



PFAS: Chemistry, Regulations, Replacement

Jeff Strahan, Ph.D. | Director of Research, Compliance, and Sustainability | July 2023

3 TAKE HOME MESSAGES



1 PFAS science is broad, deep, and active.



2 PFAS regulations are a patchwork.



3 Substituting PFAS is resource intensive but possible... sometimes.

PFAS IS A CHEMICAL ACRONYM.

According to the United States of America's Environmental Protection Agency (EPA), "PFAS are a group of man-made chemicals that have been manufactured and used by a variety of industries since 1940."



PFAS is a chemical acronym that stands for per- or polyfluoroalkyl substances:

Per means all

Poly means many

Fluoro means fluorine

Alkyl means carbon with all single bonds

Substances means chemical

Put it all together, and it means any chemical with a carbon atom bonded to two or more fluorine atoms.

PFAS POP QUIZ

PFAS = per or polyfluoroalkyl substances

Per = all

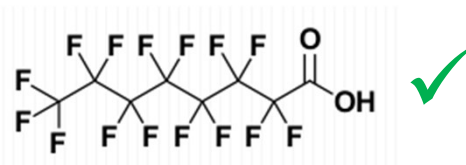
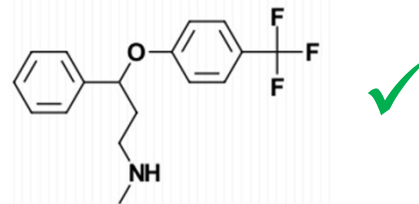
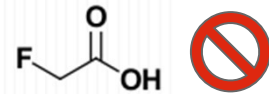
Poly = many

Fluoro = fluorine

Alkyl = carbon-based

Substance = matter

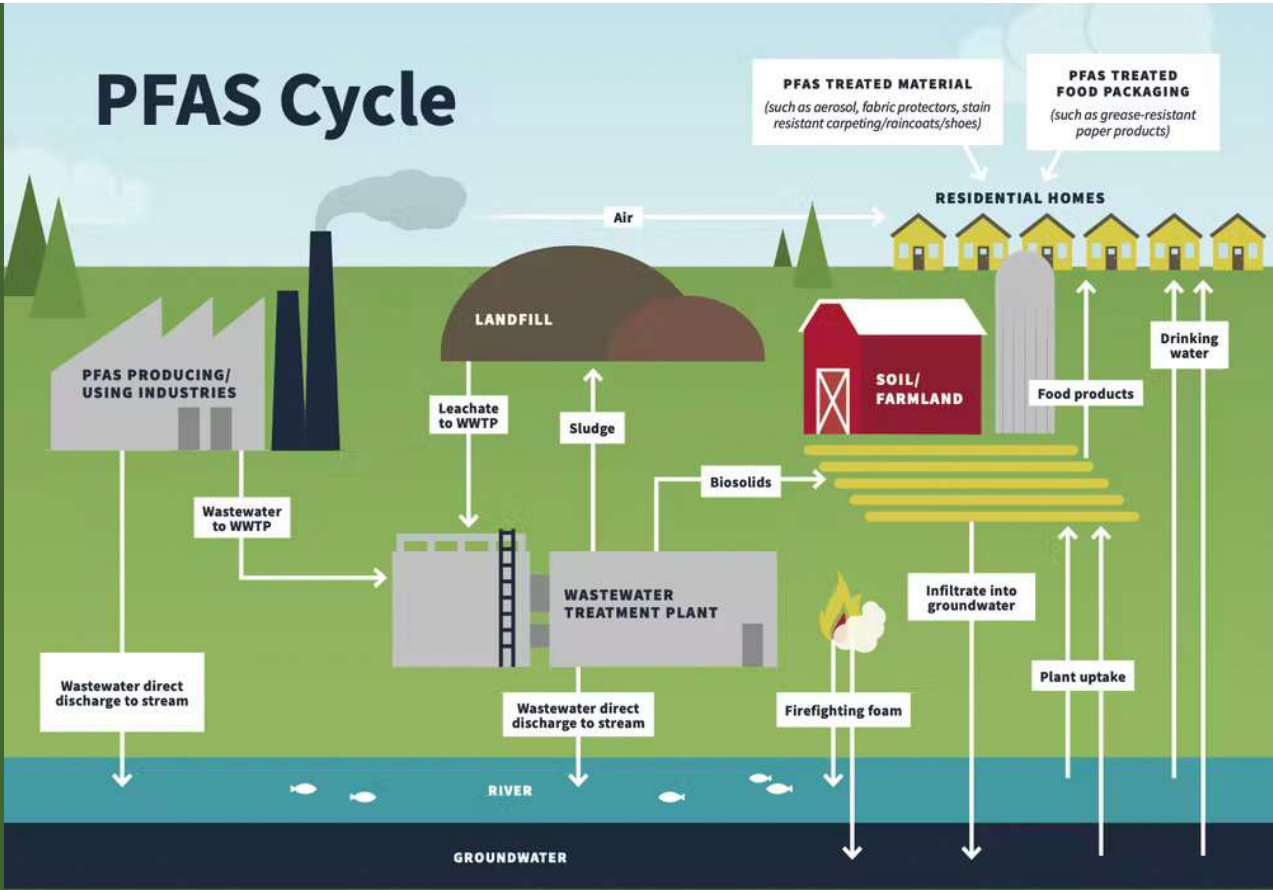
Any chemical with at least one carbon bonded to at least two or more fluorine atoms



PFAS HAS A LARGE VARIETY OF APPLICATIONS.



