



GREEN SCIENCE  
POLICY INSTITUTE

# When Do We Need PFAS?

## The Chemical Class Approach Towards a Healthier Environment

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March 2018



# GREEN SCIENCE POLICY INSTITUTE

BRJ BUILDING RESEARCH & INFORMATION (2022) 40(6): 738-755

**building insulation: building codes**

**ENVIRONMENTAL Science & Technology**

**Novel and High Volume Use Flame Retardants in US Couches**  
Heather M. Thomas F.,<sup>1</sup> Nicholas S. Department,<sup>2</sup> p. Lee Ferguson,<sup>3</sup> Michelle Gabriel,<sup>4</sup>

**ENVIRONMENTAL Science & Technology LETTERS**

**Fluorinated High Volume Use Flame Retardants in US Couches**  
Laurel A. Margaret,<sup>1</sup> Xindi C. Hu,<sup>6,7,8</sup> David Q. Andrews,<sup>9</sup> Andrew B. Lindstrom,<sup>8</sup> Thomas A. Bruton,<sup>1</sup> Laurel A. Schaidler,<sup>9</sup> Philippe Grandjean,<sup>6</sup> Rainer Lohmann,<sup>6</sup> Courtney C. Carignan,<sup>6</sup> Arlene Blum,<sup>1,5</sup> Simona A. Balan,<sup>6</sup> Christopher P. Higgins,<sup>6</sup> and Elsie M. Sunderland<sup>1,2</sup>

**ABSTRACT:** Drinking water contamination with poly- and perfluoroalkyl substances (PFASs) poses risks to the developmental, immune, metabolic, and endocrine health of consumers. We present a spatial analysis of 2013–2015 national drinking water PFAS concentrations from the U.S. Environmental Protection Agency's (US EPA) third Unregulated Contaminant Monitoring Rule (UCMR3) program. The number of industrial sites that manufacture or use these compounds, the number of military fire training areas, and the number of wastewater treatment plants are all significant

**Supporting Information**

Hydrological units with detectable PFASs



## Education

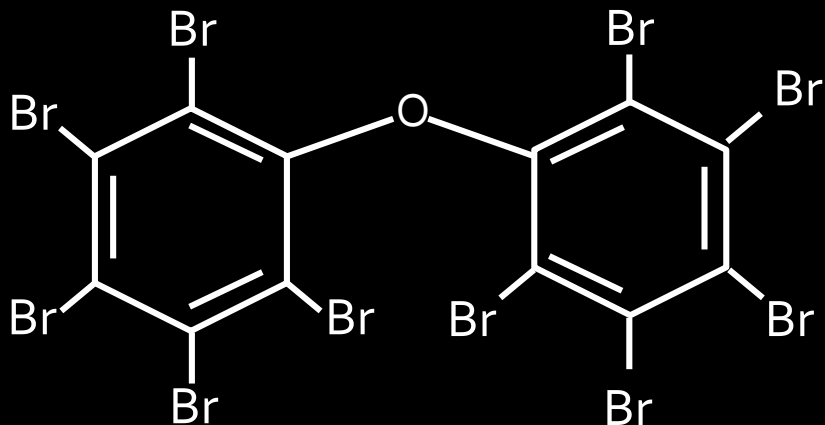


## Toxic Reduction Retreats

## Research

# Policy & Purchasing Change

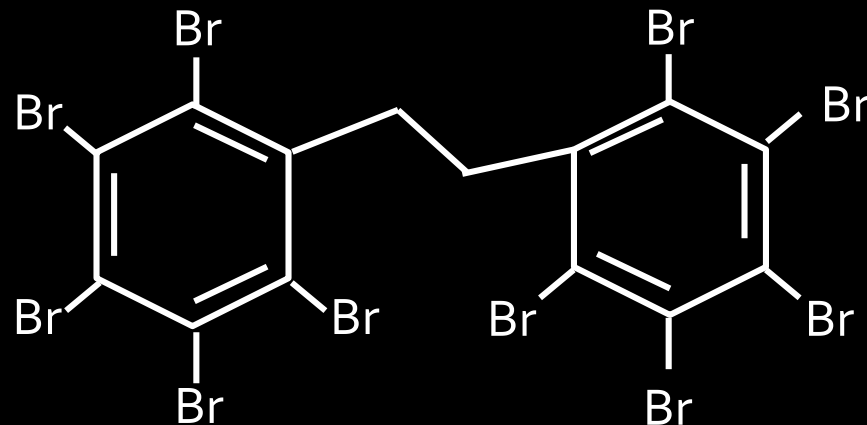
# Regrettable Substitution



Decabromodiphenyl  
ether

Concerns:

