What’s in the Water? Data Packet

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Introduction: Use the information in this packet to complete activities in Lessons 3. This packet contains data and information from a variety of sources, collected using a variety of methods. While this reference is not sufficient for achieving a complete understanding of the complex issues surrounding exposure to PFAS and potential health impacts linked to such exposure, it should provide a solid foundation. You may find it necessary to conduct more research in order to better understand specific issues discovered in this packet. Individual datasets and information are cited with the data as well as at the end of this packet.

As you work with the data provided in this packet, please remember:

- As of 2020, there are NO state or federal regulations on the PFAS family of chemicals. As you consider the data below, it may be helpful to know what the EPA has issued a non-enforceable, non-regulatory health advisory limit for PFAS at **70 parts per trillion (ppt)**. This limit is suggested in order to provide Americans with “a margin of protection from a lifetime of exposure to PFOA and PFOS from drinking water”.
- This Data Packet provides a “snapshot” of the current knowledge on the topic. There are many, many more studies that will support and/or negate the findings shown here. The information provided here represents a range of information that has been gathered by numerous scientists around the world, but it is not exhaustive or conclusive.

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Detection Data

Source 1: Herkert et al (2020)

Source 1.1: Source water concentrations for different water utilities

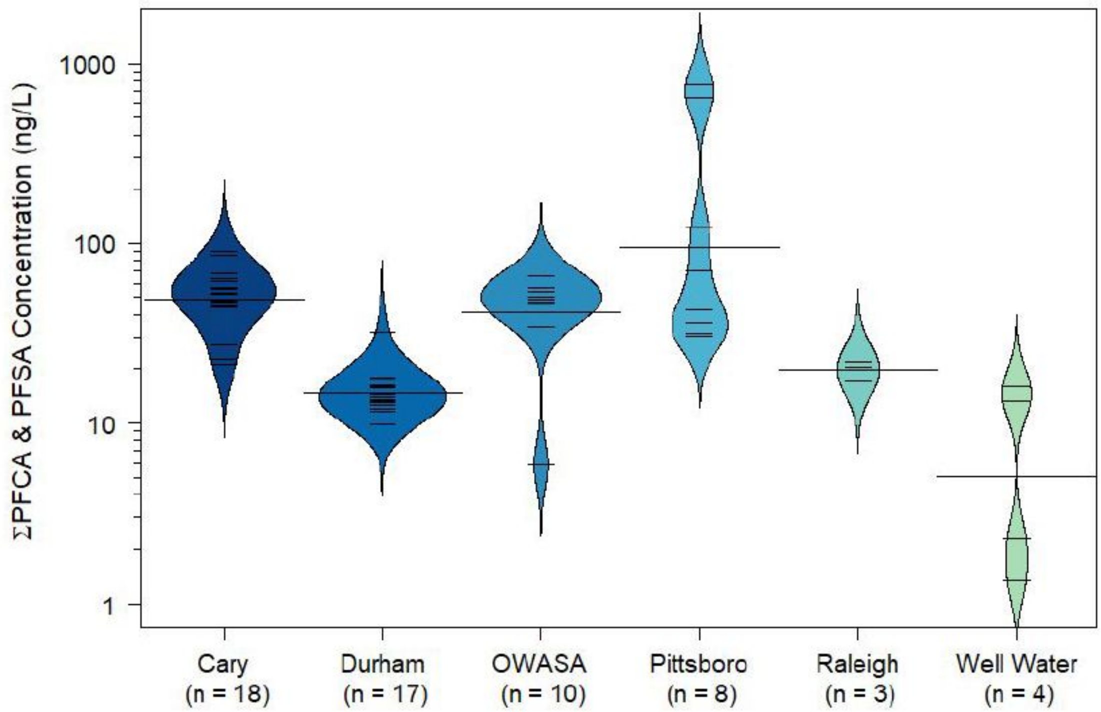

Figure S1: Source water concentrations for different water utilities.

