Per- and Polyfluoroalkyl Substances (PFAS): An Overview

Southern California Water Dialogue
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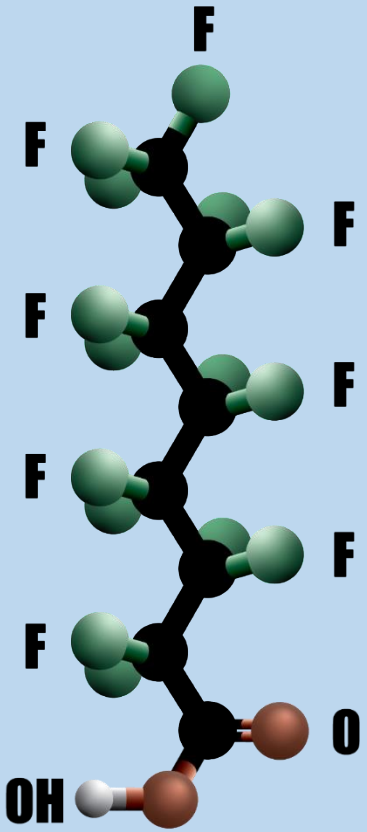
Mic H. Stewart, Ph.D.
Director of Water Quality
Metropolitan Water District of Southern California

Per- and Polyfluoroalkyl Substances (PFAS)

- Broad class of manufactured chemicals widely used to make products that resist heat, oils, grease, stains, and water
  - Teflon™ coated cookware, carpets, clothing, paper packaging for food, and fire retardants
- First developed in 1940s
  - Over 4,500 PFAS
- Extremely stable in environment (“Forever Chemicals”) and can be found in soil, air, surface water, groundwater, wastewater plant effluent, sewage sludge and landfills

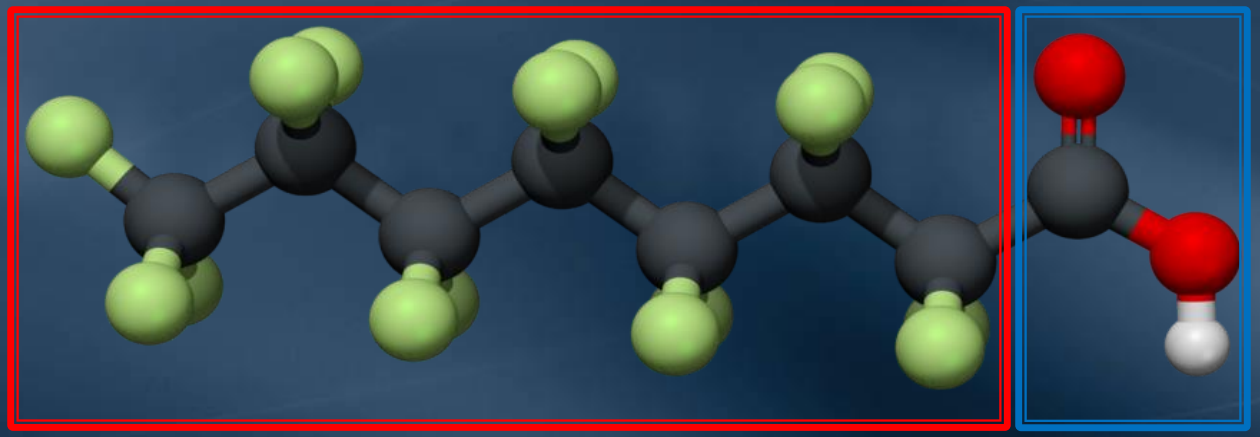


PFOA – perfluorooctanoic acid, also know as “C8”

PFAS as Industrial Surfactants

- The non-polar fluorocarbon tail is both hydrophobic (resistance to water) and lipophobic/oleophobic (resistance to fats and oil)
- The polar head group is hydrophilic (affinity for water)
- Durable/persistent
- Perfect for waterproof, stain-resistant or non-stick material in consumer products

