Welcome

Peter Durning

Chair, EBC Water Resources Committee

Managing Shareholder, Mackie Shea Durning, PC
Introduction and Program Overview

Peter Durning

Program Co-Chair and Moderator

Managing Shareholder

Mackie Shea Durning, PC
Assessing the Risk Presented by PFOA and PFOS in Drinking Water

Laura C. Green, Ph.D., D.A.B.T.

President & Senior Toxicologist
Green Toxicology, LLC
Do current exposures to PFAS’s in drinking water in Massachusetts threaten public health?

Laura C. Green, Ph.D., D.A.B.T.
Edmund A.C. Crouch, Ph.D.

Green Toxicology LLC

https://greentoxicology.com/

November 5, 2019
PFOA is a synthetic analogue of octanoic acid:
PFOA 1st produced in 1947, by 3M

Starting in 1951, used by DuPont in Teflon-manufacturing

3M workers’ median PFOA blood-levels = 1 part per million (ppm); and ranged up to 100 ppm (Olsen et al., 1990).

Did PFOA harm their health?
PFOA has anti-tumor activity: has been tested as chemotherapeutic agent in a small group of end-stage cancer patients (Convertino et al., 2018)

Patients’ PFOA blood-levels on the order of 200 ppm

Did PFOA harm their health?
The general public: PFOA present in all of us

Our exposures to, and body burdens of, PFOA peaked in the late 1990’s (in U.S. & Europe).

Public’s blood concentrations currently on the order of 0.002 ppm (median)

Are current body burdens of PFOA harming our health?
U.S. Population PFOA serum concentrations (NHANES) with 95% confidence intervals

Date (sampled over this and preceding year)

- Median
- 95th %ile
The general public: PFOS also present in all of us

Body burdens of PFOS (substantially larger than PFOA) also peaked in the late 1990’s

Public’s blood concentrations currently on the order of 0.005 ppm (median)
PFOA (and PFOS)-precursors once prevalent in (some) food packaging

12 years ago (Sinclair et al., 2007):

“PFOA was found at 5-34 ng in the vapors produced from a prepacked microwave popcorn bag. PFOA was not found in the vapors produced from plain white corn kernels popped in a polypropylene container.”
But more recently . . .

Brenes et al., 2019:

“. . . seven popcorn bags and three snack and sandwich bags were analysed for PFOA and PFOS . . . only two microwave popcorn bags had average PFOA content above the limit of quantitation . . . . Results of this study follow trends . . . suggesting a reduction in PFOS and PFOA concentrations in microwave packaging.”
PFOA and PFOS-precursors no longer used in food packaging

In 2011, most food packaging companies “voluntarily” stopped using most “long-chain” fluorotelomer-based coatings.

In 2016, U.S. FDA revoked allowable uses of remaining “long-chain” PFAS.

But our diets are still likely the largest sources of PFOA for most of us. (*We are what we eat . . .*).
How toxic is PFOA?

What’s the “lowest, observed, adverse effect level” (LOAEL)?

What’s the “no observed, adverse effect level” (NOAEL)?

If PFOA were regulated by U.S. FDA, we’d turn to laboratory studies in the “best” animal species to answer these questions...
Studies of PFOA in laboratory monkeys (Butenhoff et al., 2002, 2004a, & 2004b).

Study results:

- Doses of 30 & 20 mg PFOA/kg body weight/day plainly toxic, with clear evidence of liver injury (LOAELs);

- but doses of 10 mg/kg-day and 3 mg/kg-day were apparently not toxic: no evidence of liver (or other) injury (NOAELs)
How much PFOA do we currently ingest?

➢ Current dietary exposures ≈ 1 - 3 ng PFOA/kg-day (U.S. EPA, 2016).

➢ Drinking water @ 70 parts per trillion PFOA could add ≈ 2 ng/kg-day

➢ Thus, our PFOA dose-rate is 2,000,000 times smaller than the NOAEL, which is apparently harmless to monkeys
So why do some state agencies stringently regulate environmental exposures to PFOA?

➢ U.S. EPA (2016) “reference dose”, based on one, and only one, study in laboratory mice (which showed slight, transient effects . . .)
➢ Then applied “standard”, “conservative”, reasonably worst case assumptions
➢ Then guided by the “precautionary principle”
➢ Hampered by industry’s failure to provide sufficient test-data in suitable animal-species
What do observational, epidemiologic studies of PFOA show?

- Some associations observed between PFOA body burdens and adverse health-effects/endpoints (“vaccine responsiveness”?)
- Do these associations reflect cause-and-effect?
  - Associations not seen in PFAS workers, nor in PFOA patients
- Some associations (diminished kidney function; early menopause) apparently due to “reverse causation” (Dhingra et al., 2017)
- Does the weight of evidence suggest that U.S. EPA’s drinking water “advisory level” of 70 ppt, for PFOA + PFOS, is unsafe?
And finally, a word about the movie, *Dark Waters*

*Per* the movie trailer:

➢ A tenacious attorney uncovers a dark secret that connects a growing number of unexplained deaths [of cattle] to one of the world's largest corporations [DuPont]. While trying to expose the truth, he soon finds himself risking his future, his family and his own life . . .
Best Practices for PFAS Treatment in Drinking Water

EBC Water Resources Program:
PFAS Contamination in Drinking Water

November 5, 2019

Robert Little, P.E.
Drinking Water Practice Leader
Woodard & Curran
rlittle@woodardcurran.com
What are we talking about?

- A (brief) history of PFAS
- What are the regulations? (National perspective)
- Public perception
- How do we treat for PFAS?
- A case study & some pitfalls

What am I NOT talking about?

- State regulations
- Not too much chemistry
- Risk and Toxicology
- Health Impacts
But First...What is PFAS?

- Large class of surfactants (>3,000?) with unique chemical & physical properties that make many of them extremely persistent and mobile in the environment.

