Merrimack Village District's PFAS Journey

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Chapter Two

Introduction

In the March 2020 edition of the of the Journal of NHWWA (V.1-2020), Chapter One of Merrimack Village District's (MVD's) journey into the world of per- and poly-fluorinated alkyl substances (PFAS) was described. This article presents Chapter Two of this on-going journey. We refer the reader to the March 2020 article for details, but for context, a summary of Chapter One is given below:

- MVD Water System
    - Serves most of the Town of Merrimack, NH.
    - Groundwater system with six active wells (#2, #3, #4, #5, #7 & #8).
    - Prior to 2016, the only treatment was corrosion control and disinfection.
    - An Iron & Manganese Removal WTP was added at Wells #7 & #8 in 2016.
    - Current Avg & Max Day Demand – 2.3 mgd & 5.4 mgd respectively
- PFAS are a class of chemicals used ubiquitously to make everyday products resistant to stains, heat, grease, oil and water. The strong carbon-fluorine bond makes them very stable, long lasting in the environment, and difficult to treat.
- Perfluorooctanoic acid (PFOA) was detected in the MVD system in February 2016
- Subsequent sampling and testing showed PFOA and other PFAS compounds in all MVD's active wells.
- In May of 2016 NHDES adopted 70 ppt as an Ambient Groundwater Quality Standard (AGQS) for PFOA which is enforceable in NH as a Maximum Contaminant Level (MCL).
- MVD Wells #4 & #5 had PFOA concentrations above the AGQS and NHDES notified MVD that the wells must be kept off-line until treatment was in place.
- Granular Activated Carbon (GAC) contactors were selected for removal of PFAS.
- There was much public pressure to treat all MVD wells for PFAS regardless of the standard and in March 2019, warrant articles were passed to design and construct PFAS removal facilities for all MVD wells.
- In July 2019, NHDES adopted new lower standards for PFOA, PFOS and two other PFAS compounds which made treatment of all MVD wells a regulatory requirement due to PFOA concentrations
- As of March 2020, (end of Chapter One), MVD had:
    - Completed construction of a new booster pump station from the Pennichuck Water Works (PWW) system to replace the capacity of Wells #4 & #5 if needed
    - Initiated construction of the Well #4 & #5 PFAS WTP,
    - Completed final design of a PFAS removal addition to the Well #7 & #8 Iron & Manganese WTP,
    - Completed preliminary design of PFAS removal facilities for Wells #2 & #3, and

- Secured over $14 million in grant and loan funding through the NHDES SRF program and the Drinking Water Groundwater Trust (DGWT) Fund for PFAS related infrastructure.

March 2021 Update

Wells #4 & #5

The Well #4 & #5 PFAS WTP reached substantial completion and went online in October of 2020 and has been providing about 700,000 gpd of PFAS free water ever since. See **Figures 1 – 4** for photos from construction and startup of the WTP. The Well #4 & #5 site and WTP have the following major design components:

- Wells #4 & #5 normal yield = 625 gpm (0.43 mgd). Max short term yield = 870 gpm (1.25 mgd)
- The old Well #4 and Well #5 stations with the wells inside the buildings were demolished and replaced with submersible pumps, motors and pitless adaptors
- Replacement well for Well #4 (Well #4R), due to damaged/corroded screen
- 2,924 square foot (86 ft x 34 ft) concrete masonry unit (CMU) building with wood truss roof, asphalt shingles and vinyl siding
- One train of two 12 ft diameter, 26 ft tall GAC contactors (1,000 gpm capacity for train)
- Provisions for future resin or other treatment addition
- Chemical storage and feed rooms
- Mechanical room
- Electrical room
- Control/work room
- ADA compliant bathroom
- Sanitary sewer to Merrimack Sewer System (sanitary waste only)
- Infiltration basin for GAC backwash and filter to waste discharge

