Evaluation of Kentucky Community Drinking Water for Per- & Poly-Fluoroalkyl Substances

Department for Environmental Protection

Division of Water

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Executive Summary

This study is an examination of the occurrence of per- and poly-fluoroalkyl substances (PFAS) in a representative sample of Kentucky's public drinking water. Samples of finished (treated) water were collected and analyzed from 81 community public drinking water treatment plants (WTPs), representing 74 public drinking water systems, over the course of four months. Sampling sites were chosen to represent surface water (43 WTPs) and groundwater (38 WTPs) supplies, urban and rural land-use influence, and varying sizes of populations served. Source waters for the WTPs sampled include each of Kentucky's major river basins, the main stem of the Ohio River's and major aquifers in the state. The population served by the WTPs sampled in this study account for approximately half the population in Kentuckians on public water.

Samples were collected by the Kentucky Department for Environmental Protection (Department) personnel and analyzed at the department's Division of Environmental Program Support (DEPS) laboratory. The DEPS laboratory analyzed eight PFAS in each sampling event. Those analytes were: Perfluorobutanesulfonic acid (PFBS); Perfluoroheptanoic acid (PFHpA); Perfluorohexanesulfonic acid (PFHxS); Perfluorononanoic acid (PFNA); Perfluorooctanesulfonic acid (PFOS); Perfluorooctanoic acid (PFOA); 4,8-dioxa-3H-perfluorononanoic acid (ADONA); and Hexafluoropropylene oxide dimer acid (HFPO-DA).

Quality assurance samples, including laboratory blanks, trip blanks and field blanks were also analyzed to ensure proper quality assurance protocols were followed throughout each sampling event.

Samples from the 81 WTPs were each analyzed for eight (8) analytes, which yielded a total of 648 analyses. There were 96 PFAS sample detections of one or more PFAS, which equates to a 15% sample detection rate overall. Furthermore, 79 of the PFAS sample detections that occurred were less than 5 ng/L. Therefore, only 17 of PFASs sample detections (3%) were greater than 5 ng/L.

One or more PFAS were detected at 41 of the 81 WTPs sampled, which were predominantly surface water sources. One or more PFAS were detected at 31 of 43 (72%) surface water WTPs sampled and 10 of 38 (26%) groundwater WTPs sampled. The most frequently detected analyte was PFOS, which was identified in 33 samples. This was followed by PFOA, which was detected in 24 samples. The highest concentration of any analyte detected was HFPO-DA at 29.7 ng/L. The least frequently detected PFAS was ADONA, which was not detected in any samples.

Drinking water systems that utilize surface water from the Ohio River had 32 PFAS detections occurring at the ten (10) WTPs sampled (100%). Public water systems using surface water in the Kentucky River Basin had twelve (12) PFAS detections at eight of the nine (89%) of the WTPs sampled. Public water systems using surface water in the Big Sandy, Cumberland, Green, Licking and Salt river basins each had very few or no detections of PFAS.

For drinking water systems using groundwater as a source, PFAS compounds were most commonly detected in the Ohio River Alluvium, where 22 PFAS detections were located at nine of the 22 (41%) WTPs sampled. Drinking water systems utilizing the Mississippi Embayment aquifers had a single PFAS detection which occurred at one WTP. No PFAS were detected in groundwater systems using the Pennsylvanian Sandstone aquifer or the Tennessee River alluvial aquifer.

There were 32 drinking water systems whose sources were determined to be under urban land-use influence; one or more PFAS were detected at 23 of those WTPs (72%). The remaining 49 drinking water systems have sources primarily influenced by rural land use and on or more PFAS were detected at 18 of those WTPs (37%).

Of the Kentucky public water systems sampled in this study that had detections of one or more PFAS, all the analytical results for PFOA and PFOS, both individually and when added [PFOA + PFOS] were below the 2016 EPA-recommended Human Health Advisory of 70 ng/L for PFOA and PFOS.

Introduction and Background

PFAS have been identified as contaminants of emerging concern. These compounds are ubiquitous and have been used since the 1940s for their ability to resist heat, oil, grease and water. The most common uses have been stain resistance for carpets, non-stick cookware, and aqueous film-forming foam (AFFF) which is used in fire-fighting. These chemicals are persistent in the environment, and can bioaccumulate in organisms. There is evidence that exposure to PFAS may impact reproductive and developmental health, increase the risk for cancer, disrupt thyroid hormones, and affect the immune system (USEPA, 2018a). The United States Environmental Protection Agency (USEPA) and many states are assessing the need to establish Maximum Contaminant Levels (MCLs) for PFAS exposure in drinking water as well as remediation goals for sites contaminated by PFAS.

Major known PFAS sources include fire training and response sites, industrial sites, landfills and wastewater treatment plant effluent. Point source discharges and atmospheric transport (non-point sources) both contribute to PFAS distribution in the environment (ITRC, 2018).

There are a number of PFAS that fall into two broad categories: polymer and non-polymer. Non-polymer PFAS include the per- and poly-fluorinated compounds most commonly found in the environment. Polymer PFAS are generally thought to represent less of a threat to human health and the environment. With respect to per- and poly-fluoroalkyl substances, the per-fluoroalkyl varieties are typically the most problematic (ITRC, 2018).

The chemical characteristics of PFAS are also key to each compound's environmental transport and fate. These molecules form carbon chains with fluorine atoms inhabiting some or all of the potential bonding sites, and non-fluorine charged *heads* on one end (ITRC, 2018). The carbon-fluorine bond is one of the strongest known in organic chemistry (Lemal, 2004). The strong bonds create a molecule that is very unreactive and resistant to chemical or biological breakdown (deSilva, 2019). Therefore, standard remediation technologies and biological activity have little to no effect on these molecules.

The USEPA's Third Unregulated Contaminant Monitoring Rule (UCMR3) efforts examined the occurrence of six PFAS compounds in drinking water nationwide from 2013 to 2015. The finished water from all community water systems in the United States serving more than 10,000 people, and a representative sample of 800 systems serving less than 10,000 people, were sampled. In Kentucky, 121 water systems with 165 drinking water sources were monitored under this rule for the occurrence of PFAS. Nationally, 4% of public water systems reported detections of PFAS while Kentucky had detections in 1.8% of sampled sources. Detections in drinking water were associated with numerous potential sources of PFAS, including industrial sites, areas where fire training with AFFF occurred, and wastewater treatment facilities (ITRC, 2018).

On May 19, 2016, the USEPA issued a drinking water lifetime health advisory (HA) for two PFAS compounds, PFOA and PFOS. The HA level is 70 ng/L (nanograms per liter, or parts per trillion)

for PFOA, and 70 ng/L for PFOS. EPA further recommended that when these two chemicals co-occur in a drinking water source, a conservative approach to protect human health would be to compare the sum of the concentrations ([PFOA] + [PFOS]) to the HA (70 ng/L). Lifetime health advisories are not primary drinking water standards (MCLs or Treatment Technology) but may be used for developing drinking water standards at the state or local level. For this study, the HA is utilized as a screening level of public drinking water. USEPA is also proposing to use the HA as a preliminary remediation goal (PRG) for PFAS-contaminated groundwater being used for consumptive purposes. The USEPA has not established health advisories for other PFAS compounds at this time.

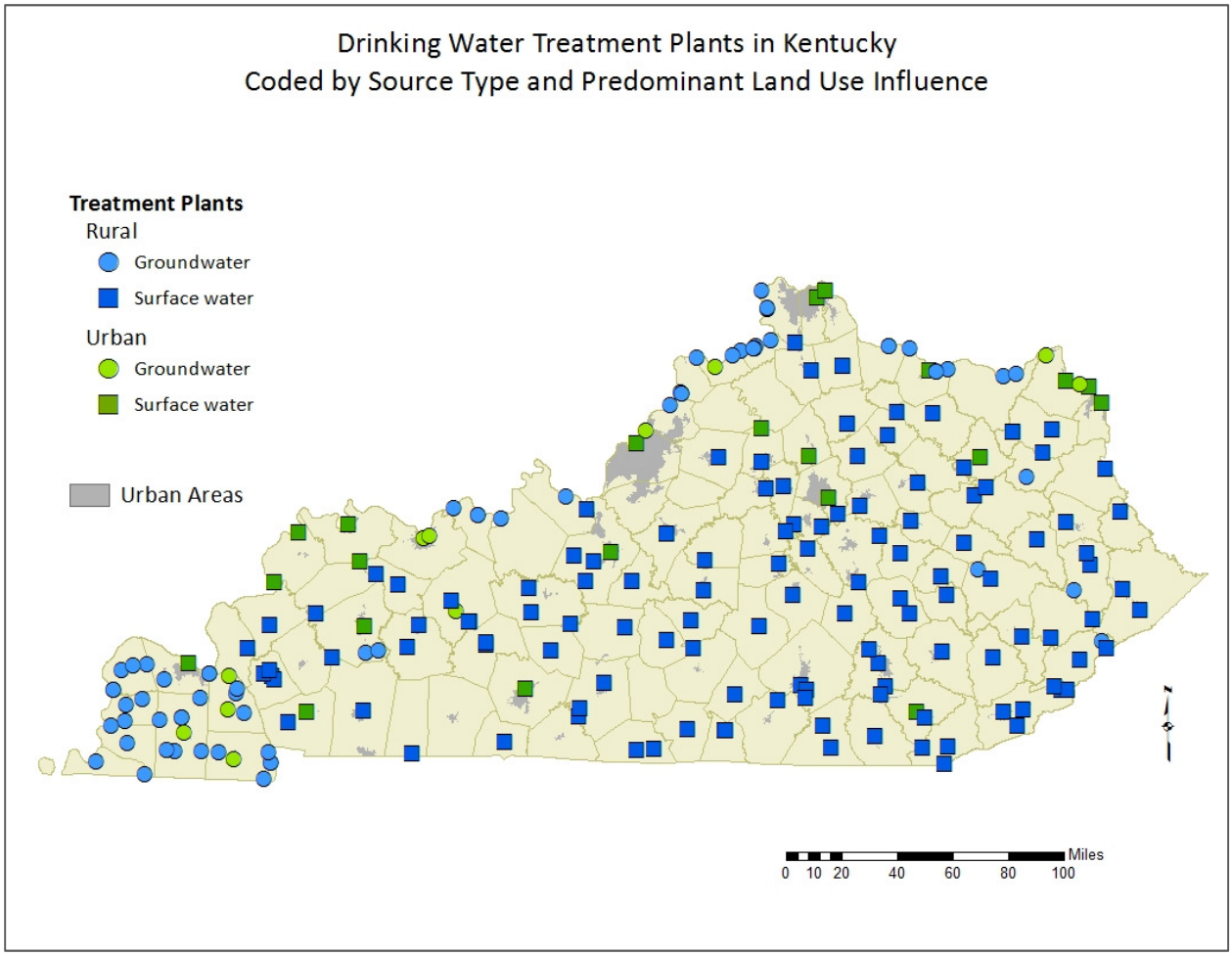
Purpose and Scope

Kentucky is served by 195 community water systems that produce treated drinking water. Another 190 consecutive community water systems purchase treated drinking water and provide water to their customers. Approximately 97% of Kentuckians are served by publicly supplied drinking water. Figure 1 illustrates the distribution of the 210 WTP locations associated with these 195 community public water systems. The WTPs are identified by the type of source water (surface water or groundwater) on which the facilities rely and whether the source water is predominantly in an urban or a rural setting.

The purpose of this study is for the Department to determine the presence of PFAS at public WTPs as a means to determine whether public drinking water is a potential source of significant exposure to PFAS. The results of this study may be used to identify watersheds or aquifers that have potential sources of PFAS contamination. Determining the presence of PFAS in public drinking water was accomplished through systematic sampling focused on these emerging contaminants.

In developing this systematic approach and upon reviewing the results of the UCMR3 study, the Department chose to classify and sample WTPs based on their source water type (surface water or groundwater) and by the associated predominant land use (urban or rural) in the area proximal to or influencing the public water supply's wells or intakes. Following the approach described later in this document, 81 WTPs were selected that cumulatively provide drinking water to approximately 2.27 million people which is more than half of Kentucky's population served by public drinking water.

Figure 1. Drinking Water Treatment Plant Locations



Previous Investigations

The USEPA's UCMR3 examined PFAS occurrence in 121 drinking water systems in Kentucky in 2013-2015. Of those 121 water systems, 77 were drinking water producers and 44 were consecutive systems that purchase finished water. Two PFAS, PFOA and PFOS, were detected in drinking water in the UCMR3 study, and each analyte was detected twice. PFOA was detected at two water treatment plants, both of which are operated by the same water system on the Ohio River. PFOS was detected at two pump stations where water system interconnections occur for a purchasing water system. The source water for that producing system is the Licking River. Table 1 is a summary of PFAS detections in the USEPA UCMR3.

Table 1. PFAS Detections in USEPA UCMR3 (ng/L)

Water System Name	Sample Location	Analyte Detected	Result Value	MDL
Louisville Water Company	B.E. Payne WTP	PFOA	20	20
Louisville Water Company	Crescent Hill WTP	PFOA	20	20
Pendleton Co. Water Dist. #1 South*	Pump Station	PFOS	50	40
Pendleton Co. Water Dist. #1 South*	Pump Station	PFOS	59	40

*Indicates finished water purchaser, sampled at interconnection point.

The infrequent detection of PFAS in the UCMR3 efforts is likely attributable to the relatively high laboratory method detection limits (MDL) available at the time. These detection limits ranged from 10 ng/L (PFHpA) to 90 ng/L (PFBS). The MDL for PFOA used in the UCMR3 was 20 ng/L, and the MDL for PFOS was 40 ng/L. These MDLs are much higher than those attained by the DEPS laboratory using method 537.1 for this study (see Table 7).

Study Objectives and Strategy

This study has two main objectives:

- The primary objective of this study was to assess treated, publicly supplied drinking water for the occurrence of PFAS via both probabilistic and targeted sampling approaches.
- The second objective was to identify watersheds or aquifers that serve as source water to the WTPs for which potential sources of PFAS contamination may exist.

These objectives were pursued using the following methods. The Department selected for monitoring public WTPs that represent each of the source-water categories – surface water and groundwater, and each of the land-use categories – urban or rural. In doing so, the study also included public water systems of various sizes, as determined by population served. The Department also conducted a probabilistic (random) selection of a subset of the remaining public WTPs for monitoring, which served as an unbiased representation of all public WTPs.

WTPs using surface water in all six of Kentucky's major river basins were monitored as part of this study, as well as ten WTPs that withdraw water from the Ohio River. In addition, WTPs using all of the major groundwater aquifers in Kentucky that are used to supply source water for drinking water were sampled in this study, including the alluvial aquifers associated with major rivers, Cretaceous deposits of the Mississippi Embayment and Pennsylvanian sandstones of the Eastern and Western Coal Fields. WTPs using karst aquifers for source water were also included in this study. However, karst aquifer sources are regulated as surface water systems because they are presumed to be under the direct influence of the surface and their subsequent Safe Drinking Water Act treatment requirements. Therefore karst aquifer sources are tallied with the surface water systems. Table 2 summarizes the number of WTPs sampled in each of the major river basins and generalized aquifers.

Table 2. Number of WTPs sampled in each source water area

Surface Water Systems		Groundwater Systems	
River Basin	**Number of WTPs**	**Generalized Aquifer**	**Number of WTPs**
Ohio River-main stem	10	Mississippi Embayment	11
Big Sandy	5	Ohio River Alluvium	22
Cumberland	5	Pennsylvanian Sandstone	4
Green	8	Tennessee River Alluvium	1
Kentucky	9		
Licking	5		
Salt	1		

Sampling Strategy

The sampling strategy was designed to address the limited knowledge of PFAS occurrence in drinking water in the Commonwealth. The UCMR3 provided an initial evaluation of PFAS in Kentucky's drinking water and this study further expands our knowledge of their occurrence. Because these compounds are not currently regulated by the Safe Drinking Water Act, there is no systematic monitoring of their occurrence in public drinking water. Additionally, the limited occurrence and associated method detection and reporting levels of PFAS in the UCMR3 study does not provide adequate data for a predictive approach to assessing the occurrence of PFAS in public drinking water. Therefore, a systematic assessment of drinking water systems was a reasonable approach to evaluating the occurrence of PFAS in public drinking water within the Commonwealth.

The PFAS analyzed for this study are summarized in Table 3, below. The analytes selected include the six compounds that were analyzed in the UCMR3, which allows for comparability to previous datasets. These analytes may also serve as surrogates for the overall occurrence of PFAS. Two analytes were selected as surrogate representatives for the next generation of chemicals (GenX and ADONA) developed to replace PFOS and PFOA in commerce. These analytes are commonly used for numerous commercial applications. The DEPS laboratory has the capability to analyze drinking water samples for all of the analytes selected for this study. (*N.B.* While there are several thousand compounds in the PFAS class of contaminants, the analytical methods to detect most of these compounds have not been developed, and analytical standards are available for a limited number of PFAS compounds. These eight analytes are appropriate surrogates for the PFAS class of contaminants as they are thought to be the most persistent in the environment and are presently thought to be the most problematic PFAS compounds with regard to human health.)

Table 3. PFAS analyzed for this study

Analyte	Acronym	CAS Number
Perfluorobutanesulfonic acid*	PFBS	375-73-5
Perfluoroheptanoic acid*	PFHpA	375-85-9
Perfluorohexanesulfonic acid*	PFHxS	355-46-4
Perfluorononanoic acid*	PFNA	375-95-1
Perfluorooctanesulfonic acid*#	PFOS	1763-23-1
Perfluorooctanoic acid*#	PFOA	335-67-1
4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6

*Indicates PFAS analyzed in UCMR3.

#Indicates PFAS for which EPA has issued a Health Advisory

Sampling and laboratory analysis of PFAS is costly due to the rigorous sample collection protocols and paucity of laboratories available to conduct the analyses, as well as the availability of PFAS analytical standards versus the current demand. Therefore, this study focused on two subsets of drinking water systems, which encapsulates 40% of the drinking water plants, and represents approximately half of the population served by public water systems in Kentucky.

An adaptive approach to sample collection allowed for efficient data acquisition as the study progressed. The initial subset of sample sites were those 43 WTPs selected to represent land-use categories and source water types (Table 4). The second subset of 38 sites were drawn randomly from the remaining water treatment plants (Table 5). The WTPs selected for monitoring were then grouped by region for sample collection to accommodate logistical concerns. Figure 2 is a map showing the community public drinking water WTPs sampled for this study.

The original work plan included four sites that were selected for monitoring, but were not sampled as part of the study, including the Northern Kentucky Water District's Taylor Mill WTP and three WTPs that are part of the Center Ridge Water District. Northern Kentucky's Taylor Mill WTP is a back-up supply that was not in operation during the monitoring period. The three Center Ridge WTPs could not be sampled due to logistical challenges during the study period. These four sites were replaced with the next four randomly selected sites: Barlow Water System, Brandenburg Water Works, Vanceburg Plant Board and Carroll County Water District #1 Ghent WTP.

Table 4. Sample sites selected to represent various criteria

Water System Name	Treatment Plant Name	Source	Land Use	County
ASHLAND WATER WORKS*	OHIO RIVER WTP	SW	urban	BOYD
AUGUSTA REGIONAL WTP	AUGUSTA WTP	GW	rural	BRACKEN
BARBOURVILLE UTILITIES*	BARBOURVILLE WTP	SW	urban	KNOX
BARDSTOWN MUNICIPAL WATER DEPT*	SYMPSON LAKE WTP	SW	rural	NELSON
BEAVER DAM MUNICIPAL WATER & SEWER	BEAVER DAM WTP	GW	urban	OHIO
BENTON WATER & SEWER	BENTON WTP	GW	urban	MARSHALL
BOWLING GREEN MUNICIPAL UTILITIES*	BARREN RIVER WTP	SW	urban	WARREN
CADIZ MUNICIPAL WATER CO	CADIZ SPRING WTP	SW	urban	TRIGG
CALVERT CITY MUNICIPAL WATER DEPARTMENT	CALVERT CITY WTP	GW	urban	MARSHALL
CARROLL CO WATER DISTRICT #1	GALLATIN CO WTP	GW	rural	GALLATIN
CARROLLTON UTILITIES	CARROLLTON WTP	GW	urban	CARROLL
CITY OF SOUTH SHORE WATER WORKS	SOUTH SHORE WTP	GW	urban	GREENUP
CYNTHIANA MUNICIPAL WATER WORKS	LICKING RIVER WTP	SW	rural	HARRISON
FALMOUTH WATER DEPARTMENT	FALMOUTH WTP	SW	rural	PENDLETON
FRANKFORT PLANT BOARD*	FRANKFORT WTP	SW	rural	FRANKLIN
GEORGETOWN MUNICIPAL WATER SERVICE*	ROYAL SPRING WTP	SW	urban	SCOTT
GRAVES CO WATER DIST - HICKORY	GRAVES CO WD - HICKORY WTP	GW	rural	GRAVES
GREENUP WATER SYSTEM*	GREENUP WTP	SW	urban	GREENUP
HARDIN COUNTY WATER DISTRICT #2*	CITY SPRINGS TPB	SW	urban	HARDIN
HAWESVILLE WATER WORKS	HAWESVILLE WTP	GW	rural	HANCOCK
HENDERSON WATER UTILITY/NORTH*	HENDERSON WTP	SW	urban	HENDERSON
HENDERSON WATER UTILITY/SOUTH	HENDERSON/SOUTH WTP	SW	urban	HENDERSON
KENTUCKY-AMERICAN WATER CO*	KY RIVER STATION II WTP	SW	urban	FAYETTE
KENTUCKY-AMERICAN WATER CO*	RICHMOND RD STATION WTP	SW	urban	FAYETTE
LEDBETTER WATER DISTRICT	LEDBETTER WTP	GW	rural	LIVINGSTON
LOUISVILLE WATER COMPANY*	CRESCENT HILL WTP	SW	urban	JEFFERSON
LOUISVILLE WATER COMPANY*	B E PAYNE WTP	GW	urban	JEFFERSON
MADISONVILLE LIGHT & WATER*	MADISONVILLE WTP #1	SW	urban	HOPKINS
MAYFIELD ELECTRIC & WATER*	MAYFIELD WTP	GW	urban	GRAVES
MAYSVILLE UTILITY COMMISSION*	MAYSVILLE WTP	SW	urban	MASON
MOREHEAD STATE UNIVERSITY	MSU WTP	SW	urban	ROWAN
MURRAY WATER SYSTEM*	MURRAY WTP	GW	urban	CALLOWAY
NORTHERN KENTUCKY WATER DISTRICT*	FT THOMAS WTP	SW	urban	KENTON
NORTHERN KENTUCKY WATER DISTRICT*	MEMORIAL PARKWAY WTP	SW	urban	KENTON
OLIVE HILL MUNICIPAL WATER WORKS	OLIVE HILL WTP	SW	rural	CARTER
OWENSBORO MUNICIPAL UTILITIES*	FOURTH STREET WTP	GW	urban	DAVIESS
OWENSBORO MUNICIPAL UTILITIES*	WILLIAM R CAVIN WTP	GW	urban	DAVIESS
PADUCAH WATER WORKS*	PADUCAH WTP	SW	urban	MCCRACKEN
RUSSELL WATER COMPANY	RUSSELL WTP	SW	urban	GREENUP
WARSAW WATER WORKS	WARSAW TPB	GW	rural	GALLATIN
WESTERN LEWIS RECTORVILLE WATER DISTRICT	W. LEWIS RECTORVILLE WTP	GW	rural	MASON
WICKLIFFE MUNICIPAL WATER SYSTEM	WICKLIFFE WTP	GW	rural	BALLARD
WORTHINGTON MUNICIPAL WATER WORKS	WORTHINGTON WTP	GW	urban	GREENUP

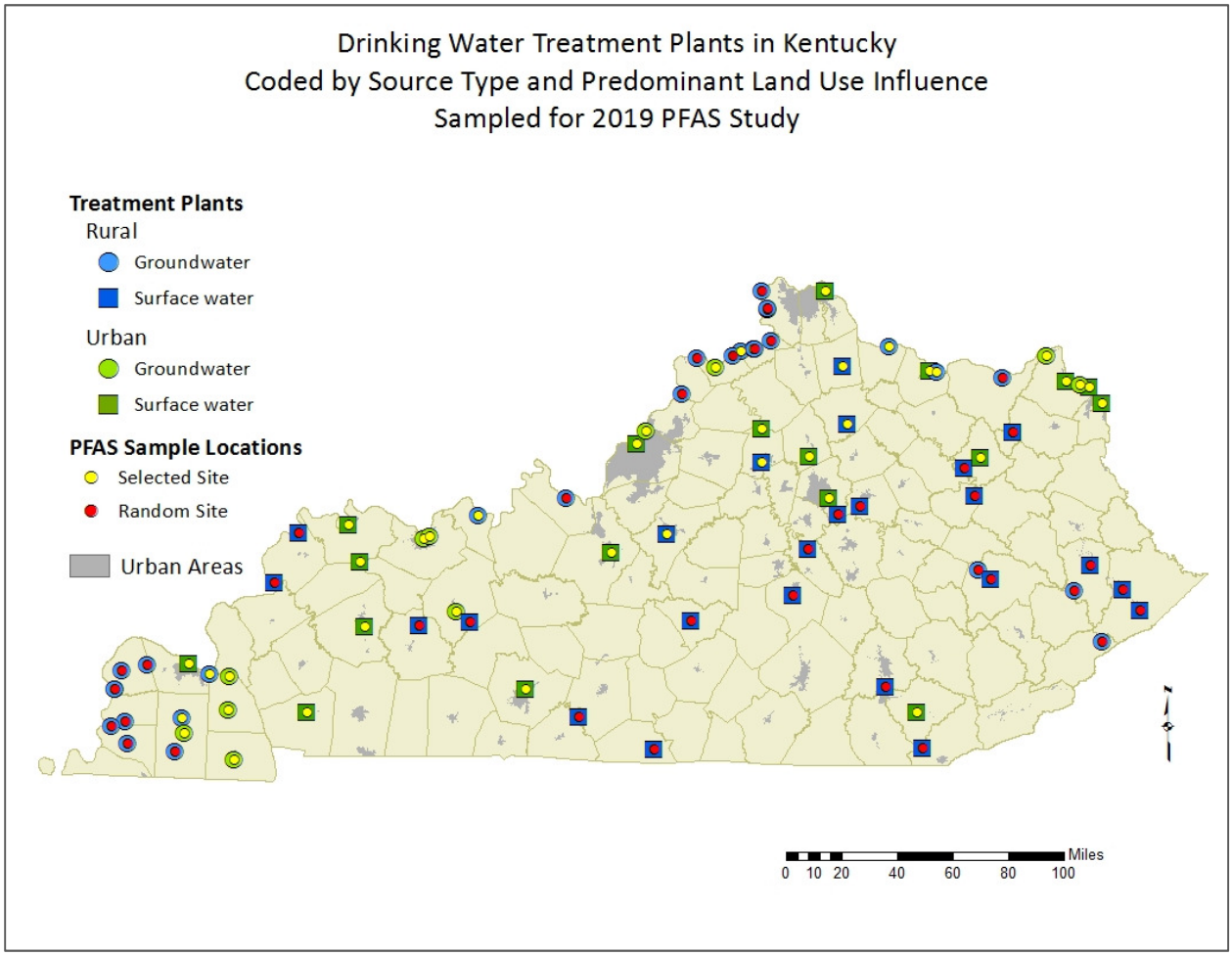
*Indicates UCMR3 sample site. Note on Source: GW=Groundwater; SW=Surface Water.

