TURA Science Advisory Board Evaluation of 11 PFAS

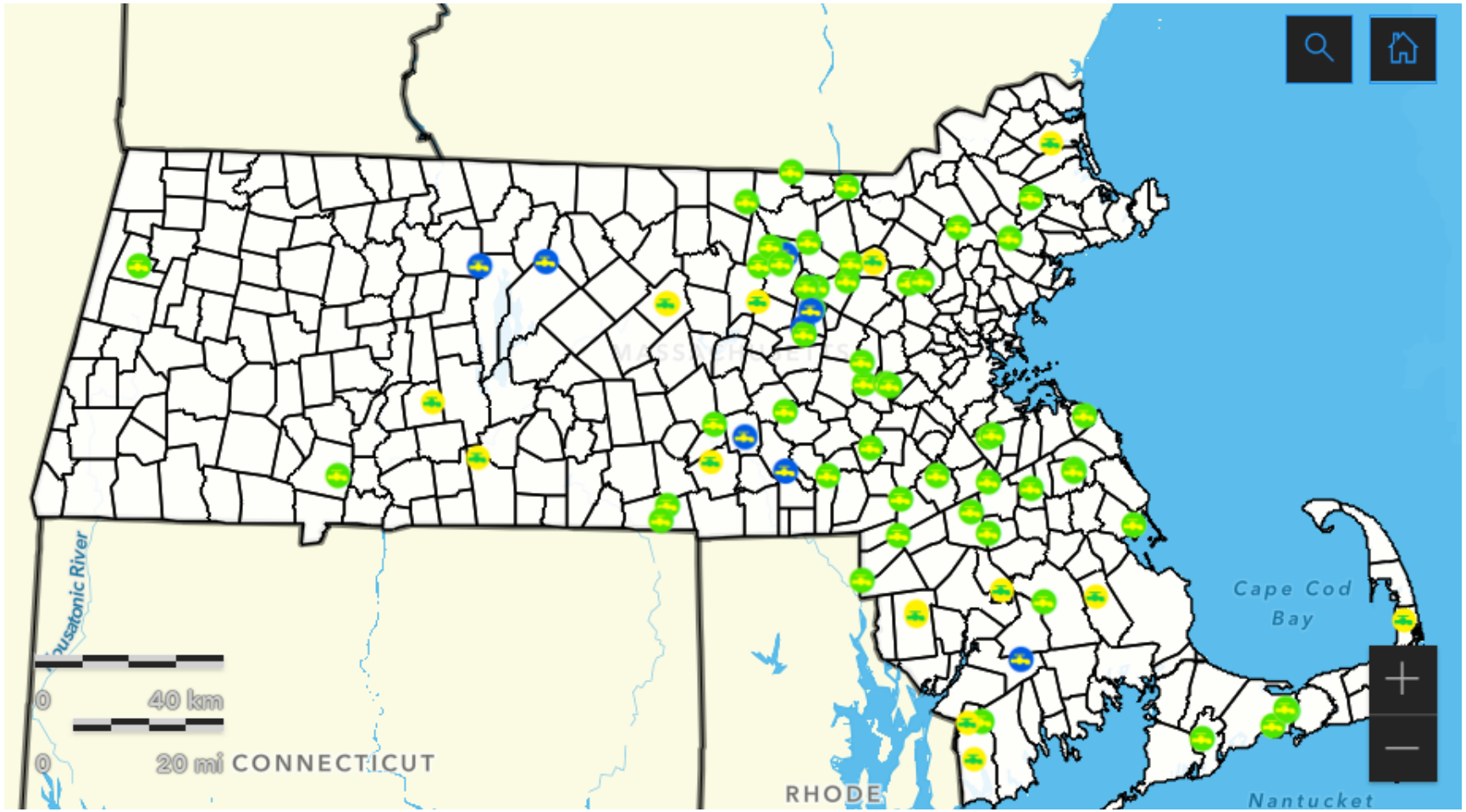
April 2022

Toxics Use Reduction Institute

Heather Tenney

