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PFAS Issues (and Solutions): Uses, Toxicity, Occurrence, Environmental Fate, and Mitigation

PRESENTERS: **Cardno, Inc.**

Mehmet Pehlivan, Heather Lynch, Scott Duzan

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Presentation Outline

- > Presenters
- > Purpose
- > PFAS 101
- > Environmental Fate & Toxicology
- > Regulatory Response Levels
- > PFAS Implications for Metals Finishers
- > Local Regulatory Activities in CA
- > Sampling Considerations for PFAS
- > Mitigation Measures
- > Conclusion and Q&A

Presenters

- **Mehmet Pehlivan, PG, CHG, QISP, QSP**. Mr. Pehlivan is a Senior Consultant/Remediation Hydrogeologist with Cardno Assessment and Remediation Santa Ana, California Office. He has more than 35 years of experience in geological and hydrogeological assessment, soil and groundwater remediation involving chlorinated solvents, metals, and recalcitrant compounds.

- **Heather N. Lynch, MPH**. Ms. Lynch is a Supervising Health Scientist with Cardno ChemRisk's Boston office. She has more than 10 years of experience in toxicology and human health risk assessment consulting. She has spent a large portion of the last 6 years of her career managing PFAS projects.

- **Scott Duzan, QEP, LEED AP, TRUE Advisor**. Mr. Duzan is a Senior Business Development Manager with Cardno's Assessment and Remediation division and is based in Seattle, Washington. He has spent his entire 15-year career in the environmental consulting industry working throughout the U.S. (Honolulu, Denver, Minneapolis, Washington DC, and Seattle). Mr. Duzan is currently facilitating Cardno's corporate-wide PFAS Initiative.

Purpose

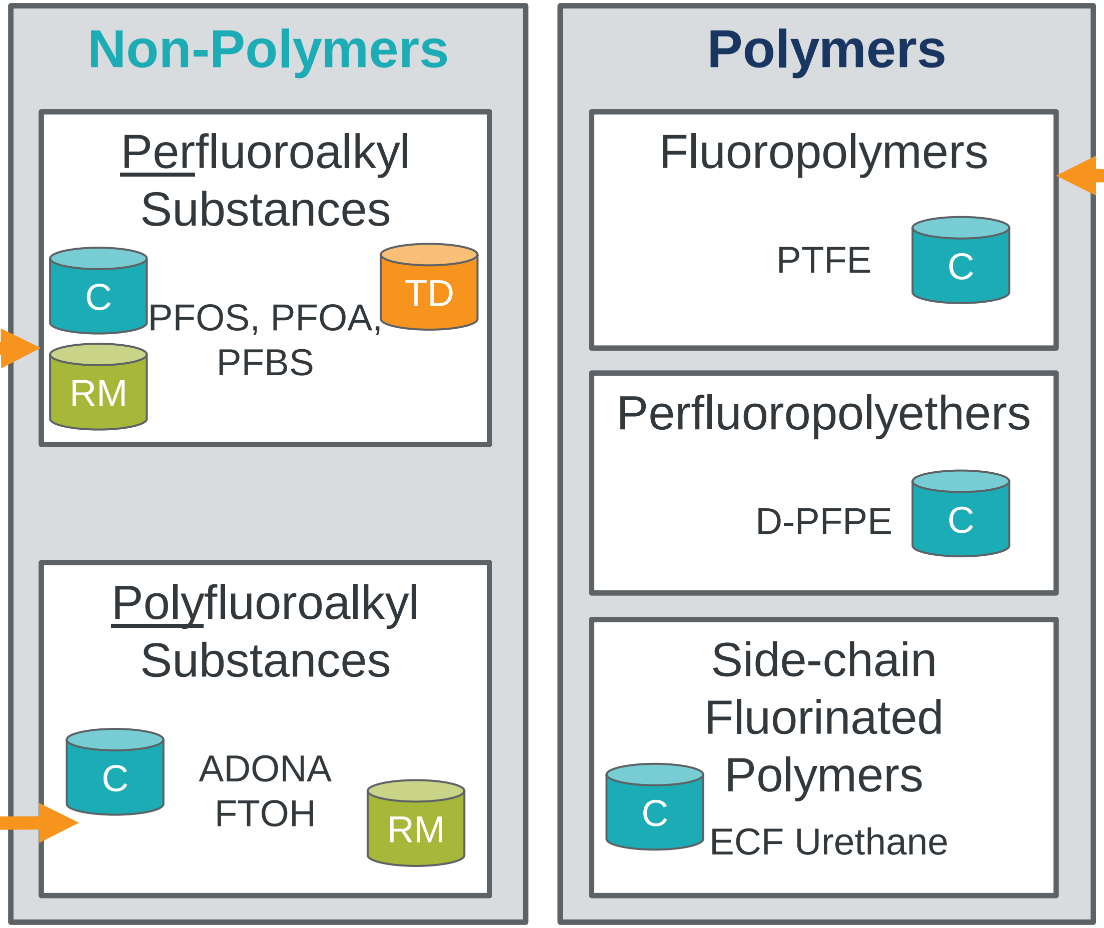
Provide actionable information to industry professionals responding to PFAS-related regulatory requests and other PFAS issues