Figure 1-GAC Vessel Installation at Well 4/5 WTP

Figure 2-Completed Well #4 & #5 WTP **Figure 3-GAC Media Installation-Well 4/5 WTP**

Figure 4-Initial Backwash of GAC at Startup-Well 4/5 WTP

GAC is highly porous with a large surface area to volume ratio. Contaminants such as PFAS are removed by being adsorbed, a process in which the contaminant molecules "stick" to the carbon due to electrochemical forces and are bound there. When the adsorptive capacity of the media is exhausted, contaminants will start to appear in the contactor effluent, which is defined as "breakthrough", at which point the media needs to be replaced. Spent media may be disposed of or regenerated. GAC is not backwashed like filter media since the contaminants are bound to the media. Backwashing is only done once at startup to remove fines and stratify the bed.

The main design parameter for a GAC contactor is "empty bed contact time" (EBCT), or the time that the water is in contact with the media. This is nominally determined by dividing the volume of the empty media bed by the flow rate, but it is noted that different GAC's have different densities so if a manufacturer indicates the pounds of GAC in a vessel, it is necessary to get the density to determine volume. The minimum recommended GAC EBCT for PFAS removal is about 10 minutes. The Well #4 & #5 WTP was designed to provide 10 minutes of EBCT at the peak flow of 870 gpm so at normal lower flows, the EBCT will be greater than 10 minutes.

The most important operating parameter for GAC is bed life since the largest O&M cost is replacement of this media. This is measured either as time to reach breakthrough or the number of bed volumes treated before breakthrough. Bed life is a function of the influent PFAS concentration, EBCT, and water quality, especially parameters that compete with PFAS for adsorption sites such as natural organic matter (NOM), sulfate, iron or manganese. The only way to definitively determine bed life is to conduct a pilot test to breakthrough, but this could take a year or more and is often not practical. Rapid Scale Small Column Tests (RSSCT's) have been developed as a quicker way to verify PFAS removal and estimate bed life. This involves using columns less than 1 inch in diameter, GAC ground to a corresponding particle size, and a large sample of the raw water to be treated. This technique allows thousands of bed volumes to be treated much faster so that different GAC's can be compared under the same water quality and conditions until breakthrough is achieved. The bed volumes from the RSSCT can be equated to the full-scale operation to estimate the bed life. It is noted that bed life determined by an RSSCT is an estimate, and lab results do not always exactly match actual field results, but when there is limited time, it is currently the best tool available. RSSCT's were conducted on water samples from Wells #4 & #5, and eventually, all MVD Wells, to compare up to four different types of GAC. The RSSCT for the GAC selected for Wells #4 & #5 indicated a bed life of up to 20 months based on breakthrough of PFOA, the primary contaminant, but "short chain" compounds (currently unregulated PFAS compounds with shorter carbon chains) that are not removed as efficiently as longer chain PFAS compounds, may breakthrough by about 13 months.

The Well #4 & #5 GAC treatment train consists of the two GAC vessels to which water is fed in series in a lead/lag configuration. When breakthrough is either reached or approached on the lead vessel, the valve rack between the vessels (**Figure 5)** is used to change the flow direction so that the lag vessel becomes the lead vessel and the GAC in the former lead vessel can be changed out. Design of the GAC vessels includes the following sample taps:

- Raw water before lead vessel
- Points within the GAC bed of each vessel (25%, 50% and 75% of bed) (**Figure 5**)
- Midpoint between the lead and lag vessels
- Finished water after lag vessel

These sample taps are used to track the progress of PFAS adsorption through the bed and the train so that the switch from lead to lag vessel and media changeout can be scheduled at the appropriate time. A very important decision with regard to O&M costs is when to change the media. One approach is to wait until breakthrough of regulated contaminants to make sure compliance with the NH PFAS MCL's is achieved. Another approach, however, it to make the change when there is imminent breakthrough of any PFAS compound. Since short chain compounds will usually breakthrough first, this could lead to more frequent changeouts and higher costs. It is important to note that breakthrough in this discussion refers to PFAS entering the lag vessel, not the system. MVD's goal is non-detection of PFAS in water entering the distribution system.