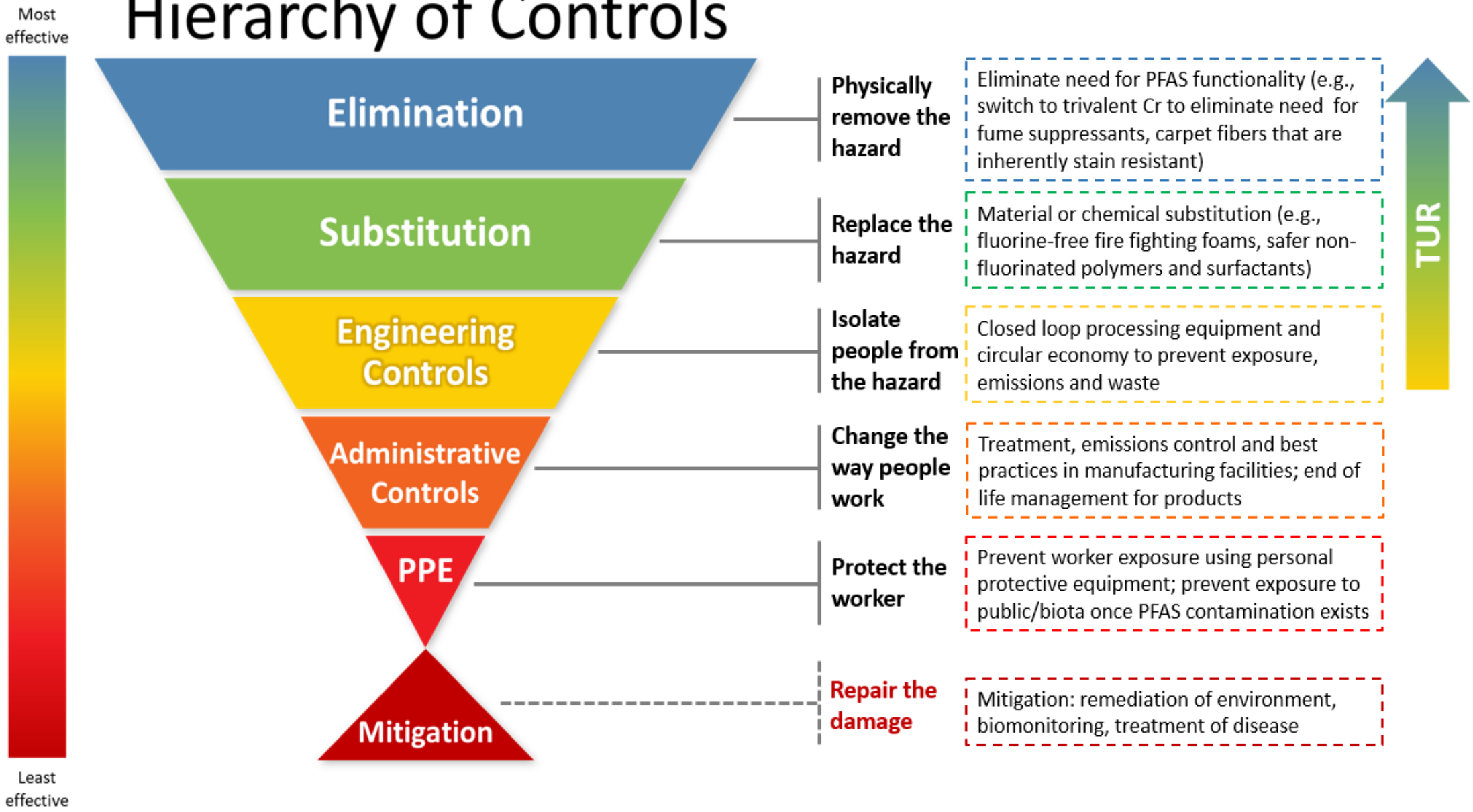
TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

Why a preventative approach?



[Per- and Polyfluoroalkyl Substances (PFAS) | Mass.gov]

