



STATE OF MICHIGAN

DEPARTMENT OF HEALTH AND HUMAN SERVICES
LANSING

GRETCHEN WHITMER
GOVERNOR

ROBERT GORDON
DIRECTOR

Date: May 21, 2019

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

Dear Ms. Bryan:

As requested, the Michigan Department of Health and Human Services (MDHHS) is updating the previous August 1, 2017 letter health consultation of per- and polyfluoroalkyl substance (PFAS) in Van Etten Lake (Oscoda, MI) foam (MDHHS 2017¹). This letter health consultation supports and clarifies the District Health Department #2 September 22, 2017 note regarding foam ingestion². The updated assessment includes the recent toxicity information from Agency for Toxic Substances and Disease Registry (ATSDR) (ATSDR 2018³), all Van Etten Lake foam and surface water PFAS data, and an updated hazard calculations more representative of summer recreation.

In the attachments (Technical Document #1 & #2), MDHHS evaluates Van Etten Lake recreational exposures other than fish consumption, considering both absorption of PFAS due to whole body skin contact as well as incidental ingestion⁴ of water or foam (e.g., playing in foam or swimming in the lake). As previously discussed, accidentally ingesting PFAS-containing lake foam is the primary concern for recreational lake exposures and dermal contact was a lesser concern because available information indicates that PFAS do not easily absorb through the skin.

Based on the updated assessment, current science, and current data, MDHHS concludes:

1. Incidental ingestion of or dermal contact to Van Etten PFAS-containing lake water, is not an apparent public health hazard to children and adults.

¹ [MDHHS] Michigan Department of Health and Human Services. Technical Review Evaluating Potential Exposure to Per- and Polyfluoroalkyl Substances (PFAS) in Foam and Surface Water at Van Etten Lake, Oscoda (Iosco County), Michigan. Lansing, Michigan 2017 August 1.

² <https://www.dhd2.org/additional-information>

³ Agency for Toxic Substances and Disease Registry (ATSDR). 2018. Toxicological profile for Perfluoroalkyls. (Draft for Public Comment). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

<https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=1117&tid=237>

⁴ Incidental ingestion of water or foam is the small amount that could be accidentally swallowed while swimming or other recreational activities.

2. Incidental ingestion of Van Etten PFAS-containing lake foam can result in a public health hazard to children and adults.
3. Extended, recurring, whole body skin contact to Van Etten PFAS-containing lake foam can result in a public health hazard for children and adults.

Therefore, MDHHS recommends continuation of the current advisory to rinse off Van Etten Lake foam and avoid contact with the foam. MDHHS supports additional surface water analysis during the recreational season to more fully characterize surface water exposures.

Background and Evaluation

The public health evaluation considers the concentrations measured in surface water and foam, uses standard exposure assumptions (e.g., incidental ingestion rate, skin surface area, available skin permeability coefficient for PFAS), and measured foam volume to liquid ratio to determine a reasonable maximum exposure dose for different age groups during recreation. The comparison of the exposure dose to an acceptable daily dose from the Agency for Toxic Substances and Disease Registry (ATSDR Minimal Risk Level or MRL) results in a Hazard Quotient (HQ). A HQ that is greater than one indicates that further evaluation of the exposure is needed, while a HQ that is one or less indicates that further evaluation may not be needed.

Surface Water

Surface water samples were collected from Van Etten Lake beginning in 2011 through 2018 (see Figure 1 in attached Technical Document 1). Additionally, in December 2018 both surface water and pore water (i.e. water free in sediment) samples were collected from the west shore of Van Etten Lake roughly located between Lawrence Hobey Ct and E Van Ettan St (see Figure 2 in attached Technical Document 1). PFAS concentrations in the surface water samples ranged from non-detect (ND) to 131 ng/L for perfluorooctanoic acid (PFOA), ND to 497 ng/L for PFOS, ND to 531 ng/L for (perfluorohexane sulfonate) PFHxS and ND to 3 ng/L for perfluorononanoic acid (PFNA). For the purposes of capturing a reasonable maximum exposure scenario, MDHHS evaluated the highest concentrations reported to-date. While maximum levels may have been from the December 2018 sampling, they were included as the current dataset was limited.

Under the recreational exposure scenario evaluated (see detailed description in the attached Technical Document 1), for the December 2018 sampling results the calculated Hazard Quotients (HQs) for a child aged 1-2 years old is less than 2 (<2) and for a child aged 2-6 years old is 1. Evaluation of the data collected at the same location of the December 2018 sampling but at different time points indicated HQs of 1 for a child aged 1-2 years old (using March 2017 sampling results). All other age groups had HQs less than 1 (<1). The surface water sampling results indicated that there are variable concentrations of PFAS at different times of the year and/or over time. Furthermore, based on the inherent chemical properties of PFAS causing them to migrate toward air-water interfaces, the concentrations of PFAS at water surfaces may be much higher than concentrations at depth. Therefore, MDHHS is recommending that focused sampling

during recreational seasons at the top of the water where incidental ingestions could occur during swimming would be preferred for public health evaluations.

Foam

The most recent samples of foam were collected in August, October and December of 2017. Please note, some of the concentrations of PFAS detected in these foam samples were considerably higher than those detected from an earlier, July 2017, sample. The conclusions reached here are different than those described in an earlier letter and accompanying technical document (August 2017) sent to your attention regarding foam on Van Etten Lake. The current conclusions reflect the newest data available and updated toxicity information from the Agency for Toxic Substances and Disease Registry (ATSDR).

Concentrations of PFOS in foam were considerably higher than those found in surface water. The hazard quotients derived from the concentrations of PFOS in foam samples range from **6 – 38** (see details in Technical Document 2). **Therefore, MDHHS recommends a public health advisory to avoid the incidental ingestion of and whole-body skin contact with foam on Van Etten Lake as a precaution.**

This advisory should be in place on Van Etten Lake, as foam could appear anytime and anywhere on the lake. Please see https://www.michigan.gov/pfasresponse/0,9038,7-365-88059_91295---00.html for information on physical characteristic of PFAS foam on lakes and streams.

Conclusions

- MDHHS evaluated the surface water data reported from 2011 through 2018. MDHHS used a reasonable maximum exposure scenario for re-occurring Van Etten Lake surface water during the recreational season that included incidental ingestion and dermal contact. MDHHS concludes that there is no current public health hazard for recreational users in surface water.
- For recreational exposure to PFAS in foam, MDHHS used a reasonable maximum exposure scenario similar to that used for surface water exposure. Concentrations of PFAS in foam were considerably higher than those found in surface water, and incidental ingestion and extended, recurring, whole body skin contact with PFAS foam may present a public health hazard both for children and adults.

These conclusions have the following limitations:

- These conclusions and recommendations are based on the highest levels measured and reasonable maximum exposure assumptions. Both surface water and foam concentrations are known to vary over time. Actual conditions may or may not pose health risks.

- Analytical data from future surface water sampling events could change MDHHS' conclusions and recommendations regarding recreational contact with surface water.
- Standard, accepted values for some of the properties of PFAS are not yet available or are considered unmeasurable. The availability of new information about the properties of PFAS could alter MDHHS' conclusions and recommendations.
- There are other potential exposure pathways of PFAS near the Van Etten Lake, including the consumption of locally caught fish or deer or drinking from water wells that have an elevated concentration of PFAS. The recommendations here, alone, may not ensure that all unacceptable exposures have been eliminated.

