Water Treatment Feasibility Study
For Manganese Removal

Long Pond
Housatonic Water Works

March 2021

Prepared for:

Housatonic Water Works
Great Barrington, Massachusetts

COMMONWEALTH OF MASSACHUSETTS
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FOR MANGANESE REMOVAL
LONG POND
HOUSATONIC WATER WORKS
GREAT BARRINGTON, MASSACHUSETTS

I. INTRODUCTION

In 2020, the Housatonic Water Works (HWW) commissioned the Cornwell Engineering Group from Newport News, Virginia to do a desktop study of water quality issues in their system. Specifically, this study focused on the cause of the colored water events that seasonally occur, as well as the corrosivity of the water.

The October 29, 2020 final report entitled "Desktop Study- Colored Water and Corrosion Assessent" had the following major conclusions:

1. Manganese concentrations above the secondary maximum contaminant limit (SMCL) of 0.05 mg/L are the identified source of the colored water. The manganese is in the treated water leaving the water treatment plant.

2. Manganese removal should be evaluated and implemented at least seasonally (warmer weather) when higher manganese and higher true color results are observed.

A copy of Cornwell's Recommendations and Action Plan are attached in **Appendix A**.

The Housatonic Water Works (HWW) retained Lenard Engineering, Inc. (LEI) to evaluate available treatment technologies for removing manganese from their drinking water. Manganese is present in Long Pond sporadically, but most frequently during the summer during periods of elevated water temperature (> 75 degrees F). As the major conclusion in the Cornwell report, discolored water in the distribution system has been attributed to elevated manganese concentrations.

Copies of water quality spreadsheets showing raw water, point of entry and distribution system manganese concentrations are provided in **Appendix B**.

Some of the technologies evaluated were applicable for both manganese removal, as well as for total surface water treatment, which could potentially replace the existing slow sand filters and disinfection in place at Long Pond. The applicability of replacing the current slow sand filtration with specific technologies is discussed below.

II. TREATMENT TECHNOLOGIES

LEI contacted three different water treatment vendors, and provided raw water quality and design flow information to each vendor. The design criteria were as follows:

- Design flow rate = 100 gpm capacity, producing a finished water volume of 144,000 gpd,
- Provide a second 100 gpm capacity treatment capacity, which could provide the minimum design flow and volumes with one unit off-line.
- Minimum manganese removal target concentration = < 0.015 mg/L. Note the secondary water quality standard for manganese is 0.05 mg/L, but removing manganese below this lower concentration should ensure water leaving the plant is not contributing to discolored water in distribution.

The need to run both units simultaneously is not of utmost importance, as the 1 million gallon storage tank provides approximately 6-7 days of treated water storage, so peak distribution demands can easily be supplied from the tank.

A) OXIDATION AND FILTRATION TECHNOLOGY (HUNGERFORD & TERRY)

LEI contacted Hungerford & Terry (H&T) from Clayton, New Jersey. H&T is an industry leader in providing water treatment systems for iron and manganese removal, hardness reduction and other treatment processes. For iron and manganese removal, they utilize a specialized filter media (Greensand Plus), which is a coated mineral which has an affinity for iron and manganese. Water is typically pre-treated with chlorine, to help oxidize the iron and manganese into a state where it can be readily attracted to the media and effectively filtered.

Based on preliminary discussions, and given the relatively low concentrations of manganese in the raw water, as well as the raw water being surface water, H& T could not guarantee manganese removal to the desired treatment goals. Their process is generally utilized for groundwater systems, where iron and manganese are at much higher raw water concentrations.

Therefore, this technology was not considered further.

B) DISSOLVED AIR FLOATATION AND FILTRATION (KROFTA)

Krofta Technologies provides a packaged water treatment system which utilizes dissolved air floatation during the coagulation process, followed by dual media filtration. It is in use in several western Massachusetts communities, successfully treating surface water of similar quality to Long Pond.

In addition to removing manganese, the Krofta system could replace the current slow sand filters. Chemical addition for coagulants, chlorination and perhaps pH adjustment would be required to optimize the operation of this system. Although approved for use in Massachusetts, piloting is highly recommended to determine the proper chemical dosages to optimize water treatment at Long Pond.

One- 10 foot diameter treatment vessel would be required to produce the required 100 gpm (0.144 MGD) of treated water. A second – 10 foot diameter vessel would be required for redundancy, and could provide instantaneous treatment flows of up to 200 gpm.

Manufacturer's information on the Krofta Technologies system is provided in **Appendix C**.

One main drawback with the Krofta system is the high volume of backwash water generated, estimated anywhere between 35,000 to 85,000 gpd. Although 10 % of this could be potentially recycled for use, it produces fairly large amounts of water treatment wastewater that would need to be properly treated and discharged to waste.

The estimated cost to provide two- 100 gpm Krofta treatment vessels is **$ 1,050,000**. This cost is for the treatment units only, and does not include a new treatment plant building, site work, piping, chemical feed systems, primary and standby power, etc.

Due to the high cost of the treatment equipment (as compared to other options), and the potential for generating large volumes of backwash water to treat and dispose of properly, this option was not considered further.

C) ULTRA-FILTRATION (KOCH MEMBANES)

Membrane filtration has been successfully used to treat a variety of water and wastewater with high amounts of suspended solids in both municipal and industrial settings. Koch Separation Technologies are one of several vendors who specialize in this technology. These membranes are in use at four Massachusetts groundwater supplies for iron and manganese removal, as well as in several out-of-state surface water supplies

According to Koch Separation Technologies, their membrane filtration systems would be effective for manganese removal alone, as well as a stand-alone treatment system for Long Pond. Piloting would likely be a requirement for using this technology on Long Pond.

Koch indicates that its PURON MP-6 skid system could meet treatment flow rates of 100 gpm. Chlorine would be fed ahead of the membrane units to help oxidize manganese, after which it would be removed with the membranes.

Used as a polishing unit after the slow sand filters for manganese removal, approximately 98 % of the raw water would be processed as finished water. If this were used for total solids removal as a replacement to the slow sand process, this percentage would drop to approximately 96 %.

Information on the Koch membrane filtration technology is provided in **Appendix D**.

The estimated cost of providing two 100 gpm capacity MP-6 skid systems is **$ 450,000**. This cost is for the treatment units only, and does not include a new treatment plant building, site work, piping, chemical feed systems, primary and standby power, etc.

Based on the significantly lower equipment cost for the Ultra-Filtration membrane system as compared to other technologies, and the relatively low amount of water treatment wastewater generated, we recommend HWW further investigate this option.

III) SCHEMATIC TREATMENT PLANT DESIGN

Utilizing product information provided by Koch, LEI prepared schematic level design plans for a new water treatment facility. As the cost for treating the entire flow is essentially the same as treating the flow after slow sand filtration for manganese only, we designed this as a complete replacement to the existing slow sand treatment system.

A) SITE PLAN – **Figure 1** provides a schematic level site plan for the proposed plant. Water from Long Pond would be piped into the new plant, with pre- and post-chlorination, pH adjustment and space for potential corrosion control chemicals is also provided, as determined during piloting.

Water would be pumped through one or both membrane skid units, which would remove particulates from the raw water. Water would then be discharged into the existing chlorine contact basin to take advantage of the detention time already provided. Water would then flow back into the existing slow sand building, where existing pumps would discharge into the dedicated 6" main and feeding the 1.0 million gallon standpipe.

A backwash water settling and recycle lagoon is shown downgradient from the new plant, where backwash water will settle out. Up to 10 % of this water could be typically recycled back to the head of the plant, where the remaining 90 % would settle, and overflow into the stream downstream of Long Pond.

B) TREATMENT PLANT LAYOUT – **Figure 2** provides a schematic level treatment plant layout. Two Koch MP-6 units, each capable of treating 100 gpm are shown in parallel. Chemical feed systems for chlorination and pH adjustment are shown, as well as space for a corrosion control chemical, if needed in the future.

Individual turbidimeters are provided for each filter, as well for the combined filter effluent leaving the plant. Chlorine and pH analyzers are also provided as water leaves the plant. An emergency eyewash / shower unit is provided. Finally, dedicated wall space for electrical and water system control panels is provided.

A separate office / laboratory space is provided, adjacent to the water treatment process room.

C) PROJECT COST ESTIMATE- **Table 1** provides a schematic design level cost estimate, based on costs provided by the treatment vendor, and recently bid projects. As noted in **Table 1**, major costs include the treatment systems, a new 30' x 60' water treatment building with a 20' x 20' office / lab space, new electrical service and standby generator, site work including a backwash water lagoon, chemical feed systems, and other items.

As this design is Schematic in nature, a 20 % construction cost contingency and 10 % design and permitting contingency is included, in the overall project cost of **$ 1.7 million**.

D) OPERATION AND MAINTENANCE COST ESTIMATE- **Table 2** provides an estimate of the annual cost to operate the Koch Membrane treatment system, including estimates for annual power, membrane replacement, and miscellaneous chemicals. The estimated annual cost for operation and maintenance is approximately $ 22,000.

Note this does not include labor, routine water treatment chemicals (liquid chlorine, etc.) or other incidental costs, which take place currently at the existing plant.

IV) SUMMARY AND CONCLUSIONS

1) The Housatonic Water Works utilizes slow sand filtration and disinfection, which has been effective in meeting State and Federal drinking water standards.

2) Recently, discolored water in distribution has been linked to manganese concentrations in Long Pond, which seem to be most prevalent during extremely warm water conditions (> 75 degrees F).

3) LEI contacted three manufacturers of packaged treatment systems, to initially provide a treatment system which would target only manganese removal. Two of the vendors, Krofta Technologies and Koch Separation Solutions, offer systems which could not only remove manganese, but treat the entire surface water flow from Long Pond.

4) Based on a comparison of these two technologies, LEI recommends Housatonic Water Works further investigate the membrane filtration for manganese removal, as well to potentially replace the existing slow sand filtration plant. Additional membrane filtration manufacturers can also be contacted if this project moves forward, to find the product which optimizes water quality treatment at the lowest overall cost.

