

US EPA ARCHIVE DOCUMENT

BINATIONAL FRAMEWORK FOR IDENTIFYING SUBSTANCES OF POTENTIAL THREAT TO THE GREAT LAKES BASIN

Test Case: Perfluorooctane Sulfonate (PFOS), its Salts and its Precursors, and Perfluorooctanonic Acid (PFOA) (Larger Class: Perfluorinated Compounds (PFCs))

I. FEEDERS FOR SUBSTANCE IDENTIFICATION

National Chemical Management Programs

Canada

PFOS has been assessed CEPA toxic under the Canadian Environmental Protection Act (CEPA, 1999) and was added to CEPA 1999 Schedule 1- List of Toxic Substances in 2006.¹

A key element of the Chemicals Management Plan (CMP) involves taking immediate action on five substance categories including PFOS.² The Canadian Government has proposed to prohibit uses of 50 PFOS substances because there is strong evidence that they pose a risk to the environment or human health.³ PFOS is included in the monitoring plan for the CMP (either Year 1 or Year 2).⁴

PFOA (an 8 carbon PFCA) is currently being assessed by Environment Canada and Health Canada. A Draft Assessment Report could be published in spring or summer 2009.⁵ Dependent on the conclusions within the final screening assessment report, risk management measures could be proposed

Environment Canada and Health Canada have put forward an Action Plan (*Perfluorinated Carboxylic Acids (PFCAs) and Precursors: An Action Plan for Assessment and Management*) in order to 'provide a broad perspective on the Departments' approach to PFCAs and their precursors'.⁶

United States

PFOS is not included in EPA's High Production Volume (HPV) Program. 3M, the principal global manufacturer of PFOS, working in partnership with EPA, announced in 2000 that it would voluntarily phase out production by the end of 2002. Following the voluntary phaseout of PFOS by 3M, EPA took prompt regulatory action on March 11, 2002,⁷ and December 9, 2002,⁸ by publishing two significant new use rules (SNURs) under the Toxic Substances Control Act (TSCA) to limit any future manufacture or importation of 88 PFAS chemicals specifically included in that phaseout. Furthermore, on October 9, 2007,⁹ EPA published another SNUR on 183 additional PFAS chemicals. These SNURs recognized the continuation of a few specifically limited, highly technical uses of these chemicals for which alternatives were not available, and which were characterized by very low volume, low exposure, and low releases. Any other uses of these chemicals would require prior notice to and review by the USEPA.

The October 2007 SNUR allowed for one existing use of one PFOS salt as a mist suppressant in chromium plating, especially to promote compliance with a Clean Air Act MACT standard and the OSHA permissible exposure limit (PEL) for hexavalent chromium. The preamble to the final rule

noted EPA's concern about ongoing PFOS releases to wastewater, and the Agency's interest in ways to minimize and/or prevent these releases.

PFOA is not included in EPA's HPV Program.

Great Lakes Monitoring and Surveillance

There are specific PFOS substances (and its salts) common with the Great Lakes Screening Project. These include:¹⁰

CAS #	Chemical Name
1691-99-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-
2795-39-3	1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, potassium salt
2991-51-7	Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt
4151-50-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-
24448-09-7	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-N-methyl-
31506-32-8	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-methyl-
25268-77-3	2-Propenoic acid, 2-[[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl ester
38006-74-5	1-Propanaminium, 3-[[[(heptadecafluorooctyl)sulfonyl]amino]-N,N,N-trimethyl-, chloride
57589-85-2	Benzoic acid, 2,3,4,5-tetrachloro-6-[[[3-[[[(heptadecafluorooctyl)sulfonyl]oxy]phenyl]amino]carbonyl]-, monopotassium salt
67969-69-1	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-[2-(phosphonoxy)ethyl]-, diammonium salt
68298-11-3	1-Propanaminium, 3-[[[(heptadecafluorooctyl)sulfonyl](3-sulfopropyl)amino]-N-(2-hydroxyethyl)-N,N-dimethyl-, hydroxide, inner salt
68891-96-3	Chromium, diaquatetrachloro[μ-[N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]glycinato-O':O"]][μ-hydroxybis(2-methylpropanol)di-
68608-14-0	Sulfonamides, C4-8-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 1,1'-methylenebis[4-isocyanatobenzene]
307-35-7	1-Octanesulfonyl fluoride, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-
376-14-7	2-Propenoic acid, 2-methyl-, 2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl ester
14650-24-9	2-Propenoic acid, 2-methyl-, 2-[[[(heptadecafluorooctyl)sulfonyl]methylamino]ethyl ester
179005-06-2	Sulfonamides, C4-8-alkane, perfluoro, N-[3-(dimethyloxidoamino)propyl], potassium salts
1763-23-1	1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-

The Canadian Management Plan Monitoring Program for 2009-2010 will be monitoring PFOA in the Great Lakes. Sediments, aquatic biota, air/precipitation, wildlife and wastewater/biosolids will be monitored for PFOA.¹¹

PFOA substances on the Domestic Substances List (substances that are currently in commerce or in use in Canada) are listed in the table below.