Source 1.2: Map of PFAS profiles from different drinking water sources

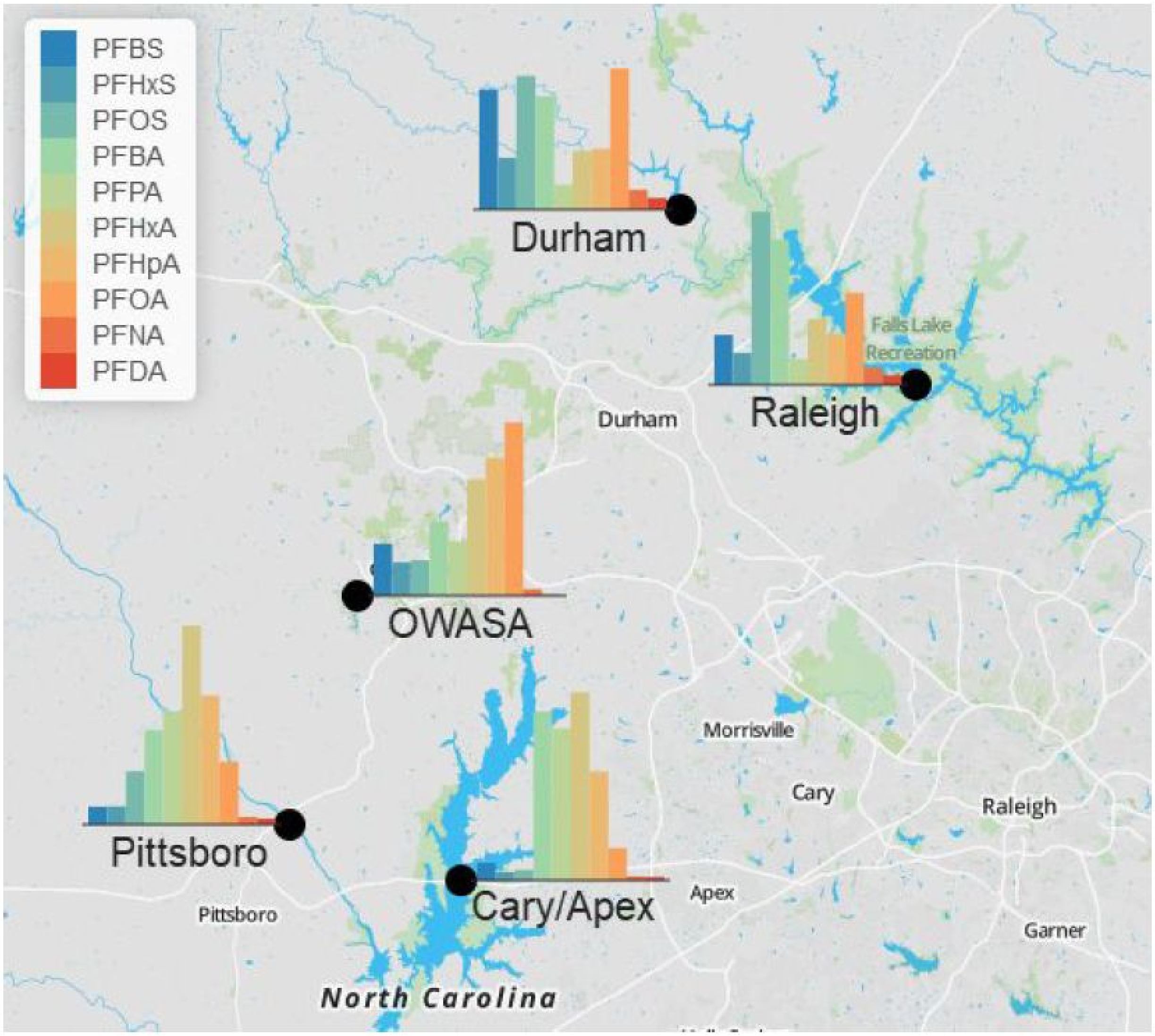

Figure S3: Map of PFASs profiles from different drinking water sources.

Source 2: Haw River Assembly Data

Source 2.1: Slides from September 2018

Haw Riverkeeper Sample Collection

- 6 sites in Haw Watershed for PFAS and non-targeted sampling
- 10 sites in Haw watershed for 1,4 Dioxane
- Samples collected since December 2017
- Monitoring below suspected sources and at confluences in order to track

Source 2.2: PFAS chemicals in Haw River samples

PFAS data

Sample ID	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFBS	PFHxS	PFOS	Totals
Haw001	25	58.6	68.2	34.4	33.8	<MRL	<MRL	20.1	12.2	33.2	**285.5**
Haw002	50.5	116.5	155.6	117.9	43.2	<MRL	16.3	15.5	<MRL	30.4	**545.9**
Haw003	86.5	244.4	321.3	253.6	73.2	12	18.7	13.5	11.2	41.7	**1076.1**
Haw004	17	32.1	26.9	26.5	16.5	<MRL	<MRL	10.2	<MRL	19.4	**148.6**
Haw005	80.7	205.3	220.2	161.9	39.2	<MRL	<MRL	14.5	<MRL	18.2	**740**
Haw006	15.1	21.1	18.9	11.6	<MRL	<MRL	<MRL	<MRL	<MRL	<MRL	**66.7**