Table 5. Randomly selected sampling sites

Water System Name	Treatment Plant Name	Source	Land Use	County
ARLINGHAUS PROPERTY	ARLINGHAUS WTP	GW	rural	BOONE
ARLINGTON WATER DEPARTMENT	ARLINGTON WTP	GW	rural	CARLISLE
BARLOW WATER SYSTEM	BARLOW WTP	GW	rural	BALLARD
BELL COUNTY FORESTRY CAMP	BELL CO FC WTP	SW	rural	BELL
BIRKLE WATER SUPPLY	BIRKLE WTP	GW	rural	BOONE
BRANDENBURG WATER WORKS	BRANDENBURG WTP	GW	rural	MEADE
CAMPBELLSVILLE MUNICIPAL WATER*	CAMPBELLSVILLE WTP	SW	rural	TAYLOR
CARROLL COUNTY WATER DISTRICT #1	GHENT WTP	GW	rural	CARROLL
CAVE RUN REGIONAL WT COMM	CAVE RUN WTP	SW	rural	MENIFEE
CENTRAL CITY WATER & SEWER	CENTRAL CITY WTP	SW	rural	MUHLENBERG
COLUMBUS WATER WORKS	COLUMBUS WTP	GW	rural	HICKMAN
FLEMING-NEON WATER COMPANY	SHEA FORK MINE WTP	GW	rural	LETCHER
FRANCIS WATER COMPANY	FRANCIS WTP	GW	rural	FLOYD
GALLATIN COUNTY WATER DISTRICT	GALLATIN CO WTP-A	GW	rural	GALLATIN
GALLATIN COUNTY WATER DISTRICT	GALLATIN CO WTP-B	GW	rural	GALLATIN
GRAVES CO WATER DIST - SOUTH GRAVES	SOUTH GRAVES WTP	GW	rural	GRAVES
JACKSON MUNICIPAL WATER WORKS	JACKSON MWW WTP	SW	rural	BREATHITT
KENTUCKY-AMERICAN WATER CO*	KY RIVER STATION 1	SW	rural	FAYETTE
KEVIL WATER DEPARTMENT	KEVIL WTP	GW	rural	BALLARD
LANCASTER WATER WORKS	LANCASTER WTP	SW	rural	GARRARD
LAUREL CO WATER DISTRICT #2*	LAUREL CO WD#2 WTP	SW	rural	LAUREL
MILTON WATER & SEWER DEPARTMENT	MILTON WTP	GW	rural	TRIMBLE
MONROE COUNTY WATER DISTRICT	MONROE CO WD WTP	SW	rural	MONROE
MOREHEAD UTILITY PLANT BOARD*	MOREHEAD UPB WTP	SW	rural	ROWAN
MORGANFIELD WATER WORKS	MORGANFIELD WTP	SW	urban	UNION
MOUNTAIN WATER DISTRICT*	MOUNTAIN WD WTP	SW	rural	PIKE
MT CARMEL HIGH BOARDING SCHOOL	MT CARMEL HIGH WTP	GW	rural	BREATHITT
PERDUE FARMS INC	PERDUE FARMS WTP	SW	rural	OHIO
PIKEVILLE WATER DEPARTMENT*	PIKEVILLE WTP	SW	rural	PIKE
SCOTTSVILLE WATER DEPARTMENT	SCOTTSVILLE WTP	SW	rural	ALLEN
SOUTHERN WATER & SEWER DISTRICT*	SOUTHERN WSD WTP	SW	rural	FLOYD
STANFORD WATER WORKS	STANFORD WTPS	SW	rural	LINCOLN
STURGIS WATER WORKS	STURGIS WTP	SW	urban	UNION
TRAPP WATER COMPANY	TRAPP WTP	GW	rural	BOONE
TRIMBLE CO WATER DISTRICT #1	TRIMBLE # 1 WTP B	GW	rural	TRIMBLE
VANCEBURG ELECTRIC PLANT BOARD	VANCEBURG WTP	GW	rural	LEWIS
WATER SERVICE CORP OF KENTUCKY	DEEP WELLS WTP	GW	rural	HICKMAN
WINCHESTER MUNICIPAL UTILITIES*	WINCHESTER MU WTP	SW	rural	CLARK

*Indicates UCMR3 sample site. Note on Source: GW=Groundwater; SW=Surface Water.

Figure 2. Drinking Water Treatment Plants sampled for PFAS



Materials and Methods

Training and Quality Assurance of Sample Collection

Due to the rigorous requirements of sample collection and the potential for cross contamination, significant effort was focused on training personnel and quality assurance. The Department's Standard Operating Procedure (SOP) for sampling PFAS, located in Appendix A, provided guidance for field staff throughout this process. Furthermore, all field staff had significant experience with environmental sample collection under varying conditions and requirements. A Program Management Plan (PMP), located in Appendix B, was developed for this study, and is subordinate to the Quality Assurance Project Plan for the Division of Water, Water Quality Branch monitoring programs.

Sampling

Sample collection and analyses commenced in June 2019, following approval by the Department of the project work plan and associated quality assurance documents. The DEPS laboratory analyzed all samples, including all quality-control samples. The analytical method protocol (EPA 537.1) requires a trip blank for each sampling event, field blank sample for each site and one triplicate sample per sampling event (trip). The trip blank is used to determine possible cross contamination due to sample holding and handling, and is provided by the DEPS laboratory. The trip blank is also used the temperature blank for the sample event. The field blank is used to determine possible cross contamination during sampling activities. The field blank is collected at the sampling site by pouring PFAS-free water, preserved with 1.25 grams of Trizma, into a container provided by the DEPS laboratory. Triplicate samples are used by the laboratory for internal quality control of the analytical process. Two sample containers of finished water were collected at each site along with a field blank sample. Two additional samples (triplicate) of finished water were collected from a single site on each sampling day. The quality control sample requirements resulted in more quality control samples than field samples. Therefore, laboratory capacity limited sampling to roughly six sites per week.

Sample collection was scheduled by regional grouping of selected sites for optimum efficiency of field staff time. This was accomplished by laying out a sampling schedule plan based on the site lists in Table 4 and Table 5 prior to initiation of field activities. Technical Assistance personnel from the Drinking Water Branch served as liaisons with the identified public water systems in their regions to aid in outreach and schedule planning. In some cases, targeted and randomly drawn sites were sampled simultaneously later in the study to increase efficiency. Table 6, below, shows the study timeline and progression.

Table 6. Study timeline

	May	June	July	Aug	Sept	Oct	Nov
Training/Coordination	X						
Sample Collection		X	X	X	X		
Sample Analysis		X	X	X	X		
Receive Lab Results		X	X	X	X	X	
Data Analysis/Reporting						X	X

Custody and Security of Materials and Samples

Due to the sensitivity of laboratory analyses and the potential for cross contamination, the custody and security of materials and samples was of paramount concern. To assure data quality, access to field materials, the sampling vehicle and collected samples was stringently controlled. Sample containers were kept at the DEPS laboratory, along with the necessary preservative, verified PFAS-free water for sample blanks and coolers dedicated to this project. One vehicle, that has previously been used with success for PFAS sampling was designated for all sampling

events. This vehicle is assigned to one Department staff member and is not shared-use in the motor pool. All materials and samples were locked in the bed of this truck with no potential cross-contamination sources. Standard chain-of-custody protocols were followed for transport and sample delivery to the DEPS laboratory.

Preparation for Sample Collection

At least one week prior to scheduled sampling, water systems were contacted to ensure access to the WTP. The route and order of sampling sites for each event was predetermined for logistical efficiency. The DEPS laboratory provided three empty 250 mL HDPE containers, two of which were pre-preserved with 1.25 grams of Trizma, for each sample site. The DEPS laboratory also provided two 250 mL HDPE containers with verified PFAS-free water preserved with Trizma, to be used for field blank collection at each sample site, as well as a trip blank for each sampling event. Coolers dedicated to this study were kept at the DEPS laboratory and provided for each sampling event. All materials were loaded into the bed of the sampling truck, which has a bed cover for safety and security.

Sample Collection

The sampling team consisted of a regional Drinking Water Technical Assistance staff member and two dedicated personnel from the Department's central office. Previous experience indicated that a sampling team consisting of three members is optimum. This three-member team allows for two samplers to operate in the critical sampling zone – one collecting samples and the second assisting as needed – while the third staff member is outside of this zone taking notes and available to assist. Sample collection strictly adhered to the protocols defined in the Department's SOP for PFAS sampling (Appendix A). Chain of Custody (COC) forms (Appendix C), developed for this study were completed on site by the third team member as sample collection was completed. Any deviations from standard methods or concerns relative to sample collection were noted on the COC. Upon completion of sample collection, containers were placed into Ziploc® storage bags and placed in the dedicated cooler on loose, wet ice.

Sample Transport and Delivery

All samples collected for a single event were loaded into the sample vehicle and delivered directly to the DEPS laboratory with the accompanying COCs. Samples were not held in a vehicle or deposited in any other building overnight. When after-hours delivery was required, the DEPS laboratory was informed, and sampling personnel were granted necessary access to deliver samples.

Laboratory Methods

All samples collected for this study were analyzed by the DEPS laboratory using USEPA Method 537.1 Version 1.0 (USEPA, 2018b). The DEPS laboratory uses DES Method 5275 sample preparation of PFAS in drinking water by solid phase extraction. The 250 mL water sample is

fortified (spiked) with surrogates and passed through a solid phase extraction cartridge containing styrenedivinylbenzene resin to extract the method analytes and surrogates. The compounds are eluted with a small amount of methanol. The extract is then concentrated to dryness with nitrogen in a heated water bath and adjusted to a 1 mL volume with 96:4% (volume/volume) methanol-to-water ratio after adding internal standard(s). The DEPS laboratory method for analysis of PFAS is DES Method $6065 determination of PFAS in drinking water by LC/MS/MS. After the sample has been prepared, a 10 µL injection of the extract is made into a liquid chromatograph (LC) equipped with a Carbon-18 column that is interfaced to a triple quad mass spectrometer (MS/MS) detection system. The analytes are separated and identified by comparing the acquired mass spectra and retention time to reference values for calibration standards under identical LC/MS/MS conditions. The concentration of each analyte is determined by using the internal standard technique. Surrogate analytes were added to all extracted samples to monitor the extraction efficiency of the method analytes.

Analysis and Findings

This study examined the occurrence of per- and poly-fluoroalkyl substances (PFAS) in a representative sample of Kentucky's drinking water. Samples of finished water were collected and analyzed from 81 public drinking water WTPs, representing 74 public drinking water systems, over the course of four months. Sampling sites were chosen to represent surface water (43 WTPs) and groundwater (38 WTPs) supplies, urban (32 WTPs) and rural (49 WTPs) land-use influence, and varying sizes of populations served. Source waters for the WTPs sampled include each of Kentucky's major river basins, the main stem of the Ohio River as well as the major aquifers in the Commonwealth. Maps showing the results for selected analytes are presented below in figures 3 through 6, and maps for all analytes that were evaluated are located in Appendix E.

Quality Assurance and Quality Control

Initial sampling was conducted in the first two weeks of June, 2019, with four sites sampled in each of those weeks. Following the analysis and reporting of all eight samples, the collection team, laboratory analyst and Department management met to discuss the process logistics and the quality of resulting data. This was done to determine whether adjustments or corrections were necessary to achieve the project goals. Following a thorough review and discussion the determination was made that sample collection and analyses had been successful and no changes to the sample collection protocol or analysis method were necessary.

The analytical method protocol (EPA 537.1) requires a field blank sample for each site and one triplicate sample per sampling event (trip). The field blank is used to determine possible cross contamination during sampling activities. The field blank is collected at the sampling site by pouring PFAS-free water, preserved with 1.25 grams of Trizma, into a container provided by the

DEPS laboratory. Triplicate samples are used by the laboratory for internal quality control of the analytical process. Two sample containers of finished water were collected at each site along with a field blank sample. Two additional samples (triplicate) of finished water were collected at a single, randomly selected site on each sampling day. A single trip/temperature blank was taken on each sampling trip and analyzed with each batch of samples.

A total of 12 trip blank samples were utilized and analyzed in the course of this study. No PFAS were detected in any of these trip/temperature blank samples, indicating that cross contamination due to sample holding was not an issue.

Results for field blank samples that were collected at each site provided evidence of proper sample collection and handling. One field blank had a detection of PFAS, which was PFOA at 6.16 ng/L. However, the associated field sample results showed no PFAS detections. To insure all data were reliable this site was resampled. Analytical results of the follow up samples indicated that no PFAS were detected in the field sample and no contamination of the field blank occurred.

Triplicate samples were collected from one, randomly selected WTP on each day that monitoring occurred. This yielded a total of 13 samples that were collected and analyzed in triplicate as internal laboratory quality assurance measures. The results of these samples showed that the same analyte detections were identified in each set of triplicate samples, and that the resulting concentrations of detected analytes were nearly identical. An assessment of the quality of data obtained by the DEPS laboratory analyses is included in Appendix F along with a table of results for all quality assurance samples.

Statewide Analyses

On or more PFAS were detected at 41 of the 81 water treatment plants sampled and tested. The majority of detections of PFAS were at WTPs that utilize surface water as a source. One or more PFAS were detected at 31 of the 43 (72%) surface WTPs and 10 of the 38 (26%) groundwater WTPs sampled. The most frequently detected analyte was PFOS, which was found in 33 of 81 (41%) of samples analyzed. This was followed by PFOA, which was detected in 24 of 81 (30%) of samples analyzed. The highest concentration of any PFAS detected was HFPO-DA at 29.7 ng/L at the South Shore WTP (groundwater source). The least frequently detected analyte was ADONA, which was not detected in any samples. Table 7 provides a summary of the number of times each analyte was detected, along with maximum and median values, as well as method detection and reporting limits. (*N.B.* The median values for each analyte are the same as the individual method detection limits due to the large number of non-detections for each analyte.)

Table 7. Statewide PFAS Detections (ng/L)

Analyte	Detection Limit	Reporting Limit	Number of Detections	Median	Maximum
PFBS	1.32	3.96	10	< 1.32	8.55
PFHpA	1.08	3.24	9	< 1.08	5.02
PFHxS	1.08	3.24	7	< 1.08	11.00
PFNA	1.08	3.24	2	< 1.08	1.58
PFOS	1.08	3.24	33	< 1.08	18.09
PFOA	1.08	3.24	24	< 1.08	23.20
ADONA	1.08	3.24	0	< 1.08	< 1.08
HFPO-DA	1.32	3.96	11	< 1.32	29.70

Table 8 illustrates the detection rate of unique PFAS across the WTPs sampled. This table clarifies that no PFAS compounds were detected at nearly half of the WTPs sampled. Additionally, Table 8 illustrates that the majority of WTPs with one or more PFAS detections had only one or two analytes present.

Table 8. Number of unique PFAS detected per WTP

Number of PFAS detected	Number of sites
0	40
1	16
2	9
3	8
4	3
5	4
6	1

Figure 3 illustrates the number of unique PFAS detected at each of the WTPs. This map illustrates that the highest PFAS detection rates occurred in WTPs where the source waters are under urban influence, especially for the Ohio River.

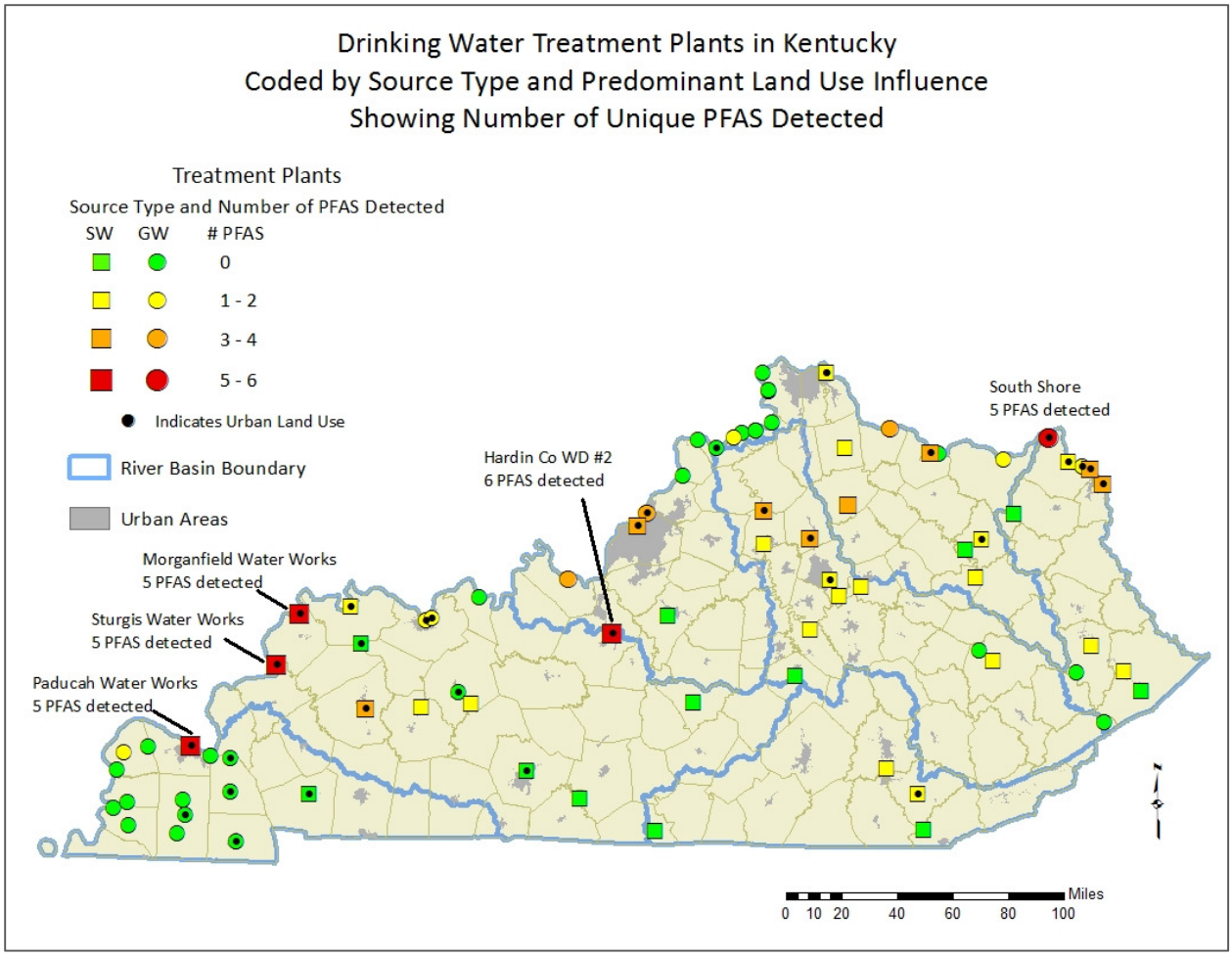


Figure 3. Number of unique PFAS detected at each WTP

A summary of statewide data is located in Table 9, which includes the number of PFAS results for varying value ranges. This table illustrates that the majority of sample results for each of the PFAS analyzed were below their respective analytical method detection limits.

This study included 81 WTPs, the finished water at each of which were analyzed for the same eight PFAS compounds. This sampling yielded a total of 648 individual analyte analyses. There were 96 PFAS compound detections, which equates to a 15% sample detection rate. Of the 96 analyte detection, 79 of the detections were less than 5 ng/L, and 17 (3%) of PFAS sample detections were greater than 5 ng/L.

Table 9. Number of sample results in each value range

Analyte	Number of sample results in each value range			
	Not Detected	DL - 5 ng/L	5 -10 ng/L	10 -30 ng/L
PFBS	71 (88%)	9	1	0
PFHpA	72 (89%)	8	1	0
PFHxS	74 (91%)	6	0	1
PFNA	79 (98%)	2	0	0
PFOS	48 (59%)	30	2	1
PFOA	57 (70%)	20	3	1
ADONA	81 (100%)	0	0	0
HFPO-DA	70 (86%)	4	2	5

(Note: DL = Detection Limit)

Comparison of Surface Water and Groundwater WTP Results

The sample population of WTPs was split almost evenly between surface water (43) and groundwater (38) sources. Surface water sources included WTPs in each of Kentucky's major river basins and on the main stem of the Ohio River. Sample sites also included WTPs using groundwater sources that represent each of Kentucky's major aquifers. Detection rates of one or more PFAS were highest at surface water WTPs, where 73 analyte detections (21% of samples) occurred at 31 of the 43 (72%) WTPs sampled. In contrast, groundwater WTPs had only 23 analyte detections (8% of samples) at 10 of the 38 (26%) of WTPs sampled. Table 10 is a summary of PFAS detections comparing surface water and groundwater WTPs.

Table 10. Comparison of Surface Water and Groundwater WTP results (ng/L)

Analyte	Surface Water WTPs (43)			Groundwater WTPs (38)		
	# Detections	Median	Maximum	# Detections	Median	Maximum
PFBS	6	< 1.32	2.73	4	< 1.32	8.55
PFHpA	8	< 1.08	1.49	1	< 1.08	5.02
PFHxS	3	< 1.08	2.20	4	< 1.08	11.00
PFNA	2	< 1.08	1.58	0	< 1.08	< 1.08
PFOS	27	1.19	8.35	6	< 1.08	18.90
PFOA	17	< 1.08	5.62	7	< 1.08	23.20
ADONA	0	< 1.08	< 1.08	0	< 1.08	< 1.08
HFPO-DA	10	< 1.32	29.70	1	< 1.32	4.42

The table above illustrates that PFOS and PFOA were the most commonly detected analytes at both surface water and groundwater WTPs. PFOS was detected at 27 surface water WTPs and only six groundwater WTPs. The highest PFOS concentration detected was at a WTP in Greenup County using groundwater from the Ohio River alluvial aquifer. PFOA was detected at 17 WTPs

using surface water and only 7 WTPs using groundwater. Similar to PFOS, the highest PFOA concentration was found was found at a WTP in Greenup County using groundwater from the Ohio River alluvial aquifer. The maps in figures 4 and 5 show the results for PFOS and PFOA, respectively, and are color coded to indicate the analyte concentrations found at each site. The WTP with the highest concentration of each analyte is identified on both maps.