PFOA substances on Canada's Domestic Substances List (DSL)¹²

CAS #	Chemical Name
3825-26-1	Octanoic acid, pentadecafluoro-, ammonium salt
53515-73-4	2-Propenoic acid, 2-methyl-, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluorooctyl ester, polymer with 2-propenoic acid
68187-42-8	Propanamide, 3-[(γ - ω -perfluoro-C ₄₋₁₀ -alkyl)thio] derivatives
95370-51-7	Carbamic acid, [2-(sulfothio)ethyl]-, C-(γ - ω -perfluoro-C ₆₋₉ -alkyl) esters, monosodium salts
678-39-7	1-Decanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluoro

Other Sources of Information

Organization for Economic Co-operation and Development (OECD)

In 2000, several member countries collected information on the environmental and human health hazards of PFOS to produce a hazard assessment report.¹³ The report concluded that PFOS's persistence, its presence in the environment and in a number of wildlife species, and bioaccumulation potential are a cause for concern.¹⁴

European Union

In 2007 EU measures were adopted introducing legislation across Europe restricting PFOS. The new restrictions became effective June 27, 2008.¹⁵

The EU also published Directive 2006/122/EC on December 27, 2006, which states that PFOS and related substances shall not be placed on the market according to the following restrictions:¹⁶

- in concentrations equal to or higher than 0.005% by mass as a substance or constituent of preparations;
- in semi-finished products or products, or parts thereof, at a level of 0.1% by mass; and
- in textiles or other coated materials in which the amount of PFOS will be equal to or higher than 1 $\mu\text{g}/\text{m}^2$ of the coated material.

Australia

In Australia, there has been a voluntary phase-out agreement for PFOS since 2000.¹⁷

Norway

In April 2005, Norway proposed major reductions in emissions of PFOS by 2010.

The Norwegian Pollution Control Authority has adopted new legislation on PFOS in textiles, firefighting foams and impregnating agents. The new law came into force on July 1, 2007.

Norway has laid down the same limits for the use of PFOS as the EU.¹⁸

Norway announced in December 2007 that the discharges of PFOA should be significantly reduced by 2010 and eliminated before 2020. The Norwegian Pollution Control Authority

commissioned a survey of national sources of PFOA and PFOA-precursors in Norway. They have committed to identify all possible sources of PFOA in Norway along the whole life cycle from production, use and disposal in industrial manufacturing and applications and other possible sources such as long range transport by air and sea currents.¹⁹

Sweden

In 2005, Sweden proposed PFOS and 96 PFOS-related substances as candidates for the Stockholm Convention on Persistent Organic Pollutants (POPs). A draft risk management evaluation was prepared for discussion at the third meeting of the POPRC (November 2007) recommending listing PFOS under the Annex A of the Convention in order to eliminate or restrict production and use. It is expected that this recommendation will be put forward for decision at the 4th Conference of the Parties in May 2009.²⁰

United Nations Economic Commission for Europe (UNECE)

In December 2005, the Parties to the United Nations Economic Commission for Europe (UNECE) Long-Range Transboundary Air Pollution (LRTAP) Convention's Protocol on POPs agreed that PFOS should be considered as a persistent organic pollutant. The convention explored management strategies in 2006.²¹

United States

The Minnesota Pollution Control Agency and Department of Health have undertaken significant work with respect to PFC contamination in Minnesota. See

<http://www.health.state.mn.us/divs/eh/hazardous/topics/pfcs/index.html> and <http://www.pca.state.mn.us/cleanup/pfc/index.html>.

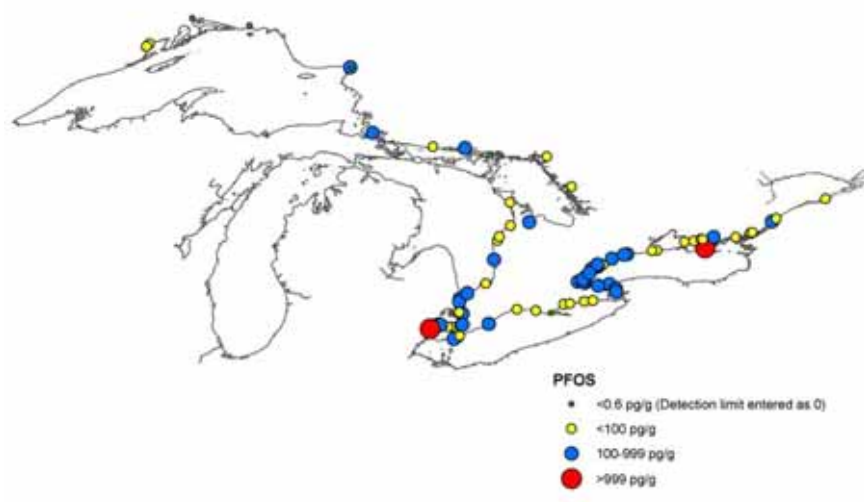
II. CONSIDERATIONS FOR SUBSTANCE SELECTION

Monitoring and Surveillance

Numerous monitoring and surveillance data are available which demonstrates the presence of PFOS (and related substances (PFA)) in the Great Lakes Basin. For example:

