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CORRECTIVE ACTION PLAN

Chemours Fayetteville Works

Prepared for

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LIST OF ABBREVIATIONS

%	percent
3D	three-dimensional
µg/s	micrograms per second
CAP	Corrective Action Plan
CO	Consent Order
CFPUA	Cape Fear Public Utility Authority
CFRW	Cape Fear River Watch
CSM	Conceptual Site Model
DFSA	Difluoro-sulfo-acetic acid
DWR	Division of Water Resources
E&SC	Erosion and Sediment Control
EAA	Engineering Alternatives Analysis
Ecological SLEA	Ecological Screening Level Exposure Assessment
EU	exposure unit
EVE-acid	perfluoroethoxypropionic acid
EVS	Earth Volumetric Studio
FEFLOW	Finite Element subsurface FLOW system
ft	feet
ft bgs	feet below ground surface
f_{oc}	fraction organic carbon
GAC	granular activated carbon
gabions	large wire basket like devices to hold media
gpm	gallons per minute
HDPE	high-density polyethylene
HFPO-DA	hexafluoropropylene oxide dimer acid
HH-SLEA	Human Health Screening Level Exposure Assessment
HQ	hazard quotient
Hydro-EVE acid	perfluoroethoxsypropanoic acid
K_d	soil-water partition coefficient
K_{OC}	organic carbon-water partition coefficient
K_{OW}	octanol-water partition coefficient
L/Kg	liter per kilogram
lbs/yr	pounds per year
MGD	millions of gallons per day
mg/kg-day	milligram per kilogram per day
MMF	Difluoromalonic acid
MTP	Perfluoro-2-methoxypropanoic acid
NCCW	non-contact cooling water
NCDEQ	North Carolina Department of Environmental Quality
NCDHHS	North Carolina Department of Health and Human Services
NC DWR	North Carolina Division of Water Resources
NPDES	National Pollutant Discharge Elimination System

LIST OF ABBREVIATIONS (CONTINUED)

NPV	net present value
NRMS	Normalized Root Mean Square
ng/L	nanogram per liter
NVHOS	perfluoroethoxysulfonic acid
NWP	Nationwide Permit
OOF2	Old Outfall 002
PEPA	perfluoroethoxypropyl carboxylic acid
PES	perfluoroethoxyethanesulfonic acid
PFAS	per- and polyfluoroalkyl substances
PFBS	Potassium perfluoro-1-butanesulfonate
PFECA B	perfluoro-3,6-dioxaheptanoic acid
PFECA-G	perfluoro-4-isopropoxybutanoic acid
PFESA-BP1	Byproduct 1
PFESA-BP2	Byproduct 2
PFMOAA	perfluoro-1-methoxyacetic acid
PFOA	Perfluoro-n-octanoic acid
PFOS	Sodium perfluoro-1-octanesulfonate
PFO2HxA	perfluoro(3,5-dioxahexanoic) acid
PFO3OA	perfluoro(3,5,7-trioxaoctanoic) acid
PFO4DA	perfluoro(3,5,7,9-tetraoxadecanoic) acid
PFO5DA	perfluoro-3,5,7,9,11-pentaoxadodecanoic acid
PMPA	perfluoromethoxypropyl carboxylic acid
PPA	polymer processing acid
PQL	practical quantitation limit
PVF	polyvinyl fluoride
RCRA	Resource Conservation and Recovery Act
RfDo	reference dose
RFI	RCRA Facility Investigation
RL	reporting limit
SLEA	Screening Level Exposure Assessment
SWPPP	Stormwater Pollution Prevention Plan
TDI	total daily intake
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWTP	wastewater treatment plant

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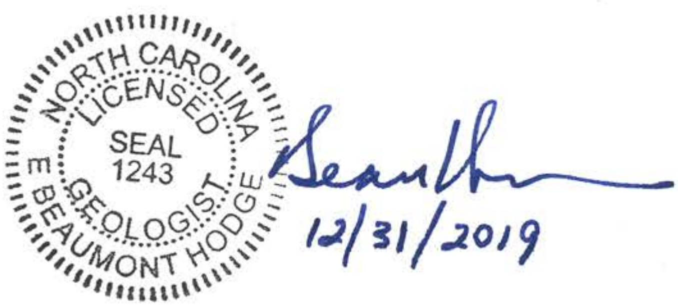
DOCUMENT: **CORRECTIVE ACTION PLAN**
CHEMOURS FAYETTEVILLE WORKS

Seals, as applicable:



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CORRECTIVE ACTION PLAN
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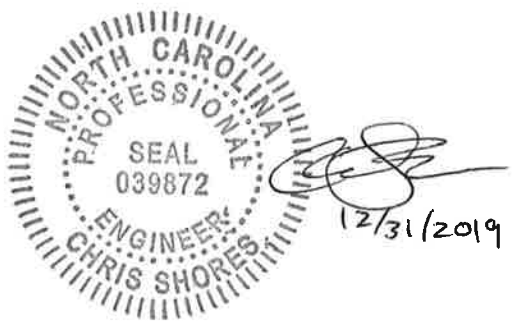

EXECUTIVE SUMMARY

This Corrective Action Plan (CAP), prepared by Geosyntec Consultants of NC, P.C. (Geosyntec) for The Chemours Company FC, LLC (Chemours), describes proposed remediation activities to address per- and polyfluoroalkyl substances (PFAS) in groundwater and surface waters at the Chemours Fayetteville Works Site (the Site). This CAP was prepared following North Carolina 2L Rules and Paragraph 16 of the executed Consent Order (CO) among Chemours, the North Carolina Department of Environmental Quality (NCDEQ), and Cape Fear River Watch (CFRW). The corrective actions proposed in this CAP were developed to comply with CO requirements and North Carolina 2L rules and to be protective of human health and the environment.

As summarized below and detailed in the body of the CAP, measures already taken by Chemours have addressed and abated almost entirely discharges of PFAS from Chemours's continuing operations at the Site. The remaining areas of PFAS contamination at the Site and associated discharges are almost entirely the legacy of pre-Chemours operations.

PFAS are an emerging class of contaminants; therefore, the understanding of fate and transport of this contaminant class as well as remedial technologies continue to advance and evolve. As such, remedial processes presented herein are intended to be flexible and adaptive so that new understandings, discoveries and technologies can be incorporated in the future. Further, promulgated toxicity criteria for PFAS are limited. However, based on a provisional hazard characterization predicated on exposure to hexafluoropropylene dimer acid (HFPO-DA), no significant human health hazards or negative impacts to ecological receptors were identified based on the projected concentrations to which relevant receptor populations are assumed to be exposed. Nonetheless, the CAP proposes a robust set of remedial actions that will further reduce offsite PFAS loadings, and thus potential exposure, from the Site.

Since 2017, numerous investigations and assessments focused on PFAS have been completed and reported on. These assessments have characterized the facility, surrounding topography, geology and surface water. These assessments served to identify target media for remediation to address CO requirements.

The Site is an active manufacturing facility and is located approximately 20 miles southeast of the city of Fayetteville along the Bladen-Cumberland county line in North Carolina. The Site is bounded by NC Highway 87 to the west, the Cape Fear River to the east, and on the north and south by forested areas, farmland and private residences. The Site has been active since the 1970s. The manufacturing facilities at the Site sit atop a plateau which leads to a bluff with a 100-foot elevation change to a floodplain area and the Cape Fear River. The Cape Fear River is a water source for a number of communities downstream of the Site. Raw water intakes are located at Bladen Bluffs and Kings Bluff Intake Canals, located approximately 5 miles and 55 miles downstream from the Site, respectively.

Historically there have been three release routes of PFAS from the Site to the environment:

1) emissions to air
2) releases of process water to subsurface soil and groundwater; and
3) releases of process wastewater to surface water (Cape Fear River) via the onsite Wastewater Treatment Plant (WWTP).

These release pathways are now being controlled by Chemours for its operations at the Site, but the releases have resulted in secondary sources of PFAS in the environment to groundwater and surface water receptors. This CAP describes actions to address these secondary, and primarily legacy, sources.

The PFAS that originate from the Site are referred to as Table 3+ PFAS. The Table 3+ analytical method was developed to analyze PFAS specific to the Site that were identified through non-targeted chemical analyses. Currently the Table 3+ method can quantitate for 20 PFAS compounds including HFPO-DA, i.e. "GenX". When examining PFAS at the Site, the sum of these compounds, i.e. total Table 3+ PFAS compounds, is often used to evaluate concentration trends and distributions.

The Table 3+ PFAS compounds are found onsite and offsite. The highest Table 3+ PFAS concentrations (by two to three orders of magnitude - i.e. 100 to 1000 times higher) are found onsite. Onsite the PFAS in many of the wells and surface water drainage features have a PFAS signature indicating the PFAS in these wells or surface water features originated from historical direct releases of process water. Onsite the process water signature is found over an area of approximately one square mile. Offsite Table 3+ PFAS in groundwater have an aerial deposition signature and a much lower and diffuse concentration of PFAS over a much larger area (70+ square miles) than the onsite process water signature. The Cape Fear River as it flows past the Site gains a process water PFAS signature indicating that transport pathways comprised of process water signature PFAS loading dominate the mass loading in the Cape Fear River.

Table 3+ PFAS mass loading to the Cape Fear River has been evaluated by measuring flow and Table 3+ PFAS concentrations in the Cape Fear River and the nine transport pathways that contribute Table 3+ PFAS mass loading to the Cape Fear River. The loading per pathway has been estimated using a Mass Loading Model which has been calibrated and evaluated against observed downstream river PFAS concentrations. Based on mass loading model results, the three pathways presently contributing the most Table

3+ PFAS mass to the Cape Fear River are the onsite groundwater seeps, the Old Outfall 002 and onsite groundwater.

Mass Loading Model Total Table 3+ PFAS including HFPO-DA Contributions per Pathway

Transport Pathway	**Total Table 3+ Estimated Loading Percentage per Pathway per Event**		
	May 2019 Event	**June 2019 Event**	**Sept. 2019 Event**
[1] Upstream River Water and Groundwater	4%	15%	8%
[2] Willis Creek	10%	4%	3%
[3] Aerial Deposition on the River	< 2%	< 2%	< 2%
[4] Outfall 002	4%	7%	4%
[5] Onsite Groundwater	22%	17%	14%
[6] Onsite Groundwater Seeps (Seeps A, B, C, D)	32%	24%	42%
[7] Old Outfall 002	23%	29%	27%
[8] Offsite Adjacent and Downstream Groundwater	< 2%	< 2%	< 2%
[9] Georgia Branch Creek	4%	3%	2%

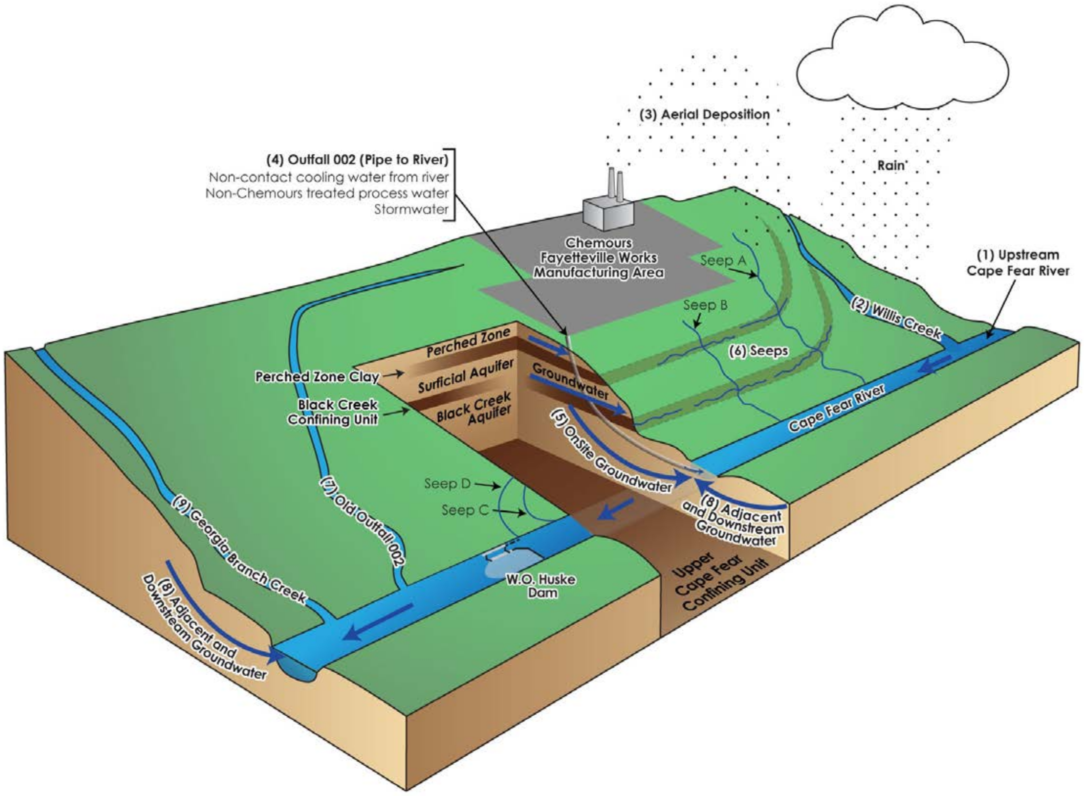

Figure ES1 – Schematic Conceptual Site Model of the Site including geological layers, and PFAS transport pathways

To address PFAS in the environment from past (i.e., legacy) releases, this CAP developed objectives and cleanup goals to guide the evaluation and selection of corrective actions. The CO's remedial and management goals for the Site are:

- Reduce the total loading of PFAS originating from the Site to the Cape Fear River by at least 75 percent (%) from baseline (CO paragraph 16);
- Provide whole building filtration units and reverse osmosis units to qualifying surrounding residents (CO paragraphs 19 and 20);
- Comply with 2L Rules (CO paragraph 16), including following the policy for the intention of the 2L Rules "to maintain and preserve the quality of the groundwaters, prevent and abate pollution and contamination of the water of the

state, protect public health, and permit management of the groundwaters for their best usage by the citizens of North Carolina" (15A NCAC 02L .0103)[1]; and

- Comply with other requirements of the CO.

To support evaluating the need for actions to protect public health and for the actions to reduce exposures, preliminary human health and ecological screening level exposure assessments (HH-SLEA and Ecological SLEA) were completed and are attached to the CAP as Appendices G and H.

The HH-SLEA quantifies exposures of offsite human receptors to released Table 3+ PFAS for several receptor-exposure scenarios and provides a provisional human health hazard characterization for HFPO-DA based on quantified intakes and the North Carolina Department of Health and Human Services (NC DHHS) 2017 draft oral reference dose (RfDo). Calculated hazards for HFPO-DA for all receptor-exposure scenarios evaluated in the HH-SLEA are less than 1 which, as defined by the United States Environmental Protection Agency (USEPA), indicates that adverse effects to human receptors, including sensitive subpopulations, are unlikely. Untreated well water was identified as the primary source of potential PFAS intake and hazard. Furthermore, the HH-SLEA demonstrates that supplying whole building filtration systems and reverse osmosis units for qualifying residents offsite reduces HFPO-DA (and Table 3+ PFAS) intake by over 92%, ensuring human receptor exposures remain below hazard limits for HFPO-DA, based on the NC DHHS draft RfDo. Last, human exposure to PFAS in environmental media will continue to decrease over time as a result of facility air emissions reductions and corrective actions proposed in this CAP. Therefore, based on the HH-SLEA findings, human receptor populations are not being exposed to HFPO-DA above the NC DHHS reference dose by the exposure pathways evaluated. Therefore, the HH-SLEA findings do not necessitate the formation of a cleanup goal.

An Ecological SLEA was also completed to quantify exposure of terrestrial and aquatic ecological receptors to Table 3+ PFAS and evaluate potential hazards related to HFPO-DA. Exposures to Table 3+ PFAS may potentially occur via surface soil, surface water and sediment, along with potential dietary exposures of Table 3+ PFAS that may accumulate in plants, invertebrates and fish. The Ecological SLEA field investigations included collection of onsite and offsite soils, invertebrates and offsite vegetation, and sediment, vegetation, fish and clams from the Cape Fear River for analysis of Table 3+ PFAS. The Ecological SLEA evaluates potential exposure of receptors to Table 3+ PFAS,

[1] The NC DHHS provisional health goal for GenX in drinking water assumes an individual receives 80% of the acceptable dose (i.e., the RfDo) via other sources, such as food. Hence, the provisional health goal was determined such that intake via drinking water does not exceed 20% of the RfDo.

including aquatic life in the Cape Fear River, aquatic dependent wildlife foraging in the Cape Fear River and banks, terrestrial plant and invertebrate communities, and herbivorous, and invertivore wildlife. The Ecological SLEA evaluation indicates there are no adverse effects expected from HFPO-DA exposures. At present, Ecological SLEA findings do not indicate the necessity to develop cleanup goals for HFPO-DA.

Because the results of the HH-SLEA and Ecological SLEA indicate that exposures to HFPO-DA in offsite environmental media do not pose a hazard to human health or the environment, site-specific, risk-based cleanup goals were not developed; rather, cleanup goals are based on CO and 2L rules. The CO requires a minimum of a 75% reduction of total Table 3+ PFAS mass loading originating from the facility to the Cape Fear River. For corrective action under 2L rules when no groundwater standard exists, groundwater must, to the extent technologically and economically feasible, be restored to practical quantitation limits (PQLs) except as otherwise provided in the rules. At present, restoring groundwater to PQLs onsite or offsite is technologically and economically infeasible.

The technical and economic infeasibility to remediate to PQLs is driven by two factors, (a) the area over which the PFAS are detected and (b) the lack of remedial technologies that are effective over large areas and effectively destroy PFAS mass in-situ at a technically achievable and affordable scale. To date, Table 3+ PFAS have been detected over an area of 70+ square miles (over 45,000 acres). The size of the area encompasses thousands of private land parcels and any remedial construction activities using currently available remedial technologies (excavation and groundwater extraction) would be very disruptive to the local community and this disruption would continue for a lengthy period of time. Any remedy which in principle could help make progress towards PQLs over this large area would cost in the billions to tens of billions of dollars. In addition, this hypothetical offsite remedy is unnecessary based on the results of the HH-SLEA and Ecological SLEA; the remedy would result in significant disruption and cost and would result in no meaningful increase in protectiveness. Based on this challenge, in the future NCDEQ and Chemours may need to consider alternate cleanup standards conceived under 15A NCAC 02L .0106 (a) and (i) together and 15A NCAC 02L .0106 (k) individually or risk-based remediation as described by N.C.G.S. § 130A-310.66 et seq.

Therefore, the cleanup goals which drove remedial action evaluation and selection were primarily:

- Achieve a minimum 75% Table 3+ PFAS mass loading reduction to the Cape Fear River;
- For offsite groundwater receptors, provide public water connections or whole building filtration units or reverse osmosis units to qualifying surrounding residents (CO paragraphs 19 and 20);

- For onsite groundwater, mitigate discharge of PFAS with a process water signature to the Cape Fear River and Willis Creek to support achieving the minimum 75% reduction of Table 3+ PFAS mass loading to the Cape Fear River.

Cleanup goals were developed for the Cape Fear River, onsite groundwater seeps, Willis Creek, Georgia Branch Creek and Old Outfall 002 per CO and 2L requirements. These goals are described in the CAP. All these goals support mitigating PFAS loads to the Cape Fear River to help achieve the 75% total Table 3+ PFAS loading reduction to the Cape Fear River.

Based on these goals, and actions proposed in prior CO submittals, a total of nine corrective actions and two interim actions are proposed. The overall schedule for implementation and expected reductions are shown below in Table ES2. These 11 actions include interim and long-term actions that will address at least 95% of the loadings from the onsite groundwater seeps (Seeps A, B, C and D), at least 99% of the loadings from the Old Outfall 002 channel, and significant loading reductions from current Outfall 002.

The CAP also addresses remediation of onsite groundwater and proposes an interim action of extraction of groundwater from existing monitoring wells in the Black Creek Aquifer and treatment prior to discharge. Concurrently, efforts will proceed in developing the detailed design, including collection of extensive pre-design data, for a long-term groundwater containment approach. At this time, the calibrated numerical model indicates the most effective means to mitigate flux of onsite groundwater is the installation of a barrier wall coupled with hydraulic containment of groundwater. The barrier wall component of the remedy would serve to cut off the interface between groundwater and river water and prevent the undesired extraction of river water at the extraction wells.

Extensive investigation, analysis, and numerical model refinement would be required to properly design a remedy of this scale, including but not limited to geotechnical borings, contamination distribution investigations, in-river flux analyses, and pilot testing. It is anticipated that in the course of two years, these activities would allow for model refinement and completion of the design and permitting effort. In the absence of this data, the proposed long-term groundwater remedy is still highly conceptual, and it is not presently possible to conclude with confidence whether this alternative is economically feasible. At the conclusion of the PDI, Chemours will either present a detailed onsite remedial design or a remedial alternative to DEQ for approval based upon achieving at least a 75% Table 3+ PFAS loading reduction and the other CO objectives.

The actions proposed in this Corrective Action Plan will be supported by performance monitoring. Additionally, select onsite and offsite groundwater wells will be monitored at least annually and more frequently for some wells. Last, the CO paragraph 16 requirement for a minimum of a 75% reduction in total Table 3+ PFAS mass loading will be evaluated quarterly. The best available and most representative data will be used to develop the baseline and evaluate reductions performance. These data will include empirically measured flows and concentrations from PFAS transport pathways. These data will include measurements such as flow and concentrations of PFAS in the creeks and in the Cape Fear River in addition to contextual information from groundwater wells including concentrations and groundwater potentiometric surface data. These data will produce direct measurements of PFAS mass loading in multiple pathways and more importantly in the Cape Fear River itself.

Table ES2: Overall Estimated Reductions Plan Schedule and Reductions to Cape Fear River Total Table 3+ PFAS Loadings

Proposed and Provisional Remedial Alternatives	Loading Reduction	Duration (Years)	Year					
			2019	2020	2021	2022	2023	2024
Air Abatement Controls and Thermal Oxidizer[1]	<2%	1	✓					
Conveyance Network Sediment Removal - Outfall 002[2]	NQ[3]	1	✓					
Capture and Treat Old Outfall 002	26%	1						
Terracotta Pipe Replacement - Outfall 002	0.1%	2						
Stormwater Pollution Prevention Plan - Outfall 002	NQ[3]	1						
Groundwater Intrusion Mitigation - Outfall 002	0.7%	2						
Interim Action - CFR Seeps	NQ[3]	2						
Interim Action - Onsite Groundwater	NQ[3]	1						
Targeted Stormwater Control - Outfall 002	1.3%	4						
Ex Situ Capture and Treatment - CFR Seeps[4]	33%	4						
Onsite Groundwater Treatment	18%	5						
Cumulative Estimated Total Table 3+ PFAS River Reductions to River[5]	79%	--	<2%	26%	27%	43%	60%	79%

Notes

- Schedule for multiple alternatives are dependent upon permitting requirements.
- Loading reductions to CFR based on average of May, June, Sep. 2019 data
- Duration listed for implementation

1 - Scheduled implementation is December 31, 2019.
2 - Completed October 2019.
3 - Anticipated reduction from action cannot be quantified at present.
4 - Assumed to be Ex Situ Capture as the permanent remedial alternative for seeps.
5 - Cumulative estimated reductions assumes:
a) that reductions are achieved at the end of the implementation period; and
b) that the time period for contingent actions is not needed.

Legend

Action Complete	✓
Planned Action Implementation Period	
Time Period for Contingent Actions	

1 INTRODUCTION

This Corrective Action Plan (CAP) was prepared by Geosyntec Consultants of NC, P.C. (Geosyntec) for The Chemours Company FC, LLC (Chemours) and describes proposed remediation activities to address per- and polyfluoroalkyl substances (PFAS) in groundwater and surface waters at the Chemours Fayetteville Works Site (the Site). This CAP was prepared following North Carolina 2L Rules and Paragraph 16 of the executed Consent Order (CO) among Chemours, the North Carolina Department of Environmental Quality (NCDEQ), and Cape Fear River Watch (CFRW).

The corrective actions proposed in this CAP have been developed to comply with CO requirements and North Carolina 2L Rules, including being protective of human health and the environment. The corrective actions proposed in this CAP will be refined over time as both remedial technologies and understanding advance. PFAS are an emerging class of contaminant, with the Table 3+ PFAS present at the Site from this facility one of the newer sets of PFAS being examined by the remediation industry. The state of knowledge regarding the fate and transport properties, toxicological characteristics, and potential remedial approaches for PFAS and Table 3+ PFAS are continuing to evolve and advance.

The corrective actions have been developed based on multiple investigations and assessments reported since 2017, including multiple actions taken in 2019. These assessments have characterized the facility, an active manufacturing facility, and the surrounding topography, geology, surface water, and groundwater. These assessments enable preparing this CAP by characterizing the Site, identifying which environmental media to target for remediation to reduce human and ecological exposures to PFAS, meet CO requirements, and adapt to Site access conditions such as active equipment, steeply sloping terrain and periodically inundated flood plains.

This CAP is organized into seven sections as follows:

- **Site History and Description** – describes the setting and use of the Site, permitted activities and wastes, and the assessment and regulatory history;
- **Conceptual Site Model** – describes the geology and hydrogeology of the Site, PFAS detected at the Site, the source of the PFAS and PFAS signatures, the distributions and travel times of PFAS in the subsurface and the present mass loading estimate of PFAS to the Cape Fear River;
- **Receptor Information** – describes receptors surrounding the Site and describes the results of both Human Health and Ecological Screening Level Exposure Assessments (SLEAs);

- **Numerical Model Summary** – describes the numerical model used to evaluate groundwater flow at the Site and support onsite groundwater remedy selection and costing;
- **Proposed Corrective Actions** – corrective action objectives, cleanup goals, potential and proposed remedial alternatives, estimated costs, schedules and permitting needs;
- **Performance Monitoring** – describes a baseline monitoring program, remedy performance monitoring, and Cape Fear River PFAS mass loading reductions monitoring;
- **References** – lists documents referenced in this CAP.

Many of the figures and tables referred to in this CAP are from the On and Offsite Assessment report (Geosyntec, 2019a) and herein are referred to by their original number, but with the prefix A, for instance Figure 1-1 becomes Figure A1-1. Tables and figures from the On and Offsite Assessment are provided in Appendix A.

Figures and many tables are embedded for ease of reading, and are ordered sequentially in order of first appearances, i.e. Figure 1, Figure 2, etc. Additional, supporting detail tables are provided in Appendix B and referred to sequentially in order of first mention.

