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3M Environmental, Health and Safety Operations

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St. Paul, MN 55144-1000

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3M

Certified Mail

February 6, 2013

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Document Processing Center
EPA East – Room 6428 Attn: Section 8(e)
Office of Pollution Prevention and Toxics, U.S. EPA
1200 Pennsylvania Avenue NW
Washington, DC 20460-0001

Re: TSCA 8(e) Substantial Risk Notice: Sulfonate-based and Carboxylic-based Fluorochemicals, Docket 8EHQ-0598-373 - Results from 2011 Analyses of Fish and Surface Water from the Mississippi River

Dear Sir or Madam:

3M is submitting this notice to supplement previous submissions on sulfonyl and carboxylic-based fluorochemicals (FCs), and more specifically our June 20, 2006, November 9, 2009 and February 11, 2010 submittals concerning fish studies conducted by the Minnesota Pollution Control Agency (MPCA) and our own study that was the subject of correspondence dated December 23, 2011.

The aforementioned December 23, 2011 submittal documented an extensive study of Pool 2 of the Mississippi River that was commissioned by 3M to evaluate the summer 2011 levels of FCs in fish tissue and surface water. At that time, the analytical work for perfluorooctane sulfonate (PFOS) for the study had been completed and was documented in a report entitled Mississippi River Pool 2 PFOS Assessment – Fish Tissues and Surface Water – Summer 2011. This report, along with three supporting analytical reports, was submitted to the subject docket in December 2011.

Subsequently, final analytical results have been generated for the twelve additional FC analytes that were also part of the 2011 Mississippi River Pool 2 study. These include perfluorobutane sulfonate, perfluorohexane sulfonate, perfluorooctane sulfonamide, perfluorobutyric acid, perfluoropentanoic acid, perfluorohexanoic acid, perfluoroheptanoic acid, perfluorooctanoic acid, perfluorononanoic acid, perfluorodecanoic acid, perfluoroundecanoic acid and perfluorododecanoic acid. Results for these constituents, along with the previously submitted perfluorooctane sulfonate data, for both fish tissue and surface water, have recently been compiled in a comprehensive report entitled Mississippi River Pool 2 PFC Assessment – Fish Tissues and Water – Summer 2011 (enclosed).

CONTAINS NO CBI

While 3M does not believe that any of these data taken alone or cumulatively meet the "substantial risk" reporting threshold, we nevertheless recognize the ongoing work by U.S. EPA to assess fluorochemical exposure pathways. Therefore, we are placing these results in the 8(e) docket as a supplement to previous submissions.

If you have any questions, please contact Deanna Luebker at 651-737-1374 or djluebker@mmm.com .

Sincerely,

Jean B. Sweeney (DL)

Jean B. Sweeney
Vice President
Environmental, Health and Safety Operations

Enclosure

Cardno ENTRIX

Shaping the Future

Mississippi River Pool 2 PFC Assessment – Fish Tissues and Water – Summer 2011

November 2012

Project No. 70784004

Prepared For

3M Company

Mississippi River Pool 2 PFC Assessment – Fish Tissues and Water – Summer 2011

November 2012

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Prepared for

3M

3M Company
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List of Acronyms

ASTM	ASTM International; formerly known as American Society for Testing and Materials
CCV	Continuing Calibration Verification
CoC	Chain of Custody
DI	Deionized (water)
ECF	Electrochemical fluorination
GPS	Global Positioning System
HPLC/MS/MS	High Performance Liquid Chromatography/Tandem Mass Spectrometry
IQR	Interquartile Range
LC-MS/MS	Liquid Chromatography/Mass Spectrometry or Triple Quadrapole Mass Spectrometry
LCS	Laboratory Control Spike
LIMS	Laboratory Information Management System
LLOQ	Lower Limit of Quantitation
LMS	Laboratory Matrix Spike
LOQ	Limit of Quantitation
MDH	Minnesota Department of Health
MDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MRM	Multiple Reaction Monitoring
MSU	Michigan State University
OPR	Ongoing Precision and Recovery
PFC	Perfluorochemical
PFAS	Perfluoroalkyl Sulfonate
PFCA	Perfluorocarboxylic Acid
PFOS	Perfluorooctane sulfonate

QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SOP	Standard Operating Procedure
SPE	Solid Phase Extraction
TMDL	Total Maximum Daily Loading
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WTL	Wildlife Toxicology Laboratory, Michigan State University
WW	wet weight

Executive Summary

The presence of perfluorochemicals (PFCs) in the ambient environment is of interest to numerous stakeholders. In Minnesota, there is a growing dataset of measured levels of PFCs in surface waters and fish tissue. The Mississippi River, and more specifically Pool 2 of the river, is one water body that has experienced such an increase in monitoring data in recent years.

In May 2011, Cardno ENTRIX was contracted by 3M to collect fish and water samples from Pool 2 of the Mississippi River. Cardno ENTRIX and Cardno JFNew personnel made three trips to Pool 2 throughout the summer. The study objective called for the collection of ten samples of each of four fish species (freshwater drum, bluegill, smallmouth bass and white bass) from ten reaches within Pool 2 for a total fish collection target of up to 400 fish. This goal was essentially met with the collection of 396 fish. A contemporaneous collection of 30 water samples, 3 from each of the 10 reaches, was also completed. Blinded fish tissue and water samples were analyzed for 4 perfluoroalkyl sulfonates (PFAS) including perfluorooctane sulfonate (PFOS) and nine other perfluoroalkyl carboxylates (PFCAs) at the 3M Environmental Laboratory (3M lab, ISO17025 Accredited) and at the AXYS Analytical Services laboratory (AXYS, ISO17025 Accredited). The 3M lab in St. Paul, MN received all fish fillet and water samples while AXYS served as a third-party confirmation laboratory and received splits of 68% of the water samples and ~10% of the fish fillet tissue samples generated.

In November 2011, a report titled "Mississippi River Pool 2 PFOS Assessment – Fish Tissues and Water – Summer 2011" was prepared by Cardno ENTRIX. At that time, the analytical results for PFOS had been finalized. Subsequently, final analytical results for additional analytes have been completed. This report has been written to present all of the results, including those previously reported for PFOS, in one comprehensive document.

While the focus of this study was on PFOS, this report presents analytical results for PFOS and twelve other PFCs that have been measured in 30 surface water samples and in 396 fish tissue samples. Arithmetic mean results, by species and for the water samples collected, are summarized in Table ES-1. For fish tissue, PFOS was clearly the dominant analyte in terms of measured concentrations with arithmetic means ranging from 36 to 64 ng/g across the four species. The means for all species for all of the other twelve analytes were less than 4 ng/g and the means were less than 0.5 ng/g for seven of the twelve (PFBS, PFHS, PFBA, PFPeA, PFHxA, PFOA and PFNA). For the surface water samples, arithmetic means were from highest to lowest: PFBA (32 ng/L) > PFBS (12 ng/L) ≈ PFOA (10 ng/L) > PFOS (6.1 ng/L) with the means for all other analytes being at or below 5 ng/L.

To elaborate on the PFOS results, the concentration of PFOS in the surface water samples ranged from less than the limit of quantitation (LOQ) up to 136 ng/L with 21 of the samples being less than the LOQ. PFOS concentrations based on the arithmetic and geometric means for Pool 2 were 6.14 and 1.67 ng/L, respectively. The median PFOS water concentration was equivalent to the LOQ. The concentrations of PFOS in the 2011 Mississippi River fish samples ranged from 3.17 to 757 ng/g. Arithmetic mean, geometric mean, and median PFOS concentrations for all fish samples from Pool 2 were 46, 31 and 34 ng/g, wet weight (ww), respectively. The arithmetic means for bluegill, freshwater drum, smallmouth bass, and white base were 36, 46, 39, and 64 ng/g ww, respectively.

Table ES-1. Mean Concentrations of Target Analytes in Fish Tissue (ng/g ww) and Surface Water (ng/L) Samples (ND= 1/2LOQ)

	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
Bluegill	0.06	0.42	36	0.08	0.27	0.17	0.19	0.04	0.09	0.10	1.4	0.83	0.59
Freshwater drum	0.09	0.09	46	0.33	0.38	0.18	0.24	0.03	0.12	0.28	1.7	1.1	1.1
Smallmouth bass	0.06	0.04	39	0.97	0.21	0.21	0.16	0.04	0.08	0.05	1.7	1.2	1.2
White bass	0.06	0.12	64	1.3	0.26	0.15	0.20	0.03	0.08	0.51	3.6	1.8	1.5
Water	12	3.0	6.1	1.0	32	5.1	2.2	1.0	10	1.0	1.0	1.0	1.0

With the exception of PFBS, the agreement between laboratories for reported fish and water sample concentrations was good with the average relative percent differences (RPD) for PFASs and PFCAs generally being 25% or less. Interpretation of PFBS result was confounded by the fact that two of the 30 samples had concentrations greater than the LOQ as reported by both laboratories. For PFOS, the RPD for fish tissue concentrations was generally less than 25%. The interlaboratory comparison of water PFC concentrations was limited due to the large number of non-detects reported by both laboratories. Based on water samples that had reported concentrations from both laboratories, the RPD ranged from 1.6 to 135% with an overall arithmetic average and median of 36% and 33%, respectively. For PFOS, the RPD ranged from 17 to 56% with an average of 35%.

An additional post-study validation exercise, focused on PFOS, was also completed at both the 3M Environmental and AXYS laboratories. This effort included the analysis of blinded duplicate standard reference fish tissues (SRM) from the National Institute of Standards and Technology (NIST) and splits of previously analyzed archived Pool 2 fish tissue samples. Results from this exercise showed good agreement between PFOS concentration measured in this study to that reported in the previous analyses conducted by both laboratories. In addition, PFOS concentration reported by both laboratories for the SRM samples fell within the acceptable range reported by NIST.

This report summarizes the field sampling activities, the analytical procedures followed throughout the study, and the analytical results associated with the Mississippi River fish and water samples.

Chapter 1

Introduction, Objectives, and Scope of 2011 Fish and Water Collection Efforts

1.1 Introduction and Objectives

The purpose of this study is to provide current and comprehensive site-specific measures of perfluorooctane sulfonate (PFOS) and 12 other perfluorochemicals (PFCs) in fish fillet tissues and surface water samples from Pool 2 of the Mississippi River.

Previous studies have reported varying concentrations of PFOS in a variety of fish species and surface water from various locations within Pool 2 (Weston 2006; MPCA 2010); the current collections are meant to improve the knowledge base concerning PFOS and other PFCs in these media.

The data from this study is intended to be used to evaluate current levels of PFCs in fish fillet tissue and water surface samples from Pool 2. In addition, these data support the formulation of a baseline that can be used to identify and characterize the impact of potential sources throughout the pool as well as evaluate the potential effects of mitigation efforts to reduce PFCs within Pool 2. Furthermore, it was envisioned that data gathered in this study might be helpful in preparing a Total Maximum Daily Loading (TMDL) for PFOS in Pool 2 should the impairment status remain unchanged.

Sample collection and analysis activities were carried out under guidelines introduced in the project work plan titled "Work Plan for the Collection of Fish and Surface Water from Pool 2 of the Upper Mississippi River, Minnesota" (Cardno ENTRIX, 2011) and the Quality Assurance/Quality Control (QA/QC) conditions specified in the associated Quality Assurance Project Plan (QAPP). These documents are available upon request.

1.2 General Site Description

The upper and lower extent of Mississippi River Pool 2 is defined by two dams and locks (see Figure 1-1). The upper extent of this pool is bounded by Lock & Dam #1 (River Mile 847.9) located between Minneapolis and Saint Paul just north of the confluence of the Mississippi and Minnesota Rivers. The lower extent of Pool 2 is defined by Lock & Dam #2 located upstream of Hastings, MN (River Mile 815.2). To date, several studies have evaluated the presence of multiple PFCs in several fish species within Pool 2. Early work was focused on very limited areas within the pool and generally involved small numbers of fish collected. More recently, a study conducted by Minnesota Pollution Control Agency (MPCA) in 2009 (MPCA, 2010) focused on 5 fish species collected from four unequally divided reaches within the pool.

For the current study, a total of 10 sampling reaches of approximately three miles in length were identified between the Ford Dam (Dam/Lock #1) and the Hastings Dam (Dam/Lock #2). The exact size and coordinates of each reach was adapted to take into account factors such as input from Minnesota Department of Natural Resources (MDNR) personnel, conversations with local anglers, amount of suitable habitat for each targeted species, proximity to public access sites and other recognizable landmarks (e.g. public parks and fishing areas, boat launches), etc. The approximate

location of reach boundaries is provided in Figure 1-1 and general descriptions of geographic landmarks that correspond with reach boundaries is provided below. Field crews used these approximate locations as guides and final reach boundaries were selected based upon landmarks and points of reference that could be easily identified in the field. The field crew also incorporated 100-200 m "buffer zones" between reaches.

Reach 1: Ford Dam (River Mile 847.9) downriver to the Pike Island Daymark (River Mile 844.7R)

Reach 2: Pike Island Daymark downriver to the ADM Dock Lights (River Mile 841.7L)

Reach 3: ADM Dock Lights marker downriver to the Farm Bureau Dock Lights (River Mile 838.6R)

Reach 4: Farm Bureau Dock lights to the tip of Pigs Eye Island #1 (River Mile 835.3L)

Reach 5: Pigs Eye Island #1 marker downriver to the South St. Paul Access boat launch (River Mile 832.4R)

Reach 6: South St. Paul Access boat launch downriver to the Merimac Island Light and Daymark (River Mile 829.2R)

Reach 7: Merimac Island Daymark downriver to the Robinson Rocks Light and Daymark (River Mile 825.9R)

Reach 8: Robinsons Rocks Daymark downriver to the Grey Cloud Landing & Daymark (River Mile 822.4L)

Reach 9: Grey Cloud Daymark downriver to the Freeborn Island Light and Daymark (River Mile 818.9L)

Reach 10: Freeborn Island Daymark down river to the Hastings Dam (River Mile 815.2)

This stretch of river is historically heavily industrialized and populated. Sources of discharge to this water body include municipal storm water, publicly owned treatment works, refineries, airports and industrial facilities.

1.3 Target Analytes

Based on numerous PFC assessments that have been conducted in Minnesota, a broad suite of analytes were targeted in this study (see Table 1-1). The selection of these constituents took into account previous fish tissue monitoring activities, thereby enabling the possibility of comparisons over time. Limits of quantitation for all target analytes were 5 ng/L for water and 0.25 ng/g for fish fillet tissue. This report contains the results for all target analytes.

1.4 Target Fish Species

The target species in this study were smallmouth bass (*Micropterus dolomieu*), white bass (*Morone chrysops*), freshwater drum (*Aplodinotus grunniens*), and bluegill (*Lepomis spp*). These species were chosen for a variety of reasons:

- They represent several species that may be harvested by licensed anglers for consumption;
- They are species that have been previously assessed relative to PFC levels and represent those most inclined to have higher levels; and/or
- They constitute a representative scientific assessment of the water body.

A basic study objective was to collect 10 samples of each species in each of the 10 reaches defined in this study, i.e., total fish collection of 400 specimens.

1.5 Tables and Figures

Table 1-1. Targeted PFCs in Tissues of Fish and Water Samples Collected from the Mississippi River, MN

Compound	Acronym	CAS #	Molecular Formula
Perfluorosulfonates			
Perfluorobutane sulfonate	PFBS	29420-49-3	$CF_3(CF_2)_3SO_3H$
Perfluorohexane sulfonate	PFHS	432-50-7	$CF_3(CF_2)_5SO_3H$
Perfluorooctane sulfonate	PFOS	1763-23-1	$CF_3(CF_2)_7SO_3H$
Perfluorooctane sulfonamide	PFOSA	4151-50-2	$CF_3(CF_2)_7SO_2NH_2$
Perfluorocarboxylates			
Perfluorobutyric acid	PFBA	375-22-4	$CF_3(CF_2)_2CO_2H$
Perfluoropentanoic acid	PFPeA	2706-90-3	$CF_3(CF_2)_3CO_2H$
Perfluorohexanoic acid	PFHxA	307-24-4	$CF_3(CF_2)_4CO_2H$
Perfluoroheptanoic acid	PFHpA	375-85-9	$CF_3(CF_2)_5CO_2H$
Perfluorooctanoic acid	PFOA	335-67-1	$CF_3(CF_2)_6CO_2H$
Perfluorononanoic acid	PFNA	375-95-1	$CF_3(CF_2)_7CO_2H$
Perfluorodecanoic acid	PFDA	335-76-2	$CF_3(CF_2)_8CO_2H$
Perfluoroundecanoic acid	PFUnA	2058-94-8	$CF_3(CF_2)_9CO_2H$
Perfluorododecanoic acid	PFDoA	307-55-1	$CF_3(CF_2)_{10}CO_2H$

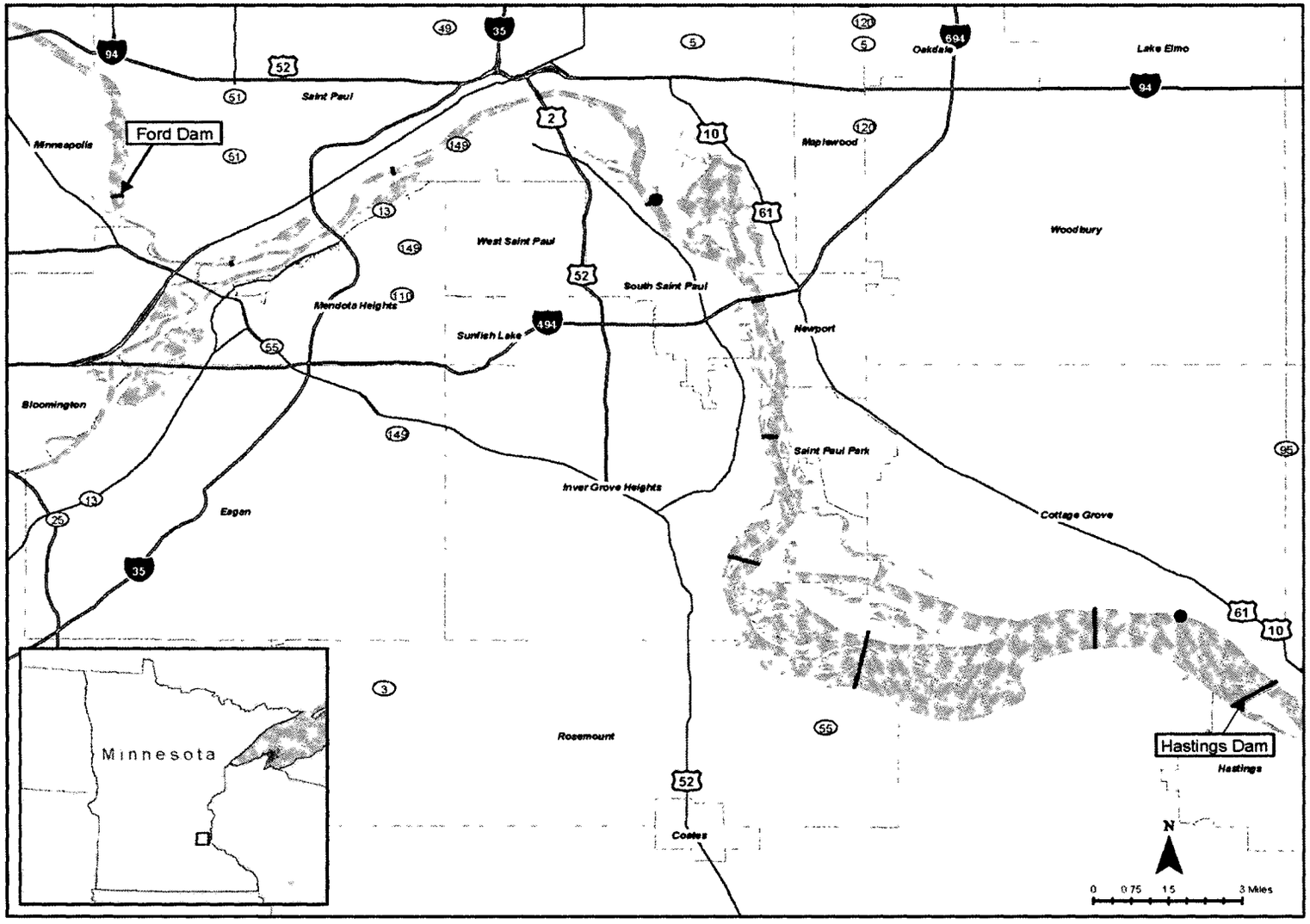


Figure 1-1. Overview of Sampling Area and Approximate Reach Boundaries of 2011 Fish and Water Collection

Chapter 2

Sample Collection Summary

2.1 Fish Collection and Shipment

Electrofishing was the primary sampling method utilized in this effort. Field personnel operated a Smith-Root boat-mounted electrofishing unit with one person navigating and two persons stunning and capturing fish. Non-target species (e.g., channel catfish) were returned to the river. In order to collect fish where electrofishing was not effective, hook and line sampling was also conducted during the last two days of the sampling effort. The sample collection was conducted under a Scientific Collector's Permit granted to Cardno ENTRIX by the MDNR. All practices were conducted in such a way to ensure public and worker safety.

Upon arriving at a given reach, the field crew assessed the area for habitat suitable for the targeted fish species. Once a starting point had been identified, the crew collected GPS coordinates and began an electrofishing "run." Electrofishing runs varied in length depending on the availability of suitable fish habitat, boat traffic, etc. GPS coordinates were collected at the end of each run as well, providing start and end coordinates (See Appendix A, Table A-1). The number of runs conducted in each reach varied but in general, ranged between 10-20 total. Field crew worked both sides of the river in each reach. Figure 2-1 provides an overview of fish collection locations for Pool 2 and the maps in Appendix A show start and end points for electrofishing runs from which fish were collected in a given reach.

Upon collection, fish were placed in clean coolers containing bagged wet ice until the end of a electrofishing run. After this each fish was tagged with a unique ID number and stored in a clean cooler containing bagged wet ice. When the day's collection activities were finished, fish were placed in an individual bag and the bagged fish were then transferred to clean coolers containing double-bagged wet ice. Chain of custody (CoC) forms were filled out for each cooler and placed inside a Ziploc bag. Coolers were taped shut with the CoC form inside and one or more custody seals were affixed to each cooler.

In most cases, coolers were shipped (FedEx or UPS Priority Overnight) at the end of each collection day. Occasionally, fish needed to be held overnight and shipped out the next morning. Shipments were sent to the Wildlife Toxicology Laboratory (WTL) at Michigan State University (MSU). Upon receipt, WTL personnel cross-referenced fish in each cooler against the accompanying CoC form(s). Once the information was verified as correct, the CoC was signed, dated, and stored in a three-ring binder.

2.2 Water Collection

Water samples were collected from 3 locations within each sampling reach (Figure 2-2). However, due to high water levels (Figures 2-3 and 2-4), sampling was conducted in two sampling rounds (see Sections 2.3 and 2.4 for a summary of sampling periods). Water samples were taken from the water column approximately 12 to 24 inches below the surface and from the main river channel and/or locations from which fish were collected. All samples were collected as grab samples using a 1.5 L wide-mouthed Nalgene® polyethylene bottle. Water was then poured from the 1.5 L bottle into

smaller (generally 250 ml) bottles supplied by the analytical laboratories. All water samples (44 total) were sent to the 3M Environmental Laboratory (3M lab) for analysis. Splits of ~68% of the water samples were sent to AXYS for confirmatory analysis. Sample bottles for each set were provided by the respective analytical laboratory. Bottles provided by the 3M lab were weighed and then spiked with internal standard, surrogate, or target analyte for QC purposes prior to providing the bottles to Cardno ENTRIX field personnel. Water samples sent to the AXYS lab were spiked with surrogate standards at the laboratory. Water samples were transported to the laboratory on wet ice and refrigerated until analyzed for PFCs.

In Round 1, GPS coordinates as well as field measurements of water temperature, dissolved oxygen, pH and conductivity were recorded at each sampling location. In Round 2, GPS coordinates, water temperature, and dissolved oxygen measurements were also recorded, but due to equipment failure pH and conductivity measurements were not taken.

2.3 Pool 2 Sampling Rounds

The original study design called for all fish and water sampling activities to be completed in a two to three week period commencing May 31st. However, due to precipitation events preceding the start of field efforts, water levels in Pool 2 were highly variable and elevated (see Figures 2-3 and 2-4). As a result of these unusually high water levels, electrofishing was hampered by at least the following factors:

- Defined structure (e.g., rip rap, downed timber, etc) where fish would normally hold was under significant amounts of water and therefore not available;
- High river current decreased the general effectiveness of electrofishing and specifically the amount of time the crew had to net stunned fish;
- Water clarity was extremely low (< 3ft) making fish capture more difficult; and
- Increased safety concerns related to high current and invisible underwater obstacles.

Accordingly, after a concerted two week effort, a decision was made to postpone fish and water collection and resume a few weeks later after water levels had dropped. With the suspension of fish collection efforts due to high water levels, it was decided that the full longitudinal water sample collection needed to be repeated with the next round of sampling. Accordingly, it is the full set of water samples collected on August 11, 2011, (Round 2) that is considered primary for this study.

At the close of the scheduled August sampling period, the number of fish collected was at approximately 90% of the study objective. In an effort to meet the study objective of 10 fish per species per reach, a third sampling period was arranged for early September.

In summary, three sampling trips, or rounds, were required to complete the fish collection. Round 1 took place from May 31-June 9; Round 2 from August 1-10, and Round 3 from September 11-15. Details concerning each of these sampling periods are provided in Section 2.4.

2.4 Fish and Water Collection Rounds

2.4.1 Round 1: May 31 – June 9, 2011

A total of 148 fish and 14 water samples were collected during Round 1 (Table 2-1).

During discussions leading up to the field effort, MDNR fisheries biologists informed Cardno ENTRIX and Cardno JFNew personnel that large (> 5 in) bluegills were relatively scarce in Pool 2 and that target numbers of bluegill may be hard to collect in all reaches. Therefore, the work plan called for the collection of any *Lepomis* species including sunfish as they share many similar traits (e.g., preferred prey and habitat) with bluegills and would likely be a suitable surrogate species in the event that target numbers of bluegill could not be collected from a given reach or reaches.

One sunfish was collected from Reach 2 during Round 1. Since this fish was the only *Lepomis* individual collected from Reach 2, the decision was made to process and analyze the fish because at that time, it was not clear whether or not the field crew would be able to collect 10 bluegill of sufficient size from Reach 2. Ultimately, 10 bluegill were collected and analyzed from this reach. As a result, the data from the sunfish is not presented in this report but PFC results can be found in Appendix A, Table A-1.

During Round 1, a total of 15 drum were collected from Reach 10. The extra 5 drum (beyond the study objective of 10) were collected in error when the field crew inadvertently did not check the drum tally sheet upon ending an electrofishing run. The error was caught by the MSU lab during sample check-in and the decision was made to process the drum in sequential order, send the first 10 drum for PFC analysis, and archive the extra 5.

During Round 1, water sample collection was conducted in Reaches 1, 2, 3, 8, and 10 as those reaches are where the majority of fish were collected. A total of 14 water locations were sampled at this time. Splits of each water sample were provided to the 3M and AXYS labs as part of the data validation process. Results from these water samples were used only for the interlab comparison (As previously discussed the Round 2 samples are considered the primary data from this study).

2.4.2 Round 2: August 1 – August 11, 2011

A total of 206 fish and 30 water samples were collected during Round 2 (Table 2-2). Pool 2 water levels and current were decreased from Round 1 conditions.

One green sunfish was collected from each of Reaches 4 and 5 during Round 2. These fish were processed and analyzed. The rationale for keeping the green sunfish was that the majority of bluegill that had been collected through Rounds 1 and 2 were small (4-5 in) and it was not apparent if the bluegill would yield sufficient tissue mass for PFC analysis. In addition, there was still doubt that the target sample size of 10 bluegill per reach could be obtained. Ultimately, 10 bluegill were collected and analyzed from all reaches. As a result, the data from the green sunfish are not presented in this report but PFC results can be found in Appendix A, Table A-1.

Water samples were collected on August 11, 2011, from all reaches (3 samples per reach) and delivered to the 3M lab. AXYS received a subset of the water samples from reaches that had not been sampled in Round 1 (3 samples from Reaches 4, 5, 6, 7, and 9 each, plus 1 sample from Reach 10) for a total of 16 samples. When combined with the 14 water samples collected in Round 1, a grand

total of 30 water samples, 3 from each of the 10 reaches were shipped to AXYS. Results from the samples sent to AXYS were used for the interlab comparison.

2.4.3 Round 3: September 11 – September 15, 2011

A total of 51 fish were collected during Round 3 (Table 2-3). Pool 2 water levels and current had decreased compared to Rounds 1 and 2 and the visibility had improved.

In order to reach study objectives, the field crew mainly focused on freshwater drum and white bass during this effort. An extra bluegill was collected from Reach 9, bringing the bluegill collection total to 11 from Reach 9. The extra bluegill was collected because the 10th bluegill kept was a small fish and the field crew was not certain whether sufficient tissue mass could be obtained for analysis. It was later determined during processing at the MSU lab that the 10th bluegill was large enough for analysis so the extra Reach 9 bluegill was archived and not sent for analysis.

No water samples were collected in Round 3 since a full representative set was obtained in August.

2.5 Fish Lengths and Weights

Fish length (cm) and weight (g) was recorded prior to filleting. Fish age (yr) was determined from otoliths. Condition factors (K) were determined as K= Weight*100/ Length^3. Average values for target fish species analyzed for PFCs are provided on a whole pool basis in Table 2-4 and on a reach-specific basis in Table 2-5.

2.6 Field QA/QC Measures

Collection equipment used during investigation activities that could come into contact with potentially chemically affected materials were thoroughly cleaned with Liqui-Nox ® (a laboratory-grade detergent) and rinsed with deionized (DI) or distilled water.

Four field equipment blank samples (Field IDs: FEB060111W1, FEB060211F1, FEB060611W1, and FEB081111W1) were collected during this effort. These samples were generated by pouring laboratory reagent water supplied by the 3M lab in/over equipment that could come into contact with samples during the field effort such as the 1.5 L polyethylene water sample collection bottle and a cooler used to hold fish. This water was then poured directly into a sample container(s) and sent to the 3M lab for analysis. A set of field blank samples was provided by the 3M lab during Rounds 1 and 2. Each set of field blank samples consisted of a field blank (Milli Q water), and a 25 ng/L trip blank spike, which were prepared at the 3M lab and sent with the sample bottles for each sampling round.

In addition, consumable samples utilized in the field effort such as acetonitrile gloves, polyethylene bags, etc. were analyzed at the 3M lab prior to study commencement to confirm the presence/absence of PFCs.

Field efforts were documented on bound, waterproof field logbooks with waterproof ink. Deviations from protocol described in the work plan and/or QAPP were documented and, if necessary, corrective action documents were generated.

2.7 Tables and Figures

Table 2-1. Fish and Water Sample Collection Summary During Round 1 (June 2011)

	Sampling Reach										
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Bluegill	10	6	6	--	--	--	1	1	4	4	32
Freshwater drum	5	1	5	--	--	--	1	9	10	15	46
Smallmouth bass	9	--	2	--	--	--	4	1	5	10	31
Sunfish	--	1	--	--	--	--	--	--	--	--	1
White bass	2	3	2	--	--	--	7	6	8	10	38
Water	3	3	3	--	--	--	--	3	--	2	14

-- Not sampled during this round

Table 2-2. Fish and Water Sample Collection Summary During Round 2 (August 2011)

	Sampling Reach										
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Bluegill	--	3	4	10	8	10	9	9	5	2	60
Freshwater drum	5	5	2	6	9	10	1	1	--	--	39
Green sunfish	--	--	--	1	1	--	--	--	--	--	2
Smallmouth bass	1	10	8	6	10	10	6	9	4	--	64
White bass	--	7	8	8	3	8	3	4	--	--	41
Water	3	3	3	3	3	3	3	3	3	3	30 [1]

[1]AXYS received a subset of the round 2 water samples

-- Not sampled during this round

Table 2-3. Fish Sample Collection Summary During Round 3 (September 2011)

	Sampling Reach										
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Bluegill	--	1	--	--	2	--	--	--	2	4	9
Freshwater drum	--	4	3	4	1	--	8	--	--	--	20
Smallmouth bass	--	--	--	4	--	--	--	--	1	--	5
White bass	4	--	--	2	7	2	--	--	2	--	17

-- Not sampled during this round

Table 2-4. Descriptive Statistics for Sample Size, Age, Length, Mass and Condition Factor of Target Fish Species Collected from Pool 2

Characteristic	Species			
	Bluegill	Freshwater drum	Smallmouth bass	White bass
Number (N)	100	100	100	96
Age (year)	3.3 (2.0)	9.9 (5.8)	3.3 (1.4)	4.5 (2.6)
Length (cm)	15 (2.4)	36 (5.0)	32 (5.8)	34 (5.5)
Mass (g)	77 (42)	657 (424)	497 (287)	540 (223)
Condition Factor (K)	2.304 (0.597)	1.354 (0.685)	1.406 (0.164)	1.313 (0.352)

Arithmetic mean and standard deviation in parentheses

Table 2-5. Descriptive Statistics for Sample Size, Age, Length, Mass and Condition Factor (CF) of Target Fish Species Collected from Pool 2 by Reach

Species		Sampling Reach									
		1	2	3	4	5	6	7	8	9	10
Bluegill	Number (N)	10	10	10	10	10	10	10	10	10	10
	Avg Age (yr)	5.4	4.5	4.9	3.0	2.8	3.9	2.0	2.5	2.0	2.2
	Avg Length (cm)	14.8	15.4	15.2	13.5	13.8	15.0	13.0	14.4	15.8	15.7
	Avg Mass (g)	72.6	79.8	82.4	60.0	69.4	79.4	53.8	75.6	99.1	102
	Avg CF	2.241	2.027	2.382	2.301	2.422	2.001	2.555	2.377	2.276	2.457
Freshwater drum	Number (N)	10	10	10	10	10	10	10	10	10	10
	Age (yr)	9.2	6.9	7.0	10.0	11.7	10.3	13.6	8.7	13.0	8.2
	Avg Length (cm)	36.1	32.8	32.0	37.7	37.8	33.4	40.1	32.4	37.9	36.4
	Avg Mass (g)	589	455	386	1210	775	543	871	416	691	637
	Avg CF	1.222	1.236	1.145	2.265	1.346	1.401	1.305	1.170	1.220	1.231
Smallmouth bass	Number (N)	10	10	10	10	10	10	10	10	10	10
	Avg Age (yr)	4.1	2.9	3.1	3.5	2.7	2.9	3.3	2.6	3.8	3.6
	Avg Length (cm)	35.2	31.4	29.2	34.5	30.6	30.3	32.9	28.9	32.2	32.6
	Avg Mass (g)	655	496	412	692	376	436	515	342	533	514
	Avg CF	1.346	1.504	1.450	1.574	1.314	1.466	1.361	1.328	1.338	1.378
White bass	Number (N)	6	10	10	10	10	10	10	10	10	10
	Avg Age (yr)	4.8	4.8	5.5	4.3	4.4	5.3	3.6	2.6	5.0	4.4
	Avg Length (cm)	33.2	37.2	36.5	34.5	35.1	37.4	33.4	29.3	34.6	29.2
	Avg Mass (g)	544	608	666	592	600	698	501	335	565	304
	Avg CF	1.284	1.172	1.361	1.411	1.372	1.330	1.226	1.235	1.513	1.202

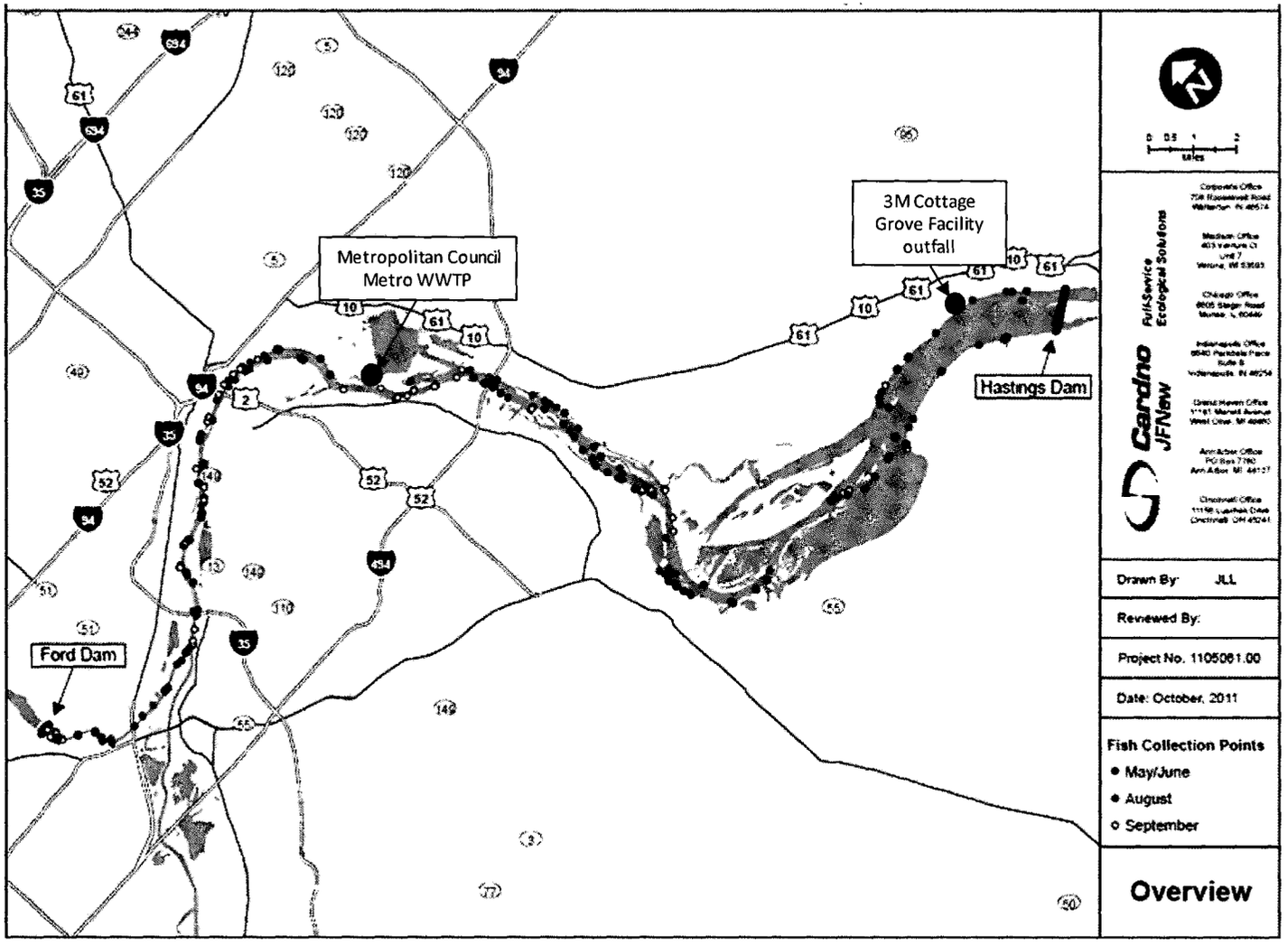


Figure 2-1. Fish Collection Locations for Pool 2 of the Mississippi River, 2011

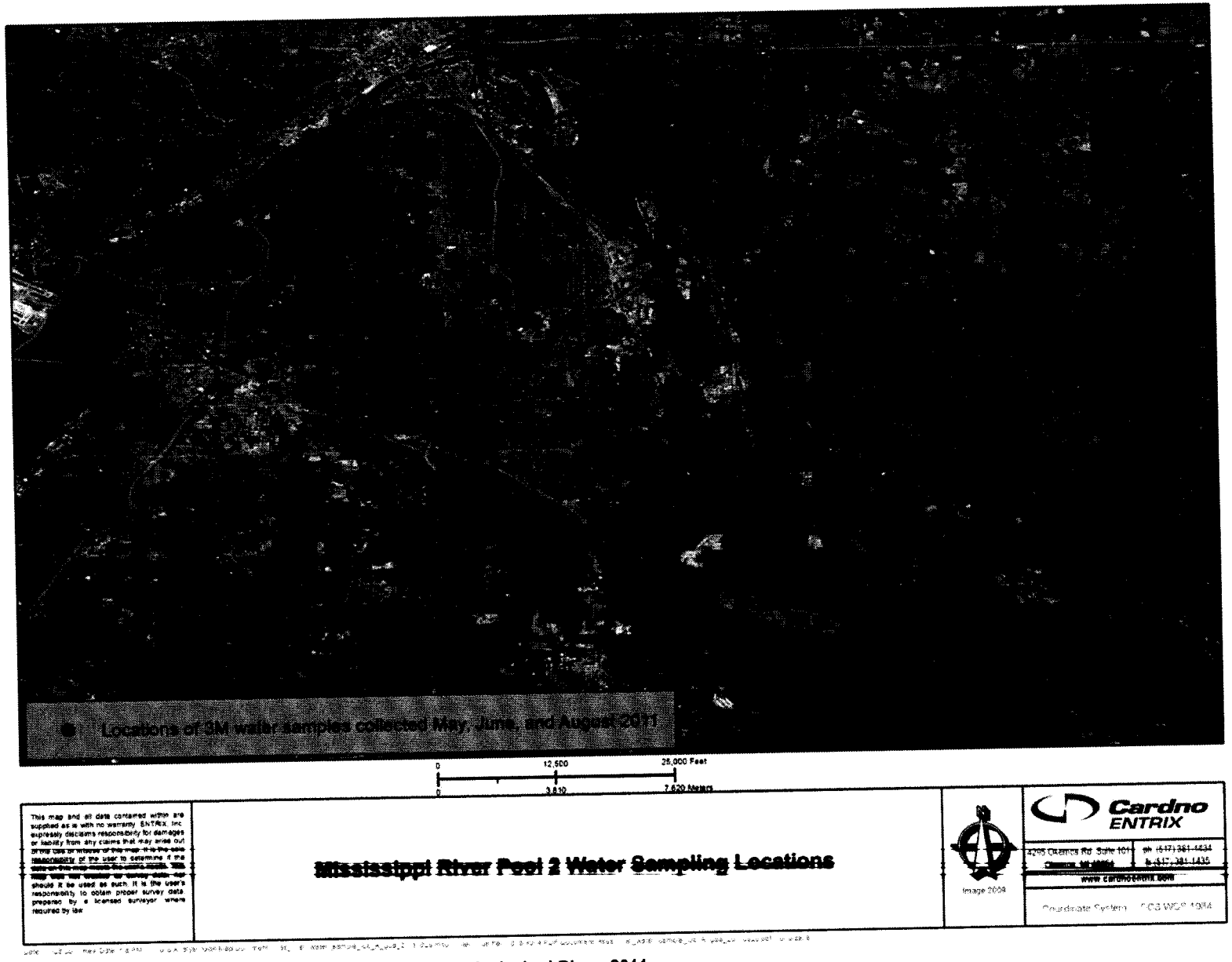


Figure 2-2. Water Sampling Locations for Pool 2 of the Mississippi River, 2011

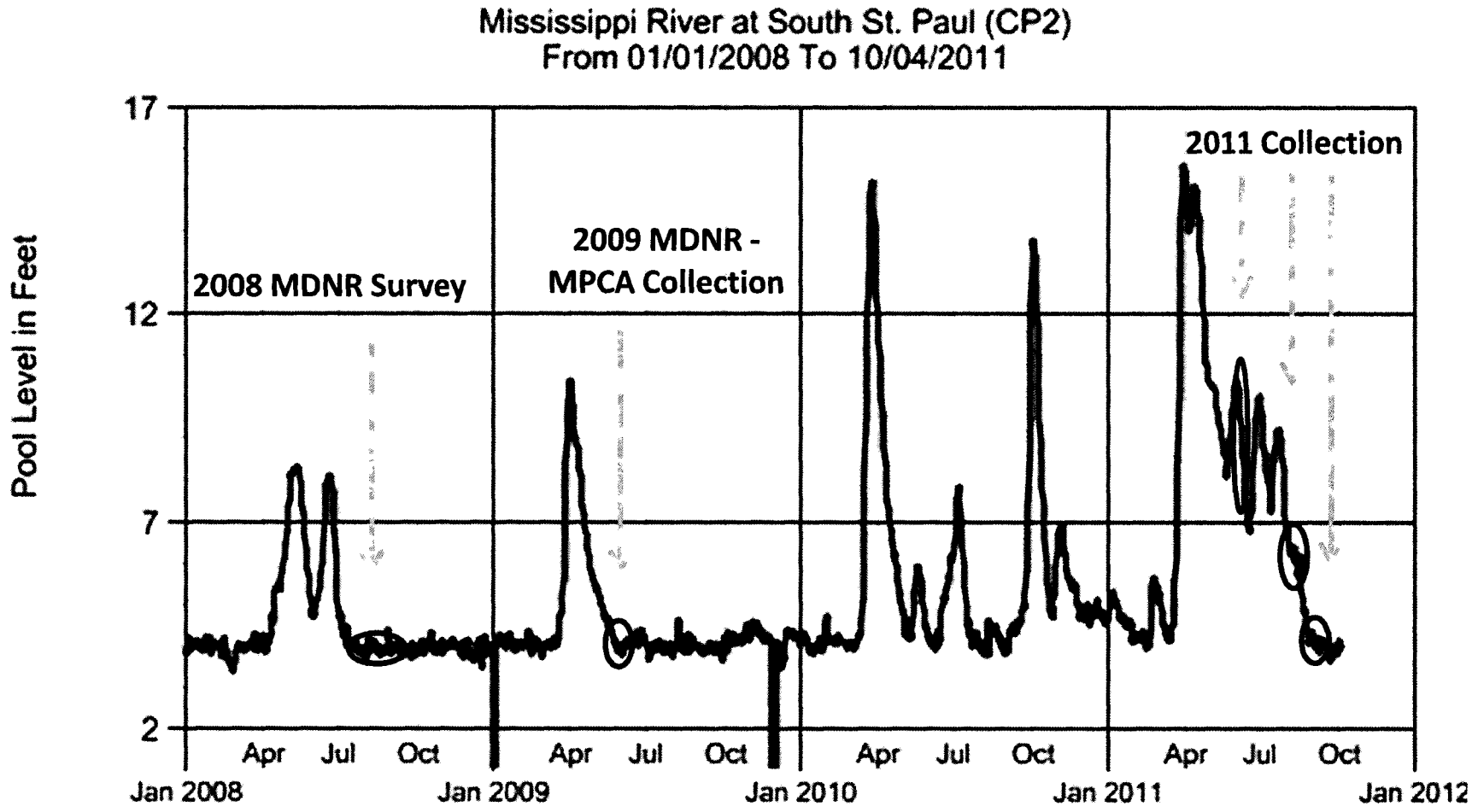


Figure 2-3. Mississippi River Pool 2 Water Levels 2008-2011

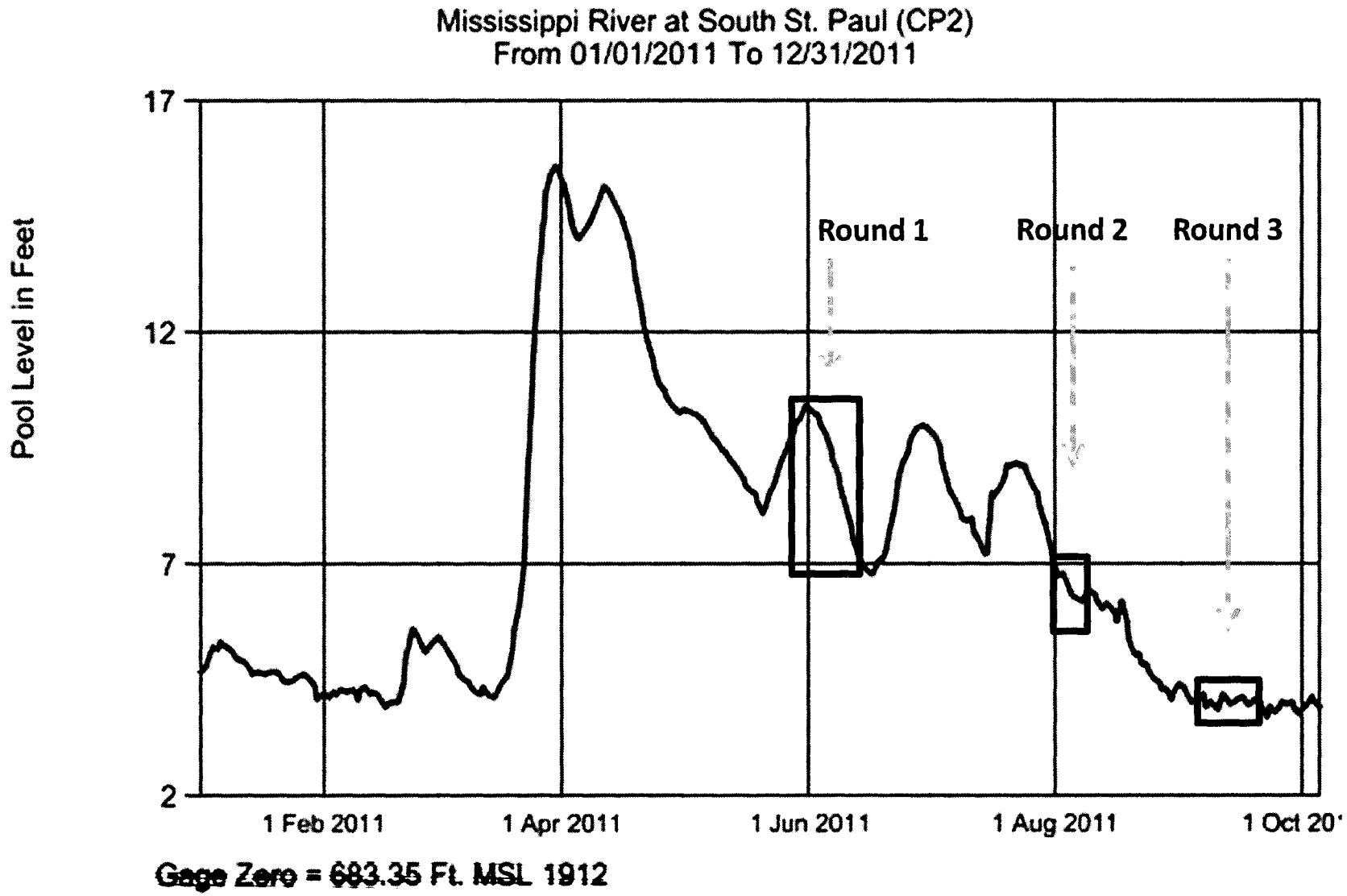


Figure 2-4. Mississippi River Pool 2 Water Levels During 2011 Fish and Water Collection

Chapter 3

Sample Handling and Processing

3.1 Sample Tracking

Sample labeling, preservation and tracking procedures were conducted as outlined in project-specific Standard Operating Procedure (SOP) documents and as detailed in the project QAPP.

The following field observations and measurements were recorded:

- Species and number of fish collected;
- Field ID associated with each fish;
- General location of fish collection (See Section 2.1 and Appendix A for more information);
- Date and approximate time of collection (beginning/ending time of electrofishing run); and
- Initials of field crew

3.1.1 Sample ID key

Unique IDs were assigned to individual fish tissue samples to ensure accuracy in sample tracking. The section below describes the sequence of ID assignment and a description of each ID. All IDs listed below are in the project database.

3.1.1.1 Field ID

Upon collection in the field a tag displaying a number (started with 001) was affixed to each fish (through the mouth or jaw). This number is the field ID associated with that individual fish.

Example Field ID: 008 (the eighth fish collected)

3.1.1.2 Tissue ID

Tissue IDs were assigned to individual fillet samples during the filleting process. Each tissue ID consists of the three-digit field ID number and a two-letter abbreviation "FN", indicating the tissue type (fillet, skin-on). All fish samples were scaled and skin-on fillets.

Example Lab ID: 008FN (the eighth fish collected, fillet skin-on)

Field ID	Tissue ID
008	008FN

3.1.1.3 Lab ID

Lab IDs are tissue IDs with a single number appended that ensures tracking of samples sent to the two analytical labs.

Example Lab ID: 008FN2 (the eighth fish collected, fillet skin-on, tissue split #2)

Field ID	Tissue ID	Lab ID
008	008FN	008FN2

3.2 Fish Filleting and Homogenization

The processing of fish tissue samples was consistent with methods previously established by Cardno ENTRIX. Fillets were removed from fish based on United States Environmental Protection Agency (USEPA) guidelines (USEPA, 2000). The fillet type for all fish species was scaled and skin-on (major bones removed), which is consistent for data used by the Minnesota Department of Health (MDH) to establish fish consumption advisories for these species. Given the species and size of fish that were collected in the study, a single fillet was collected from each fish for homogenization. For smaller fish such as bluegill, however, fillets from both sides of the fish were sometimes collected to achieve necessary tissue mass for analysis of PFCs.

Prior to filleting, fish were sorted by species, size, and reach in accordance with sample handling procedures. Before filleting, each fish was photographed and the length and mass of each fish was recorded in carbon-copy laboratory notebooks. Otoliths were removed from each fish and stored for aging. All fish samples were filleted on the day they were received. Fillets from individual fish were deposited into clean and labeled polyethylene bags that were labeled with fish ID number, date collected, species, and reach collected. The fillet samples were stored frozen in accordance with the QAPP until they were homogenized.

Homogenization was performed using a freeze-fracture technique in accordance with the appropriate Cardno ENTRIX SOP. Briefly, fish fillets were transferred from polyethylene storage bags into a Robot Coupe® industrial food processor and enough liquid nitrogen was added to ensure sample solidity. The tissue was then homogenized until a smooth, sawdust-like texture was achieved. The homogenate was distributed to several analytical-grade sample containers and stored frozen in accordance with the QAPP until shipment to the analytical laboratory or laboratories.

Blind duplicate samples were designated during the filleting process (see section 3.2.1 for more details). All remaining fillet tissue was deposited into clean polyethylene bags and stored prior to shipping to 3M for archiving. The carcass and any other materials from each fish were disposed of using the appropriate methods for handling biological materials as outlined by Michigan State University regulations.

3.2.1 Blind Duplicate and Interlaboratory Comparison Samples

In accordance with the QAPP, approximately 10% (41 total) of all fish tissue samples were split and sent in duplicate to the 3M lab. These splits were prepared as "blind" samples so that laboratory personnel were not able to tell that both tissue splits were from the same fish. In all cases, when a blind duplicate sample was created from a given fish, an additional tissue split was generated for AXYS as part of the interlaboratory comparison.

Blind duplicate samples were designated during the filleting process by selecting every tenth sample on the chain of custody and assigning a Field ID number that was withheld from circulation prior to commencing field efforts and randomly selected during fish filleting. If the 10^{th} sample mass was less than 60 grams, the following sample (11^{th}) was selected until a fish with sufficient tissue mass was encountered.

As an example, a blind duplicate sample was created based on the fish with Field ID 010 and the following steps were taken:

1) Verify that selected fish is large enough to generate multiple tissue splits;

2) Create primary 3M and AXYS tissue splits (Lab IDs 010FN1 and 010FN2); and

3) Create duplicate sample for 3M and assign "blind" ID; in this case the Lab ID for the 3M blind duplicate sample was 012FN1.

The following table illustrates the relationships between the various tissue splits and IDs.