Recommendations

Based on the conclusions above, and its limitations, MDHHS recommends the following:

- Michigan Department of Environmental, Great Lakes, and Energy (EGLE, previously known as Michigan Department of Environmental Quality or MDEQ) continues its investigation of PFAS contamination in the area of Van Etten Lake. All information developed during this on-going investigation will be evaluated, and if a concern is identified in the future, the need for further actions will be assessed.
- District Health Department #2, with support from MDHHS, issue a public health advisory to avoid foam during recreational activities, such as swimming, canoeing/kayaking, and fishing, in water or along the shore of Van Etten Lake.
- Recreational users rinse off foam after contact, and bathe or shower after the day's outdoor activities.

Public Health Action Plan

- MDHHS will remain available to evaluate any sampling plans and resulting data to assess people's PFAS exposure during recreational activities.
- MDHHS will continue to discuss with the Human Health Work Group, best practices for recreational exposures related to PFAS.
- MDHHS has issued Eat Safe Fish guidelines for the Van Etten Lake due to a variety of chemicals, including perfluorooctane sulfonate (PFOS, a common PFAS) and mercury. See michigan.gov/pfasresponse for more information and current advisories. MDHHS will continue to evaluate fish tissue data and issue fish consumption guidelines for area water bodies.

The attached discussion shows the details of the evaluation of the data. If I can be of further assistance in this matter, please do not hesitate to contact me.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Abiy Mussa', written over a horizontal line.

Abiy Mussa, Toxicologist
Toxicology and Response Section
Division of Environmental Health

CC: EGLE
MDNR
Oscoda Township
U.S Air Force
ATSDR

1. Technical Review Evaluating Recreational Exposure to Per- and Polyfluoroalkyl Substances (PFAS) in Surface Water Samples at Van Etten Lake, Oscoda (Iosco County), Michigan.

Prepared by Abiy Mussa, PhD, Toxicologist, Toxicology and Response Section, Division of Environmental Health, Michigan Department of Health and Human Services.

Background and Environmental Data

The Michigan Department of Environmental, Great Lakes, and Energy (EGLE, previously known as Michigan Department of Environmental Quality or MDEQ) has been collecting surface water samples from Van Etten Lake since 2011. A total of 34 surface water samples, four pore water samples and two seep samples were collected, and the sampling locations are shown in Figure 1. The range of concentrations of select PFAS detections in the surface water, porewater and seep samples are shown in Table 1. *Note, there is also potential exposure to PFAS via foam in the lake and on the shore. This is discussed in Technical Document 2 and not in this technical report.*

On December 27, 2018, EGLE contractor, AECOM, identified four locations on the southwestern side of the Van Etten Lake as potential groundwater discharge areas based on foam events observed at that particular location. The locations were identified by observing areas with the absence of near shore ice and/or where water discharging from onshore sediments was visible. A Forward-Looking Infrared camera was used to further verify potential warmer groundwater discharge areas at each of the four locations. Please refer to the attached memo for detailed methodology. From each identified location, one surface water and one pore water sample were collected (Figure 2).

The samples were analyzed for 24 different PFAS analytes. In June 2018, the Agency for Toxic Substances and Disease Registry (ATSDR)¹ established draft Minimal Risk Levels (MRLs) for four PFAS analytes namely perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorohexane sulfonate (PFHxS) and perfluorononanoic acid (PFNA). MRLs represent the amount of a chemical that can be ingested daily over a specified period of exposure below which there is not expected to be adverse health effects. It is considered protective of the general population as well as sensitive subpopulations including infants, children and pregnant women.

MDHHS considered four PFAS analytes for this evaluation: PFOA, PFOS, PFHxS, and PFNA. MDHHS used the result for the surface water sample with the highest concentrations of PFOA, PFOS, PFHxS and PFNA (Table 1). Please note that the concentrations of PFOS and PFHxS are higher in the pore water sample; the assumptions used in this evaluation are that the young child will be in contact with surface water and there will be mixing of pore and surface water during recreational activities such as swimming, but that pore water is not reflective of the water the child is accidentally ingesting. Additionally, due to the time of the year of the sampling and ice formation on the lake there was limited mixing of pore water into the surface water.

In this evaluation dermal exposure and incidental ingestion, which often occurs during recreational activities, were considered.

¹ <https://www.atsdr.cdc.gov/mrls/mrlolist.asp>

Table 1. Range of concentrations (in nanograms per Liter [ng/L]) of select PFAS in the surface water, pore water and seep water sampled from Van Etten Lake, Oscoda, Michigan. Please see Table 5 for the total list of analytes tested.

PFAS	Surface Water ¹	Pore water ²	Seep water ³
	Range (ng/L)	Range (ng/L)	Range (ng/L)
PFOA	ND ⁴ - 131	11 - 108	15 - 25
PFOS	ND - 497	55 - 566	ND - 3
PFHxS	ND - 531	54 - 591	17 - 120
PFNA	ND - 3	ND - 4	ND

¹Surface water sample collected from 2011 through 2018. The highest concentrations were reported from December 2018 sampling results.

²Pore water samples were collected in 2018.

³Seep water samples were collected in 2012.

⁴ND: non-detect

Dermal Exposure

Scientific information about PFAS dermal uptake is quite limited. *In vitro* experiments reported by DuPont have suggested that under certain experimental conditions PFOA can permeate through the skin (Fasano et al. 2005²; Franko et al. 2012³), and a single *in vivo* study at NIOSH documented dose-dependent uptake of dermally applied PFOA under experimental conditions into serum of mice (Franko et al. 2012). The dermal uptake of PFAS from water is expected to be minimal under environmental conditions where they exist in various ionic forms.

Some information traditionally used to evaluate dermal environmental exposures is not yet available for many PFAS, such as permeability coefficients (K_p), octanol/water partition coefficients ($K_{o/w}$) and precise degrees of ionization (for environmental samples). Therefore, MDHHS has used values for PFOA that have been derived in the experimental literature. PFOA, although not the only or primary PFAS detected in the pore and surface water samples, is thought to have a higher capacity for skin permeability than PFOS due to physicochemical properties and therefore should capture a reasonable maximum dermal exposure from PFAS-containing surface water.

When considering the concentration to evaluate for the dermal and oral risk assessment, MDHHS used the highest concentrations of PFOA, PFOS, PFHxS and PFNA observed in the surface water samples collected in December 2018.

To further capture the most conservative, reasonable maximum exposure scenario, MDHHS has considered that a child (1-2-year-old, 2-3-year-old and 3-6-year-old) spends 2-hr per day, 5 days per week during the summer months on the Lake shore. The following reasonable maximum exposure variables were included using the 2011 US EPA Exposure Factors Handbook⁴ to define human factors where applicable. This scenario is also protective for older children and adults as their exposure would be lower than the exposure to a young child. Please note, December is not a typical recreational season month.

² <https://www.ncbi.nlm.nih.gov/pubmed/15720037>

³ <https://www.ncbi.nlm.nih.gov/pubmed/22047163>

⁴ <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252>

The EPA Dermal Exposure Assessment Guide⁵ describes an equation for quantifying an absorbed dose per exposure event (Equation 1). Equation 1 is then used to quantify the total dermal absorbed dose (Equation 2):

$$\text{Equation 1. } DA_{\text{event}} = K_p \times C_w \times T_{\text{event}}$$

Where,

DA_{event} = absorbed dose per event in $\text{mg}/\text{cm}^2/\text{event}$

K_p = permeability in cm/hr

C_w = concentration in the surface water in mg/cm^3

T_{event} = hours of dermal contact with surface water in hr/event

Dermal permeability (K_p). Franko et al. (2012) reported average model based K_p of PFOA to be **0.00009 cm/hr**.