2 SITE HISTORY AND DESCRIPTION

This section provides a brief description of the site location, history of property ownership and use, surrounding land use and adjacent surface water bodies, permitted site activities, assessment and regulatory history. The On and Offsite Assessment Report (Geosyntec 2019a) provides additional details.

2.1 Site Location, Acreage, and Ownership

The Site is located within a 2,177-acre property at 22828 NC Highway 87, approximately 20 miles southeast of the city of Fayetteville along the Bladen-Cumberland county line in North Carolina. Figure A2-1 presents an overview of the Site location. Figure A2-2 presents a regional topographic map and Figure A2-3 presents a higher resolution topographic map of the Site.

The Site property was originally purchased by E.I. du Pont de Nemours and Company (DuPont) in 1970 for production of nylon strapping and elastomeric tape. DuPont sold its Butacite® and SentryGlas® manufacturing units to Kuraray America Inc. (Kuraray) in June 2014 and subsequently spun off its specialty chemicals business to Chemours in July 2015. Chemours and its two tenants, Kuraray and DuPont, currently operate manufacturing areas on the Site, described below.

2.2 Site Description

Presently, the manufacturing area of the Site consists of five production areas (Figure A2-1): Chemours Monomers IXM; Chemours Polymer Processing Aid (PPA) Area; Kuraray Trosifol® Leased Area; Kuraray SentryGlas® Leased Area; and DuPont polyvinyl fluoride (PVF) Leased Area. Chemours also operates the wastewater treatment plant (WWTP) and Power Area at the Site; filtered water and demineralized water are produced in the Power Area. The manufacturing area is approximately 312 acres, as shown in Figure A2-1, the remaining areas are grassy areas, forests and wetlands.

2.3 Adjacent Property, Zoning, and Surrounding Land Uses

The Site is bounded by NC Highway 87 to the west, Cape Fear River to the east, and on the north and south by forested areas, farmland and private residences. Cumberland and Bladen County zoning maps indicate that the surrounding areas are zoned as residential, agricultural, conservation, industrial or commercial.

2.4 Adjacent Surface Water Bodies and Classifications

To the east of the Site is the Cape Fear River. The Cape Fear River and its entire watershed are located in the state of North Carolina (Figure A2-4). The Cape Fear River drains 9,164 square miles and empties into the Atlantic Ocean near the City of Wilmington, North

Carolina. The Site draws water from the Cape Fear River and returns over 95% of this water via Outfall 002 after being used primarily as non-contact cooling water. Two lock and dam systems with United States Geological Survey (USGS) stream gauges are located downstream of the Site: (1) W.O. Huske Lock and Dam, located 0.5 river miles from the Site (USGS 02105500); and (2) Cape Fear Lock and Dam #1, located 55 river miles downstream (USGS 02105769).

The Cape Fear River is a water source for communities downstream of the Site. Raw water intakes are located at Bladen Bluffs and Kings Bluff Intake Canals, located approximately 5 miles and 55 miles downstream from the Site, respectively. These intakes serve as Cape Fear River water intakes for the Lower Cape Fear Water and Sewer Authority, which in turn provides water to Cape Fear Public Utility Authority (CFPUA) and other water providers. Drinking water sourced from the Cape Fear River contains certain chemicals from multiple sources including:

- 1,4-dioxane from industrial activities not related to Chemours;
- trihalomethanes associated with bromide content from other industrial and agricultural sources (NC DWR, 2017) in raw river water,
- pharmaceuticals, personal care products, and endocrine disrupting chemicals primarily from treated municipal waste waters,
- and PFAS from the Site and other sources.

A brief description of these chemicals and their presence in the Cape Fear River was reported previously (Geosyntec, 2018a).

Two tributaries to the Cape Fear River, located to the north and south of the Site, are described in the Seeps and Creeks Investigation Report (Geosyntec, 2019b). To the north of the property is Willis Creek. During the Seeps and Creeks Investigation, Willis Creek was observed to have a flow rate of approximately 2,900 gallons per minute (gpm) in dry weather and 6,500 gpm following significant rainfall. Willis Creek reaches from Highway 87 to the Cape Fear River. To the south of the property is Georgia Branch Creek, which is offsite for its entire course. During the Seeps and Creeks Investigation, Georgia Branch Creek was observed to have flow rates ranging from 2,400 to 2,600 gpm in both wet and dry weather. Georgia Branch Creek runs northwest-southeast beside Highway 87 before turning east towards the Cape Fear River to the south of the Site. These creeks are shown in Figure A2-1.

2.5 Permitted Activities and Permitted Wastes

The Site received its initial Resource Conservation and Recovery Act (RCRA) Permit (NCD047368642) to operate a hazardous waste container storage area and tanks in February 1983, while under DuPont ownership. DuPont submitted an amended Part A application in 1991 to document upgrades to its fluorocarbon waste treatment and tank system. The RCRA Part B permit application submitted in August 1993 identified 71,750 gallons of container storage capacity at the container storage area. Stored waste included characteristic wastes (D001, D002, D003, D007, D009, and D029) and listed wastes (F002, F003, and F005). The Site's RCRA Permit was re-issued in January 1998 and September 2012.

The National Pollutant Discharge Elimination System (NPDES) permit for the Site (NC0003573) includes operations of Site tenants Kuraray and DuPont. There are permit limits for internal Outfall 001, after biological wastewater treatment, that includes the Kuraray and DuPont manufacturing processes, demineralized water neutralized regenerate, sanitary wastewater, and process area stormwater. Effluent limits for Outfall 002, the Site's discharge to the Cape Fear River, include the treated flow from Outfall 001, non-contact cooling water, cooling water discharge from thermal oxidizer cooling tower, stormwater, and boiler condensate blowdown.

In June 2017, Chemours began capturing certain process water from the Monomers IXM area for offsite disposal. Since November 2017, as directed by NCDEQ, all process wastewaters from Chemours's operation have been captured and transported for offsite disposal.

Chemours recently submitted a NPDES permit renewal application for the Site, which contemplates numerous actions, including: (i) continued shipping of Chemours process wastewater from the Monomers IXM and PPA areas offsite, (ii) the intent to build a treatment facility to treat captured baseflow originating from Old Outfall 002, and (iii) a thermal oxidizer with water discharges where no additional PFAS outside of those PFAS present in the river water intake are expected to be present. The recent permit application includes descriptions of recent extensive sampling at the Site for hexafluoropropylene oxide dimer acid (HFPO-DA) and perfluoro-1-methoxyacetic acid (PFMOAA), as well as a number of other PFAS.

On March 14, 2019, Chemours received a Title V Air Quality Permit No. 03735T44 from NCDEQ to construct and operate the emissions sources and associated air pollution control devices(s). This permit authorized Chemours to continue manufacturing operations and install a thermal oxidizer which, along with other air abatement measures, will dramatically reduce aerial PFAS emissions from the Site, with reduction of aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, and expected comparable reductions for other PFAS.

2.6 Prior Site Investigations and Regulatory History

Since 1996, several stages of RCRA Facility Assessments and Investigations have been conducted and are detailed in the RCRA Facility Investigation (Parsons, 2014). The

RCRA Facility Investigation (RFI) process was performed for Site COCs identified in the 2014 RFI including multiple VOCs, metals, other inorganic compounds and perfluorooctanoic acid (PFOA). The RFI process did not include the Site Associated PFAS that are now analyzed by the Table 3+ SOP method; these compounds are listed in Table 2-1. The outcome of the RFI process was the *Corrective Measures Study Work Plan* submitted to NCDEQ on December 2, 2016 (Parsons, 2016). On February 8, 2017, NCDEQ approved Chemours Work Plan for preparing the Final Corrective Measures Study. On July 7, 2017, Chemours requested a delay in the completion of the Corrective Measures Study. The delay was requested as Chemours began voluntary additional sampling and characterization in response to state requests regarding identification and detection of additional PFAS present at the Site.

Since identifying the presence of the PFAS associated with the Site, Chemours has performed multiple investigations and assessments and is continuing to perform assessments that support corrective action for PFAS at the Site. On October 31, 2019, Chemours submitted an updated version of the On and Offsite Assessment report (Geosyntec, 2019a). The tables and figures from this report are attached to the CAP as Appendix A; references to these tables in the text of this CAP report are referred to by the prefix "A" before the table or figure number. The table below list assessments conducted and the second table lists assessments in-progress and planned. Many of these assessment have been required under the CO.

Table 1: PFAS Focused Assessment Activities to Date

Assessment	**Reference**
2018 Cape Fear River Sampling	Geosyntec, 2018a
2018 Stormwater Characterization	Geosyntec, 2018b
2019 On and Offsite Assessment	Geosyntec, 2019a
2019 Seeps and Creeks Investigation	Geosyntec, 2019b
2019 Fate and Transport Study	Geosyntec, 2019c
2019 Mass Loading Reductions Plan	Geosyntec, 2019d
2019 Outfall 002 Assessment	Geosyntec, 2019e
2019 Terracotta Pipe Section Grouting	Geosyntec, 2019f
2019 Mass Loading Model	Geosyntec, 2019g
2018 Post Florence Characterization	Geosyntec, 2019i
2019 Conveyance Network Sampling	Geosyntec, 2019j and 2019k

Assessment	**Reference**
2017 Groundwater Investigation	Parsons, 2017a
2017 Soil Investigation	Parsons, 2017b
2017 Surface Water Investigation	Parsons, 2017c
2018 Terracotta Pipe Investigation	Parsons, 2018a
2018 Additional Investigation	Parsons, 2018b
2018 VE South Sampling	Parsons, 2018c
2018 Old Outfall 002 Sampling	Parsons, 2018d
2018 Exclusion Zone Investigation	Parsons, 2018e
2018 Southeast Perched Zone Investigation	Parsons, 2018f
2018 - 2019 Private Well GAC Pilot	Parsons, 2018g
On-going Private Well Sampling	Parsons, 2019a
2019 PlumeStop™ Pilot Study	Parsons, 2019c
2019 Old Outfall 002 GAC Pilot Study	Parsons, 2019d
2019 Old Outfall Sampling Results	Parsons, 2019e

Ongoing PFAS Assessment and Planned Activities

Activity	Description and Status
Offsite Wells	Continued assessment of offsite soil and groundwater in addition to private well data; 20 wells installed. Wells have been redeveloped and resampled.
Private Well Delineation	By August 26, 2020 Chemours is required by CO Paragraph 21 to delineate the extent of private wells offsite with any PFAS on Attachment C of the CO present above 10 nanograms per liter (ng/L) within a quarter mile of other wells with similar detections.
Human Health Screening Level Exposure Assessment	Assessment of human receptor exposures to historically deposited PFAS from the Site. All samples collected and data generated are reported in conjunction with this CAP.
Ecological Screening Level Exposure Assessment	Assessment of ecological exposures to PFAS originating from the Site. Sampling was performed in part with the Human Heath SLEA sampling with dedicated Ecological SLEA sampling and are reported in conjunction with this CAP.
Empirical Laboratory Study	Assessment of Table 3+ PFAS empirical fate and transport characteristics. Portions of the study have begun. Components of assessment are reported in this CAP. The full set of data will be reported in 2020.
Onsite Characterization	Assessment of onsite groundwater levels and concentrations; in 2019, 42 wells installed. Data collected from new wells are reported in the On and Offsite Assessment Report (Geosyntec, 2019a) with redeveloped and resampled well data reported in this CAP.
Sediment Characterization	Chemours submitted the Sediment Characterization plan to NCDEQ on August 21, 2019 and received comments from DEQ dated November 20, 2019.
Quarterly Mass Loading Sampling	Assessment to evaluate mass loading to the Cape Fear River. Sampling and flow gauging performed quarterly in seeps, creeks, the Old Outfall 002,

Activity	Description and Status
	Outfall 002 and groundwater adjacent to surface water.
Numerical Groundwater Model	Quantitative assessment of groundwater at the Site to assess flow to surface water features and assess performance of potential remedies. Results of the numerical modeling are reported as part of this CAP.
Bimonthly PFAS Characterization Sampling	Bimonthly assessment of PFAS concentrations in the Site conveyance network. Data and interpretations are reported quarterly.

3 CONCEPTUAL SITE MODEL

This section describes multiple aspects of the Site including geology, hydrogeology, Table 3+ PFAS, PFAS signatures, distributions, travel times, mass loadings to the Cape Fear River and PFAS reduction actions Chemours has taken to date.

The Site is located in the Coastal Plain of North Carolina and is situated adjacent the Cape Fear River atop a bluff with a 100-foot elevation change to a floodplain area and the Cape Fear River. Willis Creek borders the Site to the north, which flows through an erosional channel and empties into the Cape Fear River. To the south is Georgia Branch Creek which also flows through erosional channels as it empties into the Cape Fear River. Onsite there are groundwater seeps where groundwater is expressed at surface and flows to the Cape Fear River. The largest of these groundwater-fed seeps is the Old Outfall 002, along with four seeps, A, B, C and D located on the bluff slope facing the Cape Fear River.

3.1 Geology and Hydrogeology

The geology at the Site consists of sands and clays. The geology and land use at the Site have influenced the hydrogeology of the Site. The geology of the Site is depicted in a series of cross sections identified in Figure A10-1 and presented in Figures A10-2 through A10-6. The list below describes geological features at Site from surface downward:

- Perched Zone. The Perched Zone is a relatively thin, spatially limited layer of groundwater present in silty sands to a depth of about 20 feet below ground surface (ft bgs) (Figures A10-2 to A10-6). Groundwater in the Perched Zone is recharged through precipitation onsite, and in the past, has received enhanced infiltration through unlined ditches and sedimentation ponds – the sedimentation ponds and the cooling water channel in the Monomers IXM Area have since been lined. Groundwater flows radially away from groundwater mounds in the Perched Zone. This leads to groundwater discharge to the east at seeps on the edge of the bluff, to the south toward the Old Outfall 002 and to the north and to the west downwards through the geological sequence towards the Surficial and Black Creek Aquifers. Based on groundwater extraction rates from the Perched Zone wells MW-24, NAF-03 and NAF-12, the Perched Zone does not produce sufficient or sustainable groundwater yields to be considered an aquifer.
- Perched Clay Unit. The Perched Clay Unit gives rise to the Perched Zone as it presents a barrier to direct downward groundwater infiltration. The Perched Clay is spatially limited at the Site. To the north it pinches out. To the east and south, it outcrops along the bluff face. To the west, it terminates and becomes absent (Figure A10-6). In cross sections through

the Site and observations of grainsizes and lithologic contact elevations from the boring logs, there suggest an erosional feature in the western portion of the geology underlying the manufacturing areas. This erosional surface, described later in this list, is interpreted to have eroded the Perched Clay Unit enabling downward migration of groundwater off the western edge of the Perched Zone.

- Surficial Aquifer. The Surficial Aquifer is an unconfined silty sand aquifer lying atop the Black Creek Confining Unit and is present beneath the Perched Clay Unit. Groundwater in the Surficial Aquifer flows towards the bluff faces at the Site – It flows both north, east and west toward surface water bodies (Willis Creek, Seeps, Old Outfall 002) and discharges into them as seeps. The Surficial Aquifer is interpreted to be in contact with the Black Creek Aquifer in places due to an erosional feature. This feature is labeled on the cross sections and is interpreted to have enabled downward cross formational groundwater flow. Based on North Carolina groundwater classifications (15A NCAC 02L .0201), the Surficial Aquifer is presently classified as a GA groundwater.

- Black Creek Confining Unit. The Black Creek Confining Unit is a layer of silty or sandy clay that separates the Surficial Aquifer from the Black Creek Aquifer. The lithologic contact elevation with the overlying Surficial Aquifer is variable, as is the unit thickness –the Black Creek Confining Unit is interpreted to have been eroded under the western portion of the manufacturing areas at Site. In addition to the Black Creek Confining unit being discontinuous, the potential for downward cross formational flow, also exists based on multiple vertical joints (i.e., fractures in the clay) observed in the Black Creek Confining Unit where it outcrops at the Site.

- Flood Plain Deposits. Surface soils in the flood plain immediately adjacent to the Cape Fear River are comprised of finer grained, likely more recently deposited sediments during river flood stages. These deposits have lower hydraulic conductivity than the Surficial and Black Creek Aquifers. The seeps at the Site cut into Floodplain Deposits as they flow towards the Cape Fear River.

- Black Creek Aquifer. The Black Creek Aquifer is comprised of fine to medium grained sands. The Black Creek Aquifer is in contact with the Surficial Aquifer under the western portion of the manufacturing area at the Site and then is separated from the Surficial Aquifer under most of the manufacturing area by the Black Creek confining unit. The Black Creek

Aquifer directly adjacent to the Cape Fear River is overlain by Flood Plain Deposits and the Black Creek Confining Unit. The Black Creek Aquifer is interpreted to be the only transmissive groundwater zone at Site in direct contact with the Cape Fear River. Groundwater in the Black Creek Aquifer flows from west to east towards the Cape Fear River. Based on North Carolina groundwater classifications (15A NCAC 02L .0201), the Black Creek Aquifer is presently classified as a GA groundwater.

- Upper Cape Fear Confining Unit. The Upper Cape Fear Confining Unit underlies the Black Creek Aquifer. The Upper Cape Fear Confining unit is regionally extensive clay layer which is upwards of 75 feet (ft) thick at the Site and is likely a barrier to downwards groundwater flow. Groundwater levels in the Upper Cape Fear Aquifer measured at North Carolina Division of Water Resources (NC DWR) wells are 80 ft lower than Black Creek Aquifer groundwater levels immediately above the Upper Cape Fear Aquifer. If the two units were in hydraulic connection, they would have similar groundwater elevations. The dissimilarity in water levels for these co-located NC DWR wells demonstrates that the Upper Cape Fear Confining Unit is a barrier to downward flow from the Black Creek Aquifer to the Cape Fear Aquifer.
- Erosional Feature. A paleo-era process appears to have eroded the Perched Clay Unit, portions of the Surficial Aquifer and the Black Creek Confining Unit in the geological sequence under the western portion of the manufacturing area. This erosional feature potentially enables cross formational flow of groundwater from the Perched Zone, through the Surficial Aquifer and into the Black Creek Aquifer. This feature is a likely controlling factor of the distribution of PFAS observed in the Surficial and Black Creek Aquifers at Site. At present there is no direct evidence to confirm this erosional feature does not cut through the Upper Cape Fear Confining Unit.

3.2 Table 3+ PFAS

This section provides a description of the physical and chemical properties of Table 3+ PFAS found at the Site. Pursuant to CO Paragraph 27, Chemours funded a study analyzing the fate and transport characteristics of identified PFAS compounds originating from the Site in air, surface water, and groundwater (Geosyntec, 2019c). This section summarizes the findings of this study and provides descriptions of empirical fate and transport measurements completed to date on Table 3+ PFAS, including values for the octanol-water partition coefficient (K_{ow}), organic carbon-water partition coefficient (K_{oc})

and surface tension of water containing Table 3+ PFAS. These fate and transport parameters enable a more quantitative estimate of transport times in groundwater and estimates of the partitioning between soil and groundwater these PFAS undergo (i.e. where is most of the mass located, sorbed to soils or dissolved in groundwater).

3.2.1 Summary of Fate and Transport Study

PFAS are a group of man-made carbon-based chemicals composed of a fully or partially fluorinated chain of carbon atoms (referred to as a “tail”) and a nonfluorinated, polar functional group (referred to as a “head”) at one end of the carbon chain. Fluorination of the carbon chain renders it hydrophobic and lipophobic, while the polar head group is hydrophilic (Mueller and Yingling, 2018). Generally, PFAS vapor pressures are low and water solubilities are high. Most PFAS have one or more negatively charged head groups, so they are likely to be relatively mobile in the subsurface due to the affinity of the head group for water molecules (Mueller and Yingling, 2018).

Most Site associated PFAS, i.e. Table 3+ PFAS, are fluoroethers: their structure includes two carbons connected by an oxygen atom to form an ether bond. PFAS with ether bonds are expected to be less volatile and more soluble in water than non-ether PFAS of equivalent chain length due to the polar oxygen atoms included in their structures. Table 3+ PFAS contain at least one polar head group and many contain additional polar head groups. The structural information for the Table 3+ PFAS is provided in Table A4-1. Also, more PFAS originating from the facility may be identified as part of the non-targeted analytical assessment being performed pursuant to paragraph 11(a) of the CO.

Generally, Table 3+ PFAS are expected to be mobile in the environment given the presence of charged head groups and ether bonds, but they will experience some retardation due to sorption to soils. For some Table 3+ PFAS, mobility may be enhanced relative to straight-chain, non-ether PFAS by their branched structure and the presence of two charged head groups. The mobility of the Table 3+ PFAS will be retarded by various chemical processes but will likely have lower retardation than long-chain PFAS without ether bonds. Chemical processes expected to have the most impact on mobility are sorption to naturally occurring organic carbon in soil and, in the unsaturated soil zone, preferential partitioning to the air-water interface.

The tails of PFAS are made primarily of carbon atoms. They tend to be nonpolar and sorb to organic carbon species in soil and sediment (Higgins and Luthy 2006, Guelfo and Higgins, 2013). Because PFAS tails are also lipophobic, sorption to organic carbon tends to be weaker than that of alkanes. The sorption and retardation of PFAS will increase with increasing fluorinated tail length. For a given soil, sediment, or organic carbon type, the structure of the PFAS tail affects its interactions with organic carbon molecules. Branched isomers tend to have lower sorption affinity than linear isomers of equal chain length (Kärrman et al., 2011). Sorption of PFAS to charged particle surfaces in common soils and sediments is expected to be negligible relative to sorption to particulate organic carbon (Higgins and Luthy, 2006).

Current literature indicates that transformation of most PFAS in the environment is negligible. An important observed environmental transformation of PFAS has been the hydrolysis of some polyfluorinated precursors to form perfluorinated compounds (Mueller and Yingling, 2018) and the biotic degradation of trifluoroacetate (e.g., Visscher et al., 1994). Recently, researchers identified an *Acidimicrobium* microbial species that appears capable of defluorinating select PFOA and Perfluorooctane Sulfonate (PFOS) (Huang and Jaffe, 2019). Components of the Table 3+ PFAS that may be amenable to transformation reactions that degrade the tails of these compounds are ether bonds present in 21 of 24 Site associated PFAS, and carbon-hydrogen bonds present in 5 of 24 Site associated PFAS. (e.g., Weber et al., 2017; note, presently Table 3+ can quantitate 20 of the identified 24 PFAS compounds identified at the Site).

3.2.2 Measured K_{ow} and Calculated K_{oc} for Table 3+ Compounds

The process of retardation of organic compounds, including Table 3+ compounds, will influence their fate and transport in the subsurface. Retention in the saturated zone is controlled by sorption to the solid phase of porous media. Sorption by the solid phase is described by the soil-water distribution coefficient (K_d), which is related to K_{oc} by the fraction of organic carbon in the soil. K_{oc} and K_{ow} are often highly correlated. K_{ow} is a standard parameter used for estimating bioconcentration factors. In this section, a summary of log K_{oc} and log K_{ow} measurements or calculations are described along with a discussion of the impact of the values on Table 3+ compounds fate and transport. Details are provided in Appendix C. Other mechanisms of sorption can also include the potential for PFAS, including Table 3+ compounds to bioaccumulate in organisms. Bioaccumulation in potential receptors is discussed in Section 4.

Log K_{ow} measurements were performed using liquid chromatography retention times (OECD, 2004). Retention times for a set of 11 reference compounds with known log K_{ow} values were first determined, and a calibration curve of retention time versus log K_{ow} created. Then, the retention time for each Table 3+ compound was measured, and log K_{ow} calculated using the calibration curve. The measured Table 3+ log K_{ow} values are presented in Table 2.

To calculate K_{oc}, an equation was developed for the relationship between log K_{ow} and log K_{oc} using 20 reference compounds for which both K_{oc} and K_{ow} values were available. Using the measured log K_{ow} values, log K_{oc} values were calculated for Table 3+ compounds (Table 2).

As expected, log K_{ow} and log K_{oc} values are structure dependent where the longer the chain length, the higher the log K_{ow} and log K_{oc} values, indicating higher sorption and retardation. Branched isomers and increasing number of ether bonds results in lower log K_{ow} and log K_{oc} values, indicating lower sorption and retardation.

For comparative purposes, PFOA, a linear C8 PFAS, has log K_{ow} and log K_{oc} values of 5.3 and 2.35 liter per kilogram (L/kg), respectively, while HFPO-DA, a C6 branched PFAS, has log K_{ow} and log K_{oc} values of 4.24 and 1.69 L/kg, respectively. Also by comparison perfluoro-1-butanesulfonic acid (PFBS), a relatively mobile PFAS, has a measured K_{oc} of 1.0 L/kg. The results in Table 2 indicate that all Table 3+ compounds are more mobile and are expected to be less bio-accumulative than PFOA, with the exception of perfluoro-3,5,7,9,11-pentaoxadodecanoic acid (PFO5DA).

Table 2: Table 3+ Measured Log Kow and Calculated Log Koc Values

Table 3+ PFAS	Log K_{ow}[1] at pH 5	Log K_{ow}[2] at pH 8	Log K_{oc} (L/Kg)[2] at pH 5
MMF	<2.92 (1.08)*	<3.11 (1.09)*	--
DFSA	<2.90 (1.19)*	<3.11 (1.05)*	--
MTP	<2.90 (2.19)*	<3.11 (2.42)*	0.52
PPF	<2.93 (2.43)*	<2.98 (2.48)*	0.67
PFMOAA	<2.82 (2.45)*	<2.83 (2.43)*	0.89
NVHOS	2.92	2.93	0.95
R-EVE	3.04	3.14	1.01
PMPA	3.05	3.05	1.02
Byproduct 4	3.09	3.19	1.04
Byproduct 5	3.14	3.23	1.07
PFO2HxA	3.32	3.30	1.17
PEPA	3.63	3.60	1.35
PES	3.80	3.78	1.44
PFECA B	3.98	3.95	1.54
PFO3OA	4.17	4.13	1.65
HFPO-DA	4.24	4.23	1.69
Byproduct 6	4.61	4.57	1.90
Hydro-EVE Acid	4.68	4.66	1.94
Byproduct 2	4.72	4.68	1.96
PFECA-G	4.79	4.77	2.00
PFO4DA	4.98	4.95	2.11
PFESA-BP1	5.09	5.06	2.17
EVE Acid	5.10	5.06	2.17
PFO5DA	5.78	5.72	2.56

1 Measured by HPLC

2 Calculated by correlation

*Extrapolated values in parenthesis
-- Koc values for Difluoromalonic acid (MMF) and Difluoro-sulfo-acetic acid (DFSA) fell in the negative range of the calibration curve

3.3 Site Related PFAS Sources

Fluoroproduct manufacturing at the Site has resulted in three primary PFAS release routes to environmental media: (1) emissions to air, (2) releases of process water to soil and groundwater, and (3) releases of process water to surface water. These releases also resulted in secondary sources of PFAS in the environment to groundwater and surface water receptors. Primary PFAS releases have been identified and are being controlled. The primary and secondary sources are described in the following subsections.

