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

Quarterly Progress Report (#5) submitted to the North Carolina General Assembly Environmental Review Commission, the NC Department of Environmental Quality, the NC Department of Health and Human Services, and the Environmental Protection Agency (Region 4)

October 1, 2019

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 in well underway, and progress made to date is summarized in this this document which represents the fifth [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 and summarizes the work conducted since the last progress report which was submitted on July 1, 2019. The project's final report will be submitted no later than December 1, 2019.

The NCGA-mandated Per- and Polyfluoroalkyl 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."*

The April 1, 2019 Quarterly Report noted submission of a letter by PFAST Network scientists to the NC Policy Collaboratory on March 13, 2019 (Appendix II of the April report) requesting a 1-year extension of the study. The reasoning for the request was twofold: 1) to ensure sufficient time for comprehensive analysis and interpretation of non-targeted data and 2) to enable additional sampling of drinking water supply intakes during different seasons. The Collaboratory transmitted this request to the NC General Assembly on March 25, 2019. The study extension was included in the compromise budget (H966) passed by the NCGA and sent to the Governor on June 27, 2019, which he subsequently vetoed on June 28th. While the NC House of Representatives voted to override the Governor's veto of the state budget on September 11, 2019, the NC Senate has yet to call for a vote. Also included in this budget was an additional $2 million appropriation to the Collaboratory, which will use these funds for the additional year of water sampling and analysis as well as project management activities that will occur during the PFAS study extension if the budget becomes law.

3.0 QUARTERLY PROGRESS UPDATE

NC PFAST Network investigators are busy wrapping up more than a year of research. They have been collecting and analyzing field samples, conducting laboratory experiments, preparing manuscripts to summarize results, and interfacing with the public to share information about the study objectives and preliminary findings. For reference, the PFAST Network organizational structure and team leaders were provided in Appendix II of the January 1, 2019 quarterly report, and the specific aims of the research projects were described in Appendix III of that same report. Copies of prior reports can be accessed on the NC PFAST Network website under "Resources" https://ncpfastnetwork.com/resources/. Accomplishments during the past quarter from July 1 through September 30, 2019 are summarized in the following bullet points:

Overall Program Activities

- Since its launch in April 2019, the PFAST Network website (https://ncpfastnetwork.com) has had 1,849 unique users and 2,837 visits. This website created and maintained by the Network's Risk Communications Team is an important source of information providing background on the study objectives and researchers, details on events and public presentations, as well as other resources such as Frequently Asked Questions. Following completion of the study, results will be made available by the Data Science and Management Team via links on this website. Questions about the Network's PFAS testing or related research can be sent to the general e-mail: ncpfastnetwork@unc.edu, and the Program Management Team will either respond directly or forward specific requests for information to the appropriate team leaders.
- The PFAST Network's synthetic organic chemist has been working to prepare chemical standards which are not commercially available. He revisited the synthesis of Hydro Eve Acid because the starting materials are expensive and have limited availability. In the end, an alternative synthetic strategy was not found. In addition, he is still searching for a commercial source of the starting materials required to synthesize PFO4DA (perfluoro-3,5,7,9-tetraoxadecanoic acid) and PFO5DoA (perfluoro- 3,5,7,9,11-pentaoxadecanoic acid). Chemical structures for these PFAS were presented in Appendix II of the July 1, 2019 quarterly report.
- The PFAST Network's Risk Communications Team continues to serve a critical role by interfacing with the public and identifying the concerns of key stakeholders within North Carolina and others outside the state. They have provided training and consultation for Network scientists to enable more effective communication with the public regarding the complex experiments and concepts involved in their research. In addition to an internal Network presentation on sharing information about PFAS research through social media, they also prepared social media tips and reference sheets for the researchers.
- PFAST Network investigators, postdocs, and students have participated in national conferences, local workshops, and public meetings to raise awareness of the NC PFAST Network study and to share goals of the various research projects, workflow strategies, and updates with legislative and regulatory committees and community stakeholders. One example is highlighted below, and a list of presentations from the past quarter can be found in Appendix II of this report.
    - The PFAS Network was well represented at the Society of Environmental Toxicology and Chemistry (SETAC) North America's Focused Topic Meeting on Environmental Risk Assessment of PFAS held August 12-15, 2019 in Durham, NC. Faculty, students, and post-docs showcased their work in 10 posters summarizing their goals, experiments, and results if available. In addition, two of the Network's team leaders delivered presentations during the oral sessions. Dr. Mei Sun from UNC Charlotte presented "Methods for assessing total exposure to per- and polyfluoroalkyl substances with co-authors Detlef Knappe, Chuhui Zhang, Yuling Han, and Vivek Pulikkal, and Dr. Jamie DeWitt of East Carolina University presented ""Immunotoxicological Findings of PFAS: Consistency of Effects Between Human and Rodent Models" with co-authors Sam Vance, Tracey Woodlief, and Qing Hu.