Hierarchy of Controls



Overview

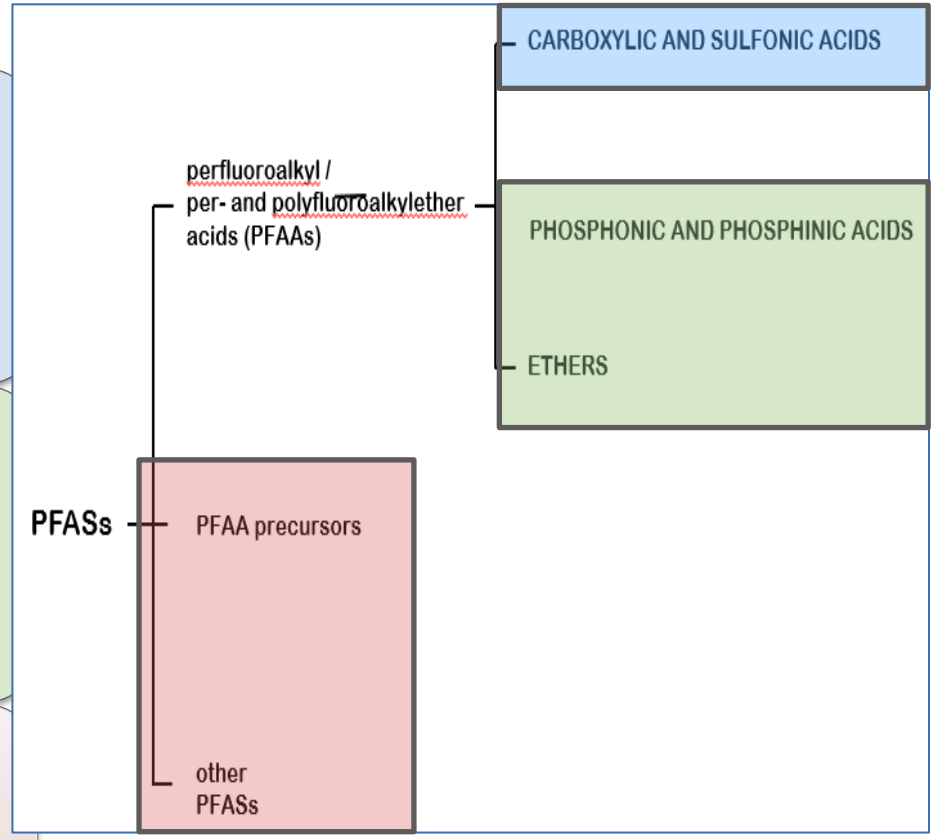
- TURA SAB Review of PFAS 2016-2020
- Review by TURA Advisory Committee and Administrative Council 2019-2021
- Listing of TURA PFAS Category 2021
- Currently implementing…

TURA SAB PFAS Evaluation

To understand the characteristics of a range of PFAAs, the SAB examined eight substances of varying chain lengths: PFNA (C9); PFOS and PFOA (C8); PFHpA (C7); PFHxA and PFHxS (C6); and PFBA and PFBS (C4).

The SAB then reviewed two ethers (GenX and ADONA), and phosphonic and phosphinic acids (PFPA and PFPiAs) of varying chain lengths.

The SAB reviewed various health impacts as well as a number of degradation/transformation pathways, through which a PFAS precursor breaks down into one of the end degradation products.



Chronic Health Effects

	PFNA	PFOA	PFOS	PFHpA	PFHxA	PFHxS	PFBA	PFBS	Gen X	ADONA	PFPA/ PFPiA
Cancer		Kidney, Testicular							X		
Immunotoxicity	X	Ulcerative colitis	X					X	X		
Thyroid		X			X	X	X	X		X	X
Endocrine (other than thyroid)					X	X	X	X			
Hematological		cholesterol				X	X	X			
Liver/metabolic	X			X	X	X	X	X	X	X	X
Reproductive	X	PIH							X	X	X
Developmental	X			X	X		X	X	X		
Neurodevelopmental						X					
Neurotoxicity	X				X	X		X			
Asthma						X		X			
Other	Mutagenicity				Kidney			Kidney	Kidney		Acute toxicity

Note: The SAB did not conduct a literature review for PFOS and PFOA due to the volume of information available through authoritative bodies and large-scale epidemiological studies.