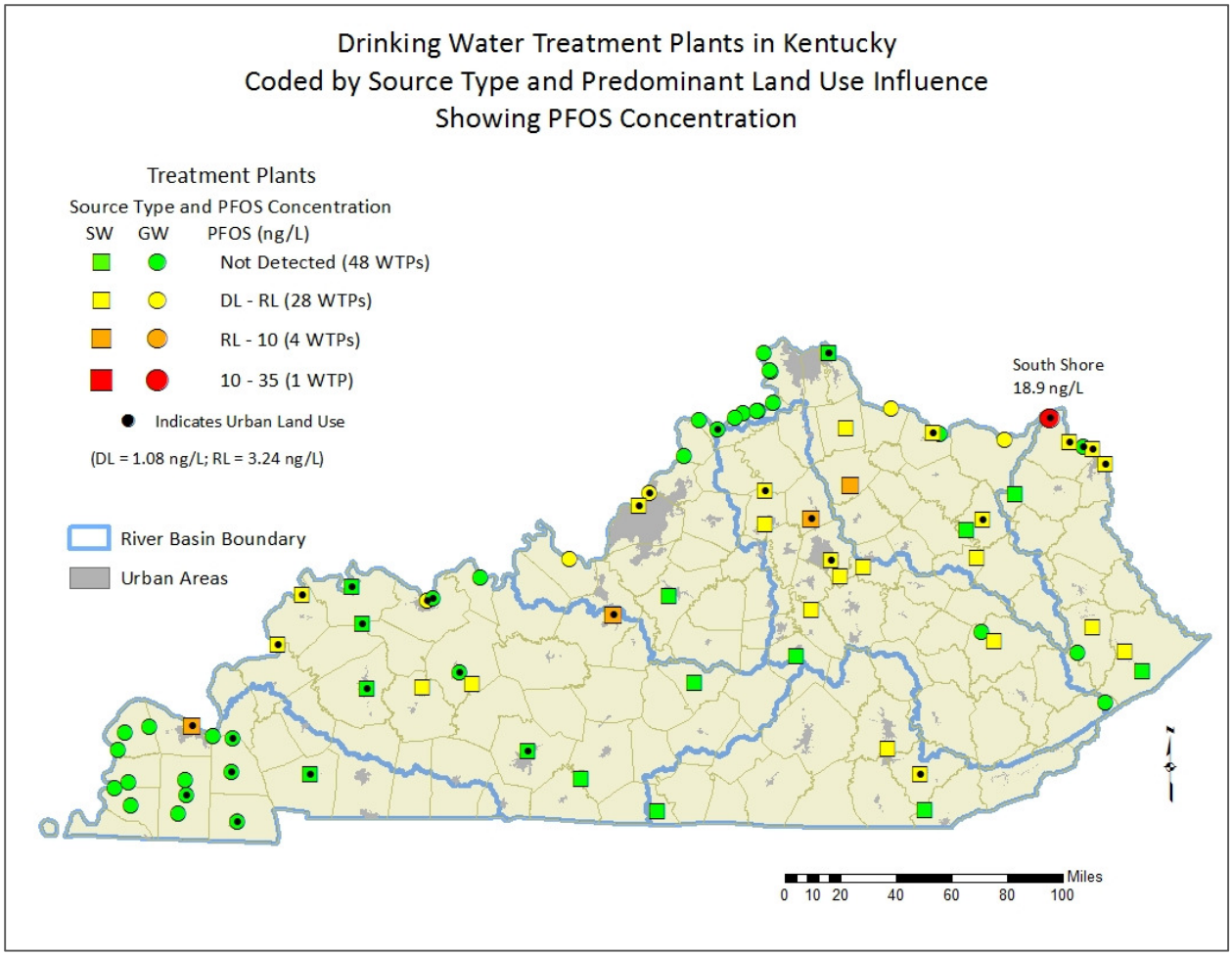


Figure 4. PFOS results

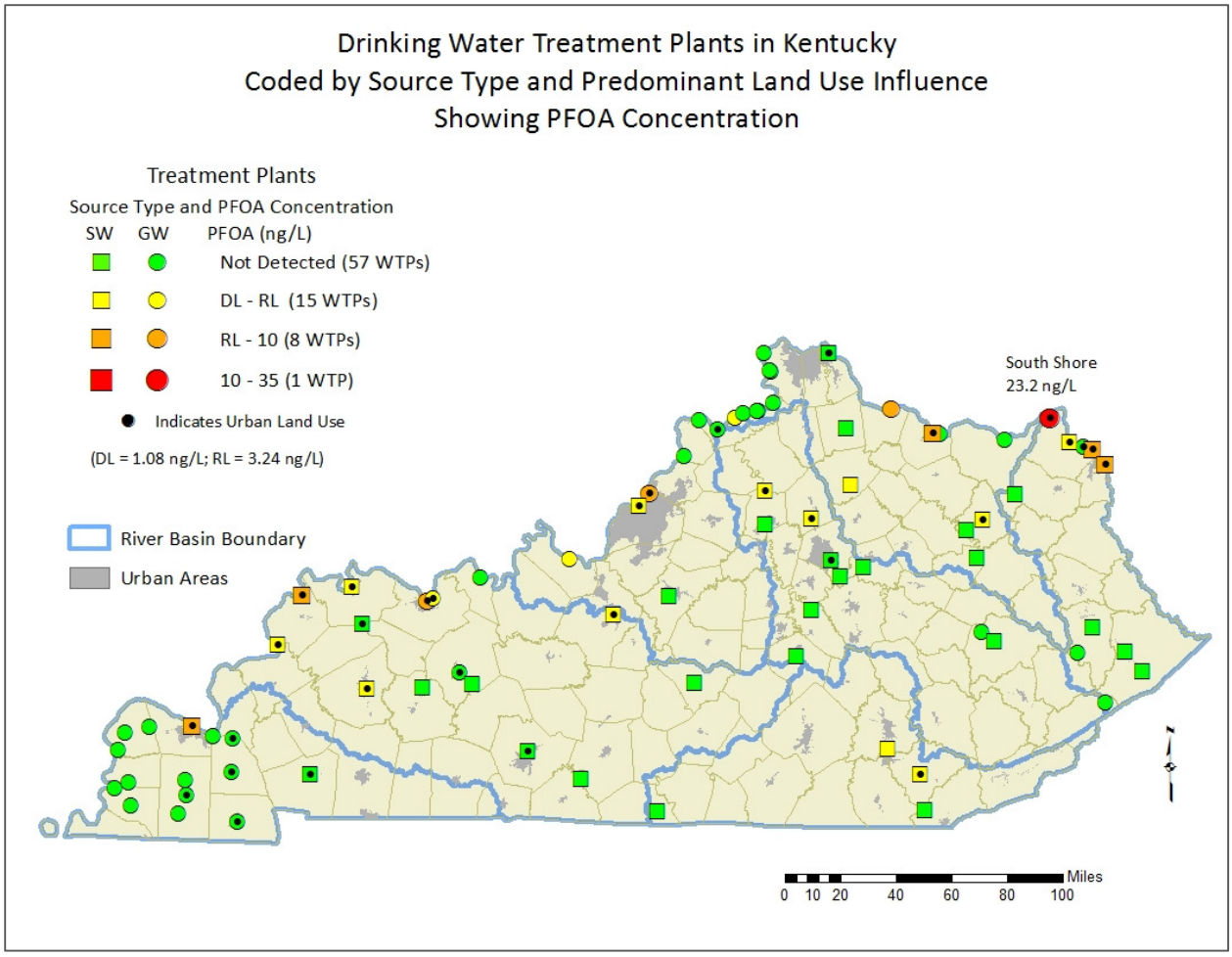


Figure 5. PFOA Results

The analyte with the highest concentration detected was HFPO-DA, which is also called GenX. This analyte was also the third most frequently detected in this study with 10 detections at WTPs using surface water and one detection at a WTP using groundwater. All of the detections of this analyte occurred at WTPs using the Ohio River and Ohio River Alluvium as sources. The map in Figure 6 illustrates these results and identifies the WTPs with the highest concentrations.

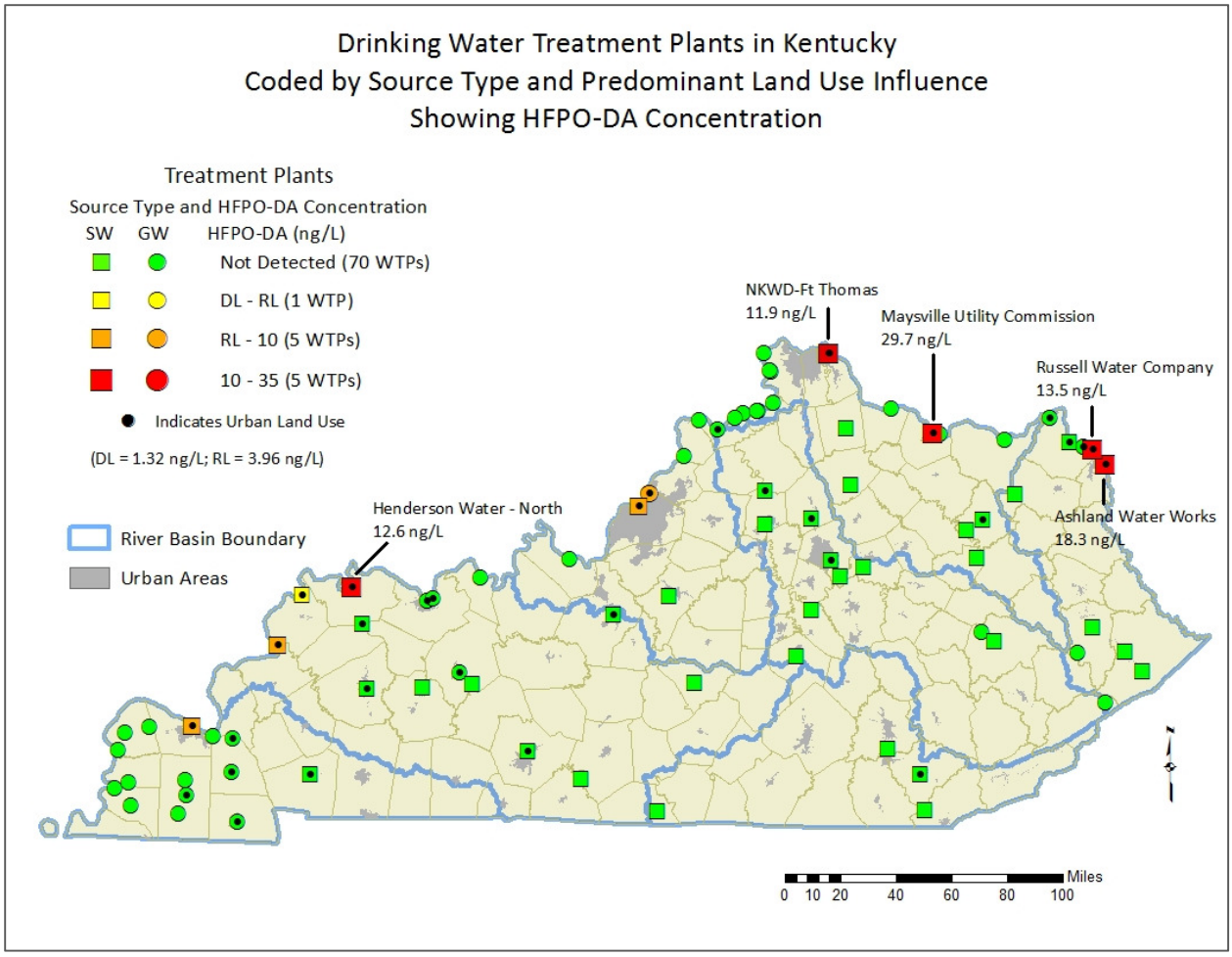


Figure 6. HFPO-DA results

WTPs using surface water included sites in the Big Sandy, Cumberland, Green, Kentucky, Licking and Salt River basins, as well as the main stem of the Ohio River. The number of analytes detected and overall concentrations vary considerably between WTPs in the various river basins. However, the most frequent detections and highest concentrations were found in WTPs that use the Ohio River as a source. Results for WTPs in each river basin are summarized below and presented on tables 11 and 12.

The WTPs drawing from the Ohio River had 32 detections of five different PFAS, and PFAS was detected at all 10 WTPs sampled. HFPO-DA was the most frequently detected analyte at the Ohio River WTPs. The Ohio River WTPs were also where the highest concentrations of HFPO-DA were detected. The next most frequently detected analytes at the Ohio River WTPs were PFOA and PFOS, respectively.

The WTPs drawing from the Kentucky River had 12 detections of 4 different PFAS that were detected at 8 out of 9 sites. PFOS was the most frequently detected analyte at the Kentucky River WTPs. PFOS also had the highest concentrations of PFAS at the Kentucky River WTPs.

Four out of the eight WTPs in the Green River Basin had 11 detections of 6 different PFAS. PFOS was the most frequently detected analyte.

The Licking River Basin results indicated 8 detections of four different PFAS at four out of five WTPs. PFOS was also the most frequently detected analyte at Licking River WTPs. The highest detection of PFOS at a WTP using surface water occurred in the Licking River Basin.

Table 11. PFAS summary for Ohio, Kentucky, Green and Licking River WTPs (ng/L)

	Ohio (10)		Kentucky (9)		Green (8)		Licking (5)	
Analyte	Detections	Max	Detections	Max	Detections	Max	Detections	Max
PFBS	3	2.73	1	2.50	1	2.16	0	ND
PFHpA	4	1.49	0	ND	2	1.44	1	1.00
PFHxS	0	ND	1	1.74	1	1.96	1	2.20
PFNA	0	ND	0	ND	2	1.58	0	ND
PFOS	7	4.54	8	5.46	3	4.00	4	8.35
PFOA	8	5.62	2	1.38	2	1.83	2	1.21
ADONA	0	ND	0	ND	0	ND	0	ND
HFPO-DA	10	29.70	0	ND	0	ND	0	ND

(Note: ND = Not Detected)

PFAS detection frequency and concentrations were much lower at WTPs in the Big Sandy and Cumberland River basins. Detections were noted at three WTPs in the Big Sandy River and two WTPs in the Cumberland River. PFOS and PFOA were the most frequently detected analytes. Only one WTP was sampled in the Salt River Basin and no PFAS were detected.

Table 12. PFAS summary for Big Sandy, Cumberland and Salt River WTPs (ng/L)

	Big Sandy (5)		Cumberland (5)		Salt (1)	
Analyte	Detections	Max	Detections	Max	Detections	Max
PFBS	0	ND	0	ND	0	ND
PFHpA	1	0.99	0	ND	0	ND
PFHxS	0	ND	0	ND	0	ND
PFNA	0	ND	0	ND	0	ND
PFOS	3	1.58	2	1.19	0	ND
PFOA	1	1.28	2	1.52	0	ND
ADONA	0	ND	0	ND	0	ND
HFPO-DA	0	ND	0	ND	0	ND

(Note: ND = Not Detected)

Sources for the WTPs using groundwater that were sampled include the Ohio River Alluvium, aquifers of the Mississippi Embayment, Pennsylvanian Sandstone aquifers and the Tennessee River alluvial aquifer. The aquifers of the Mississippi Embayment are stratified and occur at varying depths. However, for the purpose of this analysis they have been generalized into a single, regional aquifer setting. Similarly, aquifers in the Pennsylvanian Sandstone of the Eastern and Western Coal Fields occur at varying depths, but are uniform enough to generalize their characteristics for this analysis. Only one WTP sampled uses the Tennessee River alluvial aquifer as a source, but it is far enough removed from the Ohio River alluvial aquifer to have significantly different characteristics and should be considered separately.

The most frequent and highest detections of PFAS were located in WTPs using the Ohio River alluvial aquifer. There were 22 detections of six different PFAS at nine out of 22 WTPs that draw water from this aquifer. Additionally, the highest concentrations of PFOA and PFOS (23.2 ng/L and 18.9 ng/L, respectively) occurred at a WTP using the Ohio River alluvial aquifer. Furthermore, the highest concentrations of PFBS, PFHpA and PFHxS occurred at a WTP using this aquifer. All five of these analytes were detected at the same WTP in Greenup County. Only one PFAS detection occurred at a single WTP in the Mississippi Embayment, which was PFHxS at a very low level. There were no PFAS detections at WTPs using the Pennsylvanian Sandstone aquifers or the Tennessee River alluvial aquifer. These results are summarized in Table 13.

Table 13. PFAS Summary for Groundwater WTPs (ng/L)

	OH R. Alluvium (22)		MS Embayment (11)		Penn. Sandstone (4)		TN R. Alluvium (1)	
Analyte	Detections	Max	Detections	Max	Detections	Max	Detections	Max
PFBS	4	8.55	0	ND	0	ND	0	ND
PFHpA	1	5.02	0	ND	0	ND	0	ND
PFHxS	3	11.00	1	1.62	0	ND	0	ND
PFNA	0	ND	0	ND	0	ND	0	ND
PFOS	6	18.90	0	ND	0	ND	0	ND
PFOA	7	23.20	0	ND	0	ND	0	ND
ADONA	0	ND	0	ND	0	ND	0	ND
HFPO-DA	1	4.42	0	ND	0	ND	0	ND

(Note: ND = Not Detected)

Comparison of Urban and Rural WTP Results

The predominant land-use influence on each WTP sampled was determined by comparing the intake or wellfield location to aerial imagery and Department databases using GIS. It was determined that 32 of the WTPs had sources that are predominantly influenced by urban land use: 21 WTPs using surface water; and 11 WTPs using groundwater. The remaining 49 WTPs were determined to use sources that are predominantly influenced by rural land use: 22 WTPs using surface water; and 27 WTPs using groundwater.

Table 14 summarizes the PFAS detected for each land-use category. The WTPs whose sources are influenced by urban land use had 67 detections of 7 different PFAS at 23 WTP sites, which equates to detections of at least one PFAS at 72% of urban WTPs. The WTPs whose sources are influenced by rural land use had only 29 detections of 5 different PFAS at 18 WTP sites, which equates to detections of at least one PFAS at 37% of WTPs. In addition, the maximum concentrations of the PFAS detected occurred at urban WTPs.

Table 14. PFAS Summary for Urban and Rural WTPs (ng/L)

	Urban (32)			Rural (49)		
Analyte	Detections	Median	Maximum	Detections	Median	Maximum
PFBS	8	< 1.32	8.55	2	< 1.32	1.88
PFHpA	7	< 1.08	5.02	2	< 1.08	1.00
PFHxS	4	< 1.08	11.00	3	< 1.08	2.49
PFNA	2	< 1.08	1.58	0	< 1.08	< 1.08
PFOS	17	1.11	18.90	16	< 1.08	8.35
PFOA	18	1.3	23.20	6	< 1.08	4.43
ADONA	0	< 1.08	< 1.08	0	< 1.08	< 1.08
HFPO-DA	11	< 1.32	29.70	0	< 1.32	< 1.32

Discussion and Conclusions

This study represents an examination of the occurrence of PFAS in Kentucky's drinking water. The 81 WTPs sampled account for 40% of the drinking water facilities in the state and provide treated public drinking water to approximately 2.27 million people, which is more than half of the population (~4.27 million people) served by community water systems.

PFAS were detected at 41 of the 81 water treatment plants, the majority of which represent surface water sources. All detections of PFAS were below the EPA Health Advisory of 70 ng/L. One or more PFAS were detected at 31 surface WTPs (72%) and 10 groundwater WTPs (26%). Drinking water systems that utilize surface water from the Ohio River manifested the highest sample detection rate, which was 32 overall analyte detections at each of the 10 WTPs sampled. WTPs using surface water in the Kentucky River Basin had the second highest detection rate for PFAS, which included 12 analyte detections at eight of 9 (89%) WTPs sampled. Surface water systems in the Big Sandy, Cumberland, Green, Licking and Salt river basins had very few or no analyte detections. Drinking water systems using groundwater from the Ohio River alluvial aquifer as their source had the highest detection rate for systems using groundwater. There were 22 PFAS detections which occurred at nine of 22 (41%) of WTPs sampled that rely on the Ohio River alluvial aquifer. Drinking water systems utilizing the Mississippi Embayment aquifers had a single PFAS detection at one of 11 (9%) of WTPs sampled. No PFAS were detected in groundwater systems using Pennsylvanian Sandstone or the Tennessee River alluvial aquifers.

The most frequently detected analyte was PFOS, which was identified in 33 of 81 (41%) samples. This was followed by PFOA, which was detected in 24 of 81 (30%) samples. The highest concentration of any PFAS detected was HFPO-DA at 29.7 ng/L. ADONA was not detected in any samples.

This study included 81 WTPs that were each analyzed for the same 8 PFAS, which yields a total of 648 analyses. There were 96 detections of PFAS, which equates to a 15% sample detection rate. Furthermore, 79 of the PFAS detections that occurred were less than 5 ng/L. Therefore, only 17 of the PFAS detections (3%) were greater than 5 ng/L. Of the 81 WTPs sampled, the approximate population directly served is 2.27 million people. The 40 WTPs in this study that had no detections of PFAS directly serve a population of approximately 308,540 (~14% of sampled population) people. The 41 WTPs that had detections of one or more PFAS directly serve a population of approximately 1.9 million (86% of sampled population) people..

PFAS detection rates were highest in surface water WTPs, where 73 analyte detections (21% of samples) occurred at 31 WTPs (72%). In contrast, groundwater WTPs had only 23 analyte detections (8% of samples) at 10 WTPs (26%).

Of the drinking water systems whose sources were determined to be under urban land use influence, one or more PFAS analytes were detected at 23 of those 32 (72%) WTPs, which included 67 PFAS detections in 256 samples (26%). Eighteen of the 49 (37%) drinking water

systems that utilize sources under rural land-use influence had detections of one or more PFAS analytes, which included 29 of 392 (7%) analytes detected in samples collected. These results provide evidence that urban land use is more likely to contribute PFAS to water sources.

It is noteworthy to evaluate the results of this study in the context of the U.S. EPA's HA for PFOA and PFAS. On May 19, 2016, the USEPA issued drinking water lifetime health advisories (HA) for two PFAS compounds, PFOA and PFOS. The HA level is 70 ng/L for PFOA, and 70 ng/L for PFOS. EPA further recommends that when these two chemicals co-occur at the same time and location in a drinking water source, a conservative and health-protective approach would be to compare the sum of the concentrations ([PFOA] + [PFOS]) to the HA (70 ng/L). Lifetime health advisories are not drinking water standards (MCLs or Treatment Technology) but may be used for developing local standards. In addition, the HA is being utilized as a screening level of public and private drinking water. USEPA is also proposing to use the HA as a remediation goal for PFAS-contaminated groundwater being used for consumptive purposes. The USEPA has not established health advisories for the other PFAS at this time. Nevertheless, the EPA Health Advisory of 70 ng/L, was used as a screening level for all of the analytes used in this study.

In this study, 37 of the 81 WTPs sampled had detections of PFOS and/or PFOA. None of these analyte detections of PFOA and PFOS exceeded the HA. It is noteworthy that 96% of the population directly served by the 81 WTPs sampled in this study had no detections of PFOA and/or PFOS, or had PFOA + PFOS results that were less than 7 ng/L. The 7 ng/L is significant because it is an order of magnitude lower than the HA, therefore providing an order of magnitude greater protection.

The population directly served by the 37 WTPs that had detections of PFOS and/or PFOA is approximately 1.7 million people, which is 76% of the population directly served by the 81 WTPs sampled (~2.27 million people). Five of the 81 WTPs sampled, directly serving a population of ~85,300 (or 4% of the study population served) had PFOA and/or PFOS detections [PFAO + PFOS] that exceeded 7 ng/L. In comparison, 32 of the 81 WTPs sampled, serving a population of ~1.6 million (72% of sampled population) had PFOA and/or PFOS detections [PFAO + PFOS] that were less than 7 ng/L. Furthermore, the 44 WTPs that had no detection for PFOA and PFOS directly serve approximately 554,140 (24% of sampled population) people. Therefore, 96% of the population directly served (2.18 million people) by the WTPs sampled in this study had no detections of PFOA + PFOS or had detections of PFOA + PFOS that were an order of order of magnitude below the HA.

Although PFAS were detected in finished drinking water, the occurrences of PFAS in drinking water were generally infrequent and at concentrations well below the EPA Health Advisory of 70 ng/L. Based on the results of this study, and when compared to the federal Environmental Protection Agency (USEPA) health advisory of 70 ng/L, the Department has determined that there are no evident PFAS health concerns in the Commonwealth's public drinking water supply.

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APPENDIX A

Sampling Procedures for Per- and Poly-Fluorinated Alkyl Substances

Standard Operating Procedure

Sampling Procedures for Per- & Poly-Fluorinated Alkyl Substances

Department for Environmental Protection
Prepared By: Division of Water and Division of Waste Management

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Revision History

Date of Revision	Page(s) Revised	Revision Explanation	Comments
May 22, 2019	Entire document	Technical corrections and clarifications	

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PURPOSE

This Standard Operating Procedure (SOP) provides guidance for collecting samples for per- and poly-fluorinated alkyl substances (PFAS) analysis. PFAS are unregulated emerging contaminants and the regulatory status of PFAS is still being evaluated and researched. These procedures will be updated as more is known about PFAS.

Special care should be taken in handling and sampling for PFAS because PFAS are commonly found in many consumer products and in equipment typically used in collecting environmental samples. The analytical methods for laboratory analysis of PFAS have very low detection limits.

This SOP outlines general practices for collecting PFAS samples and provides a summary of field and sampling materials that are likely to contain PFAS and acceptable alternatives. Any modifications to this SOP shall be approved in advance by the Kentucky Department for Environmental Protection (KDEP) Project Manager (DWM and\or DOW), documented in the field logbook and presented in the final sampling report.

BACKGROUND

Based on U.S. Environmental Protection Agency (USEPA) guidance[1], "per- and polyfluoroalkyl substances (PFAS)" is the preferred term to refer to this class of chemicals, although the general public and others may also refer to them as "perfluorinated chemicals (PFCs)" or "perfluorinated compounds (PFCs)."

PFAS are a family of man-made compounds that do not naturally occur in the environment. They have a large number of industrial uses and are found in many commercial products because of their properties to resist heat, oil, grease and water. Once released to the environment, PFAS are persistent and do not readily biodegrade or break down. Several states within the United States are dealing with sites where there have been widespread PFAS impacts to drinking water supplies.

The USEPA issued drinking water lifetime health advisories for two PFAS compounds, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate on May 19, 2016: 70 parts per trillion (ppt) for PFOA, 70 ppt for perfluorooctane sulfonic acid (PFOS) and 70 ppt for PFOA and PFOS combined. Lifetime Health Advisories are not drinking water standards (MCLs or Treatment Technology) but are being used for screening of drinking water, groundwater and source water used by Public Water Systems. The USEPA has not established Health Advisories for the other PFAS at this time. Additionally, the USEPA

[1] https://www.epa.gov/pfas/what-are-pfcs-and-how-do-they-relate-and-polyfluoroalkyl-substances-pfass

developed Method 537 to analyze for PFAS in the UCMR3 program but has not promulgated an analytical method for use in regulation of drinking water as of the date of this SOP.

RESOURCES

Frequently Asked Questions, fact sheets and additional information concerning PFAS can be found on the EPA website[2]. The Interstate Technology & Regulatory Council (ITRC)[3] is also in the process of preparing educational materials, which will also be available online when completed. ITRC is also conducting a series of training events on PFAS during 2019.

GENERAL GUIDANCE

Personal Protective Equipment

Disposable nitrile gloves must be worn at all times while sampling. Hands should be washed prior to donning gloves and initiating sample collection activities. A new pair of nitrile gloves should be donned prior to the following activities at each sample location:

1. Decontamination of re-usable sampling equipment.
2. Contact with sample bottles or water containers.
3. Insertion of anything into a well (e.g., tubing, pump, bailer, water level meter).
4. Insertion of silicon tubing into the peristaltic pump.
5. Sample collection upon completion of monitoring well purging.
6. Handling of any quality control samples including field blanks and equipment blanks.

New gloves shall also be donned after the handling of any non-dedicated sampling equipment, contact with surfaces that have not been decontaminated, or when judged necessary by field personnel.

The use of a different colored glove (e.g., bright orange) for the collection of PFAS samples can serve as a visual reminder to prevent potential cross-contamination if sampling for other contaminants or parameters during the same event.

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[2] https://www.epa.gov/pfas

[3] http://www.itrcweb.org

Sample Collection Method/Sequence

1. Review requirements for sample bottles, preservation, storage, and handling techniques for PFAS samples shown in Table 4 and from the analytical laboratory.
2. After donning a new pair of nitrile gloves, the sample for PFAS should be collected ***first***, prior to collecting samples for any other parameters into any other containers; this avoids contact with any other type of sample container, bottles or packaging materials that may have PFAS-related content. Separate coolers should be utilized for PFAS and other samples to prevent cross-contamination during the sample collection event. This may include either dedicated PFAS only coolers or coolers properly decontaminated prior to sampling for PFAS.
3. Do not place the sample bottle cap on any surface when collecting the sample and avoid all contact with the inside of the sample bottle or its cap.
4. Once the sample is collected, capped and labeled, place the sample bottle(s) in an individual re-sealable plastic bag and place in an appropriate cooler packed only with loose "wet" ice (preferably from a verified PFAS-free source). Double-bagged ice in new, re-sealable plastic bags may be used to prevent leaking if necessary, but loose ice is preferable. Do not use a plastic garbage bag to line the cooler for that purpose unless the garbage bags have been verified PFAS-free. Blue ice or ice packs are prohibited.
5. Collect duplicate samples using the same sample collection techniques following quality control requirements.
6. The laboratory will provide a bottle with reagent water and preservatives and an empty labeled bottle for the field blank. Collect a field blank using laboratory–provided reagent water with preservative while in the field by opening the provided reagent and pouring into the appropriate PFAS sample container.

