NORH CAROLINA PER- AND POLYFLUOROALKYL SUBSTANCES TESTING (PFAST) NETWORK

Progress Report #2 submitted to the North Carolina General Assembly

January 1, 2019

NC Policy Collaboratory

1.0 INTRODUCTION

The North Carolina General Assembly (NCGA), in the passing of Session Law (SL) 2018-5, Sections 13.1.(g), directed the North Carolina Policy Collaboratory (Collaboratory) to *"identify faculty expertise, technology, and instrumentation, including mass spectrometers, located within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T University, Duke University, and other public and private institutions, and coordinate these faculty and resources to conduct nontargeted analysis for PFAS, including GenX, at all public water supply surface water intakes and one public water supply well selected by each municipal water system that operates groundwater wells for public drinking water supplies as identified by the Department of Environmental Quality, to establish a water quality baseline for all sampling sites. The Collaboratory, in consultation with the participating institutions of higher education, shall establish a protocol for the baseline testing required by this subsection, as well as a protocol for periodic retesting of the municipal intakes and additional public water supply wells."* The term 'PFAS', listed above, refers to Per- and Polyfluoroalkyl Substances and the study is sometimes referred to herein as the PFAST Network (PFAS Testing Network).

In addition to the water sampling identified above, additional study parameters are mandated in Section 13.1.(l), which states, *"The Collaboratory shall identify faculty expertise within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, and use technology and instrumentation existing throughout the institutions to conduct the following research (i) develop quantitative models to predict which private wells are most at risk of contamination from the discharge of PFAS, including GenX; (ii) test the performance of relevant technologies in removing such compounds; and (iii) study the air emissions and atmospheric deposition of PFAS, including GenX. In addition, Collaboratory may, using relevant faculty expertise, technology, and instrumentation existing throughout institutions identified, evaluate other research opportunities and conduct such research for improved water quality sampling and analyses techniques, data interpretation, and potential mitigation measures that may be necessary, with respect to the discharge of PFAS, including GenX."*

Research to carry out these legislative mandates has commenced, and progress made to date is summarized in this this document which represents the second [quarterly] report. All provisions passed by the NCGA referring to this project are included in Appendix I of this report.

2.0 REPORTING REQUIREMENTS

Section 13.1.(h) of SL 2018-5 states, *"Beginning October 1, 2018, the Collaboratory shall report no less than quarterly to the Environmental Review Commission, the Department of Environmental Quality, and the Department of Health and Human Services on all activities conducted pursuant to this section, including any findings and recommendations for any steps the Department of Environmental Quality, the Department of Health and Human Services, the General Assembly, or any other unit of government should take in order to address the impacts of PFAS, including GenX, on surface water and groundwater quality, as well as air quality in the*

State." This report fulfills the NCGA requirement for the submission of quarterly progress reports starting on October 1, 2018. Four additional progress reports will be submitted no later than January 1, 2019; April 1, 2019; July 1, 2019; October 1, 2019. The project's final report will be submitted no later than December 1, 2019.

The NCGA-mandated Per- and Polyfuoroalkyl Substances (PFAS) study (herein referred to as the PFAS Testing Network or PFAST Network) was funded by an appropriation from the NCGA. Section 13.1.(i) of SL 2018-5 states, *"Five million thirteen thousand dollars ($5,013,000) of the funds appropriated in this act for the 2018-2019 fiscal year to the Board of Governors of The University of North Carolina shall be allocated to the Collaboratory to manage and implement the requirements of this section, which shall include distribution to the Collaboratory and participating institutions of higher education (i) to cover costs incurred as a result of activities conducted pursuant to this section, (ii) for acquisition or modification of essential scientific instruments, or (iii) for payments of costs for sample collection and analysis, training or hiring of research staff and other personnel, method development activities, and data management, including dissemination of relevant data to stakeholders. No overhead shall be taken from these funds from the participating institutions that receive any portion of these funds. Funds appropriated by this section shall not revert but shall remain available for nonrecurring expenses."*

3.0 PROGRESS TO DATE

During 3Q'18, Statements of Work (SOWs) were finalized by the PFAST Network research teams and approved by the Program Management Team and the Executive Advisory Committee. For reference, the PFAST Network organizational structure and team leaders are provided in Appendix II. Research activities described in the team SOWs are currently underway and the specific aims are summarized in Appendix III. Since the previous Quarterly Report submitted October 1, 2018, the following accomplishments are highlighted:

Overall Program Management Activities

- Budgets were finalized (refer to Appendix IV) and funds distributed to PIs at each institution. Research teams have hired postdoctoral fellows and identified graduate and/or undergraduate students to support sample collection, data acquisition and analyses. The teams have been meeting regularly and have initiated research activities.
- PFAST Network members from the program management, communications, and data teams met with Sheila Holman and representatives of the NC Department of Environmental Quality (DEQ) in Raleigh, NC on October 31, 2018 to provide an overview of the research teams' objectives, discuss recent and planned activities, identify potential challenges, and discuss communications.
- Dr. Jeffrey Warren, Research Director of the NC Policy Collaboratory, PFAST Network Program Director Dr. Jason Surratt and several members of the research and support teams attended the 2018 annual conference of the American Geophysical Union held in Washington DC, December 10-14, 2018 to increase visibility of the NC PFAST research program and to share information and establish connections with others across the nation interested in PFAS and emerging contaminants.

- A data policy agreement has been drafted by the project management and data science teams to ensure security, consistency, accessibility, and understandability of PFAST Network data and results.
- The Knappe lab at NCSU provided aliquots of commercially unavailable PFAS standards to Duke and UNC Chapel Hill. PFAST Network synthetic chemist, Dr. Zhenfa Zhang has begun synthesis of Nafion byproduct 2.

PFAS Water Sampling and Analysis

- In collaboration with the NCSU Center for Geospatial Analytics, the project team created a plan for efficient sampling of the 348 sites across the state (190 surface water intakes and 158 municipal public water supply wells) which were identified in conjunction with the NC DEQ (Fig. 1). The team has started contacting water treatment plants to schedule the sampling trips. The first quarter 2019 sample collection schedule and a full list of sampling sites is included in Appendix V.
- New Orbitrap and triple quadrupole mass spectrometers were acquired by the Knappe lab and the NCSU METRIC mass spectrometry facility (not funded through PFAST Network) mirroring the instrumentation available at Duke University in the Ferguson lab. Hardware, software, and workstation for data processing have been installed and optimized for PFAS analyses and vendor-provided training of post-docs and students was completed.
- Analytical methods and Standard Operating Procedures (SOPs) have been developed for non-targeted analysis on the high resolution, Thermo Scientific™ Orbitrap ID-X Tribid MS (NCSU) and Orbitrap Fusion Lumos (Duke) employing either direct injection of filtered water samples or solid phase extraction prior to LC-MS.
- A list of suspect compound mass to charge values (*m/z*) was generated and uploaded to the commercial software packages (Thermo Scientific™ Compound Discoverer and Tracefinder™) and a script was developed in "R" for automated *in silico* fragmentation processing of raw data in publicly available algorithms (e.g. Sirius, MetFrag).
- Analytical methods and SOPs for targeted, quantitative analysis of PFAS have been developed for the Agilent Ultivo (NCSU) and the Thermo Scientific™ Altis (Duke) triple quadrupole mass spectrometer systems.
- In preparation for Adsorbable Organic Fluorine (AOF) measurements, the Sun lab at ECU has verified clean background levels using their new adsorption unit and five commercially available adsorbents: two activated carbon; one non-ionic resin; and two ionic resins. Method validation is in progress.

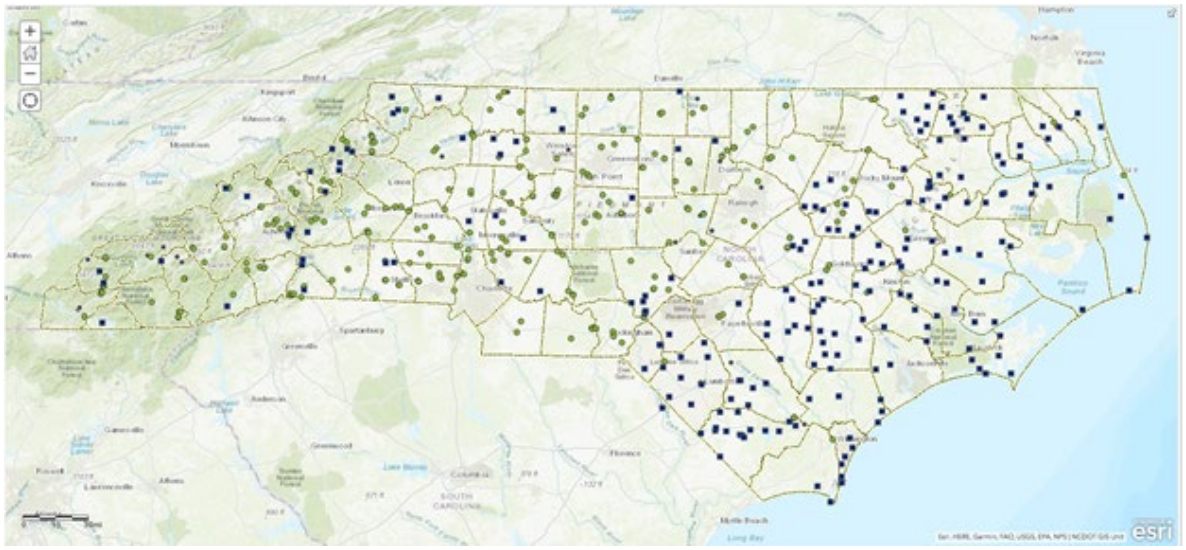


Figure 1: Surface (green dots) and groundwater (blue dots) sampling sites for drinking water sources to be analyzed for PFAS including GenX.

Private Well Risk Modeling

- Based on results from previous survey sampling for PFAS discharge from groundwater in four streams directly or indirectly tributary to the Cape fear River (Georgia Branch, Mines creek, Kirks Mill Creek, and Willis Creek), a detailed sampling campaign was carried out in Georgia Branch and Miles Creek in October 2018. Water flux through the streambed was determined at 30 points (Fig. 2), and groundwater samples for PFAS analysis were collected just beneath the streambed. Stream water samples were also collected and are being analyzed along with the groundwater samples in the Knappe lab for PFAS levels.
- Preliminary estimates of GenX loading from groundwater to the Cape Fear River suggest that groundwater discharge to streams in the Chemours area may account for a significant fraction of the persistent low-level GenX concentrations observed (~ 8 ng/L at seasonal summer low flow, W.O. Huske Lock gauging station near Chemours). The preliminary calculations were based on initial survey sampling in summer 2018 and will be updated with results from the October 2018 field work.
- A talk was presented at the December 2018 annual conference of the American Geophysical Union (AGU) in Washington, DC: Koropeckyj-Cox, L., D.P. Genereux, and D.R.U. Knappe. 2018. “Field Determination of the PFAS Flux from Groundwater to Streams in a Contaminated Area of the North Carolina Coastal Plain”.

