STATE OF MICHIGAN
DEPARTMENT OF HEALTH AND HUMAN SERVICES
LANSING

RICK SNYDER
GOVERNOR

NICK LYON
DIRECTOR

March 11, 2016

Denise Bryan, Health Officer
District Health Department #2
630 Progress Street
West Branch, MI 48661

Dear Ms. Bryan:

This letter is in response to your request that the Michigan Department of Health and Human Services (MDHHS) evaluate perfluorinated chemical (PFC) concentrations detected in private drinking water wells near the former Wurtsmith Air Force Base (WAFB) and the municipal water system (Huron Shores Regional Utility Authority [HSRUA]) in Oscoda (Iosco County), Michigan. MDHHS previously evaluated PFCs detected in four private drinking water wells in Oscoda in 2015. Additional water sampling has occurred since then, including samples collected from two Type 1 water-supply wells at a mobile home park and from HSRUA, which gets its water from Lake Huron.

This letter focuses on the drinking water pathway, although other exposure pathways are likely present near WAFB: PFC contamination at the former base has impacted on-site soils, groundwater, surface water, and some area fish and wildlife.

Total PFC concentrations in the private wells and the mobile home park wells ranged up to 249 parts per trillion (ppt). Treated water from HSRUA had 6.7 ppt total PFCs and is considered to be anthropogenic (i.e., caused by human activity) background. Although the U.S. Environmental Protection Agency (EPA) has Provisional Health Advisory Levels (which address short-term drinking water exposure) for two specific PFCs, there are no final EPA or State of Michigan drinking water standards for these chemicals at this time.

MDHHS has concluded that continued exposure to PFCs in groundwater-derived drinking water near WAFB could harm human health. This is based on the following facts:

- There is a completed exposure pathway connecting the release of PFCs at WAFB to residents that use the PFC-contaminated groundwater as their drinking water source.
- The various PFC release areas at the base have not been fully characterized or controlled.
- Concentrations of PFCs in the drinking water wells are higher than in the municipal system, which obtains its water supply from Lake Huron.
- Animal and laboratory research has shown that PFCs can adversely affect the thyroid, liver, immune system, and developing fetus and neonate.
- Studies of human populations have linked PFC exposure to negative health outcomes such as lowered immune response and certain cancers.
- PFCs are persistent in the environment and build up in the food chain.

- ❖ Some PFCs have long half-lives in humans, meaning they can build up and remain in the human body for many years.

MDHHS's conclusion is limited by:

- the small number of drinking water well samples taken so far (only two Type 1 water-supply and 24 private residential wells at this time),
- uncertainty about the magnitude of past exposure,
- uncertainty about the duration of any past exposure,
- lack of a comprehensive knowledge base of PFC toxicity,
- lack of predictability about the groundwater plumes and how PFC concentrations could change, and
- the likelihood and magnitude of other exposures (consumption of local fish or wild game).

MDHHS recommends the following actions be conducted by the appropriate agencies and responsible party for the protection of public health:

- ➢ Sample remaining drinking water wells that are downstream of WAFB.
- ➢ Prevent exposure to site-related PFCs in the drinking water.
- ➢ Control PFC contamination at WAFB so that PFCs do not continue to enter drinking water wells.

The attached technical review details the supporting information for the conclusion above. Please contact MDHHS toxicologist Christina Bush at bushc6@mi.gov or 517-335-9717 if you have questions about the review.

In closing, thank you for continuing to partner with MDHHS in striving to protect the public health from environmental contamination.

Sincerely,

Nick Lyon
Director

NL:jb

Enclosure

CC: James Baier, Oscoda Township Supervisor
Agency for Toxic Substances and Disease Registry (ATSDR), Division of Community Health Investigations
ATSDR, Region 5 Office
Mary Ann Dolehanty, Michigan Department of Environmental Quality (MDEQ), Office of Drinking Water and Municipal Assistance Chief
Robert Wagner, MDEQ, Division of Remediation and Redevelopment Chief
David Strainge, U.S Air Force Civil Engineering Center

Technical Review Evaluating Perfluorinated Chemicals (PFCs) in Drinking Water Wells near the former Wurtsmith Air Force Base in Oscoda (Iosco County), Michigan

Prepared by Christina Bush, Toxicologist
Michigan Department of Health and Human Services, Division of Environmental Health
March 8, 2016

Perfluorinated chemical (PFC) contamination exists in on-site soils and groundwater monitoring wells at the former Wurtsmith Air Force Base (WAFB, see Figure 1) in Oscoda, Michigan, due to the use of PFC-containing Aqueous Film-Forming Foam (AFFF, a fire-fighting foam) for training and crash response at the base (MDHHS 2016). The area of highest contamination is at the fire-training site in the southwest portion of the base property, but there are documented release sites elsewhere at WAFB (Figure 2). These other sites have not yet been fully characterized, nor have steps been taken to remediate them. The PFC contamination has impacted some area fish and wildlife (MDHHS 2012a, b; MDHHS 2015c).

The contaminated groundwater has migrated off the base (Figure 3). On-site groundwater monitoring wells on the east side of WAFB (Figure 4) had detections of perfluorooctane sulfonate (PFOS), one of the PFCs in the AFFF used at the base, ranging from 3.6 to 20,000 parts per trillion (ppt; Table 1). There was concern that area drinking water wells could be impacted by the groundwater plumes.