PFAS Water Sampling and Analysis

- The PFAST Network's Water Sampling and Analysis Team led by Dr. Detlef Knappe (NC State University) and Dr. Lee Ferguson (Duke University) has completed the first round of sampling from public drinking water sources throughout the state. Raw water samples from 190 surface water intakes, 158 municipal groundwater wells, and 57 county or regional water supplies have been collected and more than half have been analyzed for levels of legacy and emerging PFAS, including GenX, using a targeted mass spectrometry approach. One of challenges the team faced was obtaining accurate contact information (name, phone, e-mail) of the operator in responsible charge for each water system. Also, in some instances the team was met with resistance and had to enlist the help of DEQ staff to gain access to the water treatment facility. Another challenge was the addition of 57 sampling sites identified by DEQ mid-way through the first sampling campaign. The Data Science and Management Team incorporated these new sites into their geospatial mapping analysis and re-optimized the remaining sampling trip schedules.
- Automated reports of targeted PFAS levels are now being generated from the processed data and are being e-mailed to each municipality and to representatives from NC DEQ, NC DHHS, and local legislators in accordance with the PFAST Network notification policy. An example report showing which PFAS were targeted and the method reporting limits is provided in Appendix III. Furthermore, the corresponding county health department director is also notified whenever the observed sum of PFOA + PFOS is above the US EPA Health Advisory Limit (HAL) of 70 nanogram per liter (ng/L) or parts-per-trillion (ppt) or if one or more PFAS are observed above 70 ng/L (out of an abundance of caution since there are no established regulatory limits). To date, only 6 municipalities have been notified of PFAS levels meeting the aforementioned criteria.
- Round 2 of raw drinking water sampling has begun, and the labs are ramping up collection efforts with the assistance of graduate research students. Three examples of re-optimized sampling trips are provided in Appendix IV.
- Non-target analyses are ongoing in Dr. Knappe's (NC State) and Dr. Ferguson's (Duke) labs. A higher-throughput method using on-line solid phase extraction (SPE) with high-resolution LC-MS/MS analysis has been established on the Orbitrap mass spectrometers and is undergoing final validation in both labs. This type of analysis will reveal the presence of additional PFAS not quantified in the targeted analysis. It requires intensive data analysis and interpretation and relies on the availability of certified chemical standards for confirmation of proposed chemical structures.
- An Extractable Organic Fluorine (EOF) method for estimation of the total PFAS amount in water samples was optimized and validated in Dr. Mei Sun's lab at UNC Charlotte. They demonstrated that 4 out of 8 samples analyzed contained total organic fluorine levels (reported in ng/L) between 6- and 16-times that of the ultra-pure water control sample. This method is currently being applied to the remaining raw water samples collected in round 1. The team is also testing and optimizing an approach called the Adsorbable Organic Fluorine (AOF) method as another way to characterize total PFAS.

Private Well Risk Modeling

- The group led by Dr. David Genereux (NC State) has compiled all available GIS data and converted the map files (Google Earth) of previous sampling locations for use in ArcGIS, a Geographic Information System for creating and working with maps and analyzing spatial data such as topography and aquifer thickness. They also built a database of hydrogeological data (hydraulic conductivity, porosity, storage coefficient, thickness) for the aquifers in recent consultant reports in the Fayetteville Works area. Furthermore, they conducted a site survey in the Chemours area, and prepared a work plan and provisional budget for additional field work there.
- Recently the team met with DEQ personnel from 1) the NC Geological Survey Raleigh field office to get more information about the geological data they are using to create the isopach (thickness) map of the surficial aquifer and 2) the Division of Waste Management to obtain additional information about groundwater investigations and results from the Fayetteville Works area. They worked closely with the PFAST Network's Data Science and Management Team to acquire lidar-based elevation data for the development of the aquifer thickness map which is needed for well water risk analysis.
- The team obtained a copy of the Private Well Database from NCDEQ and plotted data for a subset of 30 wells for which construction information and a unique ID code were available. This subset shows no PFAS contamination in the 6 deepest wells completed in the Black Creek Aquifer, and the GenX concentration values do not show any spatial trend. The total depth of the well seems to be the main factor controlling the GenX concentration for this subset. The team has also contacted two drilling companies in the region in an attempt to collect more data on the private wells included in the study.
- The group led by Dr. Jackie MacDonald Gibson (UNC Chapel Hill) sent letters to 1000 homeowners with private wells in the study area to collect additional information and to identify new volunteers to sample their well water for analysis. They have extracted data from the survey responses and continue to refine the predictive model as new data become available. For example, Soil Organic Carbon (SOC) data as well as vegetation and tree coverage data with lower resolution have been added to the model. Overall they have increased the number of variables from 86 to 240 and have improved the accuracy of the model for predicting private wells with greatest risk for contamination.

PFAS Removal Performance Testing

- The Knappe lab at NC State continued their rapid small-scale column tests with granular activated carbons (GAC) to test the effect of particle size on PFAS breakthrough. They also collected additional surface water from CFPUA for experiments to evaluate other carbon types (subbituminous coal-based and lignite-based) for PFAS removal efficiency and the effects of organic matter on PFAS breakthrough.
- The Coronell lab at UNC Chapel Hill continued testing commercial and hand-cast high-pressure membranes for removal of PFAS from contaminated groundwater. They evaluated water flux and rejection of total dissolved solids and characterized the physico-chemical properties of the commercial membranes to better understand the property-performance relationships as related to PFAS removal.

- The team also optimized their analytical method for detection of 42 PFAS and 20 internal standards in spiked groundwater and completed their screening tests of 9 Ion Exchange (IX) resins. They selected the 5 best performing resins for further kinetics and regeneration experiments to evaluate operational feasibility for water facilities.
- The Stapleton lab at Duke completed tests of in-home filters for PFAS removal and are finalizing a manuscript from the "PFAS removal from finished drinking water by in-home filters in NC households" study. Preliminary data suggests a general increase in levels over the summer, likely due to reductions in flow associated with high temperatures and evaporation.
- The Leibfarth lab at UNC Chapel Hill completed their adsorption profiling of 22 legacy and emerging PFAS in real well water samples. Results were positive with greater than 90% removal of most PFAS after 2 hours. The team is finalizing a manuscript detailing the Ionic Fluorogel work thus far. They have also started to synthesize and test the next generation of Ionic Fluorogels for improved mechanical properties and chemical stability in harsh environments. Preliminary sorption studies have been promising with many of the new materials performing as well or better than the first generation Ionic Fluorogels. In addition, they have synthesized negatively charged (anionic) resins to test for adsorption of positively charged (cationic) and neutral (zwitterionic) PFAS.
- The Sun lab at UNC Charlotte conducted electrochemical degradation reactor experiments on PFOA using a ruthenium oxide coated titanium (Ti/RuO_2) anode as a means to remove PFAS from waste streams generated in challenge tests. Sample analysis revealed that aerosol-based loss of PFOA is significant during electrochemical treatment and the team concluded that the Ti/RuO2 anode was ineffective in degrading PFOA. They plan to modify the reactor set-up and electrodes to minimize aerosol based PFOA loss in the next round of tests.