- Furdui *et al.* 2007, "Spatial Distribution of Perfluoroalkyl Contaminants in Lake Trout from the Great Lakes".²²
 - Reports perfluoroalkyl contaminant concentrations in Lake Trout from the Great Lakes.
 - Lowest average concentration of ΣPFC found in samples from Lake Superior ($13 \pm 1 \text{ ng g}^{-1}$). Highest average concentration found in samples from Lake Erie ($152 \pm 14 \text{ ng g}^{-1}$). Samples from Lake Ontario ($60 \pm 5 \text{ ng g}^{-1}$) and Lake Huron ($58 \pm 10 \text{ ng g}^{-1}$) showed similar average ΣPFC concentrations.
 - The major perfluoroalkyl contaminant observed was perfluorooctane sulfonate (PFOS) with the highest concentration found in samples from Lake Erie ($121 \pm 14 \text{ ng g}^{-1}$), followed by samples from Lake Ontario ($46 \pm 5 \text{ ng g}^{-1}$), Lake Huron ($39 \pm 10 \text{ ng g}^{-1}$), Lake Michigan ($16 \pm 3 \text{ ng g}^{-1}$), and Lake Superior ($5 \pm 1 \text{ ng g}^{-1}$).
- Martin *et al.* 2004, "Perfluoroalkyl Contaminants in the Lake Ontario Food Web".²³

- Reports concentrations of PFOS in various organisms from a food web of Lake Ontario.
- The highest levels were found in polar bear, with a mean level of 3100 ng/g from seven animals (maximum value > 4000 ng/g). The concentrations of PFOS in polar bear are 5-10 times higher than the concentration of all other perfluoroalkyl substances and were higher than any other previously reported concentrations of persistent organochlorine chemicals in polar bear fat.
- Boulanger *et al.* 2004, "Detection of perfluorooctane surfactants in Great Lakes water".²⁴
 - Reports concentrations of perfluorooctane surfactants from 16 water samples from Lakes Erie & Ontario.
 - Concentrations of PFOS in the two lakes ranged from 21-70 ng/L.
 - Concentrations of PFOA in the two lakes ranged from 27-50 ng/L, respectively.
 - Analysis also showed the presence of PFOS and PFOA precursors in both lakes, N-EtFOSAA (range of 4.2-11 ng/L) and FOSA (range of 0.6-1.3 ng/L), in all samples above the LOQ.
 - PFOSulfinate, another precursor, was identified at six of eight locations with a concentration range, when present, of <2.2-17 ng/L.
 - These are the first reported concentrations of perfluorooctane surfactants in Great Lakes water and the first report of PFOS precursors in any water body.
- Sinclair *et al.* 2006, "Occurrence of Perfluoroalkyl Surfactants in Water, Fish, and Birds from New York State".²⁵
 - Analyzed concentrations of PFOS and several other perfluoroalkyl surfactants (PASS) in nine major water bodies in New York State.
 - Elevated levels of PFOA were found in the Hudson River.
 - PFOS was the most abundant perfluorinated compound in all fish and bird liver samples.
 - Overall average concentrations of PFOS in fish were 8850-fold greater than that in surface water.
- Environment Canada June 2006, "Ecological Screening Assessment Report on Perfluorooctane Sulfonate, Its Salts and Its Precursors that Contain the C₈F₁₇SO₂, C₈F₁₇SO₃ or C₈F₁₇SO₂N Moiety".²⁶
 - Reports concentrations of PFOS in air, water, sediment & biota.
 - Information available at:
http://www.ec.gc.ca/CEPARRegistry/documents/subs_list/PFOS_SAR/PFOS_P5.cfm, (section 3.0 Environmental Concentrations).
- Concentrations of PFOS collected in a screening-level survey of recently deposited sediments in Canadian Great Lakes tributaries from 2001 to 2005 indicated relatively low PFOS concentrations that appear to be indicative of land use (i.e., elevated levels are generally found in more populated watersheds) (see figure below).²⁷



Levels of PFOS in Surficial Sediments of Canadian Tributaries to the Great Lakes, 2001-2005

The four following published studies examined concentrations of PFOA in different Great Lakes locations. These studies represent the publicly available Canadian data on PFOA concentration in the Great Lakes water.

PFOA concentrations in water in the Great Lakes

Sampling Location (Year)	PFOA Identity	Concentration (µg/L)	No. of Samples	Detection Limit (µg/L)	Reference
Toronto, ON	PFOA	0.007–0.055	NA	0.001	Crozier et al. (2005) ²⁸
Etobicoke Creek, ON (2002) (AFFF Spill)	Conjugate base	<0.009–11.3 (Measured in surface water)	61	0.009	Moody et al. (2002) ²⁹
Algoma, ON (2001)	Conjugate base	<0.0005–0.004 (Measured in rainwater)	16	0.0005	Scott et al. (2003) ³⁰
Lake Erie (August 7–12, 2003)	PFOA, ammonium salt	0.021–0.047	8	0.000 013	Boulanger et al. (2004) ³¹
Lake Ontario (August 7–12, 2003)	PFOA, ammonium salt	0.015–0.070	8	0.000 013	Boulanger et al. (2004) ³²

Environmental Levels and Trends

For environmental levels, please see monitoring and surveillance data.

Retrospective analyses of archived lake trout samples from Lake Ontario have identified a 4.25-fold increase (from 43 to 180 ng/g wet weight, whole fish) from 1980 to 2001.³³

A summary of studies of fluorinated surfactants in the Great Lakes environment is presented in Appendix A.

Source/Use/Release/Exposure Information

Source/use/release/exposure information available primarily from Environment Canada's *Perfluorooctane Sulphonate (PFOS), Its Salts and Its Precursors Risk Management Strategy*.³⁴

Source/Use

PFOS, its salts and its precursors are not manufactured in Canada but rather are imported as chemicals or products from the United States for Canadian uses. The principal applications of PFOS and its precursors were for water, oil, soil and grease repellents for use on rugs, carpets, fabric and upholstery, and in food packaging, as well as specialized chemical applications such as fire-fighting foams, hydraulic fluids, carpet spot removers, mining and oil well surfactants and other specialized chemical formulations. In Canada, in the past, PFOS substances were typically imported as raw chemicals and in products and formulations.