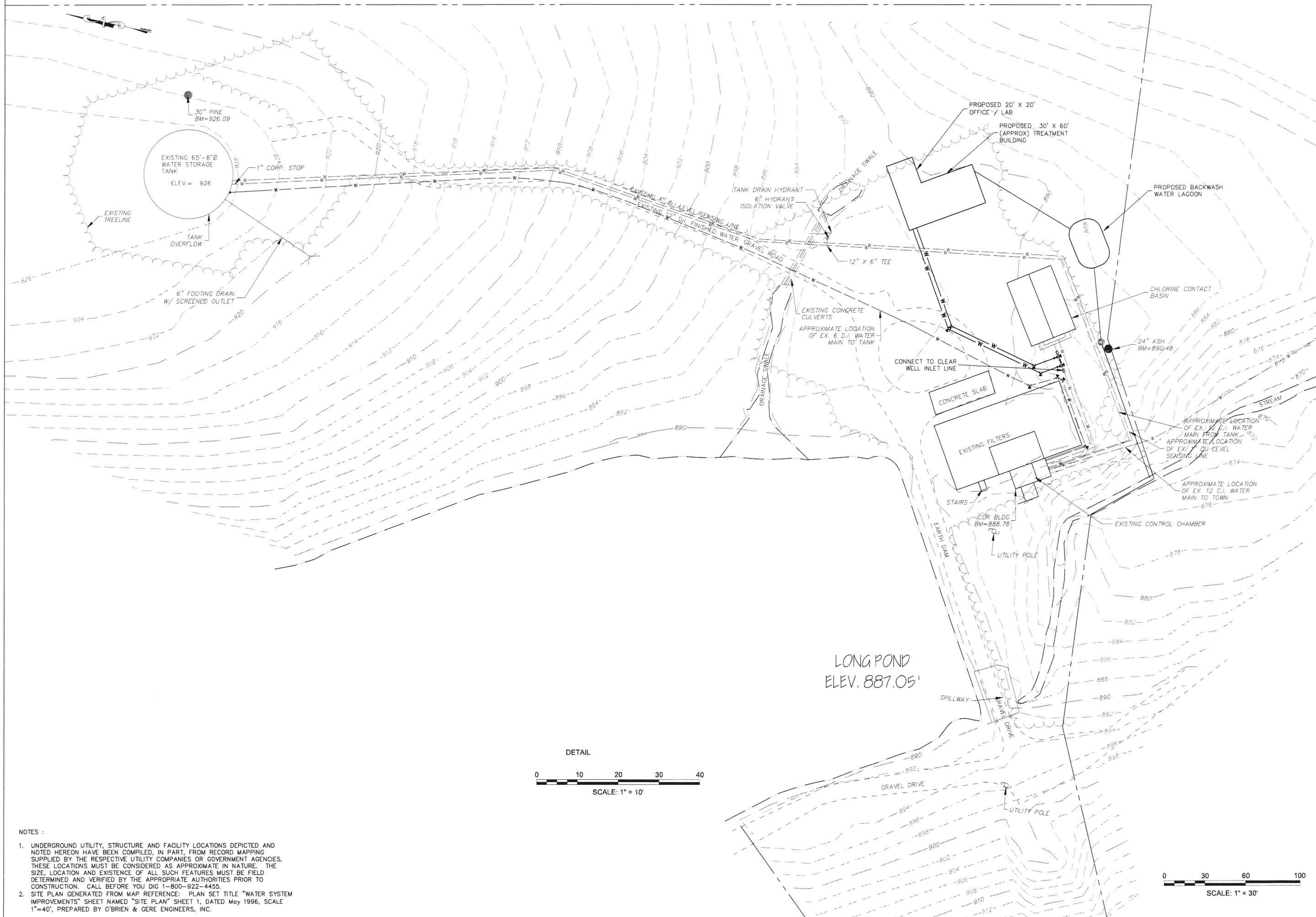
5) **Figure 1** provides a Schematic Site Plan for a new treatment plant using the Koch membrane technology. Included would be two- 100 gpm capacity skid systems, located in a new treatment plant building.

6) **Figure 2** provides a Schematic Treatment Plant layout, show the locations of the two membrane filtration skid systems, interior piping, chemical feed systems, and related equipment.

7) Using the Koch membrane system to replace the existing slow sand filters, approximately 4 %, or 5,700 gallons per day of water treatment wastewater would be generated, and assumed to be discharged to an on-site settling or infiltration lagoon, prior to discharging to the stream leaving Long Pond.

8) **Table 1** provides an overall project cost estimate of **$ 1.7 million** for the design, permitting and construction of this project.

9) Piloting of the membrane filtration units will be required, to verify that it is appropriate to treat Long Pond during all seasons of the year, especially during the warm weather seasons when manganese has been present. The chemical types and dosages can be refined during the piloting.



NOTES :

1. UNDERGROUND UTILITY, STRUCTURE AND FACILITY LOCATIONS DEPICTED AND NOTED HEREON HAVE BEEN COMPILED, IN PART, FROM RECORD MAPPING SUPPLIED BY THE RESPECTIVE UTILITY COMPANIES OR GOVERNMENT AGENCIES. THESE LOCATIONS MUST BE CONSIDERED AS APPROXIMATE IN NATURE. THE SIZE, LOCATION AND EXISTENCE OF ALL SUCH FEATURES MUST BE FIELD DETERMINED AND VERIFIED BY THE APPROPRIATE AUTHORITIES PRIOR TO CONSTRUCTION. CALL BEFORE YOU DIG 1-800-922-4455.
2. SITE PLAN GENERATED FROM MAP REFERENCE: PLAN SET TITLE "WATER SYSTEM IMPROVEMENTS" SHEET NAMED "SITE PLAN" SHEET 1, DATED May 1996, SCALE 1"=40', PREPARED BY O'BRIEN & GERE ENGINEERS, INC.

Designed By: JED
Drawn By: JED
Checked By: JEE
CAD File: WM Design

Drawing Scale: 1" = 30'
Drawing date: March 25, 2021

Rev.	Date	Revision	By

FIGURE 1- SCHEMATIC SITE PLAN

PREPARED FOR

Proposed Water Treatment Plant

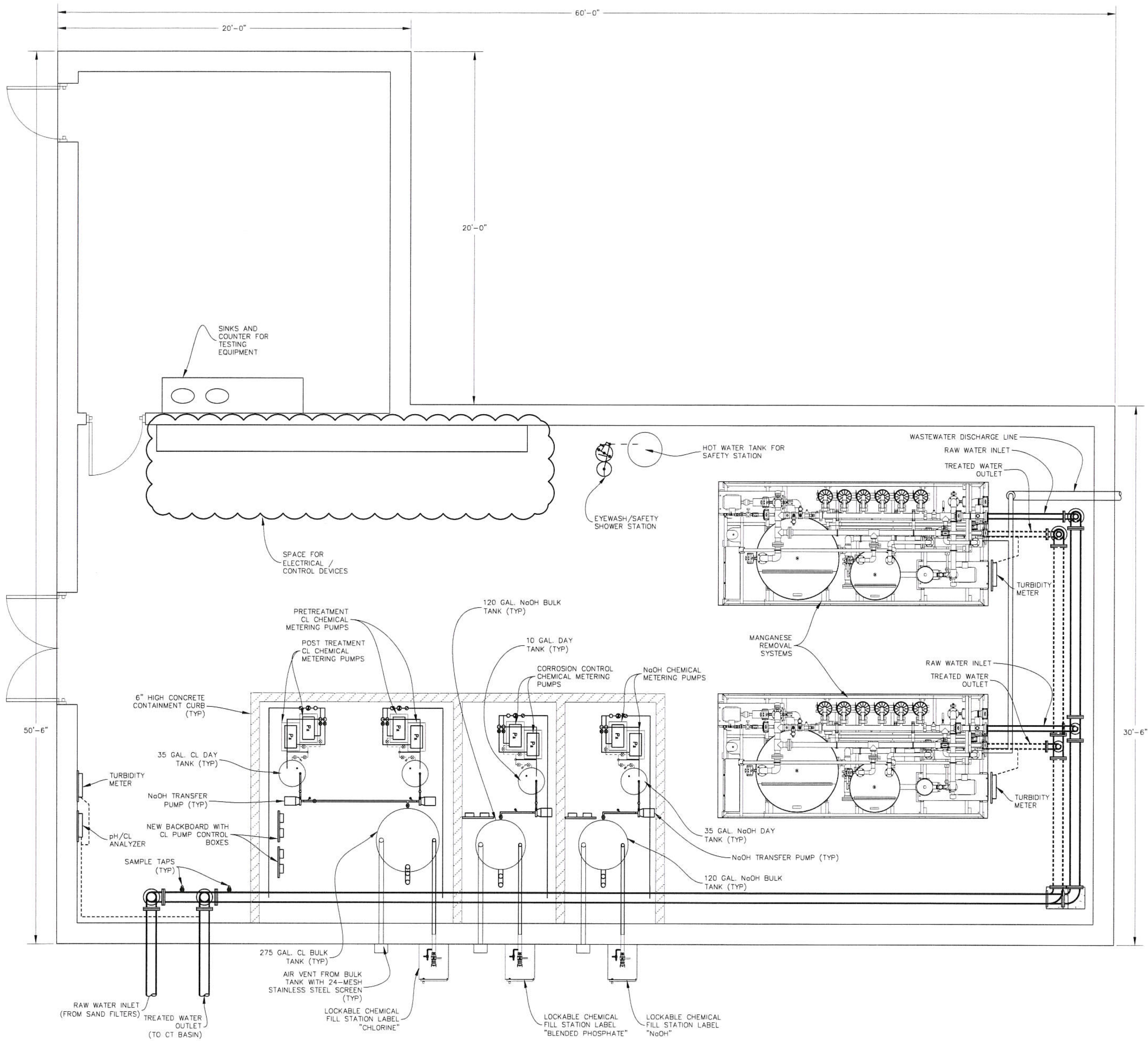
Housatonic Water Works

Great Barrington, Massachusetts

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants
2210 Main Street GLASTONBURY, CT (860) 659-3100
140 Willow Street WINSTED, CT (860) 379-6669
19 Midstate Drive AUBURN, MA (508) 721-7600

Drawing #: 1

Job #: 21-308



Designed By: JED
Drawn By: JED
Checked By: JEE
CAD File: PS Design

Drawing date: March 25, 2021
Drawing Scale: 3/8" = 1'-0"

Rev.	Date	Revision	By

FIGURE 2- SCHEMATIC TREATMENT PLANT LAYOUT

PREPARED FOR

Proposed Water Treatment Plant

Housatonic Water Works
Great Barrington, Massachusetts

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Civil, Environmental and Hydrogeological Consultants
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19 Midstate Drive AUBURN, MA (508) 721-7600

Drawing #: 2

Job #: 21-308

Lenard Engineering, Inc.
2210 Main Street
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TABLE 1 -
OPINION OF PROBABLE COST
MANGANESE REMOVAL SYSTEM
HOUSATONIC WATER WORKS CO.
GREAT BARRINGTON, MA

