

FINAL

## PROGRESS UPDATE NO. 4

Emerging Contaminants Treatment  
Strategy Pilot Study

B&V PROJECT NO. 196369



PREPARED FOR

Cape Fear Public Utility Authority

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## 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 Plant (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

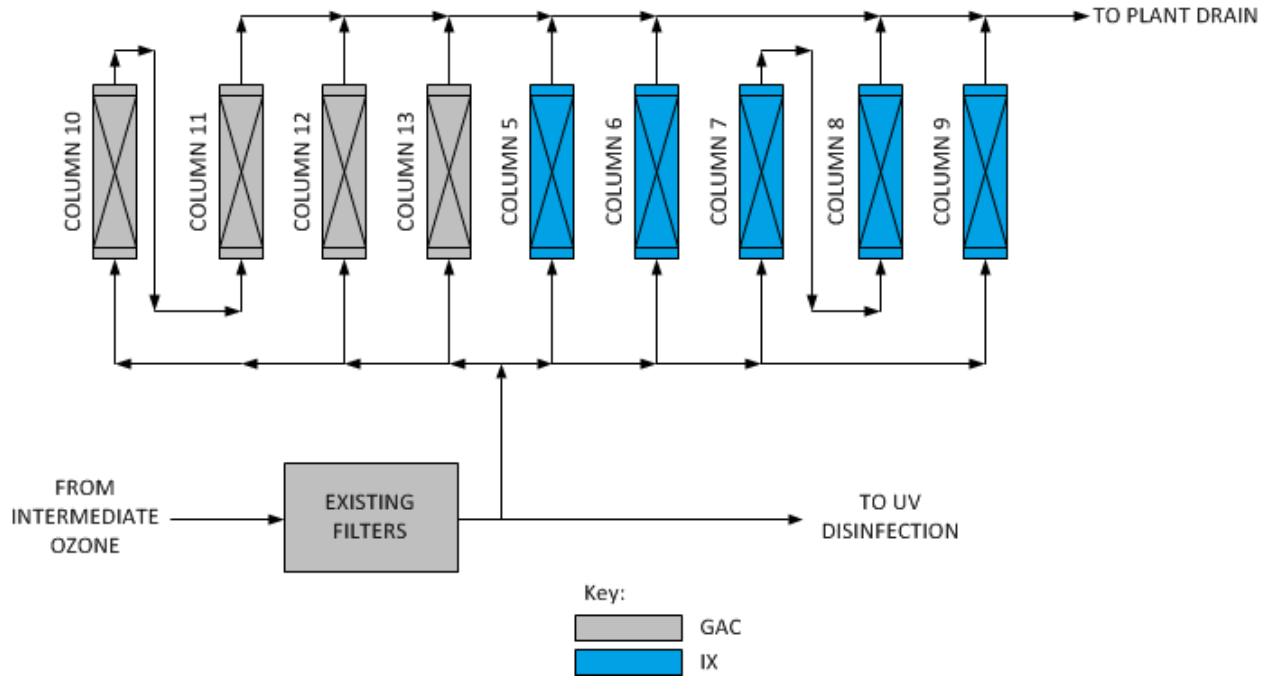
The primary goal of the testing is to establish the adsorption characteristics for PFASs and other contaminants of emerging concern (CECs) on GAC media and IX resin. These characteristics will be used to refine the previous study-related evaluations and identify the most advantageous short- and longer-term 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 PILOT MODIFICATIONS

The configuration of the pilot columns was modified for the second phase of testing in mid-January. The second phase of pilot testing is aimed at refining the basis for a full-scale design and to identify configurations with the lowest life-cycle cost. A flow diagram for the new configuration is included in Figure 3-1.



**Figure 3-1 Pilot Test Flow Diagram**

Columns 10 through 13 include new GAC media. Columns 5 and 6 are the remaining two ion exchange columns from the initial phase of piloting that are still in service. Columns 7 through 9 include new ion exchange resins. The media and resins contained in each pilot column are shown in Table 3-1 and Table 3-2.

Columns 10 and 11 are operated in series to evaluate the effects of a longer empty bed contact time (EBCT) on adsorption characteristics of GAC. Columns 7 and 8 are also operated in series in the same manner for ion exchange resins.

**Table 3-1 Pilot Modifications – GAC Media**

Column No.	10	11	12	13
EBCT, min	10	10	10	10
Supplier	Calgon	Calgon	Cabot	Cabot
Media/Resin	Filtrisorb 400	Filtrisorb 400	Hydrodarco 4000	GAC 400

**Table 3-2 Pilot Modifications – IX Resins**

Column No.	5	6	7	8	9
EBCT, min	1.5	1.5	1.5	1.5	1.5
Supplier	Evoqua	Calgon	Purolite	Purolite	Calgon
Media/Resin	DOWEX PSR-2 Plus	CalRes 2304	Purofine PFA694E	Purofine PFA694E	CalRes 2301

### 3.4 GAC INTERIM RESULTS TO DATE

The initial phase of piloting for GAC consisted of four pilot columns that all began operation on Aug. 2, 2017. Operation of those columns was terminated in December and final results were reported in Progress Update No. 3, dated Jan. 8, 2018.

