THE TRIPLE-THREAT EMERGING CONTAMINANT

An Examination of PFAS in Products, Liability, Environmental Cleanup, and Toxic Torts

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PFAS: THE TRIPLE THREAT EMERGING CONTAMINANT

PFAS Background
Toxicology
Defense and Plaintiff Perspectives
Regulatory Developments
Site Assessment and Remediation
Environmental Forensics
WHAT ARE PFAS?

PFAS: perfluoroalkyl and polyfluoroalkyl substances

- Strong, stable C-F bonds
- Hydrophobic (water-hating) AND lipophobic (oil-hating)
- Relatively low volatility and high solubility
- Mobile in the environment
- Resistant to degradation
- Some highly toxic
- No natural environmental source

X

ABA
PFOA and PFOS

Most researched and prevalent PFASs in the environment

**PFOA**

perfluorooctanoic acid

perfluorooctanoate (PFOA)

**PFOS**

Perfluorooctanesulfonic acid

perfluorooctanesulfonate (PFOS)
PFAS have a spectrum of chemical shapes and sizes

Other PFAS tested under Unregulated Contaminant Monitoring Rule 3 (UCMR3):

- **PFNA** – Perfluorononanoic acid
- **PFHxS** – Perfluorohexanesulfonic acid
- **PFHpA** – Perfluoroheptonic acid
- **PFBS** – Perfluorobutanesulfonic acid

FluoroTechnology makes important products for vital industries possible.

First Responders
- Offers life-saving protection in safety gear and firefighting foams used to fight flammable liquid fires.

Automotive
- Provides every automotive system with durability, heat and chemical resistance and vapor barriers.
- Increases reliability of engine compartment wirings and gauges and improves auto safety by reducing engine compartment fires.
- Protects carpets and seats against stains, soil, oil and water.

Military
- Enables apparel and equipment to provide high barrier skin protection in extreme environments and against chemical warfare agents.

Chemical/Pharmaceutical Manufacturing
- Provides sterile, corrosion-resistant coatings, linings and equipment.

Healthcare
- Serves as high dielectric insulators in medical equipment that relies on high frequency signals, like defibrillators, pacemakers and CRT, PET and MRI imaging devices.
- Used to treat medical garments, drapes and cubicle curtains to protect against the transmission of diseases and infections.

Outdoor Apparel/Equipment
- Creates breathable membranes and long-lasting finishes that provide water repellency, oil repellency, stain resistance and soil release with abrasion-resistant finishes for apparel and equipment.

Semiconductors
- Creates the ultra-pure manufacturing environments necessary for microelectronics.
- Used for plasma machinery, etching materials, cleaning fluids and wetting surfactants for chemical etchants.

Alternative Energy
- Enables lithium batteries, fuel cells and solar panels, which contribute to reduced emissions and energy costs.

Building/Construction
- Enhances durability, UV resistance and anti-corrosive properties to lengthen the lifetime of infrastructure, facades and surfaces.

Aerospace/Defense
- Enables chemical-resistant tubes, hoses and fluid seals; high and low temperature brake and hydraulic fluids used in aircraft control systems and brakes; and ultra-high frequency wire and cable insulation necessary for navigation, fly-by-wire control and aircraft communications.

Electronics
- Improves insulation, weather ability, transparency and water-resistance.
- Provides smooth and smudge-resistant touch screens.

Oil and Gas
- Provides reliable equipment to help improve the safety and affordability of oilfield and pipeline operations.
- Improves the reliability and safety of fuel system seals and hoses, O-rings and downhole and field equipment gaskets.

FluoroTechnology is the use of fluorine chemistry to create any fluorinated product. When fluorine and carbon atoms join together, they create a powerful chemical bond. The use and manipulation of this bond gives FluoroTechnology its distinct properties of strength, durability, heat-resistance and stability. These properties are critical to the reliable and safe function of myriad products that industry and consumer rely on every day.
EXAMPLE – AFFF USE

- AFFF – Aqueous Film Form Foam
- Used since 1970s to fight petroleum fires
  - Airport
  - Refineries
  - Military Bases
- Formulations have changed over time but all contain PFAS
- Applied during active fire-fighting and training exercises
- As of October 2018 AFFF no longer required to be used at airports under FAA
- Continued AFFF use under military specifications while alternatives are researched and developed

Locations of US Airports

Timeline of AFFF Manufacturers

WHY IS PFAS AN ISSUE NOW?