Field ID	Tissue ID	Lab ID	Notes
010	010FN	010FN1	Primary 3M sample
010	010FN	010FN2	AXYS split
010	010FN	012FN1	3M blind duplicate

3.3 Sample Processing QA/QC Measures

The sample processing area and equipment at the WTL was decontaminated using general laboratory techniques including washing of sample processing equipment in Liqui-Nox detergent followed by copious rinsing with tap water and then generous rinsing with ASTM type II reagent water. Equipment then received an acetone rinse followed by a methanol rinse. Solvents were allowed to evaporate from the equipment surfaces prior to use.

Prior to the initiation of sample filleting, a daily laboratory processing (start) blank was collected. This blank was generated by rinsing a selection of processing hardware (knives, cutting board, bench paper, etc.) with 100 mL of ASTM type II reagent water and collecting the rinsate in a polypropylene sample bottle. After all sample filleting was completed for the day, a second rinse (end) blank was generated using the same protocol. Rinse blanks were frozen in accordance with the QAPP for later analysis, if necessary.

Prior to homogenization, a daily homogenization (start) blank was generated using the technique noted above for the Robot Coupe® bowl, blade, lid, and lab spatula. Fillet tissue samples were homogenized using a freeze-fracture technique employing liquid nitrogen. The homogenate was split into two fractions if the mass was greater than 20 g, and into four fractions if a primary aliquot, sample split, blind duplicate, and archive were requisite. Homogenization end rinse blanks were collected at the conclusion of daily sample processing and all blanks were archived (frozen) in accordance with the QAPP. In total, upwards of 50 processing or homogenization rinse blanks were generated during the study. Since it was not necessary to analyze every blank, the archived blanks were only analyzed if PFCs were detected in QC samples at unacceptable concentrations.

The 3M lab provided the WTL with three control fish tissue samples with known concentrations of PFOS to evaluate for contamination before, during, and after the sample processing (homogenization, splitting) was completed at the WTL. These tissue samples underwent the same homogenization and splitting process as did all the other fish tissue samples. One control fish tissue sample (bass fillet, "pre-study process control") was subjected to the homogenization process prior to the processing of any experimental samples. Analytical results for the pre-study sample were determined to be acceptable and indicated no laboratory contamination issues, therefore processing was initiated. The

second control fish tissue sample (bluegill fillet, "mid-study process control") was processed in between samples 164FN and 165FN. The third control fish tissue sample (bluegill fillet, "post-study process control") was processed at the conclusion of the project. The IDs reported in 3M analytical reports for these control fish tissue samples were E11-0356-01-001, E11-0356-01-316, and E11-0356-01-443, respectively. See Section 5.2 for more discussion of results associated with control fish tissue samples.

3.4 Post-Study Fish Tissue Evaluation

In addition to the QA/QC procedures outlined in the original QAPP, additional fish tissue samples were sent to 3M and AXYS for a post-study PFOS analysis in November 2011. The goal of this study was to further evaluate potential interlaboratory differences as well as to assess the accuracy and precision of the individual laboratories. The additional samples were comprised of tissues from three sources: National Institute of Standards and Technology standard reference material (NIST SRM) for lake trout tissue from Lake Superior (SRM 1946) and Lake Michigan(SRM 1947) for which PFOS values have been generated and were provided to Cardno ENTRIX (personal communication with Dr. Michele Schantz of NIST); splits of control fish tissue provided by 3M (see last paragraph of Section 3.3 for more detail) which were analyzed previously as part of the primary PFC study; and tissues from fish collected from Pool 2 which were also analyzed previously as part of the primary PFC study.

The post-study samples were analyzed for PFOS following the same methods employed for the analysis of the fish collected in the summer and fall of 2011. Cardno ENTRIX started with 8 samples: 2 NIST SRM tissue samples, 3 control fish tissue samples provided by 3M, and 3 Mississippi River fish tissue samples that were collected and analyzed as part of the primary study. Four duplicate tissue splits were created from each of these samples and all splits were assigned four-digit IDs that were blind to the analytical labs. Two duplicates were provided to both the 3M and AXYS labs for a total of 16 samples per lab (Table 6-16). Tissue samples were split at WTL facilities and shipped for overnight delivery in coolers containing ice. The sample processing area and equipment was decontaminated using the same techniques described previously.

Chapter 4

PFC Analysis by 3M and AXYS

4.1 Sample Preparation and Analysis: 3M Environmental Laboratory

4.1.1 Fish Tissue Samples

Once received at the 3M lab, all samples were checked into the electronic laboratory information management system (LIMS) where each sample was assigned a unique 3M LIMS sample ID and then stored frozen until they could be prepared for analysis. Analysis of fish tissues followed the validated 3M lab method ETS-8-045.1 "Determination of Perfluorinated Alkyl Acids (PFAAs) via Protein Precipitation of Fish Tissues (Fillet or Whole Body) and Analysis by High Performance Liquid Chromatography with Tandem Mass Spectrometry" (Malinsky *et al.*, 2011). Briefly, samples were prepared for analysis by re-homogenizing with dry ice and allowed to sit overnight, or longer, in a refrigerator to allow the dry ice to dissipate. Then, duplicate 0.5 grams aliquots of each sample were transferred to centrifuge tubes, with accurate weight of each aliquot determined. Each analytical batch typically consisted for 20 samples extracted in duplicate with the following QC elements: (1) for every 10^{th} fish sample, two additional aliquots were prepared as laboratory matrix spike (LMS) preparations with a low-level LMS fortified with predominately linear isomer reference material at a nominal 2.0 ng/g each and second high-level LMS fortified at 40 ng/g each; (2) a set of calibration standards that was fortified with internal standards (IS), surrogate recovery standards (SRS), and predominately linear forms of each reference materials, with the exception of PFOSA which was a technical grade material; (3) a set of normal "linear isomer" laboratory control spikes (LCS) consisting of control bluegill homogenate fortified with linear reference materials and technical PFOSA; (4) a set of ECF-LCS samples consisting of control bluegill homogenate fortified with technical PFOS (30.3% branched isomers), technical PFOA (22.2% branched isomers), and technical PFHS (15.6% branched isomers); (5) method blanks consisting of bluegill homogenate with and without ISs and SRSs, and (6) solvent blanks prepared with and without ISs and SRSs.

Each sample aliquot received a fixed quantity of stable isotope labeled internal standard and surrogate for use in quantitation and for evaluation of analyte recovery, respectively. The LCS samples were used to determine the accuracy (average recovery) and precision (RSD) for the PFC analytes. PFC recovery was determined directly via LMS in 10% of the samples. In some samples prepared as LMSs, the endogenous PFC levels were greater than the low-level LCS concentration and were insufficient for proper analyte recovery determination. Those samples were re-prepared with a higher level LMS and the original samples results were not used. In the remaining samples, PFC recovery was based on the measurement result of the appropriate surrogate. Each batch of samples had two freshly prepared sets of LCSs, each consisting of 3 levels of nominal 1.00 ng/g, 10.0 ng/g, and 100 ng/g concentrations of each target analyte. The first set of LCS samples were fortified with "normal" linear isomer reference materials (PFOA, PFHS, PFOS, and PFOSA) similar to that used to construct the calibration standards. The second set of LCS samples were fortified with mixed linear and branched PFC isomers (PFOA, PFHS, and PFOS) to verify the quantitative accuracy of PFC compositions that are typically found in environmental samples.

Extraction of each sample was performed by an acetonitrile protein precipitation method followed by centrifugation and transfer to autosampler for analysis by high performance liquid

chromatography/tandem mass spectrometry (HPLC/MS/MS). Pertinent instrument parameters, the liquid chromatography gradient program, and the multiple mass transitions (Table 4-1) used to analyze PFCs are outlined in Malinsky *et al.* (2011) as well as in the 3M Laboratory analytical reports. The relative percent difference (RPD) of duplicate analytical sample results was used as a measure of sample-specific analytical precision. The determined recoveries of fortified target analytes from LMS samples were used as a measure of sample-specific analytical accuracy while the recovery of SRSs in each analytical sample was used as a secondary measure of target analyte recovery from each sample.

4.1.2 Surface Water Samples

Analysis of water samples followed the 3M lab Method ETS-8-154.4 "Determination of Perfluorinated Acids, Alcohols, Amides and Sulfonates in Water by Solid Phase Extraction and High Performance Liquid Chromatography/Mass Spectrometry" (Wolf *et al.*, 2011). Briefly, all samples, calibration standards, and associated quality control samples were extracted by passing 50 mL water samples through a pre-conditioned solid phase extraction (SPE) cartridge followed by the elution of PFCs with 2.5 mL methanol. Surface waters samples were extracted using a Waters tC18 SPE cartridge (0.5 g, 3 cc) for PFNA, PFDA, PFUnA, PFDoA, PFBS, PFHS, PFOS, PFOSA, $^{13}C_4$-PFOS and $^{13}C_2$-PFUnA. An Oasis HLB SPE cartridge (0.5 g, 3 cc) was used to extract PFBA, PFPeA, PFHxA, PFOA, and $^{13}C_4$-PFOA. This procedure concentrates the samples by a factor of twenty-five. All samples and quality control samples were analyzed for 13 target analytes using high performance liquid chromatography/tandem mass spectrometry (HPLC/MS/MS). Pertinent instrument parameters, the liquid chromatography gradient program, and the specific mass transitions analyzed (Table 4-1) are described in their respective 3M analytical reports. Three types of blanks were prepared and analyzed with samples including method blanks, solvent blanks, and field/trip blanks. Each blank result was reviewed and used to evaluate method performance to determine the LOQ for each analyte.

Calibration standards were prepared by spiking known amounts of PFC analytes into Milli Q water and internal standards were added from a separate spiking solution at the same levels as those used in water samples, 0.1 ng/ml. A total of 12 spiked standards were prepared. The data for each analyte was fitted to a quadratic, weighted calibration curve that was not forced through zero. If necessary, low and/or high curve points were disabled to help meet linearity or accuracy criteria of 100 ± 25% (100 ± 30% for the lowest curve point). The limit of quantitation (LOQ) was defined as the lowest non-zero calibration standard in the calibration curve that met linearity and accuracy requirements.

Laboratory control spikes (LCSs) were prepared by spiking analytes into Milli Q water to produce three concentrations: low, mid and high. In Round 1, all PFCs and SRSs were spiked at nominal concentrations of 5, 50, and 500 ng/L with the exception of PFBA, which was spiked at 10, 50, and 200 ng/L. In Round 2, PFNA, PFDA, PFUnA, PFDoA, $^{13}C_2$-PFUnA, PFBS, PFHS, PFOS (linear), and PFOSA were spiked at a nominal concentration of 5, 50, and 500 ng/L. For PFBA, PFPeA, PFHxA, PFHpA, PFOA (linear), and $^{13}C_4$-PFOA nominal spike concentrations were 5, 50, and 250 ng/L. For PFOS and PFOA that contained both linear and branched isomers, samples were spiked at 5 and 500 ng/L. The spiked water samples were extracted and analyzed in the same manner as the water samples.

Field matrix spikes (FMS) were collected at each sampling point to verify that the analytical method was applicable to the collected matrix. FMS recoveries within the method acceptance criteria of 100% ± 30% confirm that unknown components in the sample matrix do not significantly interfere

with the extraction and analysis of the analytes of interest. Samples were collected in 250 ml Nalgene bottles spiked with 25 ppt (nominal) field matrix spike that were marked with a "fill to line" line at 200 ml. In Round 1, five of the 12 samples were overfilled by more than 10% while in Round 2, 15 of 30 samples were overfilled. In each of these instances, the true value of the FMS was adjusted based on the volume determined from the pre- and post-fill bottle weights.

4.2 Sample Preparation and Analysis: AXYS Analytical Services

4.2.1 Fish Tissue Samples

Samples were received by AXYS and stored frozen in accordance with the QAPP prior to extraction and analysis. Samples were analyzed in multiple batches; each batch included a procedural blank, a lab-generated reference Ongoing Precision and Recovery (OPR) sample, and a duplicate sample. OPR samples were prepared using a fish tissue that was free of PFCs. Sample extraction, instrumental analysis, and analyte quantification procedures were in accordance with AXYS method MLA-043 "Analytical Procedure for the analysis of Perfluorinated Organic Compounds in Tissues Samples by LC-MS/MS". The surrogate and recovery standards were sourced from Wellington Laboratories® while the authentic standard used in OPR samples was sourced from Sigma Aldrich®. Samples were prepared in batches that consisted of a set of calibration standards, laboratory control samples, blanks, and tissue samples. Briefly, the samples were accurately weighed (approximately 2 g), spiked with surrogate standards (Table 4-2) and extracted in basic methanol by shaking. Extracts were then cleaned up by SPE extraction using disposable cartridges containing a weak anion exchange sorbent. The resulting extracts were instrumentally analyzed using HPLC coupled to a triple quadrapole mass spectrometer (LC-MS/MS) that was run in the multiple reaction monitoring (MRM) mode. Pertinent instrument parameters, liquid chromatography gradient program and mass transitions (Table 4-2) used to analyze PFOS are described in the AXYS analytical report.

Analyte concentrations were determined by isotope dilution/internal standard quantification, comparing the area response of the quantification ion to that of the ^{13}C-labeled standards and correcting for response factors. Linear quantification equations with $1/X^2$ weighting fit were determined from a multi-point calibration series using matrix matched calibration solutions prepared alongside the samples. For the calculated concentrations, a maximum of 1 point per calibration solution with a maximum of three points for all the calibration solutions had to fall within 60 to 140% of actual concentrations provided that all remaining points including those for PFOA, PFOS and PFDA fell within 70-130% of actual concentration. A mid-level calibration solution was analyzed at least after every 20th sample with concentrations having to be within 30% of the actual concentrations. The reporting limit was defined as the concentration equivalent to the lowest calibration solution run with a particular batch of samples, or the sample specific detection limit, whichever was greater. The range of acceptable matrix spike recoveries for PFBA, PFPeA, PFBS, PFHS, and PFOSA was 40 to 150%. The acceptable recovery range for $^{13}C_2$-PFBA was 20 to 150% while for $^{13}C_2$-PFHxA, $^{13}C_2$-PFOA, $^{13}C_5$-PFNA, $^{13}C_2$-PFDA, $^{13}C_2$-PFDoA, $^{18}O_2$-PFHS, $^{13}C_4$-PFOS and $^{13}C_8$-PFOA it was 40 to 150%.

The reported concentrations of PFCs in fish tissues were not blank corrected and the data were evaluated with consideration of the procedural blanks. All linearity, calibration/verification, OPR, duplicate, and labeled recovery samples met the method specifications with the exception of two samples. In one sample the percent recovery of PFUnA in an OPR was slightly above the method upper limit specification and as a result, the concentration reported for this sample may have been over reported. In a second sample, the percent recovery of the surrogate ^{13}C-PFBA (154%) was

slightly above the upper limit, but given that the analyte was not detected, it had no effect on the reported value.

4.2.2 Surface Water Samples

Samples were received by AXYS and stored at 4°C prior to extraction and analysis. Samples were analyzed in multiple batches; each batch included a procedural blank, lab-generated reference Ongoing Precision and Recovery (OPR) sample, and a duplicate sample. OPR samples were started with the samples and carried through in the same analytical batch. The blanks were prepared using Canadian Springs ™ water.

Sample extraction, instrumental analysis and analyte quantification procedures were in accordance with the AXYS method MLA-060 "Analytical Procedure for the Analysis of Perfluorinated Organic Compounds in Aqueous Samples by LC-MS/MS". Briefly, the unfiltered samples were accurately weighed and adjusted to pH 6.5. They were then spiked with surrogate ^{13}C-labeled surrogate standards (Table 4-2) and extracted using SPE with a weak anion exchange cartridge. Eluates were spiked with a $^{13}C_2$-PFOUEA recovery standard and then analyzed using liquid chromatography/mass spectrometry (LC-MS/MS). Pertinent instrument parameters, liquid chromatography gradient program, and mass transitions used to analyze PFCs (Table 4-2) are described in the AXYS analytical report.

Analyte concentrations were determined by isotope dilution/internal standard quantification, comparing the area response of the quantification ion to that of the 13C-labeled standards and corrected for response factors. Quadratic quantification of the $1/X^2$ weighting fit was determined from multi-point calibration series using matrix matched calibration solutions prepared alongside the aqueous samples. Acceptance criteria for the calculated concentrations based on the initial calibration curve was 75-125% of actual concentration (lowest calibration point may be 70-130%) with a coefficient of determination (R^2) of 0.990 or greater. The reporting limit was defined as either the concentration equivalent to the CS0 calibration standard, the lowest calibration solution run with a particular batch of samples, or the sample specific detection limit, whichever was greater. The acceptable OPR recovery range was 80% to 120% for perfluoroalkyl carboxylate analytes while for perfluoroalkyl sulfonates it was 70-130%. With the exception of ^{13}C-PFBA, the surrogate standard acceptable recovery range was 40-150% while for ^{13}C-PFBA it was 20-150%.

In Round 1, all linearity, CAL/VER, OPR, duplicate, and labeled compound standards met recovery specifications. In Round 2, all standards also met recovery specification with the exception of two samples where $^{13}C_2$-PFDoA did not meet the criteria and were flagged accordingly. However, given that the isotope dilution method of quantification produces data that are recovery corrected, the slight variance from the method acceptance criteria was deemed to not have significantly affected the quantification of analytes.

4.3 Samples Analyzed

The number fish tissue samples, surface water samples and additional QA/QC samples analyzed by 3M and AXYS for this study are reported in Table 4-3. Table 4-4 reports the number collected and fish species analyzed on a reach-specific basis.

4.4 Tables and Figures

Table 4-1. Target Analytes and Surrogate Standards for 3M Environmental Laboratory

Compound	Analyte Description	Water MRM Transition(s)	Fish MRM Transition(s)
Target Analytes			
PFBA (C4 Acid)	Target	213>169	213>169
PFPeA (C5 Acid)	Target	263>219	263>219 263>119
PFHxA (C6 Acid)	Target	313>119 313>269	313>269 313>119
PFHpA (C7 Acid)	Target	363>319 363>119	363>319 363>169
PFOA (C8 Acid)	Target	413>369 413>219 413>169	413>369 413>219 413>169
PFNA (C9 Acid)	Target	463>419 463>219 463>169	463>419 463>219 463>169
PFDA (C10 Acid)	Target	513>469 513>219 513>269	513>469 513>269 513>219
PFUnA (C11 Acid)	Target	563>519 563>269 563>219	563>519 563>269 563>219
PFDoA (C12 Acid)	Target	613>569 613>319 613>269	613>569 613>319 613>169
PFBS (C4 Sulfonate)	Target	299>80 299>99	299>80 299>99
PFHS (C6 Sulfonate)	Target	399>99 399>80	399>80 399>99
PFOS (C8 Sulfonate)	Target	499>99 499>80 499>130	499>80 499>99 499.130
FOSA (C8 Sulfonamide)	Target	498>78	498>78
Internal Standards (IS)			
[$^{13}C_4$]-PFBA	IS for PFBA	217>172	217>172
[$^{13}C_5$]-PFPeA	IS for PFPeA	268>223	
[$^{13}C_2$]-PFHxA	IS for PFHxA	315>270	
[$^{13}C_2$]-PFHxA	IS for PFPeA, PFHxA and PFHpA		315>270
[$^{13}C_5$]-PFHpA	IS for PFHpA	368>273	
[$^{13}C_8$]-PFOA	IS for PFOA and [$^{13}C_4$]-PFOA	421>376	421>376
[$^{13}C_5$]-PFNA	IS for PFNA		468>423
[$^{13}C_9$]-PFNA	IS for PFNA	472>427	

Table 4-1. Target Analytes and Surrogate Standards for 3M Environmental Laboratory

Compound	Analyte Description	Water MRM Transition(s)	Fish MRM Transition(s)
$[^{13}C_2]$-PFDA	IS for PFDA	515>470	515>470
$[^{13}C_6]$-PFDA	IS for PFDA	519>474	
$[^{13}C_7]$-PFUnA	IS for PFUnA and $[^{13}C_2]$-PFUnA	570>525	565>520
$[^{13}C_2]$-PFDoA	IS for PFDoA	615>570	615>570
$[^{18}O_2]$-PFBS	IS for PFBS	303>84	303>84
$[^{13}C_3]$-PFHS	IS for PFHS	402>80	402>80
$[^{13}C_8]$-PFOS	IS for PFOS and $[^{13}C_4]$-PFOS	507>80	507>80
$[^{13}C_8]$-PFOSA	IS for FOSA	506>78	506>78
Surrogate Recovery Standards (SRS)			
$[^{13}C_4]$-PFOA	Surrogate (C4-C9 Carboxylates)	417>372	417>372
$[^{13}C_4]$-PFOS	Surrogate (PFBS, PFHS, PFOS and PFOSA)	503>80	503>80
$[^{13}C_2]$-PFUnA	Surrogate (C10-C12 Carboxylates)	565>520	565>520

Multiple MS/MS ion transitions are summed when more than one transition is listed for the analyte.

Table 4-2. Target Analytes and Surrogate Standards for AXYS Analytical Laboratory

Compound	MRM Transition(s)	Quantified Against
Target Analyte		
Perfluorobutanoate (PFBA)	213>169	$^{13}C_4$-PFBA
Perfluoropentanoate (PFPeA)	263>219	$^{13}C_2$-PFHxA
Perfluorohexanoate (PFHxA)	313>269	$^{13}C_2$-PFHxA
Perfluoroheptanoate (PFHpA)	363>319	$^{13}C_2$-PFHxA
Perfluorooctanoate (PFOA)	413>369 413>169	$^{13}C_2$-PFOA
Perfluorononanoate (PFNA)	463>419	$^{13}C_5$-PFNA
Perfluorodecanoate (PFDA)	513>469	$^{13}C_2$-PFDA
Perfluoroundecanoate (PFUnA)	563>519	$^{13}C_2$-PFDA
Perfluorododecanoate (PFDoA)	613>569	$^{13}C_2$-PFDoA
Perfluorobutane sulfonate (PFBS)	299>80 299>99	$^{18}O_2$-PFHS
Perfluorohexane sulfonate (PFHS)	399>80 399> 99 399>119	$^{18}O_2$-PFHS
Perfluorooctane sulfonate (PFOS)	499>80 449>99	$^{13}C_4$-PFOS
Perfluorooctane sulfonamide (PFOSA)	498>78	$^{13}C_4$-PFOS
Surrogate Standard		
$^{13}C_4$-Perfluorobutanoic acid ($^{13}C_4$-PFBA)	217>172	$^{13}C_4$-PFOA
$^{13}C_2$-Perfluorohexanoic acid ($^{13}C_2$-PFHxA)	315>270	$^{13}C_4$-PFOA
$^{13}C_2$-Perfluorooctanoic acid ($^{13}C_2$-PFOA)	415>370	$^{13}C_4$-PFOA
$^{13}C_5$-Perfluorononanoic acid ($^{13}C_5$-PFNA)	468>423	$^{13}C_4$-PFOA
$^{13}C_2$-Perfluorodecanoic acid ($^{13}C_2$-PFDA)	515>470	$^{13}C_4$-PFOA
$^{13}C_2$-Perfluorododecanoic acid ($^{13}C_2$-PFDoA)	615>570	$^{13}C_4$-PFOA
$^{18}O_2$–Perfluorohexanesulfonate ($^{18}O_2$-PFHS)	403>84 403>103	$^{13}C_4$-PFOA
$^{13}C_4$–Perfluorooctanesulfonate ($^{13}C_4$-PFOS)	503>80 503>99	$^{13}C_4$-PFOA
Clean-up Standard		
$^{13}C_8$-Perfluorooctanoic acid ($^{13}C_8$-PFOA)	421>376	$^{13}C_4$-PFOA
Recovery Standard		
$^{13}C_2$-2H-Perfluoro-2-decenoic acid ($^{13}C_2$-PFOUEA)	459>394	-
$^{13}C_4$-Perfluorooctanoic acid ($^{13}C_4$-PFOA)	417>372	-

Table 4-3. Summary of Samples Shipped to Analytical Laboratories

Lab	Fish Tissue Samples	Interlaboratory Blind Duplicate Fish Tissue Samples	Water Samples	Other QA/QC Samples[1]	Target Analytes
3M	399[2]	41	44	7	PFBS, PFHS, PFOS, PFOSA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA
AXYS	41[3]	--	30	--	Same as above

[1] Field and MSU laboratory equipment rinsate blanks and control fish tissue processing blanks

[2] Includes 396 target species plus two non-target green sunfish and one sunfish

[3] Duplicates of 41 samples sent to 3M

Table 4-4. Species and Number of Fish Analyzed by 3M from Pool 2 of the Mississippi River, 2011

	Sampling Reach										
Species	1	2	3	4	5	6	7	8	9	10	Total
Bluegill	10	10	10	10	10	10	10	10	10[1]	10	100
Freshwater drum	10	10	10	10	10	10	10	10	10	10[2]	100
Green sunfish	--	--	--	1	1	--	--	--	--	--	2
Smallmouth bass	10	10	10	10	10	10	10	10	10	10	100
Sunfish	--	1	--	--	--	--	--	--	--	--	1
White bass	6	10	10	10	10	10	10	10	10	10	96

[1] The first 10 bluegill collected from Reach 9 were analyzed; tissues from an 11th were archived

[2] The first 10 drum collected from Reach 10 were analyzed; tissues from an extra five (11-15) were archived

-- Not sampled during this round

Chapter 5

QA/QC Results

5.1 3M Laboratory QA/QC Samples

5.1.1 Fish Tissue QA Results

Calibration curves were not forced through zero and when calculated standard concentrations from the calibration curve were compared to known concentrations, the accuracy of each curve point was within 100 ± 25% with a coefficient of determination that was greater than 0.990. The lower limit of quantitation (LLOQ) was the lowest non-zero calibration standard in the curve that met linearity and accuracy requirements (100 ± 30%) and for which the area counts were at least two times that of the average response determined from the method blanks. In this study, the LLOQ for C7-C12 PFCAs, PFBS, PFHS, PFOSA, and the surrogate reference standards was in nearly all instances the nominal concentration of 0.25 ng/g (0.025 ng/ml acetonitrile), or less. However, in no more than eight analytical batches, the LLOQs for PFBA, PFPeA and PFHxA were raised to 0.35 ng/g, 0.5 ng/g, or 1.0 ng/g fish tissue. For PFOS, the required 0.250 ng/g LLOQ was met for all analyses.

Continuing calibration verifications (CCV) were performed during the course of each analytical batch by injection of mid-level calibration standards to help verify instrumental response and that the initial calibration curve was still in control. The average recoveries for all CCVs ($n \geq 190$) from all analytical batches were within 100% ± 15% and had RSDs less than 15%. The CCV for PFOSA in all analytical batches met the method criteria of 100% ± 25%. All other analytes met the same criterion with only a few exceptions. The number of exceptions for each analyte was never greater than 15% of the total number of CCVs and the exceedences typically were not greater than 30% of the acceptable range.

The average LMS recovery for all target analytes ranged from 91.7% to 113% with RSDs less than 20%. Additionally, the average LMS recoveries for the three stable isotope labeled surrogate recovery standards (SRS) showed good precision and accuracy with average recoveries of 107%, 107%, and 112%, and RSDs < 20%, for $^{13}C_4$-PFOS, $^{13}C_4$-PFOA and $^{13}C_2$-PFUnA, respectively. The SRS recovery results from LMSs were similar to the overall accuracy and precision achieved for the SRSs added to fish tissues prior to extraction (sample and sample duplicate, n = 880), with average recoveries and RSDs of 103% ± 10% for $^{13}C_4$-PFOS, 107% ± 13% for $^{13}C_4$-PFOA, and 106% ± 11% for $^{13}C_4$-PFUnA. The results determined from LMSs and SRSs indicated excellent overall data accuracy and precision for the study sample fish results.

The recoveries of fortified PFOS from the 45 LMS samples prepared from samples analyzed throughout the study were within the acceptance criterion of 100 ± 30% recovery and ranged from 77.1% to 120%, with an average recovery and standard deviation of 102% ± 11%. Additionally, the surrogate recoveries from all samples were within 100 ± 30%, indicating good analytical accuracy for PFOS in all samples. The average recovery for all $^{13}C_4$-PFOS surrogate recovery standards in the study samples and duplicates was 99.9% with an RSD of 10.3%. The analytical method uncertainty was determined from the analysis of LCS sets prepared with each extraction batch by spiking PFOS in control fish tissue homogenates at nominal concentrations of 1.0, 10.0 and 100 ng/g. The method

uncertainty was determined to be ± 17% for linear PFOS (linear isomer) and ± 19% for PFOS (mixed linear + branched isomers), determined at the 95% confidence interval (i.e. 2 standard deviations).

The LCS average accuracy and precision results for the target analytes in fish tissues were as follows: 113% ± 21% for PFBA, 106% ± 24% for PFPeA, 102% ± 13% for PFHxA, 93.6% ± 10% for PFHpA, 96.1% ± 15% for PFOA, 99.2% ± 11% for PFNA, 102% ± 11% for PFDA, 96.7% ± 9.7% for PFUnA, 98.9% ± 9.8% for PFDoA, 98.8% ± 13% for PFBS, 97.0% ± 9.8% for PFHS, PFOS 96.4% ± 8.9%, and 95.8% ± 6.9% for PFOSA. Overall, the inter-batch average recovery for linear LCS recoveries were within the 100 ± 30% with RSDs of less than 20% with the exception of PFBA and PFPeA. The average SRS recovery and RSD for linear LCSs were as follows: 109% ± 12% for $^{13}C_4$-PFOA, 105% ± 8.6% for $^{13}C_2$- PFUnA and 105% ± 8.5% for $^{13}C_4$-PFOS. The LCS results indicated excellent method performance for all target analytes.

The ECF-LCSs average and RSD recovery results for technical PFHS, technical PFOS, and technical PFOA fortified into bluegill control fillet homogenate were 100% ± 8.6%, 116% ± 8.1%, and 87.8% ± 13%, respectively. The SRS average recoveries and RSDs for ECF-LCSs were 109% ± 8.6% for $^{13}C_4$-PFOA and 104% ± 8.7% for $^{13}C_4$-PFOS. Overall, the ECF-LCS results showed that mixed and linear branched isomer reference materials for PFOA, PFHS and PFOS were quantified with excellent accuracy and precision using linear isomer calibration.

The analytical method uncertainties (95% confidence interval) were determined as two-times the standard deviation of recovery results for all linear LCS samples and were as follows: ± 48% for PFBA, ± 50% for PFPeA, ± 26% for PFHxA, ± 20% for PFHpA, ± 28% for PFOA, ± 22% for PFNA, ± 22% for PFDA, ± 19% for PFUnA, ± 19% for PFDoA, ± 26% for PFBS, ± 19% for PFHS, ± 18% for PFOS, and ± 13% for PFOSA. Measurement uncertainties for the SRSs were as follows: ± 25% for $^{13}C_4$-PFOA, ± 18% for $^{13}C_2$-PFUnA, and ± 18% for $^{13}C_4$-PFOS.

5.1.2 Surface Water QA Results

For both Round 1 and 2 water collections, correlation coefficients (r) for calibration curves for all PFC analytes and surrogate recovery standards were 0.995 or greater and met the acceptance criteria. During the course of the analytical sequence, several continuing calibration verification (CCV) samples were analyzed to confirm that the instrument response and the initial calibration curve were still acceptable. The method acceptance criteria of 100% ± 25% was met for almost all reported data with exception of four instances, one each for PFBA, PFPeA, PFHxA, and PFHpA.

The limit of quantitation (LOQ) for Round 1 water samples was 2.0 ng/L for PFHpA, PFOA, PFNA, PFBS, PFHS, and PFOS while the LOQ for PFBA was 5.0 ng/L. For PFPeA, PFUnA, PFDoA, and PFOSA, the LOQ was 4.0 ng/L. The LOQ for PFHxA and PFDA was 2.5 ng/L. However, for sample 505SF1, the LOQ for PFHxA and PFOSA was 2.0 ng/L while for PFBA it was 2.5 ng/L. In Round 2, the LOQ for nearly all PFCs was 2.0 ng/L. Exceptions were observed for PFBA, PFPeA, $^{13}C_4$-PFOA, and $^{13}C_4$-PFOS where the LOQs were 10.0, 5.0, 2.99, and 2.87 ng/L, respectively.

For Round 1 water samples, the low set of LCS samples for PFBA did not met the acceptance criteria with an RSD of 41% while the mid and high sets met method acceptance criteria of 100 ± 20% with RSDs ≤ 20%. For PFPeA and linear PFOA and PFOS, the high curve points were disabled to meet accuracy and linearity criteria. Acceptance criteria were met for all analytes with the exception of the low level set of LCS samples for PFUnA which had an average recovery of 76.6%, with an RSD of 21%. For Round 2 water samples, all three sets of LCS samples for PFNA, PFDA, PFUnA, PFDoA,

PFBS, PFHS, PFOS (linear), PFOSA, $^{13}C_4$-PFOS, $^{13}C_2$-PFUnA, PFOA, and $^{13}C_4$-PFOA met the acceptance criteria of 100% ± 20%, with an RSD of ≤20%. For PFBA and PFPeA, the low set of LCS samples were below the LOQ and recovery could not be determined. For PFHxA, all replicates for the high set of LCS samples exceeded the calibration range and were disabled to meet method linearity criteria. When considering all LCS sets, all PFC analytes met the acceptance criteria of an RSD ≤20%.

Given that reference materials used for quantitation of PFOS and PFOA are predominately linear isomers while surface water samples collected from Pool 2 contain both linear and branched isomers, laboratory control samples (LCS) containing both linear and branched isomers were prepared to evaluate the potential for analytical bias. LCS samples were prepared at the same time as the calibration curve and SPE extraction of the samples. For Round 1 water samples, the average recovery for the low set of LCS samples for PFOA was 66.1%± 7.9%(RSD) and did not meet the method criteria . In contrast the mid set for PFOA and both sets of LCS samples for PFOS met the method acceptance criteria. For Round 2 water samples, both sets of LCS samples met the method acceptance criteria. For PFOS, the low set of LCS samples met method acceptance criteria while 2 out of the 3 replicates in the high set inadvertently did not receive internal standard spikes, therefore recovery could not be calculated. However, the peak count areas for those 2 samples were very similar to the third replicate that was quantified to have a recovery of 109%.

Analytical uncertainty was determined using historical QC data that is control charted and used to evaluate method accuracy and precision. The method uncertainty is calculated as the standard deviation for a set of accuracy results (%) obtained for QC samples. The expanded uncertainty is calculated by multiplying the standard deviation by a factor of 2. This corresponds to a confidence level of 95%. For Round 1 water samples, the analytical uncertainties were ± 28% for PFBA, ±34% for PFPeA, ±27% for PFHxA, ±24% for PFHpA, ± 25% for PFOA, ± 17% for PFNA, ± 18% for PFDA, ±24% for PFUnA, ± 20% for PFDoA, ±22% for PFBS, ± 17% for PFHS, ±32% for PFOS, and ±16% for PFOSA. For Round 2 water samples, the analytical uncertainties were ± 35% for PFBA, ± 35% for PFPeA, ± 31% for PFHxA, ±27% for PFHpA, ±27% for PFOA, ±16% for PFNA, ±17% for PFDA, ±22% for PFDoA, ±22% for PFBS, ±17% for PFHS, ±23% for PFOS, and ±16% for PFOSA.

In Round 1, a total of 6 out of 12 samples met the acceptance criteria for all PFCs in the field matrix spikes. In the 6 samples that did not meet the acceptance criteria, no single exceedence was greater than 40%. The recovery for PFHxA was 31% in one sample while in 4 other samples the recovery for PFPeA ranged from 134% up to 139%. In each instance, the analytical uncertainty was adjusted for these exceedences. The sixth exception, due to the level of analyte detected in the sample, the 25 ppt FMS was not an appropriate spike level for PFBA, PFOA, and PFOS. However, the $^{13}C_4$-PFOA and $^{13}C_4$-PFOS surrogates met the method acceptance criteria and as a result, no additional matrix spikes were prepared. In this sample the recovery was 132% and the analytical uncertainty was adjusted accordingly.

In Round 2, a total of 14 out of 30 water samples met the acceptance criteria for all PFCs in the field matrix spikes. In 12 samples, recoveries for PFBA exceeded the criteria and ranged from 135% up to 165%. For PFPeA, 8 samples had recoveries that exceeded their criteria and ranged from 132% up to 163%. In all but two of these instances, the analytical uncertainty was adjusted for the exceedence. For the other two instances, the recovery was within the analytical uncertainty of ± 35% and no further adjustment was made. For one sample, the 25 ppt FMS was not an appropriate spike level for PFBA, PFPeA, PFOA, PFBS, PFHS, and PFOS due to the low level of analyte detected. However,

the $^{13}C_4$-PFOA and $^{13}C_4$-PFOS surrogates met the method acceptance criteria and no additional matrix spikes were prepared.

5.2 Field QA/QC Samples

Four field equipment blanks were analyzed as part of this study. With the exception of PFOS, all target analytes were reported as less than their LOQ in all 4 blank samples. In 3 of the 4 blanks, PFOS was less than the LOQ (2 ng/L), while PFOS was detected in the 4th blank with a reported result of 6.38 ng/L. This sample was a rinsate blank from a cooler used to temporarily store fish during collection. These coolers were routinely washed and rinsed during the collection and it is highly unlikely that cross contamination would occur through contact with coolers.

5.3 Fish Processing QA/QC Samples

In the pre-study process control, concentrations of target analytes in bass tissue that had been homogenized at WTL remained relatively unchanged when compared to non-WTL homogenized tissue. Exceptions to this were observed for PFBA, PFPeA, and PFHxA where concentrations increased by 3.7 ng/g, 0.73 ng/g, and 1.93 ng/g, respectively and for PFHpA and PFOA where concentrations decreased by 0.06 ng/g, and 0.07 ng/g, respectively. The relative percent difference (RPD) for PFBA, PFPeA, PFHxA, PFHpA, and PFOA were 26%, 64%, 22%, and 25%, respectively. In the mid-study process control, only PFOSA did not meet the acceptance criteria with a concentration difference of 0.041 ng/g and a RPD of 85%. In the post-study process control, concentrations in the WTL-homogenized samples were increased from non-homogenized values for PFHxA (0.81 ng/g), PFNA (0.23 ng/g), PFOA (0.11 ng/g), and PFUnA (0.042 ng/g) with RPD values of 154%, 121%, 59%, and 32%, respectively. All other analytes in the three process controls samples, including PFOS, met the acceptance criteria (RPD $\leq$ 20%) for WTL versus non-WTL homogenized tissue samples. The changes in analyte concentrations observed in the pre-, mid- and post-study process control samples did not appear to be due to gross contamination from the homogenization process at the WTL-MSU laboratory. This is based on the fact that the variability within these sets of process samples were within the acceptance criteria for most target PFCs, including PFOS. Furthermore, the largest variations on a ng/g basis were predominately with the C4-C6 PFCA analytes, all of which were infrequently measured at levels above the LOQs in fish collected from Pool 2 of the Mississippi River. As a result, the changes in PFC concentrations observed between the WTL and non-WTL homogenized samples did not appear to have significantly affected the data reported for fish collected in this study.

A rinse blank (ID HSR060911F1) containing approximately 100 mL of water was generated by WTL personnel prior to the processing of the pre-study control fish tissue sample mentioned above. With the exception for PFOA, PFNA, and PFOS, all analyte concentration reported in this sample were less than their LOQ. For PFOA, PFNA, and PFOS, concentrations reported in this blank were 2.66, 2.30, and 20.8 ng/L, respectively. However, in the fish tissue pre-study control sample (E11-0356-01-001) that was processed after this blank was generated, PFOA, PFNA and PFOS concentrations were reported as 0.209, <0.250, and 0.576 ng/g, respectively, which indicates there was no apparent cross-contamination from equipment to sample.

In addition to the analysis of fish tissues, consumable supplies (baggies, bench paper, rinse water, etc.) used at MSU for fish processing were sent prior to the commencement of the study to the 3M lab for analysis to ensure that contact contamination would not occur by using those supplies during fish processing. The results from the extraction with methanol: water (1:1) and analysis by

LC/MS/MS of those consumable supplies are documented in the 3M final analytical reports and showed all PFCs were less than their respective LOQ, and therefore sufficiently demonstrated that the consumable supplies used at MSU for fish processing did not have significant extractable PFOS at levels that would pose a contact contamination concern.

Chapter 6

PFOS Results

6.1 Intralaboratory Blind Duplicate Samples

PFOS was detected in all 41 of the intralaboratory blind duplicate samples analyzed by the 3M lab. PFOS concentrations ranged from 7.07-305 ng/g ww in the primary fish samples (Figure 6-7). In the blind duplicate samples, PFOS ranged from 7.79-257 ng/g ww. A comparison of the primary and blind duplicate samples showed that PFOS concentrations differed by less than 20% in 38 of the 41 tissue samples. The average relative percent difference (RPD) between the primary and blind duplicate samples was approximately 9% (Table 6-1).

6.2 Interlaboratory Comparison Samples

6.2.1 Fish Tissue

PFOS was detected in all 41 of the interlaboratory fish tissue samples in both laboratories. PFOS concentrations for all fish ranged from 9.33 to 356 ng/g ww from AXYS and 7.07 to 305 ng/g ww from the 3M lab (Figure 6-8; Table 6.2). A comparison of PFOS concentrations measured in individual fish samples indicated good agreement between laboratories. PFOS concentrations reported by AXYS were greater than those from the 3M lab for 38 of the 41 samples with RPDs that ranged from 1.27 to 53.6% with an average value of 16%. When evaluated on a percent difference basis, values ranged from 1.2 to 73% with an average of 19%. While there was a systematic difference in the reported PFOS concentrations between both laboratories, this is not unexpected given the differences in analytical methodologies used at each laboratory (Lindström *et al.* 2009). For instance, the use of linear isomer PFOS calibration with a 499 to 80 MS/MS transition for data acquisition as was used by AXYS, not the 3M lab, can bias high the quantification of mixed branched/linear PFOS in environmental samples by 8% (Riddell *et al.* 2009). Given what is known about the variability in the quantification of PFOS in biological tissues, results from this interlaboratory comparison reinforce the validity of the results of this study.

6.2.2 Surface Water

The interlaboratory comparison of PFOS concentrations in the 30 surface water samples shows good agreement with concentrations reported by 3M being approximately 1.24-fold greater than those reported by AXYS (Figure 6-9). For AXYS, 25 out of 30 the samples had PFOS concentrations less than the reporting limit while for the 3M lab, 23 of the 30 samples had PFOS concentrations below the reporting limit (Table 6-3). For samples where PFOS was detected, concentrations ranged from 3.45 to 84.9 ng/L for AXYS and 2.15 to 136 ng/L for the 3M lab. While the RPD for all 30 water samples ranged between < 1 to 107%, it is important to note that for the five samples where PFOS was detected by both laboratories, the relative percent difference (RPD) ranged from 17% to 56% with an average of 33%.

6.3 Study Fish Tissue Samples

All bluegill, freshwater drum, smallmouth bass, and white bass tissue samples were successfully analyzed for PFOS with concentrations being reported as greater than the limit of quantitation. The

concentrations of PFOS in the 2011 Mississippi River fish samples ranged from 3.17 to 757 ng/g ww. The arithmetic mean, geometric mean, and median PFOS concentrations for all fish from Pool 2 were 46.3, 31.1 and 34.1 ng/g ww, respectively. In total, the number of samples with PFOS concentrations greater than 40 ng/g ww was 165 while there were 11samples with PFOS concentrations greater than 200 ng/g ww. No sample had a PFOS concentration greater than 800 ng/g ww. PFOS concentrations as reported by 3M for each fish are provided in Appendix A, Table A-1.

Summary statistics for species PFOS concentrations for the entirety of Pool 2 are provided in Table 6-4. In Figure 6-1, box plots provide additional summary statistics on a species specific basis for the entirety of Pool 2. By species, the arithmetic mean and its 95% confidence limits are: bluegill - 36 (24-47) ng/g ww; freshwater drum – 46 (32-61) ng/g ww; smallmouth bass - 39 (25-54) ng/g ww; and white bass - 64 (56-72) ng/g ww. The rank order of PFOS concentrations based on arithmetic means from least to greatest was bluegill, smallmouth bass, freshwater drum and white bass with average PFOS concentrations ranging from 36 to 64 ng/g ww. The rank order of PFOS concentrations from least to greatest based on median values was bluegill, followed by freshwater drum, smallmouth bass and then white bass with median PFOS concentrations ranging from 18 to 58 ng/g ww. An examination of the interquartile ranges in Figure 6-1 as a measure of the variation of PFOS concentrations on a species specific basis shows the greatest degree of variation was associated with bluegill and least for white bass.

In general, the concentration of PFOS in the target fish species did not vary greatly between reaches (Tables 6-5 through 6-14). Based on median values, Reach 6 was highest for bluegill, Reach 5 for freshwater drum, and Reach 10 for smallmouth bass and white bass. For bluegill, PFOS concentrations levels generally increased from Reach 1 (where the lowest levels were observed) through Reach 6, decreased in Reach 7 and then steadily increased through Reach 10 (Figure 6-2). For freshwater drum, median values for the reaches only varied between 12 ng/g (Reach 9) to 38.2 ng/g (Reach 5) with no clear patterns evident from upstream to downstream (Figure 6-3). In similar fashion, the median values for smallmouth bass between reaches were relatively uniform with the exception of Reach 10 which had the highest value of 55 ng/g (Figure 6-4). The white bass results showed the least variability and had fairly consistent median values across all reaches with a minimum of 47 ng/g in Reach 3 and a maximum of 71 ng/g in Reach 10 (Figure 6-5).

Correlation analysis was conducted to evaluate the potential association between fish characteristics (mass, length and age) and fillet PFOS concentrations (Table 6-15). Statistically significant, positive correlations between mass and PFOS concentrations were observed for bluegill ($p=0.026$) and white bass ($p= 0.024$) while a statistically significant, negative association was observed in freshwater drum ($p=0.024$). However, all these associations were weak with only up to 5% of the total variation being accounted for in both bluegill and white bass while only 9% of the variation was accounted for in freshwater drum. There were no statistically significant ($p< 0.05$) species-specific association between mass and PFOS concentration with less than 2% of the total variation being accounted for by these associations. For length and PFOS concentrations, the only statistically significant correlation was observed for freshwater drum ($p =0.006$); however, this association was negative and only accounted for approximately 7% of the total variation. There was statistically significant positive association between PFOS concentrations and age for white bass ($p=0.010$), however this association only accounted for approximately 6.8% of the total variation. Overall, there were no strong associations between mass, length, or age with PFOS concentrations in any fish species collected during the study.

6.4 Study Surface Water Samples

Of the 30 water samples collected in Round 2 (August) from Pool 2, 21 samples (70%) had PFOS concentrations that were less than the LOQ of 2.0 ng/L (Table 6-15; Figure 6-6; Appendix B, Table B-1). The majority of the non-detect samples were collected from Reaches 1 through 4 where all results were less than the LOQ. Of the 9 samples that had measurable PFOS concentrations, the greatest PFOS concentration was measured in Reach 10 at Station 517 (136 ng/L) while the second greatest PFOS concentration was measured in Reach 5 at Station 530 (7.1 ng/L). Both of these locations likely are impacted by point source mixing zones, i.e., they may not be representative of the composite river concentration for that cross section or transect of river. This hypothesis appears to be supported by downstream concentrations that decrease (in the case of Reach 10, rather dramatically). Finally, as presented in Table 6-15, with the exception of Reach 10, the average PFOS concentrations in water samples from all reaches are well below 7.0 ng /L, which is the site-specific Water Quality Criterion for PFOS established by the MPCA (http:/www.pca.state.mn.us/cleanup/pfc/index.html). As previously noted, given the nature of the Station 517 result (i.e., likely taken within a point source mixing zone), it is most likely not representative PFOS concentrations in Reach 10 and as such, PFOS concentrations that reflect the actual exposure to fish may be less than the PFOS water quality criterion.

Fourteen water samples were also collected in Round 1 (June) when it was believed that a single sampling period would be needed for the study. These 14 samples were split, sent to both laboratories, analyzed and became part of the interlaboratory validation element of the study. Because the June sampling locations were replicated by the complete sample set collected in August, the results from the June to August collections were compared at these 14 locations. As summarized in Table 6-3, there are no observable differences in PFOS concentrations observed for these specific locations.

6.5 Post-Study Fish Tissue Evaluation

Based on average PFOS concentrations, the relative percent difference between the reported NIST SRM 1945 concentration and those measured by 3M and AXYS labs was less than 10% indicating excellent accuracy by both laboratories (Table 6-20). However, for the NIST SRM 1946 sample AXYS reported PFOS concentrations as less than the LOQ (detection limits reported for the duplicate tissue splits were 4.81 and 5.1 ng PFOS/g, ww) and as a result the accuracy could not be assessed for this sample (Tables 6-17 and 6-18).

Intralaboratory precision was also excellent with RPDs of less than 6 and 10% for all blind duplicate pairs analyzed at 3M and AXYS labs, respectively (Table 6-19). In addition, the average PFOS values reported by 3M and AXYS labs were very consistent, with RPDs ranging from 7-16% providing further support for the overall quality of the analytical data reported by these labs.

