Holden Water & Sewer Advisory Board
Meeting Minutes
March 7, 2024 – 18 Industrial Drive Holden, MA, Holden Public Works Facility and Remote via Zoom

Call to Order
Mark Johnson called to order a meeting of the Water & Sewer Advisory Board at 6:05 PM on March 7, 2024 at the Holden Public Works Facility, 18 Industrial Drive, Holden, MA.

Roll Call
Board Members Present:
Mark Johnson, Larry Kowalczyk, Dawn Michanowicz, Michael Andrus and Robert Dempski.
Board Member(s) Absent:
Tito Sanchez.
Other Attendees:
Ryan Fleming and Tony da Cruz of Tighe & Bond, John Woodsmall, Joseph Kenney and Heather Van Hazinga of the Holden DPW.

1. Public Comment
None.

2. Tighe and Bond presenting the Spring Street Well
Mr. Fleming presented quality concerns for Spring Street Well with Iron and Manganese. They looked at biological and traditional filtration options. The building footprint is about the same. Mr. Fleming discussed the capital cost of Greensand and Biological and the overall expense over time. They also looked at the alternative, which is purchasing more water from Worcester. There was discussion of increase in cost over time. Mr. Fleming also discussed that they left room to build for PFAS treatment. If Worcester has issues with their water down the road, then it's inevitable that their rates would increase. If there is a facility that is built in town, then the town has control and that leaves Worcester as a backup. Tighe & Bond will be doing a presentation at the Board of Selectman's meeting March 18th. The board discussed the details of building the Spring Street Well. There was also discussion about ECC and the numbers are going down. There will be more investigation in June. Mr. Andrus made a motion to endorse the recommendation for a pilot study. Mr. Kowalczyk seconded the motion. There are limited firms that do pilot study and allocation of funds would be needed.

3. Water and Sewer Superintendent Update
Mr. Kenney mentioned that ninety percent of meters were delivered. Through testing, it was discovered that all meters and ERT's were wired incorrectly. The meters have been sent back to Diehl.

4. FY Budget Recap
Mr. Woodsmall said there is new budgeting software. Expenses are going up, however the total revenue has gone up. There has been no rate increase. There was a discussion of finances and potential use of the stabilization fund.

There was a discussion on the increase in fees to HMLD, which they agreed to spread out over two years.

Mr. Woodsmall continued to discuss budget next season, which included testing at Spring Street Well, water storage tank chemical addition retrofit. Mr. Kenney added that we are still waiting for some information. There is also acid management capital improvement plan for the thirty-one sewer pump stations. Three quarters are due for replacement. There is an Influent and Infiltration plan to keep investigation and remedial efforts. Then there is continuing with our water main replacement program. Also, replacement of truck five, the water main dig vehicle, replacing the superintendent's vehicle and the Engineering vehicle. This all being done without raising rates.

5. Iron and Manganese – Jefferson Area Updates

In a few weeks, there will be flushing in the area.

6. ECC site Update

There was discussion of using ECC wells. Not sure of permitting.

7. City of Worcester – DCR Sewer Rate Court Case Update

Mr. Woodsmall stated that they are waiting for the State. Our response is due in April.

8. Sewer Rules and Regulations

Mr. Kenney would like to keep this on the agenda. No change at this point. Will get examples from other towns. We will discuss in the next meeting on how we can update the regulations.

9. Other Business

None.

10. Discuss Next Meeting Date

Meetings are scheduled for the first Thursday of the month. The next meeting is scheduled for April 4, 2024.

11. Adjourn

On a motion by Mr. Kowalczyk to adjourn the meeting, seconded by Mrs. Michanowicz, it was unanimously agreed to adjourn the meeting at 7:57 PM.

Minutes taken and submitted by: Heather Van Hazinga
Minutes approved by: WSAB on 4/4/2024

Town of Holden Department of Public Works – Water and Sewer Division
Alternatives Analysis for the Spring Street Well Treatment Facility

TO: John Woodsmall, PE, DPW Director
Joseph Keeney, Water & Sewer Superintendent

FROM: Tighe & Bond

DATE: 01/05/2024

This memo summarizes Tighe & Bond's alternatives analysis of strategies to address increasing water demands in the Town of Holden through design and construction of a new Spring Street Well Treatment Facility to remove iron and manganese. The alternatives analysis presents the long-term costs/benefits of constructing a treatment facility to remove iron and manganese from Spring Street Well compared with purchasing water from the City of Worcester.

1 Background

The Spring Street Well is located on 69 Spring Street on a 15.78-acre parcel that is owned by the Town of Holden. The original well was constructed in 1958 with a capacity of 250 gallons per minute (gpm). In 2003, the Spring Street Replacement Well was installed and has an approved pumping rate of 140 gpm.

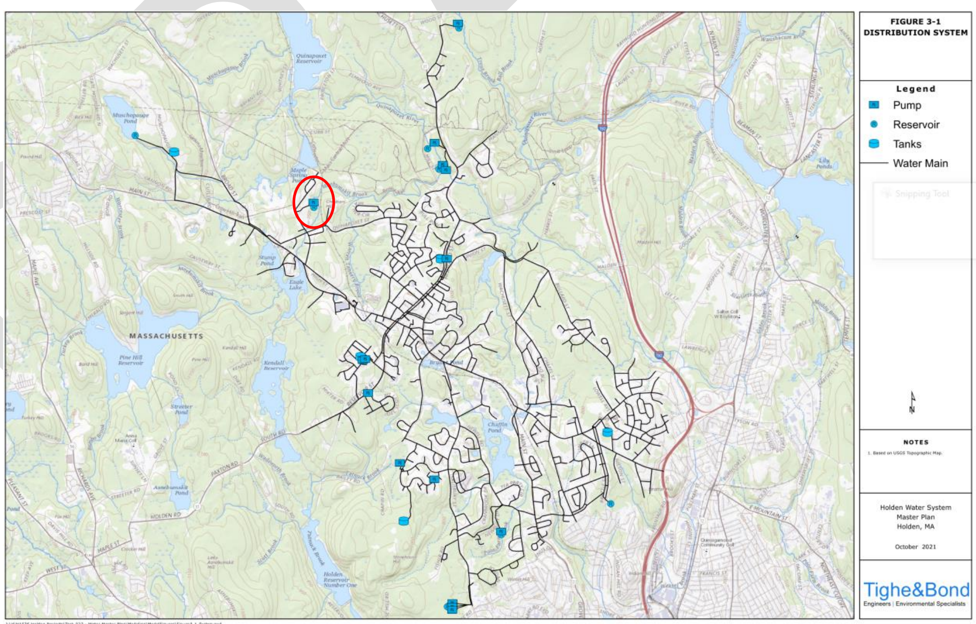

Figure 1: Spring Street Well Location

There is a small treatment station at the site where water from the Spring Street Well is chemically treated with potassium hydroxide (KOH) to raise pH and sodium fluoride (NaF) for dental benefits.

The Town also purchases water from the City of Worcester through two interconnections – The Brattle Street Interconnection and the Salisbury Street Booster Pump Station. Under normal conditions, the City of Worcester is supplied entirely by surface water from its 10 reservoir sources. Worcester also maintains several inactive groundwater wells that can be used as backup in case of an emergency. The surface water from Worcester undergoes advanced pre-oxidation and filtration through a conventional surface water treatment plant (SWTP). Water supplied at the two interconnections with the Town of Holden contains chlorine for disinfection, has been pH adjusted using lime (CaO), and contains a blended phosphate corrosion inhibitor. Since Worcester does not fluoridate its water, both interconnections are equipped with sodium fluoride chemical treatment systems.

