



ENVIRONMENTAL SURVEILLANCE AND ASSESSMENT

m e m o

DATE: May 17, 2017  
TO: James Kelly, Manager, Environmental Assessment and Surveillance Section  
VIA: Sarah Johnson<sup>CS</sup>, Supervisor, Health Risk Assessment Unit  
FROM: Nancy Rice<sup>ML</sup>, Health Risk Assessment Unit  
SUBJECT: Health-Based Values for Perfluorooctane Sulfonate  
CAS: 1763-23-1 (acid)  
29081-56-9 (ammonium salt)  
70225-14-8 (diethanolamine salt)  
2795-39-3 (potassium salt)  
29457-72-5 (lithium salt)

Since 2002, staff have completed several evaluations of perfluorooctane sulfonate (PFOS). A chronic non-cancer Health-Based Value (HBV) of 1 µg/L was first derived by Minnesota Department of Health (MDH) in 2002 after perfluorochemicals were found in drinking water in several locations in Minnesota. This value was updated to 0.3 µg/L in 2007 when more toxicological information was available. In 2009, the value of 0.3 µg/L was adopted into rule. When the U.S. Environmental Protection Agency (EPA) began a review of PFOS, MDH committed to another review of the HBV value after EPA provided the results of its review. The EPA announced a Health Advisory Value of 0.07 µg/L in 2016 and MDH then began reviewing its 2009 guidance for PFOS to determine if the guidance values remained sufficiently protective.

PFOS is highly bioaccumulative in the serum, with a human half-life of about 5.4 years. During the 2016/2017 review, MDH determined that serum concentration was the most appropriate dose metric, and that the concentration of PFOS in drinking water must be kept below levels that could result in serum concentrations of concern. Further, MDH concluded that protecting against high, short-term exposures that formula-fed and breast-fed infants experience is important, in addition to protecting against long-term exposures. Given these considerations, the standard MDH equation used for deriving health-based guidance was not adequate, and MDH developed a toxicokinetic model to assess the effect of PFOS concentrations in drinking water on serum concentration.

The Contaminants of Emerging Concern (CEC) program completed the review. Helen Goeden completed the primary review and Jim Jacobus completed the secondary review. An interim team review was held on August 30, 2016, and the final team review was held on April 20, 2017. PFOS is the fifth chemical review completed in FY2017 by the CEC program, and the 11th completed by the CEC program in the 2016/2017 biennium.

**Exhibit**  
**2477**  
State of Minnesota v. 3M Co.,  
Court File No. 27-CV-10-28862

PFOS bioaccumulates within the body, crosses the placenta, and partitions to breastmilk. Short-term exposures have the potential to stay in the body for an extended period of time. Therefore a single HBV has been recommended for short-term, subchronic, and chronic duration. Staff recommend the following non-cancer Health-Based Values (HBVs) for all durations: short-term (up to 30 days); subchronic (up to approximately 8 years); and chronic (lifetime) exposure.

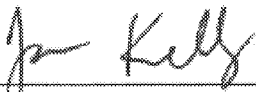
The following HBVs have been derived for PFOS:

<u>CAS Nos.</u>	<u>Chemical</u>	<u>Duration</u>	<u>Endpoints</u>	<u>HBV (ug/L)</u>
1763-23-1 (acid) 29081-56-9 (ammonium salt) 70225-14-8 (diethanolamine salt) 2795-39-3 (potassium salt) 29457-72-5 (lithium salt)	PFOS	Acute	--	NA
		Short-term	Developmental, Hepatic (Liver) system, Immune system, Thyroid (E)	0.027
		Subchronic		
		Chronic		
		Cancer	-	NA

NA = Not Applicable

The updated PFOS guidance values and the attached summary documentation will be added to the Human Health-Based Water Guidance table on MDH's website. The Guidance Implementation Team members, which include representatives from Minnesota Department of Agriculture, Minnesota Pollution Control Agency, MDH Drinking Water Protection and other MDH programs will be informed about the new values in an upcoming meeting. A GovDelivery message announcing the finalized values will be sent when the updated information is added to the MDH website.

Your signature, indicating that you have reviewed and approved this value, is requested.