Duration of dermal contact (T_{event}). The duration per event of dermal contact with surface water is assumed to be **2 hours**, which is based on the professional judgement and thought to represent the maximal, reasonable time per day that a young child might be engaging in recreational activities on the lake shoreline during summertime.

$$\text{Equation 2. } DAD = \frac{DA_{\text{event}} \times EV \times ED \times EF \times SA}{BW \times AT}$$

Where,

DAD= dermal absorbed dose in $\text{ng}/\text{kg}/\text{day}$

EV= events/day

ED= exposure duration in years

EF= exposure frequency in days/year

SA= skin surface area in cm^2

BW= body weight in kg

AT= averaging time in days

⁵ <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=183584>

Surface area (SA). The mean skin surface area (entire body) for a child aged 1-2 years old (**5300 cm²**), 2-3 years old (**6100 cm²**) and 3-6 years old (**7600 cm²**) were used.

Body weight (BW). The mean body weight for a child aged 1-2 years old (**11.4 kg**), 2-3 years old (**13.8 kg**) and 3-6 years old (**18.6 kg**) were used.

Events per day (EV). **One event per day** (lasting 2 hours in duration) is assumed to be representative of the reasonable maximum exposure scenario for a young child.

Exposure frequency (EF). Van Etten Lake is typically used for recreation only during the summer months. The dermal exposure scenario here assumes a child spends **5 days per week for 12 weeks (60 days)** out of the year in shallow water along the shore of the lake.

Exposure Duration (ED). An exposure duration equal to **1 year** (which matches the intermediate duration for ATSDR MRLs) was considered for this model scenario, and the *averaging time (AT)* was set to **84 days (7 days per week for 12 weeks)**.

Equation 2 yields the expected absorbed dose of the chemical resulting from skin contact with surface water. This equation includes factors that capture the size (body weight and surface area of the skin) of the person, the length of time they are exposed and the ability for the chemical to effectively penetrate the skin barrier and enter the body.

Oral Exposure

To calculate an oral exposure dose⁶, the concentrations of PFAS in the surface water were multiplied by the ingestion rate (the amount of water swallowed), bioavailability factor, exposure factor and divided by the body weight.

Equation 3.
$$\text{Dose} = \frac{\text{Cw} \times \text{IR} \times \text{BF} \times \text{EF}}{\text{BW}}$$

Where,

Dose= oral exposure dose

Cw= concentration in the surface water in ng/L

IR = ingestion rate (L)

BF = bioavailability factor (unitless)

EF = exposure factor (unitless)

BW= body weight in kg

Body weight (BW). The mean body weight for a child aged 1-2 years old (**11.4 kg**), 2-3 years old (**13.8 kg**) and 3-6 years old (**18.6 kg**) were used.

⁶ <https://www.atsdr.cdc.gov/hac/phamanual/appg.html>

Ingestion rate (IR). According to the 2011 US EPA Exposure Factors Handbook⁷, the rate of incidental ingestion of water during swimming for children is 0.049 L/hour. For a two-hour exposure, this would result in 0.098 L of water swallowed.

Bioavailability factor (BF). Bioavailability factor is assumed to be 100 %.

Exposure factor (EF). It is calculated by multiplying the exposure frequency (**60 days**) by the exposure duration (**1 year**) and dividing by averaging time (**84 days**).

The same exposure scenario as described above for dermal exposure was applied here. A body weight of different age groups along with the amount of water swallowed during a 2-hr exposure and the maximum concentration of PFOA, PFOS, PFHxS and PFNA reported in surface water samples were considered.

Using the highest concentrations of PFAS in the surface water from December 2018 sampling event, dermal absorbed doses and oral exposure doses were estimated. MDHHS then compared the total exposure doses from dermal (Equation 2) and oral (Equation 3) routes to MRLs of PFOA, PFOS, PFHxS and PFNA. MRLs represent the amount of a chemical per body weight that can be ingested daily and not expected to cause harm over a specified period of exposure for any individual including sensitive populations. Dividing the exposure dose by the MRL results in a Hazard Quotients (HQs). The HQs of select PFAS for different age groups are shown in Table 2.

Table 2. Total exposure dose (in nanograms per kilogram per day [ng/kg/day]) and Hazard Quotients (HQs) of select PFAS from the surface water sampled on December 2018 from Van Etten Lake, Oscoda, Michigan for children of different age group. (Sample Location: SW1 on Figure 2)

A. Children 1-2-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.008	0.804	0.812	3	< 1
PFOS	0.030	3.052	3.082	2	< 2
PFHxS	0.032	3.261	3.293	20	< 1
PFNA	0.000	0.019	0.019	3	< 1

B. Children 2-3-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.007	0.664	0.671	3	< 1
PFOS	0.028	2.521	2.549	2	1
PFHxS	0.030	2.693	2.723	20	< 1
PFNA	0.000	0.016	0.016	3	< 1

⁷ <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252>

C. Children 3-6-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.007	0.493	0.500	3	< 1
PFOS	0.026	1.870	1.896	2	1
PFHxS	0.028	1.998	2.026	20	< 1
PFNA	0.000	0.012	0.012	3	< 1

As shown in Table 2 the exposure dose from the dermal route is negligible relative to the oral route and the oral route (incidental ingestion) is the major route of exposure.

MDHHS also reviewed historical surface water data from different sampling locations collected across Van Etten Lake. Dermal and oral exposure doses and HQs from a sample collected at approximate the same location of the December 2018 sampling but at different time points are shown in Table 3 and 4. For Tables 3 and 4, the exposure doses and HQs were only calculated up to children 3 years old and 2 years old, respectively, as the HQs were already less than one and would only be smaller for older children.

Table 3. Total exposure doses and HQs of select PFAS from the surface water sampled on March 2017 from Van Etten Lake, Oscoda, Michigan for children of different age group. (Sample location: SW VEL L4. Figure 1)

A. Children 1-2-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.001	0.103	0.104	3	<1
PFOS	0.019	1.910	1.929	2	1
PFHxS	0.010	0.982	0.992	20	<1
PFNA	0.000	0.011	0.011	3	<1

B. Children 2-3-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.001	0.085	0.086	3	<1
PFOS	0.018	1.578	1.596	2	<1
PFHxS	0.009	0.812	0.821	20	<1
PFNA	0.000	0.009	0.009	3	<1

Table 4. Total exposure doses and HQs of select PFAS from the surface water sampled on July 2017 from Van Etten Lake, Oscoda, Michigan for children 1-2-year-old (Sample location: SW VEL L4. Figure 1).

A. Children 1-2-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.003	0.309	0.312	3	<1
PFOS	0.015	1.560	1.575	2	<1
PFHxS	0.011	1.087	1.098	20	<1
PFNA	0.000	0.014	0.014	3	<1

Based on the evaluation of the December 2018 surface water data, the calculated HQs for PFOS for a child aged 1-2 years old is <2 and for a child aged 2-6 years old is 1 (Table 2). All other age groups had HQs <1. Using March 2017 sampling results, the calculated HQs for a child aged 1-2 years old is 1 (Table 3). Using July 2017 sampling results, the calculated HQs for a child aged 1-2 years old is <1 (Table 4). Please note that the most sensitive age group (e.g. young child 1-2 years old) and reasonable maximum exposure assumptions are considered for this evaluation; however, the actual conditions may not represent the above scenario. Moreover, December sampling is not representative of the recreational season and additional surface water data should be collected during the recreational season to further evaluate recreational contact with PFAS containing surface water from Van Etten Lake. Furthermore, based on the inherent chemical properties of PFAS causing them to migrate toward air-water interfaces, the concentrations of PFAS at water surfaces may be much higher than concentrations at depth. Therefore, sampling during recreational seasons at the water surface would be preferred for public health evaluation and recommendations.

Limitations.

- There is a lack of standard and relevant physicochemical information for nearly all PFAS. There is a lack of understanding about how mixture exposures can influence the absorption, distribution, metabolism and excretion of individual PFAS. Additional experimental data could indicate a higher (or lower) dermal permeability of PFOA and/or a reliable Kp for PFOS or other PFAS, in which case the HQs discussed here would need recalculating. The variables used for these factors were based on the best information currently available.
- Analytical data from future surface water sampling events could change MDHHS's conclusions and recommendations regarding recreational contact with the surface water.