6.6 Tables and Figures

Table 6-1. Intralaboratory Blind Duplicate Comparison of PFOS (ng/g, ww) in Fish Collected from Pool 2 and Analyzed by 3M

		Primary Samples		Blind Duplicates		
Reach	Species	Lab ID	PFOS	Lab ID	PFOS	Relative Percent Difference
10	Freshwater drum	010FN1	29.1	012FN1	27.4	6.02
10	Bluegill	022FN1	305.0	019FN1	257.0	17.1
8	White bass	033FN1	42.1	042FN1	37.8	10.8
8	White bass	045FN1	59.5	043FN1	51.4	14.6
3	Smallmouth bass	054FN1	30.0	060FN1	27.7	7.97
2	White bass	065FN1	34.9	068FN1	32.8	6.2
1	Freshwater drum	078FN1	35.2	073FN1	33.1	6.15
1	Smallmouth bass	092FN1	13.5	077FN1	13.3	1.49
1	Smallmouth bass	102FN1	44.2	089FN1	41.6	6.06
7	White bass	113FN1	45.3	090FN1	44.9	0.89
9	Bluegill	126FN1	21.6	105FN1	23.3	7.57
9	Freshwater drum	137FN1	11.9	121FN1	11.6	2.55
9	White bass	149FN1	71.4	122FN1	68.9	3.56
10	Smallmouth bass	159FN1	76.7	139FN1	82.5	7.29
6	Freshwater drum	170FN1	28.6	147FN1	27.7	3.2
5	Smallmouth bass	180FN1	13.7	169FN1	11.1	21
5	Freshwater drum	192FN1	41.9	173FN1	44.1	5.12
5	Smallmouth bass	203FN1	41.9	182FN1	52.7	22.8
6	White bass	214FN1	73.4	184FN1	89.8	20.1
4	Smallmouth bass	224FN1	23.5	196FN1	27.9	17.1
4	White bass	232FN1	54.7	210FN1	59.0	7.56
4	Smallmouth bass	246FN1	18.6	225FN1	19.0	2.13
4	Freshwater drum	258FN1	7.1	228FN1	7.8	9.69
1	Freshwater drum	269FN1	40.3	233FN1	39.5	2.01
2	Smallmouth bass	280FN1	46.1	244FN1	50.0	8.12
7	Smallmouth bass	291FN1	42.3	245FN1	35.8	16.6
7	Smallmouth bass	302FN1	36.8	255FN1	32.7	11.8
8	Freshwater drum	315FN1	27.0	265FN1	31.6	15.7
6	Freshwater drum	323FN1	14.6	275FN1	13.7	6.36
6	Freshwater drum	334FN1	31.3	284FN1	30.4	2.92
3	White bass	346FN1	34.8	314FN1	40.5	15.1

Table 6-1. Intralaboratory Blind Duplicate Comparison of PFOS (ng/g, ww) in Fish Collected from Pool 2 and Analyzed by 3M

		Primary Samples		Blind Duplicates		
Reach	Species	Lab ID	PFOS	Lab ID	PFOS	Relative Percent Difference
3	Smallmouth bass	360FN1	32.6	324FN1	33.0	1.22
2	White bass	370FN1	66.3	327FN1	52.1	24
8	Smallmouth bass	383FN1	40.1	339FN1	35.8	11.3
9	Smallmouth bass	390FN1	9.5	347FN1	8.3	14
5	White bass	400FN1	56.7	348FN1	57.6	1.57
1	White bass	411FN1	62.2	357FN1	67.3	7.88
9	White bass	425FN1	66.4	371FN1	67.7	1.94
4	Smallmouth bass	436FN1	39.1	375FN1	41.3	5.47
3	Freshwater drum	447FN1	10.1	376FN1	9.5	6.02
1	White bass	450FN1	68.0	406FN1	68.4	0.59

Table 6-2. Interlaboratory Comparison of PFOS (ng/g, ww) in Fish Collected from Pool 2 and Analyzed by 3M and AXYS

		PFOS			
Reach	Species	Field ID	3M Split	AXYS split	Relative Percent Difference
9	Bluegill	126	21.6	37.4	[illegible]
10	Bluegill	22	305	356	[illegible]
1	Freshwater drum	78	35.2	42.15	[illegible]
1	Freshwater drum	269	40.3	44.4	9.68
3	Freshwater drum	447	10.1	11.8	15.5
4	Freshwater drum	258	7.07	9.33	27.6
5	Freshwater drum	192	41.9	46.3	[illegible]
6	Freshwater drum	170	28.6	29.3	[illegible]
6	Freshwater drum	323	14.6	17.5	[illegible]
6	Freshwater drum	334	31.3	31.7	1.27
8	Freshwater drum	315	27	31.3	14.8
9	Freshwater drum	137	11.9	12.6	5.71
10	Freshwater drum	10	29.1	34	[illegible]
1	Smallmouth bass	92	13.5	15.6	[illegible]
1	Smallmouth bass	102	44.2	51.3	[illegible]
2	Smallmouth bass	280	46.1	52.5	13
3	Smallmouth bass	54	30	34.3	13.4
3	Smallmouth bass	360	32.6	33.8	3.61
4	Smallmouth bass	224	23.5	31.1	[illegible]
4	Smallmouth bass	246	18.6	21.6	[illegible]
4	Smallmouth bass	436	39.1	43	[illegible]
5	Smallmouth bass	180	13.7	13.2	3.72
5	Smallmouth bass	203	41.9	61.9	38.5
7	Smallmouth bass	291	42.3	44.6	5.29
7	Smallmouth bass	302	36.8	35.6	[illegible]
8	Smallmouth bass	383	40.1	51.5	[illegible]
9	Smallmouth bass	390	9.5	10.9	[illegible]
10	Smallmouth bass	159	76.7	112	37.4
1	White bass	411	62.2	83.3	29
1	White bass	450	68	80.6	17
2	White bass	65	34.9	40	[illegible]
2	White bass	370	66.3	75.5	[illegible]
3	White bass	346	34.8	45.7	[illegible]

Table 6-2. Interlaboratory Comparison of PFOS (ng/g, ww) in Fish Collected from Pool 2 and Analyzed by 3M and AXYS

		PFOS			
Reach	Species	Field ID	3M Split	AXYS split	Relative Percent Difference
4	White bass	232	64.7	79.4	20.4
5	White bass	400	56.7	66.9	16.5
6	White bass	214	73.4	89.1	19.3
7	White bass	113	45.3	59.5	27.1
8	White bass	33	42.1	44.6	5.77
8	White bass	45	59.5	75.3	23.4
9	White bass	149	71.4	88.6	21.5
9	White bass	425	66.4	65.2	1.82

Table 6-3. Interlaboratory Comparison of PFOS (ng/L) in Surface Water Collected from Pool 2 During Rounds 1 and 2 and Analyzed by 3M and AXYS

		AXYS Lab		3M Lab		
Reach	Field ID	PFOS	Qualifier[1]		Qualifier[1]	Relative Percent Difference
1	512	< 1.98	U	< 2.00	U	NA
1	513	< 2.50	U	< 2.00	U	NA
1	514	< 2.00	U	< 2.00	U	NA
2	509	< 1.99	U	< 2.00	U	NA
2	510	< 2.00	U	< 2.00	U	NA
2	511	< 2.03	U	< 2.00	U	NA
3	506	< 1.99	U	< 2.00	U	NA
3	507	<1.95	U	< 2.00	U	NA
3	508	< 1.98	U	< 2.00	U	NA
4	533	< 3.17	U	< 2.00	U	NA
4	534	< 6.62	U	< 2.00	U	NA
4	535	< 3.53	U	< 2.00	U	NA
5	530	***9.17***		***7.10***		***25.4***
5	531	< 3.67	U	< 2.00	U	NA
5	532	< 4.28	U	< 2.00	U	NA
6	527	***3.45***		***2.60***		***28.1***
6	528	< 3.74	U	< 2.00	U	NA
6	529	< 3.53	U	< 2.00	U	NA
7	524	***4.94***		***2.77***		***56.3***
7	525	< 4.94	U	< 2.00	U	NA
7	526	< 4.94	U	< 2.00	U	NA
8	503	< 1.97	U	< 2.00	U	NA
8	504	< 2.48	U	< 2.00	U	NA
8	505	< 2.30	U	< 2.00	U	NA
9	518	< 4.13	U	***2.15***		NA
9	519	< 3.65	U	< 2.00	U	NA
9	520	< 3.46	U	***2.77***		NA
10	501	***84.9***		***136***		***46.3***
10	502	< 2.69	U	< 2.00	U	NA
10	515	***4.96***		***4.20***		***16.6***

[1] U = undetected

Bold italicized values indicate detected PFOS results

Table 6-4. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Pool 2 (2011) and Analyzed by 3M

ALL SAMPLES

Statistic	Species			
	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	100	100	100	96
Arithmetic Mean [PFOS]	36	46	39	64
Standard Deviation	57	75	75	41
Maximum [PFOS]	392	607	757	394
Minimum [PFOS]	4	3	5	13
Median [PFOS]	18	30	30	58
Geometric Mean [PFOS]	20	28	29	58

Table 6-5. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 1 of Pool 2 (2011) and Analyzed by 3M

REACH 1

Statistic	Species			
	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	6
Arithmetic Mean [PFOS]	7	53	23	53
Standard Deviation	2	59	15	22
Maximum [PFOS]	11	213	56	76
Minimum [PFOS]	4	13	8	13
Median [PFOS]	6	33	17	56
Geometric Mean [PFOS]	7	37	20	46

Table 6-6. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 2 of Pool 2 (2011) and Analyzed by 3M

REACH 2	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	12	40	30	61
Standard Deviation	6	33	15	16
Maximum [PFOS]	27	97	52	89
Minimum [PFOS]	7	6	5	35
Median [PFOS]	10	30	29	63
Geometric Mean [PFOS]	11	29	25	59

Table 6-7. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 3 of Pool 2 (2011) and Analyzed by 3M

REACH 3	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	34	36	29	47
Standard Deviation	20	15	9	18
Maximum [PFOS]	72	55	45	70
Minimum [PFOS]	9	9	16	20
Median [PFOS]	29	37	31	47
Geometric Mean [PFOS]	29	31	28	44

Table 6-8. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 4 of Pool 2 (2011) and Analyzed by 3M

REACH 4

Statistic	Species			
	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	33	24	34	64
Standard Deviation	20	23	9	20
Maximum [PFOS]	66	76	44	91
Minimum [PFOS]	10	3	19	36
Median [PFOS]	26	14	38	61
Geometric Mean [PFOS]	27	16	33	61

Table 6-9. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 5 of Pool 2 (2011) and Analyzed by 3M

REACH 5

Statistic	Species			
	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	32	70	30	66
Standard Deviation	16	91	10	30
Maximum [PFOS]	56	316	46	152
Minimum [PFOS]	7	10	14	51
Median [PFOS]	34	38	31	58
Geometric Mean [PFOS]	27	44	28	63

Table 6-10. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 6 of Pool 2 (2011) and Analyzed by 3M

REACH 6	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	95	26	31	63
Standard Deviation	121	14	11	18
Maximum [PFOS]	392	57	51	105
Minimum [PFOS]	10	10	19	47
Median [PFOS]	52	27	29	58
Geometric Mean [PFOS]	52	23	29	61

Table 6-11. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 7 of Pool 2 (2011) and Analyzed by 3M

REACH 7	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	11	26	32	61
Standard Deviation	5	29	11	29
Maximum [PFOS]	21	105	48	139
Minimum [PFOS]	4	9	7	36
Median [PFOS]	11	17	34	52
Geometric Mean [PFOS]	10	19	29	57

Table 6-12. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 8 of Pool 2 (2011) and Analyzed by 3M

REACH 8

Statistic	Species			
	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	16	39	31	52
Standard Deviation	6	17	13	11
Maximum [PFOS]	28	79	60	71
Minimum [PFOS]	10	15	16	34
Median [PFOS]	14	34	27	50
Geometric Mean [PFOS]	15	36	28	51

Table 6-13. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 9 of Pool 2 (2011) and Analyzed by 3M

REACH 9

Statistic	Species			
	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	39	37	19	66
Standard Deviation	31	64	10	26
Maximum [PFOS]	99	215	35	112
Minimum [PFOS]	11	5	7	33
Median [PFOS]	22	12	17	67
Geometric Mean [PFOS]	30	18	16	62

Table 6-14. Descriptive Statistics for PFOS (ng/g, wet weight) in Fish Collected from Reach 10 of Pool 2 (2011) and Analyzed by 3M

REACH 10	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
N of Cases	10	10	10	10
Arithmetic Mean [PFOS]	79	114	135	103
Standard Deviation	103	186	222	105
Maximum [PFOS]	305	607	757	394
Minimum [PFOS]	5	12	35	41
Median [PFOS]	26	26	55	71
Geometric Mean [PFOS]	36	48	76	80

Table 6-15. Correlations of PFOS with Species-Specific Fish Characteristics (ND=0)

		Bluegill	Freshwater drum	Smallmouth bass	White bass
Mass vs [PFOS]	Spearman r	0.2224	-0.3020	0.1255	0.2309
	p-value	0.0261	0.0023	0.2136	0.0234
	n	100	100	100	96
Length vs [PFOS]	Spearman r	0.1936	-0.27213	0.0651	0.1984
	p-value	0.0536	0.0062	0.5196	0.0527
	n	100	100	100	96
Age vs [PFOS]	Spearman r	-0.1244	-0.0124	0.0583	0.2614
	p-value	0.2198	0.9028	0.5646	0.0101
	n	99	100	100	96

Table 6-16. Summary of Average PFOS Concentrations (ng/L) in Water Collected from Pool 2 in Round 2 (August) and Analyzed by 3M

Reach	Field ID	Lab ID	Detection limit	Units	Results[1]	Average by Reach[2]
1	542SF	542SF1	2	ng/L	<2.0	
1	543SF	543SF1	2	ng/L	<2.0	1.00
1	544SF	544SF1	2	ng/L	<2.0	
2	539SF	539SF1	2	ng/L	<2.0	
2	540SF	540SF1	2	ng/L	<2.0	1.00
2	541SF	541SF1	2	ng/L	<2.0	
3	536SF	536SF1	2	ng/L	<2.0	
3	537SF	537SF1	2	ng/L	<2.0	1.00
3	538SF	538SF1	2	ng/L	<2.0	
4	533SF	533SF1	2	ng/L	<2.0	
4	534SF	534SF1	2	ng/L	<2.0	1.00
4	535SF	535SF1	2	ng/L	<2.0	
5	530SF	530SF1	2	ng/L	7.1	
5	531SF	531SF1	2	ng/L	<2.0	3.03
5	532SF	532SF1	2	ng/L	<2.0	
6	527SF	527SF1	2	ng/L	2.6	
6	528SF	528SF1	2	ng/L	<2.0	1.53
6	529SF	529SF1	2	ng/L	<2.0	
7	524SF	524SF1	2	ng/L	2.77	
7	525SF	525SF1	2	ng/L	<2.0	1.59
7	526SF	526SF1	2	ng/L	<2.0	
8	521SF	521SF1	2	ng/L	2	
8	522SF	522SF1	2	ng/L	3.51	2.17
8	523SF	523SF1	2	ng/L	<2.0	

Table 6-16. Summary of Average PFOS Concentrations (ng/L) in Water Collected from Pool 2 in Round 2 (August) and Analyzed by 3M

Reach	Field ID	Lab ID	Detection limit	Units	Results[1]	Average by Reach[2]
9	518SF	518SF1	2	ng/L	2.15	1.97
9	519SF	519SF1	2	ng/L	<2.0	
9	520SF	520SF1	2	ng/L	2.77	
10	515SF	515SF1	2	ng/L	4.2	47.07
10	516SF	516SF1	2	ng/L	<2.0	
10	517SF	517SF1	2	ng/L	136	

[1] <2.0 ng/L = undetected sample

[2] Average values were calculated using ½ the detection limit for non-detect samples

Table 6-17. Post-Study Fish Tissue Samples analyzed for PFOS by the 3M Lab and AXYS

Sample Class	Tissue ID	Split 1 Lab ID (3M)	Split 2 Lab ID (AXYS)	Split 3 Lab ID (3M)	Split 4 Lab ID (AXYS)
3M Fish Tissue Control	E11-0356-01-316	1000	1001	1002	1003
3M Fish Tissue Control	E11-0356-01-001	1020	1021	1022	1023
3M Fish Tissue Control	E11-0356-01-443	1028	1029	1030	1031
NIST-SRM Lake Michigan Fish Tissue	SRM 1947	1012	1013	1014	1015
NIST-SRM Lake Superior Fish Tissue	SRM 1946	1008	1009	1010	1011
Pool 2 Fish	436FN3	1004	1005	1006	1007
Pool 2 Fish	214FN3	1016	1017	1018	1019
Pool 2 Fish	323FN3	1024	1025	1026	1027

Table 6-18. Summary of PFOS (ng/g, wet weight) in Post-Study Fish Tissue Samples Analyzed by the 3M Lab and AXYS

Sample Class	Split 1 Lab ID (3M)	PFOS	Split 3 Lab ID (3M)	PFOS	RPD	Split 2 Lab ID (AXYS)	PFOS	Split 4 Lab ID (AXYS)	PFOS	RPD
3M Fish Tissue Control	1000	0.73	1002	0.76	4.42	1001	**< 5.0**	1003	**< 5.03**	–
3M Fish Tissue Control	1020	0.61	1022	0.59	3.02	1021	**< 5.13**	1023	**< 4.95**	–
3M Fish Tissue Control	1028	0.72	1030	0.69	4.25	1029	**< 5.08**	1031	**< 5.03**	–
NIST-SRM Lake Michigan Fish Tissue	1012	6.27	1014	6.33	1.04	1013*	5.76	1015	5.94	3.08
NIST-SRM Lake Superior Fish Tissue	1008	2.23	1010	2.24	0.37	1009	**< 4.81**	1011	**< 5.1**	–
Pool 2 Fish	1004	42.16	1006	39.8	5.89	1005	48.8	1007	44.3	9.67
Pool 2 Fish	1016	87.70	1018	85.8	2.23	1017	93.9	1019	92.0	2.04
Pool 2 Fish	1024	14.01	1026	14.8	5.68	1025	17.1	1027	16.7	2.37

*Duplicate (1013-D) reported by AXYS - 6.68 ng/g PFOS

[1]NIST-SRM 1947 value 5.90 ± 0.39

[2]NIST-SRM 1946 value 2.19 ± 0.08

Bold font = PFOS not detected; detection limit provided

Table 6-19. Average PFOS (ng/g, wet weight) in Post-Study Fish Tissue Samples Analyzed by 3M and AXYS

	PFOS		
Sample Class	**3M**	**AXYS**	**Relative Percent Difference**
3M Fish Tissue Control	0.74	**ND**	--
3M Fish Tissue Control	0.60	**ND**	--
3M Fish Tissue Control	0.71	**ND**	--
NIST-SRM Lake Michigan Fish Tissue[1]	6.30	5.85	7.39
NIST-SRM Lake Superior Fish Tissue[2]	2.24	**ND**	--
Pool 2 Fish	40.95	466	12.8
Pool 2 Fish	86.73	93.0	6.92
Pool 2 Fish	14.42	16.9	15.8

[1]NIST-SRM 1947 value 5.90 ± 0.39

[2]NIST-SRM 1946 value 2.19 ± 0.08

Bold font = PFOS not detected so average not calculated, DLs for non-detect samples ~ 5 ng/g, wet weight

Table 6-20. Relative Percent Difference (RPD) of Average PFOS Concentrations (ng/g, wet weight) in Post-Study Fish Tissue Samples Analyzed by 3M and AXYS

		PFOS[1]				
Sample Class	**Tissue ID**	**3M**	**AXYS**	**NIST Value**	**3M-NIST RPD**	**AXYS-NIST RPD**
NIST-SRM Lake Michigan Fish Tissue	SRM 1947	6.30	5.85	5.90	6.54	0.85
NIST-SRM Lake Superior Fish Tissue	SRM 1946	2.24	**ND**	2.19	2.15	--

[1]Samples analyzed in duplicate, average result of duplicates is presented

Bold font = PFOS not detected so average not calculated

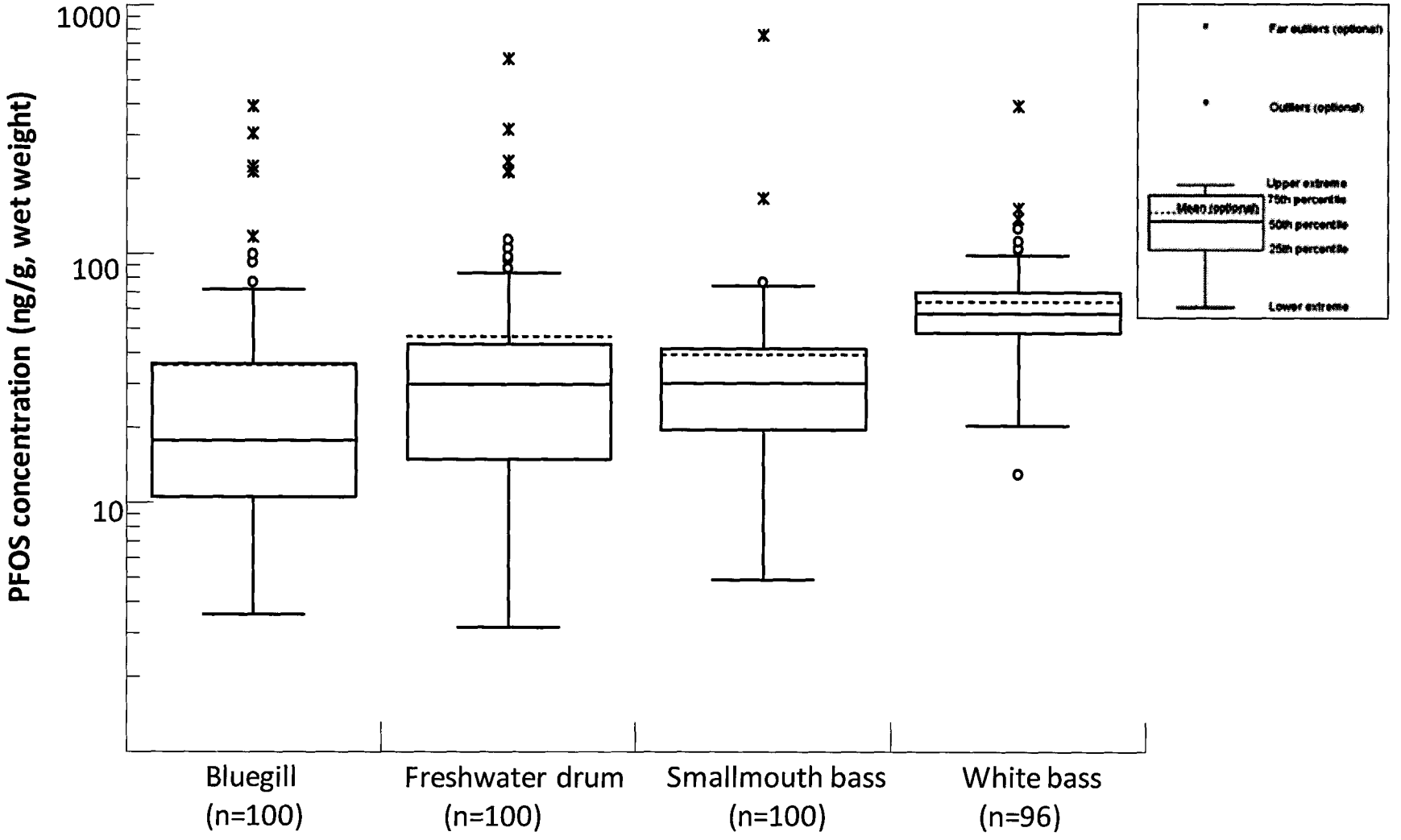


Figure 6-1. PFOS in Fish Tissues from Pool 2 (2011)

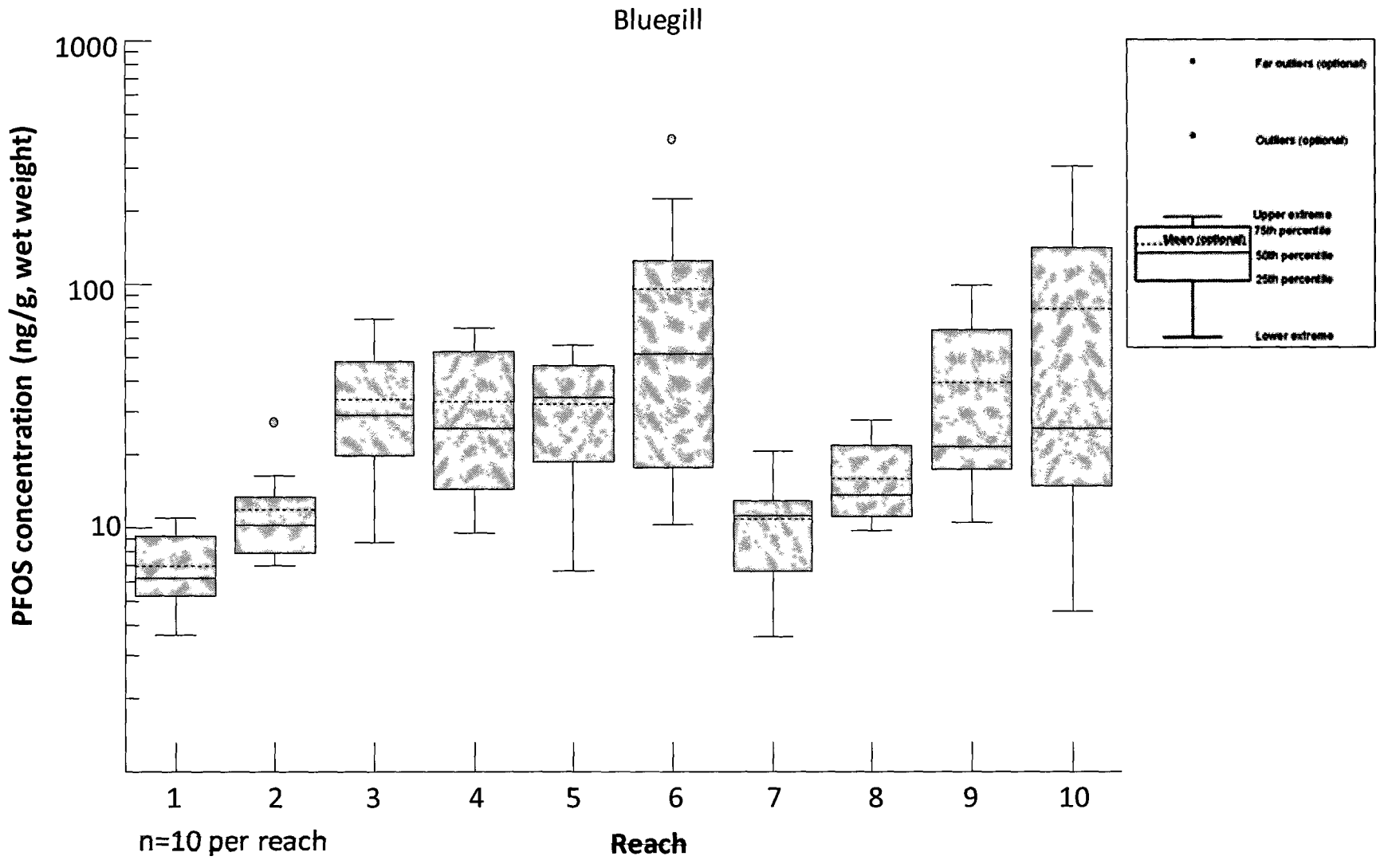


Figure 6-2. PFOS in Fillet Tissues of Bluegill Collected from Pool 2 (2011)

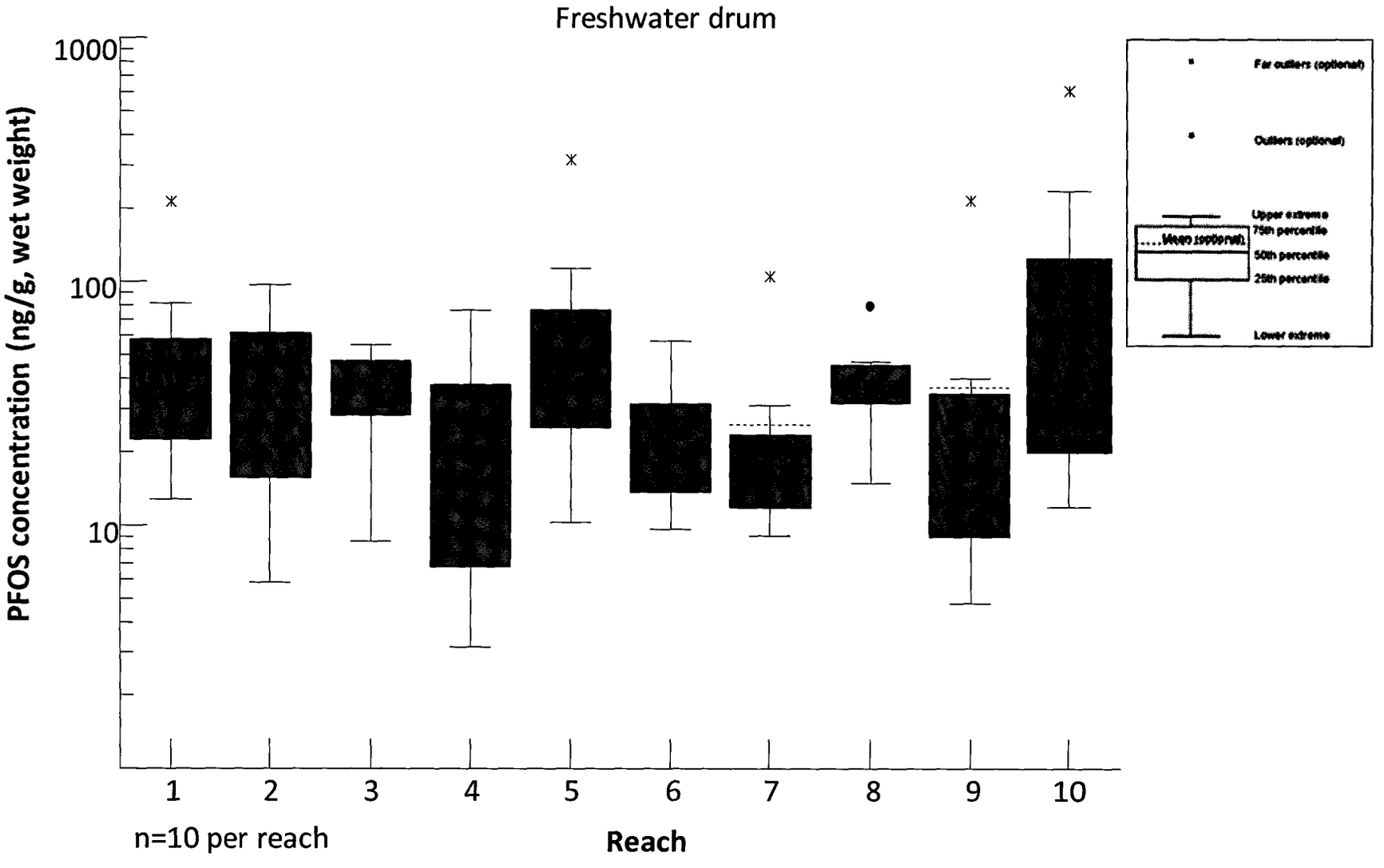


Figure 6-3. PFOS in Fillet Tissues of Freshwater Drum Collected from Pool 2 (2011)

Figure 6-4. PFOS in Fillet Tissues of Smallmouth Bass Collected from Pool 2 (2011)

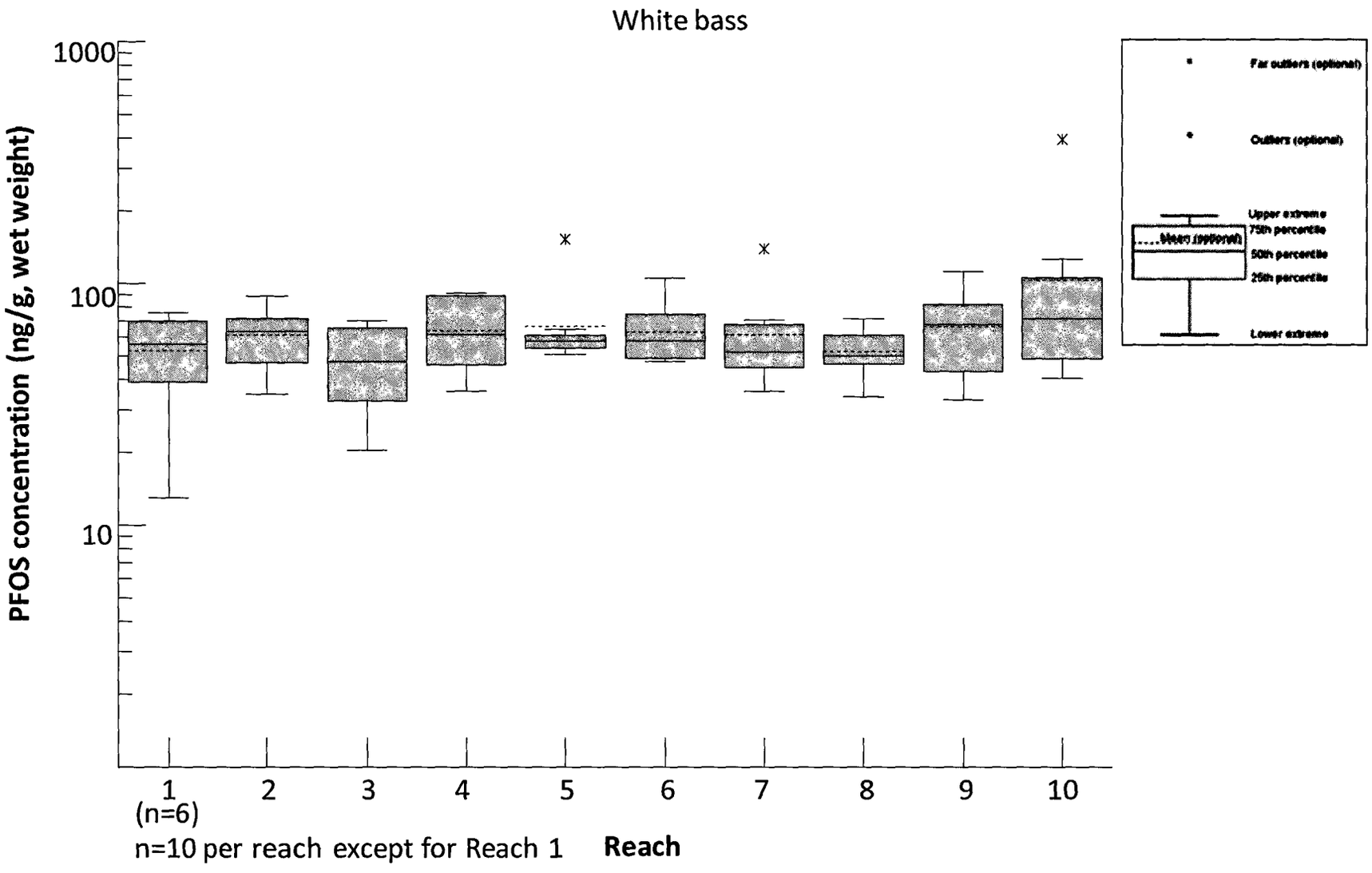


Figure 6-5. PFOS in Fillet Tissues of White Bass Collected from Pool 2 (2011)

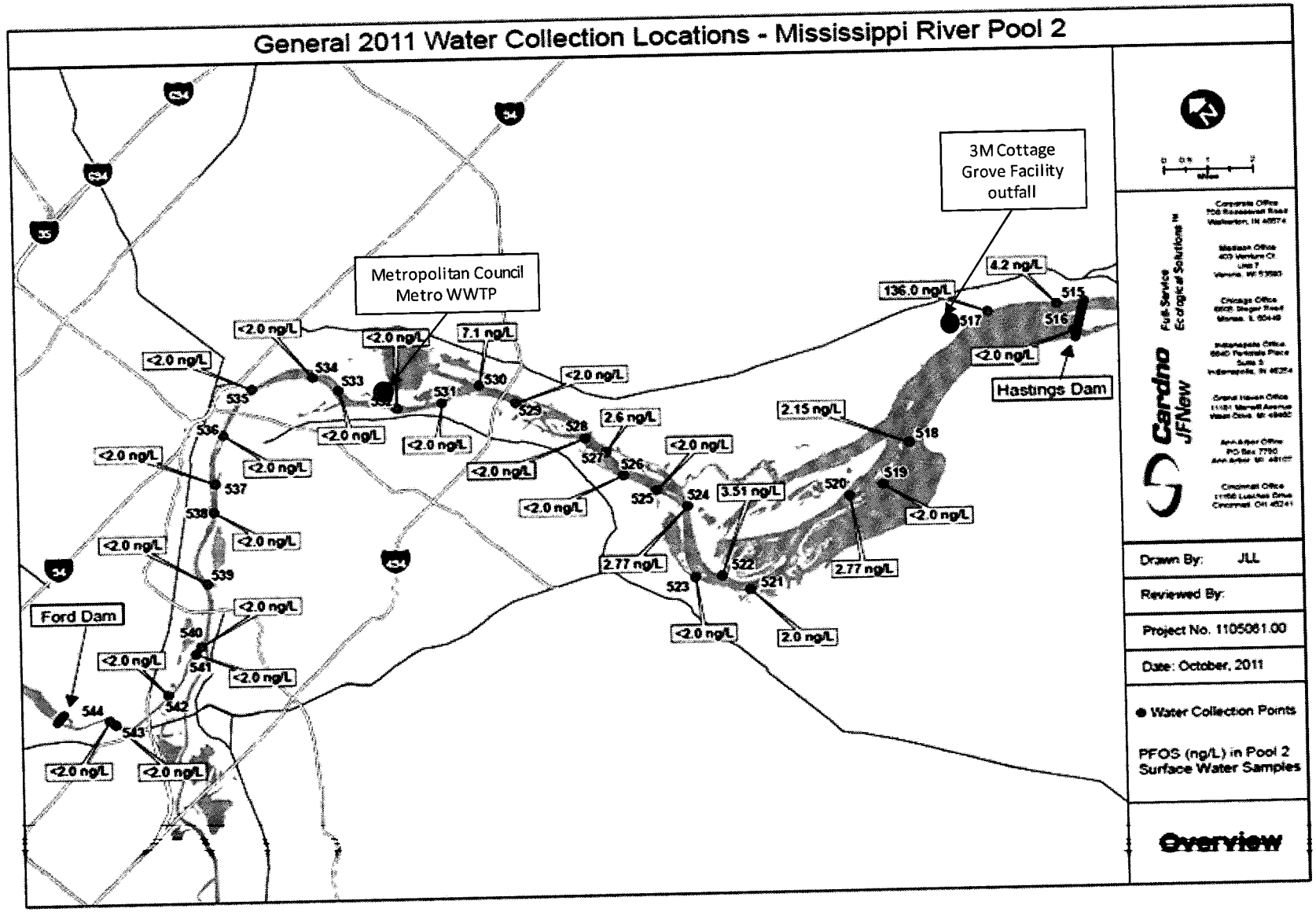


Figure 6-6. PFOS Concentrations (ng/L) in Surface Water Samples Collected from Pool 2 in 2011 (Round 2) and Analyzed by 3M

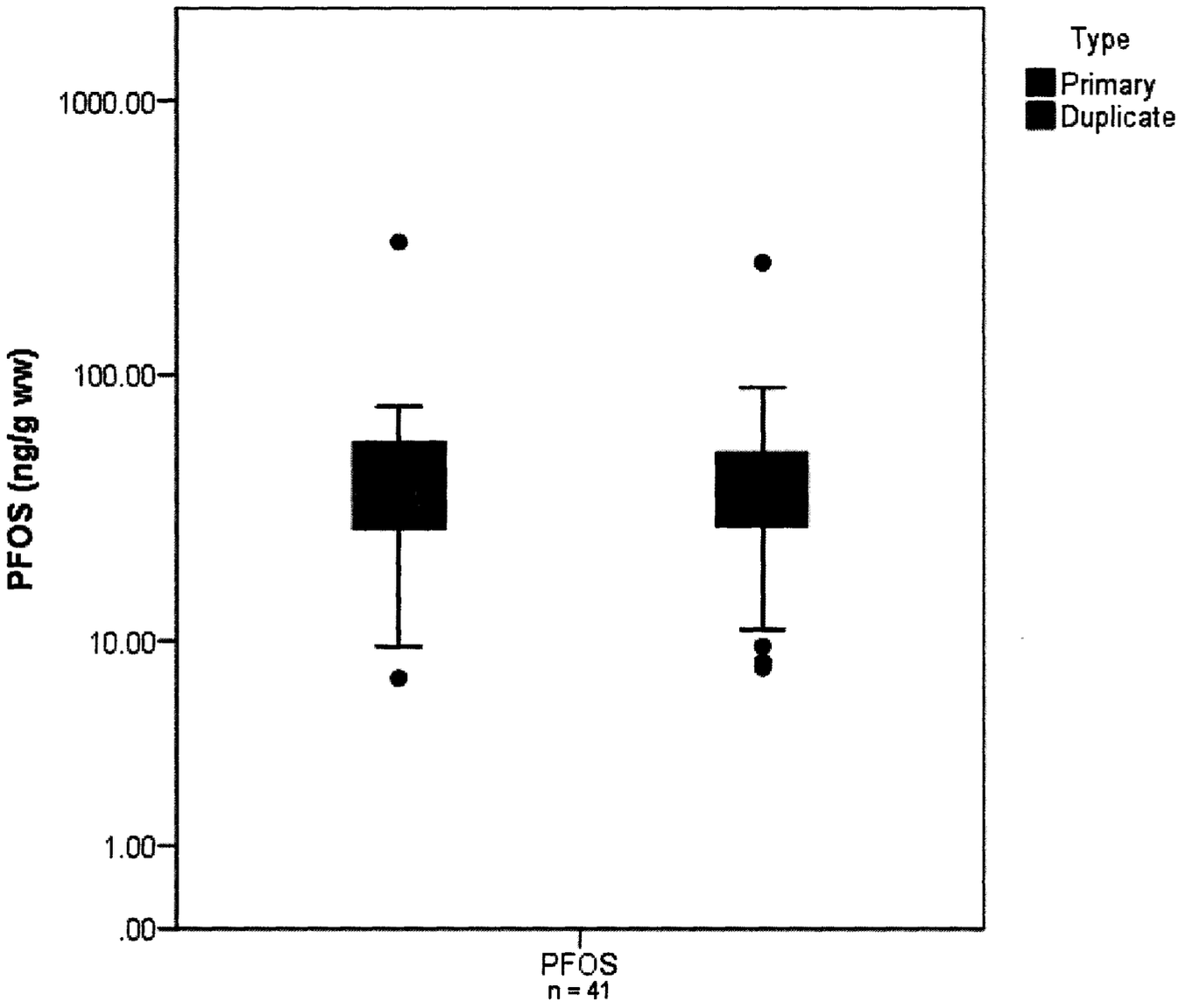


Figure 6-7. Blind Duplicate Fish Tissue Comparison of PFOS Results (3M Lab Only), 2011

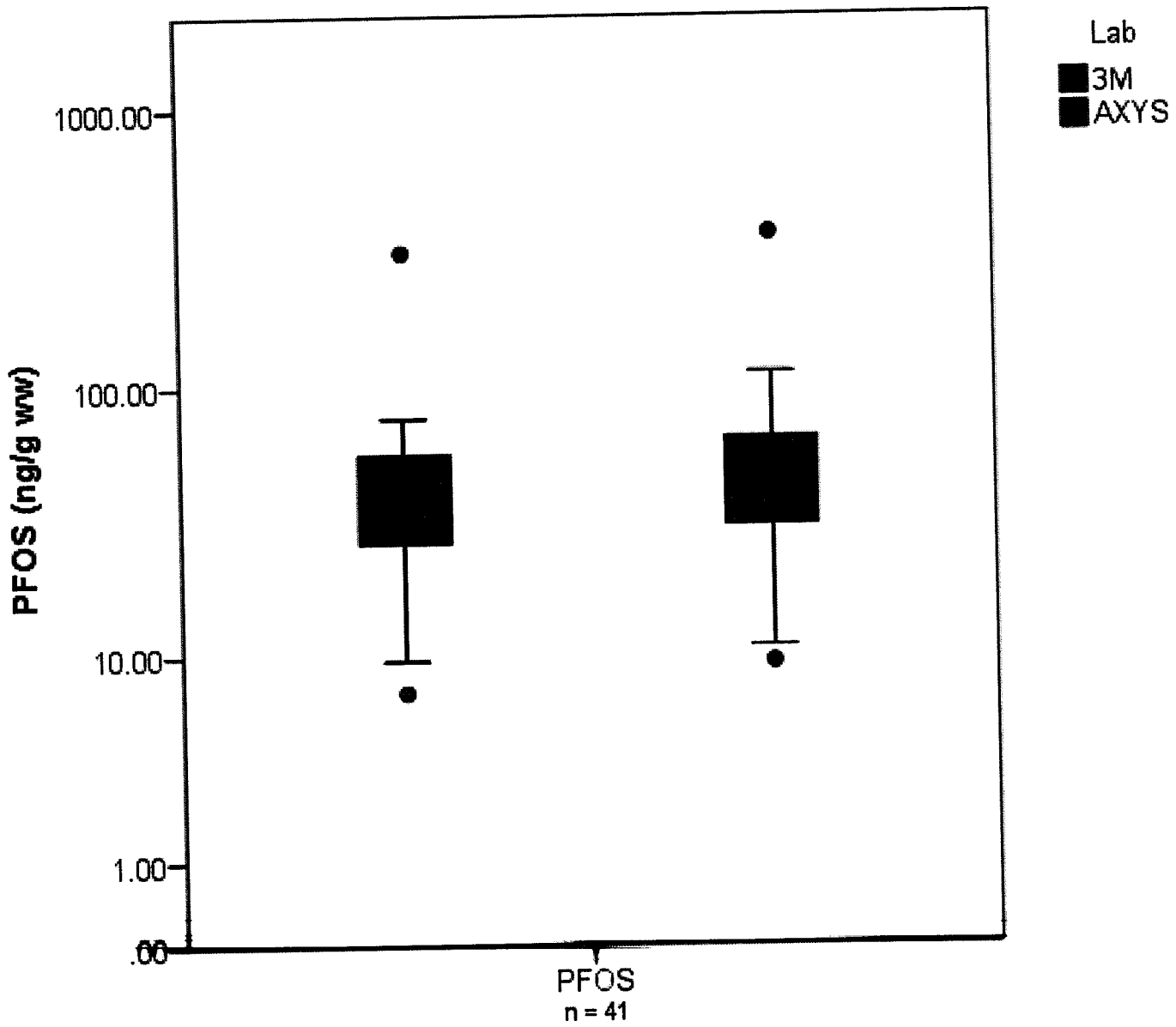


Figure 6-8. Interlaboratory Fish Tissue Comparison of PFOS Results, 2011

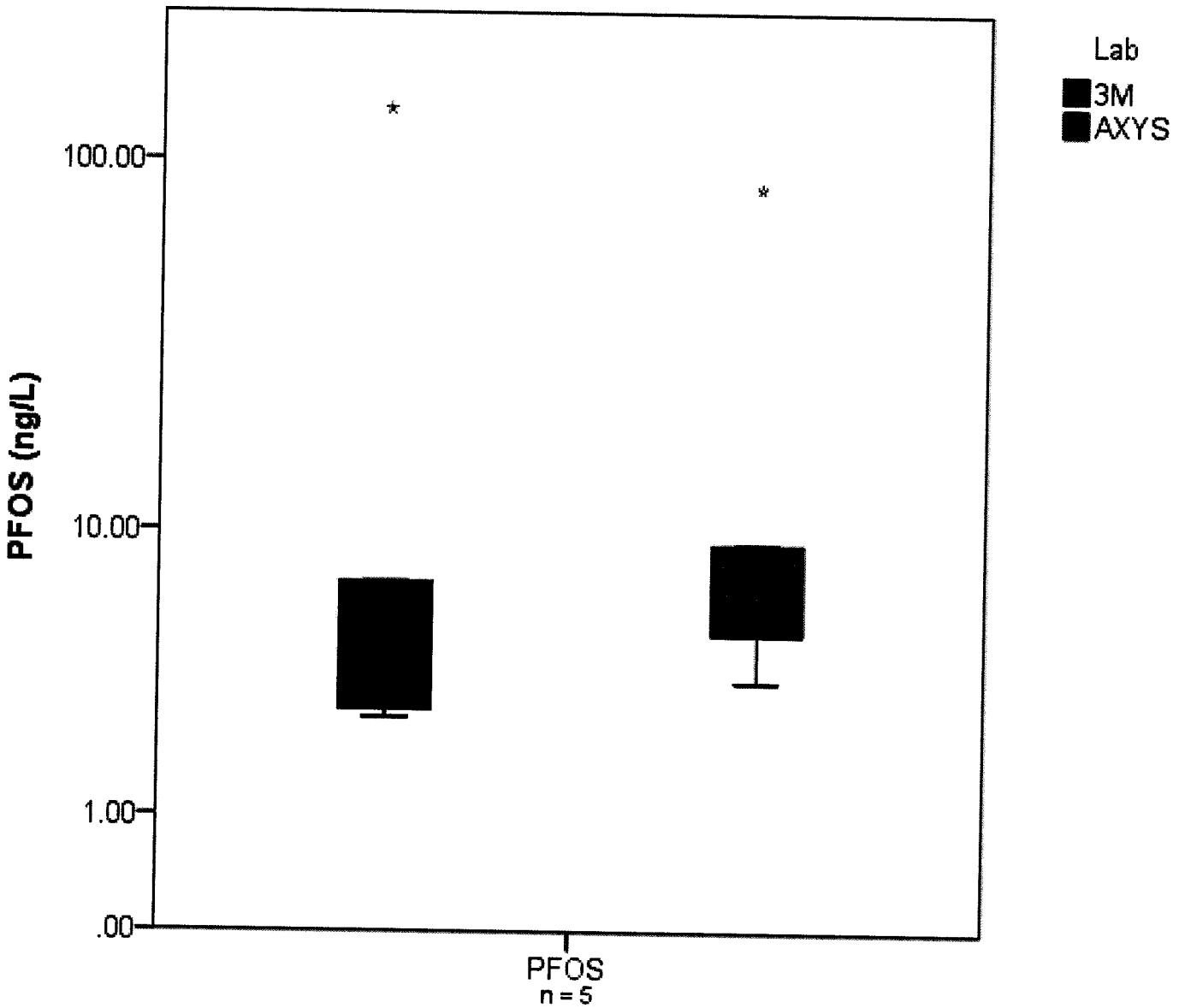


Figure 6-9. Interlaboratory Surface Water Comparison of PFOS Results, 2011

Chapter 7

Perfluorosulfonate Results

7.1 Intralaboratory Blind Duplicate Samples

Results from the analysis of fish tissue in both the primary and blind duplicate sample sets indicated good agreement for all perfluoroalkyl sulfonates (Table 7-1). PFBS was detected in 3 of 41 samples in both the primary and blind duplicate sample sets with concentrations ranging from 0.27 to 0.55 ng/g and 0.059 to 1.26 ng/g in the primary and blind duplicate sample sets, respectively. Of the 3 samples in both datasets, only 2 samples had matched IDs with an average fold difference of 1.7 and an average RPD of 92%. Taking into consideration the small sample size and low concentrations, a definitive evaluation of the data quality is not possible but appear to be of acceptable.

PFHS was detected in 14 of 41 samples in the primary sample set and 12 of 41 samples in the blind duplicate sample set. The concentration range in the primary dataset was 0.04 to 1.7 ng/g while it was 0.05 to 0.22 ng/g in the blind duplicate set. With one exception, there was less than a two-fold difference in measured concentrations with an average RPD of 19%. The exception was observed in one fish sample (Field ID 370) that had a 32-fold difference and a RPD of 188% in measured concentrations. This relatively large difference was due the primary sample having a measured concentration of 1.7 ng/g while in the blind duplicate it was 0.05 ng/g, a value that approaches the LOQ. Based on the results from the other 8 matched samples, this sample was considered to be an outlier and not indicative of the quality of the data for this analyte.

PFOSA was detected in all 41 samples in both the primary and blind duplicate sample sets with concentrations ranging from 0.09 to 8.54 ng/g and 0.09 to 9.37 ng/g, respectively. Fold differences between sample sets ranged from 0.18 to 1.3 with an average RPD of 7.7%. Overall, perfluoroalkyl sulfonate concentrations reported by 3M for both the primary and blind duplicate sample sets were in close agreement demonstrating the accuracy and precision of the data reported by the 3M lab.

7.2 Interlaboratory Comparison Samples

7.2.1 Fish Tissue

The interlaboratory comparison of PFBS, PFHS and PFOSA was limited in scope due to the large number of non-detects (Table 7-2). While the 3M laboratory reported PFBS concentrations in three of the 41 interlaboratory fish samples, all the samples analyzed by AXYS were reported as less than the LOQ. Likewise for PFHS, the 3M lab reported 14 of the 41 samples with measured concentrations while all of the samples analyzed by AXYS had concentrations less than the LOQ. As a result, an interlaboratory comparison was not conducted for these two analytes. PFOSA was detected in all 41 fish tissue samples by the 3M lab while AXYS measured concentrations in 4 fish samples. Based on the results for the 4 matched samples, PFOSA concentrations ranged from 1.74 to 8.54 ng/g and 2.54 to 13.0 ng/g as reported by the 3M lab and AXYS, respectively. PFOSA concentrations measured by AXYS were approximately 23% greater than those reported by the 3M lab with RPDs ranging from 21 to 42% with an average of 31%. Overall, while the average RPD was greater than 20%, there was good agreement between the analytical results given by both laboratories when compared to results typically observed in other interlaboratory studies.

7.2.2 Surface Water

The interlaboratory comparison for PFBS, PFHS, and PFOSA in the 30 water samples were limited by the predominance of non-detects associated with the data reported by both laboratories (Table 7-3). For PFBS, both laboratories reported measured concentrations in three matched surface water samples that ranged from 2.4 to 26 ng/L and 2.3 to 29 ng/L for the 3M Lab and AXYS, respectively. In general concentrations reported by 3M were 24% less than that reported by AXYS with an average RPD of 47%. PFHS was measured in only one matched surface water sample with a concentration of 12.5 and 6.3 ng/L reported by the 3M Lab and AXYS, respectively. The relative percent difference was 67%. PFOSA concentrations in all surface water samples analyzed by both laboratories had reported values that were less than the LOQ. As such comparison was not done for this analyte.

7.3 Study Fish Tissue Samples

Concentrations of PFBS in all fish samples collected from Pool 2 were dominated by non-detects (93%) and of the samples with measurable concentration, only a single sample was greater than 1.0 ng/g ww (Table 7-4). With non-detects set to half the LOQ, concentrations of PFBS in all fish ranged from 0.03 to 1.70 ng/g ww with an overall arithmetic mean, geometric mean and median of 0.6, 0.49, and 0.4 ng/g ww, respectively. Species-specific arithmetic means (95% confidence limit) were: bluegill 0.05 (0.04-0.07) ng/g ww, freshwater drum 0.09 (0.06-0.13) ng/g ww, smallmouth bass 0.06 (0.05-0.07) ng/g ww, and white bass 0.06 (0.05-0.07) ng/g ww (Table 7-5). Species-specific median PFBS concentrations were: bluegill 0.03 ng/g ww, freshwater drum 0.05 ng/g ww, smallmouth bass 0.05 ng/g ww and white bass 0.03 ng/g ww. Due to the large number of non-detects, the low measured PFBS concentrations, and variability observed in those measured values, no species-specific trend in PFBS concentrations was identified for fish collected in Pool 2. Likewise, when average PFBS concentrations for all fish by reach were compared, no discernible trend in PFBS concentration was observed in Pool 2. All PFBS concentrations as reported by 3M for each fish are provided in Appendix A, Table A-1.

PFHS concentrations in fish tissues were also dominated by the presence of non-detects, however the frequency of non-detects was species specific (Table 7-6). For instance, the number of samples with measured PFHS concentrations for bluegill, freshwater drum, smallmouth bass and white bass were 38, 31, 7 and 53, respectively. PFHS was detected in at least one sample from each reach for bluegill, freshwater drum, and white bass while for smallmouth bass, concentrations are only reported for Reaches 9 and 10. Concentrations of PFHS in all fish ranged from 0.01 to 22.9 ng/g ww with arithmetic mean, geometric mean and median of 0.17, 0.048 and 0.03 ng/g ww, respectively. Only one sample had a concentration greater than 10 ng/g ww. Species-specific arithmetic averages (95% confidence limits) for Pool 2 were: bluegill 0.42 (0.0-0.90) ng/g ww, freshwater drum 0.9 (0.04-0.14) ng/g ww, smallmouth bass 0.04 (0.03-0.05) ng/g ww, and white bass 0.12 (0.07-0.17) ng/g ww (Table 7-7). Species-specific median PFHS concentrations for bluegill, freshwater drum, smallmouth bass and white bass were 0.05, 0.03, 0.03, and 0.06 ng/g ww, respectively. The species-specific rank order, from least to greatest PFHS concentrations based on either arithmetic mean or median, was smallmouth bass, freshwater drum, white bass, and bluegill. With the exception of smallmouth bass, a comparison of species-specific average PFHS concentration by reach showed that reaches with the greatest concentrations tend to cluster into three groups, regardless of species (Table 7-6). The first cluster included Reaches 2 and 3, the second cluster consisted of Reach 6 and the third cluster included Reach 10. While the higher PFHS concentrations in Reach 6 and 10 are most likely are due to the presence of upriver PFC, the relatively great concentration observed for bluegill and white bass

in Reaches 2 and 3 were unexpected and cannot be accounted for at this time. All PFHS concentrations as reported by 3M for each fish are provided in Appendix A, Table A-1.

Measured PFSOA concentrations were reported for 100% of the freshwater drum, smallmouth bass, and white bass samples while only 93% of the bluegill samples had measured concentrations (Table 7-8). PFOSA concentrations in all Pool 2 fish ranged from 0.1 to 31.5 ng/g ww with arithmetic mean, geometric mean and median of 0.67, 0.28 and 0.28 ng/g ww, respectively. Of the 396 samples that were analyzed, 60 samples had PFOSA concentrations greater 1 ng/g ww, 5 samples with concentrations greater than 5 ng/g ww and 2 samples with concentrations greater than 10 ng/g ww. Species-specific arithmetic mean (95% confidence limits) PFOSA concentrations were: bluegill 0.08 (0.07-0.10) ng/g ww, freshwater drum 0.33 (0.23-0.43) ng/g ww, smallmouth bass 0.97 (0.32-1.62) ng/g ww and white bass 1.31 (1.05-1.57) ng/g ww (Table 7-9). Species-specific median PFOSA concentrations were 0.07, 0.18, 0.40, and 0.92 ng/g ww for bluegill, freshwater drum, smallmouth bass and white bass respectively. The species rank order of PFOSA concentrations from least to greatest based on either mean or median values was bluegill, freshwater drum, smallmouth bass and white bass. In general, there was less than a 5-fold difference in mean PFOSA concentrations across all 10 reaches for all species (Table 7-8). However, the trend in PFOSA concentrations across all 10 reaches was not monotonic, rather it appeared to be biphasic with PFOSA concentrations being greatest in Reach 9-10 followed by Reaches 3 and 5 with concentrations between these two reach sets being less. All PFOSA concentrations as reported by 3M for each fish are provided in Appendix A, Table A-1.

Correlation analysis was conducted to evaluate the potential association between fish mass, length and age with fillet PFAS concentrations (Table 7-10). For PFBS, negative but statistically significant ($p \leq 0.05$) correlations were observed between bluegill tissue concentrations and mass, length), and age; however, these associations were weak and accounted for less than 5% of the total variation. With the exception of age in freshwater drum, correlations coefficients between PFBS tissue concentrations and mass, length and age in freshwater drum, smallmouth bass and white bass were not statistically significant ($p > 0.10$). There was a statistically significant ($p = 0.01$) but weak negative association ($r^2 = 0.0677$) between PFBS concentration and age in freshwater drum. No statistically significant ($p > 0.30$) associations between PFHS tissue concentrations and mass, length, and age were observed for freshwater drum, smallmouth bass and white bass with typically coefficients of determination (r^2) generally being less than 0.0256. For bluegill, there was positive and statistically significant correlation with age and PFHS ($p < 0.05$) with approximately 15% of the total variation accounted by this association.

PFOSA fillet concentrations in bluegill were not significantly correlated ($p > 0.20$) to mass, length and age, these metrics were significantly correlated ($p < 0.005$) to PFOSA fillet concentrations in freshwater drum, smallmouth bass and white bass. For freshwater drum and smallmouth bass, there was a positive correlation between PFOSA concentrations and mass, length and age while for white bass there was a negative correlation between tissue concentrations and these metrics. Coefficients of determination (r^2) for freshwater drum, smallmouth bass, and white bass ranged from 0.0759 for age in bluegill up to 0.1804 for length in bluegill with an overall average r^2 of 0.1145. Overall the association between fish mass, length and age with PFAS tissue concentrations were weak with all associations accounting less than 30% of the total variation.

7.4 Study Surface Water Samples

In Round 2 (August), PFBS was measured in 3 of the 30 samples with all other samples having reported values less than the LOQ (Table 7-11). For PFHS, only one sample had a concentration greater than the LOQ while for PFOSA no water sample had a concentration greater than the LOQ. For surface water samples that had measurable concentrations, the greatest concentrations of PFBS (336 ng/L) and PFHS (61 ng/L) were observed at Station 517.

In Round 1 (June), the only detectable concentration of PFBS and PFHS were observed in surface water collected from Station 501 the same locations as Station 517 sampled in Round 2. In Round 1, water concentrations of PFBS and PFHS at Station 501 were 26 and 13 ng/L, respectively (Table 7-12). At Station 517, the Round 1 PFBS concentration was approximately 13-fold greater than Round 2 while for PFHS it was approximately1.8-fold less. The basis for these differences is unknown but most likely due to multiple factors including changes in river water levels as well as changes in discharge concentrations from sources to the river.