Estimate 3/25/21
LEI Job No. 21-308
Prepared By: JED

	Total	Estimated Quantity and Unit Measure	Estimated Unit Price	Extended Price
	Item			
1	Mobilization	1 LS	$50,000	$50,000
2	Erosion and Sediment Control	1 LS	$10,000	$10,000
3	Tree Cutting, Clearing and Grubbing	1 LS	$10,000	$10,000
4	New 2200 s.f Treatment Building @ $150/sf	1 LS	$330,000	$330,000
5	New Electrical Service	1 LS	$30,000	$30,000
6	New Interior Electrical / Lighting	1 LS	$40,000	$40,000
7	SCADA upgrades	1 LS	$25,000	$25,000
7	Generator Set / Transfer Switch	1 LS	$60,000	$60,000
8	Building HVAC	1 LS	$35,000	$35,000
9	Interior Piping	1 EA	$35,000	$35,000
10	New CL and pH Chemical Feed Systems, Analyzers	1 EA	$50,000	$50,000
11	Manganese Removal System (Koch)	1 LS	$450,000	$450,000
12	Below Ground Water Piping	1 LS	$30,000	$30,000
13	Backwash Lagoon	1 LS	$50,000	$50,000
14	Site Work	1 LS	$30,000	$30,000
15	Loam and Seed	1 LS	$10,000	$10,000
16	Startup and Testing	1 LS	$10,000	$10,000
	Estimated Construction Cost			**$1,255,000**
	20 % Contingency			**$251,000**
	10 % Engineering Design Permitting Allowance			**$125,500**
	Allowance for Piloting			**$50,000**
	Estimated Construction Administration and Inspection	**TBD**		
	Estimated Project Cost w/Contingency			**$1,681,500**
			Say	**$ 1.7 million**

Lenard Engineering, Inc.
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Glastonbury, CT 06033-6088

TABLE 2
YEARLY OPERATION AND MAINTENANCE
MANGANESE REMOVAL SYSTEM
HOUSATONIC WATER WORKS CO.
GREAT BARRINGTON, MA

Estimate 3/25/21
LEI Job No. 21-308
Prepared By: JED

	Total Item	Estimated Quantity and Unit Measure	Estimated Unit Price	Extended Price
1	Electrical	20547 kwh	$0.26	$5,342
2	Membranes 6@ $3400 ea/7 yrs	1 LS	$2,920	$2,920
3	Chemicals	1 LS	$10,000	$10,000
	Estimated Construction Cost			**$18,262**
	20 % Contingency			**$3,652**
	Estimated Project Cost w/Contingency			**$21,914**
			Say	**$22,000**

APPENDIX A
CORNWELL ENGINEERING GROUP
EXCERPTS FROM
"DESKTOP STUDY – COLORED WATER AND CORROSION ASSESSMENT

CORNWELL
ENGINEERING GROUP

October 29, 2020
Housatonic Water Works
Memorandum No. 15400-002

Subject: **Desktop Study – Colored Water and Corrosion Assessment**

Housatonic Water Works Company (HWWC) has tasked Cornwell Engineering Group, Inc. (Cornwell) with investigating the colored water events that seasonally occur in their system (typically during warner months), as well as the corrosivity of the water. The following memorandum discusses and summarizes the HWWC water quality characteristics and their implications on solubility or precipitation of hardness, iron, manganese, lead, or copper, and provides direction for an action plan to resolve the issues.

SYSTEM DESCRIPTION

The water source for the HWWC system is surface water from Long Pond. Treatment consists of slow sand filtration, addition of sodium hypochlorite, and chlorine contact as depicted in the treatment schematic in Figure 1. Current average daily production is 0.11 MG.

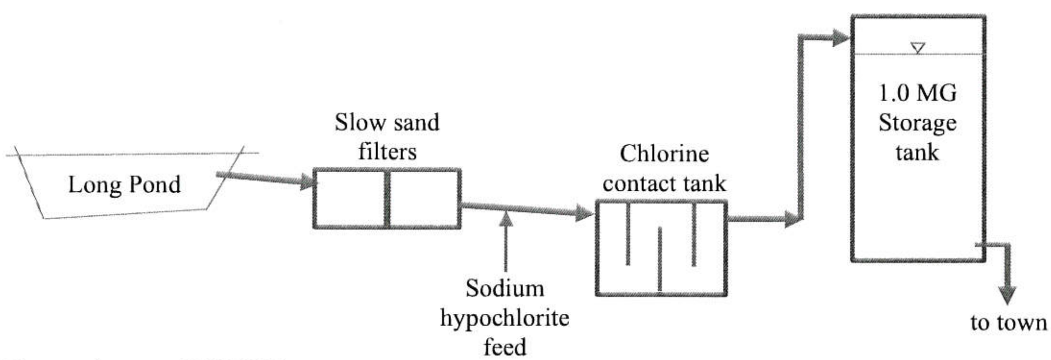

Figure 1 **HWWC treatment schematic**

Characteristics of the water mains and service lines, as reported in the December 2016 Desktop Study Report (Lenard 2016), are summarized in Table 1 and in the following items:

- Water main upgrades were initiated in the 1990s and included about 14,000 LF (mostly ductile iron and polyethylene as per Table 1), and most (if not all) of the remaining system pipes are >100 years old and are made of cast iron or steel.

RECOMMENDATIONS AND ACTION PLAN

Based on previous analysis and discussion:

1. **Manganese concentrations above the secondary maximum contaminant limit (SMCL) of 0.05 mg/L are the identified source of the colored water. The manganese is in the treated water leaving the water treatment plant.**

2. Manganese removal should be evaluated and implemented at least seasonally (warmer weather) when higher manganese and higher true color results are observed.

3. The addition of a polyphosphate or a blended phosphate to sequester manganese or iron is not recommended. Polyphosphate or blended phosphate can have a negative effect on lead and copper corrosion.

4. Iron removal at the source does not appear to be necessary, but treatment installed for manganese removal should remove iron if present

5. The current water chemistry in the distribution system, using samples representing "normal" conditions, results in a low Larson-Skold Index, suggesting the water may not be susceptible to iron corrosion. Results from a designated "color event" also show an iron concentration well below the SMCL.

6. Based on the data reviewed, treated water pH has typically been $\geq$7.4 in the distribution system without pH adjustment. However, if future monitoring shows that these pH levels are not regularly achieved, pH adjustment should be evaluated.

7. Free chlorine residuals should be maintained at the target residual of $\geq$0.2 mg/L in all parts of the distribution system in all seasons.

8. Sequential sampling to identify locations of the lead source in the customers' home or service lines is suggested for locations with historically high lead levels, and should also be considered after a treatment change, for example, after addition of: a) manganese removal processes, b) pH adjustment, or c) orthophosphate addition.

9. The current distribution system pH is already close to the saturation pH (8.2), so it may not be possible to increase the pH much higher. Consequently, if lead and copper cannot be controlled under current conditions, the addition of orthophosphate may need to be evaluated. Evaluation of orthophosphate and pH adjustment should include, at minimum,

laboratory solubility studies for lead and copper to evaluate optimal pH and orthophosphate dose.

The conclusions and recommendations for action are summarized in the table below:

Table 5 Summary of recommendations for treatment of metals

Metal	Problem	Evidence	Recommended solution
Lead	Maybe	Action Level (AL) exceedance in past compliance periods, though < AL for the 6 most recent periods after improving sampling procedures	Identify lead sources. If LCR data increase again over time then possibly re-evaluate CCT
Copper	Maybe	AL exceedance in past compliance periods. Theoretical modeling shows POE water likely is corrosive to copper, while the measured values are substantially higher than is typically observed.	Conduct laboratory solubility studies
Iron	No	Levels <SMCL	None needed, but manganese removal will likely remove iron (prior to POE)
Manganese	Yes	Levels >SMCL Colored water complaints	Evaluate removal via oxidation and filtration

REFERENCES

ASTM 2019. *Standard Test Method for Color of Clear Liquids (Platinum-Cobalt Scale) – ASTM D1209-05*. ASTM International: West Conshohocken, PA.

Leitz, F., and K. & Guerra, K. (2013). *Water Chemistry Analysis for Water Conveyance, . Storage, and Desalination Projects: Manuals and Standards Program.* US Department of the Interior, Bureau of Reclamation, Technical Service Center: Denver, CO.

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Lenard (Lenard Engineering, Inc.) 2017. *Basis of Design Report: Proposed Corrosion Control Treatment (October 2017).* Housatonic Water Company: Great Barrington, MA.

Lytle, D., M. Schock, J. Leo, and B. Barnes. 2018. "A Model for Estimating the Impact of Orthophosphate on Copper in Water." *Jour. AWWA*, 110 (8): E1-E15.

APPENDIX B
WATER QUALITY SUMMARY

	Filter influent (raw water)			Filter #1 (Lake side)			Filter #2 (Land side)		
Date	Mn (mg/L)	Fe (mg/L)	Color	Mn (mg/L)	Fe (mg/L)	Color	Mn (mg/L)	Fe (mg/L)	Color
11/23/20				< 0.0020			0.0100		
11/30/20				< 0.0020			< 0.0020		
12/4/20	0.0099	< 0.0500	< 1	< 0.0020	< 0.0500	< 1	< 0.0020	< 0.0500	< 1
12/7/20	0.0076	< 0.0500	< 1	< 0.0020	< 0.0500	< 1	< 0.0020	< 0.0500	< 1
12/16/20	0.0070	< 0.0500	15	< 0.0020	< 0.0500	< 1	< 0.0020	< 0.0500	< 1

Berkshire Meadows (249 N. Plain)													
Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		
8/22/18	B. Prendergast	26	8.1	75.7	<0.0500	0.0503	20	0	0.0503	20	100	0.008	0.4
9/5/18	B. Prendergast	31.0	7.99	75.7	<0.0500	0.0195	0	0	0.0195	0	101	0.004	0.15
9/19/18	Tom Lussier	32	7.7	79.9	<0.0500	0.0163	0	0	0.0163	0	105	0.021	0.24
10/3/18	TCV		7.17	82.5	0.0779	0.0074	0	0.0779	0.0074	0	106	0.022	0.23
10/16/18	Tom Lussier	21	7.7	75.3	<0.0500	0.0079	10	0	0.0079	10	99	0.018	0.7
10/19/18													
10/24/18													
10/31/18	TCV		7.55	80.3	<0.0500	<0.0020	0	0	0	0	97	0.020	0.69
11/7/18													
11/14/18	Erick Bartlett (?)		8.14	80.3	<0.0500	0.002	0	0	0.002	0	129	0.025	1.08
11/20/18													
11/28/18	TCV		7.65	87.4	<0.0500	<0.0020	0	0	0	0	102	0.030	0.81
12/5/18													
12/11/18	Erick Bartlett		8.30	87.4	<0.0500	<0.0020	0	0	0	0	137	0.357	0.55
12/19/18													
12/26/18	Erick Bartlett		7.58	88.6	<0.0500	<0.0020	0	0	0	0	130	0.297	0.93
1/2/19													
1/8/19	Erick Bartlett		8.14	88.6	<0.0500	<0.0020	0	0	0	0	100	0.31	1.06
1/16/19													
1/22/19	Erick Bartlett		7.3	88.6	<0.0500	<0.0020	0	0	0	0	125	0.007	0.78
1/28/19													
2/6/19	Erick Bartlett	12	7.8	91.2	<0.0500	<0.0020	0	0	0	0	109	0.017	0.78
2/12/19													
2/20/19	Erick Bartlett	9.7	8.3	89.9	<0.0500	<0.0020	<1	0	0	0	112	0.007	0.64
2/27/19													
3/6/19	Erick Bartlett	11.1	7.4	31.7	<0.0500	<0.0020	<1	0	0	0	106	0.015	0.57
3/11/19													
3/18/19	Erick Bartlett	11.2	7.85	91.6	<0.0500	<0.0020	<1	0	0	0	132	0.007	0.59
3/26/19													
4/3/19	Erick Bartlett	10.8	8.1	83.9	<0.0500	<0.0020	<1	0	0	0	97.0	0.009	0.66
4/10/19													
4/15/19	Tim Vreeland	18.1	7.7	83.5	<0.0500	<0.0020	<1	0	0	0	123	0.022	0.59
4/23/19													
5/6/19													
5/15/19	Tom Lussier	13	7.5	77.5	<0.0500	<0.0020	<1	0	0	0	89.0	0.009	0.68