Introduction to PFAS

~5,000 PFASs!

Perfluorinated carboxylic and sulfonic acids: older mist suppressants, carpet care

Fluorotelomer alcohols: new mist suppressants



Teflon pans, specialty plastics, weatherproof clothing/gear, FCMs

RM Raw Materials

C Commercial Products

TD Terminal Degradation Products

Source: Fluorocouncil

PFAS Uses

PTFE (polymer)

Fluorotelomers

PFOS, PFOA (historically), now fluorotelomer sulfonates

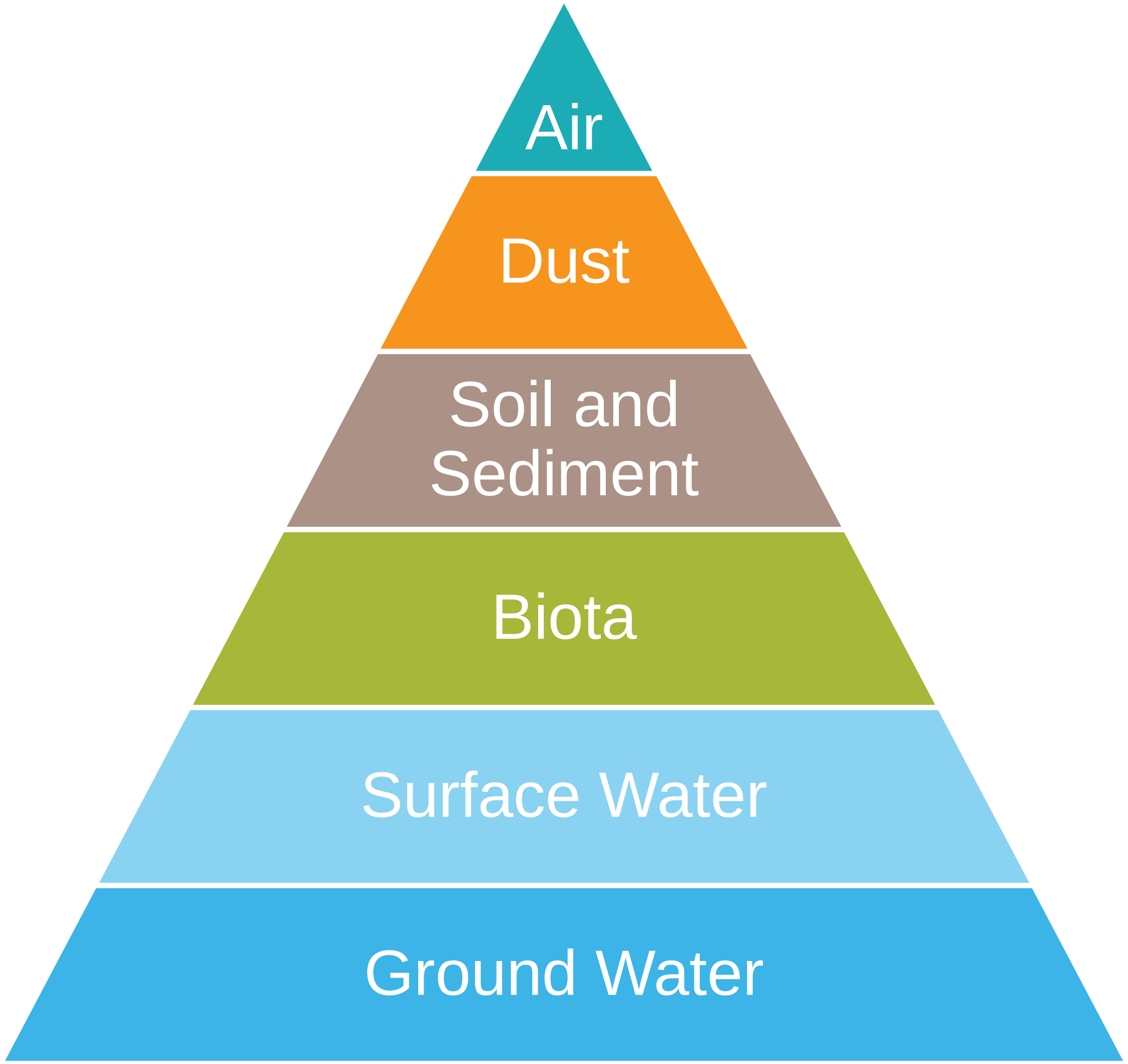
Environmental Fate

- Carbon-fluorine tail and a non-fluorinated head. Hydrophobic and generally lipophobic tail (attracted neither to water nor to nonpolar organic matter)
- Many less volatile than many other groundwater contaminants
- Can occur in a gaseous state or be incorporated within particulate matter or other aerosols
- High solubility = PFAS occurrence as a separate phase in the environment (e.g., pure phase NAPLs) is uncommon
- Persistent in the environment and resistant to degradation by biological or chemical means
- Long half-life in humans (several years) for long chains (C8, C9); shorter half life for short-chain compounds (~ 30 days)

PFAS Occurrence in Environment

Media-Specific Occurrence

- **Air:** Elevated concentrations possible near major emission sources
- **Soil and Sediment:** Atmospheric deposition, impacted media (landfill leachate, biosolids), direct discharge
- **Groundwater:** Prevalent across U.S.
- **Surface Water:** Concentrations related to proximity to the point of release
- **Biota:** Ubiquitous in fish, wildlife, and humans
- **Indoor Air and Dust:** Caused by breakdown of PFAS-containing products



Key Potential Hazards of PFOS and PFOA

Developmental Toxicity

> Offspring body weight, developmental delays, fetal mortality in animals

Liver Toxicity

> Effects on cholesterol
> Evidence of liver toxicity in animals

Immunological

> Immune suppression in animal models

Endocrine System

> Effects on thyroid hormone levels
> Effects on estrogen and testosterone levels