7.5 Tables and Figures

Table 7-1. Intralaboratory Blind Duplicate Comparison of Perfluorosulfonate Concentrations (ng/g, wet weight) in Fish Collected from Pool 2 and Analyzed by 3M (2011)

					Relative Percent Difference (RPD, %)		
Reach	Species	Field ID	Primary Lab ID	Duplicate Lab ID	PFBS	PFHS	PFOSA
10	Bluegill	022	022FN	019FN1		15.5	11.7
9	Bluegill	126	126FN	105FN1		9.98	8.68
10	Freshwater drum	010	010FN	012FN1			0.59
1	Freshwater drum	078	078FN	073FN1		8.01	0.89
9	Freshwater drum	137	137FN	121FN1			5.08
6	Freshwater drum	170	170FN	147FN1			2.16
5	Freshwater drum	192	192FN	173FN1			1.61
4	Freshwater drum	258	258FN	228FN1			21.0
1	Freshwater drum	269	269FN	233FN1			9.34
8	Freshwater drum	315	315FN	265FN1			1.92
6	Freshwater drum	323	323FN	275FN1			10.7
6	Freshwater drum	334	334FN	284FN1			4.30
3	Freshwater drum	447	447FN	376FN1	102		24.9
3	Smallmouth bass	054	054FN	060FN1			0.46
1	Smallmouth bass	092	092FN	077FN1			8.27
1	Smallmouth bass	102	102FN	089FN1			5.47
10	Smallmouth bass	159	159FN	139FN1			9.31
5	Smallmouth bass	180	180FN	169FN1	81.9		2.01
5	Smallmouth bass	203	203FN	182FN1			15.4
4	Smallmouth bass	224	224FN	196FN1			17.5
4	Smallmouth bass	246	246FN	225FN1			3.31
2	Smallmouth bass	280	280FN	244FN1			4.18
7	Smallmouth bass	291	291FN	245FN1			28.0
7	Smallmouth bass	302	302FN	255FN1			18.7
3	Smallmouth bass	360	360FN	324FN1			3.03
8	Smallmouth bass	383	383FN	339FN1			6.34
9	Smallmouth bass	390	390FN	347FN1			2.32
4	Smallmouth bass	436	436FN	375FN1			4.68
8	White bass	033	033FN	042FN1			5.66
8	White bass	045	045FN	043FN1		45.9	4.16
2	White bass	065	065FN	068FN1		2.48	7.89
7	White bass	113	113FN	090FN1		10.2	2.66
9	White bass	149	149FN	122FN1		43.3	0.04

Table 7-1. Intralaboratory Blind Duplicate Comparison of Perfluorosulfonate Concentrations (ng/g, wet weight) in Fish Collected from Pool 2 and Analyzed by 3M (2011)

					Relative Percent Difference (RPD, %)		
Reach	Species	Field ID	Primary Lab ID	Duplicate Lab ID	PFBS	PFHS	PFOSA
6	White bass	214	214FN	184FN1			16.7
4	White bass	232	232FN	210FN1			3.83
3	White bass	346	346FN	314FN1			15.6
2	White bass	370	370FN	327FN1		188	9.25
5	White bass	400	400FN	348FN1			2.47
1	White bass	411	411FN	357FN1			5.63
9	White bass	425	425FN	371FN1			8.05
1	White bass	450	450FN	406FN1		18.0	2.40

All reported RPD values were for samples that had paired results greater than the LOQ

Table 7-2. Interlaboratory Comparison of Perfluorosulfonate Concentrations (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M and AXYS (2011)

					Relative Percent Difference (RPD, %)		
Reach	Species	Field ID	3M Lab ID	AXYS Lab ID	PFBS	PFHS	PFOSA
10	Bluegill	022	022FN	019FN1			
9	Bluegill	126	126FN	105FN1			
10	Freshwater drum	010	010FN	012FN1			
1	Freshwater drum	078	078FN	073FN1			
9	Freshwater drum	137	137FN	121FN1			
6	Freshwater drum	170	170FN	147FN1			
5	Freshwater drum	192	192FN	173FN1			
4	Freshwater drum	258	258FN	228FN1			
1	Freshwater drum	269	269FN	233FN1			
8	Freshwater drum	315	315FN	265FN1			
6	Freshwater drum	323	323FN	275FN1			
6	Freshwater drum	334	334FN	284FN1			
3	Freshwater drum	447	447FN	376FN1			
3	Smallmouth bass	054	054FN	060FN1			
1	Smallmouth bass	092	092FN	077FN1			
1	Smallmouth bass	102	102FN	089FN1			
10	Smallmouth bass	159	159FN	139FN1			42
5	Smallmouth bass	180	180FN	169FN1			
5	Smallmouth bass	203	203FN	182FN1			
4	Smallmouth bass	224	224FN	196FN1			
4	Smallmouth bass	246	246FN	225FN1			
2	Smallmouth bass	280	280FN	244FN1			
7	Smallmouth bass	291	291FN	245FN1			
7	Smallmouth bass	302	302FN	255FN1			
3	Smallmouth bass	360	360FN	324FN1			
8	Smallmouth bass	383	383FN	339FN1			
9	Smallmouth bass	390	390FN	347FN1			
4	Smallmouth bass	436	436FN	375FN1			
8	White bass	033	033FN	042FN1			
8	White bass	045	045FN	043FN1			21.4
2	White bass	065	065FN	068FN1			
7	White bass	113	113FN	090FN1			
9	White bass	149	149FN	122FN1			
6	White bass	214	214FN	184FN1			
4	White bass	232	232FN	210FN1			
3	White bass	346	346FN	314FN1			

Table 7-2. Interlaboratory Comparison of Perfluorosulfonate Concentrations (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M and AXYS (2011)

Reach	Species	Field ID	3M Lab ID	AXYS Lab ID	Relative Percent Difference (RPD, %)		
					PFBS	PFHS	PFOSA
2	White bass	370	370FN	327FN1			
5	White bass	400	400FN	348FN1			23.4
1	White bass	411	411FN	357FN1			
9	White bass	425	425FN	371FN1			
1	White bass	450	450FN	406FN1			37.1

All reported RPD values were for samples that had paired results greater than the LOQ

Table 7-3. Interlaboratory Comparison of Perfluorosulfonate Concentrations (ng/L) in Surface Water Collected from Pool 2 During Rounds 1 and 2 and Analyzed by 3M and AXYS (2011)

				Relative Percent Difference (RPD, %)		
Reach	Field ID	3M Lab ID	AXYS Lab ID	PFBS	PFHS	PFOSA
1	512	512SF1	512SF2			
1	513	513SF1	513SF2			
1	514	514SF1	514SF2			
2	509	509SF1	509SF2			
2	510	510SF1	510SF2			
2	511	511SF1	511SF2			
3	506	506SF1	506SF2			
3	507	507SF1	507SF2			
3	508	508SF1	508SF2			
4	533	533SF1	533SF2			
4	534	534SF1	534SF2			
4	535	535SF1	535SF2			
5	530	530SF1	530SF2	47.4		
5	531	531SF1	531SF2			
5	532	532SF1	532SF2			
6	527	527SF1	527SF2			
6	528	528SF1	528SF2			
6	529	529SF1	529SF2			
7	524	524SF1	524SF2			
7	525	525SF1	525SF2			
7	526	526SF1	526SF2			
8	503	503SF1	503SF2			
8	504	504SF1	504SF2			
8	505	505SF1	505SF2			
9	518	518SF1	518SF2			
9	519	519SF1	519SF2			
9	520	520SF1	520SF2			
10	501	501SF1	501SF2	31.1	66.7	
10	502	502SF1	502SF2			
10	515	515SF1	515SF2	61.4		

All reported RPD values were for samples that had paired results greater than the LOQ

Table 7-4. Descriptive Statistics for PFBS (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFBS]	0.06	0.09	0.06	0.06
Number of Detects	7	8	1	2
Number of Non-detects	91	89	93	89
Number of Samples Not Reported	2	3	6	5
Maximum [PFBS]	0.46	1.70	0.13	0.19
Minimum [PFBS]	0.03	0.03	0.03	0.03
Median [PFBS]	0.04	0.05	0.05	0.03
Geometric Mean [PFBS]	0.04	0.06	0.05	0.05
Standard Deviation	0.06	0.18	0.04	0.05

1/2 RL was used as a proxy value for all non-detects

Table 7-5. Mean and 95% Confidence Intervals for PFBS Concentrations (ng/g, wet weight) in All Fish Collected in Pool 2 by Reach (2011)

		Reach									
Species	Statistic	1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.03[1]	0.05[1]	0.03[1]	0.07	0.04[2]	0.07[2]	0.11[2]	0.04[1]	0.07[2]	0.05[1]
	95% CI	-	-	-	[-0.02, 0.17]	-	-	-	-	-	-
Freshwater drum	Mean	0.04[2]	0.11[2]	0.12	0.05[1]	0.03[1]	0.05[1]	0.05[1]	0.24[2]	0.11[1]	0.13[1]
	95% CI	-	-	[0.03, 0.21]	-	-	-	-	-	-	-
Smallmouth bass	Mean	0.03[1]	0.07[1]	0.03[1]	0.06[1]	0.03[1]	0.11[1]	0.09[2]	0.07[1]	0.06[1]	0.05[1]
	95% CI	-	-	-	-	-	-	-	-	-	-
White bass	Mean	0.07[2]	0.10[1]	0.03[1]	0.03[1]	0.03[1]	0.09[1]	0.07[1]	0.08[1]	0.08[1]	0.10[1]
	95% CI	-	-	-	-	-	-	-	-	-	-

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 7-6. Descriptive Statistics for PFHS (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFHS]	0.42	0.09	0.04	0.12
Number of Detects	38	31	7	53
Number of Non-detects	62	69	93	43
Number of Samples Not Reported	0	0	0	0
Maximum [PFHS]	22.89	2.45	0.26	1.70
Minimum [PFHS]	0.01	0.03	0.01	0.01
Median [PFHS]	0.05	0.03	0.03	0.06
Geometric Mean [PFHS]	0.07	0.04	0.03	0.06
Standard Deviation	2.43	0.26	0.04	0.24

1/2 RL was used as a proxy value for all non-detects

Table 7-7. Mean and 95% Confidence Intervals for PFHS Concentrations (ng/g, wet weight) in Fish Collected in Pool 2 by Reach (2011)

		Reach									
Species	Statistic	1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.09	0.1	2.49	0.13[2]	0.08	1.06	0.09[2]	0.04[2]	0.04[2]	0.05[2]
	95% CI	[0.05, 0.14]	[0.05, 0.15]	[-2.64, 7.62]	-	[0.02, 0.14]	[-0.89, 3.01]	-	-	-	-
Freshwater drum	Mean	0.13	0.05	0.04	0.10	0.06	0.06[2]	0.04[2]	0.06[2]	0.04[2]	0.33
	95% CI	[0.02, 0.24]	[0.02, 0.08]	[0.03, 0.04]	[-0.05, 0.24]	[0.02, 0.10]	-	-	-	-	[-0.21, 0.87]
Smallmouth bass	Mean	0.02[1]	0.07[1]	0.02[1]	0.04[1]	0.04[1]	0.03[1]	0.08[1]	0.03[1]	0.03[2]	0.06
	95% CI	-	-	-	-	-	-	-	-	-	[0.01, 0.11]
White bass	Mean	0.05	0.34	0.03	0.09[2]	0.05	0.16	0.12	0.06	0.06	0.21
	95% CI	[0.01, 0.08]	[-0.07, 0.74]	[0.02, 0.05]	-	[0.03, 0.07]	[0.07, 0.26]	[0.04, 0.20]	[0.03, 0.10]	[0.03, 0.10]	[-0.07, 0.50]

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 7-8. Descriptive Statistics for PFOSA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFOSA]	0.08	0.33	0.97	1.31
Number of Detects	93	100	100	96
Number of Non-detects	7	0	0	0
Number of Samples Not Reported	0	0	0	0
Maximum [PFOSA]	0.49	2.97	31.45	10.40
Minimum [PFOSA]	0.01	0.05	0.12	0.34
Median [PFOSA]	0.07	0.18	0.40	0.92
Geometric Mean [PFOSA]	0.07	0.21	0.45	1.05
Standard Deviation	0.07	0.48	3.28	1.26

1/2 RL was used as a proxy value for all non-detects

Table 7-9. Mean and 95% Confidence Intervals for PFOSA Concentration (ng/g, wet weight) in Fish Collected in Pool 2 by Reach (2011)

		Reach									
Species	Statistic	1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.05	0.07	0.13	0.06	0.09	0.06	0.05	0.06	0.09	0.18
	95% CI	[0.04, 0.06]	[0.04, 0.09]	[0.05, 0.22]	[0.04, 0.08]	[0.06, 0.13]	[0.04, 0.08]	[0.03, 0.06]	[0.04, 0.07]	[0.07, 0.11]	[0.10, 0.27]
Freshwater drum	Mean	0.20	0.30	0.19	0.18	0.29	0.14	0.24	0.15	0.44	1.17
	95% CI	[0.07, 0.34]	[-0.14, 0.75]	[0.12, 0.26]	[0.11, 0.26]	[0.16, 0.42]	[0.09, 0.19]	[0.19, 0.29]	[0.12, 0.17]	[0.27, 0.60]	[0.44, 1.90]
Smallmouth bass	Mean	0.35	0.25	0.37	0.59	0.46	0.40	0.38	0.25	0.57	6.05
	95% CI	[0.25, 0.45]	[0.21, 0.30]	[0.27, 0.47]	[0.50, 0.67]	[0.39, 0.54]	[0.34, 0.45]	[0.23, 0.54]	[0.18, 0.33]	[0.34, 0.79]	[-0.60, 12.70]
White bass	Mean	0.96	1.04	0.66	1.42	1.70	0.79	1.52	1.26	1.07	2.53
	95% CI	[0.28, 1.65]	[0.71, 1.37]	[0.50, 0.82]	[0.43, 2.41]	[1.13, 2.28]	[0.65, 0.92]	[0.80, 2.24]	[0.53, 1.98]	[0.72, 1.43]	[0.43, 4.63]

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 7-10. Correlations of Perfluorosulfonate Concentrations with Species Specific Fish Characteristics (ND=0)

		Bluegill			Freshwater drum			Smallmouth bass			White bass		
Correlation	**Statistic**	**PFBS**	**PFHS**	**PFOSA**	**PFBS**	**PFHS**	**PFOSA**	**PFBS**	**PFHS**	**PFOSA**	**PFBS**	**PFHS**	**PFOSA**
	Spearman r	-0.1984	-0.1159	0.0708	-0.1697	0.0136	0.3984	0.0917	0.0386	0.3286	-0.1593	0.0561	-0.3110
Mass vs [PFC]	p-value	0.0502	0.2510	0.4838	0.0966	0.8933	< 0.0001	0.3792	0.7027	<0.0008	0.1338	0.5890	0.0022
	n	98	100	100	97	100	100	94	100	100	90	95	95
	Spearman r	-0.2001	-0.0620	0.0441	-01721	0.0781	0.42427	0.1282	0.0418	0.3257	-0.1611	0.1034	-0.3193
Length vs [PFC]	p-value	0.0483	0.5403	0.6628	0.0918	0.4399	< 0.0001	0.2183	0.6800	0.0009	0.1272	0.3162	0.0015
	n	98	100	100	97	100	100	94	100	100	91	96	96
	Spearman r	-0.2137	0.3906	-0.1278	-0.2601	0.0447	0.2755	0.0997	0.0508	0.3171	-0.1662	0.0612	-0.3462
Age vs [PFC]	p-value	0.0356	<0.0001	0.2076	0.0101	0.6586	0.0055	0.3391	0.6159	0.0013	0.1154	0.5337	0.0006
	n	97	99	99	97	100	100	94	100	100	91	96	96

Table 7-11. 3M Analysis of Round 2 (August) Surface Water Samples for Perfluorosulfonates (ND=RL)

Field ID	Tissue ID	Lab ID	Reach	Start Northing	Start Westing	PFBS	PFHS	PFOS	PFOSA
515	515SF	515SF1	10	N44° 46.018'	W92° 52.305'	***2.37***	< 2.0	***4.2***	< 2.0
516	516SF	516SF1	10	N44° 45.382'	W92° 52.521'	< 2.0	< 2.0	< 2.0	< 2.0
517	517SF	517SF1	10	N44° 46.926'	W92° 53.313'	***336***	***60.5***	***136***	< 2.0
518	518SF	518SF1	9	N44° 46.207'	W92° 56.501'	< 2.0	< 2.0	***2.15***	< 2.0
519	519SF	519SF1	9	N44° 45.987'	W92° 57.531'	< 2.0	< 2.0	< 2.0	< 2.0
520	520SF	520SF1	9	N44° 46.333'	W92° 58.151'	< 2.0	< 2.0	***2.77***	< 2.0
521	521SF	521SF1	8	N44° 46.444'	W93° 00.988'	< 2.0	< 2.0	***2***	< 2.0
522	522SF	522SF1	8	N44° 47.081'	W93° 01.130'	< 2.0	< 2.0	***3.51***	< 2.0
523	523SF	523SF1	8	N44° 47.463'	W93° 01.516'	< 2.0	< 2.0	< 2.0	< 2.0
524	524SF	524SF1	7	N44° 48.609'	W93° 00.424'	< 2.0	< 2.0	***2.77***	< 2.0
525	525SF	525SF1	7	N44° 49.305'	W93° 00.573'	< 2.0	< 2.0	< 2.0	< 2.0
526	526SF	526SF1	7	N44° 50.012'	W93° 00.740'	< 2.0	< 2.0	< 2.0	< 2.0
527	527SF	527SF1	6	N44° 50.602'	W93° 00.576'	< 2.0	< 2.0	***2.6***	< 2.0
528	528SF	528SF1	6	N44° 51.126'	W93° 00.620'	< 2.0	< 2.0	< 2.0	< 2.0
529	529SF	529SF1	6	N44° 52.673'	W93° 00.927'	< 2.0	< 2.0	< 2.0	< 2.0
530	530SF	530SF1	5	N44° 53.478'	W93° 01.101'	***4.17***	< 2.0	***7.1***	< 2.0
531	531SF	531SF1	5	N44° 53.772'	W93° 01.866'	< 2.0	< 2.0	< 2.0	< 2.0
532	532SF	532SF1	5	N44° 54.371'	W93° 02.547'	< 2.0	< 2.0	< 2.0	< 2.0
533	533SF	533SF1	4	N44° 55.507'	W93° 03.004'	< 2.0	< 2.0	< 2.0	< 2.0
534	534SF	534SF1	4	N44° 56.082'	W93° 03.129'	< 2.0	< 2.0	< 2.0	< 2.0
535	535SF	535SF1	4	N44° 56.830'	W93° 04.115'	< 2.0	< 2.0	< 2.0	< 2.0
536	536SF	536SF1	3	N44° 56.586'	W93° 05.248'	< 2.0	< 2.0	< 2.0	< 2.0
537	537SF	537SF1	3	N44° 56.006'	W93° 06.160'	< 2.0	< 2.0	< 2.0	< 2.0
538	538SF	538SF1	3	N44° 55.616'	W93° 06.650'	< 2.0	< 2.0	< 2.0	< 2.0
539	539SF	539SF1	2	N44° 54.672'	W93° 07.920'	< 2.0	< 2.0	< 2.0	< 2.0
540	540SF	540SF1	2	N44° 53.865'	W93° 09.056'	< 2.0	< 2.0	< 2.0	< 2.0
541	541SF	541SF1	2	N44° 53.827'	W93° 09.236'	< 2.0	< 2.0	< 2.0	< 2.0
542	542SF	542SF1	1	N44° 53.637'	W93° 10.279'	< 2.0	< 2.0	< 2.0	< 2.0
543	543SF	543SF1	1	N44° 53.995'	W93° 11.442'	< 2.0	< 2.0	< 2.0	< 2.0
544	544SF	544SF1	1	N44° 54.140'	W93° 11.461'	< 2.0	< 2.0	< 2.0	< 2.0

RL was used as a proxy value for all non-detects

Bold, italicized text = Detects

Table 7-12. 3M Analysis of Round 1 (June) Surface Water Samples for Perfluorosulfonates (ND=RL)

Field ID	Tissue ID	Lab ID	Reach	Start Northing	Start Westing	PFBS	PFHS	PFOS	PFOSA
501	501SF	501SF1	10	N44° 46.926'	W92° 53.313'	***26***	***12.5***	***136***	< 4.0
502	502SF	502SF1	10	N44° 45.382'	W92° 52.521'	< 2.0	< 2.0	< 2.0	< 4.0
503	503SF	503SF1	8	N44° 47.471'	W93° 01.521'	< 2.0	< 2.0	< 2.0	< 4.0
504	504SF	504SF1	8	N44° 47.086'	W93° 01.118'	< 2.0	< 2.0	< 2.0	< 4.0
505	505SF	505SF1	8	N44° 46.447'	W93° 00.999'	< 2.5	< 2.0	< 2.0	< 2.0
506	506SF	506SF1	3	N44° 56.048'	W93° 06.085'	< 2.0	< 2.0	< 2.0	< 4.0
507	507SF	507SF1	3	N44° 56.589'	W93° 05.240'	< 2.0	< 2.0	< 2.0	< 4.0
508	508SF	508SF1	3	N44° 55.611'	W93° 06.663'	< 2.0	< 2.0	< 2.0	< 4.0
509	509SF	509SF1	2	N44° 53.823'	W93° 09.231'	< 2.0	< 2.0	< 2.0	< 4.0
510	510SF	510SF1	2	N44° 53.865'	W93° 09.064'	< 2.0	< 2.0	< 2.0	< 4.0
511	511SF	511SF1	2	N44° 54.699'	W93° 07.907'	< 2.0	< 2.0	< 2.0	< 4.0
512	512SF	512SF1	1	N44° 54.149'	W93° 11.459'	< 2.0	< 2.0	< 2.0	< 4.0
513	513SF	513SF1	1	N44° 54.001'	W93° 11.443'	< 2.0	< 2.0	< 2.0	< 4.0
514	514SF	514SF1	1	N44° 53.636'	W93° 10.274'	< 2.0	< 2.0	< 2.0	< 4.0

RL was used as a proxy value for all non-detects

Bold, italicized text = Detects

Chapter 8

Perfluorocarboxylate Results

8.1 Intralaboratory Blind Duplicate Samples

The comparison of analytical results for perfluorocarboxylic acids in fish tissue indicated good agreement between the primary and blind duplicate sample sets (Table 8-1). However, due to the large number of non-detects observed in both datasets, the evaluation of C4 to C8 PFCAs was limited. For instance, while PFPeA was detected in 4 samples in both the primary and blind duplicate samples sets, no matched samples were available for conducting the analysis. Likewise, no matched samples were available for PFHxA. For PFBA, 2 matched samples had measured concentrations that ranged from 0.12 to 1.3 ng/g and 0.21 to 2.4 ng/g with an average RPD of 20% in the primary and duplicate sample sets, respectively. For PFHpA, only 1 matched sample reported measured concentrations a RPD of 0.98%. Finally, only 1 matched sample had measured concentrations with a fold difference of 1.03 and a RPD of 2.9%. Regardless of the limited sample size, the measured concentrations of these PFCAs demonstrated that there was good agreement between the two sample sets with RPD value generally $\leq 20\%$.

The frequency of samples with measured concentrations was greater for PFCAs with carbon chains greater than 8. For PFNA, 21 matched samples reported measured concentrations that ranged from 0.03 to 0.8 ng/g ww in the primary dataset and 0.05 to 0.15 ng/g ww in the duplicate dataset. The average fold difference and RPD was 1.02 and 11%, respectively.

All 41 samples in both the primary and duplicate datasets had PFDA concentrations greater than the LOQ. PFDA concentrations in the primary dataset ranged from 0.48 to 11 ng/g ww and from 0.59 to 9.3 ng/g in the duplicate dataset. Likewise, all 41 samples in both the primary and duplicate sample had measured PFUnA concentrations that ranged from 0.47 to 6.3 ng/g and 0.44 to 5.24 ng/g, respectively. For PFDoA, all 41 samples in both the primary and duplicate sample sets had concentrations greater than the LOQ that ranged from 0.25 to 4.75 ng/g and 0.25 to 4.41 ng/g, respectively. The average fold difference between both sample sets for PFDA, PFUnA and PFDoA were 1.03, 1.02 and 1.02, respectively. The average RPD values for PFDA, PFUnA and PFDoA were 13%, 10% and 9.9%, respectively that indicated good agreement between the both datasets.

8.2 Interlaboratory Comparison Samples

8.2.1 Fish Tissue

Due to the large number of non-detects reported by one or both laboratories, the interlaboratory comparison of PFCAs in the fish tissue could not be conducted (Table 8-2). This resulted in no matched samples where both laboratories reported concentrations of PFBA, PFPeA, PFHxA, PFHpA, PFOA, and PFNA that were above the LOQ of each analyte. As such, a comparison of analytical results for these analytes was not conducted.

PFDA was detected in all 41 fish samples by the 3M lab but was only detected in 14 samples by AXYS. Based on the14 matched samples, PFDA concentrations ranged from 2.1 to 11 ng/g ww and 2.3 and 11 ng/g ww for the 3M and AXYS laboratories, respectively. PFDA concentrations reported

by the 3M Lab were slightly greater with an average RPD of 11%. PFDoA was also detected in all 41 fish samples by the 3M lab but was only detected in 3 samples by the AXYS. Based on the matched samples, measured PFDoA concentrations in fish ranged from 2.7 to 4.8 ng/g and 3.1 to 4.5 ng/g for the 3M Lab and AXYS, respectively. The average fold-difference between laboratories was 0.98 with an average RPD of 6.91%. For PFUnA, 3M reported measured concentrations for all 41 interlaboratory fish samples while AXYS reported measured concentrations for 4 samples. Based on the 4 matched samples, PFUnA concentrations ranged from 2.0 to 6.3 ng/g ww and 2.4 to 5.4 ng/g for the 3M Lab and AXYS, respectively. Average PFUnA concentrations were 3.6 ng/g and 3.9 ng/g ww for 3M and AXYS, respectively with an average fold-difference of 0.88 and a RPD of 22%. Overall, these data indicate that there was good agreement between the laboratories with and overall average fold-difference for all PFCS of 0.90 with an average RPD of 16%.

8.2.2 Surface Water

For surface water concentrations, an interlaboratory comparison of PFPeA, PFNA, PFDA, PFUnA and PFDoA was not conducted due to the great frequency of non-detects that resulted in no matched samples with measurable concentration (Table 8-3). For PFHxA only 1 matched sample had a measurable concentrations with the 3M Lab reporting a value of 16 ng/L and AYXS reporting a value of 6.9 ng/L. This resulted in a percent difference of 230% with a RPD of 79%. Likewise, only 2 matched samples had measurable PFHpA water concentrations with an average fold-difference of 0.42 and an average RPD of 89%. For PFBA, 12 matched samples had measurable concentrations that ranged from 11 to 74 ng/L and 9.1 to 92 ng/L for 3M and AXYS, respectively. Average PFBA concentrations were 21 and 22 ng/l for 3M and AXYS, respectively with an average fold-difference of 1.1 and a RPD of 12%. For PFOA, 3M reported concentrations for 10 samples while AXYS reported concentrations for 22 samples for a total of 10 matched samples. PFOA water concentrations ranged from 1.3 to 77 ng/L and 2.5 to 137 ng/L for 3M and AXYS respectively. The average interlaboratory fold-difference between measured PFBA concentrations was 0.66 with an average RPD of 39%. Overall, there was good agreement between the target analyte concentrations reported by both laboratories. Percent differences for target analytes detected in surface waters by both laboratories ranged from 20% to 140% with an overall average of 80%. Relative percent differences ranged from 1.6% to 135% with an overall average of 33%. The greatest divergence in reported PFCA concentrations was observed for one sample where the concentration of PFHpA reported by 3M was approximately five-fold greater than that reported by AXYS. Without this sample, the average fold difference between the two laboratories was approximately 1.0.

8.3 Study Fish Tissue Samples

Of the 9 perfluorocarboxylates that were analyzed in fish, the concentrations reported for PFBA, PFPeA, PFHxA, PFHpA and PFOA were dominated by values less than the LOQ (Table 8-4, 8-6, 8-8. 8-10, and 8-12). PFBA was detected in 37 of 396 fish samples with species-specific detection rate that was less than or equal to 16% (Table 8-4). PFBA was detected in 9 bluegill, 16 freshwater drum, 4 smallmouth bass and 8 white bass with concentrations that ranged from 0.05 to 5.59 ng g ww. The grand arithmetic mean (95% confidence limit) and median for all fish analyzed in this study were 0.28 (0.24-0.32) ng/g ww and 0.13 ng/g ww, respectively (Table 8-5). Of the 37 samples with detected values, only 12 samples had PFBA concentrations greater than 1 ng/g ww and none were greater than 5 ng/g ww.

PFPeA was detected in 38 of 396 fish samples with species-specific detection rate that was less than or equal to 12% (Table 8-6). PFPeA was detected in 7 bluegill, 6 freshwater drum, 22 smallmouth

bass, and 9 white bass with concentrations that ranged from 0.03 to 1.37 ng/g ww. The grand arithmetic mean and median for all fish were 0.18 (0.16-0.19) ng/g ww and 0.13 ng/g ww, respectively (Table 8-7). Of the 38 samples with detected PFPeA concentrations, only 1 sample was greater than 1 ng/g ww.

PFHxA was detected in 46 of 396 fish samples with species-specific detection rate that was less than or equal to 15% (Table 8-8). PFHxA was detected in 12 bluegill, 15 freshwater drum, 10 smallmouth bass, and 9 white bass with concentrations ranging from 0.03 to 1.19 ng/g ww. The grand arithmetic mean (95% confidence limit) and median for all fish analyzed in this study were 0.20 (0.18-0.22) ng/g ww and 0.13 ng/g ww, respectively (Table 8-9). Of the 46 samples with detected concentrations, none had concentrations greater than 5 ng/g ww and only 2 had concentrations greater than 1 ng/g ww.

PFHpA was detected in 33 of 396 fish samples with species-specific detection rate that was less than or equal to 14% (Table 8-10). PFHxA was detected in 10 bluegill, 14 freshwater drum, 3 smallmouth bass, and 6 white bass with concentrations ranging from 0.01 to 0.15 ng/g ww. The grand arithmetic mean (95% confidence limit) and median for all fish analyzed in this study were 0.04 (0.03-0.04) ng/g ww and 0.03 ng/g ww, respectively (Table 8-11). Of the 33 samples with detected concentrations, none had concentrations greater than 1 ng/g ww.

PFOA was detected in 46 of 396 fish samples with species-specific detection rate that was less than or equal to 25% (Table 8-12). PFOA was detected in 11 bluegill, 25 freshwater drum, 1 smallmouth bass, and 9 white bass with concentrations ranging from 0.03 to 1.86 ng/g ww. The grand arithmetic mean (95% confidence limit) and median for all fish analyzed in this study were 0.09 (0.08-0.10) ng/g ww and 0.05 ng/g ww, respectively (8-13). Of the 46 samples with detected concentrations, 3 had concentrations greater than 1 ng/g ww.

While concentrations of C4 to C8 PFCAs in fish collected from Pool 2 were dominated by non-detects, longer chain PFCA were detected at a much greater frequency with 55% of the fish samples reporting detected concentrations for PFNA and 100% of the sample reporting PFDA, PFUnA and PFDoA. PFNA was detected in 41 bluegill, 86 freshwater drum, 7 smallmouth bass and 84 white bass with concentrations that ranged from 0.01 to 1.13 ng g ww (Table 8-14). The grand arithmetic mean (95% confidence limit) and median for all fish analyzed in this study were 0.23 (0.21-0.26) ng/g ww and 0.13 ng/g ww, respectively (Table 8-15). Of the 218 samples with detected values, only 3 samples had PFNA concentrations greater than 1 ng/g ww and none were greater than 2 ng/g ww. Species-specific arithmetic mean (95% confidence limits) PFNA concentrations were: bluegill 0.10 (0.08-0.12) ng/g ww, freshwater drum 0.28 (0.25-0.32) ng/g ww, smallmouth bass 0.05 (0.05-0.06) ng/g ww, and white bass 0.51 (0.46-0.56). Median PFNA concentrations were 0.08, 0.26, 0.03, and 0.51 ng/g ww for bluegill, freshwater drum, smallmouth bass, and white bass respectively. The rank order from least to greatest concentration was smallmouth bass, bluegill, freshwater drum, and white bass with an overall difference of 10-fold between the least and greatest species-specific values. However, much of this difference was derived from the large number of non-detects observed for smallmouth bass, when this species was removed, the difference was only 5.6-fold. Comparison of fish tissue PFNA concentrations over the 10 sampling reaches in Pool 2 indicated that while the greatest concentrations typically were observed in Reach 10, no gradient or trend was observed across all the reaches for any of the fish species (Table 8-15).

PFDA was detected in 100% of the fish sampled in Pool 2 with concentrations ranging from 0.32 to 10.9 ng g ww (Table 8-16). The overall arithmetic mean (95% confidence limit) and median for all

fish analyzed in this study were 2.11 (1.97-2.25) ng/g ww and 1.79 ng/g ww, respectively. Of the 396 samples with detected values, 310 samples had PFDA concentrations greater than 1 ng/g ww, 17 samples greater than 5.0 ng/g ww and 1 sample greater than 10.0 ng/g ww. Species-specific arithmetic mean (95% confidence limits) PFNA concentrations were: bluegill 1.41 (1.11-1.71) ng/g ww, freshwater drum 1.74 (1.57-1.91) ng/g ww, smallmouth bass 1.74 (1.60-1.87) ng/g ww, and white bass 3.61 (3.4-3.9) (Table 8-17). Median PFDA concentrations were 0.90, 1.52, 1.63, and 3.44 ng/g ww for bluegill, freshwater drum, smallmouth bass, and white bass respectively. The rank order from least to greatest concentration was bluegill, freshwater drum, smallmouth bass, and white bass with an overall three-fold difference between the least and greatest species-specific values. Comparison of fish PFDA concentrations across all 10 sampling reaches indicated that while the greatest concentrations typically were observed in Reach 10, a concentration gradient was not apparent for any of the 4 fish species in the rest of Pool 2 (Table 8-17).

PFUnA was detected in 100% of the fish sampled in Pool 2 with concentrations ranging from 0.19 to 6.32 ng g ww (Table 8-18). The overall arithmetic mean (95% confidence limit) and median for all fish analyzed in this study were 1.22 (1.15-1.30) ng/g ww and 1.11 ng/g ww, respectively. Of the 396 samples with detected values, 221 samples had PFUnA concentrations greater than 1 ng/g ww, 10 samples greater than 3.0 ng/g ww and 3 samples greater than 5.0 ng/g ww. Species-specific arithmetic mean (95% confidence limits) PFUnA concentrations were: bluegill 0.83 (0.66-1.01) ng/g ww, freshwater drum 1.07 (0.96-1.18) ng/g ww, smallmouth bass 1.22 (1.13-1.32) ng/g ww, and white bass 1.79 (1.65-1.93) (Table 8-19). Median PFUnA concentrations were 0.61, 0.89, 1.20, and 1.69 ng/g ww for bluegill, freshwater drum, smallmouth bass, and white bass respectively. The rank order from least to greatest concentration was bluegill, freshwater drum, smallmouth bass, and white bass with an overall 2.8-fold difference between the least and greatest species-specific values. Comparison of fish tissue PFUnA concentrations across all 10 sampling reaches indicated that while the greatest concentrations typically were observed in Reach 10, equivalent concentrations of PFUnA were observed in Reaches 5 through 7 and as a result, a concentration gradient was not apparent for any of the 4 fish species in Pool 2 (Table 8-19).

PFDoA was detected in 100% of the fish sampled in Pool 2 with concentrations ranging from 0.13 to 4.75 ng g ww (Table 8-20). The overall arithmetic mean (95% confidence limit) and median for all fish analyzed in this study were 1.08 (1.01-1.14) ng/g ww and 1.00 ng/g ww, respectively. Of the 396 samples with detected values, 199 samples had PFDoA concentrations greater than 1 ng/g ww, 36 samples greater than 2.0 ng/g ww and no samples greater than 5.0 ng/g ww. Species-specific arithmetic mean (95% confidence limits) PFDoA concentrations were: bluegill 0.59 (0.48-0.70) ng/g ww, freshwater drum 1.05 (0.92-1.18) ng/g ww, smallmouth bass 1.16 (1.07-1.25) ng/g ww, and white bass 1.51 (1.39-1.64) (Table 8-21). Median PFDoA concentrations were 0.46, 0.85, 1.16, and 1.40 ng/g ww for bluegill, freshwater drum, smallmouth bass, and white bass respectively. The rank order from least to greatest concentration was bluegill, freshwater drum, smallmouth bass, and white bass with an overall three-fold difference between the least and greatest species-specific values. Comparison of fish tissue PFDoA concentrations across all 10 sampling reaches indicated that while the greatest concentrations typically were observed in Reach 10 followed by Reach 5, a concentration gradient was not observed for any of the 4 fish species in Pool 2 (Table 8-21).

Correlation analysis of PFBA, PFPeA, PFHxA, PFHpA, and PFOA tissue concentrations with fish mass, length and age resulted in few statistically significant correlations and of those correlations that were statistically significant, the correlations accounted for only a small amount of the total variation (Table 8-22). For PFCA's with carbon chains of 8 or less, the only statistically significant correlations observed in bluegill were for PFHxA and mass ($p = 0.02$) and length ($p = 0.034$) as well

as for age and PFBA ($p= 0.02$) and PFHpA ($p= 0.002$). In freshwater drum, the only significant correlation was observed between mass and PFHpA ($p=0.037$) where as all correlations for smallmouth bass and white bass were not statistically significant ($p< 0.05$). In contrast, with exception of bluegill and age ($p= 0.46$), all correlations of PFDoA were statistically significant for all fish species. Furthermore, the all correlations between PFUnA and fish characteristics were statistically significant ($p< 0.05$) while for PFDA the only correlations that were not statistically significant were for mass and length in bluegill and mass in freshwater drum. Unlike the other long chain PFCAs, PFNA demonstrated the greatest interspecies differences in that while all correlations in freshwater drum and smallmouth bass were not statistically significant ($p> 0.18$), all correlations with fish characteristics for bluegill and white bass were statistically significant ($p< 0.05$). Overall, fish mass, length and age were poor predictors of PFCA tissue concentrations.

8.4 Study Surface Water Samples

Concentrations of PFDA, PFUnA and PFDA in surface water samples collected in Round 2 (August) were all reported as less than their LOQ (Table 8-23). Furthermore, only 1 sample had detectable concentrations of PFHpA and PFNA while PFPeA and PFHxA had detectable concentrations in 3 and 4 samples, respectively. In contrast, PFBA was measured in 16 of the 30 surface water samples while PFOA was measured in 20 of 30 samples. In all instances, the location with the greatest frequency of PFC detection, as well as measured PFC concentration, was observed in the water sample collected in Reach 10 at Station 530. The location with the second greatest number of PFC detections, as well as PFC concentrations, was in water collected from Reach 5 at Station 517. In general, the surface water samples collected throughout the entirety of Pool 2 had PFCA concentrations that were predominately non-detects with the exception of those sample collected immediately downriver of known point sources to the river. The exceptions to this general finding PFBA and PFOA that were measured in surface water samples throughout Pool 2 but that had their greatest concentrations downriver of two known point sources.

While Round 1 (June) surface water samples were collected from only 14 locations and as a result can be used to evaluate the distribution of PFCs throughout the entirety of Pool 2, the results from these samples can be used to explore temporal changes in PFC concentrations at these locations (Table 8-24). The total number of detects for PFBA, PFPeA, PFHxA, PFHpA, PFNA and PFOA in these samples were 3, 3, 2, 1, 1, and 13, respectively. In general, concentrations reported in Round 1 were less than those reported in Round 2 for the same locations. For instance, the average fold-concentration difference between Rounds 2 and 1 were 3.0, 2.3, 1.7, 1.7, 1.1, and 1.3 for PFBA, PFPeA, PFHxA, PFHpA, PFNA, and PFOA, respectively. The greatest differences observed between the two sampling Rounds were observed for samples collected at Station 517/501, downstream of the 3M facility. At this location the fold difference between Rounds 2 and 1 for PFBA, PFPeA, PFHxA, and PFOA were 7.0-, 4.7-, 2.5 and 1.6, respectively. For all other locations and analyte combinations, the fold-differences ranged from 0.7 to 2.0.

8.5 Tables and Figures

Table 8-1. Intralaboratory Blind Duplicate Comparison of Perfluorocarboxylates (ng/g, wet weight) in Fish Collected from Pool 2 and Analyzed by 3M (2011)

					Relative Percent Difference (RPD, %)								
Reach	Species	Field ID	Primary Lab ID	Duplicate Lad ID	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
10	Bluegill	022	022FN	019FN1	33.29				2.89	14.2	16.3	18.7	18.5
9	Bluegill	126	126FN	105FN1							8.36	4.6	30.5
10	Freshwater drum	010	010FN	012FN1	6.95					15.1	2.79	18.7	1.15
1	Freshwater drum	078	078FN	073FN1				0.98			17.4	0.2	2.38
9	Freshwater drum	137	137FN	121FN1						0.2	13.6	9.8	7.94
6	Freshwater drum	170	170FN	147FN1							6.73	10.0	9.58
5	Freshwater drum	192	192FN	173FN1						6.5	3.99	9.6	7.40
4	Freshwater drum	258	258FN	228FN1						0.1	7.52	7.0	0.34
1	Freshwater drum	269	269FN	233FN1						5.5	25.2	13.7	13.4
8	Freshwater drum	315	315FN	265FN1						30.4	31.3	14.5	19.3
6	Freshwater drum	323	323FN	275FN1						10.1	4.52	6.5	20.4
6	Freshwater drum	334	334FN	284FN1						11.1	0.26	1.8	13.2
3	Freshwater drum	447	447FN	376FN1						19.7	19.1	3.0	6.84
3	Smallmouth bass	054	054FN	060FN1							8.37	19.2	16.4
1	Smallmouth bass	092	092FN	077FN1							7.42	4.6	0.72
1	Smallmouth bass	102	102FN	089FN1							3.92	6.0	0.83
10	Smallmouth bass	159	159FN	139FN1							7.01	3.0	1.53
5	Smallmouth bass	180	180FN	169FN1							28.5	28.2	11.6
5	Smallmouth bass	203	203FN	182FN1							28.9	32.4	15.1
4	Smallmouth bass	224	224FN	196FN1						18.2	13.8	5.9	7.91
4	Smallmouth bass	246	246FN	225FN1							1.79	2.3	2.61
2	Smallmouth bass	280	280FN	244FN1							8.44	8.4	4.34
7	Smallmouth bass	291	291FN	245FN1							20.3	14.8	13.3
7	Smallmouth bass	302	302FN	255FN1							12.4	7.3	2.54

Table 8-1. Intralaboratory Blind Duplicate Comparison of Perfluorocarboxylates (ng/g, wet weight) in Fish Collected from Pool 2 and Analyzed by 3M (2011)

					Relative Percent Difference (RPD, %)								
Reach	Species	Field ID	Primary Lab ID	Duplicate Lad ID	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
3	Smallmouth bass	360	360FN	324FN1							2.41	3.1	15.6
8	Smallmouth bass	383	383FN	339FN1							7.70	11.8	7.58
9	Smallmouth bass	390	390FN	347FN1							15.3	5.4	5.56
4	Smallmouth bass	436	436FN	375FN1							16.0	15.9	18.3
8	White bass	033	033FN	042FN1							26.8	5.6	17.3
8	White bass	045	045FN	043FN1							21.0	8.9	17.9
2	White bass	065	065FN	068FN1							9.38	7.8	0.73
7	White bass	113	113FN	090FN1						2.0	6.82	8.7	8.78
9	White bass	149	149FN	122FN1						4.1	6.91	9.3	12.2
6	White bass	214	214FN	184FN1						9.0	12.3	16.8	4.33
4	White bass	232	232FN	210FN1						8.8	7.06	3.1	7.94
3	White bass	346	346FN	314FN1						20.3	14.2	15.8	17.6
2	White bass	370	370FN	327FN1						23.3	33.5	24.4	13.4
5	White bass	400	400FN	348FN1						13.1	10.1	15.1	7.18
1	White bass	411	411FN	357FN1						0.2	16.5	6.3	8.73
9	White bass	425	425FN	371FN1						0.8	14.6	14.3	6.97
1	White bass	450	450FN	406FN1						18.9	3.17	4.8	7.52

All reported RPD values were for samples that had paired results greater than the LOQ

Table 8-2. Interlaboratory Comparison of Perfluorocarboxylates (ng/g, wet weight) in Fish Collected from Pool 2 and Analyzed by 3M and AXYS (2011)

					Relative Percent Difference (RPD, %)								
Reach	Species	Field ID	3M Lab ID	AXYS Lab ID	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
10	Bluegill	022	022FN	019FN1					200.00		3.0	15.1	1.6
9	Bluegill	126	126FN	105FN1									
10	Freshwater drum	010	010FN	012FN1									
1	Freshwater drum	078	078FN	073FN1									
9	Freshwater drum	137	137FN	121FN1									
6	Freshwater drum	170	170FN	147FN1									
5	Freshwater drum	192	192FN	173FN1									
4	Freshwater drum	258	258FN	228FN1									
1	Freshwater drum	269	269FN	233FN1									
8	Freshwater drum	315	315FN	265FN1									
6	Freshwater drum	323	323FN	275FN1									
6	Freshwater drum	334	334FN	284FN1									
3	Freshwater drum	447	447FN	376FN1									
3	Smallmouth bass	054	054FN	060FN1									
1	Smallmouth bass	092	092FN	077FN1									
1	Smallmouth bass	102	102FN	089FN1									
10	Smallmouth bass	159	159FN	139FN1									13.38
5	Smallmouth bass	180	180FN	169FN1									
5	Smallmouth bass	203	203FN	182FN1							9.0		
4	Smallmouth bass	224	224FN	196FN1									
4	Smallmouth bass	246	246FN	225FN1									
2	Smallmouth bass	280	280FN	244FN1							22.98		
7	Smallmouth bass	291	291FN	245FN1									
7	Smallmouth bass	302	302FN	255FN1									
3	Smallmouth bass	360	360FN	324FN1									

Table 8-2. Interlaboratory Comparison of Perfluorocarboxylates (ng/g, wet weight) in Fish Collected from Pool 2 and Analyzed by 3M and AXYS (2011)

Reach	Species	Field ID	3M Lab ID	AXYS Lab ID	Relative Percent Difference (RPD, %)								
					PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
8	Smallmouth bass	383	383FN	339FN1									
9	Smallmouth bass	390	390FN	347FN1									
4	Smallmouth bass	436	436FN	375FN1							0.3		
8	White bass	033	033FN	042FN1							3.1		
8	White bass	045	045FN	043FN1									
2	White bass	065	065FN	068FN1									
7	White bass	113	113FN	090FN1									
9	White bass	149	149FN	122FN1							11.90		
6	White bass	214	214FN	184FN1							23.8	22.8	
4	White bass	232	232FN	210FN1							5.93		
3	White bass	346	346FN	314FN1							16.4		
2	White bass	370	370FN	327FN1							6.7	16.7	
5	White bass	400	400FN	348FN1							0.7		
1	White bass	411	411FN	357FN1							12.2		
9	White bass	425	425FN	371FN1							24.3		
1	White bass	450	450FN	406FN1							16.99	34.3	5.73

All reported RPD values were for samples that had paired results greater than the LOQ

Table 8-3. Interlaboratory Comparison of Perfluorocarboxylates (ng/L) in Surface Water Collected from Pool 2 During Rounds 1 and 2 and Analyzed by 3M and AXYS (2011)

				Relative Percent Difference (RPD, %)								
Reach	Field ID	3M Lab ID	AXYS Lab ID	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
1	512	512SF1	512SF2									
1	513	513SF1	513SF2									
1	514	514SF1	514SF2									
2	509	509SF1	509SF2									
2	510	510SF1	510SF2									
2	511	511SF1	511SF2									
3	506	506SF1	506SF2									
3	507	507SF1	507SF2									
3	508	508SF1	508SF2									
4	533	533SF1	533SF2	1.25								
4	534	534SF1	534SF2									
4	535	535SF1	535SF2									
5	530	530SF1	530SF2	17.52		24.57		24.58				
5	531	531SF1	531SF2									
5	532	532SF1	532SF2									
6	527	527SF1	527SF2	3.51				37.69				
6	528	528SF1	528SF2	6.57								
6	529	529SF1	529SF2									
7	524	524SF1	524SF2	6.94				32.87				
7	525	525SF1	525SF2									
7	526	526SF1	526SF2									
8	503	503SF1	503SF2									
8	504	504SF1	504SF2	32.98				69.42				
8	505	505SF1	505SF2					66.32				

Table 8-3. Interlaboratory Comparison of Perfluorocarboxylates (ng/L) in Surface Water Collected from Pool 2 During Rounds 1 and 2 and Analyzed by 3M and AXYS (2011)

				Relative Percent Difference (RPD, %)								
Reach	Field ID	3M Lab ID	AXYS Lab ID	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
9	518	518SF1	518SF2	2.76				28.30				
9	519	519SF1	519SF2	5.41				25.00				
9	520	520SF1	520SF2	5.92				34.71				
10	501	501SF1	501SF2	21.72	86.23	60.21	67.02	55.60				
10	502	502SF1	502SF2	33.81								
10	515	515SF1	515SF2	1.60				42.62				

All reported RPD values were for samples that had paired results greater than the LOQ

Table 8-4. Descriptive Statistics for PFBA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES

	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFBA]	0.27	0.38	0.21	0.26
Number of Detects	9	16	4	8
Number of Non-detects	90	84	96	88
Number of Samples Not Reported	1	0	0	0
Maximum [PFBA]	3.12	4.59	0.54	2.41
Minimum [PFBA]	0.05	0.05	0.05	0.05
Median [PFBA]	0.13	0.18	0.18	0.13
Geometric Mean [PFBA]	0.16	0.22	0.17	0.17
Standard Deviation	0.42	0.63	0.15	0.32

1/2 RL was used as a proxy value for all non-detects

Table 8-5. Mean and 95% Confidence Intervals for PFBA Concentration (ng/g, ww) in Fish Collected in Pool 2 by Reach (2011)

		Reach									
Species	**Statistic**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Bluegill	Mean	0.24[1]	0.38[1]	0.35[1]	0.11[2]	0.43[2]	0.22[2]	0.12	0.44[2]	0.07[1]	0.33[2]
	95% CI	-	-	-	-	-	-	[0.08, 0.16]	-	-	-
Freshwater drum	Mean	0.23[1]	0.17[1]	0.29[1]	0.31[2]	0.13[1]	0.56[2]	0.57[2]	0.48[1]	0.15	0.93
	95% CI	-	-	-	-	-	-	-	-	[0.09, 0.22]	[0.34, 1.53]
Smallmouth bass	Mean	0.36[1]	0.16[2]	0.24[1]	0.24[1]	0.13[1]	0.22[2]	0.08[1]	0.25[1]	0.17[2]	0.29[2]
	95% CI	-	-	-	-	-	-	-	-	-	-
White bass	Mean	0.09[1]	0.51[2]	0.36[1]	0.20[2]	0.15[2]	0.24[2]	0.16[1]	0.50[2]	0.09[1]	0.25[2]
	95% CI	-	-	-	-	-	-	-	-	-	-

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-6. Descriptive Statistics for PFPeA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES	Species			
Statistic	**Bluegill**	**Freshwater drum**	**Smallmouth bass**	**White bass**
Arithmetic Mean [PFPeA]	0.17	0.18	0.21	0.15
Number of Detects	7	6	22	3
Number of Non-detects	92	94	78	93
Number of Samples Not Reported	1	0	0	0
Maximum [PFPeA]	0.50	0.50	1.37	0.50
Minimum [PFPeA]	0.01	0.01	0.03	0.01
Median [PFPeA]	0.13	0.13	0.13	0.13
Geometric Mean [PFPeA]	0.11	0.12	0.15	0.09
Standard Deviation	0.17	0.16	0.20	0.16

1/2 RL was used as a proxy value for all non-detects

Table 8-7. Mean and 95% Confidence Intervals for PFPeA Concentration (ng/g, ww) in Fish Collected in Pool 2 by Reach (2011)

Species	Statistic	Reach 1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.19[1]	0.37[1]	0.35[1]	0.09	0.12[2]	0.07[1]	0.13[2]	0.12[1]	0.05[2]	0.26[1]
	95% CI	-	-	-	[0.05, 0.14]	-	-	-	-	-	-
Freshwater drum	Mean	0.19[2]	0.14[1]	0.29[1]	0.11[1]	0.12[1]	0.08[2]	0.08[1]	0.46[1]	0.04	0.25[1]
	95% CI	-	-	-	-	-	-	-	-	[0.02, 0.06]	-
Smallmouth bass	Mean	0.41[2]	0.14[1]	0.22[2]	0.18	0.18[1]	0.16[2]	0.17[2]	0.32	0.17	0.23[1]
	95% CI	-	-	-	[0.10, 0.25]	-	-	-	[0.18, 0.47]	[0.03, 0.31]	-
White bass	Mean	0.05[1]	0.22[2]	0.20[1]	0.08[2]	0.07[1]	0.11[1]	0.11[2]	0.34[1]	0.04[1]	0.21[1]
	95% CI	-	-	-	-	-	-	-	-	-	-

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-8. Descriptive Statistics for PFHxA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES

Statistic	Species: Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFHxA]	0.19	0.24	0.16	0.20
Number of Detects	12	15	10	9
Number of Non-detects	87	85	90	87
Number of Samples Not Reported	1	0	0	0
Maximum [PFHxA]	1.07	0.79	0.50	1.19
Minimum [PFHxA]	0.03	0.03	0.03	0.03
Median [PFHxA]	0.13	0.14	0.13	0.13
Geometric Mean [PFHxA]	0.13	0.18	0.12	0.15
Standard Deviation	0.19	0.17	0.14	0.18

1/2 RL was used as a proxy value for all non-detects

Table 8-9. Mean and 95% Confidence Intervals for PFHxA Concentration (ng/g, wet weight) in Fish Collected in Pool 2 by Reach (2011)

		Reach									
Species	Statistic	1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.24[1]	0.38[1]	0.33[2]	0.15	0.14[1]	0.07[2]	0.09	0.15[2]	0.12[1]	0.28[1]
	95% CI	-	-	-	[0.08, 0.22]	-	-	[0.05, 0.12]	-	-	-
Freshwater drum	Mean	0.22[2]	0.17[1]	0.34[2]	0.22[2]	0.13[1]	0.10	0.14[1]	0.47[2]	0.37	0.25[1]
	95% CI	-	-	-	-	-	[0.05, 0.15]	-	-	[0.18, 0.56]	-
Smallmouth bass	Mean	0.35[1]	0.11[1]	0.18	0.17[2]	0.13[1]	0.11[2]	0.08[2]	0.09[2]	0.11[2]	0.28[1]
	95% CI	-	-	[0.05, 0.31]	-	-	-	-	-	-	-
White bass	Mean	0.13[1]	0.24[1]	0.23[1]	0.13[2]	0.15[1]	0.14[1]	0.12[2]	0.33[2]	0.17	0.37
	95% CI	-	-	-	-	-	-	-	-	[0.09, 0.24]	[0.15, 0.59]