Berkshire Meadows (249 N. Plain)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		
5/22/19													
5/29/19	Tim Vreeland	19.3	7.8	82.5	<0.0500	<0.0020	<1	0	0	0	120	0.010	0.67
6/5/19													
6/12/19	Erick Bartlett	19.8	8.0	77.5	<0.0500	0.0043	<1	0	0.0043	0	115	0.001	0.60
6/19/19													
6/24/19	Erick Bartlett	20.6	7.9	80	<0.0500	0.0124	10	0	0.0124	10	80.0	0.011	0.55
7/1/19													
7/10/19	Tim Vreeland	17.3	7.61	77.5	<0.0500	0.0065	10	0	0.0065	10	120	0.018	0.3
7/15/19													
7/24/19	TCV	21.6	7.71	77.5	<0.0500	0.0053	10	0	0.0053	10	105	0.015	0.32
7/29/19													
8/5/19	Erick Bartlett	25.2	7.89	72.5	<0.0500	0.0040	<1	0	0.0040	0	132	0.010	0.37
8/14/19													
8/21/19	Erick Bartlett	24.6	7.81	72.5	<0.0500	0.0027	<1	0	0.0027	0	92.0	0.010	0.3
8/26/19													
9/4/19	Erick Bartlett	24.7	8.12	70.0	<0.0500	<0.0020	<1	0	0	0	107	0.010	0.37
9/11/19													
9/18/19	Erick Bartlett	21.2	7.88	70.0	<0.0500	<0.0020	<1	0	0	0	101	0.021	0.20
9/23/19													
10/2/19	Tim Vreeland	20.1	7.79	67.5	<0.0500	<0.0020	<1	0	0	0	78.0	0.042	0.16
10/7/19													
10/16/19	Erick Bartlett	14.2	7.82	70.0	<0.0500	<0.0020	10	0	0	10	90.0	0.014	0.23
10/22/19													
10/30/19	Tim Vreeland	17.9	7.51	72.5	<0.0500	<0.0020	<1	0	0	0	97.0	0.032	0.10
11/6/19													
11/13/19	Tim Vreeland	14.3	7.81	72.5	<0.0500	<0.0020	<1	0	0	0	100	0.03	0.12
11/20/19													
11/25/19	Tim Vreeland	11.8	7.59	75.0	<0.0500	<0.0020	<1	0	0	0	92.0	0.028	0.25
12/4/19													
12/10/19	Tim Vreeland	12.6	7.51	72.5	<0.0500	<0.0020	<1	0	0	0	106	0.033	0.31
12/17/19													
12/31/19													
1/6/20	Tim Vreeland	13.4	7.43	75.0	<0.0500	<0.0020	<1	0	0	0	93.0	0.032	0.45
1/14/20													
1/22/20	Erick Bartlett	12.3	7.76	75.0	<0.0500	<0.0020	<1	0	0	0	118	0.014	0.3

Berkshire Meadows (249 N. Plain)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		
1/28/20													
2/5/20	Erick Bartlett	10.5	7.83	75.0	<0.0500	<0.0020	<1	0	0	0	114	0.018	0.27
2/10/20													
2/19/20	Erick Bartlett	9.1	7.40	82.5	<0.0500	<0.0020	<1	0	0	0	34.0	0.022	0.31
3/4/20	Erick Bartlett	12.9	7.56	80.0	<0.0500		<1	0		0	108	0.021	0.23
3/10/20													
3/16/20	Erick Bartlett	10.6	7.76	77.8	<0.0500	<0.0020	<1	0	0	0	105	0.02	0.32
8/25/20	colored water complaint				0.0928	0.109							
Count =		32	40	40	2	13	17	40	39	40	40	40	40
Average =		17.2	7.8	77.9	0.0854	0.0190	4.1	0.0019	0.0036	1.8	105	0.04	0.47
Minimum =		9.1	7.2	31.7	0.0779	0.0020	0	0.0000	0.0000	0	34	0.00	0.10
Maximum =		32.0	8.3	91.6	0.0928	0.1090	20	0.0779	0.0503	20	137	0.36	1.08
Median =		15.8	7.8	77.5	0.0854	0.0074	0.0	0.0000	0.0000	0.0	105	0.02	0.39

Berkshire Meadows (249 N. Plain)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		

Pleasant and Main Café (1063 Main St.)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		
8/22/18													
9/5/18													
9/19/18													
10/3/18													
10/16/18													
10/19/18	TCV		7.27	80.3	<0.0500	0.0027	10	0	0.0027	10	117	0.031	0.36
10/24/18	TCV		7.23	82.8	<0.0500	0.0021	0	0	0.0021	0	111	0.023	0.26
10/31/18													
11/7/18	TCV		7.61	80.3	<0.0500	0.004	0	0	0.004	0	103	0.04	0.31
11/14/18													
11/20/18	TCV		7.29	82.8	<0.0500	<0.0020	0	0	0	0	101	0.020	0.39
11/28/18													
12/5/18	TCV	7.1	7.59	84.7	<0.0500	<0.0020	0	0	0	0	123	0.028	0.64
12/11/18													
12/19/18	Erick Bartlett	2.8	7.47	92.7	<0.0500	<0.0020	0	0	0	0	107	0.26	0.55
12/26/18													
1/2/19	Erick Bartlett	5.3	8.36	91.2	<0.0500	<0.0020	0	0	0	0	94.0	0.511	0.99
1/8/19													
1/16/19	Tom Lussier	5.1	7.6	86.00	<0.0500	<0.0020	0	0	0	0	115	0.3	0.5
1/22/19													
1/28/19	Erick Bartlett	9.4	7.1	88.6	<0.0500	<0.0020	0	0	0	0	101	0.007	0.43
2/6/19													
2/12/19	Erick Bartlett	6	8.3	86	<0.0500	<0.0020	<1	0	0	0	124	0.019	0.57
2/20/19													
2/27/19	Erick Bartlett	6.9	8.2	89.9	<0.0500	<0.0020	<1	0	0	0	104	0.009	0.47
3/6/19													
3/11/19	Erick Bartlett	8	7.8	89.9	<0.0500	<0.0020	<1	0	0	0	109	0.022	0.54
3/18/19													
3/26/19	Tim Vreeland	11.2	7.97	86.2	<0.0500	<0.0020	<1	0	0	0	114	0.018	0.41
4/3/19													
4/10/19	Tim Vreeland	11.4	7.79	83.5	<0.0500	<0.0020	<1	0	0	0	76.0	0.014	0.46
4/15/19													
4/23/19	Tim Vreeland	14.1	7.82	86.2	<0.0500	<0.0020	<1	0	0	0	103	0.020	0.43

Pleasant and Main Café (1063 Main St.)													
Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		
5/6/19	Erick Bartlett	16.1	7.8	77.5	<0.0500	<0.0020	<1	0	0	0	100	0.013	0.62
5/15/19													
5/22/19	Erick Bartlett	14.5	8.1	80.0	<0.0500	<0.0020	10	0	0	10	136	0.010	0.50
5/29/19													
6/5/19	Tim Vreeland	15.5	7.69	80.0	<0.0500	<0.0020	<1	0	0	0	124	0.014	0.34
6/12/19													
6/19/19	Tim Vreeland	16.4	7.61	80.0	<0.0500	0.0043	<1	0	0.0043	0	112	0.014	0.37
6/24/19													
7/1/19	Erick Bartlett	19	7.6	80.0	<0.0500	0.0036	<1	0	0.0036	0	123	0.008	0.37
7/10/19													
7/15/19	Erick Bartlett	24.3	7.54	77.5	<0.0500	0.0037	<1	0	0.0037	0	124	0.011	0.54
7/24/19													
7/29/19	Erick Bartlett	22.3	7.96	75.0	<0.0500	0.0046	<1	0	0.0046	0	127	0.010	0.31
8/5/19													
8/14/19	Tom Lussier			77.0	<0.0500	0.0023		0	0.0023		124	0.011	0.4
8/21/19													
8/26/19	Erick Bartlett	22.1	8.1	72.5	<0.0500	0.0022	10	0	0.0022	10	103	0.019	0.14
9/4/19													
9/11/19	Tim Vreeland	20.1	7.86	70.0	<0.0500	<0.0020	<1	0	0	0	106	0.031	0.06
9/18/19													
9/23/19	Tom Lussier	22.0	7.0	70.0	<0.0500	<0.0020	<1	0	0	0	102	0.016	0.3
10/2/19													
10/7/19	Tim Vreeland	19.0	7.81	70.0	<0.0500	<0.0020	<1	0	0	0	101	0.028	0.11
10/16/19													
10/22/19	Tim Vreeland	15.5	7.56	72.5	<0.0500	<0.0020	<1	0	0	0	82.0	0.026	0.05
10/30/19													
11/6/19	Erick Bartlett	16.1	7.83	72.5	<0.0500	<0.0020	<1	0	0	0	99.0	0.019	0.15
11/13/19													
11/20/19	Erick Bartlett	11.8	8.22	75.0	<0.0500	<0.0020	<1	0	0	0	129	0.023	0.19
11/25/19													
12/4/19	TB (Erick Bartlett	15.2	8.01	75.0	<0.0500	<0.0020	<1	0	0	0	92.0	0.021	0.2
12/10/19													
12/17/19	Erick Bartlett	11.4	7.98	75.0	<0.0500	<0.0020	<1	0	0	0	84.0	0.019	0.19

Pleasant and Main Café (1063 Main St.)													
Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		
12/31/19	Erick Bartlett	7.6	7.46	77.5	<0.0500	<0.0020	<1	0	0	0	110.0	0.021	0.23
1/6/20													
1/14/20	Tim Vreeland	13.1	7.42	75.0	<0.0500	<0.0020	<1	0	0	0	102	0.032	0.21
1/22/20													
1/28/20	TCV	11.3	7.81	77.5	<0.0500	<0.0020	<1	0	0	0	111	0.030	0.11
2/5/20													
2/10/20	Tim Vreeland	10.7	7.81	80.0	<0.0500	<0.0020	<1	0	0	0	111	0.028	0.24
2/19/20													
3/4/20													
3/10/20	Tim Vreeland	11.2	7.77	82.5	<0.0500	<0.0020	10	0	0	10	102	0.032	
3/16/20													

Pleasant and Main Café (1063 Main St.)													
Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		