James Kelly, Section Manager

Date: 5/17/17

Attachment: Toxicological Summary for PFOS

Web Publication Date: May 2017

## Toxicological Summary for: Perfluorooctane Sulfonate

CAS: 1763-23-1 (acid)

29081-56-9 (ammonium salt)

70225-14-8 (diethanolamine salt)

2795-39-3 (potassium salt)

29457-72-5 (lithium salt)

*[Note: perfluorooctanoate anion does not have a specific CAS number.]*

Synonyms: PFOS, Perfluorooctane sulfonic acid

***MDH conducted a focused re-evaluation, which relied heavily upon EPA's hazard assessment and key study identification contained within the EPA Health Effects Support Document for Perfluorooctane Sulfonate (PFOS) released in May 2016 (EPA 2016a). A complete evaluation of the toxicological literature was not conducted.***

### Short-term, Subchronic and Chronic\* – Non-Cancer Health Based Value (nHBV) = 0.027 µg/L\*\*

\*Due to the highly bioaccumulative nature of PFOS and human half-life of nearly 5.4 years, serum concentrations are the most appropriate dose metric and the standard equation to derive the HBV was not appropriate. Short-term exposures have the potential to stay in the body for an extended period of time. Therefore a single HBV has been recommended for short-term, subchronic, and chronic durations. The 2017 HBV was derived using a toxicokinetic (TK) model developed by MDH with input from an external peer review panel. Model details are presented below.

\*\*Relative Source Contribution (RSC): based on current biomonitoring serum concentrations from local and national general populations to represent non-water exposures, an RSC of 0.5 (50%) was selected for water ingestion.

Intake Rate: In keeping with MDH's practice, 95<sup>th</sup> percentile water intake rates (Table 3-1 and 3-3, USEPA 2011) or upper percentile breastmilk intake rates (Table 15-1, USEPA 2011) were used. Breastmilk concentrations were calculated by multiplying the maternal serum concentration by a PFOS breastmilk transfer factor of 1.3%. For the breast-fed infant exposure scenario, a period of exclusive breastfeeding for one year was used as representative of a reasonable maximum exposure scenario.

A simple equation is typically used to calculate HBVs at the part per billion level with results rounded to one significant digit. However, the toxicokinetic model used to derive the HBV for PFOS showed that serum concentrations were impacted by changes in water concentrations at the part per trillion level. As a result, the 2017 HBV contains two digits.

Reference Dose/Concentration:  $\text{HED/Total UF} = 0.00051/100 = 0.0000051 \text{ mg/kg-d}$   
(Cr:CD(SD)IGS VAF Rats). *[The corresponding serum concentration is  $6.26/100 = 0.063 \text{ mg/L}$ . Note: this serum concentration is inappropriate to use for individual assessment.\*\*\*]*

Source of toxicity value: Determined by MDH in 2017

Point of Departure (POD):	6.26 mg/L serum concentration (EPA 2016a predicted average serum concentration for F2 generation. NOAEL from Luebker et al 2005b)
Dose Adjustment Factor (DAF):	0.000081; Toxicokinetic Adjustment based on Chemical-Specific Clearance Rate = Volume of Distribution (L/kg) x (Ln2/Half-life, days) = 0.23 L/kg x (0.693/1971 days) = 0.000081 L/kg-day (US EPA 2016a)
Human Equivalent Dose (MDH, 2017):	POD x DAF = 6.26 mg/L x 0.000081 L/kg/day = 0.00051 mg/kg-day
Total uncertainty factor (UF):	100
Uncertainty factor allocation:	3 for interspecies differences (for toxicodynamics), 10 for intraspecies variability and 3 for database uncertainty (additional studies regarding immunotoxicity are warranted)
Critical effect(s):	Decreased pup body weight
Co-critical effect(s):	In offspring exposed during development: delayed eye opening, increased sternal defects, changes in lung development, decreased glucose tolerance, increased motor activity and decreased habituation, decreased levels of thyroxine (T4), and decreased survival. In adult animals: liver weight changes accompanied by changes in cholesterol levels and histology; decreased levels of thyroxine (T4); decreased SRBC response, increased NK cell activity, decreased spleen and thymus weight and cellularity
Additivity endpoint(s):	Developmental, Hepatic (Liver) system, Immune system, Thyroid (E)

\*\*\* Serum concentration is useful for informing public health policy and interpreting population-based exposures. This value is based on population-based parameters and should not be used for clinical assessment or for interpreting serum levels in individuals.

#### Toxicokinetic Model Description:

Serum concentrations can be calculated from the dose and clearance rate using the following equation. This equation was used by EPA, to calculate the HEDs from the POD serum concentrations.

$$\text{Serum Concentration} \left( \frac{\text{mg}}{\text{L}} \right) = \frac{\text{Dose} \left( \frac{\text{mg}}{\text{kg} \cdot \text{day}} \right)}{\text{Clearance Rate} \left( \frac{\text{L}}{\text{kg} \cdot \text{day}} \right)}$$

Where:

*Dose (mg/kg-day) = Water or Breastmilk Intake (L/kg-day) x Level in Water or Breastmilk (mg/L)*

and

*Clearance (L/kg-d) = Volume of distribution (L/kg) x (Ln 2/half-life (days))*

Two exposure scenarios were examined: 1) an infant fed with formula reconstituted with contaminated water starting at birth and continuing ingestion of contaminated water through life; and 2) an infant exclusively breast-fed for 12 months, followed by drinking contaminated water. In both scenarios the simulated individuals began life with a pre-existing body burden through placental transfer of PFOS

(maternal serum concentration x 46%) based on average cord to maternal serum concentration ratios reported in the literature. The serum concentration of the mother at delivery was assumed to be at steady-state.