Hydrophobic - oleophobic



Hydrophilic

Source: PFOA, by Manuel Almagro Rivas

History and Use of PFAS

"Better Things For Better Living…Through Chemistry"
[DuPont advertising slogan (1935)]

https://commons.wikimedia.org/wiki/File:Happy_Pan_Poster.jpg

PFAS[1]	Development Time Period							
	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
PTFE	Invented	Non-Stick Coatings			Waterproof Fabrics			
PFOS		Initial Production	Stain & Water Resistant Products	Firefighting foam				U.S. Reduction of PFOS, PFOA, PFNA (and other select PFAS[2])
PFOA		Initial Production		Protective Coatings				

Adapted from Interstate Technology Regulatory Council

PTFE = Polytetrafluoroethylene

Per- and Polyfluoroalkyl Substances (PFAS)

- Can bioaccumulate in humans and wildlife
- Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS) are the most common PFAS in U.S.
  - Found in the blood of 95% of people tested, but declining since voluntary phase-out began in 2000
- Exposure continues due to presence in products from some companies not participating in the voluntary phase-out and from products imported from other countries

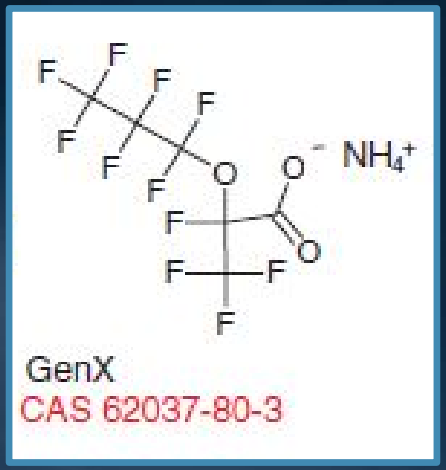
PFOA and PFOS Health Effects

	Cancer		Non-Cancer	
	Animal Studies	Human Studies	Animal Studies	Human Studies
PFOA				
	Liver Pancreatic Testicular	Testicular Kidney	Increased liver weight Male reproductive effects Immune system effects (not consistent between species) Delayed mammary gland development	High cholesterol (liver effect) Ulcerative colitis Thyroid disease Immune response Pregnancy-induced hypertension Decreased fertility
PFOS				
	Liver	General population studies have not consistently reported increases in malignant tumors for PFOS (ATSDR, 2019)	Increased liver weight Male reproductive effects Immune system effects (not consistent between species)	High cholesterol (liver effect) Ulcerative colitis Thyroid disease Immune response Pregnancy-induced hypertension Decreased fertility

Slide content courtesy of Lisa Corey, Ph.D.; Intertox

Replacement chemicals for PFOS and PFOA

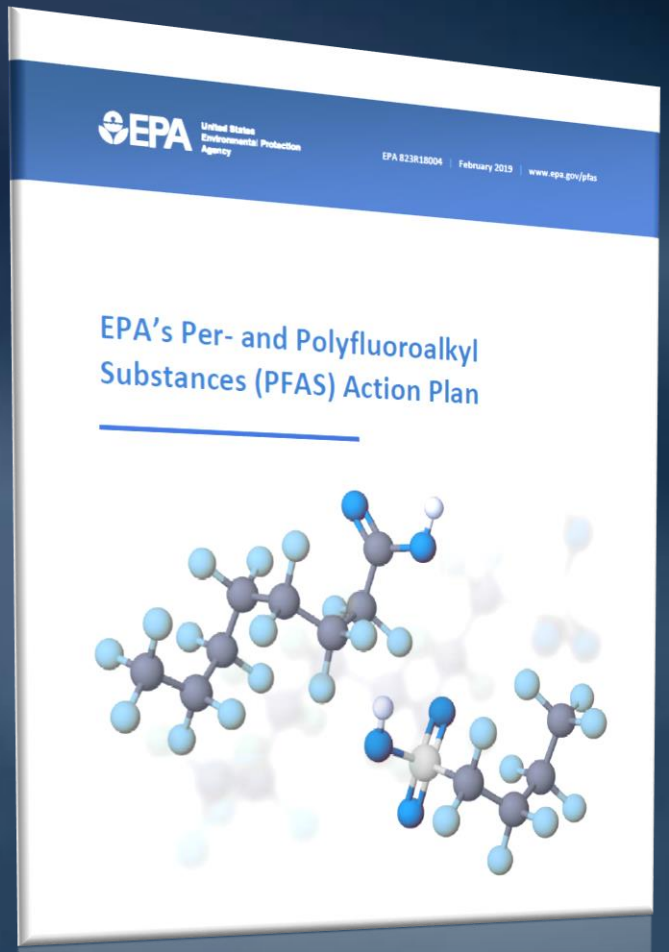
- Health concerns associated with PFOS and PFOA prompted industry to develop other "replacement chemicals"
- GenX
  - Technology used to make high performance fluoropolymers
  - Also refers to an individual chemical
- ADONA (ammonium 4,8-dioxa-3H-perfluorononanoate)
- Recent studies suggest that these chemicals may also have adverse human health effects



