regard to Manchester supplying Hamilton. Regarding the WMA, sharing water amongst communities within the same river basin is allowable so long as the overall allocations for that basin is not exceeded. There are two scenarios where this could work. Under **Scenario One**, so long as an individual community does not exceed their authorized withdrawal volume, they would be free to share water to another community within a basin. Under **Scenario Two**, a community could exceed its withdrawals to share with another in-basin community so long as the receiving community reduced its withdrawal by a like amount.

Taking all of this into account, the only realistically feasible scenario where towns can share water on a mutual aid basis is to do so within existing WMA allocations as described in the earlier sections of this task namely:

- Withdrawals made from the Ipswich Basin in Topsfield, Wenham, Hamilton and Ipswich could be shared with each other so long as their combined allocations are not exceeded.
- Although Manchester could theoretically share water drawn from the North Coastal Basin with Hamilton or other Towns in the Parker or Ipswich Basins, it would be difficult to do so as explained in the Task 4 Technical Memorandum.
- Although Ipswich could share water drawn from the Parker Basin with Hamilton or other towns in the Ipswich or North Coastal Basins it would be difficult to do so for the same reasons as explained in the Task 4 Technical Memorandum.

4.2 Regulatory Considerations for Possible Supply Surplus

Although the earlier part of this task identified potential water surpluses that could be shared amongst certain communities that are part of this study, there are additional regulatory considerations to consider as part of the new WMA and IBTA regulations in the Ipswich, Parker and North Coastal Basins. First, it is ***highly unlikely*** that increased water allocations would be allowed in the Ipswich, North Coastal or Parker River sub-basins where current withdrawals are being made to meet the needs of other communities because they are all currently located in a level 4 or 5 sub-basin. As such, any realistic water sharing scenarios would be limited to existing allocations. Second, although Hamilton appears to have a significant amount of surplus water within its permitted allocation, the State bases their allocations on ***actual*** need as determined by local use statistics and the official DCR Water Needs Forecast.

As such, it is possible that their allocation would be deemed unavailable by DEP to be shared with other towns. When coupled with the physical limitations of Hamilton's water supply documented earlier in Section 3.6 of this memorandum, it is questionable if this surplus could ever be made available to other communities. Finally, the region has witnessed two severe droughts and one of the wettest summers on record just in the last 6 years making annual water use statistics difficult to use as a basis for confidently estimating the sustainability of the local water surpluses identified earlier in this memorandum in light of climate change.

To help provide for a broader range of scenarios given the extreme variability in weather and water use statistics in recent years, we compiled water use data for the last 6 full years (which encompassed two droughts, one wet year and three normal years) to provide a more representative picture. Also, given the number of permitting caveats identified in this section, we developed additional water savings estimates that could be implemented to examine if this were a means to provide additional water supply resiliency. Table 4.1 on the following table presents existing and projected water use that was developed to assess the feasibility of various water sharing scenarios amongst the communities in this study.

Table 4.1. Water Supply Needs by Community Under Various Scenarios

City or Town	Avg. Use: Current MGD(1)	Summer Use: High Month(2)	DEP Allocation MGD(3)	10-Year Need Projection(4)	Potential Water Savings(5)	Net Available Supply(6)	Net Available Supply(7)
Salem/Beverly	8.50	10.39	12.44	9.85	1.7 (20%)	2.59	4.29
Hamilton	0.55	0.65	1.02	0.75	0.8 (15%)	0	0.8
Ipswich	1.03	1.28	1.18	1.09	0.15 (15%)	0	0.15
Topsfield*	0.40	0.53	0.43	0.44	0.06 (15%)	0	0.05
Wenham	0.34	0.44	0.29	0.37	0.07 (20%)	0	-0.01
Essex	0.23	0.31	0.22	0.24	0.05 (20%)	0	-0
Manchester**	0.71	1.22	0.72	0.62	0.21 (30%)	0.10	0.31
Totals:	11.76	14.82	16.3	n/a	3.04	2.69	5.61