Consistent with MDH methodology, 95<sup>th</sup> percentile water intake and upper percentile breastmilk intake rates were used to simulate a reasonable maximum exposed individual. A PFOS breastmilk transfer factor of 1.3%, based on average breastmilk to maternal serum concentration ratios reported in the literature, was used to calculate breastmilk concentration. According to the 2016 Breastfeeding Report Card (CDC, 2016), nearly 66 percent of mothers in Minnesota report breastfeeding at six months, with 31.4 percent exclusively breastfeeding. The percent breastfeeding dropped to 41% at twelve months. MDH selected an exclusive breastfeeding duration of one year for the breast-fed infant scenario.

Daily post-elimination serum concentration was calculated as:

$$\text{Serum Conc.} \left( \frac{\text{mg}}{\text{L}} \right) = \left[ \text{Prev. day Serum Conc.} \left( \frac{\text{mg}}{\text{L}} \right) + \frac{\text{Today's Intake}(\text{mg})}{V_d \left( \frac{\text{L}}{\text{kg}} \right) \times \text{BW}(\text{kg})} \right] \times e^{-k}$$

To maintain mass balance, daily maternal serum concentrations and loss-of-chemical via transfer to the infant as well as excretion represented by the clearance rate, were calculated.

#### Summary of Model Parameters

Model Parameter	Value Used
Half-life	1971 days (US EPA 2016c)
Volume of distribution (Vd)	0.23 L/kg (US EPA 2016c)
Vd Age Adjustment Factor	2.1 age 1-30 days decreasing to 1.2 age 5-10 years and 1.0 after age 10 years (Friis-Hansen 1961)
Clearance Rate (CR)	0.000081 L/kg-d, calculated from Vd x (Ln 2/half-life)
Placental transfer factor (% of maternal serum level)	46% (MDH 2017b)
Breastmilk transfer factor (% of maternal serum level)	1.3% (MDH 2017b)
Water Intake Rate (L/kg-d)	95 <sup>th</sup> percentile consumers only (default values, MDH 2008) (Table 3-1 & 3-3, USEPA 2011)
Breastmilk Intake Rate (L/kg-d)	Upper percentile exclusively breast-fed infants (Table 15-1, US EPA 2011)
Body weight (kg)	Calculated from water intake and breastmilk intake rate tables

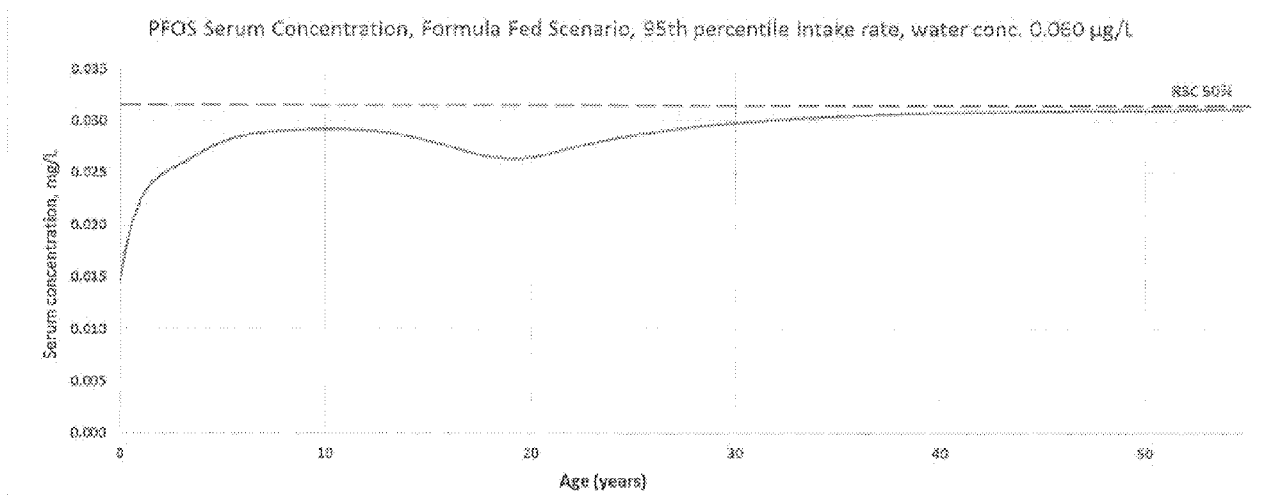
A relative source contribution factor (RSC) is incorporated into the derivation of a health-based water guidance value to account for non-water exposures. MDH utilizes the Exposure Decision Tree process presented in US EPA 2000 to derive appropriate RSCs. MDH relied upon the percentage method to reflect relative portions of water and non-water routes of exposure. The values of the duration specific default RSCs (0.5, 0.2, and 0.2 for short-term, subchronic, and chronic, respectively) are based on the magnitude of contribution of these other exposures that occur during the relevant exposure duration (MDH 2008). However, in the case of PFOS, application of an RSC needs to account for the long elimination half-life, such that a person's serum concentration at any given age is not only the result of his or her current or recent exposures within the duration of concern, but also from exposure from years past.