Federal Guidelines for PFOA and PFOS

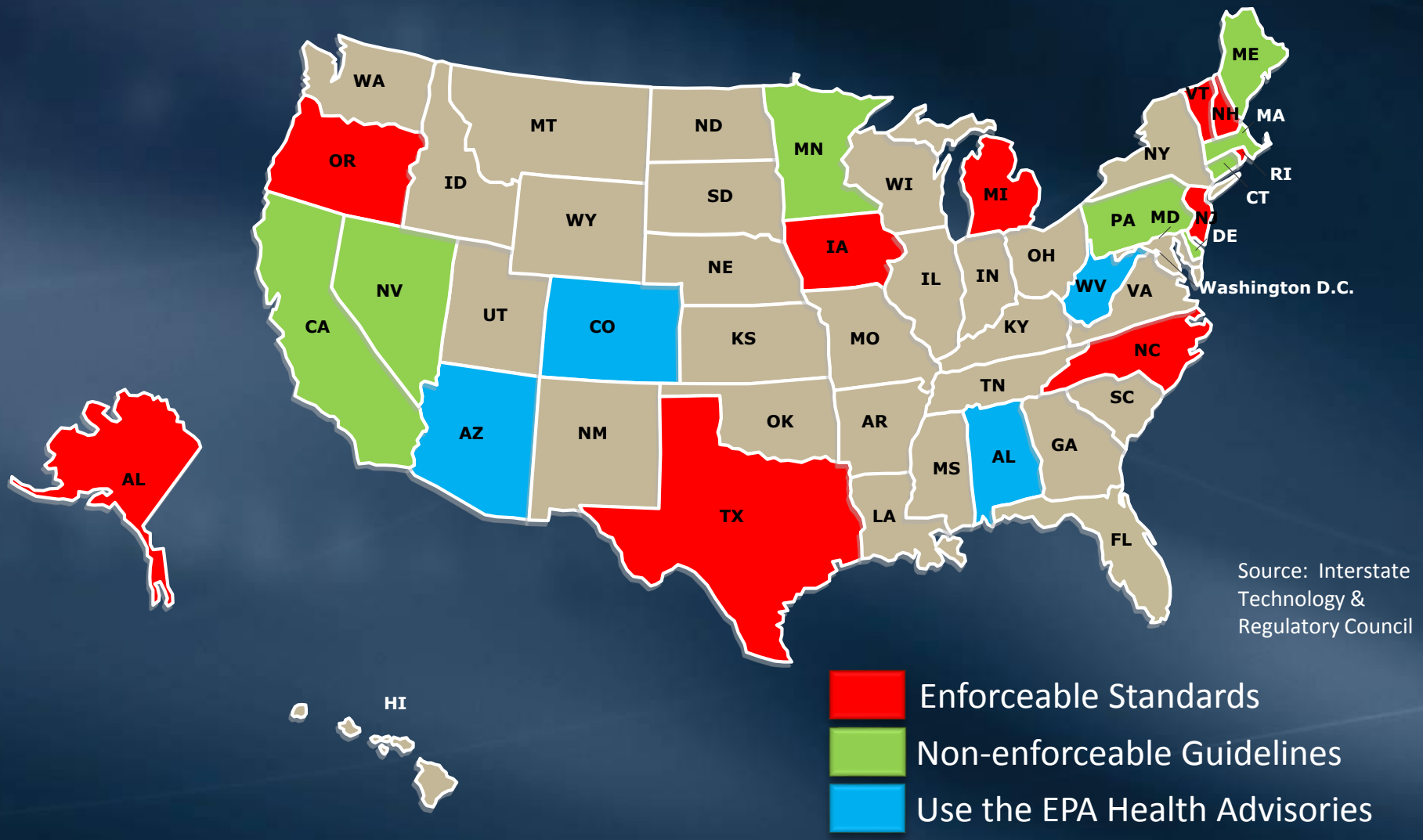
- May 2016 - USEPA established a drinking water Health Advisory (HA) at 70 ng/L [or parts per trillion (ppt)] for treated drinking water
  - HA based on combined concentration of PFOA and PFOS
  - Includes most sensitive populations with a margin of protection from lifetime exposure
  - Not a drinking water standard
  - USEPA recommends drinking water agencies take steps to assess contamination, inform consumers, and limit exposure if HA exceeded