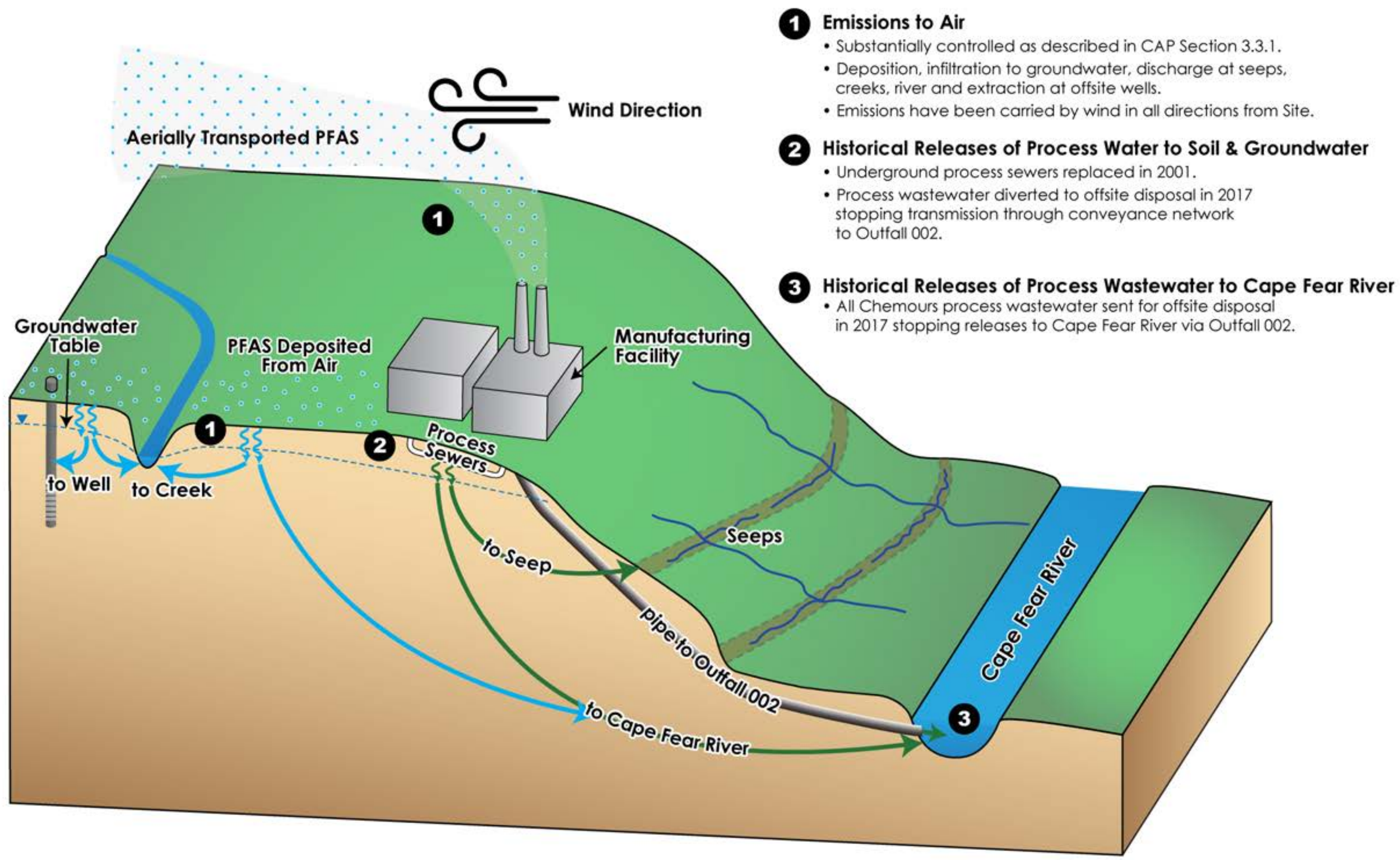

Figure 1: Primary PFAS Sources – Historical Pathways and Present Controls

3.3.1 Emissions to Air

The facility operates multiple permitted air discharge stacks, blowers and vents as part of manufacturing activities. As part of CO compliance, the facility is implementing air control technology improvements that will reduce aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, with expected comparable reductions for other PFAS. Prior to these in-progress reductions and other interim reductions achieved over the past two years, and subject to air abatement systems that had been in place previously, PFAS compounds had been emitted to air and subsequently deposited both onsite and in the area surrounding the Site. The locations of emissions to air and locations of past loading are presented in *Modeling Report: HFPO-DA Atmospheric Deposition and Screening Groundwater Effects* (ERM, 2018) and shown in Figure A4-1. Estimates of past loadings to air and surface water and reductions in loadings achieved are presented in the PFAS Loading Reductions Plan (Geosyntec, 2019d).

3.3.2 Releases of Process Water and Wastewater to Soil and Groundwater

On Site releases of PFAS to soil and groundwater occurred in the manufacturing areas. Known specific release pathways included (i) leakage from historical process water discharge lines, (ii) leakage of combined process water from the terracotta pipe and (iii) a manufacturing (scrubber) upset which occurred in October 2017. Each of these pathways is described below.

Historical process sewer system in Monomers IXM

In 2000, the facility replaced underground piping in the Monomers IXM area that conveyed process waters and wastewaters with aboveground piping (DuPont, 2006). Replacement with aboveground piping enabled routine inspections and the ability to perform more rapid leak detection and repair. The facility has identified one remaining underground pipe connecting the sump at Vinyl Ethers South to the Vinyl Ethers South retention basin. The basin ensures that the Vinyl Ethers South sump does not overflow during heavy rainstorm events.

Terracotta Pipe Leakage

The terracotta pipe was designed to convey wastewater from the various manufacturing areas to the WWTP (Figure A4-1). Prior to June 21, 2017, the facility transmitted PFAS containing process wastewater containing Table 3+ PFAS to the WWTP from the Monomers IXM Area via the terracotta pipe. Leaking of this process water from the terracotta pipe to groundwater is probable and these releases are likely the source of elevated PFAS detections at location PZ-18 and its replacement well, MW-24 (Parsons, 2018a). Chemours no longer transmits process water from the Monomers IXM Area to the WWTP. This process water is sent offsite for disposal. In 2018, Chemours grouted a portion of the terracotta pipe, and by 2021 Chemours and Kuraray plan to fully decommission and replace the terracotta pipe with above-ground piping (Geosyntec, 2019e, f).

October 2017 Scrubber Upset

In October 2017, a scrubber upset occurred in the Vinyl Ethers South area of the Monomers IXM Area (Arnold and Porter, 2017). This release resulted in process water containing PFAS contacting site soils and infrastructure in the Monomers IXM area. Subsequent to this release, Chemours removed soils from this area, replaced some roofing materials and re-lined the cooling water channel with new materials. The scrubber upset resulted in increased HFPO-DA concentrations in the Outfall 002 after rainfall events for up to seven months. As materials were replaced, soils were removed, and the area flushed, observed HFPO-DA concentrations diminished at Outfall 002.

3.3.3 Releases of Process Water to Surface Water

Prior to June 21, 2017, Chemours transmitted PFAS containing process water to the WWTP from the Monomers IXM Area via the terracotta pipe and then to Outfall 002 where this PFAS containing water was discharged to the Cape Fear River. As of November 29, 2017, Chemours diverted Chemours Monomers IXM Area process wastewater flows away from the WWTP and currently containerizes this wastewater for offsite disposal. PPA process water also contains PFAS, and this waste stream has always been collected and sent for offsite disposal since commissioning of the PPA Area.

3.3.4 Secondary Sources

Chemours has taken measures to mitigate releases of PFAS to groundwater, soil, and surface water. Chemours will be implementing air control technology improvements which will reduce aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, with expected comparable reductions for other PFAS. Historical releases resulted in the following secondary sources of PFAS being present in the environment:

- PFAS in unsaturated soils from aerial deposition infiltrating to groundwater. Aerial deposition has resulted in a distributed, non-point source of PFAS in onsite and offsite soils that represent a secondary source to groundwater. Infiltrating rainfall has transported these PFAS downward to groundwater. The currently identified extent of this secondary PFAS source is shown in Figures 4-2A and 4-2B.
- PFAS in soils and groundwater from Site process water releases. Process water leaks in the manufacturing areas resulted in PFAS in Site soil and groundwater. Based on the hydrogeology of the Site, these PFAS are detected in the Perched Zone, Surficial Aquifer, or Black Creek Aquifer and then

migrate towards primarily the Cape Fear River and Old Outfall 002 with some component reaching Willis Creek.

3.4 Monitoring Well Redevelopment and Resampling

Between October 17 and November 8, 2019, a total of 17 wells were redeveloped and 45 wells were resampled (Table 3) based on the recommendations listed below from the Onsite and Offsite Assessment (Geosyntec, 2019a):

- Additional sampling of recently installed wells to evaluate consistency of results;
- Additional development prior to any sampling of wells reporting higher turbidity or perfluoromethoxypropyl carboxylic acid (PMPA) detections below 200 ng/L or non-detect PMPA values with reporting limits above 200 ng/L;

Table 3: Summary of well redevelopment and resampling

Location	No. Wells Redeveloped	No. Wells Resampled
Onsite	11	27
Offsite	6	18
Total	17	45

The list of wells redeveloped and resampled is provided in Appendix B, Table B-1 and Table B-2. Well redevelopment logs/field notes are provided in Appendix B. The results from the resampled wells are provided in the copy of the On and Offsite Assessment Tables A9-3 and A9-4 and in Table B-3.

The total Table 3+ concentrations in resampled wells collected between October 17 and November 8, 2019 were generally within ± 25% range (with some notable exceptions) compared to prior results from June and September 2019 with the following observations:

- Total Table 3+ PFAS concentrations from wells PW-02 and PW-14 were approximately 100 times lower in the resampled results compared to the original samples (15,000,000 to 140,000 ng/L and 18,000,000 to 160,000 ng/L respectively). Resampled total Table 3+ PFAS concentrations for both PW-02 and PW-14 are consistent and within the same order of magnitude as results from nearby onsite wells screened in the Surficial and Black Creek Aquifer, respectively. The concentrations in these wells will continue to be monitored as part of monitoring plan activities described in Section 7.

- For offsite wells where Table 3+ PFAS concentrations were close to detection limits in June, resampled Table 3+ PFAS concentrations were similar or lower in concentrations in October and November. Comparison of Table 3+ PFAS concentrations in offsite wells before and after redevelopment indicate that PMPA had the most notable decrease in concentrations following redevelopment and resampling. PMPA was previously detected in drill water at a concentration of 130 ng/L. Lower concentrations of PMPA in offsite wells may be indicative of well development completion and return to formation water.
- Total Table 3+ PFAS concentrations for wells PIW-7S and PW-06 following redevelopment and resampling were greater than previous results. For example, total Table 3+ PFAS concentrations for PW-06 increased from 3,000 ng/L to 4,400 ng/L while PIW-7S increased from 17,000 ng/L to 54,000 ng/L.

3.5 Southwestern Offsite Seeps

Groundwater seeps are common hydrogeological features in sloping terrain, such as the bluffs found at the Site in the areas around the Site, and much of the Cape Fear River watershed. Onsite there are four seep features with channelized flow that enter the Cape Fear River. In October 2019, ten offsite groundwater seeps - the Lock and Dam Seep and Seeps E to M - were identified on the west bank of the Cape Fear River to the south of the Site. The seeps were identified by performing a visual survey from a boat on the western side of the Cape Fear River between Old Outfall 002 and Georgia Branch Creek. Flow from these seeps ranged from seeping water from an embankment (i.e. trickles) to a visible small stream in one of the seeps. Results from samples collected from the seeps indicate Total Table 3+ PFAS concentrations ranged between 2,600 to 6,800 ng/L. The seven southernmost seeps (G to M) had similar concentrations to the mouth of Georgia Branch Creek sampled in September (2,100 ng/L). However, all offsite seeps had lower concentrations of Total Table 3+ compared to onsite seeps and Old Outfall 002 by one to two orders of magnitude. Similar to Georgia Branch Creek, all of the Southwestern Offsite Seeps had an aerial PFAS deposition signature indicating these PFAS originated from aerial deposition with subsequent infiltration to groundwater and discharge at these seeps.

As these offsite seeps are groundwater fed, their mass loading to the Cape Fear River was included in the offsite adjacent and downstream groundwater transport pathway described in detail in the August 2019 mass loading model report (Geosyntec, 2019) and later in Section 3.10. The offsite adjacent and downstream groundwater pathway was estimated to contribute less than 2% total Table 3+ PFAS loading to the Cape Fear River. Additional details regarding the identification, sampling and photographs of the Southwestern Offsite Seeps are provided in Appendix D.

3.6 PFAS Signatures and Distribution

Releases of PFAS at the Site have created two primary categories of PFAS signatures detected in groundwater and surface water: (1) An aerial deposition PFAS signature from emissions to air and (2) a combined process water PFAS signature from historical releases of process water to soil and groundwater. These primary signature categories are reflected in the PFAS signatures identified in the On and Offsite Assessment report (Geosyntec, 2019a). For this CAP, the data set used to examine PFAS signatures was expanded upon to include offsite private well data and samples from the Cape Fear River, onsite and offsite groundwater seeps, Willis Creek, Georgia Branch Creek, and Old Outfall 002 in addition to the prior use of onsite groundwater results. A hierarchical cluster analysis was performed similarly to the one performed for the On and Offsite Assessment with the exception that this cluster analysis used data for the 11 Table 3+ PFAS data on Attachment C of the CO. Private well data were analyzed for only the Attachment C PFAS and therefore this was the set of Table 3+ PFAS that could facilitate the identification and subsequent comparison of signatures between the samples of private well data and other data sets. The details of the analysis are described Appendix E and the results described below.

3.6.1 Aerially Deposited PFAS Signature and Distribution

The aerially deposited PFAS signature is predominantly found offsite at low concentrations (Figure 2, Table 4). Emissions to air were deposited on surface soils onsite and offsite and have over time infiltrated to groundwater, and in some cases, migrated in groundwater to surface water receptors including the Cape Fear River, Willis Creek and Georgia Branch Creek. Air emission controls will be reducing facility wide emissions of HFPO-DA by 99% compared to 2017 baseline, and are expected to produce a comparable decrease in aerial deposition for other PFAS.

The hierarchical cluster analysis identified two clusters of aerially deposited PFAS signatures. The first cluster (i.e. signature) identified was the 'Aerial – Mixture of PFAS' signature. This signature was a mixture of Table 3+ PFAS where PMPA is commonly the highest concentration with other Table 3+ PFAS (HFPO-DA, perfluoro(3,5-dioxahexanoic) acid [PFO2HxA], perfluoroethoxypropyl carboxylic acid [PEPA] and PFMOAA) detected in a substantial proportion in the samples. Both PMPA and HFPO-DA comprise a substantial proportion of the 'Aerial - mixture of PFAS' signature.

The second signature identified was 'Aerial – Predominant PMPA or HFPO-DA'. Here either PMPA or HFPO-DA dominate the concentration as a proportion of Table 3+ or one of HFPO-DA or PMPA were the only PFAS detected in the sample collected.

Onsite in the Monomers IXM Area, some groundwater wells with high concentrations exhibit a PFAS signature similar to the aerial PFAS signature. These wells are in areas where historically various process sewers were leaking before being replaced. These wells likely have an aerial PFAS signature due to individual historically leaking processes that generated a PFAS distribution similar to the aerial PFAS signature.

3.6.2 Combined Process Water PFAS Signature and Distribution

Among the wells that exhibit the process water PFAS signature, the highest Table 3+ PFAS concentration is PFMOAA, particularly for the combined process water component of the signature. Overall, HFPO-DA, PFMOAA, PFO2HxA, PMPA, and PEPA also comprise a substantial proportion of this signature.

The combined process water PFAS signature is found onsite at high concentrations. As described in the On and Offsite Assessment report (Geosyntec, 2019a), the combined process water signature is associated with release from where various process wastewaters were combined or where PFMOAA dominated the proportion of PFAS present in an individual process water stream. Offsite detections of the combined process wastewater signature were only observed where releases are presently discharging into the Old Outfall 002, the Cape Fear River and Willis Creek (Figure 2, Table 4). Leaking sewers, the terracotta pipe and other potential direct releases of process water onsite lead to infiltration of process water through soil onsite to groundwater with eventual discharge to onsite groundwater seeps, Old Outfall 002, Willis Creek and the Cape Fear River.

3.6.3 Comparison of Aerial vs. Process Water Signatures

Process water signatures are confined to detections onsite in groundwater while aerial signatures are found offsite and onsite (Figure 2 and Table 4). Process water signatures are associated with much higher concentrations over approximately one square mile. Meanwhile, the aerial PFAS signature are diffuse, at lower concentrations over a 70+ square mile area. The Cape Fear River downstream of the Site has a process water signature based on loading to the river primarily coming from pathways with a process water signature (onsite seeps, Old Outfall 002 and onsite groundwater); historical process water releases are estimated to account for between 76% to 86% of the Table 3+ PFAS detected in the Cape Fear River, with the remainder of 14% to 24% coming almost entirely from historical air process releases.

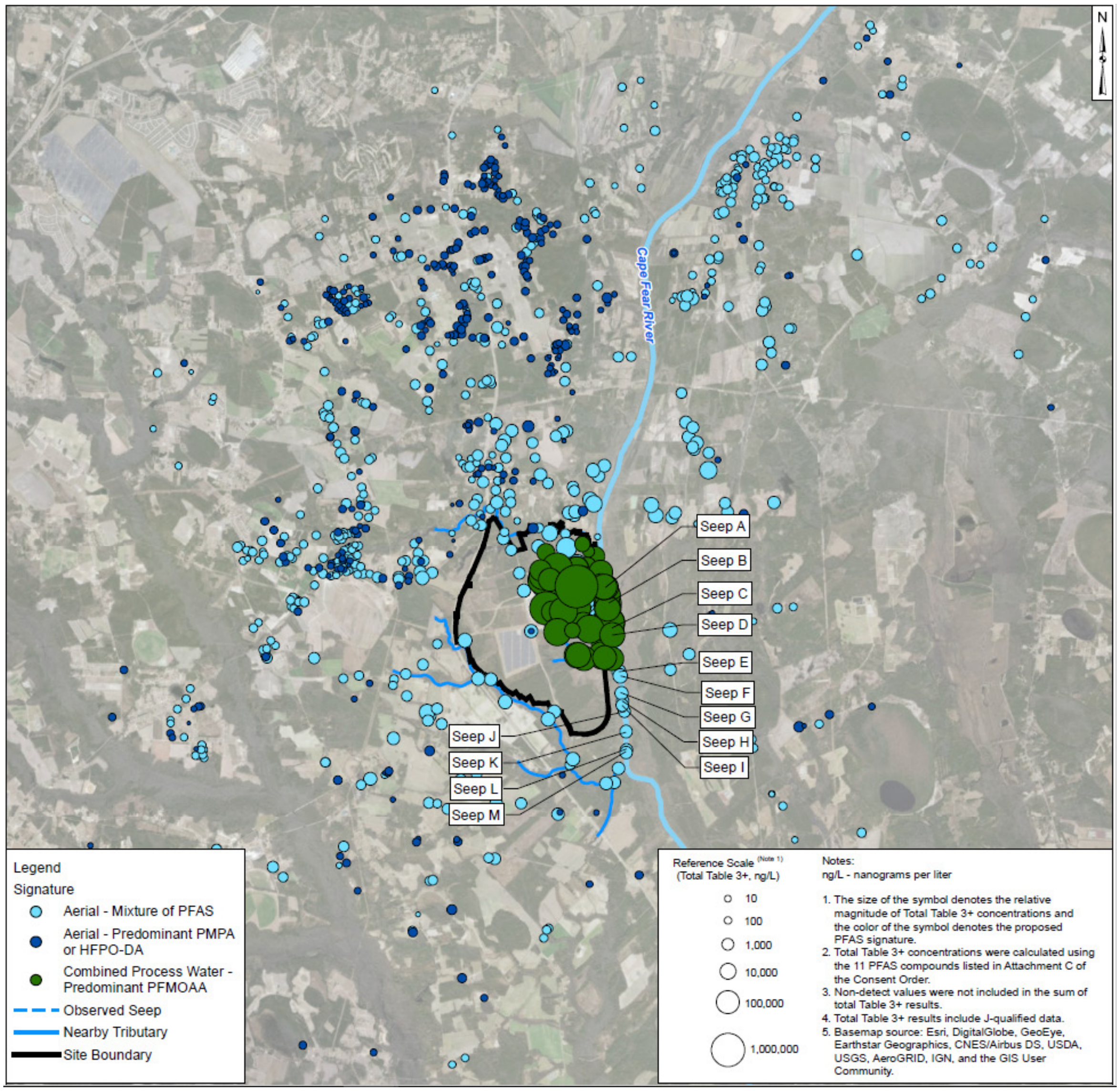

Figure 2: PFAS Signatures by Primary Source

Table 4: PFAS Source Types

Characteristic	Historical Source Type	
	Emissions to Air	Process Water Releases
PFAS Signature	Aerial	Process Water
Detected Onsite	Yes	Yes
Detected Offsite	Yes	No
Estimated Area over which Signature is Detected (mi^2)[1]	70+	1
Onsite Total Table 3+ Concentration Range of Detections (ng/L)[2,3]	15 to 13,000	2,900 to 18,000,000
Offsite Total Table 3+ Concentration Range of Detections (ng/L)[4]	10 to 4,500	NA
Percentage Table 3+ Loading to Cape Fear River	14% - 24%	76% - 86%

Notes:

1 - The estimated area with offsite Table 3+ PFAS detections may increase in the future as the offsite private well sampling program continues per CO Paragraph 21 requirements.
2 - For aerially deposited PFAS onsite, the range of detections considered wells located hydraulically upgradient from process water releases; some process water releases had similar PFAS patterns to aerially deposited PFAS. The low and high concentration wells identified were PW-12 and SMW-11, respectively.
3 - For process water PFAS releases onsite the low and high concentrations wells were MW-28 and PIW-14 respectively.
4 - For aerially deposited PFAS off site, low and high concentrations came from private well sampling data. No process water release signatures were detected in offsite groundwater.

3.7 Table 3+ PFAS Mass Distribution

An analysis was performed to determine if Table 3+ PFAS mass was primarily found in the unsaturated zone or in the saturated zone. This analysis was conducted to help evaluate the potential relative benefit between corrective action for unsaturated zone versus saturated zone.

The analysis indicated Table 3+ PFAS mass is predominantly found in the saturated zone at both onsite and offsite locations. This finding was developed by comparing the total mass in a normalized volume (i.e., one cubic meter) of the unsaturated zone (PFAS mass in pore water plus PFAS mass sorbed on unsaturated soil) to the total mass in the same normalized volume (one cubic meter) of the saturated zone (PFAS mass in groundwater plus PFAS mass sorbed on saturated soil) for samples taken from the same location.

The total Table 3+ PFAS mass in a normalized volume of one cubic meter was estimated as follows:

- In the unsaturated zone - the total Table 3+ PFAS mass was estimated using unsaturated soil sample data (unsaturated soil samples are assumed to include both PFAS sorbed on the soil material and PFAS in water content present in the soil sample at the time of collection);
- In the saturated zone - the total Table 3+ PFAS mass was estimated by summing Table 3+ PFAS mass in saturated soil and groundwater. The mass of PFAS in saturated soil was estimated from groundwater data and partitioning calculations. Measured fraction organic carbon (f_{oc}) values and calculated K_{oc} values were used to estimate the mass of PFAS sorbed to soil from which the groundwater sample originated. Values used for f_{oc} were the median value for each lithological unit for both onsite and offsite samples using data presented in the On and Offsite Assessment report (Geosyntec, 2019a). For this assessment, non-detect data were not included.

Results were divided into offsite and onsite locations (Figure 3). The total PFAS mass per cubic meter is higher, by up to almost 4 orders of magnitude (note the vertical axis is logarithmic), in the saturated zone than in the unsaturated zone, except at PW-12 and Cumberland-4S. The detailed calculations behind this assessment are provided in Appendix C. Overall, the results of this assessment indicate that the PFAS mass on and offsite is likely primarily located in the saturated zone.

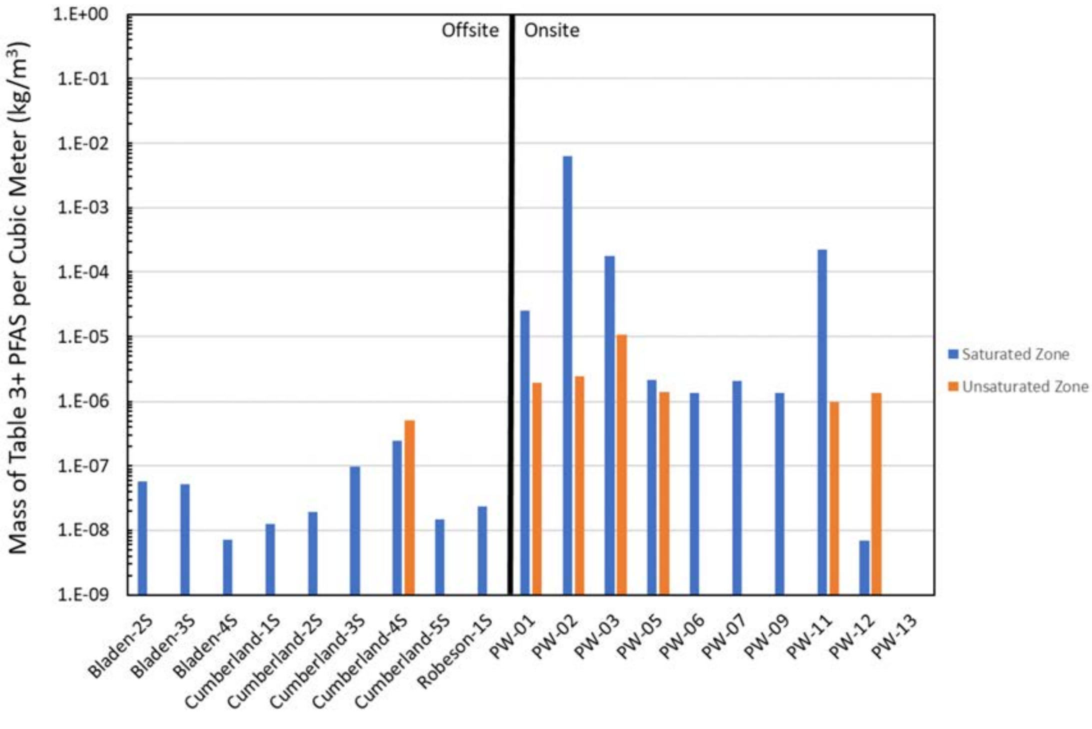

Figure 3: Total PFAS Mass Distribution in a Normalized Volume of the Saturated and Unsaturated Zones

3.8 Table 3+ PFAS Contaminant Retardation

Table 3+ PFAS transport in the subsurface will experience a certain degree of retardation, i.e. slower transport than groundwater as the compounds interact with the aquifer materials. The retardation factor describes how much slower transport will be for a compound compared to groundwater flow. For instance, a compound with a retardation factor of 2 is expected to be transported at only half the rate of groundwater flow (i.e. twice as slow). When combined with groundwater travel time estimates, retardation factors enable estimating travel times for compounds in the subsurface.

