MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
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STAFF REPORT

# INVESTIGATION OF PERFLUORINATED COMPOUND CONTAMINATION IN THE CLINTON RIVER, LAKE ST. CLAIR, AND SELECTED TRIBUTARIES STATUS UPDATE 2018 MACOMB COUNTY

## Background

Perfluorinated and polyfluorinated alkyl substances (PFAS) are a very large class of man-made organic chemicals that have been used in numerous industrial processes and consumer products for over 60 years. Analysis of PFAS in environmental samples is relatively new and methodology has been developed for relatively few of the thousands of compounds. Until recently environmental monitoring of PFAS in Michigan has focused on measuring only perfluorinated chemicals.

Many of the compounds are persistent, some bioaccumulate in the environment, and several have proven to be toxic to birds and mammals in laboratory testing. The toxicities of most PFAS have not been evaluated. Two perfluorinated compounds, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), have been the subject of the most toxicological work and environmental monitoring. Both compounds have been manufactured intentionally, but they can also be generated as byproducts when other fluorinated compounds break down. Both PFOS and PFOA have been measured in surface waters across the state, and it is apparent that PFOS can be found in most fish tissue samples from Michigan waters.

Michigan has developed Water Quality Standards (WQS) for both PFOS and PFOA in surface waters. The WQS for PFOS is 12 nanograms per liter (ng/L) in surface water not used as a source of drinking water, and 11 ng/L for those waters used as a drinking water source. The WQS for PFOA are 420 ng/L and 12,000 ng/L for drinking and non-drinking water, respectively. In addition, the U.S. Environmental Protection Agency (USEPA) has established a Lifetime Health Advisory for finished drinking water of 70 ng/L of PFOS and PFOA combined.

Firefighting foams, metal and plastic plating operations, as well as domestic use of PFAS-containing products are known to be significant sources of PFOS, PFOA, and other PFAS in surface waters. These and other sources are known to be prevalent in the Clinton River watershed and Macomb County in general. Contamination may enter surface water through point sources (direct industrial or waste treatment discharges), surface runoff, or groundwater venting. Because of this and because Lake St. Clair is a drinking water source for a large population the Michigan Department of Environmental Quality (MDEQ), Water Resources Division (WRD), decided to monitor the lake, river, and tributaries to evaluate the potential risk to human health caused by PFAS in area surface waters.

Water sampling in Lake St. Clair and the Clinton River has been conducted by the MDEQ, WRD, in a stepwise fashion. Initial limited sampling indicated that there were PFOS concentrations in area surface waters exceeding WQS. Two subsequent sampling events have been conducted to confirm the initial results and to begin tracking potential sources of contamination.

In addition, samples were collected by a contractor from storm water outfalls draining the Selfridge Air National Guard (ANG) Base and discharging to the Clinton River and Lake St. Clair. Results of that sampling were provided to the MDEQ.

Summary

1. Ambient surface water samples were collected from the Clinton River, Lake St. Clair, and tributaries to those water bodies during 3 sampling events in 2017 and 2018 and analyzed for perfluorinated compounds.
2. PFOS was detected in 21 of 23 samples collected from the Clinton River or its tributaries, and the concentration exceeded WQS in 4 of the samples.
3. PFOS was detected in all 10 samples collected from Lake St. Clair and a tributary and exceeded WQS in 2 samples.
4. PFOA was detected in all samples from the Clinton River or its tributaries and in all but 1 of the Lake St. Clair and tributary samples. PFOA concentrations did not exceed WQS.
5. PFAS contamination of the Clinton River appears to be influenced by wet weather events.
6. Additional sampling should target storm water discharge after a rain event.

Methods

Surface water grab samples were collected from Lake St. Clair, the Clinton River, or tributaries to those water bodies and analyzed for PFAS on 3 occasions between August 2017 and February 2018 (Table 1; Figures 1 and 2). A total of 33 water samples have been collected and analyzed to-date.

Samples were collected in two 250 milliliter HDPE bottles (lab certified as PFAS free). In wadeable stream sections subsurface grab samples were taken by hand or by use of a dip pole. Field personnel used gloved hands, collecting the samples upstream of any sampling equipment or personnel and avoiding the collection of surface scums. Stream samples were taken at or near a point of greatest current, and both sample bottles were filled simultaneously.

Lake samples were collected from a boat using a weighted, depth-integrating 1 liter HDPE bottle. The bottle was lowered with a rope swiftly to depth and gradually retrieved to provide a composite sample approximately representative of the water column. The collected water was then dispensed into the 2 sample bottles.

Field sampling and analytical quality was assessed using replicate, duplicate, field blank, and trip blank samples. Replicate samples were taken by collecting 2 sets of samples in succession at the same site. One replicate sample was collected during both the November 2017 and February 2018 sampling events. A duplicate sample consisting of a 1 liter composite sample

dispensed into 2 sets of two 250 milliliter bottles was collected during the February 2018 sampling event. One field blank was collected during both the November 2017 and February 2018 sampling events by filling a clean set of sample bottles with PFAS-free deionized water in the field. A trip blank was analyzed for the February 2018 sampling event and consisted of 1 laboratory prepared bottle of PFAS-free deionized water that was transported unopened to the field and returned to the lab for analysis.

No preservatives were added to the samples, and the samples were placed on ice. Sample site coordinates were recorded. Samples were shipped on ice via overnight delivery to the TestAmerica Sacramento laboratory at the end of the sample collection event. TestAmerica is an MDEQ contract laboratory and analyzes surface water samples using a modified version of USEPA Method 537, a process using isotope dilution for analyte quantification. The lab provided analytical results for 19 perfluorinated compounds (Table 2) to the MDEQ, WRD, in an electronic spreadsheet format as well as in a Level 2 report (a Level 2 report includes a brief narrative, results, and basic quality control results).

## Results and Discussion

### *Quality Control Results*

All analytes were below detection levels in the field and trip blank samples with 1 exception: PFHxS was reported at 0.2 ng/L in the field blank sample collected in November 2017 and in both the field and the trip blank samples collected during the February 2018 sampling event; however, the compound was also detected at the same level in the laboratory method blanks for both events, indicating the source was most likely within the analytical process.

### *Ambient Sample Results*

A total of 33 ambient surface water samples were taken over the 3 sampling events. PFOA was detected at all sites and PFOS was detected at all but 2 sites. In addition to PFOA, 6 other compounds (PFBA, PFPeA, PFHxA, PFHpA, PFBS, and PFHxS) were detected at all sites. Six compounds (PFUnA, PFDoA, PFTriA, PFTeA, PFODA, and PFDS) were not detected in any of the samples.

#### *Lake St. Clair*

A total of 8 surface water samples have been taken from Lake St. Clair and analyzed for PFAS, including 2 samples nearshore at the Selfridge Public Boat Launch near the discharge of the Tucker-Jones Drain.

The PFOS concentration in the Lake St. Clair sample collected on August 31, 2017, at the Selfridge Public Boat Launch (LSC001) exceeded WQS while the PFOA concentration was measurable but low (Tables 3 and 4; Figures 3 and 4). The sample was taken nearshore near the discharge of the Tucker-Jones Drain 3 days after a storm event during which nearly 2.3 inches of rainfall was measured at the Selfridge ANG Base. The high PFOS concentration exceeded the USEPA Health Advisory level and prompted concern since the lake is a source of drinking water to a large population.