Samples Collected From Public Water System (PWS)

1. Contact the PWS to sample their system.
2. Collect a source water sample and a finished water sample for analysis.
3. The source water sample must be collected from a point in the treatment works prior to any type of water treatment system, preferably from the sampling tap in the treatment works. Remove any screens or tubing. Water should be flushed for several (3-5) minutes if tap is not continuously flowing.
4. As described above in the **Sample Collection Method/Sequence** section, don a new pair of nitrile gloves and collect PFAS samples ***first***, prior to collecting samples for any other parameters. The PFAS sample must be collected directly from the sampling port. Some systems may use a pre-oxidant (potassium or sodium permanganate) prior to the sampling port. Inquire whether chemical addition occurs prior to the sampling port and whether there is a sampling tap prior to the

chemical addition or request that the feed be turned off long enough to clear the raw water line.

5. Do not place the sample bottle cap on any surface when collecting the sample and avoid all contact with the inside of the sample bottle or its cap.
6. Once the sample is collected, capped, and labeled, place the sample in an individual re-sealable plastic bag and then into loose "wet" ice (preferably from a verified PFAS-free source) within the cooler. Blue ice or ice packs are prohibited.
7. Repeat procedures for finished water sample.
8. Collect duplicate samples using the same sample collection techniques following quality control requirements.
9. The laboratory will provide a bottle with reagent water and preservatives and an empty labeled bottle for the field blank. Collect a field blank using laboratory–provided reagent water with preservative while in the field by opening the provided reagent and pouring into the appropriate PFAS sample container.

Samples Collected From Drinking Water Supply Wells

1. Contact the owner to get permission to sample their drinking water supply well.
2. Document available well data including: the well depth, type of well (e.g., deep bedrock or shallow dug well) and type of treatment system, if any (e.g., cartridge filter, water softener, pH adjuster, point of entry, radon, granular activated carbon or an ultraviolet system).
3. The sample must be collected from a point in the plumbing system that is prior to any type of water treatment system, preferably from the closest spigot to the holding tank in the plumbing system, or the treatment system must be bypassed. For convenience and to prevent unnecessary loading of the septic system, an outside spigot is preferable to an inside faucet.
4. The water (cold water) should be purged by flushing the spigot at a high rate of flow for several minutes.
5. Once the well has been purged, reduce the rate of flow to a very slow rate.
6. As described above in the **Sample Collection Method/Sequence** section, don a new pair of nitrile gloves and collect PFAS samples ***first***, prior to collecting samples for any other parameters. The PFAS sample must be collected directly from the spigot or sampling port.
7. Do not place the sample bottle cap on any surface when collecting the sample and avoid all contact with the inside of the sample bottle or its cap.
8. Once the sample is collected, capped, and labeled, place the sample in an individual re-sealable plastic bag and then into loose ice (preferably from a verified PFAS-free source) within the cooler.

9. Collect remaining samples as required.

Samples Collected From Monitoring Wells

1. If collecting field parameters using a multiparameter meter, collect samples for laboratory analysis before the flow-through cell and the three-way stopcock. This may be done by disconnecting the three-way stopcock from the pump discharge tubing so that the samples are collected directly from the pump tubing.
2. It is preferred to use dedicated, single-use or disposable polyethylene or silicone materials (tubing, bailers, etc.) for monitoring well purging and sampling equipment.
3. When it is necessary to reuse materials or sampling equipment across multiple sampling locations, follow project decontamination protocols with allowable materials identified in Table 4 and incorporate collection of equipment rinsate blanks into the sampling program, as appropriate.
4. When using positive displacement/submersible pump or bladder pump sampling equipment, familiarize yourself with the sampling pump/accessory equipment specifications to confirm that device components are not made of nor contain polytetrafluoroethylene (PTFE, a.k.a. Teflon®) or other PFAS-containing components identified in Table 4.
5. Collect duplicate samples using the same sample collection techniques following quality control requirements.
6. The laboratory will provide a bottle with reagent water and preservatives and an empty labeled bottle for the field blank. Collect a field blank using laboratory–provided reagent water with preservative while in the field by opening the provided reagent and pouring into the appropriate PFAS sample container.

Samples Collected During Production Well Pumping Tests

1. If feasible, do not use tape or pipe thread sealant containing Teflon on pipe fittings or sampling tap threads on the pump discharge pipe.
2. As with all other sample parameters, the sample for PFAS will be collected at the last hour (or hours) of the pumping portion of the testing program, but before the collection of other sample parameters.
3. Discharge water will be purged through the sampling tap on the discharge pipe for several minutes prior to collection of samples.
4. Collect duplicate samples using the same sample collection techniques following quality control requirements.
5. The laboratory will provide a bottle with reagent water and preservatives and an empty labeled bottle for the field blank. Collect a field blank using laboratory–

provided reagent water with preservative while in the field by opening the provided reagent and pouring into the appropriate PFAS sample container.

Samples Collected From Active Production Wells

1. If feasible, avoid contact with any tape or pipe thread paste containing Teflon on pipe fittings or sampling tap threads that may be present on the water supply discharge pipe.
2. The sample for PFAS will be collected while the production well pump is operating, and, preferably, has been operating for at least one hour.
3. Discharge water will be purged through the sampling tap on the discharge pipe for several minutes prior to collection of samples.
4. Collect duplicate samples using the same sample collection techniques following quality control requirements.
5. The laboratory will provide a bottle with reagent water and preservatives and an empty labeled bottle for the field blank. Collect a field blank using laboratory–provided reagent water with preservative while in the field by opening the provided reagent and pouring into the appropriate PFAS sample container.

Decontamination

Decontamination fluids are a potential source of cross-contamination of equipment. Equipment that requires reuse shall be decontaminated prior to reuse. Decontamination fluids should be collected for disposal. A final rinse with laboratory-provided, PFAS-free deionized (DI) water is required. One rinse sample shall be collected for an equipment blank per sampling event. Frequent changes of decontamination fluids is advisable. Refer to Table 4 for allowable and prohibited decontamination fluids.

SITE-SPECIFIC SOPs AND SAMPLING AND ANALYSIS PLANS

Site-specific SOPs or site-specific Sampling and Analysis Plans (SAP) or its equivalent (e.g, Project Management Plan (PMP) may be developed to supplement this general SOP. The site-specific SOPs and SAPs shall be developed to provide additional detail for the sampling process. The site-specific SAP will provide the following information:

- Sample collection objectives;
- Locations to be sampled;
- Type and number of sample containers.
- Number and volume of samples to be collected at each location;
- Types of chemical analyses to be conducted for the samples;

- Method of preservation;
- Method of transport and shipping (dedicated PFAS-free cooler or properly cleaned cooler);
- Sample holding times;
- Specific quality control procedures and sampling required to include frequency;
- Personnel responsibilities;
- Site-specific Health and Safety Plan; and
- Any additional sampling requirements or procedures beyond those covered in this SOP, as necessary.

All field personnel shall consult with the Project Manager or Field Lead before deviating from approved procedures, and any modifications to this SOP shall be approved in advance by the Project Manager. All deviations must be documented in the field log book and presented in the final sampling report.

Sample Collection Objectives, Locations, and Number of Samples

The scope of the investigation of a site-specific sampling and analysis plan shall evaluate whether the site history includes, or has the potential to include, industrial processes that manufactured, processed, or used PFAS or PTFE, solid waste management (e.g., landfilling), fire training and/or response with storage or use of Class B Foam (e.g., aqueous film-forming foam [AFFF]), wastewater management (e.g., on-site septic or disposal, treatment facilities, sludge and/or biosolids management). It is appropriate to consider the wide-ranging use of PFAS in commercial and industrial applications, as summarized, but not limited to, the uses shown in Table 1 below.

Table 1. Commercial and Industrial Uses of PFAS	
Commercial Products	**Industrial Uses**
Cookware (nonstick, Analon®, Teflon®)	Photo Imaging
Fast Food Containers and Bags	Metal Plating
Candy Wrappers	Semiconductor Coatings
Microwave Popcorn Bags	Hydraulic Fluids
Personal Care Products (Shampoos, Lotion)	Medical Devices (Including Implants)
Cosmetics (Nail Polish, Eye Makeup)	Class B Firefighting Foams (AFFF)
Paints and Varnishes	Insect Bait
Stain-Resistant Carpet	Printers and Copiers
Stain-Resistant Applications (Scotchgard®)	Oil Additives
Water-Resistant Clothing	Automobile Parts and Lubricants
Cleaning Products	Oil Production Fluids
Electronics and Circuit Boards	Textiles and Carpet Manufacture
Ski Wax	Paper and Packaging
Sunblock	Rubber and Plastics

The site-specific Sampling and Analysis Plan and Work Plan should describe sample locations, media (e.g., soil, groundwater, drinking water, surface water), and number of samples that are selected based on previous and current uses of the site, site hydrogeology, proximity to sensitive receptors, and other known releases. Samples collected from Public Water Systems, water supply wells, and private wells must be collected from a point in the system that is prior to treatment.

Additional phases of sampling and characterization may be required following review of the PFAS sampling and analysis results. Data results should be evaluated for usability based on the concentrations, types, and distribution of PFAS, the site remedial status, and the proximity to sensitive receptors.

Chemical Analyses

Field personnel shall coordinate sampling events with the laboratory prior to scheduling sampling activities. Provide number of samples and dates of the sampling event.

Chemical analysis shall use the Kentucky Department for Environmental Protection Division of Environmental Program Support laboratory or laboratories that are certified or accredited for PFAS analysis with methods and equipment for analysis of PFAS. Accreditation may obtained under NELAP or DoD QSM 5.1. The USEPA has not established certification for PFAS in drinking water as of the date of this SOP.

Note: The laboratory used for analysis of other site samples does not need to be the same as the laboratory that analyzes the PFAS samples.

Analysis by a method that uses isotope dilution techniques is required, unless otherwise specified in the site-specific Sampling and Analysis Plan. Both linear and branched isomers shall be reported, consistent with USEPA's September 2016 Technical Advisory: https://www.epa.gov/sites/production/files/2016-09/documents/pfoa-technical-advisory.pdf

As of the date of this document, there is no USEPA promulgated isotope dilution method for PFAS analysis. Therefore, individual laboratories have developed their own methods using the USEPA Method 537 as a basis. USEPA is developing a standardized method for analysis of samples from groundwater and other media.

At a minimum, samples shall be submitted for analysis of the following compounds, unless otherwise specified in the site-specific SAP or work plan. This list of compounds

represents those 14 compounds in EPA Method 537[4] that are included in the analyte lists available from most laboratories.

Table 2. Method 537 Rev 1.1 Analytes	
Compound Name	**CAS #**
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	-
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	-
Perfluorobutanesulfonic acid (PFBS)	375-73-5
Perfluorodecanoic acid (PFDA)	335-76-2
Perfluorododecanoic acid (PFDoA)	307-55-1
Perfluoroheptanoic acid (PFHpA)	375-85-9
Perfluorohexanesulfonic acid (PFHxS)	355-46-4
Perfluorohexanoic acid (PFHxA)	307-24-4
Perfluorononanoic acid (PFNA)	375-95-1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1
Perfluorooctanoic acid (PFOA)	335-67-1
Perfluorotetradecanoic acid (PFTA)	376-06-7
Perfluorotridecanoic acid (PFTrDA)	72629-94-8
Perfluoroundecanoic acid (PFUnA)	2058-94-8

EPA Method 537.1[5] includes an additional 4 compounds that have been identified or introduced as alternatives to PFOA and PFOS. These compounds are listed in the following table. Analytes in addition to those identified in Tables 2 and 3 may be added to provide additional information based on site-specific conditions and on those PFAS commonly used in commerce.

Table 3. Method 537.1 Analytes	
Compound Name	**CAS #**
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid 11Cl-(PF3OUdS)	763051-92-9
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4

The analytical minimum reporting level (MRL) of analyses for PFOA and PFOS shall be no greater than 5 nanograms per liter (ng/L, equivalent to ppt) for drinking water samples;

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[4] EPA Method 537 Rev. 1.1
https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NERL&dirEntryId=198984&simpleSearch=1&searchAll=EPA%2F600%2FR-08%2F092

[5] EPA Method 537.1
https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=343042&Lab=NERL&simpleSearch=0&showCriteria=2&searchAll=Determination+of+Selected+Per-+and+Polyfluorinated+Alkyl+Substances+&TIMSType=&dateBeginPublishedPresented=11%2F02%2F2016

however, available MRL from some laboratories for compounds other than PFOA and PFOS may be slightly higher (e.g., 10 ng/L), and may be acceptable but should be reviewed and approved by the Project Manager. Site-specific reporting requirements should be documented in the site-specific Sampling and Analysis Plan, SOP or Work Plan.

The laboratory must report the results to the MRL. Note: If the method detection limits (MDLs) are required by the KDEP Project Manager (DWM and\or DOW), the lab must still report the results to the MRL and flag any results between the MDL and the MRL as "estimated" on the report.

Some analytical laboratories report slightly different forms of sulfonic acids, such as PFOS (i.e., perfluoroactanesulfonic acid vs. perfluorooctane sulfonate), which vary slightly from one another in molecular weight, resulting in slight differences in reported concentrations. The analytical results should clearly document form of sulfonic acids being analyzed and the appropriate CAS Number. If the lab analyzes for one form and reports the other form, the lab must show the conversion calculations in the report.

Quality Control

Many clothing items and types of field equipment may contain PFAS, which increases the potential for inadvertent contamination of the samples. In order to evaluate the potential impact of these items, as well as laboratory-provided materials, Quality Control (QC) samples are to be considered in the PFAS sampling and analysis plan.

The site-specific SAP should document specific information on QC samples to be collected. QC requirements may vary for initial screening and assessment, and site investigations.

To support the validity of the data, the following QC is suggested:

- Trip Blanks
  - Trip blanks for PFAS samples shall be prepared by the laboratory prior to the sampling event using PFAS-free DI water.
  - One PFAS trip blank per chain-of-custody and per cooler is acceptable.
- Field Duplicates
  - Duplicate samples shall be collected by filling a separate container for each analysis immediately following the collection of the primary sample (e.g., PFAS sample then PFAS duplicate sample).
  - Duplicate samples are typically collected at a frequency of one duplicate sample per twenty field samples (1:20), with a minimum of one field duplicate per sampling event.

- The duplicates may be Blind Duplicates where the sample container is labeled in the same manner as a regular sample, rather than a duplicate, to evaluate laboratory variability.

- Equipment Blanks - for all non-dedicated equipment used to collect samples
  - Equipment blanks shall be prepared using PFAS-free laboratory grade DI water provided by the laboratory.
  - Equipment blanks consist of a sample of PFAS-free laboratory grade DI water which has been poured around and through sample collection equipment following decontamination procedures to ensure effectiveness of the procedures and the potential for cross-contamination between sample locations.
  - One equipment blank per type of non-dedicated equipment is typically collected per sampling event (e.g., water level meter, bailer, submersible pump, bladder pump) to evaluate the decontamination procedure.
  - A second equipment blank on certain types of equipment (e.g., bladder pump) may be useful in order to evaluate the potential influence of components within the piece of equipment.
- Field Blanks
  - A field blank is a clean sample (e.g., distilled water), carried to the sampling site, exposed to sampling conditions (e.g., bottle caps removed, preservatives added) and returned to the laboratory and treated as an environmental sample. Field blanks are used to check for analytical artifacts and/or background introduces by sampling and analytical procedures.
  - The laboratory will provide a bottle with reagent water and preservatives and an empty labeled bottle for the field blank. Collect a field blank using laboratory–provided reagent water with preservative while in the field by opening the provided reagent and pouring into the appropriate PFAS sample container.
  - Refer to the site-specific Sampling and Analysis Plan for the quantity of field blanks to be collected. At a minimum, field blanks must be collected by each person collecting PFAS samples. Consideration should also be given to when the field blank should be collected so that it is representative of the conditions most likely to influence the sample.

The Division's Quality Assurance Officer is responsible for ensuring that field staff are familiar with and follow site-specific quality assurance procedures including sampling techniques, field documentation, decontamination, sample packaging, chain of custody sample handling and shipping documentation procedures, and equipment calibration.

EQUIPMENT AND MATERIALS

Table 4 summarizes materials that should be used and those that should be avoided when sampling for PFAS. These guidelines are based on a review of the New Hampshire Department of Environmental Services (NHDES) *Sample Collection Guidance*[6] and Michigan Department of Environmental Quality (MDEQ) *General PFAS Sampling Guidance*[7] and provides a summary of items that are likely to contain PFAS along with acceptable alternatives. This list will be amended as new information becomes available.

Prohibited identifies items and materials that should not be used when sampling. It is well documented that they contain PFAS or that PFAS are used in their manufacture. – **Allowable** identifies items and materials that have been proven not to be sources of PFAS cross-contamination and are considered allowable for sampling. – **Needs Screening** identifies items and materials that have the potential for PFAS cross-contamination due to a lack of scientific data or statements from manufacturers to prove otherwise.

Table 4. Allowable and Prohibited Materials Used in Sampling.	
Category	
Field Equipment Including: • Pumps • Tubing • Bailers	**Prohibited Items:** Teflon® and other fluoropolymer-containing materials (e.g., Teflon tubing, bailers, tape; Teflon –containing plumbing paste, or other Teflon materials) **Note**: The Grundfos Redi-Flow Submersible Pump is a submersible pump that, as of this revision, has a Teflon impeller and is not recommended for collecting PFAS samples. Polyvinylidene fluoride (PVDF) that includes the trademark Kynar® Polychlorotrifluoroethylene (PCTFE) that includes the trademark Neoflon® Ethylene-tetrafluoroethylene (ETFE) that includes the trademark Tefzel®
	Allowable Items: High-density polyethylene (HDPE) -*preferred,* low density polyethylene (LDPE)*,or silicone tubing HDPE/LDPE* or stainless steel bailers Peristaltic pumps

[6] https://www.des.nh.gov/organization/commissioner/documents/pfas-sample-guidance-201611.pdf

[7] https://www.michigan.gov/documents/pfasresponse/General_PFAS_Sampling_Guidance_634597_7.pdf

	Stainless steel submersible pumps (e.g., ProActive stainless steel pumps with PVC [polyvinyl chloride]) leads and Geotech Stainless Steel Geosub pumps)
	Needs Screening: *LDPE may be used if an equipment blank has confirmed it to be PFAS-free. LDPE does not contain PFAS in the raw material but may contain PFAS cross-contamination from the manufacturing process. Bladder pumps with polyethylene bladders and tubing need to be evaluated on a case-by-case basis because the gaskets and O-rings may contain PFAS. Equipment with Viton components needs to be evaluated on a case-by-case basis. Viton contains PTFE, but may be acceptable if used in gaskets or O-rings that are sealed away and will not come into contact with sample or sampling equipment.)
Decontamination	**Prohibited Items:** Decon 90
	Allowable Items: Alconox® or Liquinox® [8], potable water followed by laboratory "PFAS-free" DI water rinse.
Sample Storage and Preservation	**Prohibited Items:** LDPE or glass bottles, PTFE-or Teflon-lined caps, blue or chemical ice packs
	Allowable Items: Laboratory-provided sample container; HDPE or polypropylene bottles with an unlined plastic screw cap, as specified by the laboratory doing the analysis Regular loose ice (preferably from a known PFAS-free source).
	Needs Screening: If it is necessary to use blue or chemical ice packs, they should be tested to ensure that they are PFAS-free.
Field Documentation	**Prohibited Items:** Waterproof/treated paper or field books, plastic clipboards, non-Sharpie® markers, Post-It® and other adhesive paper products.
	Allowable Items: Plain Paper, metal clipboard, Sharpies[9], ballpoint pens
Clothing/laundering	**Prohibited Items:** Clothing or boots made of or with Gore-Tex™ or other synthetic water proof/ resistant and/or stain resistant materials, coated Tyvek® material that may contain PFAS;

[8] While Alconox and Liquinox soap is acceptable for use for PFAS decontamination, they may contain 1,4-dioxane. If Alconox and Liquinox soap is used at sites where 1,4-dioxane is a contaminant of concern/interest, then equipment blanks analyzed for 1,4-dioxane will be required.
[9] Fine point Sharpies may be used if necessary; however, KDEP does not recommend using Sharpies as they can bleed through pages and smudge, making the documentation hard to read.

	fabric softener
	Allowable Items: Synthetic or cotton material, previously laundered clothing (preferably previously washed greater than six times) without the use of fabric softeners. Polyurethane and wax coated materials. Neoprene Boots made with polyurethane and PVC, well worn or untreated leather boots
	Needs Screening: Tyvek material that is PFAS free (e.g., uncoated)
Personal Care Products (for day of sample collection) **Note:** Guidance from New Hampshire and Michigan both contain lists of sunscreens and insect repellants and each contain different allowable products. Michigan lists some products as requiring screening prior to use that New Hampshire lists as allowable. In the interest of caution, always verify that a product has been confirmed before use.	**Prohibited Items:** Cosmetics, moisturizers, hand cream and other related products
	Allowable Items: **Sunscreens:** Alba Organics Natural Yes to Cucumbers Aubrey Organics Jason Natural Sun Block Kiss My Face Baby-safe sunscreens ('free' or 'natural') **Insect Repellents**: Jason Natural Quit Bugging Me Repel Lemon Eucalyptus Herbal Armor California Baby Natural Bug Spray BabyGanics **Sunscreen and Insect Repellents:** Avon Skin So Soft Bug Guard-SPF 30
	Needs Screening: Any Personal Care Products that have not been tested for PFAS
Food and Beverage	**Prohibited Items:** Pre-packaged food, fast food wrappers or containers
	Allowable Items: Bottled water or hydration drinks (i.e., Gatorade® and Powerade®) Eating should take place away from the sampling zone with PPE (fabric coveralls and gloves removed and replaced prior to resuming sampling)

REFERENCES

The Northeast Waste Management Officials' Association (NEWMOA), five-part webinar training series, 2016; http://www.newmoa.org/cleanup/workshops.cfm

New Hampshire Department of Environmental Services (NHDES) Website:
NH PFAS Investigation at https://www4.des.state.nh.us/nh-pfas-investigation/
Guidance for Waste Sites (https://www4.des.state.nh.us/nh-pfas-investigation/?page_id=130)

Michigan Department of Environmental Quality (MDEQ) guidance
https://www.michigan.gov/documents/pfasresponse/General_PFAS_Sampling_Guidance_634597_7.pdf

EPA PFAS Webpages
https://www.epa.gov/pfas/what-are-pfcs-and-how-do-they-relate-and-polyfluoroalkyl-substances-pfass
https://www.epa.gov/pfas

Interstate Technology and Regulatory Council PFAS page:
https://www.itrcweb.org/Team/Public?teamID=78

APPENDIX A – Sample Delivery Procedure

1. Ensure all caps are secured on sample containers.
2. Check that all containers are labeled correctly, and the label is affixed with clear tape. If writing directly on bottle, use clear tape to prevent smearing of ink.
3. Seal sample bottles for each station in a re-sealable plastic bag.
4. Fill a bottom layer of cooler with loose "wet" ice; place bagged sample bottles on ice, surround bottles with loose "wet" ice. Fill cooler to top with ice. Blue ice or ice packs are prohibited. Double-bagged ice in new, re-sealable plastic bags may be used to prevent leaking of water, if necessary, but loose ice is preferable. Do not use a plastic garbage bag to line the cooler for that purpose unless the garbage bags have been verified PFAS-free.
5. Ensure all QC samples are included in the cooler.
6. Include a temperature "blank" in all coolers. This sample container contains PFAS free water that allows the laboratory to evaluate if samples were adequately cooled during transport. The sample is not analyzed.
7. Record date and time on Chain of Custody (COC) using permanent black or blue ink; the last person in custody of the samples should sign and date their name on a 'relinquished by' blank line. When received, the lab will sign and date on a 'received by' blank space.
8. Before shipping, copy the COC after signing and dating, and file in project file.
9. Place original COC in clear plastic bag, and attach to the inside lid of one of the coolers to be shipped.
10. Use clear packaging tape around the entire cooler, covering the cooler opening. The tape should begin and end on the top or bottom of the cooler, not at the junction of the lid.
11. Sign, not print, your name in permanent black or blue marker across the junction of the lid and main body of the cooler, on the tape - or affix and sign using custody seals.
12. For security during shipping, tape over and around the cooler hinges, surrounding entire cooler.
13. Label coolers 'This End Up', arrow pointing towards the cooler lid.
14. Drain all water out of coolers immediately before shipping. Ensure the cooler spouts or 'plugs' are sealed or completely closed.
15. Depending on sample holding time, shipping overnight, and/or express may be required.
16. It is recommended to ship all coolers certified, overnight to ensure samples are received within required holding time periods.
17. Notify the lab by email, telephone, etc. that the COCs are inside one of the taped coolers.

APPENDIX B – Sample Container Description

1. EPA Method 537 requires two 250 ml HPDE containers preserved with Trizma per water sample. Polypropylene may be used as an alternative.
2. Holding time is 14 days.
3. Coolers should be dedicated to PFAS samples or thoroughly cleaned after use for other sample types.