Retardation factors were estimated for compounds PFMOAA, PMPA, PEPA, HFPO-DA, PFESA-BP2 and PF5ODA in each of the three saturated zones at Site (Perched Zone, Surficial Aquifer and Black Creek Aquifer). These five compounds spanned the range of estimated K_{oc} values presented in section 3.2.2. Retardation factors were calculated only for saturated zone transport following the work of Brusseau et al., 2019. Chemours is developing and reviewing literature data sets to enable quantitative estimates of unsaturated zone transport retardation factors. The saturated zone retardation factors were calculated as follows:

$$R = 1 + \frac{K_d \rho_b}{\theta_w} = 1 + \frac{K_{oc} f_{oc} \rho_b}{\theta_w}$$

Where:

- R is the retardation factor;
- K_d is the soil-water distribution coefficient;
- K_{oc} is the organic carbon-water distribution coefficient;
- f_{oc} is the fraction of organic carbon in the soil;
- ρ_b is the soil bulk density; and
- θ_w is the volumetric water content (i.e. the fraction of soil porosity filled with water).

The f_{oc} , ρ_b and θ_w used in the calculation for each saturated zone unit are presented below in Table 5. The K_{oc} values used in the calculation and the estimated retardation factors are presented below in Table 6.

Table 5: Soil Property Values

Soil Property	Perched Zone	Surficial Aquifer	Black Creek Aquifer
Median f_{oc}	0.0013	0.0012	0.0034
Median ρ_b (kg/L)	1.45	1.50	1.56
θ_w	100%	100%	100%

The retardation factor estimates suggest in the saturated zone approximately half of the Table 3+ PFAS will experience minimal retardation where travel times will be similar to groundwater travel times; i.e. factors were close to 1. The largest estimated retardation coefficient was for PFO5DA with retardation coefficients calculated to range between 1.7 to 2.9, meaning transport in groundwater will be up to three times as slow as groundwater travel times. The variation in calculated retardation coefficients between aquifer units is primarily a result of differences in fraction of organic carbon values used in the calculations between the different saturated zones. A higher fraction of organic carbon results in a greater degree of retardation; there is more sportive material for the PFAS to interact with during transport. The variation in retardation coefficients between compounds is related to the degree of sorption the compound will experience as described by the K_{oc} value. Overall, the Table 3+ PFAS are estimated to be relatively mobile in saturated zone conditions. These retardation factor estimates can be refined using Site specific measurements of K_{oc} and K_d and evaluating the effects of matrix storage on retardation (i.e. dual phase porosity). These present and future refined estimates of retardation factors can be used to estimate groundwater travel times for flow paths of interest.

Table 6: Calculated Groundwater PFAS Transport Retardation Factors

Compound	Log K_{oc} (L/kg)	Calculated Retardation Factor		
		Perched Zone	Surficial Aquifer	Black Creek Aquifer
PFMOAA	0.89	1.0	1.0	1.0
PMPA	1.02	1.0	1.0	1.1
PEPA	1.35	1.0	1.0	1.1
HFPO-DA	1.69	1.1	1.1	1.3
Byproduct 2	1.96	1.2	1.2	1.5
PFO5DA	2.56	1.7	1.6	2.9

3.9 Actions and PFAS Reductions to Date

Actions already implemented by Chemours have reduced yearly HFPO-DA mass loadings from the facility to the environment by at minimum 5,150 pounds per year (lbs/yr) compared to pre-June 2017 emissions and discharges (Geosyntec 2019g). Air emission reductions to date, on an annualized basis for 2019, have resulted in an estimated yearly reduction of 2,150 pounds of HFPO-DA, a greater than 93% reduction. Cessation of Chemours process water discharge to Outfall 002 resulted in at minimum an estimated yearly reduction of 3,000 lbs/yr of HFPO-DA. These actions have reduced HFPO-DA mass loadings, through Outfall 002, by over 99% from June 2017 levels (Geosyntec 2019g). This has resulted in substantial reductions of HFPO-DA to the Cape Fear River. Present estimates of HFPO-DA mass loading to the Cape Fear River from all pathways are between 64 and 129 lbs/yr. This represents a 95% reduction in mass loading to the Cape Fear River from all pathways (Geosyntec 2019g) achieved with remedial measures implemented to date.

Chemours has also implemented multiple actions to further reduce loading of PFAS to the Cape Fear River as outlined in the Reduction Plan (Geosyntec, 2019d).

These reductions will be further enhanced by the operation of the Thermal Oxidizer, which will dramatically reduce aerial PFAS emissions from the Site, with reduction of aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, and expected comparable reductions for other PFAS, and the actions proposed in this plan will further reduce HFPO-DA and other PFAS loadings to the environment.

Actions outlined in this CAP are intended to address PFAS that is present in soil and groundwater from historical operations.

3.10 Present PFAS Mass Loading to the Cape Fear River

Table 3+ PFAS originating from the Site may reach the Cape Fear River via nine possible pathways identified in the Cape Fear Mass Loading Model Report (Geosyntec, 2019g). These pathways are shown in Figure 4 and listed below as follows:

Transport Pathway 1: Upstream Cape Fear River and Groundwater – pathway is comprised of contributions from non-Chemours related PFAS sources on the Cape Fear River and tributaries upstream of the Site, and upstream offsite groundwater with Table 3+ compounds present from aerial deposition

Transport Pathway 2: Willis Creek – Groundwater and stormwater discharge and aerial deposition to Willis Creek and then to the Cape Fear River

Transport Pathway 3: Direct aerial deposition of PFAS on the Cape Fear River;

Transport Pathway 4: Outfall 002 – Comprised of (i) water drawn from the Cape Fear River and used as non-contact cooling water, (ii) treated non-Chemours process water and (iii) Site stormwater which are then discharged through Outfall 002;

Transport Pathway 5: Onsite Groundwater – Direct upwelling of site groundwater to Cape Fear River from Black Creek Aquifer;

Transport Pathway 6: Seeps – Groundwater Seeps (currently identified seeps are A, B, C and D) above the Cape Fear River water level on the bluff face from the facility that discharge into the Cape Fear River;

Transport Pathway 7: Old Outfall 002 – Groundwater discharge to Old Outfall 002 and stormwater runoff flows into the Cape Fear River;

Transport Pathway 8: Adjacent and Downstream Groundwater – Offsite groundwater adjacent and downstream of the Site upwelling to the Cape Fear River; and,

Transport Pathway 9: Georgia Branch Creek – Groundwater, stormwater discharge and aerial deposition to Georgia Branch Creek and then to the Cape Fear River.

Total Table 3+ PFAS loading to the Cape Fear River has been estimated using a combination of measured and estimated data to develop mass loading estimates by pathway. Data inputs for the mass loading model were collected in May, June and September 2019. Results from the May and June sampling events were previously reported in the Cape Fear Mass Loading Model Report (Geosyntec, 2019g). The mass loading model was updated using the same framework as previously described (Geosyntec 2019 g) for the September mass loading sampling event. The analytical data and supporting figures presenting the September data are provided in Appendix B. The mass loading model reporting will be updated in 2020 to incorporate data from the numerical model and be part of the integrated monitoring and assessment activities described in Section 7.

The mass loading model is calibrated and evaluated against observed downstream river PFAS mass loadings. The mass loading model estimates that the Old Outfall 002 and Seeps (Transport Pathways 6 and 7 respectively) have the highest contribution of Table 3+ PFAS mass loading to the Cape Fear River. These two pathways (Transport Pathways 6 and 7) combined are estimated to contribute most of the loading to the Cape Fear River, with totals between 53% and 69% based on May, June and September results (Table 7). Onsite groundwater (Transport Pathway 5) is the next highest mass loading pathway to the Cape Fear River with estimated loading of between 14 and 22% based on May, June and September results.

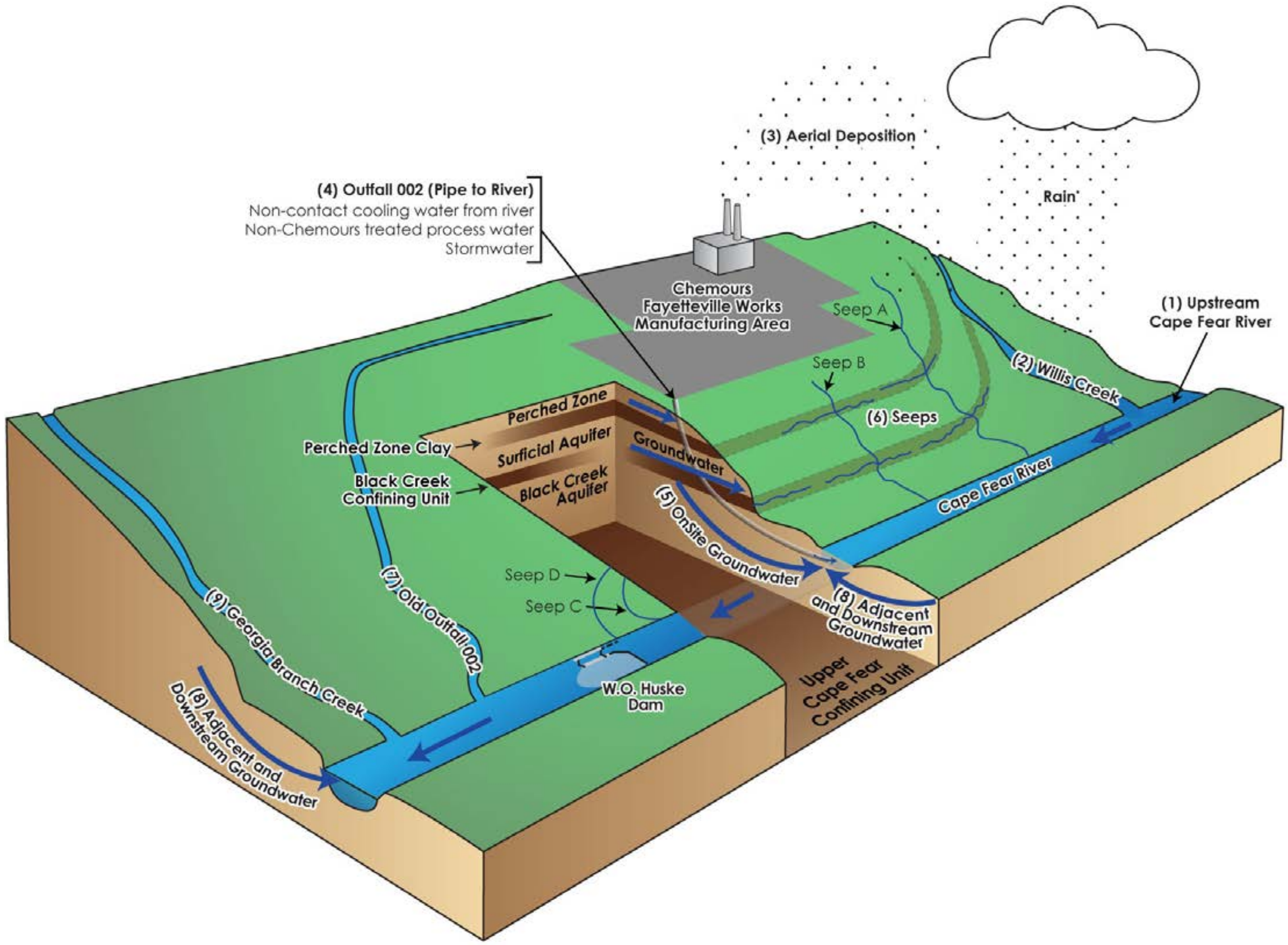

Figure 4: Schematic Conceptual Site Model of the Site Including Geological Layers, and PFAS Transport Pathways

Table 7: Mass Loading Model Total Table 3+ PFAS including HFPO-DA Contributions per Pathway

Pathway	Total Table 3+ Estimated Loading Percentage per Pathway per Event		
	May 2019 Event	**Jun. 2019 Event**	**Sep. 2019 Event**
[1] Upstream River Water and Groundwater	4%	15%	8%
[2] Willis Creek	10%	4%	3%
[3] Aerial Deposition on the River	< 2%	< 2%	< 2%
[4] Outfall 002	4%	7%	4%
[5] Onsite Groundwater	22%	17%	14%
[6] Onsite Groundwater Seeps (Seeps A, B, C, D)	32%	24%	42%
[7] Old Outfall 002	23%	29%	27%
[8] Offsite Adjacent and Downstream Groundwater	< 2%	< 2%	< 2%
[9] Georgia Branch Creek	4%	3%	2%

For the Transport Pathways, the loading estimates will vary over time due to a range of potential factors, including but not limited to:

- Detections of PFAS at or near analytical practical quantitation limits have more variability;
- Elevated method reporting limits;
- Standard uncertainty (often ± 20%) in analytical laboratory results;
- Flow rate estimates in the river, seeps, groundwater and creeks are over- or under-predicted compared to actual flow rates.

Chemours will continue to integrate additional sampling data to the mass loading model. Quarterly mass loading sampling will continue to be collected as part monitoring activities described later in Section 7.

4 RECEPTOR INFORMATION

In support of the CAP objectives, Chemours directed Geosyntec to perform a receptor survey as described in the On and Offsite Assessment (Geosyntec, 2019a), a Human Health SLEA, and an Ecological SLEA (SLEA: Screening Level Exposure Assessment). The SLEAs identify potentially complete exposure pathways by which human and ecological receptors may be exposed to PFAS in the environment and use intake models to calculate and rank exposure potential for exposure media such that future evaluations and/or risk management decisions are focused on the most significant contributors of overall human and ecological exposure. The human and ecological SLEAs are provided in Appendices G and H respectively. The following subsections describe the results of a receptor survey and the results from the SLEAs.

4.1 Receptor Survey Results

4.1.1 Wells and Wellhead Protection Areas

As reported in the On and Offsite Assessment (Geosyntec, 2019a), 75 public/community wells and 926 private wells have been identified in the counties surrounding the Site (see Figure A5-1). Community wells are those that serve more than one household. The full extent of offsite PFAS contamination originating from the Site is still being assessed. As such the number of identified private wells is expected to increase. There is limited availability of drilling records including logs and installation depths for many private wells. The geological and hydrogeological settings where these well receptors are present are described, to the extent possible, in Section 3.1. The offsite groundwater monitoring wells installed in August and September 2019 are described in the On and Offsite Assessment Report (Geosyntec, 2019a). Public/community wells identified are listed in Table A5-1, along with their locations, depths, usage, and distance from the Site. Private wells shown on Figure A5-1 are not included in Table A5-1 in order to protect the privacy of well owners. Surrounding property owners are similarly not identified for privacy reasons.

Wellhead protection areas, as defined in the Safe Drinking Water Act: 42 U.S. Code § 300h–7, surrounding the Site are identified in Figure A5-2. According to publicly available data, there is one wellhead protection area in the extent of Figure A5-2, including three municipal water supply wells (PWS ID 03-78-030). Daily water extraction from these wells taken together ranges from 0.18 to 0.30 million gallons per day (MGD). Further details available regarding these wells in the wellhead protection area is provided in Table A5-1.

4.1.2 Surface Water Receptors

Surface waters in the region surrounding the Site include the Cape Fear River, tributaries, ponds, swamps and marshes, and several small streams and ditches. Figure A5-3 identifies named surface water bodies from the USGS National Hydrography Dataset surrounding the Site. Sampling of the Cape Fear River and tributaries to the Cape Fear River has been performed as part of multiple site investigation activities. Sampling of ponds and tissues of fish from the Cape Fear River and one onsite pond has been performed for the Human Health and Ecological SLEAs. These SLEAs are described in the following sub-sections.

4.1.3 Mitigation Measures/Point of Use Treatment

Pursuant to CO Paragraphs 19 to 25 (Compliance Measures - Replacement Drinking Water Supplies), Chemours is implementing a Drinking Water Compliance Plan (Parsons, 2019a). Through this plan, Chemours is providing replacement drinking water to private residents whose drinking water wells are impacted by PFAS listed in Attachment C of the CO. Replacement drinking water is being provided through a range of options depending on the levels of PFAS found as required and defined in CO Paragraphs 19 and 20.

4.2 Human Health SLEA

An Offsite Human Health Screening Level Exposure Assessment (HH-SLEA) was completed to quantify exposure of offsite human receptors to Table 3+ PFAS. The HH-SLEA quantifies exposures of offsite human receptors to released Table 3+ PFAS for several receptor-exposure scenarios and provides a provisional human health hazard characterization for HFPO-DA based on quantified intakes and the North Carolina Department of Health and Human Services (NC DHHS) 2017 draft oral reference dose (RfDo). The HH-SLEA is attached to this document as Appendix F. The subsections below summarize the key components of the HH-SLEA.

Calculated hazards for HFPO-DA for all receptor-exposure scenarios evaluated in the SLEA were less than 1 which, as defined by the United States Environmental Protection Agency (USEPA), indicates adverse effects to human receptors are unlikely, including sensitive subpopulations. Untreated well water was identified as the primary source of potential PFAS intake and hazard. Additionally, when the HH-SLEA accounts for the effectiveness of the Chemours-provided drinking water treatment systems that are currently in-place, PFAS intake via drinking water and associated hazards are substantially reduced and may be as low as zero. While other media were not identified as significantly contributing to overall intake and hazard, human exposure to PFAS in environmental media will continue to decrease over time as a result of Facility air emissions reductions.

4.2.1 Receptors and Exposure Pathways

At the Site, human activities are limited to facilities operations and maintenance, office workers, and environmental monitoring activities. In the area surrounding the Site, there are a wide range of human and land use activities, including private residences, farms, commercial businesses, and recreational areas. Based on the Site setting, the HH-SLEA intake characterization quantifies Table 3+ PFAS intake for the receptor-exposure scenarios identified below. These exposure pathways are assumed to be complete for the purposes of the HH-SLEA but some or all related exposure pathways may be incomplete for an actual offsite receptor. For example, the HH-SLEA assumes gardeners and farmers only consume fruits and vegetables that are homegrown whereas, in reality, most people also (or exclusively) consume store-brought fruits and vegetables grown in a variety of locations. Based on the Site setting, the HH-SLEA intake characterization quantifies Table 3+ PFAS intake for the receptor-exposure scenarios identified below:

1. Residents (adult and child) were assumed to be exposed to surface soil via incidental ingestion; untreated well water as drinking water via ingestion; current conditions well water as drinking water via ingestion; and untreated Cape Fear River surface water from Bladen and Kings Bluffs intakes as drinking water via ingestion.
2. Farmers (adult and child) were assumed to be exposed to surface soil via incidental ingestion; untreated well water as drinking water via ingestion; current conditions well water as drinking water via ingestion; and, aboveground leafy vegetables (e.g., lettuce), aboveground fruits (e.g., tomatoes), and belowground vegetables (e.g., carrots) via ingestion.
3. Gardeners (adult and child) were assumed to be exposed to surface soil via incidental ingestion; untreated well water as drinking water via ingestion; current conditions well water as drinking water via ingestion; and, aboveground leafy vegetables (e.g., lettuce), aboveground fruits (e.g., tomatoes), and belowground vegetables (e.g., carrots) via ingestion.
4. Recreational Canoeists/Swimmers (adult and child) were assumed to be exposed to surface water via incidental ingestion.
5. Recreational Anglers (adult and child) were assumed to be exposed to fish tissue fillets via ingestion.

4.2.2 Intake Characterization

For the purposes of the HH-SLEA, the upland portion of the offsite study area was conceptualized as 12 exposure units (EUs). These EUs were defined by three concentric circles originating from the approximate center-point of the Facility that correspond to radial distances of 2.5, 5, and 10 km; these circles were then bisected north-to-south and east-to-west into four quadrants (see Figure 3 of the HH-SLEA). Five EUs were defined within the Cape Fear River: 10 miles upstream, site-adjacent, 4 miles downstream, 8 miles downstream (Bladen Bluffs), and 55 miles downstream (Kings Bluffs). Finally, an onsite pond and offsite pond were also identified as EUs for evaluation in the SLEA.

Potential PFAS intake from each medium for relevant receptors was estimated using standard regulatory risk assessment equations that combine receptor-specific exposure assumptions recommended by USEPA with media-specific exposure point concentrations (EPCs). Receptor-specific exposure assumptions represent a "reasonable maximum exposure" (RME) scenario and are detailed in Appendix F of the HH-SLEA. Two EPCs were calculated: a central tendency exposure (CTE) EPC represented by the mean concentration and an upper-bound, RME EPC represented by the 95% upper confidence limit on the mean (UCL). If the data did not support calculation of a UCL, the maximum detected concentration was selected as the EPC to support the RME condition.

EPCs for soil, well water, surface water and fish fillets were calculated using empirical data; EPCs for produce were calculated using approved USEPA models. The empirical data used to calculate EPCs in the HH-SLEA are summarized below and presented in Appendix B of the HH-SLEA report.

- *Soil*. The HH-SLEA evaluated offsite surface soil data collected between July and September 2019 from the 12 upland EUs. In each EU, 30 discrete soil aliquots were collected from 0 to 6 inches below ground surface and aggregated into a single composite sample submitted for laboratory analysis that is considered representative of the EU.
- *Well Water*. The HH-SLEA evaluated untreated well water collected between September 2017 and October 2019 from private residences located within the 12 upland EUs. The maximum concentration of each target analyte for each well was included in the HH-SLEA. In many cases, untreated well water is not representative of current drinking water conditions. Therefore, a Current Conditions well water exposure scenario was also quantified, which considers the requirements of the CO for providing replacement drinking water and treatment systems. The Current Conditions intake characterization scenario incorporates an assumption 70 ng/L total PFAS in untreated groundwater to address the scenario where no drinking water treatment may have been required; the Current Conditions hazard characterization incorporates an assumption of 10 ng/L HFPO-DA.
- *Surface Water*. The HH-SLEA evaluated surface water data collected by Chemours from the Cape Fear River between September 2017 and September 2019, from an onsite pond in July 2019, and an offsite pond in September 2019. Additionally, the HH-SLEA evaluated raw surface water data collected by the NC DEQ from the Bladen Bluffs intake point on the Cape Fear River between June

and July 2017 and raw surface water data collected by the CFPUA from the Kings Bluffs intake point on the Cape Fear River between September 2018 and October 2019.

- *Fish Tissue*. The HH-SLEA evaluated fish fillet data collected by Chemours from the Cape Fear River and onsite pond between July and September 2019.

4.2.3 Hazard Characterization

The estimated intakes of HFPO-DA were also used to calculate provisional quantitative estimates of potential noncarcinogenic hazard based on the RfDo of 1E-04 milligram per kilogram per day (mg/kg-day) adopted by the NC DHHS. The ratio of intake to the RfDo is defined as the hazard quotient (HQ). An HQ greater than unity (1) was used as the benchmark for identifying potentially unacceptable hazard.

There are other published RfDo values available that may better reflect the toxicological profile of HFPO-DA but a detailed evaluation of the uncertainties associated with these values was outside the scope and objectives of the HH-SLEA. Therefore, the HH-SLEA relied upon the determination from the NC DHHS that, in a regulatory context, the RfDo is protective of human health. Because regulatory risk assessment generally “errs on the side of caution,” it must be reiterated that this (or any) RfDo is not predictive of an actual health outcome. As additional toxicological data become available, it may be appropriate to review the hazard characterization results.

4.2.4 HH-SLEA Results

The results of the HH-SLEA intake characterization and provisional hazard characterization are presented in Table 3 of the HH-SLEA and summarized below.

The HH-SLEA identifies untreated well water as the primary source of potential PFAS intake, accounting for over 92% of RME intake for residents, farmers, and gardeners. Additionally, when the HH-SLEA accounted for the effectiveness of the Chemours-provided drinking water treatment systems that are currently in-place, PFAS intake via drinking water was substantially reduced and may be as low as zero. While other media were not identified as significantly contributing to overall intake, human exposure to PFAS in all environmental media will continue to decrease over time as a result of Facility air emissions reductions. As described further below, calculated hazards for HFPO-DA for all receptor-exposure scenarios evaluated in the HH-SLEA were less than 1 which, as defined by USEPA, indicates adverse effects to human receptors are unlikely, including sensitive subpopulations.

Calculated HQs were less than 1 for residents, farmers, and gardeners exposed to soil, produce, and well water in EU1 through EU12, indicating potential HFPO-DA exposure is unlikely to pose a hazard, even in the absence of drinking water treatment. The estimated HQ from untreated well water consumption accounted for 92% or more of total

RME hazard for each receptor. As stated previously, the use of untreated well water to calculate domestic use likely overstates the population's potential exposure, as treatment systems provided by Chemours have reduced PFAS in drinking water to below detection limits. HQ estimates based on an assumption of 10 ng/L of HFPO-DA in drinking water, which is the maximum concentration in well water that would not require a treatment system, range from 0.003 to 0.07 and, hence are more than an order of magnitude below a level of concern (unity or 1). This indicates that there are no hazards to populations of offsite residents, farmers, and gardeners under current conditions, based on HFPO-DA.

Calculated HQs are less than 1 for recreationalists exposed to surface water and fish tissue in the vicinity of the Site, indicating potential HFPO-DA exposure in the Cape Fear River and nearby ponds does not pose an unacceptable hazard to recreationalist populations. The highest HQs (0.08 to 0.1) were driven by consumption of fish from the downstream EU16 at Bladen Bluffs; otherwise, HQs were less than 0.01, indicating there are no hazards to recreationalist populations.

Calculated HQs were less than 1 for domestic use intakes of Cape Fear River untreated surface water from Bladen Bluffs (EU16) and Kings Bluffs (EU17), indicating potential HFPO-DA exposure in surface water does not pose a hazard to residential consumers.

4.2.5 HH-SLEA Uncertainties

Uncertainties are inherent in the process of quantifying exposure (and hazard) due to the use of environmental sampling results, assumptions regarding receptor behavior, and the quantitative representation of chemical toxicity. Therefore, assumptions used in the HH-SLEA aimed to provide additional conservatism where there was significant uncertainty. Key uncertainties identified for the HH-SLEA are summarized below and a more comprehensive list is provided in the HH-SLEA report.