An Environment Canada use pattern survey undertaken in 2000 indicated that, from 1997 to 2000, an estimated 318 tonnes of PFOS substances were used in Canada.

Background information collected in support of the PFOS Regulations indicated that, since 2002, imports into Canada of PFOS as raw chemicals and in products or formulations have essentially ceased. This finding was confirmed by a use pattern survey published on January 15, 2005.

The 2005 survey results indicated that there are no manufacturers or exporters of PFOS in Canada, that approximately three tonnes of PFOS were imported in 2004 for use as a surfactant in fume suppressants for the metal plating sector, and that it is very likely that most inventories of PFOS in all other sectors have been depleted, except for an estimated 300 tonnes of stock piled fire fighting foams.

PFOA is used to make fluoropolymers, substances with special properties that have thousands of important manufacturing and industrial applications in almost all industry segments, including the aerospace, automotive, building/construction, chemical processing, electrical and electronics, semiconductor, and textile industries. Consumer products made with fluoropolymers include non-stick cookware and breathable, all-weather clothing.

PFOA may be a breakdown product of some fluorotelomers, which are used as surface application treatments on carpets, textiles, paper, leather, and construction materials to provide water, stain, grease, and soil resistance properties. Fluorotelomers may also be used as surfactants in cleaning and coating products.

Globally, there are eight major manufacturers of PFOA. 3M, the original manufacturer of PFOA, has phased out PFOA production in the U.S. Dyneon, a 3M subsidiary in Europe that continues to use PFOA, has announced plans to discontinue the use of PFOA by the end of 2008.

Release

PFOS, its salts and its precursors may enter the environment through treated or untreated municipal/industrial wastewater discharges to surface water and through leachates from landfills when products and materials containing these substances are sent for final disposal. PFOS may also be released directly to air, land, and surface water when products containing PFOS are used.

PFOA may be released during fluoropolymer and fluorotelomer manufacturing.

Exposure

Exposure in the Canadian environment likely results from the release, transformation, and movement of PFOS and its precursors in effluents and fugitive emissions from manufacturing sites elsewhere in the world, and releases from industrial and municipal wastewater effluents.

PFOA has been detected in the blood of the general U.S. population, although it is not fully understood how individuals are exposed to the chemical. Occupational exposures have been documented at manufacturing facilities.

Environmental Benchmarks

A few states have established environmental quality benchmark criteria. No benchmarks are available from Canada. EPA and the United Kingdom have issued criteria for PFOS and PFOA in drinking water.

States

Minnesota has issued a Health Risk Limit for PFOS (0.3 ug/L) and PFOA (0.5 ug/L) in drinking water, and fish contaminant advisories for several highly impacted bodies of water. Minnesota is also considering effluent limits for perfluorinated compounds (PFCs) in wastewater. Two other states, New Jersey and North Carolina, also regulate PFCs in drinking water.

United States

On January 8, 2009, EPA's Office of Water issued Provisional Health Advisories for PFOA and PFOS to assess potential risk from exposure to these chemicals through drinking water. EPA used the exposure scenario of a 10-kg child consuming 1 L/day of drinking water to calculate Provisional Health Advisories of 0.4 µg/L (ppb) for PFOA and 0.2 µg/L (ppb) for PFOS.¹

United Kingdom

The Health Protection Agency advises that the maximum acceptable concentration of PFOS in drinking water is 0.3 µg/L. The maximum acceptable concentration of PFOA in drinking water is 10 µg/L.³⁵

Environmental and Health Data

Information on health data can be found from Health Canada's State of the Science Report for a Screening Health Assessment for PFOS (July 2006).³⁶

The final ecological screening assessment report concludes that PFOS, its salts and its precursors are considered to meet the criteria set out in section 64(a) of CEPA 1999. The draft 2004 human health screening assessment report concludes that PFOS, its salts and its precursors do not meet the criteria set out in section 64(c) of CEPA 1999.³⁷

The U.S. Centers for Disease Control (CDC) published a study in 2007 which reported significant reductions in human blood concentrations of PFOS and PFOA from 1999 to 2000 compared to the most recent 2003-2004 data. The geometric mean for PFOA in human blood was reduced by 25 percent over this period, and PFOS was reduced by 32 percent. The report concluded that these reductions were most likely related to changes brought about by EPA efforts on these chemicals and other related efforts by government and industry.

EPA prepared and submitted a *Draft Risk Assessment of the Potential Human Health Effects Associated With Exposure to Perfluorooctanoic Acid and Its Salts (PFOA)* to the EPA Science Advisory Board (SAB) for peer review in 2005. Most of SAB Panel members agreed that PFOA cancer data are consistent with the EPA guidelines descriptor 'likely to be carcinogenic to humans'.

¹ U.S. EPA. 2009. Provisional Health Advisories for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS). Available at http://www.epa.gov/waterscience/criteria/drinking/pha-PFOA_PFOS.pdf. Accessed: February 24, 2009.

EPA is still in the process of evaluating this information and has not made any definitive conclusions regarding potential risks, including cancer, at this time.