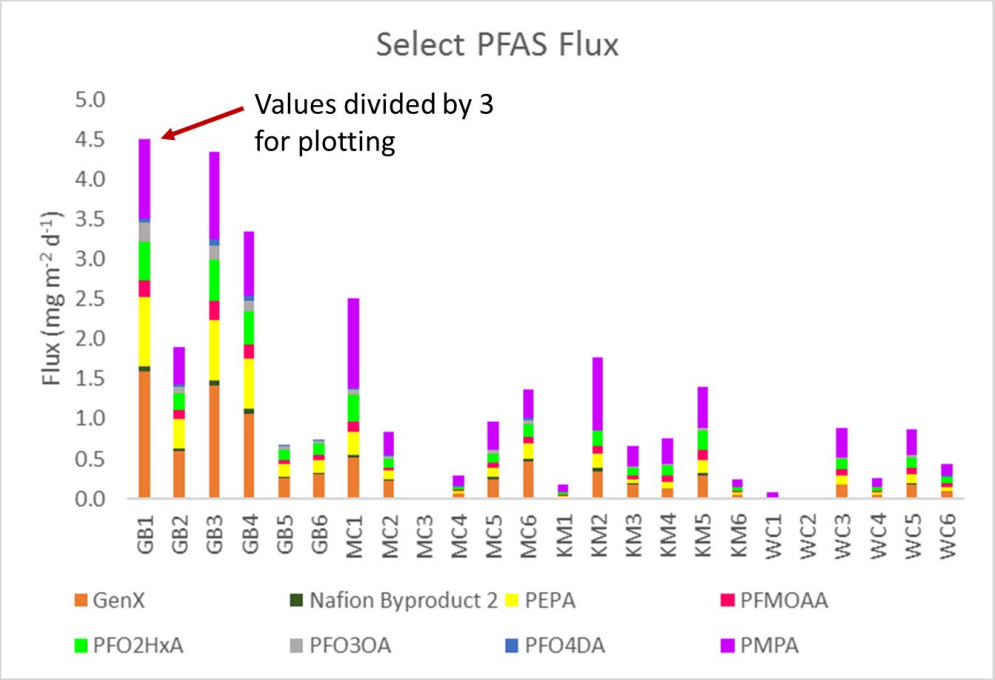


Figure 2: The plot shows the flux from aquifer to stream for the 8 most abundant PFAS in the groundwater near Chemours, at 24 different streambed points in four streams (6 points per stream): GB = Georgia Branch, MC = Mines Creek, KM = Kirks Mill Creek, and WC = Willis Creek. Note that the high results at location GB1 had to be divided by 3 in order to be plotted at the scale shown. These 8 PFAS account for over 96% of the total flux of measured PFAS chemicals from aquifer to stream at these measurement points. Additional points have been and will be measured to better define these fluxes.

- The team obtained data on 1,221 GenX measurements in 769 private drinking water wells previously collected by the NC Department of Environmental Quality (DEQ) Chemours. For 102 of these samples, PFAS was also measured and for 98 PFOA was measured. These data are being used to generate a curated data set for development of the risk model for private well contamination.

PFAS Removal Performance Testing

- Data collected from rapid small-scale column tests with granular activated carbons demonstrates the effect of chain-length and branching on the absorbability of PFASs. Determination of scale-up and removal efficiency of PFAS in settled surface water collected from Cape Fear Public Utility Authority (CFPUA) through rapid small-scale column tests is in progress.
- Commercial high-pressure membranes for testing have been selected and are being procured. Assembly of the membrane testing rig that will be dedicated to this project is close to completion. Specific experimental details and procedures for the membrane tests are being finalized between the Coronell and Knappe labs.
- The first set of electrochemical degradation tests have been completed using a commercial titanium oxide electrode "®Ebonex Plus", which has been successfully used for degrading other organic contaminants. No PFAS mineralization was

achieved using up to the maximum current density (7.9mA per 100mm) allowed by the electrode material. Other electrode materials which would allow higher current application will be explored.

- The study "PFAS removal from finished drinking water by in-home filters in NC households" is underway. To date 61 participants have been recruited from the cities of Durham, Raleigh, Cary, Apex, Chapel Hill and Pittsboro. Each participant has provided a tap water and filtered water sample. Preliminary analyses indicate that the PFAS levels are highest in Pittsboro, followed by Cary and Chapel Hill. The PFAS signature is dominated by the C5-C7 PFCAs, and removal efficiency by activated carbon is significantly correlated to chain length.
- Sampling and analysis continue on the Haw River and Jordan Lake, where the team has been collecting surface water samples on a weekly basis. PFAS levels are being analyzed in association with river flow rates and drinking water levels in respective townships and temporal variations in PFAS levels will be examined.
- Adsorption of PFAS (Gen-X, PFOA, PFHxA, 50 ug/L each) onto 12 different Ionic Fluorogel samples (100 mg/L) was tested under conditions simulating drinking water (200 ppm NaCl). For 8 of the 12 samples tested, >95% equilibrium adsorption of all PFAS was observed after 21h. Therefore, 8 samples were deemed successful and prioritized for further testing. These 8 Ionic Fluorogel samples were challenged with simulated ground water containing 200 ppm NaCl + 20 mg/L organic contaminants (Humic acid). Five of the 8 samples demonstrated >95% equilibrium adsorption of all PFAS after 21h.

Air Emissions and Atmospheric Deposition

- Preliminary air sampling experiments were conducted in Chapel Hill using low volume samplers to evaluate collection times with respect to analytical detection limits and to compare breakthrough on two different adsorbents, polyurethane foam (PUF) and resin-based activated carbon monolith (ACM). Air sampling SOPs, field data sheets and chain of custody forms have been created and optimization of the analytical method is in progress.
- Air samplers have been deployed and are currently collected samples in Fayetteville at Honeycutt (between Fort Bragg and Chemours), in Greenville at ECU, and Wilmington at UNC-W. Additional air samplers are being installed in Chapel Hill (co-located with deposition sampler) and Charlotte.
- Samples from seven rain events as well as precipitation from Hurricanes Florence and Michael have been collected for PFAS analysis. Two custom wet/dry atmospheric deposition samplers dedicated for this study have been installed at the UNC-W atmospheric chemistry research station. Based on initial experiments, an SOP has been written for field sample collection with the automated systems at UNC-W and five secondary locations. Precipitation collectors and sampling equipment for 3 wet deposition and 3 dry deposition winter season collections have been set up at Baldhead Island (Fig. 3) and shipped to ECU, UNC-CH, Appalachian State and UNC-C.

Figure 3: Remote wet/dry deposition sampling station at Baldhead Island located on a 50 ft. dune ridge overlooking Cape Fear. This will allow collection of both wet and dry deposition samples representing a true marine air mass during certain wind directions.

Other Applied Research Opportunities

Novel PFAS Inputs into the environment: landfill leachates

- Dr. Barlaz spoke at a meeting of the NC Chapter of the Solid Waste Association of North America (NC-SWANA) on November 14th and at a private meeting with landfill owners on November 8th to discuss data needs and to build support for sampling. In addition he met with NC DEQ Solid Waste Division to describe the project and is meeting with the NC Urban Water Consortium in January to make contact with wastewater treatment plant operators. He met with a local consultant in the wastewater field to identify candidate landfills.

PFAS bioaccumulation in aquatic environments: alligator and fish studies

- Dr. Belcher delivered a public presentation to 50-60 attendees at the Cape Fear River Watchers First Saturday Seminar Series on December 12th. The title of his talk was: Studies of Fish and Alligator Exposures to PFAS in North Carolina: The SAFEwater-NC Study. Striped bass blood samples from Cape Fear River (n=64) and Pamlico Aquaculture Facility (n=30) have been collected and preliminary analyses are in progress. The team also captured and collected Alligator samples from 1 male and 1 female alligator from Greenfield Lake in Wilmington. Due to the seasonal nature of the study, no sample collections have been possible during this the past month, but the team is preparing for the spring collection. Optimization of the PFAS

analytical method is in progress and the SOP for non-targeted analysis on the high resolution Orbitrap mass spectrometer is being finalized.

Health effects following exposure: mouse model of immunotoxicity

- The first dosing study has been completed in Dr. DeWitt's lab (Fig 4). Mice were administered PFMOAA, one PFAS found in high concentrations in the Cape Fear River in 2016, and the dosing groups are illustrated in Figure 4. Immunophenotype data have been collected and are being analyzed, and adaptive immunity (T-cell dependent antibody response), and innate immunity (Natural Killer cell cytotoxicity) will be assessed next.
- Dr. DeWitt's lab was awarded PFAS funding from the US EPA via subcontract from Oregon State University. The goal of this funded research will be to evaluate the ability of selected PFAS to induce developmental immunotoxicity in a mouse model.

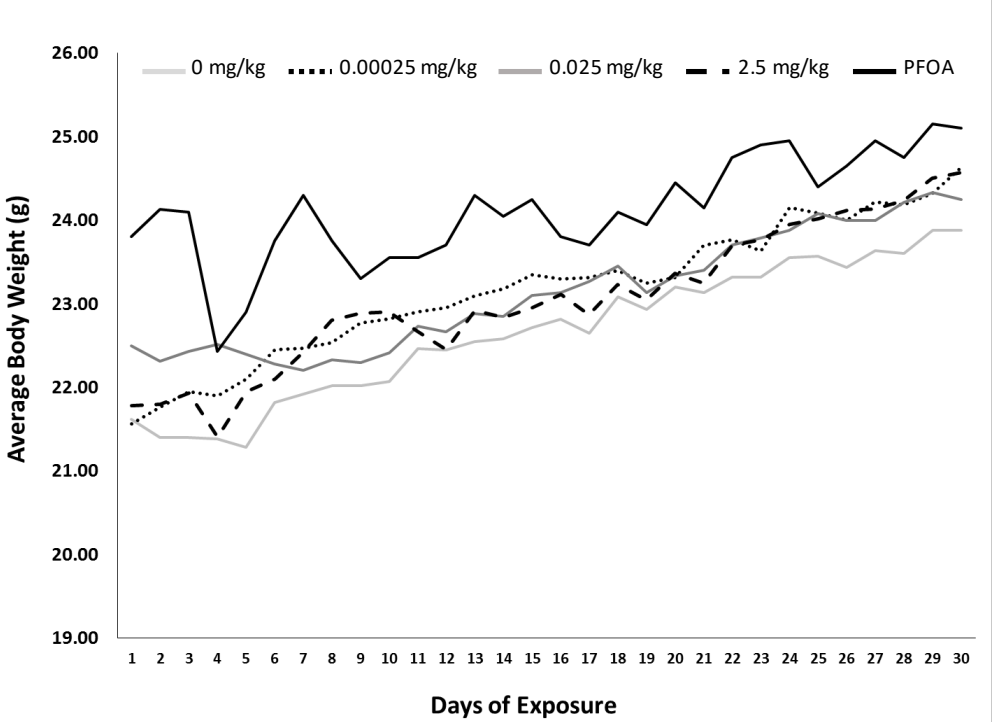


Figure 4: Average body weight (g) of male C57BL/6 mice orally exposed to PFMOAA for 30 days.