Table 5. List of PFAS analytes tested in the surface water and pore water samples at Van Etten Lake, Oscoda (Iosco County), Michigan.

Perfluorobutanesulfonic acid (PFBS)
Perfluorobutanoic acid (PFBA)
Perfluoropentanesulfonic acid (PFPeS)
Perfluoropentanoic acid (PFPeA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorohexanoic acid (PFHxA)
Perfluoroheptanesulfonic Acid (PFHpS)
Perfluoroheptanoic acid (PFHpA)
Perfluorooctane Sulfonate (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorononanoic acid (PFNA)
Perfluorononane sulfonate (PFNS)
Perfluorodecanesulfonic acid (PFDS)
Perfluorodecanoic acid (PFDA)
Perfluoroundecanoic acid (PFUnA)
Perfluorododecanoic acid (PFDoA)
Perfluorotridecanoic Acid (PFTriA)
Perfluorotetradecanoic acid (PFTeA)
Perfluorooctane Sulfonamide (FOSA)
Methyl perfluorooctane-sulfonamidoacetic acid (MeFOSAA)
Ethyl perfluorooctane-sulfonamidoacetic acid (EtFOSAA)
4:2 Fluorotelomer sulfonic acid (4:2 FTS)
6:2 Fluorotelomer sulfonic acid (6:2 FTS)
8:2 Fluorotelomer sulfonic acid (8:2 FTS)



Figure 1. Surface water and seep sampling locations from Van Etten Lake, Oscoda, Michigan since 2011.

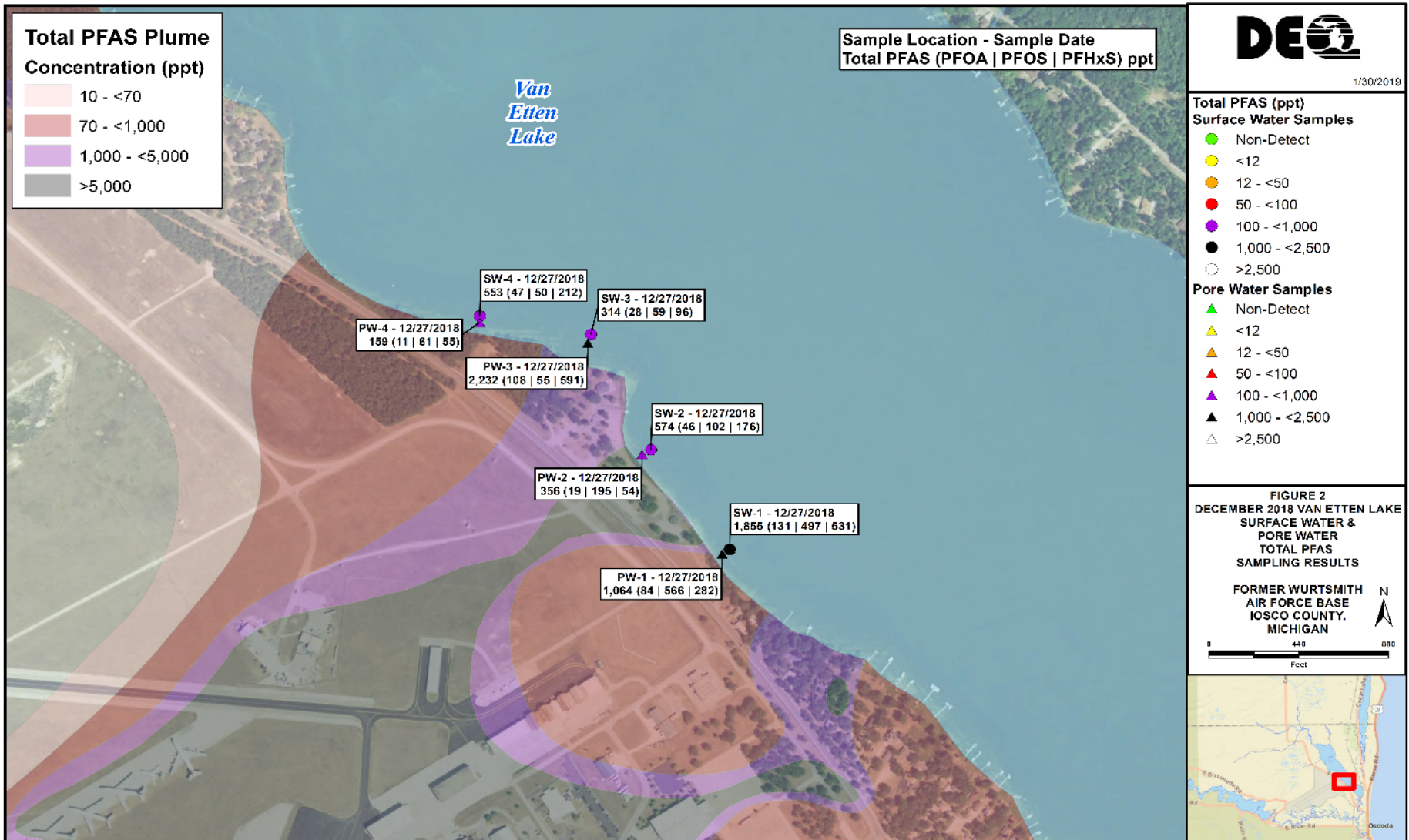


Figure 2. Surface water and pore water sampling locations and concentration of total PFAS, PFOA, PFOS and PFHxS from Van Etten Lake, Oscoda, Michigan on December 27, 2018.

2. Technical Review Evaluating Recreational Exposure to Per- and Polyfluoroalkyl Substances in Foam on Van Etten Lake, Oscoda (Iosco County), Michigan.

Prepared by Jordan Bailey, PhD, Toxicologist, Toxicology and Response Section, Division of Environmental Health, Michigan Department of Health and Human Services.

Per- and polyfluoroalkyl substances (PFAS), although manmade, are found ubiquitously in nature and are present in many marine and terrestrial animals, including humans. PFAS have been found in particularly high concentrations in areas where aqueous film-forming foam (AFFF, a.k.a. aqueous fire-fighting foam) has been used, and PFAS can readily migrate into groundwater and contaminate surface waters. An unusual foam¹ has appeared on water bodies in Michigan located near known sources of PFAS, notably Air Force/Air National Guard bases where AFFF was used regularly, such as Van Etten Lake in Iosco County, MI on which the former Wurtsmith Air Force Base is located.

A previous evaluation was released in an August 1, 2017 letter from MDHHS to District Health Department #2 using data collected in July 2017. Additional samples of this foam were taken from the surface of the lake water and a beach at Van Etten Lake in August, October and December 2017 and tested for the presence of PFAS. It is noted that the December samples were described as “ice and foam” by the individuals collecting it and likely represent foam diluted in (or mixed with) lake water. The concentrations of total PFAS, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) detected from each sampling event are shown in Table 1. All foam samples were analyzed for numerous individual PFAS (Table 3). *Note, there is also potential exposure to PFAS via surface water during recreational activities. This is discussed in Technical Document 1 and not in this technical document.*

In June 2018, the Agency for Toxic Substances and Disease Registry (ATSDR)² established draft Minimal Risk Levels (MRLs) for four PFAS namely perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorohexane sulfonate (PFHxS) and perfluorononanoic acid (PFNA). MRLs represent the amount of a chemical that can be ingested daily over a specified period of exposure below which there is not expected to be adverse health effects. It is considered protective of the general population as well as sensitive subpopulations including infants, children, and pregnant women. Note, the foam sampled from Van Etten Lake was found to be >97-98% PFOS and PFOA (the “icy foam” sample was >90% PFOS and PFOA), with the vast majority of that as PFOS (>97%). Therefore, this health consultation focuses on evaluations for these two PFAS, and PFOS in particular, although total PFAS is also considered (again, see Table 1 for concentrations of PFAS from each sampling event).