In September 2015, the Michigan Department of Environmental Quality (MDEQ) Remediation and Redevelopment Division (RRD), which has regulatory oversight of cleanup at WAFB, identified two Type 1 drinking water wells at a mobile home park near the base. The U.S. Air Force (USAF) and RRD sampled the wells for PFCs (Table 2), sending their samples to separate laboratories. The analytical results indicated detections of up to 12 PFCs (Table 3).[1] The owner has been notified of the results.

Following the discovery of PFCs in the drinking water at the mobile home park, USAF initiated a potable well survey, to identify and sample residential drinking water wells that may be impacted by contamination from the base (Figure 5). USAF and RRD sampled 24 wells concurrently (in December 2015) and sent the samples to separate laboratories. The analytical results indicated detections of up to 14 PFCs (Table 3). Notifications have been sent to the property owners, along with an MDHHS fact sheet helping people understand their well test results.

During the potable well survey, MDHHS requested that water from the public water system that serves Oscoda (Huron Shores Regional Utility Authority [HSRUA]) be sampled and analyzed

[1] MDEQ and the USAF used separate laboratories for the drinking water analyses. The laboratories' analyte lists differ slightly, as shown in Table 2.

for PFCs. The MDEQ Office of Drinking Water and Municipal Assistance (ODWMA) obtained water samples from HSRUA in December 2015. The analytical results indicated detections of 6 PFCs (Table 3). ODWMA has notified HSRUA of the results.

It is not surprising that PFCs were detected in the samples taken at HSRUA, which obtains its water supply from Lake Huron. Due to the global distribution of PFCs in the environment, PFCs can be detected in surface waters that do not have a known source discharging to that waterbody. MDHHS and MDEQ measured PFCs in Michigan surface water and fish and found the chemicals in every sample (MDHHS 2015a). The PFC concentrations detected in the HSRUA samples are similar to those reported for "background" locations in Michigan and can be considered anthropogenic (i.e., caused by human activity) background.

Michigan currently does not have promulgated criteria for PFCs in drinking water. The U.S. Environmental Protection Agency (EPA) has not yet determined safe drinking water standards for these chemicals. MDHHS compared the concentrations of PFCs detected in the drinking water sampled near WAFB (Table 3) to EPA and several states' screening levels (Table 4). None of the PFCs detected in the samples exceeded the screening levels. However, the PFC groundwater plumes migrating from WAFB have not been fully characterized nor have they been controlled. It is possible that PFC concentrations in the drinking water wells could increase over time.

The understanding of the toxicity of PFCs is limited and still evolving. It has been reported that PFCs are present in everyone's blood (CDC 2009), due to the global nature of their manufacture, use, and resultant releases. Animal and laboratory studies have indicated that certain PFCs may cause thyroid, liver, immune system, and developmental effects. Human population studies have suggested a link between some PFCs and certain health outcomes, such as liver and thyroid changes and lowered immune response. PFC exposure may also be associated with some cancers in humans (MDHHS 2014, ATSDR 2015). Some PFCs have long half-lives and could build up in the body. Therefore, further risk evaluation of the drinking water data is necessary.

To meet this need, MDHHS conducted the following risk evaluation based on the maximum PFOS and PFOA private well water results and a child drinking water exposure scenario (Appendix A).[2] For this risk analysis, we did not include other possible exposure pathways or any estimate of background exposure.

The federal Agency for Toxic Substances and Disease Registry (ATSDR) has calculated Minimal Risk Levels (MRLs) for PFOS and PFOA (ATSDR 2015). An MRL is “an estimate of the daily

[2] A child receptor was used because the expected dose to a child would be greater than that to an adult, based on intake rate and body weight.

human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure." Exposure duration may be acute (up to 14 days), intermediate (more than 14 days to one year), or chronic (greater than one year). MRLs are not cleanup or action levels, but serve as screening levels to identify hazardous substances that may be of concern at contaminated sites (ATSDR 2016).

The ATSDR (2015) intermediate MRLs for PFOS and PFOA are:

PFOS = 0.00003 milligrams per kilogram per day (mg/kg/day)
PFOA = 0.00002 mg/kg/day

ATSDR has not established chronic MRLs for PFOS or PFOA, nor have they calculated MRLs for other PFCs.

In this risk evaluation, a child who regularly drank water or formula that had the maximum concentration of PFOS and PFOA detected in a drinking water well near WAFB (39 and 36 parts per trillion [equivalent to nanograms per liter], respectively), would receive a dose of up to 0.0000055 mg/kg/day PFOS and 0.0000051 mg/kg/day PFOA (see Appendix A for the calculations). Dividing the expected (calculated) dose by the acceptable dose (i.e., the MRL) yields a "Hazard Quotient" of 0.2 for PFOS and 0.3 for PFOA. In risk assessment, if a Hazard Quotient does not exceed 1, the conclusion is that the expected exposure is acceptable; if it exceeds 1, then further evaluation is necessary to determine the risk of harm. Although the Hazard Quotients for PFOS and PFOA do not exceed 1, the acceptable dose in the calculations was for intermediate exposure (up to one year). It is possible that the derivation of chronic MRLs (for exposure longer than one year) would be 10 times lower by applying a subchronic-to-chronic uncertainty factor, commonly done in risk assessment. In that case, the Hazard Quotients for PFOS and PFOA would equal 2 and 3, respectively, indicating an exceedance of acceptable exposure.