PFAS bioaccumulation and distribution in crop plants: greenhouse studies

- Dr. Duckworth's team has recruited a postdoc, added an undergraduate student to the project, designed their greenhouse experiments and started procuring PFAS chemicals and supplies.

Health effects following exposure: placental inflammation and immune cell signaling

- The IRB amendments submitted by Drs. Fry and Manuck were approved to permit collection of multiple water samples per enrolled subject. This expanded study including multiple water samples is termed "EPOCH-PLUS". The EPOCH-PLUS clinical study manual was finalized and an official study logo (Fig. 5) was generated to

promote the study and to encourage placental sample collection during delivery. Sample collection supplies and patient incentives (tote bag and metal water bottle) with EPOCH logo were purchased using internal funds from Dr. Manuck to encourage participation and facilitate collection of multiple water samples.

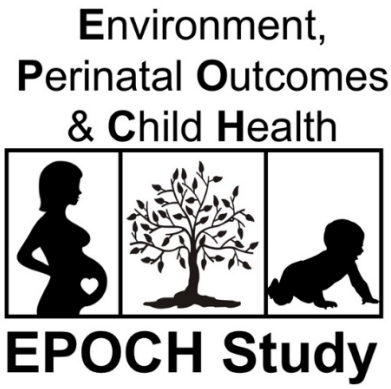


Figure 5: New logo to promote EPOCH-PLUS study recruitment and collection of water and placenta samples.

- The team has recruited 10/11 women (91%) who were approached for EPOCH-PLUS or EPOCH-CASE during the enrollment period of 11/1/18 through 12/6/18. Total cumulative enrollment is 16 women (12 EPOCH-PLUS and 4 EPOCH-CASE) (10/23/18-12/6/18). The first water sample from 9 of the 12 EPOCH-PLUS participants has been received, and of those 1 participant has sent in her second water sample. Out of the four EPOCH-CASE participants, so far only one has provided a water sample. The team is following up with subjects who are missing water samples and is completing demographic and past history data collection for enrolled subjects.
- In vitro experiments aimed at assessing PFAS-induced inflammatory effects on placental cells are underway. JEG-3 cells were treated with a range of doses of PFOS, PFOA, and GenX in serum containing and serum free media for 24h and collected. Cytotoxicity assessments were performed to characterize the NOAEL of PFOS, PFOA, and GenX and compare the effect of utilizing or omitting fetal bovine serum. RNA was analyzed for quality and content, converted to cDNA, and submitted to the UNC Advanced Analytics core for gene expression analysis. Supernatant and whole cell lysate of JEG-3 cells treated with PFOS, PFOA, and GenX are being analyzed by ELISA (supernatants) and Western blot (lysates) to confirm significant changes observed in expression of inflammatory genes. Optimization of the extraction protocol for LC-MS analysis is nearing completion. The team is also working on cloning JEG-3 cells transfected to express the fluorescent proteins eGFP and mCherry. A pilot 3D invasion experiment using breast cancer cells and PFOS, PFOA, and GenX was conducted and initial results indicate that PFAS increase invasion, but more replicates are needed to confirm.

Construction of complex physiologically based computer models

- In preparation for working with data obtained in the animal dosing studies, Dr. Luke has conducted a literature review for previously published quantitative models involving PFASs and has downloaded the Benchmark Dose (Modeling) Software (BMDS) from the US EPA and completed the familiarization tutorials.

Risk Communications

- The Fall 2018 research symposium held at Duke University which focused on emerging contaminants (including PFAS) in the ambient environment was well attended with 216 participants representing academia, government, nonprofit and private sector entities. An edited recording of the event is available at: https://www.youtube.com/watch?v=7rdEJFaZ0DI&feature=youtu.be
- Following the very successful symposium, the team presented an overview of the PFAST Network and associated communications activities at an October 1, 2018 meeting in Raleigh, NC organized by the League of Municipalities for its members, which included local governments and water utilities. They also participated in a PFAST Network meeting with NCDEQ staff in Raleigh, NC on October 31, 2018 to discuss data and communications issues and strategies.
- A meeting of media contacts from Duke, NCSU, and UNCCCH was convened to outline communications protocols for the project, on October 15, 2018. UNC-CH staff drafted FAQs for review by team media contacts and the project management team.
- UNC-CH purchased domain names and developed a prototype web site during September and October 2018, which was shared with NCSU when they took responsibility for the site in November 2018. Content for the website is being finalized and public access is expected by the end of January.
- Organizers/leaders of all three of the Triangle's science café series (Duke, UNC and NC Museum of Natural Sciences) have been contacted to request that PFAST research scientists be added to the 2019 lineup for each series. The team hopes to have 2019 science café dates locked in for at least one or two of the local events.

Data Science and Management

- Team leaders Dr. Mitasova from NCSU Center for Geospatial Analytics (CGA) and Dr. Christopher Lenhardt from UNC-CH Renaissance Computing Institute (RENCI) and their team have been working with the PFAST Network researchers to identify the spatial components for each project, to create a tool for determining an efficient plan for sample collection trips across the state, to identify data types (e.g. raw, processed, meta) and storage requirements and to develop a data management strategy and knowledge base infrastructure.

APPENDIX I

LEGISLATIVE LANGUAGE PASSED BY THE NORTH CAROLINA GENERAL ASSEMBLY

(Session Law 2018-5, Sections (f) through (l), effective June 12, 2018)

FUNDING TO ADDRESS PER- AND POLY-FLUOROALKYL SUBSTANCES, INCLUDING GENX/USE OF EXPERTISE AND TECHNOLOGY AVAILABLE IN INSTITUTIONS OF HIGHER EDUCATION LOCATED WITHIN THE STATE

SECTION 13.1.(f) The General Assembly finds that (i) per- and poly-fluoroalkyl substances (PFAS), including the chemical known as "GenX" (CAS registry number 62037-80-3 or 13252-13-6), are present in multiple watersheds in the State, and impair drinking water and (ii) these contaminants have been discovered largely through academic research not through systematic water quality monitoring programs operated by the Department of Environmental Quality or other State or federal agencies. The General Assembly finds that the profound, extensive, and nationally recognized faculty expertise, technology, and instrumentation existing within the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions of higher education located throughout the State should be maximally utilized to address the occurrence of PFAS, including GenX, in drinking water resources.

SECTION 13.1.(g) The North Carolina Policy Collaboratory at the University of North Carolina at Chapel Hill (Collaboratory) shall identify faculty expertise, technology, and instrumentation, including mass spectrometers, located within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, and coordinate these faculty and resources to conduct nontargeted analysis for PFAS, including GenX, at all public water supply surface water intakes and one public water supply well selected by each municipal water system that operates groundwater wells for public drinking water supplies as identified by the Department of Environmental Quality, to establish a water quality baseline for all sampling sites. The Collaboratory, in consultation with the participating institutions of higher education, shall establish a protocol for the baseline testing required by this subsection, as well as a protocol for periodic retesting of the municipal intakes and additional public water supply wells. No later than December 1, 2019, Collaboratory shall report the results of such sampling by identifying chemical families detected at each intake to the Environmental Review Commission, the Department of Environmental Quality, the Department of Health and Human Services, and the United States Environmental Protection Agency.

SECTION 13.1.(h) Beginning October 1, 2018, the Collaboratory shall report no less than quarterly to the Environmental Review Commission, the Department of Environmental Quality, and the Department of Health and Human Services on all activities conducted pursuant to this section, including any findings and recommendations for any steps the Department of Environmental Quality, the Department of Health and Human Services, the General Assembly, or any other unit of government should take in order to address the impacts of PFAS, including GenX, on surface water and groundwater quality, as well as air quality in the State.

SECTION 13.1.(i) Five million thirteen thousand dollars ($5,013,000) of the funds appropriated in this act for the 2018-2019 fiscal year to the Board of Governors of The University of North Carolina shall be allocated to the Collaboratory to manage and implement the requirements of this section, which shall include distribution to the Collaboratory and participating institutions of higher education (i) to cover costs incurred as a result of activities conducted pursuant to this section, (ii) for acquisition or modification of essential scientific instruments, or (iii) for payments of costs for sample collection and analysis, training or hiring of research staff and other personnel, method development activities, and data management, including dissemination of relevant data to stakeholders. No overhead shall be taken from these funds from the participating institutions that receive any portion of these funds. Funds appropriated by this section shall not revert but shall remain available for nonrecurring expenses.

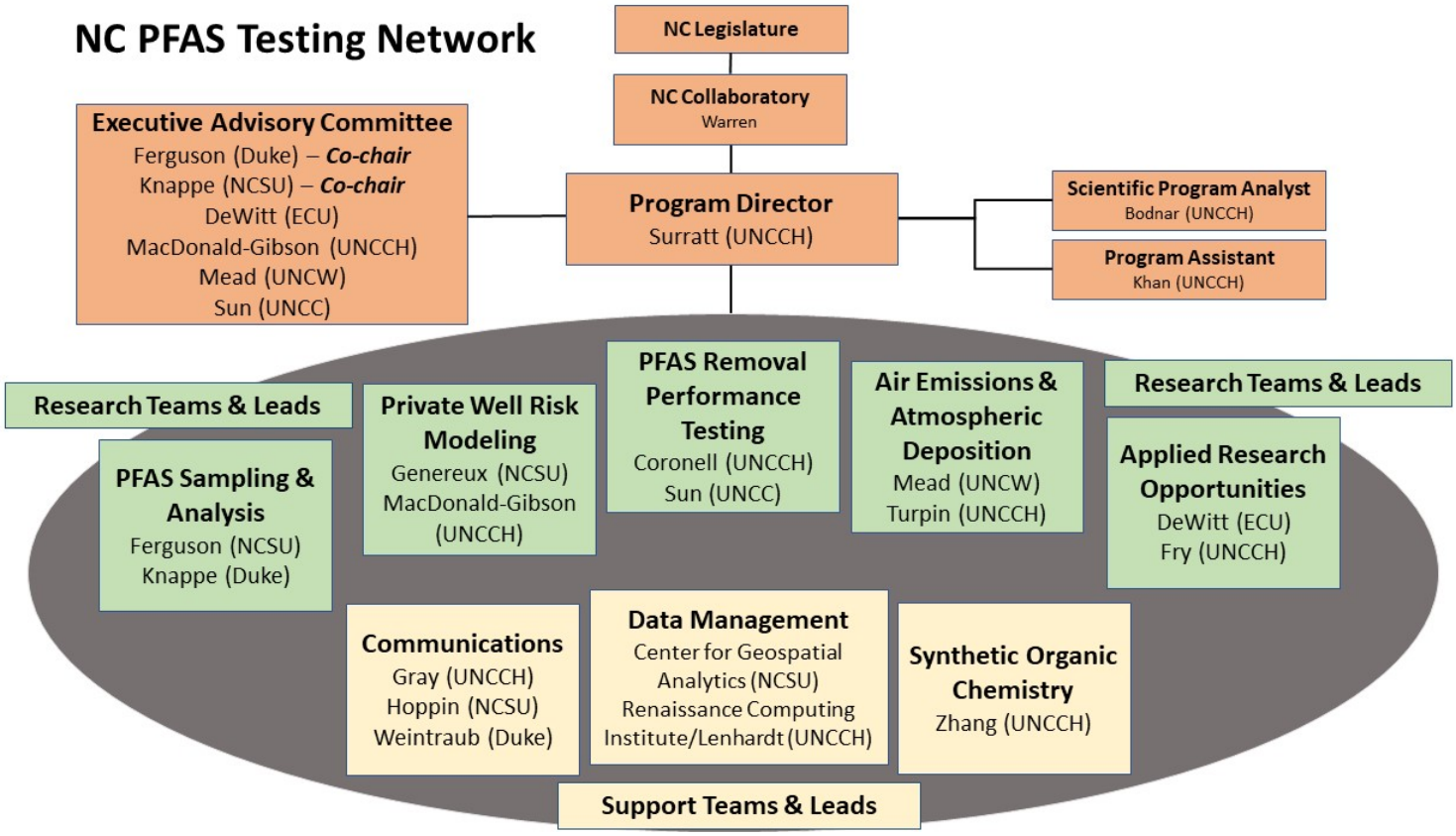
SECTION 13.1.(j) The Collaboratory should pursue relevant public and private funding opportunities that may be available to address the impacts of PFAS, including GenX, on surface water and groundwater quality, as well as air quality, in order to leverage funds appropriated by this section, or any other funds provided to the Collaboratory, including the Challenge Grant authorized in Section 27.5 of S.L. 2016-94, as amended by Section 10.4(a) of S.L. 2017-57.