PFAS IS AN ACTIVE AREA OF RESEARCH.

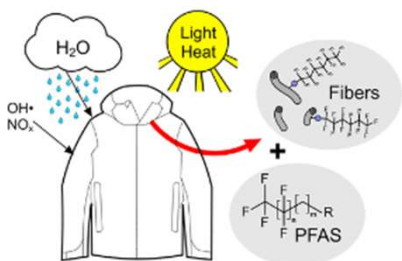


EGL MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

800-662-9278 | Michigan.gov/PFASresponse

7/2019

PFAS IS AN ACTIVE AREA OF RESEARCH.



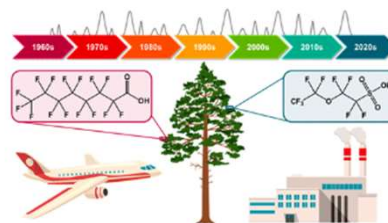
An Outdoor Aging Study to Investigate the Release of Per- And Polyfluoroalkyl Substances (PFAS) from Functional Textiles

Steffen Schellenberger, Ioannis Liagkouridis, Raed Awad, Stuart Khan, Merle Plassmann, Gregory Peters, Jonathan P. Benskin, and Ian T. Cousins*



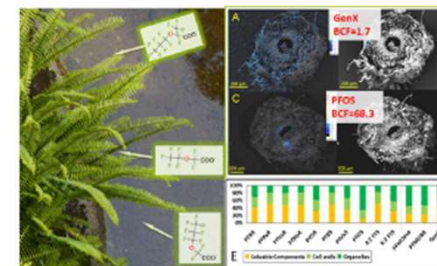
Per- and Polyfluoroalkyl Substances (PFAS) in Breast Milk: Concerning Trends for Current-Use PFAS

Guomao Zheng, Erika Schreder, Jennifer C. Dempsey, Nancy Uding, Valerie Chu, Gabriel Andres, Sheela Sathyanarayana, and Amina Salamova*



Utilizing Pine Needles to Temporally and Spatially Profile Per- and Polyfluoroalkyl Substances (PFAS)

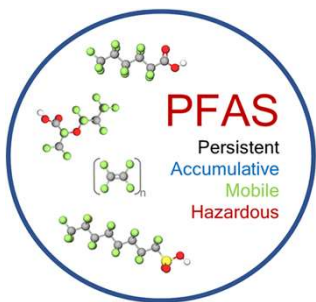
Kaylie I. Kirkwood, Jonathon Fleming, Helen Nguyen, David M. Reif, Erin S. Baker*, and Scott M. Belcher*



Bioaccumulation of Per- and Polyfluoroalkyl Substances (PFAS) in Ferns: Effect of PFAS Molecular Structure and Plant Root Characteristics

Shenhua Qian, Hongying Lu, Tiantian Xiong, Yue Zhi*, Gabriel Munoz, Chuhui Zhang, Zhengwei Li, Caihong Liu, Wei Li, Xiaoming Wang, and Qiang He

PFAS IS AN ACTIVE AREA OF RESEARCH.



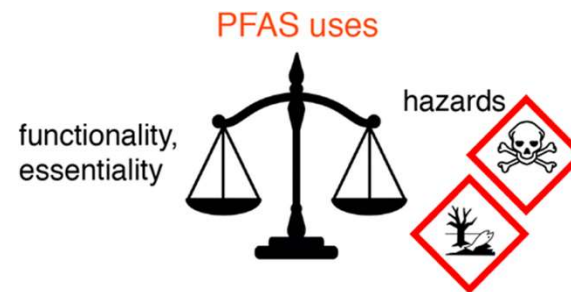
Scientific Basis for Managing PFAS as a Chemical Class

Carol F. Kwiatkowski*, David Q. Andrews, Linda S. Birnbaum, Thomas A. Bruton, Jamie C. DeWitt, Detlef R. U. Knappe, Maricel V. Maffini, Mark F. Miller, Katherine E. Pelch, Anna Reade, Anna Soehl, Xenia Trier, Marta Venier, Charlotte C. Wagner, Zhanyun Wang, and Arlene Blum



Addressing Urgent Questions for PFAS in the 21st Century

Carla Ng*, Ian T. Cousins, Jamie C. DeWitt, Juliane Glüge, Gretta Goldenman, Dorte Herzke, Rainer Lohmann, Mark Miller, Sharyle Patton, Martin Scheringer, Xenia Trier, and Zhanyun Wang



Information Requirements under the Essential-Use Concept: PFAS Case Studies

Juliane Glüge, Rachel London, Ian T. Cousins, Jamie DeWitt, Gretta Goldenman, Dorte Herzke, Rainer Lohmann, Mark Miller, Carla A. Ng, Sharyle Patton, Xenia Trier, Zhanyun Wang, and Martin Scheringer*

3 TAKE HOME MESSAGES



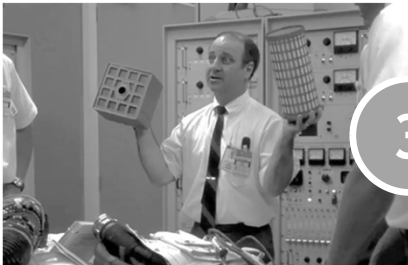
1

PFAS science is broad, deep, and active.