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-10. Descriptive Statistics for PFHpA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFHpA]	0.04	0.03	0.04	0.03
Number of Detects	10	14	3	6
Number of Non-detects	90	86	97	90
Number of Samples Not Reported	0	0	0	0
Maximum [PFHpA]	0.13	0.15	0.13	0.13
Minimum [PFHpA]	0.01	0.01	0.01	0.01
Median [PFHpA]	0.03	0.03	0.03	0.03
Geometric Mean [PFHpA]	0.03	0.03	0.03	0.03
Standard Deviation	0.03	0.03	0.04	0.03

1/2 RL was used as a proxy value for all non-detects

Table 8-11. Mean and 95% Confidence Intervals for PFHpA Concentration (ng/g, wet weight) in Fish Collected in Pool 2 by Reach (2011)

Species	Statistic	Reach 1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.04	0.04	0.03[2]	0.03[1]	0.04[2]	0.06[1]	0.09[1]	0.03[1]	0.02[1]	0.02[1]
	95% CI	[0.02, 0.05]	[0.03, 0.05]	-	-	-	-	-	-	-	-
Freshwater drum	Mean	0.05	0.04[2]	0.04	0.04[1]	0.03[1]	0.05[2]	0.02[1]	0.02[1]	0.01[1]	0.03[2]
	95% CI	[0.02, 0.09]	-	[0.02, 0.06]	-	-	-	-	-	-	-
Smallmouth bass	Mean	0.02[2]	0.05[1]	0.03[1]	0.05[1]	0.04[1]	0.11[1]	0.08[1]	0.03[1]	0.03[2]	0.01[2]
	95% CI	-	-	-	-	-	-	-	-	-	-
White bass	Mean	0.03[2]	0.04[1]	0.03[1]	0.03[1]	0.03[1]	0.08[2]	0.04[1]	0.04[2]	0.02[1]	0.01[2]
	95% CI	-	-	-	-	-	-	-	-	-	-

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-12. Descriptive Statistics for PFOA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES

Statistic	Species: Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFOA]	0.09	0.12	0.08	0.08
Number of Detects	11	25	1	9
Number of Non-detects	89	75	99	87
Number of Samples Not Reported	0	0	0	0
Maximum [PFOA]	1.10	1.86	0.18	0.40
Minimum [PFOA]	0.03	0.03	0.03	0.03
Median [PFOA]	0.05	0.05	0.05	0.05
Geometric Mean [PFOA]	0.06	0.08	0.07	0.07
Standard Deviation	0.11	0.24	0.04	0.05

1/2 RL was used as a proxy value for all non-detects

Table 8-13. Mean and 95% Confidence Intervals for PFOA Concentrations (ng/g, wet weight) in Fish Collected in Pool 2 by Reach (2011)

		Reach									
Species	**Statistic**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Bluegill	Mean	0.06[2]	0.07[1]	0.19[2]	0.05[1]	0.08[2]	0.04[2]	0.11[2]	0.04[1]	0.10[1]	0.12
	95% CI	-	-	-	-	-	-	-	-	-	[0.05, 0.19]
Freshwater drum	Mean	0.09[1]	0.11[2]	0.09	0.05	0.13	0.06	0.09[2]	0.07[2]	0.07[1]	0.45
	95% CI	-	-	[0.07, 0.12]	[0.03, 0.08]	[0.05, 0.22]	[0.02, 0.09]	-	-	-	[-0.03, 0.93]
Smallmouth bass	Mean	0.06[1]	0.13[1]	0.06[1]	0.04[1]	0.06[2]	0.05[1]	0.11[1]	0.08[1]	0.11[1]	0.05[1]
	95% CI	-	-	-	-	-	-	-	-	-	-
White bass	Mean	0.07[2]	0.09[1]	0.06[1]	0.04[2]	0.09[2]	0.10[2]	0.10[1]	0.08[2]	0.07[1]	0.08[2]
	95% CI	-	-	-	-	-	-	-	-	-	-

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-14. Descriptive Statistics for PFNA (ng/g, wet weight) in Fish Collected from Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES	Species			
Statistic	**Bluegill**	**Freshwater drum**	**Smallmouth bass**	**White bass**
Arithmetic Mean [PFNA]	0.10	0.28	0.05	0.51
Number of Detects	41	86	7	84
Number of Non-detects	59	14	93	12
Number of Samples Not Reported	0	0	0	0
Maximum [PFNA]	0.56	0.95	0.13	1.13
Minimum [PFNA]	0.03	0.03	0.01	0.05
Median [PFNA]	0.08	0.26	0.03	0.51
Geometric Mean [PFNA]	0.08	0.24	0.04	0.42
Standard Deviation	0.08	0.17	0.04	0.26

1/2 RL was used as a proxy value for all non-detects

Table 8-15. Mean and 95% Confidence Intervals for PFNA Concentrations (ng/g, wet weight) in Fish Collected from Pool 2 by Reach (2011)

Species	Statistic	Reach 1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.16[2]	0.12	0.09[2]	0.08	0.08	0.07	0.06[1]	0.06	0.12	0.16
	95% CI	-	[0.05, 0.19]	-	[0.04, 0.11]	[0.03, 0.13]	[0.04, 0.09]	-	[0.03, 0.08]	[0.08, 0.17]	[0.05, 0.28]
Freshwater drum	Mean	0.27	0.37	0.33	0.25	0.30	0.25	0.30	0.21	0.29	0.26
	95% CI	[0.14, 0.40]	[0.20, 0.55]	[0.21, 0.46]	[0.17, 0.32]	[0.22, 0.39]	[0.15, 0.36]	[0.19, 0.41]	[0.11, 0.31	[0.15, 0.43]	[0.09, 0.44]
Smallmouth bass	Mean	0.12[1]	0.03[1]	0.05[2]	0.03[2]	0.03	0.03[1]	0.08[1]	0.04[1]	0.07[1]	0.08[1]
	95% CI	-	-	-	-	[0.02, 0.04]	-	-	-	-	-
White bass	Mean	0.47	0.63	0.50	0.68	0.45	0.71	0.44	0.42	0.47	0.33
	95% CI	[0.21, 0.73]	[0.39, 0.87]	[0.32, 0.69]	[0.56, 0.79]	[0.37, 0.52]	[0.53, 0.89]	[0.32, 0.55]	[0.20, 0.64]	[0.26, 0.68]	[0.15, 0.52]

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-16. Descriptive Statistics for PFDA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES

Statistic	Species: Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFDA]	1.41	1.74	1.74	3.61
Number of Detects	100	100	100	96
Number of Non-detects	0	0	0	0
Number of Samples Not Reported	0	0	0	0
Maximum [PFDA]	10.92	4.78	3.84	7.47
Minimum [PFDA]	0.32	0.47	0.53	0.92
Median [PFDA]	0.90	1.52	1.63	3.44
Geometric Mean [PFDA]	1.04	1.54	1.60	3.42
Standard Deviation	1.53	0.87	0.69	1.19

1/2 RL was used as a proxy value for all non-detects

Table 8-17. Mean and 95% Confidence Intervals for PFDA Concentrations (ng/g, wet weight) in Fish Collected from Pool 2 by Reach (2011)

Species	Statistic	Reach 1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	1.51	1.81	1.96	0.99	1.17	0.86	0.51	0.78	1.46	3.04
	95% CI	[0.66, 2.35]	[0.57, 3.05]	[1.31, 2.61]	[0.71, 1.27]	[0.78, 1.56]	[0.66, 1.07]	[0.39, 0.64]	[0.56, 1.01]	[0.82, 2.10]	[0.39, 5.70]
Freshwater drum	Mean	1.57	1.57	1.50	1.14	2.30	1.34	2.13	1.66	2.06	2.13
	95% CI	[0.87, 2.28]	[0.76, 2.39]	[0.97, 2.04]	[0.80, 1.48]	[1.69, 2.90]	[0.88, 1.79]	[1.56, 2.69]	[1.22, 2.11]	[1.54, 2.58]	[1.37, 2.89]
Smallmouth bass	Mean	1.48	2.20	1.81	2.13	1.75	1.73	1.74	1.47	1.20	1.85
	95% CI	[0.97, 1.98]	[1.51, 2.89]	[1.34, 2.28]	[1.74, 2.51]	[1.43, 2.06]	[1.30, 2.16]	[1.35, 2.13]	[0.95, 2.00]	[0.88, 1.52]	[1.30, 2.40]
White bass	Mean	3.65	4.12	3.24	3.35	3.68	3.91	3.57	3.11	3.89	3.60
	95% CI	[1.94, 5.37]	[3.31, 4.92]	[2.24, 4.24]	[2.73, 3.96]	[2.80, 4.57]	[3.24, 4.59]	[2.48, 4.66]	[2.70, 3.53]	[3.15, 4.64]	[2.48, 4.72]

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-18. Descriptive Statistics for PFUnA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES	Species			
Statistic	Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFUnA]	0.83	1.07	1.22	1.79
Number of Detects	100	100	100	96
Number of Non-detects	0	0	0	0
Number of Samples Not Reported	0	0	0	0
Maximum [PFUnA]	6.32	2.65	3.87	5.46
Minimum [PFUnA]	0.19	0.27	0.27	0.58
Median [PFUnA]	0.61	0.89	1.20	1.69
Geometric Mean [PFUnA]	0.65	0.94	1.15	1.69
Standard Deviation	0.86	0.54	0.48	0.67

1/2 RL was used as a proxy value for all non-detects

Table 8-19. Mean and 95% Confidence Intervals for PFUnA Concentrations (ng/g, wet weight) in Fish Collected from Pool 2 by Reach (2011)

Species	Statistic	Reach 1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.65	0.99	1.13	0.59	0.59	0.68	0.36	0.51	0.89	1.94
	95% CI	[0.43, 0.88]	[0.45, 1.53]	[0.77, 1.50]	[0.48, 0.69]	[0.46, 0.72]	[0.44, 0.93]	[0.29, 0.43]	[0.40, 0.62]	[0.50, 1.27]	[0.38, 3.50]
Freshwater drum	Mean	0.95	1.01	0.76	0.76	1.44	0.92	1.50	0.81	1.21	1.32
	95% CI	[0.60, 1.29]	[0.53, 1.48]	[0.60, 0.92]	[0.55, 0.97]	[1.06, 1.83	[0.46, 1.38]	[1.14, 1.85]	[0.59, 1.03]	[0.90, 1.52]	[0.87, 1.76]
Smallmouth bass	Mean	1.08	1.27	1.11	1.56	1.29	1.29	1.08	1.01	0.97	1.57
	95% CI	[0.76, 1.40]	[1.00, 1.54]	[0.92, 1.30]	[1.05, 2.08]	[1.16, 1.42]	[1.06, 1.52]	[0.84, 1.32]	[0.80, 1.22]	[0.75, 1.19]	0.95, 2.19]
White bass	Mean	2.01	1.94	1.51	1.65	1.81	2.01	1.87	1.60	1.85	1.75
	95% CI	[0.94, 3.07]	[1.55, 2.34]	[1.14, 1.88]	[1.36, 1.94]	[1.31, 2.30]	[1.63, 2.39]	[0.95, 2.80]	[1.39, 1.81]	[1.39, 2.32]	[1.42, 2.07]

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-20. Descriptive Statistics for PFDoA (ng/g, wet weight) in Fish Collected From Pool 2 and Analyzed by 3M (2011)

ALL SAMPLES

Statistic	Species: Bluegill	Freshwater drum	Smallmouth bass	White bass
Arithmetic Mean [PFDoA]	0.59	1.05	1.16	1.51
Number of Detects	100	100	100	96
Number of Non-detects	0	0	0	0
Number of Samples Not Reported	0	0	0	0
Maximum [PFDoA]	3.91	3.13	3.36	4.75
Minimum [PFDoA]	0.13	0.25	0.24	0.29
Median [PFDoA]	0.46	0.85	1.09	1.40
Geometric Mean [PFDoA]	0.47	0.88	1.08	1.41
Standard Deviation	0.56	0.65	0.46	0.60

1/2 RL was used as a proxy value for all non-detects

Table 8-21. Mean and 95% Confidence Intervals for PFDoA Concentrations (ng/g, wet weight) in Fish Collected from Pool 2 by Reach (2011)

Species	Statistic	Reach 1	2	3	4	5	6	7	8	9	10
Bluegill	Mean	0.35	0.47	0.82	0.53	0.44	0.52	0.32	0.48	0.62	1.38
	95% CI	[0.25, 0.46]	[0.26, 0.68]	[0.51, 1.14]	[0.36, 0.69]	[0.24, 0.65]	[0.36, 0.69]	[0.24, 0.39]	[0.36, 0.60]	[0.33, 0.91]	[0.43, 2.34]
Freshwater drum	Mean	0.82	0.95	0.74	0.89	1.57	0.98	1.59	0.62	1.07	1.29
	95% CI	[0.43, 1.21]	[0.29, 1.62]	[0.44, 1.04]	[0.57, 1.21]	[0.95, 2.18]	[0.57, 1.39]	[1.13, 2.06]	[0.46, 0.79]	[0.77, 1.38]	[0.89, 1.70]
Smallmouth bass	Mean	1.08	1.17	1.00	1.26	1.32	1.11	0.97	1.08	0.91	1.71
	95% CI	[0.80, 1.36]	[0.92, 1.43]	[0.78, 1.23]	[1.03, 1.50]	[1.08, 1.55]	[0.93, 1.29]	[0.74, 1.19]	[0.65, 1.51]	[0.69, 1.12]	[1.15, 2.27]
White bass	Mean	2.01	1.62	1.28	1.46	1.34	1.84	1.38	1.51	1.51	1.39
	95% CI	[0.44, 3.59]	[1.29, 1.94]	[0.92, 1.64]	[1.10, 1.81]	[0.95, 1.74]	[1.48, 2.20]	[0.97, 1.80]	[1.22, 1.80]	[1.22, 1.80]	[1.10, 1.68]

[1] All samples < LOQ; only mean DL reported

[2] Sample size ≤ 2; only mean reported

Table 8-22 Correlations of Perfluorocarboxylates Fillet Concentrations with Species Specific Fish Characteristics (ND=0)

Bluegill

Correlation	Statistic	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
Mass vs [PFC]	Spearman r	-0.0167	0.1338	-0.2342	-0.0867	0.1137	-0.2001	0.0728	0.2745	0.3368
	p-value	0.8701	0.1869	0.0196	0.3908	0.2601	0.0460	0.4716	0.0057	0.0006
	n	99	99	99	100	100	100	100	100	100
Length vs [PFC]	Spearman r	-0.0614	0.1603	-0.2129	-0.1382	0.0637	-0.2135	0.1253	0.3142	0.2923
	p-value	0.5460	0.1131	0.0344	0.1703	0.5290	0.0329	0.2142	0.0015	0.0032
	n	99	99	99	100	100	100	100	100	100
Age vs [PFC]	Spearman r	-0.2531	0.0004	-0.1122	0.3642	-0.0902	-0.3409	0.2260	0.2396	-0.0750
	p-value	0.0119	0.9970	0.2713	0.0002	0.3749	0.0006	0.0245	0.0169	0.4604
	n	98	98	98	99	99	99	99	99	99

Freshwater drum

Correlation	Statistic	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
Mass vs [PFC]	Spearman r	0.0114	0.0023	0.0017	-0.2085	0.0228	-0.1141	0.1678	0.4569	0.5744
	p-value	0.9107	0.9822	0.9866	0.0374	0.8219	0.2584	0.0952	< 0.0001	<0.0001
	n	100	100	100	100	100	100	100	100	100
Length vs [PFC]	Spearman r	0.0660	0.0348	-0.0302	-0.1787	0.0124	-0.1259	0.2139	0.4707	0.5332
	p-value	0.5142	0.7309	0.7654	0.0752	0.9028	0.2120	0.0326	< 0.0001	< 0.0001
	n	100	100	100	100	100	100	100	100	100
Age vs [PFC]	Spearman r	0.2303	0.0899	-0.1413	-0.1185	-0.1308	-0.1331	0.4338	0.3999	0.3284
	p-value	0.0212	0.3740	0.1609	0.2404	0.1947	0.1868	< 0.0001	< 0.0001	0.0009
	n	100	100	100	100	100	100	100	100	100

Smallmouth bass

Correlation	Statistic	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
Mass vs [PFC]	Spearman r	0.0821	-0.0759	0.1092	0.1949	0.0348	0.0384	0.3422	0.3373	0.3191
	p-value	0.4166	0.4530	0.2797	0.0519	0.7309	0.7043	0.0005	0.0006	0.0012
	n	100	100	100	100	100	100	100	100	100
Length vs [PFC]	Spearman r	0.0764	-0.0897	0.1093	0.2054	0.0174	0.0054	0.2721	0.2791	0.2752
	p-value	0.4500	0.3747	0.2791	0.0404	0.8634	0.9578	0.0062	0.0049	0.0056
	n	100	100	100	100	100	100	100	100	100
Age vs [PFC]	Spearman r	0.1016	-0.0898	0.1081	0.2151	-	-0.0385	0.2470	0.2428	0.2718
	p-value	0.3146	0.3745	0.2845	0.0316	-	0.7040	0.0132	0.0150	0.0062
	n	100	100	100	100	100	100	100	100	100

[1] 99% of samples were ND

White bass

Correlation	Statistic	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
Mass vs [PFC]	Spearman r	0.1147	0.0295	-0.1705	-0.0850	-0.0992	0.5422	0.4764	0.4266	0.3935
	p-value	0.2685	0.7769	0.0986	0.4124	0.3389	<0.0001	< 0.0001	<0.0001	<0.0001
	n	96	96	96	96	96	96	96	96	96
Length vs [PFC]	Spearman r	0.1034	0.0461	-0.1800	-0.0892	-0.0777	0.4937	0.4828	0.4065	0.3960
	p-value	0.3163	0.6559	0.0793	0.3876	0.4516	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	n	96	96	96	96	96	96	96	96	96
Age vs [PFC]	Spearman r	0.0908	-0.0175	-0.1546	-0.1247	-0.0714	0.3125	0.4426	0.3901	0.3345
	p-value	0.3789	0.8655	0.1327	0.2261	0.4897	0.0019	< 0.0001	< 0.0001	0.0009
	n	96	96	96	96	96	96	96	96	96

Table 8-23. 3M Analysis of Round 2 Water Samples for Perfluorocarboxylates (ND=RL)

Field ID	Tissue ID	Lab ID	Reach	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
515	515SF	515SF1	10	***18.6***	***6.05***	***2.96***	< 2.0	***6.12***	< 2.0	< 2.0	< 2.0	< 2.0
516	516SF	516SF1	10	***19.5***	< 5.0	< 2.0	< 2.0	***3.96***	< 2.0	< 2.0	< 2.0	< 2.0
517	517SF	517SF1	10	***648***	***74.6***	***31.7***	***8.4***	***219***	***2.02***	< 2.0	< 2.0	< 2.0
518	518SF	518SF1	9	***14.7***	< 5.0	< 2.0	< 2.0	***3.59***	< 2.0	< 2.0	< 2.0	< 2.0
519	519SF	519SF1	9	***11.4***	< 5.0	< 2.0	< 2.0	***2.52***	< 2.0	< 2.0	< 2.0	< 2.0
520	520SF	520SF1	9	***16.4***	< 5.0	< 2.0	< 2.0	***3.55***	< 2.0	< 2.0	< 2.0	< 2.0
521	521SF	521SF1	8	***17.2***	***6.02***	< 2.0	< 2.0	***3.46***	< 2.0	< 2.0	< 2.0	< 2.0
522	522SF	522SF1	8	***20***	< 5.0	***2.15***	< 2.0	***3.95***	< 2.0	< 2.0	< 2.0	< 2.0
523	523SF	523SF1	8	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
524	524SF	524SF1	7	***16.7***	< 5.0	< 2.0	< 2.0	***4.57***	< 2.0	< 2.0	< 2.0	< 2.0
525	525SF	525SF1	7	< 10.0	< 5.0	< 2.0	< 2.0	***2.75***	< 2.0	< 2.0	< 2.0	< 2.0
526	526SF	526SF1	7	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
527	527SF	527SF1	6	***16.8***	< 5.0	< 2.0	< 2.0	***4.73***	< 2.0	< 2.0	< 2.0	< 2.0
528	528SF	528SF1	6	***10.3***	< 5.0	< 2.0	< 2.0	***2.26***	< 2.0	< 2.0	< 2.0	< 2.0
529	529SF	529SF1	6	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
530	530SF	530SF1	5	***39.1***	< 5.0	***3.29***	< 2.0	***23.3***	< 2.0	< 2.0	< 2.0	< 2.0
531	531SF	531SF1	5	< 10.0	< 5.0	< 2.0	< 2.0	***2.97***	< 2.0	< 2.0	< 2.0	< 2.0
532	532SF	532SF1	5	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
533	533SF	533SF1	4	***12.1***	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
534	534SF	534SF1	4	< 10.0	< 5.0	< 2.0	< 2.0	***2.32***	< 2.0	< 2.0	< 2.0	< 2.0
535	535SF	535SF1	4	< 10.0	< 5.0	< 2.0	< 2.0	***2.51***	< 2.0	< 2.0	< 2.0	< 2.0
536	536SF	536SF1	3	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
537	537SF	537SF1	3	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
538	538SF	538SF1	3	***12.8***	< 5.0	< 2.0	< 2.0	***2.77***	< 2.0	< 2.0	< 2.0	< 2.0
539	539SF	539SF1	2	< 10.0	< 5.0	< 2.0	< 2.0	***3.16***	< 2.0	< 2.0	< 2.0	< 2.0
540	540SF	540SF1	2	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0

541	541SF	541SF1	2	< 10.0	< 5.0	< 2.0	< 2.0	***2.34***	< 2.0	< 2.0	< 2.0	< 2.0
542	542SF	542SF1	1	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
543	543SF	543SF1	1	***11***	< 5.0	< 2.0	< 2.0	***2.53***	< 2.0	< 2.0	< 2.0	< 2.0
544	544SF	544SF1	1	***12.2***	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0

Bold, italicized text = *Detects*

Table 8-24. 3M Analysis of Round 1 (June) Water Samples for Perfluorocarboxylates (ND=RL)

Field ID	Tissue ID	Lab ID	Reach	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
501	501SF	501SF1	10	***92.4***	***16***	***12.9***	***5***	***137***	< 2.0	< 2.5	< 4.0	< 4.0
502	502SF	502SF1	10	***9.24***	***4.43***	< 2.5	< 2.0	***2.39***	< 2.0	< 2.5	< 4.0	< 4.0
503	503SF	503SF1	8	***5***	< 4.0	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
504	504SF	504SF1	8	***9.14***	< 4.0	< 2.5	< 2.0	***4.56***	< 2.0	< 2.5	< 4.0	< 4.0
505	505SF	505SF1	8	< 5.0	< 4.0	< 2.0	< 2.0	***2.53***	< 2.0	< 2.5	< 4.0	< 4.0
506	506SF	506SF1	3	< 5.0	< 4.0	< 2.5	< 2.0	***2.81***	< 2.0	< 2.5	< 4.0	< 4.0
507	507SF	507SF1	3	< 5.0	< 4.0	< 2.5	< 2.0	***2.25***	< 2.0	< 2.5	< 4.0	< 4.0
508	508SF	508SF1	3	< 5.0	< 4.0	< 2.5	< 2.0	***2.24***	< 2.0	< 2.5	< 4.0	< 4.0
509	509SF	509SF1	2	< 5.0	< 4.0	< 2.5	< 2.0	***2.06***	< 2.0	< 2.5	< 4.0	< 4.0
510	510SF	510SF1	2	< 5.0	< 4.0	< 2.5	< 2.0	***2.15***	< 2.0	< 2.5	< 4.0	< 4.0
511	511SF	511SF1	2	< 5.0	< 4.0	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
512	512SF	512SF1	1	< 5.0	***5.15***	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
513	513SF	513SF1	1	< 5.0	< 4.0	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
514	514SF	514SF1	1	< 5.0	< 4.0	< 2.5	< 2.0	***2.23***	< 2.0	< 2.5	< 4.0	< 4.0

Bold, italicized text = Detects

Chapter 9

Conclusions

The analysis of all fish and water samples for perfluorinated compounds was conducted by the ISO17025 Accredited 3M Environmental Laboratory. For quality assurance, 30 water samples representing all 3 sampling locations within each reach and 41 fish representing 10% of the total number of fish analyzed by the 3M Laboratory were also analyzed by ISO17025 Accredited AXYS Analytical Ltd.

With one exception, the data agreement for fish tissue samples was good between the laboratories with the average relative percent differences (RPD) for PFAS and PFCAs generally being 25% or less. PFBS was the exception with an average RPD of approximately 90%; however, the significance of this difference is difficult to evaluate given that it was based on only 2 samples. A comparison of the PFOS analytical results for fish indicated a very good match (RPD range 1.3-54%, mean of 17%) between the two laboratories. The interlaboratory comparison based on water PFC concentrations was limited due to the large number of non-detects reported by both laboratories. Using data from matched samples with measured concentration in both laboratories, the RPD ranged from 1.6 to 135% with an overall arithmetic average and median of 36% and 33%, respectively. For PFOS, the RPD ranged from 17 to 56% with an average of 35%.

PFOS water concentrations were detected only in Reaches 5, 6, 7, 8, 9, and 10 with all other samples having concentrations less than the LOQ. The greatest concentration was measured in Reach 10 at Station 517 with the second greatest concentration being measured in Reach 5 at Station 530. PFOS concentrations decreased with distance downriver from these two locations indicating the potential presence of point sources of PFOS to the river. With the exception of Stations 517 and 530, all water concentrations were less than the site-specific water quality value of 7.0 ng PFOS/L established by the MPCA. With the exception of PFBA and PFOA, the other PFAS and PFCA compounds were detected in patterns similar to that observed for PFOS with concentrations being greatest near Reaches 5 and 10. Measurable surface water PFBA and PFOA concentration showed a more ubiquitous distribution in that, while concentrations were greatest in Reach 10, they were also measured throughout the entirety of Pool 2 indicating that additional sources of these compounds to the river may exist.

Detectable concentrations of PFOS were measured in all fish collected from Pool 2. PFOS concentrations in all fish samples from Pool ranged from 3.17 to 757 ng/g ww. Arithmetic mean, geometric mean, and median fish PFOS concentrations were 46.3, 31.1 and 34.1 ng/g ww, respectively. The arithmetic means for bluegill, freshwater drum, smallmouth bass and white bass were 36, 46, 39, and 64 ng/g ww, respectively. While some statistically significant correlations were observed between PFOS concentrations and fish length, weight and age, for the targeted species, the correlations were weak and typically accounted for less than 20% of the variation for any specific correlation. Based on arithmetic average, the greatest concentrations were observed in white bass followed in decreasing order by freshwater drum, smallmouth bass, and bluegill. Concentrations of PFBS, PFHS, PFOSA as well as that of the other nine PFCAs were measured in all fish species but the species-specific average concentrations were less than 5 ng/g ww on a pool wide basis. Overall, the most dominant PFC measured in fish collected from Pool 2 of the Upper Mississippi River was PFOS.

Chapter 10

References

Cardno ENTRIX, 2011. Work Plan for the Collection of Fish and Surface Water from Pool 2 of the Upper Mississippi River, Minnesota. Submitted to the 3M Company May 26, 2011.

Lindström G., Karrman A., and van Bavel B. (2009). Accuracy and precision in the determination of perfluorinated chemicals in human blood verified by interlaboratory comparisons. J. Chromatogr. A 1216: 394-400.

MPCA 2010. Mississippi River Pool 2 Intensive Study of Perfluorochemicals in Fish and Water: 2009. Minnesota Pollution Control Agency, MN. 37p.

Malinsky MD., Jacoby CB., and Reagen WK. (2011). Determination of perfluorinated compounds in fish fillet homogenates: Method validation and application to fillet homogenates from the Mississippi River. Analytica Chimica Acta 683: 248-257.

Riddell N, Arsenault G., Chittim B., Martin JW., McAlees A., and McCrindle R. (2009). Branched perfluorooctane sulfonate isomer quantification and characterization in blood serum samples by HPLC/ESI-MS/(/MS). Environ. Sci. Technol. 43: 7902-7908.

Stiras, J.K. 2008. Major River Report, Initial River Survey, Upper Mississippi River, Pool 2, 2008. Minnesota Department of Natural Resources. Division of Fish and Wildlife. MN. 36p.

USEPA. 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Volume 1: Fish Sampling and Analysis Third Edition. United States Environmental Protection Agency, Office of Water (4305). EPA 823-B-00-007. November 2000. Washington, D.C.

Weston 2006. Fluorochemical (FC) Data Assessment Report for the 3M Cottage Grove, MN Facility. April 2006.

Wolf, S. T., W.K. Reagen. "Method for the Determination of Perfluorinated Compounds (PFCs) in Water by Solid-Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)" Anal Methods; 2011, 3, 1485.

Appendix A

Fish Sample Collection Tables & Figures

Appendix A

Fish Sample Collection

A.1 Tables

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
001	001FN	001FN1	F drum	648.64	37.5	10	10	1	N44° 47.108'	N44° 46.926'	W92° 55.010'	W92° 53.313'	< 0.25	0.40	83.5	1.79	0.49	< 0.5	< 0.5	< 0.025	0.29	0.12	2.00	1.83	1.44
002	002FN	002FN1	F drum	857.29	41	24	10	1	N44° 47.108'	N44° 46.926'	W92° 55.010'	W92° 53.313'	< 0.25	0.21	235.0	2.97	1.14	< 0.5	< 0.5	0.03	1.86	0.28	1.93	0.84	0.92
003	003FN	003FN1	F drum	589.67	35	8	10	1	N44° 47.108'	N44° 46.926'	W92° 55.010'	W92° 53.313'	< 0.25	2.45	87.1	1.57	< 0.5	< 0.5	< 0.5	< 0.025	0.20	0.17	2.45	2.19	2.01
004	004FN	004FN1	F drum	376.48	32	5	10	1	N44° 47.108'	N44° 46.926'	W92° 55.010'	W92° 53.313'	< 0.25	0.11	607.0	2.56	0.86	< 0.5	< 0.5	< 0.025	1.57	0.95	4.78	1.07	1.29
005	005FN	005FN1	F drum	798.32	39.5	10	10	1	N44° 47.108'	N44° 46.926'	W92° 55.010'	W92° 53.313'	< 0.25	< 0.05	23.2	1.19	< 0.5	< 0.5	< 0.5	< 0.025	0.22	0.23	1.91	1.86	2.05
006	006FN	006FN1	W bass	426.38	34	3	10	1	N44° 47.108'	N44° 46.926'	W92° 55.010'	W92° 53.313'	< 0.25	0.11	77.6	0.93	< 0.05	< 0.5	< 0.5	< 0.025	0.22	0.34	2.70	1.31	1.11
007	007FN	007FN1	F drum	1247.38	45	17	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	< 0.05	17.7	0.45	1.80	< 0.5	< 0.5	< 0.025	0.15	0.19	2.78	2.19	1.71
008	008FN	008FN1	F drum	825.54	41	12	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	< 0.05	11.9	0.52	< 0.5	< 0.5	< 0.5	< 0.025	< 0.1	0.12	1.70	1.32	1.60
009	009FN	009FN1	F drum	376.48	32	5	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	0.05	20.7	0.27	2.86	< 0.5	< 0.5	0.15	0.11	0.17	1.24	0.76	0.80
010	010FN	010FN1	F drum	326.59	30	5	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	< 0.05	29.1	0.17	0.94	< 0.5	< 0.5	< 0.025	< 0.1	0.16	1.48	0.88	0.80
011	011FN	011FN1	F drum	326.59	31	8	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	< 0.05	21.5	0.20	0.51	< 0.5	< 0.5	< 0.025	< 0.1	0.26	1.06	0.44	0.32
013	013FN	013FN1	W bass	235.87	27	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	< 0.05	40.5	1.00	< 0.5	< 0.5	< 0.5	0.03	< 0.1	< 0.1	2.21	1.27	1.15
014	014FN	014FN1	W bass	249.48	28	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	0.05	72.7	3.67	0.5	< 0.5	< 0.5	< 0.025	< 0.1	0.20	3.13	1.70	1.24
015	015FN	015FN1	W bass	208.65	24	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.25	0.13	98.7	1.66	0.38	< 0.5	< 0.5	< 0.025	< 0.1	0.48	3.05	1.64	1.42
016	016FN	016FN1	W bass	176.90	24.5	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	0.12	48.8	2.83	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	0.33	2.86	1.69	1.01
017	017FN	017FN1	W bass	226.80	26	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	1.33	394.0	10.40	< 1.0	< 1.0	1.19	< 0.025	0.13	0.84	7.47	2.56	2.28
018	018FN	018FN1	Bluegill	99.79	16	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	< 0.05	214.0	0.16	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	7.96	5.28	3.18
020	020FN	020FN1	Bluegill	136.08	17.5	3	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	< 0.05	52.0	0.19	< 1.0	< 1.0	< 1.0	< 0.025	0.36	< 0.25	2.10	1.57	1.30
021	021FN	021FN1	Bluegill	199.58	19.5	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	< 0.05	29.5	0.18	< 1.0	< 1.0	< 1.0	< 0.025	0.12	< 0.25	0.73	0.77	0.76

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
022	022FN	022FN1	Bluegill	108.86	17	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	0.26	305.0	0.49	1.03	< 1.0	< 1.0	< 0.025	0.16	0.56	10.92	6.32	3.91
023	023FN	023FN1	Sm bass	217.72	26	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	< 0.05	44.4	0.69	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	1.90	1.67	1.75
024	024FN	024FN1	Sm bass	335.66	28	3	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	< 0.05	44.4	0.72	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	1.55	1.20	1.36
025	025FN	025FN1	Sm bass	285.76	27.5	3	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	< 0.05	41.7	1.10	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	1.83	1.40	1.34
026	026FN	026FN1	Sm bass	789.25	39	5	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 0.1	< 0.05	35.0	0.91	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	1.44	0.89	0.85
027	027FN	027FN1	F drum	666.78	36	8	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	0.13	14.9	0.11	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	0.85	0.53	0.46
028	028FN	028FN1	F drum	657.71	37	13	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	0.12	46.7	0.15	< 1.0	< 1.0	< 1.0	< 0.025	0.23	< 0.25	1.79	0.67	0.47
029	029FN	029FN1	F drum	349.27	32	8	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	< 0.05	39.3	0.13	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	1.58	0.91	0.48
030	030FN	030FN1	F drum	399.16	32.5	10	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	< 0.05	34.9	0.22	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	1.93	0.95	0.78
031	031FN	031FN1	Sm bass	249.48	27	2	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	< 0.05	16.0	0.49	< 1.0	< 1.0	< 0.1	< 0.025	< 0.1	< 0.25	1.29	1.23	1.09
032	032FN	032FN1	Bluegill	36.29	14	4	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	0.18	9.7	0.09	< 1.0	< 1.0	1.07	< 0.025	< 0.1	< 0.25	1.57	0.72	0.28
033	033FN	033FN1	W bass	226.80	26.5	2	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	< 0.05	42.1	0.96	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	3.00	1.52	1.52
034	034FN	034FN1	W bass	226.80	27	2	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	0.06	48.4	0.89	< 1.0	< 1.0	< 1.0	0.12	< 0.1	0.51	3.18	1.78	1.51
035	035FN	035FN1	W bass	249.48	27.5	2	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 0.1	< 0.05	34.0	0.59	< 1.0	< 1.0	< 1.0	< 0.025	< 0.1	< 0.25	2.63	1.28	1.29
036	036FN	036FN1	W bass	199.58	26	2	8	2	N44° 47.649'	N44° 47.086'	W93° 01.340'	W93° 01.118'	< 0.25	0.14	53.5	0.96	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.24	3.12	1.43	1.59
037	037FN	037FN1	W bass	235.87	27	2	8	2	N44° 47.649'	N44° 47.086'	W93° 01.340'	W93° 01.118'	< 0.25	< 0.1	50.1	1.19	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.31	3.01	1.72	1.32
038	038FN	038FN1	F drum	498.95	36	8	8	3	N44° 47.171'	N44° 46.447'	W93° 01.438'	W93° 00.999'	< 0.25	< 0.1	33.5	0.12	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.18	1.25	0.67	0.45
039	039FN	039FN1	F drum	426.38	35	10	8	3	N44° 47.171'	N44° 46.447'	W93° 01.438'	W93° 00.999'	< 0.25	< 0.1	79.0	0.15	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.51	3.02	1.46	0.76
040	040FN	040FN1	F drum	308.44	30.5	8	8	3	N44° 47.171'	N44° 46.447'	W93° 01.438'	W93° 00.999'	1.7	< 0.1	33.3	0.13	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.1	1.04	0.59	0.58
041	041FN	041FN1	F drum	199.58	26	6	8	3	N44° 47.171'	N44° 46.447'	W93° 01.438'	W93° 00.999'	< 0.25	< 0.1	44.9	0.21	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.29	1.65	0.50	0.50
044	044FN	044FN1	F drum	439.98	32	13	8	3	N44° 47.171'	N44° 46.447'	W93° 01.438'	W93° 00.999'	< 0.25	< 0.1	33.9	0.15	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.20	2.16	1.15	1.16
045	045FN	045FN1	W bass	185.97	25.5	2	8	3	N44° 47.171'	N44° 46.447'	W93° 01.438'	W93° 00.999'	< 0.25	0.17	59.5	3.90	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.1	2.07	1.16	0.91
~~046~~	~~046FN~~	~~046FN1~~	~~W bass~~	~~249.48~~	~~28~~	~~2~~	~~7~~	~~1~~	~~N44° 49.258'~~	~~N44° 49.290'~~	~~W93° 00.454'~~	~~W93° 00.933'~~	~~< 0.25~~	~~< 0.1~~	~~66.4~~	~~1.22~~	~~< 1.0~~	~~< 1.0~~	~~< 1.0~~	~~< 0.05~~	~~< 0.1~~	~~0.39~~	~~4.63~~	~~2.14~~	~~1.86~~
047	047FN	047FN1	F drum	358.34	33	8	3	1	N44° 55.509'	N44° 56.048'	W93° 06.777'	W93° 06.085'	< 0.25	< 0.1	54.9	0.14	< 1.0	< 1.0	< 1.0	< 0.05	0.13	0.34	1.80	0.98	0.65
048	048FN	048FN1	F drum	249.48	29	6	3	1	N44° 55.509'	N44° 56.048'	W93° 06.777'	W93° 06.085'	< 0.25	< 0.1	36.5	0.19	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.11	1.09	0.58	0.42
049	049FN	049FN1	F drum	308.44	32	8	3	1	N44° 55.509'	N44° 56.048'	W93° 06.777'	W93° 06.085'	< 0.05	0.03	37.8	0.12	< 1.0	< 1.0	< 1.0	0.06	< 0.25	0.70	1.91	0.80	0.48

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
050	050FN	050FN1	F drum	226.80	29	8	3	1	N44° 55.509'	N44° 56.048'	W93° 06.777'	W93° 06.085'	< 0.05	0.03	43.7	0.14	< 1.0	< 1.0	< 1.0	0.09	< 0.25	0.38	2.59	1.07	0.70
051	051FN	051FN1	F drum	426.38	35	16	3	1	N44° 55.509'	N44° 56.048'	W93° 06.777'	W93° 06.085'	< 0.05	0.04	37.1	0.18	< 1.0	< 1.0	< 1.0	0.06	< 0.25	< 0.25	2.72	0.84	0.45
052	052FN	052FN1	W bass	526.17	35.5	7	3	1	N44° 55.509'	N44° 56.048'	W93° 06.777'	W93° 06.085'	< 0.05	0.05	29.1	1.17	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	2.46	1.12	0.80
053	053FN	053FN1	W bass	739.36	40	6	3	1	N44° 55.509'	N44° 56.048'	W93° 06.777'	W93° 06.085'	< 0.05	< 0.025	57.5	0.63	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	0.50	6.03	2.08	2.11
054	054FN	054FN1	Sm bass	249.48	27	3	3	2	N44° 56.139'	N44° 56.589'	W93° 06.019'	W93° 05.240'	< 0.05	< 0.025	30.0	0.43	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	2.92	1.43	1.60
055	055FN	055FN1	Bluegill	68.04	15	4	3	2	N44° 56.139'	N44° 56.589'	W93° 06.019'	W93° 05.240'	< 0.05	22.89	71.9	0.11	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	2.44	1.04	0.51
056	056FN	056FN1	Bluegill	86.18	15	9	3	2	N44° 56.139'	N44° 56.589'	W93° 06.019'	W93° 05.240'	< 0.05	0.85	29.2	0.15	< 1.0	< 1.0	< 1.0	0.05	< 0.25	< 0.25	3.28	1.64	1.32
057	057FN	057FN1	Bluegill	77.11	14	4	3	2	N44° 56.139'	N44° 56.589'	W93° 06.019'	W93° 05.240'	< 0.05	0.18	17.2	0.10	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	2.16	1.33	0.83
058	058FN	058FN1	Bluegill	77.11	15.5	5	3	2	N44° 56.139'	N44° 56.589'	W93° 06.019'	W93° 05.240'	< 0.05	0.16	26.6	0.12	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	1.91	1.35	0.91
059	059FN	059FN1	Bluegill	86.18	16	4	3	2	N44° 56.139'	N44° 56.589'	W93° 06.019'	W93° 05.240'	< 0.05	< 0.025	20.6	0.06	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	2.29	1.35	0.85
061	061FN	061FN1	Bluegill	99.79	15	4	3	3	N44° 56.528'	N44° 55.611'	W93° 05.683'	W93° 06.663'	< 0.05	0.69	28.7	0.20	< 1.0	< 1.0	< 1.0	< 0.05	1.10	< 0.25	3.09	2.05	1.75
062	062FN	062FN1	Sm bass	367.41	30	3	3	3	N44° 56.528'	N44° 55.611'	W93° 05.683'	W93° 06.663'	< 0.05	< 0.025	34.3	0.61	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	2.03	1.17	0.94
063	063FN	063FN1	Sunfish	86.18	16	4	2	1	N44° 53.659'	N44° 53.823'	W93° 09.916'	W93° 09.231'	0.40	0.35	34.1	0.22	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	1.15	0.72	1.05
064	064FN	064FN1	W bass	467.20	35	5	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	< 0.025	66.7	2.10	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	3.85	1.72	1.31
065	065FN	065FN1	W bass	217.72	26.5	2	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	0.05	34.9	1.48	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	2.09	1.10	1.10
066	066FN	066FN1	Bluegill	86.18	17	5	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	< 0.025	26.9	0.13	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	< 0.25	6.08	2.87	1.24
067	067FN	067FN1	Bluegill	49.90	13.5	5	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	0.12	8.1	0.08	< 1.0	< 1.0	< 1.0	< 0.05	< 0.25	0.32	3.31	1.72	0.47
069	069FN	069FN1	Bluegill	49.90	14	5	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	0.08	7.2	0.06	< 1.0	< 1.0	< 1.0	0.05	< 0.1	< 0.25	1.17	0.74	0.32
070	070FN	070FN1	Bluegill	49.90	13	5	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	0.21	11.0	0.07	< 1.0	< 1.0	< 1.0	0.06	< 0.1	< 0.25	1.47	0.82	0.36
071	071FN	071FN1	Bluegill	36.29	13	5	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	0.12	9.5	0.10	< 1.0	< 1.0	< 1.0	0.06	< 0.1	0.25	2.02	1.02	0.40
072	072FN	072FN1	Bluegill	36.29	12.5	5	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 0.05	0.06	7.0	0.04	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	1.71	0.74	0.24
074	074FN	074FN1	W bass	839.15	42.5	10	2	3	N44° 53.871'	N44° 54.699'	W93° 08.945'	W93° 07.907'	< 0.05	< 0.025	41.5	0.69	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	0.64	3.97	2.19	2.39
075	075FN	075FN1	F drum	376.48	33	10	2	3	N44° 53.871'	N44° 54.699'	W93° 08.945'	W93° 07.907'	< 0.05	0.03	37.1	0.10	< 1.0	< 1.0	< 1.0	0.06	< 0.1	0.42	1.95	0.93	0.40
076	076FN	076FN1	F drum	517.10	35	6	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	0.50	81.3	0.41	< 1.0	< 1.0	< 1.0	0.13	< 0.1	0.30	1.76	1.51	1.51
078	078FN	078FN1	F drum	716.68	36	8	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	0.05	35.2	0.12	< 1.0	< 1.0	< 1.0	0.10	< 0.1	< 0.25	1.33	0.78	0.25
079	079FN	079FN1	Sm bass	1165.73	44.5	7	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	< 0.025	16.9	0.33	< 1.0	< 1.0	< 1.0	0.05	< 0.1	< 0.25	1.28	1.07	1.31

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
080	080FN	080FN1	Sm bass	1188.41	42.5	5	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	< 0.025	27.3	0.67	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	1.83	1.08	0.88
081	081FN	081FN1	Sm bass	1088.62	42	5	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	< 0.025	55.5	0.38	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	2.70	1.76	1.53
082	082FN	082FN1	Sm bass	449.06	33	3	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	< 0.025	10.8	0.40	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	0.77	0.86	0.78
083	083FN	083FN1	Sm bass	607.81	35.5	4	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	< 0.025	14.4	0.45	< 1.0	1.37	< 1.0	< 0.05	< 0.1	< 0.25	1.03	0.89	1.02
084	084FN	084FN1	Sm bass	199.58	26	3	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	< 0.025	14.4	0.28	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	0.97	0.80	0.73
085	085FN	085FN1	Bluegill	77.11	15	6	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	0.10	5.5	0.04	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	0.65	0.40	0.24
086	086FN	086FN1	Bluegill	77.11	16	6	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	0.03	6.4	0.05	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	2.12	0.95	0.53
087	087FN	087FN1	Bluegill	68.04	16	6	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	0.03	3.6	0.03	< 1.0	< 1.0	< 1.0	< 0.05	< 0.1	< 0.25	0.89	0.41	0.53
088	088FN	088FN1	Bluegill	49.90	13	4	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	0.17	9.2	0.05	< 0.25	< 0.1	< 0.25	0.03	0.14	0.26	2.25	0.78	0.39
091	091FN	091FN1	Bluegill	77.11	15	5	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 0.05	0.06	9.4	0.05	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	1.03	0.68	0.47
092	092FN	092FN1	Sm bass	607.81	35	4	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	< 0.025	13.5	0.30	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	0.91	0.75	1.04
093	093FN	093FN1	F drum	349.27	34	8	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	0.03	25.8	0.06	< 0.25	< 0.1	< 0.25	0.03	< 0.1	< 0.25	1.26	0.51	0.39
094	094FN	094FN1	F drum	467.20	35	6	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	0.29	50.0	0.22	< 0.25	0.19	< 0.25	0.12	< 0.1	0.56	1.53	0.89	0.79
095	095FN	095FN1	F drum	417.30	34	6	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	0.05	0.04	17.7	0.06	< 0.25	< 0.1	0.29	0.04	< 0.1	< 0.25	0.79	0.40	0.36
096	096FN	096FN1	Bluegill	86.18	15	6	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	0.04	6.0	0.05	< 0.25	< 0.1	< 0.25	0.08	0.11	< 0.25	0.89	0.52	0.21
097	097FN	097FN1	Bluegill	58.97	14	5	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	0.10	8.2	0.05	< 0.25	< 0.1	< 0.25	0.08	< 0.1	< 0.25	1.34	0.66	0.27
098	098FN	098FN1	Bluegill	86.18	15.5	6	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	0.11	4.7	0.05	< 0.25	< 0.1	< 0.25	0.06	< 0.1	< 0.25	0.77	0.34	0.20
099	099FN	099FN1	Bluegill	68.04	14	5	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	0.22	11.0	0.08	< 0.25	< 0.1	< 0.25	0.04	< 0.1	0.31	4.45	1.37	0.52
100	100FN	100FN1	Bluegill	77.11	14.5	5	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 0.05	0.05	5.7	0.04	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	0.68	0.41	0.18
101	101FN	101FN1	W bass	317.51	30	2	1	4	N44° 53.972'	N44° 53.636'	W93° 11.441'	W93° 10.274'	< 0.05	0.07	47.7	1.83	< 0.25	< 0.1	< 0.25	0.03	< 0.1	0.25	2.87	1.46	1.23
102	102FN	102FN1	Sm bass	498.95	33	4	1	4	N44° 53.972'	N44° 53.636'	W93° 11.441'	W93° 10.274'	< 0.05	< 0.025	44.2	0.29	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	2.24	1.80	1.78
103	103FN	103FN1	Sm bass	208.65	28	3	1	4	N44° 53.972'	N44° 53.636'	W93° 11.441'	W93° 10.274'	< 0.05	< 0.025	8.5	0.15	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	0.82	0.53	0.48
104	104FN	104FN1	W bass	757.50	40.5	8	1	5	N44° 54.806'	N44° 54.370'	W93° 12.036'	W93° 11.713'	< 0.05	< 0.025	88.9	0.71	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	0.36	4.13	2.00	2.03
106	106FN	106FN1	Sm bass	675.85	36	3	7	2	N44° 50.286'	N44° 49.790'	W93° 00.813'	W93° 00.580'	< 0.05	< 0.025	29.0	0.61	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	1.87	0.91	0.77
107	107FN	107FN1	Sm bass	648.64	39	4	7	2	N44° 50.286'	N44° 49.790'	W93° 00.813'	W93° 00.580'	0.05	< 0.025	32.7	0.88	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	2.34	1.30	1.03
108	108FN	108FN1	W bass	185.97	26	2	7	2	N44° 50.286'	N44° 49.790'	W93° 00.813'	W93° 00.580'	< 0.05	0.05	70.4	4.05	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	0.37	2.74	1.34	1.32

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
109	109FN	109FN1	Bluegill	68.04	15	5	7	2	N44° 50.286'	N44° 49.790'	W93° 00.813'	W93° 00.580'	< 0.05	0.06	7.1	0.08	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.25	0.76	0.45	0.26
110	110FN	110FN1	W bass	226.80	27	2	7	3	N44° 50.336'	N44° 49.900'	W93° 00.595'	W93° 00.532'	< 0.05	0.11	49.8	1.89	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.40	2.58	1.22	1.12
111	111FN	111FN1	W bass	739.36	38.5	4	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 0.05	0.12	139.0	1.75	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.65	7.46	5.46	2.82
112	112FN	112FN1	W bass	467.20	33	3	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 0.05	0.05	59.0	1.89	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	< 0.25	3.59	1.77	1.43
113	113FN	113FN1	W bass	1016.05	42.5	7	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 0.05	0.06	45.3	1.12	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.35	3.19	1.33	0.99
114	114FN	114FN1	W bass	639.57	38	4	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 0.05	0.09	43.3	0.95	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.60	3.06	1.27	1.11
115	115FN	115FN1	Sm bass	1038.73	43.5	7	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 0.05	< 0.05	7.3	0.34	< 0.25	0.12	< 0.1	< 0.025	< 0.25	< 0.25	0.53	0.27	0.24
116	116FN	116FN1	Sm bass	476.27	32	2	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 0.05	< 0.05	25.7	0.36	< 0.25	0.44	< 0.1	< 0.025	< 0.25	< 0.25	1.32	0.93	0.84
117	117FN	117FN1	F drum	367.41	32	7	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 0.05	< 0.05	31.0	0.13	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.30	1.52	0.70	0.45
119	119FN	119FN1	Sm bass	1106.77	44	8	9	1	N44° 46.322'	N44° 46.000'	W92° 58.180'	W92° 57.239'	< 0.05	< 0.05	20.3	0.62	< 0.25	0.15	< 0.1	< 0.025	< 0.25	< 0.25	1.89	0.86	0.75
120	120FN	120FN1	W bass	258.55	18	2	9	1	N44° 46.322'	N44° 46.000'	W92° 58.180'	W92° 57.239'	< 0.05	0.13	68.4	1.93	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.27	4.67	2.19	1.95
123	123FN	123FN1	Sm bass	648.64	36	4	9	2	N44° 46.162'	N44° 46.244'	W92° 57.877'	W92° 56.370'	< 0.05	< 0.05	8.0	0.70	0.54	0.17	0.18	0.04	< 0.25	< 0.25	0.96	0.80	0.76
124	124FN	124FN1	F drum	1006.98	44	34	9	2	N44° 46.162'	N44° 46.244'	W92° 57.877'	W92° 56.370'	< 0.05	< 0.05	6.7	0.72	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.33	3.45	1.84	1.72
125	125FN	125FN1	F drum	408.23	33.5	9	9	2	N44° 46.162'	N44° 46.244'	W92° 57.877'	W92° 56.370'	< 0.05	0.11	39.8	0.19	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.75	2.32	1.04	0.82
126	126FN	126FN1	Bluegill	158.76	20	4	9	2	N44° 46.162'	N44° 46.244'	W92° 57.877'	W92° 56.370'	< 0.05	0.05	21.6	0.12	< 0.25	0.05	< 0.1	< 0.025	< 0.25	< 0.25	1.12	0.60	0.31
127	127FN	127FN1	W bass	616.89	37	4	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.05	0.13	45.0	1.44	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	0.44	2.89	1.34	1.21
128	128FN	128FN1	Sm bass	807.39	39	4	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.05	< 0.05	34.2	1.02	< 0.25	0.12	< 0.1	< 0.025	< 0.25	< 0.25	2.12	1.63	1.29
129	129FN	129FN1	Sm bass	426.38	32	4	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.05	< 0.05	18.9	1.03	< 0.25	< 0.05	< 0.1	< 0.025	< 0.25	< 0.25	1.01	1.13	1.02
130	130FN	130FN1	F drum	1029.65	43	10	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.25	< 0.05	9.7	0.38	0.29	< 0.025	0.53	< 0.025	< 0.1	0.265	1.25	0.88	0.79
131	131FN	131FN1	F drum	698.53	39	13	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.25	< 0.05	22.9	0.32	0.21	0.03	0.53	< 0.025	< 0.1	< 0.25	1.56	0.58	0.51
132	132FN	132FN1	F drum	889.04	41	13	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.25	< 0.05	4.8	0.58	0.18	0.05	0.47	< 0.025	< 0.1	< 0.25	2.89	1.53	1.50
133	133FN	133FN1	F drum	399.16	32	6	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.25	< 0.05	10.2	0.26	< 0.1	0.09	0.65	< 0.025	< 0.1	< 0.25	1.31	0.94	1.00
134	134FN	134FN1	W bass	557.92	37.5	6	9	3	N44° 45.972'	N44° 46.210'	W92° 56.343'	W92° 55.880'	< 0.25	< 0.05	74.4	0.58	< 0.1	< 0.025	< 0.25	< 0.025	< 0.1	< 0.25	4.53	1.82	1.38
135	135FN	135FN1	Bluegill	68.04	14.5	1	9	4	N44° 46.725'	N44° 46.982'	W92° 56.028'	W92° 56.022'	< 0.25	< 0.05	99.1	0.13	< 0.1	< 0.025	< 0.25	< 0.025	< 0.1	< 0.25	2.92	1.75	1.15
136	136FN	136FN1	Bluegill	68.04	14	1	9	4	N44° 46.725'	N44° 46.982'	W92° 56.028'	W92° 56.022'	< 0.25	< 0.05	21.4	0.10	< 0.1	< 0.025	< 0.25	< 0.025	< 0.1	< 0.25	0.77	0.57	0.29
137	137FN	137FN1	F drum	725.75	40	11	9	4	N44° 46.725'	N44° 46.982'	W92° 56.028'	W92° 56.022'	< 0.25	< 0.05	11.9	0.57	< 0.1	< 0.025	< 0.25	< 0.025	< 0.1	0.44	2.05	1.42	1.15