SECTION 13.1.(k) In the event that the United States Environmental Protection Agency no longer provides access to its analytical instrumentation at no cost to the State for water quality sampling analysis related to per- and poly-fluoroalkyl substances (PFAS), including the chemical known as "GenX" (CAS registry number 62037-80-3 or 13252-13-6), or if the Department of Environmental Quality determines that such analysis is not being performed in a sufficiently timely manner, the Collaboratory shall coordinate such analysis in the most cost-effective manner using relevant faculty expertise, technology, and instrumentation, including mass spectrometers, existing throughout institutions of higher education located throughout the State, until such time as the Department of Environmental Quality is able to perform such analysis with instrumentation acquired pursuant to subsection (q) of this section. The Collaboratory, in consultation with the Department and relevant experts across institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, shall establish a protocol for delivery of such samples taken by the Department to the entity designated to perform analysis of the samples, chain of custody protocols, and other matters to ensure proper handling and processing of the samples, which protocols shall be subject to approval by the United States Environmental Protection Agency, if such approval is required pursuant to authority delegated from the United States Environmental Protection Agency to the Department to administer federal environmental law.

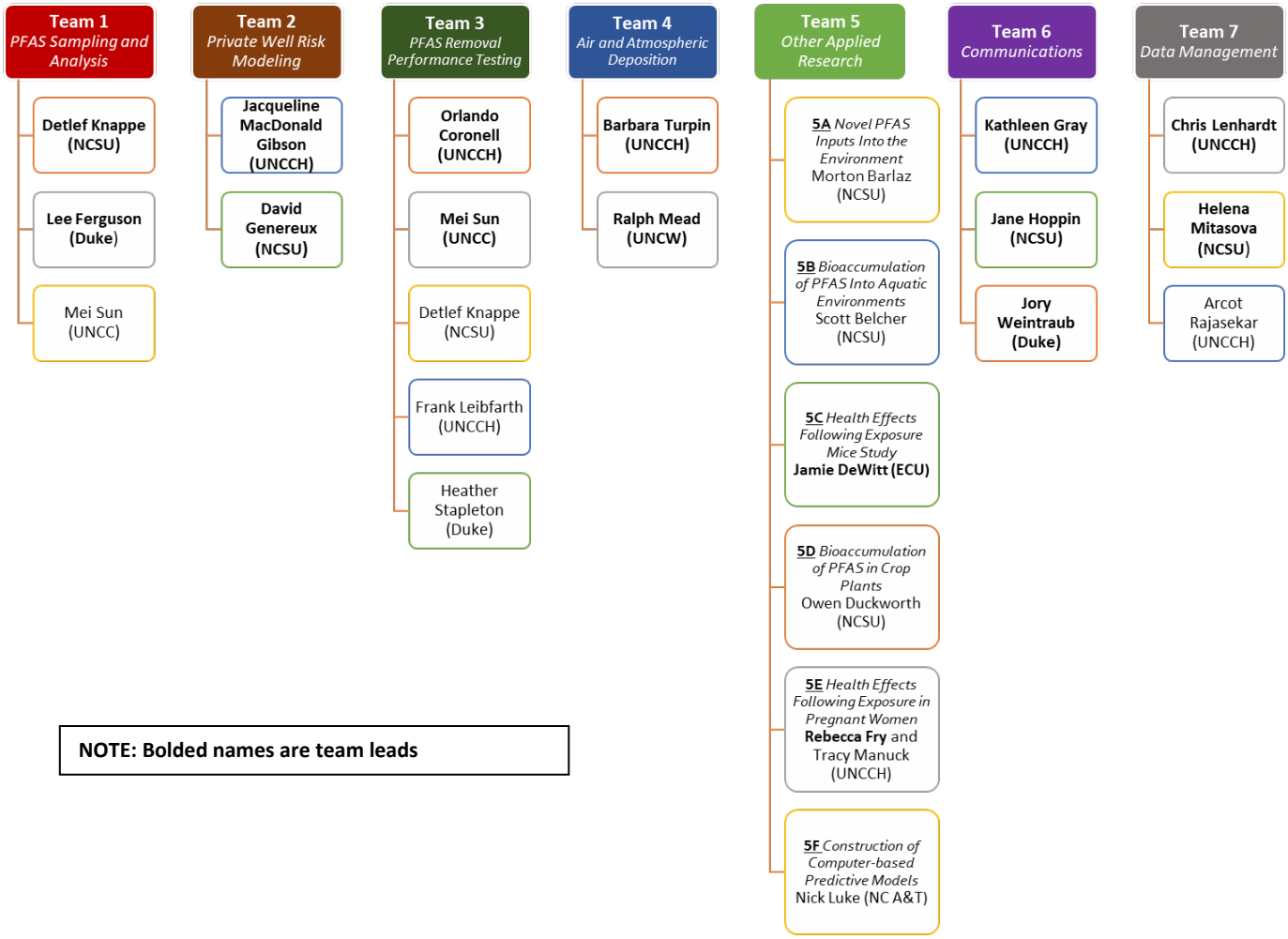
SECTION 13.1.(l) The Collaboratory shall identify faculty expertise within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, and use technology and instrumentation existing throughout the institutions to conduct the following research (i) develop quantitative models to predict which private wells are most at risk of contamination from the discharge of PFAS, including GenX; (ii) test the performance of relevant technologies in removing such compounds; and (iii) study the air emissions and atmospheric deposition of PFAS, including GenX. In addition, Collaboratory may, using relevant faculty expertise, technology, and instrumentation existing throughout institutions identified, evaluate other research opportunities and conduct such research for improved water quality sampling and analyses techniques, data interpretation, and potential mitigation measures that may be necessary, with respect to the discharge of PFAS, including GenX.

APPENDIX II

PFAST NETWORK ORGANIZATIONAL CHARTS



PFAST NETWORK RESEARCH TEAMS: PRINCIPLE INVESTIGATORS, INSTITUTIONS AND RESEARCH FOCI



NOTE: Bolded names are team leads

APPENDIX III

LISTING OF SPECIFIC GOALS AND AIMS/ACTION PLANS FOR EACH PFAST NETWORK TEAM*

** PFAST Network team goals and aims are part of each team's peer-reviewed Scopes of Work as of December, 2018. These may be revised, in consultation with the Project Management Team, based on future research results or unforeseen circumstances.*

Team ONE	
Project Team:	PFAS Sampling and Analysis
Team Leaders:	Detlef Knappe (NCSU); Lee Ferguson (Duke)

Team Objectives

Goal: To analyze all municipal drinking water sources in NC for PFASs using suspect screening, non-targeted analysis, and quantitative analysis

Specific Aims

1. Collect water samples in two consecutive quarters at the intake of all 191 municipal surface water systems in NC and from one well each at all 149 municipal systems treating groundwater in NC. For systems with detectable PFAS, collect additional set of samples in 3Q19.
2. Quantify targeted PFAS in water samples using high-sensitivity triple quadrupole LC-MS/MS approaches
3. Analyze all water samples using high-resolution mass spectrometry for PFAS compounds by non-targeted and suspect screening
4. Complement non-targeted analyses with adsorbable organic fluorine (AOF) measurements to estimate what fraction of measured AOF can be explained by quantifiable PFAS identified in targeted and non-target analyses.

Team TWO	
Project Team:	Private Well Risk Modeling
Team Leaders:	Jacqueline MacDonald Gibson (UNCCH); David Genereux (NCSU)

Team Objectives

Goal: To uncover factors influencing the risk of PFAS contamination in water supply wells near the Chemours plant by collecting and interpreting new data on the fate and transport of PFAS contaminants in the surficial groundwater system near Chemours and by building and validating machine-learned Bayesian network (BN) models for risk prediction

Specific Aims

1. Advance quantitative understanding of PFAS Transport, focusing on PFAS input to and output from the surficial aquifer and on PFAS distribution within the aquifer. Gather critical data to address six fundamental questions: 1) rate of input; 2) rate of output; 3) rate of change of mass storage; 4) relationships; 5) transit time distribution; 6) retardation factors
2. Build machine-learned BN models predicting private well contamination risk using new data from aim 1 and prior monitoring results provided by DEQ for 1,000 water supply wells; Validate models; and Develop interactive web-based version using *BayesiaLab*'s Web Simulator platform. Model will be linked to a GIS mapping application for easy visualization.