- Evolving Federal requirements and advisories
  - 2002 TSCA SNUR
  - 2009 Short term health advisories (200 ppt for PFOS, 400 ppt for PFOA)
  - 2012 UCMR 3
  - 2016 lifetime health advisory (70 ppt for PFOS+PFOA)

- Environmental occurrences proximal to potential sources
  - Industrial, WWTP, airports, military facilities

- Evolving state regulations
  - 2017 New Jersey sets MCL of 14 ppt for PFOA

- Threat of Environmental Reopeners

- Ongoing efforts to better understand toxicity
  - June 2018 ATSDR Report
TOXICOLOGY OF PFOA AND PFOS

• Most toxicology studies have focused on PFOA and PFOS
  – Non-cancer effects in mammals are primarily focused on developmental effects
  – Immunotoxicity potential
  – Potential carcinogenic properties
    • “Suggestive” for both (USEPA) and “Possibly” for PFOA (International Agency for Research on Cancer)

• Human health reference doses for PFOS and PFOA currently both 20 ng/kg body weight*day (USEPA)
  – Some states have alternate values

• Ecological
  – Wildlife effects
    • Effects on liver and kidney
    • Reproduction
  – Aquatic toxicity data (fish, invertebrates) for some compounds
  – Plants and soil invertebrates not as sensitive
EXPOSURES AND PATHWAYS

• Major
  – Diet (bioaccumulation)
    • Fish and seafood
    • Homegrown produce
  – Drinking water
  – Incidental soil/dust ingestion

• Usually insignificant or minor
  – Dermal absorption
  – Inhalation
PFAS IN MUNICIPAL DRINKING WATER SUPPLIES

- PFAS detected above drinking water health criteria > 60 drinking water systems
  - EPA Unregulated Contaminants Monitoring program (UCMR3)

BIOLOGICAL FATE

• Detectable in nearly any biological tissue

• Partitions to protein (proteinophilic), not fat/lipid
  – Blood, liver, kidney, muscle are primary repositories
  – Traditional models not useful for understanding or predicting bioaccumulation and toxicity

• Not metabolized, or metabolizes to persistent PFAS (precursors)

99% of California teachers with detectable PFAS

Chemical Group: Perfluorochemicals (PFCs)
  Measured in: Serum

Project: California Teachers Study (CTS)
  Study Group: All
  Sample Collection Date: 2011

Source: Open source graphics from USFWS, Cal EPA DTSC
DOCUMENTATION OF PFAS EXPOSURES

• Manufacture of PFAS since 1940s-1960s
• Detection of PFAS in occupationally-exposed workers in 1970s, then general population in 1990s
• Minneapolis St. Paul (Minnesota) area investigations (mid 2000s-present); $850 million for future research
• Australia (2018) PFAS public health study
  – “no current evidence that supports a large impact on an individual’s health”
  – “no current evidence that suggests an increase in overall cancer risk”
• C8 Science Panel exposure and health studies in the Mid-Ohio Valley communities potentially affected by the releases of PFOA from the Washington Works plant in Parkersburg, West Virginia, 2005-2013
• Human exposures documented, potential linkages to adverse health effects (remains controversial)
NOT ALL PFAS CASES ARE ALIKE

• Nationwide litigation
• What is causing the PFAS contamination?
  – Aqueous Film-Forming Foam ("AFFF")
    • Contamination from airports/air bases and industrial facilities
  – Other PFAS Industrial Sites
• Defendants
  – Manufacturers
  – Direct Spillers
• Culpability
• Key legal issues
  – Causation
  – Injury
  – Government Contractor Defense
WHERE ARE THE CASES?

