MiPEHS

Michigan PFAS Exposure & Health Study

Phase 2

Summary Report

MDHHS

Michigan Department of Health & Human Services

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MiPEHS continues to advance the science in PFAS and health.

The Michigan PFAS Exposure and Health Study (MiPEHS) is one of the first longitudinal research projects launched about per- and polyfluoroalkyl substances (PFAS) and health in the United States.

MiPEHS connects specific, local environmental PFAS contamination to blood PFAS levels in people to health effects. These connections are directly answering urgent public health questions about PFAS in Michigan.

This groundbreaking public health investigation not only fulfills MDHHS's obligations under the public health code but also advances public health policy and practice around PFAS.

Record numbers of Michiganders joined MiPEHS when it first launched in 2020. Many new and returning participants helped make Phase 2 a success. This report provides a summary of information from Phase 2 of this three-phase project.

For detailed information about MiPEHS Phases 1 and 2, please refer to:

- Phase 1 Summary Report: EH.Michigan.gov/MiPEHS-Phase1-Summary.
- MiPEHS Technical Appendix to Summary Reports with more information about the background and study design: EH.Michigan.gov/MiPEHS-Phase1-TechApp.
- Phase 2 Addendum Tables, which provide details and more results about the data presented in this Phase 2 Summary Report. The tables start on page 51: EH.Michigan.gov/MiPEHS-Phase1-TechApp.

A few explanations about this report:

MiPEHS is described as **longitudinal** because it follows participants over time. This is the second summary report, covering MiPEHS Phase 2. Data collection for Phase 2 took place during 2023. This report also makes comparisons to data collected during MiPEHS Phase 1 (2020-2021).

Blood **concentration** is used in this report to describe how much PFAS was measured in blood samples. PFAS was measured in the serum of blood samples provided by participants. **Serum** is the part of blood that is left over after blood cells and platelets are removed.

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Highlights

- Most participants had a history of drinking PFAS-contaminated drinking water. MiPEHS Phase 1 data showed they had elevated blood PFAS levels of many of the same PFAS found in their drinking water.
- Blood concentrations of many PFAS, including PFOS and PFOA, are **declining over time** among MiPEHS participants.
- Like most people in the U.S., MiPEHS Phase 2 participants have **detectable concentrations** of several PFAS in their blood, including PFOS and PFOA.
- On average, MiPEHS Phase 2 participants have **higher** blood PFOS and PFOA concentrations than the general U.S. population.
- **There is more to come!** Researchers continue analyzing data from Phases 1 and 2 while looking forward to Phase 3.

Over **980** people participated in MiPEHS Phase 2.

Nearly 80% of participants from Phase 1 of MiPEHS returned for Phase 2.

Belmont/Rockford Study Area

- Number of Participants: **564**
- Number of Females: **266 (52.84%)**
- Number of Males: **266 (47.16%)**
- Average age: **53 years old**
- Youngest participant(s): **6 years old**
- Oldest participant(s): **89+ years old**

Parchment/Cooper Township Study Area

- Number of Participants: **418**
- Number of Females: **230 (55.02%)**
- Number of Males: **188 (44.98%)**
- Average age: **53 years old**
- Youngest participant(s): **5 years old**
- Oldest participant(s): **89+ years old**

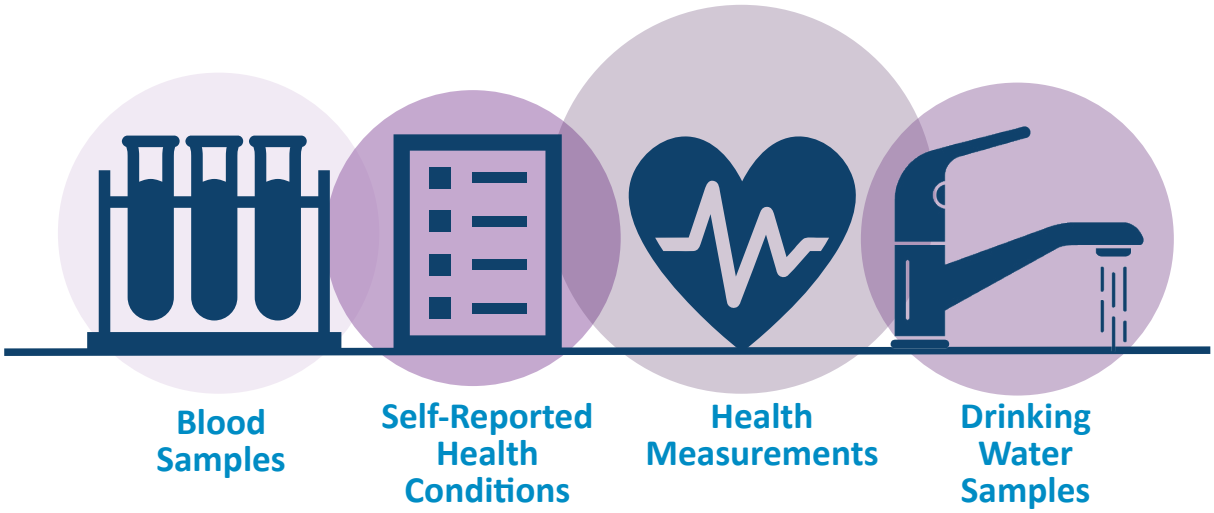
Note: Totals presented here do not always equal the total number of participants because some participants did not provide all their demographic information. Ages over 89 years are not reported to maintain participant privacy.

Information from MiPEHS will answer questions about PFAS and health.

MiPEHS is designed to answer questions about relationship(s) between blood PFAS concentrations and autoimmune, cardiovascular, kidney, liver, reproductive and thyroid health.

Researchers can answer these questions because of the data they collect during each phase of MiPEHS, which includes:

- Two types of blood samples: samples from their vein, which are tested for PFAS and health markers, and samples from a finger poke, which is only tested for PFAS.
- Body and blood pressure measurements.
- Answers to questions about past and current health, as well as past and current exposure to PFAS.
- Some households are also asked to provide a sample of their drinking water.