Source: open access images – bing.com
Some Terminology

- **PFAS**
  - Per- and PolyFluoroAlkyl Substances
  - Perfluoroalkyl substances
    - Perfluorooctanoic acid (PFOA)
    - Perfluorooctane sulfonate (PFOS)
  - Newer Compounds
    - GenX
    - PFBS

**CEC = Contaminants of Emerging Concern** ("Emerging Contaminants")

- **PFAA** = Perfluorinated Alkyl Acids
- **PFCA** = Perfluorinated Carboxylic Acid
- **PFSA** = Perfluorosulfonic Acid

Long and Short Chain
PFAS in Products

- Teflon (e.g. non-stick cookware)
- Waterproof textiles (e.g. Tyvek, GoreTex)
- Scotchgard, Stainmaster and other stain/waterproofing products
- Waxes (e.g. ski, automotive, floor)
- Food wrappers (e.g., fast food containers and wraps, pizza boxes)
- Microwave popcorn bags
- Dental floss
- Shampoos/sunscreens/moisturizers/insect repellents
- Cosmetics
- AFFF – Aqueous Film-Forming Foam (Fighting petroleum fires - Class B Foam)
Possible Sources of PFAS in the Environment

- Fire training facilities
- Fire stations
- Refineries
- DoD sites/Military bases
- Commercial and private airports
- Landfills (leaching from consumer products)
- Biosolids land application
- Chemical and plating facilities
- Textile/carpet manufacturers
- Many more…
Properties of Concern

▪ “Forever Chemicals” – very stable
▪ Water soluble and mobile in groundwater
▪ Bioaccumulate
▪ Some PFAS compounds determined to be toxic with high concentrations and/or long-term exposure:
  ➢ Developmental effects in fetuses
  ➢ Likely impacts to thyroid, liver, kidneys, hormone levels and the immune system
  ➢ Possible cancer risk

▪ Half-lives in humans
  ➢ PFOA: 2 to 4 years
  ➢ PFOS: 5 to 6 years
▪ EPA Lifetime Health Advisory of 70 ppt

(PFOA is pictured)
By Manuel Almagro Rivas - Own work using: Avogadro, Discovery Studio, GIMP, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=47567609
Are PFASs a concern in US drinking water?

- Six PFASs were included in the third Unregulated Contaminant Monitoring Rule (UCMR3)

<table>
<thead>
<tr>
<th>Compound</th>
<th>MRL (ng/L)</th>
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<tbody>
<tr>
<td>Perfluoroheptanoic acid (PFHpA, C7)</td>
<td>10</td>
</tr>
<tr>
<td>Perfluorooctanoic acid (PFOA, C8)</td>
<td>20</td>
</tr>
<tr>
<td>Perfluorononanoic acid (PFNA, C9)</td>
<td>20</td>
</tr>
<tr>
<td>Perfluorobutanesulfonic acid (PFBS)</td>
<td>90</td>
</tr>
<tr>
<td>Perfluorohexanesulfonic acid (PFHxS)</td>
<td>30</td>
</tr>
<tr>
<td>Perfluorooctanesulfonic acid (PFOS)</td>
<td>40</td>
</tr>
</tbody>
</table>

- Samples collected from January 2013 – December 2015
- Public Water Systems (PWSs) serving >10,000 people
PFAS Timeline – Drinking Water

2009
PFOS and PFOA added to CCL 3 and assigned Provisional Health Advisory

2012
UCMR 3 published, includes six PFASs

2016
EPA recommends health advisory limit of 70 ppt for PFOA and PFOS

2019
EPA releases PFAS Action Plan
Elevated PFAS levels affect a sizeable number of US residents

PFOS+PFOA levels estimated to exceed the 70 ng/L HAL in the drinking water of 6 million US residents

Hu et al. ES&T Letters (2016)
Contamination Location

Contamination Location

Northeastern University Website
Parts per trillion!?
Risk Perception

- **Regulators** think in terms of safety, threshold criteria and standards (well established process)
- **Scientists/Engineers** think in terms of numerical values and technologies
- **General Public:** How will it affect me? Am I safe? Will my child get sick?

“Compounding Conservatism” and “Reasonable Maximum Exposure”
Science, Risk and Regulation

- Prior and ongoing studies – lots!
- Regulators and utilities trying to keep pace
- In public eye, the established regulatory process is too slow, they want zero now

ONE PART PER TRILLION IS

- 1 postage stamp in the area of the city of Dallas
- 1 inch in 16 million miles (more than 600 times around the earth)
- 1 second in 320 centuries
- 1 flea on 360 million elephants
- 1 grain of sugar in an Olympic sized pool
- 1 bad apple in 2 billion barrels

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Zhanyun Wang; Jamie C. DeWitt; Christopher P. Higgins; Ian T. Cousins; Environ. Sci. Technol. 2017, 51, 2508-2518
Standards Comparison – Can’t We All Get Along?

PFOA GW Standards, MCLs, or Guidelines

<table>
<thead>
<tr>
<th>Location</th>
<th>Standard (ng/L)</th>
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<tr>
<td>New York (announced)</td>
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<tr>
<td>California</td>
<td>14</td>
</tr>
<tr>
<td>New Jersey</td>
<td>14</td>
</tr>
<tr>
<td>Massachusetts (proposed)</td>
<td>20</td>
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<tr>
<td>Vermont</td>
<td>20</td>
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<tr>
<td>Minnesota</td>
<td>35</td>
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<tr>
<td>New Hampshire (proposed)</td>
<td>38</td>
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<tr>
<td>AK, CT, DE, IA, ME, NH, PA, RI</td>
<td>70</td>
</tr>
<tr>
<td>Michigan</td>
<td>70</td>
</tr>
<tr>
<td>U.S. Lifetime Health Advisory</td>
<td>70</td>
</tr>
<tr>
<td>Sweden (administrative)</td>
<td>90</td>
</tr>
<tr>
<td>Denmark</td>
<td>100</td>
</tr>
<tr>
<td>Germany</td>
<td>100</td>
</tr>
<tr>
<td>Italy (screening)</td>
<td>100</td>
</tr>
<tr>
<td>Canada</td>
<td>90</td>
</tr>
<tr>
<td>Texas</td>
<td>290</td>
</tr>
<tr>
<td>United Kingdom (administrative)</td>
<td>300</td>
</tr>
<tr>
<td>Italy (health-based)</td>
<td>500</td>
</tr>
<tr>
<td>Australia</td>
<td>560</td>
</tr>
<tr>
<td>Nevada</td>
<td>667</td>
</tr>
<tr>
<td>North Carolina</td>
<td>2,000</td>
</tr>
<tr>
<td>United Kingdom (health-based)</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Oregon has an initiation level of 24,000 ng/L for PFOA.