- Persistence
- Bioaccumulation
- Toxicity



Decabromodiphenyl  
ethane

Concerns:

- Persistence
- Bioaccumulation
- Toxicity

# Six Classes of Chemicals of Concern

1

Highly  
Fluorinated



2

Antimicrobials



3

Flame  
Retardants



4

Bisphenols  
+ Phthalates



5

Some  
Solvents



6

Certain Metals



Four-minute videos at  
[www.SixClasses.org](http://www.SixClasses.org)

Is it necessary?

Is it worth it?

Is there a safer alternative?

# Periodic table of elements

hydrogen 1 <b>H</b> 1.0079																	Halogens					helium 2 <b>He</b> 4.0026	
lithium 3 <b>Li</b> 6.941	beryllium 4 <b>Be</b> 9.0122																	boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.998	neon 10 <b>Ne</b> 20.180
sodium 11 <b>Na</b> 22.990	magnesium 12 <b>Mg</b> 24.305																	aluminium 13 <b>Al</b> 26.982	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453	argon 18 <b>Ar</b> 39.948
potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078	scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845	cobalt 27 <b>Co</b> 58.933	nickel 28 <b>Ni</b> 58.693	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.39	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	krypton 36 <b>Kr</b> 83.80						
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62	yttrium 39 <b>Y</b> 88.906	zirconium 40 <b>Zr</b> 91.224	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	ruthenium 44 <b>Ru</b> 101.07	rhodium 45 <b>Rh</b> 102.91	palladium 46 <b>Pd</b> 106.42	silver 47 <b>Ag</b> 107.87	cadmium 48 <b>Cd</b> 112.41	indium 49 <b>In</b> 114.82	tin 50 <b>Sn</b> 118.71	antimony 51 <b>Sb</b> 121.76	tellurium 52 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.90	xenon 54 <b>Xe</b> 131.29						
caesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	57-70 *	lutetium 71 <b>Lu</b> 174.97	hafnium 72 <b>Hf</b> 178.49	tantalum 73 <b>Ta</b> 180.95	tungsten 74 <b>W</b> 183.84	rhenium 75 <b>Re</b> 186.21	osmium 76 <b>Os</b> 190.23	iridium 77 <b>Ir</b> 192.22	platinum 78 <b>Pt</b> 195.08	gold 79 <b>Au</b> 196.97	mercury 80 <b>Hg</b> 200.59	thallium 81 <b>Tl</b> 204.38	lead 82 <b>Pb</b> 207.2	bismuth 83 <b>Bi</b> 208.98	polonium 84 <b>Po</b> [209]	astatine 85 <b>At</b> [210]	radon 86 <b>Rn</b> [222]					
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]	89-102 * *	lawrencium 103 <b>Lr</b> [262]	rutherfordium 104 <b>Rf</b> [261]	dubnium 105 <b>Db</b> [262]	seaborgium 106 <b>Sg</b> [266]	bohrium 107 <b>Bh</b> [264]	hassium 108 <b>Hs</b> [269]	meitnerium 109 <b>Mt</b> [268]	ununnium 110 <b>Uun</b> [271]	ununium 111 <b>Uuu</b> [272]	unubium 112 <b>Uub</b> [277]		ununquadium 114 <b>Uuq</b> [289]									

\* Lanthanide series

lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04
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\*\* Actinide series