Team THREE

Project Team:	PFAS Removal Performance Testing
Team Leaders:	Orlando Coronell (UNCCH); Mei Sun (UNCC)

Team Objectives

Goal: To identify optimum technologies for removing both legacy and emerging PFASs from contaminated surface and ground waters in NC as well as from finished drinking water

Specific Aims

1. Characterize PFAS removal from drinking water sources by a wide range of commercially available activated carbons, IX resins, and high-pressure membranes
2. Evaluate electrochemical oxidation for PFAS removal from waste streams generated during challenge tests (Aim 1) and analyze resulting degradation products
3. Characterize PFAS removal from finished drinking water by in-home filters in NC households
4. Evaluate enhancement of PFAS rejection by means of membrane modification to reduce contaminant permeation and passage
5. Develop an IX resin (Ionic Fluorogels) optimized for PFAS removal to overcome the limitations of activated carbon and ion-exchange technology

Team FOUR

Project Team:	Air and Atmospheric Deposition
Team Leaders:	Ralph Mead (UNCW); Barbara Turpin (UNCCH)

Team Objectives

Goal: To better understand the airborne composition, distribution and concentrations of gas- and particle-phase PFAS

Specific Aims

1. Measure atmospheric gas- and particle-phase concentrations of PFAS compounds in Wilmington, Chapel Hill, Charlotte, Greenville, and possibly a 5th location, providing monthly averages
2. Measure highly polar gas-phase PFAS species in real-time in one location during a single 1-2 week intensive field campaign by I-HR-TOF-CIMS
3. Conduct preliminary experiments to examine multi-phase chemistry (or reactive uptake) of HFPO with atmospheric aerosol
4. Determine the concentration of PFAS in rainwater at the Wilmington site (intensive sampling)
5. Examine the influence of airmass back trajectory and season on the atmospheric concentration and distribution of PFAS at the Wilmington site
6. Determine PFAS concentration and distribution in wet and dry deposition at other selected locations on a less frequent basis (e.g., ECU, UNCCH, UNCC, WCU, Bald Head Island)
7. Determine the wet/dry areal deposition of GenX and other PFAS to surface waters including the Cape Fear River drainage basin

Team FIVE - A

Project Team:	Novel PFAS Inputs Into the Environment (Landfills)
Sub-Team Leader:	Morton Barlaz (NCSU)

Team Objectives

Goal: To estimate the total quantity of PFASs present in leachate that is subsequently discharged to either Publicly Owned Treatment Works (POTWs) or to surface water after on-site treatment at a landfill

Specific Aims

1. Estimate the mass of PFASs that are discharged to POTWs by characterizing the PFAS fingerprint of MSW landfill leachates using non-targeted analysis
2. Estimate the mass of PFASs entering POTWs in NC via municipal wastewater and assess the relative importance of MSW landfills as a source of PFASs to POTWs
3. Estimate the release of PFASs to surface water downstream of POTWs using published information on attenuation during treatment
4. Estimate the release of PFASs from landfills that receive C&D waste and document C&D landfill location

Team FIVE - B

Project Team:	Bioaccumulation of PFAS Into Aquatic Environments
Sub-Team Leader:	Scott Belcher (NCSU)

Team Objectives

Goal: To increase understanding of the potential for bioaccumulation and adverse impacts of PFASs, including GenX, on the health of the Cape Fear River aquatic ecosystem.

Specific Aims

1. Conduct untargeted analysis of alligator and striped bass serum samples collected from the Cape Fear River and Pamlico Aquaculture Facility
2. Collect and analyze liver and muscle of adult sunfish/bluegill and largemouth bass from other smaller water sources associated with known point source of PFASs (near Chemours)
3. Develop detailed ecological models to help identify geographical areas of concern within the CF watershed and share derived data with NC DEQ and other regulatory agencies

Team FIVE - C

Project Team:	Health Effects Following Exposure
Sub-Team Leader:	Jamie DeWitt (ECU)

Team Objectives

Goal: To evaluate immunotoxicity (dose-responsive suppression of antigen-specific antibody responses) in mice exposed to PFASs

Specific Aims

1. Determine effects of selected PFASs on major immune cell subpopulations in primary (thymus) and secondary (spleen) lymphoid organs
2. Assess functional responsiveness of the adaptive immune system (T cell-dependent antibody response targeting B cells) following exposure to selected PFASs
3. Asses functional responsiveness of the innate immune system (NK cell cytotoxicity) following exposure to selected PFASs

Team FIVE - D

Project Team:	Bioaccumulation of PFAS in Crop Plants
Sub-Team Leader:	Owen Duckworth (NCSU)

Team Objectives

Goal: To improve understanding of PFAS uptake and distribution within plant tissues and to explore how soil properties and management strategies may impact PFAS uptake and distribution

Specific Aims

1. Measure uptake of PFAS compounds by two plants relevant to Eastern NC agriculture via greenhouse experiments and determine the effects of organic carbon content on PFAS availability by varying compost composition of the soil
2. Image plant tissues found to contain high level PFAS by STXM (scanning X-ray transmission spectroscopy) to determine the distribution and molecular associations of PFAS in plant tissues

Team FIVE - E

Project Team:	Health Effects Following Exposure
Sub-Team Leader:	Rebecca Fry (UNCCH); Tracy Manuck (UNCCH)

Team Objectives

Goal: To determine levels of PFAS in drinking water, asses exposure in pregnant women, and investigate the impact of PFAS on the placenta and pregnancy outcomes as well as the mechanisms underlying the adverse effects

Specific Aims

1. Determine levels of PFAS in drinking water, placenta, cord blood, maternal urine, and maternal serum in a pregnancy cohort in NC
2. Examine PFAS-induced inflammatory effects on the placenta in vitro

Team FIVE - F

Project Team:	Construction of Computer-based Predictive Models
Sub-Team Leaders:	Nick Luke (NC A&T)

Team Objectives

Goal: To conduct quantitative analysis of experimental immunotoxicity and systemic toxicity data and construct computer-based models to support derivation of health goals

Specific Aims

1. To derive Reference Doses (RfDs) from experimental data (in collaboration with Team 5c) using Benchmark Dose Modeling Software (BMDS, US EPA)
2. To construct and apply PBPK model to predict ADME properties (absorption, distribution, metabolism, excretion) of emerging PFASs

Team SIX

Project Team:	Communications
Team Leaders:	Kathleen Gray (UNCCH); Jane Hoppin (NCSU); Jory Weintraub (Duke)

Team Objectives

Goal: The communications initiative has two overarching goals:

(1) To increase awareness of the PFAST study and its findings among NC policymakers, the media and lay publics
(2) To create opportunities for dialogue about the study among diverse groups, including student scientists, key stakeholders, and lay publics

Specific Aims

1. Engage policymakers, water utilities, and other stakeholders in dialogue about emerging contaminants, PFAS, and study findings
2. Increase awareness of emerging contaminants, PFAS, and study findings among lay publics
3. Build capacity of study investigators and trainees to effectively communicate about emerging contaminants and potential risks to public health

Team SEVEN

Project Team:	Data Science and Management
Team Leaders:	Chris Lenhardt (UNCCH); Helena Mitasova (NCSU)

Team Objectives

Goal:

(1) To support PFAST Network data science requirements related to collecting, managing, and disseminating Network data.
(2) Provide geospatial data expertise and tools to support PFAST data-related activities.

Specific Aims

1. Prepare document identifying geospatial components for each team
2. Discuss and define specific data management logistics
3. Further improve sampling planning tool
4. Develop project relevant data catalogs.
5. Develop a workflow and tools catalog.
6. Develop and maintain PFAST data policies.
7. Develop data package descriptions.
8. Metadata and documentation support.

9. Develop Project Data Repository

10. Develop Re-usable Scientific Workflow Tools

11. Data Dissemination

12. Project Coordination, Communications and Reporting

APPENDIX IV

OVERVIEW OF BUDGET BREAKDOWN FOR PFAST NETWORK BASED ON $5,013,000 LEGISLATIVE APPROPRIATION

Table 1. Total Budgeted Expenditures Per University

Breakdown of budget allocations for each campus involved in the NCGA-mandated PFAST Network. Numbers have been rounded to the nearest dollar.

UNIVERSITY	AMOUNT
University of North Carolina at Chapel Hill	$1,889,652
University of North Carolina at Wilmington	$299,942
North Carolina State University	$1,550,762
North Carolina A&T State University	$20,521
University of North Carolina at Charlotte	$341,406
East Carolina University	$171,068
Duke University	$739,649
TOTAL	**$5,0130,000**

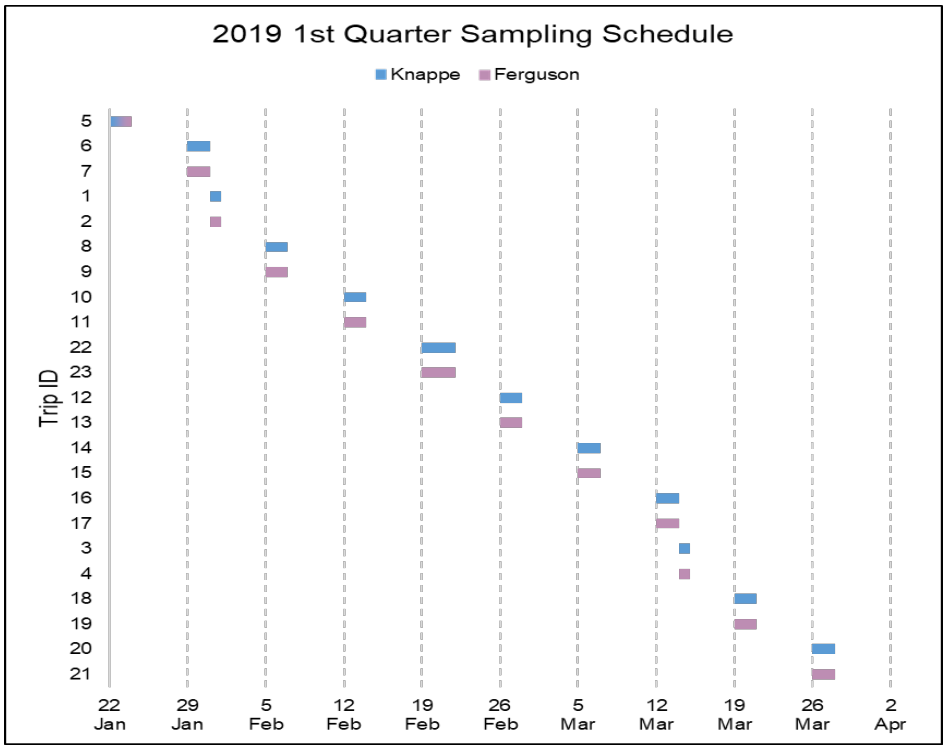
Table 2. Total Budgeted Expenditures Per Team

Breakdown of budget allocations for each team (which includes multiple campuses) involved in the NCGA PFAST Network. Numbers have been rounded to the nearest dollar.