Primary Source: ITRC – Interstate Technology and Regulatory Council
Science vs Perception

- Data indicates concentrations of PFAS in virtually all media going down over time (since phase-out) as well as in blood levels in humans.
- Leads to questioning of “relative source contribution” component of health advisories/drinking water standards (often assume 20%).
- “Maine dairy farm plagued by chemical contaminants may be tip of the toxic iceberg” Bangor Daily News – 3/23/2019.
The Devil We Know
- Netflix Documentary
- January, 2018
- How did the toxicity, pervasiveness, persistence of these chemicals go unrecognized for so long?
- “The Chemistry of a Cover-Up”

Dark Waters
- Focus Features (Comcast) & Participant Media
- November, 2019
PFAS in the News

Eco-friendly packaging could be poisoning our compost

"We are moving forward with several important actions, including the maximum contaminant level for PFAS in drinking-water and the National COBRA program to address PFAS contamination in drinking-water. These actions will protect public health and ensure that our drinking-water is safe for everyone."

Erin Brockovich is warning about an emerging drinking-water crisis in the US. Here’s how she recommends you protect yourself.

-- EPA Administrator Andrew Wheeler

recommendations for cleaning up groundwater contaminated with PFOA and PFOS. Learn more.

Boston.com - May 30, 2019

And because they persist for so long in the environment, PFAS has been ... With the
Public Perception of PFAS

- It’s everywhere!
- It doesn’t go away
- It’s toxic
- It’s present in my tap water
- I want it to be zero
- What are you doing about it?!?!

We’ll sample
We’ll notify
We’ll treat
Options Are Limited

- Alternate supplies
  - Abandon sources (who has this ability while still satisfying MDD)
  - Can change groundwater flow paths

- Blending
  - May require infrastructure (piping)
  - Does the public want to hear that the solution is dilution

- Treatment – today’s focus
Drinking Water Treatability Database

- Publicly available
- https://oaspub.epa.gov/tdb/pages/contaminant/findContaminant.do
PFAS Treatment Technologies

<table>
<thead>
<tr>
<th>Proven / Mature</th>
<th>Emerging / Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pump and Treat</td>
<td>• Flocculation / Electrocoagulation</td>
</tr>
<tr>
<td>• Granular Activated Carbon (GAC)</td>
<td>• Foam Fractionation</td>
</tr>
<tr>
<td>• Ion Exchange (IX)</td>
<td>• Ozofractionation</td>
</tr>
<tr>
<td>• Nanofiltration (NF) / Reverse Osmosis (RO)</td>
<td>• Polymeric Adsorbents</td>
</tr>
<tr>
<td>• Incineration (not for water)</td>
<td>• Sonolysis</td>
</tr>
<tr>
<td>• Excavation</td>
<td>• Electrochemical Treatment</td>
</tr>
<tr>
<td>• On or off site</td>
<td>• Advanced Oxidation / Reduction Processes</td>
</tr>
<tr>
<td>• Requires extremely high temperatures (&gt;1,000 deg.C)</td>
<td>• Photolysis</td>
</tr>
<tr>
<td></td>
<td>• Fungal Enzymes</td>
</tr>
<tr>
<td></td>
<td>• Monitored Natural Attenuation (MNA)</td>
</tr>
</tbody>
</table>

Blue denotes adsorption / separation
Red denotes Destruction
PFAS Treatment Technologies

- Granular Activated Carbon (GAC)
- Ion Exchange (IX) Resin
- High Pressure Membranes (RO and Nanofiltration)
Granular Activated Carbon

-Granular Activated Carbon is highly porous; large surface area for adsorption of organic contaminants.
-Granular Activated Carbon (GAC) is the most widely used technology.
-Granular Activated Carbon (GAC) is less effective for short chain PFAS (PFBS, PFBA).
-Granular Activated Carbon (GAC) is less effective for PFCAs than PFAS of same chain length.
Granular Activated Carbon

- All carbon is not created equal (coal-based vs coconut-based)
- Performance determined by porosity and surface chemistry
Long-Chain vs. Short-Chain

Long-chain PFCAs >= C8
PFSA >= C6

Half-life of long-chain compounds measured in years. Much longer than short-chain (days, weeks).

Source: ITRC – Interstate Technology Regulatory Council
Ion Exchange

- All resin is not created equal
- Performance determined by chemistry and contaminants
**Ion Exchange**

**Per-fluoroalkyl substances:** fully fluorinated alkyl tail

- **(PFOA)**
- **(PFOS)**

**Simplified Resin Bead**

Dual mechanism of removal: IEX AND Adsorption
Overview of GAC and IX Resin Technologies

Granular Activated Carbon

- **Pros**
  - Good removal of PFOS/PFOA and most long-chain PFAS
  - Readily available network of GAC vendors and reactivation facilities
  - NSF approved for drinking water
  - GAC media is less expensive

- **Cons**
  - Less effective on short-chain PFAS
  - Virgin GAC ($$$) significantly outperforms reactivated GAC
  - Requires larger footprint
  - Organic co-contaminants compete for adsorption sites

IX Resins

- **Pros**
  - Higher capacity than GAC – more versatile against short- and long-chain PFAS
  - Requires smaller footprint
  - Single-use resins NSF approved for drinking water

- **Cons**
  - Media is more expensive than GAC
  - Co-contaminants (e.g. iron, manganese, chlorides) may result in media fouling
Membrane Filtration

- Nanofiltration and Reverse Osmosis have been proven to be very effective for PFAS removal

- Cons
  - Portion of feedwater is retained as high-strength concentrated waste
  - Potential corrosion control issues
  - Energy intensive
  - Operationally complex

- Pros – do you already have it?
Selecting the Right Technology

- There is no “One Size Fits All” Solution

- Considerations
  - Concentrations and composition of PFAS in source water
  - Reaction kinetics – how fast does adsorption occur
  - Source water co-contaminants
  - Capacity – how much contaminant can be loaded onto the media/resin
  - Other water treatment processes
  - Space constraints
  - Capital costs
  - O&M Costs (media changeout, maintenance)
  - Flexibility (changing science, changing regulation)
Some Key Design Factors – Membrane

- Solids and co-contaminant content (brackish water?)
- Flux rate (gals/sf/day)
- Number of stages
- Closed loop systems
- Waste stream handling
Some Key Design Factors – GAC and IX