In 2024 the Intermunicipal Agreement between Worcester and Holden regarding the purchase of water will shift. At present, Holden pays the City of Worcester residential water rate. In fiscal year 2023 (FY2023), the rate was $3.68 per hundred cubic feet (CCF). The FY2024 rate has increased by 2.7 percent to $3.78/CCF. Once the Intermunicipal Agreement ends in 2024, Holden will pay the residential water rate plus an additional 10% surcharge ($4.16/CCF). Future rate increases imposed by the City of Worcester would also be subject to a 10% surcharge. Holden's agreement is for purchase of up to 4 million gallons per day (MGD).

High concentrations of iron and manganese have forced the Town to limit production from Spring Street Well. The Town is currently running Spring Street Well at roughly 50% of its rated capacity (75 gpm). This results in more water being purchased from the City of Worcester than would be necessary if there was adequate treatment.

Increasing demands and expiration of the Intermunicipal Agreement with Worcester has led the Town to initiate this study to assess the costs/benefits of continuing to purchase water from Worcester at a new, higher rate versus constructing a new Spring Street Well Treatment Facility to remove iron and manganese and allow the Town to maximize this source.

2 Alternatives Analysis

As stated above, the Town is considering two primary alternatives with respect to meeting current and projected water demands: 1) continue purchasing large quantities of water from the City of Worcester at new, higher rates due to the poor water quality from Spring Street Well; or 2) design and construct a new Spring Street Well Treatment Facility, which would reduce the Town's reliance on purchased water. In the case of a Spring Street Well Treatment Facility to remove iron and manganese, we have provided considerations and costs for two treatment technologies: A) traditional autocatalytic oxidation/filtration (i.e., "Greensand"); and B) biological filtration. Each of the two approaches described above were evaluated according to water quality, reliability, and economic factors.

2.1 Continue Purchasing Water from City of Worcester

Continuing to purchase water from the City of Worcester represents the "do nothing" alternative. Poor water quality from Spring Street Well will force the Town to limit its production, thereby maintaining reliance on water coming from its two interconnections with Worcester. Below are some considerations for how this approach could affect Holden.

2.1.1 Water Quality

Water from the City of Worcester undergoes a high level of treatment to remove pathogens and other contaminants. However, there are fundamental differences between the surface water supplied by the City of Worcester and the Town of Holden's groundwater sources.

First of all, the City of Worcester adds chlorine for disinfection. This is required of all surface water sources and creates a unique set of challenges and risks. Chlorine reacts with natural organic matter (NOM) found in the water and produces disinfection byproducts (DBPs). There are currently two classes of DBPs that are regulated under the Safe Drinking Water Act (SDWA) – total trihalomethanes (TTHMs) and haloacetic acids (HAA5). In its most recent annual Water Quality Report, the City of Worcester had levels of 56 parts per billion (ppb) for TTHMs and 23.75 ppb for HAA5s, based on a locational running annual average (LRAA), compared with the federally established limits of 80 ppb and 60 ppb for TTHMs and HAA5s, respectively. Thus, these contaminants are currently well within compliance in the City of Worcester's water system. Looking at Holden's 2022 Water Quality Report, we find that TTHMs were as high as 109 ppb at one of its sampling locations. Since Holden does not, under normal operating conditions, add chlorine to its water sources, this high result can be attributed directly to water being supplied from the City of Worcester. DBPs increase with increasing water age, distance from the source of supply, temperature, ambient conditions in the water body and other factors. The two interconnections with Holden are far from Worcester's SWTP and must travel through Holden's distribution as well. Thus, the concentrations of DBPs in Holden will consistently exceed those found at the interconnections with Worcester. Additionally, regulations are constantly evolving, and limits for currently regulated DBPs may shift lower or other, different DBPs may be regulated in the future.

Another unique characteristic of surface water is parameters related to corrosivity, which can disrupt scale on the interior surfaces of water mains, premise plumbing, and fixtures. This could potentially affect compliance with the Lead & Copper Rule (LCR). Both Holden and Worcester show historically low levels of lead below the federal Action Level under the LCR. Worcester's corrosion inhibitor provides a level of protection and assurance of continued compliance, but dependence on large quantities of Worcester water could render the Town of Holden powerless in the event of an upset in corrosion control treatment from water supplied through the interconnection. While this risk is minor and would be addressed collaboratively if it were to happen, it is desirable to maintain consistent water quality throughout the distribution system (unchlorinated groundwater versus a blend) and have the ability to manage corrosion control optimization independently, when possible.

Iron and manganese are non-issues in water supplied from the City of Worcester, particularly when compared with the current levels found in Spring Street Well. This comparison would become moot, however, if a Spring Street Well Treatment Facility to remove iron and manganese is constructed as described in later sections of this memo.

2.1.2 Reliability

Worcester's water is supplied by 10 reservoirs. Despite the seemingly abundant source of water, the possibility remains that there could be a disruption caused by failure or damage to water treatment/distribution systems, drought, accidental or intentional contamination, as well as other forms of threats. Although the risk of supply disruption is low, the fact remains that without treatment, Spring Street Well cannot reliably produce its rated capacity without contributing large quantities of mineral deposits to the distribution system and generating dirty water complaints from customers.

2.1.3 Economic Considerations

Once the Intermunicipal Agreement with Worcester expires, the Town of Holden will be subject to the retail rate plus an additional 10% surcharge. The current retail rate for water in the City of Worcester is $3.68/CCF. The FY2024 rate has increased 2.7% to $3.78/CCF. Adding the 10% surcharge will make Holden's rate $4.16/CCF.

The rated capacity of the Spring Street Well is 140 gpm (0.202 MGD). To limit the impacts of high iron and manganese, the Town runs the well at around 75 gpm (0.108 MGD) – a difference of 65 gpm (0.094 MGD).

We ran an economic analysis under two scenarios:

1) Spring Street Well Offline (0.202 MGD purchased water) – this scenario would result in a higher cost to purchase water but would produce water quality that would be equivalent to that of a new Spring Street Well Treatment Facility – that is, water with very low iron and manganese concentrations. This is the scenario that can be fairly compared with a new Spring Street Well Treatment Facility.
2) Spring Street Well at 50% Capacity (0.108 MGD purchased water) – although this is the current practice, it would not be fair to compare this with the Spring Street Well Treatment Facility since a portion of the customer base would continue to receive diminished water quality. This scenario is presented for the purpose of projecting costs into the future if the Town continued operating as-is.

Table 1-Annual Cost for Purchased Water at Worcester Present/Projected Retail Rates

	Scenario 1 Purchased Water Cost		Scenario 2 Purchased Water Cost	
	0.202	MGD	0.108	MGD
	365	days	365	days
	73.73	MG/yr	39.42	MG/yr
Cost @ FY2023 retail rate ($3.68/CCF)	$362,736		$193,938	
Cost @ FY2024 retail rate ($3.78/CCF)	$372,593	$/yr	$199,208	$/yr
Cost @ FY2024 retail rate + 10% surcharge ($4.16/CCF)	$410,049		$219,234	

The costs in Table 1 provide a comparison between what Holden currently pays for water versus what they would pay after the Intermunicipal Agreement expires. However, it is likely that Worcester's rates will escalate over time, which will compound the annual cost for purchased water. Table 2 shows estimated annual costs assuming 2% to 4% annual escalation over 25-year and 50-year time horizons. The costs presented in Table 2 are based on scenario 1, which would completely offset the quantity of water that could be produced by a new Spring Street Well Treatment Facility.

Table 2-Projected Escalation of Annual Costs for Purchased Water

	Annual Cost of Purchased Water (0.202 MGD)		
	Year 1	Year 25	Year 50
@ 2% Inflation	$410,059	$659,538	$1,082,043
@ 4% Inflation	$410,059	$1,051,081	$2,802,009

To compare with the *capital* cost of a new Spring Street Well Treatment Facility, we computed the *Present Value* (PV) of purchased water based on the escalating annual costs over 25- and 50-year timeframes. It is reasonable to assume that a new treatment facility for iron and manganese removal would operate at the upper end of this service life (i.e., 50 years).