Summary of SAB Recommendations on PFAS

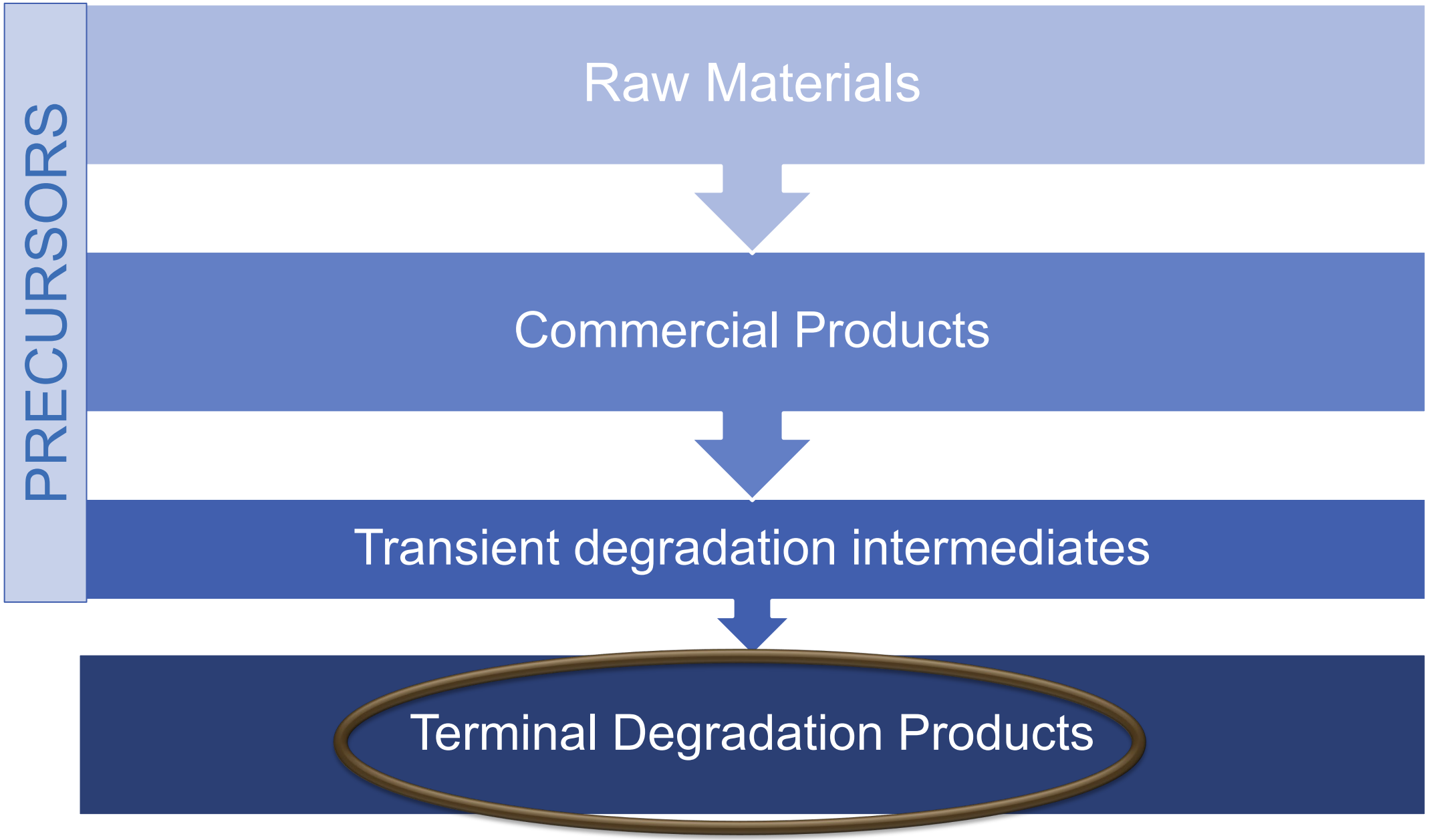
Chemical Name	SAB Recommendation Rationale
Perfluorooctane Sulfonic Acid (PFOS) and its salts (C8)	persistence, bioaccumulation, ecotoxicity, and animal acute toxicity.
Perfluorooctanoic Acid (PFOA) and its salts (C8)	persistence, bioaccumulation, ecotoxicity, and animal acute toxicity.
Perfluorohexanesulphonic acid (PFHxS) (C6)	persistence, bioaccumulation, mobility, corrosivity and mammalian toxicity: thyroid, liver/metabolic, and endocrine effects.
Perfluorohexanoic Acid (PFHxA) and its salts (C6)	persistence, mobility, corrosivity, and mammalian toxicity: thyroid and liver, with concerns for kidney and developmental effects.
Perfluorobutanesulfonic acid (PFBS) and its salts (C4)	persistence, mobility, corrosivity and mammalian toxicity: thyroid and developmental toxicity, with additional concerns for reproductive toxicity, neurotoxicity and immunotoxicity.
Pentafluorobenzoic acid (PFBA) and its salts (C6)	persistence, mobility, corrosivity and mammalian toxicity: liver/endocrine with additional concerns for thyroid, developmental toxicity, hematological effects, and phytoaccumulation.
Perfluoroheptanoic Acid (PFHpA) and its salts (C7)	persistence and liver effects, with concerns for corrosivity, mobility and bioaccumulation.
Perfluorononanoic Acid (PFNA) and its salts (C9)	persistence, bioaccumulation, developmental/ reproductive effects, immunotoxicity, and effects on liver, with additional concerns for mobility in the environment, neurotoxicity and corrosivity.
Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (GenX) (C6)	persistence, mobility, corrosivity, and liver toxicity.
Hexafluoropropylene Oxide (HFPO) Dimer Acid and its Acyl Halides (C6)	Recommended listing the salts of HFPO-DA and its acyl halides which are precursors to HFPO-DA.
ADONA - Ammonium 4,8-dioxa-3H-perfluorononanoate or 3H-perfluoro-3-[(3-methoxy-propoxy)propanoic acid] (C8)	Board agreed that ADONA followed the patterns of the other PFAS that the SAB has reviewed, such as liver effects, persistence, gender differences, corrosivity, and maternal toxicity. However, available data were not sufficient for a listing recommendation. The SAB noted an over-all lack of studies, especially for cancer, immunotoxicity, neurotoxicity, thyroid and more complete reproductive details.
Perfluoroalkyl Phosphonic and Phosphinic Acids (C4-C12)	persistence, mobility, corrosivity (pKa). Additional evidence shows compounds are precursors to PFCAs (e.g. PFOA, previously recommended for listing). Additional concerns based on evidence of liver toxicity and acute toxicity for some of the compounds.