USEPA February 2019 PFAS Action Plan



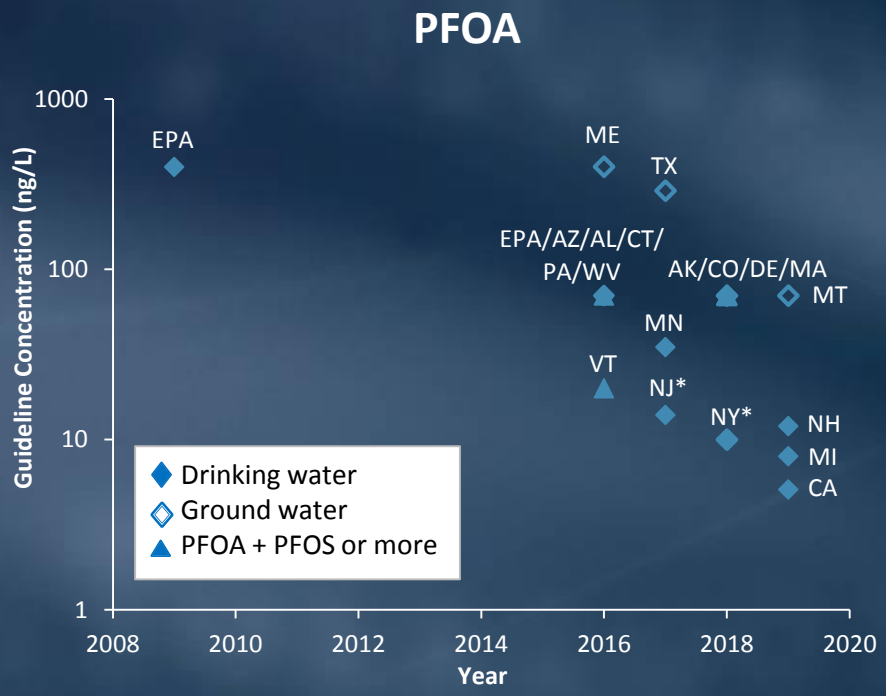
- Cleanup
- Toxics
- Monitoring
- Research
- Enforcement
- Risk Communications
- Drinking Water
  - EPA is moving forward with developing drinking water regulations for PFOA and PFOS