- Toxicity Data. The SLEA provisional hazard characterization is based on the HFPO-DA RfDo of 1E-04 mg/kg-day adopted by the NC DHHS, which is predicated on liver toxicity endpoints from two subchronic studies in mice. There is inherent uncertainty in the use of animal toxicity data to characterize potential human health hazards and the RfDo could potentially change as new information becomes available. Others have used the available toxicological data to develop alternative toxicity values, including a probabilistic RfDo of 1E-02 mg/kg-day developed by Thompson, et al. (2019) and a draft RfDo of 8E-05 mg/kg-day developed by USEPA. Notably, RME hazard indices for the maximally-exposed populations for each EU that are predicated on use of the NC DHHS, USEPA and Thompson RfDo values are equal to or less than 1, indicating no exceedance of available health benchmarks or of USEPA's threshold for identifying a potential human health hazard, even in the absence of drinking water treatment. In addition to the uncertainty associated with the HFPO-DA RfDo, the lack of toxicity information for other Table 3+ PFAS also introduces uncertainty to the HH-SLEA but data are not available to evaluate the potential effect, if any, on the conclusions hazard characterization.

- Laboratory Analytical Limits. For groundwater and surface water, the reporting limits (RLs) for Table 3+ PFAS were below the State's provisional health goal for HFPO-DA in drinking water of 140 ng/L, indicating the method is sufficiently sensitive for identifying concentrations that may potential pose a human health hazard. The HH-SLEA also demonstrated that methods for analyzing HFPO-DA in soil and fish tissue are sufficiently sensitive to estimate exposures that could pose a potential human health hazard based on comparisons to the NC DHHS HFPO-DA RfDo.
- Media-Specific EPCs. The SLEA was prepared to provide a screening-level evaluation of intake on a regional basis. As such, the EPCs evaluated herein are not representative of a specific exposure point. Use of EPCs based on upper-bound estimates of concentration (i.e., 95% UCLs and maximum detected concentrations) reduces the likelihood that potential intake and hazard were underestimated.
- Well Water EPCs. The primary source of uncertainty associated with well water EPCs used in the HH-SLEA was the use of untreated well water data, which does not reflect current conditions; however, even this conservative evaluation of potential intake resulted in HQs less than 1. HQs calculated for current conditions are substantially lower.
- Soil EPCs. Reliance upon a single composite soil sample in each EU is a source of uncertainty but, given that incidental soil ingestion accounts for less than 1% of the total intake of Table 3+ PFAS, it is unlikely that this uncertainty affects the overall conclusions of the HHSLEA.

The HH-SLEA demonstrates no unacceptable hazards to human receptors are anticipated from current exposures to HFPO-DA in offsite environmental media. While there are uncertainties associated with the analyses supporting the HH-SLEA conclusions, where uncertainty is evident, conservative assumptions were used (e.g., use of untreated well water, upper-bound estimates of exposure, and toxicity estimates that are two orders of magnitude higher than those developed by others). Hence, the uncertainty assessment supports that the HH-SLEA can be used to inform risk management decisions.

4.3 Ecological SLEA

Chemours performed an Ecological Screening Level Exposure Assessment (Ecological SLEA) to quantify exposure of terrestrial and aquatic ecological receptors to Table 3+

PFAS and evaluate potential hazards related to HFPO-DA. The Ecological SLEA is attached to this document as Appendix G. The Ecological SLEA evaluation indicated there were no unacceptable adverse effects expected from HFPO-DA exposures. The full details of the Ecological SLEA are described in the *Ecological Screening Level Exposure Assessment (SLEA) of Table 3+ PFAS* report provided in Attachment F.

4.3.1 Receptors and Exposure Pathways

The ecological Conceptual Site Model (CSM) reflects the potential exposure of receptors to Table 3+ PFAS, including aquatic life in the Cape Fear River and tributaries, aquatic dependent wildlife foraging in the Cape Fear River and banks, terrestrial plant and invertebrate communities, and herbivorous and invertivore wildlife and carnivorous wildlife. Exposures may potentially occur to Table 3+ PFAS via surface soil, surface water and sediment, along with potential exposures via diet items for Table 3+ PFAS that may accumulate in plants, invertebrates and fish. Representative wildlife receptors were selected to represent various feeding guilds for terrestrial birds and mammals (herbivore, invertivore) and aquatic-dependent birds and mammals (herbivore, invertivore, piscivore).

4.3.2 Exposure Quantification

Field investigations included collection of onsite and offsite soils, invertebrates and offsite vegetation, and sediment, vegetation, fish and clams from the Cape Fear River for analysis of Table 3+ PFAS. These data were used to quantify exposures to selected mammalian and avian receptors and evaluate the potential for adverse effects to wildlife from current exposures to HFPO-DA. Site-specific doses for all Table 3+ PFAS were calculated for all terrestrial and aquatic-dependent wildlife receptors (birds and mammals). Ingested doses are presented in daily dose rates per unit of body weight (mg/kg-day) and referred to as total daily intake (TDI). Terrestrial wildlife was assumed to be exposed to Table 3+ PFAS via incidental ingestion of soil during foraging, consumption of surface water and consumption of food/prey items that have accumulated Table 3+ PFAS. Aquatic wildlife receptors were assumed to be exposed to Table 3+ PFAS via incidental ingestion of sediment, consumption of surface water and consumption of food/prey items that have accumulated Table 3+ PFAS. The estimated TDI for each receptor was calculated using generic dose formulas from the Wildlife Exposure Factors Handbook (USEPA, 1993), as well as receptor-specific exposure factors as discussed in the Ecological SLEA Section 3.

4.3.3 Ecological SLEA Results

The empirical data collected under the Ecological SLEA and HH-SLEA indicated 17 of 20 Table 3+ PFAS were present in detectable concentrations in onsite soils, invertebrates, terrestrial and aquatic vegetation and/or fish, with only two Table 3+ PFAS detected in sediment, benthic invertebrates and offsite soils. Samples collected from on-site locations had higher PFAS concentrations relative to samples collected from the Cape Fear River and offsite terrestrial areas. TDIs indicated predominant exposures are related to consumption of terrestrial and aquatic plants by herbivorous vertebrate wildlife like rabbits and muskrats. Terrestrial herbivores are primarily exposed to perfluoroethoxysulfonic acid (NVHOS) and PFMOAA. Aquatic herbivores in the Cape Fear River are primarily exposed to PFMOAA followed by Byproduct 4, Byproduct 5 and PMPA. Exposures for invertivores were lower than for herbivores, with exposures primarily associated with PMPA, Byproduct 4, Byproduct 5, and R-EVE offsite, and PFMOAA and Byproduct 4 onsite. Aquatic invertivores are not highly exposed based on the currently available dataset, and though exposure to aquatic piscivores does occur with exposed primarily associated with perfluoro(3,5,7,9-tetraoxadecanoic) acid (PFO4DA), PFMOAA and Byproduct 4.

No adverse hazards were identified to ecological receptors from current exposures to HFPO-DA. The Table 3+ PFAS with the highest exposures in the most-exposed ecological feeding guilds (herbivores) in both terrestrial and aquatic habitats were NVHOS, PFMOAA, PMPA, Byproduct4, and PFO2HxA. Fish-consuming receptors were most exposed to PFO4DA. As the primary exposures are related to the onsite seep areas and consumption of plants in the offsite area, source control of air emissions and discharges to the Cape Fear River will decrease exposures to ecological receptors.

4.3.4 Ecological SLEA Uncertainties

There are a number of uncertainties related to all SLEAs, based on the use of assumed parameters for ecological modeling, spatial variation of chemicals in media, and organism habitat use patterns, therefore the assumptions used in the Ecological SLEA aimed to provide additional conservatism, i.e., protectiveness where there was significant uncertainty. Specific key uncertainties in the Ecological SLEA include:

- Lack of Toxicity Information. This analysis was unable to assess hazards to exposed receptors for Table 3+ PFAS other than HFPO-DA due to the lack of Table 3+ PFAS specific TRVs (a testing program is presently in progress to evaluate toxicity of five additional Table 3+ PFAS [Chemours, 2019]);
- Use of practical quantitation limits (PQL) for Exposure Point Concentration. If a Table 3+ PFAS was detected in some media of an EU, it was carried forward in the quantification of exposures using the PQL as the EPC for media where that compound was not detected. The use of the PQLs as EPCs leads to overestimates of exposures.
- Large Carnivores. Larger ranging carnivores that consume small birds and mammals were not included in this evaluation as the collection of small bird and

mammal tissue samples to understand exposure to these receptors is a significant undertaking and was not feasible in the SLEA development timeframe.

- Sediment and Benthic Invertebrates. The sediment and benthic invertebrates (Asian clam) samples collected from the Cape Fear River were widely non-detect for Table 3+ PFAS. However, given the noted analytical sensitivities between soil and aqueous matrices and the lower organic carbon partitioning of Table 3+ PFAS, and that Asian clams are filter feeders with a lower level of sediment association than many other benthic invertebrates, there is uncertainty that this exposure route is under represented.

This Ecological SLEA demonstrates no adverse hazards to ecological receptors are anticipated from current exposures to HFPO-DA. This was done by including a number of conservative assumptions to address uncertainties when estimating exposure of ecological receptors to Table 3+ PFAS and estimating hazards from exposures to HFPO-DA.

5 NUMERICAL MODEL

5.1 Study Objectives

The objective of the numerical modeling of onsite groundwater was to develop a platform for use in the development and evaluation of remedial alternatives, including estimation of cost. In addition, the model in the future will aid in assessing the effectiveness of remedial implementation. The model is intended to be hydraulic only, to aid in assessment of pumping and recharge reduction approaches. Model details are provided in Appendix H.

5.2 Selection of Model

The model is required to simulate saturated and unsaturated flow behaviors at the Site. The steep topography surrounding the site is challenging to simulate, and therefore a finite element model was deemed to be more appropriate than a finite difference model. Various commercially available finite element models were assessed based on their ability to meet the study objectives, their maturity and acceptance in the scientific and regulatory communities, and the familiarity of the team with the code. Finite Element subsurface FLOW system (FEFLOW) (DHI-WASY) was the most suitable numerical model based on those criteria.

5.3 Model Construction

A three-dimensional (3D) hydrostratigraphic model of the Site was constructed using CTech Earth Volumetric Studio (EVS) software (https://www.ctech.com/products /earth-volumetric-studio/). The EVS model was developed to interpolate the hydrostratigraphic model, along the horizontal and vertical directions, and develop the model mesh for the numerical groundwater model.

The EVS geologic model was translated into a series of shape files representing each of the 7 hydrostratigraphic units. The shape files were assembled and meshed within FEFLOW using the triangle mesh generation algorithm. The mesh was further refined vertically to allow for more accurate simulation of vertical gradients and hydraulic processes in the vicinity of the bluffs leading to the Cape Fear River and Willis Creek. Overall the mesh contained 1,878,129 elements and 372,054 nodes. Details are presented in the incorporated modeling report.

5.3.1 Calibration

Calibration was performed using a sequenced trial and adjustment approach. Calibration variables consisted of rainfall recharge applied to the top boundary of the model, hydraulic conductivities of the Black Creek Aquifer, the Surficial Aquifer, the Perched

Clay, and the Perched Aquifer, as well as the formulation of the constant head condition on the western boundary.

Final model calibration resulted in a Normalized Root Mean Square (NRMS) error of 12.5%. This is considered satisfactory based on the scale of the model and its intended end use in costing and preliminary design focusing on hydraulics only (as opposed to contaminant fate and transport). The majority of the error in the calibrated model occurs in the Perched Zone and will have limited effect on the ability of the model to predict capture of groundwater discharge to the surface water bodies.

5.4 Predictive Simulations

The six most representative remedy simulations are presented below in Table 8. In total, 21 simulations were conducted using the calibrated model to aid in the evaluation of an appropriate groundwater remedy.

Table 8: Predictive Model Simulations

Simulation	Description	Total Extraction Rate (gpm)	Total Diverted Flow Rate (gpm)[1]	Number of Extraction Wells
1	Extraction wells at a 50-ft spacing (30 gpm) with no barrier wall	4,920	N/A	164
2	Extraction wells at a 200-ft spacing (20 gpm) with a barrier wall between the river and the extraction wells	820	569	41
3	Extraction wells at a 50-ft spacing (variable pumping between 20 to 40 gpm) with no barrier wall	4,430	N/A	164
4	Extraction wells at a 200-ft spacing (variable pumping between 20 to 30 gpm) with a barrier wall between the river and the extraction wells	930	491	41
5	Extraction wells at a 250-ft spacing (30 gpm) with a barrier wall between the river and the extraction wells	930	489	31
6	Extraction wells at a 250-ft spacing (variable pumping between 20 to 30 gpm) with a barrier wall between the river and the extraction wells	840	611	31

Notes:

N/A – not applicable.

[1] – Diverted flow accounts for the reduced discharge to the Cape Fear River due to the barrier wall.

The various simulations can be summarized as follows:

- Simulation 1 resulted in a large groundwater depression along the Cape Fear River in areas surrounding the pumping wells. A large portion of the extracted water was from the Cape Fear River.
- Simulation 2 resulted in minimal contributing flow from the Cape Fear River. Pumping wells create a groundwater depression in portions of the extraction wells.
- Simulation 3 reduced the groundwater depressions observed at higher pumping rates (simulation 1). Pumping wells still extract water from the Cape Fear River.
- Simulation 4 increased the groundwater capture along the extents of the barrier wall in comparison to simulation 2. The variable pumping rates minimized the groundwater depressions observed along portion of the extraction wells.
- Simulation 5 decreased the groundwater depressions observed along section of the barrier wall. However, in comparison to simulation 2 mounding was observed along section of the barrier wall. Also, a portion of the flow was not captured at the edges of the barrier wall.
- Simulation 6 increased pumping at the targeted extraction wells and increased the capture of flow at the extents of the barrier wall. However, in comparison to simulation 4 mounding was observed along section of the barrier wall.

The remedy modeling results indicate that without a barrier wall, the increase in total flow due to influx of Cape Fear River water makes these types of scenarios less feasible. The scenario that best meets the hydraulic containment objectives presented in Table 8 consists of an extraction well spacing of 200 feet, with pumping rates varying between 25 and 30 gpm per well. Ideally, there would be minimal drawdown to reduce the volume of water that requires treatment while also maintaining hydraulic containment. Additional aquifer tests would be required to assess the spacing and corresponding pumping rates.

The calibrated FEFLOW model meets the requirements of the NCDEQ 2007 Groundwater Modeling Policy (NCDEQ, 2007) and supports remedy evaluation, selection and design at the Site. The calibrated model is deemed sufficiently accurate for the modeling goals of this work however new data should be incorporated into both the conceptual and numerical models when it becomes available.

Numerical modeling is an effective technique for identifying areas of uncertainty in conceptual models and source-pathway-receptor models. Based on the results of the numerical modeling program, groundwater remedy development would be supported by reducing uncertainty regarding:

- Interactions between the Surficial Aquifer and the Black Creek Aquifer along the bluffs. Additionally; and
- Distribution of groundwater flows into surface water drainage features including onsite groundwater seeps, Willis Creek and Old Outfall 002.

A combination of additional simulations and targeted field investigations (aquifer testing) to address these uncertainties is recommended before selecting a final remedy for design.

6 PROPOSED CORRECTIVE ACTIONS

This section describes the proposed corrective actions to treat groundwater and surface water where these pathways are contributing PFAS loading to the Cape Fear River, including those actions proposed in the previous Paragraph 12 submittals: the August 2019 Reduction Plan and the November 2019 Reduction Plan – Supplemental Information Report. Together these corrective actions have been developed to meet the objectives and cleanup goals that are described in Section 6.1 and Section 6.2, respectively. The detailed development of potential remedial alternatives and evaluation of technical and economic feasibility that was provided in the Paragraph 12 submittals is not reproduced in this CAP, which rather focuses on further developing the groundwater and surface water remedies that were proposed for advancement. Table 9 provides a summary, by pathway, of the results of this screening process.

The remaining subsections below provide detailed discussion for these advanced groundwater and surface water alternatives in terms of design, construction, and operation; estimation of construction and operational costs; permits anticipated to be required; and sequencing and schedule. Performance monitoring of the remedies, compliance with CO Paragraph 16, and onsite and offsite groundwater quality monitoring are discussed in Section 7.

6.1 Corrective Action Objectives

The selection of corrective actions presented in this CAP is based on the CO's remedial requirements and management goals for the Site which are as follows:

- Reducing the total loading of PFAS originating from the Site to the Cape Fear River by at least 75 percent (%) from baseline (CO paragraph 16);
- Provide whole building filtration units and/or reverse osmosis units to qualifying surrounding residents (CO paragraphs 19 and 20);
- Comply with 2L Rules (CO paragraph 16), including following the policy for the intention of the 2L Rules "to maintain and preserve the quality of the groundwaters, prevent and abate pollution and contamination of the water of the state, protect public health, and permit management of the groundwaters for their best usage by the citizens of North Carolina" (15A NCAC 02L .0103); and
- Comply with other requirements of the CO.

Table 9: Summary of Remedial Alternatives Evaluation Process

Pathway	Retained for Further Development	Not Advanced in P12 Submittals
Direct Aerial Deposition	Air Emission Control Technologies	N/A
Old Outfall 002	Capture and Treat Old Outfall 002	N/A
Groundwater Seeps	*Interim and Long-Term*: Flow Through Cells and French Drains	PlumeStop™ at CFR and Willis Creek Seeps
Onsite Black Creek Aquifer Groundwater	*Interim*: Pumping from Existing Wells *Long-Term*: Onsite Barrier Wall with Hydraulic Containment	*Interim*: Pumping from Additional Extraction Wells *Long-Term*: Hydraulic Containment
Outfall 002	Sediment Removal Stormwater Pollution Prevention Plan Targeted Stormwater Control Terracotta Pipe Decommissioning Mitigation of Groundwater Intrusion	Treat all stormwater at Outfall 002 Treat all flows at Outfall 002
Willis Creek and Georgia Branch Creek	Air Emission Control Technologies Onsite Barrier Wall with Hydraulic Containment	Treat all Flows at Mouths PlumeStop™ along Creek Lengths
Offsite Groundwater	Air Emission Control Technologies	Offsite Barrier Wall with Hydraulic Containment

The Table 3+ PFAS compounds at the Site have only been recently considered for environmental remediation and the availability of treatment technologies is limited at this time. This is a rapidly evolving field and new technologies may become available. Chemours' implementation of actions for these goals may be refined as both remedial technologies for PFAS develop and a greater body of scientific understanding develops regarding PFAS originating from the Site.

6.2 Cleanup Goals and Standards by Media

Pursuant to the 2L Rules and CO requirements, this section describes the development of cleanup goals for surface water and groundwater on and offsite. This section begins by describing the factors influencing the developed clean up goals, then the cleanup goals by media are described, and lastly the potential need for alternative groundwater cleanup standards in the intermediate to long term future are discussed.

6.2.1 Cleanup Goal Factors

The cleanup goals were developed based on the following five factors:

- Time horizons (Near, Intermediate, Long-Term);
- Human health exposure considerations;
- Ecological exposure considerations;
- CO requirements; and
- 2L Rules.

First, cleanup goals were developed for near, intermediate and long-term time horizons. Near term goals reflect what can be accomplished in the next two years and have an emphasis on taking actions that lead to the greatest reduction in exposures to potential receptors. Intermediate goals reflect implementing long term remedial actions and reflect presently available technologies and approaches. Long term goals reflect the long-term operation and maintenance of remedial actions and recognize that advancements in the understanding of potential toxicity of compounds and abilities to remediate compounds may evolve and lead to refinement of cleanup goals.

Second, human health exposure considerations were considered. The HH-SLEA described in Section 4.2 demonstrated that at present human HFPO-DA exposures are estimated to be below the NC DHHS chronic, long-term exposure reference dose. Furthermore, the HH-SLEA demonstrated that supplying whole building filtration systems or reverse osmosis units for qualifying residents offsite is reducing HFPO-DA (and Table 3+ PFAS) intake by over 92% further ensuring human receptor exposures remain below hazard limits for HFPO-DA, based on the NC DHHS draft oral reference dose. Therefore, the current HH-SLEA findings do not necessitate the formation of a cleanup goal.

Third, ecological exposures were considered. The Ecological SLEA described in Section 4.3 demonstrated that present ecological exposures at and surrounding the Site to HFPO-DA are not expected to result in adverse effects to terrestrial and aquatic ecological receptors. Therefore, the current Ecological SLEA findings do not necessitate the formation of cleanup goals.

Fourth, CO paragraph 16 requires, at minimum, a 75% reduction in the loading of Table 3+ PFAS originating from facility to surface water (Old Outfall 002, Willis Creek, Georgia Branch Creek, and the Cape Fear River). The Cape Fear River receives discharge from Old Outfall 002, Willis Creek and Georgia Branch Creek, onsite seeps and onsite groundwater. Therefore, reducing Cape Fear River PFAS mass loading by at least 75 % was established as a cleanup goal. Corrective actions outlined in Paragraph 12 submittals and described in this CAP are estimated to lead to greater than 75% reduction in the mass loading of Total Table 3+ PFAS to the Cape Fear River.

Last, for Corrective Actions under the 2L Rules, 15A NCAC 02L .0106 (a), "Where groundwater quality has been degraded, the goal of any required corrective action shall be restoration to the level of the standards, or as closely thereto as is economically and technologically feasible as determined by the Department in accordance with this Rule." At present, no standards exist for Table 3+ PFAS under North Carolina law, and the 2L Rules, 15A NCAC 02L .0202(c) states such "substances…shall not be permitted in concentrations at or above the PQL in Class GA or Class GSA groundwaters." At present, reducing Table 3+ PFAS concentrations in onsite and offsite groundwater to below the PQL is not technologically or economically feasible as described later in section 6.2.4. In the future, groundwater cleanup standards based on scientific studies may be developed and improvements and breakthroughs in in situ treatment of PFAS and Table 3+ PFAS may occur. For example, in late December 2019 the EPA issued a preliminary remediation goal of 70 ppt for groundwater impacted with two PFAS compounds (PFOA and PFOS)[2], showing that the state of the science is advancing as a whole for PFAS and in future science based regulatory standards may become available for Table 3+ PFAS.

Together, both regulatory standards and PFAS treatment improvements may make remediation to 2L standards possible. Until that time, alternate cleanup standards may need to be considered as described in 15A NCAC 02L .0106 (a) and (i) together and 15A NCAC 02L .0106 (k). These potential alternate cleanup criteria are described in greater detail later in sub-section 6.2.3 as well as the possibility of performing risk-based remediation as described by N.C.G.S. § 130A-310.66 et seq.

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[2] EPA, 2019. The preliminary remediation goal (PRG) was set as 70 ppt (the current lifetime drinking water health advisory level) for contaminated groundwater that is a current or potential source of drinking water, where no state or tribal MCL or other applicable or relevant and appropriate requirements (ARARs) are available or sufficiently protective. The guidance recommends using a screening level of 40 ppt to determine if PFOS and/or PFOA is present at a site and may warrant further investigation.

6.2.2 Cleanup Goals by Media / Surface Water Body

Cleanup Criteria are described in Table 10 of this subsection by describing the basis of the cleanup goals for media / pathway and then describing what the developed cleanup goals are on a Near Term (2 years), Intermediate Term (up to 5years) and Long Term (> 5 years) basis.

Table 10: Cleanup Goals

Media / Pathway	Cleanup Goal Basis	Near Term (2 years)	Intermediate Term (up to 5 years)	Long-Term (>5 years)
Cape Fear River	- CO paragraph 16: minimum 75% reduction of Table 3+ PFAS Loading - Reduce HFPO-DA and Table 3+ PFAS loading concentrations such that exposures continue to decrease as provided in SLEAs.	- Begin implementation of interim actions proposed in this CAP to decrease Table 3+ PFAS loading to the Cape Fear River.	- Complete implementation of interim actions and proposed corrective actions outlined here to reduce Table 3+ PFAS loading to the Cape Fear River by at least 75% from baseline.	- Achieve 75% Table 3+ PFAS Loading Reduction; - Maintain HFPO-DA and other Table 3+ PFAS in accordance with surface water standards in the Cape Fear River.
Old Outfall 002	- CO paragraph 12: capture dry weather flows of Outfall 002 and treat to 99% removal of HFPO-DA and PFMOAA before subsequent discharge. - Supports CO paragraph 16 requirement of minimum 75% Table 3+ PFAS loading reduction in Cape Fear River. - Comply with NPDES permit.	- Implement dry weather flows capture and treat system.	- Maintain dry weather flows capture and treat system as long as needed.	- Maintain dry weather flows capture and treat system as long as needed
Onsite Groundwater Seeps	- As per Paragraph 12 Cape Fear River PFAS Loading Reduction Plan reduce Total Table 3+ PFAS mass loading to Cape Fear River. - Supports CO paragraph 16 requirement of minimum 75% loading reduction in Cape Fear River.	- Begin implementing and optimizing interim actions and long-term remedies.	- Seep treatment remedy operating to reduce Table 3+ PFAS loading as long as needed	- Maintain seep treatment remedy as needed
Willis Creek	- Achieve economically and technically feasible reductions to support CO paragraph 16 requirement of minimum 75% Table 3+ PFAS mass loading reduction in Cape Fear River. - Reduce discharge to Willis Creek of onsite Table 3+ PFAS with a process water signature	- Implement thermal oxidizer and other air abatement controls to reduce offsite groundwater concentrations over time; offsite groundwater discharges to Willis Creek. - Design and begin construction process for onsite groundwater remedy which will reduce PFAS mass loading via the Black Creek Aquifer to Willis Creek.	- Maintain air abatement controls. - On Site Groundwater Remedy will address PFAS loading to Willis Creek.	- Maintain air abatement controls. - Maintain groundwater remedy as needed

Media / Pathway	Cleanup Goal Basis	Near Term (2 years)	Intermediate Term (up to 5 years)	Long-Term (>5 years)
Georgia Branch Creek	- Achieve economically and technically feasible reductions to support CO paragraph 16 requirement of minimum 75% Table 3+ PFAS mass loading reduction in Cape Fear River	- Implement thermal oxidizer and other air abatement controls to reduce offsite groundwater concentrations over time;	- Maintain air abatement controls.	- Maintain air abatement controls.
Onsite Groundwater	- Reduce discharge of PFAS with a PFAS process water signature to Cape Fear River and to Willis Creek to support CO paragraph 16 requirement of minimum 75% Table 3+ PFAS mass loading reduction in Cape Fear River (Process water signature discharge to Old Outfall 002 is addressed by Old Outfall 002 capture and treatment system; PFAS historically released in process water does not discharge to Georgia Branch Creek) - Comply with 2L Rules	- Implement interim actions. - Conduct pre-design investigations for on-site groundwater remedy and treatment.	- Implement groundwater remedy.	- Evaluate 2L cleanup standards based on potentially existing cleanup standards developed from newly available scientific studies and potentially more effective remedial approaches recently developed. Presently both technically and economically infeasible to cleanup onsite groundwater to PQLs.
Offsite Groundwater	- Provide replacement drinking water to surrounding residents where groundwater based on requirements of CO paragraphs 19 and 20 - Maintain human exposures to HFPO-DA below the North Carolina Department of Health and Human Services (NCDHHS) reference dose (achieved per HH-SLEA results and replacement drinking water actions)	- Provide replacement drinking water. - Implement thermal oxidizer and other air abatement controls to reduce offsite groundwater concentrations over time.	- Maintain provision of replacement drinking water as long as needed - Maintain air abatement controls.	- Maintain provision of replacement drinking water as long as needed - Maintain air abatement controls.