Count =		32	36	37				37	37	36	37	37	36
Average =		13.2	7.7	80.1	<0.0500	0.0033	3.3	<0.0500	0.0008	1.1	108	0.05	0.36
Minimum =		2.8	7.0	70.0	0.0000	0.0021	0	0.0000	0.0000	0	76	0.01	0.05
Maximum =		24.3	8.4	92.7	0.0000	0.0046	10	0.0000	0.0046	10	136	0.51	0.99
Median =		12.5	7.8	80.0	<0.0500	0.0036	0.0	<0.0500	0.0000	0.0	107	0.02	0.37
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500		

Park Street Housing Auth. (2 Bernard Gibbons Dr.)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500				
8/22/18															
9/5/18															
9/19/18															
10/3/18															
10/16/18															
10/19/18	TCV		7.3	77.8	<0.0500	0.0078	20	0	0.0078	20	122			0.027	0.49
10/24/18	TCV		7.55	80.3	<0.0500	0.0054	0	0	0.0054	0	116			0.020	0.19
10/31/18															
11/7/18	TCV		7.76	80.3	<0.0500	0.0042	0	0	0.0042	0	74.0			0.038	0.55
11/14/18															
11/20/18	TCV		7.6	80.3	<0.0500	<0.0020	0	0	0	0	93			0.021	0.36
11/28/18															
12/5/18	TCV		7.88	87.4	<0.0500	<0.0020	0	0	0	0	120			0.030	0.81
12/11/18															
12/19/18	Erick Bartlett		7.56	90	<0.0500	<0.0020	0	0	0	0	119			0.41	0.77
12/26/18															
1/2/19	Erick Bartlett		8.35	91.2	<0.0500	<0.0020	0	0	0	0	104			0.416	0.95
1/8/19															
1/16/19	Tom Lussier		7.6	86.0	<0.0500	<0.0020	0	0	0	0	117			0.08	0.4
1/22/19															
1/28/19	Erick Bartlett		7.45	91.2	<0.0500	<0.0020	0	0	0	0	100			0.017	0.8
2/6/19															
2/12/19	Erick Bartlett	8.7	7.9	88.6	<0.0500	<0.0020	<1	0	0	0	42.0			0.013	0.71
2/20/19															
2/27/19	Erick Bartlett	7.9	8.5	89.9	<0.0500	<0.0020	<1	0	0	0	115			0.008	0.54
3/6/19															
3/11/19	Erick Bartlett	10	7.7	87.3	<0.0500	<0.0020	<1	0	0	0	109			0.008	0.75
3/18/19															
3/26/19	Tim Vreeland	13.1	7.92	83.5	<0.0500	<0.0020	<1	0	0	0	109			0.012	0.58
4/3/19															
4/10/19	Tim Vreeland	11.1	7.59	83.5	<0.0500	<0.0020	<1	0	0	0	121			0.016	0.45
4/15/19															
4/23/19	Tim Vreeland	13.5	7.85	86.2	<0.0500	<0.0020	<1	0	0	0	108			0.018	0.67
5/6/19	Erick Bartlett	14.0	8.0	77.5	<0.0500	<0.0020	<1	0	0	0	99.0			0.003	0.7
5/15/19															
5/22/19	Erick Bartlett	13.5	8.0	77.5	<0.0500	<0.0020	<1	0	0	0	98.0			0.009	0.6
5/29/19															
6/5/19	Tim Vreeland	15.9	7.77	80.0	<0.0500	<0.0020	<1	0	0	0	122			0.009	0.42
6/12/19															
6/19/19	Tim Vreeland	16	7.69	80.0	<0.0500	0.0049	<1	0	0.0049	0	115			0.018	0.41
6/24/19															
7/1/19	Erick Bartlett	17.3	7.8	75.0	<0.0500	0.0048	<1	0	0.0048	0	101			0.013	0.42

Park Street Housing Auth. (2 Bernard Gibbons Dr.)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500				
7/10/19															
7/15/19	Erick Bartlett	25.1	7.42	77.5	<0.0500	0.0041	<1	0	0.0041	0	99.0			0.008	0.37
7/24/19															
7/29/19	Erick Bartlett	22.4	7.81	75.0	<0.0500	0.0079	<1	0	0.0079	0	106			0.012	0.42
8/5/19															
8/14/19	Tom Lussier			77.5	<0.0500	0.0021		0	0.0021		108			0.013	
8/21/19															
8/26/19	Erick Bartlett	22.7	7.95	70.0	<0.0500	0.0022	10	0	0.0022	10	102			0.010	0.22
9/4/19															
9/11/19	Tim Vreeland	19.5	7.81	70.0	<0.0500	<0.0020	<1	0	0	0	88.0			0.027	0.08
9/18/19															
9/23/19	Tom Lussier	24.0	7.4	70.0	<0.0500	<0.0020	<1	0	0	0	98.0			0.020	0.4
10/2/19															
10/7/19	Tim Vreeland	19.3	7.73	70.0	<0.0500	<0.0020	<1	0	0	0	95.0			0.022	0.08
10/16/19															
10/22/19	Tim Vreeland	15.8	7.64	72.5	<0.0500	<0.0020	<1	0	0	0	109			0.030	
10/30/19															
11/6/19	Erick Bartlett	17.3	7.87	72.5	<0.0500	<0.0020	<1	0	0	0	97.0			0.021	0.08
11/13/19															
11/20/19	Erick Bartlett	12.4	8.06	75.0	<0.0500	<0.0020	<1	0	0	0	101			0.019	0.15
11/25/19															
12/4/19	'B (Erick Bartlett	16.5	7.89	75.0	<0.0500	<0.0020	<1	0	0	0	96.0			0.023	0.25
12/10/19															
12/17/19	Erick Bartlett	12.6	8.04	75.0	<0.0500	0.0023	<1	0	0.0023	0	92.0			0.015	0.27
12/31/19	Erick Bartlett	10.1	7.68	75.0	<0.0500	<0.0020	<1	0	0	0	98.0			0.015	0.021
1/6/20															
1/14/20	Tim Vreeland	13.3	7.46	75.0	<0.0500	<0.0020	<1	0	0	0	92.0			0.028	0.16
1/22/20															
1/28/20	TCV	10.8	7.68	77.5	<0.0500	<0.0020	<1	0	0	0	105			0.036	0.27
2/5/20															
2/10/20	Tim Vreeland	10.9	7.69	80.0	<0.0500	<0.0020	<1	0	0	0	99.0			0.034	0.31
2/19/20															
3/4/20															
3/10/20	Tim Vreeland	10.4	7.47	80.0	<0.0500	<0.0020	10	0	0	10	114			0.036	
3/16/20															
8/5/20	Nick Bruzzi	23.9	7.69	80.0	0.0682	0.102	50	0.0682	0.102	50	117	14.3	< 5.00	0.604	0.08
8/11/20	Erick Bartlett	23.7	7.59	82.5	<0.0500	0.0131	<1	0	0.0131	0	113	14.4	< 5.00	0.23	0.13
8/19/20	Tim Vreeland	24.9	7.41	80.0	<0.0500	0.0285	<1	0	0.0285	0	103	14.8	< 5.00	0.02	0.09

Park Street Housing Auth. (2 Bernard Gibbons Dr.)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500				
8/25/20	Erick Bartlett	21.2	7.58	82.5	0.0580	0.0099	<1	0.058	0.0099	0	128	15.1	< 5.00	0.28	0.1
9/9/20	Erick Bartlett	20.5	7.64	80.0	<0.0500	0.0052	<1	0	0.0052	0	102			0.23	0.31
9/22/20	Tim Vreeland	19.2	7.72	80.0	<0.0500	0.0817	40	0	0.0817	40	117			0.75	0.37
10/6/20	Erick Bartlett	17.8	7.72	77.5	<0.0500	<0.0020	<1	0	0	0	96.0			0.198	0.26
10/8/20	Tim Vreeland	15.7	7.63								110			0.034	0.27
10/13/20	Erick Bartlett	16.2	7.86								120			0.1	0.46
10/19/20	Erick Bartlett	17.2	7.79	80.0	<0.0500	0.0117	<1	0	0.0117	0	102			0.29	0.51
10/26/20	Tim Vreeland	15.3	7.51								110			0.17	0.50
11/9/20	Erick Bartlett	7.9	15.9	77.5	<0.0500	<0.0020	< 1	0	0	0	117			0.2	0.71
11/24/20	Tim Vreeland			80.0	<0.0500	0.003	< 1	0	0.003	0	107			0.18	0.91
12/7/20	Erick Bartlett	14.3	7.86	82.5	<0.0500	<0.0020	< 1	0	0	0	122			0.17	1.07
12/16/20	Tim Vreeland	12.9	7.71	82.5	<0.0500	<0.0020	< 1	0	0	0	125			0.14	1

Count =		41	50	49	2	18	13	49	49	48	52	4	0	37	34
Average =		16.0	7.9	79.7	<0.0500	0.0167	10.0	<0.0500	0.0061	2.7	106	15	#DIV/0!	0.10	0.44
Minimum =		7.9	7.3	70.0	0.0580	0.0021	0	0.0000	0.0000	0	42	14	0	0.00	0.02
Maximum =		25.1	15.9	91.2	0.0682	0.1020	50	0.0682	0.1020	50	128	15	0	0.75	1.07
Median =		15.8	7.7	80.0	<0.0500	0.0053	0.0	<0.0500	0.0000	0.0	107	15	#NUM!	0.03	0.41
SMCL =			6.5 - 8.5	none	0.3	0.05	15	0.3	0.05	15	500	500	500		