2

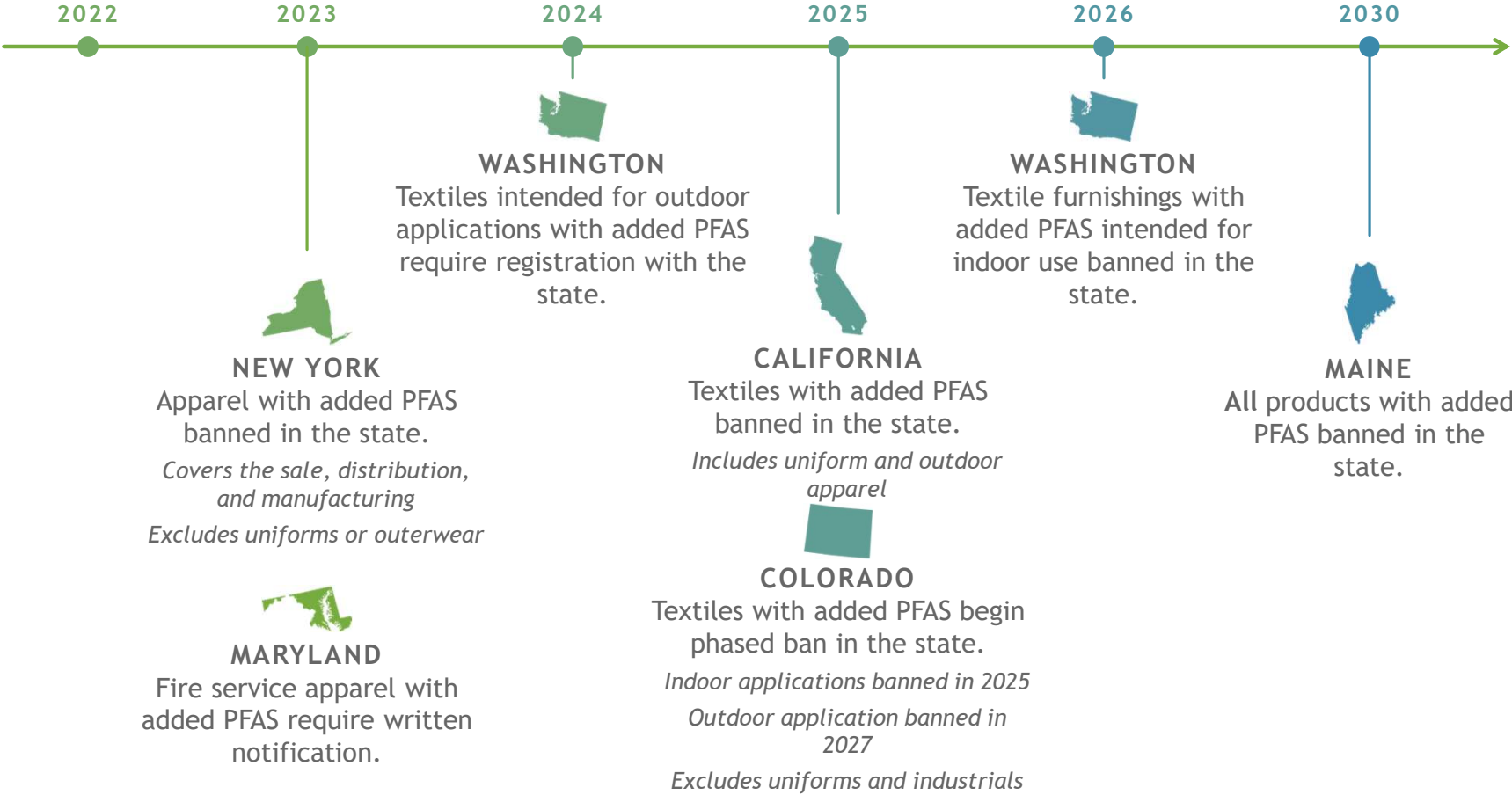
PFAS regulations are a patchwork.



3

Substituting PFAS is resource intensive but possible... sometimes.

TIMELINE OF UPCOMING PFAS LEGISLATION



THE EPA HAS BUILT AND IS EXECUTING THEIR PFAS STRATEGIC ROADMAP.

“This comprehensive, national PFAS strategy will deliver protections to people who are hurting, by advancing bold and concrete actions that address the full lifecycle of these chemicals. Let there be no doubt that EPA is listening, we have your back, and we are laser focused on protecting people from pollution and holding polluters accountable.”

Michael Regan, EPA Administrator, October 2021

RESTRICT Pursue a comprehensive approach to proactively prevent PFAS from entering air, land, and water at levels that can adversely impact human health and the environment.	Objectives <ul style="list-style-type: none">• Use and harmonize actions under all available statutory authorities to control and prevent PFAS contamination and minimize exposure to PFAS during consumer and industrial uses.• Place responsibility for limiting exposures and addressing hazards of PFAS on manufacturers, processors, distributors, importers, industrial and other significant users, dischargers, and treatment and disposal facilities.• Establish voluntary programs to reduce PFAS use and release.• Prevent or minimize PFAS discharges and emissions in all communities, regardless of income, race, or language barriers.
---	---

Source: www.epa.gov/system/files/documents/2021-10/pfas-roadmap_final-508.pdf

The EPA just proposed a PFAS national primary drinking water regulation with 4 ppt limits on PFOA and PFOS.