We used the same inflation rates from Table 2 (2% to 4%) and discount rates (i.e., interest rates) of 3.5% and 5.5% to compute the Present Value estimates. The 50-year equivalent present value for purchased water ranges from $9.5M to $22.3M, with a nominal estimate of approximately $14M. The 25-year costs range from $6.7M to $10.5M ($8.3M nominal).

Table 3-Calculated Present Value of Annual Costs for Purchased Water

Inflation Rate	2%	4%	2%	4%
Discount Rate	3.50%	3.50%	5.50%	5.50%
PV_{25yr}	$8,400,000	$10,500,000	$6,700,000	$8,200,000
PV_{50yr}	$14,200,000	$22,300,000	$9,500,000	$14,000,000

To compare annual expenses, we estimated annual operating & maintenance costs for a new Spring Street Well Treatment Facility based on four major categories: electricity, labor, treatment chemicals, and waste disposal. These costs are summarized in Table 4 and discussed below.

Biological filtration, as explained later in this memo, is less labor-intensive than conventional greensand filtration because it involves fewer chemicals and is backwashed less frequently. However, biological filter systems require separate iron and manganese filtration vessels and a dedicated clearwell. The clearwell serves to provide equalization storage and a dedicated source for unchlorinated backwash water. Because booster pumping is required, electricity costs are higher for biological filtration than for greensand. On the flip side, operators are able to dedicate time and resources to other tasks and activities, so the equivalent labor demands for biological filtration are roughly 75% those of a traditional greensand plant.

For simplicity, we assumed approximately $100,000/year (today's dollars) for 1 full-time employee (FTE). This was supported by Town officials based on a salary of $62,400/year, family health plan ($23,750/year), retirement ($11,200), Medicare match (1.45% or $900), worker's compensation ($1,400), and other post-employment benefits ($1,500/year).

Chemical usage was based on current prices for potassium hydroxide and sodium hypochlorite, assuming the 0.202 MGD production rate and appropriate doses based on the selected treatment technology and water quality parameters.

The Town provided electricity costs for the Spring Street facility from 2020-2023. Based on these records, the average cost per kW-hr in 2023 is around $0.21. Electricity costs for a greensand plant are likely to be similar to current conditions. To estimate the additional costs for a biological filtration facility we sized a pump to convey treated water from a storage tank (i.e., clearwell) and applied the average cost/kW-hr.

As stated later in this memorandum, backwash water from either system can be recycled and blended with the raw well water, which will significantly reduce waste generation. Plus, the Town owns/operates its own wastewater collections and treatment systems. Despite these factors, the equalization tank used to store the backwash water will need periodic cleanout, so a nominal fee was applied to account for this expense.

Table 4 – Estimated Annual O&M Costs for New Spring Street Treatment Facility

	Biological	Conventional
Electricity	$50,000	$30,000
Labor	$75,000(1)	$100,000
Chemical	$20,000	$24,000
Waste Handling	$1,000	$4,000
TOTAL	$146,000	$158,000

(1) Cost for one FTE will remain $100k/annum, but due to ease of operation, staff will have time to provide other services beyond treatment system operation, so expense attributed to the new facility was reduced by 25%.

In total, the estimated annual cost to operate a new Spring Street Treatment Facility is around $152,000. This amounts to a per-gallon cost of approximately $0.002 (< than 1¢ per gallon). Worcester water, by comparison, costs $0.0056/gallon – a more than 2.5X increase.

Table 5 - Comparison of Cost/Gallon – New Treatment Facility versus Purchased Water

	Biological	Conventional
Production Rate (MGD)	0.2016	0.2016
Annual Production (MG)	73.584	73.584
Annual O&M Cost	$146,000	$158,000
$/MG	$1,984.13	$2,147.21
$/gal	$0.0020	$0.0021
Worcester Water		
$/CCF	$4.16	$4.16
$/gal	$0.0056	$0.0056
Relative Difference	280%	260%

The relative difference in cost becomes more pronounced over time. In year 1 (i.e., 2024), the annual cost to purchase 0.201 MGD (73.584 MG total) from Worcester would be $410,059. This compares with approximately $152,000 in O&M costs if the new Spring Street Treatment facility were operational. Assuming a 2% escalation for each, the cost of purchased water in year 25 would be $659,538 versus $236,038 for Spring Street Well water. Cumulatively over that 25-year period, the amount paid for Worcester water would be $8,433,552 greater than the cost of operating a new treatment facility. Under this constant 2% cost escalation scenario, the gap in expenses widens over time, as demonstrated in Figure 2.

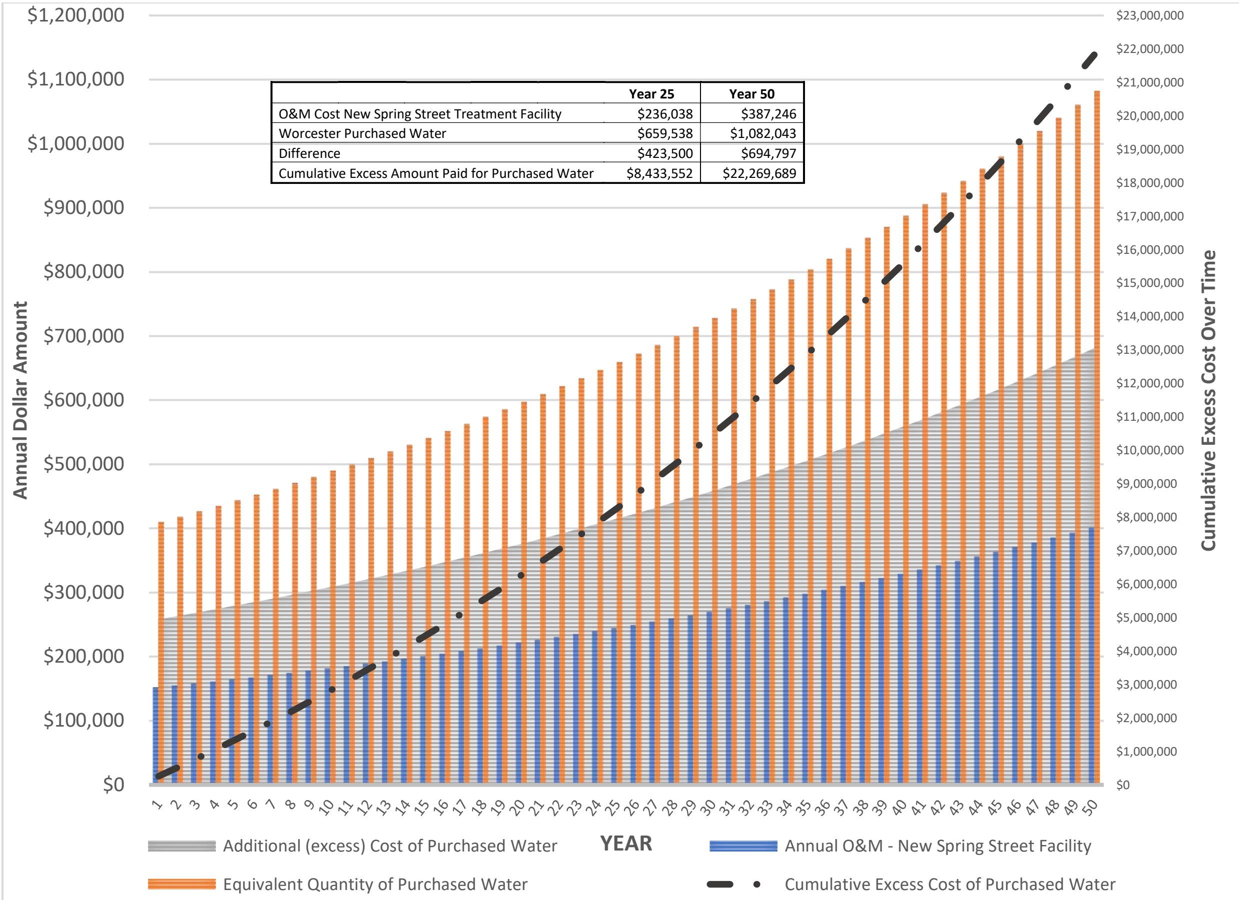

Figure 2 - Comparison of Yearly Costs over 50 Years
(0.201 MGD, 73.584 MG/YR, 2% annual escalation factor)