Other considerations regarding the evaluation of the drinking water well data include:

- *Whether and how the PFCs may interact with each other.* Several modes of action have been suggested to explain individual PFC toxicity (Peters and Gonzalez 2011). The toxicity of PFCs with the same mode of action may be additive and increase the risk of harmful health effects.
- *How long the PFCs have been in the drinking water.* According to the USAF, the use of PFC-containing AFFF at WAFB began in the early 1970s (J. Anderson, USAF Emerging Issues Program, personal communication, 2012). The soil around the base is sandy, which would allow the contamination to leach to the groundwater relatively quickly. It is possible PFCs could have entered the drinking water in the later 1970s. MDHHS previously evaluated PFCs in four residential drinking water wells that were sampled between 2011 and 2014 (MDHHS 2015b). Some PFCs have a long half-life (years), and

prolonged exposure increases levels in the body, increasing the risk for harmful health effects.

- *The exposure magnitude in the past and how it might change in the future.* Drinking water concentrations of PFCs may have been higher in the past, could increase in the future, or could fluctuate, depending on the sources of PFCs at WAFB and how they are entering the groundwater.
- *Other exposures people may be experiencing.* Some locally caught fish from certain waters near WAFB have been shown to have very high levels of PFCs in the edible tissue (MDHHS 2012a, 2012b, 2016). While there is a "do not eat" advisory for several area waterbodies, and "Eat Safe Fish" guidelines are in place for other waterbodies near WAFB, it is not known whether people adhere to the advice. Also, locally harvested wild game may contain PFCs and present another exposure pathway (MDHHS 2015c).

Assuming that the concentrations of PFCs detected in the potable well survey are indicative of past exposure, then short-term exposure may not represent an immediate health threat. However, on-going exposure to the PFC contamination originating from WAFB could harm human health.

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Figure 1. Former Wurtsmith Air Force Base, Oscoda (Iosco County), Michigan, and vicinity (AFCEC 2016).