A more intensive sampling effort followed on November 7, 2017, with 6 composite surface water samples collected from Lake St. Clair (Figure 4). The samples had a mean PFOS concentration of 2.9 ng/L, with a median PFOS concentration 2.0 ng/L (Table 3). The mean and median PFOA concentrations were 1.7 and 1.6 ng/L, respectively. The combined PFOS and PFOA concentrations ranged from 3 to 9 ng/L, well below the USEPA Health Advisory level of 70 ng/L.

One sample was collected from Lake St. Clair at the Selfridge Public Boat Launch through ice on February 13, 2018. The PFOS concentration was 1.3 ng/L while the PFOA concentration was less than the detection limit of 0.8 ng/L (Figure 4).

*Tucker-Jones Drain*

The Tucker-Jones Drain provides an outlet for storm water at the western and northern perimeter of the Selfridge ANG Base, part of northeastern Mt. Clemens, and part of southern Chesterfield Township. The drain empties into Lake St. Clair at the Selfridge Public Boat Launch. Two samples have been collected from the drain near its mouth (TJDr010).

The first sample was collected on November 7, 2017, following an extended wet period (precipitation had been recorded at the Selfridge ANG Base each of the previous 8 days with a total rainfall of 1.3 inches). The PFOS concentration exceeded WQS at 13 ng/L (Figure 5), while the PFOA concentration was 4 ng/L.

A second sample was collected from the Tucker-Jones Drain through ice on February 13, 2018. Little if any runoff from meltwater was likely to be contributing to the drain discharge since the high temperature had been below freezing for the previous 8 days. Both PFOS and PFOA concentrations were low in the sample, measuring 3.2 and 3.6 ng/L, respectively.

*Clinton River and Selected Tributaries*

A total of 23 samples over 3 sampling events were collected from the Clinton River or selected tributaries and analyzed for PFAS.

The first sample, collected near the river mouth on August 31, 2017, had a PFOS concentration exceeding WQS at 36 ng/L (Table 3; Figure 3), while the PFOA concentration was well below WQS (Table 4).

Additional sampling conducted on November 7, 2017, again indicated PFOS concentrations were above WQS near the river mouth (Figure 5). However, overall results for the sampling event were puzzling; replicate samples taken near the river mouth were very different (although both were above WQS). The analytical laboratory re-analyzed the samples in question and confirmed the original results. In addition, samples from the next 2 sites upstream (CR040 and CR060) were below WQS while the furthest upstream site (CR090) exceeded WQS. There are 2 storm water outfalls draining the Selfridge ANG Base that discharge to the Clinton River between the river mouth site and the next sampling site upstream (CR020 and CR040, respectively). Since the November 7, 2017, sampling event followed a period of rainfall, contaminated storm water is a possible cause of the high PFOS concentration measured at

CR020 as compared to CR040. The high PFOS concentration at CR090 remained unexplained and was presumed to be due to another source further upstream.

The third and more intensive Clinton River sampling plan was developed with a goal of clarifying previous results and beginning steps toward tracking contaminant sources. The sampling event was conducted in mid-February 2018 when 18 sites on the river and selected tributaries were sampled. The results indicated that PFOS concentrations were below WQS at all sites except for the Greiner Drain, a tributary to the North Branch Clinton River (GDR002, Figure 1). Excluding the Greiner Drain sample, PFOS concentrations varied only slightly between sites without an apparent pattern, ranging from below the detection level to 7.9 ng/L (Table 3; Figure 6), with mean and median concentrations of 4.1 and 4.6, respectively.

The February 2018 sampling was conducted after an 8-day period of below freezing air temperatures, and presumably melt/storm water discharge to the river was minimal. The apparently consistent PFAS concentrations throughout most of the sampled watershed may indicate that any significant source of PFAS contamination is due to surface runoff or discharge from storm water systems rather than direct discharges from facilities to the river.

*Selfridge ANG Base Storm Water Samples*

Surface water samples were collected by AECOM, contractors for the Selfridge ANG Base, on February 8, 2018, and analyzed for perfluorinated compounds using USEPA Method 537 Rev 1.1 Modified. Samples were collected from 5 storm water compliance sampling points, 2 of which (Outfalls 001A and 002A) discharge to the Clinton River between MDEQ sampling points CR010 and CR040 (Figure 1). The PFOS concentrations in all 5 samples exceeded WQS, and the concentrations from the discharges to the river were very high at 2,000 ng/L and 2,400 ng/L.

The elevated PFOS levels in the Selfridge ANG Base storm water measured in the February samples did not result in a measurable increase in the February river samples collected by the MDEQ (Figure 6), but this could be explained by the overall relatively low river discharge in winter. In addition, the Selfridge ANG Base storm water discharge is not continuous; the drainage system includes wet wells with pumps that operate only when the water reaches a designated level within the sump. High Selfridge ANG Base storm water concentrations could explain the relatively high PFOS concentrations measured at the river mouth in August and November 2017 after periods of significant rainfall (Figures 3 and 4).

Figure 7 compares the percentage composition of the 6 perfluorinated compounds measured in Selfridge ANG Base Outfalls 001 and 002 with the composition in samples collected at the river mouth. The Selfridge ANG Base outfall samples were dominated by PFOS and PFHxS, making up an average of 45% and 43% of the total measured PFAS, respectively. The 3 ambient samples collected at the river mouth averaged 48% PFOS, similar to that in the Selfridge ANG Base outfalls, but overall PFHxS was less important and PFOA comprised a larger percentage of the total PFAS as compared with the Selfridge ANG Base outfalls (Table 5).

*Compliance Sampling Inspection*

Effluent samples were collected from 3 wastewater treatment facilities with National Pollutant Discharge Elimination System permitted discharges to the Clinton River in October 2017 during statewide compliance sampling inspections as part of a separate monitoring effort. The PFOS concentrations in the effluents ranged from 7 to 14 ng/L, PFOA ranged from 11 to 14 ng/L, and total PFAS ranged from 100 to 116 ng/L.

Conclusions and Recommendations

The offshore waters of Lake St. Clair generally had low levels of PFOS, with 5 of the 6 offshore samples ranging from 1.4 to 2.7 ng/L; the sixth sample had a PFOS concentration of 7.4 ng/L. The PFOA concentrations were consistently low, ranging from 1.5 to 2 ng/L. These results are similar to concentrations measured in both the St. Clair River and the Detroit River in 2017. Concentrations of PFOS in those waters ranged from 1.5 to 2.2 ng/L in samples taken at the head and mouth of each river on 4 occasions in 2017. PFOA concentrations ranged from 1.0 to 1.6 ng/L in those samples. Additional surface water sampling in Lake St. Clair is not needed at this time.

Concentrations of PFAS in the lower Clinton River and its tributaries have varied both spatially and temporally. Effluents from the 3 major wastewater treatment facilities in the Clinton River watershed contribute some amount of PFAS to the river, but the levels do not appear to be significant. The generally low concentrations measured in the winter during a period of low storm water runoff indicates that surface drainage is a likely source of contamination to the river.