TEAM	UNCCH	UNCW	NCSU	NCA&T	UNCC	ECU	DUKE
Project Mgmt	$715,923	$0	$0	$0	$0	$0	$0
Team 1 H2O sampling	$0	$0	$502,075	$0	$171,478	$0	$582,906
Team 2 well risk models	$137,100	$0	$240,927	$0	$0	$0	$0
Team 3 PFAS removal tests	$256,882	$0	$126,907	$0	$166,928	$0	$99,689
Team 4 air deposition	$235,246	$299,942	$0	$0	$3,000	$3,000	$0
Team 5 Applied R&D	$199,207	$0	$510,857	$20,521	$0	$168,068	$0
Team 6 communications	$61,054	$0	$57,054	$0	$0	$0	$57,054
Team 7 data mgmt	$284,239	$0	$112,942	$0	$0	$0	$0
TOTAL	**$1,889,652**	**$299,942**	**$1,550,762**	**$20,521**	**$341,406**	**$171,068**	**$739,649**

APPENDIX V

STATEWIDE WATER SAMPLING PLAN LOCATIONS AND SCHEDULE*



* *Sampling locations and schedule may be revised, in consultation with the Program Management Team, based on future research results or unforeseen circumstances.*

Sampling Site Trip and Location IDs for 1Q'19

Trip ID	Total Sites	Est. time (h)	Location IDs
1	10	7.4	319,339,42,44,43,303,63,40,301,302
2	9	7.4	323,322,304,305,296,321,295,294,278
3	9	7.6	310,312,313,299,300,273,274,272,28
4	8	7.6	311,250,249,251,252,279,280,268
5	17	15.8	29,338,277,276,275,256,255,253,254,271,270,263,30,269,282,281,31
6	19	15.6	267,264,266,290,265,320,125,157,124,123,122,331,152,330,329,107,325,104,103
7	20	15.7	298,297,62,60,61,59,64,99,97,94,102,98,95,100,101,151,335,116,96,117
8	20	16	154,155,336,153,156,337,327,326,328,133,129,132,130,109,134,131,73,108,110,111
9	18	15.3	341,115,89,92,106,105,142,143,145,146,334,144,119,120,118,121,342,72
10	14	15.3	74,112,80,141,137,148,150,149,71,68,67,147,70,69
11	19	16	49,308,309,47,46,307,45,48,50,234,235,174,173,22,170,172,230,171,231

12	17	15.1	228,229,21,260,259,257,262,258,292,32,261,283,33,289,284,285,288
13	14	15.4	91,136,93,90,78,77,79,114,113,135,76,140,139,127
14	15	15.4	207,205,248,247,27,287,286,291,1,161,3,4,2,245,244
15	16	15.7	41,66,52,58,55,340,37,35,36,34,38,158,138,126,128,75
16	14	15.5	241,240,26,242,243,6,246,8,7,5,222,18,223,19
17	17	15.9	306,236,24,220,189,193,187,188,191,190,210,192,186,185,12,184,183
18	12	15.9	206,232,233,227,225,226,224,20,23,202,199,198
19	12	15.6	176,175,177,169,15,9,162,10,165,166,201,200
20	9	15.7	168,237,197,14,13,194,196,195,182
21	9	14.3	163,164,203,204,238,25,216,217,215
22	19	23.1	181,180,208,209,17,16,167,219,218,159,160,213,212,214,178,179,211,221,11
23	26	21.4	39,332,333,343,324,87,86,85,81,82,83,88,84,54,51,318,57,53,56,65,314,317,293,239,316,315

Details of Sampling Site Locations

Trip ID	Site ID	Water System ID	Y-coordinate	X-coordinate	Water System Name
1	40	NC0326040	155962.3716	633692.9671	WADE, TOWN OF
	42	NC0351015	197626.6242	672887.3116	SELMA, TOWN OF
	43	NC0351040	195220.1523	678003.26	PINE LEVEL, TOWN OF
	44	NC0351045	200882.0926	681819.028	MICRO, TOWN OF
	63	NC0382035	166058.7677	668070.3404	NEWTON GROVE, TOWN OF
	301	NC0343010	175100.6443	637008.8572	DUNN, CITY OF
	302	NC0343045	184063.7351	626046.2971	HARNETT CO DEPT OF PUBLIC UTIL
	303	NC0351010	196571.9739	668647.9557	SMITHFIELD, TOWN OF
	319	NC0392010	212193.4852	644784.1305	RALEIGH, CITY OF
	339	NC0351070	203643.5839	670665.4221	JOHNSTON CO-WEST
2	278	NC0276020	221316.7301	548248.2596	RAMSEUR, TOWN OF
	294	NC0319010	223355.138	568366.5063	SILER CITY, CITY OF
	295	NC0319015	224703.9141	596004.6377	PITTSBORO, TOWN OF
	296	NC0319126	220612.6989	607789.2084	CHATHAM CO-NORTH
	304	NC0353010	199519.1808	607297.3571	SANFORD, CITY OF
	305	NC0353130	200326.6846	587505.0984	PILGRIM`S PRIDE WATER SYSTEM
	321	NC0392020	220592.9623	607733.3954	CARY, TOWN OF
	322	NC0392992	208531.9217	613612.0969	HARRIS NUCLEAR PLANT WATER SYSTEM
	323	NC0392992	208565.7434	613821.5777	HARRIS NUCLEAR PLANT WATER SYSTEM
3	28	NC0217015	308277.7198	590812.4643	MILTON, TOWN OF
	272	NC0273010	292616.2696	600197.3562	ROXBORO, CITY OF
	273	NC0273010	296700.5294	608063.4013	ROXBORO, CITY OF
	274	NC0273409	303114.3292	603347.9477	ROXBORO STEAM PLANT
	299	NC0332010	262034.0234	621348.8615	DURHAM, CITY OF

	300	NC0332010	266322.3934	624854.787	DURHAM, CITY OF
	310	NC0368010	238158.5358	601267.2135	ORANGE WATER & SEWER AUTHORITY
	312	NC0368015	257493.7463	597828.9003	HILLSBOROUGH, TOWN OF
	313	NC0368020	258971.1052	596889.4797	ORANGE-ALAMANCE WATER SYSTEM
4	249	NC0201010	263848.4652	573020.3858	BURLINGTON, CITY OF
	250	NC0201010	254190.39	564158.2709	BURLINGTON, CITY OF
	251	NC0201015	260633.1776	579900.9956	GRAHAM, CITY OF
	252	NC0217010	292622.1781	577141.7428	YANCEYVILLE, TOWN OF
	268	NC0241010	270782.0804	543779.9263	GREENSBORO, CITY OF
	279	NC0279010	303882.9396	541562.6658	EDEN, CITY OF
	280	NC0279020	281165.311	550112.2859	REIDSVILLE, CITY OF
	311	NC0368010	244087.5369	587811.0217	ORANGE WATER & SEWER AUTHORITY
5	29	NC0276025	232407.5949	556284.0153	LIBERTY, TOWN OF
	30	NC0285015	282238.7047	506554.228	WALNUT COVE, TOWN OF
	31	NC0285020	295677.2872	500255.3036	DANBURY, TOWN OF
	253	NC0229010	236001.1915	501697.281	LEXINGTON, CITY OF
	254	NC0229020	238153.3103	502940.0906	THOMASVILLE, CITY OF
	255	NC0229025	234229.5302	484461.5946	DAVIDSON WATER INC
	256	NC0229030	205851.1327	497869.0751	DENTON, TOWN OF
	263	NC0234010	260892.526	502327.1658	WINSTON-SALEM, CITY OF
	269	NC0241010	269021.6349	534204.6864	GREENSBORO, CITY OF
	270	NC0241020	251377.2632	520659.9514	HIGH POINT, CITY OF
	271	NC0241020	249538.6735	524364.3937	HIGH POINT, CITY OF
	275	NC0276010	214629.7111	521817.7159	ASHEBORO, CITY OF
	276	NC0276010	220639.0211	530168.0267	ASHEBORO, CITY OF
	277	NC0276010	219097.6899	531756.5959	ASHEBORO, CITY OF
	281	NC0279025	296774.3088	523163.4439	MAYODAN, TOWN OF
	282	NC0279030	291669.6153	520523.4901	MADISON, TOWN OF
	338	NC3076010	234747.2362	534868.8816	PIEDMONT TRIAD REGIONAL
6	103	NC0433015	222709.5741	732622.5204	PINETOPS, TOWN OF
	104	NC0433020	223113.706	727890.1925	MACCLESFIELD, TOWN OF
	107	NC0442035	254006.7122	752431.9173	HOBGOOD, TOWN OF
	122	NC0464020	245534.5733	699582.1008	NASHVILLE, TOWN OF
	123	NC0464025	241967.7849	689166.4285	SPRING HOPE, TOWN OF
	124	NC0464035	225930.8644	689099.1262	BAILEY, TOWN OF
	125	NC0464050	225863.5886	680861.9649	MIDDLESEX WATER SYSTEM
	152	NC0498020	227920.7318	710507.2508	ELM CITY, TOWN OF
	157	NC0498045	223681.2805	694471.8429	SIMS TOWN OF
	264	NC0235010	261450.4818	657061.2825	FRANKLINTON, TOWN OF
	265	NC0235010	260243.6191	654977.3329	FRANKLINTON, TOWN OF

	266	NC0235015	261074.1439	671984.9892	LOUISBURG, TOWN OF
	267	NC0239107	268238.0302	629969.9583	SOUTH GRANVILLE WTR&SEWER AUTHORITY
	290	NC0291010	298359.9263	667023.9509	HENDERSON-KERR LAKE REG WTR
	320	NC0392010	244144.773	647344.5241	RALEIGH, CITY OF
	325	NC0433010	241667.4172	744032.076	TARBORO, TOWN OF
	329	NC0442025	267362.3352	726671.1089	ENFIELD WATER SYSTEM
	330	NC0464010	244965.3091	716115.9771	ROCKY MOUNT, CITY OF
	331	NC0464010	239000.7282	710213.0935	ROCKY MOUNT, CITY OF
7	59	NC0382010	135766.9411	669865.5048	CLINTON, CITY OF
	60	NC0382015	132985.9361	654285.1525	ROSEBORO, TOWN OF
	61	NC0382020	115527.0209	664473.7311	GARLAND, TOWN OF
	62	NC0382025	141252.7734	654572.1675	SALEMBURG, TOWN OF
	64	NC0382040	138381.8964	684186.2966	TURKEY, TOWN OF
	94	NC0431010	108880.5711	700955.1434	WALLACE, TOWN OF
	95	NC0431015	136274.5103	693109.3226	WARSAW, TOWN OF
	96	NC0431020	130537.6238	721278.9715	BEULAVILLE, TOWN OF
	97	NC0431025	119521.2549	696992.244	ROSE HILL, TOWN OF
	98	NC0431030	134156.1666	703856.4194	KENANSVILLE, TOWN OF
	99	NC0431035	127628.9743	695453.7836	MAGNOLIA, TOWN OF
	100	NC0431040	150248.9664	687984.4373	FAISON, TOWN OF
	101	NC0431045	155294.9314	691481.3915	CALYPSO, TOWN OF
	102	NC0431060	118877.1274	706049.6156	GREENEVERS, TOWN OF
	116	NC0454015	169720.5166	718907.2939	LA GRANGE WATER SYSTEM
	117	NC0454020	145178.3036	724194.5325	PINK HILL, TOWN OF
	151	NC0496015	159311.8098	694888.78	MOUNT OLIVE, TOWN OF
	297	NC0326010	146344.6368	618998.1081	FAYETTEVILLE PUBLIC WORKS COMM
	298	NC0326010	147826.3981	622019.8148	FAYETTEVILLE PUBLIC WORKS COMM
	335	NC0496010	180656.755	697311.7648	GOLDSBORO, CITY OF
8	73	NC0408015	274974.9574	777807.209	AULANDER, TOWN OF
	108	NC0446010	281632.0346	789869.56	AHOSKIE, TOWN OF
	109	NC0446015	298721.662	778801.0272	MURFREESBORO, TOWN OF
	110	NC0446020	294719.4787	794929.7475	WINTON, TOWN OF
	111	NC0446030	290799.3442	797229.451	VILLAGE OF COFIELD
	129	NC0466010	294656.3869	751574.9982	JACKSON, TOWN OF
	130	NC0466015	308396.7301	772146.7189	SEVERN, TOWN OF
	131	NC0466020	281258.0434	763991.6124	RICH SQUARE, TOWN OF
	132	NC0466025	299240.9067	768480.2481	CONWAY, TOWN OF
	133	NC0466035	306155.9711	749147.3165	SEABOARD, TOWN OF
	134	NC0466040	286474.6741	768419.012	WOODLAND, TOWN OF
	153	NC0498025	205748.1206	715752.7402	STANTONSBURG, TOWN OF
	154	NC0498030	210037.9339	698601.904	LUCAMA, TOWN OF