APPENDIX C – Chain of Custody Example

CHAIN OF CUSTODY RECORD

DEPARTMENT FOR ENVIRONMENTAL PROTECTION

Program/DOW: ☐ 106 ☐ NPS ☐ SDWA ☐ Stream Survey ☐ Groundwater ☐ Wild Rivers ☐ Tox. Test ☐ Ref. Reach ☐ Lakes ☐ Pretreatment ☐ BMP ☐ ERT

Program/DWM: ☐ RCRA ☐ UST ☐ TSCA ☐ Solid Waste ☐ Fed. CERCLA ☐ St. CERCLA

Fund Source/MARS # _____ Site # _____ Other Program _____ Incident #/AI # _____

SITE LOCATION: _____ FACILITY NO.: _____ COUNTY: _____

FIELD ID #	DATE TIME	DESCRIPTION OF SITE	MATRIX	NUMBER OF CONTAINERS	PRESER-VATION	ANALYSIS REQUESTED	pH	LAB USE ONLY
	Date: ___/___/___ Time: ☐ am ___:___ ☐ pm	AKGWA #: _____ - _____	☐ Liquid ☐ Solid ☐ Chemical ☐ Grab ☐ Composite ☐ Other	___ Glass 1000 ml ___ Plastic 1000 ml ___ VOA 40 ml ___ Glass 140 ml ___ 280 ml ___Other:	☐ Ice ☐ H_2SO_4 ☐ NaOH ☐ HNO_3 ☐ HCI ☐ Other	☐ ABN ☐ VOC ☐ NH_3 ☐ TO14 ☐ TOC ☐ TSS ☐ CI ☐ HERB ☐ TKN ☐ BOD ☐ CN ☐ T. METALS ☐ O&G ☐ PAH ☐ FP ☐ PEST/PCB ☐ TDS ☐ ALK ☐ TCLP ☐ N/P PEST ☐ BTEX ☐ ORTHO/P ☐ OTHER: _____		Sample # Report #
	Date: ___/___/___ Time: ☐ am ___:___ ☐ pm	AKGWA #: _____ - _____	☐ Liquid ☐ Solid ☐ Chemical ☐ Grab ☐ Composite ☐ Other	___ Glass 1000 ml ___ Plastic 1000 ml ___ VOA 40 ml ___ Glass 140 ml ___ 280 ml ___Other:	☐ Ice ☐ H_2SO_4 ☐ NaOH ☐ HNO_3 ☐ HCI ☐ Other	☐ ABN ☐ VOC ☐ NH_3 ☐ TO14 ☐ TOC ☐ TSS ☐ CI ☐ HERB ☐ TKN ☐ BOD ☐ CN ☐ T. METALS ☐ O&G ☐ PAH ☐ FP ☐ PEST/PCB ☐ TDS ☐ ALK ☐ TCLP ☐ N/P PEST ☐ BTEX ☐ ORTHO/P ☐ OTHER: _____		Sample # Report #
	Date: ___/___/___ Time: ☐ am ___:___ ☐ pm	AKGWA #: _____ - _____	☐ Liquid ☐ Solid ☐ Chemical ☐ Grab ☐ Composite ☐ Other	___ Glass 1000 ml ___ Plastic 1000 ml ___ VOA 40 ml ___ Glass 140 ml ___ 280 ml ___Other:	☐ Ice ☐ H_2SO_4 ☐ NaOH ☐ HNO_3 ☐ HCI ☐ Other	☐ ABN ☐ VOC ☐ NH_3 ☐ TO14 ☐ TOC ☐ TSS ☐ CI ☐ HERB ☐ TKN ☐ BOD ☐ CN ☐ T. METALS ☐ O&G ☐ PAH ☐ FP ☐ PEST/PCB ☐ TDS ☐ ALK ☐ TCLP ☐ N/P PEST ☐ BTEX ☐ ORTHO/P ☐ OTHER: _____		Sample # Report #

Relinquished by:	Date	Received by:
Representing:	Time	Representing:
Relinquished by:	Date	Received by:
Representing:	Time	Representing:

SITE LOCATION: _____ FACILITY NO.: _____ COUNTY: _____

FIELD ID #	DATE TIME	DESCRIPTION OF SITE	MATRIX	NUMBER OF CONTAINERS	PRESER-VATION	ANALYSIS REQUESTED	pH	LAB USE ONLY
	Date: ___/___/___ Time: ☐ am ____:____ ☐ pm	AKGWA #: _____ - _____	☐ Liquid ☐ Solid ☐ Chemical ☐ Grab ☐ Composite ☐ Other	___ Glass 1000 ml ___ Plastic 1000 ml ___ VOA 40 ml ___ Glass 140 ml ___ 280 ml ___Other:	☐ Ice ☐ H_2SO_4 ☐ NaOH ☐ HNO_3 ☐ HCI ☐ Other	☐ ABN ☐ VOC ☐ NH_3 ☐ TO14 ☐ TOC ☐ TSS ☐ CI ☐ HERB ☐ TKN ☐ BOD ☐ CN ☐ T. METALS ☐ O&G ☐ PAH ☐ FP ☐ PEST/PCB ☐ TDS ☐ ALK ☐ TCLP ☐ N/P PEST ☐ BTEX ☐ ORTHO/P ☐ OTHER: _____		Sample # Report #
	Date: ___/___/___ Time: ☐ am ____:____ ☐ pm	AKGWA #: _____ - _____	☐ Liquid ☐ Solid ☐ Chemical ☐ Grab ☐ Composite ☐ Other	___ Glass 1000 ml ___ Plastic 1000 ml ___ VOA 40 ml ___ Glass 140 ml ___ 280 ml ___Other:	☐ Ice ☐ H_2SO_4 ☐ NaOH ☐ HNO_3 ☐ HCI ☐ Other	☐ ABN ☐ VOC ☐ NH_3 ☐ TO14 ☐ TOC ☐ TSS ☐ CI ☐ HERB ☐ TKN ☐ BOD ☐ CN ☐ T. METALS ☐ O&G ☐ PAH ☐ FP ☐ PEST/PCB ☐ TDS ☐ ALK ☐ TCLP ☐ N/P PEST ☐ BTEX ☐ ORTHO/P ☐ OTHER: _____		Sample # Report #
	Date: ___/___/___ Time: ☐ am ____:____ ☐ pm	AKGWA #: _____ - _____	☐ Liquid ☐ Solid ☐ Chemical ☐ Grab ☐ Composite ☐ Other	___ Glass 1000 ml ___ Plastic 1000 ml ___ VOA 40 ml ___ Glass 140 ml ___ 280 ml ___Other:	☐ Ice ☐ H_2SO_4 ☐ NaOH ☐ HNO_3 ☐ HCI ☐ Other	☐ ABN ☐ VOC ☐ NH_3 ☐ TO14 ☐ TOC ☐ TSS ☐ CI ☐ HERB ☐ TKN ☐ BOD ☐ CN ☐ T. METALS ☐ O&G ☐ PAH ☐ FP ☐ PEST/PCB ☐ TDS ☐ ALK ☐ TCLP ☐ N/P PEST ☐ BTEX ☐ ORTHO/P ☐ OTHER: _____		Sample # Report #
	Date: ___/___/___ Time: ☐ am ____:____ ☐ pm	AKGWA #: _____ - _____	☐ Liquid ☐ Solid ☐ Chemical ☐ Grab ☐ Composite ☐ Other	___ Glass 1000 ml ___ Plastic 1000 ml ___ VOA 40 ml ___ Glass 140 ml ___ 280 ml ___ Other:	☐ Ice ☐ H_2SO_4 ☐ NaOH ☐ HNO_3 ☐ HCI ☐ Other	☐ ABN ☐ VOC ☐ NH3 ☐ TO14 ☐ TOC ☐ TSS ☐ CI ☐ HERB ☐ TKN ☐ BOD ☐ CN ☐ T. METALS ☐ O&G ☐ PAH ☐ FP ☐ PEST/PCB ☐ TDS ☐ ALK ☐ TCLP ☐ N/P PEST ☐ BTEX ☐ ORTHO/P ☐ OTHER: _____		Sample # Report #

Appendix B

Program Management Plan

COORDINATION SHEET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
DIVISION of WATER

Date: 05/09/19

Reference: PFAS Program Management Plan	
FROM: Lisa Hicks – return final	**PURPOSE: Review and Approval**
(1) TO: Peter Goodmann ☑ **APPROVE** ☐ **DISAPPROVE** **Initials** PG **Date** 5/14/2019	**COMMENTS:**
(2) TO: Larry Taylor ☑ **APPROVE** ☐ **DISAPPROVE** **Initials** LT **Date** 5/14/19	**COMMENTS:**

Evaluating Kentucky Community Drinking Water Supplies for Per- & Poly-Fluorinated Alkyl Substances

Program Management Plan

Program Lead:
Peter T. Goodmann, Director
Kentucky Division of Water
300 Sower Blvd 3rd Floor
Frankfort, KY 40601

Effective Date: May 15, 2019

Revision No.: 1.0

APPROVAL SHEET

Review / Approval By	Signature	Date
Robert J. Blair, Author Project Coordinator/Activity Lead Watershed Management Branch		5/10/19
Peter T. Goodmann, Director Program Lead Division of Water		5/14/2019
Lisa Hicks, Approve Quality Assurance Officer Division of Water		05/09/2019
Larry Taylor, Approve Quality Assurance Manager Department for Environmental Protection		5/14/19

This Program Management Plan is administratively and technically valid under the main Quality Assurance Project Plan (QAPP), 'Kentucky Water Quality Monitoring Quality Assurance Project Plan for Programs Implemented by the Water Quality Branch', effective date 03/01/2019, version 2.0.

REVISION HISTORY

Date of Revision	Page(s)/Section(s) Revised	Revision Explanation
04-May-2019	All	Document Created
07-May-2019	ii, 1-4	Added signature page, addressed missing information
20-May-2019	1-4	Various comments from Lab Cert, DWB

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1.0 PROJECT MANAGEMENT

1.1-Project Background and Overview

Per- and poly-fluoroalkyl substances (PFAS) have been identified as contaminants of emerging concern. These compounds are ubiquitous and have been used since the 1940s for their ability to resist heat, oil, grease and water. The most common uses have been stain resistance for carpets, non-stick cookware, and aqueous film-forming foam (AFFF). These chemicals are persistent in the environment, and can bio-accumulate in organisms. There is evidence that exposure to PFAS chemicals may impact reproductive and developmental health, increase the risk for cancer, disrupt thyroid hormones, and affect the immune system (USEPA, 2018). The United States Environmental Protection Agency (USEPA) and many states are assessing the need to establish Maximum Contaminant Levels (MCL) for PFAS exposure in drinking water.

The USEPA's Third Unregulated Contaminant Monitoring Rule (UCMR3) examined the occurrence of six different PFAS in drinking water nationwide. The finished water from all community water systems in the United States serving more than 10,000 people, and a representative sample of 800 systems serving less than 10,000 people, were sampled. In Kentucky, 121 water systems with 165 drinking water sources were monitored under this rule for the occurrence of PFAS. Nationally, 4% of public water systems reported detections of PFAS while Kentucky had detections in 1.8% of sampled sources. Detections in drinking water were associated with numerous potential sources of PFAS, including industrial sites, areas where fire training with AFFF occurred, and wastewater treatment facilities (Interstate Technology Regulatory Council, 2018).

Kentucky is served by 195 community water systems that produce treated drinking water. Another 190 consecutive community water systems purchase treated drinking water and provide water to their customers. Approximately 95.5% of Kentuckians are served by publicly supplied, treated drinking water.

The purpose of this study is for the Kentucky Department for Environmental Protection to determine the presence of PFAS at public water treatment plants (WTP) as a means to determine whether public drinking water is a potential source of exposure to PFAS. The results of this study may be used to identify watersheds or aquifers that have sources of PFAS contamination. Determining the occurrence of PFAS in public drinking water will be accomplished through a systematic sampling project focused on these emerging contaminants.

1.2-Project/Task Organization

Each job classification below lists all of the personnel that are properly trained for each role, and can thus complete the tasks associated with each personnel role in the program. The WQB main QAPP outlines specific details of the roles and responsibilities for each job classification.

Program Lead: Peter Goodmann, Director, Division of Water. Provides program oversight and guidance.

Project Coordinator: Robert J. Blair, Environmental Scientist, Watershed Management Branch (WMB). Conducts logistics and planning relative to project goals and timelines.

Activity Lead: Robert J. Blair, Environmental Scientist, WMB. Schedules sampling events, coordinates with laboratory, field samplers and sample site contacts, lead field sampler.

Technical Staff: Jackie Logsdon (DWB), Mark Martin (DWB), Allan Shingleton (WMB), David Messer (DWB), C.J. Bailey (DWB), Gabe Tanner (DWB), Colin Arnold (WQB) – assists Activity Lead with sample collection. Caroline Chan (WMB) – project quality control officer and statistical analysis.

1.3-Data Quality Objectives Process

On May 19, 2016, the USEPA issued drinking water lifetime health advisories (HA) for two PFAS compounds, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). The HA level is 0.07 µg/L for PFOA, and 0.07 µg/L for PFOS. EPA further recommends that when these two chemicals co-occur at the same time and location in a drinking water source, a conservative and health-protective approach would be to compare the sum of the concentrations ([PFOA] + [PFOS]) to the HA (0.07 µg/L). Lifetime health advisories are not drinking water standards (MCLs or Treatment Technology) but may be used for developing local standards. In addition, the HA is being utilized as a screening level of public and private drinking water. USEPA is also proposing to use the HA as a remediation goal for PFAS-contaminated groundwater being used for consumptive purposes. The USEPA has not established health advisories for the other PFAS at this time.

The PFAS to be analyzed for this study are summarized in Table 1.0, below. The analytes selected include the six compounds that were analyzed in the UCMR3, which allows for comparability to previous datasets. These analytes may also serve as surrogates for the overall occurrence of PFAS. Two analytes were selected as surrogate representatives for the next generation of chemicals (GenX) developed to replace PFOS and PFOA in commerce. These analytes are commonly used for numerous commercial applications. The Division of Environmental Program Support (DEPS) laboratory has the capability to analyze drinking water samples for all of the analytes selected for this study.

Data Quality Objectives will be met with intensive quality assurance sampling required by the EPA Method 537.1 Rev 1 used by the laboratory. This requires a field blank sample of verified PFAS-free water for each field sample location, as well as one duplicate sample with each sampling event (trip). Comparison of duplicate samples results will ensure analytical method precision and accuracy. Field blank sample results will ensure appropriate sample collection protocol and identify background contamination, if present.

Table 1.0 – PFAS to be analyzed for this study

Analyte	Acronym	CAS Number
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexanesulfonic acid	PFHxs	355-46-4
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorooctanoic acid	PFOA	335-67-1
4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4

1.4-Special Training Requirements

Due to the low detection limit of EPA Method 537.1 and potential for cross contamination of samples, all field staff must review and demonstrate understanding of the PFAS Sampling Procedures outlined in the SOP.

1.5-Documentation and Records

Documents specific to this program will be stored on the DEP servers in the following directory: V:\DOW_Share\PFAS Study. Documents and records generated by this program for storage include those identified in Table 1.1:

Table 1.1 – Documents and Records

Field Documents	Format	Electronic Filename Template	Required?
Sample Chains of Custody	PDF	StationID-Date-COC	Y
Laboratory Documents	**Format**	**Electronic Filename Template**	
DEPS Sample Analysis Reports	PDF	StationID-Date-LabResults	Y
QAQC Records and Reports	**Format**	**Electronic Filename Template**	
Project Data Spreadsheet	XLSX	Not Applicable	Y
Project QA Tracking Sheet	XLSX	Not Applicable	Y
Project QA Summary	XLSB & PDF	Not Applicable	Y
Project Final Data Report	DOCX	Not Applicable	Y

2.0-DATA ACQUISITION

2.1-Sampling Design

The PFAS sampling project is a proactive evaluation of the occurrence of these analytes in drinking water in Kentucky. The purpose of this study is for DEP to determine the potential for exposure to PFAS through publicly supplied drinking water. This will be accomplished through a systematic sampling project that is focused on these emerging contaminants. One-time samples of finished, treated drinking water will be collected from water treatment plants (WTP).

2.2-Sampling Procedures and Requirements

Sample scheduling and collection will follow the procedures outlined in the PFAS SOP and Work Plan, respectively. Field samplers will utilize only those containers obtained from the DEPS laboratory for sample collection. Special care will be taken to avoid cross contamination from vehicles, personal items and food.

2.3-Sample Handling and Custody Requirements

A sample is in "custody" if it is in the actual possession of a sampler or in a secured area that is restricted to authorized personnel. Once a sample is in the custody of DOW staff it will be remitted to the DEPS sample custodian only. All custody transfers will be documented on the signed chain of custody form.

2.4-Analytical Method Requirements

The DEPS laboratory utilizes EPA Method 537.1 Rev 1 for PFAS analysis, and will report results for the eight analytes selected for this study. These analytes were selected based the availability of comparable data

from previous research and their prevalence in commerce. The DEPS laboratory reports current Limit of Detection to be less than or equal to 5 ng/L, and the Limit of Quantitation to be less than or equal to 10 ng/L. Each of these are well below the lifetime health advisory of 70 ng/L set by USEPA.

2.5-Quality Control Requirements

Due to the wide use of these compounds the potential for cross contamination of samples is elevated. In addition, the laboratory analysis is extremely sensitive and can detect parts per trillion (nanograms per liter). Therefore, quality control requirements are very stringent. Field samplers must strictly adhere to the procedures outlined in the Sampling SOP, including sample collection instructions and use of various personal care products before and during field activities. Quality control samples include one field blank of verified PFAS-free water collected at each sample site, one triplicate sample collected for each sampling event and one trip blank for each sampling event. The sampling event trip blank will also serve as the temperature blank for the sample cooler.

2.6-Data Management Requirements

Electronic documents specific to this program will be stored in a centralized directory on the DEP servers. Files will generally be organized by type and date. Analytical results will be saved as original PDFs from the DEPS laboratory and entered into a spreadsheet that contains fields for site names, site geographic location (latitude and longitude), source water type, land-use influence, resulting values for each PFAS, sample date and laboratory qualifier codes (aka Flags). Analytical Reports of Analysis from the DEPS laboratory will also be backed up on their LIMS database. Further data management requirements may be added to aide in statistical and geospatial analyses, as needed.

3.0-ASSESSMENTS and OVERSIGHT

3.1-Project-Level Assessments and Response Actions

Project-level assessments requiring response actions will be reported through the chain of command and oversight for this project will be the responsibility of the Program Lead.

4.0-DATA VERIFICATION, VALIDATION and USABILITY

4.1-Data Review, Validation and Verification Criteria Documentation

There are no data review, validation, and verification criteria and documentation details specific to this program. Please see Section 4.1 of the QAPP main document for guidelines on project-level assessment and response actions.

4.2-Validation and Verification Methods

Initial data review will be completed as soon as possible after data generation (Section 4.2.1 of the QAPP main document). Field activity QA will include a review of each COC to verify consistent adherence to procedures.

4.3-Reconciliation with Project Requirements

Reconciliation with project requirements will follow section 4.3 of the QAPP main document.

APPENDIX C

PFAS Project COC Forms

CHAIN OF CUSTODY RECORD
ENERGY and ENVIRONMENT CABINET
DIVISION OF WATER
KENTUCKY PFAS DRINKING WATER STUDY – A70

Site Identification	Collection Date/Time
Location: PWS ID: County:	Date: Time:

Sampler ID:_____

Division of Environmental Program Support				
Number of Containers	**Container Size, Type**	**Preservation Method**	**Parameters**	**DEPS Sample #**
	250 ml HDPE	1.25 g Trizma Cool to 4°C	**PFAS**	
	250 ml HDPE	1.25 g Trizma Cool to 4°C	**Field Blank Analysis**	

Signatures:

Relinquished by: _____ Date: _____ Time: _____

Received by: _____

Relinquished by: _____ Date: _____ Time: _____

Received by: _____

COMMENTS:

***Note here if site sampled in Triplicate:**

Revised 6/5//2019

CHAIN OF CUSTODY RECORD
ENERGY and ENVIRONMENT CABINET
DIVISION OF WATER
KENTUCKY PFAS DRINKING WATER STUDY – A70

Site Identification	Preparation Date/Time
PFAS Trip and Temperature Blank	Date: Time:

Sampler ID:_____

Division of Environmental Program Support				
Number of Containers	**Container Size, Type**	**Preservation Method**	**Parameters**	**DEPS Sample #**
	250 ml HDPE	1.25 g Trizma Cool to 4°C	**PFAS Trip Blank**	

Signatures:

Relinquished by: _____ Date: _____ Time: _____

Received by: _____

Relinquished by: _____ Date: _____ Time: _____

Received by: _____

COMMENTS:

Revised 5/3/2019

APPENDIX D - PFAS Sample Results Table

Sample	Collected	Received	Location	Type	PFBS	HFPO- DA	PFHpA	PFHxS	ADONA	PFOA	PFOS	PFNA	Units	LATITUDE_M	LONGITUDE_	Aquifer/Source	River Basin	Aquifer General	Land Use
AQ03020	7/15/2019	7/16/2019	Ashland Water Works	SW	0.00	18.30	0.00	0.00	0.00	4.74	1.96	0.00	ng/L	38.45277800000	-82.61305600000	Ohio R	Ohio		urban
AQ02922	7/8/2019	7/9/2019	Augusta WTP	GW	1.88	0.00	0.00	0.00	0.00	4.43	1.00	0.00	ng/L	38.77361100000	-84.01944400000	Ohio R Alluvium		ORA	rural
AQ04874	10/1/2019	10/1/2019	Barbourville	SW	0.00	0.00	0.00	0.00	0.00	1.39	1.03	0.00	ng/L	36.86444400000	-83.88194400000	Cumberland River	Cumberland		urban
AQ03210	7/22/2019	7/23/2019	Bardstown Municipal Water	SW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	37.81055600000	-85.50583300000	Buffalo Cr	Salt		rural
AQ03216	7/22/2019	7/23/2019	Beaver Dam Municipal Water	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	37.40250000000	-86.87750000000	Breathitt SS		Pennsylvanian Sandstone	urban
AQ03410	7/29/2019	7/30/2019	Benton Water & Sewer	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	36.86305600000	-88.34916700000	McNairy		Mississippi Embayment	urban
AQ03214	7/22/2019	7/23/2019	Bowling Green Mun Utilities	SW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	36.99944400000	-86.42472200000	Barren R	Green		urban
AQ03408	7/29/2019	7/30/2019	Cadiz Municipal Water	SW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	36.85944400000	-87.83805600000	St. Louis LS	Cumberland	Karst	urban
AQ03420	7/29/2019	7/30/2019	Calvert City Municipal Water Dept	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	37.03972200000	-88.34916700000	TN River Alluvium		TN R Alluvium	urban
AQ03654	8/13/2019	8/14/2019	Carroll Co WD - Gallatin Plant	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	38.81611100000	-84.80930500000	Ohio R Alluvium		ORA	rural
AQ02383	6/10/2019	6/11/2019	Carrollton Utilities	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	38.67916700000	-85.17972200000	Ohio R Alluvium		ORA	urban
AQ02853	7/1/2019	7/1/2019	Cynthiana Municipal	SW	0.00	0.00	0.00	2.20	0.00	1.21	8.35	0.00	ng/L	38.37694400000	-84.30333300000	S Licking R	Licking		rural
AQ02920	7/8/2019	7/9/2019	Falmouth WTP	SW	0.00	0.00	1.00	0.00	0.00	0.00	1.24	0.00	ng/L	38.67583300000	-84.32583300000	Licking R	Licking		rural
AQ02257	6/3/2019	6/3/2019	Frankfort Plant Board	SW	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	ng/L	38.18194400000	-84.87222200000	KY River	Kentucky		rural
AQ02253	6/3/2019	6/3/2019	Georgetown MWSS	SW	2.50	0.00	0.00	1.74	0.00	1.38	5.46	0.00	ng/L	38.20861100000	-84.56222200000	Royal Sp	Kentucky	Karst	urban
AQ03416	7/29/2019	7/30/2019	Graves Co WD - Hickory	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	36.81305600000	-88.64916700000	Claiborne		Mississippi Embayment	rural
AQ03026	7/15/2019	7/16/2019	Greenup Water System	SW	0.00	0.00	0.00	0.00	0.00	1.28	1.19	0.00	ng/L	38.57388900000	-82.84527800000	Little Sandy	Big Sandy		urban
AQ03212	7/22/2019	7/23/2019	Hardin County WD #2	SW	2.16	0.00	1.44	1.96	0.00	1.83	4.00	1.58	ng/L	37.71500000000	-85.87000000000	St. Louis LS	Green	Karst	urban
AQ03400	7/29/2019	7/30/2019	Hawesville Water Works	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	37.90166700000	-86.74666700000	Ohio R Alluvium		ORA	rural
AQ03402	7/29/2019	7/30/2019	Henderson Water - North	SW	0.00	12.60	0.00	0.00	0.00	1.43	0.00	0.00	ng/L	37.84500000000	-87.59194400000	Ohio R	Ohio		urban
AQ03404	7/29/2019	7/30/2019	Henderson Water - South	SW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	37.64916700000	-87.51666700000	Green River	Green		urban
AQ02259	6/3/2019	6/3/2019	KY-American KY River Sta II	SW	1.53	0.00	0.00	0.00	0.00	1.10	2.29	0.00	ng/L	38.35611100000	-84.86944400000	KY River	Kentucky		urban
AQ02255	6/3/2019	6/3/2019	KY-American Richmond Rd Sta	SW	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	ng/L	37.99000000000	-84.43638900000	KY River	Kentucky		urban
AQ03418	7/29/2019	7/30/2019	Ledbetter WD	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	37.04777800000	-88.47750000000	Ohio R Alluvium		ORA	rural
AQ02857	7/1/2019	7/1/2019	Louisville Water Co Crescent Hill	SW	0.00	5.36	0.00	0.00	0.00	2.75	1.55	0.00	ng/L	38.28111100000	-85.70250000000	Ohio R	Ohio		urban
AQ02855	7/1/2019	7/1/2019	Louisville Water Co Payne Plant	GW	0.00	4.42	0.00	0.00	0.00	4.31	1.34	0.00	ng/L	38.34583300000	-85.63750000000	RFB		ORA	urban
AQ03406	7/29/2019	7/30/2019	Madisonville Light & Water	SW	0.00	0.00	0.99	0.00	0.00	1.32	0.00	0.99	ng/L	37.31500000000	-87.47805600000	UT Flat Creek	Green		urban
AQ03414	7/29/2019	7/30/2019	Mayfield Water & Sewer	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	36.73583300000	-88.63250000000	Claiborne		Mississippi Embayment	urban
AQ03032	7/15/2019	7/16/2019	Maysville Utility Commission	SW	0.00	29.70	0.00	0.00	0.00	5.09	1.94	0.00	ng/L	38.64500000000	-83.75138900000	Ohio R	Ohio		urban
AQ02924	7/8/2019	7/9/2019	Morehead St University WTP	SW	0.00	0.00	0.00	0.00	0.00	1.20	1.51	0.00	ng/L	38.18444400000	-83.43000000000	Triplett Cr	Licking		urban
AQ03412	7/29/2019	7/30/2019	Murray Water System	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	36.60583300000	-88.30277800000	McNairy		Mississippi Embayment	urban
AQ02379	6/10/2019	6/11/2019	NKWD FT Thomas WTP	SW	0.00	11.90	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	39.07027800000	-84.43750000000	Ohio R	Ohio		urban
AQ02381	6/10/2019	6/11/2019	NKWD Memorial Pkwy WTP	SW	0.00	5.75	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	39.07000000000	-84.43638900000	Ohio R	Ohio		urban
AQ02926	7/8/2019	7/9/2019	Olive Hill WTP	SW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	38.31194400000	-83.21277800000	Perry Br	Big Sandy		rural
AQ03218	7/22/2019	7/23/2019	Owensboro Mun Utilites - Cavin Plant	GW	0.00	0.00	0.00	0.00	0.00	2.13	0.00	0.00	ng/L	37.79222200000	-87.05750000000	Ohio R Alluvium		ORA	urban
AQ03220	7/22/2019	7/23/2019	Owensboro Mun Utilities	GW	0.00	0.00	0.00	0.00	0.00	5.02	1.85	0.00	ng/L	37.77611100000	-87.09638900000	Ohio R Alluvium		ORA	urban
AQ03422	7/29/2019	7/30/2019	Paducah Water Works	SW	2.73	4.89	1.12	0.00	0.00	4.07	4.54	0.00	ng/L	37.09666700000	-88.61388900000	Ohio R	Ohio		urban
AQ03022	7/15/2019	7/16/2019	Russell Water Company	SW	0.00	13.50	1.20	0.00	0.00	5.62	2.01	0.00	ng/L	38.53611100000	-82.69444400000	Ohio R	Ohio		urban
AQ03028	7/15/2019	7/16/2019	South Shore	GW	8.55	0.00	5.02	11.00	0.00	23.20	18.90	0.00	ng/L	38.70777800000	-82.97000000000	Ohio R Alluvium		ORA	urban
AQ03030	7/15/2019	7/16/2019	W Lewis Rectorville	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	38.63527800000	-83.70444400000	Ohio R Alluvium		ORA	rural
AQ02851	7/1/2019	7/1/2019	Warsaw Water Works	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	38.77389881100	-84.91727241860	Ohio R Alluvium		ORA	rural
AQ04039	8/27/2019	8/28/2019	Wickliffe Municipal Water System	GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ng/L	36.95589343870	-89.08946132020	Claiborne		Mississippi Embayment	rural
AQ03024	7/15/2019	7/16/2019	Worthington Mun Water	GW	2.10	0.00	0.00	2.80	0.00	0.00	0.00	0.00	ng/L	38.54944400000	-82.75361100000	Ohio R Alluvium		ORA	urban
AQ03648	8/13/2019	8/14/2019	Arlinghaus WTP	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	38.97805600000	-84.82583300000	Ohio R Alluvium		ORA	rural
AQ04035	8/27/2019	8/28/2019	Arlington Water Department	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	36.78972200000	-89.01444400000	Claiborne		Mississippi Embayment	rural