Distribution System: Water Quality Parameter and Secondary Contaminant Data

Race Property (377 N. Plain Rd.)													
Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganes e (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15				500		
8/22/18	B. Prendergast	24	7.75	75.7	0.203	0.0178	20	0.203	0.0178	20	106	0.01	0.5
9/5/18	B. Prendergast	23.8	7.8	75.7	0.0683	0.0152	0	0.0683	0.0152	0	103	0.005	0.0
9/19/18	Tom Lussier	25	7.7	79.9	<0.0500	0.0099	0	0	0.0099	0	104	0.013	0.21
10/3/18	TCV		7.09	79.9	<0.0500	0.0075	0	0	0.0075	0	106	0.016	0.05
10/16/18	Tom Lussier	22	7.6	80.3	<0.0500	0.0063	20	0	0.0063	20	108	0.022	0.6
10/19/18													
10/24/18													
10/31/18	TCV	11.8	7.9	77.8	<0.0500	0.0044	0	0	0.0044	0	94	0.018	0.14
11/7/18													
11/14/18	Erick Bartlett (?)	7.2	8.06	80.3	<0.0500	0.0027	0	0	0.0027	0	130	0.020	0.37
11/20/18													
11/28/18	TCV	7.1	7.6	84.7	0.0804	0.0033	0	0.0804	0.0033	0	114	0.036	0.2
12/5/18													
12/11/18	Erick Bartlett	6.6	7.81	84.7	0.119	0.0036	0	0.119	0.0036	0	142	0.385	0.35
12/19/18													
12/26/18	Erick Bartlett	5.0	7.89	88.6	0.0972	0.0031	0	0.0972	0.0031	0	111	0.393	0.59
1/2/19													
1/8/19	Erick Bartlett	5.5	8.43	88.6	<0.0500	0.0021	0	0	0.0021	0	101	0.26	0.67
1/16/19													
1/22/19	Erick Bartlett	4.9	7.3	88.6	0.0933	0.0033	0	0.0933	0.0033	0	119	0.012	0.46
1/28/19													
2/6/19	Erick Bartlett	10	7.4	88.6	0.0663	0.0024	0	0.0663	0.0024	0	102	0.010	0.37
2/12/19													
2/20/19	Erick Bartlett	8.9	8.7	87.3	0.0546	0.002	<1	0.0546	0.002	0	114	0.019	0.42
2/27/19													
3/6/19	Erick Bartlett	6.7	7.2	87.3	<0.0500	<0.0020	<1	0	0	0	174	0.016	0.45
3/11/19													
3/18/19	Erick Bartlett	8.9	7.88	91.6	<0.0500	<0.0020	<1	0	0	0	133	0.026	0.55
3/26/19													
4/3/19	Erick Bartlett	11.9	8	86.2	0.0554	0.0026	<1	0.0554	0.0026	0	102	0.027	0.45
4/10/19													
4/15/19	Tim Vreeland	14.4	7.57	86.2	<0.0500	<0.0020	<1	0	0	0	127	0.02	0.30
4/23/19													

Race Property (377 N. Plain Rd.)													
Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganes e (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15				500		
5/6/19													
5/15/19	Tom Lussier	12	8.1	77.5	0.0613	0.0032	<1	0.0613	0.0032	0	94.0	0.022	0.52
5/22/19													
5/29/19	Tim Vreeland	19.1	7.8	80.0	0.154	0.0034	10	0.154	0.0034	10	110	0.029	0.47
6/5/19													
6/12/19	Erick Bartlett	19.7	7.8	80.0	<0.0500	0.0037	<1	0	0.0037	0	114	0.020	0.50
6/19/19													
6/24/19	Erick Bartlett	18.4	7.70	80.0	<0.0500	0.0062	10	0	0.0062	10	92.0	0.016	0.45
7/1/19													
7/10/19	Tim Vreeland	17.1	7.7	77.5	<0.0500	0.0065	<1	0	0.0065	0	99.0	0.021	0.15
7/15/19													
7/24/19	TCV	21.2	7.86	77.5	0.0685	0.0073	10	0.0685	0.0073	10	104	0.024	0.17
7/29/19													
8/5/19	Erick Bartlett	23.1	8.2	75.0	<0.0500	0.0057	<1	0	0.0057	0	101	0.012	0.29
8/14/19													
8/21/19	Erick Bartlett	22.5	8.0	72.5	<0.0500	0.0042	<1	0	0.0042	0	102	0.015	0.17
8/26/19													
9/4/19	Erick Bartlett	21.8	7.83	67.5	<0.0500	0.0029	<1	0	0.0029	0	115	0.021	0.21
9/11/19													
9/18/19	Erick Bartlett	20.1	7.96	70.0	<0.0500	0.0039	<1	0	0.0039	0	101	0.014	0.08
9/23/19													
10/2/19	Tim Vreeland	21	7.61	67.5	<0.0500	0.0028	<1	0	0.0028	0	87.0	0.036	0.10
10/7/19													
10/16/19	Erick Bartlett	16.7	7.83	70.0	<0.0500	0.0024	<1	0	0.0024	0	94.0	0.021	0.08
10/22/19													
10/30/19	Tim Vreeland	18.3	7.6	75.0	<0.0500	0.0041	<1	0	0.0041	0	99.0	0.028	0.07
11/6/19													
11/13/19	Tim Vreeland	14.6	7.78	72.5	<0.0500	0.0024	<1	0	0.0024	0	102	0.034	0.08
11/20/19													
11/25/19	Tim Vreeland	13.1	7.7	75.0	<0.0500	0.0031	10	0	0.0031	10	104	0.024	0.18
12/4/19													
12/10/19	Tim Vreeland	12.4	7.46	75	0.0552	0.0038	<1	0.0552	0.0038	0	118	0.022	0.17
12/17/19													
12/31/19													
1/6/20	Tim Vreeland	13.7	7.21	75.0	0.0723	0.0027	<1	0.0723	0.0027	0	90.0	0.028	0.1
1/14/20													
1/22/20	Erick Bartlett	7.0	7.49	77.5	0.0933	0.0031	<1	0.0933	0.0031	0	117	0.022	0.22

Race Property (377 N. Plain Rd.)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15				500		
1/28/20													
2/5/20	Erick Bartlett	7.9	7.91	80	0.0523	<0.0020	<1	0.0523	0	0	104	0.016	0.20
2/10/20													
2/19/20	Erick Bartlett	7.4	7.89	82.5	0.0753	0.0028	<1	0.0753	0.0028	0	114	0.027	0.19
3/4/20	Erick Bartlett	7.9	7.86	79.5	0.0665		<1	0.0665		0	108	0.019	0.19
3/10/20													
3/16/20	Erick Bartlett	7.9	7.83	80.0	0.0752	0.0024	<1	0.0752	0.0024	0	115	0.03	0.25
Count =		39	40	40	19	35	17	40	39	40	40	40	40
Average =		14.0	7.8	79.5	0.0848	0.0047	4.7	0.0403	0.0042	2.0	109	0.05	0.29
Minimum =		4.9	7.1	67.5	0.0523	0.0020	0	0.0000	0.0000	0	87	0.01	0.00
Maximum =		25.0	8.7	91.6	0.2030	0.0178	20	0.2030	0.0178	20	174	0.39	0.67
Median =		13.1	7.8	79.9	0.0723	0.0033	0.0	0.0000	0.0032	0.0	105	0.02	0.22
SMCL =				none	0.3	0.05	15				500		

Race Property (377 N. Plain Rd.)

Date	Sampler	Temp (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Iron (mg/L)	Manganese (mg/L)	Color (color units)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Chlorine Residual (mg/L)
SMCL =			6.5 - 8.5	none	0.3	0.05	15				500		

Total # of samples =	144	166	166				166	164	164	169	154	150
Overall minimum (all samples) =	2.8	7.0	31.7	0.000	0.002	0.0	0.000	0.000	0.0	34.0	0.001	0.00
Overall maximum (all samples) =	32.0	15.9	92.7	0.203	0.109	50.0	0.203	0.102	50.0	174.0	0.750	1.08

APPENDIX C
KROFTA TREATMENT SYSTEM INFORMATION

SANDFLOAT SAF-BP™

DISSOLVED AIR FLOTATION CLARIFIER / DUAL MEDIA FILTER

The **KROFTA™ Sandfloat SAF-BP™** is a patented Dissolved Air Flotation Clarifier and Media Bed Filter that combines flocculation, flotation, and filtration in one piece of equipment. The unit is designed so that individual segments in the filtration process can be backwashed without shutting down the entire unit. There are 19 standard sizes to choose from with capacities ranging from 65 to 16,000 gpm. In addition, the unit can be customized for industrial or municipal applications. Some of the more common applications for the SAF-BP™ include:

- Potable Water Clarification
- Raw Process Water Clarification
- Tertiary Clarification & Polishing
- Reverse Osmosis/Membrane Protection

SANDFLOAT SAF-BP PROCESS DESCRIPTION

FLOCCULATION

Raw water mixed with flocculation and coagulation agents is introduced into the bottom center of the unit in a mixing chamber. Several directional nozzles and baffles within the chamber cause a slow mixing of the raw water and chemicals. The chamber can be designed for extended flocculation times when necessary. As the raw water and flocculated particles rise out of the chamber, they are gently mixed with the aerated water at the surface. Typical retention time within the flocculator is 3-4 minutes.

FLOTATION

Aerated water from the ADT mixes with the flocculated raw water and flows under a baffle that slows horizontal velocity into the flotation zone. The flocculated solids attach to the air bubbles that are formed during the aerated water pressure release and are floated to the surface. The clarified water flows onto the media beds below for filtration.

FILTRATION

The lower section of the SAF-BP™ is divided into individual filter bed segments or cells. Depending on the application or site specification, each cell is provided with a plate and nozzle base or stainless steel underdrain wedge wire extraction assembly. The clarified water gravity flows through the media beds to the extraction points. Typically there is a minimum of 2 feet of filtration media in each cell. The media may consist of sand and anthracite, sand only, greensand, or some combination of these types of filtering materials; a wide variety of filtering media may be used depending on the application. Clarified/filtered water is collected in a central header attached to each cell segment for discharge.

FLOATED SLUDGE REMOVAL

A spiral scoop assembly removes floated sludge from the clarifier. As used in conjunction with the Krofta Automatic Level Control System, the scoop removes only the top layer of the floated materials. This keeps the sludge consistency high, and minimizes sludge volume. Sludge removed from the top of the flotation zone is deposited into the sludge cone located in the center of the unit.

BACKWASHING

Individual segments or cells are continuously isolated for backwashing without stopping the filtration process. Each cell is taken off-line independently of the others. The pipe rings which surround the unit incorporate one effluent valve and one backwash line valve per filter cell. Normal operation has the backwash valves closed and the effluent valves open. When the rotating carriage assembly on the unit increments to an individual cell it activates the backwashing sequence for that cell. The position of the two valves on the backwashing cell are reversed, stopping effluent flow through the media in that cell. An inflatable neoprene seal inflates, isolating the backwashing cell from the rest of the on-line cells. Water is drawn down through the backwash line to approximately four to six inches above the media. Next, an air scour is injected into the cell's media to gently lift the media followed by a partial flow backwash. This is followed by a full flow backwash, followed by a partial flow to allow the media to re-stratify. Backwash water is directed up into a backwash trough and can be either recycled into the flocculator for re-treatment or directed out as waste. The hood seal is then deflated and water is drawn off again through the backwash ring. This continues for a short period until the filtered water returns to the required turbidity specification (NTU). This process may be monitored in each cell with an optional turbidity monitoring system. The valve positions are then reversed and the carriage moves to the next cell repeating the process.

