PFAS 101
FOR LOCAL GOVERNMENTS

LAWRIE J. KOBZA
608.283.1788
LKOBZA@BOARDMANCLARK.COM

PAUL G. KENT
608.256.0226
PKENT@STAFFORDLAW.COM

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What Are PFAS?

- PFAS stands for
  - perfluoroalkyl substances, and
  - polyfluoroalkyl substances
- Large family of compounds containing carbon-fluorine bonds
- Man-made; over 4,000
- Wide variety of physical and chemical properties
  - Gases, liquids, surfactants, solid material

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Highly Useful Characteristics

- Repel oil and water
- Reduce surface tension by concentrating at the liquid-air interface
- Temperature resistance
- Friction reduction

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Manufacturing History

- PFAS manufacturing began in 1940's
  - 3M primary manufacturer
- Secondary manufacturing facilities used PFAS to produce other goods
  - Used by many different industries
    - Source of following slides: Interstate Technology and Regulatory Council (ITRC), 2017, PFAS Fact Sheet, *History and Use of Per- and Polyfluoroalkyl Substances (PFAS), Table 4-1*

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Textiles and Leather

- Factory- or consumer-applied coating to repel water, oil, and stains
- Applications include
  - Carpets and upholstery (Scotchguard)
  - Protective clothing and outerwear, umbrellas (Gore-tex)
  - Tents, sails, architectural materials

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Paper Products

- Surface coatings to repel grease and moisture
- Non-food paper packaging
  - Cardboard, carbonless forms, masking papers
- Food-contact materials
  - Pizza boxes, fast food wrappers, microwave popcorn bags, baking papers, pet food bags

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Metal Plating and Etching

- Corrosion prevention
- Mechanical wear reduction
- Aesthetic enhancement
- Surfactant
- Wetting agent/fume suppressant for chrome, copper, nickel, and tin electroplating
- Post-plating cleaner

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Industrial Surfactants, Resins, Molds, Plastics

- Manufacture of plastics and fluoropolymers, rubber, and compression mold release coatings
- Plumbing fluxing agencies
- Fluoroplastic coatings, composite resins, and flame retardant for polycarbonate

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Other Manufacturing Uses

- Wire Manufacturing
  - Coating and insulation
- Photolithography and Semiconductor Industry
  - Photoresists, top anti-reflective coatings, bottom anti-reflective coatings, and etchants, with other uses including surfactants, wetting agents, and proto-acid generation

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PFAS in Commercial and Consumer Products

- Paper and packaging
- Clothing and carpets
- Outdoor textiles and sporting equipment
- Ski and snowboard waxes
- Non-stick cookware (Teflon)
- Cleaning agents and fabric softeners
- Polishes and waxes, and latex paints
- Pesticides and herbicides
- Hydraulic fluids
- Windshield wipers
- Paints, varnishes, dyes and inks
- Adhesives
- Medical products
- Personal care products (ex. shampoo, conditioners, sunscreen, cosmetics, toothpaste, dental floss)

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PFAS used in Firefighting Foam

- Class B foam is designed to extinguish
  - Flammable and combustible liquids and gases
  - Petroleum greases, tars, oil, and gasoline
  - Solvents and alcohol
- Most (but not all) Class B foam is aqueous film-forming foam (AFFF)
- All AFFF contain PFAS
- Highly effective
  - When mixed with water, creates a film that spreads across the surface of the hydrocarbon fuel to extinguish flame and create a barrier to prevent re-ignition

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Use of AFFF Foam

- Used where there is a significant flammable liquid hazard present
  - Chemical plants
  - Flammable liquid storage and processing facilities
  - Oil tankers, offshore platforms
  - Fire departments, firefighting training centers
  - Oil refineries, terminals, bulk fuel storage farms
  - Airports, aircraft rescue and firefighting, hangars
  - Military facilities

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Table 2-1. Discovery and manufacturing history of select PFAS

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				
PFNA					Initial Production	Architectural Resins		
Fluoro-telomers					Initial Production	Firefighting Foams		Predominant form of firefighting foam
Dominant Process[3]		Electrochemical Fluorination (ECF)						Fluoro-telomerization (shorter chain ECF)
Pre-Invention of Chemistry /			Initial Chemical Synthesis / Production			Commercial Products Introduced and Used		

Notes:
1. This table includes fluoropolymers, PFAAs, and fluorotelomers. PTFE (polytetrafluoroethylene) is a fluoropolymer. PFOS, PFOA, and PFNA (perfluorononanoic acid) are PFAAs.
2. Refer to Section 3.4.
3. The dominant manufacturing process is shown in the table; note, however, that ECF and fluorotelomerization have both been, and continue to be, used for the production of select PFAS.