Although data are limited, it is likely that storm water runoff from the Selfridge Air National Guard Selfridge ANG Base delivers a significant amount of PFAS to the lower river. Discharge from the Greiner Drain may also be a source.

Additional surface water sampling timed to follow a wet weather event should be planned and should target the discharge from suspect storm water outfalls.

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Table 1. Clinton River and Lake St. Clair watershed surface water PFAS sampling sites, 2017 and 2018.

| Site # | Location | Nearest Landmark | Latitude | Longitude | Sample Date | | |
|---|---|---|---|---|---|---|---|
| | | | | | 8/31/2017 | 11/7/2017 | 2/14/2018 |
| CR010 | Mouth of Clinton River | Bryers Cottage Marina | 42.594761 | -82.796282 | | x | x |
| CR020 | Mouth of Clinton River, off Riverside Bay Ct. | | 42.592844 | -82.817119 | x | | |
| CR040 | Main Branch d/s Mt. Clemens WWTP | d/s I-94 | 42.590733 | -82.854550 | | x | x |
| CR060 | Main Branch d/s of Spillway split | d/s Shadyside Park | 42.584004 | -82.874052 | | x | x |
| CR080 | Main Branch d/s railroad & confluence w/Harrington Drain | Southbound Gratiot Avenue | 42.584918 | -82.883581 | | | x |
| CR090 | Clinton River d/s confluence w/North Branch | Moravian Drive | 42.596023 | -82.909469 | | x | x |
| CR100 | Main Branch u/s confluence w/North Branch, d/s Canal Drain | Off Clinton River Road | 42.600034 | -82.915830 | | | x |
| CR110 | Main Branch u/s of confluence w/Canal Drain | Canal Park | 42.594518 | -82.914804 | | | x |
| SP010 | Mouth of Spillway | Jefferson Avenue | 42.562510 | -82.848466 | | | x |
| SP020 | Spillway d/s confluence w/Main Branch, u/s Cottrell Drain | Harper Avenue | 42.577182 | -82.872295 | | | x |
| CDr010 | Canal Drain u/s of confluence w/Main Branch | Bike Path Crossing | 42.598622 | -82.926828 | | | x |
| HDr010 | Harrington Drain u/s of confluence w/Main Branch | Harrington Street | 42.587956 | -82.903676 | | | x |
| NBC010 | North Branch u/s of confluence w/Middle Branch | Cass Avenue | 42.600472 | -82.909318 | | | x |
| NBC030 | North Branch u/s confluence w/Middle Branch, d/s Greiner Drain | Little Road | 42.619201 | -82.901343 | | | x |
| NBC040 | North Branch u/s Greiner Drain, d/s of "fire" drain | 22050 Hall Road, Clinton Twp. | 42.625978 | -82.8954 | | | x |
| MBC010 | Middle Branch u/s of confluence w/North Branch | ~100m d/s Miller Drain | 42.606666 | -82.914171 | | | x |
| MBC020 | Middle Branch u/s of confluence w/Miller Drain | Heydenreich Road | 42.606056 | -82.917756 | | | x |
| MDr010 | Miller Drain u/s of confluence w/Middle Branch | Heydenreich Road | 42.608972 | -82.917262 | | | x |
| GDr002 | Axalta Drainage Swale/Greiner Drain | North Groesbeck Hwy | 42.612844 | -82.890803 | | | x |
| LSC001 | Lake St. Clair at Selfridge Public Boat Launch | At Drain Mouth | 42.629597 | -82.818876 | x | | x |
| TJDr010 | Tucker-Jones Drain | Pedestrian Crossing | 42.630221 | -82.823845 | | x | x |
| LSC010 | Lake St. Clair / L'anse Creuse Bay | St. Clair Shores | 42.517458 | -82.873176 | | x | |
| LSC020 | Lake St. Clair / L'anse Creuse Bay | Cottrell Road | 42.550998 | -82.843378 | | x | |
| LSC030 | Lake St. Clair / L'anse Creuse Bay | Metropark | 42.568634 | -82.812159 | | x | |
| LSC040 | Lake St. Clair / Anchor Bay | Selfridge ANG Base | 42.622207 | -82.817595 | | x | |
| LSC050 | Lake St. Clair / Anchor Bay | New Baltimore | 42.654285 | -82.760033 | | x | |
| LSC060 | Lake St. Clair / Anchor Bay | Fair Haven | 42.674468 | -82.632334 | | x | |

| Table 2. Perfluorinated compounds analyzed in surface water samples. | |
|---|---|
| Compound | Abbreviation |
| Perfluorobutanoic acid | PFBA |
| Perfluorooctanoic acid | PFOA |
| Perfluorooctane sulfonate | PFOS |
| Perfluoropentanoic acid | PFPeA |
| Perfluorohexanoic acid | PFHxA |
| Perfluoroheptanoic acid | PFHpA |
| Perfluorononanoic acid | PFNA |
| Perfluorodecanoic acid | PFDA |
| Perfluoroundecanoic acid | PFUnA |
| Perfluorododecanoic acid | PFDoA |
| Perfluorotridecanoic acid | PFTriA |
| Perfluorotetradecanoic acid | PFTeA |
| Perfluoro-n-hexadecanoic acid | PFHxDA |
| Perfluoro-n-octadecanoic acid | PFODA |
| Perfluorobutane sulfonate | PFBS |
| Perfluorohexane sulfonate | PFHxS |
| Perfluoro-1-heptane sulfonate | PFHpS |
| Perfluorodecane sulfonate | PFDS |
| Perfluorooctane sulfonamide | PFOSA |

Table 3. PFOS concentrations in surface water samples collected from the Clinton River, Lake St. Clair, and selected tributaries during 3 sampling events. Values in **bold** exceed the MDEQ WQS.