At the time of publication of this article, the Well #4 & #5 PFAS WTP has been online for about six months. No PFOA has been detected within the lead vessel bed. Three short chain compounds have been detected in the top 25% of the bed and one short chain compound at the bed midpoint.

Figure 5-GAC Vessel Pipe Rack & Sample Taps-Well 4/5 WTP

<u>*Wells #7 & #8*</u>

Final design of the PFAS Removal Addition to the existing Wells #7 & #8 WTP (1,250 gpm (1.8 mgd)) Iron & Manganese Removal WTP was completed in March of 2020. Bids were opened on May 27, 2020 and the construction contract award was on July 21, 2020. Construction started at the beginning of August 2020 and substantial completion is expected in October of 2021.

Some challenges with design of this addition were:

- Limited area for expansion due to soil conditions and wetland constraints
- Height of the GAC vessels (26 ft) versus that of the existing GreensandPlus™ vessels (12 ft)

The geotechnical evaluation conducted for the design phase of the Iron & Manganese WTP revealed sands that could liquify during an earthquake which required soil stabilization using rammed aggregate piers for the entire building footprint. In order to provide expansion area for the Iron & Manganese WTP, additional soil stabilization was completed to accommodate a 48 ft x 34 ft addition. After the PFAS contamination however, the decision was made to use this area for PFAS treatment. To treat 1,250 gpm, two trains (two vessels/train) of 10 ft diameter GAC vessels (500 gpm/train) was not enough, so 12 ft diameter GAC vessels were evaluated (1,000 gpm/train). While the existing expansion area was sufficient for the smaller GreensandPlus™ vessels, it was not adequate for four 12 ft diameter GAC vessels and associated piping. Additional ground stabilization would have been required for a larger addition, and the 2,000 gpm of treatment capacity was much greater than required. Working with the GAC vessel manufacturers, it was determined that one train of 15 ft diameter vessels (1,500 gpm capacity) would fit in the available space. Vessels of this size require special trucking arrangements, mainly due to bridge clearance, but analysis of the route by the manufacturer indicated that these vessels can be shipped to the site, so the design was based on 15 ft diameter vessels.

Ion exchange resin, which uses smaller tanks than GAC, was considered for this application. However, the chloride levels in Wells #7 & #8 (about 100 mg/l) were such that the resin manufacturers contacted indicated that given such a high chloride to PFAS ratio (ppm vs ppt), the resin's ability to remove short chains would be impacted and lead to shorter bed life than GAC. Additionally, resin cannot tolerate any residual chlorine in the water as it will damage the resin beads. Since there is chlorine in the GreensandPlus™ effluent, dechlorination would have been required with the use of resin, either through the use of chemical addition, or GAC.

A slab-on-grade construction was evaluated for the new addition, but the roof trusses of the existing WTP building were not sufficient for the additional snow load that may occur due to drifting snow that could pile up against the gable end of the new higher building addition. To reduce the height of the building to match the existing roof line, the floor of the addition was recessed to match the floor of the existing recycle basins, clearwell, and pipe gallery. **Figure 6** shows the difference in tank sizes and floor elevations.

