Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

September 15, 2023

Mr. Eric Hooper
Town of Sharon DPW
217 Rear South Main Street
Sharon, MA 02067

RE: SHARON – Public Water Supply
Sharon Water Department
PWS ID#: 4266000
BRP WS22D, Approval of Pilot Study Report
Record #23-WS22-0015-APP

Dear Mr. Hooper:

The Southeast Regional Office of the Massachusetts Department of Environmental Protection (MassDEP), Drinking Water Program, is in receipt of a pilot study report summarizing the pilot test at the Wellfield 2, in the Town of Sharon, Massachusetts.

Please find attached MassDEP approval of the Pilot Study Report.

Please note that the signature on this cover letter indicates formal issuance of the attached document. If you have any questions regarding this document, please contact Giliane Tardieu at (774-384-7861 or Giliane.tardieu@mass.gov.

Sincerely,

Jim McLaughlin, Chief
Drinking Water Program
Bureau of Water Resources

DWP Archive/SERO/SHARON-4266000-System Modifications-2023-09-15 WS22

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The Southeast Regional Office of the Department of Environmental Protection, Drinking Water Program ("the Department"), has received and reviewed the report entitled "Pilot Study Approval Application, Town of Sharon, Massachusetts". The report was submitted on behalf of the Sharon Water Department ("the PWS") by Environmental Partners of Quincy, Massachusetts, was received by the Department on August 25, 2023, and bears the seal and signature of Alston Potts, a Massachusetts Registered Professional Engineer, P.E. No.46074 ("the Engineer").

Specific documents relative to this submission received and reviewed by the Department for conformance with the Department's Water Supply Regulations, 310 CMR 22.00 (Regulations) and "Guidelines and Policies for Public Water Systems" (Guidelines) are as follows:

- Water Supply Certification Form.
- Pilot Study Report.
- Preliminary WTP Process Flow Diagram & Layouts.
- Cover Letter

Background: Historically, raw water from Well #2 (Source ID 4266000-01G) and Well #3 (Source ID 4266000-02G) has exceeded the Secondary Maximum Contaminant Level (SMCL) of 0.3 milligrams per liter (mg/L) for iron and 0.05 mg/L for manganese. Environmental Partners (EP) and Blueleaf, Inc. (Blueleaf) conducted pilot studies for the Wellfield 2 (Well #2) raw water only because iron and manganese levels at this well are the highest of the two sources. A pilot study for PFAS removal was not performed. Based on the results of initial testing performed in the spring of 2021 on all of the PWS's sources, Well #4 (Source ID 4266000-03G) had the highest levels of PFAS of Wells 2, 3 or 4. PFAS levels at Well #4 exceeded the MassDEP regulation for six PFAS compounds (PFAS6). In response to exceeding the MassDEP regulation, the Town designed, constructed, and is now operating a full-scale, temporary ion exchange treatment system for the removal of PFAS from Well #4 raw water. This system has proved effective at removing raw water PFAS to non-detect levels for all PFAS compounds regulated by MassDEP. Due to the success of PFAS treatment at Well #4, and the relatively lower levels of PFAS6 at Well #2 and Well #3, EP did not propose a pilot study for PFAS removal for Well #2 or Well #3.

Pilot Study: Blueleaf performed two pilot studies in parallel between December 2022 and March 2023 to evaluate the use of pressure filtration technology for the removal of iron and manganese from Sharon's Well #2. The first pilot study, referred to as Pilot Study #1, evaluated the oxidation and subsequent removal of iron and manganese using oxide coated media filtration. The second pilot study, referred to as Pilot Study #2, evaluated the removal of iron and manganese using biologically activated media filtration. Due to the longer duration of Pilot Study #2, this pilot study began approximately two months before Pilot Study #1. Each pilot test included a trailer with chemical feed equipment, 6-inch filter columns (four for Pilot Study #1 and three for Pilot Study #2), and online water quality analyzers. Blueleaf operated the equipment and conducted field water quality analyses during the 44 filter runs of Pilot Study #1 and 45 filter runs of Pilot Study #2 at the well. Phoenix Environmental Labs in Manchester, Connecticut provided certified laboratory analyses for this study.