MiPEHS participants helped MDHHS researchers collect information about the following:

38 unique health markers (examples: cholesterol and thyroid hormones)

39 PFAS in blood (examples: PFOA, PFOS and PFHxS)

52 unique health questions (examples: diagnosis of diabetes, arthritis, or liver disease)

5 body measures (examples: blood pressure and body weight)

39 PFAS in water (examples: PFOA, PFOS and PFHxS)

MiPEHS Phase 2 participants' exposure to PFAS through drinking water was reduced before they joined MiPEHS.

Participants new to MiPEHS during Phase 2, or who had a change in their water supply since Phase 1, were asked to provide a sample of their home drinking water. Over 100 households provided a water sample during MiPEHS Phase 2.

When tested for PFAS, researchers found:

100% of drinking water samples had PFAS concentrations **below** current health-based comparison levels.[1]

[1]MDHHS health-based comparison levels are the lowest of Michigan Department of Environment, Great Lakes, and Energy (EGLE) maximum contaminant levels (MCLs) or MDHHS (2019) public health drinking water comparison levels for PFAS.

How is this information used?

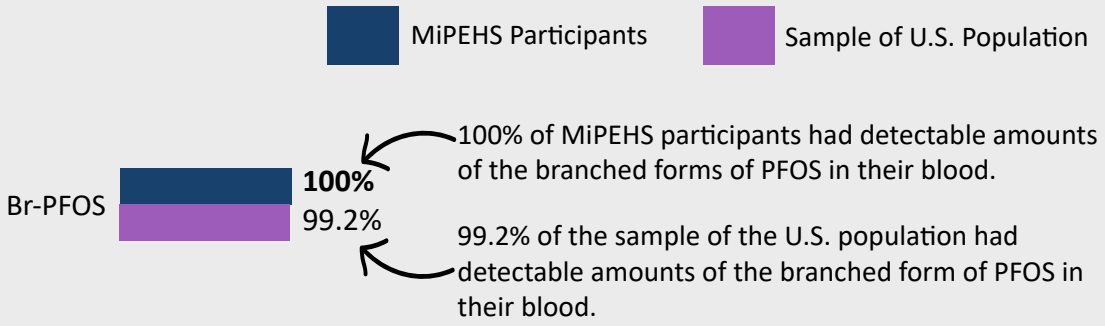
Researchers are comparing current drinking water PFAS test results to older, past drinking water PFAS test results. Knowing both the past and current PFAS drinking water concentrations that participants experienced helps researchers better understand the PFAS concentrations currently in the blood of participants.

Like most people in the U.S., MiPEHS Phase 2 participants had PFAS in their blood.

Understanding the information on the next page

Blood samples from MiPEHS Phase 2 participants were tested for 39 PFAS, which is more PFAS than most studies test. On the opposite page, you will see what percentage of MiPEHS participants had each of the 39 PFAS in their blood. You can find the name of each PFAS to the far left of each column. Among the general U.S. population, the Centers for Disease Control and Prevention (CDC) monitors 16 of the 39 PFAS measured in MiPEHS. For those 16 PFAS tested in both the general U.S. population and MiPEHS, you'll see how MiPEHS participants compare to the U.S. population. The CDC's National Health and Nutrition Examination Survey (NHANES) is the source of PFAS information for the general U.S. population and is used as a comparison throughout this report.

For example:



Conclusion: All MiPEHS participants had detectable amounts of Br-PFOS in their blood, which is similar to the sampled U.S. population.

Key Conclusions

- Nearly everyone who joined MiPEHS Phase 2 had some detectable amount of PFOA and PFOS in their blood. Some of those people had very little PFOA or PFOS in their blood and others had much more (see density plots in the next section). Almost everyone (more than 99%) in the U.S. population also has detectable amounts of PFOA and PFOS in their blood.
- Not all PFAS tested for were found in the blood of every MiPEHS participant. Very few people (fewer than 1%) who joined MiPEHS Phase 2 had a detectable amount of PFHxA or Gen X, for example.
- Of the 39 PFAS tested for, the average MiPEHS Phase 2 participant had 16 PFAS detected in their blood. The number of PFAS detected in MiPEHS participants ranged from 0 to 24 PFAS.

Which PFAS do we find in MiPEHS participants compared to the U.S. population?

