FINAL

PROGRESS UPDATE NO. 3

Emerging Contaminants Treatment Strategy Pilot Study

B&V PROJECT NO. 196369

PREPARED FOR

Cape Fear Public Utility Authority

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BLACK & VEATCH

Table of Contents

LIST OF TABLES

1.0 Purpose

This document presents the status of ongoing bench- and pilot-scale testing to evaluate the performance of several proposed treatment technologies in their removal of perfluoroalkyl substances (PFASs), including perfluoro-2-propoxypropanoic acid (commonly known as GenX).

2.0 Introduction

PFASs have been detected in the Cape Fear River, which is the source of raw water for the Sweeney Water Treatment Plan (WTP). The Sweeney WTP provides drinking water to Cape Fear Public Utility Authority (CFPUA) customers in the City of Wilmington and New Hanover County in North Carolina.

In response to the detection of GenX and other PFASs in the Cape Fear River and because of concern over potential health effects, CFPUA is proactively investigating the feasibility and effectiveness of PFAS removal technologies. CFPUA is one of the first utilities in the United States to pursue treatment to target removal of these compounds. Initial evaluations performed by Black & Veatch were provided in Technical Memoranda 1 and 2. As a result of those evaluations, bench- and pilot-scale testing of granular activated carbon (GAC) filter media and ion exchange (IX) resins was initiated. The details of the bench- and pilot- scale testing are presented herein.

3.0 Testing and Analysis

Granular activated carbon filter media and ion exchange resin were selected for bench- and pilot-scale testing. Reverse osmosis/nanofiltration was excluded because of much higher life-cycle cost and potential challenges related to disposal of the concentrate, but the technology will be considered if testing of GAC and IX fail to meet testing goals. The following sections provide information on the testing.

3.1 TESTING GOALS

The primary goal of the testing is to establish the adsorption characteristics for PFASs and other contaminants of emerging concern (CECs) on GAC media and IX resin. These characteristics will be used to refine the previous study-related evaluations and identify the most advantageous short- and longer-term treatment strategies for removal of PFASs and CECs at the Sweeney WTP. The data will help define a design basis for full-scale implementation of the selected technology. Ancillary benefits are also being identified as part of the study, such as reductions in total organic carbon (TOC), disinfection byproduct (DBP) formation, and inorganic compounds.

3.2 MEANS AND METHODS

Means and methods for the bench- and pilot-scale testing were included in a previous progress report dated Nov. 3, 2017. Refer to the previous report for details.

3.3 GAC INTERIM RESULTS TO DATE

Interim results of the ongoing pilot testing are presented in Table 3-1. All data is reported based on equivalent bed volumes of water treated.

Each GAC test column continues to exhibit gradual breakthrough of TOC and PFASs, led by shorter chain per- and polyfluorinated compounds. Each GAC media is exhibiting chromatographic peaking, which is the preferential adsorption of one molecule over another. As a result, shorter

carbon chain molecules are being released by the GAC into the effluent contributing to greater than 100 percent breakthrough values. Results also continue to show that shorter carbon chains (PFBA, PFBS, GenX, etc.) are not as strongly adsorbed on the GAC media as the longer carbon chain molecules (PFDA, PFOS).

Table 3-1 Sampling Results as of December 5, 2017

	Column Influent	GAC-1	GAC-2	GAC-3	GAC-4	IX-1	IX-2
Bed Volumes	---	17,340	17,640	18,000	18,050	90,900	90,900
Empty Bed Contact Time (min)	---	10	10	10	10	1.5	1.5
Perfluoroalkyl Carboxylic Acids (PFCAs)	**ng/L**	**Percent Breakthrough**					
PFBA	23-24.3	119	126	131	114	105	100
PFPeA	55.6-58.7	150	122	131	120	70	86
PFHxA	64.5-65.2	76	83	135	132	58	57
PFHpA	42.3-42.6	79	89	113	113	37	6
PFOA	23.3-23.7	90	102	105	88	15	ND
PFNA	5.21-6.52	69	80	93	104	ND	ND
PFDA	4.68-5.91	54	65	61	61	ND	ND
PFUdA	ND-0.871	ND	ND	ND	ND	ND	ND
PFDoA	ND	ND	ND	ND	ND	ND	ND
PFTrDA	ND	ND	ND	ND	ND	ND	ND
PFTeDA	ND	ND	ND	ND	ND	ND	ND
Perfluoroalkyl Sulfonates (PFSs)	**ng/L**	**Percent Breakthrough**					
PFBS	5.9-6.31	81	86	105	109	ND	ND
PFPeS	1.32-1.34	69	67	76	85	ND	ND
PFHxS	9.19-9.34	59	66	75	84	ND	ND
PFHpS	ND	ND	ND	ND	ND	ND	ND
PFOS	20.2-21.4	45	53	55	59	ND	ND
PFNS	ND	ND	ND	ND	ND	ND	ND
PFDS	ND	ND	ND	ND	ND	ND	ND
Perfluoroalkyl Sulfonamides (PFSAs)	**ng/L**	**Percent Breakthrough**					
PFOSA	ND	ND	ND	ND	ND	ND	ND