actinium 89 <b>Ac</b> [227]	thorium 90 <b>Th</b> 232.04	protactinium 91 <b>Pa</b> 231.04	uranium 92 <b>U</b> 238.03	neptunium 93 <b>Np</b> [237]	plutonium 94 <b>Pu</b> [244]	americium 95 <b>Am</b> [243]	curium 96 <b>Cm</b> [247]	berkelium 97 <b>Bk</b> [247]	californium 98 <b>Cf</b> [251]	einsteinium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendelevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]
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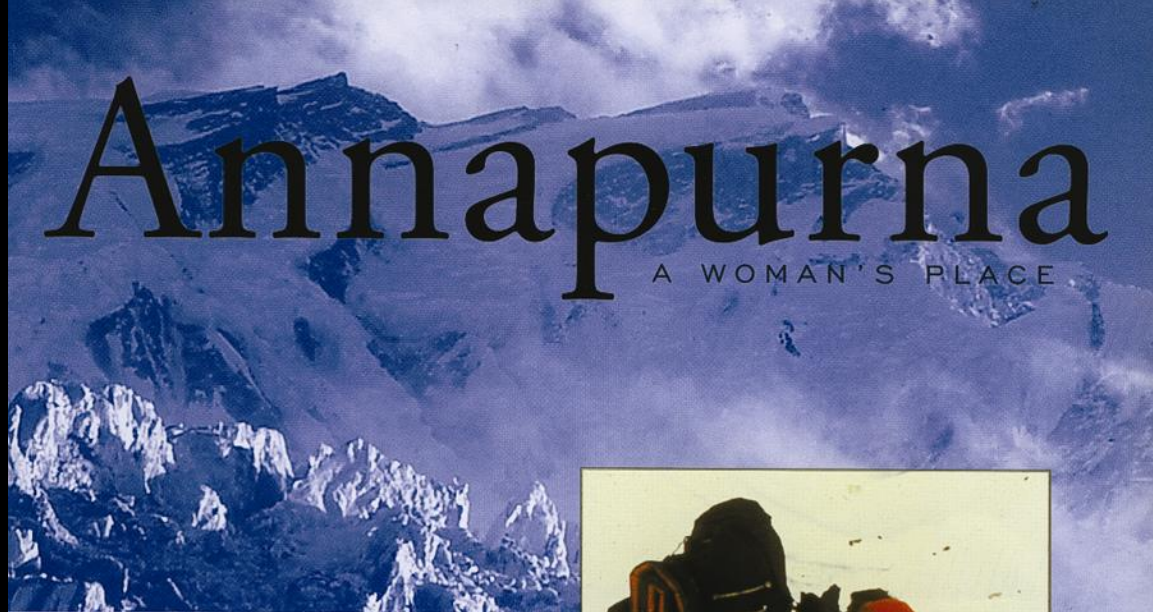






# Annapurna

A WOMAN'S PLACE



The dramatic  
story of the first  
American ascent of  
one of the world's  
highest peaks