- Empty Bed Contact Time (EBCT)
  - Measure of time water is in contact with activated carbon

- Superficial Velocity (gpm/sf)
  - Velocity disregarding porous media

- Media Use Rate (lbs/1,000 gals)
  - Rate media will be exhausted

- Breakthrough Rate
  (bed volumes or gallons treated)
  - Measure of adsorption capacity

<table>
<thead>
<tr>
<th></th>
<th>GAC</th>
<th>IX Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBCT (mins)</td>
<td>10 - 15</td>
<td>2.5 - 5</td>
</tr>
<tr>
<td>Superficial Velocity (gpm/ft²)</td>
<td>3 - 5</td>
<td>6 - 12</td>
</tr>
</tbody>
</table>
Example Design

- Flow Rate: 500 gpm

<table>
<thead>
<tr>
<th></th>
<th>GAC</th>
<th>IX Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBCT (mins)</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>Superficial Velocity (gpm/ft²)</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Diameter (ft)</td>
<td>11.25</td>
<td>8.5</td>
</tr>
<tr>
<td>Bed Depth (ft)</td>
<td>6.75</td>
<td>3</td>
</tr>
<tr>
<td>Media Volume (ft³)</td>
<td>675</td>
<td>167</td>
</tr>
</tbody>
</table>
Example Design

- Simplest Setup
  - Lead/Lag Vessels
  - Pre-filter to prevent fouling (e.g. 5-micron)

```
INFLUENT WATER

Bag or cartridge filter

Carbon

Resin

Carbon

Resin

TREATED WATER
```
Influent Water
[Fe] ~ 0.77 mg/L
[Mn] ~ 1.08 mg/L
PFASs ~ 125 ng/L
Chloride ~ 140 mg/L

Oxide Coated Media (Greensand) Filtration

KOH NaOCl

NaHSO₃

DECHLORINATION!

- No chlorine at influent to GAC or IX;
- Anions may compete for IX adsorption sites
- May need repumping

- Pump once from individual wells;
- Chlorinate and maintain residual through greensand filters;
- No atmospheric storage

TREATED WATER
Case Study

- Hudson, MA
- ~30 miles west of Boston
- Population ~19,000
- Treatment capacity = 2.9 MGD
Hudson Water Supply - 5 Wells

Sources: Google Earth
Rapid Small-Scale Column Testing (RSSCT)

- Scaled down version of pilot test. Use equations and dimensional analysis to extrapolate to full-scale implementation.
- Less accurate; doesn’t provide same breadth of understanding.
- Provides results in hours/days vs. weeks/months.
- For GAC, there is an ASTM Standard (D6586) for RSSCT.
Pilot Testing

- Move from theory to practice
- Demonstrates performance under actual WQ conditions
- Provides additional information for design (effects on and reactions with other anions, e.g. chloride, sulfate)
- Good estimate of real-life media/resin life (time to breakthrough)
Performance Comparison

- Fabricated dual sided pilot skid for side-by-side testing: IX Resin vs. GAC
- Set-up is specific to technology
- 4 EBCTs evaluated
- Sampled & analyzed for 23 PFAS compounds out of each column
- Plot breakthrough curves to compare effectiveness of IX Resin vs. GAC
- Long duration (6 months)
PFAS Found! Time is of the essence

- Higher levels detected, lower limits expected
- Summer was coming
- Everything went out the window!
Temporary / Emergency System

- Rudimentary design
- Procurement waivers
- Agency approvals
- Design Build Delivery
- Lots of DPW staff time
Temporary / Emergency System

ALL FIELD TESTS DONE ACCORDING TO ASTM: C-172 C-31 C-143 C-1064 C-2

ALL COMPRESSIVE STRENGTH TESTS DONE ACCORDING TO ASTM: C-39 C-12

CLASS CONCRETE: 5000# 3/4" *

No. Of Sets: 1 CUBIC

SET 1 LOCATION: Slab; Right Rear Corner

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Size (in.)</th>
<th>Area (sq. in.)</th>
<th>Condition</th>
<th>Date Cast</th>
<th>Date Tested</th>
<th>Age Days</th>
<th>Total Load (lbs.)</th>
<th>Unit Load (psi)</th>
<th>Fracture Type</th>
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<tbody>
<tr>
<td>8395</td>
<td>4.00 x 8.00</td>
<td>12.57</td>
<td>Good</td>
<td>05/16/19</td>
<td>05/23/19</td>
<td>7</td>
<td>61,500</td>
<td>4,890</td>
<td>1</td>
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<tr>
<td>8396</td>
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<td>12.57</td>
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<td>Good</td>
<td>05/16/19</td>
<td>06/13/19</td>
<td>28</td>
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Temporary / Emergency System
Considerations (and potential Pitfalls)

- Site/civil layout, pad design
- NSF61 Approval
- Piping, hydraulics (headloss) and booster pumping needs
Considerations (and potential Pitfalls)

- SCADA and electrical requirements (generator adequacy)
- De- (and re-) chlorination
- Start-up and media/resin change out
- Residuals management
Hudson MA – Current Status
Hudson MA – Current Status – Pumping
Hudson MA – Current Status – Building
Hudson MA – Current Status – Pilot Results

Resin - Effluent PFAS Concentration

GAC - Effluent PFAS Concentration
Summary

- PFAS are everywhere (but going down), drinking water is one source
- Science and technology are evolving
- Rapidly changing regulatory landscape
- Public expects “zero” – panic and political pressure is outpacing science and regulation
- Limited treatment options – **but they do work**
- Viability depends on site specifics - source water characteristics, existing treatment processes, etc – be prepared to move fast
Summary

- Open and frequent communications – dialogue and listening
- Transparency and clear presentation of facts
- Social media
- Do your homework – understand issues and results
- Gain and regain trust
- You are not alone - sharing experiences and resources will be helpful
Questions?