Notes:
1. Average daily use, 2016-2021
2. Average summer high use MGD, 2016-2021
3. Combination of registered and permitted volume
4. From official DCR Water Need Forecast (except Manchester and Essex: figures from local studies)
5. If enhanced water conservation program based on meeting Massachusetts Water Conservation Standards and Recommendations based on percentage of current use and individual town water conservation measures, UAW and summer use statistics. See publication: Recipe for Water Resiliency published by the Parker-Ipswich-Essex Rivers Resiliency Partnership, June 2022.
6. Amount of DEP allocation available to be shared with other communities based on current average use net of 10 year needs 5% protection buffer and that existing GW withdrawals in the Ipswich basin could not be shared due to regulation.
7. Amount of DEP allocation available to be shared with other communities based on average use net of implementation of enhanced water conservation program net of 10 year forecast needs and 5% protection buffer and that exiting GW withdrawals could not be shared due to regulation but water conservation savings could be.

* Based on finished water as raw water statistics unavailable for some years.
** Does not include 2017 data

Although there appears to be some surplus water available within existing WMA allocations in some of the partnering communities as identified in Section 3, it appears that sharing it other than on a mutual aid basis to provide significant water supply resiliency benefits on a consistent basis and justify the capital costs over the long term would be challenging **(with the exception of Salem/Beverly – see Task 3 Technical Memorandum).** This said, if communities were to implement an enhanced water conservation program, there should be sufficient water available to meet the needs of local communities for the short to medium term providing resiliency to both meet local growth needs and provide flexibility to address PFAS contamination. If the infrastructure investments analyzed herein to share water amongst the communities on a mutual aid basis were implemented, it would also allow for the importation and sharing of surplus water from SBWSB (and/or water from outside these basins or from a new reservoir), thereby addressing the water supply resiliency needs of these communities for the long term.

5. Water Quality Evaluation

5.1 Hamilton

The primary source of supply for the Town of Hamilton's water system is the **Idlewood wellfield** which consists of five (5) individual wells. These wells are pumped up to the Idlewood Water Treatment Plant (WTP) for treatment prior to being introduced into the distribution system. The WTP was constructed to remove elevated levels of iron and manganese from the raw water wells, and includes the following processes:

- Pre-oxidation of the incoming raw water with 15% sodium hypochlorite
- Filtration through four (4) horizontal pressure filters containing 36-inches of high rate catalyzed media
- Post-filtered disinfection with 15% sodium hypochlorite as needed prior to entering the clearwell
- Fluoridation with sodium fluoride and corrosion control with a poly/orthophosphate after the clearwell

The Town's secondary source of supply is the **School Street well** which is chemically treated only before being delivered into the distribution system with sodium hypochlorite for disinfection, sodium fluoride for fluoridation, potassium hydroxide for pH adjustment, and a poly/orthophosphate blend for corrosion control. The location of these sources is shown on **Figure No. 5 in Appendix A**.

The finished water pH being maintained at these two sources is in the range of 7.2 to 7.4 with a free chlorine residual in the range of 0.5 mg/l to 0.7 mg/l, and a total phosphate residual of about 0.4 to 0.5 mg/l. Total trihalomethanes (TTHMs) as measured within the distribution system at the Town's two Stage 2 Disinfection Byproducts Rule sites for the last two years have ranged from 47 ppb to 83 ppb, respectively, with the calculated Locational Running Annual Average (LRAA) below the maximum containment level (MCL) of 80 ppb. Haloacetic Acids (HAA5) as measured within the distribution system at the Town's two Stage 2 Disinfection Byproducts Rule sites for the last two years have ranged from 0 ppb to 46 ppb, respectively, with the calculated Locational Running Annual Averages (LRAA) below the maximum containment level (MCL) of 60 ppb **(see Figure No. 5 in Appendix A).**

TTHMs within the Town's system tend to be on the higher side for a system that has well supplies, primarily due to several wells within the Idlewood wellfield that have moderate levels of total organic carbon (TOC). As water from these wells is oxidized with sodium hypochlorite for iron and manganese removal, TTHMs are formed at the plant and carried through the system. **The Town is currently constructing a new GAC treatment system that will reduce the levels of both TOCs and TTHMs at the plant which will improve finish water quality.**