	155	NC0498035	209551.4647	705379.3695	BLACK CREEK, TOWN OF
	156	NC0498040	211212.228	719873.1558	SARATOGA TOWN OF
	326	NC0442010	303768.1352	730956.6508	ROANOKE RAPIDS SANITARY DIST
	327	NC0442010	303459.6344	728602.3296	ROANOKE RAPIDS SANITARY DIST
	328	NC0442020	303776.2603	730990.8685	WELDON WATER SYSTEM
	336	NC0498010	215542.9057	704772.6664	WILSON, CITY OF
	337	NC0498010	221735.3035	708808.7568	WILSON, CITY OF
9	72	NC0408010	249050.6461	793906.8835	WINDSOR, TOWN OF
	89	NC0425010	152871.2	762108.3404	NEW BERN, CITY OF
	92	NC0425025	163699.318	751648.5636	DOVER, TOWN OF
	105	NC0440010	186917.4513	729371.8199	SNOW HILL, TOWN OF
	106	NC0440020	185789.4986	737444.8228	HOOKERTON, TOWN OF
	115	NC0454010	165701.5725	729036.7766	KINSTON, CITY OF
	118	NC0459010	233749.6791	782660.0916	WILLIAMSTON, TOWN OF
	119	NC0459015	231540.6421	766361.2855	ROBERSONVILLE, TOWN OF
	120	NC0459025	245322.5457	770940.5648	HAMILTON, TOWN OF
	121	NC0459030	230587.8785	798763.6879	JAMESVILLE, TOWN OF
	142	NC0474020	199088.9604	734871.2374	FARMVILLE, TOWN OF
	143	NC0474025	187344.9192	749716.9549	AYDEN TOWN OF
	144	NC0474030	229779.888	756253.3776	BETHEL, TOWN OF
	145	NC0474035	183859.513	751571.2122	GRIFTON, TOWN OF
	146	NC0474040	196659.764	754284.7234	WINTERVILLE, TOWN OF
	334	NC0474010	210138.3921	754446.5645	GREENVILLE UTILITIES COMM
	341	NC6054001	164599.9327	727090.4017	NEUSE REGIONAL WTR & SWR AUTH
	342	NC6059015	236038.6929	786198.2209	MARTIN CO REGIONAL WASA
10	67	NC0407010	196814.7223	793374.7071	WASHINGTON, CITY OF
	68	NC0407015	203237.5469	824736.653	BELHAVEN WATER SYSTEM
	69	NC0407020	173952.7257	810853.3828	AURORA WATER SYSTEM
	70	NC0407025	194049.3327	783361.612	CHOCOWINITY WATER SYSTEM
	71	NC0407030	193497.4928	808265.4402	BATH WATER SYSTEM
	74	NC0408040	276390.5531	795427.2393	POWELLSVILLE, TOWN OF
	80	NC0421010	259381.3096	823718.943	EDENTON, TOWN OF
	112	NC0446040	285356.0182	808422.8501	HARRELLSVILLE, TOWN OF
	137	NC0470010	286641.8861	851813.4986	ELIZABETH CITY, CITY OF
	141	NC0472010	272412.9222	835976.7157	HERTFORD WATER SYSTEM
	147	NC0474055	202492.5505	773612.945	GRIMESLAND, TOWN OF
	148	NC0489010	243806.9726	857680.3611	COLUMBIA WATER SYSTEM
	149	NC0494010	230867.1541	811828.4663	PLYMOUTH WATER SYSTEM
	150	NC0494020	238259.2081	845124.5191	CRESWELL TOWN OF
11	22	NC0180055	203983.876	476943.4688	FAITH, TOWN OF

	45	NC0363010	148425.7284	565112.8027	SOUTHERN PINES, TOWN OF
	46	NC0363020	150142.9765	565863.5674	ABERDEEN, TOWN OF
	47	NC0363030	150484.673	565579.9721	PINEBLUFF, TOWN OF
	48	NC0363035	161592.8138	565257.7352	TAYLORTOWN, TOWN OF
	49	NC0363040	174048.9578	584299.0567	CAMERON, TOWN OF
	50	NC0363479	156541.0243	555403.819	FOXFIRE VILLAGE, TOWN OF
	170	NC0113010	193758.4577	466393.9979	CONCORD, CITY OF
	171	NC0113010	188700.3354	455235.1119	CONCORD, CITY OF
	172	NC0113010	192853.6685	465766.7453	CONCORD, CITY OF
	173	NC0113020	187593.0695	480790.4628	MOUNT PLEASANT, TOWN OF (WSACC)
	174	NC0113020	188566.3	479070.4907	MOUNT PLEASANT, TOWN OF (WSACC)
	230	NC0180065	196776.2755	460250.6258	KANNAPOLIS, CITY OF
	231	NC0180065	193344.2193	453914.0681	KANNAPOLIS, CITY OF
	234	NC0184010	194262.1505	501918.1349	ALBEMARLE, CITY OF
	235	NC0184010	191756.2905	505780.2913	ALBEMARLE, CITY OF
	307	NC0363010	145816.2237	564262.2352	SOUTHERN PINES, TOWN OF
	308	NC0363025	175463.0088	572522.9219	CARTHAGE, TOWN OF
	309	NC0363025	166830.0622	572025.2865	CARTHAGE, TOWN OF
12	21	NC0180050	220807.5979	457217.6434	CLEVELAND, TOWN OF
	32	NC0299015	264665.6814	461474.8023	YADKINVILLE, TOWN OF
	33	NC0299020	276111.5059	456817.0544	BOONVILLE, TOWN OF
	228	NC0180010	222483.4336	477617.7956	SALISBURY-ROWAN
	229	NC0180065	215830.337	462508.9197	KANNAPOLIS, CITY OF
	257	NC0230010	237051.0104	463007.1813	MOCKSVILLE, TOWN OF
	258	NC0230015	255390.2055	475174.6272	DAVIE COUNTY WATER SYSTEM
	259	NC0230015	229691.0257	468427.0481	DAVIE COUNTY WATER SYSTEM
	260	NC0230015	229496.2651	468605.0234	DAVIE COUNTY WATER SYSTEM
	261	NC0234010	266608.6815	479997.9124	WINSTON-SALEM, CITY OF
	262	NC0234010	247686.1883	483400.4655	WINSTON-SALEM, CITY OF
	283	NC0285010	274980.0869	480792.2599	KING, CITY OF
	284	NC0286010	305703.1533	461428.4909	MOUNT AIRY, CITY OF
	285	NC0286010	308988.5875	464841.4417	MOUNT AIRY, CITY OF
	288	NC0286025	295008.2487	476182.78	PILOT MOUNTAIN, TOWN OF
	289	NC0286030	296703.5721	454931.0363	DOBSON, TOWN OF
	292	NC0299015	262539.306	460526.3095	YADKINVILLE, TOWN OF
13	76	NC0416010	108722.9095	733995.5539	BEAUFORT, TOWN OF
	77	NC0416015	110644.5272	809928.34	MOREHEAD CITY, TOWN OF
	78	NC0416020	116962.0906	804260.7728	NEWPORT WATER SYSTEM
	79	NC0416035	107369.8469	814881.3958	ATLANTIC BEACH, TOWN OF
	90	NC0425015	124837.7411	802136.5894	HAVELOCK WATER SYSTEM
	91	NC0425020	173856.3279	778029.6397	VANCEBORO WATER SYSTEM

	93	NC0425113	148256.7412	778174.7346	TOWN OF RIVER BEND
	113	NC0452010	129817.6484	771069.2988	MAYSVILLE, TOWN OF
	114	NC0452015	140483.7343	771448.9872	POLLOCKSVILLE, TOWN OF
	127	NC0465020	51053.37016	717967.5161	WRIGHTSVILLE BEACH WATER SYST
	135	NC0467010	112599.9537	744631.5256	JACKSONVILLE CITY OF
	136	NC0469020	144809.8964	820289.1481	ORIENTAL WATER SYSTEM
	139	NC0471015	78254.37163	739394.653	SURF CITY, TOWN OF
	140	NC0471020	70060.36449	736517.1753	TOPSAIL BEACH, TOWN OF
14	1	NC0103010	305440.173	417984.9778	SPARTA, TOWN OF
	2	NC0105010	295557.082	385324.0933	WEST JEFFERSON, TOWN OF
	3	NC0105015	298127.4113	388854.5451	JEFFERSON, TOWN OF
	4	NC0105020	307595.2482	384684.5479	LANSING, TOWN OF
	27	NC0197050	276897.6285	434503.7544	RONDA, TOWN OF
	161	NC0105015	297892.4654	393962.3546	JEFFERSON, TOWN OF
	205	NC0149010	236912.7966	439653.218	STATESVILLE, CITY OF
	207	NC0149015	208693.1815	438174.1243	MOORESVILLE TOWN OF
	244	NC0195101	279327.2208	369608.8819	APPALACHIAN STATE UNIV WTP
	245	NC0195101	280156.545	369122.6222	APPALACHIAN STATE UNIV WTP
	247	NC0197010	269701.5049	415588.2428	NORTH WILKESBORO, TOWN OF
	248	NC0197025	267785.6964	413481.5715	WILKESBORO, TOWN OF
	286	NC0286020	279052.6016	441812.4526	ELKIN, TOWN OF
	287	NC0286020	280267.2288	441671.2626	ELKIN, TOWN OF
	291	NC0299010	277854.6007	442582.5383	JONESVILLE, TOWN OF
15	34	NC0309010	94436.30248	644179.1672	ELIZABETHTOWN, TOWN OF
	35	NC0309015	86098.66978	627886.1641	BLADENBORO, TOWN OF
	36	NC0309020	81763.13831	640747.582	CLARKTON, TOWN OF
	37	NC0309025	100045.2761	634891.4877	DUBLIN, TOWN OF
	38	NC0309030	97765.80308	653890.8903	WHITE LAKE, TOWN OF
	41	NC0347010	133466.5398	582867.9368	RAEFORD, CITY OF
	52	NC0378015	117054.8655	591506.7754	RED SPRINGS, TOWN OF
	55	NC0378030	116636.6108	610981.1942	SAINT PAULS, TOWN OF
	58	NC0378045	127450.545	608417.4925	PARKTON, TOWN OF
	66	NC0383020	126158.6277	575585.2264	WAGRAM, TOWN OF
	75	NC0410130	11353.22059	701804.9532	THE VILLAGE OF BALD HEAD ISLAND
	126	NC0465015	30057.93387	710176.4404	CAROLINA BEACH WATER SYSTEM
	128	NC0465025	25613.86716	709876.185	KURE BEACH WATER SYSTEM
	138	NC0471010	88664.95635	707321.6008	BURGAW, TOWN OF
	158	NC7071054	86642.65316	685393.455	TOWN OF ATKINSON
	340	NC5009012	112815.5068	628094.7979	BLADEN BLUFFS WATER SYSTEM
16	5	NC0106010	255735.585	344882.3095	CROSSNORE, TOWN OF