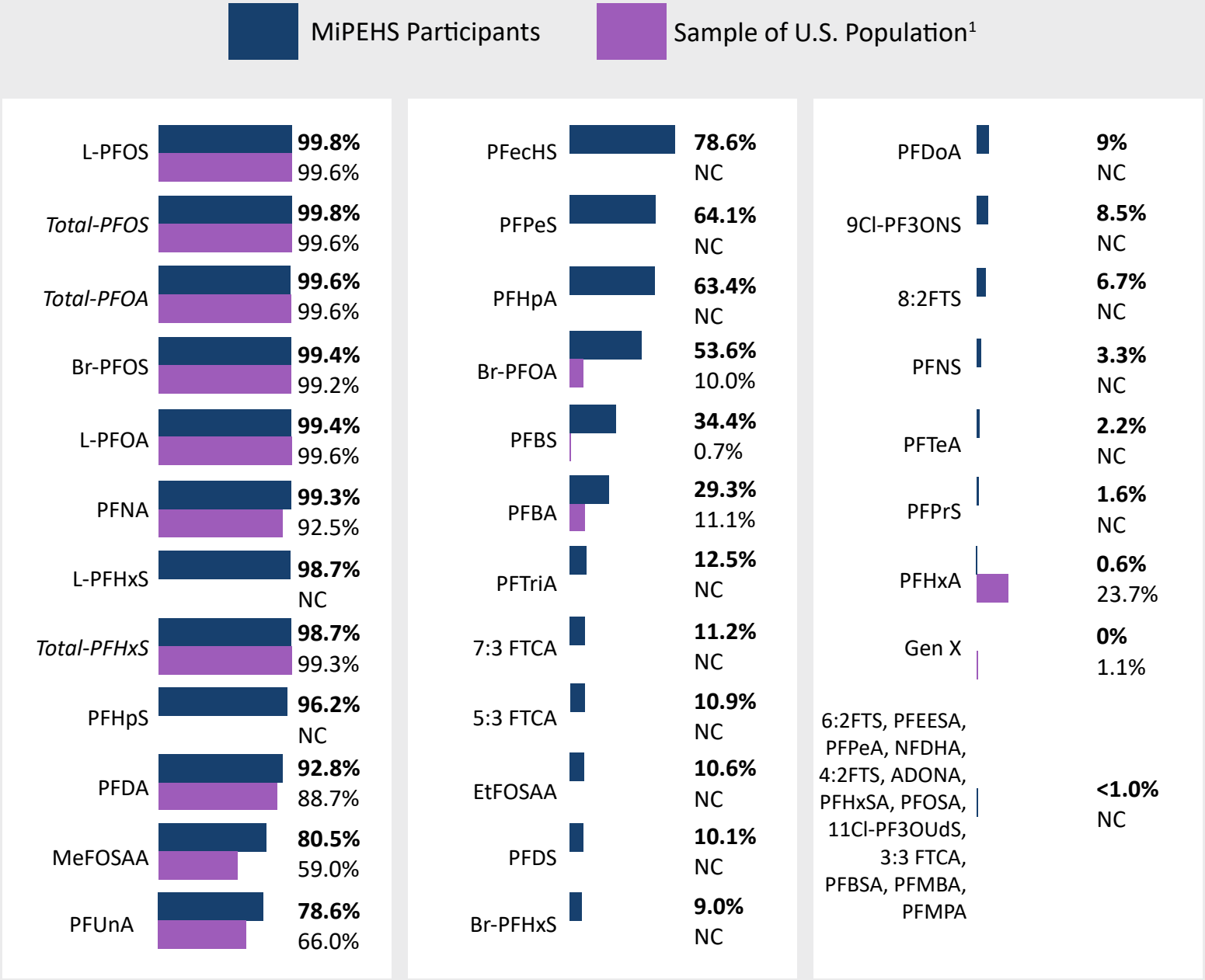


Table Notes:

MiPEHS participants from all study areas are included in the calculation of the percentages reported here.

[1]U.S. population (age 12 years or older) is estimated from NHANES data collected in 2017–2018, or the most recent year available.

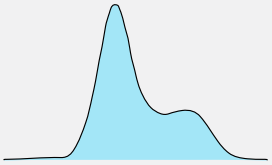
NC is used when no comparison is available, when PFAS were not tested, or the percentage calculation is not yet available from NHANES.

Italicized PFAS were measured in two different forms, or shapes: linear (L-) and branched (Br-). For these three PFAS (PFOS, PFOA and PFHxS), we can measure the amount of each of these two forms, plus their total.

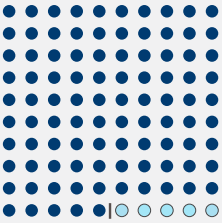
< means "less than." <1.0% reads as "less than 1.0%."

The abbreviations found on this page are defined on page 19 of this report.

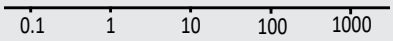
Understanding the plots used on pages 11 to 15.



The shaded curves are **density plots**. The height of the shaded area tells you the relative amount of people in each category listed on the bottom of the plot. **A taller shaded area represents more people than a shorter shaded area.**



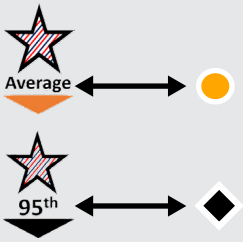
The **95th percentile** is the result that 95% of results are below and 5% of results are above. MiPEHS participants had a higher 95th percentile value than the U.S. population for PFOA and PFOS. This means the blood concentration that marks where the highest 5% of people fall is higher in MiPEHS participants compared to the U.S. population.



Results are shown on a logarithmic scale. A **logarithmic scale** is used to show a wide range of values in a compact way. On this type of scale, the distance between numbers is unequal and gets smaller as the numbers get bigger. See the numbers labeled on the bottom of each plot that span 0.1 to 1000 µg/L.

µg/L

Results are reported in **micrograms per liter** of blood (µg/L).



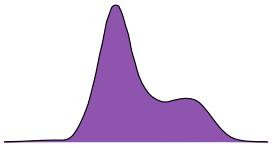
These plots compare the average and the 95th percentile concentrations of PFOS and PFOA from MiPEHS participants to a sample of people in the U.S. aged 12 years or older. The U.S. population averages and 95th percentiles come from the representative sample of people that joined NHANES.

Note:

Comparing the results of MiPEHS participants to NHANES can help put into perspective the impact that PFAS exposure has had on the blood PFAS concentrations of MiPEHS participants. Comparing results to NHANES does not tell us what health problems individual MiPEHS participants may be at risk for based on their blood PFAS concentrations.

On average, MiPEHS Phase 2 participants had higher blood PFOA and PFOS concentrations than the general U.S. population

Legend



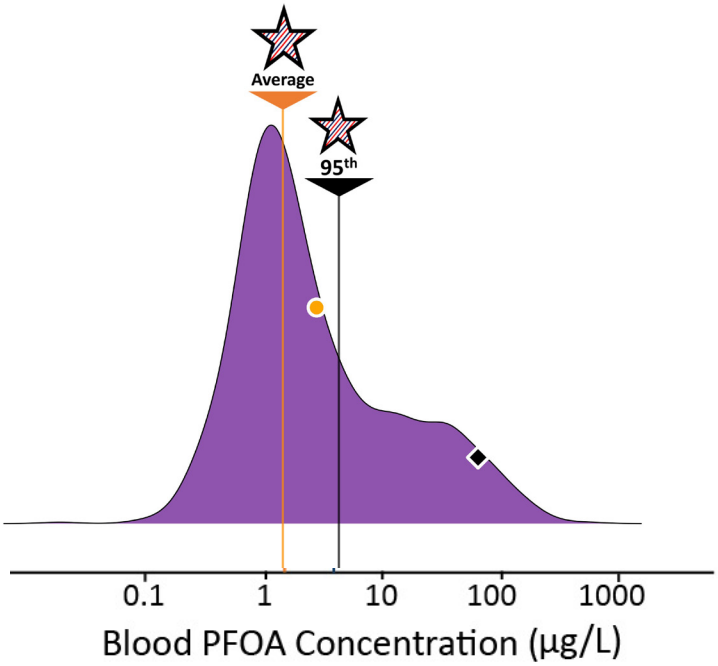
Average blood PFOA and PFOS concentration in **U.S. population from 2017 to 2018**