2.2 Design/Construct New Spring Street Well Treatment Facility

Iron and manganese affected the original Spring Street Well constructed in 1958 and have remained an ongoing issue for the Spring Street Replacement Well installed in 2003. Alternative 2 involves the design and construction of a new treatment facility to remove iron and manganese from Spring Street Well water, which would allow the Town to operate this source at its rated capacity and reduce the dependence and costs associated with purchasing water from Worcester.

2.2.1 Water Quality

Iron and manganese are nuisance contaminants subject to secondary standards under the federal SDWA. The EPA has established a Secondary Maximum Contaminant Level (SMCL) for each of these contaminants at levels that, when exceeded, are likely to cause water to appear colored/cloudy, taste or smell bad. The presence of elevated iron and/or manganese can also cause stains on plumbing fixtures and clothes and is associated with customer complaints. Table 6 shows concentrations of iron/manganese from Spring Street Well samples over the past several years in comparison with their respective SMCLs.

Table 6-Historic Iron and Manganese Concentrations

		Iron (mg/L)	Manganese (mg/L)
	SMCL	**0.3**	**0.05**
YEAR	2018	0.656	0.153
	2019	0.567	0.096
	2020	0.537	0.116
	2021	0.725	0.126

Aside from iron and manganese, Spring Street Well is a high-quality source and requires only pH adjustment and fluoridation (no disinfection). Treatment for iron and/or manganese is well-established, with dozens of facilities throughout the region. The goal of a treatment facility would be to remove iron and produce water that is well below the established SMCL. For the treatment systems described later in this memo, the filter effluent water quality targets are 0.1 mg/L and 0.02 mg/L for iron and manganese, respectively.

Samples for PFAS collected over the past several years show that the Spring Street Well is in compliance with the Massachusetts regulations for PFAS compounds. Massachusetts set its MCL at 20 ng/L (or parts per trillion, ppt) for the sum of six compounds - PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA. The proposed USEPA regulations have become even more stringent. The proposed federal MCL for PFOA and PFOS is 4 ppt. The federal MCL also includes a Hazard Index (HI) which incorporates four additional compounds and sums the ratio of their concentrations to a prescribed reference dose. The Hazard Index calculations is:

$$Hazard\ Index = \left(\frac{[GenX_{water}]}{[10\ ppt]}\right) + \left(\frac{[PFBS_{water}]}{[2{,}000\ ppt]}\right) + \left(\frac{[PFNA_{water}]}{[10\ ppt]}\right) + \left(\frac{[PFHxS_{water}]}{[9.0\ ppt]}\right)$$

A summary of Holden's Spring Street Well PFAS sample data is provided in Table 7.

Table 7-Summary of PFAS Sample Data - Spring Street Well

Collection Date	11/18/2020	4/8/2021	1/5/2022	4/8/2022	7/6/2022	1/6/2023
GenX	ND	ND	ND	ND	ND	ND
PFBS	1.8	2.5	2.5	2.4	2	2.1
PFNA	ND	ND	ND	ND	ND	ND
PFHxS	0.75	0.8	0.74	0.68	0.86	1
PFOA	3	3.5	3.8	3.4	3.3	4.5
PFOS	1.55	2	2.2	2.2	2.4	2.4
PFHpA	1.01	1.1	1.2	1.1	1.2	1.5
PFDA	ND	ND	ND	ND	ND	ND
Massachusetts PFAS6	6.31	7.4	7.94	7.38	7.76	9.4
Hazard Index	0.084	0.090	0.083	0.077	0.097	0.112

The sample collected on January 6, 2023, had 4.5 ppt PFOA, which would be above the proposed federal MCL if it is promulgated. The proposed federal rule is based on an annual average of quarterly samples, so it is possible that the Spring Street Well will remain in compliance. It is also possible that the proposed rule will be modified and/or challenged. Despite the uncertainty, it is worthwhile to incorporate planning and space for future PFAS treatment.

2.2.2 Reliability

From a reliability perspective, availability of the rated capacity from Spring Street Well is advantageous. Firstly, Holden can operate and manage the source as they see fit. Interconnections and water purchase agreements are good to have for peak demand and emergency supply, but a diverse array of water sources would provide Holden with greater flexibility and reliability across its system. Additionally, the Spring Street Well does not currently have a backup power generator. This would undoubtedly be included as part of the design/construction of a new Spring Street Well Treatment Facility. Therefore, this alternative is preferable when compared with continued dependence on purchased water from Worcester.

2.2.3 Economic Considerations

To evaluate this alternative from an economic perspective, we prepared representative design concepts of an appropriate size/scale and treatment approach for the Spring Street Well. There are two primary technologies that are used for removal of iron and/or manganese in groundwater: A) traditional autocatalytic oxidation/filtration (i.e., "Greensand"); and B) biological filtration.

Both treatment processes involve the oxidation of soluble Fe(II) and Mn(II) to insoluble Fe(III) and Mn(IV), which precipitate as metal oxides/hydroxides and are removed in the filter. A more detailed description and comparison of each process is provided below.

2.2.3.1 Greensand Filtration

Filtration through oxide-coated media (aka “greensand”) is the industry standard for removing manganese from groundwater, going back decades. Traditional greensand media was originally a product mined from a naturally occurring geological formation; however, over recent decades artificial products such as media which receives a manganese dioxide (MnO_2) coating have become the industry standard. There are several other popular media on the market that use a host material and coat it with manganese dioxide.

These oxide-coated media systems involve the addition of an oxidant (e.g., chlorine or potassium permanganate) and filtration through media coated with manganese-containing metal oxides. Chlorine oxidizes iron rapidly in solution, causing iron to precipitate and then removed by filtration, typically in a top layer above the greensand media, such as anthracite. Chlorine oxidizes manganese very slowly in solution but very rapidly in the presence of manganese oxide, which acts as a catalyst. In filters packed with manganese oxide-coated media, dissolved manganese (Mn^{2+}) absorbs onto the manganese oxide where it is oxidized autocatalytically in the presence of chlorine. Thus, iron and manganese are removed simultaneously through different reactions when chlorine is applied continuously to a filter packed with manganese oxide coated media.

2.2.3.2 Biological Filtration

In bio filters, iron- and manganese-oxidizing bacteria (IOB and MOB) naturally present in the groundwater form a biofilm on the filter media. These bacteria generate energy through the aerobic oxidation of Fe^{2+} to $Fe(OH)_3$ or Mn^{2+} to MnO_2. The metal precipitates formed by biological oxidation are denser and more crystalline than those formed through chemical oxidation; therefore, they foul the filter less rapidly and produce denser backwash sludge. Biological iron and manganese oxidation typically are accomplished in two successive stages (iron followed by manganese) because IOB and MOB have different preferential ranges of pH and oxidation-reduction potential (ORP). Other water quality constituents that result in higher oxidation potentials may affect performance or require pre-treatment (e.g., sulfate, natural organic matter and ammonia).