Available data suggests that PFOA and its salts are not genotoxic, but are tumourigenic in rats and immunotoxic in mice. PFOA and its salts show reproductive and developmental toxicity in rodents as well as moderate to high subchronic oral toxicity in rodents and monkeys after long term exposure by oral route.³⁸ PFOA and other perfluorinated substances have been found in human blood at a global scale. PFOA has also been detected in seminal plasma, breast milk and umbilical cord blood.³⁹

Other Reasons for Concern

Evidence suggests that PFOS has endocrine disrupting properties in rats.⁴⁰

III. PRESENT MANAGEMENT STATUS

Canada

On December 16, 2006, the proposed Perfluorooctane Sulfonate and Its Salts and Certain Other Compounds Regulations were published in the *Canada Gazette*, Part I. The final Regulations were published in Part II of the *Canada Gazette* on June 11, 2008. The Regulations prohibit the manufacturing, use, selling, offering for sale or importing PFOS and its salts and certain other compounds; with some exceptions. More information on this regulation can be found at: <http://gazetteducanada.gc.ca/partII/2008/20080611/html/sor178-e.html>.⁴¹

Because PFOA is currently being assessed by Environment Canada and Health Canada, the PFOA management status is not yet determined. However, as set out in the *Action Plan for the Assessment and Management of Perfluorinated Carboxylic Acids and their Precursors* published in June 2006 in the *Canada Gazette*, the Government has sought action from industry through a voluntary agreement to significantly reduce residual PFCA precursors that are present in certain substances already in Canadian commerce. The Government worked diligently with stakeholders to establish details for this action, including timelines, reduction targets and an accountability framework and is calling for voluntary actions on substances for which assessments are underway and not yet published.

The draft Performance Agreement aligns with a similar stewardship program run by the United States Environmental Protection Agency (USEPA). The voluntary proposed agreement was published for public comment on January 30, 2009.

United States

The SNURs require manufacturers and importers to notify the EPA at least 90 days before new manufacture or import of these substances. This provides the EPA with the necessary time to evaluate the intended new use and prohibit or limit the new activity if necessary. The three SNURs for PFAS chemicals (discussed in Section I) essentially restrict all manufacture and importation, with the exception of PFOS salt used as a mist suppressant in chromium plating.⁴²

EPA Region 5 recently completed a field survey of wastewater at chromium plating facilities in both Chicago and Cleveland to determine the extent of PFC releases to wastewater from this

authorized use. The survey results will be summarized and submitted to EPA Office of Air Quality Planning and Standards under the CAA residual risk analysis for the Chromium MACT, in order to inform the rulemaking with respect to the metal finishing source category.

EPA has also engaged the National Association of Surface Finishers, beginning some dialogue on the development of alternative compounds and best management practices to minimize and/or prevent PFOS releases. Future activities are being determined at this time, pending guidance from EPA Region 5.

EPA continues to work on a TSCA Risk Assessment for PFOA. A *Draft Risk Assessment of the Potential Human Health Effects Associated With Exposure to Perfluorooctanoic Acid and Its Salts (PFOA)* underwent a peer review by the EPA Science Advisory Board (SAB), and the Final SAB Report is available at <http://www.epa.gov/oppt/pfoa/pubs/pfoarisk.htm>. EPA expects to conduct a second SAB review upon completion of a final risk assessment.

EPA has a robust Safe Drinking Water Act (SDWA) settlement with DuPont with respect to a significant drinking water contamination problem in the Ohio River Valley, near DuPont's Washington Works in Parkersburg, WV.

In 2005, under TSCA EPA entered into two enforceable consent agreements with industry for laboratory-scale incineration testing of fluoropolymers and fluorotelomers to help determine whether products made or treated with these chemicals may produce PFOA when they are disposed of in municipal incinerators.

EPA, in collaboration with industry, is gathering more information about PFOA through Memoranda of Understanding (MOUs). In 2004, EPA signed an MOU with 3M and Dyneon LLC for monitoring in the vicinity of a fluoropolymer manufacturing facility in Decatur, AL. In 2005, EPA and DuPont entered into an MOU entitled *PFOA Site-Related Environmental Assessment Program* to conduct a screening level exposure assessment to characterize exposure and releases at DuPont's Washington Works Facility in West Virginia.

In January 2006, EPA negotiated the PFOA Stewardship Program with the eight major companies in the industry. The PFOA Stewardship Program commits the eight companies to voluntary reductions of facility emissions and product content of PFOA and related chemicals by 95% no later than 2010, and to work toward the elimination of emissions and product content by 2015. In 2008 annual progress reports for the PFOA Stewardship Program, four of the eight companies had met the 95% reduction commitment for PFOA emissions and had significantly reduced product content from U.S. operations, and one company had no U.S. operations. Corporate strategies to meet the program's goals included control/treatment technologies, process changes, product reformulation, and new chemical development. For example, 3M has developed new technologies—with favorable environmental, health and safety characteristics—that enable the company to reformulate many of the products affected by the PFOA phase out. Several other companies have also announced plans to introduce new chemicals that do not include PFOA and

cannot breakdown to PFOA in the environment.² More information about the PFOA Stewardship Program is available at EPA's PFC web site (<http://www.epa.gov/oppt/pfoa/index.htm>), and in electronic dockets at <http://www.regulations.gov>.