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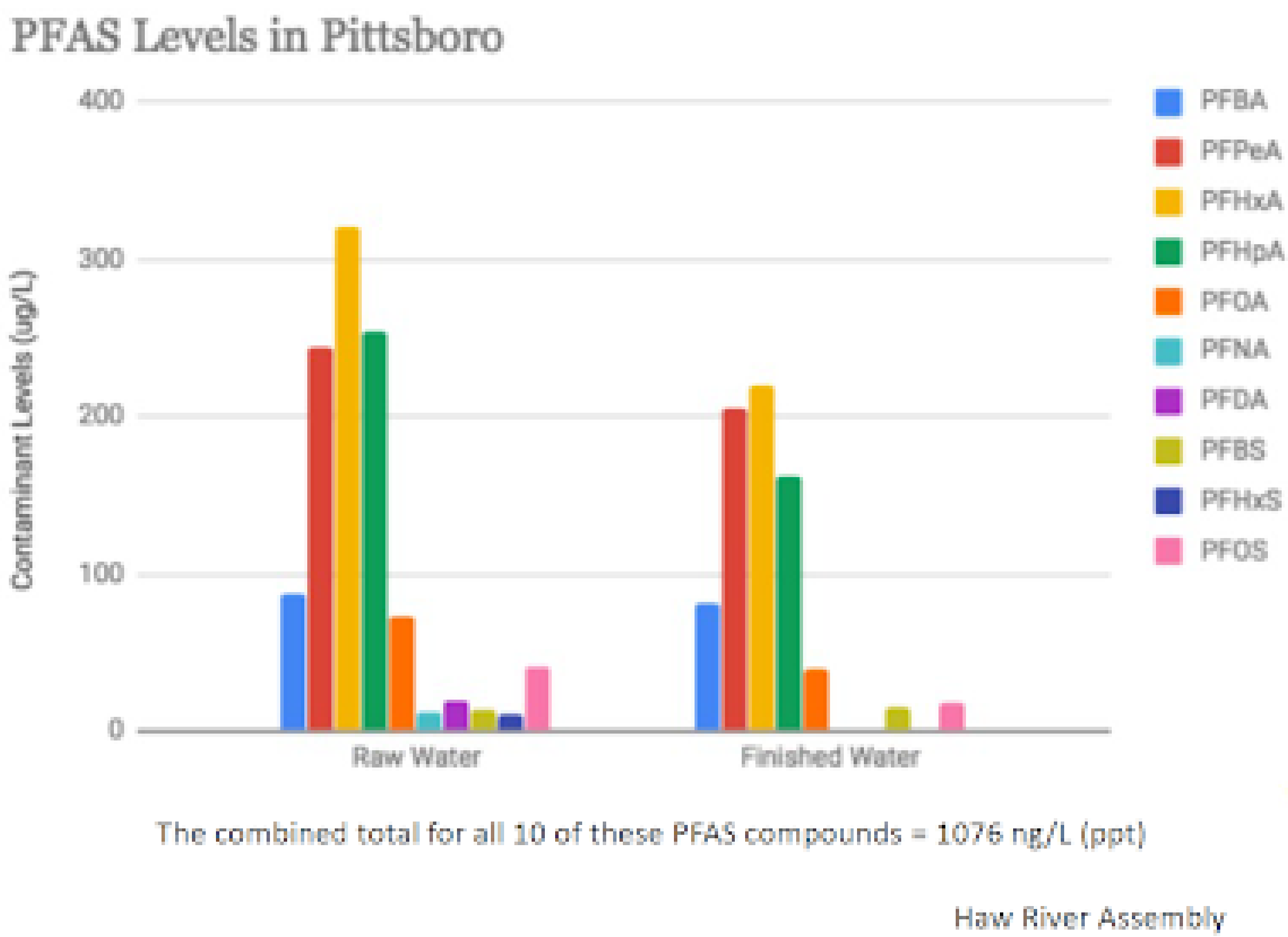
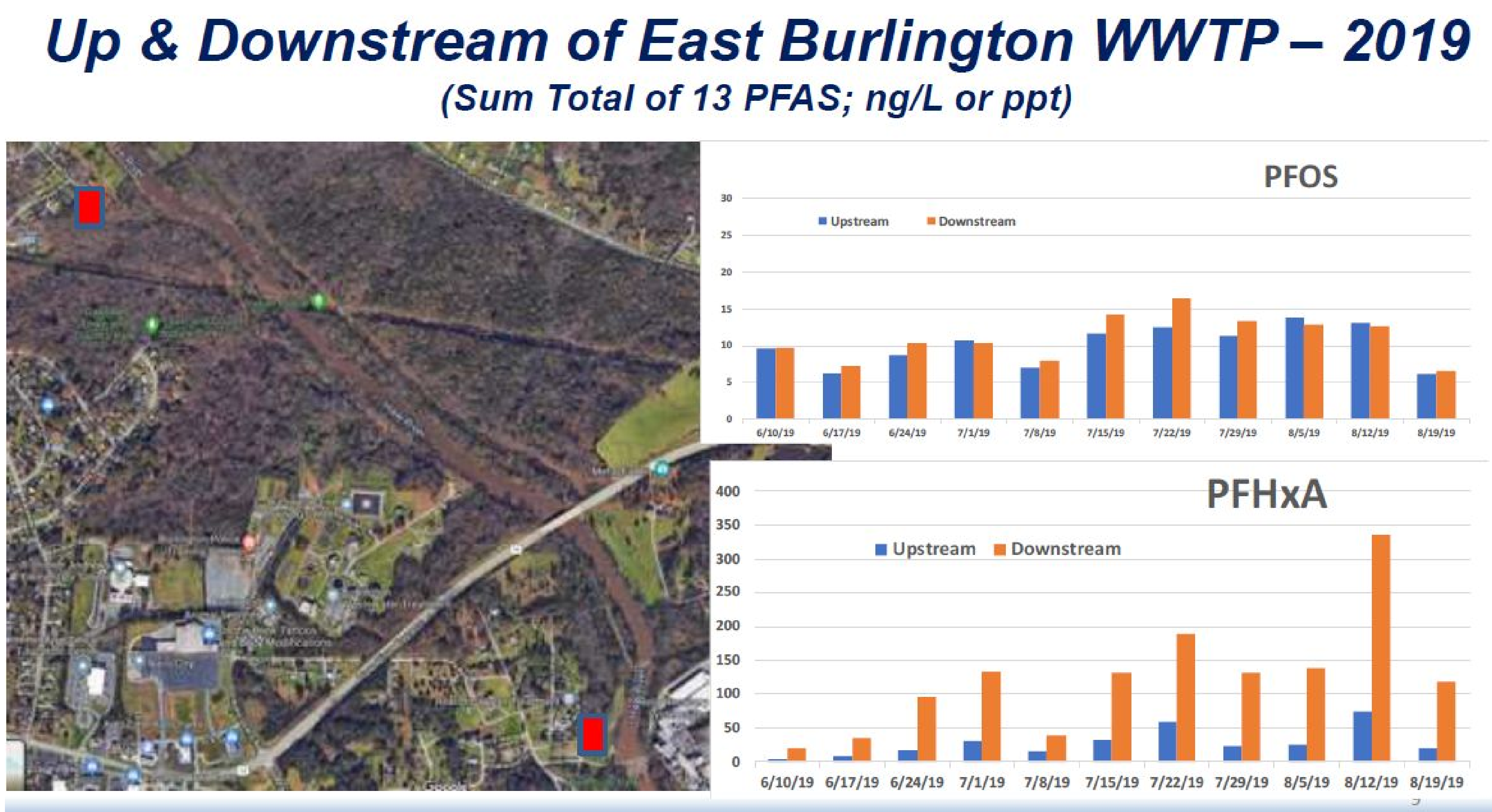
Source 2.3: PFAS Levels in Pittsboro