Air Emissions and Atmospheric Deposition

- The Turpin lab at UNC Chapel Hill has been collecting weekly composite samples (6-days collection) of atmospheric gases and particles (airborne fine particulate matter, or PM2.5) at 5 sites: Wilmington, Fayetteville, RTP, Greenville, and Charlotte. They finalized their filter extraction protocol and the analytical method which targets 41 compounds including 28 legacy and 13 emerging PFAS. Based on preliminary data, they found it necessary to combine filter extracts as seasonal composites (~3-month) for future analysis. Seasonal composites and blanks for winter (Jan-Mar) and spring (Apr-June) 2019 have been analyzed for atmospheric concentrations of PFAS in particulate matter. Selected PFAS were detected in some samples within the concentration range of measurements found elsewhere (e.g. rural Germany). Data are still preliminary, as quality assurance is not yet complete. The lab has also started method development for extraction and analysis of gas-phase PFAS collected on Polyurethane Foam (PUF) samplers.

- The team has been preparing for installation and operation of hi-volume air samplers at two secured locations near the Chemours facility in line with the main wind directions (SSW and NNE). They have also been working with EPA colleagues to coordinate an intensive, 1- to 2-week sampling study in which they will deploy an Iodide-Chemical Ionization Mass Spectrometer (CIMS) for real-time, high-resolution measurements of highly polar gases at one of the sites in the Fayetteville area. In addition, the team submitted a request to operate one hi- volume sampler at the current Fayetteville site (Honeycutt) which is hosted by NC DEQ's Division of Air Quality.
- The Mead lab at UNC Wilmington has sampled 63 rain events at the main Wilmington site and collected 20 dry deposition samples. They also collected wet and dry deposition samples at their collaborator stations: ECU (2 wet, 2 dry); UNC-CH (2 wet, 2 dry); UNC-C (3 wet, 2 dry); Bald Head Island (2 wet, 2 dry); and Appalachian State University (1 wet, 2 dry). Analyses are ongoing as new samples are generated from precipitation events. The team observed differences in PFAS distribution between rain events and found that dry deposition is also variable in terms of PFAS distributions. They also performed 72-hour air-mass back trajectory analysis on 57 of the UNC-W samples to examine the influence on PFAS concentration and distribution. With the data collected to date, the team has begun to calculate deposition rates to the water shed.

Other Applied Research Opportunities:

Novel PFAS Inputs into the environment: landfill leachates and wastewater treatment:

- The Barlaz lab at NC State has sampled a total of 18 municipal solid waste landfills and has received preliminary data for 15 of the leachate samples. They sent preliminary reports to each landfill operator and have started the second round of sampling and analysis.
- A total of 30 wastewater treatment plants have been sampled including 5 recent additions which have relatively high flow rates. All the wastewater samples collected (influent and effluent) have been extracted and are at various stages of analysis for PFAS concentrations. The team is going through databases to estimate the flow rate of treated wastewater released to NC surface to calculate the amount of PFAS discharge to surface water. There remain some large wastewater treatment plants and landfills that are not allowing the team to sample.
- The team has sampled 1 lined Construction and Demolition (C&D) waste landfill and collected water samples from runoff emanating from 3 C&D landfills. They identified one other landfill they wanted to sample, but were denied access. They plan to re-sample the 3 C&D landfills as well as a landfill in another state by the end of September.

PFAS bioaccumulation in aquatic environments: alligator and fish studies:

- The Belcher lab at NC State completed their 2018 striped bass analysis and submitted a manuscript with their U.S. EPA collaborators to *Environment International*. The title of the paper is: "Per- and Polyfluoroalkyl Substances Exposure in Cape Fear River Striped Bass (Morone saxatilis) is associated with Biomarkers of Altered Immune and Liver Function" (T.C. Guillette et al.). Analysis of the 2019 striped bass samples from the Cape Fear River and the Roanoke River is still in progress.

- The team has collected samples from 70 alligators in the Cape Fear River and the Lumbar River drainages. Health endpoint analysis is underway (blood chemistry, white cell counts, immune function) as well as PFAS measurements. Samples from catfish, sunfish/bluegill, and black bass have also been collected and are undergoing analysis. These samples include liver, muscle (filet) and other organs.
- The team shared preliminary results from analyses of catfish, striped bass, and alligators' samples with NC DEQ staff for consideration in developing fish consumption advisories. The Belcher lab also participated in Cape Fear River Watch's LakeFest 2019 which was held at Greenfield Lake in Wilmington, NC on September 28th. This was an opportunity to talk about their research with the Community and demonstrate alligator sampling techniques.

Health effects following exposure: mouse model of immunotoxicity:

- The DeWitt lab at East Carolina University is finalizing a manuscript summarizing the results from mouse immunotoxicity studies with 3 PFAS: PFMOAA (3 Carbon); PFMOPrA (4 Carbon); and PFMOBA (5 Carbon). They had levels of PFMOAA measured by Enthalpy Labs in Wilmington, NC, and all dosed animals were below the limits of detection, highlighting that the internal dose of PFMOAA was very low. Ideally, they would like to repeat this study at a higher administered dose to better reflect the likely internal dose that people may experience from a continual exposure.
- The team has started the next dosing experiment with a fourth compound called Nafion By-product 2. This compound is one of the PFAS detected in the blood of Wilmington area residents during NC State University's GenX Exposure Study. As before, mice are being orally exposed to PFAS in water, and daily body weights and in- life observations recorded. Following injection with sheep red blood cells, Immunophenotype, T-cell dependent Antibody Response (TDAR), Natural Killer cell activity, and peroxisome proliferation will be evaluated.

PFAS bioaccumulation and distribution in crop plants: greenhouse studies:

- The Duckworth lab at NC State University conducted greenhouse experiments with compost-amended and PFAS-spiked soils and harvested lettuce plants for analysis. They developed methods for extractions from plant tissues and soil for PFAS concentration analysis by targeted mass spectrometry, and those analyses are in progress. They collected pore water data from the lettuce experiment and are analyzing the soil data. The team has also initiated their second set of greenhouse experiments.