Sources: Prevedouros et al. 2006; Concawe 2016; Chemours 2017; Gore-Tex 2017; US Naval Research Academy 2017

Source: Interstate Technology and Regulatory Council (ITRC), 2017, PFAS Fact Sheet, *History and Use of Per- and Polyfluoroalkyl Substances (PFAS).*

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Concerns Emerge About PFAS

- In early 2000s, PFAS began to be documented in environmental studies
- Initial attention focused on the "longer-chain" PFAS
  - Currently, PFOA and PFOS are the most frequently detected PFAS

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Manufacturing Changes

- Due to industry and regulatory concerns about potential health and environmental impacts
  - Reduction in the manufacture and use of the long-chain PFAAs
  - Manufacture of PFOS and PFOA in U.S. is reported to be eliminated
  - But still manufactured globally in some places
- Replacement technologies are being developed
  - Not clear whether replacement PFAS will work as well and be less hazardous

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Pervasive Presence

- PFAAs are found in many places throughout the globe, even in areas well beyond where they were initially used or manufactured
- PFAAs (such as PFOS and PFOA) are also found in the blood of most people whether exposed in the workplace or not
- Mobile, persistent, and bioaccumulative
- Not known to degrade in the environment

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PFAS in Our Blood

- In 2013-2014, the mean blood serum concentration was 4.99 ppb for PFOS and 1.94 ppb for PFOA for the general population
- Down from 1999-2000 levels of 30.4 ppb for PFOS and 5.21 ppb for PFOA
- In comparison, the mean blood serum concentration for residents near a PFOA production facility in 2004-2005 was 423 ppb

Source: Interstate Technology and Regulatory Council (ITRC), March 2018, PFAS Fact Sheet, *Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances*

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What does having PFAS in your blood mean?

- From Wisconsin Dept. of Health Services Website
- *Most people in the U.S. have PFAS in their blood, similar to the low levels observed in blood for other industrial compound classes like flame retardants and plasticizers. While you can do a blood test to determine the amount of PFAS in your body, there is not enough research to determine the level at which we would expect to see health problems.*

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Over half of our contact with PFAS are estimated to come from food. The main ways people come into contact with PFAS are:

- Eating food that was packaged in material that contains PFAS.
- Eating fish caught from water contaminated by PFAS (PFOS, in particular).
- Drinking contaminated water.
- Accidentally swallowing contaminated soil or dust.

People may also come into contact with PFAS by using some consumer products, such as non-stick cookware, stain resistant carpeting, and water repellant clothing.

It's not practical to completely reduce our exposure to these chemicals as they are so common and present in our environment, but we can take simple actions to limit our contact with them. Drink safe water, follow fish consumption advice, and rinse off after touching water that contains PFAS. Even though recent federal efforts to remove PFAS have reduced the likelihood of exposure, some products may still contain them. If you have questions or concerns about products you use in your home, contact the Consumer Product Safety Commission at (800) 638-2772.

Source: Wisconsin Department of Health Services Website

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Laboratory Test Methods and Certification

- The only EPA approved test method for PFAS is for finished drinking water. EPA Method 537 Revision 1.1
- There are no EPA approved test methods for PFAS compounds in wastewater or solids
- That has not stopped DNR from issuing a Guidance for PFAS sampling

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Sampling Protocol

- Because PFAS products are so ubiquitous sampling protocols are challenging.
- For example, Michigan's protocols note that persons collecting samples:
  - Cannot use clothing washed with fabric softener
  - May not wear clothing treated for stain resistance or water proofing
  - May not apply certain sunscreen or insect repellants
  - May not come into contact with pre-wrapped food or snacks, carryout or fast food

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Wisconsin Lab Certification

- NR 149 requires that all labs generating data to determine compliance with a covered program be certified
- DNR has program guidance pending to certify labs for PFAS but it is not yet final

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USEPA Unregulated Contaminant Monitoring Rule (UCMR) Information

- Federal UCMR requires certain drinking water systems to monitor for unregulated contaminants that may be present in drinking water
- 3rd Round
  - 4,900 public water systems required to test (all systems serving more than 10,000 people plus a subset of smaller systems)
  - Monitored 6 PFAAs, including PFOS, PFOA and PFHxS
  - Sampling conducted between 2013 and 2015

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National Results of UCMR3

- 4,920 public water systems samples
- 194 systems *detected* one or more of the PFAS sampled
- 63 systems had levels above 70 ppt
  - 96% of water system tested had no detected level
  - 98.7% were below 70 ppt

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Wisconsin Results of UCMR3

- 94 systems sampled
- 3 samples *detected* one or more of the PFAS sampled
- 1 system had a PFOS level above 70 ppt

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Federal Drinking Water Standards

- The Safe Drinking Water Act authorizes USEPA to set Maximum Contaminant Levels (MCL) for drinking water supplies
- USEPA has not established MCLs for any PFAS yet

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EPA Health Advisory for PFAS

- Health Advisories are non-enforceable and non-regulatory
- Provide technical information to state agencies and other public health officials on health effects, analytical methodologies, and treatment technologies associated with contaminants known or anticipated to occur in drinking water
- Set at **70 ng/L (ppt) for PFOS and PFOA combined** in May 2016
- According to EPA, this health advisory level "offers a margin of protection for all Americans throughout their life from adverse health effects resulting from exposure to PFOA and PFOS in drinking water."