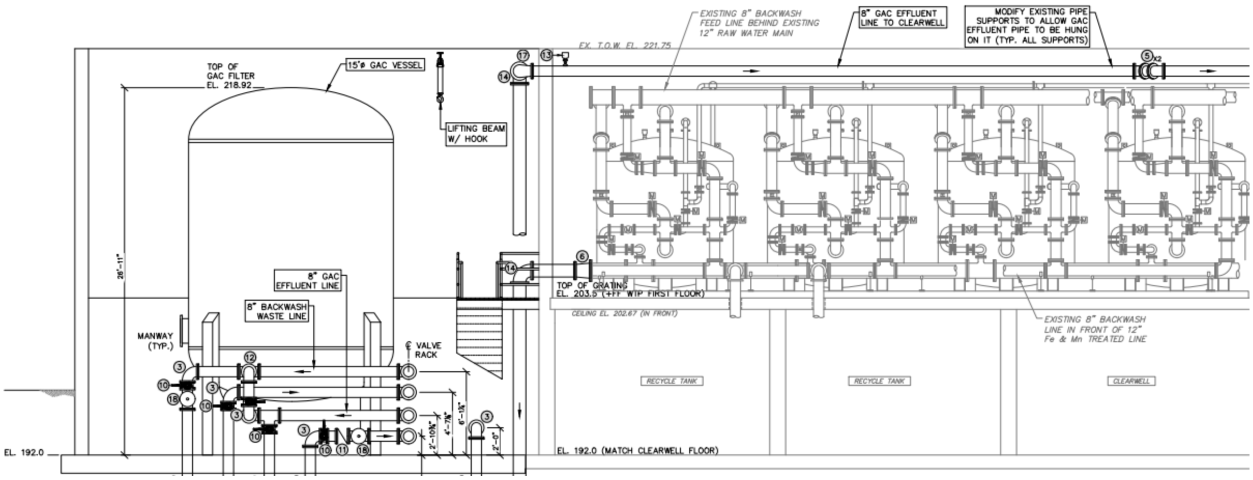

Figure 6-Elevation View of Well 7/8 PFAS WTP Addition

See **Figures 7 & 8** for photos from construction of the Well #7 & #8 PFAS WTP addition.

Wells #2 & #3

Wells #2 and #3 are about a mile apart and have capacities of 1,000 gpm and 1,500 gpm respectively. The intent was to design a single PFAS WTP for both wells with a raw water main or mains from the wells to the WTP location. Well #3 has iron and manganese levels that are respectively as much as 4 and 17 times the secondary MCL's (SMCL's) so removal of iron and manganese is necessary before directing this water to GAC contactors. The Draft Preliminary Design Report completed in December of 2019 included a 120 ft x 66 ft (6,736 sq ft) WTP with four 10.5 ft diameter GreensandPlus™ filters for removal of iron and manganese from Well #3, and six 12 ft diameter GAC vessels for PFAS removal from both wells, along with three infiltration basins


Figure 7-Inside Well 7/8 PFAS WTP Addition


Figure 8-Exterior of Well 7/8 PFAS WTP Addition

for both iron and manganese and GAC backwashing and filter to waste. The new WTP was to be sited near Well #3 with a raw water main from Well #2. Due to the Well #3 location near several busy interchanges, road salting has greatly increased sodium and chloride levels such that chloride is well above the SMCL. The size and expense of the proposed WTP along with the increasingly poor quality of Well #3 led to a decision to design and construct PFAS treatment for Well #2 only, initiate the process of installing a replacement well for Well #3 and include capacity in the Well #2 WTP for flow from the new well, designated as Well #9.

Emery & Garrett Groundwater Investigations (EGGI, a division of GZA), MVD’s hydrogeologic consultant conducted geophysics and test well work in the Naticook Brook Aquifer in which both Well #2 and #3 are located. A very favorable site was located on the north/west side of Naticook Brook about 1,000 feet from Well #2 (**Figure 9**). At this point, the Well #9 production well has been installed (18-inch diameter, screened from 86 ft to 103 ft below ground) and EGGI is in the permitting process with NHDES.

Final design of the Well #2 PFAS WTP and related work was completed in January of 2021 which includes:

- 4,280 sq ft CMU building with wood truss roof, asphalt shingles and vinyl siding
- Four 12 ft diameter, 26 ft tall GAC contactors (2,000 gpm capacity)
- Chemical storage and feed rooms
- Mechanical room
- Electrical room
- Control/work room with storage
- Standby Generator
- ADA compliant bathroom and onsite septic system
- Infiltration basin for GAC backwash and filter to waste discharge
- 1,000 ft (+/-) raw water main from Well #9
- Cleaning and rehabilitation of Well #2, new pump and motor and replacement of process piping

Bids were opened for the project on April 26, 2021. Construction is expected to start in July with substantial completion expected in August of 2022.