Health effects following exposure: placental inflammation and immune cell signaling:

- Additional women who were approached for the EPOCH-PLUS (women in early pregnancy at high risk for pre-eclampsia or fetal growth restriction) or EPOCH-CASE (women diagnosed with pre-eclampsia or fetal growth restriction) studies were recruited this quarter bringing the total cumulative enrollment to 84 women (10/23/18-9/5/19). Samples of urine, serum, drinking water (private wells), cord blood, and placenta have been (and will be) collected and stored for analysis of PFAS levels. Additional demographics, health history, and outcome data have also been entered for newly enrolled subjects.

- Experiments with placental cells have been initiated to examine changes in gene expression associated with inflammation following treatment of cells with PFAS. They found that cell migration was inhibited by PFOS, PFOA, and GenX and that expression of inflammatory genes decreased with treatment. The lab is also measuring inhibition of PPAR by PFAS and is developing a protocol to measure PPAR binding inhibition using fluorescence polarization.

Risk Communications:

- Following notification of the PFAS levels in the Town of Maysville, the Risk Communications Team worked with Drs. Ferguson and Knappe of the Water Sampling and Analysis Team and the Town Manager of Maysville to create a PFAS fact sheet to share with residents. A copy has been included in Appendix V of this report. This informative document can be used in other communities and is publicly available on the PFAST Network website under "Resources" https://ncpfastnetwork.com/resources/.
- Team members have also worked with other partners including the Duke Superfund Program and the UNC School of Government to incorporate PFAS information into materials for communities to address concerns about fish and water contamination. They contributed to a white paper that resulted from discussions at the NC Fish Forum and through their participation in in the NC Drinking Water Working Group, prepared informational materials that were incorporated in an incident response kit that communities can use to prepare for and communicate about drinking water incidents (including well water contamination).
- In support of their goal to increase awareness of PFAS among lay publics, team members created a one-page PFAS guide for educators that they shared with Durham Public School teachers. They also organized a webinar scheduled for Oct. 3, 2019 (https://ncpfastnetwork.com/event/pfas-webinar-for-educators/) to introduce the topic of PFAS to educators. The title of the webinar is: *Per- and Polyfluoroalkyl Substances (PFAS)- What are they and how are NC scientists investigating their prevalence in the environment and their potential impacts to humans and wildlife?*
- In collaboration with Network researchers, the Communications Team also developed and finalized a set of PFAS infographics and published these on the PFAST Network website. Then can be viewed and downloaded in the section: "Resources/Graphics and Printed Materials" https://ncpfastnetwork.com/printed-materials/.
- The team has been busy preparing for the fall PFAS research symposium, which is being sponsored jointly with the Research Triangle Environmental Health Collaborative (RTEHC): http://environmentalhealthcollaborative.org/. The symposium will be held October 23-24, 2019 at the NC Biotech Center in Research Triangle Park, NC.

Data Science and Management

- The PFAST Network's Data Science and Management Team has been working with all of the research teams to provide accurate location and attribute data for sampling sites that will be uploaded to the PFAS Data Hub. Their efforts for re-optimization of sample routes have been critical to the Water Sampling and Analysis Team for completing Round 1 of sampling and scheduling Round 2.

- The team completed their prototype for uploading PFAS results and Metadata into the PFAS Data Hub and started developing the mapping application for data visualization on the PFAS Network website. In addition, they have been compiling a PFAS Master Compound List which will enable comparisons of results for individual PFAS across projects.

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

LIST OF MEETINGS, WORKSHOPS, AND CONFERENCES IN WHICH NC PFAST NETWORK SCIENTISTS PRESENTED INFORMATION RELATED TO THE ONGOING RESEARCH STUDY

45th Annual Summer Meeting of The Toxicology Forum, July 8–10, 2019, Alexandria, VA. Presentation by Dr. Jamie DeWitt: "Per- and Poly-fluoroalkyl Substances (PFAS): A Lifecycle Perspective"

Dr. Jamie DeWitt provided expert testimony regarding PFAS health effects on July 24, 2019 to the Subcommittee on Environment, a Subcommittee of the US House of Representatives Committee on Oversight and Reform.

The North Carolina Section of the American Water Works Association (NC AWWA) & The North Carolina Member Association of the Water Environment Federation (NC WEA) Drinking Water Rules & Regulations Seminar, July 25 at NC State University, Raleigh, NC. Presentation by Dr. Noelle DeStefano: "NC Policy Collaboratory Statewide PFAS Study: Preliminary Findings"

National Environmental Monitoring Conference (NEMC), August 6, 2019, Jacksonville, FL. Presentation by Dr. Lee Ferguson: "Per- and Polyfluoroalkyl Substances (PFAS) in North Carolina Drinking Water Sources: Analytical Techniques and Challenges" Authors: Noelle DeStefano, Zachary Hopkins, Abigail Joyce, Lee Ferguson, Detlef Knappe

Gordon Research Conference Molecular and Cellular Mechanisms of Toxicity: Integration of Emerging Technologies in Mechanistic and Translational Toxicology, August 11 - 16, 2019 at the Proctor Academy, Andover, NH. Presentation by Dr. Rebecca Fry summarizing findings from in vitro studies investigating the effects of PFAS on trophoblast migration in placental cells.

SETAC (Society of Environmental Toxicology and Chemistry) North America Focused Topic Meeting- Environmental Risk Assessment of PFAS, August 12-15, Durham, NC.