Health and Environmental Effects

- **Highly persistent and mobile in the environment**
  - Do not break down under normal environmental conditions
- **Bioaccumulative**
  - In animals or plants
- **Health effects include:**
  - Effects on endocrine system, including liver and thyroid
  - Immunotoxicity (with implications for vaccines)
  - Metabolic effects
  - Developmental effects
  - Neurotoxicity

Persistence, Presence in the Environment, and Bioaccumulation

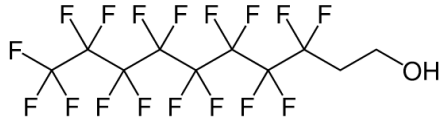
	PFNA	PFOA	PFOS	PFHpA	PFHxA	PFHxS	PFBA	PFBS	GenX	ADONA	PFPA/ PFPiA
Persistence	X	X	X	X	X	X	X	X	X	X	X
Bioaccumulation	X	X	X	X	X	X	X	X	X		X
Presence in the environment	X	X	X	X	X	X	X	X	X		
Presence in biota, including humans	X	X	X	X	X	X	X	X	X		X


PRECURSORS
Raw Materials
Commercial Products
Transient degradation intermediates
Terminal Degradation Products

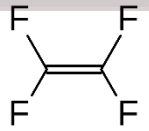
PRECURSORS

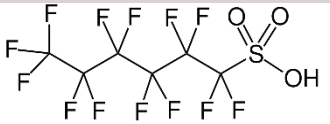
Raw Materials

8:2 FTOH



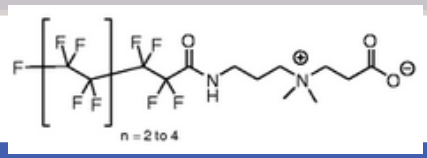
TFE and PFAAs



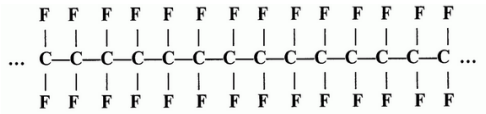


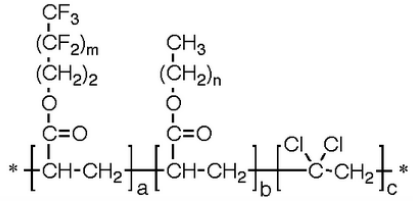
Commercial Products

Surfactants, e.g., AFFF



PTFE (Teflon); side chain polymers

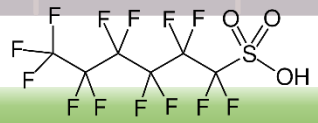




Transient degradation intermediates

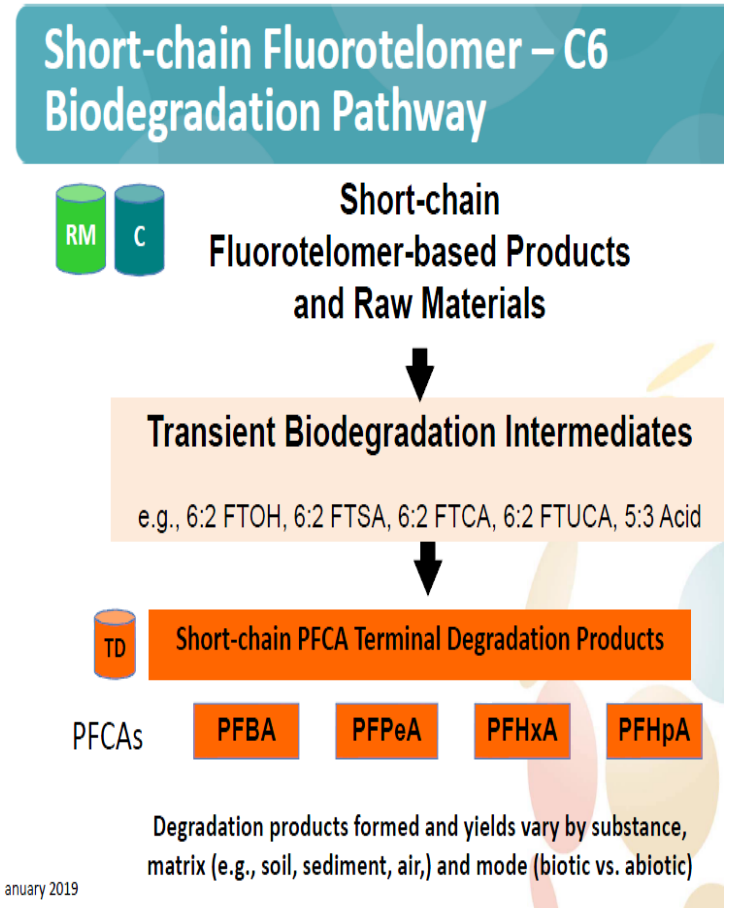
Terminal Degradation Products - PFAAs

PFBA	PFBS	PFHxA	PFHxS	PFHpA	PFOA	PFOS	PFNA	GenX	PFPAs



Degradation Pathways

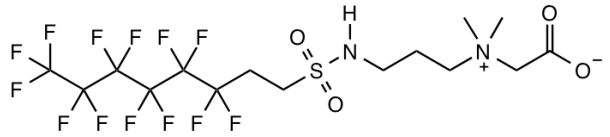
Substance	Type	Terminal Degradation Product
Perfluorohexyl Iodide	Transformation	PFHxA
C3 Dimer Acid Fluoride	Hydrolysis	Deprotonated HFPO-DA
6:2 fluorotelomer sulfonamide alkylbetaine (6:2 FTAB)	Aqueous Photolysis	PFHpA, PFHxA, PFPeA
Long chain Urethanes, acrylates, etc. based on EtFOSE - N-ethyl perfluorooctane sulfonamide ethanol	Aerobic biodegradation in activated sludge	PFCA, PFSA, PFASi, FASA, FASAA
Perfluoroalkyl Phosphinic Acid (PFPiA)	Oxidation	Perfluoroalkyl Carboxylic Acids (PFCA)
Sulfonamide derivatives: e.g., Urethane Polymers - Perfluoroalkyl sulfonamido ester	Oxidation	PFOS
PFBS salts; sulfonic acid halides; sulfonic alkyl/olefinic/aryl esters, Sulfonamides; sulfones and side-chain fluorinated polymers containing the PFBS moiety. Perfluorobutane sulfinic acid also represents a precursor to PFBS through oxidation to the required sulfonic acid group	Abiotic	PFBS
HFE-7100 and 7200/8200	Atmospheric Degradation	PFBA



Korzeniowski & Buck; "The PFAS Universe: Uses, Classification & Degradation" Webinar for IC2 & MA TURI. 30 January 2019. slide 59