| Site # | Location | PFOS Concentration (ng/L) | | |
|---|---|---|---|---|
| | | 8/31/2017 | 11/7/2017 | 2/13/2018 |
| **Clinton River, Main Branch** | | | | |
| CR010 | Mouth of Clinton River, Bryers Cottage Marina | | **31/610** | 2.3 |
| CR020 | Mouth of Clinton River, off Riverside Bay Ct. | **36** | | |
| CR040 | Main Branch d/s Mt. Clemens WWTP | | 8 | 5 |
| CR060 | Main Branch d/s of Spillway split | | 6.8 | 4.7 |
| CR080 | Main Branch d/s railroad & confluence w/Harrington Drain | | | 4.6/4.9 |
| CR090 | Clinton River at Moravian Dr. | | **470** | 4.3 |
| CR100 | Main Branch u/s confluence w/North Branch, d/s Canal Drain | | | 5.6 |
| CR110 | Main Branch u/s of confluence w/Canal Drain | | | 5.6 |
| **Clinton River Spillway** | | | | |
| SP010 | Mouth of Spillway | | | 5 |
| SP020 | Spillway d/s confluence w/Main Branch, u/s Cottrell Drain | | | 4.6 |
| **Tributaries to Main Branch Clinton River** | | | | |
| CDr010 | Canal Drain u/s of confluence w/Main Branch | | | 3.6 |
| HDr010 | Harrington Drain u/s of confluence w/Main Branch | | | 7.9 |
| **North Branch Clinton River** | | | | |
| NBC010 | North Branch u/s of confluence w/Middle Branch | | | 1.6/1.7 |
| NBC030 | North Branch u/s confluence w/Middle Branch, d/s Greiner Drain | | | < 0.5 |
| NBC040 | North Branch u/s Greiner Drain, d/s of "fire" drain | | | < 0.5 |
| **Middle Branch Clinton River** | | | | |
| MBC010 | Middle Branch u/s of confluence w/North Branch | | | 3.5 |
| MBC020 | Middle Branch u/s of confluence w/Miller Drain | | | 3.2 |
| **Tributaries to Middle Branch Clinton River** | | | | |
| MDr010 | Miller Drain u/s of confluence w/Middle Branch | | | 7.3 |
| **Tributaries to North Branch Clinton River** | | | | |
| GDr002 | Axalta Drainage Swale/Greiner Drain | | | **43** |
| **Minor Lake St. Clair Tributaries** | | | | |
| TJDr010 | Tucker-Jones Drain | | **13** | 3.2 |
| **Lake St. Clair** | | | | |
| LSC001 | at Selfridge Public Boat Launch | **180** | | 1.3 J |
| LSC010 | off St. Clair Shores | | 2.0 | |
| LSC020 | off Cottrell Rd. | | 2.7 | |
| LSC030 | off Lake St. Clair Metropark | | 1.8 J | |
| LSC040 | off Selfridge ANG Base | | 2.0 | |
| LSC050 | off New Baltimore | | 1.4 J | |
| LSC060 | off Fair Haven | | 7.4 | |

Table 4. PFOA concentrations in surface water samples collected from the Clinton River, Lake St. Clair, and selected tributaries during 3 sampling events.

| Site # | Location | PFOA Concentration (ng/L) | | |
|---|---|---|---|---|
| | | 8/31/2017 | 11/7/2017 | 2/13/2018 |
| **Clinton River, Main Branch** | | | | |
| CR010 | Mouth of Clinton River, Bryers Cottage Marina | | 6.4/6.2 | 4.2 |
| CR020 | Mouth of Clinton River, off Riverside Bay Ct. | 5 | | |
| CR040 | Main Branch d/s Mt. Clemens WWTP | | 6.2 | 9.6 |
| CR060 | Main Branch d/s of Spillway split | | 5.6 | 6.8 |
| CR080 | Main Branch d/s railroad & confluence w/Harrington Drain | | | 4.0/4.0 |
| CR090 | Clinton River at Moravian Dr. | | 5.6 | 4.3 |
| CR100 | Main Branch u/s confluence w/North Branch, d/s Canal Drain | | | 3.9 |
| CR110 | Main Branch u/s of confluence w/Canal Drain | | | 4.3 |
| **Clinton River Spillway** | | | | |
| SP010 | Mouth of Spillway | | | 6 |
| SP020 | Spillway d/s confluence w/Main Branch, u/s Cottrell Drain | | | 5.7 |
| **Tributaries to Main Branch Clinton River** | | | | |
| CDr010 | Canal Drain u/s of confluence w/Main Branch | | | 4.1 |
| HDr010 | Harrington Drain u/s of confluence w/Main Branch | | | 5.6 |
| **North Branch Clinton River** | | | | |
| NBC010 | North Branch u/s of confluence w/Middle Branch | | | 3.1/2.8 |
| NBC030 | North Branch u/s confluence w/Middle Branch, d/s Greiner Drain | | | 1.4 J |
| NBC040 | North Branch u/s Greiner Drain, d/s of "fire" drain | | | 1.2 J |
| **Middle Branch Clinton River** | | | | |
| MBC010 | Middle Branch u/s of confluence w/North Branch | | | 6.9 |
| MBC020 | Middle Branch u/s of confluence w/Miller Drain | | | 6.7 |
| **Tributaries to Middle Branch Clinton River** | | | | |
| MDr010 | Miller Drain u/s of confluence w/Middle Branch | | | 8.4 |
| **Tributaries to North Branch Clinton River** | | | | |
| GDr002 | Axalta Drainage Swale/Greiner Drain | | | 16 |
| **Minor Lake St. Clair Tributaries** | | | | |
| TJDr010 | Tucker-Jones Drain | | 4 | 3.6 |
| **Lake St. Clair** | | | | |
| LSC001 | at Selfridge Public Boat Launch | 4.3 | | < 0.8 |
| LSC010 | off St. Clair Shores | | 1.8 J | |
| LSC020 | off Cottrell Rd. | | 2.1 | |
| LSC030 | off Lake St. Clair Metropark | | 1.5 J | |
| LSC040 | off Selfridge ANG Base | | 2.0 | |
| LSC050 | off New Baltimore | | 1.5 J | |
| LSC060 | off Fair Haven | | 1.5 J | |

Table 5. Total PFAS concentrations in surface water samples collected from the Clinton River, Lake St. Clair, and selected tributaries during 3 sampling events.

| Site # | Location | Σ PFAS Concentration (ng/L) | | |
|---|---|---|---|---|
| | | 8/31/2017 | 11/7/2017 | 2/13/2018 |
| **Clinton River, Main Branch** | | | | |
| CR010 | Mouth of Clinton River, Bryers Cottage Marina | | 76/657 | 14 |
| CR020 | Mouth of Clinton River, off Riverside Bay Ct. | 73 | | |
| CR040 | Main Branch d/s Mt. Clemens WWTP | | 52 | 41 |
| CR060 | Main Branch d/s of Spillway split | | 45 | 39 |
| CR080 | Main Branch d/s railroad & confluence w/Harrington Drain | | | 36/38 |
| CR090 | Clinton River at Moravian Dr. | | 508 | 36 |
| CR100 | Main Branch u/s confluence w/North Branch, d/s Canal Drain | | | 40 |
| CR110 | Main Branch u/s of confluence w/Canal Drain | | | 42 |
| **Clinton River Spillway** | | | | |
| SP010 | Mouth of Spillway | | | 38 |
| SP020 | Spillway d/s confluence w/Main Branch, u/s Cottrell Drain | | | 38 |
| **Tributaries to Main Branch Clinton River** | | | | |
| CDr010 | Canal Drain u/s of confluence w/Main Branch | | | 28 |
| HDr010 | Harrington Drain u/s of confluence w/Main Branch | | | 51 |
| **North Branch Clinton River** | | | | |
| NBC010 | North Branch u/s of confluence w/Middle Branch | | | 22/22 |
| NBC030 | North Branch u/s confluence w/Middle Branch, d/s Greiner Drain | | | 12 |
| NBC040 | North Branch u/s Greiner Drain, d/s of "fire" drain | | | 11 |
| **Middle Branch Clinton River** | | | | |
| MBC010 | Middle Branch u/s of confluence w/North Branch | | | 44 |
| MBC020 | Middle Branch u/s of confluence w/Miller Drain | | | 41 |
| **Tributaries to Middle Branch Clinton River** | | | | |
| MDr010 | Miller Drain u/s of confluence w/Middle Branch | | | 78 |
| **Tributaries to North Branch Clinton River** | | | | |
| GDr002 | Axalta Drainage Swale/Greiner Drain | | | 185 |
| **Minor Lake St. Clair Tributaries** | | | | |
| TJDr010 | Tucker-Jones Drain | | 61 | 36 |
| **Lake St. Clair** | | | | |
| LSC001 | at Selfridge Public Boat Launch | 211 | | 6 |
| LSC010 | off St. Clair Shores | | 12 | |
| LSC020 | off Cottrell Rd. | | 16 | |
| LSC030 | off Lake St. Clair Metropark | | 9 | |
| LSC040 | off Selfridge ANG Base | | 12 | |
| LSC050 | off New Baltimore | | 8 | |
| LSC060 | off Fair Haven | | 14 | |