The pilot study data includes raw water data collected during both Pilot Study #1 and Pilot Study #2. Blueleaf also collected raw water quality data for color and total organic carbon (TOC). Apparent color, measured before filtering the water sample, was detected at 15 color units. True color, measured after filtering the water sample, was not detected in the raw water. This is similar to the well's historic average color of 15 color units. The results of Blueleaf's field analyses of TOC indicate an average TOC level of 0.35 mg/L, which is lower than the TOC level of 1.90 mg/L measured in 2021 during the Town's supplemental sampling event.

Blueleaf collected samples for a Biological Activity Reaction Test (BART), which identified the presence and level of activity of several potential inhibiting bacteria that can be found in water and Page 4 of 16 envpartners.com wastewater sources. The results of the BART test identified an elevated number of iron reducing and slime forming bacteria in the raw groundwater and a small population of sulfate reducing bacteria.

PILOT STUDY #1

The primary goal of Pilot Study #1 was to evaluate oxide coated media filtration for the removal of iron and manganese from Well #2. Blueleaf studied two oxide coated medias: GreensandPlus™ (Greensand) and Pureflow© PM-200 pyrolusite media (pyrolusite). The table below includes a summary of the water quality goals for this pilot study. The treatment goals for iron and manganese were half of each parameter's SMCL, which is 0.30 mg/L for iron and 0.05 mg/L for manganese.

Location	Parameter	Goal
Filtered Water	Iron	< 0.15 mg/L
Filtered Water	Manganese	< 0.025 mg/L
Filtered Water	Turbidity	<0.01 NTU

Blueleaf mobilized the oxide coated media pilot trailer at Well #2 on February 15, 2023. After mobilizing the pilot trailer equipment, Blueleaf optimized filter performance using sodium hypochlorite as a pre-oxidant. Blueleaf conducted Pilot Study #1 for just over three weeks, which included backwash recycle trials.

The Following table lists the four filters used in Pilot Study #1 and their designations. Filters A and C contained Greensand media and Filters B and D contained pyrolusite. All filters contained 24 inches of their respective oxide coated media and a 12-inch anthracite cap. To study the performance of the filters with different target pH values, Filters A and B had an influent target pH of 6.4 (ambient raw water pH), while Filters C and D had an influent target pH of 8.0 to match the Town's finished water pH goal. In terms of loading rates, Blueleaf operated the filters at filter surface loading rates (FSLRs) ranging from 5 gallons per minute per square foot (gpm/sf) to 10 gpm/sf.

Name	Influent Target pH	Media
Filter A	6.4	GreensandPlus™
Filter B	6.4	Pyrolusite
Filter C	8.0	GreensandPlus™
Filter D	8.0	Pyrolusite

For Pilot Study #1, Blueleaf used sodium hypochlorite as a pre-oxidant for all four filter columns. Blueleaf based their dosing on a target filtered water free chlorine residual between 0.25 mg/L and 0.50 mg/L. The exact dose of sodium hypochlorite varied between 1.5 and 2.8 mg/L depending on the strength of bleach used in the chemical storage container. Sodium hypochlorite was effective as a pre-oxidant for all four filter columns, therefore testing of alternative oxidants was not required. EP recommends a sodium hypochlorite dose of 1.50-2.80 mg/L to attain a residual filter effluent chlorine level of 0.5 mg/L.

The Town uses potassium hydroxide for pH adjustment and corrosion control at their water sources. During this pilot study, Blueleaf compared the performance of the filters at a raw water ambient pH of 6.4 and an adjusted pH of 8.0. With sodium hypochlorite as the pre-oxidant, Blueleaf found a pre-oxidation pH of 6.4 to be more effective than 8.0 in meeting pilot study goals. EP recommends that the full-scale plant does not include pre-filtration pH adjustment to minimize the number of potassium hydroxide chemical feed injection points and simplify operations.

The filters successfully met the treated water quality goals for iron, manganese, and turbidity. Blueleaf measured filter effluent turbidity in the filter effluent water as a surrogate for iron breakthrough, as turbidity is not regulated for groundwater treatment.

A comparison of online filter effluent turbidity readings with filter terminal headloss readings suggests that during many of the trials, turbidity began to rise after the filter reaches terminal headloss (greater than 10 psi differential pressure), especially at higher loading rates. However, Filter D experienced several trials that were terminated due to turbidity breakthrough (greater than 0.1 NTU). Filters C and D, which had a higher target pH, generally had more instances of turbidity reaching breakthrough levels, even if breakthrough occurred after the filters reached terminal headloss.