² Krasnic, T. 2009. *2010/15 PFOA Stewardship Program Overview and Update*. Presented at EPA Workshop on Managing Perfluorinated Chemicals and Transitioning to Safer Alternatives, Geneva, Switzerland. 12-13 February, 2009.

APPENDIX A

Fluorinated Surfactants in the Great Lakes Environment - Published Studies

1. "Monitoring perfluorinated surfactants in biota and surface water samples following an accidental fire-fighting foam release into Etobicoke Creek." C.A. Moody, J.W. Martin, W.C. Kwan, D. C. G. Muir and S. A. Mabury. Environmental Science & Technology. 2001; 36: 545-551. Fluorinated Surfactants\Moody et.al. 2002.pdf.

Summary: This study measured concentrations of perfluorinated surfactants released by a spill in Etobicoke Creek, a tributary of Lake Ontario. Measurements from surface waters and fish livers were taken. The study suggested that perfluorinated surfactants will persist and bioaccumulate following release into the aquatic environment.

2. "Detection of perfluorooctane surfactants in Great Lakes water." B. Boulanger, J. Vargo, J.L. Schnoor, K.C. Hornbuckle. Environmental Science & Technology. 2004; 38,(15): 4064-70. Fluorinated Surfactants \Boulanger et. al. 2004.pdf

Summary: This study analyzed for perfluorooctane surfactants from sixteen sites in Lake Erie and Ontario. Concentrations of PFOS and PFOA in the two lakes ranged from 21-70 and 27-50 ng/L, respectively. Precursors to these compounds were also measured in both lakes.

3. "Perfluorinated compounds in aquatic organisms at various trophic levels in a Great Lakes food chain." K. Kannan, L. Tao, E. Sinclair, S.D. Pastva, D.J. Jude and J.P. Giesy. Archives of Environmental Contamination and Toxicology. 2005; 48 (4): 559-66. Fluorinated Surfactants\Kannan et.al. 2005.pdf

Summary: Trophic transfer of perfluorooctane sulfonate (PFOS) and other related perfluorinated compounds were examined in a Great Lakes benthic food web. Concentrations of perfluorooctane sulfonate were measured in tissue from various organisms including water-algae-zebra mussel-round goby-smallmouth bass. PFOS was most widely detected in benthic organisms at various trophic levels. This study calculated the bioaccumulation factor in benthic invertebrates to be 1000, while biomagnification factors in larger predators like bald eagles and minks to be 10 to 20 times that of their prey.

4. "Mass budget of perfluorooctane surfactants in Lake Ontario." B. Boulanger, A. M. Peck, J. L. Schnoor, K. C. Hornbuckle. Environmental

Science & Technology. 2005; 39, (1):74-79 Fluorinated Surfactants
 \Boulanger et.al. 2005.pdf

Summary: A mass budget was done on eight perfluorooctane surfactants in Lake Ontario. The study showed inflow from Lake Erie as well as waste water treatment plants are the two major sources of perfluorooctane surfactants into Lake Ontario. Outflow through the St. Lawrence River is the major loss mechanism. This study also measured perfluorooctane surfactants on particulate matter in the air.

5. "Spatial Distribution of Perfluoroalkyl Contaminants in Lake Trout from the Great Lakes." V. I. Furdui, N. L. Stock, D. A. Ellis, C. M. Butt, D. M. Whittle, P. W. Crozier, E. J. Reiner, D. C. G. Muir and S. A. Mabury. Environmental Science & Technology. 2007; 41(5); 1554-1559. Fluorinated Surfactants\Furdui et.al. 2007.pdf.

Summary: This study measured concentrations of perfluorinated carboxylates (PFCAs) and perfluorinated sulfonates (PFSAs) in 4 year-old lake trout in all five Great Lakes. Results showed that the highest average concentrations were found in Lake Erie, followed by Lake Ontario and Huron, with Lake Michigan and Superior having the lowest concentrations respectively. Data also showed the major contributor to the sum concentrations of perfluorinated carboxylates (PFCAs) was from PFOA.

6. "Perfluoroalkyl Contaminants in a Food Web from Lake Ontario." J. W. Martin, D. M. Whittle, D. C. G. Muir and S. A. Mabury. Environmental Science & Technology. 2004; 38(20); 5379-5385. Fluorinated Surfactants\Martin et.al. 2004.pdf

Summary: This study analyzed PFOS, the homologous series of PFCAs, and the PFOS-precursor heptadecafluorooctane sulfonamide (FOSA) in various organisms from a food web of Lake Ontario. The highest mean concentration was found in benthic organisms at the lowest trophic level, since these organisms are foraged on by larger fish, there is potential for biomagnification. Bioaccumulation in larger fish was also shown in this study.

7. "Occurrence of Perfluoroalkyl Surfactants in Water, Fish, and Birds from New York State." E. Sinclair, D.T. Mayack, K. Roblee, N. Yamashita and K. Kannan. Archives of Environmental Contamination and Toxicology. 2006; 50, (3): 398-410. Fluorinated Surfactants\Sinclair et.al. 2006.pdf.

Summary: This study determined concentrations of perfluorooctanesulfonate (PFOS) and several other perfluoroalkyl surfactants (PASs) in nine major water bodies in New York State. Elevated levels of PFOA were found in the Hudson River. PFOS were the most abundant perfluorinated compound in all fish and bird liver samples, and overall average concentrations of PFOS in fish were 8850-fold greater than that in surface water.