Optimal pH, ORP, and dissolved oxygen (DO) are required for the correct operation of the biological process. This can be achieved through controlled injection of process air (depending on the raw water pH) to increase the DO and achieve specific target process conditions. Target pH and DO ranges are as follows:

- Bio-Iron Oxidation Process:
  - pH: 6 - 7.0 s.u., or typical raw water pH
  - DO: < 1 – 3 mg/L

- Bio-Manganese Oxidation Process:
  - pH: 7.5 – 8.0, typically filter effluent targeting distribution system pH
  - DO: 5 – 6 mg/L

In some applications, pH adjustment may require the injection of caustic, particularly for two-stage systems due to the difference in operating ranges for the processes. The time required for the initial establishment of the bacterial colony is referred to as the “seeding time,” which is how long it takes for a biological filter to remove significant quantities of iron/manganese. The amount of seeding time depends on the raw water quality, background bacterial levels, temperature, and other factors, but can be reduced by introducing a small amount of filter media or backwash waste from another mature, biologically active filter. Typical seeding times for iron filters may be within hours/days while manganese filters are typically days/weeks. However even after initial startup, additional time is needed to establish a "robust biofilm," which is resistant to influent quality swings, process changes, and washout. At some sites, where only raw water manganese and background biology is used, it may take 6 to 12 months, or beyond, to establish the desired biological community.

In addition, these filters are typically a mono-media and do not require a re-stratification step typical for dual media, such as manganese greensand with an anthracite cap. However special care should be taken to not provide backwash supply water from a distribution system or a chlorinated clearwell to avoid damaging the bacterial catalysts through disinfection. A clearwell downstream of the bio-filters is recommended to provide unchlorinated backwash water and allow any entrained air that may be present in the water to escape, thereby eliminating the risk of "milky" (supersaturated) water at customer taps.

Biological iron and manganese filtration is a relatively newer process compared with traditional chemical oxide coated media filtration in the United States. There are less than a dozen full-scale biological filtration systems operating in New England at this time, but the field is actively expanding. However, for this reason, no manufacturer offers a process guarantee of filtration effluent water quality. Piloting-scale testing is recommended to confirm operational design criteria.

Based on recent Tighe & Bond experience with over ten greensand and three biological filtration plants in operation, it is our opinion that both treatment technologies can achieve effluent iron and manganese concentrations consistently below their respective SMCLs. Bio-filters have a longer start-up period and can be inhibited at low temperatures (<45°F), but they tend to develop head loss more slowly, have longer filter run times compared to chemical oxidation/oxide-coated media filters, and use less chemicals. The longer runtimes, reduced backwash supply rate, and reduced chemical usage result in lower residuals production and lower annual O&M costs. Table 8 summarizes the advantages and considerations for iron and manganese removal with greensand filters and bio-filters.

Table 8-Comparison of Greensand Biological Filtration Technologies

	Advantages	Considerations
Greensand Filtration	• Short start-up periods • Widely adopted technology	• More frequent backwashing • More residual backwash water • Requires more chemical oxidant and labor for managing chemicals
Biological Filtration	• Less frequent backwashing • Less residual backwash wastewater • No chemical oxidants that interfere with PFAS treatment • Reduced labor costs. • Lower annual O&M costs	• Longer piloting and startup phases • Must balance dissolved oxygen, pH and other parameters to maintain biological activity in optimum range • Requires non-chlorinated backwash water • May require reconditioning after prolonged shut-down • Clearwell and repumping recommended prior to chlorine treatment

2.2.4 Conceptual Design – Greensand

Design for Greensand filtration is based on hydraulic loading rate (HLR), solids loading rate (SLR) and other parameters. We can calculate appropriate vessel diameter and select the number of filter vessels so the system operates within acceptable ranges for these parameters. Although media suppliers purport that the operating range is between 2 and 12 gpm/ft^2, most greensand filtration systems operate optimally at hydraulic loading rates between 3 and 5 gpm/ft^2 to prevent excessive head loss and ensure effective adsorption/filtration. Based on these loading rates and at a flow rate of 140 gpm, the total filter surface area should be between 28.0 ft^2 and 46.7 ft^2.

Table 9-Hydraulic Loading Rates for Selected Greensand Filter Systems

Vessel Dimensions (diameter x height)	No. of Vessels	Total Filter Area (sq. ft.)	Hydraulic Loading Rate @ 140 gpm (gpm/ft^2)	Backwash Rate for Single Vessel @ 12 gpm/ft^2 (gpm)
48" x 60"	3	37.70	3.71	150.8
54" x 60"	3	47.71	2.93	190.9
60" x 60"	3	58.90	2.38	235.6
66" x 60"	2	47.52	2.95	285.1

A minimum of two (2) filters are required per MassDEP. Having a third filter provides redundancy and will increase filter run times. Operating at the lower HLR will decrease superficial velocity through the system and therefore minimize head loss. Three (3) 4.5-ft. diameter vessels would operate at just under 3 gpm/ft^2. Three (3) 5-ft. diameter vessels would operate at the lower end of the acceptable range for Greensand filtration. Either configuration would be acceptable and reasonable. The 4.0-ft. and 4.5-ft. diameter vessels can be backwashed at lower rates and require less backwash water overall (though they may be backwashed more frequently). As shown in the sections below, the 4.0-ft. diameter system would require that more than one filter be backwashed each day and is therefore undesirable. Future pilot testing may demonstrate that the system be configured with three (3), 4.5-ft. diameter vessels. However, to be conservative at this early stage of conceptual design, we progressed assuming a system with three (3) 5-ft. diameter filter vessels.

The other key design parameter to calculate is backwash frequency and volume, which is based on the raw water mineral concentrations. For the purposes of this analysis we used GreensandPlus™ as the representative oxide-coated media. GreensandPlus is widely used due to its durability and ability to maintain an effective oxide coating for the catalytic adsorption of manganese. Typically, an anthracite layer on top of the GreensandPlus is used to capture iron precipitates ahead of the denser, finer-grained greensand media. For the purposes of a conceptual design, we included a 1-foot bed of anthracite coal media above a 2-foot bed of GreensandPlus™ media. Other oxide-coated media (glauconite, pyrolusite, etc.) can be used to filter iron and manganese, and may be investigated/piloted in later stages of design.

Using the stated assumptions above, we can estimate the throughput (in gallons) of treated water based on influent iron/manganese concentrations. Inversand™, the manufacturer of GreensandPlus, claims 700-1200 grains of oxidized iron/manganese can be captured per square foot of bed area before breakthrough and/or differential pressure buildup necessitates backwashing. In laboratory testing, roughly 1 mg/L of oxidized iron is produced for every mg/L concentration in the raw water, and 2 mg/L of oxidized manganese is produced. Using the 2021 average concentrations of 0.725 mg/L Fe and 0.126 mg/L Mn.

$$\left[0.725\frac{mg}{L}\ Fe\right] \times 1.0\ + \left[0.126\frac{mg}{L} Mn\right] \times 2.0 = 0.977\frac{mg}{L}\ oxidized\frac{Fe}{Mn} \times \frac{1\ ^{grain}/_{gallon}}{17.1\ ^{mg}/_{L}} = 0.0571\ ^{grain}/_{gal}$$

The surface area for a single 5-ft. diameter filter is 19.63 sq. ft. Using an estimated absorptive capacity of 800 grains per sq. ft. (low end of Inversand™ suggested range), throughput for a single filter would be approximately 275,000 gallons. Since each vessel would be filtering 1/3 of the total flow, and the daily flow at 140 gpm is 201,000 gpd, the expected run time between backwashes for any individual filter would be three days. This would mean that backwashing could be staggered so that one vessel is backwashed per day. The same is true, with a slimmer margin for error, of the 4.5-ft diameter, three-filter array.