Per the recently promulgated MassDEP regulation pertaining to PFAS monitoring under CMR 310 22.07G, the Town sampled its raw water sources to determine if PFAS was present at the detection levels that would trigger the need for treatment. The results of this initial sampling showed that the Town's Idlewood well supplies had a total sum of 3 ppt for the 6 regulated PFAS compounds in 2020, with 4.9 ppt in 2021, well below the established total PFAS MCL of 20 ppt. Sampling of the School Street well in 2021 showed a total sum of 13 ppt for the 6 regulated PFAS compounds which is still below the MCL of 20 ppt but is over the 10 ppt threshold which requires monthly sampling of the source. **The Town has limited the use of this well and is currently evaluating options for providing future on-site treatment for PFAS removal.**

5.2 Partnering Communities

Per Task 2 of the WMA grant study, we coordinated and requested various water quality and system infrastructure data from the partnering communities including Ipswich, Essex, Wenham and Topsfield as required to complete this task. **Table 5.1** below presents a summary of the finish water quality data collected from each of the communities as it relates to this assessment.

The **Town of Ipswich** has a combination of surface water and wells that supply their water system. The surface water source is chemically treated and filtered through a water treatment plant. The post-treatment of the filtered water at the Ipswich's plant includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid, pH adjustment with sodium hydroxide and an ortho/polyphosphate blend for corrosion control. Treatment at Ipswich's wells includes disinfection with sodium hypochlorite, fluoridation with hydrofluorosilicic acid and a poly/orthophosphate blend for corrosion control.

Table 5.1 Finish Water Quality Summary

Parameter	Essex	Ipswich	Topsfield	Wenham
pH	7.3 - 7.5	6.5 - 8.0	7.5	Unknown(2)
Chlorine (ppm)	0.53 - 0.59	0.25 - 0.89	0.22 - 0.34	0.3 - 0.88
Phosphate (ppm)	N/A(1)	0.5 - 0.80	Unknown(2)	Unknown(2)
TTHMs (ppb)	37 – 40	20 – 68	18 – 38	15.7
HAAs (ppb)	6 - 9	4.9 -35	ND - 4.5	4.4
PFAS6 (ppt)	<1.9	ND - 23.3	10-23	Unknown(2)

1. Essex does not add phosphate to their finished water.
2. Data was unable to be obtained from the partnering community.

The **Town of Essex** has only wells for supplying their system which are chemically treated and filtered through a water treatment plant that includes disinfection with chlorine gas, and pH adjustment with potassium hydroxide. The **Town of Topsfield** has only wells for supplying their system which are chemically treated and filtered through a water treatment plant that includes disinfection with sodium hypochlorite, fluoridation with sodium fluoride, pH adjustment with potassium hydroxide and an ortho/polyphosphate blend for corrosion control/sequestering. The **Town of Wenham** has only wells for supplying their system which are chemically treated only including disinfection with calcium hypochlorite, fluoridation with sodium fluoride and corrosion control with zinc orthophosphate.

In comparing the finished water quality of the partnering communities with the Town of Hamilton's current water quality and future water quality, they are similar with respect to pH and free chlorine with exception of Ipswich which maintains a larger range of pH than the other systems. However, they do use an ortho/polyphosphate blend similar to Hamilton and Topsfield for corrosion control so it is not anticipated that this larger pH range will be an issue. As shown in **Table 5.1** above, the Town of Essex does not use any phosphate addition for corrosion control which could be an issue with respect to lead and copper if supply from Hamilton, Topsfield, Ipswich and Wenham is delivered into their system. **All the partnering communities rely on free chlorine for disinfection so there is no concern of blending chlorinated water with chloraminated water between systems.** As such, it appears that Hamilton and the partnering communities should be able to share supply utilizing existing and future interconnections without any major water quality issues or impacts with meeting current drinking water standards, except for those noted below.