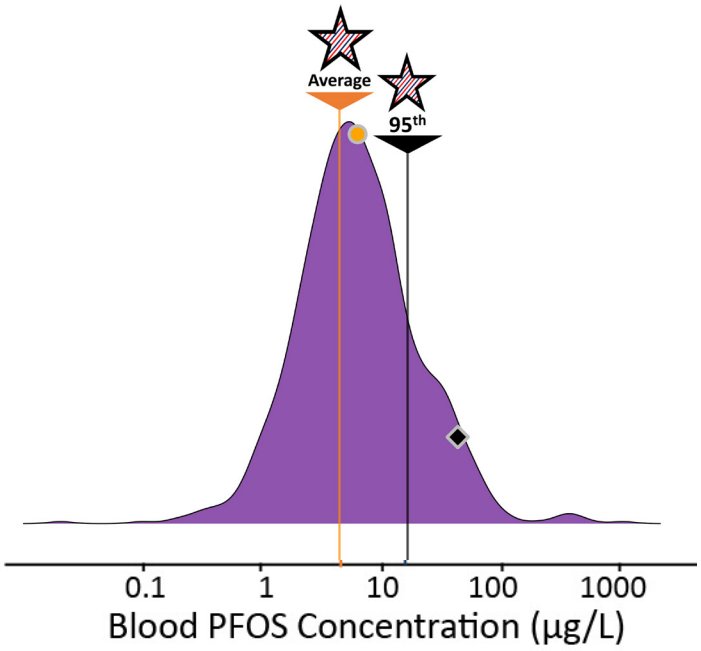
95th percentile of blood PFOA and PFOS concentrations in **U.S. population from 2017 to 2018**

Average blood PFOA and PFOS concentrations in **MiPEHS**

95th percentile of blood PFOA and PFOS concentrations in **MiPEHS**

Distribution of Blood PFOA and PFOS Concentrations among MiPEHS Phase 2 Participants





Key Conclusions

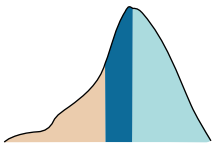
- The average concentrations of PFOA (2.52 µg/L) and PFOS (5.86 µg/L) in the blood of MiPEHS participants were higher than the average concentrations of PFOA (1.42 µg/L) and PFOS (4.25 µg/L) in the U.S. population.
- These results suggest that, as a group, MiPEHS Phase 2 participants tended to be more highly exposed to PFOA and PFOS compared to the general U.S. population. This finding aligns with what we know about their past exposure to PFAS from drinking water
- The high end of blood concentrations, represented by the 95th percentile, were also higher in MiPEHS participants for PFOA (42.7 µg/L compared to 3.77 µg/L) and PFOS (36.3 µg/L compared to 14.6 µg/L) than for other people in the U.S. population.

The average and 95th percentile blood PFOS and PFOA concentrations were different for participants in each MiPEHS study location.

Understanding the density plots on these pages

See page 10 of this report for more information about how to read density plots.
The legend on page 12 applies to all graphs on pages 12 and 13.

Legend


MiPEHS participants

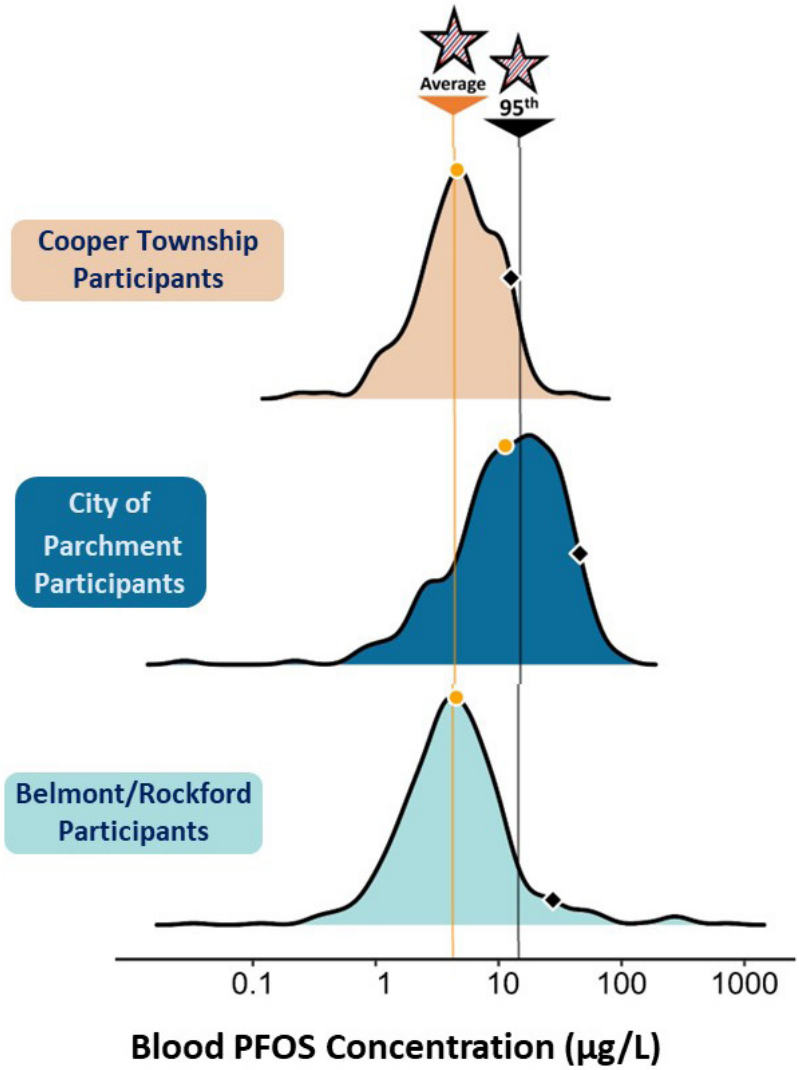
Average blood PFOA or PFOS concentration in **U.S. population from 2017 to 2018**