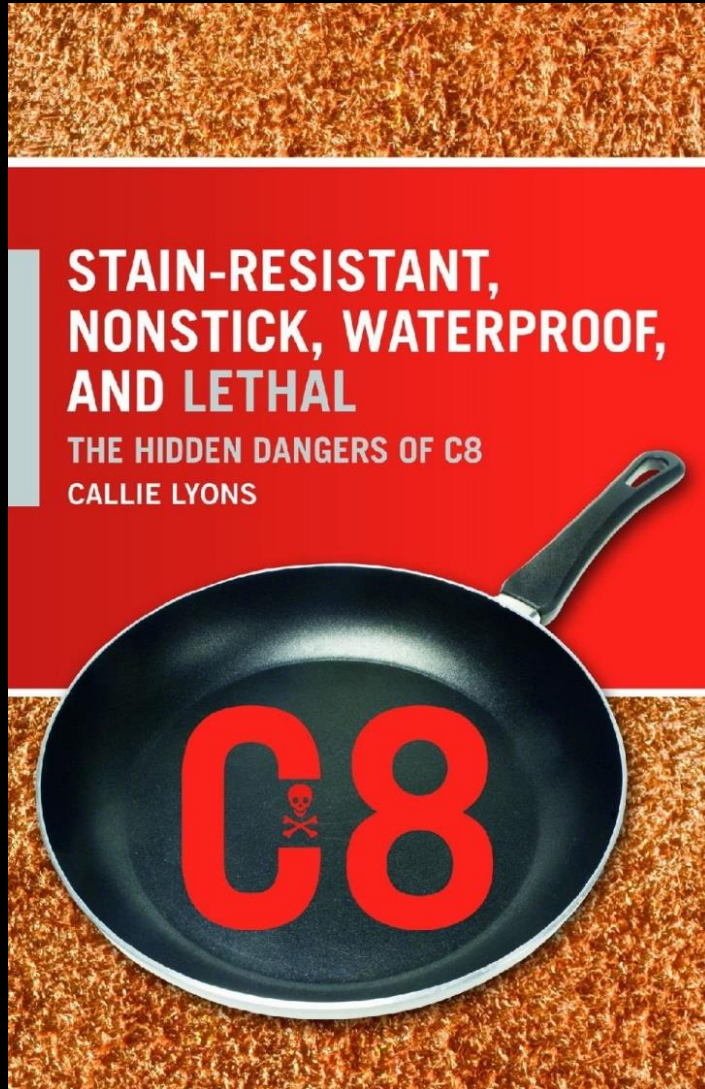


ARLENE BLUM

20TH ANNIVERSARY EDITION

With a new Preface and Afterword by the author

Published 2007



2017

Watershed

Tracy K. Smith

US Poet Laureate

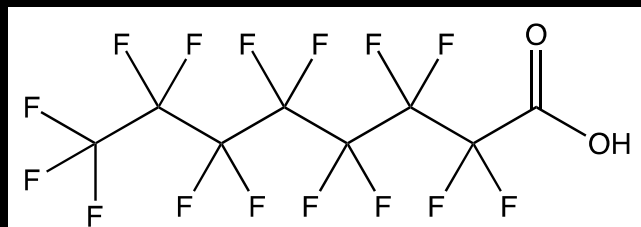
200 cows      more than 600 hilly  
acres  
property would have been even  
larger  
had J not sold 66 acres to DuPont  
for  
waste from its  
Washington Works factory  
where J was employed  
did not want to  
sell  
but needed money      poor  
health  
mysterious ailments

# PFASs

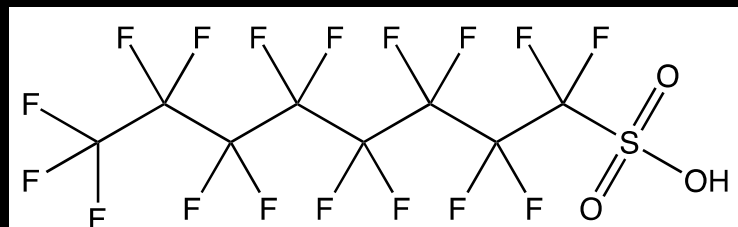
(per- and polyfluoroalkyl substances)

- **All are highly persistent<sup>1</sup>**
  - or degrade to persistent end-products
- **Long-chains are bioaccumulative<sup>2</sup>**
  - in wildlife, in human serum
- **PFOA and PFOS (C8s) are toxic<sup>2,3</sup>**
  - Cancer (kidney and testicular)
  - liver disease
  - immune system effects
  - thyroid disease
  - developmental effects

PFOA



PFOS



# PFAS exposure is a health concern

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Exposure linked to health risks:

Cancer, elevated cholesterol, obesity, immune suppression, endocrine disruption

(Ref: Lewis et al., 2015; Grandjean et al., 2012; Braun et al., 2016; Barry et al., 2013)

# May 2015 The Madrid Statement on Highly Fluorinated Chemicals



“We call on the international community to cooperate in limiting the production and use of PFASs and in developing safer non-fluorinated alternatives.”

Signed by 230 scientists from 40 countries

2015: Environmental Health Perspectives

# Common Uses



CARPETS



CARPET CLEANING PRODUCTS



FOOD PACKAGING



FURNISHINGS



COSMETICS



OUTDOOR GEAR



CLOTHING



ADHESIVES AND SEALANTS



PROTECTIVE COATINGS



NON-STICK COOKWARE



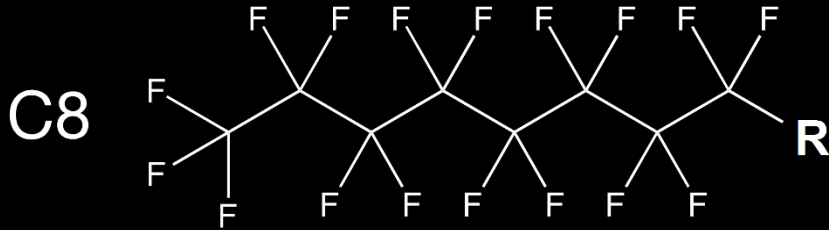
CARSEATS



FIREFIGHTING FOAM

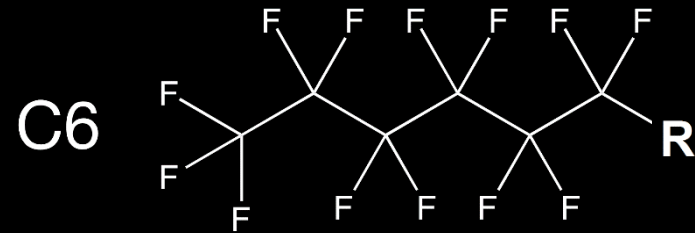


# Regrettable Substitute?



## Concerns:

- Extreme persistence
- Bioaccumulation
- Toxicity



## Concerns:

- Extreme persistence<sup>1</sup>
- Bioaccumulation in plants<sup>4-5</sup>
- Suspected toxicity<sup>1</sup>
- More mobile<sup>6</sup>
- Remediation more difficult<sup>7-9</sup>

An “environmentally friendly” alternative?