EP recommends the installation of filter effluent turbidity meters in the future WTP to help monitor for water quality breakthrough events and trigger backwashes when turbidity readings exceed 0.1 NTU. This is particularly important for filter operations at a pH of 8.0 since water quality breakthrough typically preceded terminal differential pressure for the filter runs at this higher pH target.

Filter runtimes for all four filters varied from approximately 11 hours to approximately 65 hours depending on the loading rate, type of media, and influent pH. Filter Surface Loading Rates (FSLRs) of 5 gpm/sf, 7.5 gpm/sf, and 10 gpm/sf were studied during this pilot study. Based on the pilot study data, to achieve runtimes of at least 24 hours, filters should typically be operated with loading rates that do not exceed approximately 8 gpm/sf, which is a typical maximum operating point for pressure filtration with Greensand media.

If oxide coated media is selected as the treatment technology for the WTP, EP recommends the use of Greensand over pyrolusite because there is less breakthrough with Greensand. Greensand also required a lower backwash frequency than pyrolusite media. EP recommends an average FSLR of up to 5 gpm/sf and a peak FSLR of up to 8 gpm/sf for the design of a future WTP using Greensand filtration.

pH and alkalinity are two important parameters to consider relative to corrosion control. Raw water pH ranged from approximately 6.14 to approximately 6.95 and raw water alkalinity ranged from 45.5 mg/L as CaCO3 to 52 mg/L as CaCO3. As discussed above, EP used raw water ambient pH as the target for Filters A and B and an influent target pH of 8.0 for Filters C and D. Blueleaf added potassium hydroxide to maintain the target pH for Filters C and D. Alkalinity data for the Pilot Study #1 filter trials is limited; however, a review of available filter effluent alkalinity results suggest that while alkalinity levels remained within the raw water alkalinity range for Filters A and B, alkalinity levels rose up to the low 80s for Filters C and D. Based on the performance of the filters, the filters operating at an ambient raw water pH of 6.4 provided longer filter run times at higher FSLRs than the filters operating at an influent pH of 8.0. Therefore, EP does not recommend pH adjustment prior to the iron and manganese removal system. The Town currently uses potassium hydroxide for pH adjustment and corrosion control at each of their sources to maintain a finished water pH of approximately 8.0. To increase the filter effluent water pH to 8.0, EP recommends a potassium hydroxide dose of approximately 36.5 mg/L, which is based on titrations performed by Blueleaf to assess chemical doses at different pH levels.

Blueleaf conducted bench-scale filter effluent sodium hypochlorite titrations. Blueleaf's titrations continued to an endpoint of approximately 1.8 mg/L free chlorine, which is above the Town's finished water goal of 0.2 mg/L to 1.2 mg/L free chlorine. Based on the results of the titrations, the Town will need to add approximately 0.2 mg/L to 1.2 mg/L sodium hypochlorite to the filter effluent to meet the target free chlorine residual in the filtered water of 0.2 mg/L to 1.2 mg/L.

The filtration process will generate residuals during backwashes and filter-to-waste operations. Blueleaf typically backwashed the filters for 10 minutes at 12 gpm/sf. Blueleaf found no significant negative impacts backwashing the oxide coated media filters. A backwash of 12 gpm/sf is typical for Greensand media. While pyrolusite could be backwashed at rates up to 20 gpm/sf, high backwash rates could blow out the anthracite cap on top of the pyrolusite media. Therefore, backwash rates for the pyrolusite filters remained at 12 gpm/sf for Pilot Study #1 and may not be representative of actual backwash capacity for that media.

Blueleaf successfully piloted recycling of settled backwash supernatant at 5% of raw water flow. Filtered water iron and manganese concentrations and the rate of differential pressure gain remained unaffected by backwash recycling. In addition, a review of combined backwash and settled supernatant water quality data suggests that the backwash water largely consists of readily settleable solids. The results of the Imhoff cone test indicate that after five hours, 30-40 mL (3-4%) of the iron and manganese settled in the cones. Therefore, EP recommends designing the future water treatment facility to include the option to recycle settled supernatant into the process at up to 5% of raw water flow. Additionally, EP recommends allowing solids to settle for at least 2 hours after each backwash before commencing recycle operations.