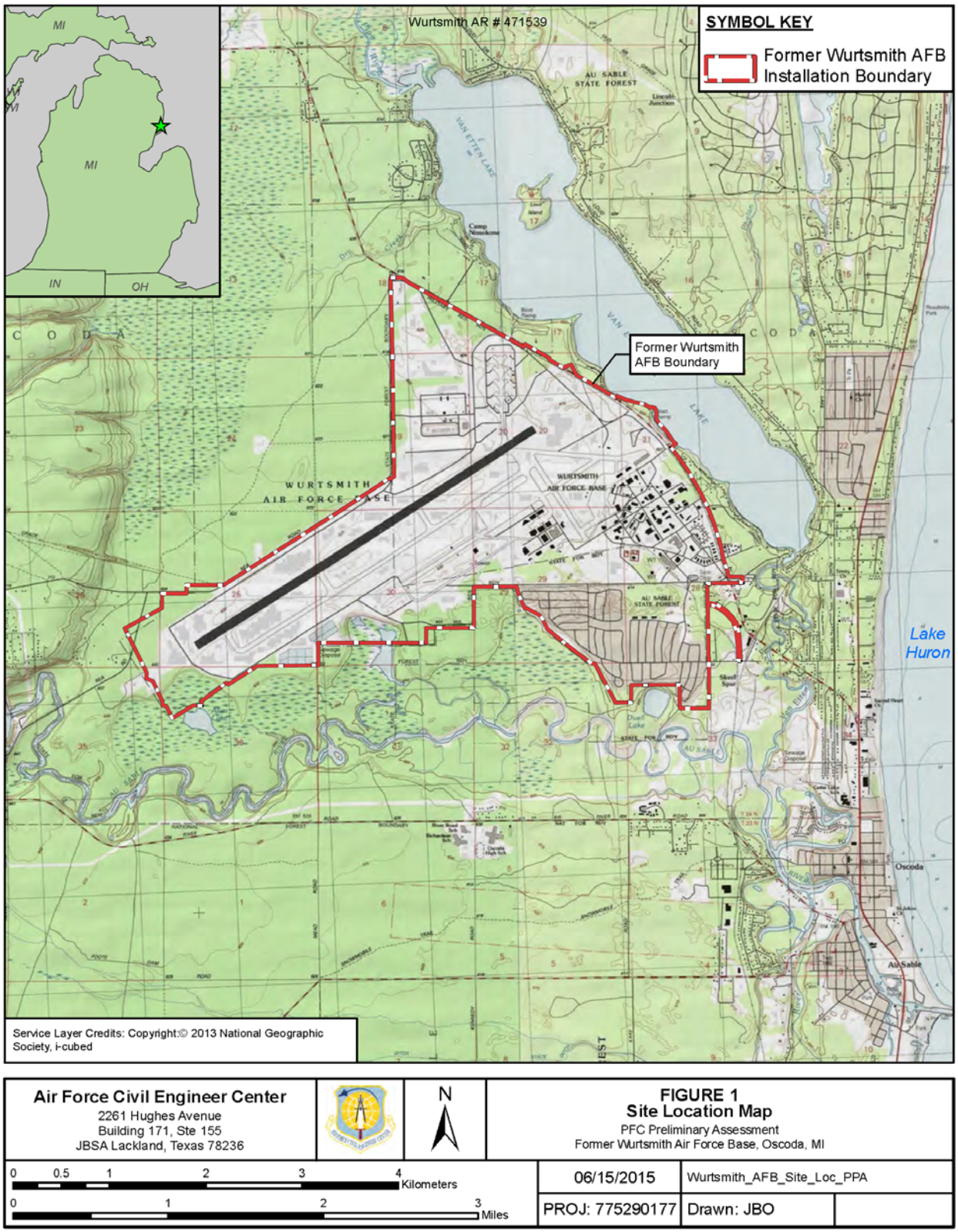


Figure 2. Potential Aqueous Film-Forming Foam (AFFF) release sites at the former Wurtsmith Air Force Base, Oscoda (Iosco