PFAS are Problematic  
& Difficult to Remediate

Prevention is Preferable!

# CA proposal to list carpets with any PFAS

February 15, 2018



The CA Department of Toxic Substances Control (DTSC) is proposing to list carpets & rugs containing any PFAS as priority products for regulation.

# BRANDS ARE ELIMINATING HIGHLY FLUORINATED CHEMICALS

IKEA

H&M

Crate&Barrel

LEVI STRAUSS & CO.

PUMA

benetton

ESPRIT

adidas

MARKS &  
SPENCER

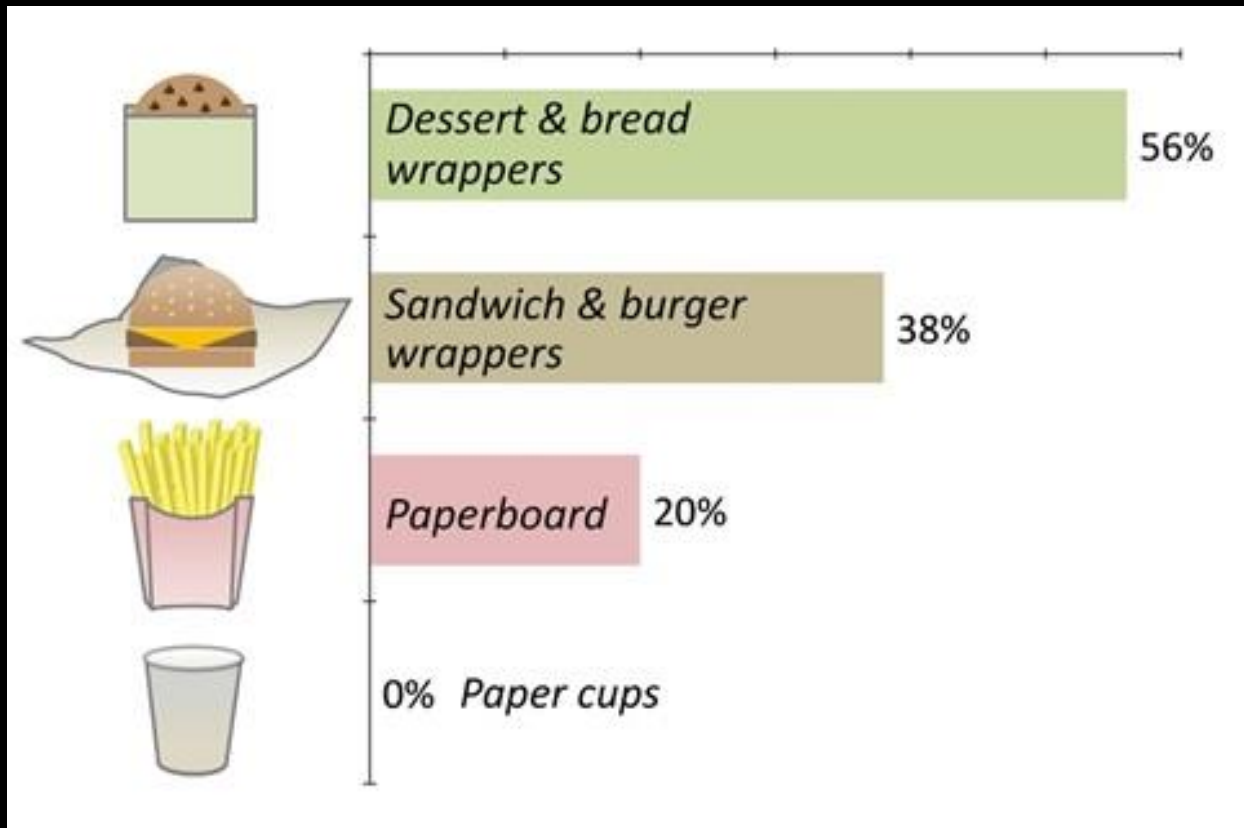
MANGO

BURBERRY<sup>®</sup>  
LONDON

ZARA

# Fluorine in U.S. fast food packaging paper

(percent positive; 400 products sampled)



Adopted from Schaidler L. 2017 *Fluorinated compounds in U.S. fast food packaging*.