Reproductive and Developmental Outcomes – PFOA and PFOS

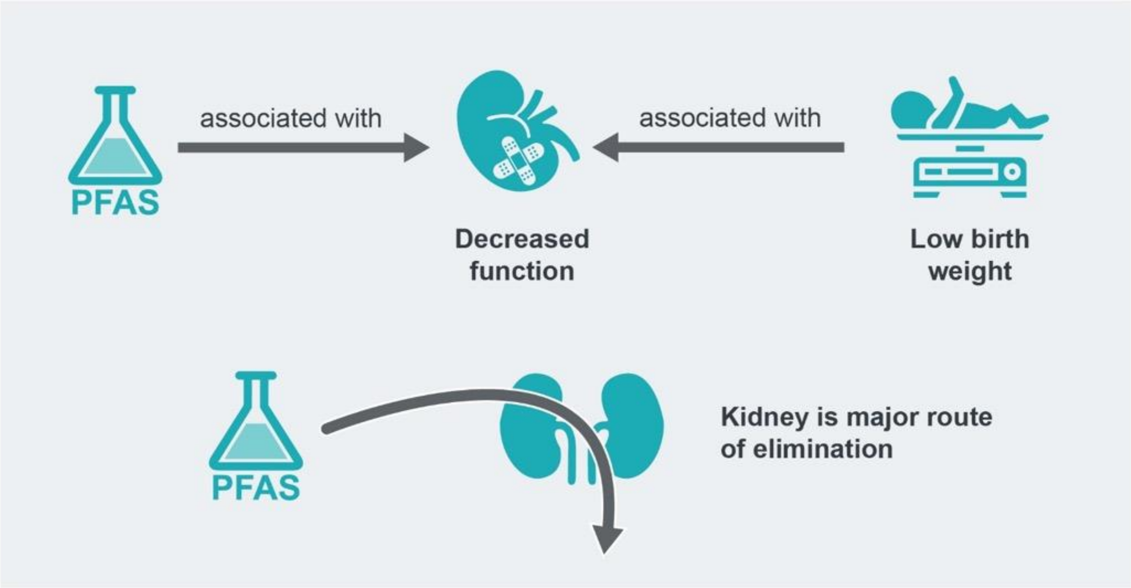
Animal Studies

- Decreased pup body weight
- Fetal mortality
- Postnatal mortality
- Developmental delays (bone formation)

Reproductive and Developmental Outcomes – PFOA and PFOS

Human Studies

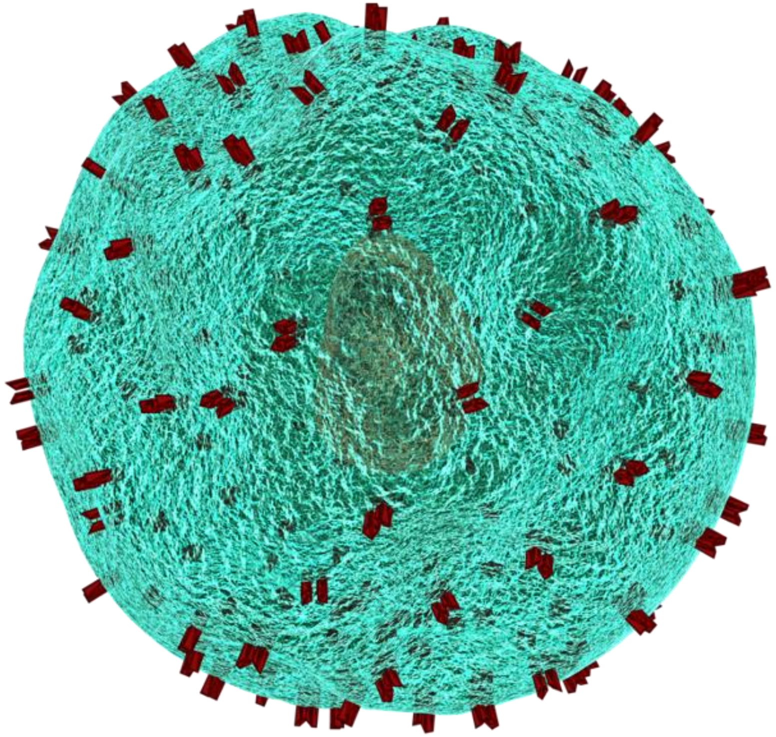
- Birth weight - ?
- No clear and consistent associations:
  - Timing of puberty and menopause
  - Male and female fertility
  - Birth defects
  - Neurobehavioral effects



Immunotoxicity – PFOA and PFOS

Animal Studies

> PFOA and PFOS:
  - Impaired responses to disease antigens and infectious disease
  - Associations with secondary outcomes:
    - ↓ spleen and thymus weights
    - ↓ number of lymphocytes