Serum concentrations are the best measure of cumulative exposure and can be used in place of the RfD in the Decision Tree process. Biomonitoring results from new residents who were not historically exposed to contaminated water in the East Metro can be used to represent non-water exposures (Nelson, 2016). The serum concentrations in these residents were similar in magnitude to those for the general public reported in the most recent National Report on Human Exposure to Environmental Chemicals (CDC 2017). MDH selected an RSC of 50% for exposure from water ingestion based on:

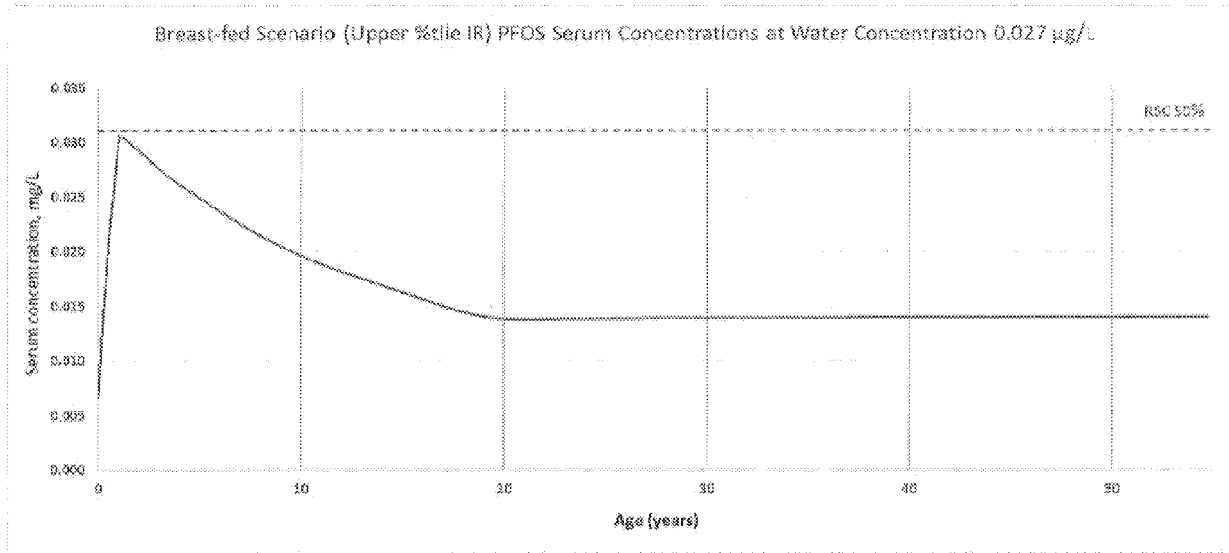
- A high-end, conservative estimate of background, non-water exposures represented by the 95<sup>th</sup> percentile serum concentration for new East Metro residents (0.021 mg/L serum), and
- The USEPA Decision Tree RSC ceiling of 80% to ensure a margin of safety to account for possible unknown sources of exposure

As mentioned above, two exposure scenarios were examined: 1) an infant fed formula reconstituted with contaminated water starting at birth and continuing ingestion of contaminated water through life; and 2) an infant exclusively breast-fed for 12 months, followed by drinking contaminated water through life.

For the first scenario, the formula-fed infant, the water concentration that maintains a serum concentration attributable to drinking water below an RSC of 50% throughout life is 0.060 µg/L. Because of the long half-life, the serum concentration curve is very flat and even a small increment increase in the water concentration (0.061 µg/L) raises the serum concentration above the 50 percent threshold for nearly 9 years.