# New York State purchasing ban on PFAS



single use food containers & packaging

"...products purchased ...on State contracts shall not contain perfluorinated chemicals (PFCs)..."



# Washington State's Healthy Food Packaging Act Passes House & Senate

February 28, 2018

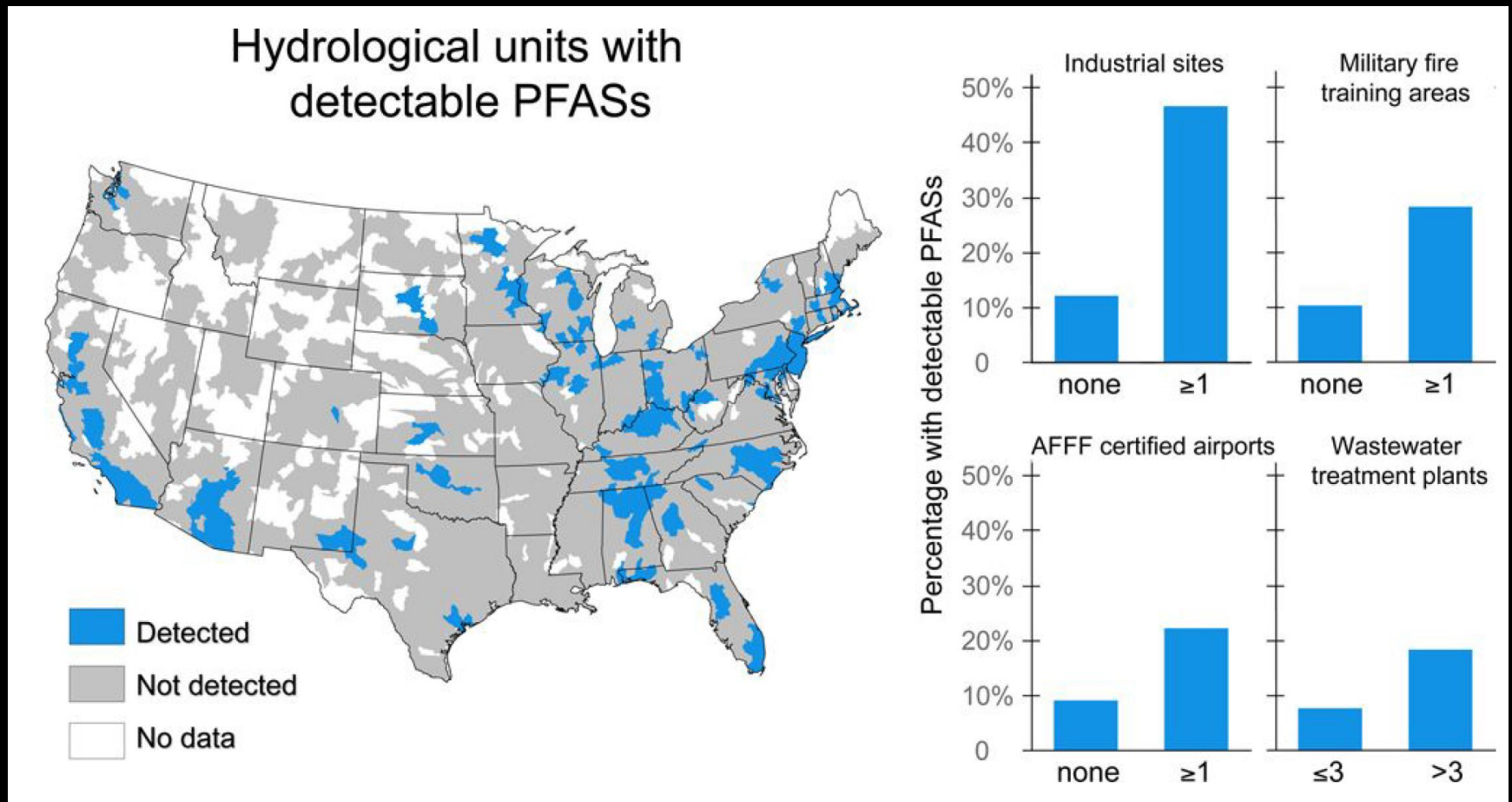


HB 2658/SB 6396 passes House  
on a 30-17 vote

Bans paper food packaging  
containing any PFAS

<https://toxicfreefuture.org/key-issues/legislative-priorities-2018/>

# EPA Lifetime Health Advisory Level of 70 ng/L PFOA + PFOS



Hu et al., Environ. Sci. Technol. Lett. 2016



# AFFF Phase-out in Norway

- 2011: Domestic airports in Norway phase out AFFF and adopt fluorine-free foam
- 2015: Norwegian Defense Force begins adoption of fluorine-free foams



Source: Norwegian Environment Agency

# South Australia: AFFF Ban

Jan. 30, 2018

Applies to all fluorinated firefighting foams for all applications

Australia: about 90% of airports are now using fluorine free foams.  
(They can reach the highest level of performance in ICAO (International Civil Aviation Organization) extinguishment tests.)



