ALTERNATIVES EVALUATION REPORT

Emerging Contaminants Treatment Strategies Study

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Executive Summary

In response to the detection of per- and polyfluorinated compounds (PFCs) in the Cape Fear River, studies were performed to determine the most effective water treatment technology at removing PFCs for implementation at the Sweeney Water Treatment Plant (WTP).

The Sweeney Plant contains several advanced water treatment processes to reduce concentrations of organics and for removal of many emerging contaminants, including 1,4-dioxane. PFCs, however, are composed of multiple, stable carbon-fluoride bonds that are resistant to oxidative processes, such as ozonation. Additionally, biologically active filters are primarily used for particulate filtration and removal of biodegradable organics and have limited adsorption capacity for PFCs. Thus, other technologies that would offer more effective PFC removal are the focus of this study.

Initial evaluations narrowed the list of alternatives to three technologies for removal of PFCs: adsorption by granular activated carbon (GAC), adsorption by ion exchange (IX) resins, and membrane separation through reverse osmosis. Each technology was evaluated based on ability to meet treatment goals and cost. Performance evaluations for the two adsorption technologies were made through pilot testing. The evaluation relied on established research for performance projections of reverse osmosis. The comparison of the advantages is summarized in Table EX-1. Cost information for each option is presented in Table EX-2.

Table EX-1 Summary Comparison of Options

POST-FILTER GAC CONTACTORS	POST-FILTER IX VESSELS	POST-FILTER REVERSE OSMOSIS
• Effective towards PFC reduction, particularly the longer chain varieties • Removes endocrine disrupting compounds (EDCs) and pharmaceutical and personal care products(PPCPs) • Reduces disinfection byproduct (DBP) formation potential • Lowers water loss due to distribution system flushing • Capable of removing multiple contaminant categories • GAC contactors can be modified to utilize IX resins to meet more stringent limits • Compliments the existing process for removal of 1,4-dioxane • Familiar technology – less impact to operations • Similar costs to IX Vessels	• Effective at PFC reduction • Not effective at removing EDCs, PPCPs, or other contaminants • Reduces disinfection byproduct (DBP) formation potential • Lowers water loss due to distribution system flushing • Less frequent and less intensive replacement of adsorbent • Similar costs to GAC contracts	• Provides broad removal of organic and inorganic compounds, including all varieties of PFCs • Presents challenge of disposing concentrated waste stream • Requires approximately 15-20% more raw water than produced drinking water which exceeds CFPUA's current raw water allocation • Requires additional stabilization processes downstream to prevent lead and copper corrosion • Highest capital and highest operating costs

Table EX-2 Cost Summary for 44 MGD Treatment Plant

	POST-FILTER GAC CONTACTORS	POST-FILTER IX VESSELS	POST-FILTER REVERSE OSMOSIS
Capital Cost (+50%/-30%)	$46M	$46M	$150M
Annual O&M Cost	$2.7M	$2.1M	$4.7M
34 Year Net Present Value	$196M	$176M	$504M

Notes:
RO costs do not include NPDES discharge or additional raw water supply costs
Additional Staff = 2 x $70,000/yr (RO option only)
Based on current PFC concentrations in river
Contingency = 30%

Post-filter deep bed GAC contractors are the best overall treatment alternative for the Sweeney Plant for the removal of manufactured chemicals discharged upstream of the plant. GAC offers highly effective PFC removal, promotes flexibility, complements other treatment processes and offers secondary benefits for removal of other emergency contaminants.

The contactors will be located downstream of the existing biologically active filters and will be dedicated to removal by adsorption of PFCs and other emerging contaminants.

1.0 Introduction

Per- and polyfluorinated compounds (PFCs)[1], including perfluoro-2-propoxypropanoic acid (commonly known as GenX or PFPrOPrA), 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 PFCs in the Cape Fear River and because of concern over potential health effects, CFPUA is proactively investigating the feasibility and effectiveness of various PFC removal technologies. CFPUA is one of the first utilities in the United States to pursue treatment to target removal of these compounds, many of which lack regulatory limits or guidance.

Initial evaluations were performed by Black & Veatch for screening of appropriate treatment technologies. As a result of those evaluations, pilot-scale testing of granular activated carbon (GAC) media and ion exchange (IX) resins was performed to establish the adsorption characteristics for PFCs and other contaminants of emerging concern (CECs) on GAC media and IX resins.