AQ04041	8/27/2019	8/28/2019	Barlow WTP	GW	0.000	0.000	0.000	1.620	0.000	0.000	0.000	0.000	ng/L	37.05247092310	-89.04769268410	Claiborne		Mississippi Embayment	rural
AQ04872	10/1/2019	10/1/2019	Bell Co Forestry Camp	SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	36.67638900000	-83.85277800000	Clear Cr	Cumberland		rural
AQ03644	8/13/2019	8/14/2019	Birkle WTP	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	39.07083300000	-84.86555600000	Ohio R Alluvium		ORA	rural
AQ04023	8/26/2019	8/28/2019	Brandenburg Water Works	GW	1.390	0.000	0.000	2.490	0.000	1.720	3.010	0.000	ng/L	37.99923361750	-86.16120941650	Ohio R Alluvium		ORA	rural
AQ04289	9/9/2019	9/10/2019	Campellsville Municiple Water	SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	37.35666700000	-85.34305600000	Trace Fk	Green		rural
AQ02385	6/10/2019	6/11/2019	Carroll Co WD-Ghent	GW	0.000	0.000	0.000	0.000	0.000	1.090	0.000	0.000	ng/L	38.73795394710	-85.06025279850	Ohio R Alluvium		ORA	rural
AQ03579	8/12/2019	8/13/2019	Cave Run Regional WT Comm	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.110	0.000	ng/L	37.98755600000	-83.47669400000	Licking R	Licking		rural
AQ04025	8/26/2019	8/28/2019	Central City Water & Sewer	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.210	0.000	ng/L	37.32416700000	-87.11750000000	Green R	Green		rural
AQ04033	8/27/2019	8/28/2019	Columbus Water Works	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	36.75888900000	-89.10305600000	Claiborne		Mississippi Embayment	rural
AQ04870	10/1/2019	10/1/2019	Fleming Neon (Shea Fk Mine)	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	37.21111100000	-82.66388900000	Mine-Elkhorn #3		Pennsylvanian Sandstone	rural
AQ04862	9/30/2019	10/1/2019	Francis Water Co	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	37.47555600000	-82.83444400000	Mine-Elkhorn #1		Pennsylvanian Sandstone	rural
AQ03650	8/13/2019	8/14/2019	Gallatin Co WD - Plant A	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	38.77027800000	-84.91166700000	Ohio R Alluvium		ORA	rural
AQ03652	8/13/2019	8/14/2019	Gallatin Co WD - Plant B	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	38.81224288660	-84.80653368840	Ohio R Alluvium		ORA	rural
AQ04021	8/26/2019	8/28/2019	Graves County Water District South	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	36.63726866650	-88.68638316840	Claiborne		Mississippi Embayment	rural
AQ04858	9/30/2019	10/1/2019	Jackson Municipal WW	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.350	0.000	ng/L	37.54797200000	-83.37738800000	N KY R	Kentucky		rural
AQ03581	8/12/2019	8/13/2019	KAWC - River Station I	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.350	0.000	ng/L	37.90444400000	-84.37833300000	KY River	Kentucky		rural
AQ04037	8/27/2019	8/28/2019	Kevil WTP	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	37.08388900000	-88.88805600000	Claiborne		Mississippi Embayment	rural
AQ03583	8/12/2019	8/13/2019	Lancaster Water Works	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.620	0.000	ng/L	37.72805600000	-84.57222200000	KY River	Kentucky		rural
AQ04876	10/1/2019	10/1/2019	Laurel Co WD 2	SW	0.000	0.000	0.000	0.000	0.000	1.520	1.190	0.000	ng/L	37.00305600000	-84.08333300000	Laurel R	Cumberland		rural
AQ03656	8/13/2019	8/14/2019	Milton Water & Sewer Dept	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	38.72527800000	-85.30000000000	Ohio R Alluvium		ORA	rural
AQ04285	9/9/2019	9/10/2019	Monroe Co. WD	SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	36.68810000000	-85.58758000000	Cumberland R	Cumberland		rural
AQ03577	8/12/2019	8/13/2019	Morehead Utility Plant Board	SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	38.13333300000	-83.54083300000	Licking R	Licking		rural
AQ04027	8/26/2019	8/28/2019	Morganfield Water Works	SW	1.510	3.570	1.350	0.000	0.000	4.500	2.650	0.000	ng/L	37.79777800000	-87.91944400000	Ohio R	Ohio		urban
AQ04868	9/30/2019	10/1/2019	Mountain WD	SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	37.36638900000	-82.41111100000	Russell Fk	Big Sandy		rural
AQ04860	9/30/2019	10/1/2019	Mt Carmel High	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	37.60222200000	-83.46111100000	Breathitt/Lee		Pennsylvanian Sandstone	rural
AQ04283	9/9/2019	9/10/2019	Perdue Farms	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.010	0.000	ng/L	37.34722200000	-86.79166700000	W Indian Camp Cr	Green		rural
AQ04866	9/30/2019	10/1/2019	Pikeville Water Dept	SW	0.000	0.000	0.986	0.000	0.000	0.000	1.190	0.000	ng/L	37.47527800000	-82.52000000000	Levisa Fk	Big Sandy		rural
AQ04291	9/9/2019	9/10/2019	Scottsville Water Dept.	SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	36.85611100000	-86.07972200000	Barren R	Green		rural
AQ04864	9/30/2019	10/1/2019	Southern Wtr-Swr Dist	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.580	0.000	ng/L	37.61027800000	-82.72694400000	Levisa Fk	Big Sandy		rural
AQ04287	9/9/2019	9/10/2019	Stanford Water Works	SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	37.48750000000	-84.67583300000	Logan Cr	Kentucky		rural
AQ04029	8/26/2019	8/28/2019	Sturgis Water Works	SW	1.350	4.500	1.490	0.000	0.000	2.770	1.260	0.000	ng/L	37.53472200000	-88.07000000000	Ohio R	Ohio		urban
AQ03646	8/13/2019	8/14/2019	Trapps Water Co	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	38.98416700000	-84.82861100000	Ohio R Alluvium		ORA	rural
AQ03658	8/13/2019	8/14/2019	Trimble County WD#1	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	38.53944400000	-85.40277800000	Ohio R Alluvium		ORA	rural
AQ04362	9/10/2019	9/10/2019	Vanceburg Electric Plant Board	GW	0.000	0.000	0.000	0.000	0.000	0.000	1.400	0.000	ng/L	38.59840195720	-83.27048732530	Ohio R Alluvium		ORA	rural
AQ04031	8/27/2019	8/28/2019	Water Service Corp of KY Clinton	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	ng/L	36.67161843140	-88.99627626600	Claiborne		Mississippi Embayment	rural
AQ03575	8/12/2019	8/13/2019	Winchester Municipal Utilities	SW	0.000	0.000	0.000	0.000	0.000	0.000	1.690	0.000	ng/L	37.94722200000	-84.22833300000	L Howard Cr	Kentucky		rural

Appendix E: PFAS Sample Results Maps

Notes on PFAS Sample Results Maps

1) Individual maps are presented for each PFAS analyzed in this study. Analyte maps appear in order of decreasing detection rate.

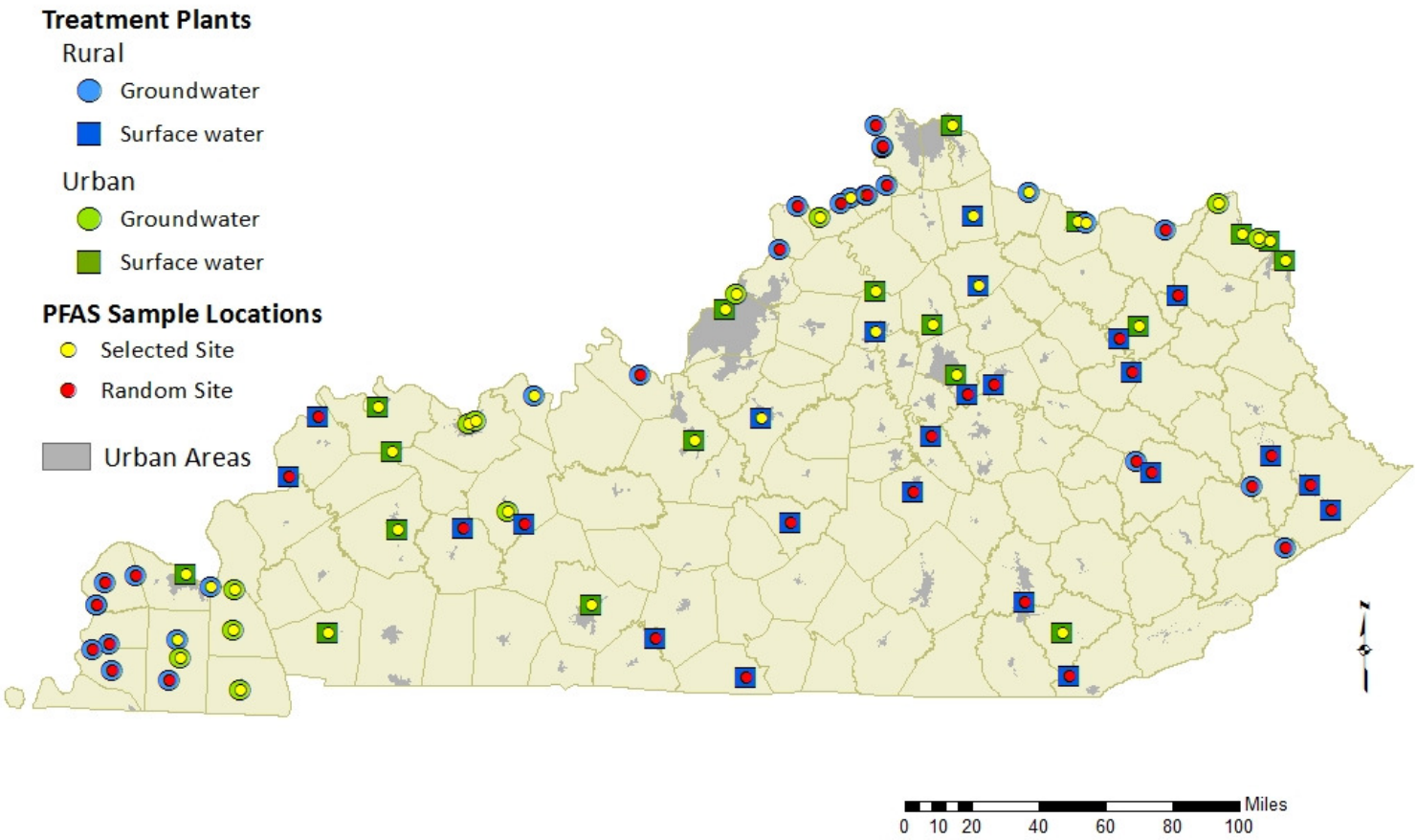
2) These maps are presented with color-coded, graduated-sized points to indicate the concentration range of sample results for each WTP, and identifies the number of WTPs in each range.

3) DL = Detection Limit; RL = Reporting Limit. The Detection Limits and Reporting Limits varied between analytes.

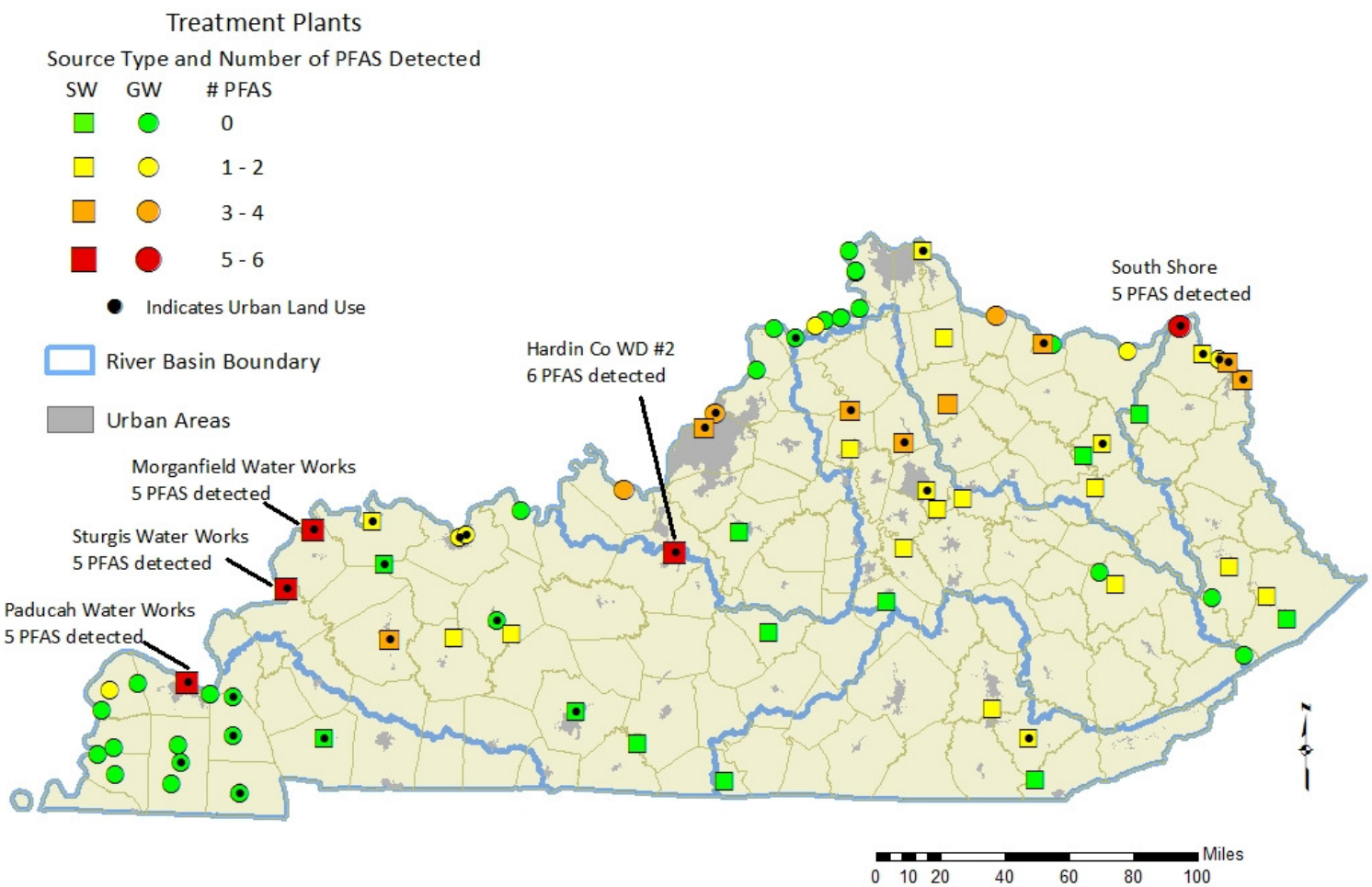
4) WTPs with noteworthy values are identified where applicable.

5) ng/L = nanograms per liter = parts per trillion

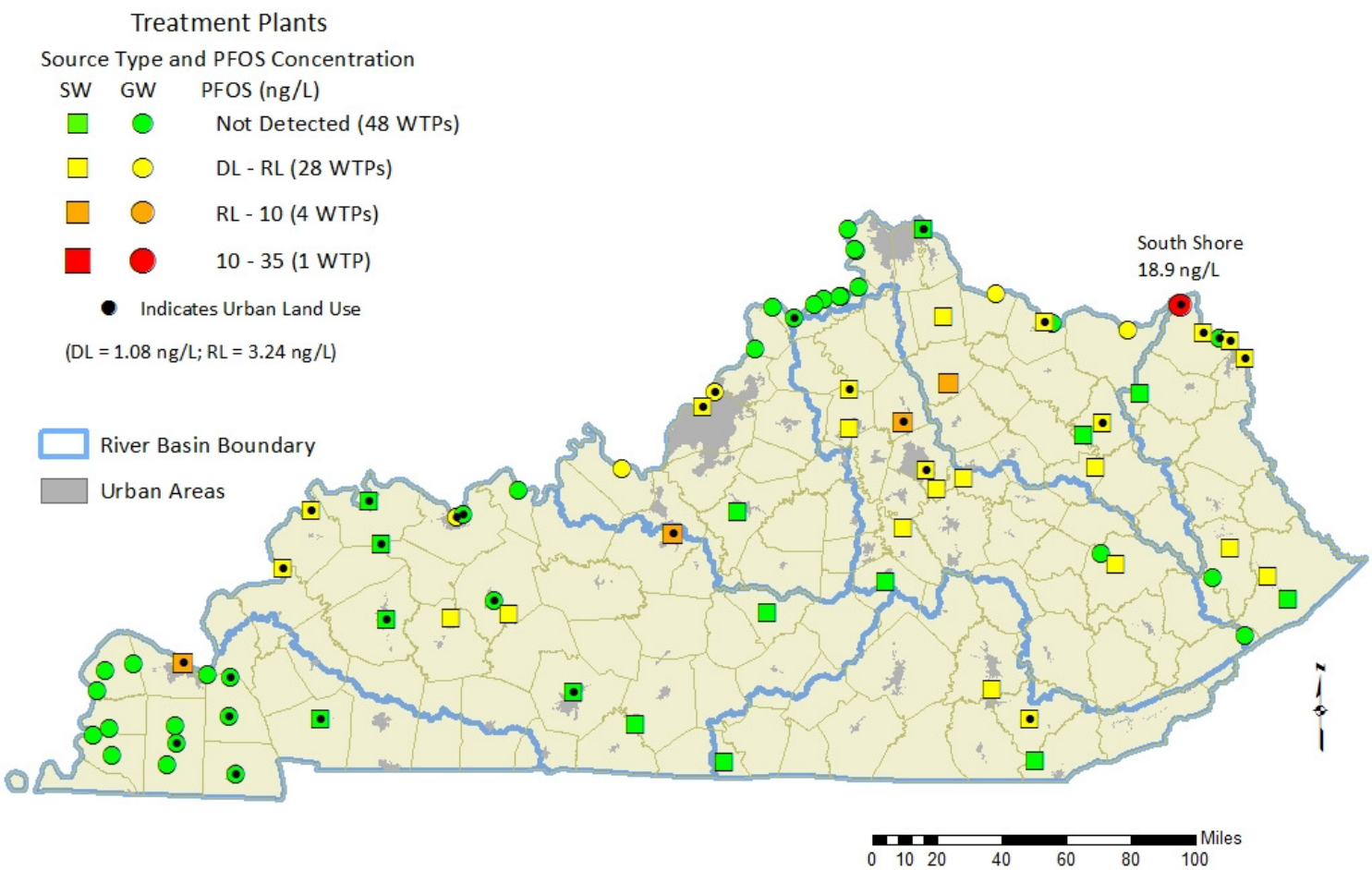
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Sampled for 2019 PFAS Study



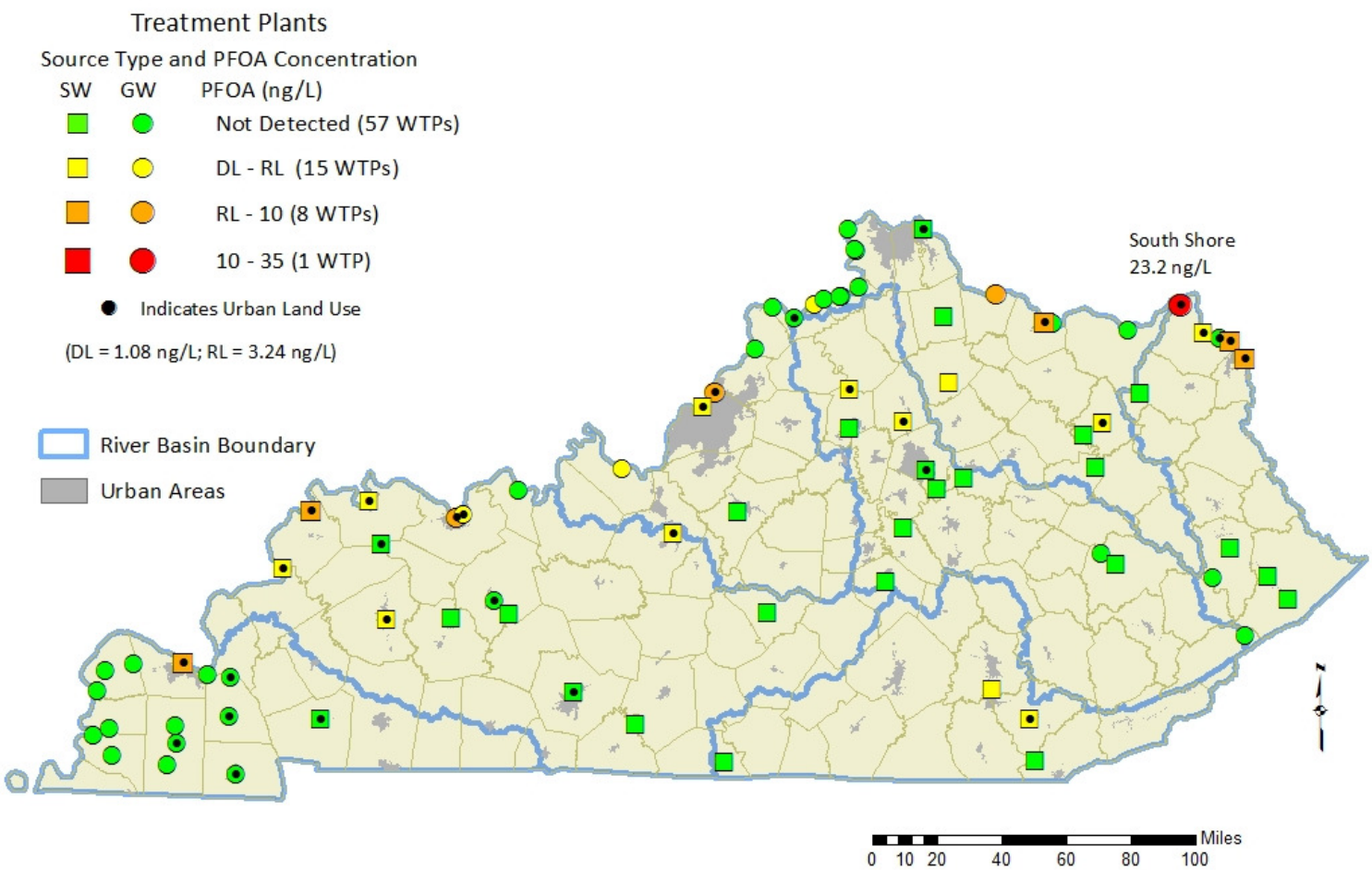
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing Number of Unique PFAS Detected