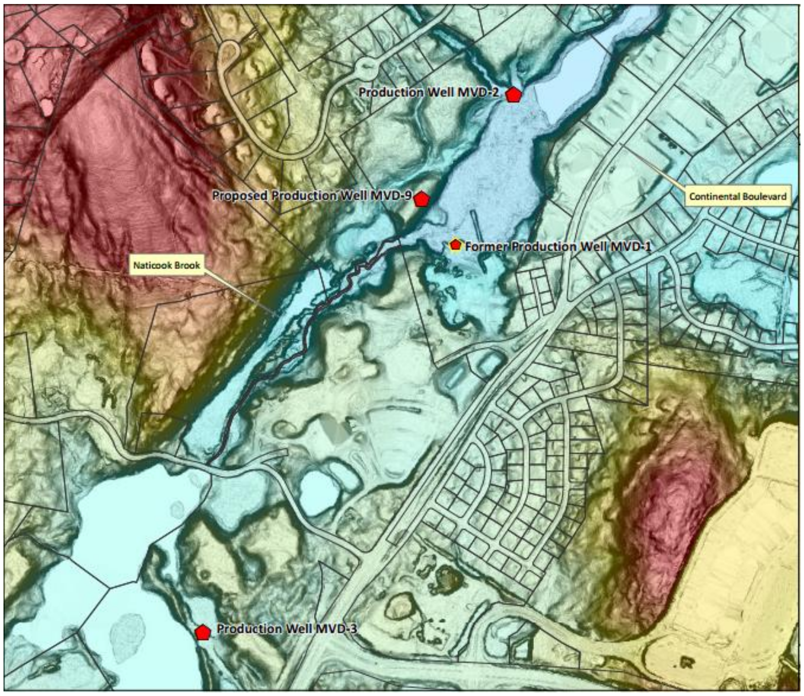

Figure 9-Location of Wells #2, #3, & #9 (EGGI)

Costs

Table 1 presents the overall budget costs for the PFAS related infrastructure referenced in both the current and the March 2020 articles.

Table 1 – PFAS Related Budget Costs

Project	Budget
PWW Booster Pump Station	$281,000
Well # 4 & #5 PFAS WTP	$5,160,000
Well #7 & #8 PFAS WTP Addition	$5,100,000
Well #2 PFAS WTP	$7,900,000
Total	**$18,441,000**

The construction cost and current status for each of the three PFAS WTP's is given in **Table 2**.

Table 2 – MVD's PFAS WTP's Costs & Status

WTP	Construction Cost	Contractor	Expected Completion
Wells #4 & #5	$4,043,243	Penta Corp	Online Oct 2020
Wells #7 & #8	$3,540,300*	Infrastructure Construction Corp.	October 2021*
Wells #2 & #9	$7,867,000*	Kinsmen Corp	August 2022*
Total Const. Cost	**$15,450,543**		

*Projects not complete so figures/dates subject to change

MVD, with assistance from UE and EGGI has completed the discovery, evaluation and design legs of their PFAS journey. They are now in the construction phase, and of course the operational part of this journey will be on-going for many years to come, but by the fall of 2022 MVD is on track to achieve their goal of providing PFAS free water from all MVD sources.

Acknowledgements

The author gratefully acknowledges the following individuals for contributions to the content of this article:

- Ron Miner, Superintendent, MVD
- Jill Lavoie, Business Manager/Water Quality & Testing Manager, MVD
- Dan Tinkham, Emery & Garrett Groundwater Investigations
- Keith Pratt, Peter Pitsas & Lynnette Carney, Underwood Engineers