5.3 Possible Water Quality Issues

As noted above, Essex does not currently add phosphate at their plant for corrosion control within their distribution system. They only provide pH adjustment. The introduction of phosphate-treated water into their system could potentially disrupt the current chemistry that is providing the protective coating on the interior lead and copper surfaces. It will also increase the chlorine demand within the distribution system which will require adjusting the current chlorine dosages to avoid having coliform issues. For emergency measures, sharing supply from the partnering communities into Essex on a short-term basis should not pose a significant issue. However, if Essex needs to rely on the partnering communities to supply their system for a more extended duration, then consideration to adjusting their current treatment practice for corrosion control to include phosphate should be made.

With respect to transferring and/or sharing supply from Essex into Hamilton and the partnering communities, the lack of phosphate within Essex's finish water could pose an issue depending on how much volume of water is being delivered as compared to what Hamilton is supplying. Any prolonged use of an interconnection with Essex on a mutual aid basis should be further evaluated and likely will require Essex to commence adding phosphate as part of the corrosion control practice.

From the noted water quality data, Hamilton's water system has higher TTHMs and HAA5s as compared to the partnering communities so there is a potential for seeing an increase in these constituents within their systems. However, blending of the supplies between the partnering communities should minimize this issue to some extent and prevent any possible MCL exceedance. **It should be noted that Hamilton will be improving their current treatment processes at their existing plant which is expected to reduce current TTHMs and HAA5s within their systems in the future.**

A major water quality impact with transferring and/or sharing supply from the partnering communities into and through Hamilton is **the presence of PFAS** within the individual supplies. As shown from **Table 5-1**, the towns of Topsfield and Ipswich have had occasional elevated PFAS levels within their well supplies just at or above the 20 ppt MCL at times. As Hamilton's primary well supply has current PFAS levels below 5 ppt, introducing water with higher PFAS levels into their system could be problematic. This matter would likely have to be reviewed with MassDEP to determine what special requirements will need to be implemented before approving such a transfer. **But if PFAS levels within Topsfield and Ipswich eventually exceed the MCL, then they would need to implement a treatment strategy or modify the current usage of their supply to comply with drinking water standards which would hopefully address this issue.** It is our understanding that Topsfield has already taken steps to address their elevated PFAS levels and is in the process of adding granular activated carbon (GAC) at their treatment plant.

6. Supplying Partnering Communities

6.1 Infrastructure Improvements Required

As previously noted herein, and as shown on **Figure No. 5 in Appendix A**, Hamilton has existing interconnections with the Towns of Ipswich, Essex and Wenham, ranging in size from 2-inches to 8-inches. There are currently no interconnections in place with Topsfield and as such, a new interconnection and related pipeline will need to be constructed to connect Topsfield with Hamilton. **The**

feasibility of a new interconnection with Topsfield is evaluated in Section 6.2. In addition to having a physical connection between systems, there may also be the need for a pressure reducing valve (PRV) or booster pump station depending on the hydraulic gradient of the systems being supplied and the flow rate to be delivered. **Table 6.1** below shows the operating gradient of Hamilton and the partnering community systems.

Table 6.1 Existing System Gradients

Community Water System	Hydraulic Gradient (feet MSL)
Hamilton	210
Ipswich	210(1)
Topsfield	260
Essex	217.7
Wenham	211

1. Main pressure zone gradient as maintained by Tower Hill Tank.

For Wenham, there are two existing interconnections with Hamilton including an 8-inch on Highland Street and a 6-inch on Woodbury Street. Based on Hamilton's existing system, the 8-inch interconnection on Highland Street would be more favorable for transferring supplying between Hamilton and Wenham. For Essex, there is an existing 4-inch and 2-inch interconnection with Hamilton at the end of Essex Street (Rte. 22) which is fed by Hamilton's 10-inch main. **To effectively share and/or transfer future supply between the two systems, these two existing interconnections should be replaced with a new single 6-inch connection.** For Ipswich, there is an existing 6-inch interconnection with Hamilton at the end of Waldingfield Road which is fed by Hamilton's 8-inch main. This interconnection should be adequate for transferring supply between Hamilton and Ipswich.