95th percentile of blood PFOA or PFOS concentrations in **U.S. population from 2017 to 2018**

Average blood PFOA or PFOS concentrations in **MiPEHS**

95th percentile of blood PFOA or PFOS concentrations in **MiPEHS**

Distribution of PFOS blood concentrations in MiPEHS participants from each location



Key Conclusions

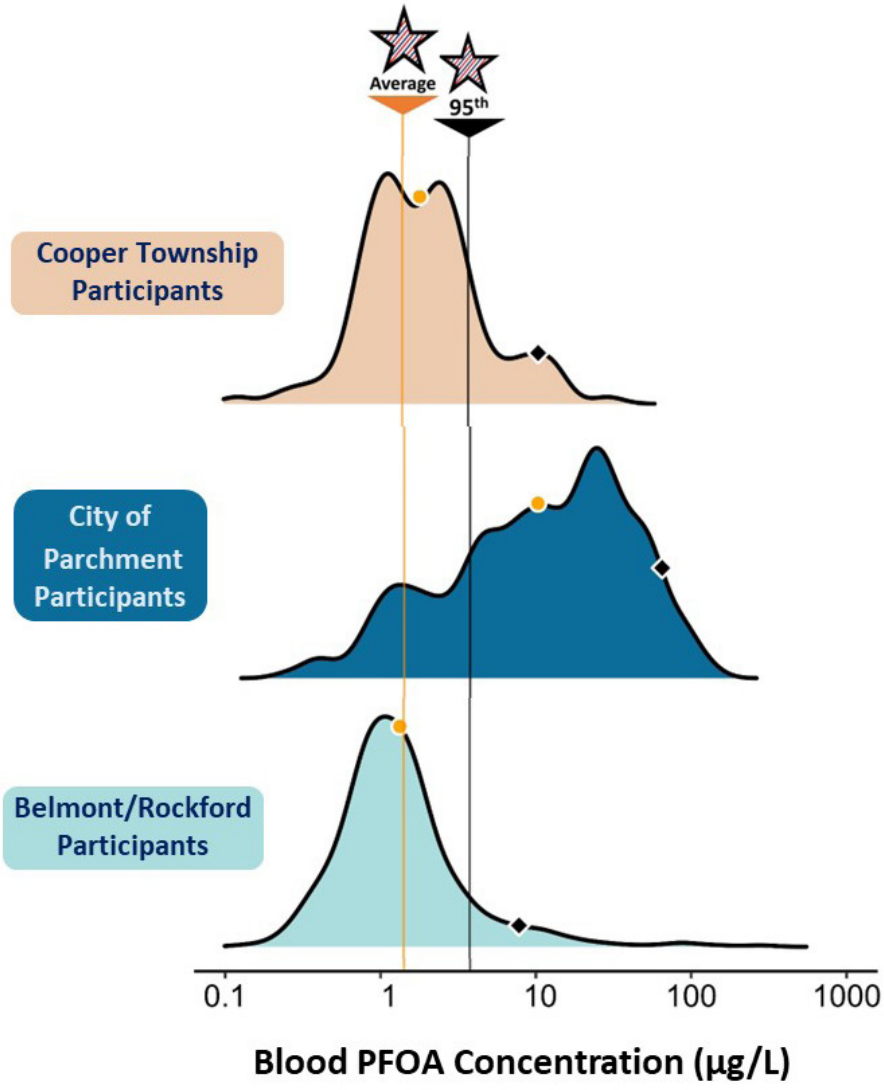
Orange Symbols

On average, MiPEHS participants have higher blood PFOS and PFOA concentrations than the general U.S. population.

Not every MiPEHS participant has more PFOS and PFOA in their blood compared to the average from the U.S. Many have much less. You can see this by looking at how much of the shaded area is on the left of the orange reference line.

More participants from the City of Parchment had elevated blood PFOS and PFOA concentrations compared to the other study areas. See how more of the dark blue shaded area is to the right of the orange reference line compared to the other plots.

Distribution of PFOA blood concentrations in MiPEHS participants from each location



A closer look:

The 95th percentile of PFOA blood concentration for City of Parchment MiPEHS participants is shown to the left.

Look at the middle, shaded plot on this page for blood PFOA concentrations from City of Parchment participants.

Follow the black diamond all the way to the numbers at the bottom. The black diamond on the City of Parchment participant's plot corresponds to 64.8 µg/L. That means 5% of City of Parchment participants have 64.8 µg/L or more PFOA in their blood.

Compare the black diamond to the black line for the U.S. population on the same plot which is found at 3.77µg/L. That means 5% of the U.S. population has 3.77 µg/L or more PFOA in their blood.

Key Conclusions

- The 95th percentiles of blood PFOS and PFOA concentrations from MiPEHS participants are higher in all three study areas than they are in the U.S. population.
- The biggest difference in 95th percentiles for PFOS and PFOA in MiPEHS compared to the U.S. population is seen in the City of Parchment study area.
- The 95th percentiles for each study area have decreased since Phase 1 of MiPEHS.

Blood PFAS concentrations go down over time.

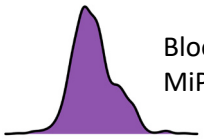
PFAS leave the body. PFAS are sometimes called "forever chemicals" because they do not break down easily in the environment or the human body. However, PFAS do not stay in the body forever – concentrations of PFAS in blood start to go down once exposure ends. PFAS leave the body on a regular basis which reduces blood PFAS concentrations going down over time.

For the first time during MiPEHS we could look at the change in blood PFAS concentration over time for our population as a whole and on an individual basis.

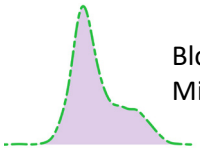
Change in PFAS among the MiPEHS population.

- Nearly 80% of participants returned for Phase 2, which means a lot of data is available for understanding changes in blood concentrations that happened from the first phase of MiPEHS to the second phase of MiPEHS.
- When comparing the distribution of blood PFAS concentrations in participants from Phase 1 to Phase 2, there has been a shift to lower concentrations.