Filter System Information	**5-ft. diameter**	**4.5-ft. diameter**	**4.0-ft diameter**
Design Flow Rate (gpm)		140	
Number of filters		3	
Filter diameter (feet)	5.0	4.5	4.0
Filter surface area (1 filter) (SF)	19.63	15.9	12.6
Flow rate per filter (gpm)	46.7	46.7	46.7
Hydraulic Loading Rate (HLR) (gpm/ft^2)	2.38	2.93	3.71
Filtered water run volumes between backwashes, ea. filter (gal)	275,000	225,000	176,532
Daily water production (gal)		201,000	
Backwash Rate @ 12 gpm/ft^2 (gpm)	235.6	190.8	151.2
Backwash Volume @ 20 min backwash duration (gal)	4,700	3,816	3,024

To ensure efficient treatment through a GreensandPlus™ filtration system, the catalytic characteristics of the media must be maintained through regeneration by exposure to an oxidant. Chlorine or permanganate are the most common oxidants used. Regeneration can be performed continuously by feeding permanganate or chlorine during filter service (continuous regeneration, CR) or intermittently by occasionally backwashing or soaking with permanganate (intermittent regeneration, IR). Operation with hypochlorite as the sole oxidant leads to higher runtimes as potassium permanganate is a stronger oxidant and will often lead to full oxidation of the dissolved manganese to a particle. A buildup of manganese in addition to the iron particles in the media bed may lead to higher head loss buildup than when manganese is only removed via adsorption and catalyzed by the media. In addition, injection of potassium permanganate increases the total manganese loading on the filters increasing the mass required for treatment. Operation with hypochlorite alone may weaken the surface charge of the media over time and require earlier replacement or intermittent regeneration with potassium permanganate. Operation with both oxidants should be tested during a pilot phase to determine the optimal pre-treatment levels prior to filtration.

GreensandPlus™ filtration systems often operate at system pressure, allowing well pumps to pump through the filtration system directly to downstream processes and into the distribution system. Simple backwash provisions can allow for the filter system to use forward flow, through the filters, as a source of backwash water or, in cases where the source flow is less than the required filter backwash flow, flow is reversed in the distribution system, using system pressure to push the required flow rate back up through the filter for cleaning. The capacity of Spring Street Well is 140 gpm, which is not enough to backwash a 4.5-ft. or 5-ft. diameter filter vessel. Although economical, flow reversals in the distribution system can stir up laden solids in the distribution system, leading to dirty water calls during backwashing. To avoid the need for flow reversals, a hydraulic break tank or a side stream backwash supply tank and pump is recommended.

Backwash waste can be discharged to the sewer, although it is important to verify that the backwash flow rates will not exceed conveyance capacity. In cases where the rate of backwash is too high for the sewer system to accept, an equalization tank is required to gradually discharge via gravity. A better option is to store backwash water and recycle it at nominally 10% of the influent flow rate after the solids have had time to settle. With backwash occurring on a single filter each day, there would be ample time for the water to quiesce and the recycle tank to be emptied before the next backwash is initiated. The backwash recycle tank will eventually accrue a layer of solids that will need to be pumped and/or drained by gravity to the sewer. This spent backwash storage and recycle system reduces "wasted" water and lowers the treatment cost at the WWTP.

The filtration system would be located within a building with a footprint of at least 1,800 square feet. This conceptual building would house the filter units, associated process piping, chemical feed and storage, backwash supply and recycle tanks, as well as a mechanical/electrical control room. The raw water will be conveyed to the WTP through a common header pipe. Chlorine and potassium hydroxide would be injected before the filters, with capability to inject into filter effluent water as well. There would also be provisions to inject $KMnO_4$, for pretreatment. The Town should consider expanding the building footprint to roughly 3,000 square feet to incorporate administrative workspace, a bathroom, etc. The layout shown in Figure 3 represents only the areas necessary to house the treatment system and appurtenances and shows possible configurations for future PFAS treatment. Note that the Construction Cost Estimate prepared in Section 2.2.6 takes into account space for the additional administrative areas but does not factor in PFAS treatment equipment and associated infrastructure upgrades, which could account for an additional $2.5M-$4M depending on site conditions and other design factors. Figure 3 includes two possible ways to integrate the PFAS treatment – an L-shaped structure or one long, continuous building. Each has its advantages/disadvantages and would be designed based on site geometry, access, ease of operation and other factors.

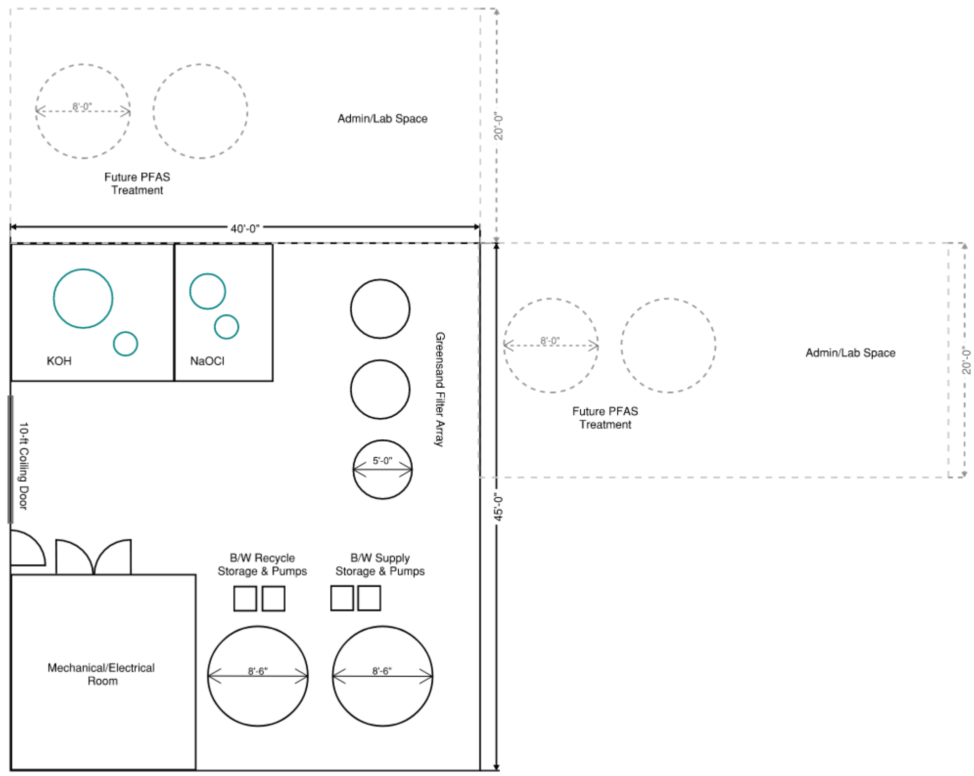

Figure 3-Conceptual Floorplan - Greensand Filtration incl. Future PFAS Treatment Options

2.2.5 Conceptual Design - Biological Filtration

Biological filtration has been widely adopted in Europe for decades and has been successfully implemented in New England over the last decade. However, due to the nature of a biological system, predicting the performance of biological filtration is more complex and is not simply estimated from a technical datasheet provided by a manufacturer. However, based on previous work performed by Tighe & Bond, we can make a conservative estimate of runtimes between backwashes based on the results of pilot and full-scale filters with similar water quality as the Spring Street Well. It is our opinion that the biological filtration systems will likely meet a minimum 48 hour run time at the design flow for loading rates of 10 gpm/sf and below. A rigorous pilot study would be required prior to construction of a full-scale biological filtration system to confirm the assumptions in this report.

Typically, biological filtration systems require a two-stage filtration system, iron followed by manganese, due to the biological preference towards higher oxidation potential. In some instances, other constituents such as sulfates, ammonia, and organics can reduce the effectiveness of biological iron oxidation because of the higher oxidation potential of nitrogen and carbon nutrients.