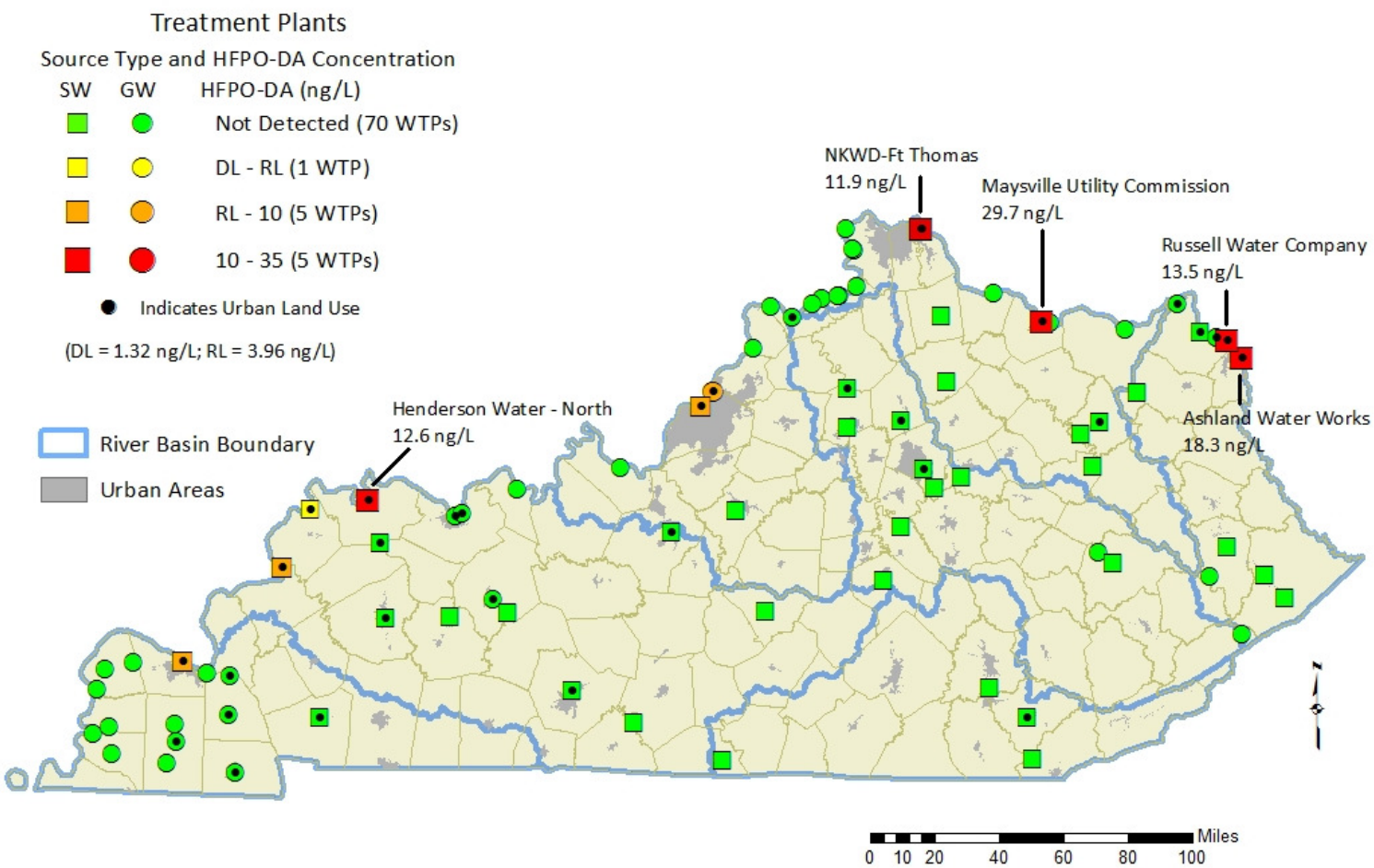
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing PFOS Concentration



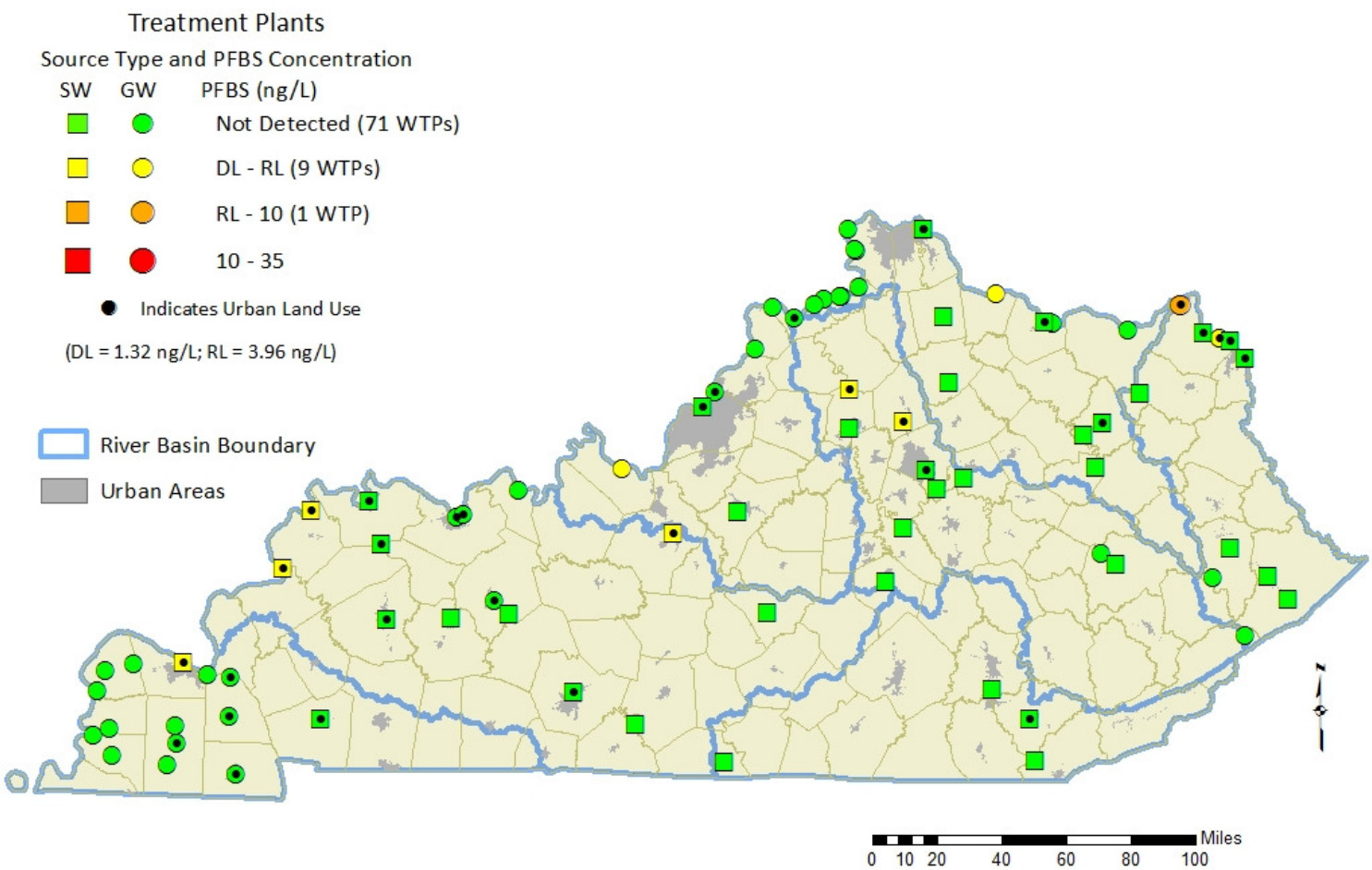
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing PFOA Concentration



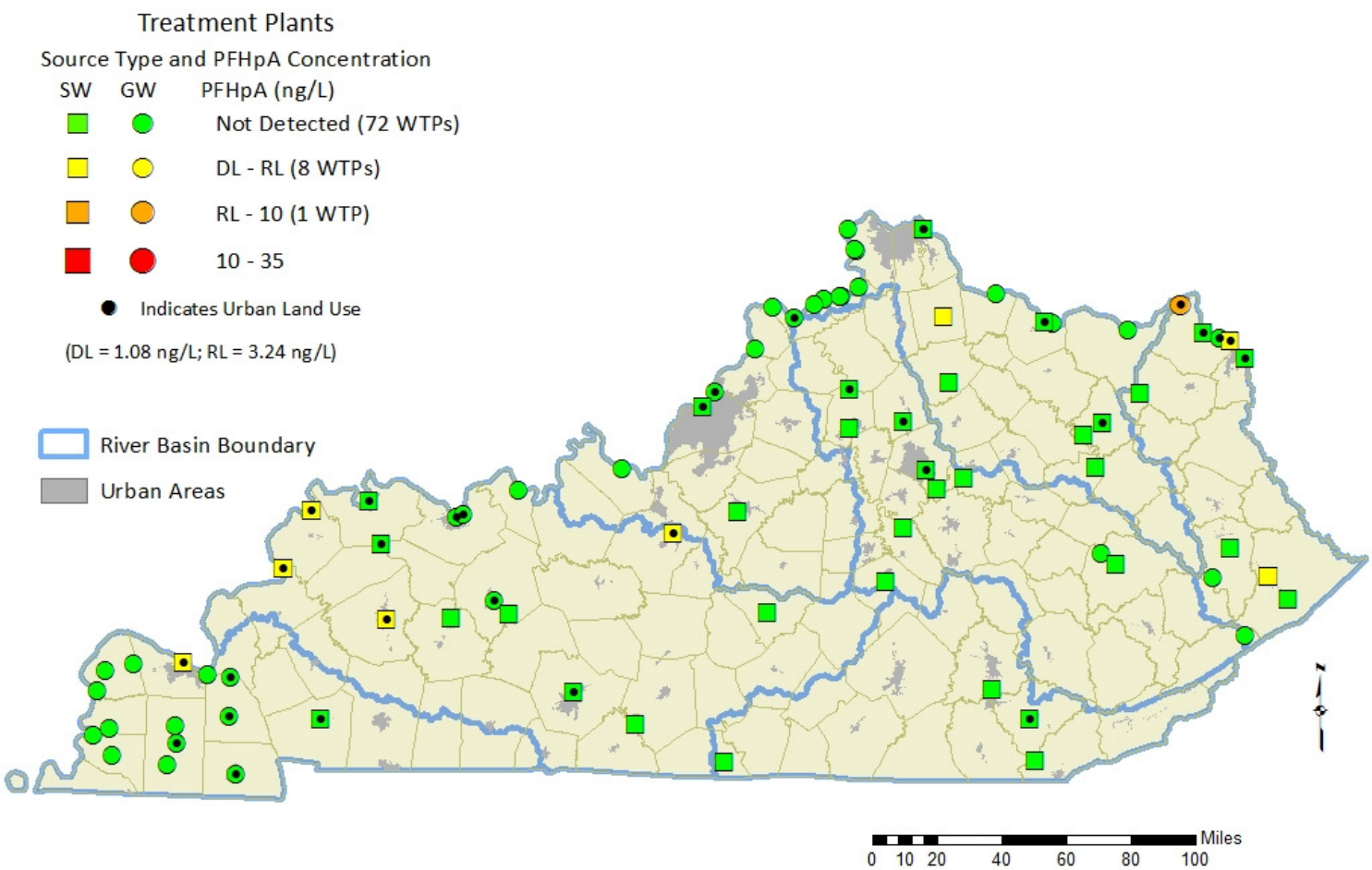
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing HFPO-DA Concentration



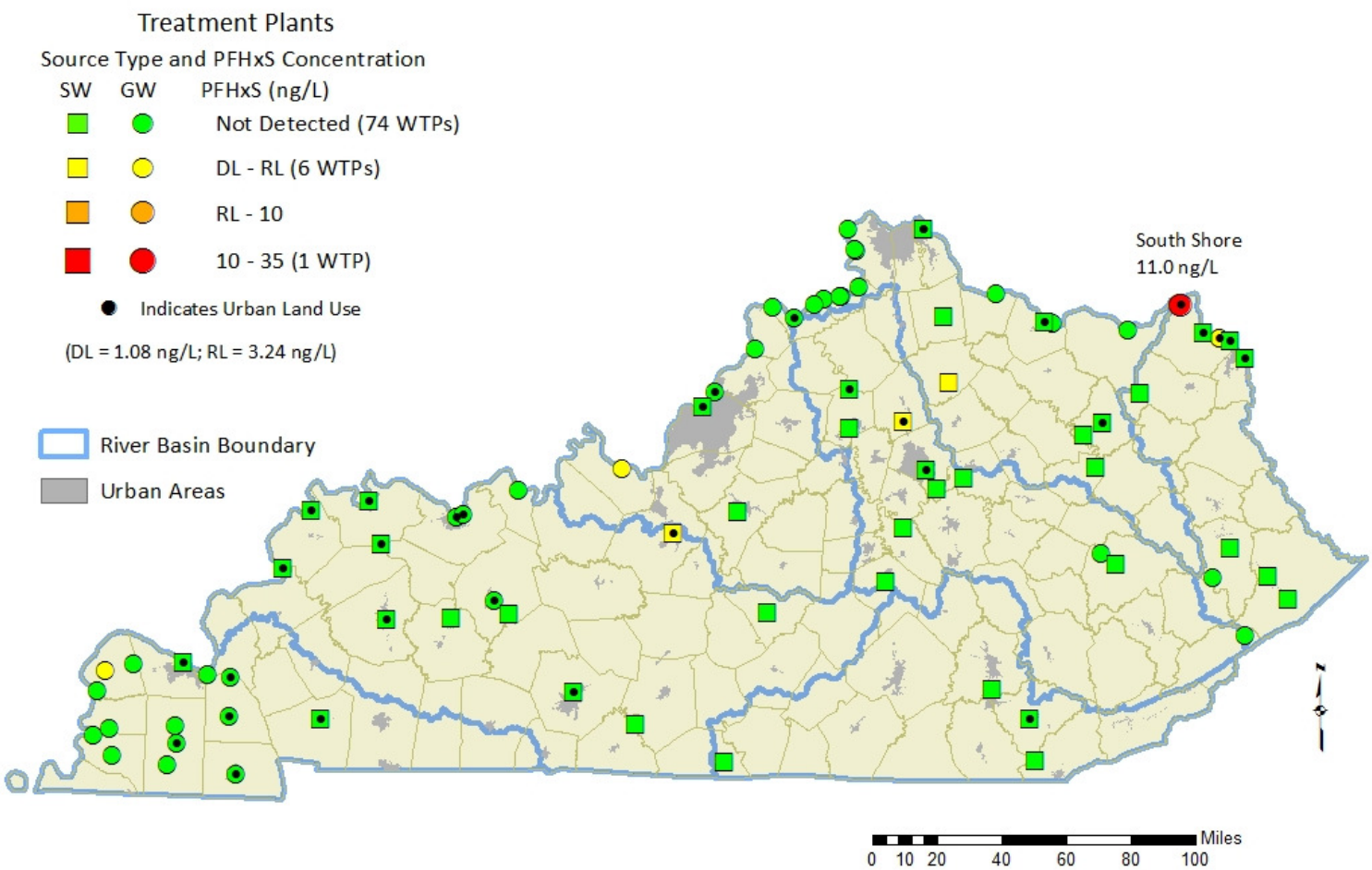
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing PFBS Concentration



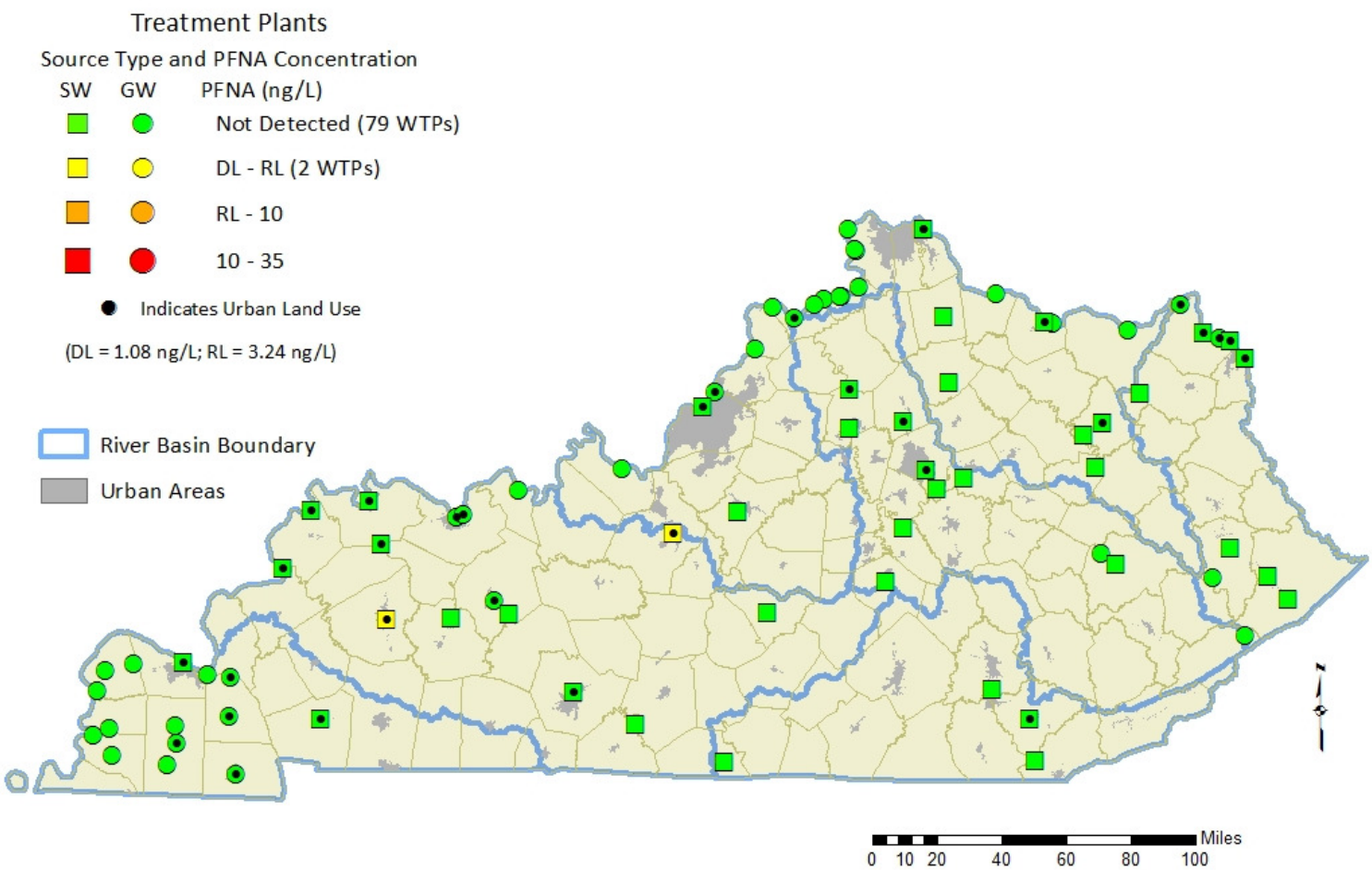
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing PFHpA Concentration



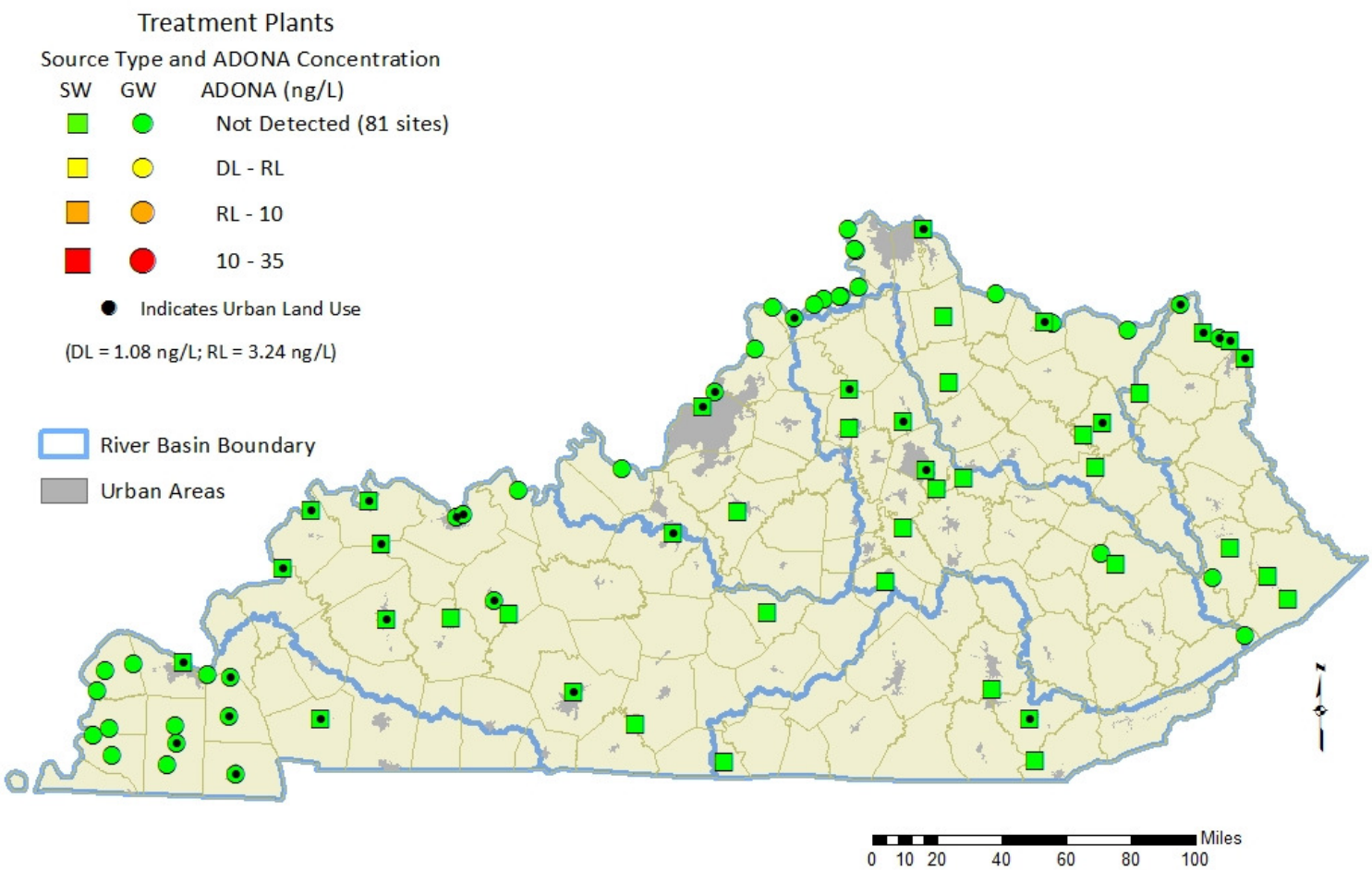
Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing PFHxS Concentration



Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing PFNA Concentration



Drinking Water Treatment Plants in Kentucky
Coded by Source Type and Predominant Land Use Influence
Showing ADONA Concentration



Appendix F

Assessment of the quality of analyses of per- and poly-fluoroalkyl substances (PFAS) by LC/MS/MS technique at the Kentucky DEPS Laboratory

Abstract

The quality of analysis of PFAS by LC/MS/MS technique is assessed via statistical analysis (DES9401) of quality control data though not all QC components have enough data points (n ≥20) for a good evaluation. This study suggests that the overall data quality of this analysis is very good and with the exception of matrix spike samples, the QC failure rate in general is very low. The good quality of analyses is also indicated by the average percent recoveries of VA, FA/A1, LBF and LFM samples for each analyte.

Summary of Analysis[1]

Note:

Average %Recovery of Some QC Samples

The following table shows the average percent recoveries of LFB, LFM, FA/A1 and VA samples:

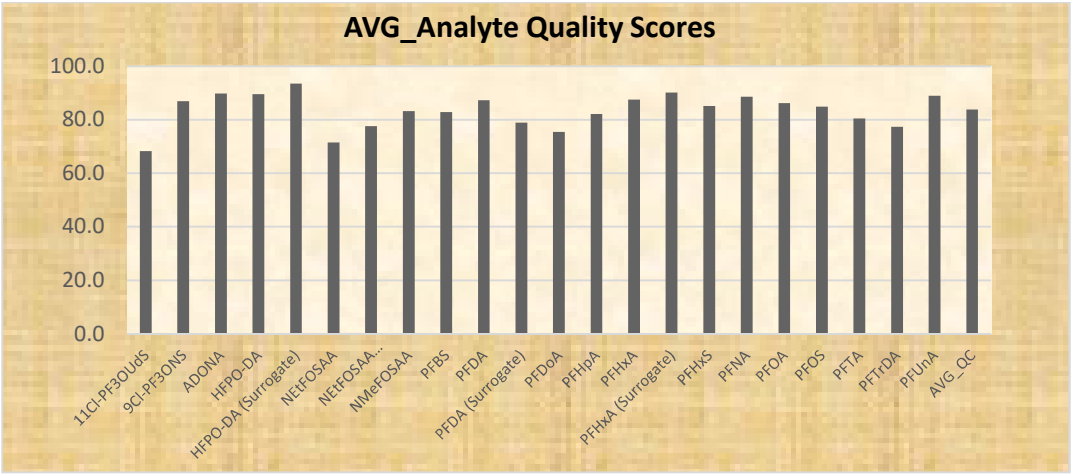
Analyte	AVG-LFB-Recovery (n=14-15)	AVG-LFM-Recovery (n=30)	AVG- FA/A1-Recovery (n=41)	AVG_VA_Recovery (n=17-22)
11Cl-PF3OUdS	98.1	85.3	98.4	68.0
9Cl-PF3ONS	103	98.4	99.8	88.6
ADONA	105	102	101	99.7
HFPO-DA	100	101	98.3	99.6
HFPO-DA (Surr)	98.7	103	98.1	na
NEtFOSAA	93.6	89.3	95.8	87.6
NEtFOSAA (Surr)	92.7	93.3	96.2	na
NMeFOSAA	95.3	92.6	98.8	85.3
PFBS	88.3	98.7	101	93.5
PFDA	100	91.8	97.4	97.7
PFDA (Surr)	102	93.4	97.0	na
PFDoA	86.3	86.8	97.8	97.4
PFHpA	103	100	102	101
PFHxA	101	103	103	100
PFHxA (Surr)	103	105	102	na
PFHxS	101	100	101	96.2
PFNA	102	98	100	97.4
PFOA	103	101	99.9	96.7
PFOS	102	97.7	101	97.3
PFTA	90.8	78	96.3	93.5
PFTrDA	92.7	83.3	96.8	94.6
PFUnA	96.5	88.4	96.4	97

[1] This is a new analysis in this Lab and hence we don't have enough QC data to make a good judgement of the quality through statistical analysis. However, whenever possible similar QC data are combined to get 20 data points or more. The QC components which have at least 20 data points are: VA (not all analytes have 20 points), FG/G1 (combined), S1/S2 (combined), MK, and L0/Q1 (combined). Other QC components like R1R2 and SPRP do not have 20 points yet.