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
138	138FN	138FN1	W bass	979.76	43	11	9	5	N44° 47.011'	N44° 47.115'	W92° 55.997'	W92° 55.353'	< 0.25	0.12	112.0	1.25	< 0.1	< 0.025	0.33	< 0.025	< 0.1	0.96	4.51	1.90	1.86
140	140FN	140FN1	F drum	739.36	36.5	8	9	5	N44° 47.011'	N44° 47.115'	W92° 55.997'	W92° 55.353'	< 0.25	< 0.05	12.7	0.81	< 0.1	< 0.025	0.36	< 0.025	< 0.1	0.32	1.73	1.64	1.46
141	141FN	141FN1	F drum	657.71	37	9	9	5	N44° 47.011'	N44° 47.115'	W92° 55.997'	W92° 55.353'	< 0.25	< 0.05	215.0	0.42	0.28	0.08	0.79	< 0.025	< 0.1	< 0.25	2.55	1.53	1.33
142	142FN	142FN1	F drum	358.34	33	17	9	5	N44° 47.011'	N44° 47.115'	W92° 55.997'	W92° 55.353'	< 0.25	0.13	32.6	0.12	0.18	< 0.025	< 0.25	< 0.025	< 0.1	0.37	1.48	0.68	0.46
143	143FN	143FN1	W bass	267.62	28	2	10	3	N44° 46.430'	N44° 46.218'	W92° 54.805'	W92° 54.893'	< 0.25	0.23	126.0	2.20	< 0.1	< 0.025	0.45	< 0.025	< 0.1	0.41	5.14	2.52	1.68
144	144FN	144FN1	W bass	267.62	27.5	2	10	3	N44° 46.430'	N44° 46.218'	W92° 54.805'	W92° 54.893'	< 0.25	0.07	55.9	1.10	< 0.1	< 0.025	0.31	< 0.025	< 0.1	0.54	2.67	1.40	1.04
145	145FN	145FN1	W bass	208.65	26	2	9	6	N44° 46.341'	N44° 46.299'	W92° 58.173'	W92° 58.093'	< 0.25	< 0.05	33.0	1.78	< 0.1	< 0.025	0.33	< 0.025	< 0.1	< 0.25	1.95	0.92	0.99
146	146FN	146FN1	W bass	598.74	36	3	9	8	N44° 46.060'	N44° 46.234'	W92° 56.769'	W92° 56.381'	< 0.25	< 0.05	37.9	0.79	< 0.1	< 0.025	< 0.25	< 0.025	< 0.1	0.28	2.99	1.41	0.99
148	148FN	148FN1	W bass	458.13	35	4	9	9	N44° 45.970'	N44° 46.163'	W92° 56.349'	W92° 56.046'	< 0.25	< 0.05	49.8	0.61	< 0.1	< 0.025	0.29	< 0.025	< 0.1	0.37	3.90	1.68	1.35
149	149FN	149FN1	W bass	725.75	40	9	9	10	N44° 47.038'	N44° 47.108'	W92° 55.897'	W92° 55.335'	< 0.1	0.09	71.4	0.96	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	0.73	4.26	2.02	1.47
150	150FN	150FN1	Sm bass	1065.94	43.5	7	10	4	N44° 47.103'	N44° 47.025'	W92° 55.049'	W92° 54.306'	< 0.1	0.07	167.0	2.93	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	2.87	1.67	1.19
151	151FN	151FN1	Sm bass	607.81	35	4	10	4	N44° 47.103'	N44° 47.025'	W92° 55.049'	W92° 54.306'	< 0.1	0.26	757.0	31.45	< 0.25	< 0.1	< 0.25	0.03	< 0.1	< 0.1	3.56	3.87	3.36
153	153FN	153FN1	W bass	566.99	37	6	10	4	N44° 47 103'	N44° 47 025'	W92° 55.049'	W92° 54.306'	< 0.1	0.03	48.5	0.89	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	3.18	1.80	1.79
158	158FN	158FN1	Sm bass	639.57	35	3	10	5	N44° 46.526'	N44° 46.230'	W92° 52.724'	W92° 52.438'	< 0.1	0.03	61.2	4.06	0.30	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	1.33	1.33	1.78
159	159FN	159FN1	Sm bass	458.13	31	3	10	5	N44° 46.526'	N44° 46.230'	W92° 52.724'	W92° 52.438'	< 0.1	0.04	76.7	8.54	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	1.39	1.66	2.73
160	160FN	160FN1	Sm bass	467.20	33	4	10	5	N44° 46.526'	N44° 46.230'	W92° 52.724'	W92° 52.438'	< 0.1	0.03	48.0	3.79	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	1.16	0.87	1.07
161	161FN	161FN1	Sm bass	276.69	28	2	10	5	N44° 46.526'	N44° 46.230'	W92° 52.724'	W92° 52.436'	< 0.1	0.04	74.2	6.31	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	1.48	1.12	1.68
162	162FN	162FN1	W bass	417.30	35	7	10	7	N44° 45.900'	N44° 45.914'	W92° 53.408'	W92° 53.419'	< 0.1	< 0.025	70.0	0.61	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	3.60	1.58	1.19
163	163FN	163FN1	Sm bass	1256.45	46	7	9	12	N44° 46.341'	N44° 46.299'	W92° 58.173'	W92° 58.093'	< 0.1	< 0.025	15.1	0.42	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	< 0.1	1.15	1.10	1.03
164	164FN	164FN1	Bluegill	36.29	13	1	9	12	N44° 46.341'	N44° 46.299'	W92° 58.173'	W92° 58.093'	0.13	0.05	18.3	0.13	< 0.25	< 0.1	< 0.25	< 0.025	< 0.1	0.11	0.54	0.26	0.21
165	165FN	165FN1	W bass	576.06	35.5	4	6	1	N44° 51.331'	N44° 52.020'	W93° 00.625'	W93° 00.780'	NR	0.13	47.4	0.94	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.42	2.96	1.48	1.52
166	166FN	166FN1	W bass	665.78	39	5	6	1	N44° 51.331'	N44° 52.020'	W93° 00.625'	W93° 00.780'	NR	0.39	55.8	0.84	< 0.25	< 0.25	< 0.25	< 0.1	0.17	0.98	4.09	2.18	2.66
168	168FN	168FN1	W bass	598.74	36	5	6	1	N44° 51.331'	N44° 52.020'	W93° 00.625'	W93° 00.780'	NR	0.16	61.3	0.84	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.52	3.71	1.83	1.68
170	170FN	170FN1	F drum	449.06	33	5	6	1	N44° 51.331'	N44° 52.020'	W93° 00.625'	W93° 00.780'	NR	0.21	28.6	0.17	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	< 0.05	1.33	0.88	0.96
171	171FN	171FN1	F drum	807.39	39	17	5	1	N44° 53.736'	N44° 53.279'	W93° 01 757'	W93° 01 129'	NR	0.15	35.5	0.33	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.31	2.65	2.26	3.10

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
172	172FN	172FN1	F drum	1505.93	49	24	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	NR	< 0.1	18.5	0.25	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.20	3.76	2.19	2.92
174	174FN	174FN1	W bass	598.74	36	4	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	NR	< 0.1	50.7	1.76	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.48	3.07	1.41	1.06
175	175FN	175FN1	Sm bass	208.65	25.5	2	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	NR	< 0.1	36.7	0.48	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	< 0.05	1.37	1.05	0.99
176	176FN	176FN1	Sm bass	258.55	28	2	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	NR	< 0.1	32.2	0.37	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	< 0.05	1.88	1.02	0.93
177	177FN	177FN1	Sm bass	367.41	31	3	5	1	N44° 53.736'	N44° 53.279'	W93° 01 757'	W93° 01 129'	NR	< 0.1	28.6	0.38	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	< 0.05	1.91	1.26	1.37
178	178FN	178FN1	Sm bass	258.55	27	2	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01 129'	NR	< 0.1	35.3	0.47	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.08	2.00	1.38	1.32
179	179FN	179FN1	Sm bass	508.02	32	4	5	1	N44° 53.736'	N44° 53.279'	W93° 01 757'	W93° 01 129'	NR	< 0.1	30.1	0.68	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	< 0.05	1.53	1.49	2.05
180	180FN	180FN1	Sm bass	426.38	31.5	3	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	NR	< 0.1	13.7	0.40	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	< 0.05	1.25	1.24	1.49
181	181FN	181FN1	Bluegill	27.22	10.5	1	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	NR	< 0.1	36.3	0.16	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.06	1.22	0.52	0.30
183	183FN	183FN1	Bluegill	18.14	10.5	1	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	NR	0.18	33.7	0.12	< 0.25	< 0.25	< 0.25	< 0.1	< 0.1	0.08	1.43	0.58	0.30
185	185FN	185FN1	F drum	1197.48	43	15	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00.922'	< 0.05	0.18	27.5	0.45	< 0.25	< 0.25	< 0.25	< 0.05	0.43	0.59	2.67	1.98	1.39
186	186FN	186FN1	Sm bass	349.27	29	2	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00.922'	< 0.05	< 0.05	19.2	0.52	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.04	1.16	1.24	1.05
187	187FN	187FN1	Bluegill	77.11	15	2	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00.922'	< 0.05	< 0.05	7.9	0.03	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.04	0.47	0.35	0.28
188	188FN	188FN1	Bluegill	136.08	18.5	4	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00.922'	0.06	0.06	56.1	0.10	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.07	1.48	0.95	1.09
189	189FN	189FN1	F drum	399.16	33	5	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00.922'	< 0.05	< 0.05	64.3	0.19	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.36	1.32	0.61	0.39
190	190FN	190FN1	F drum	399.16	32	11	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00.922'	< 0.05	0.08	316.0	0.14	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.21	2.59	1.23	0.88
191	191FN	191FN1	F drum	508.02	32	8	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00 922'	< 0.05	< 0.05	113.0	0.73	< 0.25	< 0.25	< 0.25	< 0.05	0.20	0.39	3.36	1.25	1.06
192	192FN	192FN1	F drum	449.06	33	5	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00 922'	< 0.05	< 0.05	41.9	0.24	< 0.25	< 0.25	< 0.25	< 0.05	0.21	0.21	1.79	1.28	1.47
193	193FN	193FN1	Sm bass	498.95	32	3	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00 922'	< 0.05	< 0.05	46.1	0.42	< 0.25	< 0.25	< 0.25	< 0.05	0.18	0.03	2.39	1.61	1.21
194	194FN	194FN1	W bass	666.78	37	5	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01.769'	< 0.05	0.06	57.6	0.96	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.57	4.32	2.54	1.71
195	195FN	195FN1	W bass	508.02	35	5	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01.769'	< 0.05	0.06	84.3	0.68	0.49	< 0.25	< 0.25	< 0.05	< 0.1	0.54	4.29	2.19	1.45
197	197FN	197FN1	F drum	748.43	37	8	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01.769'	< 0.05	< 0.05	38.6	0.15	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.29	1.72	1.20	1.38
198	198FN	198FN1	F drum	639.57	36	7	5	4	N44° 54.153'	N44° 53.732'	W93° 02 478'	W93° 01 769'	< 0.05	< 0.05	10.3	0.17	< 0.25	< 0.25	< 0.25	< 0.05	0.11	0.28	1.22	0.95	1.17
199	199FN	199FN1	Bluegill	58.97	13.5	2	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01 769'	< 0.05	< 0.05	22.2	0.06	< 0.25	< 0.25	< 0.25	< 0.05	0.12	0.09	0.99	0.61	0.51
200	200FN	200FN1	Bluegill	72.57	11.5	NA	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01 769'	< 0.05	0.09	34.9	0.17	< 0.25	< 0.25	< 0.25	0.07	< 0.1	0.06	1.15	0.54	0.38
201	201FN	201FN1	Bluegill	27.22	11	1	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01.769'	< 0.05	0.27	45.4	0.09	< 0.25	< 0.25	< 0.25	< 0.05	0.15	0.27	2.32	0.69	0.37

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
202	202FN	202FN1	G sunfish	27.22	11	5	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01.769'	0.08	< 0.05	12.6	0.16	< 0.25	7.77	< 0.25	< 0.05	< 0.1	0.09	0.75	0.60	0.67
203	203FN	203FN1	Sm bass	276.69	28	2	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01.769'	< 0.05	< 0.05	41.9	0.33	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	0.03	2.40	1.22	1.25
204	204FN	204FN1	Sm bass	607.81	44	4	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01 769'	< 0.05	< 0.05	18.7	0.59	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	< 0.025	1.63	1.39	1.50
205	205FN	205FN1	Bluegill	77 11	15.5	9	5	5	N44° 53.048'	N44° 52.931'	W93° 01.079'	W93° 01 014'	< 0 25	0.06	48.8	0.03	< 0.35	< 0.25	< 0.25	< 0.25	< 0 1	< 0.05	1.21	0.56	0.13
206	206FN	206FN1	W bass	707 60	37	4	6	3	N44° 52.916'	N44° 52 171'	W93° 00.857'	W93° 00.606'	< 0.25	< 0.05	48.6	0.88	1.11	< 0.25	< 0.25	< 0.25	< 0.1	0.68	3.38	1.62	1.27
207	207FN	207FN1	Bluegill	18.14	11	1	6	3	N44° 52.916'	N44° 52.171'	W93° 00.857'	W93° 00.606'	< 0.25	5.80	44.6	0.04	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.14	1.07	0.65	0.57
208	208FN	208FN1	Sm bass	467.20	32	3	6	3	N44° 52.916'	N44° 52.171'	W93° 00.857'	W93° 00.606'	< 0.25	< 0.05	26.6	0.35	0.44	< 0.25	< 0.25	< 0.25	< 0.1	< 0.05	1.93	1.34	1.28
209	209FN	209FN1	Sm bass	199.58	25	2	6	3	N44° 52.916'	N44° 52.171'	W93° 00.857'	W93° 00.606'	< 0.25	< 0.05	20.9	0.33	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	< 0.05	1.10	1.08	0.85
211	211FN	211FN1	Sm bass	557 92	34	3	6	3	N44° 52.916'	N44° 52.171'	W93° 00.857'	W93° 00.606'	< 0.25	< 0.05	28.6	0.39	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	< 0.05	1.47	1.23	1.29
212	212FN	212FN1	Sm bass	199.58	24	2	6	3	N44° 52.916'	N44° 52.171'	W93° 00.857'	W93° 00.606'	< 0.25	< 0.05	29.6	0.40	< 0.35	0.42	< 0.25	< 0.25	< 0.1	< 0.05	1.18	0.98	0.90
213	213FN	213FN1	Sm bass	217 72	24	2	6	3	N44° 52.916'	N44° 52.171'	W93° 00.857'	W93° 00.606'	< 0.25	< 0.05	33.2	0.29	< 0.35	0.28	< 0.25	< 0.25	< 0.1	< 0.05	1.52	1.22	0.95
214	214FN	214FN1	W bass	839.15	39	6	6	4	N44° 52.011'	N44° 51.810'	W93° 00.853'	W93° 00.647'	< 0.25	0.06	73.4	0.54	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.80	4.44	2.23	2.14
215	215FN	215FN1	W bass	625.96	36	7	6	4	N44° 52.011'	N44° 51.810'	W93° 00.853'	W93° 00.647'	< 0.25	0.08	48.4	0.61	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.45	2.98	1.44	1.18
216	216FN	216FN1	Sm bass	525.96	35	4	6	5	N44° 51.916'	N44° 51.655'	W93° 00.528'	W93° 00.461'	< 0.25	< 0.05	50.9	0.40	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	< 0.05	2.56	1.52	1.30
217	217FN	217FN1	Sm bass	326.59	29	3	6	5	N44° 51 916'	N44° 51.655'	W93° 00.528'	W93° 00.461'	< 0.25	< 0.05	20.5	0.39	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	< 0.05	1.41	1.18	1.01
218	218FN	218FN1	W bass	716.68	38	5	6	5	N44° 51.916'	N44° 51.655'	W93° 00.528'	W93° 00.461'	< 0.25	0.07	48.9	0.66	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.55	3.10	1.49	1.57
219	219FN	219FN1	F drum	625.96	36	7	6	5	N44° 51.916'	N44° 51.655'	W93° 00.528'	W93° 00.461'	< 0.25	< 0.05	11.0	0.07	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.15	0.83	0.68	0.88
220	220FN	220FN1	Bluegill	86.18	15.5	1	6	6	N44° 52.865'	N44° 52.675'	W93° 01.021'	W93° 01.014'	< 0.25	< 0.05	17.8	0.07	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.091	0.80	0.55	0.42
221	221FN	221FN1	Sm bass	476.27	31	3	6	6	N44° 52.865'	N44° 52.675'	W93° 01.021'	W93° 01.014'	< 0.25	< 0.05	19.1	0.37	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.05	1.56	1.24	1.18
222	222FN	222FN1	F drum	607.81	37	6	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.25	0.05	37.2	0.13	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.33	2.02	1.44	1.05
223	223FN	223FN1	Sm bass	521.63	41	5	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.25	< 0.05	44.2	0.40	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	< 0.05	3.21	1.81	1.79
224	224FN	224FN1	Sm bass	317.51	34	4	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.25	< 0.05	23.5	0.51	< 0.35	< 0.25	< 0.25	< 0.25	< 0.1	0.06	2.00	1.21	1.47
~~226~~	~~226FN~~	~~226FN1~~	~~Sm bass~~	~~117.93~~	~~27~~	~~2~~	~~4~~	~~1~~	~~N44° 56.797'~~	~~N44° 56.885'~~	~~W93° 04.519'~~	~~W93° 04.305'~~	~~< 0.05~~	~~< 0.25~~	~~30.7~~	~~0.02~~	~~< 0.1~~	~~< 0.1~~	~~0.21~~	~~< 0.05~~	~~< 0.1~~	~~< 0.05~~	~~2.87~~	~~1.38~~	~~1.08~~
227	227FN	227FN1	W bass	199.58	31	3	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	91.0	1.38	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.74	5.02	2.24	2.33
229	229FN	229FN1	W bass	322.05	37	7	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	52.7	1.08	0.16	< 0.1	0.15	< 0.05	< 0.1	0.49	3.19	1.80	1.34
230	230FN	230FN1	W bass	290.30	36	5	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	35.8	0.34	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.41	2.54	1.19	0.79

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
231	231FN	231FN1	W bass	335.66	37.5	5	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	59.2	1.06	< 0.1	0.11	< 0.1	< 0.05	< 0.1	0.92	3.25	1.46	1.21
232	232FN	232FN1	W bass	362.87	38.5	8	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	64.7	0.76	0.12	< 0.1	< 0.1	< 0.05	< 0.1	0.80	4.00	1.77	1.39
234	234FN	234FN1	Bluegill	36.29	16.5	8	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	52.5	0.05	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.05	1.07	0.57	0.25
235	235FN	235FN1	Bluegill	36.29	16	5	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	23.2	0.06	< 0.1	< 0.1	0.16	< 0.05	< 0.1	0.09	1.16	0.70	0.47
236	236FN	236FN1	Bluegill	18.14	12	2	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	12.6	0.03	< 0.1	< 0.1	0.27	< 0.05	< 0.1	< 0.05	0.42	0.35	0.52
237	237FN	237FN1	Bluegill	13.61	10.5	1	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	0.46	< 0.25	9.5	0.11	< 0.1	0.22	0.28	< 0.05	< 0.1	0.11	0.50	0.33	0.32
238	238FN	238FN1	Bluegill	13.61	10.5	1	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	15.0	0.08	0.24	< 0.1	< 0.1	< 0.05	< 0.1	0.14	0.75	0.68	0.83
239	239FN	239FN1	G sunfish	9.07	10	3	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 0.05	< 0.25	23.5	0.11	< 0.1	0.11	< 0.1	< 0.05	< 0.1	< 0.05	0.71	0.62	0.61
240	240FN	240FN1	Bluegill	63.50	18	4	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	< 0.05	< 0.25	27.9	0.04	< 0.1	0.14	< 0.1	< 0.05	< 0.1	< 0.05	0.84	0.61	0.48
241	241FN	241FN1	Bluegill	27.22	15	5	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	0.06	< 0.25	22.1	0.08	< 0.1	0.16	0.22	< 0.05	< 0.1	0.05	0.86	0.56	0.24
242	242FN	242FN1	Bluegill	27.22	13	1	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	0.06	< 0.25	47.4	0.04	< 0.1	< 0.1	0.11	< 0.05	< 0.1	0.06	1.28	0.72	0.92
243	243FN	243FN1	Bluegill	13.61	10.5	1	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	< 0.05	< 0.25	54.0	0.06	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.11	1.67	0.72	0.73
246	246FN	246FN1	Sm bass	222.26	31.5	3	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	< 0.05	< 0.05	18.6	0.60	< 1.0	0.41	< 0.5	< 0.05	< 0.05	< 0.05	1.50	1.26	1.73
247	247FN	247FN1	Bluegill	22.68	13	2	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	< 0.05	0.18	66.1	0.05	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.15	1.35	0.62	0.49
248	248FN	248FN1	W bass	367.41	38	5	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	< 0.05	0.14	90.8	5.28	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.85	4.00	2.11	1.68
249	249FN	249FN1	W bass	249.48	33	4	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	< 0.05	< 0.05	88.4	1.08	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.68	3.70	2.02	1.55
250	250FN	250FN1	Sm bass	353.80	36	4	4	3	N44° 56.670'	N44° 56.522'	W93° 03.592'	W93° 03.290'	< 0.05	< 0.05	38.1	0.68	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	< 0.05	2.31	1.43	1.08
251	251FN	251FN1	Sm bass	485.34	41	5	4	3	N44° 56.670'	N44° 56.522'	W93° 03.592'	W93° 03.290'	< 0.05	< 0.05	41.8	0.76	< 1.0	0.28	< 0.5	< 0.05	< 0.05	0.06	2.53	1.50	1.36
252	252FN	252FN1	F drum	508.02	44	13	4	3	N44° 56.670'	N44° 56.522'	W93° 03.592'	W93° 03.290'	< 0.05	< 0.05	3.2	0.17	< 1.0	< 0.25	< 0.5	< 0.05	0.06	0.15	0.90	0.74	1.26
253	253FN	253FN1	W bass	172.37	30	2	4	3	N44° 56.670'	N44° 56.522'	W93° 03.592'	W93° 03.290'	< 0.05	< 0.05	63.3	1.03	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.57	3.15	1.67	1.44
254	254FN	254FN1	F drum	1238.31	38	6	4	4	N44° 56.102'	N44° 56.035'	W93° 03.148'	W93° 03.132'	< 0.05	< 0.05	39.5	0.10	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.33	0.94	0.65	0.36
256	256FN	256FN1	F drum	108.86	27.5	3	4	4	N44° 56.102'	N44° 56.035'	W93° 03.148'	W93° 03.132'	< 0.05	< 0.05	16.4	0.08	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.42	0.92	0.41	0.32
257	257FN	257FN1	F drum	172.37	32.5	17	4	5	N44° 55.805'	N44° 55.458'	W93° 02.890'	W93° 02.999'	< 0.05	< 0.05	76.2	0.14	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.30	1.83	0.86	0.78
258	258FN	258FN1	F drum	1143.05	34	6	4	5	N44° 55.805'	N44° 55.458'	W93° 02.890'	W93° 02.999'	< 0.05	< 0.05	7.1	0.10	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.19	0.59	0.47	0.61
259	259FN	259FN1	W bass	299.37	35.5	5	3	4	N44° 56.795'	N44° 56.834'	W93° 04.887'	W93° 04.785'	< 0.05	< 0.05	68.7	0.73	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.71	3.89	1.96	1.55
260	260FN	260FN1	W bass	367.41	38	7	3	4	N44° 56.795'	N44° 56.834'	W93° 04.887'	W93° 04.785'	< 0.05	< 0.05	64.4	0.79	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	0.45	4.03	2.07	1.84

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
261	261FN	261FN1	W bass	208.65	31.5	2	3	4	N44° 56.795'	N44° 56.834'	W93° 04.887'	W93° 04.785'	< 0.05	< 0.05	***20.4***	***0.34***	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	***0.24***	***1.34***	***0.75***	***0.60***
262	262FN	262FN1	Sm bass	158.76	29	3	3	4	N44° 56.795'	N44° 56.834'	W93° 04.887'	W93° 04.785'	< 0.05	< 0.05	***44.7***	***0.53***	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	< 0.05	***2.29***	***1.51***	***1.19***
263	263FN	263FN1	W bass	385.55	40	5	3	6	N44° 55.507'	N44° 55.675'	W93° 06.773'	W93° 06.517'	< 0.05	***0.06***	***50.0***	***0.73***	< 1.0	< 0.25	< 0.5	< 0.05	< 0.05	***0.75***	***2.78***	***1.42***	***1.09***
264	264FN	264FN1	W bass	399.16	40	8	3	6	N44° 55.507'	N44° 55.675'	W93° 06.773'	W93° 06.517'	< 0.1	< 0.1	***70.2***	***0.55***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.97***	***4.46***	***2.06***	***1.72***
266	266FN	266FN1	F drum	185.97	34	7	1	5	N44° 54.735'	N44° 54.567'	W93° 11.972'	W93° 11.988'	< 0.1	< 0.1	***24.2***	***0.07***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.36***	***0.98***	***0.64***	***0.58***
267	267FN	267FN1	Sm bass	240.40	32	3	1	5	N44° 54.735'	N44° 54.567'	W93° 11.972'	W93° 11.988'	< 0.1	< 0.1	***20.3***	***0.27***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***2.23***	***1.45***	***1.24***
268	268FN	268FN1	F drum	439.98	43	17	1	6	N44° 54.711'	N44° 54.345'	W93° 12.106'	W93° 11.730'	< 0.1	< 0.1	***12.8***	***0.23***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.10***	***1.26***	***1.29***	***1.98***
269	269FN	269FN1	F drum	331.12	38.5	8	1	7	N44° 53.743'	N44° 53.634'	W93° 11.362'	W93° 10.826'	< 0.1	***0.17***	***40.3***	***0.10***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.59***	***1.32***	***0.79***	***0.75***
270	270FN	270FN1	F drum	258.55	36	13	1	8	N44° 53.815'	N44° 53.657'	W93° 11.351'	W93° 10.577'	< 0.1	< 0.1	***30.8***	***0.10***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.13***	***1.23***	***0.72***	***0.63***
271	271FN	271FN1	F drum	199.58	35	13	1	8	N44° 53.815'	N44° 53.657'	W93° 11.351'	W93° 10.577'	< 0.1	< 0.1	***213.0***	***0.64***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.29***	***4.29***	***1.92***	***0.94***
272	272FN	272FN1	Sm bass	199.58	33	2	2	4	N44° 53.661'	N44° 53.833'	W93° 09.812'	W93° 09.348'	< 0.1	< 0.1	***4.9***	***0.16***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***0.53***	***0.51***	***0.63***
273	273FN	273FN1	Sm bass	244.94	33	3	2	4	N44° 53.661'	N44° 53.833'	W93° 09.812'	W93° 09.348'	< 0.1	< 0.1	***19.5***	***0.25***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***1.64***	***1.66***	***1.49***
274	274FN	274FN1	F drum	86.18	26.5	5	2	5	N44° 53.878'	N44° 54.205'	W93° 08.835'	W93° 08.361'	< 0.1	< 0.1	***44.9***	***0.08***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.26***	***1.76***	***0.69***	***0.50***
276	276FN	276FN1	F drum	204.12	33	10	2	5	N44° 53.878'	N44° 54.205'	W93° 08.835'	W93° 08.361'	< 0.1	< 0.1	***94.1***	***0.30***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.89***	***3.87***	***2.11***	***3.13***
277	277FN	277FN1	F drum	326.59	35	7	2	5	N44° 53.878'	N44° 54.205'	W93° 08.835'	W93° 08.361'	< 0.1	< 0.1	***10.3***	***0.05***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	***0.25***	***0.63***	***0.53***	***0.50***
278	278FN	278FN1	Sm bass	122.47	27	2	2	6	N44° 54.265'	N44° 54.879'	W93° 08.260'	W93° 07.886'	< 0.1	< 0.1	***33.8***	***0.24***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***2.72***	***1.28***	***1.10***
279	279FN	279FN1	Sm bass	90.72	24	2	2	6	N44° 54.265'	N44° 54.879'	W93° 08.260'	W93° 07.886'	< 0.1	< 0.1	***47.5***	***0.33***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***2.92***	***1.19***	***1.06***
280	280FN	280FN1	Sm bass	131.54	26	2	2	6	N44° 54.265'	N44° 54.879'	W93° 08.260'	W93° 07.886'	< 0.1	< 0.1	***46.1***	***0.29***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***3.84***	***1.88***	***1.67***
281	281FN	281FN1	Sm bass	385.55	38	3	2	7	N44° 55.094'	N44° 55.337'	W93° 07.872'	W93° 07.496'	< 0.1	< 0.1	***27.1***	***0.26***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***1.80***	***1.22***	***1.14***
282	282FN	282FN1	Sm bass	335.66	35.6	3	2	7	N44° 55.094'	N44° 55.337'	W93° 07.872'	W93° 07.496'	< 0.1	< 0.1	***31.5***	***0.21***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***2.86***	***1.48***	***1.15***
283	283FN	283FN1	Sm bass	226.80	32.5	4	2	7	N44° 55.094'	N44° 55.337'	W93° 07.872'	W93° 07.496'	< 0.1	< 0.1	***14.9***	***0.35***	< 0.35	< 0.25	< 0.25	< 0.05	< 0.25	< 0.05	***1.11***	***0.97***	***1.06***
285	285FN	285FN1	Sm bass	353.80	36	4	2	7	N44° 55.094'	N44° 55.337'	W93° 07.872'	W93° 07.496'	< 0.25	< 0.25	***52.1***	***0.25***	< 0.1	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	***2.42***	***1.42***	***1.69***
~~286~~	~~286FN~~	~~286FN1~~	~~Sm bass~~	~~158.76~~	~~28.5~~	~~4~~	~~2~~	~~7~~	~~N44° 55.094'~~	~~N44° 55.337'~~	~~W93° 07.872'~~	~~W93° 07.496'~~	~~< 0.25~~	~~< 0.25~~	~~***22.7***~~	~~***0.20***~~	~~***0.11***~~	~~< 0.35~~	~~< 0.1~~	~~< 0.25~~	~~< 0.25~~	~~< 0.1~~	~~***2.12***~~	~~***1.00***~~	~~***0.72***~~
287	287FN	287FN1	Bluegill	49.90	16	2	2	7	N44° 55.094'	N44° 55.337'	W93° 07.872'	W93° 07.496'	< 0.25	< 0.25	***16.4***	***0.09***	NR	NR	NR	< 0.05	< 0.05	***0.08***	***0.58***	***0.50***	***0.53***
288	288FN	288FN1	F drum	358.34	39.5	17	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	***0.21***	***105.0***	***0.23***	***4.59***	< 0.1	< 0.25	< 0.05	***0.11***	***0.54***	***3.05***	***1.95***	***2.21***
289	289FN	289FN1	W bass	276.69	37	5	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	***0.43***	***54.2***	***0.88***	< 0.25	***0.10***	< 0.25	< 0.05	< 0.05	***0.57***	***3.49***	***1.53***	***1.22***

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
290	290FN	290FN1	W bass	267.62	35	5	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	48.0	0.88	< 0.25	< 0.35	< 0.1	< 0.25	< 0.25	0.34	2.66	1.69	1.16
291	291FN	291FN1	Sm bass	181.44	30	3	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	42.3	0.41	< 0.1	< 0.35	0.12	< 0.25	< 0.25	< 0.1	2.09	1.39	1.38
292	292FN	292FN1	Sm bass	208.65	32.5	3	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	39.9	0.26	< 0.1	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	2.22	1.45	1.27
293	293FN	293FN1	Sm bass	249.48	35	4	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	27.3	0.20	< 0.1	< 0.35	0.11	< 0.25	< 0.25	< 0.1	1.34	1.08	1.13
294	294FN	294FN1	Sm bass	90.72	25	2	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	47.5	0.25	< 0.1	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	2.08	1.24	1.06
295	295FN	295FN1	Sm bass	90.72	24	2	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	34.6	0.31	< 0.1	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	1.84	1.13	1.01
296	296FN	296FN1	Bluegill	13.61	12	2	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	12.5	0.05	< 0.1	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	0.75	0.50	0.36
297	297FN	297FN1	Bluegill	18.14	9	1	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	0.26	< 0.25	5.2	0.06	0.10	< 0.35	0.11	< 0.25	< 0.25	< 0.1	0.38	0.24	0.16
298	298FN	298FN1	Bluegill	13.61	10	1	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	3.6	0.04	< 0.1	< 0.35	< 0.1	< 0.25	0.31	< 0.1	0.32	0.24	0.19
299	299FN	299FN1	Bluegill	22.68	14	1	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	11.2	0.04	0.21	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	0.64	0.40	0.35
300	300FN	300FN1	Bluegill	36.29	14.5	2	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	11.2	0.03	< 0.1	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	0.32	0.29	0.33
301	301FN	301FN1	Bluegill	36.29	15	2	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 0.25	< 0.25	12.3	0.06	0.21	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	0.49	0.38	0.41
302	302FN	302FN1	Sm bass	226.80	32	3	7	6	N44° 49.270'	N44° 49.133'	W93° 00.587'	W93° 00.429'	< 0.25	< 0.25	36.8	0.23	< 0.1	< 0.35	< 0.1	< 0.25	< 0.25	< 0.1	1.77	1.10	0.93
303	303FN	303FN1	W bass	131.54	28.5	2	7	6	N44° 49.270'	N44° 49.133'	W93° 00.587'	W93° 00.429'	< 0.25	< 0.25	35.7	0.54	< 0.1	< 0.35	0.16	< 0.25	< 0.25	0.57	2.26	1.02	0.80
304	304FN	304FN1	W bass	285.76	36.5	4	8	4	N44° 47.832'	N44° 47 144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	49.9	0.71	1.40	< 0.1	< 0.05	0.05	0.19	0.73	3.55	1.83	2.42
305	305FN	305FN1	W bass	181.44	31	2	8	4	N44° 47.832'	N44° 47 144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	65.1	2.02	< 0.5	< 0.1	0.07	< 0.05	< 0.1	0.59	3.50	1.71	1.31
306	306FN	306FN1	Sm bass	267 62	35	4	8	4	N44° 47.832'	N44° 47.144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	19.1	0.29	< 0.5	0.17	0.18	< 0.05	< 0.1	< 0.05	1.01	0.88	0.79
307	307FN	307FN1	Sm bass	181.44	30	3	8	4	N44° 47.832'	N44° 47.144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	59.6	0.27	< 0.5	0.26	< 0.05	< 0.05	< 0.1	< 0.05	2.17	1.34	1.52
308	308FN	308FN1	Sm bass	312.98	39	4	8	4	N44° 47.832'	N44° 47.144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	41.4	0.16	< 0.5	0.16	0.05	< 0.05	< 0.1	< 0.05	3.23	1.54	2.62
309	309FN	309FN1	Sm bass	122.47	26.5	2	8	4	N44° 47.832'	N44° 47.144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	30.5	0.29	< 0.5	0.21	< 0.05	< 0.05	< 0.1	< 0.05	1.13	0.84	0.69
310	310FN	310FN1	Bluegill	36.29	15	2	8	4	N44° 47 832'	N44° 47.144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	21.5	0.07	2.63	< 0.1	< 0.05	< 0.05	< 0.1	0.09	0.92	0.53	0.64
311	311FN	311FN1	Bluegill	27.22	14	2	8	4	N44° 47.832'	N44° 47 144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	22.5	0.06	< 0.5	< 0.1	0.09	< 0.05	< 0.1	< 0.05	0.90	0.69	0.76
312	312FN	312FN1	Bluegill	27.22	13	2	8	4	N44° 47.832'	N44° 47 144'	W93° 01.351'	W93° 01.443'	< 0.05	< 0.05	16.4	0.04	< 0.5	< 0.1	< 0.05	< 0.05	< 0.1	< 0.05	0.44	0.30	0.34
313	313FN	313FN1	Sm bass	81.65	24	2	8	5	N44° 46.389'	N44° 46.256'	W93° 01.000'	W93° 00.475'	< 0.05	< 0.05	24.0	0.23	< 0.5	< 0.1	< 0.05	< 0.05	< 0.1	< 0.05	1.10	0.67	0.55
315	315FN	315FN1	F drum	99.79	27	3	8	5	N44° 46.389'	N44° 46.256'	W93° 01.000'	W93° 00.475'	< 0.05	< 0.05	27.0	0.11	< 0.5	< 0.1	0.17	< 0.05	< 0.1	0.37	1.37	0.67	0.60
316	316FN	316FN1	Sm bass	331.12	36	4	6	7	N44° 52.871'	N44° 52.507'	W93° 00.992'	W93° 00.383'	< 0.05	< 0.05	32.1	0.46	< 0.5	< 0.1	< 0.05	< 0.05	< 0.1	< 0.05	1.63	1.01	0.80

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
317	317FN	317FN1	Sm bass	254.01	33	3	6	7	N44° 52.871'	N44° 52.507'	W93° 00.992'	W93° 00.983'	< 0.05	< 0.05	47.0	0.59	< 0.5	< 0.1	0.11	< 0.05	< 0.1	< 0.05	2.99	2.10	1.58
318	318FN	318FN1	F drum	594.21	36	17	6	7	N44° 52.871'	N44° 52.507'	W93° 00.992'	W93° 00.983'	< 0.05	< 0.05	19.8	0.29	< 0.5	< 0.1	0.06	0.05	< 0.1	0.28	2.97	2.65	2.45
319	319FN	319FN1	F drum	176.90	32.5	26	6	9	N44° 51.463'	N44° 51.038'	W93° 00.437'	W93° 00.490'	< 0.05	< 0.05	9.6	0.13	1.37	0.20	0.12	< 0.05	< 0.1	0.06	0.52	0.28	0.25
320	320FN	320FN1	F drum	199.58	34.5	13	6	9	N44° 51.463'	N44° 51.038'	W93° 00.437'	W93° 00.490'	< 0.05	0.15	56.9	0.15	< 0.5	< 0.1	< 0.05	< 0.05	0.19	0.31	1.48	0.92	0.92
321	321FN	321FN1	Bluegill	18.14	13	2	6	9	N44° 51.463'	N44° 51.038'	W93° 00.437'	W93° 00.490'	< 0.05	< 0.05	91.9	0.08	0.81	< 0.1	0.13	< 0.05	< 0.1	0.06	0.99	0.77	0.79
322	322FN	322FN1	Bluegill	45.36	17	8	6	9	N44° 51.463'	N44° 51.038'	W93° 00.437'	W93° 00.490'	< 0.05	< 0.05	35.7	0.03	< 0.5	< 0.1	< 0.05	< 0.05	< 0.1	< 0.05	0.75	0.65	0.21
323	323FN	323FN1	F drum	258.55	35	8	6	10	N44° 51 137'	N44° 50.990'	W93° 00.623'	W93° 00.659'	< 0.1	< 0.05	14.6	0.18	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	0.37	1.33	0.98	1.10
325	325FN	325FN1	Bluegill	18.14	12.5	2	6	11	N44° 50.990'	N44° 50.572'	W93° 00.659'	W93° 00.530'	0.14	0.37	224.0	0.08	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.87	0.62	0.56
326	326FN	326FN1	Bluegill	13.61	11.5	8	6	11	N44° 50.990'	N44° 50.572'	W93° 00.659'	W93° 00.530'	< 0.1	0.30	62.4	0.06	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.50	0.33	0.30
328	328FN	328FN1	Bluegill	36.29	17	3	6	11	N44° 50.990'	N44° 50.572'	W93° 00.659'	W93° 00.530'	< 0.1	0.42	58.6	0.10	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	1.45	1.43	0.65
329	329FN	329FN1	Bluegill	31.75	15	4	6	11	N44° 50.990'	N44° 50.572'	W93° 00.659'	W93° 00.530'	< 0.1	< 0.05	17.2	0.06	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	0.11	0.88	0.48	0.46
330	330FN	330FN1	Bluegill	104.33	21.5	8	6	11	N44° 50.990'	N44° 50.572'	W93° 00.659'	W93° 00.530'	< 0.1	0.28	392.0	0.08	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.89	1.05	0.93
331	331FN	331FN1	F drum	213.19	34.5	3	6	11	N44° 50.990'	N44° 50.572'	W93° 00.659'	W93° 00.530'	< 0.1	< 0.05	25.2	0.13	< 0.25	< 0.1	0.27	< 0.1	< 0.05	0.16	1.20	0.85	0.90
332	332FN	332FN1	F drum	131.54	28	8	6	12	N44° 50.689'	N44° 50.435'	W93° 00.689'	W93° 00.756'	< 0.1	< 0.05	29.1	0.08	< 0.25	< 0.1	< 0.1	< 0.1	0.06	0.42	1.10	0.63	0.72
333	333FN	333FN1	F drum	172.37	30.5	14	6	12	N44° 50.689'	N44° 50.435'	W93° 00.689'	W93° 00.756'	< 0.1	< 0.05	32.1	0.10	2.90	< 0.1	< 0.1	< 0.1	< 0.05	0.29	1.33	0.58	0.57
334	334FN	334FN1	F drum	226.80	34	2	6	12	N44° 50.689'	N44° 50.435'	W93° 00.689'	W93° 00.756'	< 0.1	< 0.05	31.3	0.09	< 0.25	< 0.1	0.12	< 0.1	0.05	0.47	1.27	0.71	1.04
335	335FN	335FN1	Bluegill	45.36	16	2	6	12	N44° 50.689'	N44° 50.435'	W93° 00.689'	W93° 00.756'	< 0.1	0.30	10.3	0.05	< 0.25	< 0.1	< 0.1	< 0.1	0.06	< 0.1	0.44	0.31	0.33
336	336FN	336FN1	Bluegill	22.68	13	2	7	7	N44° 49.400'	N44° 49.118'	W93° 00.634'	W93° 00.490'	< 0.1	< 0.05	20.6	0.07	< 0.25	< 0.1	0.18	< 0.1	< 0.05	< 0.1	0.64	0.48	0.51
337	337FN	337FN1	Bluegill	27.22	14	2	7	7	N44° 49.400'	N44° 49.118'	W93° 00.634'	W93° 00.490'	< 0.1	< 0.05	14.1	0.05	< 0.25	< 0.1	0.15	< 0.1	< 0.05	< 0.1	0.46	0.29	0.27
338	338FN	338FN1	Bluegill	22.68	13.5	2	7	7	N44° 49.400'	N44° 49.118'	W93° 00.634'	W93° 00.490'	< 0.1	< 0.05	10.7	0.05	< 0.25	0.10	< 0.1	< 0.1	< 0.05	< 0.1	0.35	0.33	0.32
340	340FN	340FN1	Bluegill	27.22	13.5	2	8	6	N44° 47.945'	N44° 47.811'	W93° 01.507'	W93° 01.482'	< 0.1	< 0.05	11.2	0.07	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.80	0.54	0.47
341	341FN	341FN1	Bluegill	22.68	12	2	8	6	N44° 47.945'	N44° 47.811'	W93° 01.507'	W93° 01.482'	< 0.1	< 0.05	14.0	0.05	< 0.25	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.77	0.41	0.45
343	343FN	343FN1	Bluegill	18.14	12	2	8	6	N44° 47.945'	N44° 47.811'	W93° 01.507'	W93° 01.482'	< 0.05	< 0.05	13.2	0.05	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.07	0.58	0.34	0.33
344	344FN	344FN1	Bluegill	63.50	17	3	8	6	N44° 47.945'	N44° 47.811'	W93° 01.507'	W93° 01.482'	< 0.05	< 0.05	27.6	0.05	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	< 0.05	0.74	0.70	0.69
345	345FN	345FN1	Bluegill	77.11	19	4	8	6	N44° 47.945'	N44° 47.811'	W93° 01.507'	W93° 01.482'	< 0.05	< 0.05	11.7	0.05	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.06	0.56	0.38	0.33

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
346	346FN	346FN1	W bass	276.69	36	5	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 0.05	< 0.05	34.8	0.52	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.40	2.06	1.01	0.87
349	349FN	349FN1	W bass	299.37	37	7	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 0.05	0.05	44.8	0.59	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.64	3.25	1.59	1.29
350	350FN	350FN1	W bass	208.65	31	3	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 0.05	< 0.05	33.9	0.46	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.26	2.05	1.02	0.95
351	351FN	351FN1	Sm bass	104.33	24.5	2	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 0.05	< 0.05	29.2	0.25	< 0.25	0.32	< 0.1	< 0.05	< 0.1	< 0.05	1.60	0.90	0.65
352	352FN	352FN1	Sm bass	117.93	26.5	2	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 0.05	< 0.05	16.5	0.18	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	< 0.05	1.09	0.81	0.67
353	353FN	353FN1	Bluegill	40.82	16	5	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 0.05	< 0.05	29.4	0.04	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.06	1.05	0.64	0.43
354	354FN	354FN1	Bluegill	31.75	15	6	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 0.05	< 0.05	8.7	0.04	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	< 0.05	0.65	0.53	0.47
355	355FN	355FN1	F drum	272.16	35	5	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	0.06	48.8	0.35	< 0.25	< 0.25	0.15	< 0.05	< 0.1	0.42	1.29	0.77	1.34
356	356FN	356FN1	F drum	190.51	32	8	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	46.7	0.38	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.20	1.33	0.95	1.64
358	358FN	358FN1	Sm bass	607.81	42	8	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	36.9	0.40	< 0.25	< 0.25	0.11	< 0.05	< 0.1	< 0.05	2.38	1.20	0.95
359	359FN	359FN1	Sm bass	99.79	25	2	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	20.1	0.22	< 0.25	< 0.25	0.11	< 0.05	< 0.1	< 0.05	1.09	0.91	0.79
360	360FN	360FN1	Sm bass	208.65	32	3	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	32.6	0.40	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	0.06	1.89	1.31	1.29
361	361FN	361FN1	Sm bass	199.58	31.5	3	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	32.0	0.41	< 0.25	< 0.25	0.16	< 0.05	< 0.1	< 0.05	1.97	1.18	1.27
362	362FN	362FN1	Sm bass	90.72	24	2	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	16.1	0.27	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	< 0.05	0.82	0.71	0.70
363	363FN	363FN1	Bluegill	40.82	15	3	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	44.1	0.07	< 0.25	< 0.25	< 0.1	< 0.05	< 0.1	< 0.05	1.93	0.93	0.82
364	364FN	364FN1	Bluegill	36.29	15	5	3	8	N44° 55.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 0.05	< 0.05	60.0	0.44	< 0.25	< 0.25	0.14	< 0.05	< 0.1	< 0.05	0.74	0.46	0.38
365	365FN	365FN1	W bass	317.51	38	4	2	8	N44° 55.109'	N44° 55.335'	W93° 07.830'	W93° 07.495'	< 0.25	0.07	59.2	0.77	< 0.25	< 0.25	< 0.25	< 0.1	< 0.25	1.11	3.40	1.44	1.11
366	366FN	366FN1	Bluegill	63.50	18.5	4	2	8	N44° 55.109'	N44° 55.335'	W93° 07.830'	W93° 07.495'	< 0.25	< 0.05	8.5	0.05	< 0.25	< 0.25	< 0.25	< 0.1	< 0.25	< 0.05	0.53	0.41	0.26
367	367FN	367FN1	Bluegill	54.43	17.5	5	2	8	N44° 55.109'	N44° 55.335'	W93° 07.830'	W93° 07.495'	< 0.25	0.23	12.4	0.05	< 0.35	< 0.1	< 0.25	< 0.05	< 0.1	< 0.05	0.49	0.53	0.49
368	368FN	368FN1	W bass	335.66	37.5	6	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	0.29	88.7	0.62	0.40	< 0.1	< 0.25	< 0.05	< 0.1	1.13	6.36	3.07	2.04
369	369FN	369FN1	W bass	172.37	31.6	2	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	1.02	60.1	1.33	0.35	0.12	< 0.25	< 0.05	< 0.1	0.60	3.98	1.74	1.19
370	370FN	370FN1	W bass	303.91	37	5	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	1.70	66.3	0.80	0.35	< 0.1	< 0.25	< 0.05	< 0.1	0.75	4.67	2.01	1.69
372	372FN	372FN1	W bass	45.36	38	4	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	0.06	48.8	0.89	2.41	< 0.25	< 0.25	< 0.1	< 0.25	0.51	3.62	1.65	1.51
373	373FN	373FN1	W bass	281.23	36.5	5	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	0.05	70.2	0.86	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	0.59	4.11	2.01	1.75
374	374FN	374FN1	W bass	381.02	49	5	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	0.08	75.7	0.88	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	0.72	5.12	2.48	2.07
377	377FN	377FN1	F drum	308.44	36.5	8	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	0.17	17.5	0.06	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	0.13	0.59	0.57	0.88

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
378	378FN	378FN1	F drum	222.26	37.5	6	2	9	N44° 53.870'	N44° 54.948'	W93° 08.846'	W93° 07.857'	< 0.25	0.06	50.5	0.17	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	0.57	1.48	1.18	0.60
379	379FN	379FN1	Sm bass	86.18	25	2	8	7	N44° 47.665'	N44° 47.305'	W93° 01.546'	W93° 01.486'	< 0.25	< 0.05	25.9	0.15	< 0.35	0.29	< 0.25	< 0.1	< 0.25	< 0.05	1.38	0.95	0.87
380	380FN	380FN1	W bass	140.61	29	2	8	7	N44° 47.665'	N44° 47.305'	W93° 01.546'	W93° 01.486'	< 0.25	0.05	47.7	0.65	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	0.50	2.83	1.39	1.36
381	381FN	381FN1	Sm bass	90.72	24.5	2	8	8	N44° 46.243'	N44° 46.286'	W93° 00.491'	W93° 00.022'	< 0.25	< 0.05	28.7	0.14	< 0.35	0.39	< 0.25	< 0.1	< 0.25	< 0.05	1.04	0.79	0.83
382	382FN	382FN1	Sm bass	108.86	26.5	2	8	8	N44° 46.243'	N44° 46.286'	W93° 00.491'	W93° 00.022'	< 0.25	< 0.05	21.2	0.27	< 0.35	0.72	< 0.25	< 0.1	< 0.25	< 0.05	0.72	0.70	0.73
383	383FN	383FN1	Sm bass	185.97	31	3	8	8	N44° 46.243'	N44° 46.286'	W93° 00.491'	W93° 00.022'	< 0.25	0.05	40.1	0.25	< 0.35	0.49	< 0.25	< 0.1	< 0.25	< 0.05	1.66	1.17	1.10
384	384FN	384FN1	W bass	312.98	36.5	6	8	8	N44° 46.243'	N44° 46.286'	W93° 00.491'	W93° 00.022'	< 0.25	0.07	71.3	0.71	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	1.04	4.24	2.14	1.88
385	385FN	385FN1	Sm bass	86.18	23.5	2	9	13	N44° 46.051'	N44° 46.230'	W92° 56.800'	W92° 56.373'	< 0.25	0.08	7.3	0.57	< 0.35	0.71	< 0.25	< 0.1	< 0.25	< 0.05	0.85	0.98	1.16
386	386FN	386FN1	Sm bass	72.57	23.5	2	9	13	N44° 46.051'	N44° 46.230'	W92° 56.800'	W92° 56.373'	< 0.25	< 0.05	11.0	0.20	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	< 0.05	0.72	0.54	0.36
387	387FN	387FN1	Sm bass	81.65	24	2	9	13	N44° 46.051'	N44° 46.230'	W92° 56.800'	W92° 56.373'	< 0.25	< 0.05	26.8	0.12	< 0.35	< 0.25	< 0.25	< 0.1	< 0.25	< 0.05	1.17	0.72	0.64
388	388FN	388FN1	Bluegill	99.79	19.5	3	9	14	N44° 45.925'	N44° 45.970'	W92° 56.390'	W92° 56.333'	< 0.1	< 0.1	19.1	0.07	< 0.1	0.17	< 0.25	< 0.05	< 0.25	< 0.1	0.66	0.72	0.66
389	389FN	389FN1	Bluegill	36.29	15	2	9	14	N44° 45.925'	N44° 45.970'	W92° 56.390'	W92° 56.333'	< 0.1	< 0.1	10.5	0.03	< 0.1	< 0.05	< 0.25	< 0.05	< 0.25	< 0.1	0.73	0.44	0.36
390	390FN	390FN1	Sm bass	154.22	28.5	3	9	14	N44° 45.925'	N44° 45.970'	W92° 56.390'	W92° 56.333'	< 0.1	< 0.1	9.5	0.67	< 0.1	0.10	< 0.25	< 0.05	< 0.25	< 0.1	0.89	1.13	1.30
391	391FN	391FN1	Bluegill	63.50	17	3	9	15	N44° 46.885'	N44° 46.885'	W92° 56.091'	W92° 56.091'	< 0.1	< 0.1	50.9	0.08	< 0.1	< 0.05	< 0.25	< 0.05	< 0.25	0.10	1.77	1.03	0.64
392	392FN	392FN1	Bluegill	45.36	16	2	9	15	N44° 46.885'	N44° 46.885'	W92° 56.091'	W92° 56.091'	< 0.1	< 0.1	76.5	0.07	< 0.1	< 0.05	< 0.25	< 0.05	< 0.25	0.11	2.63	1.72	1.33
393	393FN	393FN1	Bluegill	40.82	15.5	2	9	15	N44° 46.885'	N44° 46.885'	W92° 56.091'	W92° 56.091'	< 0.1	< 0.1	60.9	0.08	< 0.1	< 0.05	< 0.25	< 0.05	< 0.25	0.15	2.37	1.31	1.00
394	394FN	394FN1	Bluegill	31.75	14.5	2	10	8	N44° 46.162'	N44° 46.162'	W92° 52.645'	W92° 52.645'	< 0.1	< 0.1	117.0	0.23	< 0.1	< 0.05	< 0.25	< 0.05	< 0.25	0.32	5.13	2.79	2.52
395	395FN	395FN1	Bluegill	49.90	16.5	3	10	9	N44° 45.922'	N44° 45.896'	W92° 53.470'	W92° 53.405'	< 0.1	< 0.1	17.8	0.20	< 0.1	< 0.05	< 0.25	< 0.05	< 0.25	0.12	0.92	0.68	0.50
396	396FN	396FN1	Bluegill	63.50	18	3	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	< 0.05	30.2	0.11	3.12	0.19	< 0.35	< 0.05	< 0.25	0.07	1.07	0.77	0.77
397	397FN	397FN1	Bluegill	27.22	14	2	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	< 0.05	6.7	0.06	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	0.07	0.36	0.34	0.30
398	398FN	398FN1	W bass	308.44	36	4	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	< 0.05	59.1	0.79	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	0.53	3.93	1.70	1.44
399	399FN	399FN1	W bass	290.30	36	6	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	0.08	59.7	1.18	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	0.57	4.14	1.65	1.37
400	400FN	400FN1	W bass	208.65	32	3	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	< 0.05	26.7	2.24	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	0.44	3.48	1.58	1.15
401	401FN	401FN1	W bass	204.12	31	2	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	< 0.05	54.5	2.85	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	0.30	2.63	1.05	0.83
402	402FN	402FN1	W bass	308.44	36	5	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	< 0.05	57.6	1.62	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	0.39	2.79	1.52	1.09
403	403FN	403FN1	F drum	498.95	43.5	17	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 0.05	< 0.05	37.6	0.25	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	0.19	1.92	1.49	1.92