Data obtained from the pilot testing has been used to refine earlier evaluations and cost opinions for each option. This report presents the findings of the study and provides recommendations for enhancing the existing treatment process to provide removal of PFCs and other emerging contaminants.

2.0 Background

2.1 SWEENEY WATER TREATMENT PLANT

The Sweeney WTP is located in Wilmington, NC. The plant provides state of the art treatment of surface water and consists of the following water treatment processes: pre-ozonation; coagulation, flocculation, and clarification; intermediate ozonation; biologically active filtration; ultraviolet (UV) disinfection; and stabilization and chlorination. A simplified process flow diagram is presented in Figure 2-1.

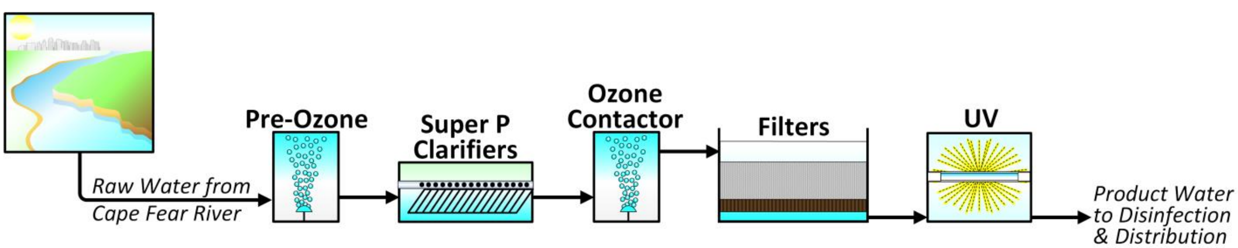

Figure 2-1 Simplified Process Flow Diagram for Sweeney WTP

The plant is currently rated for 35 million gallons per day (mgd), but can be rerated to 44 mgd without significant capital investments. Projected future flows are presented in Table 2-1.

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[1] Also known as perfluoroalkyl substances (PFASs)

Table 2-1 Projected Flows at Sweeney WTP

YEAR	AVG. DAY FLOW (MGD)	MAX. DAY FLOW (MGD)
2021	14.6	21.9
2025	15.4	23.1
2035	20.1	30.1
2041	23.3	35.0
2045	25.5	38.2
2055	29.3	43.9

The Sweeney WTP contains several advanced water treatment processes that reduce concentrations of organics and other contaminants. Total organics in surface water typically consist mostly of naturally occurring organic matter (NOM). Other organics and contaminants that may be present include synthetic compounds, such as PFCs, endocrine disrupting compounds (EDCs), and pharmaceutical and personal care products (PPCPs). Many of these compounds are considered emerging contaminants with limited research on their treatability.

Ozonation is an oxidation process used at the Sweeney WTP that applies ozone to convert many of these organic contaminants and microorganisms into degradable forms that are removed in downstream processes, such as sedimentation and biologically active filtration. Ozone is applied in two steps at the Sweeney WTP for enhanced settling, and to minimize chlorine disinfection byproducts. Ozone is effective at oxidizing many emerging contaminants, including some EDCs and PPCPs, as well as 1,4-dioxane. Ozone is not effective at oxidizing PFCs.

Biologically active filtration is another treatment process located downstream of ozonation that is capable of removing a multitude of organics and emerging contaminants. Bio-filters contain media that include an integral biofilm. One layer of media in the Sweeney WTP is granular activated carbon (GAC) – a porous adsorbent proven for removal of many organics and other contaminants. This arrangement enables three mechanisms of treatment: physical removal of particulate solids, reduction of nutrients and biodegradable organics by the biofilm, and removal of contaminants by adsorption onto the GAC media. The adsorptive capacity of the GAC is limited, however, and requires periodic media replacement (or reactivation) when exhausted. The frequency of reactivation is determined by the specific target contaminant and effluent concentration level.

The combined use of ozone and biologically active filtration at the plant makes it well suited for removal of many emerging contaminants. PFCs, however, are composed of multiple, stable carbon-fluoride bonds that are resistant to oxidative processes, such as ozonation. Additionally, biologically active filters are primarily used for particulate filtration and removal of biodegradable organics and have limited adsorption capacity for PFCs. Thus, other technologies that would offer more effective PFC removal are the focus of this study. These include adsorption technologies such as deep-bed GAC contactors and ion exchange vessels, and membrane separation processes such as low-pressure reverse osmosis.