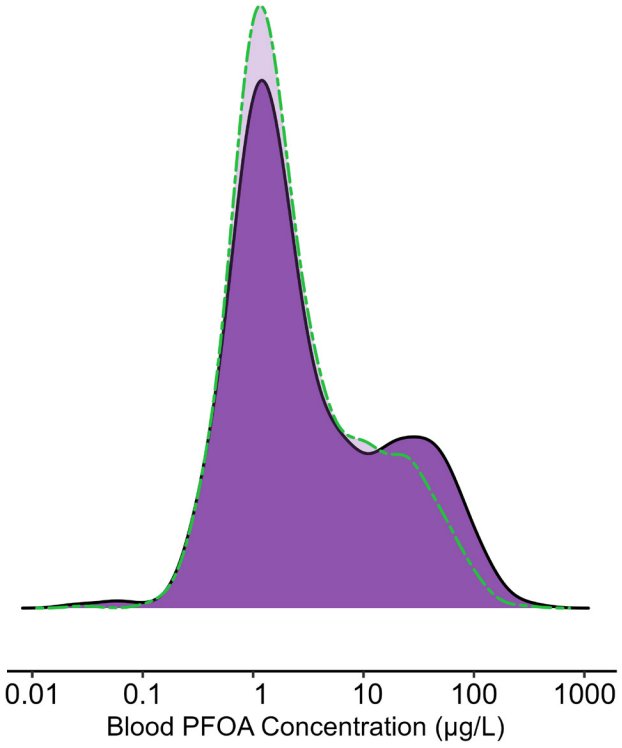
Legend

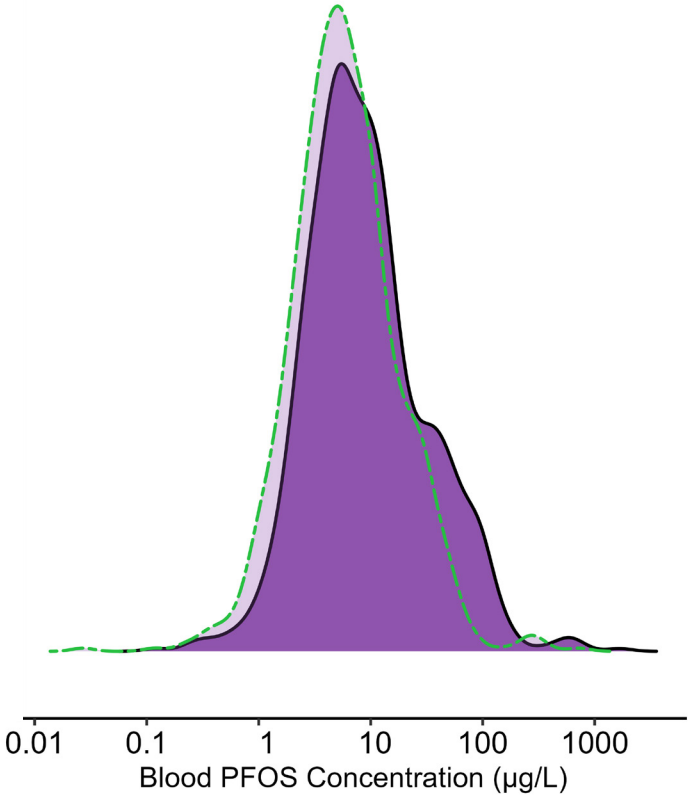


Blood concentrations of PFAS for all MiPEHS participants from Phase 1



Blood concentrations of PFAS for all MiPEHS participants from Phase 2





Understanding the density plots on these pages

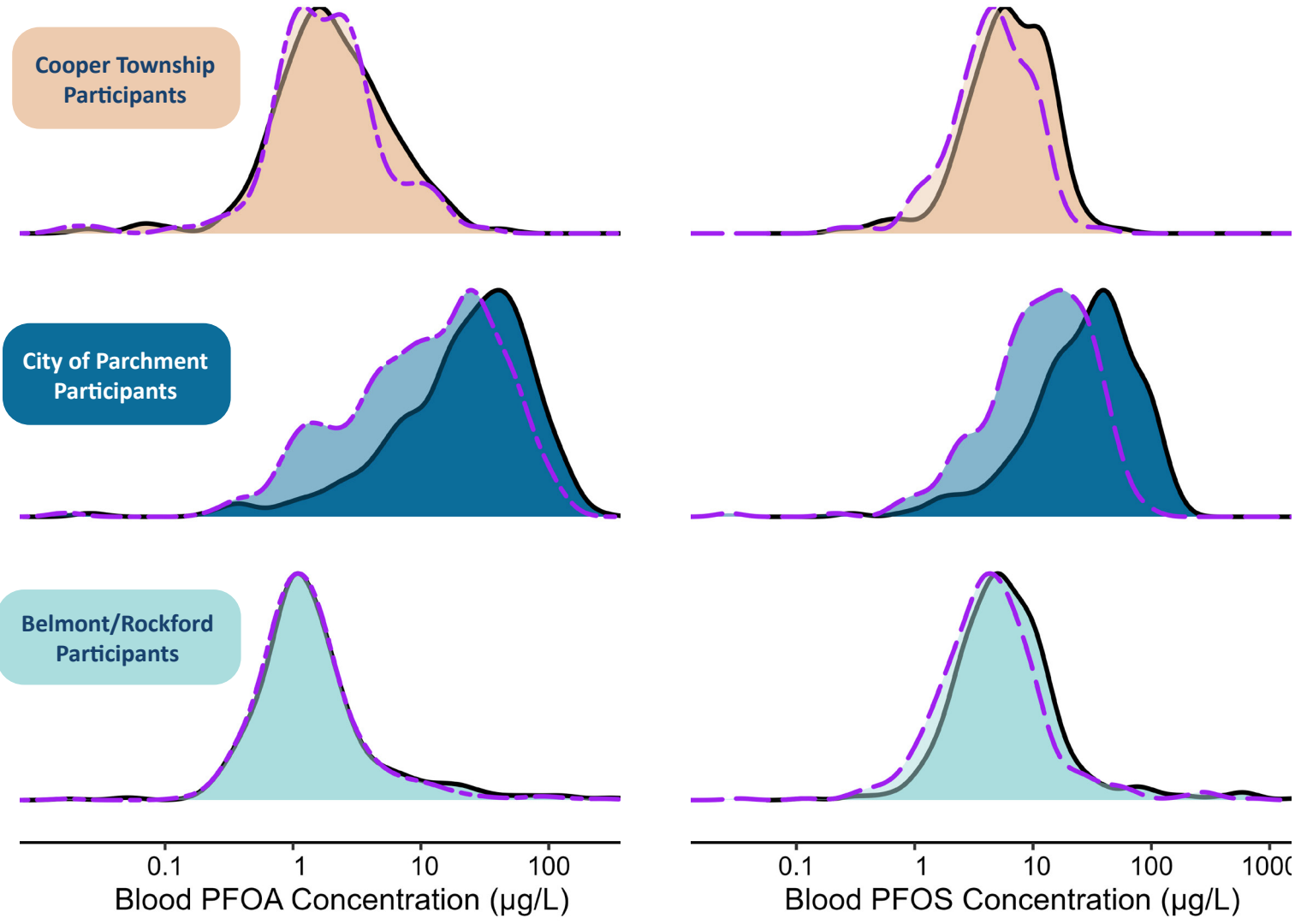
See page 10 of this report for more information about how to read density plots.