Obviously, on average, most analytes have very good percent recoveries. This is also shown by the good average quality statistical scores described below.

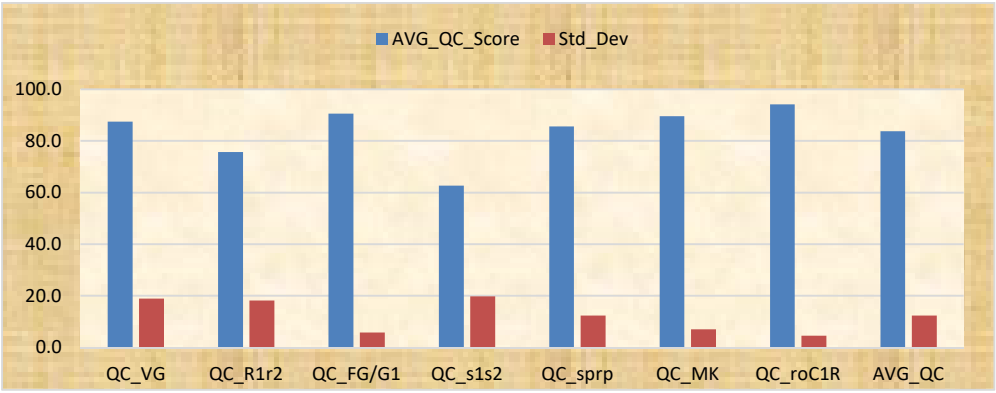
Average Analyte Quality Score

When quality scores for various QC components of an analyte are averaged, we get the average analyte quality score. For any analyte, a score below 80 but above 60 indicates that there may be, on average, one failure per QC component. In this case we have only six analytes which fell into this category. Other analytes performed very well. However, the average of all average scores is above 80 meaning overall data quality is good. Here it may be noted that failures in some analytes are somewhat compensated by better scores in other analytes which have made the grand average score greater than 80.



Average QC Score

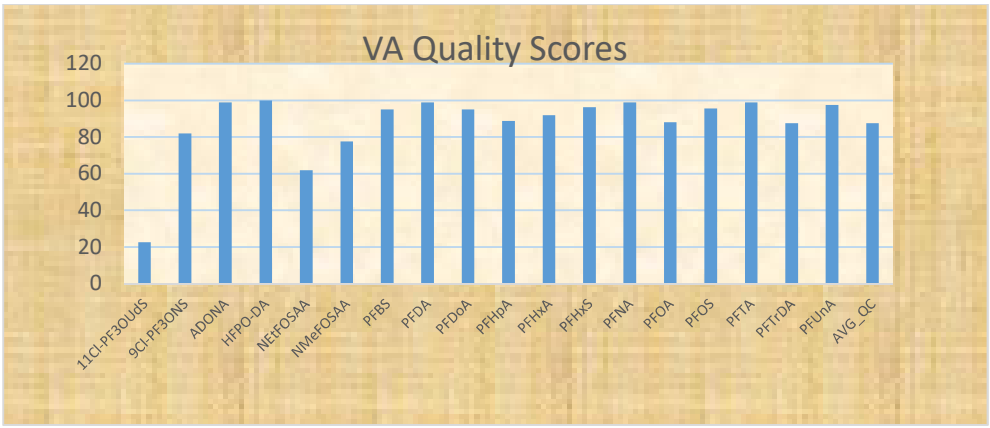
If we look at the average performances of all QC components we will find that only matrix spike recoveries have some failures which could be, on average, one failure per analyte. Also, LFB recoveries have <80 % quality score meaning failures in some analytes are somewhat compensated by good performances of other some other analytes. The average performance of all other QCs is very good meaning the failure rate is almost absent in this analysis.



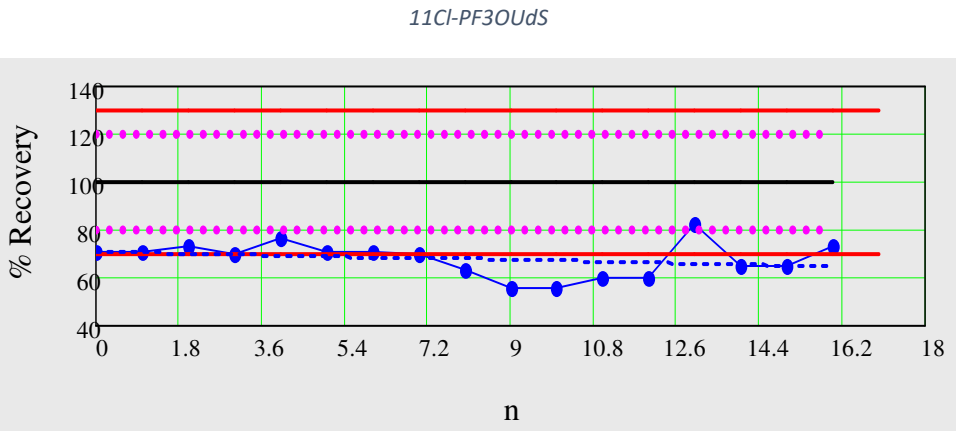
Details

1. VA Samples

For this QC, most analytes have at least 20 points to make a reasonable assessment of quality. With exception of 11Cl-PF3UdS and NEtFOSAA, most analytes performed very well. For the first analyte, there are more than two failures whereas for the second analyte, there is one failure. The quality scores, based on DES9401 method, are displayed in the following diagram:



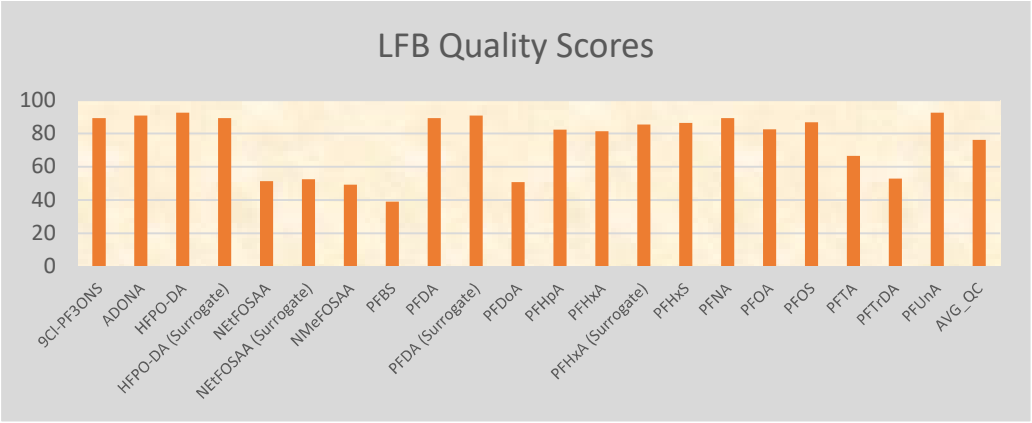
Usually quality score above 80 means data quality is very good; anything below 50 is below average indicating more than 2 failures. A value of quality score in the 60s means, there is one failure. Here most analytes scored above 80 meaning the failure rate is very low for most analytes. Here is the control chart for 11Cl-PF3UdS:



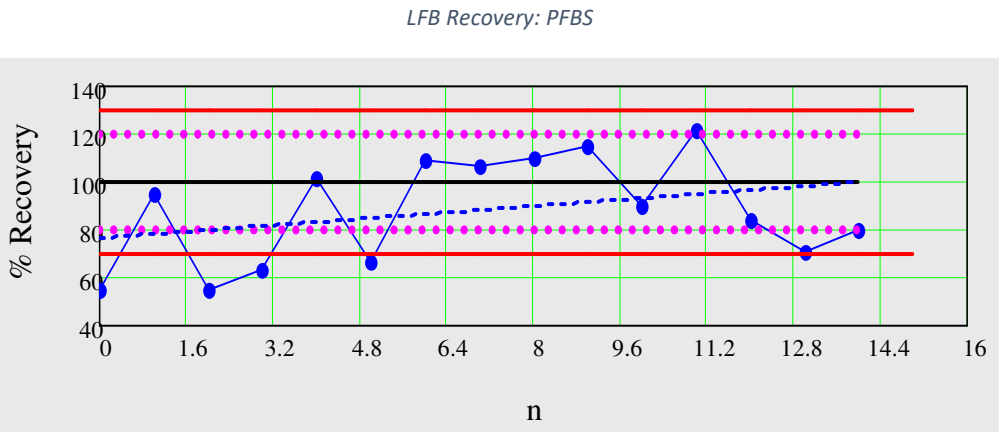
From the above chart, we see that the failure rate is very high for this compound. Some improvements are needed if this is a reportable compound.

2. LFB Samples

With the exception of a few analytes, most analytes performed well. Here also we do not have many data points (n< 20) for a good assessment.

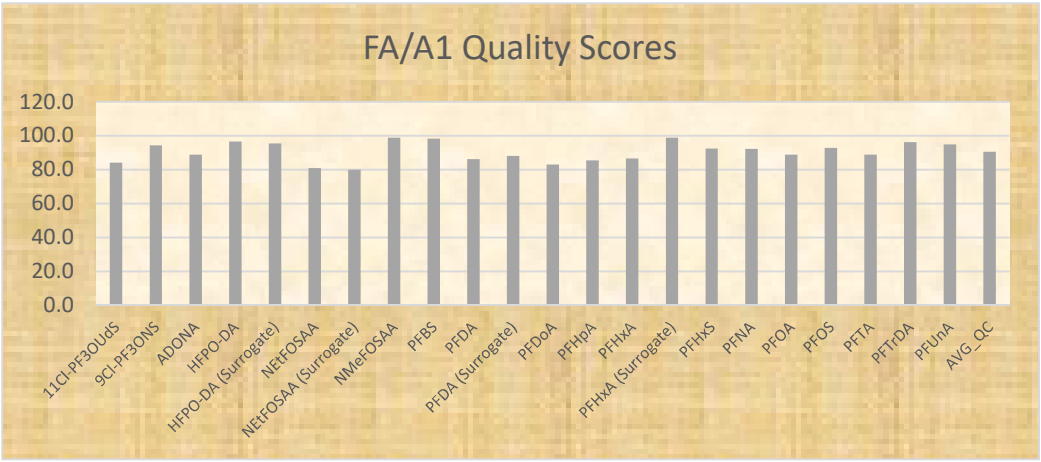


Here is the control chart for PFBS:



3. FA/A1 Samples

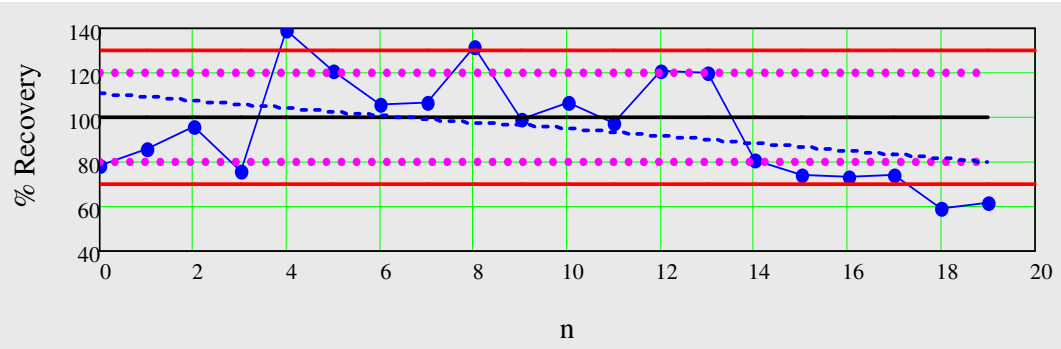
In this case, FA and A1 samples are combined so that we get enough points for making a good statistical analysis. Here the last 30 data points have been used. All analytes performed very well and the average QC quality is very good. This is displayed in the following bar diagram:



4. Matrix Spike Recovery

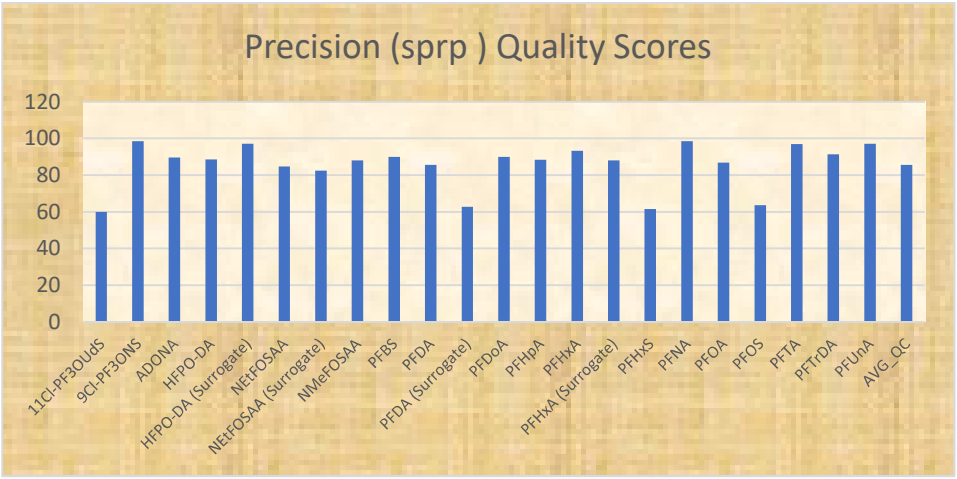
By combining S1 and S2 we got more than 20 data points of which only the last 20 points are used for this analysis. Overall quality score for this QC component is less than 70 but more than 50, meaning all analyte performance was average. The following diagram shows that only six analytes have scored below 50%. These analytes have, on average, more than 2 failures.

Here is the control chart for NEtFOSAA:



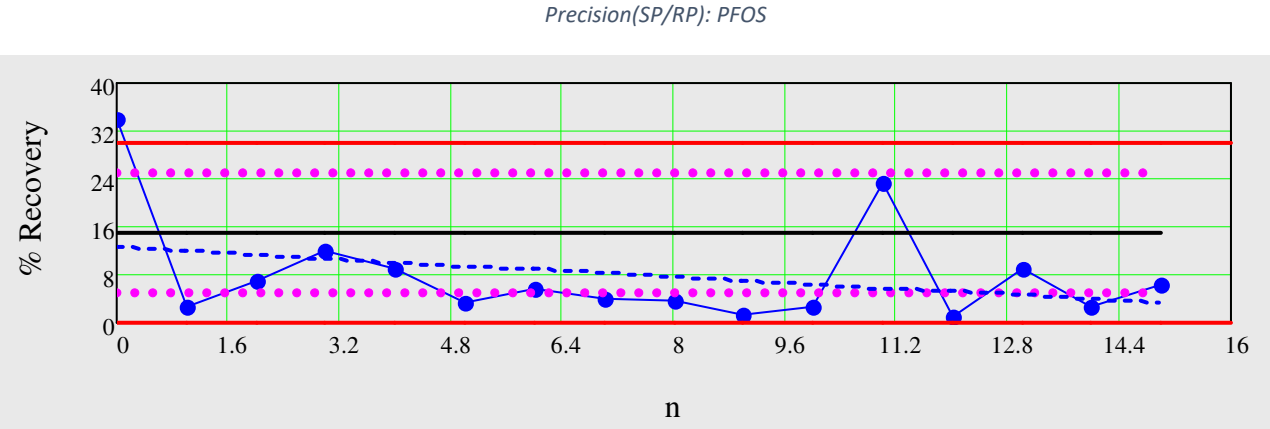
5. Precision: SP/ RP

Here SP and RP data are combined, though it still did not give 20 data points. It has only 17 points; here overall quality score is more than 80 meaning that this QC had a low failure rate.



Here only four compounds scored below 70 % but above 60%. All other compounds scored above 80%.

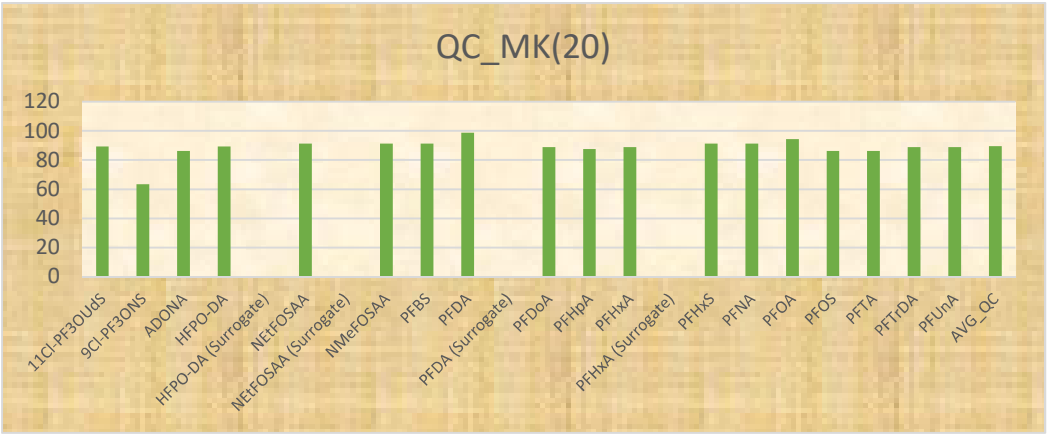
Here is the control chart for PFOS:



Only one failure out of 15 data points.

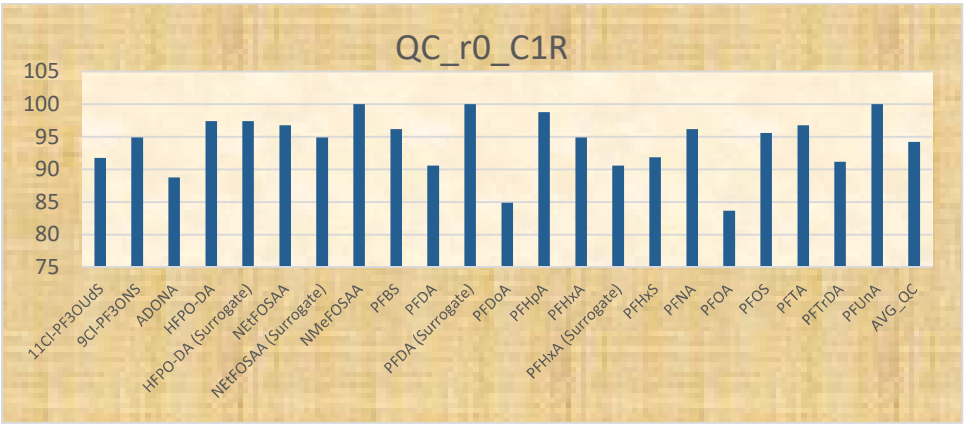
6. MB data

All MB data except 9Cl-PF3ONS performed very well (score > 80%). The following diagram displays the quality for each analyte. This QC component does have at least 20 points to make a good judgement of its quality.



7. Q1-Recovy/ R0

By combining Q1 recovery data with R0, we have more than 20 data points though only the last 20 points are used for the assessment. Overall data quality is excellent (Quality Score >90%).



Analytical Results of Trip Blank and Field Blank Samples													
Sample	Collected	Received	Location	Type	PFBS	HFPO- DA	PFHpA	PFHxS	ADONA	PFOA	PFOS	PFNA	Units
AQ02252	6/3/2019	6/3/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02254	6/3/2019	6/3/2019	Georgetown MWSS	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02256	6/3/2019	6/3/2019	KY-American Richmond Rd Sta	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02258	6/3/2019	6/3/2019	Frankfort Plant Board	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02260	6/3/2019	6/3/2019	KY-American KY River Sta II	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02378	6/10/2019	6/11/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02380	6/10/2019	6/11/2019	NKWD FT Thomas WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02382	6/10/2019	6/11/2019	NKWD Memorial Pkwy WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02384	6/10/2019	6/11/2019	Carrollton Utilities	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02386	6/10/2019	6/11/2019	Carroll Co WD	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02850	7/1/2019	7/1/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02852	7/1/2019	7/1/2019	Warsaw Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02854	7/1/2019	7/1/2019	Cynthiana Municipal	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02856	7/1/2019	7/1/2019	Louisville Water Co Payne Plant	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02858	7/1/2019	7/1/2019	Louisville Water Co Crescent Hill	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02919	7/8/2019	7/9/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02921	7/8/2019	7/9/2019	Falmouth WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02923	7/8/2019	7/9/2019	Augusta WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02925	7/8/2019	7/9/2019	Morehead St University WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ02927	7/8/2019	7/9/2019	Olive Hill WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03019	7/15/2019	7/16/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03021	7/15/2019	7/16/2019	Ashland Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03023	7/15/2019	7/16/2019	Russell Water Company	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03025	7/15/2019	7/16/2019	Worthington Mun Water	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03027	7/15/2019	7/16/2019	Greenup Water System	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03029	7/15/2019	7/16/2019	South Shore	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03031	7/15/2019	7/16/2019	W Lewis Rectorville	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03033	7/15/2019	7/16/2019	Maysville Utility Commission	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03209	7/22/2019	7/23/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03211	7/22/2019	7/23/2019	Bardstown Municipal Water	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03213	7/22/2019	7/23/2019	Hardin County WD #2	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03215	7/22/2019	7/23/2019	Bowling Green Mun Utilities	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03217	7/22/2019	7/23/2019	Beaver Dam Municipal Water	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03219	7/22/2019	7/23/2019	Owensboro Mun Utilites - Cavin Plant	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03221	7/22/2019	7/23/2019	Owensboro Mun Utilities	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03399	7/29/2019	7/30/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03401	7/29/2019	7/30/2019	Hawesville Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03403	7/29/2019	7/30/2019	Henderson Water - North	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03405	7/29/2019	7/30/2019	Henderson Water - South	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03407	7/29/2019	7/30/2019	Madisonville Light & Water	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03409	7/29/2019	7/30/2019	Cadiz Municipal Water	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03411	7/29/2019	7/30/2019	Benton Water & Sewer	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03413	7/29/2019	7/30/2019	Murray Water System	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03415	7/29/2019	7/30/2019	Mayfield Water & Sewer	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03417	7/29/2019	7/30/2019	Graves Co WD - Hickory	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03419	7/29/2019	7/30/2019	Ledbetter WD	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03421	7/29/2019	7/30/2019	Calvert City Municipal Water Dept	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03423	7/29/2019	7/30/2019	Paducah Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03576	8/12/2019	8/13/2019	Winchester Municipal Utilities	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03578	8/12/2019	8/13/2019	Morehead Utility Plant Board	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03580	8/12/2019	8/13/2019	Cave Run Regional WT Comm	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03582	8/12/2019	8/13/2019	KAWC - River Station I	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03584	8/12/2019	8/13/2019	Lancaster Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03643	8/12/2019	8/14/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03645	8/13/2019	8/14/2019	Birkle WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03647	8/13/2019	8/14/2019	Trapps Water Co	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03649	8/13/2019	8/14/2019	Arlinghaus WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03651	8/13/2019	8/14/2019	Gallatin Co WD - Plant A	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03653	8/13/2019	8/14/2019	Gallatin Co WD - Plant B	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03655	8/13/2019	8/14/2019	Carroll Co WD - Gallatin Plant	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03657	8/13/2019	8/14/2019	Milton Water & Sewer Dept	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ03659	8/13/2019	8/14/2019	Trimble County WD#2	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L

Analytical Results of Trip Blank and Field Blank Samples													
Sample	Collected	Received	Location	Type	PFBS	HFPO- DA	PFHpA	PFHxS	ADONA	PFOA	PFOS	PFNA	Units
AQ04020	8/26/2019	8/28/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04022	8/26/2019	8/28/2019	Graves County Water District South	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04024	8/26/2019	8/28/2019	Brandenburg Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04026	8/26/2019	8/28/2019	Central City Water & Sewer	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04028	8/26/2019	8/28/2019	Morganfield Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04030	8/26/2019	8/28/2019	Sturgis Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04032	8/27/2019	8/28/2019	Water Service Corp of KY Clinton	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04034	8/27/2019	8/28/2019	Columbus Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04036	8/27/2019	8/28/2019	Arlington Water Department	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04038	8/27/2019	8/28/2019	Kevil WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04040	8/27/2019	8/28/2019	Wickliffe Municipal Water System	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04042	8/27/2019	8/28/2019	Barlow WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04284	9/9/2019	9/10/2019	Perdue Farms	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04286	9/9/2019	9/10/2019	Monroe Co. WD	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04288	9/9/2019	9/10/2019	Stanford Water Works	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04290	9/9/2019	9/10/2019	Campellsville Municiple Water	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04292	9/9/2019	9/10/2019	Scottsville Water Dept.	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04364	9/9/2019	9/10/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04363	9/10/2019	9/10/2019	Vanceburg Electric Plant Board	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04857	9/30/2019	10/2/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04859	9/30/2019	10/2/2019	Jackson WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04861	9/30/2019	10/2/2019	Mt. Carmel High School WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04863	9/30/2019	10/2/2019	Francis WTP	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04865	9/30/2019	10/2/2019	Southern Water	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04867	9/30/2019	10/2/2019	Pikeville Water Department	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04869	9/30/2019	10/2/2019	Mountain Water District	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04871	10/1/2019	10/2/2019	Fleming-Neon Water Company	Blank	X	X	X	X	X	X	X	X	ng/L
AQ04873	10/1/2019	10/2/2019	Bell Co Forestry Camp	Blank	ND	ND	ND	ND	ND	6.16	ND	ND	ng/L
AQ04875	10/1/2019	10/2/2019	Barbourville Utilities	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ04877	10/1/2019	10/2/2019	Laurel Co Water District #3	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ05127	10/16/2019	10/16/2019	Trip and Temperature Blank	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L
AQ05129	10/16/2019	10/16/2019	Bell Co Forestry Camp	Blank	ND	ND	ND	ND	ND	ND	ND	ND	ng/L