8. "Perfluorinated Compounds in the Great Lakes" Persistent Organic Pollutants in the Great Lakes, Handbook in Environmental Chemistry, Vol. 5, Part N, pp. 391-438, Springer-Verlag: Berlin & Heidelberg, Germany (2006), R. A. Hites, editor.

REFERENCES

- ¹ Environment Canada- Management of Toxic Substances. *Substances Managed under CEPA 1999 (Schedule 1)*. Available online at: http://www.ec.gc.ca/TOXICS/EN/detail.cfm?par_substanceID=230&par_actn=s1.
- ² Canada Gazette. *Canadian Environmental Protection Act, 1999- Perfluorooctane Sulfonate and its Salts and Certain Other Compounds Regulation*. Vol. 142, No.12 – June 11, 2008. Available online at: <http://gazetteducanada.gc.ca/partI/2006/20061216/html/regle2-e.html>.
- ³ Government of Canada. *Chemical Substances- Chemicals Management Plan- Implementation Timetable*. Available online at: http://www.chemicalsubstanceschimiques.gc.ca/plan/table-tableau_e.html.
- ⁴ *Information from Suzanne Easton (2008)*.
- ⁵ *Information from Stéphanie Bourgeau(2009)*
- ⁶ Environment Canada – Pollution prevention, *Perfluorinated Carboxylic Acids (PFCAs) and Precursors: An Action Plan for Assessment and Management*. Available online at : <http://www.ec.gc.ca/nopp/DOCS/rpt/PFCA/en/actionPlan.cfm>
- ⁷ 67 FR 11007, March 11, 2002. <http://www.epa.gov/fedrgstr/EPA-TOX/2002/March/Day-11/t5746.htm>.
- ⁸ 67 FR 11007, December 9, 2002. <http://www.epa.gov/fedrgstr/EPA-TOX/2002/December/Day-09/t31011.htm>.
- ⁹ 72 FR 57222, October 9, 2007. <http://www.epa.gov/fedrgstr/EPA-TOX/2007/October/Day-09/t19828.htm>.
- ¹⁰ Compared: List of PFOS, its Salts and its Precursors, Appendix 1 of *PERFLUOROOCTANE SULFONATE (PFOS), ITS SALTS AND ITS PRECURSORS RISK MANAGEMENT STRATEGY*. June 2006. Available online at: <http://www.ec.gc.ca/CEPARegistry/documents/part/PFOS/app1.cfm>. To: *Excel file: EPA Report Table_SRC* (Muir, D.C., Howard, P.H. and Meylan, W. 2007. Project: Screening Chemicals in Commerce to Identify Possible Persistent and Bioaccumulative (P&B) Chemicals in the Great Lakes.)
- ¹¹ Environment Canada, CMP Monitoring and surveillance program
- ¹² Environment Canada – CEPA Environmental Registry, *Search Engine for Substances on the DSL*. Available online at : http://www.ec.gc.ca/CEPARegistry/subs_list/dsl/dslsearch.cfm
- ¹³ OECD (Organization for Economic Co-operation and Development). *Perfluorooctane Sulfonate (PFOS) and related chemical products*. Available online at: http://www.oecd.org/document/58/0,3343,fr_2649_34379_2384378_1_1_1_1,00.html.
- ¹⁴ CEPA Environmental Registry. June 2006. *Perfluorooctane Sulphonate (PFOS), Its Salts and Its Precursors Risk Management Strategy*. Available online at: <http://www.ec.gc.ca/CEPARegistry/documents/part/PFOS/s6.cfm>.
- ¹⁵ UK Statutory Instruments. 2007. *No. 3438 Environmental Protection- The Controls on Dangerous Substances and Preparations (Amendment) (No. 22) Regulation 2007*. Available online at: http://www.opsi.gov.uk/si/si2007/pdf/uksi_20073438_en.pdf.
- ¹⁶ Furdui, VI, NL Stock, DA Ellis, CM Butt, DM Whittle, PW Crozeir, EJ Reiner, DCG Muir, and SA Mabury. 2007. Spatial Distribution of Perfluoroalkyl Contaminants in Lake Trout from the Great Lakes. *Environ. Sci. Technol.* **41**:1554-1559.
- ¹⁷ *Information provided by Ted Smith: Environment Canada Restricts PFOS Substances, allows some uses. From Pesticide and Toxic Chemical New (2008)*.

¹⁸ Information provided by Ted Smith: Environment Canada Restricts PFOS Substances, allows some uses. From *Pesticide and Toxic Chemical New* (2008).

¹⁹ Norwegian Pollution Control Authority. *PFOA in Norway TA-2354/2007*. Oslo, December 2007. Available online at: <http://www.sft.no/publikasjoner/2354/ta2354.pdf>

²⁰ Information provided by Ted Smith: Environment Canada Restricts PFOS Substances, allows some uses. From *Pesticide and Toxic Chemical New* (2008).

²¹ Information provided by Ted Smith: Environment Canada Restricts PFOS Substances, allows some uses. From *Pesticide and Toxic Chemical New* (2008).

²² Furdui, VI, NL Stock, DA Ellis, CM Butt, DM Whittle, PW Crozeir, EJ Reiner, DCG Muir, and SA Mabury. 2007. Spatial Distribution of Perfluoroalkyl Contaminants in Lake Trout from the Great Lakes. *Environ. Sci. Technol.* **41**:1554-1559.