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Parts Per Trillion?

- One part per trillion =
  - Four grains of sugar in an Olympic-size swimming pool
  - One second in 32,000 years

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EPA Action Plan for PFAS

- EPA issues an Action Plan for PFAS in February 2019
- Intends to propose a regulatory determination for PFOA and PFOS by the end of 2019 for public comment
  - Regulatory determination is the next step in the SDWA process for developing an MCL
- EPA also intends to propose monitoring for additional PFAS under the next UCMR cycle
  - Require use of newer testing methods available to detect different PFAS and at lower minimum reporting levels

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States Begin to Act

Table 1: State Regulation of PFAS for Finished Drinking Water (August 12, 2019)

Type of Guidance	State	Status	Year	Drinking Water Limit (ng/L or ppt)										
				Combined PFAS	GenX	PFBA	PFBS	PFHpA	PFHxA	PFHxS	PFOA	PFOS	PFNA	PFDA
Maximum Contaminant Level	Vermont (i)	Effective	May 2019	20				*		*	*	*	*	
	New Hampshire	Effective	July 2019							18	12	15	11	
	New Jersey	Effective	Sept 2018										13	
		Rulemaking Proposed	April 2019								14	13		
	Massachusetts	Pre-Proposal Development Phase	June 2019	20				*		*	*	*	*	*
	Michigan (ii)		June 2019		370		420		400,000	51	8	16	6	6
	New York (iii)		Dec 2018								10	10		
	Pennsylvania		Feb 2018	Specific PFAS Targeted Not Yet Announced										
	Washington		May 2019	Specific PFAS Targeted Not Yet Announced										

Source: American Water Works Association Website

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Wisconsin Begins to Act

- On 3/2/18, DNR asks DHS to provide recommendations for groundwater enforcement standards for PFOS, PFOA
- On 6/21/19, DHS responds and recommends a standard of 20 ug/L for PFOS/PFOA combined
  - Concludes approach used by EPA to set LHA of 70 ug/L may not be adequately protective of infants
  - Recommendation based on animal studies

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DHS Health Effects Review

- Recommendation not based on health studies of individuals
- Health effects identified in studies of workers and people living in areas with *high levels* of PFOA/PFOS
  - Increased cholesterol
  - Liver damage
  - Cause pregnancy-induced hypertension
  - Increase the risk for thyroid disease
  - Decrease antibody response to vaccines
  - Decrease fertility
  - Cause small decreases in birth weight

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No DHS Recommendation on Groundwater or Soil

- DHS's proposed groundwater standard is based on human infant consumption
- No standard has been recommended for surface water exposure where the primary exposure is skin contact from swimming
- No standard has been recommended for soil where the primary exposure is to crops or animals grazing on soil with elevated levels

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Administrative Rule-Making Process Begins

- DNR issues Statements of Scope to develop PFAS standards for:
  - Drinking water (Revisions to NR 809)
  - Groundwater (Revisions to NR 140)
  - Surface water (Revisions to NR 105, NR 106, and NR 219)

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Legislation Introduced

- **SB 109/AB 85.** This bill imposes a 90-day timeframe for the establishment of groundwater quality standards for PFOA and PFOS.
- **SB 310/AB 323.** This bill would prohibit the use of firefighting foams that contain intentionally added PFAS in training.

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The Chemical Level Enforcement & Remediation (CLEAR) Act - SB 302/AB21

- Requires DNR to apply any DHS-recommended groundwater enforcement standard for any PFAS as an interim standard for groundwater before the normal rule making process is finished
- Imposes a financial responsibility requirement on any persons who possesses or controls a PFAS substance
- Requires DNR to establish emergency rules for drinking water, groundwater, surface water solid waste and sediment

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Governor Evers Executive Order #40

- Establishes a public information website
- Encourages collaboration with municipalities and wastewater treatment plants on screening programs to identify potential sources of PFAS
- Creates a Coordinating Council comprised of state agencies including DNR, DHS and DATCP

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Municipal Water Coalition -- Members