	Column Influent	GAC-1	GAC-2	GAC-3	GAC-4	IX-1	IX-2
Bed Volumes	---	17,340	17,640	18,000	18,050	90,900	90,900
Empty Bed Contact Time (min)	---	10	10	10	10	1.5	1.5
Perfluoroalkyl Ether Carboxylic Acids (PFECAs)	**ng/L**	**Percent Breakthrough**					
PFMOAA*	0.442-0.792	116	115	123	120	112	113
PFMOPrA*	ND	118	115	111	107	104	109
PFO2HxA*	23.8-88.4	108	124	127	128	155	143
PFMOBA*	1.74-2.13	ND	ND	ND	ND	ND	ND
PFO3OA*	12.1-71.7	186	217	136	145	91	175
PFPrOPrA/GenX	28.3-29	98	94	101	95	71	82
PFO4DA*	4.25-32.3	153	169	95	121	30	5
Other Per- and Polyfluorinated Compounds	**ng/L**	**Percent Breakthrough**					
N-MeFOSAA	ND	ND	ND	ND	ND	ND	ND
N-EtFOSAA	ND	ND	ND	ND	ND	ND	ND

* Measurement is considered an estimate as there is currently no known authentic standard for measurement of this compound.
ND – Not detected

3.4 IX INTERIM RESULTS TO DATE

Interim results of the ongoing pilot testing are presented in Table 3-1. Both ion exchange columns now show breakthrough of several shorter carbon chain molecules before 50,000 bed volumes. Both also appear to show chromatographic peaking for nearly all perfluoroalkyl ether carboxylic acids. Perfluoroalkyl sulfonates continue to be completely removed.

4.0 Discussion

- The bench-scale and pilot testing is ongoing and scheduled to continue through the first quarter of 2018 until testing goals are achieved.
- PFASs are being observed in the pilot GAC media effluent.
  - All columns are exhibiting effluent PFAS concentrations near or above the influent concentration for all but the longest carbon chain PFASs.
  - Only the longest chain PFAS molecules continue to be removed.
  - Adsorption curves for each PFAS compound have been characterized for each column.
  - GAC columns 1 through 4 have reached the end of their useful life for the first phase of piloting and will be discontinued.
- PFASs are being observed in the pilot IX resin effluent.
  - Both columns are exhibiting effluent PFAS concentrations near or above the influent concentration for a few of the shortest carbon chain PFASs.

  - Only PFASs with carboxylic acid functional groups have shown breakthrough.
  - Longer carbon chain PFAS molecules have yet to show any breakthrough.
  - PFAS molecules with sulfonate functional groups have yet to show any breakthrough.
- Additional pilot columns were installed for testing of other GAC and IX adsorbents.
  - Four new GAC pilot columns have been installed and will start operation mid-January. The four new pilot columns will be used to evaluate two more GAC media types and the effect of increasing the empty bed contact time on PFAS removal.
  - Three new IX pilot columns have been installed and will start operation mid-January. The three new pilot columns will be used to evaluate two more IX resins and the effect of increasing the empty bed contact time on PFAS removal.
- Testing will evolve as data is received to refine short- and long-term treatment strategies.

5.0 Conclusions/Recommendations

The following conclusions and recommendations can be developed based on the interim testing results.

- Pilot testing is ongoing and should continue in order to fully characterize the performance of GAC and IX technologies for PFAS removal.