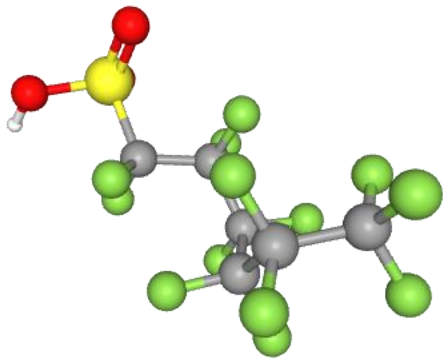
Immunotoxicity – PFOA and PFOS

Human Studies

- Decreased antibody response to vaccines
  - Two large cohort studies
  - Inconsistency across different antigens
  - Age-dependent effects?
- Unclear increased burden of disease
  - Studies of susceptibility to infection (e.g., cold/flu) inconsistent
    - Self-reported outcomes subject to bias
  - “Marginal” association with asthma (PFOA)

C4 Non Polymers

- “Replacements” (e.g., PFHxS [C6], PFHxA) and Short Chain (e.g., PFBS, PFBA)
- Fewer studies
- Target organ: typically, the liver
- Some (but not all) clear body more rapidly than C8s
- No clear and consistent associations
- Many state-level guidance values have been derived

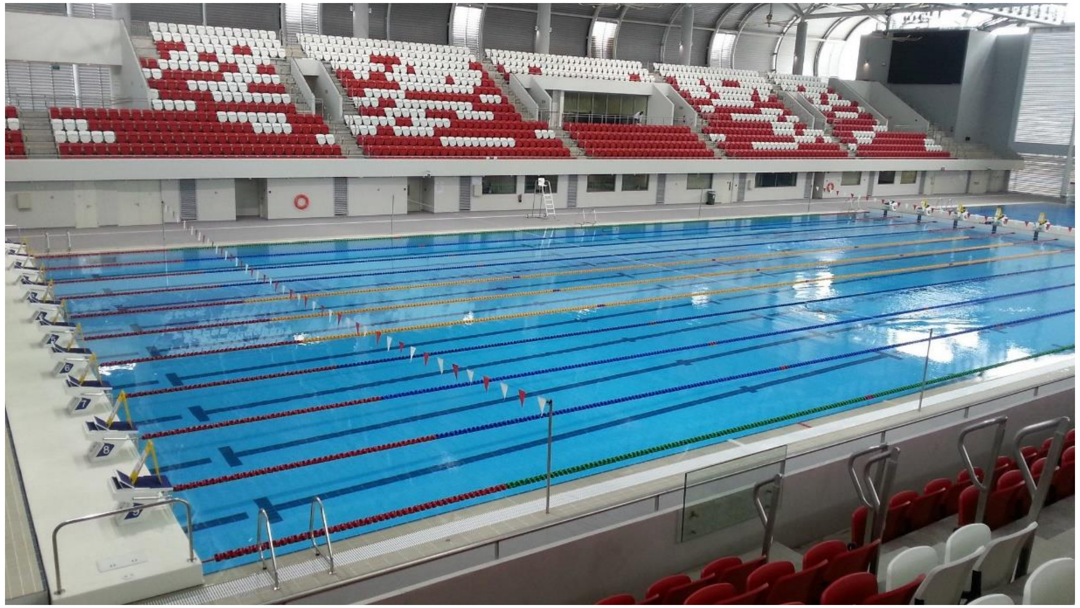


6:2 Fluorotelomer Sulfonate

- Lower bioaccumulation
- High environmental persistence
- Possible env. biotransformation to PFCAs (e.g., PFOA)
- Very little toxicity research
  - “Moderate” liver and kidney toxicity in rats
  - Not evidence of developmental toxicity
  - No chronic studies

Measuring PFAS

> PFAS in water are measured units of nanograms per liter (ng/L), which is equivalent to parts per trillion (ppt)