Example:

6:2 fluorotelomer sulfonamide alkylbetaine (6:2 FTAB) (34455-29-3)
Aqueous photoloysis



L.J. Trouborst, 2016. *Aqueous photolysis of 6:2 fluorotelomer sulfonamide alkylbetaine*

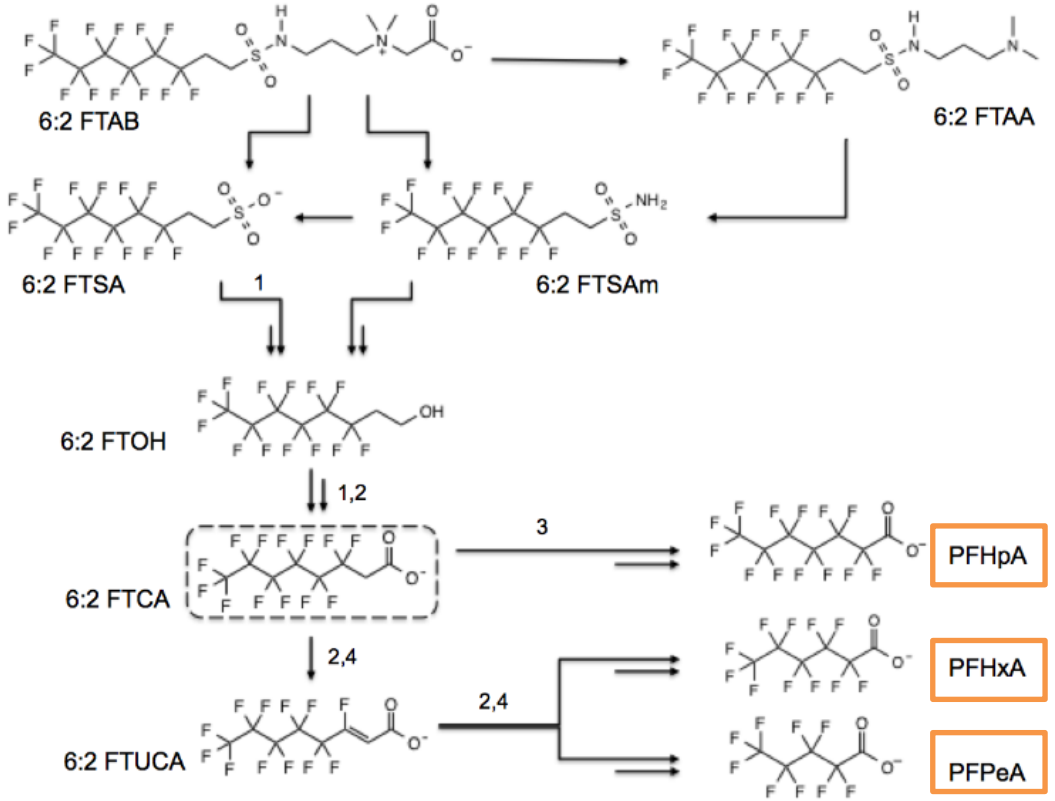
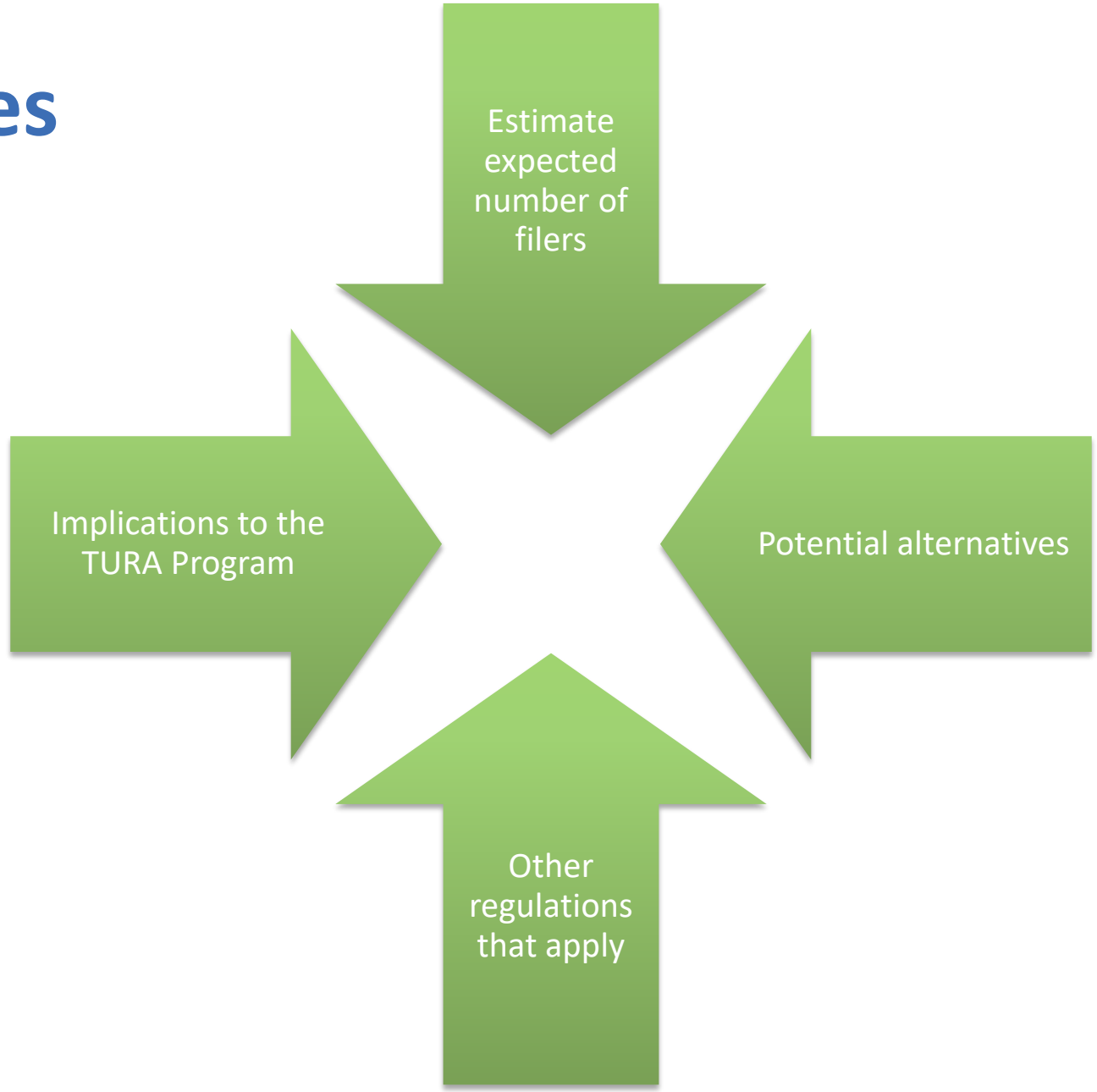