• MDL NO. 2873
  – Hearing - November 29, 2018
  – What consolidation is requested?
    • In Re: Aqueous Film-Forming Foam Products Liability Litigation
      • Just AFFF Cases
    • In Re: PFAS Products Liability and Environmental Liability Litigation
      • All cases involving PFAS
    – Nearly 100 actions and counting
    • Mostly AFFF
TARGETS OF PFAS LITIGATION

Currently targeted:

1st Stage:
- Chemical manufacturers of PFAS

2nd Stage:
- Manufacturers of AFFF and PFAS-containing products (shoes and carpets)
- Airports
- Military bases

Anticipated targets

3rd Stage:
- Refineries
- Landfill operators
- Paper mills
- Food services industry
- Hospitals
- Consumer products
TYPES OF CLAIMS CURRENTLY PURSUED IN PFAS LITIGATION

• Resource Conservation and Recovery Act (RCRA)

• Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

• State law toxic tort claims (nuisance, trespass, negligence)

• Medical monitoring

• Product liability – design defect or failure to warn

• California Proposition 65 Claims [anticipated]
RESOURCE CONSERVATION AND RECOVERY ACT

• Injunctive relief with potential for attorneys’ fees and expert cost recovery – no other monetary costs.
• Threat of civil penalties.
• Requires showing of imminent or substantial endangerment.
  – ISE may result from harm to plants and animals exposed on wellfield even though all PFOA was being removed by treatment prior to delivery to consumers. (Little Hocking Water Assn. (S.D. Ohio, 2015) 91 F.Supp.3d 940.)
• Must show disposal of hazardous substance or solid waste.
  – “Solid waste” under RCRA includes particulates included in air emissions that subsequently fall to the ground. (Little Hocking, 2015.)
• Allows for recovery of response costs against potentially responsible parties.
• PFAS not currently listed as CERCLA “hazardous substance.”
• EPA has treated PFAS standards as “applicable or relevant and appropriate requirements” (ARAR).
• “Reopener” provisions in existing consent decrees if new chemicals of concern like PFAS are discovered.
• Article III standing requires that plaintiffs’ injury must be fairly traceable to the defendants’ conduct.
• Pending 3rd Circuit case: Whether CERCLA precludes state law claims as a challenge to an ongoing response action. (Giovanni et al. v. U.S. Navy, Case No. 17-2473.)
CERCLA LITIGATION – “Washington Works”

- CERCLA claim brought by city seeking to recover costs incurred in response to discovery of perfluorochemicals (PFCs) in its drinking water supply (City of Lake Elmo, No. CV 16-2557 ADM/ SER, 2017 WL 630740 (D. Minn. Feb. 15, 2017)).

- Survived motion to dismiss for lack of standing on CERCLA claim and presently conducting discovery.
  - Injury: City allegedly built alternate water supply in response to PFC presence.
  - Traceability: Sufficiently alleged that response costs were directly related to PFCs in water, even though new system was also needed to deal with increased usage; held irrelevant that other companies also contributed to PFC contamination.
TOXIC TORTS

• Claims under state law, typically nuisance, negligence or trespass
  – Personal injury
  – Property damage

• Dependent on scope of state law
  – Existence of a duty to Plaintiffs?
  – Property right in groundwater beneath property?
  – Discovery rule for statute of limitations?
  – Recovery allowed for purely economic loss?

• Some showing required of causation
  – Suit dismissed as speculative where it named all AFFF manufacturers without allegations tying specific defendant to purchase and use at Site. (Barnstable County (D.Mass, 12/18/2017) 2017 WL 6452245.)
PRODUCT LIABILITY OR FAILURE TO WARN

• Strict Products Liability
  – Pennsylvania state court held that bystanders could not pursue strict products liability claim, particularly where plaintiffs were not in direct proximity to the allegedly defective product. (Menkes (E.D. Pa., 5/21/2018), 2018 WL 2298620.)
  – Local water authority in New York has sued five manufacturers for alleged contamination and remediation related to PFOA and PFOS based on strict products liability theory (Suffolk County Water Authority (E.D.N.Y., 11/30/2017, Case No. 2:17-cv-06982.)

• Negligent Failure to Warn
  – Courts have required sufficient allegations of negligence to proceed
  – “Plaintiffs have also successfully pled that Defendants owed them a duty, that they breached that duty by failing to warn the users of AFFF about its harmful effects on human health and the environment, and that such negligence caused their injuries.” (Menkes, 2018.)
OEHHA listed PFOA and PFOS as known to the state to cause reproductive toxicity under the Prop 65 law (Nov. 2017)

Warning requirement for listed chemicals (eff. 11/10/18)

Prohibits discharge into source of drinking water (eff. 7/10/19)

Allows for private enforcement on behalf of the state if state fails to enforce Proposition 65

Injunctive relief and civil penalties available
When and what did the chemical companies know (or should have known) and what should they have warned about water contamination?