Data from Haw River Assembly (Presented by Heather Stapleton in Feb. 2019)



Source 3: Data from Duke and UNC

Source 3.1: Upstream and Downstream PFAS Data



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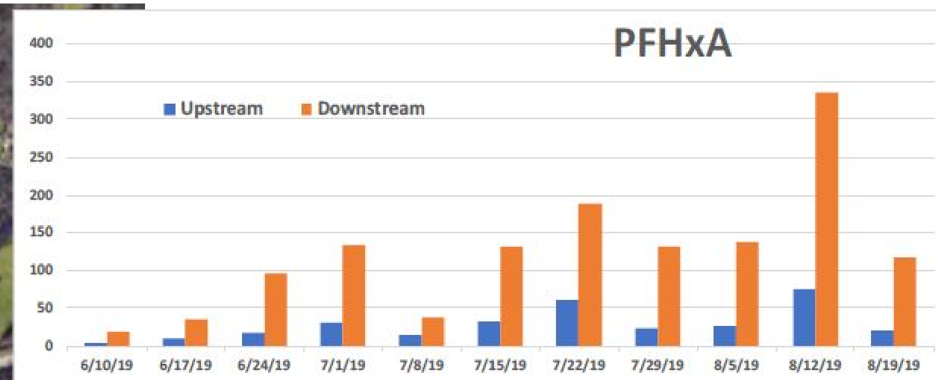
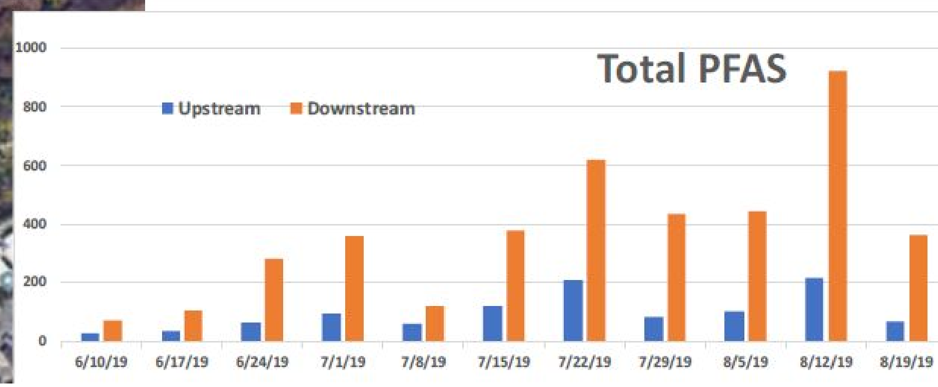
Up & Downstream of East Burlington WWTP – 2019

(Sum Total of 13 PFAS; ng/L or ppt)





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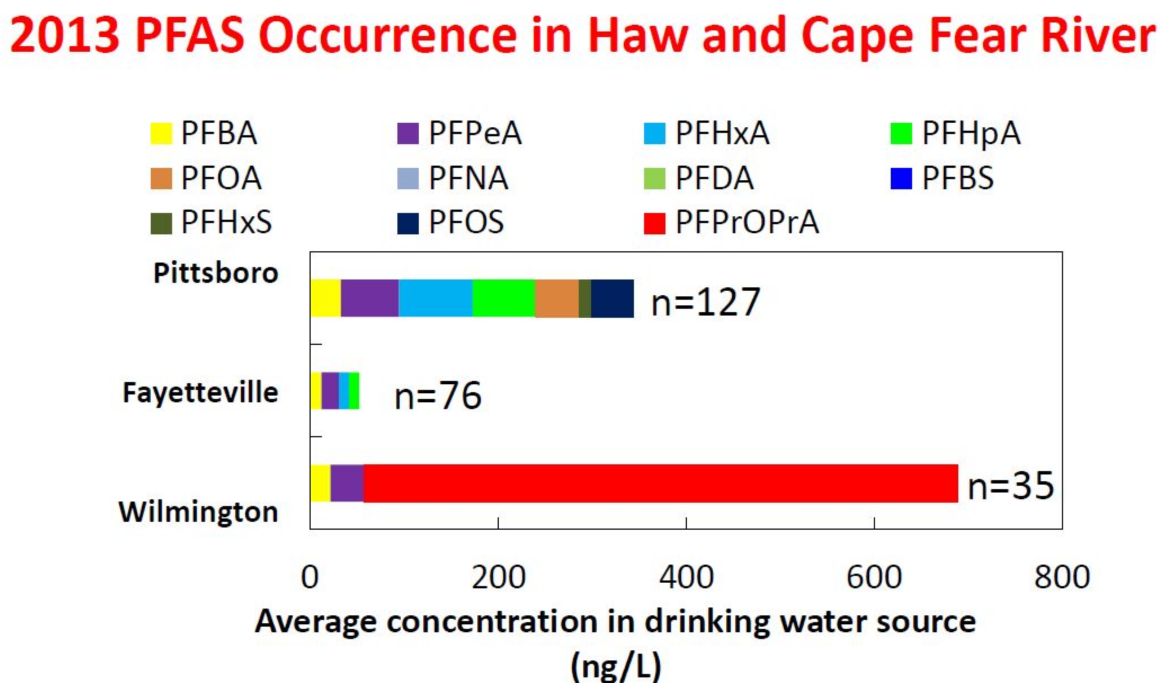
Source 3.2: Preliminary Data implications