Applying this water concentration of 0.060 µg/L in the context of a breast-fed infant resulted in not only an exceedance of the 50% RSC threshold, but of the entire reference serum concentration for more than one year. In order to maintain a serum concentration at or below an RSC of 50% for breast-fed infants, the water concentration should not exceed 0.027 µg/L.



Due to chronic bioaccumulation in the mother and subsequent transfer to breastmilk, the breast-fed infant exposure scenario is the most limiting scenario in terms of water concentrations. To ensure protection of all segments of the population, the final health-based value for PFOS is set at 0.027 µg/L.

**Cancer Health Based Value (cHBV) = Not Applicable**

- Cancer classification: Suggestive Evidence of Carcinogenic Potential (EPA 2016b)
- Slope factor (SF): Not Applicable
- Source of cancer slope factor (SF): Not Applicable
- Tumor site(s): Liver and thyroid tumors were identified in both control and exposed animals at levels that did not show a direct relationship to dose.

**Volatile: No**

**Summary of Guidance Value History:**

A chronic nHBV of 1 µg/L was first derived in 2002. A revised chronic nHBV of 0.3 µg/L was derived in 2007 and promulgated as an nHRL in 2009. In 2016, EPA released a Health Advisory of 0.07 µg/L for PFOS. MDH conducted a re-evaluation and derived a revised nHBV (applicable to all durations) of 0.027 µg/L in 2017. The 2017 nHBV is lower than the previous value as the result of: 1) incorporating the most recent toxicological information and 2) chemical-specific exposure concerns from breastmilk.

**Summary of toxicity testing for health effects identified in the Health Standards Statute (144.0751):**

Even if testing for a specific health effect was not conducted for this chemical, information about that effect might be available from studies conducted for other purposes. MDH has considered the following information in developing health protective guidance.

	Endocrine	Immunotoxicity	Development	Reproductive	Neurotoxicity
Tested for specific effect?	Yes	Yes	Yes	Yes	Yes
Effects observed?	Yes <sup>1</sup>	Yes <sup>2</sup>	Yes <sup>3</sup>	Yes <sup>4</sup>	Yes <sup>5</sup>

**Comments on extent of testing or effects:**

*[Note: MDH conducted a focused re-evaluation which relied upon EPA's hazard assessment and key study identification (EPA 2016a). A complete evaluation of the toxicological literature was not conducted.]*

<sup>1</sup> Numerous human epidemiological studies have evaluated thyroid hormone levels and/or thyroid disease in association with serum PFOS. Results from these studies have provided limited support for an association. Stronger associations were found in populations at risk for iodine deficiency or positive anti-TPO antibodies (a marker for autoimmune thyroid disease).

Studies in laboratory animals have reported decreased serum thyroid levels, in particular, thyroxin (T4) in offspring and adult animals at exposure levels similar in magnitude to the critical effect. Decreased T4 has been identified as a co-critical effect and Thyroid has been identified as an Additivity Endpoint.

<sup>2</sup> A few human epidemiology studies have evaluated associations between immunosuppression measures and serum PFOS. However, no clear associations were reported between serum PFOS and rates of infectious disease.

Studies in laboratory animals have shown that PFOS exposure alters several immunologic measures (e.g., suppression of SRBC response, and/or increased natural killer cell activity). Some of these effects occur at exposure levels similar to the POD. As a result the immune system has been identified as an Additivity Endpoint and a database uncertainty factor has been incorporated into the derivation of the RfD.

<sup>3</sup> Human epidemiology studies have suggested an association between prenatal PFOS serum levels and lower birth weight, however, this association has not been consistent.

Studies conducted in laboratory animals have identified several sensitive developmental effects. Decreased pup body weight appears to be among the most sensitive effects and, in part, forms the basis of the Reference Dose and corresponding serum concentration of concern. A limited number of studies have also reported changes in male reproductive development and changes in energy metabolism (e.g., glucose levels, lipid metabolism) following exposure during development. Additional effects, including increased pup death, were observed at higher exposure levels.

<sup>4</sup> A small number of human epidemiology studies have reported an association between preconception serum PFOS and gestational diabetes and pregnancy-induced hypertension. There has also been some evidence of associations between serum PFOS and decreased fertility, however, concerns have been raised over the possibility that this is due to reverse causation.



Studies in laboratory animals do not indicate that fertility is a sensitive endpoint, with decreases in male reproductive organs weights, decreased epididymal sperm count, and evidence of disruption of the blood-testes-barrier occurring at exposure levels higher than those causing developmental toxicity (see above). Therefore, the RfD would be protective of these effects.

<sup>5</sup> Developmental neurotoxicity and adult neurotoxicity studies have been conducted in laboratory animals. Increased motor activity and decreased habituation of male offspring was reported following gestational and lactational exposure at levels similar to the critical effect and have been included as co-critical effects. These effects are encompassed by the Developmental Additivity Endpoint. Results from studies using water maze tests for learning and memory in animals exposed during development or as adults have yielded inconsistent results or effects at higher dose levels.