<table>
<thead>
<tr>
<th>Group</th>
<th>Dosage Level</th>
<th>Survival</th>
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<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>4/4</td>
</tr>
<tr>
<td>II</td>
<td>0.5 mg/kg/day</td>
<td>4/4</td>
</tr>
<tr>
<td>III</td>
<td>1.5 mg/kg/day</td>
<td>4/4</td>
</tr>
<tr>
<td>IV</td>
<td>4.5 mg/kg/day</td>
<td>0/4</td>
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</table>

**SERUM ANALYSIS**

<table>
<thead>
<tr>
<th>Monkey</th>
<th>Dosage Level</th>
<th>FC-95 in Serum (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank on Method</td>
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<td>2</td>
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<tr>
<td>7355M</td>
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<td>7358M</td>
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<tr>
<td>7368P</td>
<td>0</td>
<td>15</td>
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<tr>
<td>7663M</td>
<td>0.5 mg/kg/day</td>
<td>150</td>
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<tr>
<td>7466P</td>
<td>-</td>
<td>150</td>
</tr>
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<td>7662M</td>
<td>1.5 mg/kg/day</td>
<td>250</td>
</tr>
<tr>
<td>7508P</td>
<td>-</td>
<td>275</td>
</tr>
</tbody>
</table>

* Our newly developed pyrolysis method was used. Precision is estimated to be ±10 - 25%.
KEY LEGAL ISSUES - CAUSATION

• Substantial Contribution

• Alternative Theories
  – Market Share
    • Liability based on market share not whose particular product is present in any particular well. State of New Hampshire, 126 A.3d 266, 297–98 (2015).
    • Circumstantial evidence to support direct causation—In re MTBE, 725 F.3d 115-117.
  – Commingled Product
    • When products “of many . . . manufacturers were present in a completely commingled or blended state at the time and place that the harm or risk of harm occurred, and the commingled product caused plaintiff’s injury,” the commingled product theory may be applied. MTBE, 591 F. Supp. 2d 259, 274.
    • Burden then shifts to the defendant to “exculpate itself by proving that its product was not present at the relevant time or in the relevant place.” MTBE, 725 F.3d at 89.
  – Concurrent Tortfeasor
    • Multiple tortfeasors held jointly and severally liable “when each tortfeasor’s independent actions combine to produce the same wrong.” MTBE, 591 F. Supp. 2d at 274.
KEY LEGAL ISSUES - INJURY

- State Maximum Contaminant Levels serve as a “guidepost” but do not define whether an injury has occurred.” MTBE, 725 F.3d at 105.

- Water provider may take remedial measures to clean water at a level lower than the MCL and recover

- Whether a reasonable water provider would treat water to reduce levels or minimize effects of the contaminant
KEY LEGAL ISSUES – GOVERNMENT CONTRACTOR DEFENSE

Because a Department of Defense facility is commonly a source of the contamination the Government Contractor Defense is a key legal issue.

• Did the United States approve reasonably precise specifications?
• Did the equipment conform to those specifications?
• Did the supplier warn the United States about the dangers in the use of the equipment that were known to the supplier but not the United States?

FED ACTION MAY SPUR MORE CASES

• EPA Action Items
  • Initiating steps to “evaluate the need” for a MCL for PFOA and PFOS
  • Considering the necessary steps to “propose” designating PFOA and PFOS as “hazardous substances,” including potentially CERCLA section 102
  • Develop groundwater cleanup recommendations for PFOA and PFOS
  • Take action to develop toxicity values for short-chain replacement PFAS compounds (GenX and PFBS)
  • National Management Plan expected by Year End
STATE REGULATORY ACTION