2.2 TREATMENT GOALS

The primary goal of this study is to evaluate the feasibility of several water treatment technologies for removal of GenX and other PFCs. There are currently no federally mandated limits on the levels of PFCs in drinking water in the U.S. The USEPA has established a health advisory for two PFCs: perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS). The USEPA health advisory for PFOA and PFOS is 70 ng/L, measured individually or in combination. In the absence of USEPA direction, various states have promulgated their own limits and guidelines on PFCs. North Carolina is the first state to issue guidance on GenX, establishing a treatment goal of 140 ng/L. North Carolina has not provided any guidance on other PFCs. Table 2-2 provides an abridged survey of PFC guidance and regulations in the U.S. and internationally.

In the absence of limits on PFCs in drinking water, each treatment technology is evaluated in terms of its flexibility to comply with future regulations, in which there is uncertainty concerning target constituents and maximum contaminant levels. Secondary goals that also contribute to the evaluation of technologies include:

- Flexibility for combined or alternative future uses
  - Removal of EDCs, PPCPs, and other contaminants of emerging concern
- Impacts to distribution system, potential for corrosion
- Reduction in potential to form disinfection byproducts (DBPs)
- Impacts to operations
  - Replacement frequency of consumables (i.e. media, resins, etc.)
  - Flushing of distribution system
  - Familiarity with technology
- Environmental impact – disposal

Table 2-2 Existing Limits and Guidance on PFCs

	State/ Agency	Agency/ Dept.	Year	Standard / Guidance	Type	Promulgated Rule	Notes	PFOA	PFOS	PFNA	PFBA	PFBS	PFHxS	PFHxA	PFPeA	PFHpA	PFOSA	PFDA	6:2 FTS	GenX
								PFAS Analyte Concentration (ng/L)												
UNITED STATES	USEPA	Office of Water	2016	HA	DW	No	a	70	70											
UNITED STATES	CT	DPH	2016	AL	GW	No	b	70	70	70				70		70				
UNITED STATES	CO	DPHE	2017	HA	DW	No		70	70							70				
UNITED STATES	MI	DEQ	2015	HNV	SW	Yes		420	11											
UNITED STATES		DEQ	2018	GCC	GW	Yes	a	70	70											
UNITED STATES	MN	MDH	2017	Short-term HBV	GW	No	c	35	27		7,000									
UNITED STATES			2017	Subchronic HBV	GW	No	c	35	27		7,000	9,000								
UNITED STATES			2017	Chronic HBV	GW	No	c	35	27		7,000	7,000								
UNITED STATES	NJ	DEP	2015	ISGWQC	GW	Yes				10										
UNITED STATES		DEP	2017	GWQS	GW	Pending				10										
UNITED STATES		DWQI	2017	MCL	DW	Pending				13										
UNITED STATES		DWQI	2017	MCL	DW	Yes		14												
UNITED STATES	NC	DENR	2006	IMAC	GW	Yes		2,000												
UNITED STATES		NCDHHS	2017	Health goal	DW	No														140
UNITED STATES	VT	DEC/DOH	2016	PGWES	GW/DW	Yes	a	20	20											
INTERNATIONAL	Denmark	EPA	2015	Health-based	DW/GW		d	100	100	100	100	100	100	100	100	100	100	100	100	
INTERNATIONAL	Netherlands	RIWT	2011	Health-based	DW				530											
INTERNATIONAL			2011	Administrative	DW				5.3											
INTERNATIONAL	Sweden	NFA	2014	Health-based	DW				90											
INTERNATIONAL			2014	Administrative	DW		e	90	90	90	90	90	90	90	90	90		90	90	

Abbreviations:

DW = Drinking Water
GW = Groundwater
SW = Surface Water
AL = Private Well Action Level
GCC = Generic Cleanup Criteria
HA = Lifetime Health Advisory
HBV = Health-Based Value
ISGWQC = Interim Specific Groundwater Quality Criterion
GWQS = Groundwater Quality Standard
MCL = Maximum Contaminant Level
IMAC = Interim Maximum Allowable Standard
PGWES = Primary Groundwater Enforcement Standard
HNV = Human Noncancer Value for Surface Drinking Water

Notes:

a. Applies to the individual results for PFOA and PFOS, as well as the sum of PFOA + PFOS.
b. Applies to the individual results for PFOA, PFOS, PFHpA, PFNA, and PFHxS as well as the sum of concentrations of these 5 PFAS.
c. HBVs just published May 2017 and full promulgation of HRLS anticipated in 2018.
d. Applies to the individual results for PFOA, PFOS, PFNA, PFBA, PFBS, PFHxS, PFHxA, PFPeA, PFHpA, PFOSA, PFDA, AND 6:2 FTS as well as the sum of concentrations of these 12 PFAS.
e. Administrative value is for the sum of eleven PFAS found in drinking water: PFBS, PFHxS, PFOS, 6:2 FTS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, and PFDA. PFOS is considered to be the most toxic. Water can still be used at up to 0.09 µg/L.