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
404	404FN	404FN1	W bass	435.45	40	7	6	13	N44° 52.007'	N44° 52.007'	W93° 00.813'	W93° 00.813'	< 0.05	*0.34*	*59.7*	*0.74*	< 0.25	< 0.1	< 0.35	*0.07*	*0.40*	*0.58*	*3.64*	*2.16*	*1.78*
405	405FN	405FN1	W bass	276.69	35.5	5	6	13	N44° 52.007'	N44° 52.007'	W93° 00.813'	W93° 00.813'	< 0.05	*0.06*	*105.0*	*0.63*	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	*0.99*	*5.85*	*3.02*	*2.48*
407	407FN	407FN1	F drum	344.73	38.5	7	7	8	N44° 49.280'	N44° 49.158'	W93° 00.537'	W93° 00.431'	< 0.05	< 0.05	*20.9*	*0.24*	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	*0.31*	*2.48*	*1.72*	*2.15*
408	408FN	408FN1	F drum	480.81	42	15	7	9	N44° 48.936'	N44° 48.259'	W93° 00.240'	W93° 00.733'	< 0.05	< 0.05	*10.3*	*0.27*	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	*0.29*	*3.35*	*1.68*	*2.13*
409	409FN	409FN1	F drum	349.27	39	8	7	9	N44° 48.936'	N44° 48.259'	W93° 00.240'	W93° 00.733'	< 0.05	< 0.05	*15.0*	*0.22*	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	*0.15*	*1.92*	*1.64*	*1.62*
410	410FN	410FN1	F drum	362.87	40	24	7	9	N44° 48.936'	N44° 48.259'	W93° 00.240'	W93° 00.733'	< 0.05	< 0.05	*12.3*	*0.22*	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	*0.58*	*2.62*	*1.93*	*1.87*
411	411FN	411FN1	W bass	340.19	37	6	1	9	N44° 54.708'	N44° 54.640'	W93° 11.978'	W93° 12.042'	< 0.05	< 0.05	*62.2*	*0.61*	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	*0.50*	*3.54*	*1.94*	*1.67*
412	412FN	412FN1	F drum	122.47	28	3	2	10	N44° 53.874'	N44° 55.312'	W93° 08.835'	W93° 07.331'	< 0.05	< 0.05	*5.9*	*0.06*	< 0.25	< 0.1	< 0.35	< 0.05	< 0.25	*0.18*	*0.47*	*0.27*	*0.26*
413	413FN	413FN1	F drum	258.55	36	10	2	10	N44° 53.874'	N44° 55.312'	W93° 08.835'	W93° 07.331'	< 0.1	< 0.05	*22.1*	*0.07*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.09*	*0.72*	*0.86*	*0.61*
414	414FN	414FN1	Bluegill	54.43	19	4	2	11	N44° 55.088'	N44° 55.349'	W93° 07.869'	W93° 07.424'	< 0.1	< 0.05	*12.0*	*0.05*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	< 0.05	*0.77*	*0.56*	*0.39*
415	415FN	415FN1	W bass	258.55	35.5	4	9	16	N44° 46.340'	N44° 46.205'	W92° 58.174'	W92° 57.782'	< 0.1	< 0.05	*104.0*	*0.83*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.83*	*5.54*	*3.38*	*2.15*
416	416FN	416FN1	Sm bass	95.25	26.5	2	9	16	N44° 46.340'	N44° 46.205'	W92° 58.174'	W92° 57.782'	< 0.1	< 0.05	*34.5*	*0.31*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	< 0.05	*1.13*	*0.79*	*0.74*
417	417FN	417FN1	Bluegill	13.61	13	1	9	17	N44° 45.898'	N44° 45.898'	W92° 56.380'	W92° 56.380'	< 0.1	< 0.05	*14.6*	*0.10*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.28*	*1.08*	*0.45*	*0.29*
419	419FN	419FN1	Bluegill	68.04	18	3	10	10	N44° 45.926'	N44° 45.898'	W92° 53.478'	W92° 53.427'	< 0.1	< 0.05	*21.5*	*0.11*	< 0.25	< 0.25	< 0.25	< 0.05	*0.11*	*0.06*	*0.77*	*0.68*	*0.63*
420	420FN	420FN1	Bluegill	31.75	13.5	2	10	10	N44° 45.926'	N44° 45.898'	W92° 53.478'	W92° 53.427'	< 0.1	< 0.05	*10.7*	*0.08*	*0.29*	< 0.25	< 0.25	< 0.05	< 0.1	*0.06*	*0.57*	*0.35*	*0.28*
421	421FN	421FN1	Bluegill	22.68	13	2	10	10	N44° 45.926'	N44° 45.898'	W92° 53.478'	W92° 53.427'	< 0.1	< 0.05	*16.2*	*0.11*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.06*	*1.02*	*0.74*	*0.57*
423	423FN	423FN1	Bluegill	13.61	11	1	10	10	N44° 45.926'	N44° 45.898'	W92° 53.478'	W92° 53.427'	< 0.1	< 0.05	*4.5*	*0.07*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.06*	*0.33*	*0.19*	*0.16*
425	425FN	425FN1	W bass	308.44	38	5	9	20	N44° 46.295'	N44° 46.257'	W92° 58.071'	W92° 57.914'	< 0.1	< 0.05	*66.4*	*0.58*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.58*	*3.72*	*1.89*	*1.76*
426	426FN	426FN1	F drum	489.88	46	24	7	10	N44° 48.956'	N44° 48.449'	W93° 00.219'	W93° 00.543'	< 0.1	< 0.05	*9.1*	*0.35*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.20*	*2.28*	*1.97*	*2.09*
427	427FN	427FN1	F drum	730.28	49	10	7	10	N44° 48.956'	N44° 48.449'	W93° 00.219'	W93° 00.543'	< 0.1	< 0.05	*21.0*	*0.16*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.23*	*0.70*	*0.57*	*0.50*
428	428FN	428FN1	F drum	349.27	36.5	15	7	10	N44° 48.956'	N44° 48.449'	W93° 00.219'	W93° 00.543'	< 0.1	< 0.05	*19.2*	*0.35*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.13*	*1.62*	*1.42*	*1.51*
429	429FN	429FN1	F drum	317.51	38	9	7	10	N44° 48.956'	N44° 48.449'	W93° 00.219'	W93° 00.543'	< 0.1	< 0.05	*15.4*	*0.22*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.28*	*1.71*	*1.40*	*1.41*
430	430FN	430FN1	F drum	743.89	49	20	4	6	N44° 56.889'	N44° 56.890'	W93° 04.565'	W93° 04.281'	< 0.1	< 0.05	*12.2*	*0.42*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.11*	*1.18*	*0.96*	*1.84*
431	431FN	431FN1	F drum	276.89	37.5	13	4	6	N44° 56.889'	N44° 56.890'	W93° 04.565'	W93° 04.281'	< 0.1	< 0.05	*32.1*	*0.20*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	*0.14*	*1.44*	*0.73*	*0.77*
432	432FN	432FN1	Sm bass	163.29	29	2	4	6	N44° 56.889'	N44° 56.890'	W93° 04.565'	W93° 04.281'	< 0.1	< 0.05	*31.9*	*0.72*	< 0.25	*0.28*	< 0.25	< 0.05	< 0.1	< 0.05	*1.61*	*1.22*	*0.99*
433	433FN	433FN1	Sm bass	331.12	36	4	4	6	N44° 56.889'	N44° 56.890'	W93° 04.565'	W93° 04.281'	< 0.1	< 0.05	*41.9*	*0.46*	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	< 0.05	*2.24*	*3.52*	*1.26*

Table A-1. 3M Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Sample mass (whole body, g)	Sample length (whole body, cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
434	434FN	434FN1	Sm bass	181.44	30	2	4	6	N44° 56.889'	N44° 56.890'	W93° 04.565'	W93° 04.281'	< 0.1	< 0.05	***24.7***	***0.63***	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	< 0.05	***1.46***	***0.98***	***0.77***
436	436FN	436FN1	Sm bass	444.52	39	4	4	6	N44° 56.889'	N44° 56.890'	W93° 04.565'	W93° 04.281'	< 0.1	< 0.05	***39.1***	***0.48***	< 0.25	< 0.25	< 0.25	< 0.05	< 0.1	< 0.05	***2.34***	***1.36***	***1.12***
437	437FN	437FN1	W bass	158.76	29.5	2	4	7	N44° 56.858'	N44° 56.732'	W93° 04.123'	W93° 03.734'	< 0.05	< 0.05	***47.4***	***0.91***	< 0.1	< 0.1	< 0.25	< 0.05	***0.08***	***0.73***	***2.09***	***0.96***	***0.75***
438	438FN	438FN1	W bass	226.80	34	2	4	7	N44° 56.858'	N44° 56.732'	W93° 04.123'	W93° 03.734'	< 0.05	< 0.05	***41.9***	***1.26***	< 0.1	< 0.1	< 0.25	< 0.05	< 0.05	***0.56***	***2.55***	***1.45***	***2.09***
439	439FN	439FN1	F drum	208.65	33	4	4	7	N44° 56.858'	N44° 56.732'	W93° 04.123'	W93° 03.734'	< 0.05	***0.05***	***9.5***	***0.24***	< 0.1	< 0.1	***0.41***	< 0.05	***0.07***	***0.26***	***0.77***	***0.67***	***0.78***
440	440FN	440FN1	F drum	467.20	44	12	4	7	N44° 56.858'	N44° 56.732'	W93° 04.123'	W93° 03.734'	***0.09***	***0.68***	***5.9***	***0.26***	***0.13***	< 0.1	< 0.25	< 0.05	***0.15***	***0.23***	***0.84***	***0.68***	***1.13***
442	442FN	442FN1	W bass	394.63	40	8	5	7	N44° 54.013'	N44° 53.739'	W93° 02.281'	W93° 01.789'	< 0.05	***0.08***	***152.0***	***2.08***	< 0.1	< 0.1	< 0.25	< 0.05	< 0.05	***0.32***	***6.43***	***3.31***	***2.64***
443	443FN	443FN1	W bass	204.12	32	2	5	7	N44° 54.013'	N44° 53.739'	W93° 02.281'	W93° 01.789'	< 0.05	***0.06***	***51.8***	***2.88***	< 0.1	< 0.1	< 0.25	< 0.05	***0.13***	***0.35***	***2.09***	***1.10***	***0.69***
444	444FN	444FN1	F drum	240.40	34	5	2	12	N44° 53.927'	N44° 54.052'	W93° 08.779'	W93° 08.597'	***0.23***	< 0.05	***98.7***	***2.07***	< 0.1	< 0.1	< 0.25	< 0.05	***0.18***	***0.59***	***3.06***	***2.25***	***2.13***
445	445FN	445FN1	F drum	122.47	28	5	2	12	N44° 53.927'	N44° 54.052'	W93° 08.779'	W93° 08.597'	***0.35***	< 0.05	***19.9***	***0.07***	< 0.1	< 0.1	< 0.25	***0.06***	***0.12***	***0.37***	***1.17***	***0.57***	***0.50***
446	446FN	446FN1	F drum	149.69	29.5	3	3	11	N44° 55.488'	N44° 55.812'	W93° 06.763'	W93° 06.352'	***0.21***	< 0.05	***8.6***	***0.12***	< 0.1	< 0.1	***0.48***	***0.06***	***0.07***	***0.28***	***0.69***	***0.33***	***0.40***
447	447FN	447FN1	F drum	276.69	36	4	3	11	N44° 55.488'	N44° 55.812'	W93° 06.763'	W93° 06.352'	***0.27***	< 0.05	***10.1***	***0.13***	< 0.1	< 0.1	< 0.25	< 0.05	***0.10***	***0.31***	***0.48***	***0.61***	***0.70***
448	448FN	448FN1	F drum	149.69	29.5	4	3	12	N44° 55.611'	N44° 55.643'	W93° 06.584'	W93° 06.556'	***0.37***	< 0.05	***34.4***	***0.15***	< 0.1	< 0.1	< 0.25	< 0.05	***0.12***	***0.46***	***1.11***	***0.69***	***0.63***
449	449FN	449FN1	W bass	208.65	33	3	1	10	N44° 54.880'		W93° 12.046'		***0.11***	***0.06***	***75.7***	***0.54***	< 0.1	< 0.1	< 0.25	***0.08***	***0.10***	***0.87***	***5.45***	***2.41***	***2.10***
450	450FN	450FN1	W bass	412.77	41	10	1	10	N44° 54.880'		W93° 12.046'		< 0.05	***0.10***	***68.0***	***1.74***	< 0.1	< 0.1	< 0.25	< 0.05	< 0.05	***0.60***	***5.01***	***3.65***	***4.75***
452	452FN	452FN1	W bass	31.75	17.5	0	1	11	N44° 54.688'	N44° 54.688'	W93° 12.088'	W93° 12.088'	***0.19***	< 0.05	***13.0***	***0.35***	< 0.1	< 0.1	< 0.25	< 0.05	***0.09***	***0.21***	***0.92***	***0.58***	***0.29***

Bold, italicized font = Detects

Table A-2. AXYS Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Fish mass (g)	Fish length (cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
010	010FN	010FN2	F drum	326.59	30	5	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 5.0	< 5.0	***34***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
022	022FN	022FN2	Bluegill	108.86	17	2	10	2	N44° 46.426'	N44° 45.382'	W92° 54.778'	W92° 52.521'	< 5.0	< 5.0	***356***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	***10.6***	***5.43***	***3.85***
033	033FN	033FN2	W bass	226.80	26.5	2	8	1	N44° 47.743'	N44° 47.471'	W93° 01.399'	W93° 01.521'	< 5.0	< 5.0	***44.6***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	***3.09***	< 2.5	< 2.5
045	045FN	045FN2	W bass	185.97	25.5	2	8	3	N44° 47.171'	N44° 46.447'	W93° 01.438'	W93° 00.999'	< 5.0	< 5.0	***75.3***	***4.83***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
054	054FN	054FN2	Sm bass	249.48	27	3	3	2	N44° 56.139'	N44° 56.589'	W93° 06.019'	W93° 05.240'	< 5.0	< 5.0	***34.3***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
065	065FN	065FN2	W bass	217.72	26.5	2	2	2	N44° 53.664'	N44° 53.865'	W93° 09.874'	W93° 09.064'	< 5.0	< 5.0	***40***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
078	078FN	078FN2	F drum	716.68	35	8	1	1	N44° 54.611'	N44° 54.149'	W93° 12.049'	W93° 11.459'	< 5.0	< 5.0	***42.15***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
092	092FN	092FN2	Sm bass	607.81	35	4	1	2	N44° 54.606'	N44° 54.001'	W93° 12.036'	W93° 11.443'	< 5.0	< 5.0	***15.6***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
102	102FN	102FN2	Sm bass	498.95	33	4	1	4	N44° 53.972'	N44° 53.636'	W93° 11.441'	W93° 10.274'	< 5.0	< 5.0	***51.3***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
113	113FN	113FN2	W bass	1016.05	42.5	7	7	4	N44° 49.719'	N44° 49.047'	W93° 00.664'	W93° 00.475'	< 5.0	< 5.0	***59.5***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
126	126FN	126FN2	Bluegill	158.76	20	4	9	2	N44° 46.162'	N44° 46.244'	W92° 57.877'	W92° 56.370'	< 5.0	< 5.0	***37.4***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
137	137FN	137FN2	F drum	725.75	40	11	9	4	N44° 46.725'	N44° 46.982'	W92° 56.028'	W92° 56.022'	< 5.0	< 5.0	***12.6***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
149	149FN	149FN2	W bass	725.75	40	9	9	10	N44° 47.038'	N44° 47.108'	W92° 55.897'	W92° 55.336'	< 5.0	< 5.0	***88.6***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	***3.78***	< 2.5	< 2.5
159	159FN	159FN2	Sm bass	458.13	31	3	10	5	N44° 46.526'	N44° 46.230'	W92° 52.724'	W92° 52.438'	< 5.0	< 5.0	***112***	***13.1***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	***3.12***
170	170FN	170FN2	F drum	449.06	33	5	6	1	N44° 51.331'	N44° 52.020'	W93° 00.780'	W93° 00.780'	< 4.9	< 4.9	***29.3***	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4
180	180FN	180FN2	Sm bass	426.38	31.5	3	5	1	N44° 53.736'	N44° 53.279'	W93° 01.757'	W93° 01.129'	< 4.9	< 4.9	***13.2***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
192	192FN	192FN2	F drum	449.06	33	5	5	2	N44° 53.430'	N44° 53.066'	W93° 01.069'	W93° 00.922'	< 4.4	< 4.4	***46.3***	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2
203	203FN	203FN2	Sm bass	276.69	26	2	5	4	N44° 54.153'	N44° 53.732'	W93° 02.478'	W93° 01.769'	< 4.9	< 4.9	***61.9***	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	***2.62***	< 2.4	< 2.4
214	214FN	214FN2	W bass	839.15	39	6	6	4	N44° 52.011'	N44° 51.810'	W93° 00.853'	W93° 00.647'	< 4.7	< 4.7	***89.1***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	***3.495***	***2.81***	< 2.3
224	224FN	224FN2	Sm bass	317.51	34	4	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 5.0	< 5.0	***31.1***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
232	232FN	232FN2	W bass	362.87	38.5	8	4	1	N44° 56.797'	N44° 56.885'	W93° 04.519'	W93° 04.305'	< 4.5	< 4.5	***79.4***	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	***4.24***	< 2.2	< 2.2
246	246FN	246FN2	Sm bass	222.26	31.5	3	4	2	N44° 56.848'	N44° 56.553'	W93° 04.049'	W93° 03.620'	< 4.8	< 4.8	***21.6***	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4
258	258FN	258FN2	F drum	1143.05	34	6	4	5	N44° 55.805'	N44° 55.458'	W93° 02.890'	W93° 02.999'	< 4.6	< 4.6	***9.33***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
269	269FN	269FN2	F drum	331.12	38.5	8	1	7	N44° 53.743'	N44° 53.634'	W93° 11.382'	W93° 10.826'	< 4.7	< 4.7	***44.4***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
280	280FN	280FN2	Sm bass	131.54	26	2	2	6	N44° 54.265'	N44° 54.879'	W93° 08.260'	W93° 07.866'	< 4.7	< 4.7	***52.5***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	***3.05***	< 2.3	< 2.3
291	291FN	291FN2	Sm bass	181.44	30	3	7	5	N44° 49.797'	N44° 49.284'	W93° 00.683'	W93° 00.585'	< 4.6	< 4.6	***44.6***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3

Table A-2. AXYS Analysis of Fish Tissue Samples for PFCs (ND = RL)

Taxa abbreviations: Freshwater drum = F drum; Smallmouth bass = Sm bass; White bass = W bass; Green sunfish = G sunfish

Field ID	Tissue ID	Lab ID	Taxa (common)	Fish mass (g)	Fish length (cm)	Age (yr)	Reach	Run	Start Northing	End Northing	Start Westing	End Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
302	302FN	302FN2	Sm bass	226.80	32	3	7	6	N44° 49.270'	N44° 49.133'	W93° 00.587'	W93° 00.429'	< 4.8	< 4.8	***35.6***	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4
315	315FN	315FN2	F drum	99.79	27	3	8	5	N44° 46.389'	N44° 46.256'	W93° 01.000'	W93° 00.475'	< 4.7	< 4.7	***31.3***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
323	323FN	323FN2	F drum	258.55	35	8	6	10	N44° 51.137'	N44° 50.990'	W93° 00.623'	W93° 00.659'	< 4.5	< 4.5	***17.5***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
334	334FN	334FN2	F drum	226.80	34	2	6	12	N44° 50.689'	N44° 50.435'	W93° 00.689'	W93° 00.756'	< 4.7	< 4.7	***31.7***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
346	346FN	346FN2	W bass	276.69	36	5	3	7	N44° 55.451'	N44° 56.031'	W93° 06.842'	W93° 06.169'	< 4.8	< 4.8	***45.7***	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	***2.43***	< 2.4	< 2.4
360	360FN	360FN2	Sm bass	208.65	32	3	3	8	N44° 56.955'	N44° 56.528'	W93° 06.374'	W93° 05.689'	< 4.5	< 4.5	***33.8***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
370	370FN	370FN2	W bass	303.91	37	5	2	9	N44° 53.870'	N44° 54.948'	W93° 06.846'	W93° 07.857'	< 4.2	< 4.2	***75.5***	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	***4.37***	***2.38***	< 2.1
383	383FN	383FN2	Sm bass	185.97	31	3	8	8	N44° 46.243'	N44° 46.286'	W93° 00.491'	W93° 00.022'	<4.5	<4.5	***51.5***	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2
390	390FN	390FN2	Sm bass	154.22	28.5	3	9	14	N44° 45.925'	N44° 45.970'	W92° 56.390'	W92° 56.333'	< 4.9	< 4.9	***10.9***	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
400	400FN	400FN2	W bass	208.65	32	3	5	6	N44° 54.134'	N44° 53.535'	W93° 02.431'	W93° 01.343'	< 4.5	< 4.5	***66.9***	***2.84***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	***3.18***	< 2.3	< 2.3
411	411FN	411FN2	W bass	340.19	37	6	1	9	N44° 54.708'	N44° 54.640'	W93° 11.978'	W93° 12.042'	< 4.7	< 4.7	***83.3***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	***3.13***	< 2.3	< 2.3
425	425FN	425FN2	W bass	308.44	38	5	9	20	N44° 46.295'	N44° 46.257'	W92° 58.071'	W92° 57.914'	< 4.7	< 4.7	***65.2***	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	***2.91***	< 2.4	< 2.4
436	436FN	436FN2	Sm bass	444.52	39	4	4	6	N44° 56.899'	N44° 56.890'	W93° 04.565'	W93° 04.281'	< 4.6	< 4.6	***43***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	***2.33***	< 2.3	< 2.3
447	447FN	447FN2	F drum	276.69	36	4	3	11	N44° 55.488'	N44° 55.812'	W93° 06.763'	W93° 06.352'	< 4.5	< 4.5	***11.8***	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2
450	450FN	450FN2	W bass	412.77	41	10	1	10	N44° 54.880'		W93° 12.046'		< 4.5	< 4.5	***80.6***	***2.535***	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	***5.945***	***5.155***	***4.49***

Bold, italicized font = Detects

A.2 Figures

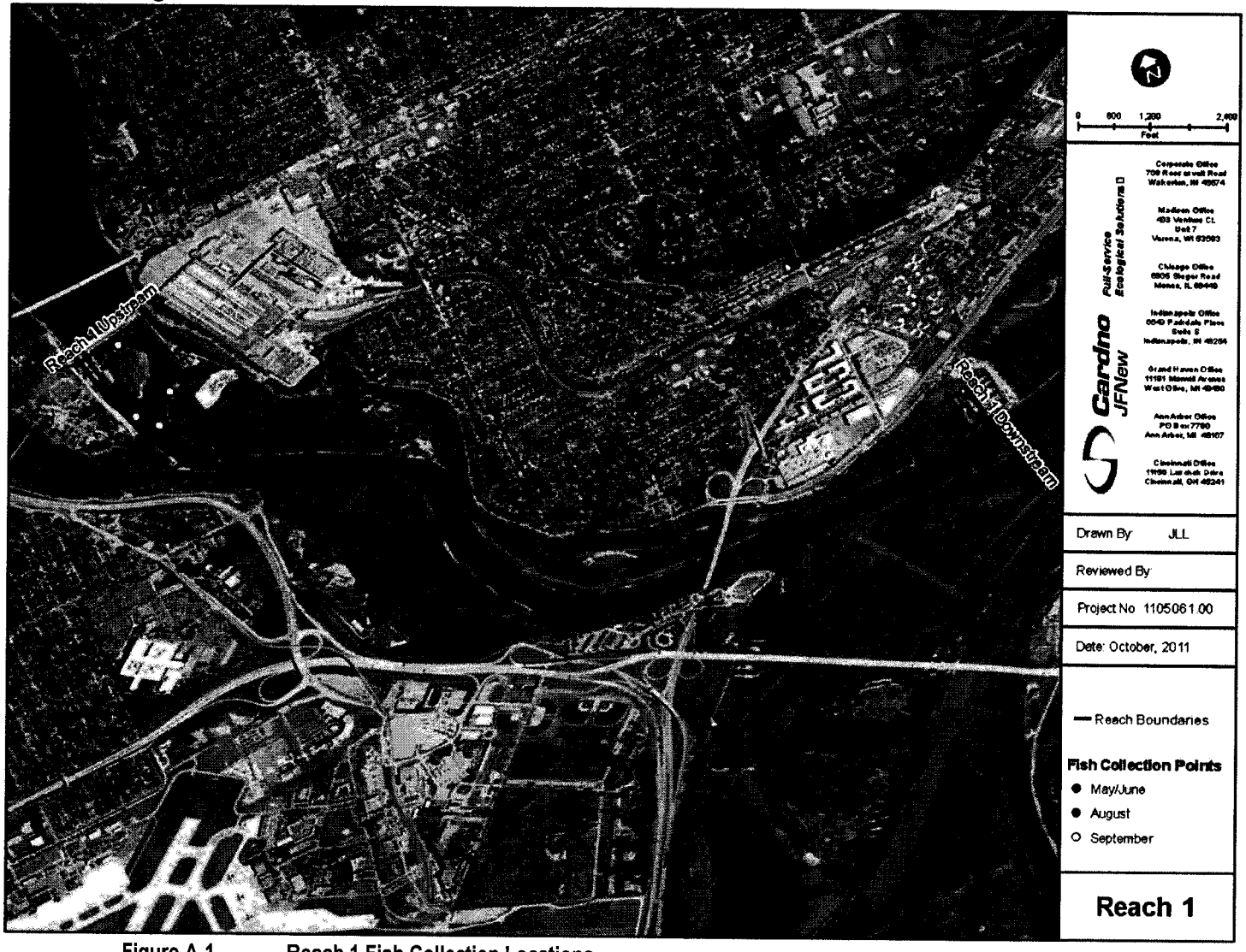
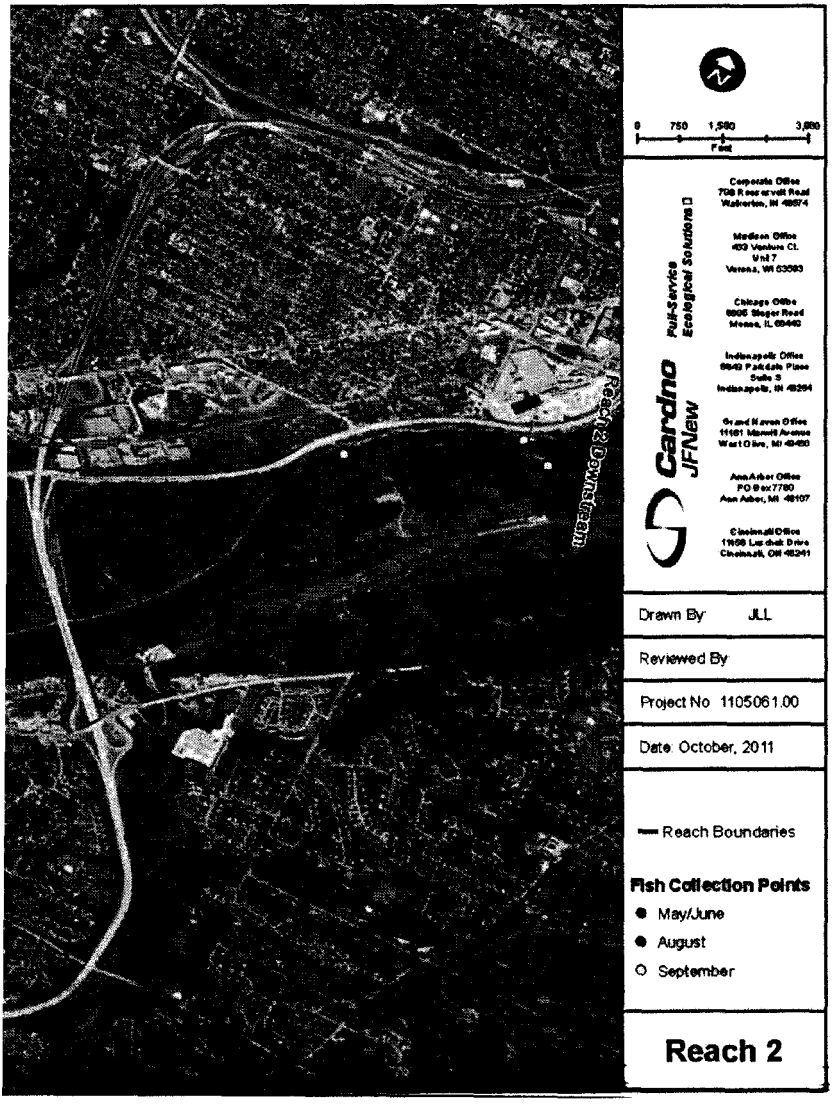


Figure A-1. Reach 1 Fish Collection Locations

Figure A-2. Reach 2 Fish Collection Locations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Feet
Cardno JFNew
Full-Service Ecological Solutions
Corporate Office
708 Roosevelt Road
Walkerton, IN 46574
Madison Office
403 Venture Ct.
Unit 7
Verona, WI 53593
Chicago Office
6805 Sleger Road
Morton, IL 61550
Indianapolis Office
8640 Parkdale Place
Suite 3
Indianapolis, IN 46294
Grand Haven Office
11481 Idlewild Avenue
West Olive, MI 49460
Ann Arbor Office
PO Box 7780
Ann Arbor, MI 48107
Cincinnati Office
11499 Lockwood Drive
Cincinnati, OH 45241
Drawn By JLL
Reviewed By
Project No 1105061.00
Date October, 2011
Reach Boundaries
Fish Collection Points
May/June
August
September
Reach 2

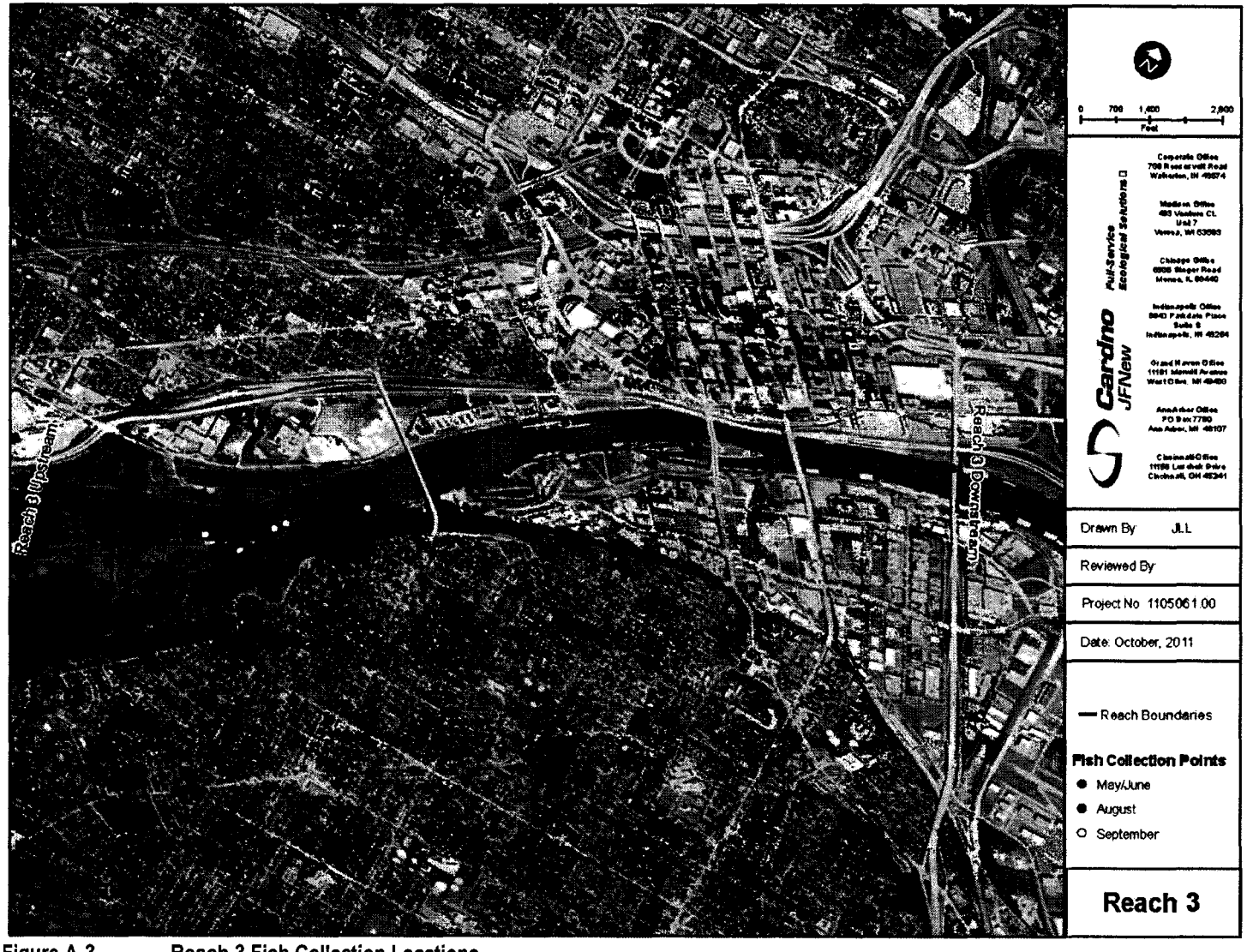


Figure A-3. Reach 3 Fish Collection Locations

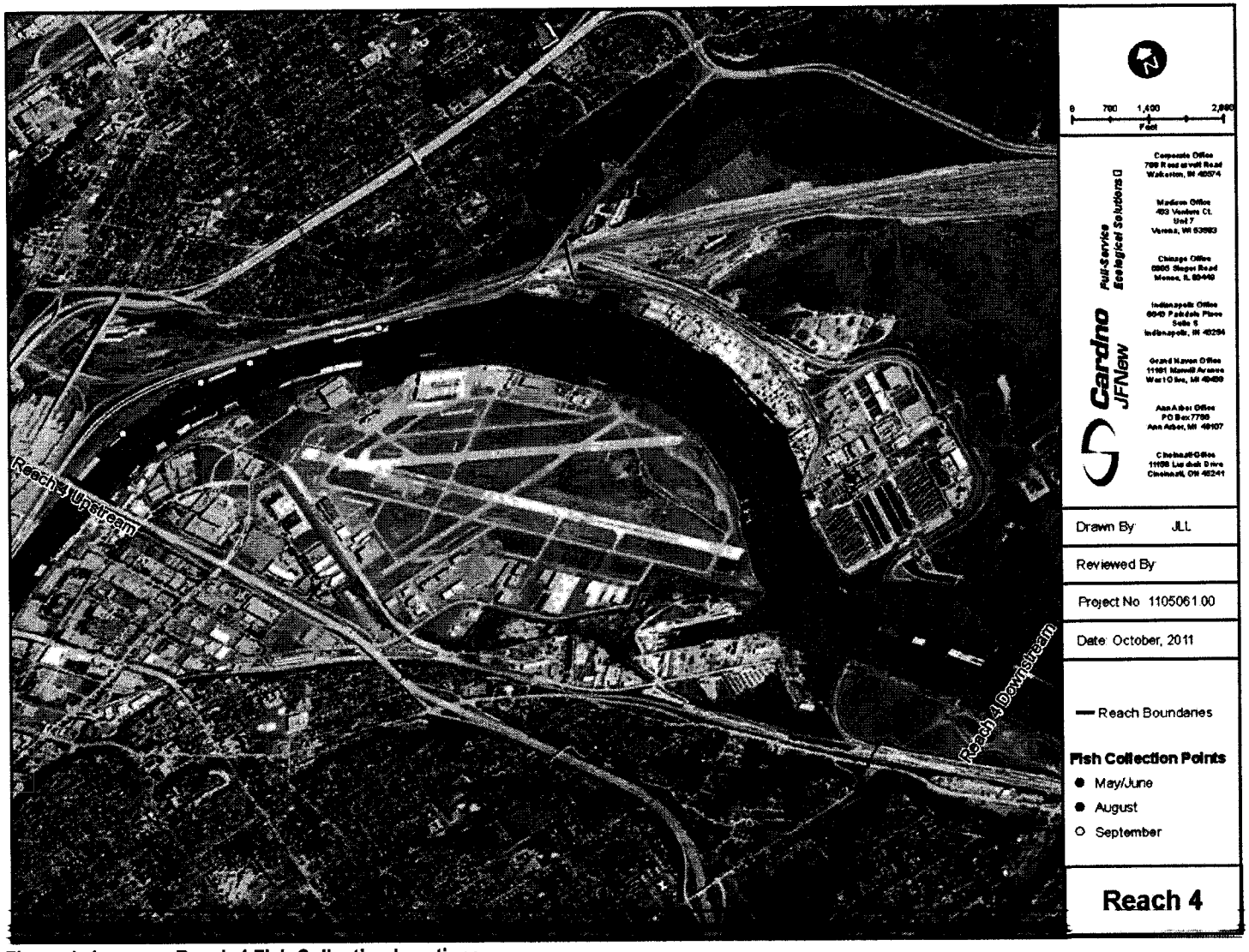


Figure A-4. Reach 4 Fish Collection Locations

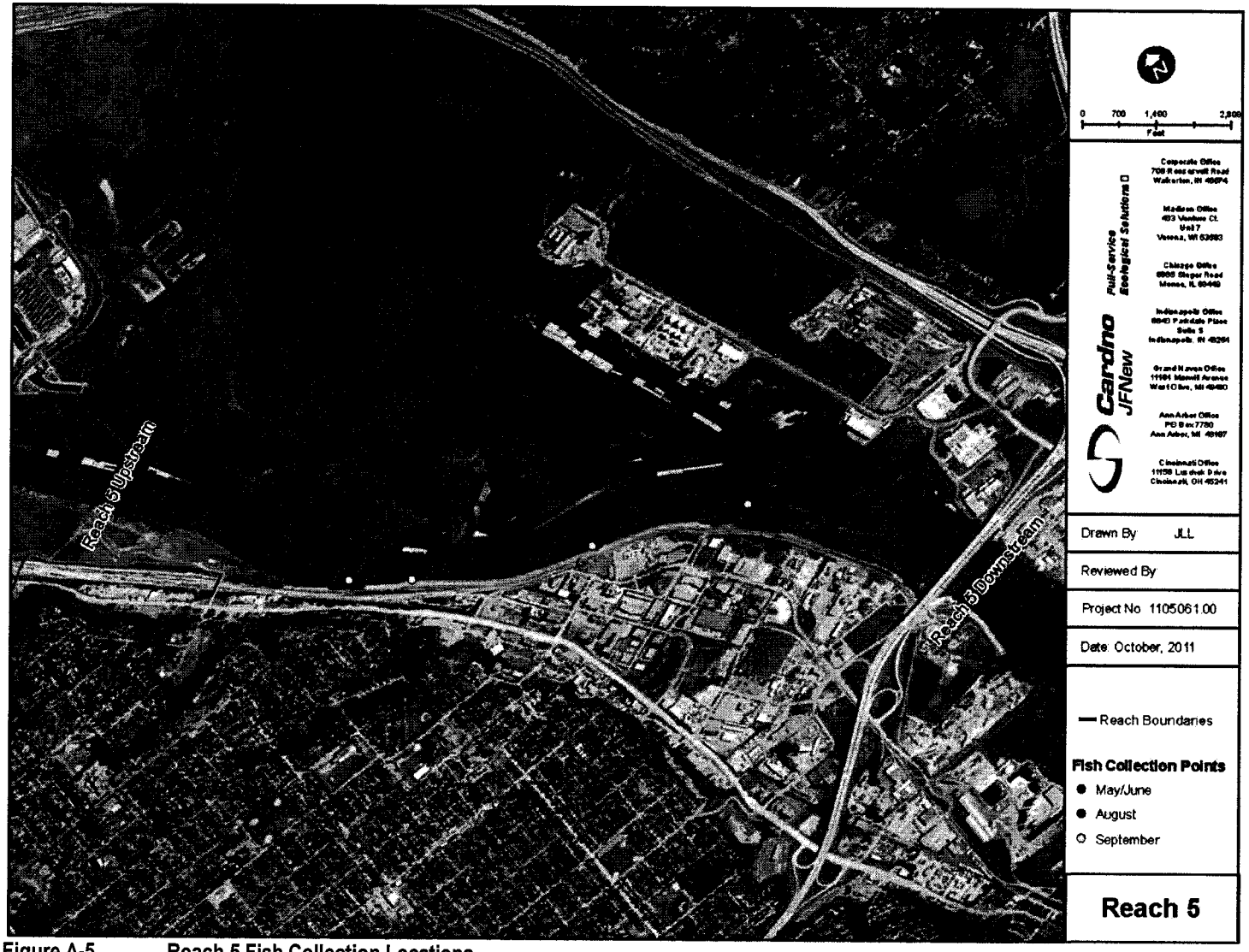


Figure A-5. Reach 5 Fish Collection Locations

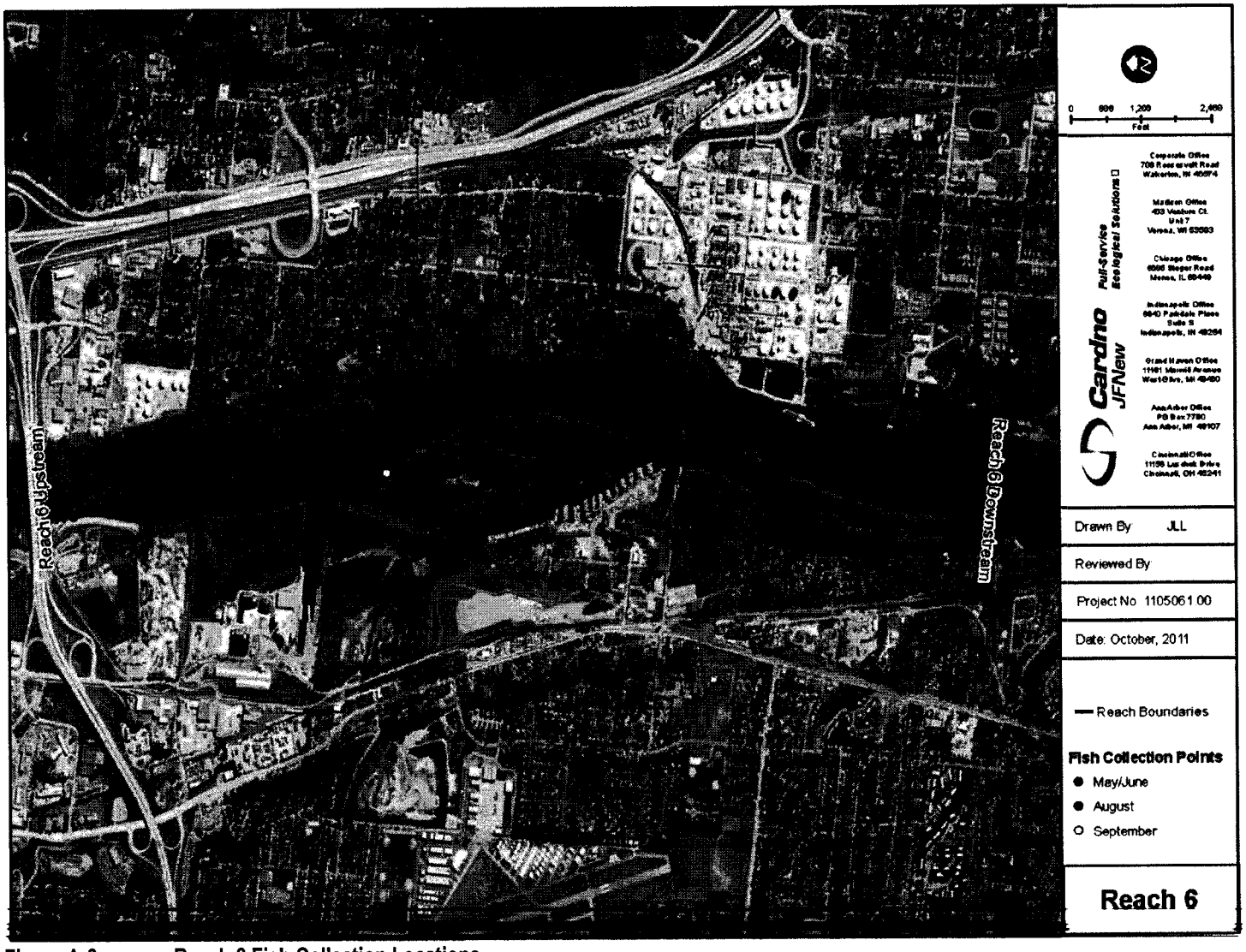


Figure A-6. Reach 6 Fish Collection Locations

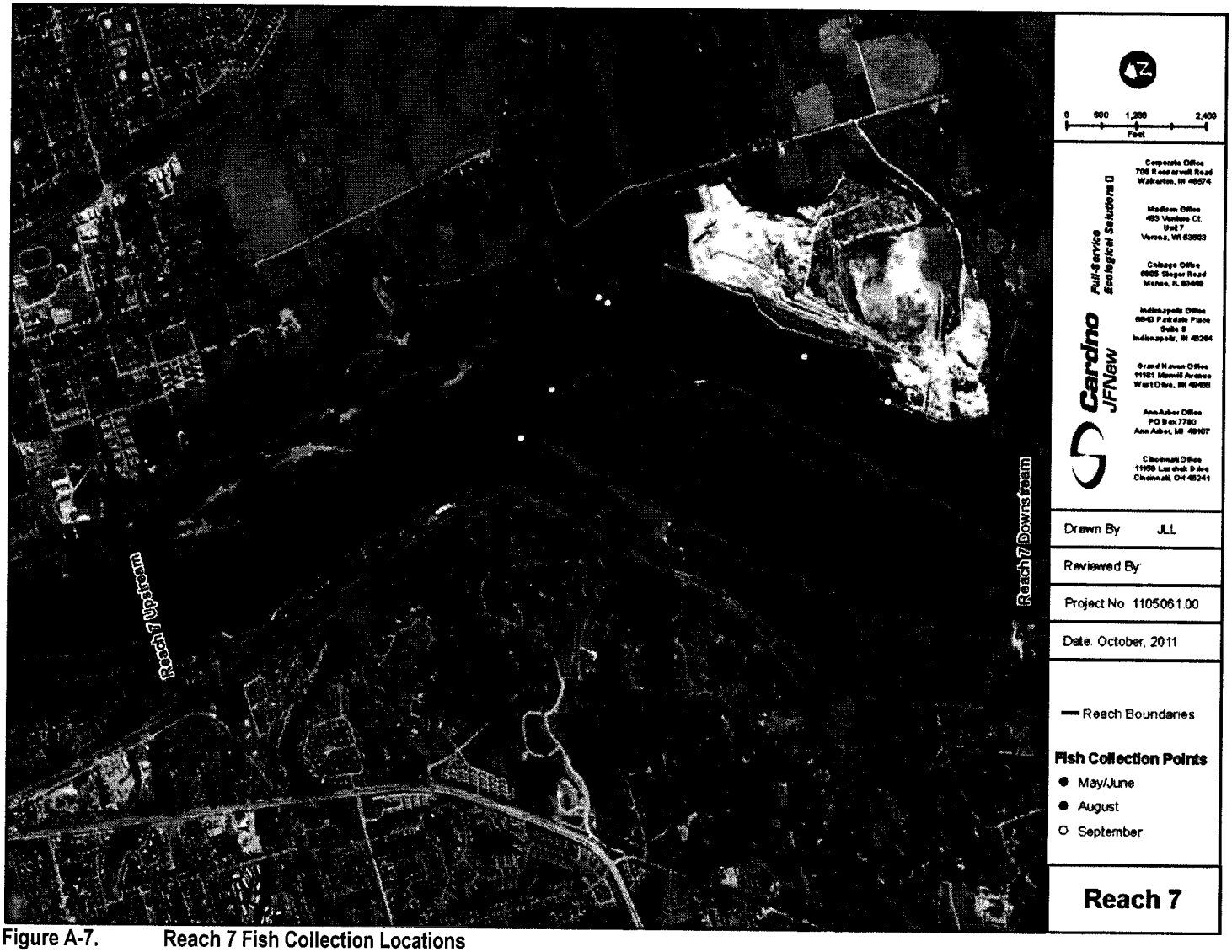


Figure A-7. Reach 7 Fish Collection Locations

Figure A-8. Reach 8 Fish Collection Locations

N

0 750 1,500 3,000
Feet

Full-Service Ecological Solutions

Corporate Office
708 Roosevelt Road
Walkerton, IN 46574

Madison Office
493 Ventura Ct.
Unit 7
Verona, WI 53593

Chicago Office
6805 Singer Road
Monee, IL 60449

Indianapolis Office
6640 Parkdale Place
Suite B
Indianapolis, IN 46254

Grand Haven Office
11181 Mercantile Avenue
West Olive, MI 49460

Ann Arbor Office
PO Box 7780
Ann Arbor, MI 48107

Cincinnati Office
11199 Lebanon Drive
Cincinnati, OH 45241

Cardno JFNew

Drawn By: JLL

Reviewed By:

Project No: 1105061.00

Date: October, 2011

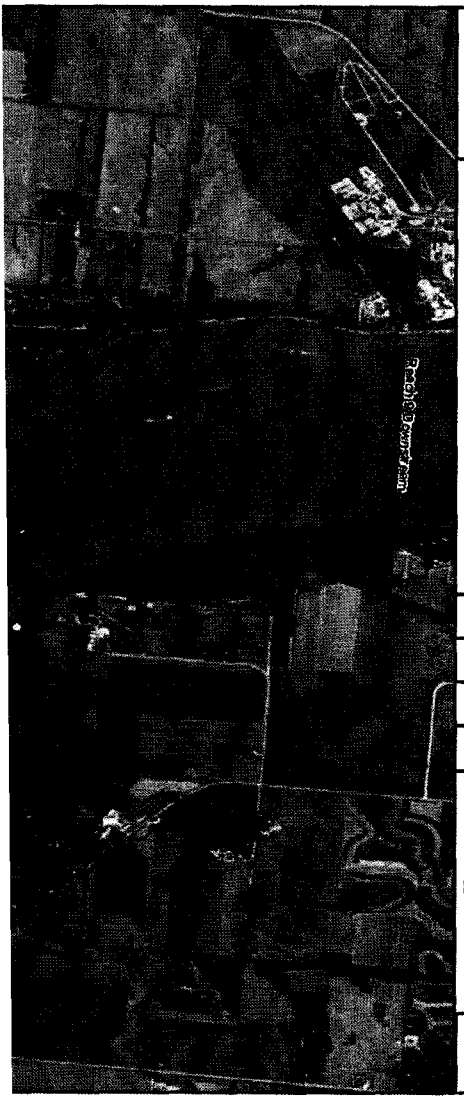
— Reach Boundaries

Fish Collection Points

- ● May/June
- ● August
- ○ September

Reach 8

Figure A-9. Reach 9 Fish Collection Locations



0 950 1,900 3,800
Feet

Gardino JFNew
Full-Service Ecological Solutions

Corporate Office
708 Roosevelt Road
Walkerton, IN 46574

Madison Office
402 Wireless Ct.
Unit 7
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Chicago Office
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Indianapolis Office
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Suite S
Indianapolis, IN 46254

Grand Haven Office
11161 Merrill Avenue
West Olive, MI 49460

Ann Arbor Office
PO Box 7766
Ann Arbor, MI 48107

Cincinnati Office
11100 Ludlow Drive
Cincinnati, OH 45241

Drawn By: JLL

Reviewed By:

Project No: 1105061.00

Date: October, 2011

Reach Boundaries

Fish Collection Points

- May/June
- August
- September

Reach 9

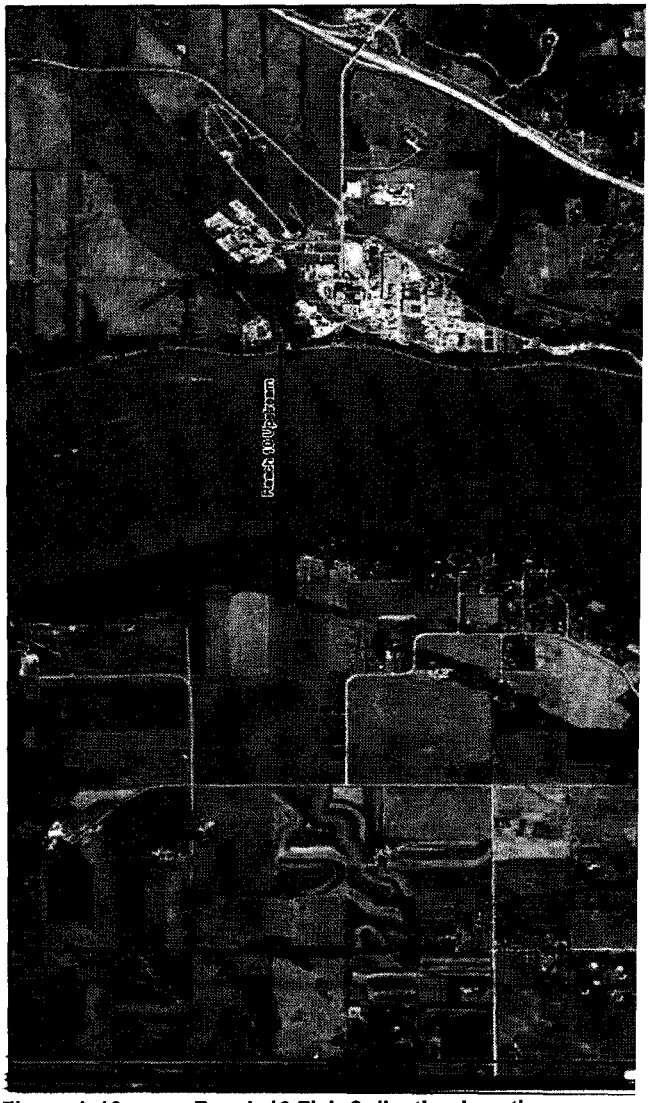
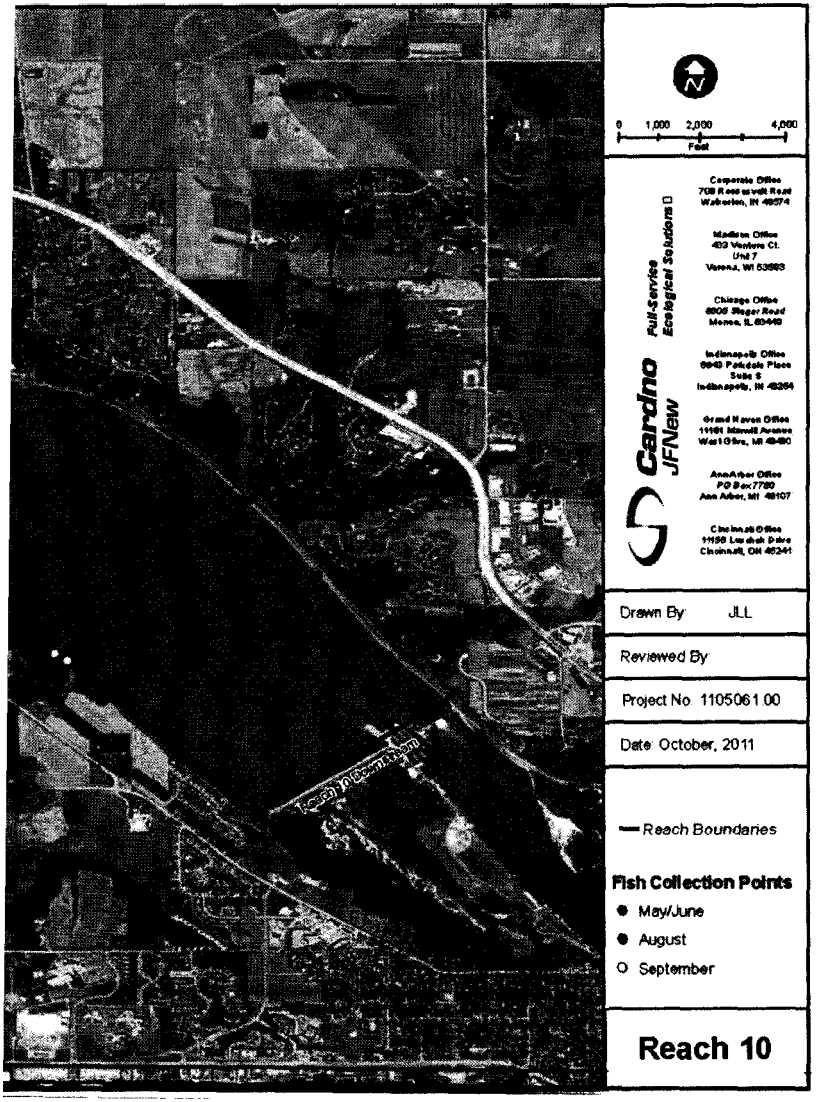