Exposure to contaminated lake foam is a novel problem and the risk assessment for this scenario is currently under development and may evolve as more data become available. Dermal (skin) contact with foam and incidental ingestion of foam, which may occur during recreational activities, were considered. PFAS are unlikely to volatilize from water or foam, therefore, inhalation was not considered to be a realistic route of exposure for PFAS in a foam medium and therefore was not considered in this health assessment.

¹This foam is thought to be a byproduct of churning water that has been contaminated with PFAS and not AFFF itself. See Appendix Images 1-2 for images of foam.

² <https://www.atsdr.cdc.gov/mrls/mrlolist.asp>

Dermal Exposure.

Neither the EPA nor any other agency has established a dermal PFAS reference dose or exposure concentration limit for PFAS-containing foam. All health advisories to-date are for the *consumption* of PFAS via contaminated water sources, and the Agency for Toxic Substances and Disease Registry (ATSDR) has stated³ that “studies have shown that only a small amount of PFAS can get into your body through your skin. Therefore, showering and bathing in water containing PFAS should not increase exposure. Washing dishes in water containing PFAS should not increase exposure.” Similar recommendations have been expressed in numerous other public health statements^{4,5,6,7,8,9}. While these statements are not made about contact with lake foam specifically, they are about dermal exposure to PFAS, for which the mechanisms of absorption are expected to be similar regardless of the matrix within which the PFAS is located (i.e. skin contact with water is considered to be comparable to skin contact with foam). However, foam has very high levels of PFAS, and because of the high levels, dermal contact was evaluated.

Some information traditionally used to evaluate dermal environmental exposures is not yet available for many PFAS, such as permeability coefficients (K_p), octanol/water partition coefficients ($K_{o/w}$) and precise degrees of ionization (for environmental samples). Therefore, MDHHS has used such values for PFOA, only, that have been derived in the experimental literature. PFOA, although not the only or primary¹⁰ PFAS found in Van Etten Lake foam, is thought to have a higher capacity for skin permeability than PFOS due to physicochemical properties and therefore should capture a reasonable maximum scenario of skin contact with PFAS-containing lake foam.

When considering the concentration to evaluate for a health assessment, MDHHS used the highest combined PFOS and PFOA concentration from a sampling event, as that is considered the most conservative and health-protective choice. The highest reported concentration of combined PFOA and PFOS from Van Etten Lake foam samples was **166,180 ng/L**, which reflects the August 2017 sampling event conducted by the U.S. Air Force. This corresponds to 165,000 ng/L PFOS and 1,180 ng/L PFOA. Total PFAS detected in the sample was 169,785 ng/L (Table 1).

³ <https://www.atsdr.cdc.gov/pfas/pfas-exposure.html>, webpage updated Jan 10, 2018

⁴ <http://www.secnv.navy.mil/eie/Documents/WhatToDoIfYouHaveBeenExposed.pdf>

⁵ http://dhss.alaska.gov/dph/Epi/eph/Documents/PFCs/Moose%20Creek_PFAS%20Fact%20Sheet_Dec%201%202016.pdf

⁶ <https://www.mass.gov/files/documents/2016/07/sy/pfas-drink-wtr-fact-sheet.pdf>

⁷ https://www.health.ny.gov/environmental/investigations/drinkingwaterresponse/docs/atsdr_pfas_factsheet.pdf

⁸ <http://www.health.state.mn.us/divs/eh/hazardous/topics/pfcshealth.pdf>

⁹ <http://www.health.ri.gov/water/about/pfas/>

¹⁰ PFOS was found in higher concentrations than PFOA.

Table 1. Concentrations (nanograms per liter [ng/L]) of PFAS in foam and icy foam sampled from Van Etten Lake, Oscoda (Iosco County), Michigan.

Sample Description/Location (Sampler)	Sample Date	PFOA (ng/L)	PFOS (ng/L)	Total ¹ Detected ² PFAS (ng/L)
Foam/Wurtsmith AFB (Air Force)	August 3, 2017	1,180	165,000	169,785
Foam/YMCA Beach (EGLE)	October 12, 2017	149	23,100	24,572
Icy Foam/ Interlake Ramp (EGLE)	December 12, 2017	11	651	732

¹The total list of analytes tested differed between the Air Force and EGLE analyses, see Table 3 for complete list of analytes sampled during each event.

²Analytes that were not quantified because they were below the detectable limit are not included in the "Total Detected PFAS" column.

The EPA Dermal Exposure Assessment Guide¹¹ describes an equation for quantifying an absorbed dose per exposure event (Equation 1) and, using that, for quantifying a total dermal absorbed dose (Equation 2):

Equation 1. $DA_{event} = Kp \times Cf \times T_{event}$

Where,

- DA_{event}= absorbed dose per event in ng/cm²/event
- Kp= permeability in cm/hr
- Cf= concentration in foam in ng/cm³
- T_{event}= hours of dermal contact with foam in hr/event

Dermal permeability (Kp). Franko et al. (2012) reported average model based Kp of PFOA to be **0.00009 cm/hr.**

Duration of dermal contact (T_{event}). The duration per event of dermal contact with foam is assumed to be **3 hours**, which is based on the professional judgement and thought to represent the maximal, reasonable time that a young child might be engaging in recreational activities on the lake including time spent in the water and playing on the shoreline. Because foam can accumulate on the beach, restricting an exposure scenario to only a reasonable swim period (2 hours) was not considered to capture a reasonable maximum exposure scenario for foam exposure. This additional time (1-hr) accounts for prolonged residency of foam on skin. To further capture a reasonable maximum exposure scenario, MDHHS has considered different age groups including a young child exposed to this foam for 3 hrs per day for 5 days per week during the summer months. The following reasonable maximum exposure variables were included using the EPA Exposure Factors Handbook¹² to define human factors where applicable:

¹¹ <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=183584>

¹² https://rais.ornl.gov/documents/EFH_2011.pdf

Equation 2.

$$DAD = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT}$$

Where,

DAD= dermal absorbed dose in ng/kg/day
DA_{event} = absorbed dose per event in ng/cm²/event
EV= events/day
ED= exposure duration in years
EF= exposure frequency in days/year
SA= surface area in cm²
BW= body weight in kg
AT= averaging time in days

Surface area (SA). The mean skin surface area (entire body) for a child aged 1-2 years old (**5300 cm²**), 2-3 years old (**6100 cm²**), 3-6 years old (**7600 cm²**), 6-11 years old (**10800 cm²**) and adults > 21 years old (**20500 cm²**) were used.

Body weight (BW). The mean body weight for a child aged 1-2 years old (**11.4 kg**), 2-3 years old (**13.8 kg**), 3-6 years old (**18.6 kg**), 6-11 years old (**31.8 kg**) and adults > 21 years old (**80 kg**) were used.

Events per day (EV). **One event per day** (lasting 3 hours in duration) is assumed to be representative of the reasonable maximum exposure scenario for a young child.

Exposure frequency (EF). Van Etten Lake is typically used for recreation only during the summer months. The dermal exposure scenario here assumes a child playing in foam **5 days per week for 12 weeks (60 days)** out of the year.

Exposure Duration (ED). An exposure duration equal **1 year** (which matches the intermediate duration for ATSDR MRLs) was considered for this model scenario, and the *averaging time (AT)* was set to **84 days (7 days per week for 12 weeks)**.