Source: <https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas>

THE EPA IS ACTIVELY COLLECTING PFAS DATA ON THE TEXTILE INDUSTRY.

Milliken is one of nine textile companies asked to submit extensive information to the EPA:

- Details regarding PFAS use
- Manufacturing and plant processes
- Waste-water processes
- Information required to EPA by January 30, 2022

PFAS testing and reporting added to water permit at Georgia Milliken location in 2022 via state agency. Other states seeking permit changes.

According to meetings with NCTO leadership, the EPA Office of Water will initiate a mandatory survey in 2023 for all domestic textile companies.

https://www.epa.gov/system/files/documents/2021-09/multi-industry-pfas-study_preliminary-2021-report_508_2021.09.08.pdf

PFAS REGULATIONS ARE ALSO ACTIVE IN THE EU AND CHINA.



- Lead authors were Denmark, Germany, the Netherlands, Norway, and Sweden
- Published in Feb 2023 for a 6-month consultation; 2025 adoption
- Restriction proposal applicable to all uses of more than 10,000 substances
- Exemptions carry an 18-month transition period and a 5- or 12-year exemption period, depending on the application
- <50 ppm of total fluorine
- NGO ChemSec survey said 53 leading brands in favor of restrictions.



- Published list of new chemical pollutants in Jan 2023
- PFOS: production, use, import and export are banned from Jan 2024;
- PFOA: production and use are restricted to limited uses;
- PFHxS: production, use, import and export are banned from March 2023

<https://chemicalwatch.com/672000/eu-pfas-restriction-proposal-applicable-to-all-uses-of-more-than-10000-substances>
https://www.ecotextile.com/index.php?option=com_content&view=article&id=30358:brands-supportive-of-eu-pfas-restrictions&catid=313&utm_source=newsletter_468&utm_medium=email&utm_campaign=ecotextile-news-bulletin-14-02-2023
<https://chemicalwatch.com/643240/china-publishes-list-of-new-chemical-pollutants-subject-to-priority-control>

PFAS LITIGATION IS RAMPANT AND EXPENSIVE.

DUPONT

- Named as defendant in >6,100 cases 2005 - 2022
- \$617M settlements with WV and NC
- \$4B cost sharing agreement with corporate spin-offs

3M

- Sued on average 3x/day for all of 2021
- \$850M settlement with MN
- Settled class-action lawsuit for \$54M with shoemaker Wolverine Worldwide
- Set aside another \$235M for future litigation

Other OEMs and Tier 1 users and producers now getting sued at similar rates as DuPont.

“It does not take a genius to figure out that if certain motions don’t go their way, the defendants are in an existential threat to their survival.”

Judge Richard Gergel, [July 2019 proceeding](#)

<https://news.bloomberglaw.com/pfas-project/companies-face-billions-in-damages-as-pfas-lawsuits-flood-courts>
<https://www.chemistryworld.com/news/duPont-and-spinoffs-reach-4bn-settlement-to-resolve-pfas-liability-issues/4013121.article>
<https://www.mlive.com/public-interest/2023/03/judge-approves-54m-wolverine-3m-pfas-lawsuit-settlement.html>

THE PFAS SUPPLY CHAIN IS CHANGING.

3M to Exit PFAS Manufacturing by
the End of 2025

Toxic Free Future Letter to
EPA



The EPA should, “use the Active TSCA Inventory to identify which of these PFAS are being produced in the U.S. or imported by other companies. Where 3M is the only domestic manufacturer or importer, the Agency would be able to designate production or import of the PFAS as a “significant new use” under section 5 of TSCA.

This would have the effect of prohibiting other companies from beginning production or importation without submitting a significant new use notice to EPA, enabling it to ban or restrict the proposed new use.”

<https://news.3m.com/2022-12-20-3M-to-Exit-PFAS-Manufacturing-by-the-End-of-2025>
<https://toxicfreefuture.org/blog/what-epa-must-do-now-that-3m-announced-it-will-no-longer-make-pfas-forever-chemicals/>

MAJOR MARKET PLAYERS HAVE PLEDGES TO EXIT PFAS.



Calvin Klein

<https://www.boston.com/news/environment/2022/04/06/clothing-brands-stopped-using-pfas-us-pirg-report/>
<https://toxicfreefuture.org/mind-the-store/retailers-committing-to-phase-out-pfas-as-a-class-in-food-packaging-and-products/>

3 TAKE HOME MESSAGES



1

PFAS science is broad, deep, and active.



2

PFAS regulations are a patchwork.



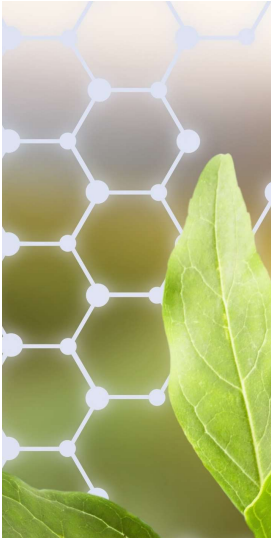
3

Substituting PFAS is resource intensive but possible... sometimes.