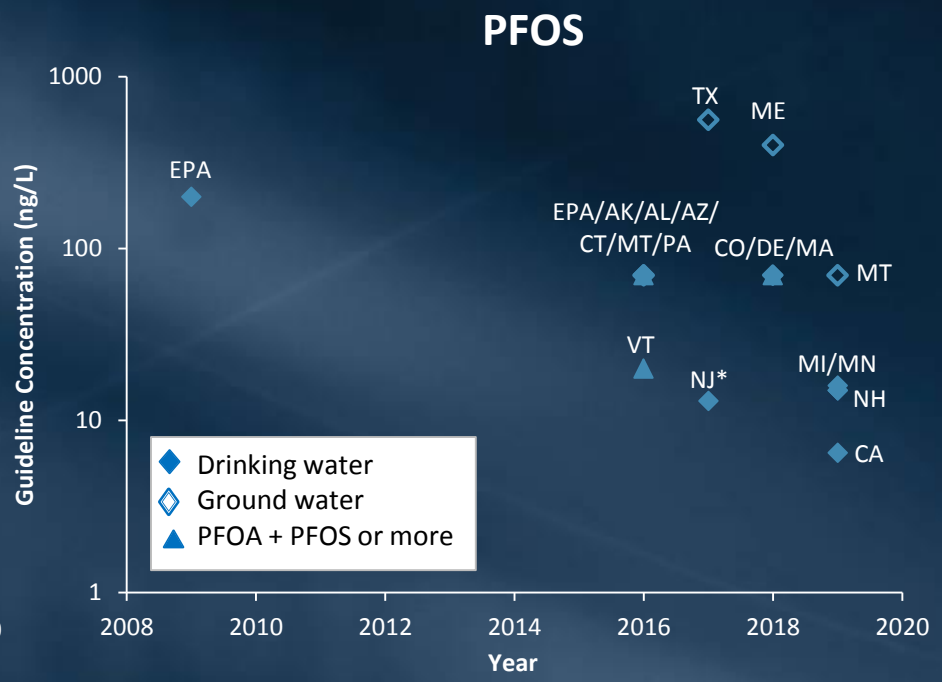
States with Standards and Drinking Water Guidelines for PFAS in the United States



Source: Interstate Technology & Regulatory Council

PFOA and PFOS Drinking Water and Groundwater Guidelines*





*Draft/proposed levels

Note: CT and MA set 70 ng/L for the sum of PFOA, PFOS, PFNA, PFHxS, and PFHpA

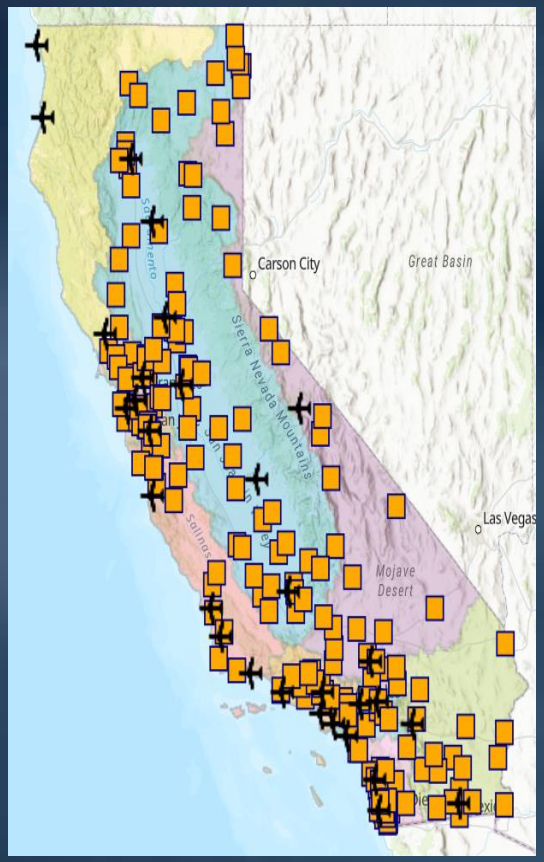
*Adapted from Cordner et. al., Journal of Exposure Science & Environmental Epidemiology; 2019; ITRC, 2019