Preliminary PFAS Data Suggests

- East Burlington WWTP is a source of PFAS to Pittsboro drinking water
  - Need to assess impact of rainfall/evaporation
  - Influence of biosolids application along river or other point sources
- PFAS "Fingerprint" is unique along the Haw River, comprised primarily of shorter chain (e.g. C4-C7) carboxylic acids
- EPA Health Advisory is currently established for PFOS and PFOA (C8 chain length)

Source 4: PFAS in the Haw and Cape Fear River (2013) from Duke and UNC

Source 4.1 PFAS Occurrence in the Haw and Cape Fear River (2013)



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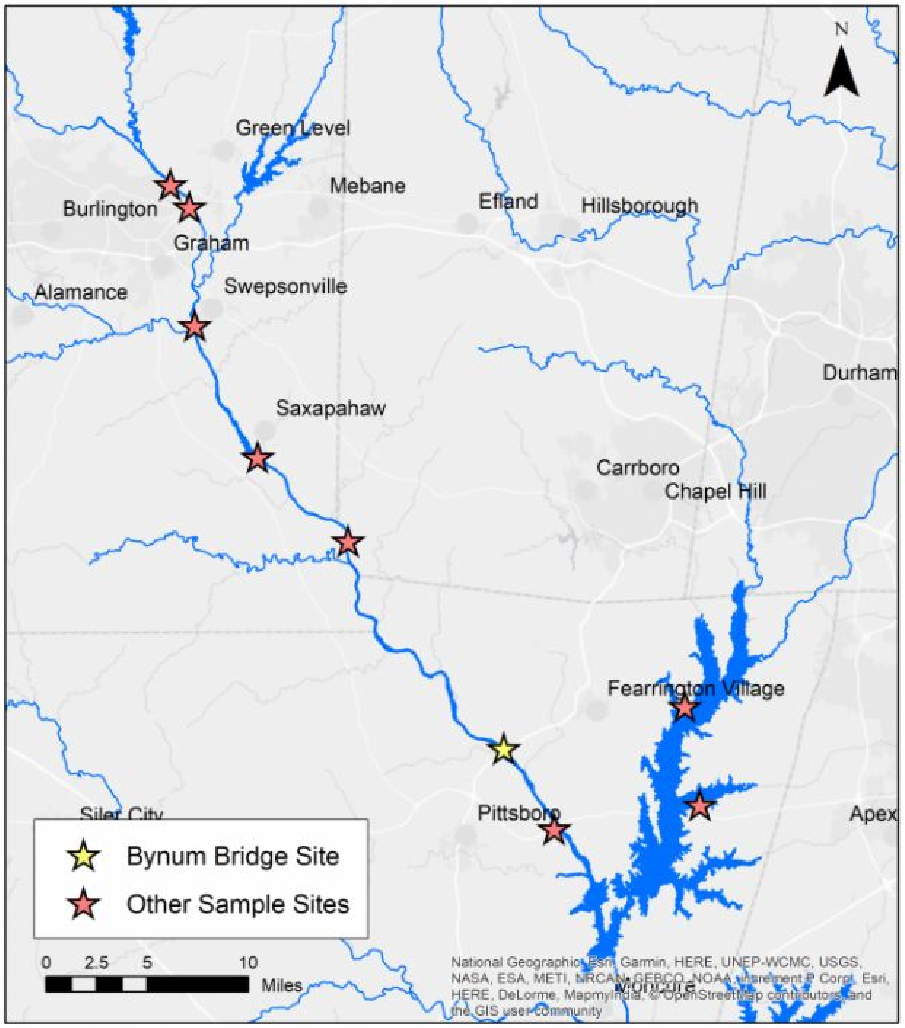
Citizen Exposure Data

Source 5: Stapleton Lab, NC PFAS Exposure Study (Duke)

Figures in this section are from the Stapleton Lab website and screenshots from the Pittsboro Town Hall meeting zoom recording.