STANDARD UNITS

SIZE Diameter (Feet)	CAPACITY gpm
5	65
8	220
10	350
12	500
15	780
18	1130
20	1400
22	1680
24	2000
27	2540
30	3100
33	3800
36	4500
40	5500
44	6700
49	8300
55	10500
62	13000
70	16000

OPERATIONAL ADVANTAGES

- Viewing windows for flotation and backwash observation
- Compact high through-put design capable of processing up to 5 gpm/sf.
- Stainless steel construction – bolt together design
- Dual media filtration
- Flocculation, flotation, and filtration in one piece of equipment
- 1st filtrate recycle capability for potable water applications
- Continuous backwash capability
- PLC/DCS/SCADA compatible

THE AIR DISSOLVING TUBE (ADT)

Common to all Krofta DAF technology, the Krofta™ Air Dissolving Tube (ADT) is in operation in thousands of applications around the world. The ADT eliminates the need for large volumes of air and water used by typical pressure vessels, by using air dispersion technology and centrifugal force in place of sheer volume and gravity. Compressed air is released into the ADT across the surface of an air panel. The panel material and design disperses the air across the entire surface of the panel. This allows for faster dissolution of air into the water and hence a retention time of only eight to twelve seconds. The flow pattern within the ADT is a cyclone or vortex which produces a centrifugal force that eliminates undesirable entrained air. A specially designed inlet nozzle is sized specifically for each application and can be easily changed out if the recycle requirements of future waste streams change significantly. In addition, a proprietary bleed-off outlet also assists in eliminating too much air in the tube itself. This ensures that the tube will never air bind or release undissolved air to the DAF. A sized globe valve is used for pressure release, generating 10-70 micron bubbles well suited for DAF operation.

KROFTA
a Waterleau company

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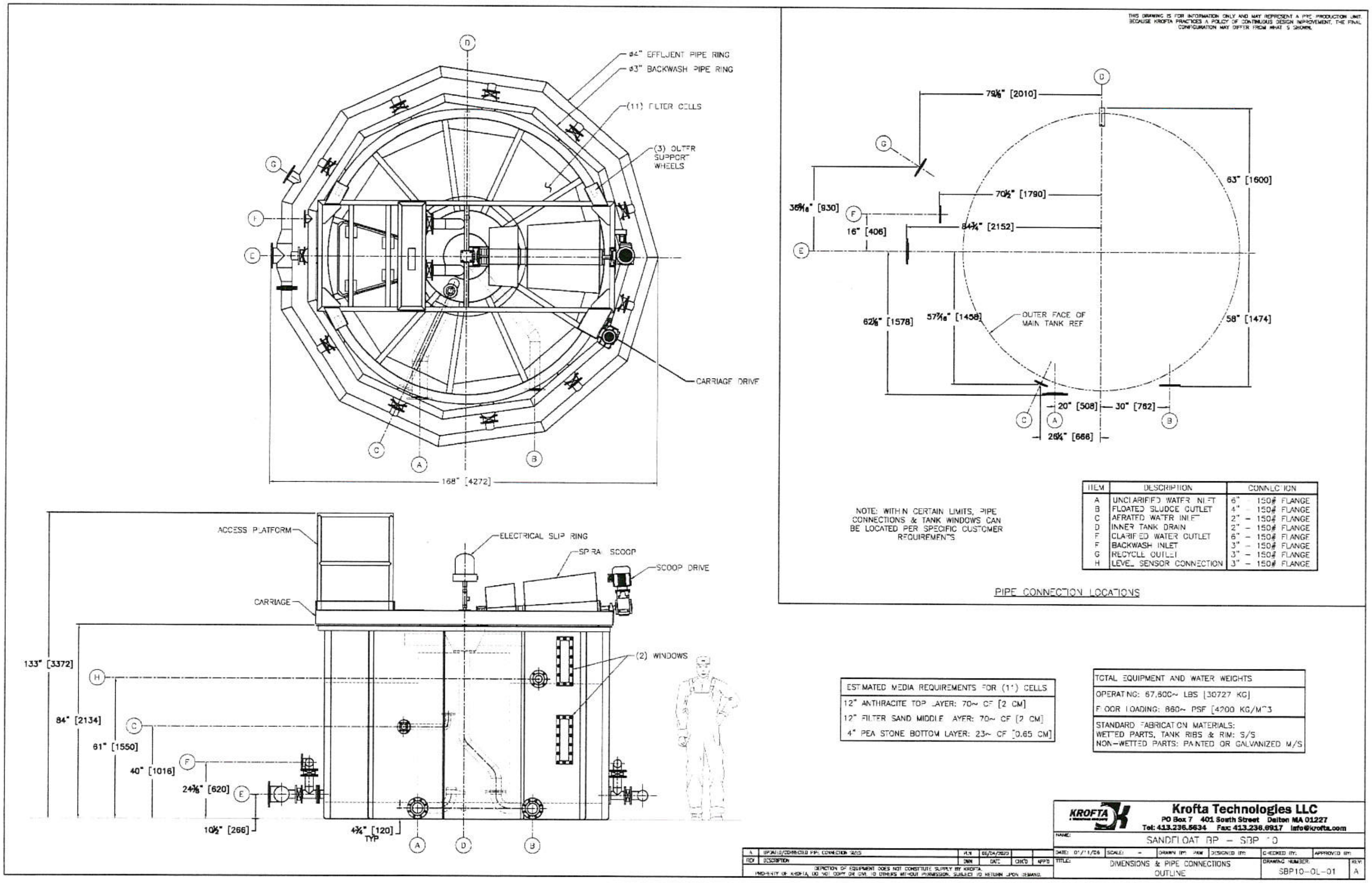


ITEM	DESCRIPTION	CONNECTION
A	UNCLARIFIED WATER INLET	6" – 150# FLANGE
B	FLOATED SLUDGE OUTLET	4" – 150# FLANGE
C	AERATED WATER INLET	2" – 150# FLANGE
D	INNER TANK DRAIN	2" – 150# FLANGE
E	CLARIFIED WATER OUTLET	6" – 150# FLANGE
F	BACKWASH INLET	3" – 150# FLANGE
G	RECYCLE OUTLET	3" – 150# FLANGE
H	LEVEL SENSOR CONNECTION	3" – 150# FLANGE

ESTIMATED MEDIA REQUIREMENTS FOR (11) CELLS
12" ANTHRACITE TOP LAYER: 70~ CF [2 CM]
12" FILTER SAND MIDDLE LAYER: 70~ CF [2 CM]
4" PEA STONE BOTTOM LAYER: 23~ CF [0.65 CM]

TOTAL EQUIPMENT AND WATER WEIGHTS
OPERATING: 67,600~ LBS [30727 KG]
FLOOR LOADING: 860~ PSF [4200 KG/M^3]
STANDARD FABRICATION MATERIALS: WETTED PARTS, TANK RIBS & RIM: S/S NON-WETTED PARTS: PAINTED OR GALVANIZED M/S

APPENDIX D
KOCH MEMBRANE TREATMENT SYSTEM INFORATION

PURON® MP System

Virtually Unbreakable Hollow Fiber Ultrafiltration

Advanced Membrane Filtration for Water Purification

KOCH™
SEPARATION SOLUTIONS

Separation Technologies for a Better Future™

Effective Solution for High-Quality Water

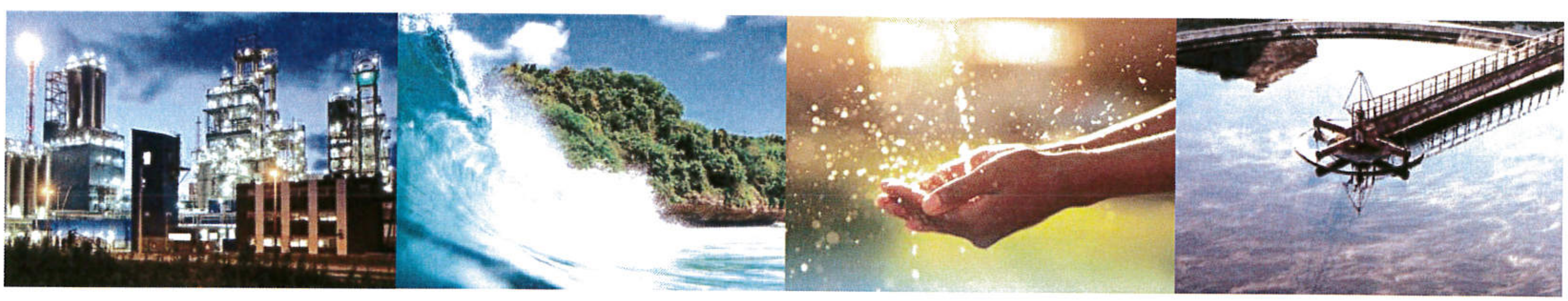
Over 50 Years of Membrane Experience

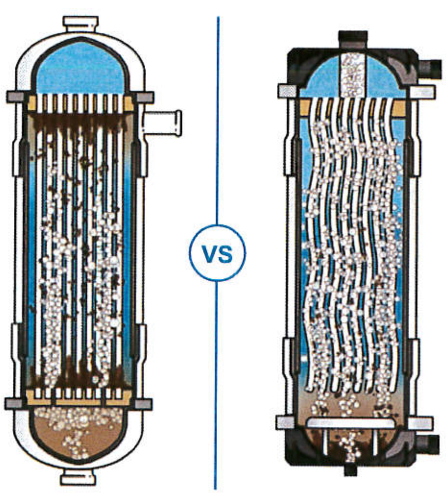
Koch Separation Solutions (KSS) is a global leader in membrane filtration technologies with over 50 years of membrane experience and thousands of system installations worldwide. The PURON® MP system, equipped with PURON MP pressurized hollow fiber cartridges, is designed to treat a variety of water and wastewater with high amounts of suspended solids in both municipal and industrial settings. The skid-mounted system offers a complete and cost-effective solution to consistently provide high-quality effluent, meeting most stringent quality regulations.

PURON MP Hollow Fiber Membrane

KSS is the only manufacturer of the industry-leading single potting hollow fiber design. This unique configuration allows the membrane fibers to move freely within the cartridge, permitting aeration to penetrate the fiber bundle and eliminate buildup to effectively increase active membrane area and overall performance.

The tight ultrafiltration pore size at 0.03 micron and narrow pore size distribution result in the PURON MP membrane's high flux tolerance, up to 60 gfd (100 lmh), and high solids tolerance, up to 1,000 mg/L. PURON MP hollow fiber cartridges are constructed with polyester reinforced PVDF membranes, making the fibers virtually unbreakable. The robust design of these membranes allows for uninterrupted operation, lower maintenance costs, and reduced manpower for fiber repair.