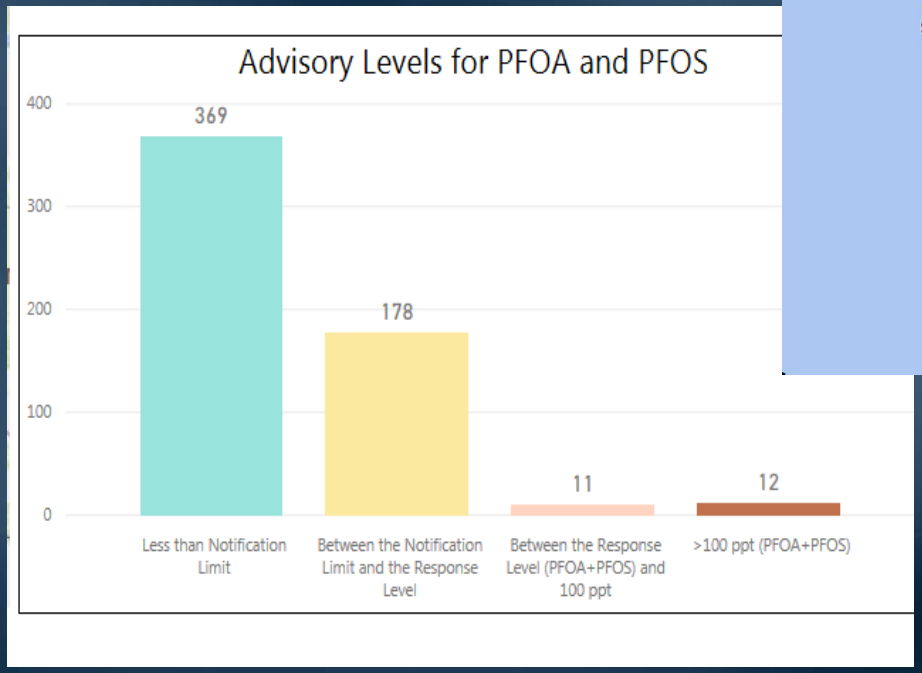
California Activities Related to PFAS

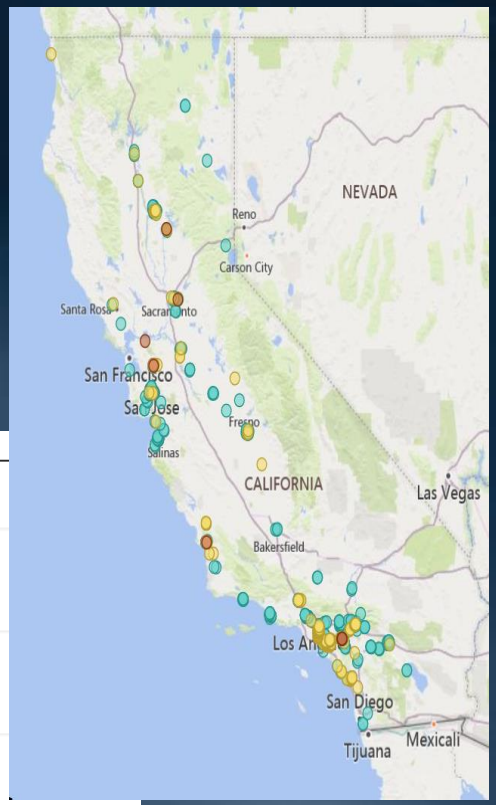
- PFAS Phased Investigation Approach
  - Phase 1: Monitoring of source water wells near airports and landfills, and known impacted drinking water sources
  - Phase 2: Monitoring of discharges from primary manufacturing facilities, refineries, bulk terminals, and non-airport firefighting facilities
  - Phase 3: Secondary manufacturing sites, wastewater treatment plants
- Sampling conducted quarterly for 1 year starting in 2019

CALIFORNIA
WATER BOARDS
State Water Resources Control Board

State Water Resources Control Board – PFAS 1st Quarter Testing Results







California Guidelines for PFOA and PFOS

- July 2018 - SWRCB established Notification Levels for PFOA at 14 ppt and PFOS at 13 ppt
- August 2019 – SWRCB revised NLs for PFOA to 5.1 ppt and 6.5 ppt for PFOS
- Notification Level
  - Health-based advisory levels for chemicals in water that lack drinking water standards
  - If Notification Level is exceeded:
    - Wholesale water systems must notify governing bodies and water systems directly supplied with that drinking water
    - Retail water systems must notify governing body
    - SWRCB recommends that customers and consumers be notified

California Guidelines for PFOA and PFOS (cont'd)

- July 2018 - SWRCB established a Response Level of 70 ppt for the total combined PFOA and PFOS concentrations – consistent with USEPA's Health Advisory
- Revisions of RLs expected end of 2019 or early 2020
- Response Level
  - Level at which SWRCB recommends removal of a drinking water source from service

California Guidelines for PFOA and PFOS (cont'd)