County), Michigan (AFCEC 2016). Note that this may not be a comprehensive representation.

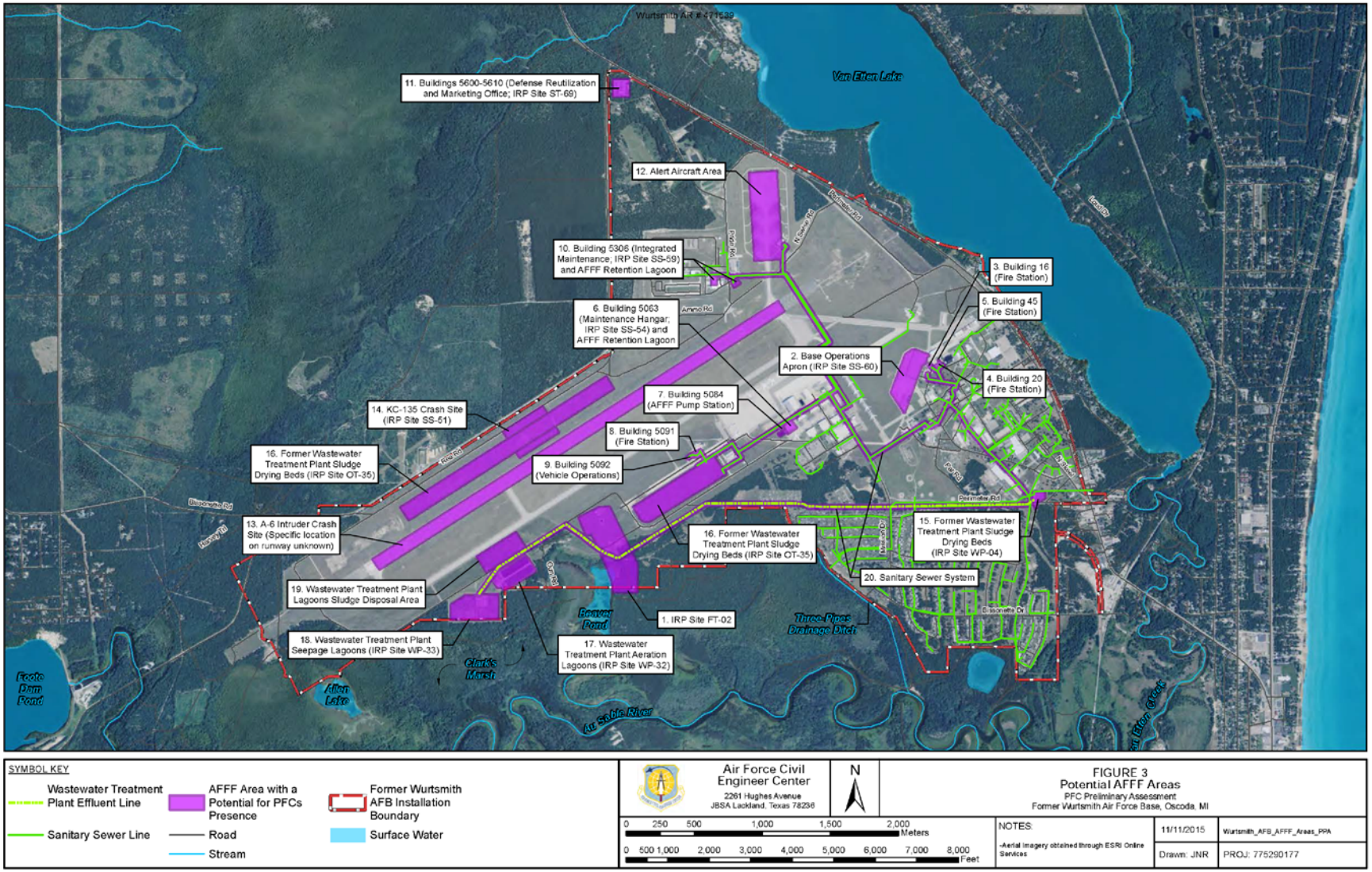
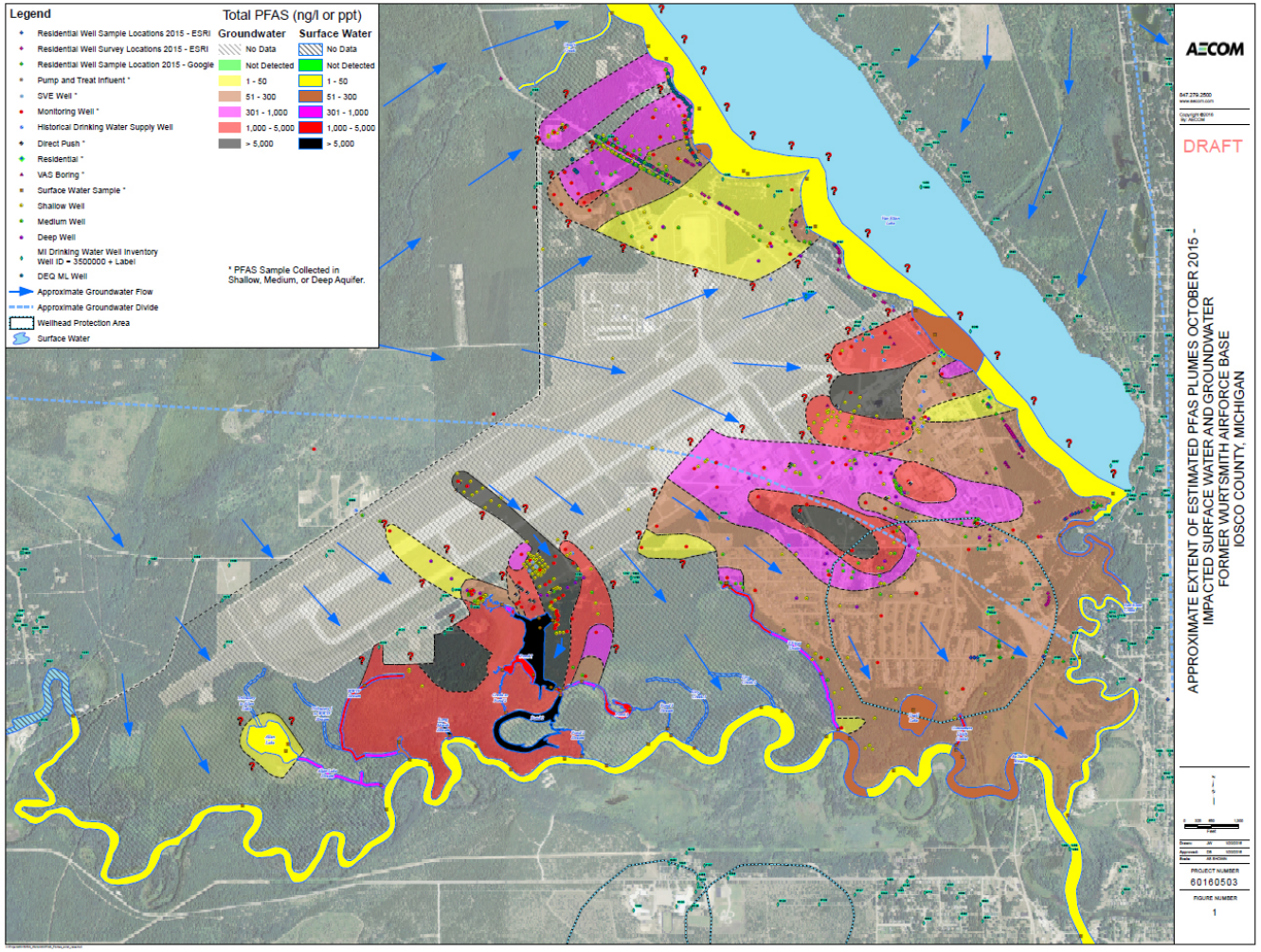