EBC Water Resources Program: PFAS Contamination in Drinking Water

November 5, 2019

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New Hampshire’s Response to PFAS in Drinking Water

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Manager, Hydrology & Conservation Section
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New Hampshire’s Response to PFAS in Drinking Water

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EBC Water Resources Program
PFAS Contamination in Drinking Water
November 5, 2019
It is not all about PFAS in NH

• NH is lowering its MCL/AGQS for arsenic from 10 to 5 ppb
• NH is doing a lot of work with lead in schools and daycares
• Numerous asset management and infrastructure initiatives
• NH is evaluating its standard for manganese
• NHDES has lowered its standard for 1,4-dioxane from 3 to 0.32 ppb
• NHDES is rapidly sampling 100 domestic wells in a recently discovered uranium hotspot
• NHDES is doing a lot of work with climate change
• NHDES is doing a lot of work with energy/water efficiency
• Everything else
PFAS – LITIGATION IN NEW HAMPSHIRE

N.H. Sues Makers of PFAS Chemicals for Drinking Water Contamination

By ANNIE ROPEIK - MAY 29, 2019

New Hampshire is suing the original makers of toxic PFAS chemicals for allegedly contaminating the state's drinking water.

At a press conference Wednesday, Gov. Chris Sununu joined officials from the Departments of Justice and Environmental Services to announce two statewide lawsuits against eight companies – including 3M, DuPont and its spinoff, Chemours.

"New Hampshire is taking, again, a preeminent position not just for ourselves and our citizens, but in the country ... in making a stand against the introduction of the PFAS compounds into our drinking water," Sununu says.

You can read the complaints at:

https://www.courts.state.nh.us/caseinfo/index.htm
3M suit aims to block tougher PFAS standards for water in NH

The city of Portsmouth, in partnership with the U.S. Air Force, installed a carbon filtration system at the Pease International Tradeport water treatment facility to system to remove PFAS from the city’s Smith and Harrison wells at the tradeport. [Rich Beauchesne/Seacoastonline file]
NH Sampling Initiatives

- Public water systems
- Random bottled water off the shelf
- Private wells contaminated by air emission sites
- Private wells not near known PFAS contamination sites
- Waste sites
- Landfills & leachate
- Wastewater
- Groundwater discharge sites
- Surface water (general and nearby contamination sites)
- Sludge and biosolids
- Air stack testing
- Non-targeted analyses
- Fire Departments
  - Water Quality Sampling
  - Foam Collection
PFAS Regulation in NH

• May 2014 - Pease Trade Port
  • Relied on 2009 USEPA Prov. Health Advisory (400 ppt – PFOA & 200 ppt PFOS)
  • USEPA cited HA in issuing SDWA 1431 Emergency Order to Air Force to Address Contamination in Drinking Water at Pease

• February/April 2016 – Saint-Gobain & TCI – Southern NH
  • Utilized 100 ppt health advisory for PFOA

• May 2016 – Statewide Ambient GW Quality Standard
  • 70 ppt combined PFOA and PFOS
  • Enforceable clean-up standard
  • Enforceable drinking water standard if data are available

• September 2019 – Statewide MCL and Revised AGQS
New Hampshire Context for MCLs/AGQS

SB309 Passed in the Summer of 2018.

Facilitated the establishment of Drinking Water Maximum Contaminant Levels (MCLs/AGQS) for four PFAS:
• Perfluorooctanoic acid (PFOA)
• Perfluorononanoic acid (PFNA)
• Perfluorooctane sulfonic acid (PFOS)
• Perfluorohexane sulfonic acid (PFHxS)

Initial proposal of MCLs/AGQS due January 1st, 2019.

SB309 also granted NHDES additional staff including:
• a Human Health Risk Assessor and a Toxicologist

SB309 requires the regulation of air emissions to protect groundwater and surface water

SB309 requires NHDES to develop a plan and a budget for developing surface water quality standards
Health-Based Risk Assessment: Exposure Assumptions – January 2019 Initial MCL Proposal

\[
\text{RfD (ng/kg−day) \times Relative Source Contribution (\%)} \div \text{Water Ingestion Rate (L/kg−day)} = \text{Maximum Contaminant Level (ng/L)}
\]

<table>
<thead>
<tr>
<th>Specific PFAS</th>
<th>Reference Dose (ng/kg-day)</th>
<th>Water Ingestion Rate (L/kg-day)</th>
<th>Relative Source Contribution</th>
<th>Proposed MCL (ng/L)</th>
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</thead>
<tbody>
<tr>
<td>PFOA</td>
<td></td>
<td></td>
<td>These values changed in the EPA Exposure Factor Handbook (Feb 2019)</td>
<td>38</td>
</tr>
<tr>
<td>PFOS</td>
<td></td>
<td></td>
<td>These values changed in response to technical comments</td>
<td>70</td>
</tr>
<tr>
<td>PFHxS</td>
<td></td>
<td></td>
<td>These values changed in response to technical comments</td>
<td>85</td>
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<tr>
<td>PFNA</td>
<td></td>
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<td>23</td>
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</table>

These values changed in response to technical comments

These values changed in the EPA Exposure Factor Handbook (Feb 2019)

These values changed in response to technical comments
New Information May Change NHDES Proposed PFAS Drinking Water Standards

Posted on February 21, 2019 by Jim Martin

On December 31, 2018, the New Hampshire Department of Environmental Services (NHDES) initiated rulemaking to establish Maximum Contaminant Levels (MCLs) and Ambient Groundwater Quality Standards (AGQs) for four per- and polyfluoroalkyl substances (PFAS) – perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorononanoic acid (PFNA) and perfluorohexanesulfonic acid (PFHxS).

After the initial proposal, new scientific information was evaluated by NHDES that may change the proposed drinking water standards. Specifically, a new assessment tool developed by the Minnesota Department of Health allows for a quantitative estimate of infant and child exposure to PFAS through breastmilk and/or formula. This peer-reviewed model was published at the beginning of January after NHDES filed its Initial Proposal. NHDES’s assessment of the exposure model for the interaction of drinking water levels of PFAS and breastfeeding (Goeden et al, 2019) indicates that health-
### NH MCLs - Based on Non-Cancer Endpoints

- Adopted July 18, 2019 & Effective September 30, 2019
- Community and non-transient water systems are sampling – 1800 sources
- NHDES intends to sample transient public water systems one time
- NH MCLs are also the Ambient Groundwater Quality Standards (AGQS)