#### Resources Consulted During Review:

*[Note: MDH conducted a focused re-evaluation which relied upon EPA's hazard assessment and key study identification (EPA 2016a). A complete evaluation of the toxicological literature was not conducted.]*

ASTSWMO (2015). Association of State and Territory Solid Waste Management Officials. Perfluorinated Chemicals (PFCs): Perfluorooctanoic Acid (PFOA) & Perfluorooctane Sulfonate (PFOS) Information Paper.

ATSDR. (2015). "Agency for Toxic Substances and Disease Registry. Draft Toxicological Profile for Perfluoroalkyls." Retrieved August 15, 2015, from <http://www.atsdr.cdc.gov/toxprofiles/tp200.pdf>.

Australian Health Protection Principal Committee. enHealth. (2016). "enHealth Statement: Interim national guidance on human health reference values for per- and poly-fluoroalkyl substances for use in site investigations in Australia." from <http://www.health.nsw.gov.au/environment/factsheets/Documents/pfas-interim-health-values-ahppc.pdf>.

Bijland, S., PCN Rensen, EJ Pieterman, ACE Mass, JW van der Hoorn, MJ van Erk, KW van Dijk, SC Chang, DJ Ehresman, JL Butenhoff, HMG Princen, (2011). "Perfluoroalkyl Sulfonates Cause Alkyl Chain Length-Dependent Hepatic Steatosis and Hypolipidemia Mainly by Impairing Lipoprotein Production in APOE\*3-Leiden CETP Mice." Toxicological Sciences 123(1): 290-303.

Butenhoff, J., SC Chang, GW Olsen, PJ Thomford, (2012). "Chronic dietary toxicity and carcinogenicity study with potassium perfluorooctane sulfonate in Sprague Dawley rats." Toxicology 293: 1-15.

Cariou, R., B Veyrand, A Yamada, A Berrebi, D Zalko, S Durand, C Pollono, P Marchand, J-C Leblanc, J-P Antignac, B Le Bizec, (2015). "Perfluoroalkyl acid (PFAA) levels and profiles in breast milk, maternal and chord serum of French women and their newborns." Environment International 84: 71-81.

CDC (2016). Centers for Disease Control and Prevention. Breastfeeding Report Card.

CDC (2017). Centers for Disease Control and Prevention (CDC). Fourth National Report on Human Exposure to Environmental Chemicals. Updated Tables, January 2017, Volume One.

Chang, S., BC Allen, KL Andres, DJ Ehresman, R Falvo, A Provencher, GW Olsen, JL Butenhoff, (2016). "Evaluation of serum lipid, thyroid, and hepatic clinical chemistries in association with serum

perfluorooctanesulfonate (PFOS) in cynomolgus monkeys after oral dosing with potassium PFOS." Toxicological Sciences (Submitted manuscript).

Chen, T., L Zhang, J-q Yue, Z-q Lv, W Xia, Y-j Wan, Y-y Li, S-q Xu, (2012). "Prenatal PFOS exposure induces oxidative stress and apoptosis in the lung of rat off-spring." Reproductive Toxicology 33: 538-545.

Danish Ministry of the Environment (2015). Perfluoroalkylated substances: PFOA, PFOS and PFOSA. Evaluation of health hazards and proposal of a health based quality criterion for drinking water, soil and ground water. Environmental project No. 1665, 2015.

Dong, G.-H., Y-H Zhang, L Zheng, W Liu, Y-H Jin, Q-C He, (2009). "Chronic effects of perfluorooctanesulfonate exposure on immunotoxicity in adult male C57BL/5 mice." Archives of Toxicology 83: 805-815.

Dong, G., MM Liu, D Wang, L Zheng, ZF Liang, YH Jin, (2011). "Sub-chronic effect of perfluorooctanesulfonate (PFOS) on the balance of type 1 and type 2 cytokine in adult C57BL6 mice." Archives of Toxicology 85: 1235-1244.

EFSA (2008). European Food Safety Authority. Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and their salts. Scientific Opinion of the Panel on Contaminants in the Food chain. (Question No EFSA-Q-2004-163).

Egeghy PP and M Lorber (2011). "An assessment of the exposure of Americans to perfluorooctane sulfonate: A comparison of estimated intake with values inferred from NHANES data." Journal of Exposure Science and Environmental Epidemiology, 21: 150-168.

Friis-Hansen, B. (1961). Body Water Compartments in Children: Changes During Growth and Related Changes in Body Composition. Pediatrics, 28(2), 169-181.