It is our understanding that the existing interconnection with Essex is currently metered, and the other interconnections with Wenham and Ipswich are not metered. However, given the age of the existing meter, we recommend that new revenue meters be installed at all three existing interconnections. As these interconnections will be normally closed and only manually opened when needed under a controlled operation, it is not expected that backflow prevention devices for cross-connection control will be needed. As such, we have not included the installation of these devices in our assessment. If, in the future, these existing interconnections are used on a more permanent basis and/or are left normally open, then the installation of a backflow prevention device may be necessary depending on applicable water system requirements and regulations.

Using Hamilton's computerized model, we conducted steady state simulations under maximum day demands to estimate the available future supply that Hamilton's existing system infrastructure could effectively deliver at each of the existing interconnections. From the results of the analyses, a supply rate of about 200 gpm could be provided at Wenham's existing interconnection location with a reduction in system pressure less than 3 psi. At Essex's existing interconnection location, a supply rate of about 300 gpm could be provided with a reduction in system pressure less than 3 psi. At Ipswich's existing interconnection location, a supply rate of about 150 gpm could be provided with a reduction in system pressure less than 3 psi.

From **Table 6.1**, given that the existing system gradients for Wenham and Ipswich are about equal to Hamilton's gradient, supply between the systems can likely be delivered via gravity without the need for a PRV or a booster pump station. Depending on the demand and pressure fluctuations that occur within each of the systems over the course of a day, there will be times when the available gravity supply from Hamilton will be slightly reduced. Since these interconnections will be used for sharing supply between both respective systems, we would recommend the use of an electromagnetic type flow meter as the revenue meter which can measure the gravity flow in either direction. Otherwise, two separate meters and pipe connections would be needed.

With Essex having a system gradient about 8 feet higher than Hamilton, **a booster pump station** will likely be needed at the interconnection to effectively supply Essex daily over an extended period. Based on the estimated supply rate of about 300 gpm that Hamilton can supply at the interconnection with Essex, we would recommend that a 350 gpm booster pump station be provided. We do not currently have a model of Essex's water system and as such, we cannot determine the actual gradient on the Essex side of the interconnection. There could be times over a course of a day when the gradients between the two systems allow for gravity flow from Hamilton into Essex without the need for pumping. Conversely, supply from Essex into Hamilton can likely be delivered via gravity since Essex maintains a higher gradient than Hamilton. **To allow this gravity flow from Essex into Hamilton, the new interconnection with Essex would need to have a bypass around the booster pump station with a separate revenue meter.**

For the analyses above, we can only determine the supply rates that Hamilton could possibly deliver into Wenham, Ipswich and Essex, since we do not have working models of the other partnering systems at this time. It is our understanding both Wenham and Ipswich do not have computerized models of their water system. However, based on the operating gradients maintained by the partnering systems as shown in **Table 6.1**, and the noted infrastructure of their systems in **Section 2**, it is reasonable to surmise that these systems should be able to deliver similar supply rates into Hamilton.

For Topsfield, with an operating gradient of 260 feet as noted in **Table 6.1**, a booster pump station will be needed for Hamilton to supply Topsfield. Conversely, a pressure reducing valve (PRV) will be needed for Topsfield to supply Hamilton. Similar to Essex, a new interconnection with Topsfield would need to have a bypass around the booster pump station for the PRV along with a separate revenue meter. The following section evaluates the feasibility of installing a new pipeline to connect Hamilton and Topsfield for sharing surplus supply between their systems and the other partnering communities.

6.2 Future Pipeline Interconnection with Topsfield

In reviewing Topsfield's existing water distribution system as provided by the Town under Task 2, the shortest route for installing a new pipeline to connect the systems of Hamilton and Topsfield within an existing public roadway would be along Asbury Street. The new pipeline would connect to Hamilton's existing 8-inch main in Asbury Street and extend westerly approximately 6,500 feet along Asbury Street terminating at Topsfield's existing 8-inch main in Asbury Street. This proposed route is shown on attached **Figure 6 – Hamilton-Topsfield Potential Interconnection included in Appendix A.**

The new interconnection will require a revenue meter chamber for measuring and totalizing flow. As this new interconnection will be normally closed and only manually opened when needed under a controlled operation, it is not expected that a backflow prevention device for cross-connection control will be needed. As such, we have not included the installation of this device in our assessment. If, in the future, this new interconnection is used on a more permanent basis and/or are left normally open, then the installation of a backflow prevention device may be necessary depending on applicable water system requirements and regulations.