Change in PFAS among participants from each study area.

Legend

Blood concentrations of PFAS for MiPEHS participants from Phase 1 are shown with the solid black lines

Blood concentrations of PFAS for MiPEHS participants from Phase 2 are shown with the purple dashed lines



Key Conclusions

- Overall, the amount of PFOA and PFOS in participants decreased between Phase 1 and Phase 2.
- The largest decrease was seen in the City of Parchment participants who previously used water from the City of Parchment before PFAS contamination was discovered and addressed.

The reduction in PFOS concentrations depended on how much was in participants' blood during Phase 1.

The change in PFOS blood concentrations between Phases 1 and 2 is shown for participants from four groups of Phase 1 blood concentrations. Participants with the lowest Phase 1 concentrations are at the bottom, and those with the most are at the top.

Legend

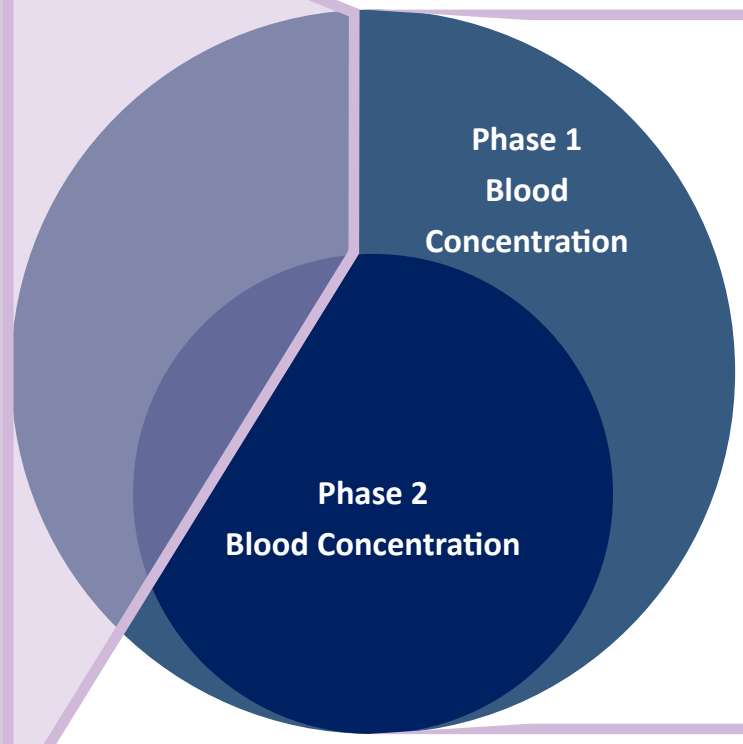
Understanding the graphics on page 17

The overall size of the circles shows the relative amount of PFOS in participants' blood.

- The **larger** the circle, the more PFOS was found in the blood.
- The **bigger the difference** in size from the outside circle to the inside circle shows how large the percent reduction in blood levels was from Phase 1 to Phase 2.

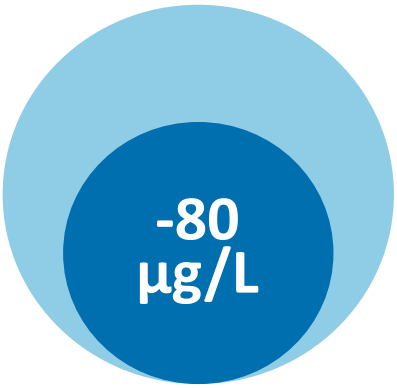
The change in size from the **outside circle (Phase 1)** to the **inside circle (Phase 2)** depicts the **relative reduction in blood concentrations over time**.

The numerical value of this change is included inside each inner circle. Negative numbers indicate a decrease in blood PFAS concentrations.

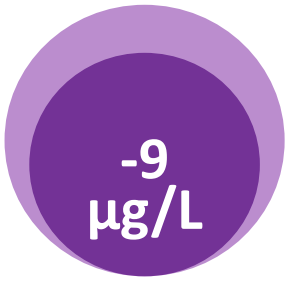


The overall relative size of the circles depicts **the amount of PFOS in blood.**

Note: Circle diagrams are stylized and not to scale. For data on other PFAS see Phase 2 Addendum Table A6 in the MiPEHS Technical Appendix.



Some participants (24 people) had PFOS blood concentrations during Phase 1 **greater than 100 µg/L**. These participants saw an average **reduction of about 80 ug/L**, or 55%, over time from Phase 1 to Phase 2 of MiPEHS.



Many participants (284 people) had PFOS blood concentration during Phase 1 **between 10 and 100 µg/L**. These participants saw an average **reduction of about 9 ug/L**, or 46%, over time from Phase 1 to Phase 2 of MiPEHS.