²³ Martin, J.W., Whittle, D.M., Muir, D.C.G., and Mabury, S.A. 2004. Perfluoroalkyl Contaminants in the Lake Ontario Food Web. *Environ. Sci. Technol.* **38**(20):5379-5385.

²⁴ Boulanger, B, Vargo, JA, Schnoor, JL and Hornbuckle, KC.* "Detection of perfluorooctane surfactants in Great Lakes water." *Environ. Sci. Technol* **38** (15), 2004 pp 4064-4070.

²⁵ Sinclair, E., Mayack, D.T., Roblee, K., Yamashita, N., and Kannan, K. 2006. Occurrence of Perfluoroalkyl Surfactants in Water, Fish, and Birds from New York State. *Archives of Environmental Contamination and Toxicology*. **50**, (3): 398-410.

²⁶ Environment Canada. June 2006. *Canadian Environmental Protection Act, 1999 (CEPA, 1999)*- Ecological Screening Assessment Report on Perfluorooctane Sulfonate, Its Salts and Its Precursors that Contain the C₈F₁₇SO₂, C₈F₁₇SO₃ or C₈F₁₇SO₂N Moiety. Available online at: http://www.ec.gc.ca/CEPARRegistry/documents/subs_list/PFOS_SAR/PFOS_TOC.cfm.

²⁷ Great Lakes Binational Toxics Strategy 2006 Annual Progress Report. Available at www.binational.net.

²⁸ Crozier, P., Furdui, V., Lucaciu, C., Stock, N., Mabury, S., and Reiner, E. 2005. Detection of perfluoro-alkyl compounds (PFCs) in sewage treatment plant effluents and biosolids by liquid chromatography – tandem mass spectrometry. Poster presentation at Fluoros, An International Symposium on Fluorinated Alkyl Organics in the Environment, August 18–20, 2005, Toronto, Ontario.

²⁹ Moody, C.A., Martin, J.W., Kwan, W.C., Muir, D.C.G., and Mabury, S.C. 2002. Monitoring perfluorinated surfactants in biota and surface water samples following an accidental release of fire-fighting foam into Etobicoke Creek. *Environ. Sci. Technol.* **36**: 545–551.

³⁰ Scott, B.F., Spencer, C., Moody, C.A., Martin, J.W., Mabury, S.A., Mactavish, D., and Muir, D.C.G. 2003. Determination of perfluoroalkanoic acids in the aquatic environment. Poster presentation at the Society of Environmental Toxicology and Chemistry's (SETAC) 23rd Annual Meeting in Europe, Hamburg, Germany.

³¹ Boulanger, B., Vargo, J., Schnoor, J.L., and Hornbuckle, K.C. 2004. Detection of perfluorooctane surfactants in Great Lakes water. *Environ. Sci. Technol.* **38**: 4064–4070

³² Ibid.

³³ Martin, J.W., Whittle, D.M., Muir, D.C.G., and Mabury, S.A. 2004. Perfluoroalkyl Contaminants in the Lake Ontario Food Web. *Environ. Sci. Technol.* **38**(20):5379-5385.

³⁴ CEPA Environmental Registry. June 2006. *Perfluorooctane Sulphonate (PFOS), Its Salts and Its Precursors Risk Management Strategy*. Available online at: <http://www.ec.gc.ca/CEPARRegistry/documents/part/PFOS/s6.cfm>.

³⁵ Health Protection Agency. *Maximum acceptable concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) in drinking water*. Available online at: http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1195733828490.

³⁶ Health Canada. 2007. *Perfluorooctane Sulfonate (PFOS) and Health*. Available online at: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/perfluorooctane_sulfonate-eng.pdf.

³⁷ CEPA Environmental Registry. June 2006. *Perfluorooctane Sulphonate (PFOS), Its Salts and Its Precursors Risk Management Strategy*. Available online at: <http://www.ec.gc.ca/CEPARRegistry/documents/part/PFOS/s6.cfm>.

³⁸ Environment Canada – Pollution prevention, *Perfluorinated Carboxylic Acids (PFCAs) and Precursors: An Action Plan for Assessment and Management*. Available online at : <http://www.ec.gc.ca/nopp/DOCS/rpt/PFCA/en/actionPlan.cfm>

³⁹ Canada Gazette. *Order Adding Toxic Substances to Schedule 1 to the Canadian Environmental Protection Act, 1999*. Vol.140, No. 24 – June 17th, 2006. Available online at: http://www.ec.gc.ca/registrelcpe/documents/regs/gl-14024_o1.pdf

⁴⁰ Environmental Science & Technology. *Science News- April 24, 2003- PFOS is an endocrine disruptor*. Available online at: http://pubs.acs.org/subscribe/journals/esthag-w/2003/apr/science/rr_disrupter.html.

⁴¹ Canada Gazette. *Canadian Environmental Protection Act, 1999- Perfluorooctane Sulfonate and its Salts and Certain Other Compounds Regulation*. Vol. 142, No.12 – June 11, 2008. Available online at: <http://gazetteducanada.gc.ca/partI/2006/20061216/html/regle2-e.html>.

⁴² CEPA Environmental Registry. June 2006. *Perfluorooctane Sulphonate (PFOS), Its Salts and Its Precursors Risk Management Strategy*. Available online at: <http://www.ec.gc.ca/CEPARRegistry/documents/part/PFOS/s6.cfm>.