Media / Pathway	Cleanup Goal Basis	Near Term (2 years)	Intermediate Term (up to 5 years)	Long-Term (>5 years)
Onsite and Offsite Soils	- Maintain human exposures to HFPO-DA below the NCDHHS reference dose (achieved per HH-SLEA results and replacement drinking water actions) - Maintain ecological exposures below adverse effects levels (achieved per Ecological SLEA results) - 2L requires removal or control of secondary sources to groundwater such as contaminated soils. Per information presented in Section 3.6 much more mass is in groundwater than in soils suggesting soil remediation would have a reduced benefit.	- Implement thermal oxidizer and other air abatement controls to reduce PFAS deposition rates to on and offsite soils.	- Maintain thermal oxidizer and other air abatement controls to reduce PFAS deposition rates to on and offsite soils.	- Maintain thermal oxidizer and other air abatement controls to reduce PFAS deposition rates to on and offsite soils.
Outfall 002	- The NPDES permit will develop effluent limits for Outfall 002 - Outfall 002 actions proposed in Chemours CO paragraph 12 Cape Fear River PFAS Loading Reduction Plan	- Comply with NPDES permit - Begin implementing actions proposed in the Reduction Plan	- Comply with NPDES permit (permit is for 5 years) - Implement actions proposed in the Reduction Plan	- Re-apply for NPDES permit - Maintain actions proposed in the Reduction Plan

6.2.3 Potential Future Alternate Groundwater Cleanup Standards

In the future NCDEQ and Chemours may need to consider alternate cleanup standards conceived under 15A NCAC 02L .0106 (a) and (i) together and 15A NCAC 02L .0106 (k) individually or risk-based remediation as described by N.C.G.S. § 130A-310.66 et seq.

6.2.4 Potential Future Alternate Groundwater Cleanup Standard 15A NCAC 02L .0106 (a) and (i)

15A NCAC 02L .0106 (a) and (i) allows for consideration of alternate cleanup criteria when it states in (a) that the goal of corrective action is, "restoration to the level of the standards, or as closely thereto as is economically and technologically feasible". And (i) states that "the Secretary shall consider the extent of any violations, the extent of any threat to human health or safety, the extent of damage or potential adverse impact to the environment, technology available to accomplish restoration, the potential for degradation of the contaminants in the environment, the time and costs estimated to achieve groundwater quality restoration, and the public and economic benefits to be derived from groundwater quality restoration." All these factors are relevant to the Chemours Fayetteville Works Site and are examined below.

<u>Technical and Economic Infeasibility</u>

The technical and economic infeasibility of Table 3+ PFAS remediation is driven by two factors, (a) the large areal extent PFAS are detected and (b) the lack of remedial technologies that are effective over large areas and effectively destroy PFAS mass in-situ at a technically achievable and affordable scale. To date Table 3+ PFAS have been detected over an area of 70+ square miles (over 45,000 acres). The size of the area encompasses hundreds of private land parcels and any remedial construction activities using currently available remedial technologies (excavation and groundwater extraction) would be very disruptive to the local community and this disruption would continue for a lengthy period of time. Any remedy which in principle could help make progress towards PQLs over this large area would cost in the billions to tens of billions of dollars. However, at this time these hypothetical remedies are not considered necessary to protect human health or ecological receptors as presented in the HH-SLEA and Ecological SLEA reports.

Additionally, there are no currently available remedies that are expected to be able to meet PQLs over an area this large. There are two candidate remedial approaches (a) in situ sorption (i.e. PlumeStop™) or pumping and treating. PlumeStop™ leaves the PFAS in place in the aquifer and over time; with additional loading these PFAS would desorb from the emplaced PlumeStop™ and become mobile again. For PlumeStop™ to meet PQLs additional product would have to be applied to the entire aquifer system across the impacted 70+ square miles repeatedly until another technology is invented that destroys the PFAS mass in place – a logistically impossible (e.g. access agreements) and economically prohibitive task (lack of PlumeStop™ supply, cost in the tens of billions of dollars).

Meanwhile, though pump and treat systems do remove mass from the aquifers, they reach points of diminishing returns where aquifer concentrations stay constant and where the technology is applied to extremely large areas. Pump and treat systems are now conceived by the remediation industry as systems to control contaminant migration, not systems to remove contaminant mass and clean aquifers of contaminants. A pump and treat system applied at the Site with the goal of restoring groundwater to PQLs would cost an economically infeasible amount of over a billion dollars and would almost certainly not achieve PQLs and not achieve any additional benefit in loading reductions to the Cape Fear River greater than those already proposed in this CAP. Likewise an offsite pump and treat system would be technically challenging to infeasible and cost an estimated tens to hundred billion dollars and achieve limited to no benefit in reducing exposures and hazards than actions already proposed and in progress.

<u>Extent of any violations</u>

Chemours has entered into the CO to comprehensively address DEQs concerns. Chemours has and is working expeditiously with DEQ to address releases and emissions to the environment.

<u>Extent of any threat to human health or safety</u>

The HH-SLEA demonstrated that offsite human exposures, both in the surrounding area, and for downstream river water users, to historically deposited PFAS and PFAS in the Cape Fear River are below the NCDHHS reference dose. Further, for private well users, replacement drinking water will reduce HFPO-DA and Table 3+ PFAS intake by over 92% and for Cape Fear River water users' actions outlined in this CAP will lead to at minimum a 75% reduction in Table 3+ PFAS intake. These actions will provide further protectiveness to human health and safety.

<u>Extent of damage or potential adverse impact to the environment</u>

The Ecological SLEA (Appendix G) concluded no adverse hazards to ecological receptors are anticipated from current exposures to HFPO-DA.

<u>Technology available to accomplish restoration</u>

There does not exist any proven technologies for passive in situ PFAS degradation. In situ sorption can lead to desorption in the future, and ex situ treatment will become asymptotic and not achieve cleanup goals.

Potential for degradation of the contaminants in the environment

Table 3+ PFAS are not expected to degrade in a reasonable time period in the environment, and therefore this is not a mechanism that will support concentration reductions.

Time and costs estimated to achieve groundwater quality restoration

Based on professional opinion the costs for on and offsite remediation to PQLs would exceed billions to potentially tens of billions of dollars and the timeframe would be on the order of multiple decades.

Public and economic benefits to be derived from groundwater quality restoration

There are limited to no additional public or economic benefits to remedial actions outside of those already proposed in the CAP. This CAP describes replacement drinking water actions to reduce intake of the most exposed offsite residents by over 92% to Table 3+ PFAS and this CAP describes actions to reduce Cape Fear River PFAS mass loading by over 75%. Even in the most conservative, hypothetical scenarios evaluated these actions will maintain river HFPO-DA concentrations below 140 ng/L at potential downstream raw water intakes.

6.2.5 Potential Future Alternate Groundwater Cleanup Standard 15A NCAC 02L .0106 (k)

15A NCAC 02L .0106 (k) allows for alternate cleanup standards by demonstrating the following seven criteria. Each of them has or will be met here:

1. All sources of contamination and free product have been removed or controlled

As described in previous sections of this CAP, air emission sources are being controlled, including by a state-of-the-art thermal oxidizer that will reduce aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, with expected comparable reductions for other PFAS. Chemours' process water is captured and shipped offsite and is not released through the WWTP and the Site Conveyance Network to the Cape Fear River. Sewers leaking process water were decommissioned and re-routed aboveground. There is no free product discharged, and all sources of contamination have been removed or are being substantially controlled and, as shown in Section 3, PFAS at the Site are mostly found in groundwater.

2. Time and direction of contaminant travel can be predicted with reasonable certainty

Travel times and directions for PFAS contamination present onsite and offsite can be estimated using a substantial data set and the numerical modeling work (Section 5) undertaken on behalf of Chemours. Specifically, the numerical model can be used to estimate groundwater travel times which can then be combined with the retardation coefficients presented in Section 3.8 of this CAP.

3. Contaminants have not and will not migrate onto adjacent properties, or such properties are served by an existing public water supply system dependent on surface waters or hydraulically isolated groundwater

Historical process water releases to groundwater are hydraulically isolated from private wells and the process water PFAS signatures have not been detected in any private or offsite wells, as described in Section 3 of this CAP. Where PFAS are present offsite at private wells, they originate from aerially deposited PFAS. Offsite groundwater wells that contain Table 3+ PFAS have PFAS signatures consistent with aerial deposition. With respect to those wells, offsite migration air abatement measures that have been installed by Chemours. including the thermal oxidizer, are mitigating PFAS air emissions that lead to offsite deposition. Moreover, parties using offsite groundwater wells for drinking water purposes, where they qualify, are being provided with replacement drinking water supplies by Chemours per CO criteria and requirements.

4. The standards specified in Rule .0202 of this Subchapter will be met at a location no closer than one year time of travel upgradient of an existing or foreseeable receptor, based on travel time and the natural attenuation capacity of subsurface materials or on a physical barrier to groundwater migration that exists or will be installed by the person making the request

As noted above, the existing receptors that have been the focus of abatement measures are the offsite drinking water wells, which may have residual PFAS from prior air emissions. The thermal oxidizer and other air abatement measures will substantially prevent further PFAS contamination from reaching these receptors. Where offsite migration via aerial emissions has occurred, private well receptors are being provided with replacement drinking water supplies by Chemours per CO criteria and requirements. Moreover, existing onsite groundwater contamination is not expected to travel to or impact receptors other than surface waters, which in turn is the subject of the next criterion.

5. If the contaminant plume is expected to intercept surface waters, the groundwater discharge will not possess contaminant concentrations that would result in violations of standards for surface waters contained in 15A NCAC 02B .0200

There are no 2B standards for Table 3+ PFAS, so there will not be violation of any such standards in surface water caused by any contaminant plume from the Site. There is a State health advisory level for HFPO-DA in drinking water, which is not a 2B standard. The health advisory has not been exceeded in the Cape Fear River since 2017 when Chemours began measures to control PFAS emissions and releases at the Site. Moreover, this CAP proposes active remediation actions to reduce Table 3+ PFAS loading to the Cape Fear River by greater than 75%.

6. Public notice of the request has been provided in accordance with Rule .0114(b) of this Section

DEQ is required to provide public notice of this CAP under the CO, so public notice will be provided. In addition, if necessary, a public notice can be made per Rule 0.114(b).

7. The proposed CAP would be consistent with all other environmental laws

Actions proposed in this CAP are fully consistent with all other environmental laws, including those requirements set forth in the CO and permits. For example, the air abatement measures are consistent with and have been permitted under the Clean Air Act.

6.2.6 Potential Future Risk-Based Remediation

North Carolina law as described in N.C.G.S. § 130A-310.66 et seq. allows for risk-based remediation. Specifically, the stated purpose of Risk-Based Remediation is:

> *It is the purpose of this Part to authorize the Department to approve the remediation of contaminated sites based on site-specific remediation standards in circumstances where site-specific remediation standards are adequate to protect public health, safety, and welfare and the environment and are consistent with protection of current and anticipated future use of groundwater and surface water affected or potentially affected by the contamination.*

As the corrective actions proposed in this CAP are completed and additional toxicity data and relative source contribution data (e.g. what percentage of HFPO-DA intake comes from drinking water) are gathered for Table 3+ PFAS, Chemours and NCDEQ can potentially evaluate the suitability of applying site-specific remediation standards and following the process outlined by N.C.G.S. § 130A-310.66 et seq.

6.3 Proposed Remedial Alternatives

The detailed development of remedial alternatives and evaluation of technical and economic feasibility that was provided in the Paragraph 12 submittals (Reduction Plan and the Supplemental Information Report) is not reproduced in this CAP. The feasibility study assessed and scored potential remedial alternatives based on five criteria (Protection of Public Health and the Environment through Reduction of PFAS Mass Loading; Adverse Environmental Effects; Technical Feasibility and Effectiveness; Timing; and Economic Feasibility). This CAP focuses on the groundwater and surface water remedial alternatives that were considered to satisfactorily meet these five criteria.

For groundwater and surface water remedies that were advanced, the following sections provide a detailed description, estimated reduction in PFAS that may be achievable, implementation schedule, and estimated cost. Construction and annual operating costs for each alternative have been estimated with a range of -30 % to +50 %, and the 20-year net present value (NPV) is estimated at a 3.5% discount rate; cost detail sheets are provided in Appendix J. Cost estimates are not intended for budgetary or future planning purposes; they have been prepared from the currently available information to facilitate an inter-alternative comparison. The final costs of any selected alternative will depend on final approved design, actual labor and material costs, and competitive variable factors.

As has been previously noted, Table 3+ PFAS at the Site are present in three aquifer units (Perched, Surficial and Black Creek) and over an extensive land area. PFAS are relatively recent compounds being considered for environmental remediation and as such there are few treatment technologies with full-scale demonstrations of effectiveness. PFAS remediation is a rapidly evolving field and new technologies may become available and suitable for the PFAS at the Site that would expand the set of alternatives available for consideration. Therefore, the set of remedial alternatives considered for this Site are subject to enhancement over time and re-evaluation of the technical and economic feasibility.

6.3.1 Pathway: Direct Aerial Deposition

Direct aerial deposition of PFAS emissions from the facility has the potential to result in mass loading to surface water bodies; however, the mass loading model estimated that aerial deposition contributed less than 2% of the mass loading observed in the Cape Fear River. Aerial deposition was identified as a pathway of concern primarily due to offsite drinking water wells. The remedial approach identified to mitigate impacts to offsite drinking water wells is a series of air emission control technologies, providing temporary alternate drinking water sources and long-term water treatment to effected households.

Pursuant to Paragraph 7 of the CO, Chemours completed a number of operational improvements to control air emissions. In November 2018, Chemours installed a packed bed scrubber to control emissions from the Division Waste Gas Scrubber and in December 2018 Chemours completed the tie-in of the Carbon Absorber unit for the Second Phase Scrubber at the Vinyl Ethers North Plant. By December 31, 2019, Chemours is completing installation of a Thermal Oxidizer to control air emissions of PFAS from process streams from the Monomers IXM Area. As required by the CO, the thermal oxidizer will dramatically reduce aerial PFAS emissions from the Site, with reduction of aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, and expected comparable reductions for other PFAS. The reduction of PFAS emissions to air will over time result in lower concentrations of PFAS in offsite soils and groundwater and lead to reductions of loading to Willis Creek, Georgia Branch

Creek and the offsite Cape Fear River. The total construction cost for the thermal oxidizer is expected to be approximately $100 million or greater (a cost detail sheet is not provided in Appendix I as this remedy is near completion).

6.3.2 Pathway: Old Outfall 002

The Old Outfall 002 (OOF2) is a natural feature that discharges to the Cape Fear River. Perched zone and surficial aquifer groundwater also discharge to this feature. Since Site groundwater has elevated PFAS concentrations, OOF2 also has elevated PFAS levels. The results of the Mass Loading Model indicate OOF2 is one of the primary contributors of PFAS mass loading originating from the facility to the Cape Fear River, estimated to contribute about 26% of observed mass loading (average of the May, June, and September 2019 sampling data).

As described in Proposed Action 1 of the Reduction Plan, Chemours will continue to comply with the existing CO requirements by implementing an ex situ capture and treatment remedy for Old Outfall 002. This process is currently in the detailed design and permitting phase. Chemours provided details on the approach for treatment in the Old Outfall 002 Engineering Report (Parsons, 2019b) and Old Outfall 002 Engineering Alternatives Report (Parsons, 2019a). A process flow diagram of the treatment process is shown in Figure 5. Based on the most recent flow measurements, the dry weather baseflow is between 500 and 750 gpm; therefore, the facility is being designed to treat up to 750 gpm. The design of the treatment system is intended to be modular and scalable if additional capacity is needed.

The treatment system is required to be constructed and operational by September 30, 2020, assuming permits are issued in a timely manner. In order to continue and accelerate progress on implementing this remedy, Chemours is clearing the land where the Old Outfall 002 treatment system will be located and is arranging for power to be available at this location by early 2020. Chemours is currently soliciting bids from water treatment vendors to provide the treatment system.

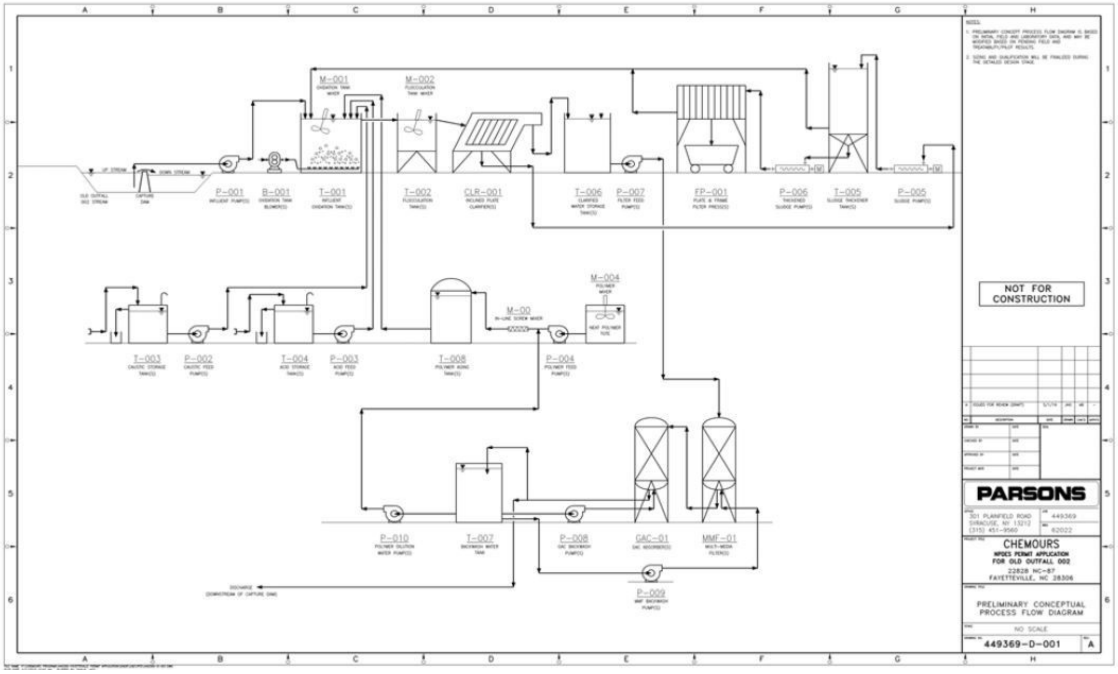

Figure 5. Old Outfall 002 Treatment System Process Flow Diagram

Schedule

Task	Duration (months)	2019				2020			
Geotechnical Investigation	2								
Electrical Enabling Package	3								
Electrical Upgrades (EMC)	6								
Prepare RFP for WTP	1								
Bidding and Award (WTP Only)	2								
Lift Station/Dam Design	2								
NPDES Permitting (1)	9								
Lift Station/Dam Construction	3								
WTP Design/Procurement	6								
Startup	1								

1 - Task timing is dependent upon agency approval timing

Cost

Costs for the OOF2 system have been previously presented in several submittals, including the Old Outfall 002 Engineering Alternatives Analysis (EAA) (Parsons, 2019b) and Reduction Plan Supplemental Information Report (Geosyntec, 2019h). Over time, the design of the system has progressed, and costs have been refined based on new flow measurements and data from the pilot treatment study (Parsons, 2019c). Chemours is currently evaluating the need for iron removal at the facility which would reduce the construction and operational requirements of the facility. The cost estimate was prepared without iron removal or a treatment building. Construction cost was estimated to be $7 to 15 million, annual O&M costs are estimated to be $1 to 2 million, and the 20-year NPV is $21 to 45 million.

It is noted that the total water balance for the comprehensive site remedies, as detailed in the following sections, may add additional water volume from the capture of seeps, Black Creek aquifer groundwater, and targeted stormwater. Based on engineering evaluations conducted to date, it appears to be more cost effective to consolidate all flows and convey captured water to the same location as the OOF2 system. Since the OOF2 system is likely to be sequenced first, a modular engineering approach will be employed, to which scaling up additional flow capacity over time is facilitated with skid-mount systems, a lack of fixed structures to the extent practical, and an overall adaptive management approach.

Presentation of cost estimates for seep, groundwater, and stormwater treatment in the following sections will note where applicable how incorporation of water treatment costs has been estimated relative to the baseline cost of the OOF2 system.

6.3.3 Pathway: Groundwater Seeps

Four groundwater seeps discharging from the bluff slope directly to the Cape Fear River were identified and described in the Seeps and Creeks Investigation report (Geosyntec, 2019b). The Mass Loading Model estimated that the onsite seeps discharging to the Cape Fear River contributed between 24% and 42% of PFAS mass load (on average, about 33% based on the May, June, and September 2019 sampling events).

Table 11: PFAS Loading from Seeps

Seeps	Flow Rate May 2019 (gpm)	T3+ PFAS May 2019 Concentration (ng/L)	Mass Loading (ug/s)
Seep A	120	300,000	2,270
Seep B	100	310,000	1,960
Seep C	30	350,000	660
Seep D	30	170,000	320
Total Cape Fear River Seeps	**280**	**N/A**	**5,200**

Notes:
Total Table 3+ PFAS concentrations come from the May 2019 sampling event for illustration purposes, as reported in the Seeps and Creeks Investigation (Geosyntec, 2019b). June 2019 and September 2019 sampling data not shown for clarity.
T3+ PFAS – Results of Table 3+ PFAS analytes summed
gpm – gallons per minute
ng/L – nanograms per liter
µg/s – micrograms per second

Interim Remedial Alternative for Seeps

As described in the Reduction Plan Supplemental Information Report, a combination of flow-through cells and ex situ capture using French drains is proposed as an interim remedial approach for the four onsite seeps. The approximate location of the seep remedies is shown below in Figure 6. The flow-through cell interim actions would start at Seep A with implementation progressing successively through Seeps B and C where lessons learned from the construction and operation of the flow-through cells at the prior seeps would be used to design and operate the subsequent flow-through cells.

An ex-situ capture French drain would be installed at Seep D. This method, while more power intensive and disruptive to habitats does have a higher certainty for water treatment capabilities and would serve as a pilot location of this option.

- *Seep A → Flow-Through cell – Phase 1*
- *Seep B → Flow-Through cell – Phase 2*
- *Seep C → Flow-Through cell – Phase 3*
- *Seep D → French Drain (to OOF2 treatment system)*

An adaptive management approach will be employed when implementing the above. For example, if flow-through cells in Seep A are determined to be ineffective or impractical to implement, while the French Drain in Seep D is performing as intended, then French

Drains may be installed in additional seeps. Detailed descriptions of the two types of seep remedies are provided in the following sections.

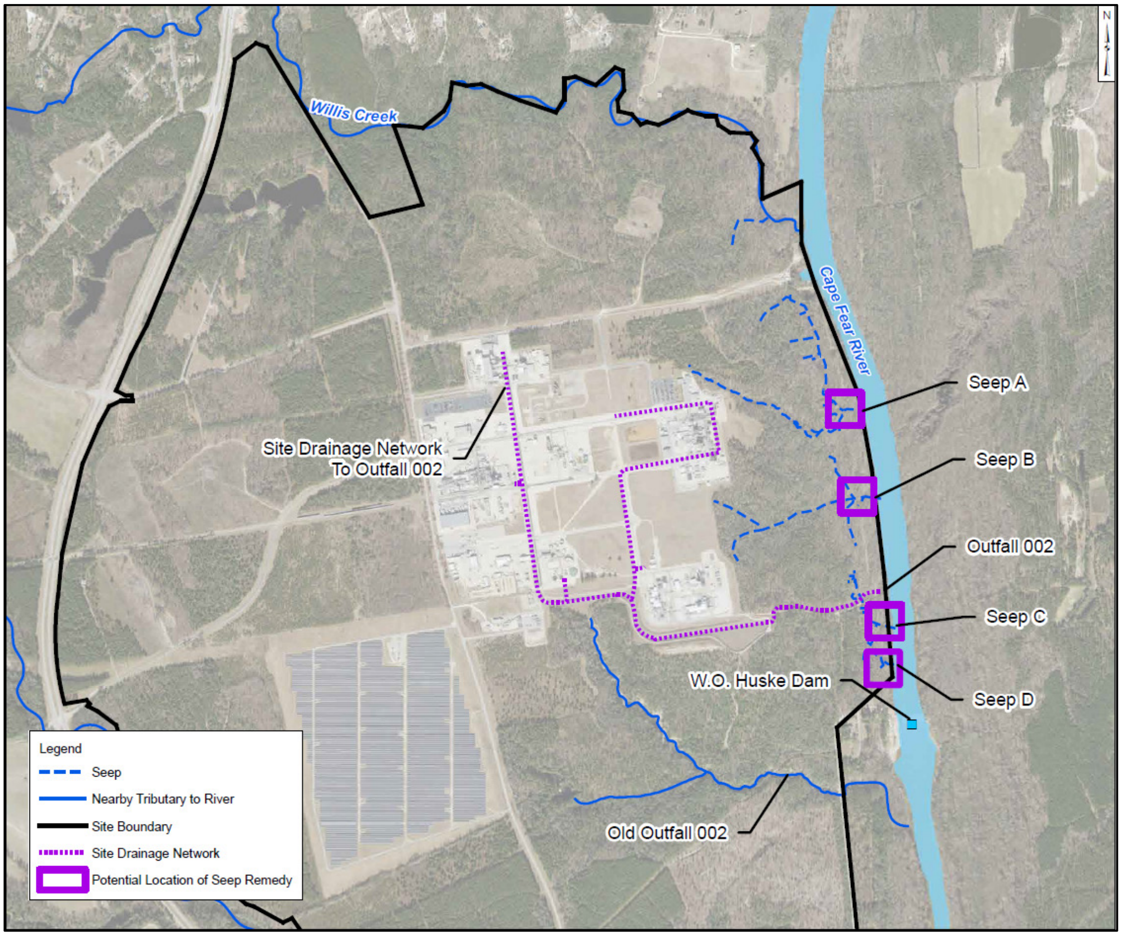

Figure 6: Location of Seep Remedial Alternatives

Flow-Through Cells

Interim application of flow-through cells would involve the installation of V-shaped sheet pile walls to guide seep water discharge through a controlled structure for on-location treatment. Large wire baskets (gabions), filled with granular activated carbon (GAC) would be installed in the discharge structures such that the water discharging from each seep location would flow through the GAC filled gabions. The PFAS compounds in the seep water would be sorbed by the GAC in the gabions and the treated water, containing much lower concentrations of PFAS compounds, would flow out the downhill side of the gabions.