Figure 2.6: Proposed aqueous photodegradation for 6:2 FTAB. Double arrows indicate that a reaction occurs in multiple steps. Only 6:2 FTCA, in the dashed box, was not

TURA Science Advisory Board Listing Recommendation

- Those PFAS that contain:
  - a perfluoroalkyl moiety with three or more carbons
    - (e.g., $-C_nF_{2n}-$, $n \geq 3$; or $CF_3-C_nF_{2n}-$, $n \geq 2$) or
  - a perfluoroalkylether moiety with two or more carbons
    - (e.g., $-C_nF_{2n}OC_mF_{2m}-$ or $-C_nF_{2n}OC_mF_m-$, n and m ≥ 1), and
  - that are not otherwise listed

Policy Issues



Listing PFAS under TURA

- Massachusetts List of Toxic or Hazardous Substances
  - Facilities meeting TURA program requirements would be required to report, plan, and pay annual fee

Implications of Category Designation

- **Similar hazards across a group**
- Avoid **adverse substitutions**
- If there is an **incomplete set of CAS numbers**, a category defined through chemical structure is more informative
- If manufacturers have claimed chemical identity as **Confidential Business Information**, facilities reporting under TURA would not have to obtain and report specific chemical identity

Currently…implementing

- Provide filers with list of PFAS in commerce and whether they meet the category
- Opportunity to educate users about PFAS regardless of reportability
- Tools to determine usage: supplier letters, surveys

Thank you

Heather Tenney
heather@turi.org

978-934-3260

www.turi.org

Toxics Use Reduction Institute
University of Massachusetts Lowell