- Presentation by Dr. Mei Sun: "Methods for assessing total exposure to per- and polyfluoroalkyl substances" Authors: Mei Sun, Detlef Knappe, Chuhui Zhang, Yuling Han, Vivek Pulikkal
- Presentation by Dr. Jamie DeWitt: "Immunotoxicological Findings of PFAS: Consistency of Effects Between Human and Rodent Models" Authors: Jamie DeWitt, Sam Vance, Tracey Woodlief, Qing Hu
- Poster: "Targeted and non-targeted analysis of per- and polyfluoroalkyl substances in North Carolina drinking water sources" Authors: Noelle DeStefano, Zachary Hopkins, Abigail Joyce, Gordon Getzinger, Yuling Han, Mei Sun, Lee Ferguson, Detlef Knappe.
- Poster: "Assessing the Effect of PFAS on Placental Epigenetic Machinery" Authors: Jackie Bangma, John Szilagyi, Cassandra Meakin, Rebecca Fry

- Poster: "Assessing the Effectiveness of Point-of-Use Residential Drinking Water Filters for Perfluroalkyl Substances (PFAS) Authors: Nick Herkert, C. Peters, David Bollinger, Sharon Zhang, Detlef Knappe, Kate Hoffman, Lee Ferguson, Heather Stapleton
- Poster: "Occurrence and Treatment of Per- and Polyfluoroalkyl Ether Acids in North Carolina Surface Water" Authors: Zack Hopkins, Detlef Knappe
- Poster: "Rapid Small-Scale Column Tests to Predict Per- and Polyfluoroalkyl Substances (PFAS) Removal by Anion Exchange Resins" Authors: Lan Cheng, Detlef Knappe
- Poster: "Fate of Per- and Polyfluoroalkyl Ether Acids in the Total Oxidizable Precursor Assay" Authors: Chuhui Zhang, Zack Hopkins, Detlef Knappe
- Poster: "Effect of Soil Compost-Amendment on Mitigation of PFAS Uptake into Lettuce" Authors Yuanbo Li, Detlef Knappe, Steve Broome, Owen Duckworth
- Poster: "Targeted and Non-Targeted Analysis of Per- and Polyfluoroalkyl Substances in Wet Deposition Events" Author: Rachel Mott
- Poster: "Screening of Novel Per- and Polyfluorinated Alkyl Substances (PFAS) in Surface Sediments of Southeastern North Carolina" Authors: Rosa Sanchez, Megumi Shimizu, G. Brooks Avery, Ralph Mead, Robert Kieber, Steve Skrabal
- Poster: "Biodegradation Rates of Perfluoro-2-propoxypropanoic Acid in Sediments of the Cape Fear River Estuary" Author: Kate Tito

The Coming Storm: Using Science to Build Community Resilience, A daylong workshop for journalists, policymakers and community leaders from North Carolina communities in the paths of past and future hurricanes, August 14, 2019 at Duke University, Durham, NC. Presentation by Lee Ferguson: "Water quality impacts from extreme storm events" Authors: P. Lee Ferguson, Abigail Joyce, Gordon Getzinger.

Environmental Research and Education Foundation (EREF) PFAS Summit, August 14-15, 2019, Ypsilanti, MI. Presentation by Dr. Morton Barlaz and Dr. Jean-Rene Thelusmond at the "PFAS in Landfill Leachate and Municipal Wastewater"

American Chemical Society National Meeting in August 27, 2019, San Diego, CA. Lecture by Dr. Frank Leibfarth in the Eco-Friendly Polymers Symposium entitled: "Ionic Fluorogels for PFAS Remediation from Water".

Triangle Machine Learning Day held September 20, 2019 at Duke University, Durham, NC. Poster presented by Dr. Javad Roostaei explaining the application of Machine Learning in Risk Analysis.

Dr. Jamie DeWitt gave a seminar at Purdue University on September 10, 2019 entitled "Addressing public health concerns about PFAS: Focus on immunotoxicology" and on September 11, 2019 she was part of a Q&A panel (with two Purdue faculty) following a showing of the film "The Devil we Know."

North Carolina Public Health Association 2019 Fall Educational Conference, Sep. 25-27, 2019, Greensboro, NC. Poster presented by Manal Khan: "A Multisectoral Approach to Researching Emerging Contaminants in North Carolina: The North Carolina Per and Polyfluoroalkyl Substances Testing (PFAST) Network Experience"

APPENDIX III

EXAMPLE REPORT PROVIDED TO PUBLIC UTILITIES FOR PFAS ANALYSIS IN RAW DRINKING WATER SOURCES ACROSS THE STATE OF NORTH CAROLINA

NC PFAST Quantitative Screening Results for Raw Drinking Water

CFPUA-WILMINGTON-2 (NC0465010-2), 2019-05-29

Disclaimer: The PFAS measurements reported here represent initial laboratory findings that have not been subjected to full validation and quality assurance/quality control procedures and should be considered preliminary.

As part of the North Carolina Per and Polyfuoroalkyl Substances Testing (PFAST) Network statewide sampling effort (ncpfastnetwork.com (https://ncpfastnetwork.com)), a raw water sample collected from CFPUA-WILMINGTON-2 (NC0465010-2) on 2019-05-29 by the Ferguson Lab was analyzed for 47 PFAS chemicals by liquid chromatography-tandem mass spectrometry (LC-MS/MS). Concentrations of individual PFAS are reported in units of parts-per-trillion (ppt, i.e., nanogram of chemical per liter water).

PFAS compounds are not currently regulated as drinking water contaminants by the United States Environmental Protection Agency (US EPA) or the North Carolina Department of Environmental Quality (NC DEQ) and thus the measurements reported here are not intended to be used in enforcement actions. The US EPA has established a lifetime health advisory level (HAL) of 70 ppt for combined perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) in drinking water (https://tinyurl.com/grwoj94). In addition, the NC DHHS has established a provisional health goal based on risk assessment for GenX in drinking water of 140 ppt (https://tinyurl.com/y3azs7j4). These advisory levels can serve as reference values when evaluating PFAS concentrations reported below for raw drinking water.

Reporting Limit (RL): This is the lowest concentration that can be confidently quantified in water samples for an individual PFAS chemical. This level is a function of instrument sensitivity, reproducibility, and precision. The RL typically (but not always) represents the lowest concentration point on the calibration curve, and it is always higher (often much higher) than the method detection limit (MDL) for a given PFAS analyte.

Sum of PFOS and PFOA

PFOA and PFOS were both below their respective reporting limits.

GenX

GenX was not detected above its reporting limit.

Total PFAS

The total PFAS concentration was **1.1** ppt.

Summary of findings

Figure 1: Concentrations of individual PFAS compounds.