Installation of the seep flow-through structures would commence after the river access road and all clearing and grubbing is complete. It is assumed that a total of 16 15-foot lengths of standard steel 22-inch wide sheet pile will be installed at each seep location. The sheet pile will be driven vertically into the ground to a depth of approximately 11 ft bgs to form a V-shaped sheet pile wall centered on and oriented perpendicular to the seep discharge channel. The center 2 sheet piles will be driven an additional approximate 3 ft to form a window in the middle of the sheet pile wall such that seep water can flow through the wall. A steel plate approximately 44-inches wide and 72-inches long will be placed flat side down in the sheet pile window and welded in place (to the sheet pile) to provide a flat stable surface for the GAC filled gabions.

Each gabion will be lined with geotextile fabric and filled with new, unused GAC. The geotextile fabric liner will then be fastened closed and the top of the gabions will be closed and fastened with steel wire such that the gabions can be moved. Three gabions will be installed first in the seep A structure as depicted in Figure 7 below using an excavator and load straps or equivalent. After installation, the gabions will be secured with sandbags to ensure they stay in place.

Construction of the flow-through cells is not anticipated to require regulatory approval via NPDES, as there is no discharge of waste, but would likely require approval from United States Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act. It is assumed that the permitting pathway would be similar to that obtained for the OOF2 structures, which were permitted under Nationwide Permit (NWP) 38 (Cleanup of Hazardous and Toxic Waste) in October 2019.

It is anticipated that the first structure will be constructed at Seep A, and operated for approximately 4-months during which performance and operational data will be collected to assess system performance. Lessons learned and performance upgrades developed during this time frame at Seep A will be incorporated as design modifications for potential application at subsequent seeps.

Ex Situ Capture French Drains

This interim remedial measure involves the installation of a French drain or equivalent sump to capture seep water discharge for subsequent conveyance to the planned treatment plant to be located at OOF2. The French drain would consist of a permeable trench excavated across the seep with perforated piping to collect the water, and a sump pump to convey the captured seep water to the river access road pipeline for subsequent conveyance to the planned OOF2 treatment system for treatment and subsequent disposal.

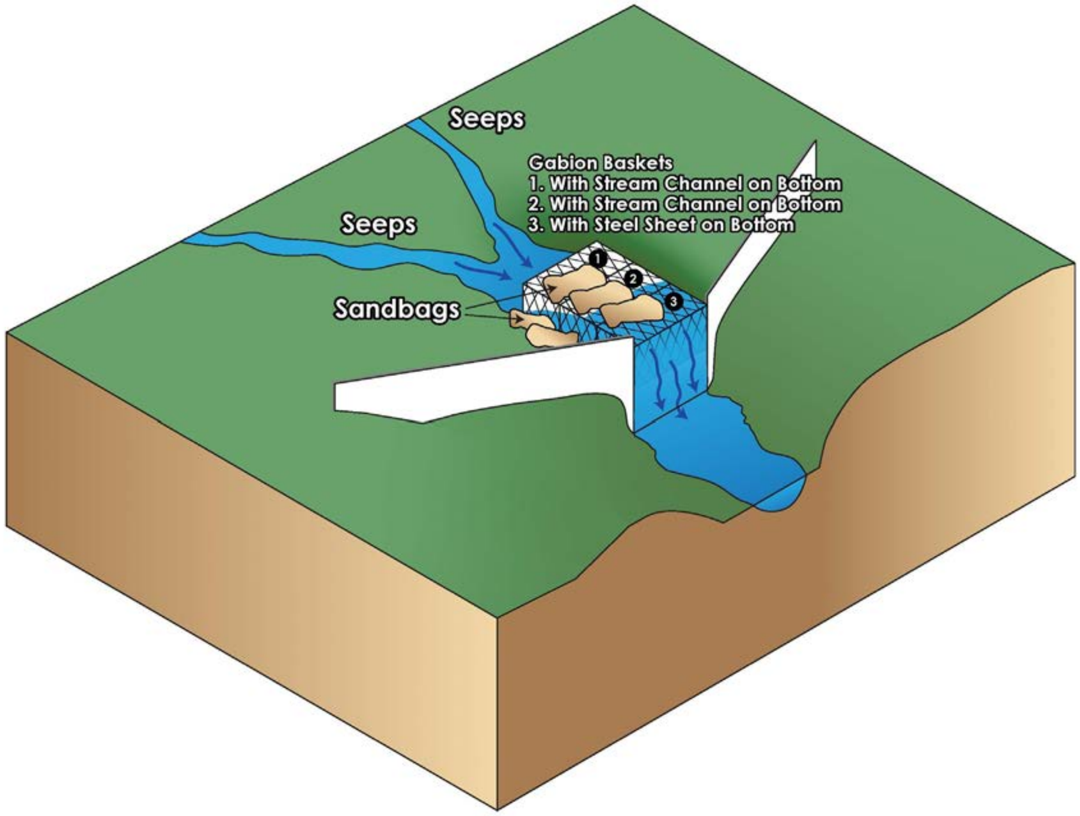

Figure 7: Conceptual Diagram of Seep Flow Through Passive Treatment

After supporting infrastructure is in place, including roads, power, and conveyance lines, a small catch basin will be excavated upstream from the planned French drain location. A portable pump with sufficient capacity for total seep flow will be placed in the basin with the pump discharge hose established to pipe water from the basin around the planned French drain location for subsequent discharge downstream from the construction area. Temporarily diverting seep discharge flow around the construction area will allow for safe and efficient French drain installation.

French drain construction is anticipated to consist of geotextile fabric lining, permeable backfill (2-inch diameter rocks), and a horizontal perforated pipe at the bottom and a vertical "sump" pipe at one end. The trench will be approximately 20-ft long and 6 ft deep with the bottom of the trench sloping to one end. After the piping is installed and the trench is backfilled, it will be armored at the ground surface with an additional layer of geotextile and concrete paver blocks to prevent erosion during storm events. A conceptual diagram is shown below in Figure 8.

After the French drain installation, a submersible pump will be installed in the vertical sump, wired to provide power, connected to the previously installed piping and function tested to ensure proper operation. The temporary seep water diversion pump and discharge hose will be removed, and the seep collection system will be put in operation.

Construction of the French drain is anticipated to require NPDES permit approval, or modification of the existing Site NPDES permit, due to the additional discharges of treated water. As with the flow-through cells, the French drains are anticipated to also require USACE NWP 38 permitting.

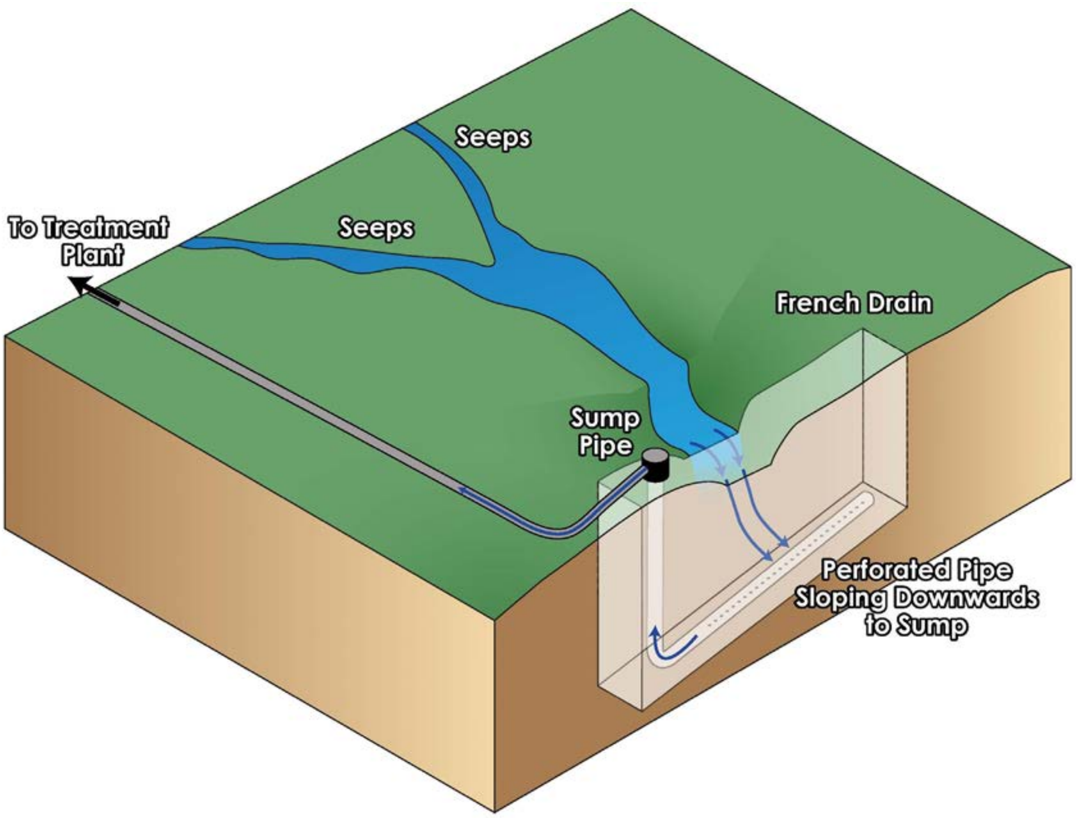

Figure 8: Conceptual Diagram of Seep French Drain Ex Situ Capture

<u>Cost</u>

The +50/-30% estimated construction cost for the interim application of flow-through cells for Seeps A through C and a French drain in Seep D is $980,000 to 2,100,000. The annual O&M cost is estimated to be between $400,000 to $870,000. Costing estimates are provided in Appendix I.

For simplicity, as interim measures are defined as implementable within two years, NPV calculations were not performed.

Long-Term Remedial Alternative for Seeps

It is anticipated to operate the interim seep actions discussed above for a period of two years during which the performance of each approach can be monitored and optimized, after which the long-term remedy will be selected. It cannot be predicted with certainty at this time which method will perform optimally at each seep.

For the purposes of this CAP, a low range cost estimate has been prepared, which assumes that the interim application of flow-through cells at Seeps A-C and a French drain at Seep D will perform as intended, and thus no additional construction costs would be required. As above, the +50/-30% estimated construction cost is $980,000 to 2,100,000, the annual O&M cost is estimated to be between $400,000 to $870,000, and the 20-year NPV is estimated to be $6.3 to 13.5 million.

In contrast, a high range cost estimate has been prepared, which assumes that the flow-through cells at Seeps A-C will not perform as intended, and that French drains will ultimately be required at all four seeps. In this scenario, the +50/-30% estimated construction cost is $8.9 to 19.1 million, the annual O&M cost is estimated to be between $400,000 to 840,000, and the 20-year NPV cost is estimated to be $15 to 32 million. Costing estimates are provided in Appendix I.

6.3.4 Pathway: Onsite Black Creek Aquifer Groundwater

The Black Creek Aquifer is interpreted to be the only transmissive groundwater zone at Site in contact with the Cape Fear River. The Mass Loading Model estimated that the Black Creek aquifer groundwater discharging to the Cape Fear River contributed between 14% and 22% of PFAS mass load (on average, about 18% based on the May, June, and September 2019 sampling events).

Interim Remedial Alternative for Black Creek Aquifer: Groundwater Extraction from Existing Monitoring Wells

As described in the Reduction Plan Supplemental Information Report, the interim remedial alternative advanced for groundwater consists of installing submersible electric pumps in seven existing black creek monitoring wells and pumping the water to the OOF2 treatment plant for treatment and discharge. Submersible electric pumps would be installed in seven site wells: BCA-01, BCA-02, PW-9D, PW-10DR, PW-11, PW-14, and PW-15R (as shown in Appendix B). Piping would be installed to convey the water to the proposed OOF2 treatment plant, potentially above-grade as a time-saving measure. Based on available information, it is anticipated that a sustained flow rate of 2 gpm from each well could be achieved. Therefore, the total flow would be 14 gpm. It is assumed that there will be sufficient excess capacity at the OOF2 treatment plant and that the discharge could be covered under the current NPDES permit application for that plant without additional modification.

Schedule

Task	Duration (months)	Year 1			
Detailed Design	2				
Contracting	1				
Installation and Operation	9				

Cost

Costs were estimated and considered to be accurate within the +50/-30 % range. The construction costs range from $560,000 to 1.2 million, annual O&M costs are $48,000 to 102,000. Costing estimates are provided in Appendix I. For simplicity, as interim measures are defined as implementable within two years, an NPV calculation was not performed.

Long-Term Remedial Alternative for Black Creek Aquifer: Barrier Wall and Groundwater Capture

At the time of the November 4 Reduction Plan Supplemental Information Report submittal, the numerical model had not been calibrated, so it was not yet clear what would be the most efficient method to mitigate the flux of onsite groundwater to the Cape Fear River. Based on the numerical modeling scenarios detailed in Section 5, it is anticipated that hydraulic containment coupled with a barrier wall will most efficiently capture the necessary component of the Black Creek aquifer without also drawing in the river.

Extensive investigation, analysis, and numerical model refinement would be required to properly design a remedy of this scale. A geotechnical investigation would be required along the alignment (anticipated boring frequency every 100 linear feet) to determine the depth and penetration resistance of the confining unit. Additional delineation consisting of borings, wells, and in-river flux analyses may also be utilized to properly target the optimal areas for containment needed to achieve the corrective action objectives. Finally, pilot testing, consisting of extraction well drilling and aquifer testing at multiple locations along the alignment, would be performed to determine the optimal well spacing and extraction rates. It is anticipated that in the course of two years, these activities would allow for model refinement and completion of design and permitting effort. In the absence of this pre-design data, the following discussion of a long-term groundwater remedy is still highly conceptual.

Figure 9 shows the area of groundwater with a process water PFAS signature that is potentially discharging to the Cape Fear River and Willis Creek. It is anticipated that hydraulic containment via extraction wells and a vertical barrier wall would be installed within this area, with the exact span and position to be determined after the pre-design investigations are complete. It is anticipated that the barrier wall would be constructed either with a one-pass trencher, as a soil-cement-bentonite slurry wall, or with steel sheet piles that are driven into the ground and interlocked. Both options are suitable means to mitigating the flow of groundwater, as slurry walls typically achieve a permeability of 10^{-7} centimeters/second.

While the slurry wall is considerably more cost-effective than steel, spoils management and sensitivity of disturbing the land surface near the river will require more detailed evaluation and potentially more site preparation to key in trenches that can manage the excess spoils that are generated during the mixing process. Nevertheless, it is anticipated that these measures can be adequately accounted for in the design process, and slurry walls will be considered the presumptive barrier method, with steel sheet piles as a contingency plan should further investigation indicate that the slurry walls cannot be managed appropriately in the field. A range of costs is provided for both options, as discussed later in this section.

Groundwater could be extracted from a series of vertical wells or horizontal wells. For the purpose of this analysis, vertical wells were assumed; however, the final design would utilize the most efficient option. The numerical model was utilized to estimate that the extraction well spacing behind a conceptual 8,500-foot long barrier wall would be 200 ft, and that extraction rates would vary from 20 to 30 gpm along the alignment, depending on localized hydrogeologic parameters (see Section 5 for more detail). This would result in approximately 930 gpm (1.3 MGD) of extracted groundwater.

It was assumed that the well pumps would feed into a common high-density polyethylene (HDPE) force main for distribution to the OOF2 treatment system location. Pipe sizing would range from 2 to 24 inches in diameter, depending on the estimated head loss, which is a factor of flow rate and distance from the system. It is assumed that the influent median PMPA and PFMOAA concentrations would be 8,200 and 150,000 ng/L, respectively. It is assumed that PFMOAA is the driving influent COC for GAC utilization, and that 99% removal would be the objective.

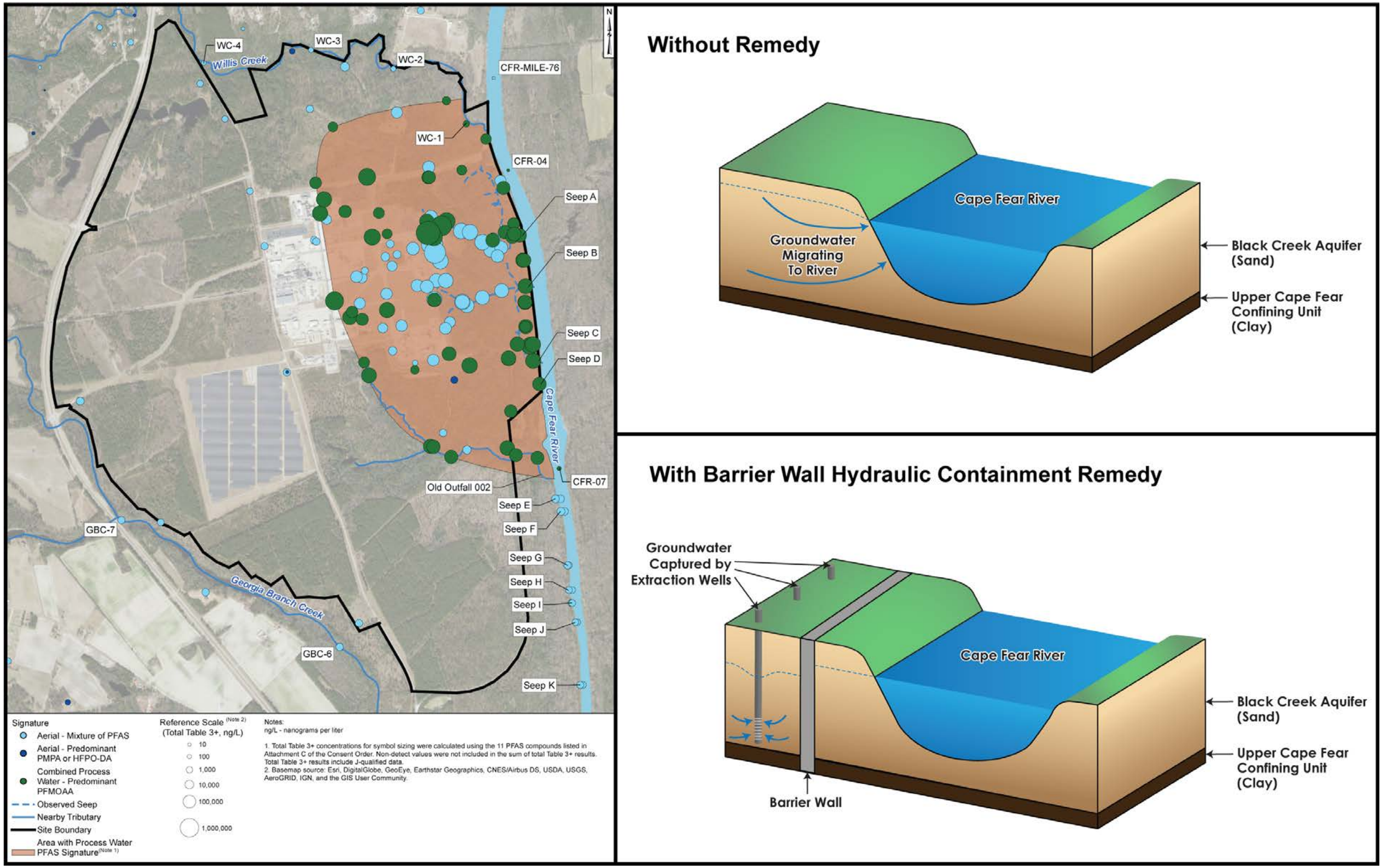

Figure 9: Area with Process Water PFAS Signature and Barrier Wall Conceptual Diagram

Cost

As discussed, many design details would still need to be determined, notably the barrier wall installation method (slurry wall vs. steel sheets), the most efficient method of incorporating flow into the Old Outfall 002 treatment system, and the exact alignment of the containment measures. For the purposes of this CAP, a low and high range cost were estimated as follows:

- Low Range: Slurry wall, with modular approach to incorporating flow into OOF2 treatment system (skid-mount systems installed with heat tracing, not within pre-fabricated building): The +50/-30% estimated construction cost is $19 to 41 million. The annual O&M cost is estimated to be $1.2 to 2.5 million. The 20-year NPV is estimated to be $36 to 77 million. Costing estimates are provided in Appendix I.
- High Range: Steel sheet pile wall, with pre-fabricated building to enclose the process equipment: The +50/-30% estimated construction cost is $34 to 74 million. The annual O&M cost is estimated to be $1.2 to 2.5 million. The 20-year NPV is estimated to be $51 to 110 million. Costing estimates are provided in Appendix I.

Path forward

The degree of PFAS loading that will be reduced by installation of the groundwater containment remedy described herein is uncertain, particularly its overall contribution to achieving a 75% Table 3+ PFAS loading reduction cost effectively. This remedy, if implemented, would reduce the PFAS loading to the river and, over time, reduce PFAS concentrations within the groundwater itself. On the other hand, the implementation of this remedy would be very costly and disruptive to the local ecological habitats.

The environmental benefits that would be realized from this remedy are at this point somewhat uncertain and based on data that have been limited by the short time frame in which the data needed to be assembled. For example, the September 2019 data show that the contributions to surface water loadings from this source may be as low as 14% of the total remaining loadings and are significantly less than the loadings from the two larger sources: groundwater seeps and Old Outfall 002. The September 2019 data show that those two sources alone could be up to 69% of the total remaining loadings. Yet, while the loadings from onsite groundwater may be only about a fifth of those for the top two sources, the costs to address onsite groundwater (see Appendix I) could be one and a half times as much as the total remedial costs for the groundwater seeps and Old Outfall 002.

With the information in hand, it is not presently possible to conclude with confidence whether this alternative is economically feasible. Accordingly, subject to DEQ approval, the best course of action is to proceed with the interim groundwater remedy described in Section, and at the same time proceed with a detailed pre-design investigation, a detailed remedy design and continued evaluation of PFAS mass loading to the Cape Fear River originating from the facility. This process of a pre-design investigation leading to a detailed design is consistent with prior remediation programs in North Carolina and the NCDEQ Guidelines (NCDEQ, 2017) that suggest CAPs include descriptions of "additional site characterization needed to support [the] proposed remedy".

Following an adaptive process allows the opportunity to further refine the understanding of PFAS mass loading from groundwater to the Cape Fear River, enabling a more detailed assessment of the technical and economic feasibility of the groundwater containment remedy. Additionally, this process will likely identify areas of higher PFAS mass discharge into the Cape Fear River from groundwater; and then remedial efforts can be focused to more expeditiously reduce loadings. Last, this process will enable adapting the scope and areas of groundwater treatment to reflect new information from other studies being conducted in support of the CO (e.g. total organic fluorine method development). Concurrent with the design effort, remedial alternative assessments will continue to evaluate the most cost-effective remedy that could achieve at least a 75% Table 3+ PFAS loading reduction and other CO objectives. The schedule for implementation of a groundwater remedy is included in Section 6.5 of this document; the pre-design investigation through detailed design and permitting is expected to take two years. At the conclusion of the effort, Chemours would present a detailed onsite remedial design to DEQ for approval.

6.3.5 Pathway: Outfall 002

Actions proposed for Outfall 002 in the previous Paragraph 12 submittals (i.e., the August 2019 Reduction Plan and the November 2019 Reduction Plan – Supplemental Information Report), which are summarized in Table 8 of Section 6, remain the same. The proposed path forward for the Outfall 002 remedies including the remedy descriptions, implementation schedules, and cost estimates can be accessed in the Supplemental Information Report (Geosyntec, 2019h).

6.3.6 Pathway: Loadings from Willis Creek and Georgia Branch Creek

While no offsite alternative was advanced for either creek, both creeks will over time have declining PFAS concentrations as a result of air control technology improvements that will reduce aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, with expected comparable reductions for other PFAS, leading to offsite aerial deposition reductions and consequently reductions over time in groundwater that discharges to these creeks. Additionally, were the onsite Black Creek aquifer groundwater extraction remedy to be implemented as conceptualized above, which would include approximately 2,100 linear feet of containment along the northeastern reach of Willis Creek that is in connection with the Black Creek aquifer, present estimates indicate the mass loading to Willis Creek may be reduced up to 65%, which in turn would reduce the mass loading to the Cape Fear River by approximately 3.7%.

6.3.7 Pathway: Offsite Groundwater

Offsite, PFAS have been aerially deposited and exist as a distributed, diffuse source potentially present over an area of at least 70+ square miles where concentrations in groundwater gradually become lower further away from the Site. Ongoing air abatement measures and the installation and operation of the thermal oxidizer will lead to a reduction of aerial HFPO-DA emissions by 99% starting in January 2020 compared to 2017 baseline, and expected comparable reductions for other PFAS. Correspondingly, the deposition of PFAS to offsite soils will be reduced by 99% and over time concentrations will decline.

Mitigation measures for offsite water supply wells have been documented previously, including the On and Offsite Assessment (Geosyntec, 2019a). As discussed, pursuant to CO Paragraphs 19 to 25, Chemours is implementing a Drinking Water Compliance Plan (Parsons, 2019a). Through this plan, Chemours is providing replacement drinking water to private residents whose drinking water wells are impacted by PFAS listed on Attachment C of the CO. Replacement drinking water is being provided through a range of options depending on the levels of PFAS found. First residents are supplied bottled water as an interim measure. Then residents, should they accept, will receive either: (i) point of use reverse osmosis systems, (ii) whole house filtration systems, or (iii) connection to public water supplies. Pursuant to CO Paragraph 19, Chemours is working with NCDEQ to identify locations where public water is available and can be provided to private residents for less than $75,000 per affected party. Beyond this threshold, permanent water supplies will be provided through whole house filtration systems or reverse osmosis systems. Chemours is providing quarterly updates on implementation of the Drinking Water Compliance Plan to NCDEQ.

6.4 Proposed Remediation Permits

The thermal oxidizer, OOF2 treatment system, and sediment removal from the on-site non-contact cooling water (NCCW) and Outfall 002 activities are not discussed in this section as these remedies are already in the process of design and permitting or have already been completed. The terracotta pipe decommissioning and mitigation of groundwater intrusion into Outfall 002 remedies are also not discussed, as permits are not anticipated to be required. This section focuses on potential permits that may be required to construct the proposed interim and long-term remedies for seeps, onsite groundwater, and onsite stormwater.