Fromme, H., C Mosch, M Morovitz, I Alba-Alejandre, S Boehmer, M Kiranoglu, F Faber, I Hannibal, O Genzel-Boroviczeny, B Koletzko, W Volkel, (2010). "Pre- and Postnatal Exposure to Perfluorinated Compounds (PFCs)." Environmental Science & Technology 44: 7123-7129.

German Ministry of Health (2006). Assessment of PFOA in the drinking water of the German Hochsauerlandkreis. Statement by the Drinking Water commission (Trinkwasserkommission) of the German Ministry of Health at the Federal Environment Agency June 21, 2006/revised July 13, 2006. Provisional Evaluation of PFT in Drinking Water with the Guide Substances Perfluorooctanoic acid (PFOA) and Perfluorooctane Sulfonate (PFOS) as Examples.

Health Canada (2010). Drinking Water Guidance Value Perfluorooctane sulfonate (PFOS).

Health Canada. (2016a). "Health Canada's Drinking Water Screening Values for Perfluoroalkylated Substances (PFAS)." Retrieved May 27, 2016, from <http://s3.documentcloud.org/documents/2756386/Health-Canada-PFAS-Screening-Values-Fact-Sheet.pdf>.

Health Canada. (2016b). "Perfluorooctane Sulfonate (PFOS) in Drinking Water. Draft for Public Consultation Document.", from <http://healthycanadians.gc.ca/health-system-systeme-sante/consultations/perfluorooctane-sulfonate/document-eng.php>.

Karrman, A., I Ericson, B van Bavel, PO Damerud, M Aune, A Glynn, S Lignell, G Lindstrom, (2007). "Exposure of Perfluorinated Chemicals through Lactation: Levels of Matched Human Milk and Serum and a Temporal Trend, 1996-2004, in Sweden." Environmental Health Perspectives 115: 226-230.

Kim, S.-K., KT Lee, CS Kang, L Tao, K Kannan, KR Kim, CK Kim, JS Lee, PS Park, YW Yoo, JY Ha, YS Shin, JH Lee, (2011). "Distribution of perfluorochemicals between sera and milk from the same mothers and implications for prenatal and postnatal exposures." Environmental Pollution 159: 169-174.

Lau, C., JR Thibodeaux, RG Hanson, JM Rogers, BE Grey, ME Stanton, JL Butenhoff, LA Stevenson, (2003). "Exposure to perfluorooctane sulfonate during pregnancy in rat and mouse. II: postnatal evaluation." Toxicological Sciences 74: 382-392.

Liu, J., J Li, Y Liu, HM Chan, Y Zhao, Z Cai, Y Wu, (2011). "Comparison on gestation and lactation exposure of perfluorinated compounds for newborns." Environment International 37: 1206-1212.

Lopez-Doval, S., R Salgado, A Lafuente, (2016). "The expression of several reproductive hormone receptors can be modified by perfluorooctane sulfonate (PFOS) in adult male rats." Chemosphere 155: 488-497.

Luebker, D., MT Case, RG York, JA Moore, KJ Hansen, JL Butenhoff, (2005b). "Two-generation reproduction and cross-foster studies of perfluorooctanesulfonate (PFOS) in rats." Toxicology 215: 126-148.

Luebker, D., RG York, KJ Hansen, JA Moore, JL Butenhoff, (2005a). "Neonatal mortality from in utero exposure to perfluorooctanesulfonate (PFOS) in Sprague-Dawley rats: dose-response and biochemical and pharmacokinetic parameters." Toxicology 215: 149-169.

Lv, Z., G Li, Y Li, C Ying, J Chen, T Chen, J Wei, Y Lin, Y Jiang, Y Wang, B Shu, B Xu, S Xu, (2013). "Glucose and Lipid Homeostasis in Adult Rat Is Impaired by Early-Life Exposure to Perfluorooctane Sulfonate." Environmental Toxicology 28: 532-542.

MDH (2008). Minnesota Department of Health. Statement of Need and Reasonableness (SONAR) in the Matter of Proposed Rules Relating to Health Risk Limits of Groundwater. NTP (2016a). National Toxicology Program. Draft Systematic Review of Immunotoxicity Associated with Exposure to Perfluorooctanoic Acid (PFOA) or Perfluorooctane Sulfonate (PFOS).

MDH (Minnesota Department of Health). (2017a). "MDH Health Risk Assessment Methods to Incorporate Human Equivalent Dose Calculations into Derivation of Oral Reference Doses (May 2011, revised 2017)." from <http://www.health.state.mn.us/divs/eh/risk/guidance/hedrefguide.pdf>.