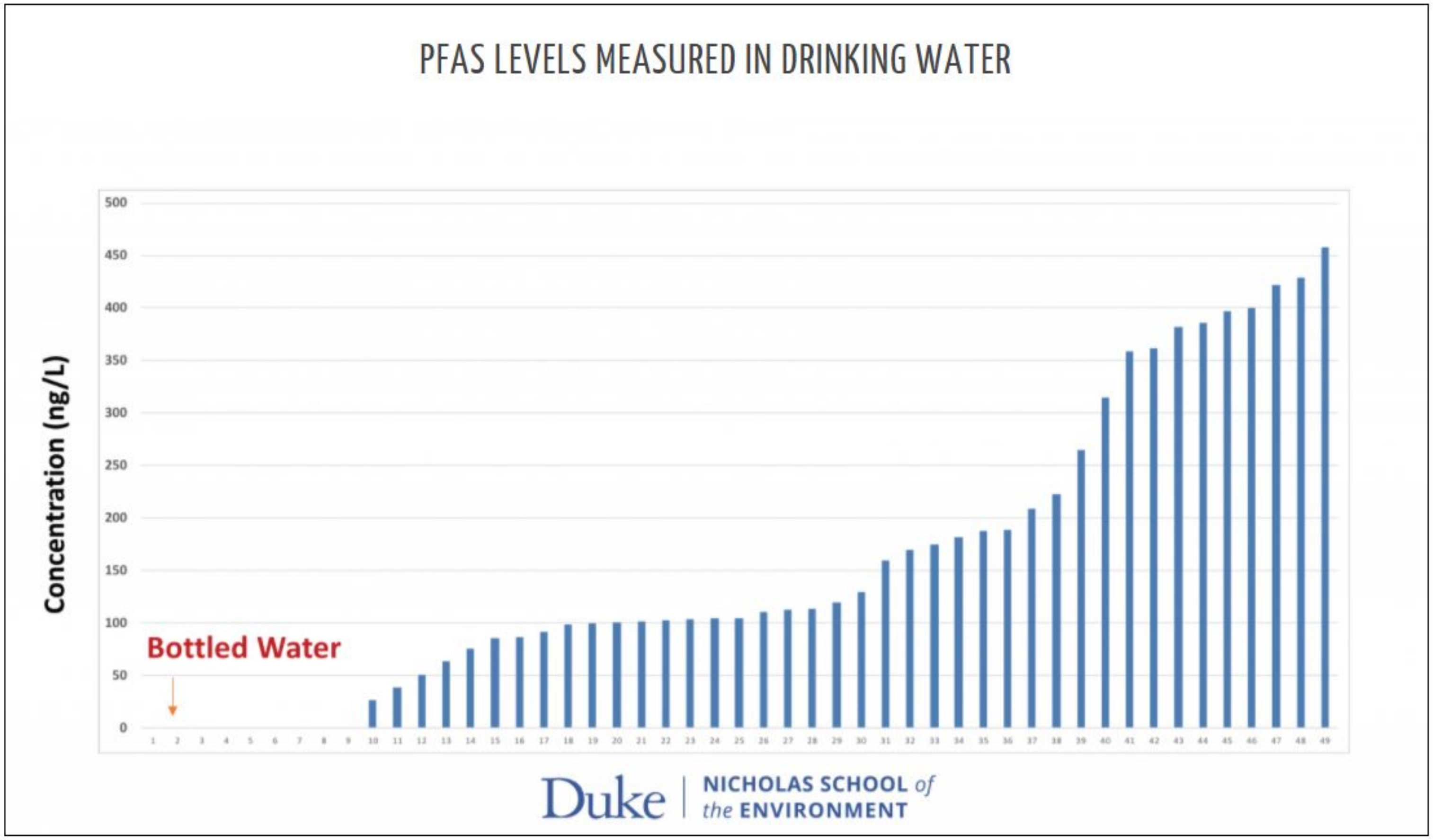
Source 5.1: Map of water sample sites



WATER SAMPLE SITES ALONG THE HAW RIVER

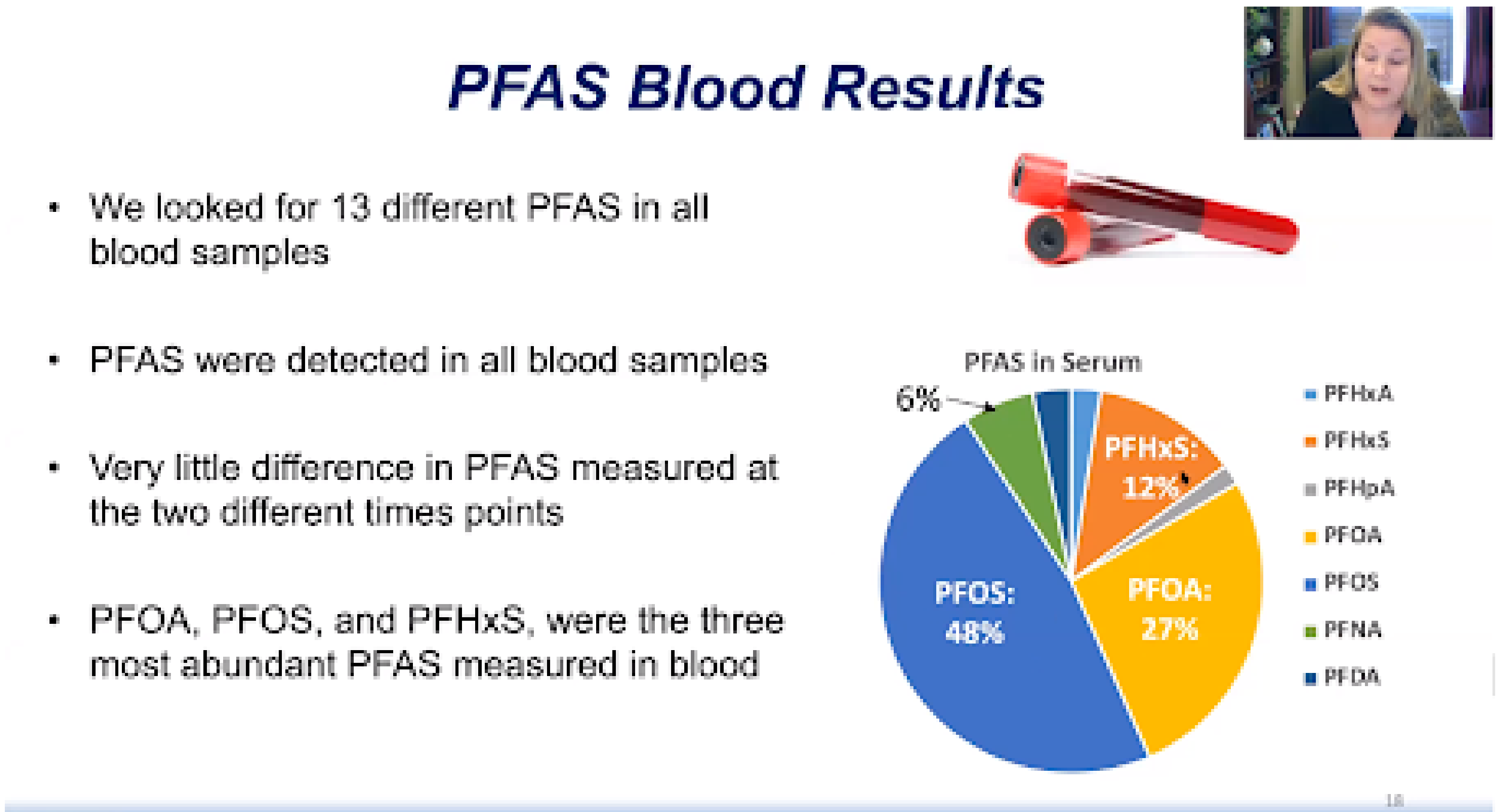
Our research team has been sampling the sites marked with stars on this map weekly since June of 2019. After collecting the water samples each week, they are analyzed for PFAS and recorded in order to study how PFAS levels change over time. The graph below shows our measurements of PFAS over time, collected at the Bynum bridge sampling site, indicated on this map with the yellow star.