<table>
<thead>
<tr>
<th>Specific PFAS</th>
<th>NHDES Revised MCLs</th>
<th>Animal Health Outcome</th>
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</thead>
<tbody>
<tr>
<td>PFOA</td>
<td>12 ng/L</td>
<td>Liver toxicity &amp; altered lipid metabolism</td>
</tr>
<tr>
<td>PFOS</td>
<td>15 ng/L</td>
<td>Suppressed immune response to vaccines</td>
</tr>
<tr>
<td>PFHxS</td>
<td>18 ng/L</td>
<td>Reduced female fertility</td>
</tr>
<tr>
<td>PFNA</td>
<td>11 ng/L</td>
<td>Liver toxicity &amp; altered lipid metabolism</td>
</tr>
</tbody>
</table>
## Costs

<table>
<thead>
<tr>
<th>PFAS Source Type</th>
<th>Initial Proposal Estimate</th>
<th>Final Proposal Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Water Systems*</td>
<td><strong>Initial Treatment Costs:</strong> $1,851,354 - $5,171,022</td>
<td><strong>Initial Treatment Costs:</strong> $65,046,987 - $142,822,884</td>
</tr>
<tr>
<td></td>
<td><strong>Initial Sampling:</strong> $1,102,500 - $2,836,000</td>
<td><strong>Initial Sampling:</strong> $1,102,500 - $2,836,000</td>
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<tr>
<td></td>
<td><strong>Annual O&amp;M Costs:</strong> $114,912 - $223,439</td>
<td><strong>Annual O&amp;M Costs:</strong> $6,914,552 - $13,444,963</td>
</tr>
<tr>
<td></td>
<td><strong>Annual Sampling Costs</strong> $73,055 - $184,825</td>
<td><strong>Annual Sampling Costs</strong> $174,257 - $444,409</td>
</tr>
</tbody>
</table>
## Costs

<table>
<thead>
<tr>
<th>PFAS Source Type</th>
<th>Initial Proposal Estimate</th>
<th>Final Proposal Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Hazardous Waste Sites*</td>
<td>Initial Corrective Action Costs: $1,350,000 - $2,310,000</td>
<td>Initial Corrective Action Costs: $2,315,000 - $4,440,000</td>
</tr>
<tr>
<td></td>
<td>Annual Operating Costs: $570,000 - $1,020,000</td>
<td>Annual Operating Costs: $980,000 - $1,795,000</td>
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<tr>
<td>Municipal Landfills</td>
<td>Initial Corrective Action Costs: $380,000 - $755,000</td>
<td>Initial Corrective Action Costs: $935,000 - $1,755,000</td>
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<tr>
<td></td>
<td>Annual Operating Costs: $260,000 - $390,000</td>
<td>Annual Operating Costs: $465,000 - $770,000</td>
</tr>
<tr>
<td>Wastewater Discharges to Groundwater*</td>
<td>Initial Corrective Action Costs: $1,100,000</td>
<td>Initial Corrective Action Costs: $5,000,000</td>
</tr>
<tr>
<td></td>
<td>Annual Operating Costs: $200,000 - $400,000</td>
<td>Annual Operating Costs: $849,000 - $1,600,000</td>
</tr>
</tbody>
</table>
Other Costs

• Air Emissions
• Wastewater/Biosolids/Sludge
• Fire Departments/Foam Sites
Financial Assistance

• Legislature understood addressing PFAS contamination would be costly
  • Passed law understanding this
  • Blocked efforts to stop the MCL rule adoption
• Allocated $6M in current budget to respond to PFAS
• NH Drinking Water and Groundwater Trust Fund is a source for financial assistance
• Responsible parties are being pursued to pay for costs
• Some municipalities elected to address this before NH had standards.
Public Comments

• A lot of competing input on toxicity and risk assessment decision points

• Unfunded mandate on municipalities

• Benefits outweigh the costs

• Need additional hearings as new information is considered

• Need a comprehensive cost-benefit analysis consistent with Federal procedures
## Drinking Water / Groundwater

*(Select Locations - Established or Proposed Standards and Guidance Values)*

<table>
<thead>
<tr>
<th>Location</th>
<th>Concentration (ng/L)</th>
<th>Rule Promulgated (Y/N/O)</th>
<th>PFOA</th>
<th>PFOS</th>
<th>PFNA</th>
<th>PFHxS</th>
<th>PFHpA</th>
<th>PFDA</th>
<th>PFBS</th>
<th>PFBA</th>
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<tr>
<td>USEPA HA, AK, DE, ME, PA</td>
<td></td>
<td>N</td>
<td>*70</td>
<td>*70</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>USEPA Draft SL</td>
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<td>N</td>
<td>40</td>
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<td></td>
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<tr>
<td>RI, MI, CO</td>
<td></td>
<td>Y</td>
<td>*70</td>
<td>*70</td>
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<td></td>
<td></td>
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<td>Connecticut</td>
<td></td>
<td>N</td>
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<td>*70</td>
<td>*70</td>
<td>*70</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vermont</td>
<td></td>
<td>Y – Draft MCL</td>
<td>*20</td>
<td>*20</td>
<td>*20</td>
<td>*20</td>
<td>*20</td>
<td></td>
<td></td>
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<tr>
<td>Massachusetts</td>
<td></td>
<td>N – Draft</td>
<td>*20</td>
<td>*20</td>
<td>*20</td>
<td>*20</td>
<td>*20</td>
<td>*20</td>
<td>2,000</td>
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</tr>
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<td>Michigan</td>
<td></td>
<td>N</td>
<td>8</td>
<td>16</td>
<td>6</td>
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<td></td>
<td></td>
<td>420</td>
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<td>Minnesota</td>
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<td>N</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>47</td>
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<td></td>
<td>2,000</td>
<td>7,000</td>
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<td>California</td>
<td></td>
<td>N</td>
<td>5.1</td>
<td>6.5</td>
<td></td>
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<td></td>
<td></td>
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<td>New Jersey</td>
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<td>MCL/DRAFT MCL</td>
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<td>13</td>
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<tr>
<td>New York</td>
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<td>Draft MCL</td>
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<td></td>
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<tr>
<td>New Hampshire</td>
<td></td>
<td>Y – MCL</td>
<td>12</td>
<td>15</td>
<td>11</td>
<td>18</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* - Indicates standard is based on the sum of multiple PFAS compounds

Sources: State webpages and ITRC PFAS Fact Sheets (https://pfas-1.itrcweb.org/fact-sheets/)
With No Federal Standards-Each State is Doing Something Different