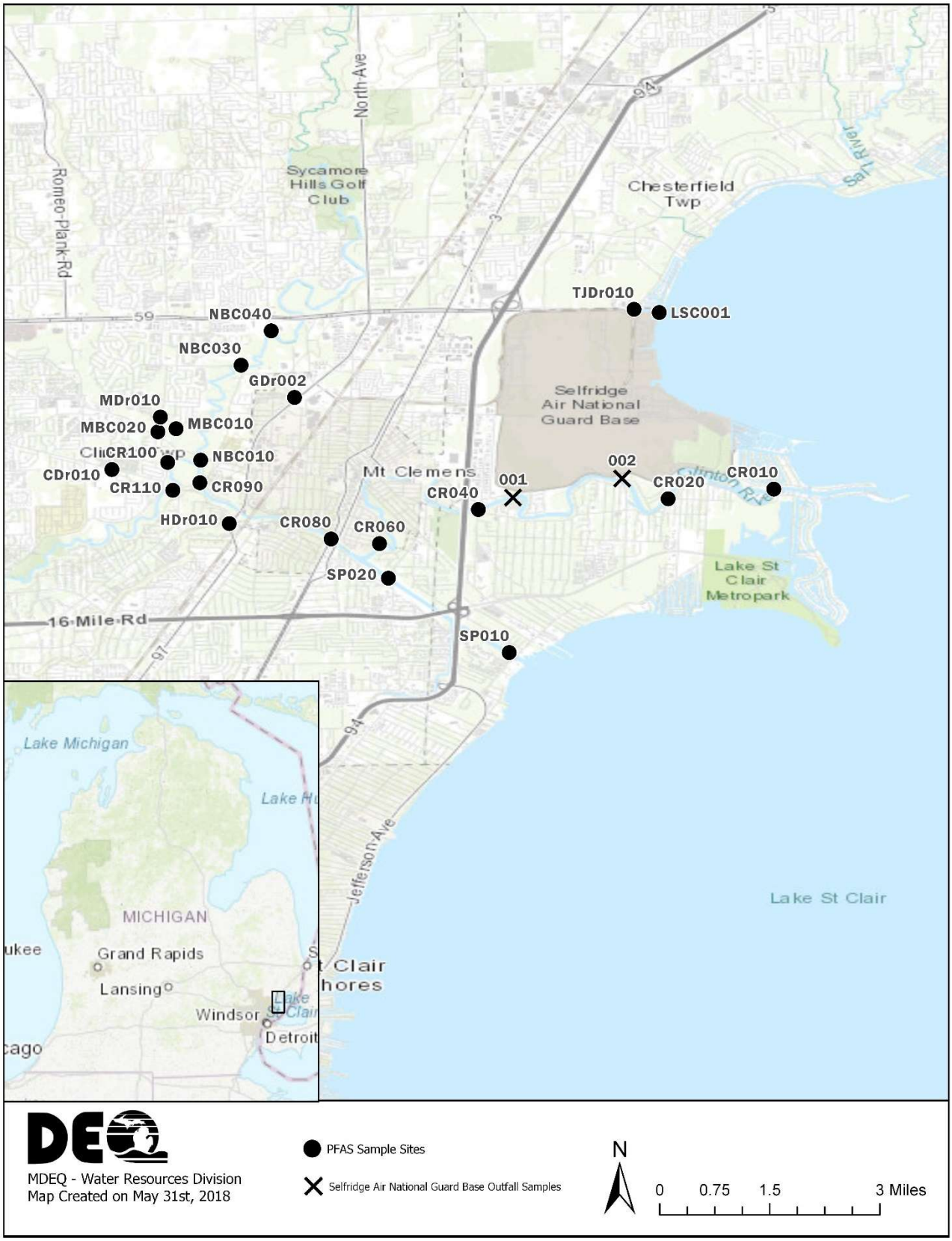


Figure 1. Surface water sampling sites on the Clinton River, Lake St. Clair shore, and selected tributaries, 2017 and 2018, and approximate locations of Selfridge ANG Base storm water outfalls to the river.