Source 5.2: PFAS in Pittsboro Residents' Drinking Water



This figure represents the total amount of PFAS measured in the 49 drinking water samples collected from each study participants' home. Values ranged from not detectable to 452 ng/L. Note that these values are higher than the EPA health advisory limit of 70 n/L. The type of water filter used in each home likely impacted the observed variability.

Source 5.3: PFAS in Residents' Blood



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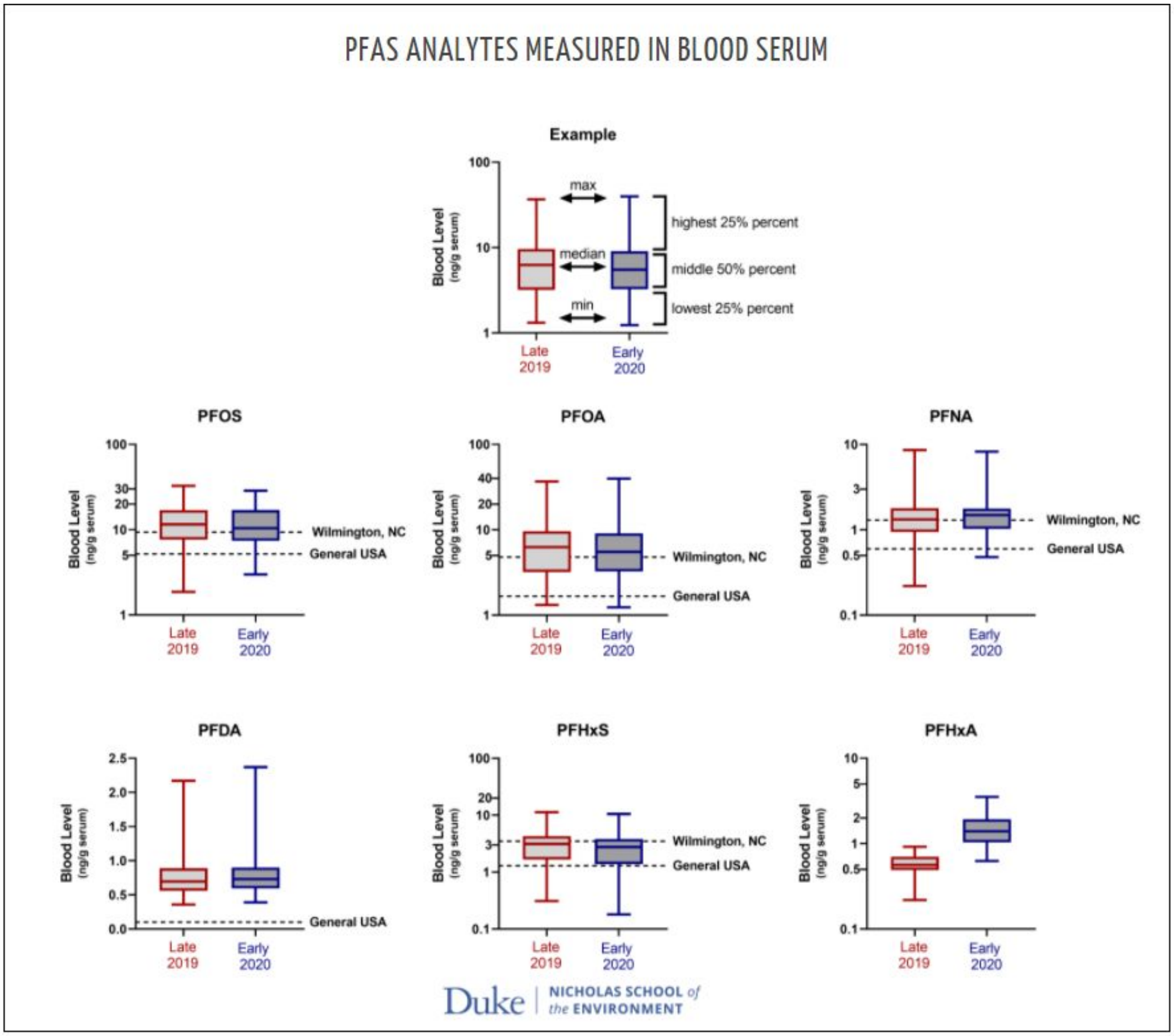

This figure shows boxplots for 6 PFAS analytes measured in blood from the PFAS Exposure Study. Blood was collected from 49 participants in total, and both of our collection timepoints are shown. Solid lines on the boxplot depict minimum, median, maximum, and 25th and 75th percentile levels. Dashed lines represent the median blood levels reported from two other adult populations: Wilmington, NC (Kotlarz et al., 2020) and General US population (NHANES 2015-2016)