Equation 2 yields the expected dose that is absorbed following skin contact with foam. This equation includes factors that capture the size (body weight and surface area of the skin) of the person, the length of time they are exposed and the ability for the chemical to effectively penetrate the skin barrier and enter the body. MDHHS considers this exposure scenario to likely over-estimate skin contact with foam, as it assumes 100% of the surface of a child's skin is in contact with foam for the length of the exposure duration and frequency. This is very unlikely to occur because foam floats on the surface of the water or blows along the beach and in most cases only a portion of the skin would contact the foam. It should also be noted that the concentration used represents the amount of PFOA+PFOS per liter of the liquid portion of the foam (liquid condensate), not per liter of foam itself. MDHHS considered that contact with the foam would likely form a uniform liquid layer on the skin (i.e. that all of the air pockets collapse upon contact), which further represents a possible overestimation of exposure. Should the foam matrix remain intact, a factor accounting for the decreased portion of the skin surface area in contact with foam that was actually exposed to PFAS-containing water would be used and would decrease the DAD accordingly (by a factor of 19 in this case, see the section on Oral Exposure below for more detail).

Oral Exposure.

The 2011 EPA Exposure Factors Handbook¹³ includes rates of incidental ingestion of water during swimming. It does not include an analogous estimate for the incidental ingestion of foam, necessitating the use of the incidental water ingestion rate as a best estimate for foam ingestion. However, the concentration of PFOS and PFOA used above reflects *the amount of PFOS and PFOA in just the liquid portion of the foam*; based on in-the-field reports from EGLE sampling, 1 gallon (3.8 L) of foam yielded approximately 0.2 L of liquid, a 19:1 ratio. Applying this ratio to the EPA estimate for incidental ingestion of water during swimming (0.049 L per hour for children and 0.021 L per hour for adults), MDHHS considered an ingestion rate of PFAS-containing *water* via foam to be 0.003 liters (L) (0.049 L/19) per hour for children and 0.001 L (0.021 L/19) per hour for adults.

To calculate an oral (ingested) exposure dose¹⁴, the concentration of the foam was multiplied by the ingestion rate (the amount swallowed), bioavailability factor, exposure factor and divided by the body weight.

Equation 3.
$$\text{Dose} = \frac{\text{Cf} \times \text{IR} \times \text{BF} \times \text{EF}}{\text{BW}}$$

Where,

Dose= oral exposure dose

Cf= concentration in the foam in ng/L

IR = ingestion rate of PFAS-containing *water* via foam (L)

BF = bioavailability factor(unitless)

EF = exposure factor (unitless)

BW= body weight in kg

Body weight (BW). The mean body weight for a child aged 1-2 years old (**11.4 kg**), 2-3 years old (**13.8 kg**), 3-6 years old (**18.6 kg**), 6-11 years old (**31.8 kg**) and adults (**80 kg**) were used.

Ingestion rate (IR). MDHHS considered an ingestion rate of PFAS-containing *water* via foam to be 0.006 liters (L) for 2 hours for children and 0.002 L for 2 hours for adults.

Bioavailability factor (BF). Bioavailability factor is assumed to be 100 %.

Exposure factor (EF). It is calculated by multiplying the exposure frequency (**60 days**) by the exposure duration (**1 year**) and dividing by averaging time (**84 days**).

A body weight of different age groups along with the amount of PFAS-containing *water* via foam ingested during a 2-hr exposure and the maximum concentration of PFOA and PFOS, reported in foam samples were considered.

Using the highest concentrations of PFOS and PFOA concentration from a sampling event, dermal absorbed doses and oral exposure doses were estimated. MDHHS then compared the total exposure

¹³ https://rais.ornl.gov/documents/EFH_2011.pdf

¹⁴ <https://www.atsdr.cdc.gov/hac/phamanual/appg.html>

doses from dermal (Equation 2) and oral (Equation 3) routes to MRLs of PFOA and PFOS. MRLs represent the amount of a chemical per body weight that can be ingested daily and not expected to cause harm over a specified period of exposure for any individual including sensitive populations. Dividing the exposure dose by the MRL results in a Hazard Quotients (HQs). The HQs of select PFAS for different age groups are shown in Table 2.

Table 2. Total exposure dose and HQs of select PFAS from the foam sampled on August 2017 from Van Etten Lake, Oscoda, Michigan for children of different age group and adults.

A. Children 1-2-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.100	0.444	0.544	3	< 1
PFOS	14.794	62.030	76.824	2	38

B. Children 2-3-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.095	0.366	0.461	3	< 1
PFOS	14.066	51.242	65.308	2	33

C. Children 3-6-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.088	0.272	0.360	3	< 1
PFOS	13.002	38.018	51.021	2	26

D. Children 6-11-year-old

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.073	0.159	0.232	3	< 1
PFOS	10.807	22.237	33.044	2	17

E. Adults (>21-year-old)

PFAS	Dermal absorbed dose (ng/kg/day)	Oral exposure dose (ng/kg/day)	Total exposure dose (ng/kg/day)	Minimal Risk Level (ng/kg/day)	Hazard Quotient (unitless)
PFOA	0.055	0.021	0.076	3	< 1
PFOS	8.154	2.946	11.100	2	6

MDHHS has concluded that there is a potential risk of harm to human health following incidental ingestion of PFAS-containing *water* via foam and skin contact with foam after exposure for three hours per day for five days a week during the recreational season during swimming or other recreational activities. Using the assumptions described above both children and adults contacting the highest-concentration-PFAS

foam over the entire surface of their body while playing in the lake for 3 hours/day, 5 days/week, 12 weeks/year are estimated to result in increased exposure that could increase people's risk of harmful health effects.

Limitations.

Limitations to the dermal exposure model used here reflect the sparsity of relevant physiochemical information on nearly all individual PFAS, as well as a lack of understanding about how mixture exposures can influence the absorption, distribution, metabolism and/or elimination of individual PFAS constituents. Specifically, MDHHS recognizes that additional experimental data could indicate a higher (or lower) dermal permeability of PFOA and/or a reliable Kp for PFOS, in which case the HQs discussed here would need recalculating. There are considerable unknowns at this time about the dermal permeability of PFAS-containing lake foam, and it is assumed that dermal permeability is dependent on the chemical form of the foam-constituents. Also, it is possible the exposure scenario selected here is not realistic for Van Etten Lake and might overestimate contact with PFAS-containing lake foam. Similarly, the estimated rate for incidental ingestion of foam may not reflect realistic events. Please also note that the concentration of PFAS in the foam vary over time. The variables used for these factors were based on the best information currently available. Please see https://www.michigan.gov/pfasresponse/0,9038,7-365-88059_91295---.00.html for information on physical characteristic of PFAS foam on lakes and streams.

Table 3. PFAS analytes tested by each agency for foam collected on Van Etten Lake across three sampling events in 2017, analyte name (common abbrev.) is provided.