Deriving a Reference Dose

- All US guidelines/limits are based upon toxicology studies
- First must derive a “safe dose”
  - Select the most sensitive effect and species (i.e., at the lowest dose)
  - Apply uncertainty factors:
    - Human variability (intraspecies): 10x
    - Extrapolation from animals to humans (interspecies): 3 or 10x
    - Use of less than chronic data: 10x
    - Use of LOAEL instead of NOAEL: 10x
    - Database uncertainty: 10x

$$Toxicity\ Value\ (RfD, RfC) = \frac{POD}{Total\ UF}$$

Deriving a Drinking Water Guidance Level

Agency	EPA	MA	VT	NJ	NH	MN	MI	WA	ATSDR	NY
RfD (ng/kg/day)	20	5	20	2	6.1	18	3.9	3.0	3.0	1.5
Ingestion Rate/ Exposure Model	0.054 L/kg/day (Lactating woman, 80^{th} percentile)		0.175 L/kg/day (infant 0-1 yr; 95^{th} percentile)	0.029 L/kg/day (default adult, upper percentile)	Modeled: Prenatal exposure; breastfeeding 1 yr + lifetime DW exposure				0.0387 L/kg/day (adult), 0.14 L/kg/day (infant 0-1 years)	Not specified
RSC	20%		20%	20%	50%				None (eq. to 100%)	60%
Guideline (ng/L)	70	20	20	14	12	35	8	10	78 (adult), 21 (child)	10

Regulatory Response Levels

State and U.S. Environmental Protection Agency guidelines for PFAS in drinking water (ng/L)

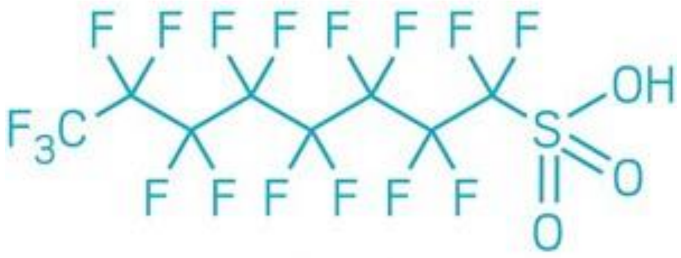
C Chain	8	8	9	6	7	10	4	6	4	6
	PFOA	PFOS	PFNA	PFHxS	PFHpA	PFDA	PFBA	PFHxA	PFBS	GenX
USEPA	70	70	—	—	—	—	—	—	—	—
CA	10	40	—	—	—	—	—	—	—	—
IL	2	14	21	140	—	—	—	—	140,000	
MA	20	20	20	20	20	20	—	—	2,000	—
MI	8	16	6	51	—	—	—	400,000	420	370
MN	35	15	—	47	—	—	7,000	—	2,000	—
NH	12	15	11	18	—	—	—	—	—	—
NJ	14	13	13	—	—	—	—	—	—	—
OH	70	70	21	140	—	—	—	—	140,000	700
VT	20	20	20	20	20	—	—	—	—	—
WA	10	15	14	70	—	—	—	—	1,300	—

PFAS in Drinking Water

> Sampling performed by EPA from 2013-2015 identified detectable concentrations of PFOA and PFAS in drinking water wells in numerous locations throughout the county, including multiple sites in CA

Why Metal Finishers Need to be Concerned about PFAS

- PFAS, particularly PFOS, have been used as mist suppressants that are added to metal plating and finishing baths to prevent air emissions of toxic metal fumes
- In chrome plating, PFAS are used as surfactants to reduce the surface tension of the electrolyte solution
- Other uses includes: post plating cleaner, corrosion prevention, mechanical wear reduction, aesthetic enhancement, wetting agent/fume suppressant for chrome, copper, nickel, and tin electroplating.
- A study in Minnesota traced PFOS releases from one chrome plating operation to a wastewater treatment plant (WWTP) where elevated levels of PFOS were detected in the biosolids, effluent water, and fish in the receiving surface water.



PFOS

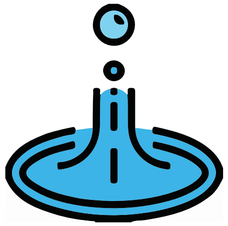
Local Regulatory Activities in CA

- July 2019 – Assembly Bill 756 approved and codified as Health and Safety Code Section 116378, authorizes the State Water Board to require public water systems to monitor for PFAS
- October 2019 – California State Water Resources Control Board (SWRCB) issued an order for all plating facilities to test for PFAS at their sites and in their wastewater system
- July 2020 – SWRCB issued an order for all Publicly Owned Treatment Works (POTWs) systems to test for PFAS at their sites and in their wastewater influent and effluent
- August 2020 – SWRCB issued an order for all drinking water system producers and operators to test for PFAS in their water wells and reservoirs
- Late 2020 – CRWQCB required testing for PFAS prior to case closure on a UST cleanup case
- Early 2021 – SWRCB expected to issue order requiring petroleum facilities to test for PFAS at their sites