Most participants (360 people) had PFOS blood concentration during Phase 1 **between 1 and 10 µg/L**. These participants saw an average **reduction of about 1 ug/L**, or 30%, in their blood PFOS levels over time from Phase 1 to Phase 2 of MiPEHS.

Few participants (13 people) had PFOS blood concentration during Phase 1 **between 0.1 and 1 µg/L**. These participants saw an average **reduction of about 0.1 ug/L**, or 18%, in their blood PFOS levels over time from Phase 1 to Phase 2 of MiPEHS.

Participants that joined both Phase 1 and 2 saw a decrease in their blood PFOS concentration. The size of this decrease depended on how high the participants' blood concentrations were during Phase 1. Participants with higher starting concentrations saw the greatest reduction in their blood concentrations.

Key Conclusions

- MiPEHS Phase 2 data show that communities benefit when MDHHS **identifies** a source of PFAS, **investigates** that PFAS exposure and **intervenes** to reduce further exposures.
- MiPEHS Phase 2 data suggest **preventing further new exposures reduces harm from environmental contamination**. MiPEHS data show this in the declining blood PFAS levels of study participants.

MiPEHS will continue for several years.

1 MiPEHS Phase 1 (2020–2021)

MiPEHS Phase 1 was completed in 2021. A Summary Report[1] is available on the MiPEHS website and shows demographics and blood PFAS concentrations from MiPEHS Phase 1 participants. More analysis of the collected data is underway.

2 MiPEHS Phase 2 (2023)

This summary report shares demographics and blood PFAS concentrations from MiPEHS Phase 2 participants. Analyses on health effects are ongoing. Once finished, MDHHS will make all reports and articles freely available on the MiPEHS website (Michigan.gov/DEHBio).

3 MiPEHS Phase 3 (2025)

MiPEHS is a longitudinal study, and Phase 3 is the final phase. Enrollment for Phase 3 began January 2025. When participants join all three phases, researchers can examine how certain PFAS in blood change over time, how certain health markers change over time and much more. Some of the questions that MiPEHS asks will be answered best by combining data from all three phases, so some conclusions will have to wait until all data collection and analysis phases have ended.

List of Abbreviations

11Cl-PF3OUDS	11-Chloroeicosalfluro-3-oxaundecane-1-sulfonic acid
3:3 FTCA	2H,2H,3H,3H-perfluorohexanoic acid (3-perfluoropropyl propanoic acid)
4:2 FTS	4:2 Flurotelomer Sulfonic Acid
5:3 FTCA	2H,2H,3H,3H-perfluorooctanoic acid (3-perfluoropentyl propanoic acid)
6:2 FTS	6:2 Flurotelomer Sulfonic Acid
7:3 FTCA	2H,2H,3H,3H-perfluorodecanoic acid (3-perfluoroheptyl propanoic acid)
8:2 FTS	8:2 Flurotelomer Sulfonic Acid
9Cl-PF3ONS	9-chlorohexadecafluro-3-oxanone-1-sulfonic Acid
ADONA	4,8-dioxa-3H-perfluorononanoic Acid
EHB	Environmental Health Bureau
EtFOSAA	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid
GenX (HFPO-DA)	Hexafluoropropylene oxide dimer
MDHHS	Michigan Department of Health and Human Services
MiPEHS	Michigan PFAS Exposure and Health Study
NFDHA	Nonafluoro-3,6-dioxaheptanoic Acid
NHANES	National Health and Nutrition Examination Survey
N-MeFOSAA	N-methylperfluorooctanesulfonamidoacetic Acid
PCB	Polychlorinated biphenyl
PFAS	Per- and Polyfluoroalkyl Substances
PFBA	Perfluorobutanoic Acid
PFBS	Perfluorobutane Sulfonic Acid
PFBSA	Perfluorobutane Sulfonamide
PFDA	Perfluorodecanoic Acid
PFDoA	Perfluorododecanoic Acid
PFDS	Perfluorodecane Sulfonic Acid
PFEESA	Perfluoro(2-ethoxyethane) sulfonic Acid
PFHxA	Perfluorohexanoic Acid
PFHxS	Perfluorohexane Sulfonic Acid
PFHxSA	Perfluorohexane sulfonamide
PFMBA	Perfluoro-4-methoxybutanoic Acid
PFMPA	Perfluoro-3-methoxypropanoic Acid
PFNA	Perfluorononanoic Acid
PFNS	Perfluorononane Sulfonic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
PFOSA	Perfluorooctane sulfonamide
PFPeA	Perfluoropentanoic Acid
PFPeS	Perfluoropentane Sulfonic Acid
PFPrS	Perfluoropropane Sulfonic Acid
PFTeA	Perfluoroetradecanoic Acid
PFTriA	Perfluorotridecanoic Acid
PFUnA	Perfluoroundecanoic Acid
µg/L	micrograms per liter

References

Additional information is available to support and expand upon the information contained in this Phase 2 summary report.

1. **Phase 1 Summary Report**: Michigan Department of Health and Human Services Environmental Health Bureau. Phase 1 Summary Report. Michigan.gov. Published April 2023. EH.Michigan.gov/MiPEHS-Phase1-Summary.

2. **Technical Appendix to the Phase 1 Summary Report**: Michigan Department of Health and Human Services Environmental Health Bureau. Phase 1 Technical Appendix to the Summary Report. Michigan.gov. Published April 2023. EH.Michigan.gov/MiPEHS-Phase1-TechApp.

3. **Phase 2 Addendum Tables**: Michigan Department of Health and Human Services Environmental Health Bureau. [Phase 1 Technical Appendix to the Summary Report. Michigan.gov. Published April 2023. EH.Michigan.gov/MiPEHS-Phase1-TechApp].

For more information

- Visit Michigan.gov/DEHBio.
  - Click on the MiPEHS icon.
- Call MDHHS to talk to the research team:
  - 844-464-7327.
  - Monday through Friday, 9 a.m. to 6 p.m.
- Email the research team:
  - MDHHS-PFASHealthStudy@Michigan.gov.

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Thank you!

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MiPEHS
Michigan PFAS Exposure & Health Study

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MDHHS
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