- Response Level (cont'd)
  - If an agency elects not to remove the source, the SWRCB recommends:
    - Notify local governing body
    - Notify customers that the contaminant exceeds level at which State recommends removal and reason for continued use
    - Issue a press release
    - Conduct regular sampling until contaminant drops below Response Level

PFAS Monitoring and Analytical Issues

- Drinking water analytical methods remain in developmental phase
  - 2009 method detects 14 PFAS
  - 2018 method detects 18 PFAS
  - EPA plans to add a method in 2019 that will detect 25 PFAS
- Some laboratories developed modified versions of USEPA Method
- Special collection procedures required due to ubiquitous occurrence of PFAS

PFAS Monitoring in Metropolitan's System

- Metropolitan
  - PFAS samples were collected in Metropolitan's source and treated waters in 2013, 2016, and 2017
  - PFOA and PFOS were not detected in any of the samples
  - Additional monitoring of Metropolitan's system will be conducted in 2019

Treatment Technologies for PFAS

Treatment	Percent Removal
Activated Carbon (PAC or GAC)	up to >98%
Ion Exchange	up to >99%
Membrane Separation (e.g., Reverse Osmosis)	up to >99%

Information from USEPA's Drinking Water Treatability Database

Federal PFAS Legislation

- In the 116th Congress (2019 – 2020), 42 PFAS related bills have been introduced
  - The legislation focuses on a wide range of issues including restrictions on the use of PFAS substances , drinking water regulation, testing and waste incineration.

- Of the 42 PFAS related bills introduced, 8 are drinking water related. Provisions include:
  - Regulation of PFAS by U.S. EPA including establishment of an maximum contaminant level,
  - Provide assistance in the form of loans and grants to water systems for treatment, and
  - Designation of PFAS substances as hazardous under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

State PFAS Legislation

- AB 841 (Ting, D – San Francisco)*
  - Requires the Office of Environmental Health Hazard Assessment (OEHHA) to adopt a work plan and identify potential risks to human health
- AB 756 (C. Garcia, D – Bell Gardens)
  - Authorizes SWRCB to more broadly order water systems to monitor for PFAS
  - Creates a new notification procedure for PFAS, if response or notification levels are exceeded
  - The law takes effect on January 1, 2020

*Held in committee

Summary

- PFAS occurrence widespread throughout U.S.
- Regulation of PFAS in drinking water will be high priority for U.S.EPA and State of California
- Water agencies with PFAS contaminated supplies are confronted with significant challenges
- Considerable information still required to develop a drinking water standard
  - Occurrence
  - Health effects
  - Treatment
  - Analytical methods
- Communication will be important


THE METROPOLITAN WATER DISTRICT OF
SOUTHERN CALIFORNIA
1928

Key Terms

- PFC: perfluorinated compounds; does not include polyfluorinated substances
- PFAS: poly and perfluoroalkyl substances
- Long chain
  - perfluoroalkyl carboxylic acids, PFCAs, with eight or more carbons (seven or more carbons are perfluorinated)
  - perfluoroalkane sulfonates, PFSAs, with six or more carbons (six or more carbons are perfluorinated)
- Short chain
  - perfluoroalkyl carboxylic acids with seven or fewer carbons (six or fewer carbons are perfluorinated)
  - perfluoroalkane sulfonates with five or fewer carbons (five or fewer carbons are perfluorinated)

Aqueous Film-Forming Foam (AFFF)

- AFFF is a highly effective foam intended for fighting high-hazard flammable liquid fires.
- AFFF products are formed by combining foaming agents with fluorinated surfactants.
- The aqueous film forms a vapor barrier between the fuel and oxygen to prevent re-ignition.
- AFFF products contain PFAS
  - legacy PFOS AFFF
  - legacy fluorotelomer AFFF (contain some long-chain PFAS)
  - modern fluorotelomer AFFF (contain almost exclusively short-chain PFAS)

PFOA Stewardship Program

- In 2006 EPA invited 8 major leading companies in the PFAS industry to meet 2 goals
  - To commit to working toward the elimination of these chemicals from emissions and products by 2015.
  - To commit to achieve, no later than 2010, a 95% reduction of PFOA..measured from 2000...