MDH (2017b). (Minnesota Department of Health) Background Document: Toxicokinetic Model for PFOS and PFOA and Its Use in the Derivation of Human Health-based Water Guidance Values.

Nelson, J. (2016). "Personal Communication regarding MDH MN (East Metro) PFC biomonitoring project data based on June 9, 2015 Meeting Agenda and Materials for the Advisory Panel to the Environmental Health Tracking and Biomonitoring Program." <http://www.health.state.mn.us/divs/hpcd/tracking/panel/2015Junematerials.pdf>."

NTP (September 2016). National Toxicology Program Monograph - Immunotoxicity Associated with Exposure to Perfluorooctanoic Acid or Perfluorooctane Sulfonate.

Qiu, L., X Zhang, X Zhang, Y Zhang, J Gu, M Chen, Z Zhang, X Wang, S-L, Wang, (2013). "Sertoli Cell Is a Potential Target for Perfluorooctane Sulfonate-Induced Reproductive Dysfunction in Male Mice." Toxicological Sciences 135(1): 229-240.

RIVM. National Institute for Public Health and the Environment (2010). Environmental risk limits for PFOS. A proposal for water quality standards in accordance with the Water Framework Directive. Report 601714013/2010.

Scher, D. Personal Communication. (2016). PFCs in FDL Study.

Seacat, A., PJ Thomford, KJ Hansen, GW Olsen, MT Case, JL Butenhoff, (2002). "Subchronic toxicity studies on perfluorooctanesulfonate potassium salt in cynomolgus monkeys." Toxicological Sciences 68: 249-264.

Seacat, A., PJ Thomford, KJ Hansen, LA Clemen, SR Eldridge, CR Elcombe, JL Butenhoff, (2003). "Sub-chronic dietary toxicity of potassium perfluorooctanesulfonate in rats." Toxicology 183: 117-131.

TCEQ. (2016). "Texas Commission on Environmental Quality. Texas Risk Reduction Program (TRRP) - Protective Concentration Levels (PCLs).", from <https://www.tceq.texas.gov/remediation/trrp/trrppcls.html>.

Thibodeaux, J., RG Hanson, JM Rogers, BE Grey, BD Barbee, JH Richards, JL Butenhoff, LA Stevenson, C Lau, (2003). "Exposure to perfluorooctane sulfonate during pregnancy in rat and mouse. I: maternal and prenatal evaluations." Toxicological Sciences 74: 369-381.

Thomford, P. (2002). 104-Week Dietary Chronic Toxicity and Carcinogenicity Study with Perfluorooctane Sulfonic Acid Potassium Salt (PFOS; T-6295) in Rats. Final Report. Volumes I-IX. Covance Study No. 6329-183.

United Kingdom. Drinking Water Inspectorate (2007). Guidance on the Water Supply (Water Quality) Regulations 2000/01 specific to PFOS (perfluorooctane sulphonate) and PFOA (perfluorooctanoic acid) concentrations in drinking water.

US EPA (2000). US Environmental Protection Agency (EPA). Office of Water. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. EPA-822-B-00-004. October 2000.

US EPA (2011). US Environmental Protection Agency "Exposure Factors Handbook. Office of Research and Development." from <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252>.

US EPA. (2016c). "US Environmental Protection Agency - Office of Water. Health Effects Support Document for Perfluorooctane Sulfonate (PFOS)." Retrieved May 19, 2016, from [https://www.epa.gov/sites/production/files/2016-05/documents/hesd\\_pfos\\_final-plain.pdf](https://www.epa.gov/sites/production/files/2016-05/documents/hesd_pfos_final-plain.pdf).

US EPA. (2016d). "US Environmental Protection Agency - Office of Water. Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)." Retrieved May 19, 2016, from [https://www.epa.gov/sites/production/files/2016-05/documents/pfos\\_health\\_advisory\\_final-plain.pdf](https://www.epa.gov/sites/production/files/2016-05/documents/pfos_health_advisory_final-plain.pdf).

Wambaugh, J., RW Setzer, AM Pitruzzello, J Liu, DM Reif, NC Kleinstreuer, N Ching, Y Wang, N Sipes, M Martin, K Das, JC DeWitt, M Strynar, R Judson, KA Houck, C Lau, (2013). "Dosimetric anchoring of *in vivo* and *in vitro* studies for perfluorooctanoate and perfluorooctanesulfonate." Toxicological Sciences 136: 308-327.

Wang, L., Y Wang, Y Liang, J Li, Y Liu, J Zhang, A Zhang, J Fu, G Jiang, (2014). "PFOS induced lipid metabolism disturbances in BALB/c mice through inhibition of low density lipoproteins excretion." Scientific Reports 4: 4582.