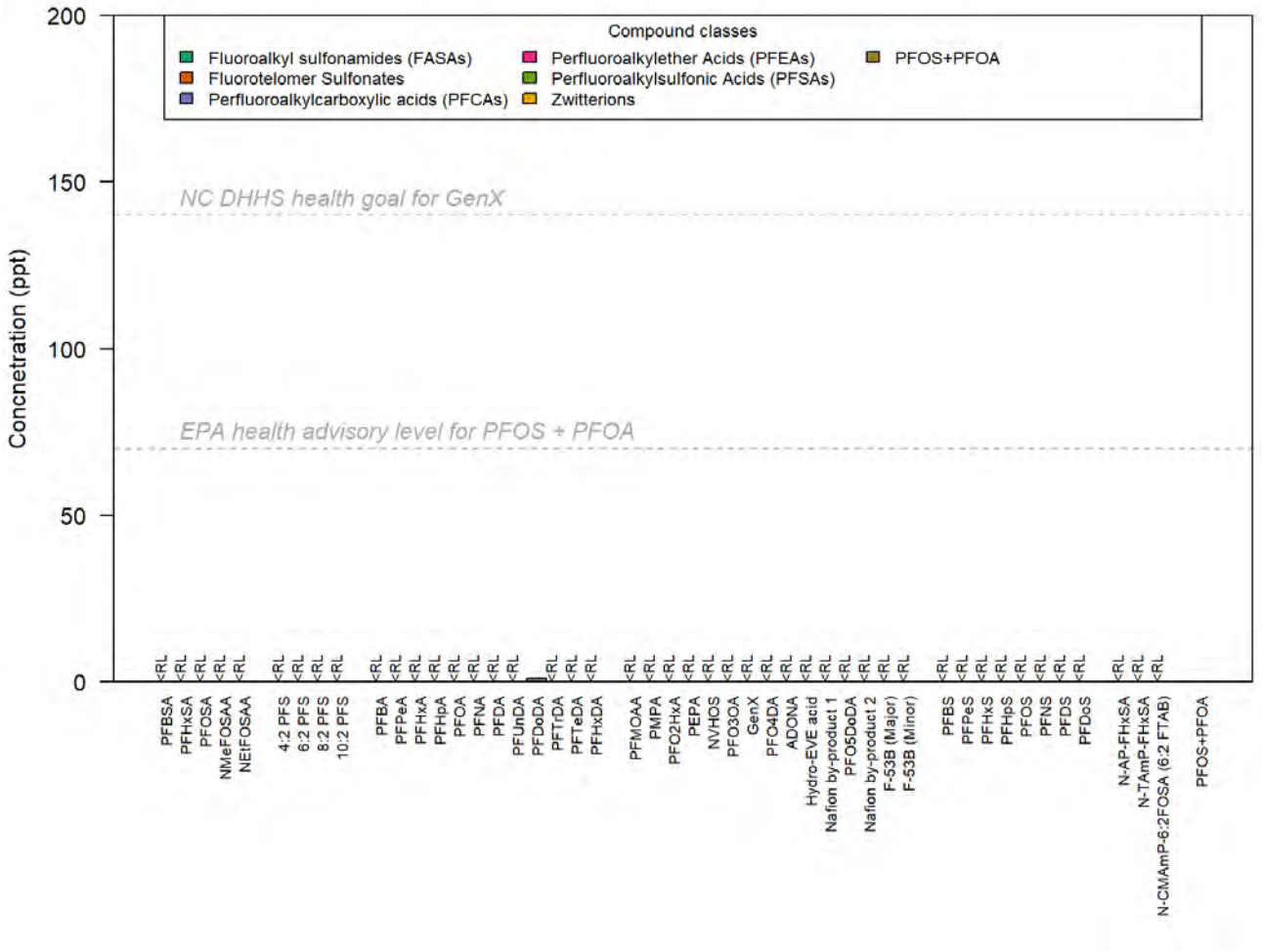


Table 1 Concentrations of PFAS compounds detected in parts-per-trillion (ppt). Gray values indicate compounds below the reporting limit (RL). Bold rows indicate occurence in excess of the EPA Health Advisory Limit (HAL) for PFOS + PFOA of 70 ppt.

Analyte Name	Abbreviation	CAS Registry Number	Concentration (ppt)	RL (ppt)
Fluoroalkyl sulfonamides (FASAs)				
Perfluorobutane sulfonamide	PFBSA	30334-69-1	<RL	1
Perfluorohexane sulfonamide	PFHxSA	41997-13-1	<RL	1
Perfluorooctane sulfonamide	PFOSA	754-91-6	<RL	1
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	<RL	1
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	<RL	5
Fluorotelomer Sulfonates				