# Washington State's Ban on PFAS in Firefighting Foam Passes both Houses

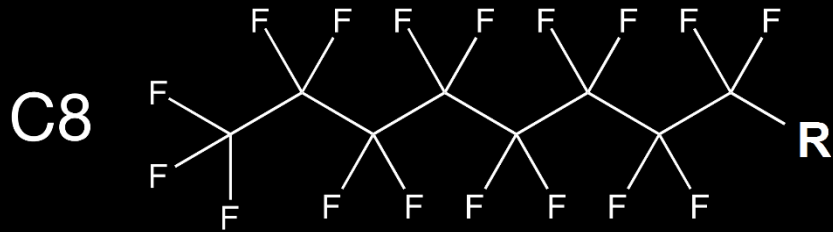
(HB 2793/SB 6413)



- Passed the Senate on a vote of 38-9 and the House 72-26 on February 27, 2018
- Bans sale of firefighting foam containing any PFAS beginning July 1, 2020
- Bans the use of PFAS-containing foam for training beginning July 1, 2018.
- Requires notification regarding firefighting gear that contains any PFAS

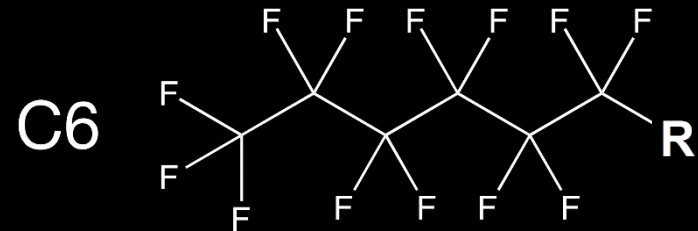
More info <https://toxicfreefuture.org/key-issues/legislative-priorities-2018/>

# US: Is C6 the “environmentally friendly” alternative to C8?



## Concerns:

- Extreme persistence
- Bioaccumulation
- Toxicity



## Concerns:

- Extreme persistence<sup>1</sup>
- Bioaccumulation in plants<sup>4-5</sup>
- Suspected toxicity<sup>1</sup>
- More mobile<sup>6</sup>
- Remediation more difficult<sup>7-9</sup>

# Recommendation 1

## Research Efficacy & Toxicology of Fluorine-Free Foams

Manufacturer	Foam
Angus / National Foam	Jetfoam (Aviation), Respondol (Class B)
Auxquimia	UNIPOL
Vsfocum	Silvara
Bioex	Ecopol
Fomtec	Enviro 3x3 Plus
Solberg	Re-healing Foam RF6 / RF3
Dr. Sthamer	Moussol F-F <sub>3</sub> /6
Biosafety Technology	Trident
3F	FREEFOR SF, HYFEX SF, FREEDOL SF

## Recommendation 2

Change the MILSpec to maintain fire safety and permit the use of fluorine-free foams.

- The MILSPEC, a U.S. military specification, requires PFAS in firefighting foam for liquid fuel fires.
- The FAA requires civilian airports to use foam that meets the MILSPEC, resulting in use of PFAS foams where they may not be needed.

**THE U.S.  
MILITARY IS  
SPENDING  
MILLIONS TO  
REPLACE TOXIC  
FIREFIGHTING  
FOAM WITH  
TOXIC  
FIREFIGHTING  
FOAM**



Sharon Lerner, The Intercept, February 10, 2018

- 2000-- 3M decides to stop making PFOS
- 2000, 2001—EPA warns of serious risk of harm
- 2001—Fire Fighting Foam Coalition founded
- 2003—EPA exempted AFFF from its regulatory process
- 2004— Fluorine free foams at 9 seconds above the Navy's 30-second requirement.
- 2010—A Solberg's fluorine-free foam at 5 seconds above the requirement





Photo credit:  
*The Telegraph*

In 2012, after extensive testing, Heathrow in the UK switched away from the use of all PFAS. In 2015, a British Airways airbus caught fire and firefighters safely put out the flames with fluorine-free foam.