Asbury Street in Hamilton and Topsfield appears to be a rural 2-lane paved roadway with gravel shoulders that extends along the southern border of the Bradley State Park from Highland Street in Hamilton to Ipswich Road in Topsfield. There are several large residences within this portion of Asbury Street along with several farms and commercial establishments, and only one intersecting road to access the Bradley State Park **(see views below).**

View of Asbury Street at Hamilton's 8-inch Water Main

View of Asbury Street at Topsfield's 8-inch Water Main

View of Asbury Street in Topsfield

As shown in **Figure 6 attached in Appendix A**, the end of Topsfield's existing 8-inch main is over 500 feet south of the Ipswich River crossing so there should be no environmental impact with respect to the river's regulated 200-foot Riverfront. However, there are some intermittent wetlands along the roadway so it is likely that a Notice of Intent will need to be filed with Hamilton's and Topsfield's conservation commissions. Given the length of new pipeline and supply rates to be shared, we do not expect that an Environmental Notification Form (ENF) will be needed. Additionally, as the supplies for both Hamilton and Topsfield are located within the Ipswich River Basin, there should not be a need for an Interbasin Transfer permit for sharing supply between each other. Except for the existing water mains that will be connected to the new pipeline, we do not anticipate that other underground utilities exist within the roadway given the rural nature of this area so there should be ample room available to install a new pipeline. Additionally, there appears to be enough space within the roadway to maintain vehicular and pedestrian access during future pipeline construction.

It is our understanding that Topsfield has previously evaluated a proposed interconnection with the City of Beverly to obtain alternate supply directly from the Salem-Beverly Water Supply Board (SBWSB). From this evaluation, the closest source of SBWSB supply is near the Beverly Airport entrance which will require **installing approximately 3.2 miles of pipeline along Route 97 to connect with Topsfield's existing system at an estimated cost of $11,500,000.** From the Task 3 Technical Memorandum, with Hamilton possibly connecting directly to Beverly for obtaining SBWSB supply, this possible new interconnection with Hamilton including 6,500 feet of pipeline may prove to be a more economical option for Topsfield to obtain SBWBS supply.

6.2.1 Hydraulic Analysis

Utilizing the Town of Hamilton's computerized water model, we conducted a hydraulic analysis to determine the design criteria for the new pipeline, PRV and booster pump station required to share supply between Hamilton and Topsfield.

Hamilton's existing primary water supply includes the Idlewood wellfield and treatement plant which currnently operates at a production capacity of approximately 650 gallons per minute (gpm), although it was originally designed for a rated capacity of about 900 gpm. The finish water pumps at the plant, which draw from the plant's clearwell, operate at a rate of about 685 gpm. The Town's secondary supply is the School Street well which is operated intermittenly at a rate of about 110 gpm. Both the plant's finish water pumps and the School Street well are controlled off the water level within the Town's only water storage tank, the Browns Hill Reservoir, which is a 12-foot tall buried concrete tank. The pumps and well are set to turn on at a level of 209 feet and turn off at a level of 210 feet. Refer to **Figure No. 5 in Appendix A** for the location of Hamilton's water supplies and storage tank.

From Hamilton's water system model, the hydraulic gradient at the proposed interconnection with Hamilton's existing 8-inch main on Asbury Street varies from **205 feet to 218 feet** over a 24-hour period depending on system demand, tank level and whether the Town's finish water pumps are operating. Upon including the new pipeline and new revenue meter into Hamilton's computerized water system model, we conducted extended period simulation (EPS) analyses for various PRV settings under average day demands computer simulations to determine the optimal PRV setting for augmenting Hamilton's existing water system from Topsfield. For the EPS analyses, the Browns Hill Reservoir was initially set at an elevation of 209 feet with the plant's finish water pumps on-line and controlled off reservoir level.