- Regulators and legislators in dozens of states considering variety of measures
  - New laws include regulations on flame retardants, food packaging, maximum allowable drinking water levels, and chemical disclosure
- New Jersey Department of Environmental Protection set maximum contaminant levels for PFNA at 10 parts per trillion in September 2018
- Washington added PFAS to list of chemicals prohibited from intentional use in food packaging in February 2018, which goes into effect in 2022
  - Washington also banned use of PFAS in firefighting foam in March 2018
  - Washington state regulators are aggressively testing public water systems for PFAS
DTSC – ENVIRONMENTAL INVESTIGATIONS (CLEANUP PROGRAM)

• Federal Facility Sites (DoD)
  – Reviewed Work Plans for 12 current or former bases (14 PFASs were measured)
  – Received initial sampling results
  – Reviewing Site Inspection reports
  – PFASs detected in groundwater, wastewater treatment plant influent/effluent, and soil

• Industrial facilities

• Expanding the focus to other sites
  – Wastewater treatment plants
  – Major industrial sites
  – AFFF-certified airports
  – Tanneries
  – Landfills
  – Plating Facilities
Current Recommended DTSC Screening Levels (SLs)

Table 1. Health-Based Drinking Water¹

<table>
<thead>
<tr>
<th>EPA Health Advisory (HA) (µg/L)</th>
<th>PFOA</th>
<th>PFOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.07</td>
<td>0.07</td>
<td></td>
</tr>
</tbody>
</table>

PFOA + PFOS = 0.07

Table 2. DTSC Risk-Based Residential SLs²

<table>
<thead>
<tr>
<th>Soil (mg/kg)</th>
<th>PFOA</th>
<th>PFOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3</td>
<td>1.3</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. DTSC Risk-Based Residential SLs²

<table>
<thead>
<tr>
<th>Tapwater (µg/L)</th>
<th>PFOA</th>
<th>PFOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

¹USEPA lifetime drinking water health advisory level issued May 2016.

²DTSC-SLs calculated using DTSC recommended default exposure parameters and the RfD from the USEPA PFOA and PFOS HA.

Tap water Risk-Based SL

For risk assessment purposes, the tap water risk-based DTSC-SL

<table>
<thead>
<tr>
<th>Tapwater (µg/L)</th>
<th>PFOA</th>
<th>PFOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>
Next Steps for Risk Assessment

– DoD finishing site investigations – Is there PFAS contamination?

– Discussions with DoD on how to conduct a risk assessment at sites with known PFAS contamination in soil, groundwater and wastewater treatment plants

– USEPA’s RSL table does not list soils/water screening levels for PFOS/PFOA

– Toxicity values for two other PFASs are listed on RSL table (Perfluorobutane sulfonic acid, Perfluorobutanesulfonate)

– One base installed activated carbon at wastewater treatment plant

– Recommendation at one Site –
  • Yes to “Further Response Actions - pending promulgated regulations”
Background:

• SCP program was established in October 2013.

• Result of a 2008 Green Chemistry law that requires DTSC to adopt regulations to identify and prioritize chemicals in consumer products.

• DTSC developed a four step process for evaluating chemicals of concern in consumer products and their possible alternatives.
The goals of the program is to:

- **Reduce** toxic chemicals in consumer products
- **Create** new business opportunities in the emerging safer consumer products industry
- **Help** consumers and businesses identify what is in the products they buy for their families and customers
PFASs in Carpets/Rugs - Identified as a Priority Product (February 2018)

• Carpets and rugs constitute nearly half of all floor coverings in U.S. homes and workplaces.

• A large percentage of the PFASs produced worldwide are used to treat carpets, rugs, and other home textiles to confer stain-, soil-, oil- or water-resistance.

• According to the Carpet and Rug Institute, “most residential and commercial carpets are treated” with PFAS-based stain- and soil-repellents.
Reasons for identifying PFASs in Carpets/Rugs as a priority Product

• there is potential for human and other organism exposure to PFASs in carpets and rugs; and

• the exposure has the potential to contribute to or cause significant and widespread adverse impacts.

Public Hearing – March 20, 2018

Next Steps:

• Rulemaking
• Alternatives Analysis
PFAS is tracked as part of CDPHs California Biomonitoring Program (established in 2006)

**Biomonitoring:** Measurement of a chemical (or its metabolite) in a person’s body (blood, urine, tissues etc). It tells us about the amount of chemical that actually gets into people from all sources.