PILOT STUDY #2

The primary goal of Pilot Study #2 was to evaluate biological filtration for the removal of iron and manganese from Well #2. Like Pilot Study #1, iron and manganese were the primary target water quality constituents evaluated during this pilot study. However, Blueleaf did not monitor turbidity during Pilot Study #2. In Pilot Study #2, Blueleaf aerated the iron filter effluent prior to the manganese filter, and the microbubbles that form during aeration can interfere with turbidity readings. Blueleaf also monitored other water quality parameters such as pH, nitrate, and TOC. The water quality goals previously listed (excluding turbidity) were also used for this pilot study.

Blueleaf mobilized their biological filtration pilot trailer at Well #2 on December 12, 2022. As mentioned previously, it took approximately 2 to 3 weeks for raw water iron and manganese concentrations to reach representative levels. Blueleaf conducted Pilot Study #2 for approximately 9 weeks, which included the completion of backwash recycle trials.

Pilot Study #2 included two pilot columns for biological iron filtration (F1 and F2) and one pilot column for biological manganese filtration (M1). Blueleaf employed two pilot columns for biological iron filtration to achieve high levels of iron removal prior to sending water to M1 and to allow for more experimentation with biological iron filter loading rates. The biological iron filtration columns contained 48 inches of 1.3 millimeters (mm) sand. Blueleaf acclimated the media for F1 and F2 with the Town's raw water, which took approximately four days.

The biological manganese filtration column contained 48 inches of 0.95 mm sand. Blueleaf acclimated the media for M1 at a full-scale biological treatment plant in Shrewsbury, Massachusetts and delivered the media to the Well #2 pilot trailer on January 16, 2023. Blueleaf acclimated M1 off-site to reduce the acclimation time of the filter and to prevent high levels of iron from entering the filter while F1 and F2 acclimated. M1 adapted to the Well #2 raw water source. It is important to note that the acclimation period for the biological manganese filter during this pilot study is not representative of full-scale acclimation. A full-scale biological manganese removal filter may take weeks to acclimate and mature.
The biological iron filters operated at FSLRs between 5 gpm/sf and 25 gpm/sf. Blueleaf used F1 to test higher surface loading rates, and operated F2 at more conservative loading rates of 5 gpm/sf to 10 gpm/sf lower than F1. Blueleaf operated the biological manganese filter at a filter surface loading rate of 5 gpm/sf to 15 gpm/sf. The biological iron filters used ambient raw water pH and dissolved oxygen. Iron removal was effective without the use of any pH adjustment or air injection pre-treatment.

Prior to entering M1, Blueleaf treated effluent from the iron filters with approximately 28 mg/L of potassium hydroxide to increase the pH from 6.4 to 7.6. Additionally, iron filter effluent flowed through an in-line air contactor without air injection to increase the dissolved oxygen concentration prior to manganese removal. This method of aeration provided enough dissolved oxygen to meet the target level of at least 4 mg/L. Biological filtration does not require any pre-treatment chlorine dose. In fact, chlorine would destroy the biological mass that helps remove iron and manganese from the water.

For F1 and F2, filter runtimes varied from 14 hours at 25 gpm/sf to almost 90 hours at 5 gpm/sf. For M1, the filter runtimes were 365 hours for the trials running at 10 gpm/sf. Blueleaf did not observe any breakthrough during any of the biological filtration trials.

Raw water pH ranged from approximately 6.14 to approximately 6.95 and raw water alkalinity ranged from 45.5 mg/L as CaCO3 to 52 mg/L as CaCO3. The average pH of the effluent from the iron filters remained within the pH range for the raw water. Due to the air contactor between the iron filters and the manganese filter, pH increased to an average of 7.6 before entering the manganese filter. However, pH tended to decrease through the manganese filter. The average pH of the manganese effluent was 7.2. This is common for healthy biological manganese filters, as it indicates that the biomass is eating the manganese and expelling acid in the process. The alkalinity of the iron filter effluent remained within the alkalinity range for the raw water. However, the alkalinity of the manganese effluent increased to the mid-70s/low-80s.

To bring the manganese filter effluent to a pH of 8.0, EP recommends a potassium hydroxide dose of 8 mg/L, which is based on titrations performed by Blueleaf to assess chemical doses at different pH levels. EP does not recommend the addition of pre-filtration sodium hypochlorite because chlorine can kill the biomass in the filters. To provide a chlorine residual of 0.2 mg/L to 1.2 mg/L in the filtered water, EP recommends a chlorine dose of 0.2 mg/L to 1.2 mg/L, which is based on titrations performed by Blueleaf to assess the relation between chlorine doses and residuals.