**“zero cleanup costs and zero environmental concerns”**

Graeme Day, fire service compliance manager, Heathrow



<http://www.bio-ex.com/responsible-commitment/responsible-environmental-commitment>

# Recommendation 3

## Coordinated health studies of PFAS-contaminated communities



- Study multiple PFASs (not just PFOA and PFOS).
- Continued & increased funding is needed.

## Recommendation 4


Develop enforceable health levels for PFOA, PFOS, GenX and other short chains.

An enforceable Maximum Contaminant Level (MCL) would:

- Require utilities to perform monitoring
- Require utilities to treat water if necessary
- Expedite cleanups by responsible parties

# Prevention is Preferable!

1. Research fluorine-free foam
2. Change the MILSpec to maintain fire safety and allow the use of fluorine-free foams
3. Coordinated health studies of PFAS-contaminated communities
4. Develop enforceable Maximum Contaminant Levels

A high-altitude mountain climber is seen from behind, ascending a steep, snow-covered ridge. The climber is wearing a yellow helmet and dark gear, and is secured by a red rope. The sun is shining brightly from the upper left, creating a lens flare effect across the scene. The background shows more rugged, snow-covered mountain peaks under a clear blue sky.

For monthly e-newsletters or  
a copy of this talk,  
give Arlene your card

[www.GreenSciencePolicy.org](http://www.GreenSciencePolicy.org)

# References

1. Wang, Z., et al. A Never-Ending Story of Per- and Polyfluoroalkyl Substances (PFASs)? *Environ. Sci. Technol.* **2017**, *51* (5), 2508-2518.
2. CDC / ATSDR. Draft Toxicological Profile for Perfluoroalkyls. **2015**. <https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf>
3. Biomonitoring California. Perfluorochemicals Factsheet. 2012. <https://biomonitoring.ca.gov/sites/default/files/downloads/PFCsFactSheet.pdf>
4. Blaine, A.C., et al. Perfluoroalkyl Acid Uptake in Lettuce (*Lactuca sativa*) and Strawberry (*Fragaria ananassa*) Irrigated with Reclaimed Water. *Environ. Sci. Technol.* **2014**, *48* (24), 14361-14368.
5. Blaine, A.C., et al. Uptake of Perfluoroalkyl Acids into Edible Crops via Land Applied Biosolids: Field and Greenhouse Studies. *Environ. Sci. Technol.* **2013**, *47* (24), 14062-14069.
6. Guelfo, J.L. and Higgins, C.P. Subsurface Transport Potential of Perfluoroalkyl Acids at Aqueous Film-Forming Foam (AFFF)-Impacted Sites. *Environ. Sci. Technol.* **2013**, *47*(9), 4164-4171.
7. Appleman, T.D., et al. Treatment of poly- and perfluoroalkyl substances in US full-scale water treatment systems. *Water Res.* **2014**, *51*, 246-255.
8. Eschauzier, C., et al. Impact of treatment processes on the removal of perfluoroalkyl acids from the drinking water production chain. *Environ. Sci. Technol.* **2012**, *46*(3), 1708-1715.
9. Xiao, X., et al. Sorption of Poly- and Perfluoroalkyl Substances (PFASs) Relevant to Aqueous Film-Forming Foam (AFFF)-Impacted Groundwater by Biochars and Activated Carbon. *Environ. Sci. Technol.* **2017**, *51*(11), 6342-6351.
10. Hu, X., et al. Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants. *Environ. Sci. Technol. Lett.* **2016**, *3* (10), 344-350.. **2017**.

# References

11. Mlive.com. Rockford well may have highest PFAS level in U.S. drinking water. Jan. 31, 2018.  
[http://www.mlive.com/news/grand-rapids/index.ssf/2018/01/58930-ppt\\_pfas\\_drinking\\_water.html](http://www.mlive.com/news/grand-rapids/index.ssf/2018/01/58930-ppt_pfas_drinking_water.html)
12. WZZM13.com. Wolverine Worldwide says no to filter for lesser-known PFAS compound. Jan. 29, 2018.  
<http://www.wzzm13.com/news/local/water-worries/wolverine-worldwide-says-no-to-filter-for-less-known-pfas-compound/512182044>
13. Lerner, S. "New Teflon Toxin Causes Cancer in Lab Animals." *The Intercept*, 2015.