**Purpose:**

- Determine levels of environmental chemicals in representative populations within California
- Establish trends of these chemicals over time
- Assess the effectiveness of public health program in reducing exposures to certain chemicals
Biomonitoring Studies in California that are tracking PFAS

- Firefighters Occupational Exposures Project (FOX)
- Maternal and Infant Environmental Exposure Project (MIEEP)
- Pilot Biomonitoring Exposures Study (PBEST)
- Measuring Analytes in Maternal Archived Samples (3 Rounds) (MAMAS)
- Expanded Biomonitoring Exposures Study (EBEST)
- Asian/Pacific Islander Community Exposures Project 1 (ACE1)
- Asian/Pacific Islander Community Exposures Project 2 (ACE2)
- California Regional Exposure Studies (8 Regions) (CARE)

OFFICE OF ENVIRONMENTAL HEALTH
HAZARD ASSESSMENT (OEHHA)

Proposition 65 – Safe Drinking Water and
Toxic Enforcement Act of 1986

- Protects state’s drinking water sources from
  being contaminated with chemicals causing
  cancer or reproductive toxicity

- Products or businesses using the chemical
  must show clear and reasonable warning

- No discharge/release to drinking water

PFOA and PFOS listed November 10, 2017

- Reproductive toxicant
Requirement/Compliance

• Clear & Reasonable Warning: 12 months
  – November 10, 2018

• Water Discharges: 20 months to comply with discharge prohibitions
  – July 10, 2019

Businesses should pay attention as it may affect supply chains & water supplies
On July 13, 2018, the State Water Resources Control Board released…

- **Interim Notification Levels** – PFOA (14 ppt); PFOS (13 ppt) - Recommendation from OEHHA
  - Report the results to their governing boards and to the State Water Board.
  - Recommend reporting this data to their customers.

- **Interim Response level** – PFOA and PFOS (70 ppt)
  - Remove water source from service
  - So far, eight (8) out of 455 public water systems that have tested for PFOA and PFOS reported exceedances of the 70 ppt level for either PFOA, PFOS or both combined.
Under UNMCR3 (2013-2015), drinking water suppliers serving > 10,000 customers were required to monitor for 6 PFAS compounds:

- **STOrage & RETrival** – Electronic data repository for water quality data
  - STORET codes for 14 PFASs
  - 1 for PFOA + PFOS

Districts and Local Primary Agencies (LPAs) are informing Public Water Systems (PWS) about new STORET numbers.

<table>
<thead>
<tr>
<th>STORE NUM</th>
<th>CHEMICAL</th>
</tr>
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<tbody>
<tr>
<td>C2800</td>
<td>PFOS + PFOA</td>
</tr>
<tr>
<td>C2801</td>
<td>PERFLUOROBUTANESULFONIC ACID (PFBS)</td>
</tr>
<tr>
<td>C2802</td>
<td>PERFLUOROHEPTANOIC ACID (PFHPA)</td>
</tr>
<tr>
<td>C2803</td>
<td>PERFLUOROHEXANE SULFONIC ACID (PFHXS)</td>
</tr>
<tr>
<td>C2804</td>
<td>PERFLUORONONANOIC ACID (PFNA)</td>
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<tr>
<td>C2805</td>
<td>PERFLUOROOCTYL SULFONATE (PFOS)</td>
</tr>
<tr>
<td>C2806</td>
<td>PERFLUOROOCTANOIC ACID (PFOA)</td>
</tr>
</tbody>
</table>
Division of Drinking Water (DDW)

- Sampling drinking water wells
- **Monitoring** for PFAS is voluntary
- DDW is receiving PFAS results
  - Determine extent of PFAS contamination
- If PFOS and/or PFOA > USEPA Health Advisory Level
  - Recommending treatment before distribution
- Developing a Public Health Notification Level based on USEPA Health Advisories
CHALLENGES AND ONGOING RESEARCH

• Address the lack of toxicity criteria for all PFASs:
  – Responsive Evaluation and Assessment of Chemical Toxicity (REACT)
    – Collaborative program between NTP and USEPA to screen as many as 75 PFASs (identified by grouping similar compounds) through high throughput screening assays- initial *in vitro* and *in silico* methods, followed by select in vivo methods to generate information.