3.0 Pilot Testing Summary

Initial studies identified three water treatment technologies appropriate for PFC removal that deserved further consideration: GAC adsorption, IX adsorption, and reverse osmosis membrane separation. Based on high level cost evaluations, GAC adsorption and IX adsorption were selected for pilot-scale testing. Reverse osmosis was considered a higher cost option, so pilot testing of reverse osmosis was reserved in the event that GAC and IX adsorption proved ineffective or cost prohibitive.

Specific types of granular activated carbon filter media and ion exchange resins were selected for pilot testing. The primary goal of the testing was to establish the adsorption characteristics for PFCs and other contaminants of emerging concern. Media and resins for testing were selected based on experience and suitability for PFC removal. Adsorbents that were piloted are presented in Table 3-1.

Table 3-1 Selected Adsorbents

Adsorbent Type	Supplier	Product
GAC	Calgon Carbon	FILTRASORB® 300
		FILTRASORB® 400
	Evoqua	AquaCarb® 1230 CX
IX	Calgon Carbon	CALRES® 2301
		CALRES® 2304
	Evoqua	DOWEX™ PSR-2 Plus
	Purolite	Purofine® PFA694E

The testing showed similar performance within each set of GAC and IX products. GAC products have shown effective removal of PFCs and other emerging contaminants at an empty bed contact time (EBCT) of 10 min. IX products have also shown effective removal of PFCs at an EBCT of 1.5 minutes, but have not been effective at removing other emerging contaminants. Pilot testing is ongoing and has been expanded to evaluate the effects of longer EBCTs. GAC is now being piloted at an EBCT of 20 min and IX is now being piloted at an EBCT of 3 min. Early results from the piloting of the longer EBCTs are so far showing extended throughput values for GAC. Not enough data is yet available on the piloting of longer EBCTs for IX to draw any conclusions. Piloting is expected to continue into the third quarter of 2018.

4.0 Process Technology Evaluations

4.1 GRANULAR ACTIVATED CARBON

Granular activated carbon (GAC) is a well-known adsorbent for organics and has been widely applied in water treatment. GAC is produced from carbon-based materials such as coal, coconut shells, peat, or wood that has been "activated" to yield adsorptive properties. Treatment applications include removal of organics, such as color, disinfection byproduct (DBP) precursors, taste and odor (T&O) causing compounds, and industrial chemicals, as well as emerging contaminants such as EDCs, PPCPs, and PFCs.

GAC has a finite capacity for adsorbing compounds. When the adsorptive capacity has been exhausted, the media must be replaced or reactivated. As a result, the concentration of contaminants in the raw water and the volume of water treated will both affect how quickly the media is exhausted. High concentrations of contaminants or increasing flow rates will lead to more frequent media replacement and higher operating costs.

Replacement with reactivated media in lieu of new GAC reduces operating costs and is more environmentally friendly. For reactivation, spent GAC is removed from the vessel or basin and shipped to a GAC supplier's reactivation facility where it is thermally processed to drive off adsorbates and restore its adsorptive properties. On-site reactivation is only economically feasible for the largest of media users, thus off-site reactivation is considered. Transport and reactivation of the media takes 30 to 45 days, so one or more spare charges (or swing loads) of GAC media are typically purchased to have on-hand to reduce the time of a media change-out. Swing loads are normally stored at the GAC supplier's facility, but are wholly owned by the utility and only used at the utility's facility.

GAC is typically applied as an adsorbent media in a basin or pressure vessel. At the Sweeney WTP, GAC would be contained in deep-bed contactor basins located downstream of the existing biologically active filters. The post-filter deep-bed GAC contactors would be dedicated to adsorbing PFCs and other emerging contaminants. A dedicated GAC contactor is utilized rather than replacing media in the existing filters because the existing filters have relatively shallow bed depths. Media replacement frequencies would be excessive resulting in an undesirable operationally condition.