Investigative Order for Plating Facilities

> Submit a site investigation work plan to SWRCB detailing the various potential pathways for discharge of PFAS and the nature of potential PFAS contamination at your facility

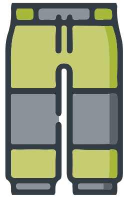
> Perform the site investigation including collecting samples from:
  - Soil: surface and subsurface
  - Groundwater
  - Wastewater effluent
  - Stormwater
  - Surface water



> Submit the results of the site investigation in a final report to SWRCB

How to Sample for PFAS

- Extreme care in selection and handling of sampling equipment is necessary due to ubiquitous presence of PFAS in many products.
- Sampling technicians must be trained for proper sample handling and equipment selection.
- Sample container must be certified clean and provided by a certified laboratory.
- Proper sample chain of custody, sample storage, and sample holding time must be met.
- Send samples to a certified laboratory with experience in analyzing for PFAS.

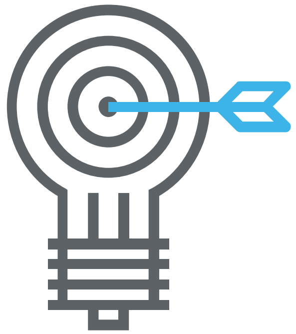




Sampling Materials: Acceptable PPE and Clothing

Acceptable Materials	Staging Area Materials	Prohibited Materials
Synthetic or 100% cotton clothing that has been well-laundered (without use of fabric softener) Waterproof clothing made with polyurethane, PVC, wax-coated fabrics, rubber, or neoprene Boots made of polyurethane and/or PVC Powderless nitrile gloves	Non PFAS-free boots (e.g. steel-toed) First-aid adhesive wrappers **Note**: Hands should be washed and gloves changed after handling these products.	Water/stain/dirt-resistant treated clothes (including but not limited to Gore-Tex™, Scotchgard™, and RUCO®) New unwashed clothing Clothes recently washed with fabric softeners Clothes chemically treated for insect resistance and ultraviolet protection Coated Tyvek® Latex gloves

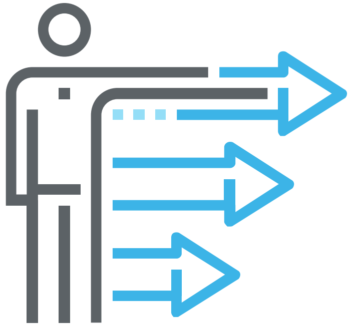
PFAS Mitigation

- Ion Exchange (Resin)
- Reverse Osmosis (RO)
- Granular Activated Carbon (GAC)
- Colloidal Activated Carbon Injection for Groundwater
- Nanofiltration (NF)
- Defluorination of Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) by Acidimicrobium sp. Strain A6-(in research phase, no field implementation yet)
- Surface Active Foam Fractionation (SAFF™) systems (OPEC Consulting)
- Hydrothermal Alkaline Treatment (HALT) by Aquagga, Inc.
- PerflourAd system
- Other emerging methods such as Photolysis/Photochemical Oxidation, Ozone/Peroxide treatment.



Conclusions

> PFAS are widely distributed over many industries and processes
> Persistent in the environment
> Bioaccumulate in fish, humans, and some other animals
> Potentially toxic to a number of body systems, but some effects only observed at very high levels in experimental animals
> CA continues to issue orders requiring numerous types of facilities to perform PFAS investigations
> Extremely low regulatory response levels and toxicity levels require special sampling and sample handling procedures
> It is better to know if you have PFAS in your system early on to prevent surprises later. You do not want to know that you have PFAS issue from the test of your neighbor.



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QUESTIONS?

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