Like the oxide coated media filters, the biological filtration process will generate residuals during backwashes and filter-to-waste (e.g. filter ripening) operations. However, biological filters require less frequent and lower volume backwashing than the oxide coated media filters (refer to Table 6). In Pilot Study #2, Blueleaf backwashed the iron and manganese filters with a low-rate wash of 6 gpm/sf for three minutes followed by a high-rate wash of 8 gpm/sf for five minutes. The biological manganese filter required less frequent backwashing than the biological iron filter, which is typical for biological filters.

As previously recommended, Environmental Partners recommends designing the future water treatment facility to include the option to recycle settled supernatant into the process at up to 5% of raw water flow. Additionally, EP recommends allowing solids to settle for at least 3-5 hours after each backwash before commencing recycle operations.

CONCLUSIONS AND RECOMMENDATIONS

Based on a review and evaluation of the pilot study results, EP recommends the following design criteria for the iron and manganese treatment system in the proposed Sharon Wells #2, #3, and #4 WTP:

Method:	Oxide Coated Media Filtration
Media:	GreensandPlus™
pH Adjustment:	Pre-filtration Potassium Hydroxide: None
	Post-filtration Potassium Hydroxide: 36.5 mg/L
	Target finished water pH: 7.8-8.2
Pre-Oxidation:	Sodium Hypochlorite: 1.5-2.8 mg/L (dry dose)
	Target finishes water free chlorine residual: 0.2-1.2 mg/L
Disinfection:	Sodium Hypochlorite: 0.2-1.2 mg/L (dry dose)
	Target finished water free chlorine residual: 0.2-1.2 mg/L
Direct Pressure Filtration:	Average loading rate of up to 5 gpm/sf
	Peak loading rate of up to 8 gpm/sf

	12-in anthracite cap
	24-in GreensandPlus™ filter media
	12-in gravel base
	3 filters
Backwash:	10-15 minutes, at least 12 gpm/sf
	Extended filter ripening time
	Includes air scour
Filter Run Termination:	>10 psi differential pressure or >0.1 NTU
	Estimated filter run time 36 hours at peak FSLR
Residuals Management:	Settle residuals for at least 2 hours
	Recycle settled supernatant at up to 5% of the raw water flow

APPROVAL CONDITIONS

Pursuant to the Department's authority under 310 CMR 22.04(7) to require that each supplier of water operate and maintain its system in a manner that ensures the delivery of safe drinking water to consumers, this approval is made subject to the following conditions:

1. The Department finds the Well 2 Pilot Study Report satisfactorily complies with the requirements of Policy 90-04 and its prior approval letter dated November 9, 2022. The Sharon Water Department (the PWS) may proceed with the design of a groundwater treatment facility and apply for a BRP WS24: Approval to Construct a Treatment Facility Greater Than 1MGD. The application shall include copies of Department approval of any New Technology treatment components or chemicals incorporated into the proposed treatment train. The design shall conform to the Department's Guidelines.

2. The BRP WS 24 shall be accompanied by the appropriate checklists for the proposed chemical systems.

3. The BRP WS 24 shall include a detailed Waste Disposal Plan including a Residuals Management Plan in accordance with Section 5.10 of the Department's Guidelines.

4. The design documents shall clearly present calculations of the design maximum filter surface loading rate for each filter along with backwash rates.

5. If applicable, the treatment plant design shall include sufficient sludge drying lagoons to allow for freeze-thaw cycles in the drying process. Backwash lagoons may need Groundwater Discharge permitting depending on their design. Please refer to Chapter 5 of the Guidelines for information.

6. Any discharges to ground must be registered with the Department's Underground Injection Control (UIC) program. Discharges from chemical analyzers may need to be neutralized prior to underground discharge.

7. The PWS shall inspect the wells and all existing infrastructure to remain in service at the site to

determine if replacement, rehabilitation or modifications should be included in the construction project. Verification of the structural and functional integrity of the facilities to be retained shall accompany the BRP WS 24 application.

Both the Administrative and Technical Reviews of the following application has been completed: BRP WS22, Record #23-WS22-0015-APP. This approval pertains only to the water supply aspects of the proposal and therefore does not negate the responsibility of the owners or operators to comply with other applicable laws, and/or regulations.