The second phase of piloting for GAC consists of four new pilot columns that will test some new GAC media as well longer empty bed contact times. Operation of the second phase of piloting for GAC began on Jan. 16, 2018. Testing results for these pilot columns have not yet been received as of the date of this report.

### 3.5 IX INTERIM RESULTS TO DATE

Interim results of the ongoing pilot testing are presented in Table 3-3. Breakthrough of perfluoroalkyl carboxylic acids appears to be consistently expanding to include the longer chain molecules. Perfluoroalkyl sulfonates continue to be completely removed. The capacity of each ion exchange resin to adsorb PFPrOPrA/GenX has been exhausted. The performance of each resin for removal of other PFECAs and Nafion byproducts is unknown at this time as the estimated results for such compounds, which have no known authentic standard, are inconsistent with previous testing results.

**Table 3-3 Sampling Results as of January 16, 2017**

	<b>Column Influent</b>	<b>IX-1</b>	<b>IX-2</b>
Bed Volumes	---	133,400	133,400
Empty Bed Contact Time (min)	---	1.5	1.5
<b>Perfluoroalkyl Carboxylic Acids (PFCAs)</b>	<b>ng/L</b>	<b>Percent Breakthrough</b>	
PFBA	18	119	113
PFPeA	43	110	144
PFHxA	53	78	106
PFHpA	37	62	27
PFOA	16	53	ND
PFNA	3	ND	ND
PFDA	2.4	ND	ND
PFUdA	ND	ND	ND
PFDoA	ND	ND	ND
PFTTrDA	ND	ND	ND
PFTeDA	ND	ND	ND

	Column Influent	IX-1	IX-2
Bed Volumes	---	133,400	133,400
Empty Bed Contact Time (min)	---	1.5	1.5
<b>Perfluoroalkyl Sulfonates (PFSS)</b>	<b>ng/L</b>	<b>Percent Breakthrough</b>	
PFBS	4.9	ND	ND
PFPeS	ND	ND	ND
PFHxS	7.8	ND	ND
PFHpS	ND	ND	ND
PFOS	11	ND	ND
PFNS	ND	ND	ND
PFDS	ND	ND	ND
<b>Perfluoroalkyl Sulfonamides (PFSAs)</b>	<b>ng/L</b>	<b>Percent Breakthrough</b>	
PFOSA	ND	ND	ND
<b>Perfluoroalkyl Ether Carboxylic Acids (PFECAs)</b>	<b>ng/L</b>	<b>Percent Breakthrough</b>	
PFMOAA*	2900 (Est.)	100	100
PFMOPrA*	ND	ND	ND
PFO2HxA*	98 (Est.)	184	163
PFMOBA*	ND	ND	ND
PFO3OA*	22 (Est.)	191	500
PFPrOPrA/GenX	44	86	100
PFO4DA*	7.9 (Est.)	124	67
<b>Other Per- and Polyfluorinated Compounds</b>	<b>ng/L</b>	<b>Percent Breakthrough</b>	
ADONA	ND	ND	ND
F-53B Major	ND	ND	ND
F-53B Minor	ND	ND	ND
Nafion Byproduct 1*	ND	ND	ND
Nafion Byproduct 2*	20 (Est.)	ND	ND
N-MeFOSAA	ND	ND	ND
N-EtFOSAA	ND	ND	ND
* Measurement is considered an estimate as there is currently no known authentic standard for measurement of this compound. ND - Not detected Est. - Estimated			

## 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.

- The first phase of piloting of GAC media (columns 1 through 4) has been completed.
- PFASs are being observed in the pilot IX resin effluent.
  - Both columns are exhibiting effluent PFAS concentrations near or above the influent concentration for 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.
  - The capacity of both ion exchange resins for adsorption of GenX has now been exhausted.
- Additional pilot columns were installed for testing of other GAC and IX adsorbents.
  - Four new GAC pilot columns have been installed and started operation on Jan. 16, 2018. 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. Results from these new columns have not yet been received.
  - Three new IX pilot columns have been installed. Column 9 was started on Jan. 16, 2018. Columns 7 and 8 were started on Jan. 17, 2018. 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. Results from these new columns have not yet been received.
- The most recent testing results for compounds which have no currently known authentic standard are inconsistent with past results. This includes the testing results for most of the listed PFECAs and both Nafion byproducts. The project changed analytical labs prior to the most recent testing, which is likely a contributing factor to the observed differences. Test methods will be reviewed to clarify observed differences.
- 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.