State PFAS Policies & Practice - Variables

- Guidance/Notification/Standards
- Number of PFAS Addressed
- Addressed Separately or Additively
- Analytical Methods
- Waste Site Clean-up/Drinking Water/MCL
- Health End Points
- Relative Source Contribution
- Uncertainty Factors
- Health Studies Relying Upon
- Amount of Water Consumed
- Susceptible Population vs. Adult
- Weight of Individual
- Drinking Water Programs/Waste Site Programs/Both
- Legal authority/No legal Authority to Regulate
- Response – “Do Not Drink” vs Notification
- Consider Health Only or Costs/Health/Technical Feasibility
- Integrate Sampling & Enforcement Into All Programs/Sites or Only Sometimes
- Standard Making Process (Agency Only/Governor/Legislature/Other)

State PFAS Policies & Practice - Variables

With No Federal Standards-Each State is Doing Something Different

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- Integrate Sampling & Enforcement Into All Programs/Sites or Only Sometimes
- Standard Making Process (Agency Only/Governor/Legislature/Other)
Based on the current evaluation of recent human and animal toxicity data, and applying OEHHA’s risk assessment methodology and the US Environmental Protection Agency’s (US EPA) human clearance factors (US EPA, 2016a,b) to account for the chemical half-life differences between rodents and humans, OEHHA developed PFOA and PFOS reference levels (RLs) for cancer effects. These levels represent concentrations of the chemicals in drinking water that would not pose more than a one in one million cancer risk over a lifetime:

- 0.1 ng/L (nanogram/liter) or parts per trillion (ppt) for PFOA, based on pancreatic and liver tumors in male rats (NTP, 2018c);
- 0.4 ng/L (or ppt) for PFOS, based on liver tumors in male rats (Butenholz et al. 2012a) and the structural and biological similarity of PFOS to PFOA.

OEHHA also developed RLs for noncancer effects as follows:

- 2 ng/L (or ppt) for PFOA, based on liver toxicity in female mice (Li et al., 2017);
- 7 ng/L (or ppt) for PFOS, based on immunotoxicity in male mice (Dong et al., 2009).
Status of States Adopting PFAS MCLs

• 8 states have or are in the process of establishing MCLs
• 3 states may establish MCLs
• 15 states can establish MCLs but currently don’t intend to
• 12 states have laws or policies prohibiting them from making any standard that is more stringent than Federal requirements

13 states did not respond to the survey
Considerations Across States

1. There is growing interest in class or sub-group regulation (tired playing whack-a-mole).

2. Emerging evidence of biological effects at lower doses. Are these relevant to human health?

3. Concern for contamination of other environmental media.

4. What role do food-related exposures play?

5. Are there more reliable PBPK models for environmentally-relevant exposures?
PFAS Impacts To Groundwater Quality Are Present Throughout New Hampshire

**PFAS SAMPLES** *(Data in NHDES’ Environmental Monitoring Database [EMD] ~6,500 groundwater samples)*
- > Old AGQS
- > New AGQS
- < New AGQS

**PFAS SITES** *(Data in NHDES’ Onestop Database ~415 sites)*
- Site with PFAS Detections > New AGQS
- Site with PFAS Detections < New AGQS
- Site with PFAS Screening No Detections

*Data current through 08/30/2019*
Water Supply Data

Public Water Systems, Private Well Water & Bottled Water Supplies in NH
Drinking Water – Public Water Systems

Approx. 360 of 3,800 PWS have screened for PFAS

- 1,800 wells for community and non-transient systems will be tested by January 1, 2020
- NHDES will test 2,200 wells for transient systems over the next 15 months

Approximate data through 07/31/2019
Drinking Water – Private Water Supplies

~250,000 private wells | ~46% of the state’s population

• Limited private well sampling based on proximity to:
  - Sensitive receptors of concern (i.e. childcare facilities, schools, etc.)
  - Industrial sites with known intensive PFAS use
  - Fire / fire department / fire training areas
  - Active waste sites / waste disposal facilities
  - Airports
  - Air Permit Sites
  - Agricultural sites / nurseries / growers
  - Town initiatives
Ongoing NH DES Initiatives Related to the Occurrence of PFAS in NH Groundwater

- Soil background and leaching
- DWGWTF background sampling
  - ~ 500 random wells
  - ~ 100 co-located biomonitoring samples
- Fire Department water supply sampling
- Town sampling initiatives
- Surface water sampling
- Control of air emissions
Private Well Sampling – No known sources of PFAS contamination

- 77 homeowner wells sampled in the seacoast region of NH not near known contamination sites – homes on septic systems

- Detection limits 0.2 - 0.4 ppt

- Detection in 87% of wells
  - Blue dot – non detect
  - Red dot – PFAS detected
Bottled Water Testing

- NHDES tests the bottled water it provides – consistently “non-detect”
- At least 100,000-200,000 people in NH have drinking water that exceeds NH’s MCL for PFAS
- NHDES purchased bottled water in stores in communities with PFAS contamination
- Tested 20+ products & approx. 15 products self tested
- 6 Products detected PFAS – all “natural spring water”
- 4 brands exceeded MCL (all originated from the same source)
- All products labeled with treatment were “non-detect”
Ongoing Initiatives

• Landfill leachate
  • 18 samples from lined facilities in 2018

• Wastewater Influent and Effluent
  • Sampled 13 WWTPs delegated to implement federal pretreatment standards, of the more than 60 WWTPs in NH in 2017

• Residuals – Sludge and Biosolids
  • 33 samples from 24 of 24 certificate holders (permittees) in 2017-2018
  • Sampling underway for all permittees in 2019, requirement in 2020 onward
  • Some residual application sites under assessment
    • One septage spreading sites with exceedances
    • One land application site with exceedances
    • One processing facility with exceedances
Residuals Assessments