The potential construction of flow-through cells, French drains, and a sheet pile barrier wall would likely require a comprehensive permitting approach, as segmented disturbances to natural features are typically required to be consolidated:

- Section 404 of the Clean Water Act as administered by the USACE. For the construction of the instream structures of OOF2, in October 2019, the USACE approved a NWP 38 - Cleanup of Hazardous and Toxic Waste. For the proposed construction of flow-through cells, French drains, and onsite barrier wall, it is anticipated that the USACE would concur that the NWP 38 similarly applies. Engagement with USACE, including an onsite review, could be required.
- Section 401 water quality certification as administered by the NCDEQ Division of Water Resources (DWR). The proposed installation of the flow-through cells, French drains, and onsite barrier wall would likely result in a disturbance to wetlands and streambeds that requires engagement with DWR and possible mitigation credits. As above with USACE, an onsite review would likely be required.
- NPDES as administered by NCDEQ. It is not anticipated that a NPDES permit would be required for the flow-through cells, as there is no point of discharge; however, engagement with NCDEQ to confirm may be warranted. For the seep French drains and for the barrier wall groundwater extraction, it is anticipated that modification of the draft NPDES permit may be required to either expand the OOF2 treatment system to accommodate this additional flow, and/or to permit the construction of a new treatment system and outfall. As NCDEQ has expressed a preference for a single NPDES permit for the Site, continued engagement with this agency will be required.
- Erosion and Sediment Control as administered by NCDEQ. For the construction of the seep and groundwater remedies, notably for the barrier wall which would require approximately 10 acres of disturbance, a comprehensive Erosion and Sediment Control (E&SC) Plan would be required, prepared in accordance with the latest revision to the E&SC Planning and Design Manual from 2013.

In addition to the above list, well construction permits will be required to install the extraction and monitoring wells. Building permits could also potentially be required for electrical connections to new treatment systems, if constructed.

6.5 Proposed Remediation Schedule

Detailed schedules for the Seeps and Onsite Groundwater remedies are provided below in Table 12 and Table 13. Table 14 describes the estimated performance and tentative schedule for proposed interim remedies and initial conceptual designs for long-term remedial strategies as both are closely integrated.

Table 12: Schedule for Proposed Seep Actions

Task	Duration (months)	Year 1	Year 2	Year 3	Year 4	Year 5
Bench Scale Testing and Lab Analysis	2					
Design, Work Planning and Permitting (1)	2					
Agency Approvals (2)	6					
Clearing and Grubbing	1					
Access Road Construction	1					
Electrical Service	3					
Seep A Flow Through Cell Construction and Pilot	6					
Seep D French Drain Construction and Pilot	6					
Seeps B and C Flow Through Cells Construction	6					
Evaluation of Initial Performance at Seeps A - D	6					
Optimization/Replacement of Cells/Drains as Needed	12					
Ongoing Operations and Maintenance	12					

1- Permits include but may not be limited to 404, 401, NPDES, and E&SC

2 - Task timing is dependent upon agency approval timing

Table 13: Schedule for Proposed Groundwater Action

Task	Duration (months)	Year 1	Year 2	Year 3	Year 4	Year 5
Interim - Design and Work Planning for Pumping from Existing MWs	3					
Interim - Installation and Operation	9					
Interim - Contingent Action Based on Performance Monitoring	12					
Pre-Design Investigation Work Planning and Contracting	3					
Geotechnical Investigation and Analysis	3					
Delineation Borings/Wells and In-River Flux Analyses	9					
Drilling and Aquifer Pump Testing	6					
Numerical Modeling Refinements	3					
30% Design	6					
Permitting Submittals (1)	12					
Permits/ Agency Approvals (2)	12					
60% Design	6					
90% Design	3					
100% Design and Contracting	3					
Mid-Implementation Review (3)	12					
Barrier Wall Installation (4)	20					
Site Work (Trenching, Piping, Electrical, Drilling, etc.)	24					
OOF2 System Upgrade (5)	24					
Testing and Commissioning	6					

1- Permits anticipated to potentially include but may not be limited to 404, 401, NPDES, and E&SC

2 - Task timing is dependent upon agency approval timing

3 - As the design and permitting process is advanced, there will be ongoing evaluation of the economical and technological feasibility of this remedial alternative, including analysis of new information that may become available over the next two years including any regulatory or permitting requirements, toxicological information, and other information concerning the condition and uses of the Cape Fear River. At the end of this two year period, Chemours would proceed with implementing this project, unless subsequent information shows that it is infeasible or if a more cost-effective alternative is available, in which case Chemours would seek DEQ approval.

4 - Material and method installation to be determined after pre-design investigation and design.

5 - Potential schedule assumes groundwater is conveyed to existing OOF2 system location and treatment train is upgraded to incorporate flow.

Table 14: Overall Estimated Reductions Plan Schedule and Reductions to Cape Fear River Total Table 3+ PFAS Loadings

Proposed and Provisional Remedial Alternatives	Loading Reduction	Duration (Years)	Year					
			2019	2020	2021	2022	2023	2024
Air Abatement Controls and Thermal Oxidizer[1]	<2%	1	✓					
Conveyance Network Sediment Removal - Outfall 002[2]	NQ[3]	1	✓					
Capture and Treat Old Outfall 002	26%	1						
Terracotta Pipe Replacement - Outfall 002	0.1%	2						
Stormwater Pollution Prevention Plan - Outfall 002	NQ[3]	1						
Groundwater Intrusion Mitigation - Outfall 002	0.7%	2						
Interim Action - CFR Seeps	NQ[3]	2						
Interim Action - Onsite Groundwater	NQ[3]	1						
Targeted Stormwater Control - Outfall 002	1.3%	4						
Ex Situ Capture and Treatment - CFR Seeps[4]	33%	4						
Onsite Groundwater Treatment	18%	5						
Cumulative Estimated Total Table 3+ PFAS River Reductions to River[5]	79%	--	<2%	26%	27%	43%	60%	79%

Notes

- Schedule for multiple alternatives are dependent upon permitting requirements.
- Loading reductions to CFR based on average of May, June, Sep. 2019 data
- Duration listed for implementation

1 - Scheduled implementation is December 31, 2019.
2 - Completed October 2019.
3 - Anticipated reduction from action cannot be quantified at present.
4 - Assumed to be Ex Situ Capture as the permanent remedial alternative for seeps.
5 - Cumulative estimated reductions assumes:
a) that reductions are achieved at the end of the implementation period; and
b) that the time period for contingent actions is not needed.

Legend

Action Complete	✓
Planned Action Implementation Period	
Time Period for Contingent Actions	

7 PERFORMANCE MONITORING

This section describes performance monitoring activities to accomplish the following objectives:

a) Corrective action performance monitoring;
b) Compliance with CO paragraph 16(d) performance monitoring;
c) On and Offsite groundwater quality monitoring.

The monitoring activities for objectives listed above are described in the following sections. These monitoring activities were developed concurrently with the CAP and may evolve during the course of pre-design investigations, pilot tests, preliminary results or other conditions. Monitoring locations, frequency and number of samples, analytical list and methods presented here may be modified to achieve objectives. Any potential recommended modifications to the monitoring plan will be presented in semi-annual monitoring data reports.

7.1 Corrective Action Performance Monitoring

Overall, the collective performance of the corrective actions will be assessed through PFAS mass loading reductions to the Cape Fear River as described in Sections 7.2 and 7.3 for Objectives (b) and (c) listed above. Individually the performance of corrective actions will be evaluated for both interim and long-term corrective actions proposed here and identified in the Reduction Plan Supplemental Information Report (Geosyntec, 2019h). Performance monitoring activities are described below for the following actions:

- Old Outfall 002
- Onsite Groundwater Seeps Interim Actions
  - Flow Through Cells
  - Capture and Treat (French Drains)
- Onsite Seeps Long-Term Actions
- Onsite Groundwater Interim Actions
- Onsite Groundwater Long-Term Actions

7.1.1 Old Outfall 002 Capture and Treatment Performance Monitoring

As required by the CO baseline surface water samples were collected from Old Outfall 002 for a six month period between March and August 2019 at locations indicated in Attachment A of the CO and analyzed for Table 3+ SOP and Modified EPA Method 537 compounds listed in Table 2. Performance monitoring for the treatment system will be performed according to the terms of the NPDES permit which in late 2019 had not yet been issued by NCDEQ.

7.1.2 Onsite Groundwater Seeps Interim Actions

Interim actions for groundwater Seeps A, B, C and D reaching the Cape Fear River at the Site include combination of flow-through cells and ex situ capture using French drains (Geosyntec, 2019h). The flow-through cell interim actions are proposed to start at Seep A with implementation progressing successively through Seeps B and C where lessons learned from the construction and operation of the flow-through cells at the prior seeps would be used to design and operate the subsequent flow-through cells. An ex-situ capture French drain would be installed at Seep D. A six-month pilot for both interim actions is recommended, followed by implementation of interim seep actions for a period of two years during which time the performance of each approach will be monitored and optimized. Operational and performance monitoring during pilot testing will be documented in pilot testing workplans. Monitoring efforts proposed during the two-year interim action implementation period are discussed below.

<u>Flow-through cells</u>

Visual inspections of flow-through cells will be performed to document and check the integrity and operation of the flow-through cell. Inspections shall be performed periodically or when circumstances beyond design limitations arise (e.g., excessive rainfall and flooding). Necessary repairs for continued operation and maintenance shall be documented including system down time, repairs/changes performed and other pertinent observations to operation of flow-through cell.

Table 3+ PFAS removal efficiency of the flow-through cell will be monitored by mass flux upstream and downstream of the cell. Mass flux will be measured by measuring flow and PFAS concentrations in surface water before it flows into the flow through structure and after it flows out. Flow rate measurement methods will be finalized following pre-design investigations. Performance sampling frequency is assumed to be at minimum quarterly during the start-up operational period of the flow-through cell. Spatial density and sampling frequency may be amended during pilot testing or under special circumstances including repair/carbon change out, flooding, etc.

<u>Seep capture and ex situ treatment</u>

Visual inspections of seep capture will be performed to evaluate the integrity and operation of the French drains periodically or when circumstances beyond design limitations arise. Necessary repairs for continued operation and maintenance shall be documented including system down time, repairs/changes performed and other pertinent observations to continued operation.

Capture efficiency of the seep capture remedy shall be assessed by monitoring influent seep flow rate, water levels in catchment basin and vertical sump and measuring sump pump rate. Treatment efficiency for this remedy is continuous operation of the collection pumps and the performance and proper operation of the treatment plant utilized. If flowing surface water is visibly expressed downgradient of the remedial system, samples may be collected for and analyzed for Table 3+ PFAS.

7.1.3 Onsite Groundwater Seeps Interim Actions

Based on operational and performance success one of the two interim remedial actions will be implemented at the Seeps as a long-term remedy (Geosyntec, 2019h). Operational and performance monitoring metrics identified for the interim actions are planned to be included in the long-term monitoring plan. Additional metrics identified during the interim operational period may be added to the long-term monitoring plan along with optimizing spatial density and temporal frequency of sampling. For the purpose of this plan, it is assumed that quarterly performance monitoring events will take place for the first two years of implementation followed by an optimization monitoring plan, which will be documented in monitoring data reports.

7.1.4 Onsite Groundwater Interim Actions

As an interim action groundwater will be extracted from seven existing onsite wells until a long-term remedy is operational unless otherwise improved, modified or demonstrated to be ineffective by subsequent analyses or evaluations. Periodic water levels will be collected from adjacent and surrounding monitoring wells to gauge a capture zone. Pumping rates will be periodically documented along with flow rate measurements in the conveyance piping to the treatment plant utilized. Treatment efficiency for this remedy is continuous operation of the collection pumps and the performance and proper operation of the treatment plant.

7.1.5 Onsite Groundwater Long-Term Remedial Actions

Monitoring actions presented here are preliminary pending pre-design investigations, pilot testing, final design, preliminary results and operational metrics or other conditions as described in Section 6.3.4. Monitoring locations and frequency and number of samples presented here may be modified to achieve the overall monitoring plan objectives.

Visual inspections of extraction wells, piping and other pertinent components will periodically be inspected to document and check the integrity and operation of the system or when circumstances beyond design limitations arise (e.g., flooding). Necessary repairs for continued operation and maintenance shall be documented including system down time, repairs/changes performed and other pertinent observations to operation of the system.

The effectiveness of the long-term groundwater remedial action will be assessed through water level measurement conducted with transducers in a network of extraction wells and monitoring wells. Transducer monitoring may also be periodically supplemented with manual water levels from representative wells in target aquifers. Water level data will be used to monitor temporal and spatial variations in hydraulic gradient magnitudes and direction to demonstrate hydraulic containment. The list of wells, including addition of new wells, will be identified during pre-design investigations and design reports. Appropriate sampling phasing and frequency may be re-evaluated during system startup and equilibration or if circumstances beyond design limitations arise. If necessary, the numerical groundwater model may be employed to perform a flow path analysis using measured water levels with particle tracking to demonstrate hydraulic capture.

7.1.6 Replacement Drinking Water Supplies

CO Section F contains requirements for Replacement Drinking Water Supplies that Chemours has been complying with, including a comprehensive program for testing private wells near the facility. Paragraph 21 states that Chemours shall perform annual retesting of private wells and "request incorporation of a plan to carry out this requirement in its Corrective Action Plan." Chemours set forth its plan for annual retesting of private wells in its April 26, 2019 Drinking Water Compliance Plan and its August 22, 2019 response to DEQ's comments on the Drinking Water Compliance Plan. Chemours hereby requests incorporation of that annual retesting plan into the CAP.

7.2 <u>Compliance with CO Paragraph 16(d) Performance Monitoring</u>

CO Paragraph 16(d) requires that Chemours:

> *"reduce PFAS loading to surface water (Old Outfall 002, Willis Creek, Georgia Branch, and the Cape Fear River), for the PFAS for which test methods and lab standards have been developed, by at least 75% from baseline.*

This subsection describes the performance monitoring activities to develop the baseline and evaluate reductions from baseline consistent with CO paragraph 16(d) requirements.

The best available and most representative data will be used to develop the baseline and evaluate reductions performance. These data will include empirically measured flows and concentrations from PFAS transport pathways described in Section 3.10. These data will include measurements such as flow and concentrations of PFAS in the creeks and in the Cape Fear River in addition to contextual information from groundwater wells including concentrations and potentiometric surface. These data will produce direct measurements of PFAS mass loading in multiple pathways and more importantly in the Cape Fear River itself. These data will be interpreted in conjunction with the Cape Fear River PFAS Mass

Loading Model (Geosyntec, 2019g) to facilitate standardized comparisons of mass loading between monitoring events.

Based on analyses presented in Section 5.4 of this CAP and the Reductions Plan Supplemental Information Report, the proposed corrective actions are intended to reduce the combined total Table 3+ PFAS mass loading reaching surface waters by 75%. Monitoring activities outlined here focus on developing additional data for the baseline of Table 3+ PFAS mass loadings to the Cape Fear River and evaluating the 75% reductions of PFAS mass loads in the Cape Fear River. While the mass loads in the other surface water bodies will be measured, only the Cape Fear River will be evaluated against 75% reductions for the following four reasons. First, all the Table 3+ PFAS mass loading to these surface waters reaches the Cape Fear River, and therefore it is a natural monitoring end point. Second, the Cape Fear River is the only surface water body listed in paragraph 16(d) that is used as a raw water intake. Third, both the human health and ecological SLEAs determined there were no presently identifiable hazards or adverse effects from HFPO-DA exposures on and offsite, including from surrounding surface waters. And fourth, as described in the Reduction Plan Supplemental Information report, reducing PFAS loading to Georgia Branch Creek and Willis Creek by over 75%, or in any other material way in the short term, is economically infeasible and technically challenging to infeasible.

The following two subsections describe how the baseline will be established and how performance monitoring towards the 75% Table 3+ PFAS mass loading reduction will be conducted.

7.2.1 Paragraph 16(d) Baseline Monitoring

The baseline monitoring program will collect additional data on flow rates and PFAS concentrations from the various potential PFAS transport pathways to the Cape Fear River, as identified in the mass loading model assessment (Geosyntec, 2019g). Specifically, Table 15 below lists transport pathways and sampling locations for where data will be collected:

The locations in the table above supplement and improve the ability to measure the PFAS mass loading baseline as described in Paragraph 16(c) of the CO:

> *"The baseline will be established using the average of the concentrations of the PFAS in groundwater monitoring wells for each surface water and LTWs along the Cape Fear River over the first four (4) quarters of sampling."*

Table 15: Baseline and Groundwater Monitoring Locations

Transport Pathway	Concentration	Flow
Willis Creek	✓	✓
Seep A	✓	✓
Seep B	✓	✓
Seep C	✓	✓
Seep D	✓	✓
Outfall 002	✓	✓
Old Outfall 002	✓	✓
Georgia Branch Creek	✓	✓
Groundwater Wells	✓	Water Levels
Cape Fear River	✓	✓

Paragraph 16(c) requires groundwater wells adjacent to Willis Creek, Old Outfall 002, Georgia Branch Creek and the Cape Fear River to facilitate developing baseline Table 3+ PFAS loadings. These wells already exist. Some of these wells pre-existed the CO and some were installed in 2019 as part of the onsite and offsite characterization programs. All the identified wells are listed in Table 16 and are adjacent to surface water bodies to fulfill paragraph 16(c) and (d) requirements. In total 22 monitoring wells, including the five LTW wells, will be monitored as part of the baseline monitoring activities. These wells are listed in Table 16 and shown on Figure 10.

Should interim or long-term corrective actions be complete at Groundwater Seeps, Old Outfall 002, or some other PFAS loading pathway before the additional monitoring data collection is complete, then the pre-treatment mass loading and/or collected Site data will be used to establish the baseline mass load. For instance, if the Old Outfall 002 treatment system is operational and removes 99% of all Table 3+ PFAS compounds, then the adjusted baseline mass loading in the river may be calculated as the measured mass loading in the river (river flow multiplied by river concentrations) plus the mass removed by the Old Outfall 002 treatment system (influent mass loading minus effluent mass loading).

The list of monitoring wells identified here, the temporal frequency of sampling, and the list of PFAS compounds analyzed, may evolve during the course of pre-design investigations, pilot tests, preliminary results or other conditions as necessary for developing the baseline. Any changes will be described, along with the rationale for the change in subsequent monitoring reports submitted to NCDEQ.

The baseline monitoring program will be completed over four quarters of sampling. After the data are received for each the first three quarters a quarterly baseline monitoring report will be prepared. After the fourth quarter of monitoring is complete a baseline monitoring report outlining the results of the program will be prepared.

The sampling activities for the first quarter of monitoring were completed between November and December 2019. Flow gauging and surface water sampling was conducted in November 2019; groundwater levels and samples were collected in December 2019. The first baseline quarterly reports will be prepared and submitted to NCDEQ in first quarter 2020.

Last, to develop a more continuous record of Table 3+ PFAS mass loading into the Cape Fear River, a pilot program will be undertaken and will be include collecting composite samples from the Cape Fear River downstream of the facility where the Cape Fear River is well mixed – about 5 miles downstream, provided required access agreements, etc., can be negotiated. These samples will enable a more consistent and continuous record of baseline Table 3+ PFAS mass loads in the Cape Fear River. Additionally, as composite samples, these samples will help attenuate the potential inherent natural variability possible when collecting and measuring samples in the Cape Fear River, a complex and dynamic system.

Table 16: Baseline Monitoring Well Locations

List Number	Well ID	Adjacent Surface Water Feature	Hydrogeological Unit
1	PIW-3D	Cape Fear River	Black Creek
2	PIW-7S	Cape Fear River	Floodplain
3	PIW-7D	Cape Fear River	Black Creek
4	LTW-01	Cape Fear River	Floodplain
5	LTW-02	Cape Fear River	Black Creek
6	LTW-03	Cape Fear River	Floodplain
7	LTW-04	Cape Fear River	Floodplain
8	LTW-05	Cape Fear River	Black Creek
9	PZ-22	Cape Fear River	Black Creek
10	PW-06	Georgia Branch Creek	Surficial
11	PW-07	Georgia Branch Creek	Surficial
12	PW-04	Old Outfall	Surficial
13	PW-11	Old Outfall	Black Creek
14	PW-09	Willis Creek	Black Creek
15	SMW-11	Willis Creek	Surficial
16	SMW-10	Willis Creek	Surficial
17	INSITU-02	Willis Creek	Surficial
18	SMW-12	Willis Creek	Black Creek
19	PIW-1S	Cape Fear River / Willis Creek	Floodplain
20	PIW-1D	Cape Fear River / Willis Creek	Surficial
21	Bladen-1S	Georgia Branch Creek	Surficial
22	Bladen-1D	Georgia Branch Creek	Black Creek

Notes:
1. Hydrogeologic units for existing wells determined based on boring log descriptions.
2. Samples to be collected quarterly, starting December 2019 through December 2020.
3. All samples to be analyzed for Table 3+ and Modified EPA Method 537.

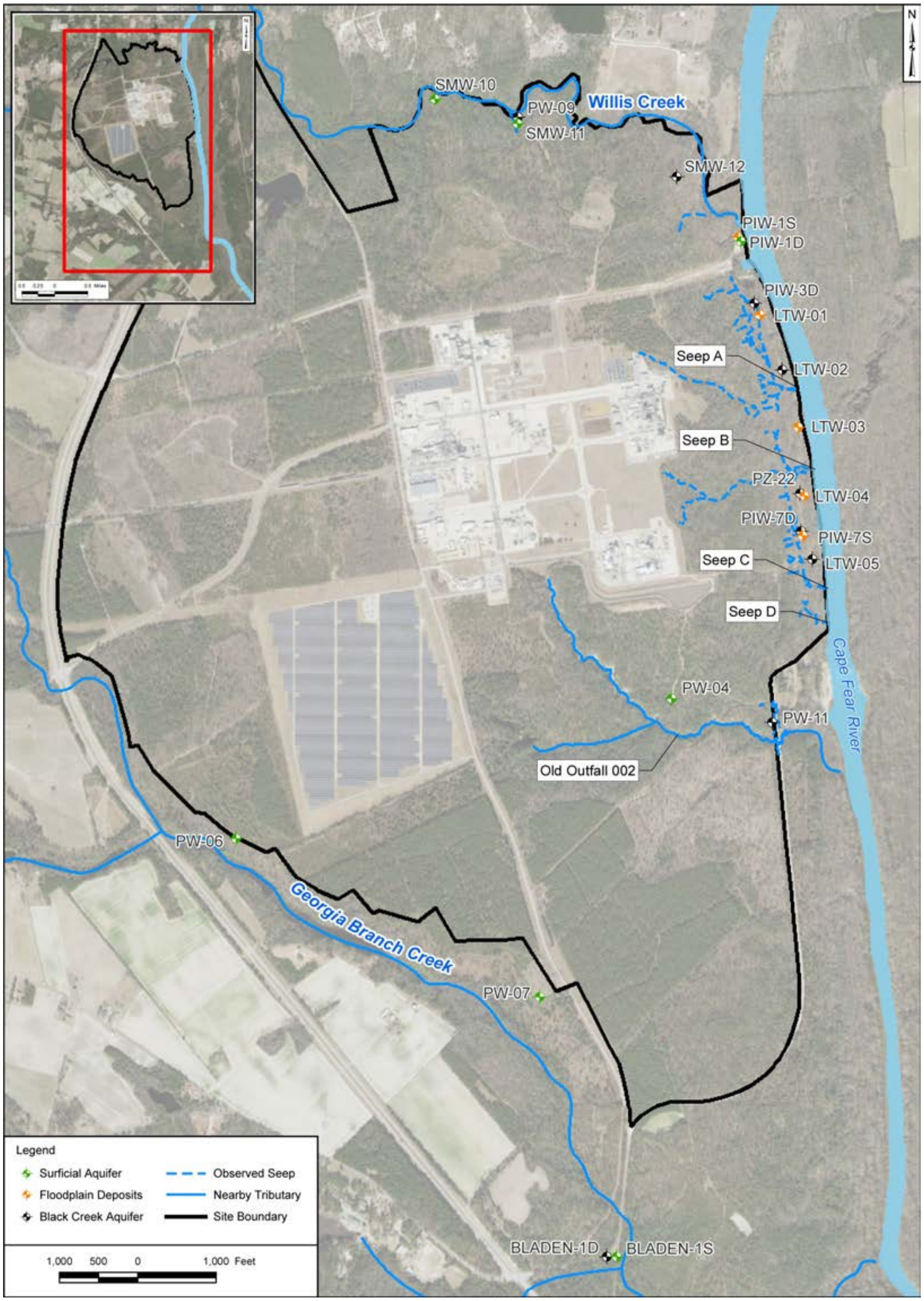

Figure 10: Baseline Monitoring Well Locations

7.2.2 Paragraph 16(d) Reductions Monitoring

Reductions in Table 3+ PFAS mass loading to the Cape Fear River will be evaluated relative to the baseline Table 3+ PFAS mass loading that will be developed during the baseline program. The reductions in the river Table 3+ PFAS loadings will be evaluated using the same set of monitoring locations identified for the baseline loading development. Potential adjustments to the reductions monitoring plan to increase its effectiveness will be outlined in the baseline monitoring report based on observations and outcomes from baseline monitoring.

A 75% reduction in Table 3+ PFAS mass loading to the Cape Fear River will be considered achieved when eight successive quarters of data show a 75% decrease in PFAS mass loads measured in the Cape Fear River. Consistent with CO paragraph 16(d) this observation will be supported using by (a) performance monitoring of the corrective actions showing successful reductions in concentrations, (b) measurements of loadings from the various PFAS transport pathways, and (c) evidence of reduction in groundwater PFAS mass loading to the Cape Fear River based on concentrations in LTW and the other groundwater wells and the groundwater gradients used to calculate flows to the surface water bodies and the Cape Fear River.

7.3 Onsite and Offsite Groundwater Quality Monitoring

Starting in 2020 in addition to the 22 wells being monitored quarterly as part of the paragraph 16(d) baseline and reduction monitoring programs, onsite and offsite wells installed by Chemours will be sampled annually between July 1st and September 30th (third quarter) for a period of three years. By March 31st each year a groundwater monitoring report will be prepared describing the results of the sampling from the prior year. After three years of sampling, the third annual groundwater monitoring report will evaluate if changes should be made to the sampling program such as reducing the number of wells sampled or abandoning certain wells. Some of the present wells at Site may be abandoned due to either construction issues or consistently dry wells screens before this sampling program is implemented.

Offsite private wells are presently being sampled on a routine bases as defined in the Drinking Water Compliance Plan (Parsons, 2019a).

8 REFERENCES

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