From the results of the analyses, the most favorable option would be to set the new PRV to a downstream gradient somewhere between **208 feet and 212 feet.** This will hydraulically allow a predicted supply rate in the range of 200 gpm to 300 gpm, respectively, into Hamilton through the new interconnection with little impact to the current operation of Hamilton's system. The final setting can be adjusted as needed based on actual system conditions when the new interconnection is installed and how much supply is to be shared. As we don't have a working model of Topsfield's water system, we cannot determine the supply rates that Topsfield could possibly deliver into Hamilton. However, based on their higher operating gradient as shown in **Table 6.1**, and the noted infrastructure of their system in

Section 2, it is reasonable to surmise that Topsfield should be able to deliver appropriate supply rates into Hamilton.

For the new pipeline, given the fact that Topsfield's gradient is 50 feet higher than Hamilton's gradient, an 8-inch diameter main should be enough to deliver flows up to 300 gpm. At this flow rate, the frictional head loss generated through 6,500 feet of 8-inch main would approximately 15 feet which, based on an operating gradient of 260 feet, would still provide an upstream gradient of about 245 feet at the new PRV. We do not have a model of Topsfield's water system and as such, we cannot determine the pressure fluctuations at the connection with Topsfield's existing 8-inch main. However, based on the higher operating gradient maintained by Topsfield, and the noted the infrastructure of their system in **Section 2**, we do not anticipate an issue.

For a new booster pump station, based on the predicted supply rates noted above, we would recommend that a 350 gpm booster pump station be provided. The new booster station should be sized to overcome both the difference in static pressure and frictional losses to supply Topsfield from Hamilton. As noted above, the head loss through 6,500 feet of 8-inch main when supplying flow at a rate of 300 gpm would be approximately 15 feet. The gradient difference between Topsfield and Hamilton is 50 feet **(260 feet – 210 feet**). Allowing for station losses and having some additional head to effectively deliver water into Topsfield's system, the new pump station should be rated for 350 gpm at a total dynamic head (TDH) of about 80 feet.

6.3 Estimated Infrastructure Costs

Table 6.2 on the following page presents the estimated costs for the infrastructure upgrades for Hamilton to supply the Towns of Ipswich, Essex and Wenham through the existing interconnections based on the above assessment. **Table 6.3** on the following page presents the estimated costs associated with a new interconnection between Topsfield and Hamilton including a new 8-inch pipeline within Asbury Street, new PRV and new booster pump station.

The estimated water main costs per foot included in the tables on the following page are weighted costs and include the cost for furnishing and installing the pipe, valves, fittings, bedding, backfill, traffic control, trench and site restoration. Costs were developed in part using recent construction cost data for new water mains, pumping stations, and appurtenances. The estimated costs do not include land acquisition, right-of-way procurement and legal fees. We have included 30% for engineering/permitting and a 25% contingency for planning purposes. All costs are presented in 2022 dollars and are based on the **May 2022 Boston ENR construction cost index of 17506.61.**

As shown in Table 6.3, the total estimated cost for a new interconnection between Hamilton and Topsfield along Asbury Street is $3.660 million which is significantly less than the $11.5 million estimated for Topsfield to connect directly with Beverly. If Hamilton does consider the approach of connecting to SBWSB in the future as evaluated under Task 3 of this WMA study, then this new interconnection would certainly be more favorable for Topsfield to consider for improving its supply resiliency along with the partnering communities.