<i>U.S. Air Force Testing</i>	<i>EGL E Testing</i>
Perfluorobutanesulfonic acid (PFBS)	Perfluorobutanesulfonic acid (PFBS)
Perfluorodecanoic acid (PFDA)	Perfluorodecanoic acid (PFDA)
Perfluorododecanoic acid (PFDoA)	Perfluorododecanoic acid (PFDoA)
Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)	Perfluorohexanesulfonic acid (PFHxS)
Perfluorohexanoic acid (PFHxA)	Perfluorohexanoic acid (PFHxA)
Perfluorononanoic acid (PFNA)	Perfluorononanoic acid (PFNA)
Perfluorooctanesulfonic acid (PFOS)	Perfluorooctane Sulfonate (PFOS)
Perfluorooctanoic acid (PFOA)	Perfluorooctanoic acid (PFOA)
Perfluorotetradecanoic acid (PFTeA)	Perfluorotetradecanoic acid (PFTeA)
Perfluorotridecanoic acid (PFTriA)	Perfluorotridecanoic Acid (PFTriA)
Perfluoroundecanoic acid (PFUnA)	Perfluoroundecanoic acid (PFUnA)
N-Ethyl perfluorooctane-sulfonamidoacetic acid (NETFOSAA)	Perfluorobutanoic acid (PFBA)
N-Methyl perfluorooctane-sulfonamidoacetic acid (NMEFOSAA)	Perfluorodecanesulfonic acid (PFDS)
	Perfluoroheptanesulfonic Acid (PFHpS)
	Perfluoro-n-hexadecanoic acid (PFHxDA)
	Perfluoro-n-octadecanoic acid (PFODA)
	Perfluorooctane Sulfonamide (FOSA)
	Perfluoropentanoic acid (PFPeA)

Note: **Bolded** analytes are common to both analyses.

Image 1. Photo of lake foam at Van Etten Lake on Thursday, July 13, 2017. Photo taken by the EGLE during the sampling event.



Note: This is a shoreline observation that occurred during the sample collection of Van Etten Lake foam.

Image 2. Photo of lake foam at Van Etten Lake on Thursday, July 13, 2017. Photo taken by the EGLE during the sampling event.



Note: This is a shoreline observation that occurred during the sample collection of Van Etten Lake foam.



STATE OF MICHIGAN
DEPARTMENT OF HEALTH AND HUMAN SERVICES
LANSING

RICK SNYDER
GOVERNOR

NICK LYON
DIRECTOR

August 1, 2017

Denise Bryan, Health Officer
District Health Department No. 2
630 Progress Street
West Branch, MI 48661

Dear Ms. Bryan:

The Michigan Department of Health and Human Services Division of Environmental Health (MDHHS) has evaluated per- and polyfluoroalkyl substance (PFAS, sometimes called perfluorinated chemical [PFC]) analytical data for surface water from and foam observed on Van Etten Lake in Oscoda (Iosco County), Michigan, and sampled on July 13, 2017.

MDHHS has determined that incidental swallowing of PFAS-containing lake water or foam is not expected to harm human health.

This conclusion has the following limitations:

1. This was a one-time sampling event of four surface water samples and one dissolved-foam sample that consisted of three containers of foam gathered and allowed to settle 24 hours, resulting in about one container of liquid.
2. Field staff indicated that the foam sample likely contained surface water as well, which would have diluted the concentration of PFAS detected in the foam (i.e., the results may have been biased low).
3. While there is information regarding how much surface water a person may swallow during recreational activities, it is difficult to estimate the amount of foam a person could swallow.
4. This evaluation assumes swallowing the water or foam on a daily basis. It is unlikely that foam would occur, or that a child would be at the beach, on a daily basis.
5. Data from future sampling events, when foam occurs on surface waters near the former Wurtsmith Air Force Base (WAFB), may show higher concentrations of PFAS in the water or foam. This may result in MDHHS's conclusions and recommendations changing.
6. There are other potential exposure pathways to PFAS near WAFB, such as eating locally-caught non-migratory fish or drinking water from wells that have elevated concentrations of PFAS. When considering all pathways to which people may be exposed to PFAS coming from WAFB, the cumulative dose could increase the risk of harm. However, if people are following already-existing fish consumption guidelines and private-well drinking water recommendations for the area, then there is less exposure concern.

Based on the conclusion above, and its limitations, MDHHS recommends the following:

- It is not necessary to post a “no-contact” advisory. Skin contact with PFAS is not a significant exposure pathway. As already stated, incidental swallowing of lake water or foam is not expected to harm human health.
- MDEQ should continue sampling and analyzing foam found in waterbodies near WAFB to determine an expected range of PFAS content.

The attached discussion shows the details of the evaluation of the data.

If I can be of further assistance in this matter, please do not hesitate to contact me.

Sincerely,

A handwritten signature in cursive script that reads "Christina Rose Bush".

Christina Bush, Section Manager (Acting)
Toxicology and Response Section
Division of Environmental Health

CC: MDEQ
MDNR
Oscoda Township
U.S. Air Force
ATSDR

Technical Review Evaluating Potential Exposure to Per- and Polyfluoroalkyl Substances (PFAS) in Foam and Surface Water at Van Etten Lake, Oscoda (Iosco County), Michigan

Prepared by Christina Bush, Acting Manager for Toxicology and Response Section
Michigan Department of Health and Human Services, Division of Environmental Health
August 1, 2017

On July 13, 2017, the Michigan Department of Environmental Quality (MDEQ) was supporting a “STEM” (Science, Technology, Engineering, and Mathematics) program, as an outreach and education effort by the agency, in which students were conducting environmental sampling. At a beach along the west shore of Van Etten Lake, the field team observed foam built up along the water’s edge. The STEM team sampled surface water near the foam and at several other locations (a total of four samples at 250 milliliters [ml] each). MDEQ collected split samples of the surface water and also sampled the foam. MDEQ collected three 250-ml containers of foam, since the matrix of the foam consisted of both air and liquid and liquid volume would likely be only a fraction of the total volume. After a 24-hour settling period, the foam had dissolved to just liquid, about 200 ml. Sample locations are shown on the attached map.

The samples were analyzed for 19 individual PFAS and two individual fluorotelomer sulfonates (a group within the PFAS family). MDHHS considered three PFAS for this evaluation: perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and perfluorohexane sulfonate (PFHxS). The U.S. Environmental Protection Agency (EPA) has set a Lifetime Health Advisory (LTHA) in drinking water for PFOA and PFOS¹ but not for other PFAS. MDHHS included PFHxS in its evaluation because PFHxS occurs frequently at sites like WAFB, where aqueous film-forming foam (AFFF) has been released to the environment: the fingerprint for AFFF plumes can consist of high levels of PFHxS, as well as PFOA and PFOS. MDHHS used the results for the surface water sample with the highest concentration of PFOA and PFOS combined, which was also the sample with the highest PFOA, PFOS, and PFHxS combined, and the results for the foam sample for this evaluation.

Table 1. Concentrations (nanograms per liter [ng/L]) of select PFAS in surface water and foam sampled from Van Etten Lake, Oscoda (Iosco County), Michigan on July 13, 2017.

	PFOA + PFOS (ng/L)	PFOS + PFOS + PFHxS (ng/L)
Surface water (STEM L3)	56	121.8
Foam	2,237	2,353

The 2011 U.S. EPA’s Exposure Factors Handbook² reports that a typical amount of water that a child less than the age of 18 would incidentally swallow while swimming for about 45 minutes is **0.037 liters (L) per event** (or per day, for this evaluation³), which is about one-quarter cup.

To be most protective, MDHHS considered a child up to the age of one year sitting at the water’s edge playing in the water or the foam. The ATSDR recommends using a body weight

¹ See https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories_pfoa_pfos_updated_5.31.16.pdf.

² Available at https://rais.ornl.gov/documents/EFH_2011.pdf.

³ Note that it is unlikely that foam would occur or that a child would be at the beach on a daily basis. “Per day” was used so that units (days) would carry forward for comparison to the Reference Dose.

for a 0-1 year old of **7.8 kilograms** (kg),⁴ which is about 17 pounds. While this scenario is not a child swimming, it may represent what an infant or toddler playing on the beach by the water line might swallow.

To calculate the exposure dose, one multiplies the concentration of the chemical in water by the ingestion rate (the amount swallowed), then dividing by the body weight:

$$Dose = \frac{Concentration \times Ingestion Rate}{Body Weight}$$

The calculated exposure doses are shown in Table 2.