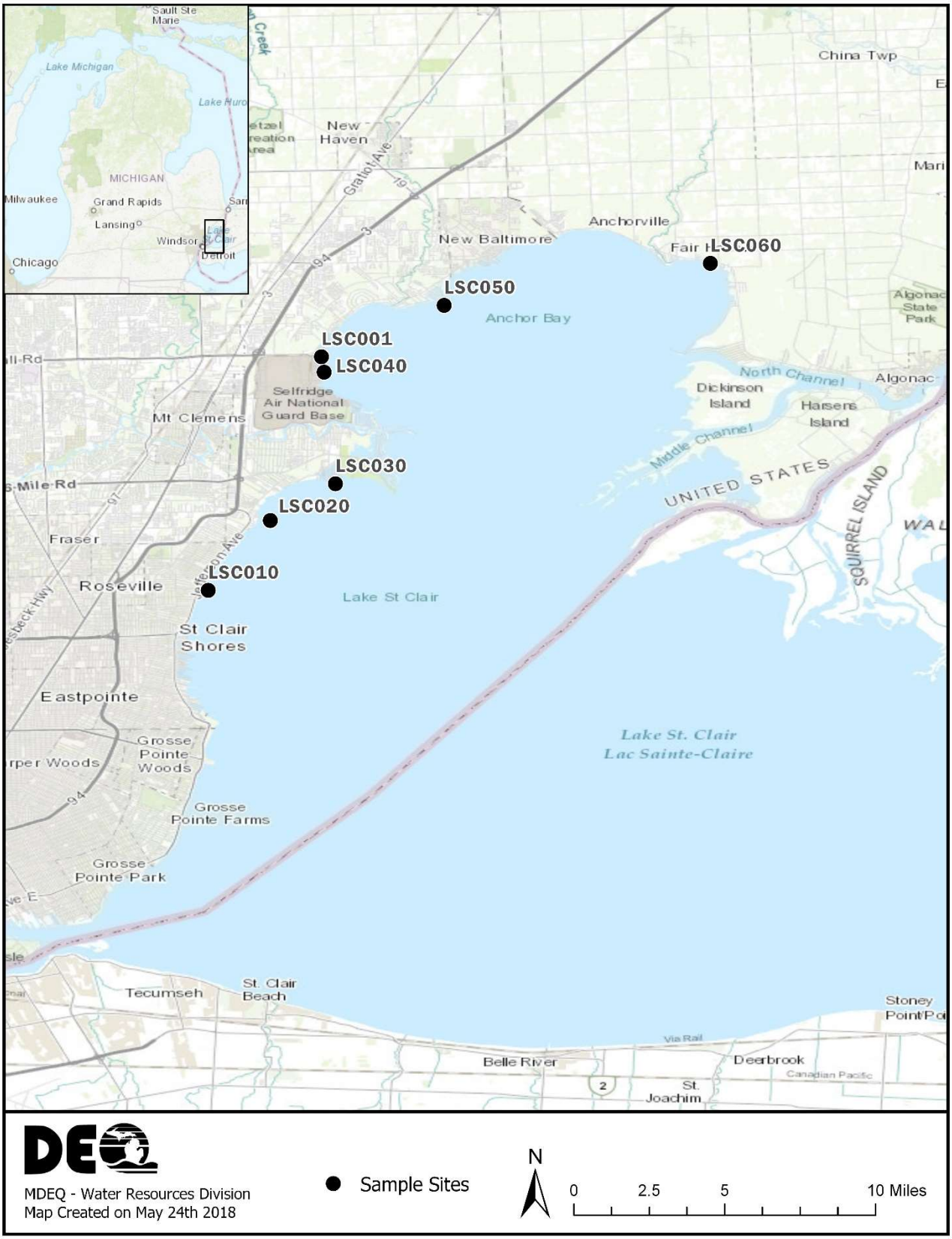


Figure 2. Surface water sampling sites on Lake St. Clair, 2017 and 2018.

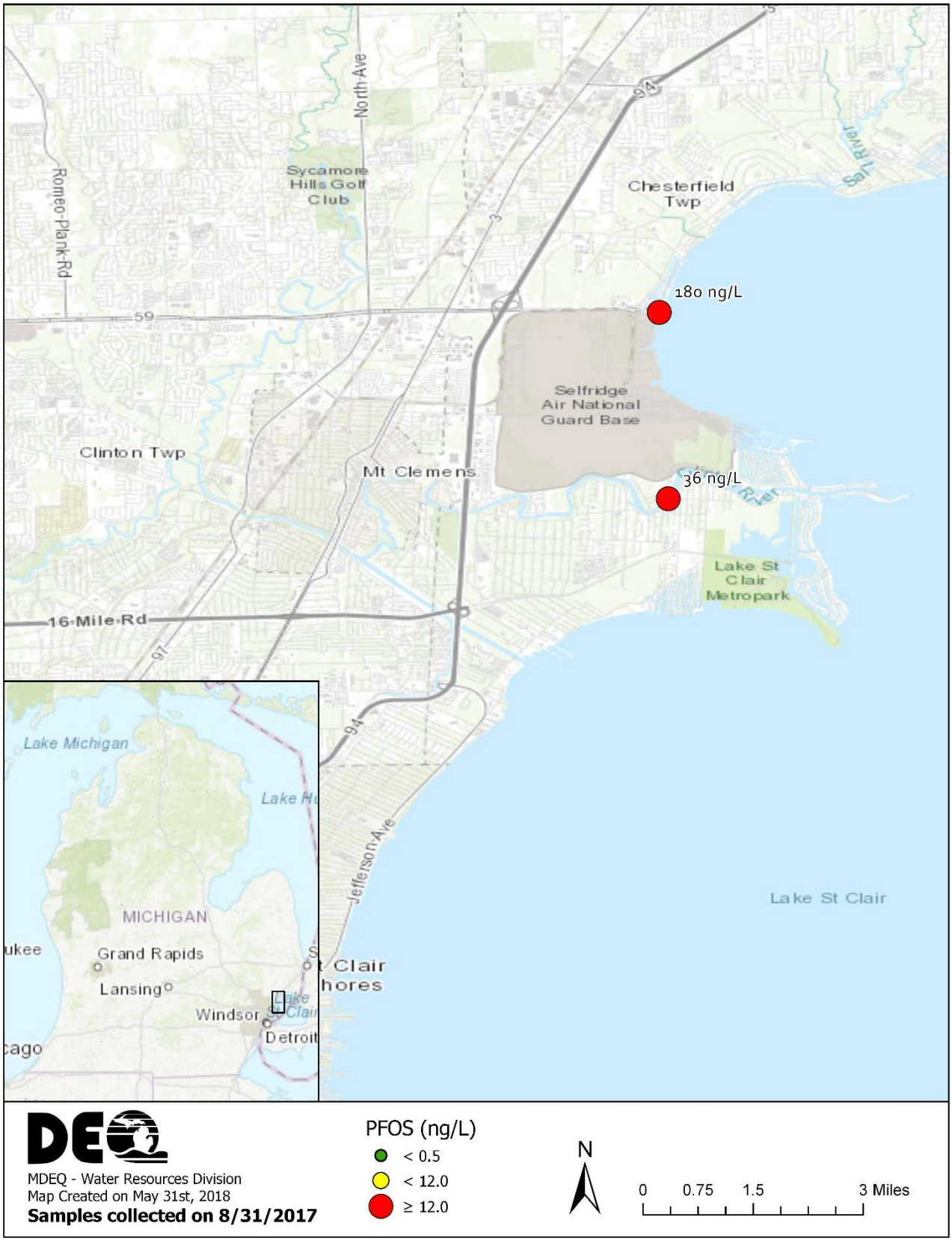


Figure 3. PFOS concentrations in surface water samples collected from the Clinton River and Lake St. Clair on August 31, 2017.