Table 6.2 Infrastructure Upgrades to Existing System Interconnections

Item	Cost[1]
Interconnection with Wenham	
New Revenue Meter Vault and appurtenances[2]	$150,000
New Electrical/Control Systems & SCADA upgrades (for meter)	$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)	$20,000
Subtotal	**$200,000**
Engineering and Permitting (30%)	**$60,000**
Subtotal – Engineering and Construction	**$260,000**
25% Contingency	**$65,000**
Total - Interconnection with Wenham	**$325,000**
Interconnection with Ipswich	
New Revenue Meter Vault and appurtenances[2]	$150,000
New Electrical/Control Systems & SCADA upgrades (for meter)	$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)	$20,000
Subtotal	**$200,000**
Engineering and Permitting (30%)	**$60,000**
Subtotal – Engineering and Construction	**$260,000**
25% Contingency	**$65,000**
Total - Interconnection with Ipswich	**$325,000**
Interconnection with Essex	
New 350 gpm Booster Pump Station w/ Above-Grade Structure (incl. Revenue Meter)	$175,0000
Site work & connections for new Booster Pump Station and Bypass	$75,000
New Revenue Meter Vault and appurtenances (for gravity flow)	$150,0000
New Electrical/Control Systems & SCADA upgrades (for meter)	$30,000
Miscellaneous (testing, commissioning, general conditions, etc.)	$50,000
Subtotal	**$480,000**
Engineering and Permitting (30%)	**$144,000**
Subtotal – Engineering and Construction	**$624,000**
25% Contingency	**$156,000**
Total - Interconnection with Essex	**$780,000**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.
2. Based on using single electromagnetic flow meter for measuring bidirectional flow.

Table 6.3 New Hamilton-Topsfield Interconnection Costs

Item			Cost[1]
New Topsfield Interconnection w/ New Pipeline, PRV and Booster Pump Station			
6,500' of New 8" Main in Asbury Street from Ex. 8" Main to Ex. 8" Main @ $225/ft			$1,462,500
New Revenue Meter Vault and appurtenances			$150,000
New PRV Vault and appurtenances			$75,000
New electrical/control systems & SCADA upgrades (for meter & PRV)			$40,000
New 350 gpm Booster Pump Station w/ Above-Grade Structure (incl. Revenue Meter)			$175,0000
Site work & connections for new Booster Pump Station and Bypass			$75,000
Site work & connections to ex. 8" main on Asbury Street (Hamilton)			$25,000
Site work & connections to ex. 8" main on Asbury Street (Topsfield)			$25,000
Miscellaneous (testing, commissioning, general conditions, etc.)			$225,000
Subtotal			**$2,252,500**
Engineering and Permitting (30%)			**$675,750**
Subtotal – Engineering and Construction			**$2,928,250**
25% Contingency			**$732,000**
Total - Interconnection with Topsfield			**$3,660,250**

1. Costs do not include land acquisition, right-of-way procurement and legal fees.

APPENDIX A

Figure 1 - Town of Ipswich Water System Plan dated June 2022

Figure 2 - Town of Essex Water System Plan dated June 2022

Figure 3 - Town of Wenham Water System Plan dated June 2022

Figure 4 - Town of Topsfield Water System Plan dated June 2022

Figure 5 - Town of Hamilton Water System Plan dated June 2022

Figure 6 – Hamilton-Topsfield Potential Interconnection dated June 2022

FIGURE 1 - Town of Ipswich Water System Plan

June 2022

Dewberry

FIGURE 2 - Town of Essex Water System Plan

June 2022

Dewberry

FIGURE 3 - Town of Wenham Water System Plan

June 2022

Dewberry

FIGURE 4 - Town of Topsfield Water System Plan

June 2022

Dewberry

FIGURE 5

TOWN OF HAMILTON, MA
WATER SYSTEM PLAN

DATE: JUNE 2022
SCALE: 1" = 1,500'

Dewberry
99 Summer Street
Boston, MA 02210
617 695-3400
617 695 3310
www.dewberry.com

FIGURE 6 - Hamilton - Topsfield Potential Interconnection

June 2022

Dewberry

APPENDIX D

Figure 1 – Updated City of Beverly Water System Plan dated June 2022

Figure 2 – Updated Town of Manchester Water System Plan dated June 2022

Figure 3 – Recommended Water Supply Infrastructure Improvements dated June 2022

FIGURE 1 -City of Beverly Water System Plan

June 2022

Dewberry

FIGURE 1 -Town of Manchester Water System Plan

June 2022

Dewberry®

Figure 3 - Recommended Water Supply Infrastructure Improvements

June 2022

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