TEXTILE MANUFACTURING INVOLVES PROCESSING POLYMERS TO GARMENTS.

POLYMER

Plant or Oil



FIBER

Plant or Extrusion



YARN

Spinning



FABRIC

Weave or Knit

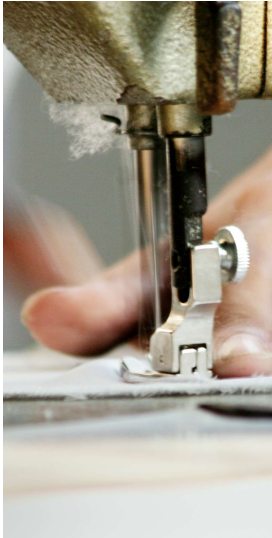


ROLL GOOD

Dye and Finish

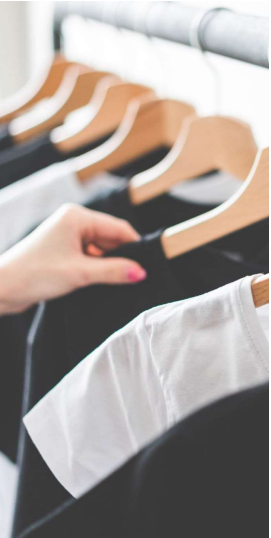


CUT AND SEW



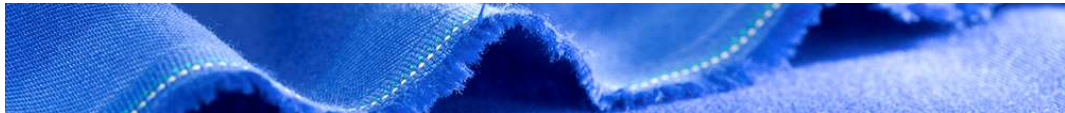
RETAIL

Distribution and Sales



TEXTILES HAVE A LENGTHY SPEC SHEET.

WHAT IT IS



- Width
- Weight
- Length
- Ends and Picks / Inch
- Color

- Stretch
- Tensile
- Seam Slippage
- Tear Strength
- Flex Abrasion
- Piling
- Water Repellency
- Soil Release
- Color Retention
- Flammability
- Shrinkage
- Air Permeability

WHAT IT DOES

TEXTILE DIVISION STATEMENT

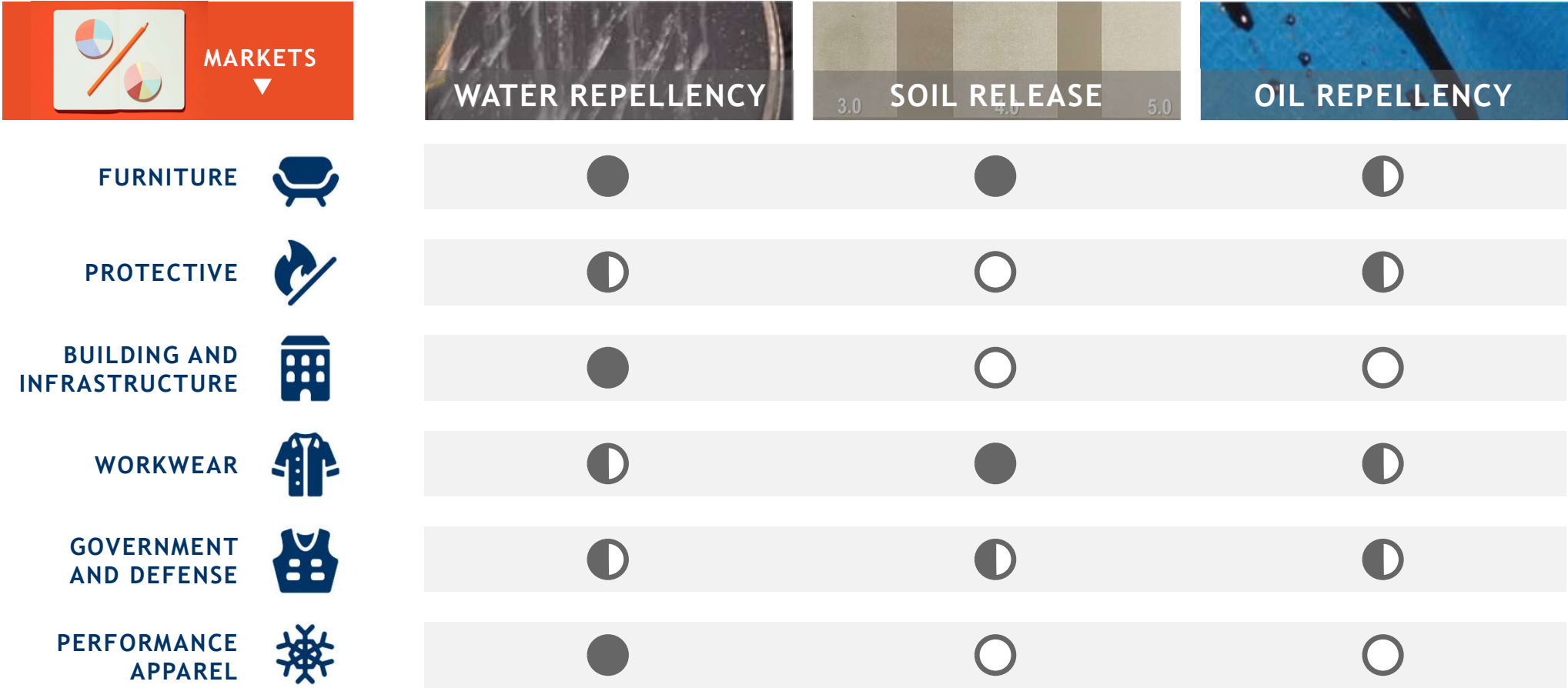
As materials science experts focused on innovation and sustainability, Milliken & Company has always tried to maintain a product portfolio that is responsive to where the market is going, not just where the market is today.