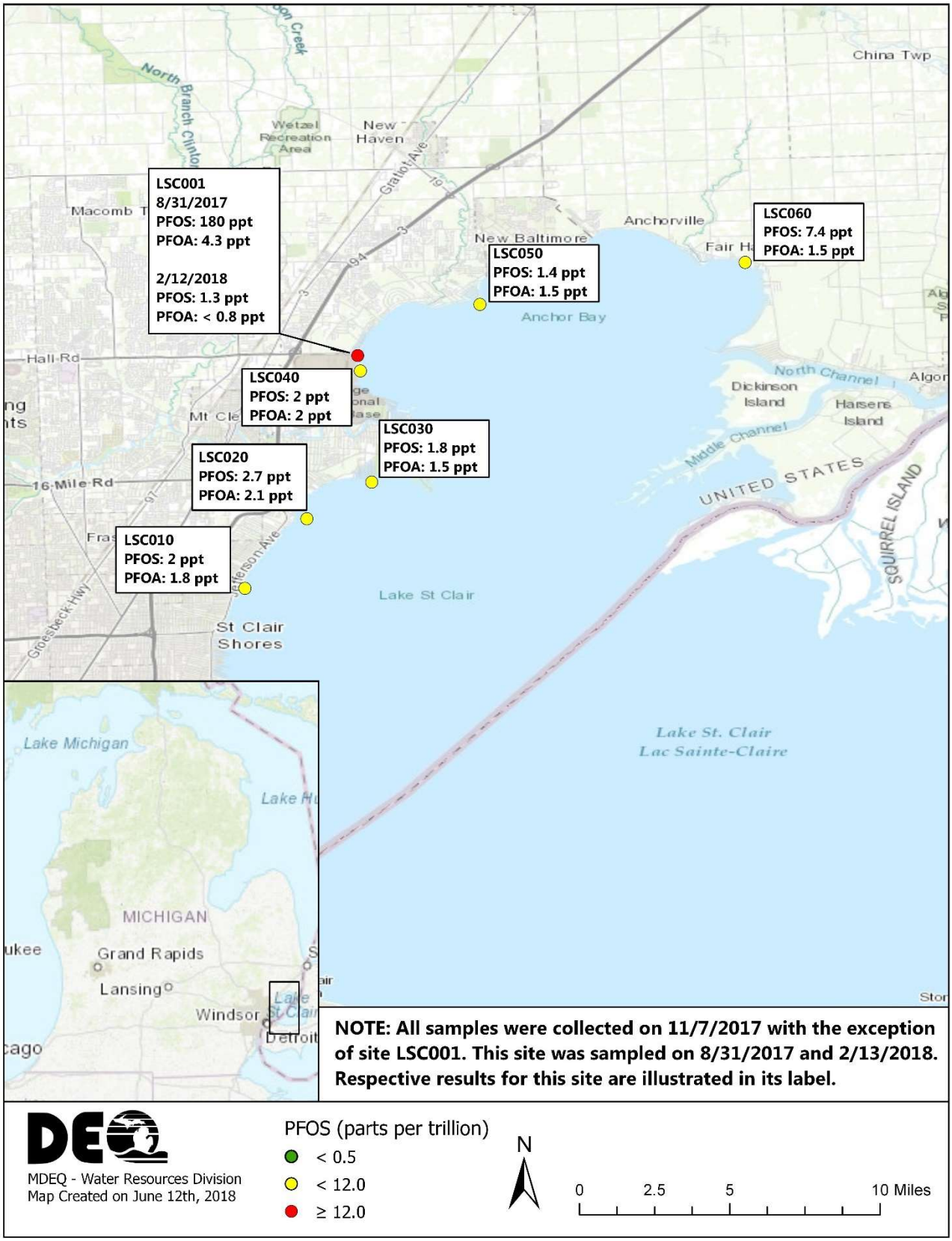


Figure 4. PFOS and PFOA concentrations in surface water samples collected from Lake St. Clair in 2017 and 2018.

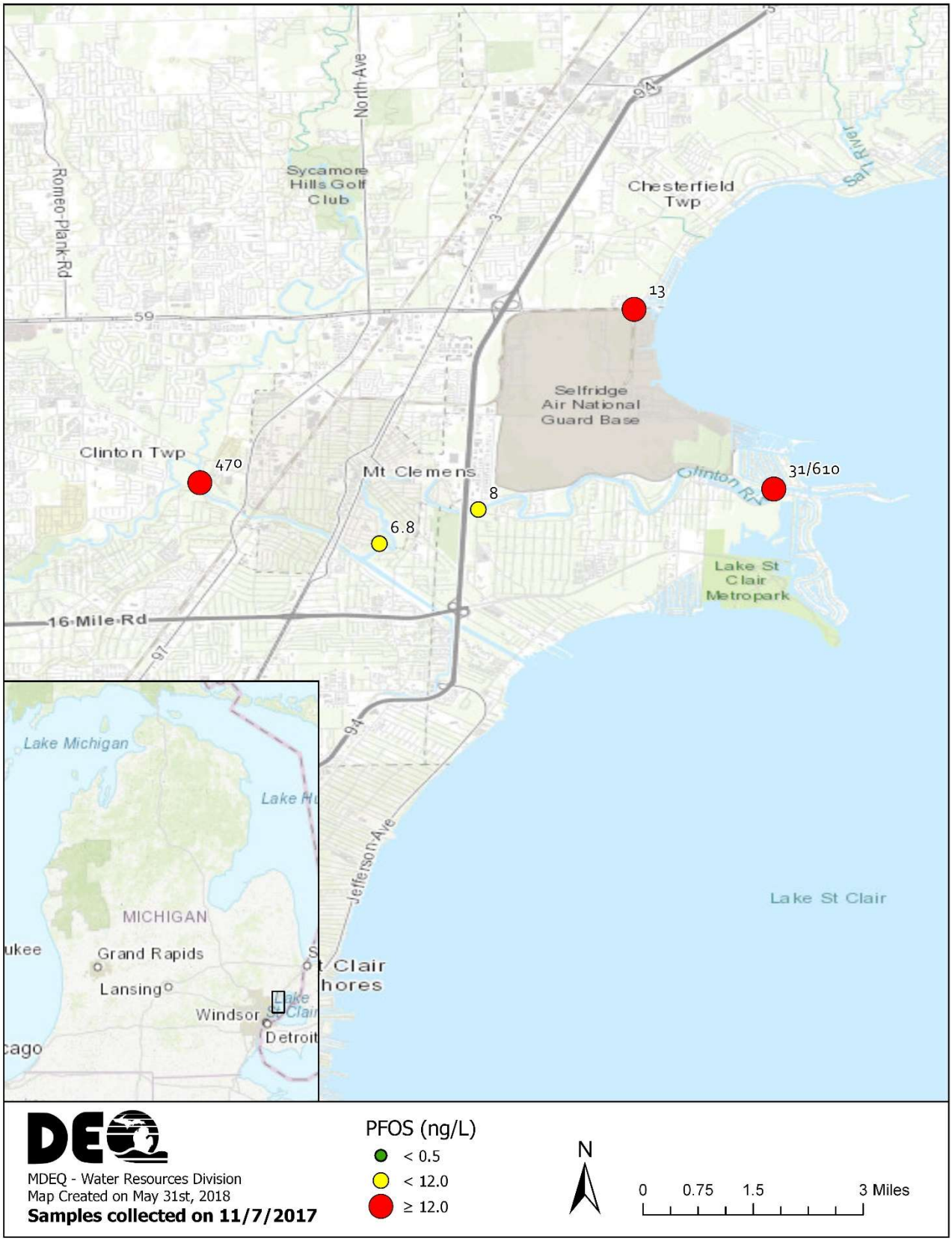


Figure 5. PFOS concentrations in surface water samples collected from the Clinton River on November 7, 2017.