Table 2. PFAS exposure doses calculated for incidental swallowing of surface water in or foam on Van Etten Lake, Oscoda (Iosco County), Michigan.

	PFOA + PFOS (ng/kg-day)	PFOS + PFOS + PFHxS (ng/kg-day)
Surface water	0.26	0.58
Foam	10.6	11.2

MDHHS then compared the exposure doses to the Reference Dose that EPA derived for PFOA and PFOS for the LTHA. Note that the Reference Dose is not the LTHA (a water concentration) but the amount of a chemical per body weight, within an order of magnitude, that is estimated not to cause harm over a lifetime of exposure, even in sensitive groups such as children and fetuses. The Reference Doses for PFOA and PFOS are the same: 0.00002 milligrams/kg-day, which is equivalent to **20 ng/kg-day**. As stated earlier, the EPA has not set a LTHA for PFHxS and therefore has not developed a Reference Dose for that PFAS. MDHHS included PFHxS in the comparison to the PFOA and PFOS Reference Dose in this evaluation to be protective.

Dividing the exposure dose by the Reference Dose results in a Hazard Quotient. A Hazard Quotient greater than one indicates that further evaluation of the exposure is necessary. A Hazard Quotient less than one indicates that further evaluation may not be necessary. The Hazard Quotients for this evaluation are shown in Table 3.

Table 3. PFAS Hazard Quotients (exposure dose divided by Reference Dose) for incidental swallowing of surface water in or foam on Van Etten Lake, Oscoda (Iosco County), Michigan.

	PFOA + PFOS (unitless)	PFOS + PFOS + PFHxS (unitless)
Surface water	0.01	0.03
Foam	0.53	0.56

As calculated, a 0-1 year old child swallowing about one-quarter cup of lake water while playing near the water's edge at Van Etten Lake would not be expected to be harmed by this exposure.

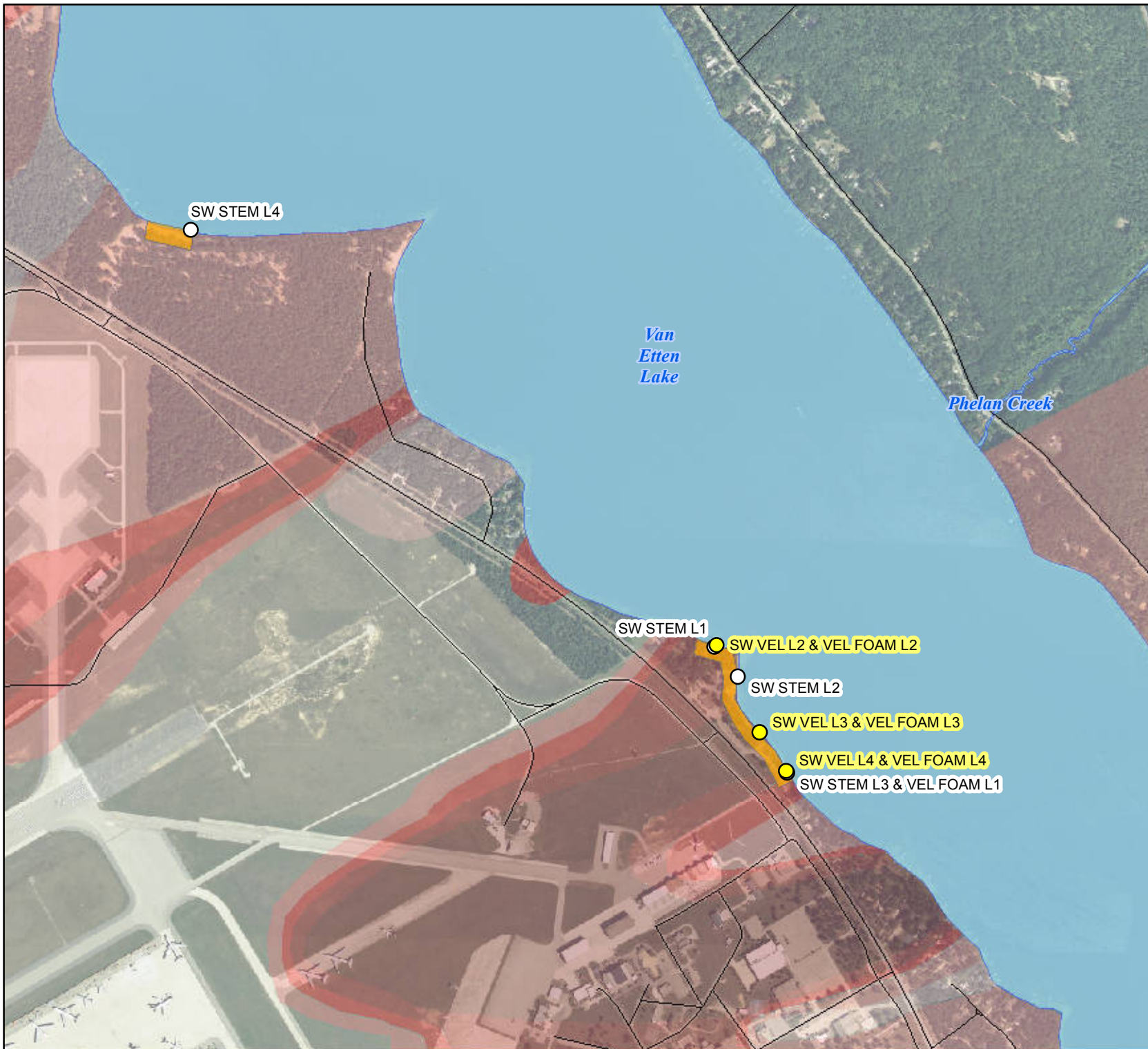
⁴ ATSDR. 2016. Exposure Dose Guidance for Body Weight. Atlanta, GA: US Dept Health and Human Services, Public Health Service, October 26.

Similarly, a 0-1 year old child swallowing the amount of foam that would equal one-quarter cup of liquid while playing near the water's edge at Van Etten Lake would not be expected to be harmed by this exposure. Follow-up sampling conducted by MDEQ, during which more care was taken to obtain only foam and no surface water, suggested that the volume of foam, when allowed to dissolve down to just liquid, would reduce 5-10 times rather than three, as happened during the first sampling event. Therefore, rather than needing three times the amount of foam to equal a certain volume of liquid, it would take 5-10 times. This translates to 1-1/4 cups to 2-1/2 cups of foam to dissolve down to one-quarter cup of liquid. It is not known if a child would swallow this volume of foam.

There are other potential exposure pathways to PFAS near WAFB: eating locally-caught non-migratory fish or drinking from wells that have elevated concentrations of PFAS. The cumulative exposure risk from multiple pathways could cause public health concerns. In 2012, MDHHS issued fish consumption guidelines pertaining to PFAS in fish for several waterbodies in the area and, in 2016, recommended that homeowners with drinking water wells downgradient of the base obtain alternate water through District Health Department No. 2.⁵ If people are following recommendations, then there is less exposure concern.

There may be future foam events at Van Etten Lake or in other waterbodies impacted by the PFAS contamination from WAFB. Additional sampling data may cause MDHHS to change conclusions and resultant recommendations regarding exposure to the foam.

⁵ See www.michigan.gov/wurtsmith.



Legend

Surface Water and Foam Sample Location

- 7/13/2017
- 7/27/2017

Foam Observation Area (7/13/2017 and 7/27/2017)

- Foam Observed

Groundwater Impact

- 1 - 50
- 51 - 300
- 301 - 1,000
- 1,000 - 5,000
- > 5,000
- Road
- Surface Water

2017 Surface Water Sampling and Foam Observations on Van Etten Lake (VEL)

Former Wurthsmith Air Force Base
Iosco County, Michigan