As part of this effort, we continuously seek feedback from the industry, including our suppliers and customers, and routinely monitor the regulatory landscape. We believe the market for products made with PFAS chemistries is shifting, and as a result, we are in the process of proactively eliminating PFAS-containing materials from our textiles.

We will complete this initiative across the Division by December 31, 2022. We remain committed to engineering high-quality, performance and protective textiles as well as environmental stewardship.

[Press Release](#)

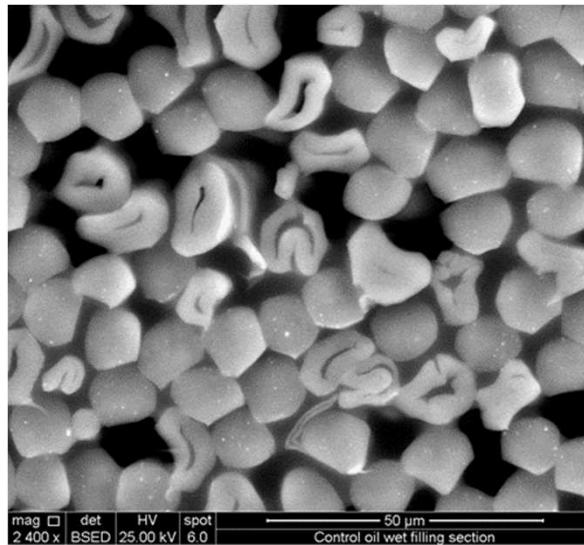
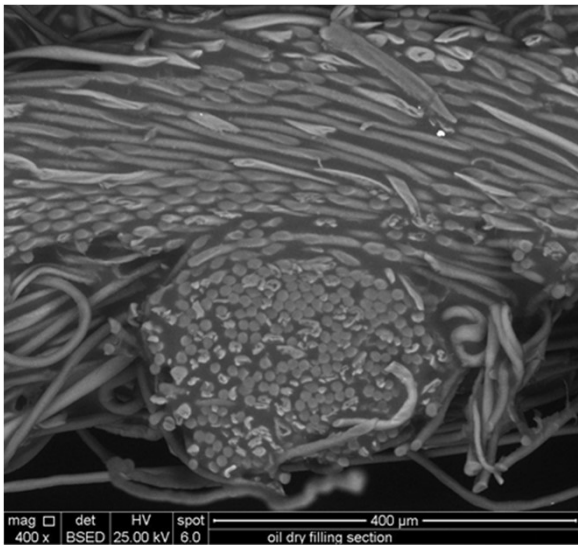
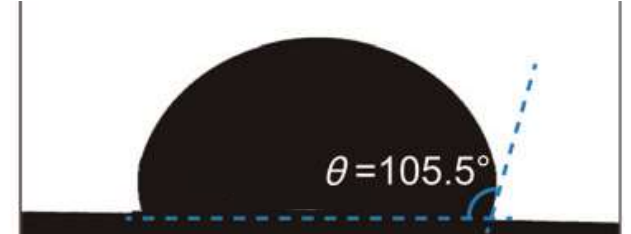
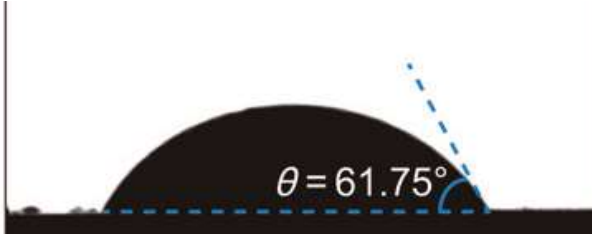
DEFINING PFAS REPLACEMENT IS SEGMENTED BY MARKET.



REPLACING PFAS PRESENTS CHALLENGES AT DIFFERENT LENGTH AND TIME SCALES.

CLASSIC SURFACE ENERGY WORLD

- Isotropic Surface
- Smooth Surface on mm Scale
- Steady State



TEXTILE WORLD


- Anisotropic Surface at micron Scale
- Smooth Surface on 10-100s nanometers
- Timed Tests

THE MARKET HAS PROVIDED SEVERAL VIABLE NON-PFAS OPTIONS FOR DWR.

AATCC 22
SPRAY TEST FOR WATER REPELLENCY



- Third-party certification
- 74 “Fluorine-free” Water Repellents
 - Silicone-based
 - Wax-based
 - Bio-based
 - Acrylic



- What did our customer mean by repellent?
- How do they define durable?
- What is my fiber content?
- What is my construction?
- How will I finish?
- Is it compatible with other finishes?
- Does it effect the hand?
- What does it cost?