Traditional Designs
Potting at Both Ends

PURON MP Design
Single Potting

Benefits

- High flux and solids tolerance eliminate need for costly pretreatment
- Robust and virtually unbreakable fibers reduce downtime and maintenance requirements
- Unique single potting design reduces buildup and "fiber sludge"
- Superior membrane chemistry and tight pore structure deliver stable membrane performance without the need for extensive chemical cleans
- Optimized design and operation to lower capital and operating costs

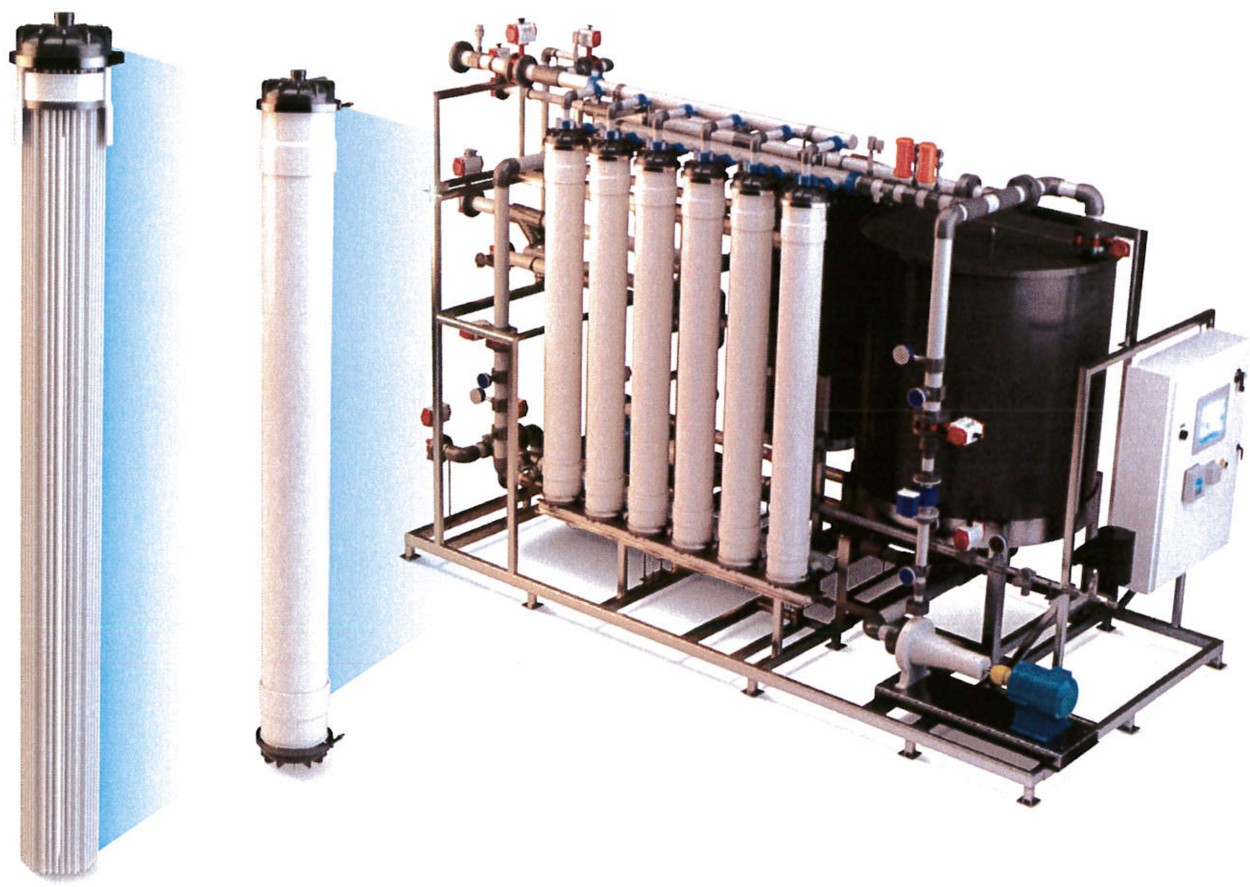
Virtually Unbreakable Hollow Fiber Ultrafiltration

PURON® MP System

The PURON MP ultrafiltration system is available in two standard pre-engineered package system sizes, with either 6 or 10 cartridges, and three standard modular system sizes, ranging from 24 to 64 cartridges. The simple design allows for easy installation and operation and requires minimal system connections, lowering capital costs. The PURON MP modular system can also be custom-designed and is scalable to meet a variety of capacity and performance requirements.

Applications

- **Industrial water:** Achieve high recoveries and remove suspended and colloidal solids while reducing footprint
- **Tertiary wastewater treatment:** Handle clarifier upsets with ease and tolerate high coagulant doses for phosphorus removal
- **Seawater pre-treatment:** Extend RO membrane life, reduce operating costs, and significantly decrease footprint
- **Potable water treatment:** Achieve greater than 4-log removal of Giardia and Crypto, treat turbid surface waters, and tolerate high coagulant doses for TOC/Color removal



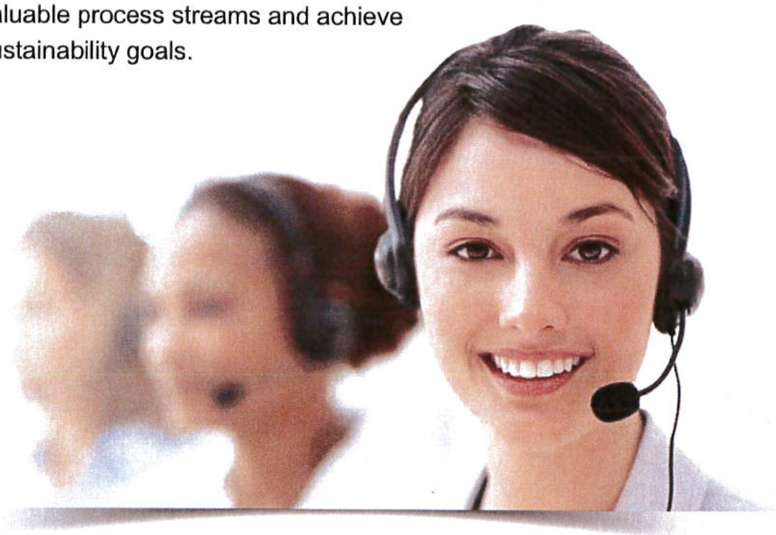
KSS ASSIST

KSS will partner with you throughout the life cycle of your membrane filtration system. Our experienced technical team will provide global service and support and will work directly with you to maximize process efficiency. KSS ASSIST®, our service and maintenance program, provides the tools to keep your system operation at the highest level, including:

- Membrane Process Optimization
- Plant Audits
- Data Collection, Analysis & Reporting
- Operator Training
- Telephone Support

Koch Separation Solutions

Koch Separation Solutions (KSS) is a global leader in membrane filtration technologies with over 50 years of membrane experience. With best-in-class domain expertise, technology and systems, KSS is uniquely positioned to help customers purify and recover valuable process streams and achieve sustainability goals.



KOCH™ SEPARATION SOLUTIONS

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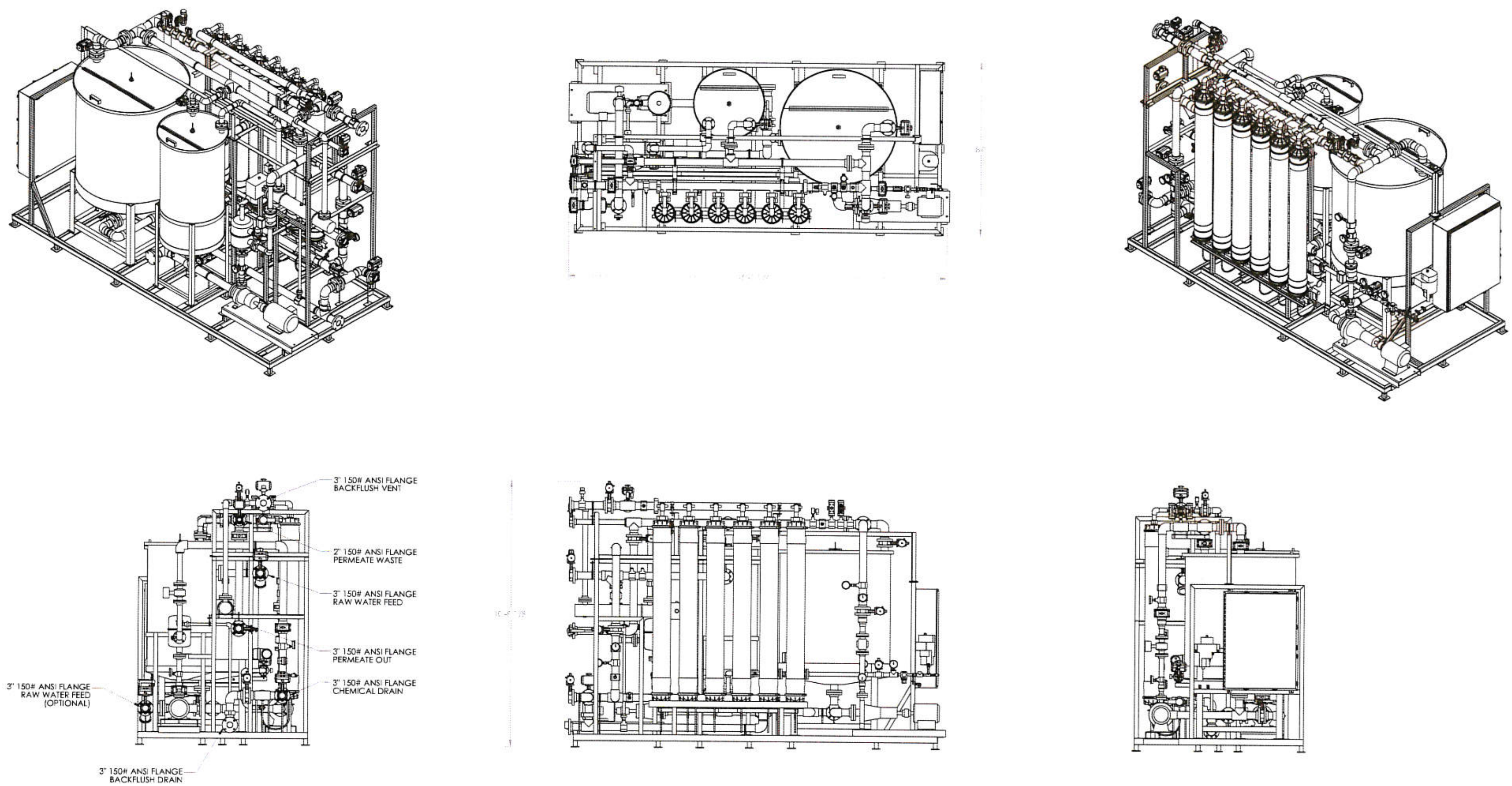
NOTES:
1. THIS DRAWING HAS BEEN PREPARED FOR SALES AND MARKETING PURPOSES ONLY AND MAY THEREFORE BE SUBJECT TO CHANGE BY OUR ENGINEERING DEPARTMENT
2. ALL DIMENSIONS ARE REFERENCE ONLY



MATERIAL: N/A	KOCH MEMBRANE SYSTEMS — KOCH MEMBRANE SYSTEMS, INC. www.kochmembrane.com					
TOLERANCE ON: LINEAR: ±1/2" ANGULAR: ±1° INTERPRET DIM AND TOL PER ASME Y14.5M-1994	TITLE: 8" PURON® MP6 STANDARD SYSTEM GENERAL ARRANGEMENT					
	DCR:	DRAWN BY: JAC	DRAWN DATE: 29.APR. 14	APPROVAL: N/A	APPROVAL: N/A	FINAL APVL:
SCALE: N/A	PROJECTION:	SHEET: 1/1	DRAWING NO: 7001205	REV: 3	SIZE: D	