- Sludge
- SPF
- Ash
- Compost

PFBS
PFBA
PFHXA
PFHXS
PFHXA
PFNA
PFOA
PFOS
PFPEA
Wastewater Assessments

ng/L
Waste Site Data
<table>
<thead>
<tr>
<th>Waste Site Sources</th>
<th>Sites Sampled</th>
<th>% Sites &gt; AGQS</th>
<th>Max. PFOA (12 ppt)</th>
<th>Max. PFNA (11 ppt)</th>
<th>Max. PFHxS (18 ppt)</th>
<th>Max. PFOS (15 ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class B Foam / AFFF</td>
<td>20</td>
<td>100%</td>
<td>130,000</td>
<td>4,500</td>
<td>31,000</td>
<td>490,000</td>
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<tr>
<td>Manufacturing – textiles</td>
<td>3</td>
<td>100%</td>
<td>69,500</td>
<td>2,960</td>
<td>200</td>
<td>2,560</td>
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<tr>
<td>Manufacturing – paper</td>
<td>6</td>
<td>75%</td>
<td>21,000</td>
<td>320</td>
<td>2,400</td>
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<tr>
<td>Metal Working/Plating</td>
<td>22</td>
<td>65%</td>
<td>1,070</td>
<td>22</td>
<td>806</td>
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<tr>
<td>Other Waste Disposal</td>
<td>15</td>
<td>67%</td>
<td>3,200</td>
<td>31</td>
<td>89</td>
<td>4,750</td>
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<tr>
<td>Unlined Landfill</td>
<td>161</td>
<td>74%</td>
<td>3,700</td>
<td>774</td>
<td>663</td>
<td>1,600</td>
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<td>Other Manufacturing</td>
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<td>36%</td>
<td>2,510</td>
<td>110</td>
<td>75</td>
<td>162</td>
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<tr>
<td>Metal Recycling</td>
<td>14</td>
<td>80%</td>
<td>1,700</td>
<td>100</td>
<td>674</td>
<td>1,440</td>
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<tr>
<td>Tannery</td>
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<td>1,230</td>
<td>4</td>
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<tr>
<td>Lined Landfill</td>
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<td>69%</td>
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<td>30</td>
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<td>632</td>
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<td>Mixed/Other/Unknown</td>
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<td>58%</td>
<td>1,090</td>
<td>960</td>
<td>745</td>
<td>1,700</td>
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<td>Dry Cleaner</td>
<td>21</td>
<td>75%</td>
<td>160</td>
<td>29</td>
<td>88</td>
<td>1,800</td>
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<tr>
<td>Semiconductor/Circuit Board</td>
<td>9</td>
<td>67%</td>
<td>170</td>
<td>13</td>
<td>150</td>
<td>850</td>
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<td>Commercial Products</td>
<td>4</td>
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<td>242</td>
<td>102</td>
<td>69</td>
<td>405</td>
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<tr>
<td>Wastewater/Residuals</td>
<td>6</td>
<td>83%</td>
<td>560</td>
<td>13</td>
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<td>204</td>
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<td>Lined Lagoon</td>
<td>12</td>
<td>8%</td>
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<td>0</td>
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</table>

Approximate data through 07/31/2019
Waste Sites – Maximum Groundwater Concentrations

AFFF

PFAS Concentration, ng/L (ppt)

Max. PFOA (12 ppt)
Max. PFNA (11 ppt)
Max. PFHxS (18 ppt)
Max. PFOS (15 ppt)

Approximate data through 07/31/2019
Waste Sites – Maximum Groundwater Concentrations – excluding AFFF

- Textiles
- Metal Working/Plating
- Paper
- Solid Waste Management and Disposal

Approximate data through 07/31/2019
Open HWRB Sites
Approx. 215 of 530 sites (state, CERCLA, Brownfields, landfills) have screened for PFAS

HWRB PFAS Data
Approximate data through 07/31/2019

71% of the waste sites that tested exceed NH’s new AGQS/MCL
AFFF Sites

Sites Sampled | % Sites > AGQS
--- | ---
20 | 100%

Approximate data through 07/31/2019
## AFFF Sites, continued

<table>
<thead>
<tr>
<th>Sites Sampled</th>
<th>% Sites &gt; AGQS</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Maximum PFAS Concentration, ng/L (ppt)

- **Site 5**: Local Fire Dept.
- **Site 6**: Bulk Oil Storage Facility
- **Site 7**: Manufacturing Fire
- **Site 8**: Training - Local
- **Site 9**: Training - DoD
- **Site 10**: Tanker Rollover
- **Site 11**: Airport

### PFAS Compounds

- **Max. PFOA (12 ppt)**
- **Max. PFNA (11 ppt)**
- **Max. PFHxS (18 ppt)**
- **Max. PFOS (15 ppt)**
- **Other PFAS**

Approximate data through 07/31/2019
Fire Station Water Supply Well Sampling Initiative

Private Wells Serve 171 (of 237) Stations

2016: Foam use survey
2017: Recommendation to test
2019: Screening effort

65 Stations Have Screened for PFAS
17% of Fire Stations Tested Exceed NH’s AGQS/MCL**

>70 ppt AGQS  >New AGQS and <70 ppt AGQS
<New AGQS  Non-Detect  Not Sampled

Approximate data through 07/31/2019
HWRB/DWGB PFAS Data

Maximum Wastewater-Related Impacts in Groundwater Monitoring Wells

(Not compliance boundary violations)

**46% of Groundwater Discharge Sites that Sampled Exceed NH’s New MCL/AGQS**

**10% of Release Detection Sites that Sampled Exceed NH’s New MCL/AGQS**
HWRB PFAS Data

172 of 187 Screened for PFAS

**73% of Landfills Sampled Exceed NH’s New MCL/AGQS**
Unlined Landfills

Sites Sampled | % Sites > AGQS
--- | ---
163 | 75%

Approximate data through 07/31/2019
NHDES Laboratory Initiatives/Requirements

• Has completed numerous double blind proficiency testing & split-sample studies

• For public water system testing requires NELAP accreditation

• Accepts proprietary isotope dilution methods or EPA methods

• Reporting limits of 2 ppt for public water systems and 5 ppt for waste sites required

• EPA methods currently do not include PFBA

• Working with other state drinking water and accreditation programs to develop <10 ppt proficiency testing program
Acknowledgements

Thank you!

Kate Emma Schlosser & Amy Doherty
NHDES Waste Division
PFAS Background References

NHDES Website

https://www4.des.state.nh.us/nh-pfas-investigation/

ITRC

- Fact Sheets
  https://pfas-1.itrcweb.org/
- Education and training
Moderated Discussion

Moderator: Peter Durning, Mackie Shea Durning

Panelists:

• Kathleen Baskin, MassDEP
• Laura C. Green, Green Toxicology LLC
• Brandon Kernan, New Hampshire DES
• Rob Little, Woodard & Curran

Environmental Business Council of New England
Energy Environment Economy