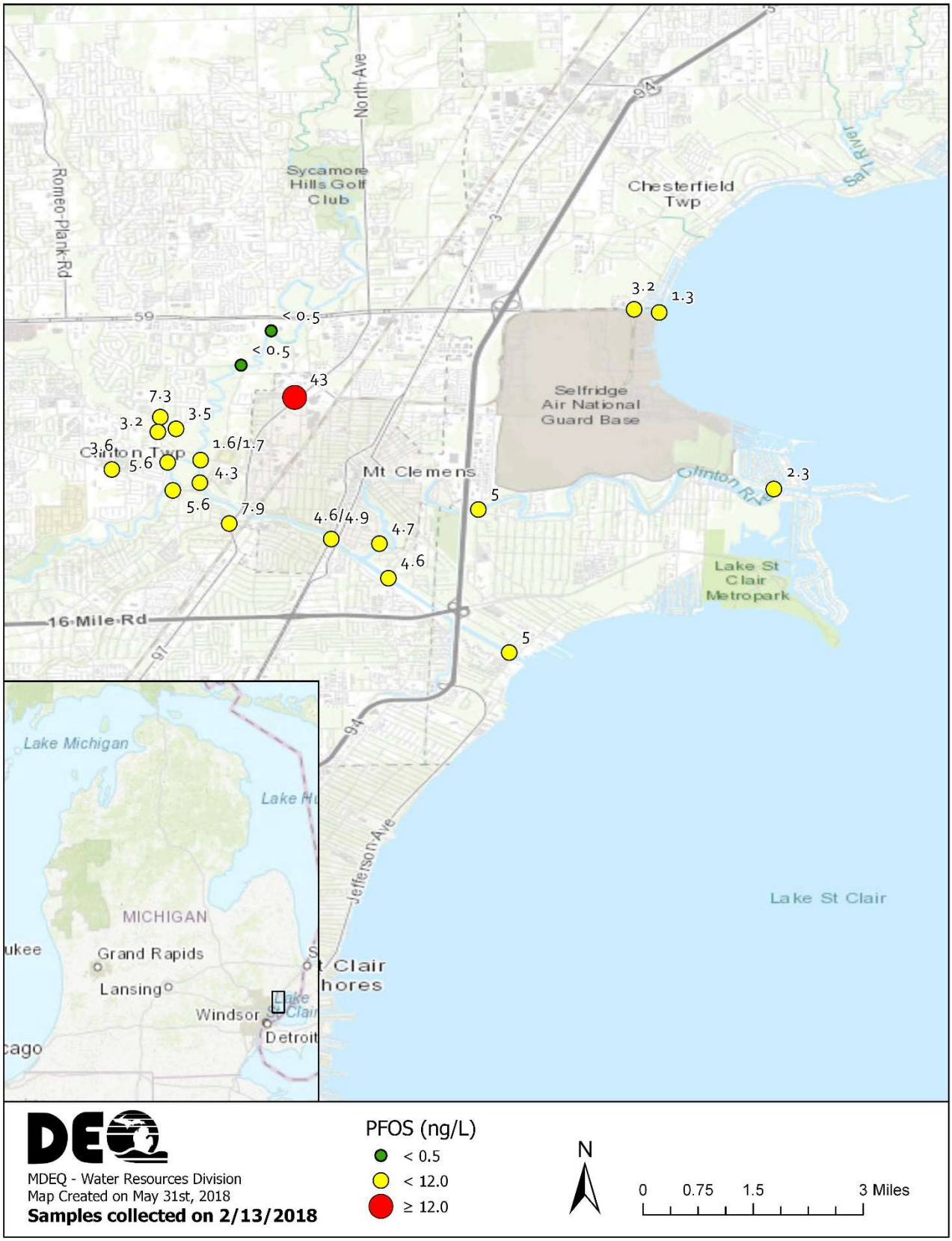


Figure 6. PFOS concentrations in surface water samples collected from the Clinton River, Lake St. Clair, and selected tributaries in February 2018.

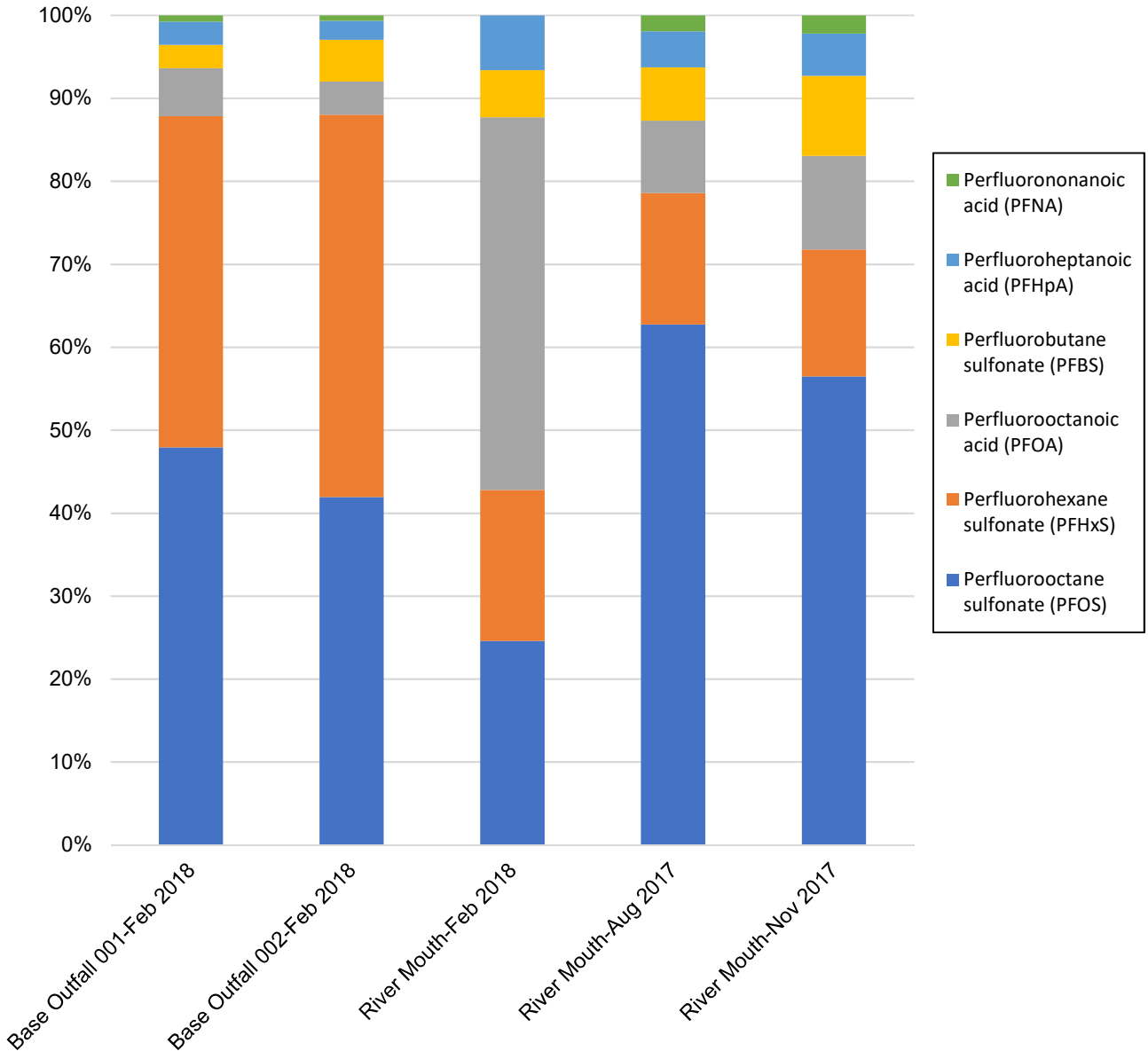


Figure 7. Percentage composition of PFAS measured in surface water collected at the Clinton River mouth compared to Selfridge ANG Base surface water runoff samples.