Figure A-10. Reach 10 Fish Collection Locations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Feet
Cardno JFNew
Full-service Ecological Solutions
Corporate Office
708 Roosevelt Road
Walkerton, IN 46574
Madison Office
493 Ventura Ct.
Unit 7
Verona, WI 53593
Chicago Office
6808 Shager Road
Monee, IL 60449
Indianapolis Office
6640 Parkdale Place
Suite S
Indianapolis, IN 46254
Grand Haven Office
11981 Idlewild Avenue
West Olive, MI 49460
Ann Arbor Office
PO Box 7780
Ann Arbor, MI 48107
Cincinnati Office
11158 Loukiak Drive
Cincinnati, OH 45241
Drawn By JLL
Reviewed By
Project No 1105061.00
Date October, 2011
Reach Boundaries
Fish Collection Points
May/June
August
September
Reach 10

Appendix B

Water Sample Collection Tables & Figures

Appendix B

Water Sample Collection

B.1 Tables

Table B- 1. 3M Analysis of Water Samples for PFCs (ND = RL)

Field ID	Tissue ID	Lab ID	Reach	Start Northing	Start Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
501	501SF	501SF1	10	N44° 46.926'	W92° 53.313'	***26***	***12.5***	***136***	< 4.0	***92.4***	***16***	***12.9***	***5***	***137***	< 2.0	< 2.5	< 4.0	< 4.0
502	502SF	502SF1	10	N44° 45.382'	W92° 52.521'	< 2.0	< 2.0	< 2.0	< 4.0	***9.24***	***4.43***	< 2.5	< 2.0	***2.39***	< 2.0	< 2.5	< 4.0	< 4.0
503	503SF	503SF1	8	N44° 47.471'	W93° 01.521'	< 2.0	< 2.0	< 2.0	< 4.0	***5***	< 4.0	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
504	504SF	504SF1	8	N44° 47.086'	W93° 01.118'	< 2.0	< 2.0	< 2.0	< 4.0	***9.14***	< 4.0	< 2.5	< 2.0	***4.56***	< 2.0	< 2.5	< 4.0	< 4.0
505	505SF	505SF1	8	N44° 46.447'	W93° 00.999'	< 2.5	< 2.0	< 2.0	< 2.0	< 5.0	< 4.0	< 2.0	< 2.0	***2.53***	< 2.0	< 2.5	< 4.0	< 4.0
506	506SF	506SF1	3	N44° 56.048'	W93° 06.085'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	***2.81***	< 2.0	< 2.5	< 4.0	< 4.0
507	507SF	507SF1	3	N44° 56.589'	W93° 05.240'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	***2.25***	< 2.0	< 2.5	< 4.0	< 4.0
508	508SF	508SF1	3	N44° 55.611'	W93° 06.663'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	***2.24***	< 2.0	< 2.5	< 4.0	< 4.0
509	509SF	509SF1	2	N44° 53.823'	W93° 09.231'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	***2.06***	< 2.0	< 2.5	< 4.0	< 4.0
510	510SF	510SF1	2	N44° 53.865'	W93° 09.064'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	***2.15***	< 2.0	< 2.5	< 4.0	< 4.0
511	511SF	511SF1	2	N44° 54.699'	W93° 07.907'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
512	512SF	512SF1	1	N44° 54.149'	W93° 11.459'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	***5.15***	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
513	513SF	513SF1	1	N44° 54.001'	W93° 11.443'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	< 2.0	< 2.0	< 2.5	< 4.0	< 4.0
514	514SF	514SF1	1	N44° 53.636'	W93° 10.274'	< 2.0	< 2.0	< 2.0	< 4.0	< 5.0	< 4.0	< 2.5	< 2.0	***2.23***	< 2.0	< 2.5	< 4.0	< 4.0
515	515SF	515SF1	10	N44° 46.018'	W92° 52.305'	***2.37***	< 2.0	***4.2***	< 2.0	***18.6***	***6.05***	***2.96***	< 2.0	***6.12***	< 2.0	< 2.0	< 2.0	< 2.0
516	516SF	516SF1	10	N44° 45.382'	W92° 52.521'	< 2.0	< 2.0	< 2.0	< 2.0	***19.5***	< 5.0	< 2.0	< 2.0	***3.96***	< 2.0	< 2.0	< 2.0	< 2.0
517	517SF	517SF1	10	N44° 46.926'	W92° 53.313'	***336***	***60.5***	***136***	< 2.0	***648***	***74.6***	***31.7***	***8.4***	***219***	***2.02***	< 2.0	< 2.0	< 2.0
518	518SF	518SF1	9	N44° 46.207'	W92° 56.501'	< 2.0	< 2.0	***2.15***	< 2.0	***14.7***	< 5.0	< 2.0	< 2.0	***3.59***	< 2.0	< 2.0	< 2.0	< 2.0
519	519SF	519SF1	9	N44° 45.987'	W92° 57.531'	< 2.0	< 2.0	< 2.0	< 2.0	***11.4***	< 5.0	< 2.0	< 2.0	***2.52***	< 2.0	< 2.0	< 2.0	< 2.0
520	520SF	520SF1	9	N44° 46.333'	W92° 58.151'	< 2.0	< 2.0	***2.77***	< 2.0	***16.4***	< 5.0	< 2.0	< 2.0	***3.55***	< 2.0	< 2.0	< 2.0	< 2.0

521	521SF	521SF1	8	N44° 46.444'	W93° 00.988'	< 2.0	< 2.0	***2***	< 2.0	***17.2***	***6.02***	< 2.0	< 2.0	***3.46***	< 2.0	< 2.0	< 2.0	< 2.0
522	522SF	522SF1	8	N44° 47.081'	W93° 01.130'	< 2.0	< 2.0	***3.51***	< 2.0	***20***	< 5.0	***2.15***	< 2.0	***3.95***	< 2.0	< 2.0	< 2.0	< 2.0
523	523SF	523SF1	8	N44° 47.463'	W93° 01.516'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
524	524SF	524SF1	7	N44° 48.609'	W93° 00.424'	< 2.0	< 2.0	***2.77***	< 2.0	***16.7***	< 5.0	< 2.0	< 2.0	***4.57***	< 2.0	< 2.0	< 2.0	< 2.0
525	525SF	525SF1	7	N44° 49.305'	W93° 00.573'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	***2.75***	< 2.0	< 2.0	< 2.0	< 2.0
526	526SF	526SF1	7	N44° 50.012'	W93° 00.740'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
527	527SF	527SF1	6	N44° 50.602'	W93° 00.576'	< 2.0	< 2.0	***2.6***	< 2.0	***16.8***	< 5.0	< 2.0	< 2.0	***4.73***	< 2.0	< 2.0	< 2.0	< 2.0
528	528SF	528SF1	6	N44° 51.126'	W93° 00.620'	< 2.0	< 2.0	< 2.0	< 2.0	***10.3***	< 5.0	< 2.0	< 2.0	***2.26***	< 2.0	< 2.0	< 2.0	< 2.0
529	529SF	529SF1	6	N44° 52.673'	W93° 00.927'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
530	530SF	530SF1	5	N44° 53.478'	W93° 01.101'	***4.17***	< 2.0	***7.1***	< 2.0	***39.1***	< 5.0	***3.29***	< 2.0	***23.3***	< 2.0	< 2.0	< 2.0	< 2.0
531	531SF	531SF1	5	N44° 53.772'	W93° 01.866'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	***2.97***	< 2.0	< 2.0	< 2.0	< 2.0
532	532SF	532SF1	5	N44° 54.371'	W93° 02.547'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
533	533SF	533SF1	4	N44° 55.507'	W93° 03.004'	< 2.0	< 2.0	< 2.0	< 2.0	***12.1***	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
534	534SF	534SF1	4	N44° 56.082'	W93° 03.129'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	***2.32***	< 2.0	< 2.0	< 2.0	< 2.0
535	535SF	535SF1	4	N44° 56.830'	W93° 04.115'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	***2.51***	< 2.0	< 2.0	< 2.0	< 2.0
536	536SF	536SF1	3	N44° 56.586'	W93° 05.248'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
537	537SF	537SF1	3	N44° 56.006'	W93° 06.160'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
538	538SF	538SF1	3	N44° 55.616'	W93° 06.650'	< 2.0	< 2.0	< 2.0	< 2.0	***12.8***	< 5.0	< 2.0	< 2.0	***2.77***	< 2.0	< 2.0	< 2.0	< 2.0
539	539SF	539SF1	2	N44° 54.672'	W93° 07.920'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	***3.16***	< 2.0	< 2.0	< 2.0	< 2.0
540	540SF	540SF1	2	N44° 53.865'	W93° 09.056'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
541	541SF	541SF1	2	N44° 53.827'	W93° 09.236'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	***2.34***	< 2.0	< 2.0	< 2.0	< 2.0
542	542SF	542SF1	1	N44° 53.637'	W93° 10.279'	< 2.0	< 2.0	< 2.0	< 2.0	< 10.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
543	543SF	543SF1	1	N44° 53.995'	W93° 11.442'	< 2.0	< 2.0	< 2.0	< 2.0	***11***	< 5.0	< 2.0	< 2.0	***2.53***	< 2.0	< 2.0	< 2.0	< 2.0
544	544SF	544SF1	1	N44° 54.140'	W93° 11.461'	< 2.0	< 2.0	< 2.0	< 2.0	***12.2***	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0

Bold, italicized text = Detects

Table B- 2. AXYS Analysis of Water Samples for PFCs (ND = RL)

Field ID	Tissue ID	Lab ID	Reach	Start Northing	Start Westing	PFBS	PFHS	PFOS	PFOSA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
501	501SF	501SF2	10	N44° 46.926'	W92° 53.313'	***19***	***6.3***	***85***	< 1.8	***74***	***6.4***	***6.9***	***2.5***	***77***	< 1.8	< 1.8	< 1.8	< 1.8
502	502SF	502SF2	10	N44° 45.382'	W92° 52.521'	< 2.7	< 2.7	< 2.7	< 1.4	***13***	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
503	503SF	503SF2	8	N44° 47.471'	W93° 01.521'	***2.3***	< 2.0	< 2.0	< 1.0	***6.4***	***1.0***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
504	504SF	504SF2	8	N44° 47.086'	W93° 01.118'	***2.9***	< 2.4	< 2.5	< 1.2	***13***	< 1.2	< 1.2	< 1.2	***2.2***	< 1.2	< 1.2	< 1.2	< 1.2
505	505SF	505SF2	8	N44° 46.447'	W93° 00.999'	< 2.3	< 2.3	< 2.3	< 1.2	***6.9***	< 1.2	< 1.2	< 1.2	***1.3***	< 1.2	< 1.2	< 1.2	< 1.2
506	506SF	506SF2	3	N44° 56.048'	W93° 06.085'	< 2.0	< 2.0	< 2.0	< 1.0	***4.3***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
507	507SF	507SF2	3	N44° 56.589'	W93° 05.240'	< 2.0	< 2.0	< 2.0	< 1.0	***4.4***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
508	508SF	508SF2	3	N44° 55.611'	W93° 06.663'	< 2.0	< 2.0	< 2.0	< 1.0	***5.5***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
509	509SF	509SF2	2	N44° 53.823'	W93° 09.231'	< 2.0	< 2.0	< 2.0	< 1.0	***9.1***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
510	510SF	510SF2	2	N44° 53.865'	W93° 09.064'	< 2.0	< 2.0	< 2.0	< 1.0	***8.1***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
511	511SF	511SF2	2	N44° 54.699'	W93° 07.907'	***2.6***	< 2.0	< 2.0	< 1.0	***3.9***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
512	512SF	512SF2	1	N44° 54.149'	W93° 11.459'	< 2.0	< 2.0	< 2.0	< 1.0	***9.2***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
513	513SF	513SF2	1	N44° 54.001'	W93° 11.443'	< 2.5	< 2.5	< 2.5	< 1.2	***8.6***	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
514	514SF	514SF2	1	N44° 53.636'	W93° 10.274'	< 2.0	< 2.0	< 2.0	< 1.0	***8.0***	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
515	515SF	515SF2	10	N44° 46.018'	W92° 52.305'	***4.5***	< 3.4	***5.0***	< 1.7	***19***	< 1.7	< 1.7	< 1.7	***4.0***	< 1.7	< 1.7	< 1.7	< 1.7
518	518SF	518SF2	9	N44° 46.207'	W92° 56.501'	< 4.1	< 4.1	< 4.1	< 2.1	***14***	< 2.1	< 2.1	< 2.1	***2.7***	< 2.1	< 2.1	< 2.1	< 2.1
519	519SF	519SF2	9	N44° 45.987'	W92° 57.531'	< 3.7	< 3.7	< 3.7	< 1.8	***11***	< 1.8	< 1.8	< 1.8	***2.0***	< 1.8	< 1.8	< 1.8	< 1.8
520	520SF	520SF2	9	N44° 46.333'	W92° 58.151'	< 3.5	< 3.5	< 3.5	< 1.7	***17***	< 1.7	< 1.7	< 1.7	***2.5***	< 1.7	< 1.7	< 1.7	< 1.7
524	524SF	524SF2	7	N44° 48.609'	W93° 00.424'	***4.7***	< 3.3	***4.94***	< 1.7	***18***	< 1.7	< 1.7	< 1.7	***3.3***	< 1.7	< 1.7	< 1.7	< 1.7
525	525SF	525SF2	7	N44° 49.305'	W93° 00.573'	< 3.4	< 3.4	< 4.9	< 1.7	***11***	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7
526	526SF	526SF2	7	N44° 50.012'	W93° 00.740'	< 3.6	< 3.6	< 4.9	< 1.8	***12***	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8
527	527SF	527SF2	6	N44° 50.602'	W93° 00.576'	< 3.3	< 3.3	***3.45***	< 1.6	***17***	< 1.6	< 1.6	***1.9***	***3.23***	< 1.6	< 1.6	< 1.6	< 1.6
528	528SF	528SF2	6	N44° 51.126'	W93° 00.620'	< 3.7	< 3.7	< 3.7	< 1.9	***11***	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9
529	529SF	529SF2	6	N44° 52.673'	W93° 00.927'	< 3.5	< 3.5	< 3.5	< 1.8	***9.9***	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8
530	530SF	530SF2	5	N44° 53.478'	W93° 01.101'	***6.8***	< 3.6	***9.2***	< 1.8	***33***	< 1.8	***2.6***	***2.1***	***18***	< 1.8	< 1.8	< 1.8	< 1.8
531	531SF	531SF2	5	N44° 53.772'	W93° 01.866'	< 3.7	< 3.7	< 3.7	< 1.8	***9.0***	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8
532	532SF	532SF2	5	N44° 54.371'	W93° 02.547'	< 4.3	< 4.3	< 4.3	< 2.1	***10***	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1

533	533SF	533SF2	4	N44° 55.507'	W93° 03.004'	< 3.2	< 3.2	< 3.2	< 1.6	***12***	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6
534	534SF	534SF2	4	N44° 56.082'	W93° 03.129'	< 6.6	< 6.6	< 6.6	< 3.3	***10***	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3
535	535SF	535SF2	4	N44° 56.830'	W93° 04.115'	< 3.5	< 3.5	< 3.5	< 1.8	***11***	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8

Bold, italicized text = Detects

B.2 Figures

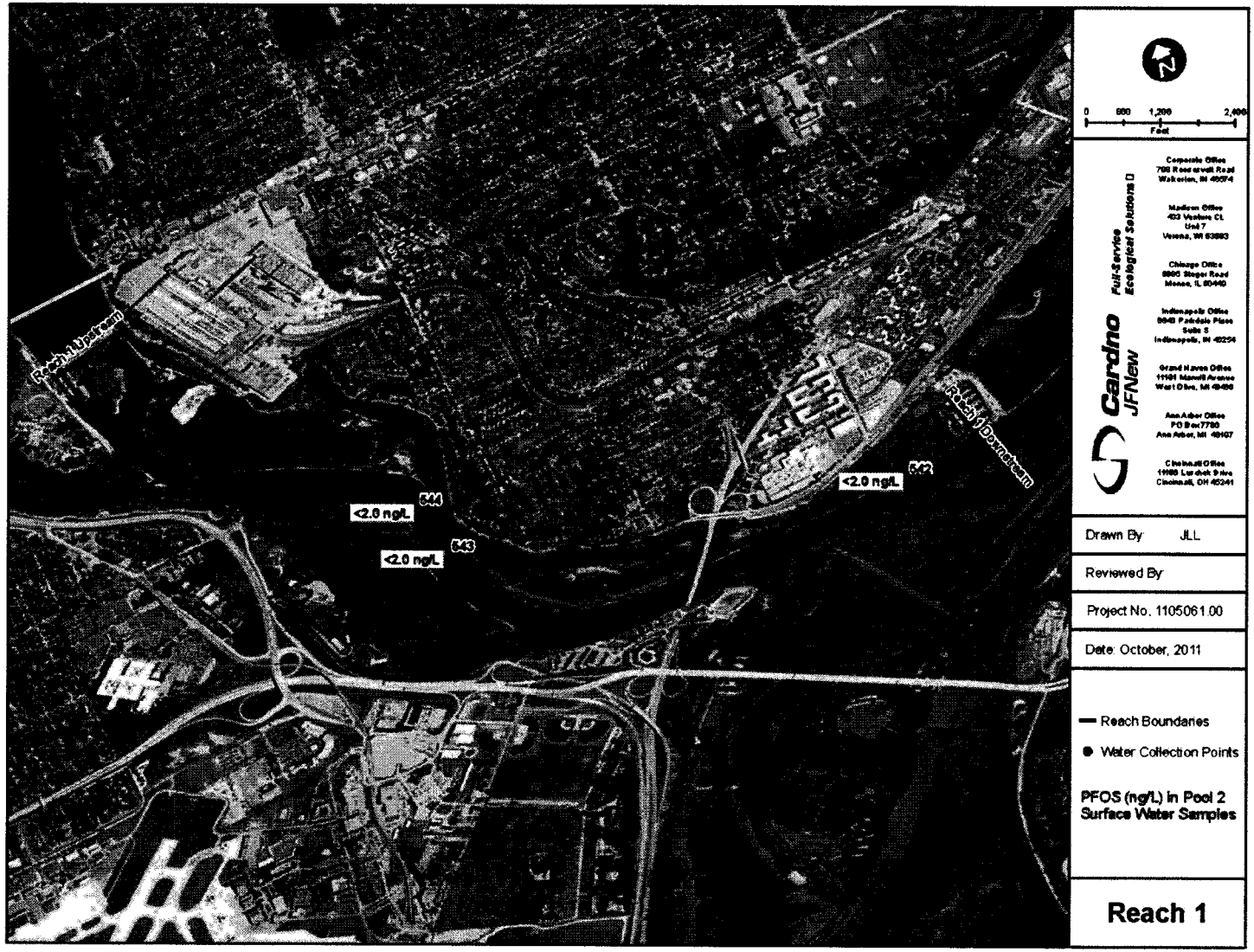

Figure B- 1. Reach 1 Water Collection Locations

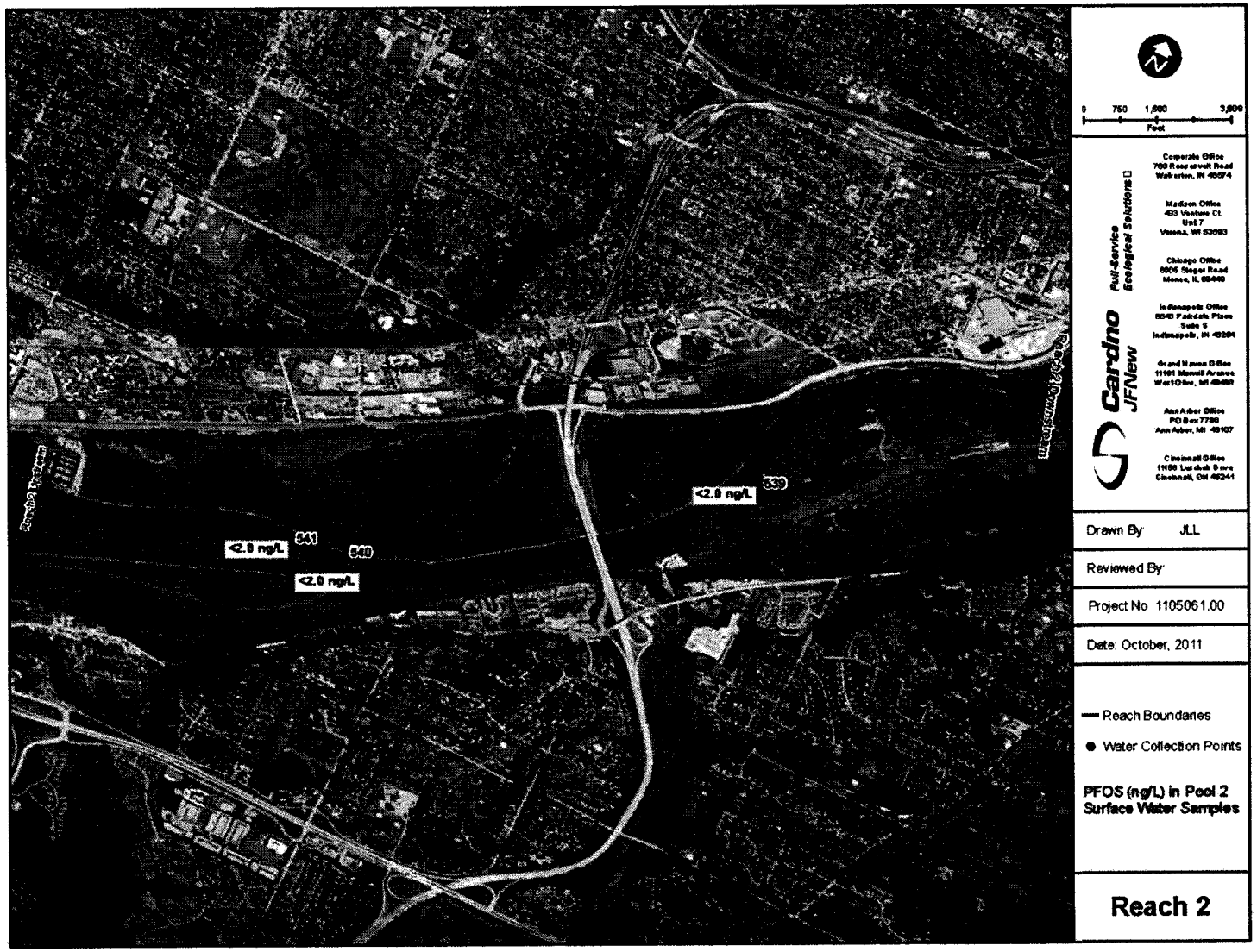

Figure B-2. Reach 2 Water Collection Locations

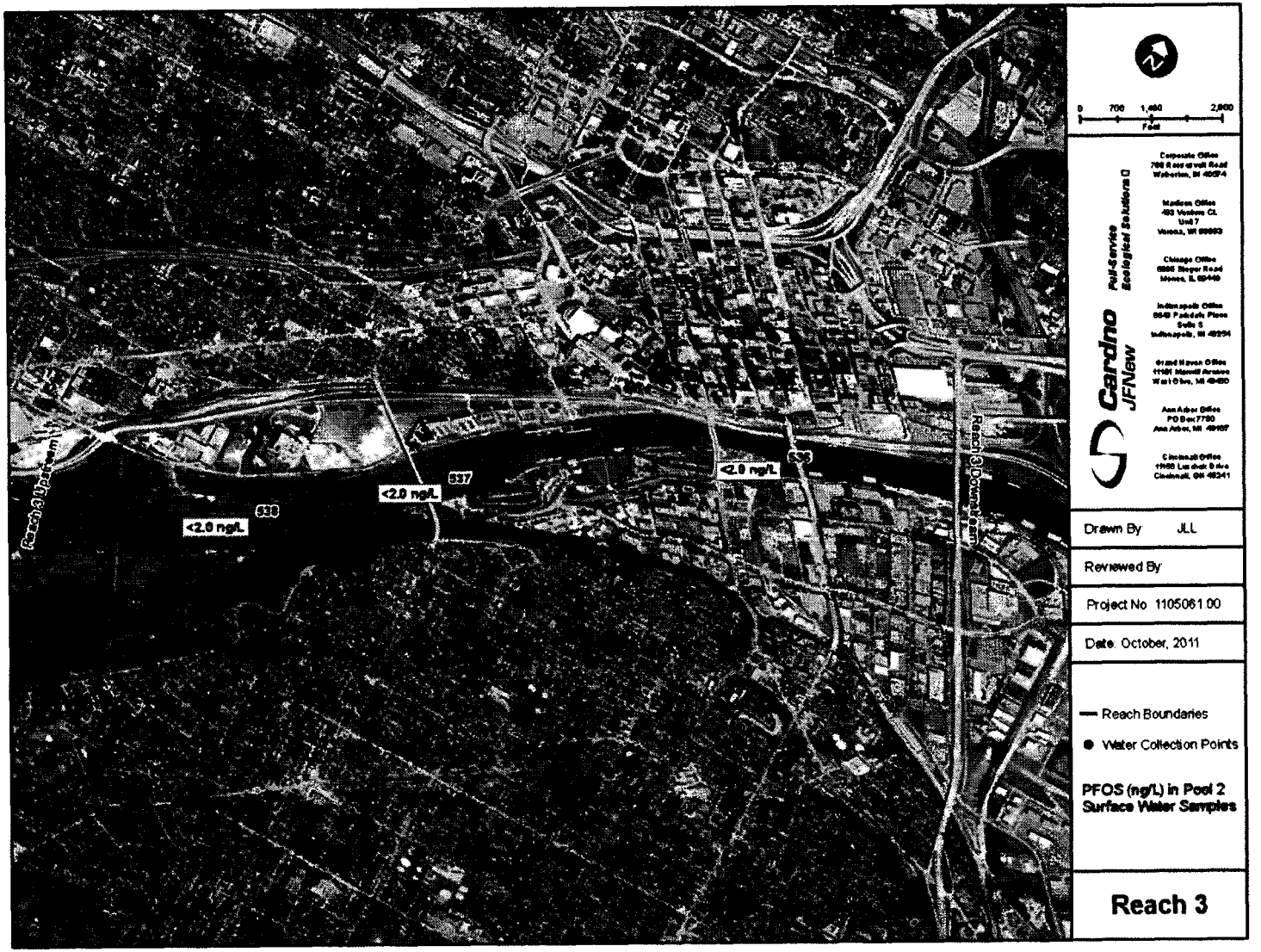

Figure B-3. Reach 3 Water Collection Locations

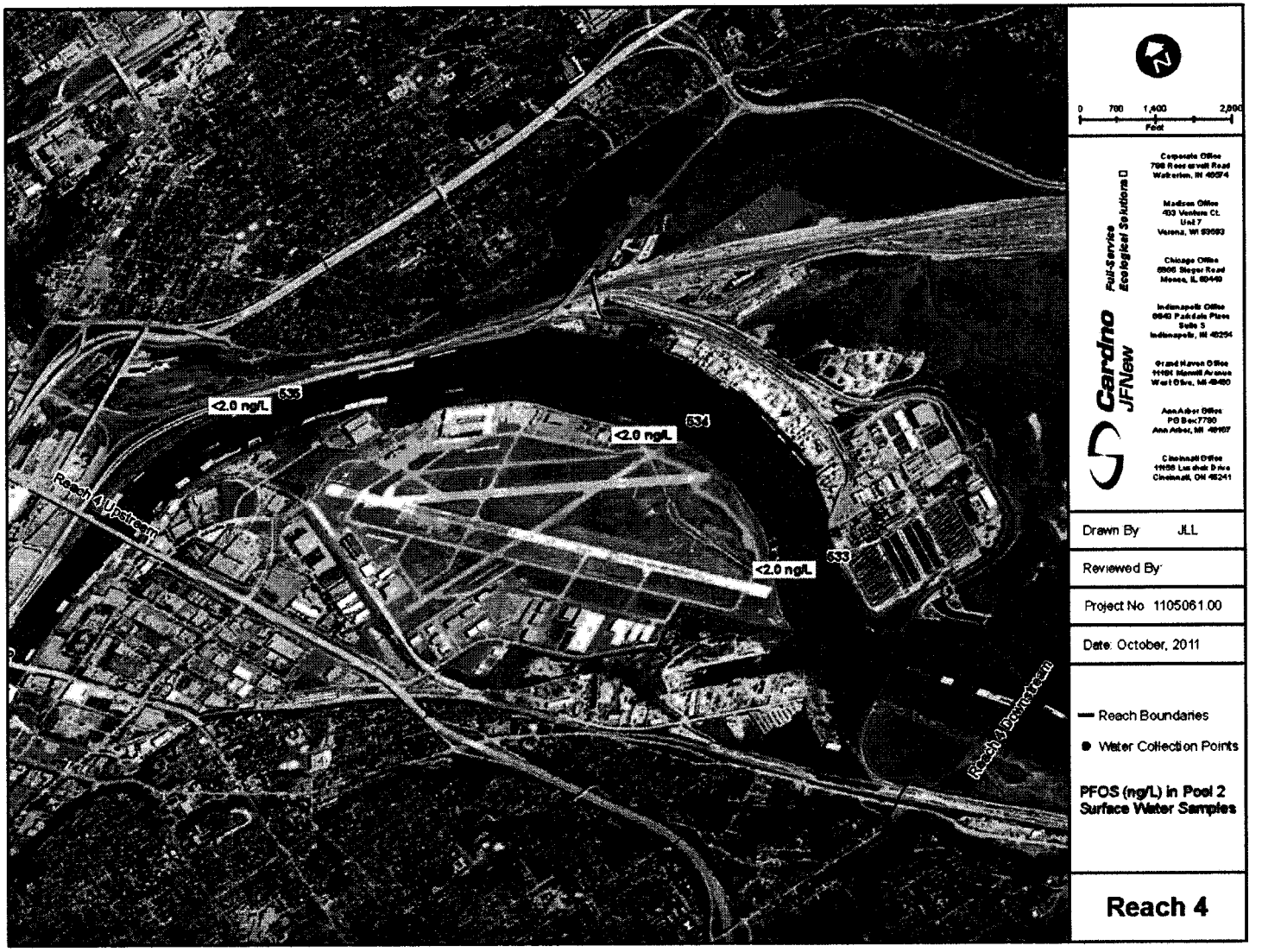

Figure B-4. Reach 4 Water Collection Locations

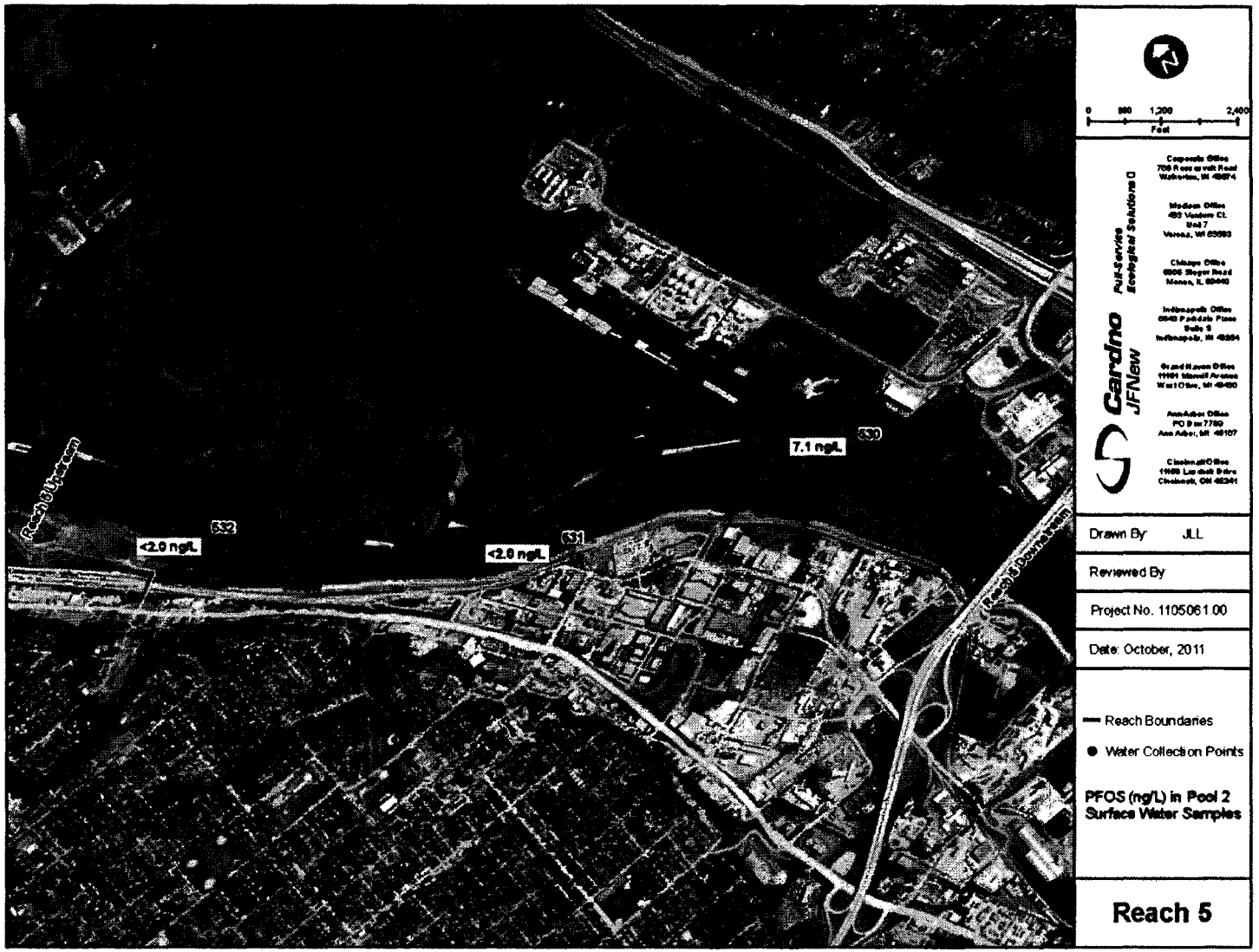

Figure B-5. Reach 5 Water Collection Locations

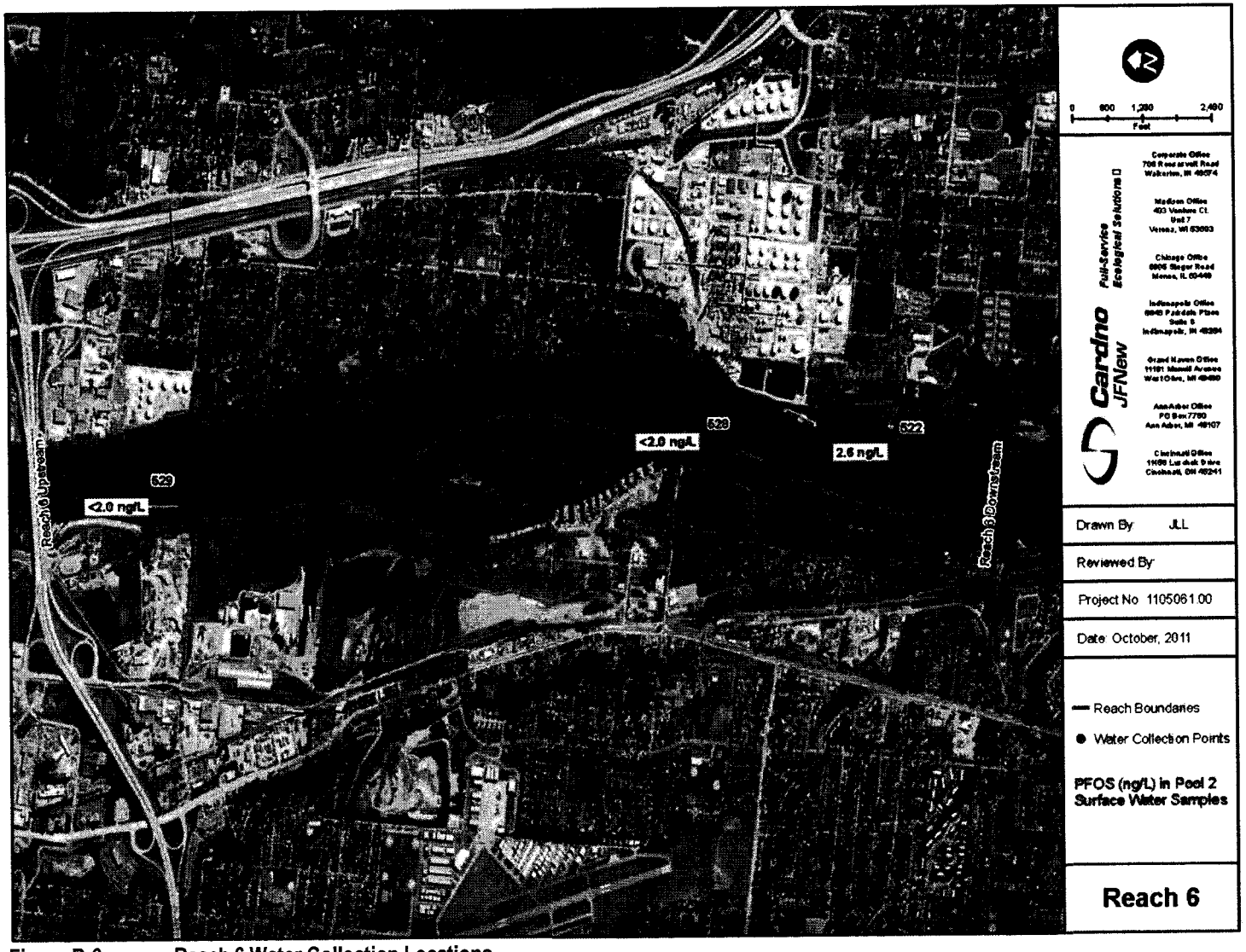

Figure B-6. Reach 6 Water Collection Locations

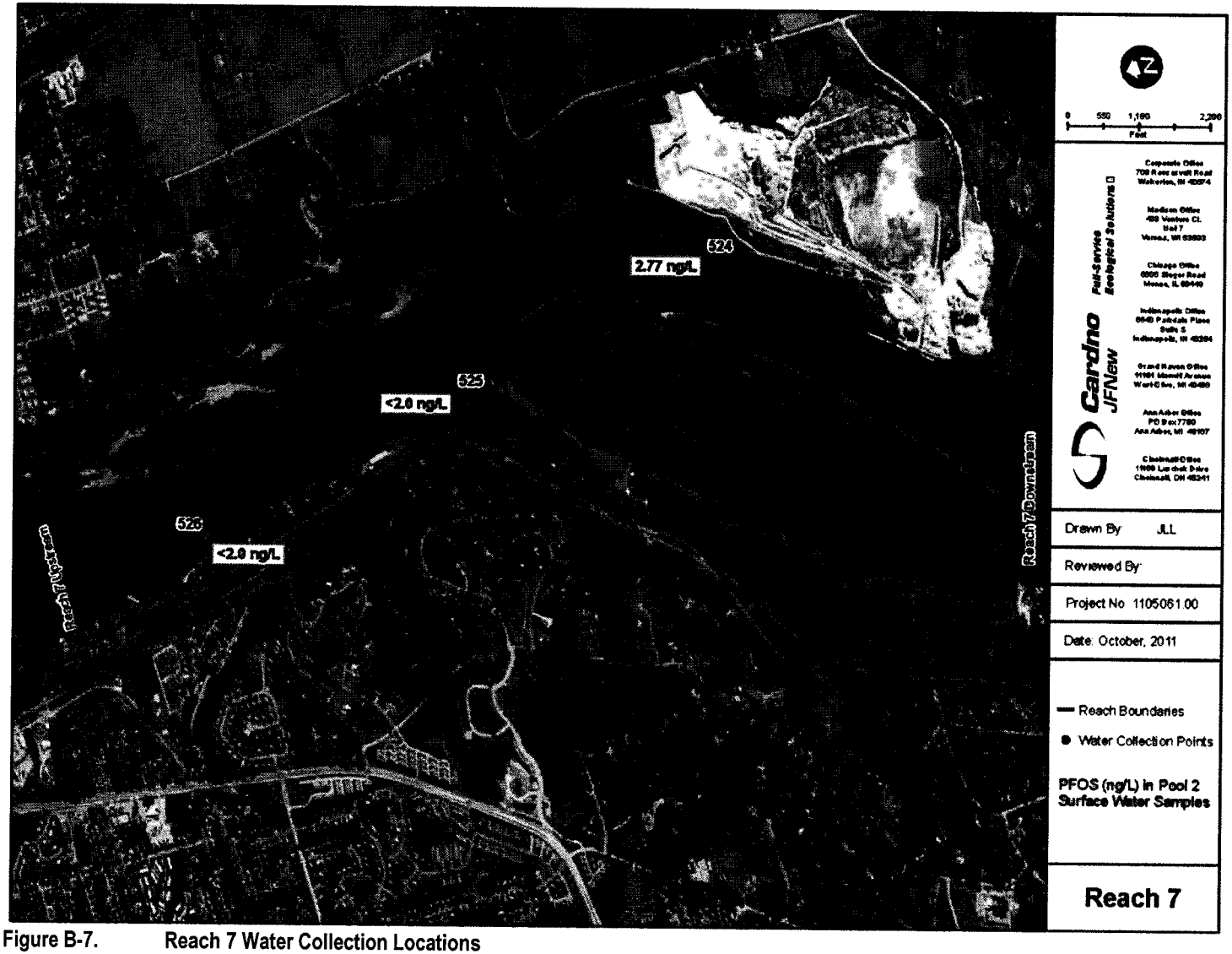

Figure B-7. Reach 7 Water Collection Locations

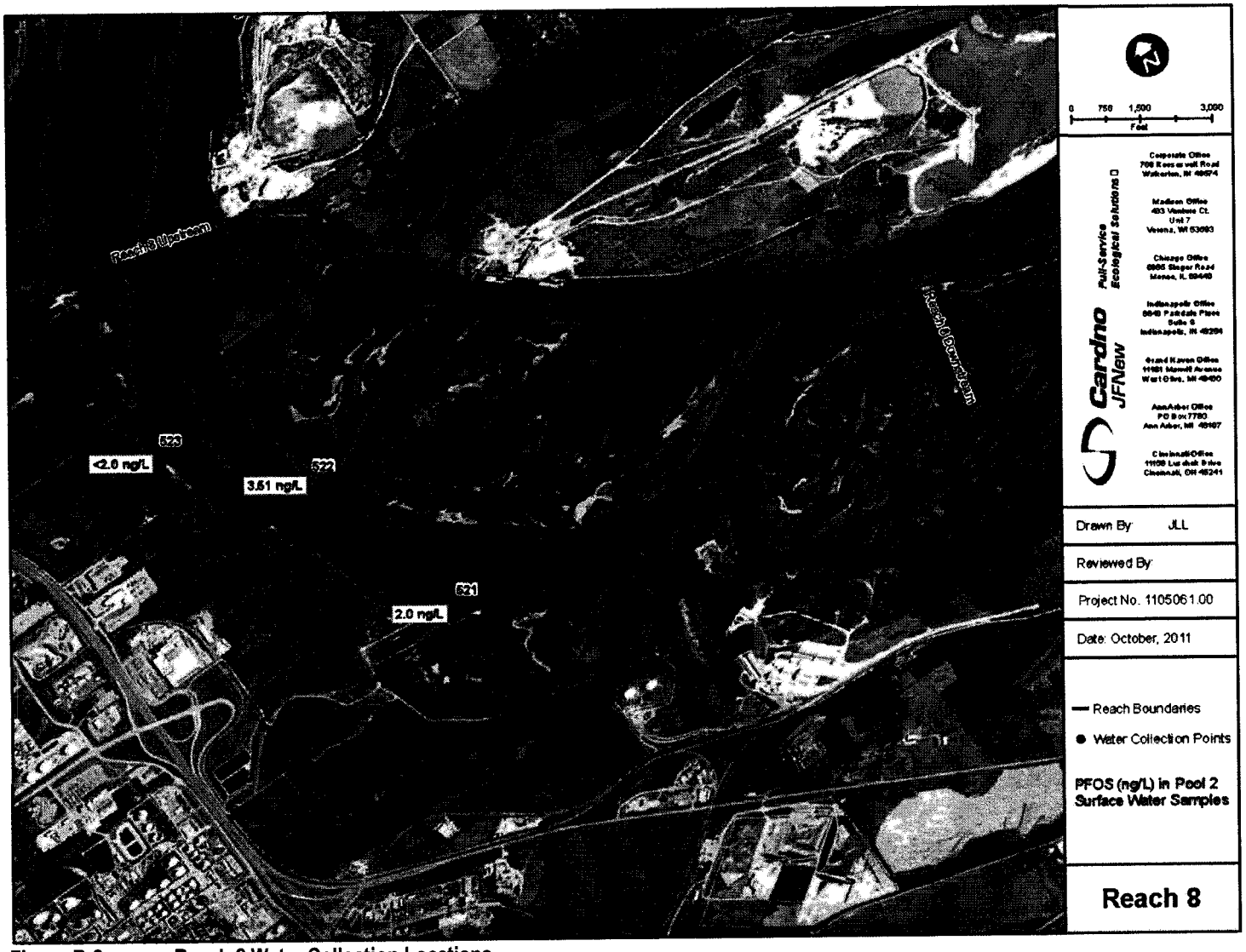

Figure B-8. Reach 8 Water Collection Locations

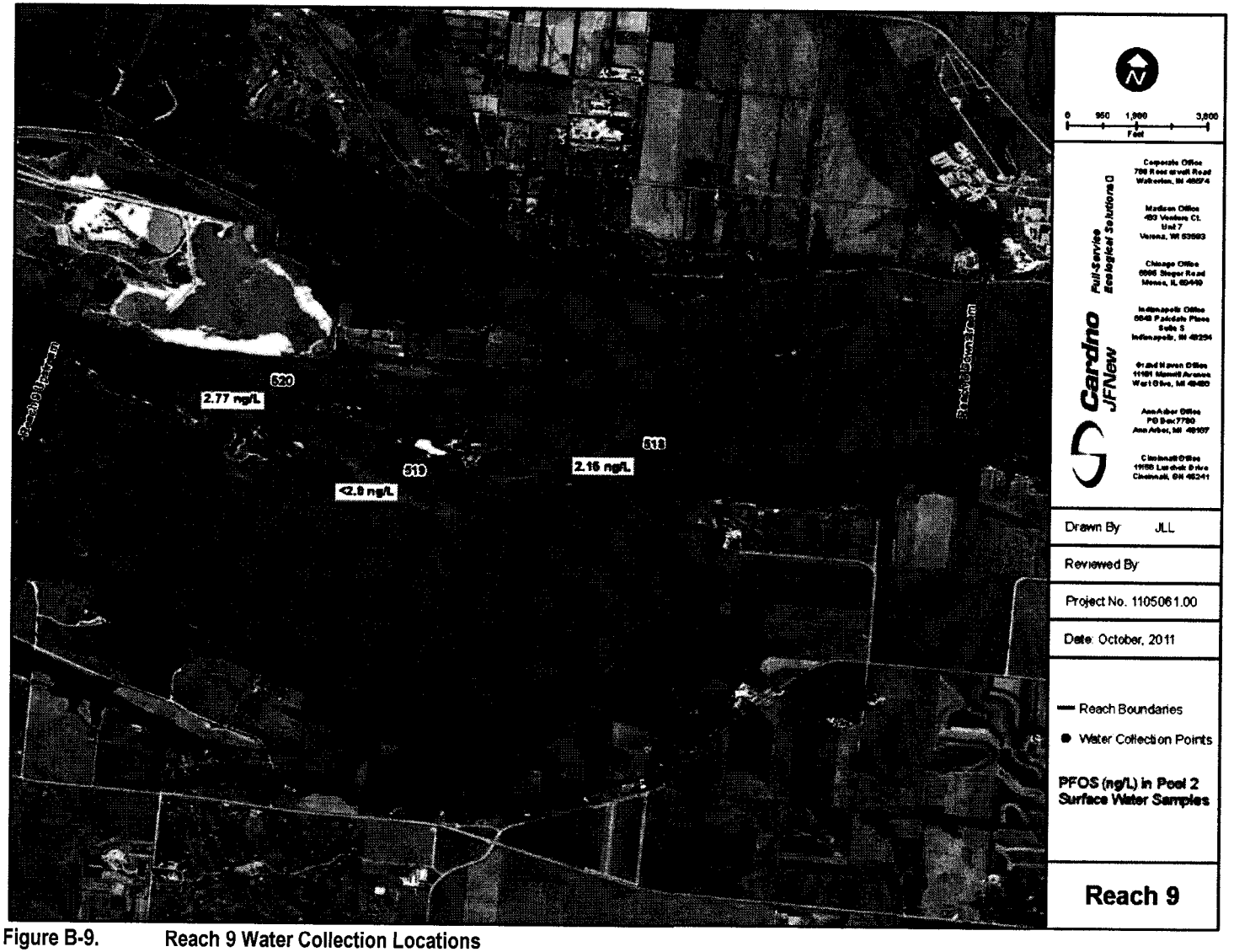

Figure B-9. Reach 9 Water Collection Locations

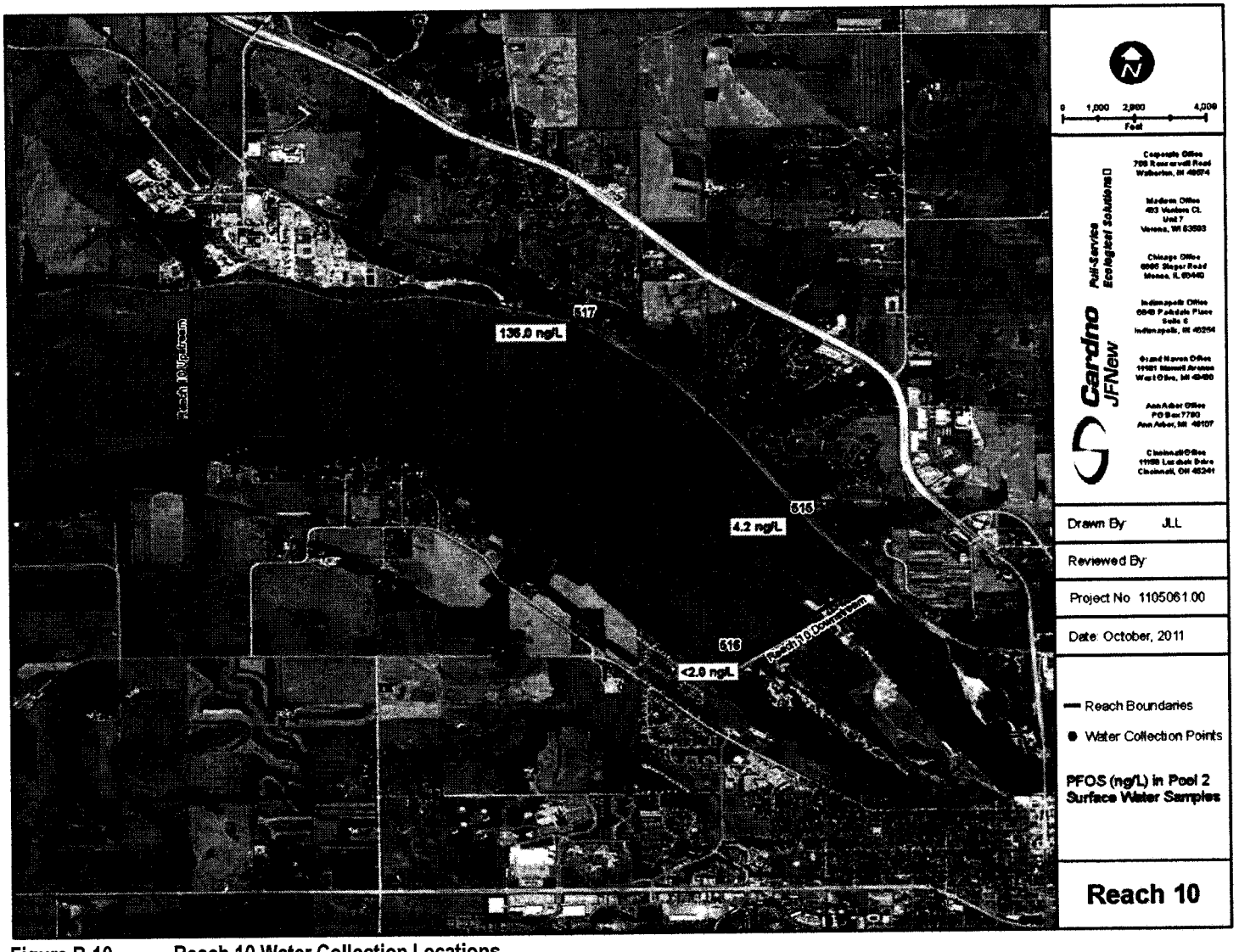

Figure B-10. Reach 10 Water Collection Locations

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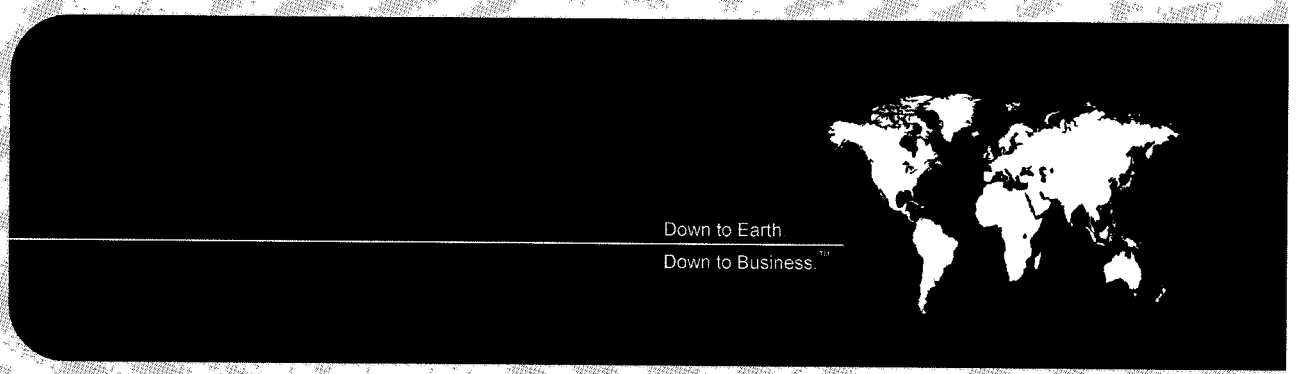

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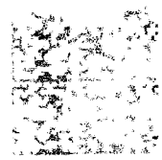

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