Pilot testing demonstrated that GAC can effectively remove GenX and other PFCs to concentrations below regulatory health advisory levels set throughout the nation and internationally. Secondary advantages for post-filter GAC contactors include:

- Removal of EDCs and PPCPs – GAC provides near complete removal of compounds that remain following biological filtration. IX is less effective in removing such compounds.
- Reduced potential for chlorination DBP formation – GAC provides a greater removal of TOC than IX, which results in a net reduction in DBPs in the distribution system.
- Lower volumes of flushing water – Reductions in TOC will improve chlorine residual stability in distribution system, resulting in reduced need for flushing.
- GAC does not present any negative corrosion effects in the existing distribution system.
- GAC contactors provide for increased flexibility for future regulatory changes.
- GAC is less selective than IX and can adsorb a broad spectrum of contaminants beyond PFCs.

4.2 ION EXCHANGE

Ion exchange (IX) is a water treatment process that involves the selective exchange of charged ions in solution with ions bound to a resin matrix. IX has a long history in water treatment and resins are manufactured for a variety of water treatment applications, including PFC removal.

Ion exchange resins, like GAC, have a limited capacity for adsorption. When the adsorptive capacity has been exhausted, the resins require replacement or regeneration. Regeneration of resins used for PFC removal is chemically and thermally intensive and is not considered feasible for use at the Sweeney WTP. Thus, exhausted resins would require disposal through incineration. The adsorptive capacity of ion exchange resins is affected by contaminant concentrations and flow rates in the same manner as GAC. However, the ion exchange resins surveyed have proved to be highly selective toward PFC removal, exhibiting minimal removal of other contaminants, resulting in a greater adsorptive capacity for PFCs.

Ion exchange would be applied downstream of the existing biologically active filters at the Sweeney WTP and would consist of multiple pressure vessels in parallel.

Pilot testing proved the effectiveness of IX applied to PFC removal at the Sweeney WTP. Advantages of post-filter ion exchange vessels include:

- IX resins have a high selectivity toward removal of PFCs. As a result, IX resins exhibit greater throughput and lower replacement frequencies.
- Resin replacement activities are less intensive than GAC.

4.3 REVERSE OSMOSIS

Reverse osmosis (RO) and nanofiltration (NF) are membrane-based water treatment processes in which a semi-permeable barrier removes dissolved contaminants from water. RO/NF processes are commonly applied in WTPs with applications ranging from desalination; removal of total dissolved solids (TDS), sodium, chloride, etc.; softening; color removal; organics removal; and specialized applications such as removing nitrate or arsenic. For instance, CFPUA's Richardson Plant applies NF to treat groundwater to remove organic materials that form DBPs when the water is chlorinated as well as softening the water at the same time.

RO/NF membrane processes achieve very high removal of a broad spectrum of contaminants, and produce very high quality water that is low in dissolved contaminants. However, RO/NF leaves the water void of stabilizing substances, such as hardness and alkalinity. Post-treatment is required to prevent corrosion in the distribution system. Contaminants are rejected into a waste brine stream that is eight to ten times more concentrated than the raw water fed to the membranes. This waste stream requires disposal, such as by discharge to the Northeast Cape Fear River which would require an NPDES permit.

The brine waste stream is typically around 15 percent by volume of the water produced by the RO/NF membrane process. As a result, an RO/NF membrane process designed to produce 44 mgd of drinking water will require approximately 51 mgd of pre-treated water and 54 mgd of raw water, requiring an expansion of the existing treatment facilities ahead of the RO/NF membrane process and a significant increase in raw water withdrawal from the Cape Fear River – a limited resource with a capacity need in excess of CFPUA's current allocation. Other considerations include the need for additional land, operator training, and/or additional staff.

5.0 Cost Evaluation

Planning-level capital, operations and maintenance (O&M), and life-cycle cost opinions were developed for each of the three proposed treatment alternatives. The cost summary is presented in Table 5-1. Capital costs for each of the 44 mgd facilities were based on Black & Veatch experience on past projects and include procurement and installation of the process, mechanical, electrical, instrumentation, and controls for a complete and operational system. Site work, engineering, and administration costs that would be anticipated for the design and construction of the improvements are also included in the development of the capital cost opinion.