The conceptual filtration system for Spring Street Well consists of two 3.5-foot diameter biological iron filters, followed by two 3.5-foot diameter biological manganese filters for a typical filter surface loading rate of 7.3 gpm/sf. We have included a reasonable estimate for filter runtimes between backwashes based on the results of other pilot and full-scale facilities in New England. For the purpose of this conceptual design, a filter runtime of 96 hours between backwashes for biological iron and 72 hours for biological manganese filtration at peak flows has been assumed. This corresponds to a unit filter run volume of approximately

0.806 MG and 0.605 MG of treated groundwater before backwashes of the iron and manganese filter systems, respectively. There are cases where filter run times are even longer than this. A pilot study would be required to estimate the backwash frequency with more confidence.

GreensandPlus™ is typically operated to 6-8 PSI as recommended by the filtration system providers, but media data sheets indicate 10 PSI to be a safe pressure where no damage will be done to the media coating. For biological filtration, there is no typical standard head loss across the filter bed recommended by a manufacturer. In practice, biological filtration systems in New England have been operated based on total number of hours online or a terminal head loss of 10 PSI. However, in several pilot studies, Tighe & Bond has observed biological filers operating to 20 PSI and above with no observed treatment impact. Previous experience indicates the possibility of issues associated with plugging of the media with biological cell material at high differential pressures and high concentrations of iron. For biological manganese filtration, we believe plugging may be less of an issue, long term, than plugging associated with high concentrations of iron. Repeatable operations to a terminal head loss of above 10 PSI may be evaluated as part of the pilot phase. Additional capacity for backwash pump design may also be provided to mitigate longer term media plugging.

Biological filtration has been observed to adapt well with changing water quality. Because the design expectations of the biological filters are significantly above the conceptual design of the GreensandPlus™ filter, it is likely these conceptual assumptions will have redundancy built into the filter loading rate. Instead of providing space or a third, redundant filter for each train, it is likely that data from the pilot will suggest the ability to significantly increase the filter surface loading rate while maintaining runtimes above the 48-hour minimum. Alternatively, the diameter of the filter vessel could be increased to 4.0-ft., which would provide additional factor of safety with respect to loading rate and filter run times, in the event that the system must operate with only a single treatment train in service.

Table 10 presents details of a conceptual biological filtration system composed of two 3.5-ft diameter biological iron filters followed by two 3.5-ft diameter biological manganese filters, each with an approximate 200 cubic feet of sand media. To ensure efficient treatment through the biological treatment system, the bacteria will need to provide the proper conditions for growth. pH and DO will be criteria design criteria, among others, which should be evaluated in a pilot study as required by MassDEP. Assuming an annual average daily withdrawal limit of 0.66 MGD as listed in the WMA permit, the WTP would typically backwash once per week.

Table 10-Conceptual Biological Filter System Sizing

Filter System Information	Design Parameter
Design Flow Rate (gpm)	140
Number of filters (two trains, Fe treatment then Mn treatment)	4
Filter diameter (feet)	3.5
Filter surface area (1 filter) (SF)	50.2
Filter surface loading rate (FSLR) (gpm/sf) @ 140 gpm	7.3
Head loss (PSI)	10
Iron - filtered water run volumes between backwashes (MG)*	0.8
Manganese - filtered water run volumes between backwashes (MG)*	0.6
Backwash Rate @ ~ 8 gpm/ft^2 (gpm)	75-80
Backwash volume – 20 mins b/w (gal per filter)	1,600

For a biological filter, due to the need for unchlorinated backwash supply and potential issues of dissolved air degassing in downstream processes, biological filter systems are often provided in a double pumping scenario where the well pumps convey raw water through the biological filter and a separate set of high lift pumps convey raw water through successive treatment processes and into the distribution system. This filter effluent tank provides both unchlorinated backwash supply and an atmospheric break to allow for dissolved gases to be released prior to re-pressurization. In previous experience, proper control of the air injection, prefiltration and pipe routing can provide de-gassing sufficient to pump through to the distribution system. At this time, it is our understanding that no full-scale biological filtration system in New England is operating in a pump through mode.

Typically, a hydraulic break is provided downstream of biological manganese filtration to allow for release of the surplus process air. Although there are no residual oxidant concerns for downstream processes, it is typical to provide post-filtration disinfection to a chlorine residual of approximately 0.3 mg/L. Because the media is specifically designed to create habitat for bacteriological growth, special consideration should be given to downstream storage or filtration systems if chlorination or other disinfection is not provided. Without disinfection using chlorine, there is a possibility for microbial growth on the media itself or in the clearwell storage.

Backwash rates for biological filter systems are lower than those required for Greensand. This fact, combined with the smaller vessel diameter, results in a backwash rate of 75-80 gpm to achieve approximately 8 gpm/ft^2. Given the Spring Street Well can operate at 140 gpm, the backwash and rinse water could be provided directly from the source; backwashing with raw water should be investigated in the pilot study. Unchlorinated filtered flow stored in the clearwell could also be used.

The filtration system would be located within a building with a footprint of 1,800 square feet (+/- 20%). This conceptual building would house the filter units, associated process piping, aeration and chemical feed systems, clearwell, as well as a mechanical/electrical control room. The raw water will be conveyed to the WTP through a common header pipe. Air would be injected before the iron filters, with provisions to inject KOH for pretreatment; both KOH and air will be injected before the manganese filters. Our design includes sodium hypochlorite (NaOCl) to prevent microbial growth in the clearwell storage tank(s), and because MassDEP may require it as a condition of permit approval. The conceptual layout also shows a redundant clearwell, which is in accordance with Ten States' Standards so the system can operate if one storage unit is down for maintenance and/or repair. The additional storage could potentially be configured to serve as a spent backwash recycle system during normal operation also. The layout shown in Figure 4 is illustrative and meant to serve as an example of what the general arrangement might look like. There are multiple design options that could be integrated in later stages of design. For example, the Town could opt to use a buried concrete tank for the clearwell, which would lower heating/cooling expense, but increase the cost of site work. For the purposes of this study, the general arrangement shown in Figure 4 is reasonable and useful for comparison with Greensand. The Town should consider expanding the building footprint to roughly 3,000 square feet to incorporate administrative workspace, a bathroom, etc. The layout shown in Figure 4 represents only the areas necessary to house the treatment system and appurtenances and shows possible configurations for future PFAS treatment. Note that the Construction Cost Estimate prepared in Section 2.2.6 takes into account space for the additional administrative areas but does not factor in PFAS treatment equipment and associated infrastructure upgrades, which could account for an additional $2.5M-$4M depending on site conditions and other design factors. Figure 4 includes two possible ways to integrate the PFAS treatment – an L-shaped structure or one long, continuous building. Each has its advantages/disadvantages and would be designed based on site geometry, access, ease of operation and other factors.