NON-PFAS DWR EXAMPLE #1

Item	Spec	Historical PFAS	Current Non-PFAS
Fiber Content	65 PET/ 35 Cotton		
Fabric Weight (osy)	6.75		
Test Method	AATCC 22		
As Received	>90	90	100
10 Industrial Laundering, 160 °F	>70	75	70
10 Home Wash, 120 °F	>70	80	90



PFAS 10 HW
120 °F

Non-PFAS 10 HW
120 °F

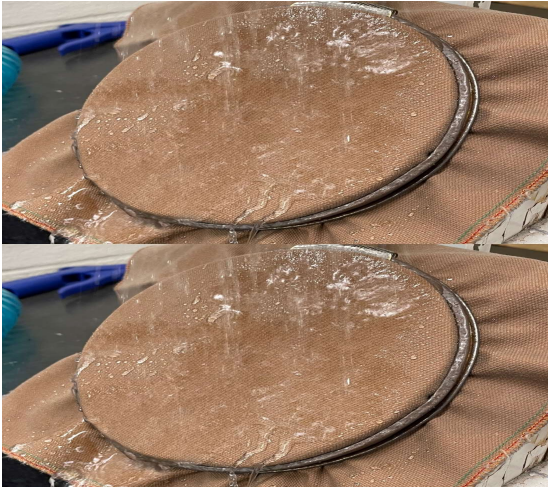


NON-PFAS DWR EXAMPLE #2



Non-PFAS AR

Non-PFAS 20 HW



Item	Spec	Historical PFAS	Current Non-PFAS
Fiber Content	88 Cotton/ 12 Nylon		
Fabric Weight (osy)	11.5		
Test Method	AATCC 22		
As Received	>80	88	91
20 Home Wash, 120 °F	>60	62	70

NON-PFAS DWR EXAMPLE #3

Item	Spec 1	Historical PFAS	Current Non-PFAS
Fiber Content	90 PET/ 10 Spandex		
Fabric Weight (osy)	6.6		
Test Method	AATCC 22		
As Received	>80	>90	>90
10 Home Wash, 120 °F	>80	90	>90





NON-PFAS DWR EXAMPLE #4

Item	Spec 1	Historical PFAS	Current Non-PFAS
Fiber Content	100 Acrylic - 100 PET		
Fabric Weight (osy)	8-15		
Test Method 1	AATCC 22		
As Received	>80	>80	80
Test Method 2	AATCC 130		
As Received	5	5	5*

*Non-oil Staining Agents
 Red Wine, Coffee, Milk,
 Ketchup, Mustard, Chocolate
 Syrup, Jelly, Blood

NON-PFAS DWR EXAMPLE #5

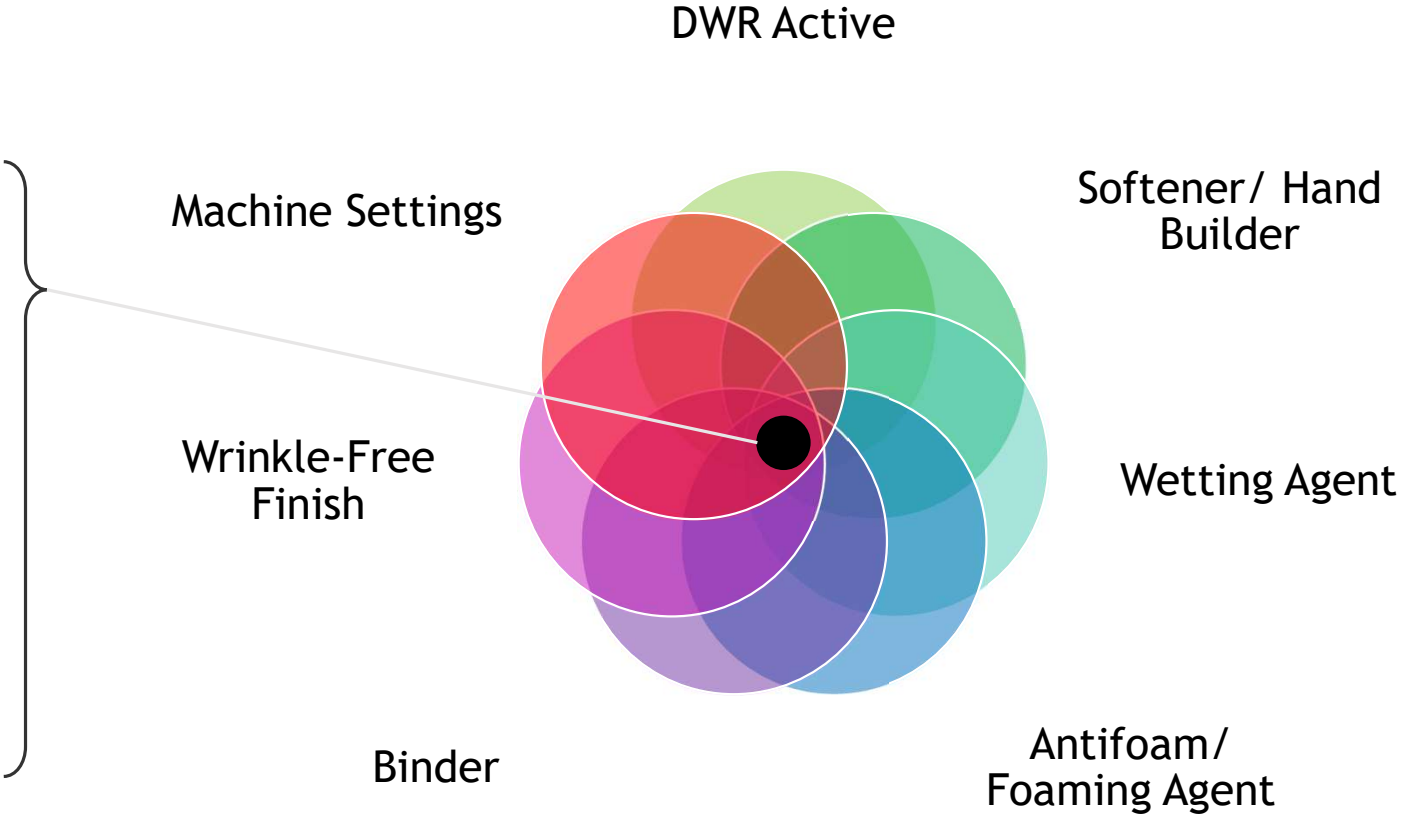
Item	Spec 1	Historical PFAS	Current Non-PFAS
Fiber Content	100 PET		
Fabric Weight (osy)	2.9		
Test Method 1	ASTM D751		
As Received	< 3%	2%	2%
Test Method 2	ASTM D570		
As Received	< 3%	2%	2%