Figure 3. Conceptual site model of perfluorinated chemicals in groundwater and surface water at and near the former Wurtsmith Air Force Base, Oscoda (Iosco County), Michigan. (Graphic provided by Dorin Bogdan of AECOM, consultant for Michigan Department of Environmental Quality Remediation and Redevelopment Division, February 16, 2016.)[3]



[3] PFCs are a subgroup of chemicals within a larger class known as per- and polyfluorinated alkyl substances (PFAS). The map shows total PFAS concentrations.

Figure 4. Eastern section of Wurtsmith Air Force Base.

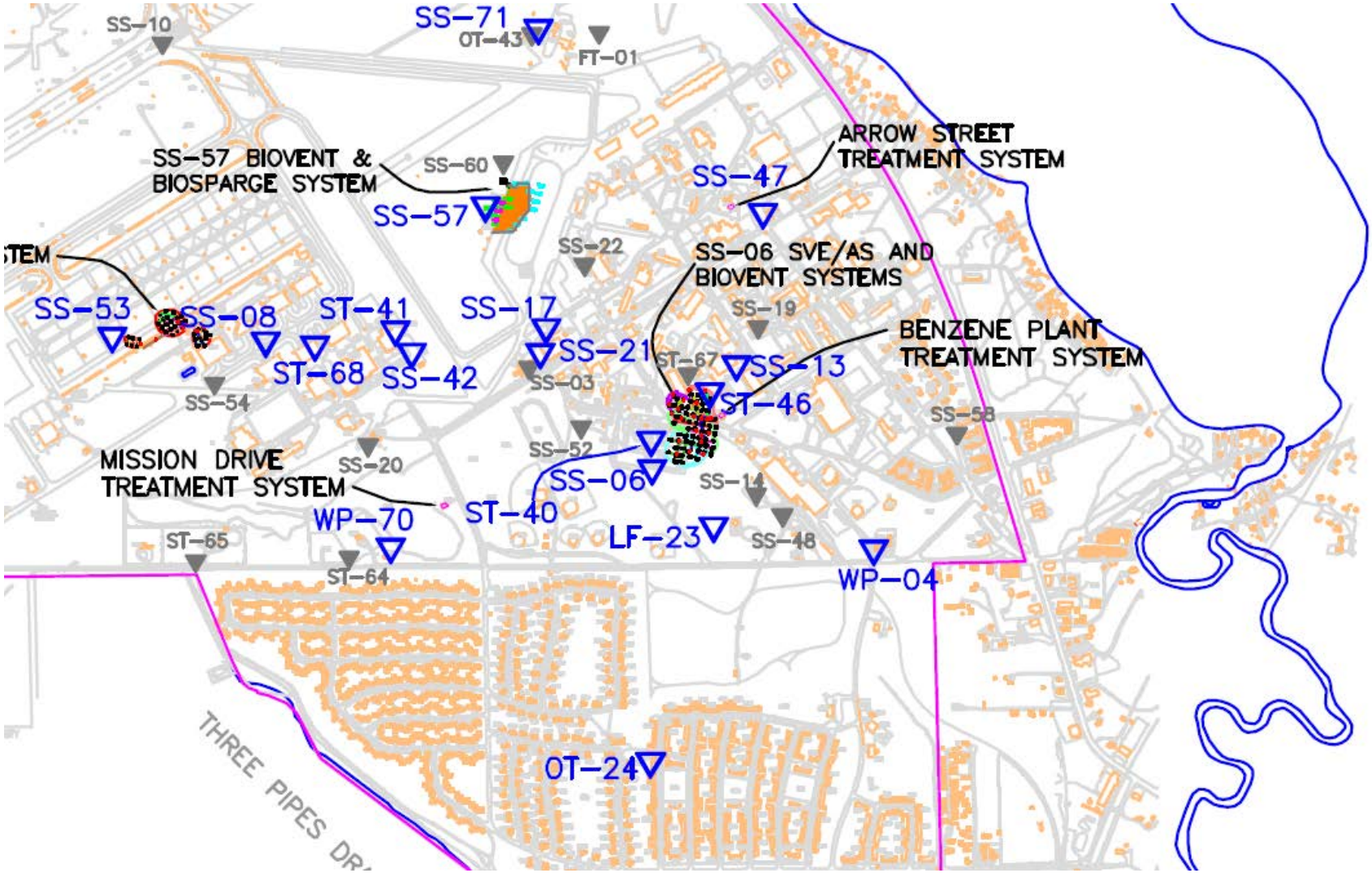


Figure 5. Area planned for potable water supply well survey near the former Wurtsmith Air Force Base, Oscoda (Iosco County), Michigan (Amec 2015).