Table 5-1 Cost Summary for 44 MGD Treatment Plant

	POST-FILTER GAC CONTACTORS	POST-FILTER IX VESSELS	POST-FILTER REVERSE OSMOSIS
Capital Cost (+50%/-30%)	$46M	$46M	$150M
Annual O&M Cost	$2.7M	$2.1M	$4.7M
34 Year Present Value	$196M	$176M	$504M
Notes: RO costs do not include NPDES discharge or additional raw water supply costs Additional Staff = 2 x $70,000/yr (RO option only) Based on current PFC concentrations in river Contingency = 30%			

No land acquisition has been included for either post-filter GAC or ion exchange options as they are anticipated to fit within the current site. Costs for stormwater management have been included to mitigate losses of pervious area due to both options. The current plant site lacks sufficient space for the RO option and costs have been included for siting the facilities on land adjacent to the existing Sweeney WTP. The costs for the expansion of the pre-treatment facilities for RO are included in the capital costs. The cost of the NPDES concentrate discharge and the cost for additional raw water supply for the RO process have not been included. Present values are based on 20 year loans for capital costs and 4 percent interest.

As an alternative to 44 mgd post-filter GAC contactors, 35 mgd contactors could be implemented at this time. This option would involve the construction of a fewer number of contactors, but could be easily expandable in the future to the full build-out capability of 44 mgd. The capital cost opinion for this 35 mgd option is $38.2M.

Operating and maintenance cost opinions for each option include annual costs for consumables (including resins, media, filter elements, or membranes), equipment maintenance, chemical consumption, waste disposal (except for RO), and energy use at the annual average daily flow rate. O&M costs are also inclusive of the following:

- Loading, unloading, transportation, and reactivation of spent GAC media, including two swing loads.
- Loading, unloading, transportation, and disposal through incineration of exhausted IX resins.

A life-cycle cost analysis was completed that covers operation from year 2021 – the anticipated project completion date – through year 2055, at which time the projected maximum daily flow will exceed the hydraulic capacity of the Sweeney WTP. The analysis included escalation of annual O&M costs due to projected increase in flow rates provided by CFPUA and inflation.

6.0 Conclusions & Recommendations

The post-filter deep bed GAC option is the best overall treatment alternative for the Sweeney Plant for the removal of manufactured chemicals discharged in the river upstream of the plant. GAC offers highly effective PFC removal, promotes flexibility, complements the other treatment processes, and offers secondary benefits for removal of other emerging contaminants. In contrast, the ion exchange option is only effective at removing PFCs. GAC and IX options greatly prevail over reverse osmosis in terms of cost. A summary comparison of each option is included in Table 6-1.

Table 6-1 Summary Comparison of Options

POST-FILTER GAC CONTACTORS	POST-FILTER IX VESSELS	POST-FILTER REVERSE OSMOSIS
• Effective towards PFC reduction, particularly the longer chain varieties • Removes endocrine disrupting compounds (EDCs) and pharmaceutical and personal care products(PPCPs) • Reduces disinfection byproduct (DBP) formation potential • Lowers water loss due to distribution system flushing • Capable of removing multiple contaminant categories • GAC contactors can be modified to utilize IX resins to meet more stringent limits • Compliments the existing process for removal of 1,4-dioxane • Familiar technology – less impact to operations • Similar cost to IX Vessels	• Effective at PFC reduction • Not effective at removing EDCs, PPCPs, or other contaminants • Reduces disinfection byproduct (DBP) formation potential • Lowers water loss due to distribution system flushing • Less frequent and less intensive replacement of adsorbent • Similar cost to GAC contractors	• Provides broad removal of organic and inorganic compounds, including all varieties of PFCs • Presents challenge of disposing concentrated waste stream • Requires approximately 15-20% more raw water than produced drinking water which exceeds CPPUA's current raw water allocation • Requires additional stabilization processes downstream to prevent lead and copper corrosion • Highest capital and highest operating cost

As a result, the recommended alternative is post-filter deep bed GAC contactors at the Sweeney WTP. The GAC option is able to satisfy all primary and secondary treatment goals, promotes operational flexibility in light of uncertainty regarding future regulations, and is one of the lower cost options.

7.0 Basis of Design

Basic design criteria for implementation of the deep bed GAC filters at the Sweeney WTP are included in Table 7-1.

Table 7-1 Design Criteria for Post-Filter Deep Bed GAC Contactors

PARAMETER	UNITS	VALUE
Design Flow Rate (Total)	mgd	44
No. of Contactors		10
Type		Concrete Basin
Contactor Length	ft	22
Contactor Width	ft	38
Bed Area	ft	836
Bed Depth	ft	10
Maximum Loading Rate	gal/min/s.f.	4
EBCT	min	20
Bed Volume (Each Contactor)	c.f.	8,360