• How to perform risk assessments:
  – A relative potency factor approach, similar to dioxin evaluation (proposed by RIVM of the Netherlands)

• Address uncertainties around the current toxicity criteria

• How to pinpoint the source of contamination - Found in almost everything
INVESTIGATION

- Site investigations ongoing now in the US and other countries to evaluate human health and ecological risks
- Most site concerns manage risks of PFOA and PFOS, and some sites are being re-opened to address PFAS
- Balancing rapid response in addressing PFOA and PFOS with multiple technical and regulatory unknowns
  - Dozens of other currently detectable PFAS (and hundreds-thousands more that may be present)
  - Shifts in PFAS toxicological benchmarks
  - PFAS analytical capabilities evolving rapidly
  - Changing regulatory landscape
  - Etc.
PFAS RISK ASSESSMENT MODEL
(AFFF SITE EXAMPLE)

Risk assessments focused primarily on PFOS and PFOA

Various methods for assessing combined risk
- PFOS+PFOA
- PFOS+PFHxS
- Total PFAS

Ecological risk assessments primarily focused on aquatic life, wildlife exposure via bioaccumulation

Human health risk assessments primarily focused on drinking water and food intake (seafood, home grown vegetables)
EXAMPLE AQUATIC ECOLOGICAL AND HUMAN HEALTH RISK MODELS FOR AFFF SITES

- Human and ecological risk modeling for PFAS at several case study AFFF sites
- Key media to investigate, data gaps, approaches for risk assessment
- Conclusions
  - Most exposure and risk potential due to PFOS exposures to wildlife
  - Assessing only groundwater and drinking water not protective of all potential risks

It’s not just PFOA and PFOS

- 12 other PFAS by USEPA Method 537
- Additional 10-15 more PFAS via other methods
- Dozens to hundreds of other PFAS in AFFF
- EPA methods in development/refinement

Lindstrom et al. (2011); Barzen-Hanson et al. (2017)
Proper sampling approaches

- PFAS are ubiquitous and often found in items for personal uses and environmental site investigations
- Typical sampling equipment and items in the sampling environment contain or may contain PFAS (e.g., non-stick material and water-proof fabric)
- Many myths and anecdotes regarding accidental cross contamination of samples for trace PFAS analysis
  - Common sense is best, and if in doubt, lots of quality assurance/quality control checks
  - Sampling guidances under refinement now
ASSESSMENT CHALLENGES

• Toxicity information
  – Room for improvement with existing PFOA and PFOS toxicity values and cancer assessments
  – Additivity of PFOS and PFOS
  – Other PFAS?

• Background/ambient issues
  – How to manage non-site related PFAS from watershed or aquifer sources?
  – Background exposures for humans
    • 5X conservatism factor built into many risk-based approaches (e.g., EPA drinking water health advisories)
  – Concentrations in some aquifers and surface waters can be in the 10-50 ng/L range, similar to many screening levels
Remediation extremely challenging because most PFAS not bio- or chemically-degradable

Current default/best approaches very expensive

- Soil
  - Excavation and disposal (landfill)
- Water
  - Pump & treat with activated carbon
  - Large volumes of carbon needed due to high water solubility of PFAS
  - Order of magnitude more expensive than pump & treat for VOCs
  - Systems optimized for VOCs not likely addressing PFAS

Carbon treatment systems to treat PFAS in water (MDH, 2012)
POTENTIAL FORENSIC TOOLS

• Historical Usage
  – Chemical structure changed over time with different manufacturing techniques

• Chemical Fingerprinting
  – Possible unique relative abundances of PFAS compounds associated with different sources

• Fate and Transport
  – Different compounds have different fate and transport properties
ITRC PFAS RESOURCES

• **ITRC Fact Sheets (Drafts/In Development):**
  
  – Naming Conventions and Physical and Chemical Properties
  
  – Regulations, Guidance, and Advisories
  
  – History and Use
  
  – Environmental Fate and Transport
  
  – Site Characterization Considerations, Sampling Precautions, and Laboratory Analytical Methods
  
  – Remediation Technologies and Methods
  
  – Aqueous Film Forming Foam

▶ [https://pfas-1.itrcweb.org/](https://pfas-1.itrcweb.org/)
PFAS: THE TRIPLE THREAT EMERGING CONTAMINANT

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