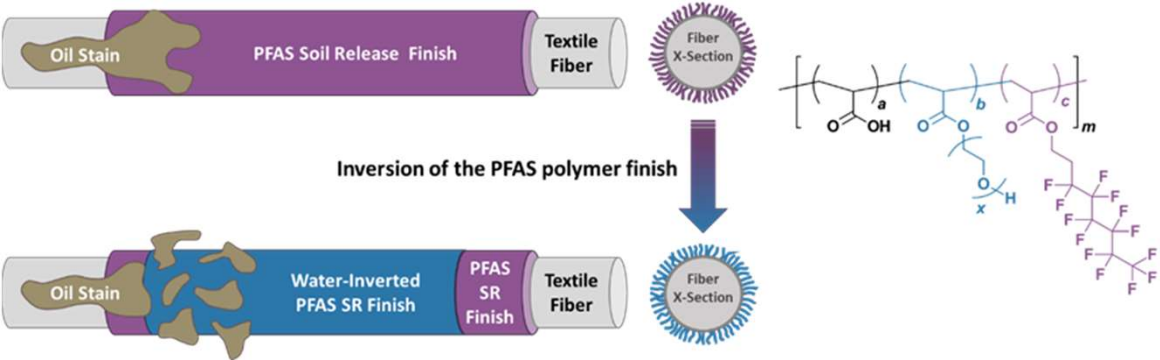
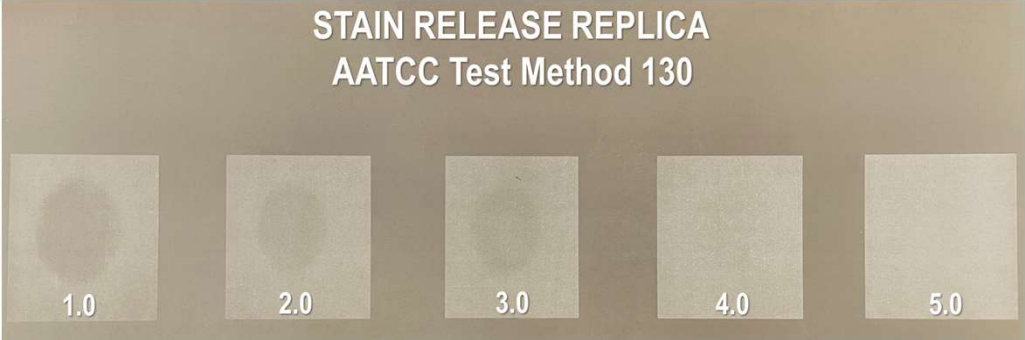
EACH SPEC SHEET WILL REQUIRE ROBUST DESIGN OF EXPERIMENT (DOE).



- Stretch
- Tensile
- Seam Slippage
- Tear Strength
- Flex Abrasion
- Piling
- Water Repellency
- Soil Release
- Color Retention
- Flammability
- Shrinkage
- Air Permeability



NON-PFAS SOIL RELEASE REQUIRED INVENTION.



# Home Washes	1960s Milliken	PFAS SR	Milliken 2021 non-PFAS SR
1	3	3.75	4.75
5	2.5	3.5	5
10	2	3.5	4.75
15	1.5	3.5	4.5
20	1	3.25	4.25
25	1	3	4
30	0.5	2.5	4
35		2	4
40			4

IT AIN'T OVER TILL IT'S OVER.



3 TAKE HOME MESSAGES



1

PFAS science is broad, deep, and active.



2

PFAS regulations are a patchwork.



3

Substituting PFAS is resource intensive but possible... sometimes.

Thank you.
Questions?



 **WESTEX**
A MILLIKEN BRAND