	6	NC0106015	270962.7002	351561.2453	BANNER ELK, TOWN OF
	7	NC0106020	261485.0574	345821.4618	NEWLAND, TOWN OF
	8	NC0106025	271088.2173	340666.4299	ELK PARK, TOWN OF
	18	NC0161010	240930.6346	334780.515	SPRUCE PINE, TOWN OF
	19	NC0161015	255739.5688	324330.5625	BAKERSVILLE, TOWN OF
	26	NC0195118	268799.6068	355014.238	SEVEN DEVILS, TOWN OF
	222	NC0161010	247899.3203	338441.2543	SPRUCE PINE, TOWN OF
	223	NC0161010	249015.1706	333343.1671	SPRUCE PINE, TOWN OF
	240	NC0195010	274657.229	369242.5655	BOONE, TOWN OF
	241	NC0195010	275398.8783	371369.239	BOONE, TOWN OF
	242	NC0195020	268703.0738	369122.4608	BLOWING ROCK, TOWN OF
	243	NC0195020	268762.7804	369148	BLOWING ROCK, TOWN OF
	246	NC0195104	277770.2199	348224.263	BEECH MOUNTAIN, TOWN OF
17	12	NC0123045	188302.3225	377170.5834	LAWNDALE, TOWN OF
	24	NC0184020	165566.6597	488757.9823	OAKBORO, TOWN OF
	183	NC0123010	175556.5882	376470.8747	SHELBY, CITY OF
	184	NC0123020	172116.9479	386422.4231	KINGS MOUNTAIN, TOWN OF
	185	NC0123055	189163.9302	377109.4256	CLEVELAND COUNTY WATER
	186	NC0123055	189153.857	377082.6436	CLEVELAND COUNTY WATER
	187	NC0136010	177629.4636	428716.917	TWO RIVERS UTILITIES
	188	NC0136015	167250.6493	426637.9681	BELMONT, CITY OF
	189	NC0136020	177573.001	428766.0648	MOUNT HOLLY, CITY OF
	190	NC0136025	174825.1737	399929.2341	BESSEMER CITY, CITY OF
	191	NC0136025	173968.4585	400531.0238	BESSEMER CITY, CITY OF
	192	NC0136030	187945.9331	394564.7399	CHERRYVILLE, CITY OF
	193	NC0136065	177602.8213	428817.215	DALLAS, TOWN OF
	210	NC0155010	194505.5309	402552.2523	LINCOLNTON, CITY OF
	220	NC0160010	178985.6828	433607.3446	CHARLOTTE WATER
	236	NC0184015	165267.084	509711.5618	NORWOOD, TOWN OF
	306	NC0362010	162599.3878	512726.7699	MONTGOMERY COUNTY WATER SYSTEM
18	20	NC0175015	170752.1608	317235.0964	COLUMBUS TOWN OF
	23	NC0181020	188321.7383	316341.8068	LAKE LURE, TOWN OF
	198	NC0144010	193110.1716	245652.8203	WAYNESVILLE, TOWN OF
	199	NC0144015	203650.2021	260564.8029	CANTON, TOWN OF
	202	NC0145010	191409.0538	275905.6522	HENDERSONVILLE, CITY OF
	206	NC0149010	225587.4312	420940.9409	STATESVILLE, CITY OF
	224	NC0175010	165275.3008	315123.6755	TRYON, TOWN OF
	225	NC0175010	167728.0526	306884.8306	TRYON, TOWN OF
	226	NC0175010	167766.3813	306238.6716	TRYON, TOWN OF
	227	NC0175010	167450.549	309109.2099	TRYON, TOWN OF
	232	NC0181010	184581.5707	349631.6073	FOREST CITY, TOWN OF

	233	NC0181035	177059.0433	337545.8701	BROAD RIVER WATER AUTHORITY
19	9	NC0111020	211131.1283	307618.7154	BLACK MOUNTAIN, TOWN OF
	10	NC0111484	214341.1437	309702.325	MONTREAT WATER SYSTEM
	15	NC0156025	212224.5317	320681.9005	OLD FORT, TOWN OF
	162	NC0111010	217320.1644	306835.6696	ASHEVILLE CITY OF
	165	NC0111010	215274.1361	301743.0973	ASHEVILLE CITY OF
	166	NC0111015	221734.7703	298733.184	WOODFIN SANITARY WATER AND SEWER
	169	NC0112015	224051.6851	362646.7529	MORGANTON CITY OF
	175	NC0114010	228379.3115	385214.7444	LENOIR, CITY OF
	176	NC0114030	228696.3733	388910.5187	GRANITE FALLS, TOWN OF
	177	NC0118010	225555.375	394916.1846	HICKORY CITY OF
	200	NC0144040	204021.2268	237354.5186	MAGGIE VALLEY SANITARY DIST
	201	NC0144040	203482.7425	238041.5853	MAGGIE VALLEY SANITARY DIST
20	13	NC0138010	181453.8108	171652.0708	ROBBINSVILLE, TOWN OF
	14	NC0138105	190225.7434	168718.7656	LAKE SANTEETLAH, TOWN OF
	168	NC0112010	227821.3389	378222.2669	VALDESE, TOWN OF
	182	NC0120020	174779.866	169885.041	ANDREWS, TOWN OF
	194	NC0138010	180317.0583	171557.0716	ROBBINSVILLE, TOWN OF
	195	NC0138010	179018.8032	171228.8704	ROBBINSVILLE, TOWN OF
	196	NC0138010	179434.2622	170893.5693	ROBBINSVILLE, TOWN OF
	197	NC0138101	199438.9721	173628.0998	TOWN OF FONTANA DAM
	237	NC0187010	198427.0888	206904.2052	BRYSON CITY, TOWN OF
21	25	NC0188115	160614.0431	260886.2092	ROSMAN, TOWN OF
	163	NC0111010	187354.7638	288737.5761	ASHEVILLE CITY OF
	164	NC0111010	187470.1383	288776.9532	ASHEVILLE CITY OF
	203	NC0145010	187929.8318	285565.101	HENDERSONVILLE, CITY OF
	204	NC0145010	186021.9582	276106.622	HENDERSONVILLE, CITY OF
	215	NC0157010	165738.975	205588.4506	FRANKLIN, TOWN OF
	216	NC0157015	154062.0375	224813.2355	HIGHLANDS, TOWN OF
	217	NC0157015	154435.5372	225022.0963	HIGHLANDS, TOWN OF
	238	NC0188010	168760.8451	265262.2252	BREVARD, CITY OF
22	11	NC0113025	172380.4433	460353.8576	HARRISBURG, TOWN OF
	16	NC0158015	239434.9862	278087.6125	MARSHALL, TOWN OF
	17	NC0158020	245774.6471	263055.9291	HOT SPRINGS, TOWN OF
	159	NC0100010	243563.9363	310404.2675	BURNSVILLE, TOWN OF
	160	NC0100010	240297.4968	313435.9144	BURNSVILLE, TOWN OF
	167	NC0111025	231426.0529	288175.6977	WEAVERVILLE, TOWN OF
	178	NC0118015	211693.3512	400522.8816	NEWTON, CITY OF
	179	NC0118015	213677.8508	405821.8013	NEWTON, CITY OF

	180	NC0120010	157567.4239	156258.7954	MURPHY, TOWN OF
	181	NC0120020	173598.0523	168867.191	ANDREWS, TOWN OF
	208	NC0150035	181500.0153	230357.4445	TUCKASEIGEE WATER & SEWER AUTH
	209	NC0150116	181567.8232	230036.2239	WESTERN CAROLINA UNIV WTP
	211	NC0155035	199061.6284	429187.1555	LINCOLN COUNTY WTP
	212	NC0156010	219942.0313	323566.9345	MARION, CITY OF
	213	NC0156010	221715.8336	326951.2799	MARION, CITY OF
	214	NC0156010	219337.5309	333093.0078	MARION, CITY OF
	218	NC0158010	248723.3976	294379.0649	MARS HILL, TOWN OF
	219	NC0158010	248669.4675	293610.0453	MARS HILL, TOWN OF
	221	NC0160010	188798.2377	436319.9345	CHARLOTTE WATER
23	39	NC0309050	69693.14021	671271.6732	EAST ARCADIA, TOWN OF
	51	NC0378010	96878.91248	606230.0813	LUMBERTON, CITY OF
	53	NC0378020	101719.1129	591216.6701	PEMBROKE, TOWN OF
	54	NC0378025	82134.10723	598723.5902	FAIRMONT, TOWN OF
	56	NC0378035	109188.368	578429.554	MAXTON, TOWN OF
	57	NC0378040	87818.63591	582639.8923	ROWLAND, TOWN OF
	65	NC0383010	108687.409	564922.3351	LAURINBURG, CITY OF
	81	NC0424010	60282.02162	634872.5487	WHITEVILLE, CITY OF
	82	NC0424015	43904.14741	620106.7576	TABOR CITY, TOWN OF
	83	NC0424020	62929.24197	624768.3064	CHADBOURN, TOWN OF
	84	NC0424030	61004.30806	606055.5397	FAIR BLUFF, TOWN OF
	85	NC0424040	59513.50936	636205.2981	BRUNSWICK, TOWN OF
	86	NC0424045	63251.67569	653548.4021	LAKE WACCAMAW, TOWN OF
	87	NC0424050	62964.62018	663429.1398	BOLTON, TOWN OF
	88	NC0424055	63110.31666	616348.0044	CERRO GORDO, TOWN OF
	239	NC0190010	143748.9474	474798.2859	MONROE, CITY OF
	293	NC0304010	138086.8154	526443.3985	ANSON COUNTY WATER SYSTEM
	314	NC0377010	127748.9572	548275.7552	HAMLET WATER SYSTEM
	315	NC0377015	135634.4468	541832.359	ROCKINGHAM, CITY OF
	316	NC0377015	132010.0337	542069.2605	ROCKINGHAM, CITY OF
	317	NC0377109	138223.2694	529270.8736	RICHMOND COUNTY WATER SYSTEM
	318	NC0378010	98029.52455	606185.7996	LUMBERTON, CITY OF
	324	NC0424820	67925.98133	682178.1067	INTERNATIONAL PAPER COMPANY
	332	NC0410045	72923.08605	674392.5943	BRUNSWICK COUNTY WATER SYSTEM
	333	NC0465010	72848.06586	674544.2843	CFPUA-WILMINGTON
	343	NC7071011	72862.97726	674577.8014	PENDER COUNTY UTILITIES