- League of Wisconsin Municipalities
- MEG – Wastewater Division
- MEG – Water Division
- Wisconsin Rural Water Association
- Wisconsin Section of American Water Works Association

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Municipal Water Coalition Goals

- To work collaboratively with DNR on developing science based PFAS standards that consider relative cost, benefit, and feasibility of different PFAS removal and treatment options
- To work collaboratively with DNR to find ways to reduce sources of PFAS before they enter public water or sewer systems
- To educate the public about the background presence of PFAS in our homes and environment from common household products and make clear that drinking water systems and wastewater treatment facilities are not producers or users of PFAS, but only recipients of the compounds

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Drinking Water Objectives

- Protection of public health
- Evaluate health risk from PFAS exposure in drinking water in the same way that health risks from other contaminants (like lead, radium, arsenic) have been evaluated
- Set PFAS drinking water standard in the same way that drinking water standards for other contaminants have been set
- Focus resources where they will provide the greatest public health protection

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Impact of State Drinking Water Standard of 20 ng/L

- Per DNR's Statement of Scope
- Approximately 15 to 30 systems would need to treat water or drill a new well
- Cost of treatment at a large municipal public water system could be at least $25 million
- "Some systems may also choose to drill a new well if it is possible to find an uncontaminated aquifer."

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National Capital Cost to Install Treatment

Treatment Objective	Capital Costs ($ millions)		
	Granular Activated Carbon	Ion Exchange	Reverse Osmosis
< 70 ng/L	$2,100 - $4,400	$1,900 - $4,100	$5,700 - $12,000
< 40 ng/L	$5,600 - $12,000	$5,400 - $12,000	$15,000 - $33,000
< 20 ng/L	$23,000- $50,000	$22,000 - $48,000	$63,000 - $140,000
Treatment Technique	$140,000 - $290,000	$130,000 - $280,000	$370,000 - $800,000

Source: American Water Works Association 8/8/19 letter to Congressional Budget Office

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National Annual Operating and Maintenance Cost for Installed Treatment

Treatment Objective	Annual Recurring Costs ($ millions)		
	Granular Activated Carbon	Ion Exchange	Reverse Osmosis
≤ 70 ng/L	$44 - $90	$210 -$460	$190 - $410
≤ 40 ng/L	$110 - $240	$540 - $1,200	$480 -$1,000
≤ 20 ng/L	$460 - $980	$2,200 - $4,800	$2,000 - $4,200
Treatment Technique	$2,700 - $5,800	$13,000 - $28,000	$12,000 - $25,000

Source: American Water Works Association 8/8/19 letter to Congressional Budget Office

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Wastewater Issues

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DNR Letter to POTWs Requesting Testing

- July 22, 2019 letter to 125 POTWs requesting voluntary testing of wastewater influent and effluent and participation in a UW study on PFAS compounds
- If over 20 ppt then initiate a Pollutant Minimization Program

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POTW Response October 18, 2019

- Agree to work on a PMP program
- Do not agree to test at this time
  - Sampling protocols and lab certification have not been completed
  - There are no surface water standards for PFAS compounds
  - Generating test results in the absence of certified labs and surface water standards does not provide POTWs, the Department, or the public with meaningful information

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The Need for Context – What do Numbers Mean

- Distinction between background and spills
- Distinction between concentrations in different media– wastewater, biosolids and landfills
- Distinction between sources and receivers

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PFAS Background Levels

- The mean and median concentration of PFOA in household dust in the United States was found to be between roughly 10 and 50 parts per billion.
- PFOA and PFOS are found in every person's blood stream in the parts per billion range. The median blood serum concentration from 2013-14 was 5.2 parts per billion for PFOS and 2.1 parts per billion for PFOA.
- Background concentrations found in soils in the National Forest range from 0.1 to 1.8 parts per billion.

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Treatment Options and Source Reduction

- Treatments for water with higher solids and organic content and biosolids are not well developed.
- For example, for large POTWs reverse osmosis would cost hundreds of millions of dollars, require large areas of land use large amounts of energy costs and will result in additional residual management challenges (e.g. brine).
- Restricting the land application of biosolids and forcing this material into landfills has adverse impacts.
- In order to address the true sources of these chemicals, discontinuation of production and use (both domestic and foreign) is necessary at manufacturing facilities and heavy use areas such as firefighting training sites.

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BoardmanClark

Lawrie Kobza
Boardman & Clark LLP
1 S. Pinckney, Suite 410
Madison, WI 53701
608.283.1723
lkobza@boardmanclark.com

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Paul G. Kent
Stafford Rosenbaum LLP
222 West Washington Avenue, Suite 900
P.O. Box 1784
Madison, WI 53701-1784
pkent@staffordlaw.com
608-2560226

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