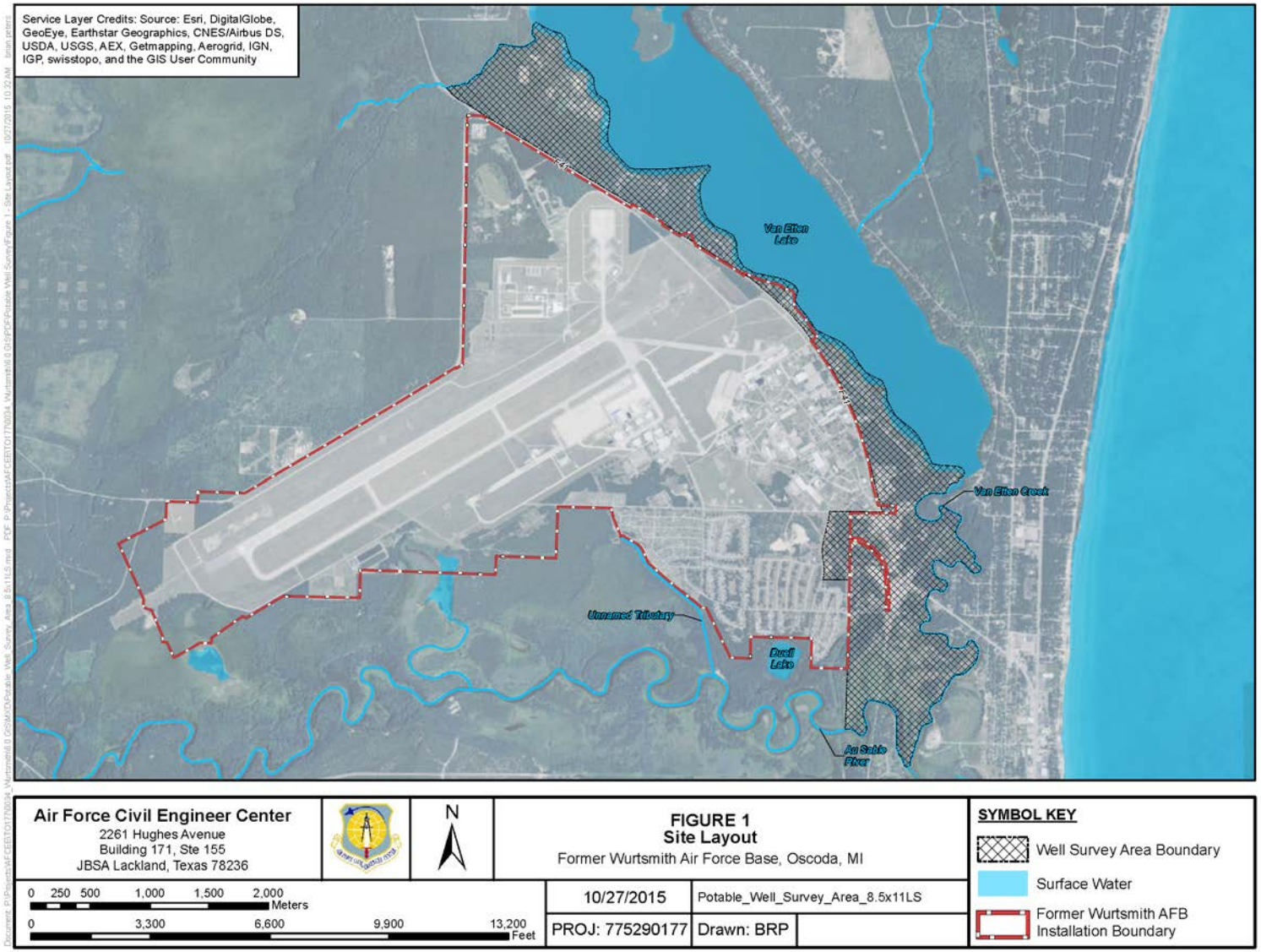


Table 1. Perfluorooctane sulfonate (PFOS) concentrations (in parts per trillion [ppt]) in groundwater samples at or near the former Wurtsmith Air Force Base (WAFB) in Oscoda, Michigan (MDHHS 2016).

Groundwater Monitoring Locations	**No. detects / No. wells sampled**	**Concentration Range (ppt)**
OT-24	0 / 7	ND
SS-06	1 / 2	ND – 3.6
SS-08	7 / 7	32 – 15,000
SS-21	3 / 6	ND – 260
SS-42	2 / 2	150 – 2,400
SS-53	1 / 1	110
SS-57	4 / 4	720 – 20,000
SS-71	2 / 2	84 – 680
ST-40	1 / 1	350
ST-46	3 / 3	490 – 3,500
WP-04	3 / 4	ND - 16

Notes:

1. ND means not detected.
2. Reporting Limit ranged from 1.2 to 4.2 ppt.

Table 2. Perfluorinated chemicals (PFCs) analyzed for during 2015 potable well sampling near former Wurtsmith Air Force Base, Oscoda (Iosco County), Michigan. Unless otherwise noted, both U.S. Air Force's and Michigan Department of Environmental Quality's (MDEQ) contract laboratories analyzed for the specific PFC. Superscript A indicates the PFC was analyzed only by the U.S. Air Force's lab; superscript B indicated the PFC was analyzed only by the MDEQ's lab. Those PFCs listed in bold print were detected in at least one sample.

N-Ethyl perfluorooctanesulfonamidoacetic acid (EtFOSAA)[A]
N-Methyl perfluorooctanesulfonamidoacetic acid (MeFOSAA)[A]
Perfluoro-1-heptanesulfonate (PFHpS)[B]
Perfluorobutanesulfonic acid (PFBS)
Perfluorobutanoic acid (PFBA)[B]
Perfluorodecane sulfonate (PFDS)[B]
Perfluorodecanoic acid (PFDA)
Perfluorododecanoic acid (PFDoA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorohexanoic acid (PFHxA)
Perfluoro-n-hexadecanoic acid (PFHxDA)[B]
Perfluoro-n-octandecanoic acid (PFODA)[B]
Perfluorononanoic acid (PFNA)
Perfluorooctane sulfonamide (FOSA)[B]
Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluoropentanoic acid (PFPeA)[B]
Perfluorotetradecanoic acid (PFTeDA or PFTeA)
Perfluorotridecanoic acid (PFTrDA or PFTriA)
Perfluoroundecanoic acid (PFUnA)

Table 3. Perfluorinated chemicals (PFCs) detected in drinking water sampled in 2015 near the former Wurtsmith Air Force in Oscoda (Iosco County), Michigan, and analyzed by U.S. Air Force and Michigan Department of Environmental Quality (MDEQ) contract laboratories. Concentrations shown in parts per trillion (ppt). "NA" indicates the PFC was not analyzed for; "ND" indicated the PFC was not detected in the sample(s).