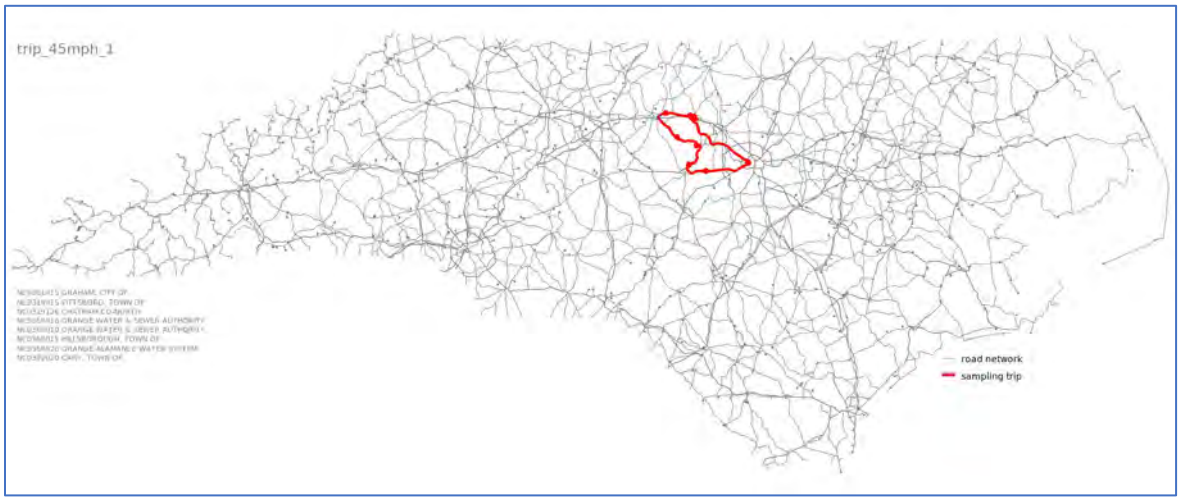
Analyte Name	Abbreviation	CAS Registry Number	Concentration (ppt)	RL (ppt)
4:2 Fluorotelomer sulfonic acid	4:2 PFS	757124-72-4	<RL	1
6:2 Fluorotelomer sulfonic acid	6:2 PFS	27619-97-2	<RL	1
8:2 Fluorotelomer sulfonic acid	8:2 PFS	39108-34-4	<RL	1
10:2 Fluorotelomer sulfonic acid	10:2 PFS	120226-60-0	<RL	1
Perfluoroalkylcarboxylic acids (PFCAs)				
Perfluorobutanoic acid	PFBA	375-22-4	<RL	1
Perfluoropentanoic acid	PFPeA	2706-90-3	<RL	2
Perfluorohexanoic acid	PFHxA	307-24-4	<RL	2
Perfluoroheptanoic acid	PFHpA	375-85-9	<RL	5
Perfluorooctanoic acid	PFOA	335-67-1	<RL	1
Perfluorononanoic acid	PFNA	375-95-1	<RL	1
Perfluorodecanoic acid	PFDA	335-76-2	<RL	1
Perfluoroundecanoic acid	PFUnDA	2058-94-8	<RL	1
Perfluorododecanoic acid	PFDoDA	307-55-1	1.1	1
Perfluorotridecanoic acid	PFTrDA	72629-94-8	<RL	2
Perfluorotetradecanoic acid	PFTeDA	376-06-7	<RL	1
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	<RL	10
Perfluoroalkylether Acids (PFEAs)				
Perfluoro-2-methoxyacetic acid	PFMOAA	674-13-5	<RL	5
Perfluoro-2-methoxypropanoic acid	PMPA	377-73-1	<RL	1

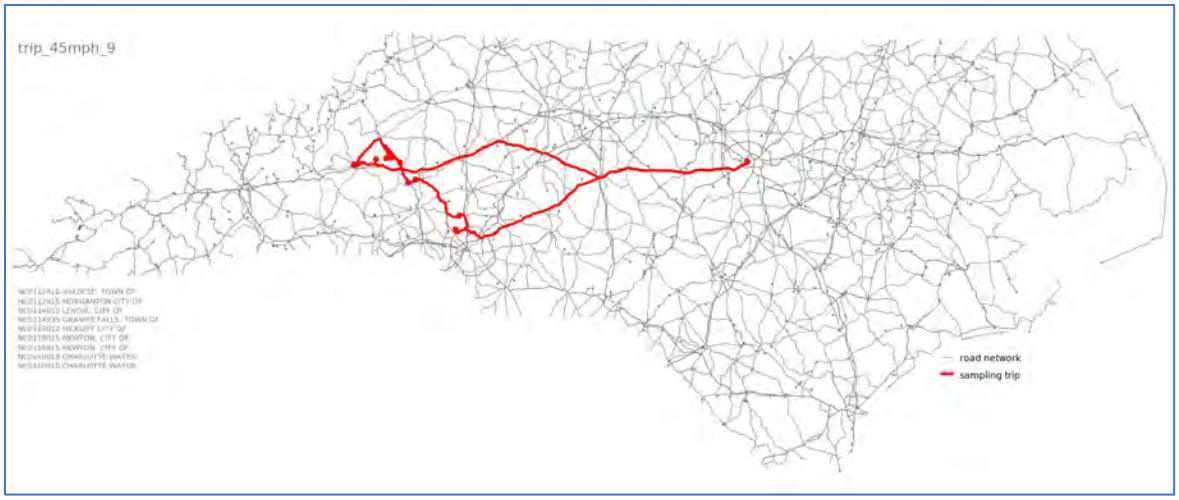
Analyte Name	Abbreviation	CAS Registry Number	Concentration (ppt)	RL (ppt)
Perfluoro(3,5-dioxahexanoic) acid	PFO2HxA	39492-88-1	<RL	1
Perfluoro-2-ethoxypropanoic acid	PEPA	267239-61-2	<RL	1
1,1,2,2-tetrafluoro-2-(1,2,2,2-tetrafluoro-ethoxy)ethane sulfonic acid	NVHOS	N/A	<RL	1
Perfluoro(3,5,7-trioxaoctanoic) acid	PFO3OA	39492-89-2	<RL	1
Perfluoro-2-propoxypropanoic acid	GenX	13252-13-6	<RL	1
Perfluoro(3,5,7,9-tetraoxadecanoic) acid	PFO4DA	39492-90-5	<RL	1
Dodecafluoro-3H-4,8-dioxanonanoic acid	ADONA	958445-44-8	<RL	1
Propanoic acid, 3-[1-[difluoro(1,2,2,2-tetrafluoroethoxy)methyl-1,2,2,2-tetrafluoroethoxy]-2,2,3,3-tetrafluoro-	Hydro-EVE acid	773804-62-9	<RL	1
Ethanesulfonic acid, 2-[1-[difluoro[(1,2,2-trifluoroethenyl)oxy]methyl]-1,2,2,2-tetrafluoroethoxy]-1,1,2,2-tetrafluoro-	Nafion by-product 1	29311-67-9	<RL	1
Perfluoro(3,5,7,9,11-pentaoxadodecanoic) acid	PFO5DoDA	39492-91-6	<RL	2
Ethanesulfonic acid, 2-[1-[difluoro(1,2,2,2-tetrafluoroethoxy)methyl]-1,2,2,2-tetrafluoroethoxy]-1,1,2,2-tetrafluoro-	Nafion by-product 2	749836-20-2	<RL	1
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	F-53B (Major)	73606-19-6	<RL	1
11-chloroeicosafluoro-3-oxanonane-1-sulfonate	F-53B (Minor)	83329-89-9	<RL	1
Perfluoroalkylsulfonic Acids (PFSAs)				
Perfluorobutanesulfonic acid	PFBS	375-73-5	<RL	1