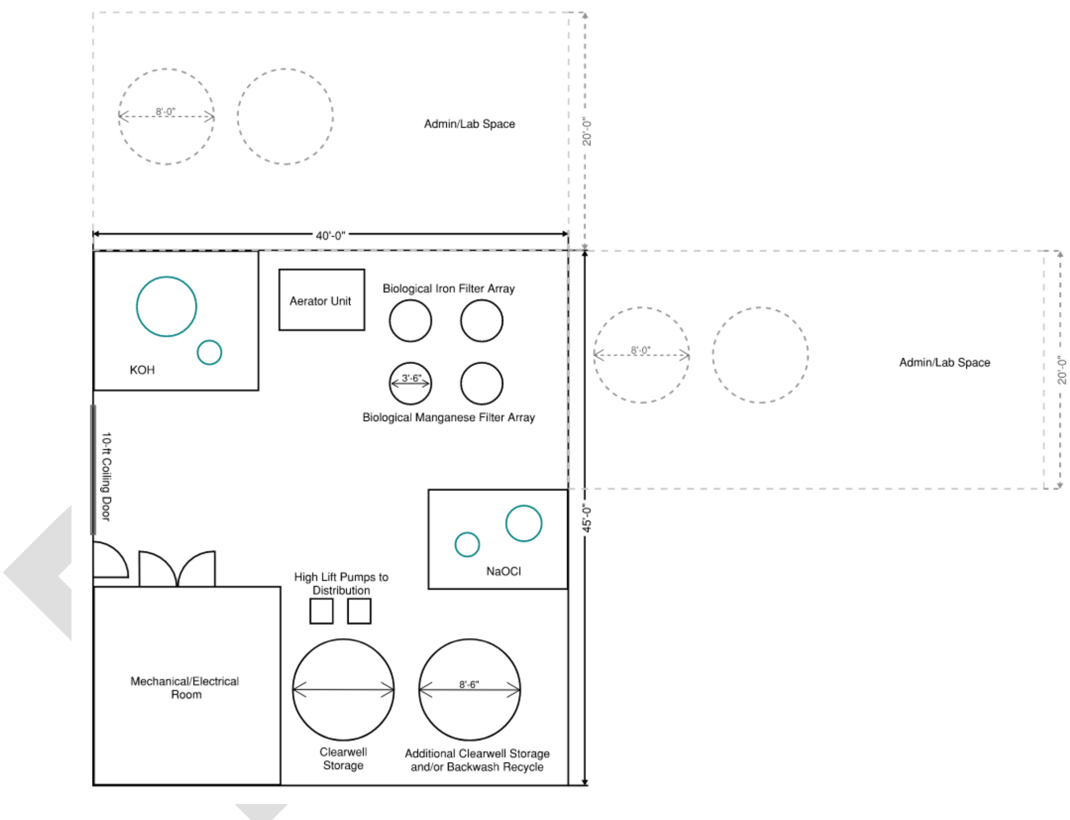

Figure 4-Conceptual Floorplan-Biological Filtration incl. PFAS Treatment Options

2.2.6 Considerations for PFAS Treatment

As discussed in Section 2.2.1 above, the most recent sample collected in January 2023 had a PFOA concentration of 4.5 ppt, which is above the proposed federal MCL. The concept layouts shown in Figure 3 and Figure 4 are based on a single train of two GAC contactors configured in series (i.e., lead-lag). The design is based on GAC since it is preferable to ion exchange where there is the possibility of residual chlorine from an upstream Greensand filtration process. The 8-foot diameter for the vessels shown in each conceptual design figure are based on a hydraulic loading rate (HLR) of 2.8 gpm/ft2 at the 140 gpm flow rate from Spring Street Well, which is within the acceptable range for GAC media. Additional treatment for PFAS will create more head loss, which may necessitate pumping upgrades and other design modifications. Also, the pressure vessels for GAC filter-adsorbers are significantly taller than those of the Greensand or biofiltration system. This results in design and construction of a separate "PFAS treatment wing" with a higher roof height or excavation to lower the finished floor of the PFAS treatment area so the building has a common roof level. There are advantages/disadvantages and cost implications associated with either configuration, which will need to be vetted in subsequent design phases.

2.2.7 Construction Cost Estimates

Capital costs included in Table 11 are provided to highlight the differences between the two Fe/Mn treatment technologies. The sitework, building and building systems, utilities and other appurtenances for each project would be relatively similar. Additional project level opinions of probable construction costs for the conceptual water treatment plant are provided in later sections.

Table 11-Summary of Process Equipment Capital Costs[1]

	Greensand	**Biological**
Pre-construction Piloting[2]	*$50,000*	*$150,000*
Backwash Supply - Storage/Pumping	$100,000	n/a
Backwash Waste Storage and Recycle	$200,000	n/a
Chemical Feed Storage & Equipment	$150,000	$150,000
Aeration and/or Oxygen Injection	n/a	$100,000
Instrumentation & Controls`	$100,000	$100,000
Clearwell & High Lift Pumps to Distribution	n/a[3]	$250,000
Filter Vessels & Process Equipment	$750,000	$800,000
Subtotal Process Equipment Costs	$1,350,000	$1,550,000

[1] The costs presented in this table are representative of typical costs for these treatment systems. The costs are for comparison of the filtration systems and associated chemical feed and pumping systems only.
[2] Piloting costs shown for reference but not included are the subtotal equipment costs. Biological pilot includes GreensandPlus pilot study for comparison.
[3] Due to the extra head loss through the treatment system, the Spring Street Well submersible pump may need to be upgraded to match existing hydraulic conditions. Since this is unknown, no cost was assigned for this study.

Table 12 provides a conceptual-level Construction Cost Estimate for either the Greensand or Biological Filtration approach. The construction costs presented are consistent with AACE International Class IV cost estimates. Class IV costs estimates have a typical expected accuracy range of -30%/+50% applied to alternatives analyses and feasibility studies with a project that is on the order of 1% to 15% complete.

Note that Figure 3 and Figure 4 above showed only generic floorplans for the process treatment equipment. Later stages of design shall incorporate other appurtenances such as a bathroom and work/storage areas (up to an additional 1,000 sq. ft.) based on input from the Town. The budgetary costs for the WTP Building in Table 12 account for additional floor space to be incorporated in final design, but do not factor in PFAS treatment.

Table 12: Preliminary Construction Cost Estimate

Description	**Greensand**	**Biological**
Site Work	$500,000	$500,000
Pre-engineered WTP Building	$1,250,000	$1,250,000
Process Treatment Equipment	$1,350,000	$1,550,000
Building Utilities	$500,000	$500,000
New B/U Electrical Power Generator	$250,000	$350,000
Electrical Upgrades	$500,000	$500,000
Subtotal	$4,350,000	$4,650,000
Contractor OH & Profit @ 15%	$650,000	$700,000
Planning Level Construction Contingency @ 35%	$1,500,000	$1,600,000
Construction Subtotal	**$6,500,000**	**$6,950,000**
Engineering Design & Permitting @ 10%	$650,000	$695,000
Construction Administration, Observation, and Startup @ 10%	$650,000	$695,000
Design/Permitting/Construction Admin Subtotal	**$1,300,000**	**$1,390,000**
Total Planning Level Project Cost	**$7,800,000**	**$8,340,000**

* as noted above, budgetary cost estimates presented in Table 12 do not account for PFAS treatment.

3 Summary & Recommendation

For the Town of Holden, a shift from its current rate for water purchases from Worcester represents a potentially significant impact to drinking water operating costs. Worcester is subject to increasingly stringent regulation, aging infrastructure and other factors that will inevitably lead to rate increases, which will directly impact Holden's cost of service. As an ordinary "customer," Holden will have little, if any, ability to influence or plan for these future rate increases. This will make capital planning and rate-making difficult for the Town of Holden. Furthermore, Worcester's reliance on surface water and Holden's two interconnections at the extremity of the Worcester distribution system present a risk for elevated DBPs, including some that are yet to be regulated.

Spring Street Well can reliably supply 140 gpm (0.2 MGD) but has iron and manganese concentrations that exceed the SMCL and cause customer complaints. The alternatives analysis described herein supports design and construction of a new Spring Street Well Treatment Facility based on water quality, reliability, and economic factors. Depending on the economic inputs used, the Present Value (PV) for the purchase of 0.2 MGD from the City of Worcester over a 50-year period ranges from $9.5M to $22.3M. Over a 25-year period the range is $6.7M to $10.5M. This compares to the cost of constructing a new treatment facility, which is estimated to be $7.8M - $8.3M. Beyond the cost implications, a new Spring Street Well Treatment Facility would provide enhanced reliability with respect to possible supply disruptions in the region and would make the best use of Holden's existing, permitted groundwater sources.