	Municipal water (Huron Shores Regional Utility Authority, treated water)[1]	Mobile home park wells (n=2; maximum detection shown)[2]	Number of private residential wells with detections (24 tested)[3]	Concentration range of PFCs detected in private residential wells
EtFOSAA	NA	ND	1	20
MeFOSAA	NA	ND	1	19
PFHpS	ND	ND	2	0.95 - 1.6
PFBS	ND	ND	22	1 - 18.5
PFBA	1.5	2.8	24	1.2 - 9.9
PFDA	0.8	1.1	1	1
PFDoA	0.61	ND	0	ND
PFHpA	ND	3	22	1.1 - 8.7
PFHxS	1.3	22	24	2 - 152
PFHxA	1.4	5.1	23	1.4 - 18
PFHxDA	ND	1.2	23	0.14 - 2.6
PFODA	ND	ND	1	0.81
PFNA	ND	0.7	2	0.93 - 1.1
PFOS	ND	15	14	1.5 - 39
PFOA	1.1	6.2	22	0.9 - 36
PFPeA	ND	4.6	22	1.2 - 18
PFTeA	ND	1.4	13	0.21 - 1.2
PFUnA	ND	2.1	0	ND

Notes:

1. Sampled only by MDEQ, on December 15, 2015. Water source is Lake Huron.
2. Two Type 1 water supply wells (groundwater) sampled by both USAF and MDEQ, on September 22, 2015. The mobile home park has 34 residences, per MDEQ.
3. Twenty-four residential drinking water wells sampled by both USAF and MDEQ, on December 1-4, 2015.

Table 4. Groundwater/drinking water screening levels for PFCs, as derived by various states and the EPA. Concentrations are in parts per trillion (ppt). Values in bold are the most restrictive screening level for that PFC.

	MI[1]	EPA[2]	ME[3]	MN[4]	NC[5]	NJ[6]	TX[7]
EtFOSAA							
MeFOSAA							
PFHpS							
PFBS				**7,000**			34,000
PFBA				**7,000**			71,000
PFDS							**290**
PFDA							**370**
PFDoA							**290**
PFHpA							**560**
PFHxS							**1,900**
PFHxA							**1,900**
PFHxDA							
PFODA							
PFNA						**10**	290
FOSA							**290**
PFOS	**100**	200	560	300			560
PFOA		400 (100)	130	300	2,000	**40**	290
PFPeA							**1,900**
PFTeA							**290**
PFTriA							**290**
PFUnA							**290**

Notes:

1. The Michigan (MI) screening value for PFOS is the Groundwater Drinking Water Value, derived by the MDEQ Water Resources Division (MDEQ 2014).
2. The U.S. Environmental Protection Agency (EPA) value for PFOS is the Provisional Health Advisory (PHA) level, for short-term exposure (EPA 2009). The first value for PFOA is the PHA level for that chemical (EPA 2009). The value in parentheses is the drinking water screening level EPA Region 2 is using for a PFOA groundwater contamination site in Hoosick Falls, New York. EPA Region 2 recommends that Hoosick Falls residents not drink water that contains 100 ppt PFOA or more (EPA 2016).
3. The Maine (ME) screening levels are Groundwater Remediation Action Guidelines (MDEP 2016).
4. The Minnesota (MN) screening levels are Health Risk Limits (MDH 2008a, b; MDH 2011a, b).
5. The North Carolina (NC) screening level is the Interim Maximum Allowable Concentration (NCDEQ 2006).
6. The New Jersey (NJ) screening levels are Drinking Water Guidance Levels (NJDEP 2007, 2015).
7. The Texas (TX) screening levels are Tier 1 Protective Concentration Levels (TCEQ 2015).

Appendix A. Calculation of PFOS and PFOA doses for a default or 0- to 1-year old child drinking water that contains the maximum concentrations of PFOS and PFOA detected in drinking water wells near the former Wurtsmith Air Force Base in Oscoda, Michigan.

$$Concentration \times Ingestion\ Rate \div Body\ Weight = Dose$$

The maximum concentrations of PFOS and PFOA detected in drinking water wells were 39 and 36 parts per trillion, respectively.

Parts per trillion (ppt) is equivalent to nanograms per liter (ng/L). There are 1,000,000 ng per mg. A conversion factor has been added to the dose equation.

The default water ingestion rate for a child is 1 liter per day (L/day; ATSDR 2005).

The default body weight for a child is 10 kilograms (10 kg; ATSDR 2005).

$$39\frac{ng}{L} \times \frac{1mg}{1{,}000{,}000ng} \times \frac{1L}{day} \div 10\ kg = \frac{0.0000039\frac{mg}{kg}}{day}\ PFOS$$

$$36\frac{ng}{L} \times \frac{1mg}{1{,}000{,}000ng} \times \frac{1L}{day} \div 10kg = \frac{0.0000036\frac{mg}{kg}}{day}\ PFOA$$

Alternatively, Exposure Dose Guidance provided by the federal Agency for Toxics Substances and Disease Registry indicates that, for drinking water exposure, a child aged 0 to 1 year old drinking formula prepared with tap water would be the most susceptible receptor (ATSDR 2014a). The mean water ingestion rate for this age range is 0.5 L/day, and the 95% Upper Confidence Limit on the mean (95% UCL) is 1.1 L/day (ATSDR 2014b). The body weight for a child in this age range is 7.8 kg (ATSDR 2014a). Using the same equation as above, the calculated dose ranges (mean to 95% UCL) are:

$$\frac{0.0000025\frac{mg}{kg}}{day}\ to\ \frac{0.0000055\frac{mg}{kg}}{day}\ PFOS$$

$$\frac{0.0000023\frac{mg}{kg}}{day}\ to\ \frac{0.0000051\frac{mg}{kg}}{day}\ PFOA$$