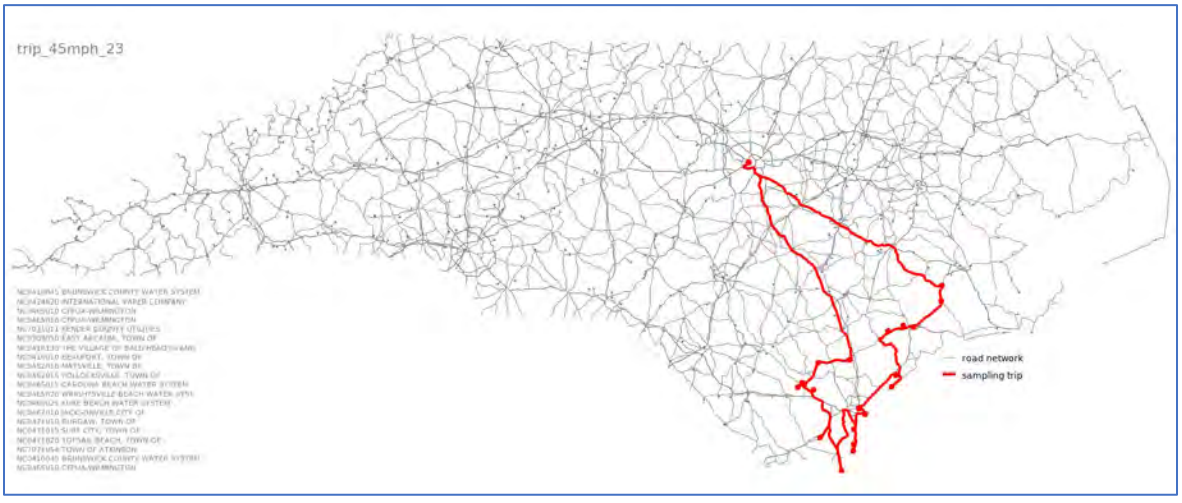
Analyte Name	Abbreviation	CAS Registry Number	Concentration (ppt)	RL (ppt)
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	<RL	1
Perfluorohexanesulfonic acid	PFHxS	355-46-4	<RL	2
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	<RL	1
Perfluorooctanesulfonic acid	PFOS	1763-23-1	<RL	1
Perfluorononanesulfonic acid	PFNS	68259-12-1	<RL	1
Perfluorodecanesulfonic acid	PFDS	2806-15-7	<RL	10
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	<RL	10
Zwitterions				
N-(3-dimethylaminopropan-1-yl)perfluoro-1-hexane-sulfonamide	N-AP-FHxSA	50598-28-2	<RL	5
N-[3-(perfluoro-1-hexanesulfonamido)propan-1-yl]-N,N,N-trimethylammonium	N-TAmP-FHxSA	38850-51-0	<RL	1
N-(carboxymethyl)-N,N-dimethyl-N-[3-(1H,1H,2H,2H-perfluoro-1-octanesulfonamido)propan-1-yl]ammonium	N-CMAmP-6:2FOSA (6:2 FTAB)	34455-29-3	<RL	2

APPENDIX IV

EXAMPLE WATER SAMPLING TRIPS OPTIMIZED FOR ROUND 2



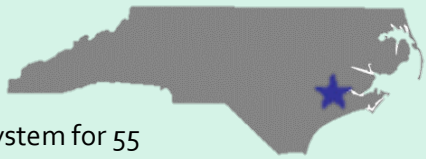




APPENDIX V

PFAS FACT SHEET CREATED FOR THE TOWN OF MAYSVILLE TO SHARE WITH RESIDENTS. CAN BE ADAPTED FOR USE IN OTHER COMMUNITIES.

PFAS in Drinking Water



The NC PFAS Testing (PFAST) Network tested a well in the Maysville drinking water system for 55 chemicals and found levels above the US EPA recommendation for two chemicals, PFOA and PFOS, and similar levels of PFHxS.

PFOA=perfluorooctanoic acid ♦ PFOS=perfluorooctane sulfonic acid ♦ PFHxS=perfluorohexane sulfonic acid

What are PFAS?

PFAS (per- and polyfluoroalkyl substances) are a large class of human-made chemicals that includes PFOA, PFOS, and PFHxS, as well as newer compounds like GenX. **PFAS are used in industry, firefighting, and commercial products that are resistant to water, grease, and stains**. PFAS are of concern because they can persist in water for a long time, and the health implications of PFAS in drinking water are not well established.

How can drinking water that contains PFAS affect your health?

PFOA and PFAS have been studied much more than the thousands of other PFAS known to exist. Health effects associated with PFOA and PFOS include elevated cholesterol, altered liver function, reduced thyroid levels, and reduced immune response to vaccines, some cancers (kidney and testicular), ulcerative colitis, and increased blood pressure during pregnancy.

What is considered a high level of PFAS?

The US Environmental Protection Agency set a health advisory level of 70 parts per trillion for PFOA and PFOS in drinking water. The health advisory level is the combined concentration of both chemicals that protects people from harmful effects of exposure to PFAS in drinking water. Health advisories are based on current scientific research, but are non-enforceable and non-regulatory.

How do we measure PFAS in people?

Some PFAS can be measured in people using a blood test, though most laboratories do not provide this service. Some PFAS do not stay in the body long, and a blood test cannot identify these chemicals. **Blood test results will tell you how much of each PFAS is in your blood on the day you are tested.** Currently, there is no information that can be used to interpret what levels in blood may be associated with harmful health effects.

How long can PFAS stay in our bodies?

Some PFAS can stay in your body for many years, while others are more rapidly removed from the body. If you are no longer exposed to PFAS, the amount of PFAS in your body will decrease gradually over time.

Where can I find more information?

ATSDR: http://bit.ly/PFASfaq
NC DEQ: http://bit.ly/PFASHealth
NC PFAST Network: https://ncpfastnetwork.com/
US EPA: http://bit.ly/HealthAdvisoryLevel

NORTH CAROLINA PFAS Testing Network

7/23/19