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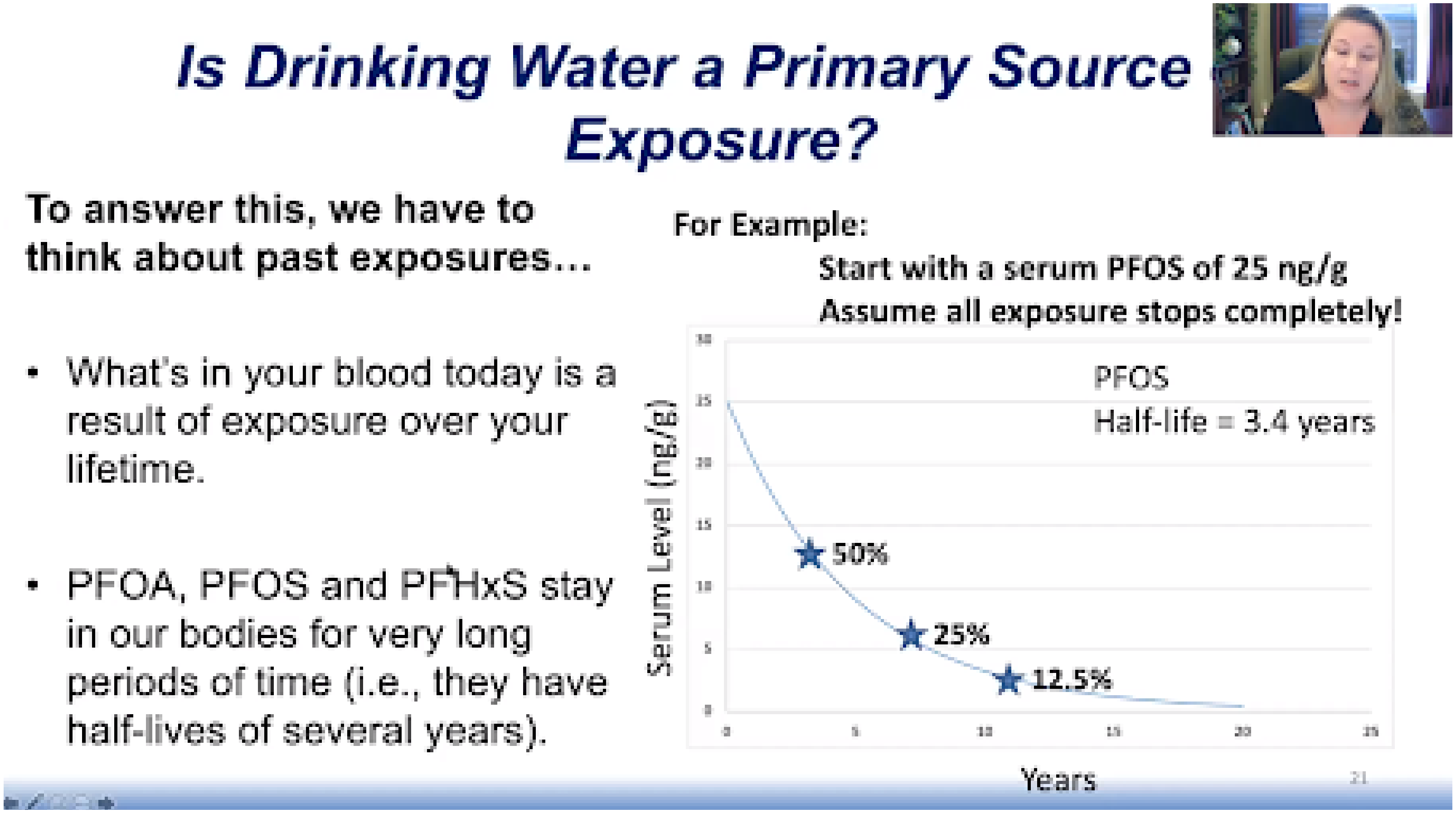
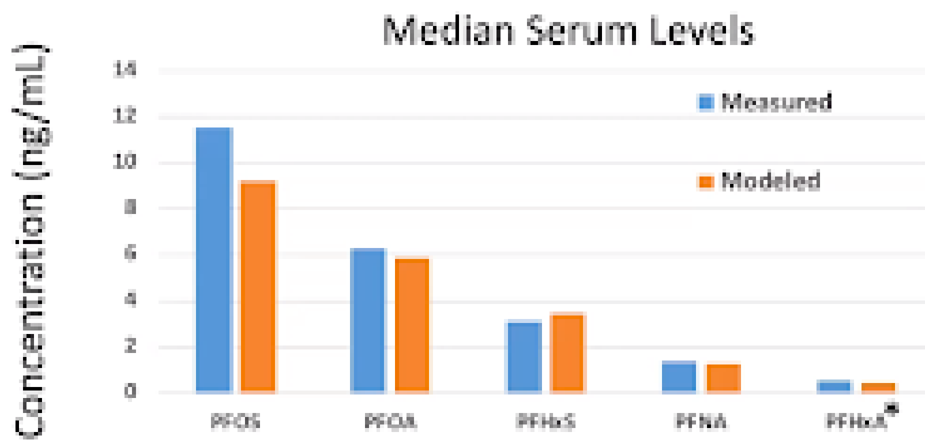


Note: The amount of PFAS in a person's blood is a reflection of their exposure over **time, not just when the blood was measured.** Many PFAS chemicals have a very long half life. In other words, it takes YEARS for it to leave the body.

Is Drinking Water a Primary Source of Exposure?

Yes, we believe so.

- Computer modeling, using historical water levels, estimates blood levels fairly accurately.
- Blue bars represent modeled serum levels using data collected from the Haw River in 2013 (Sun et al. 2016)



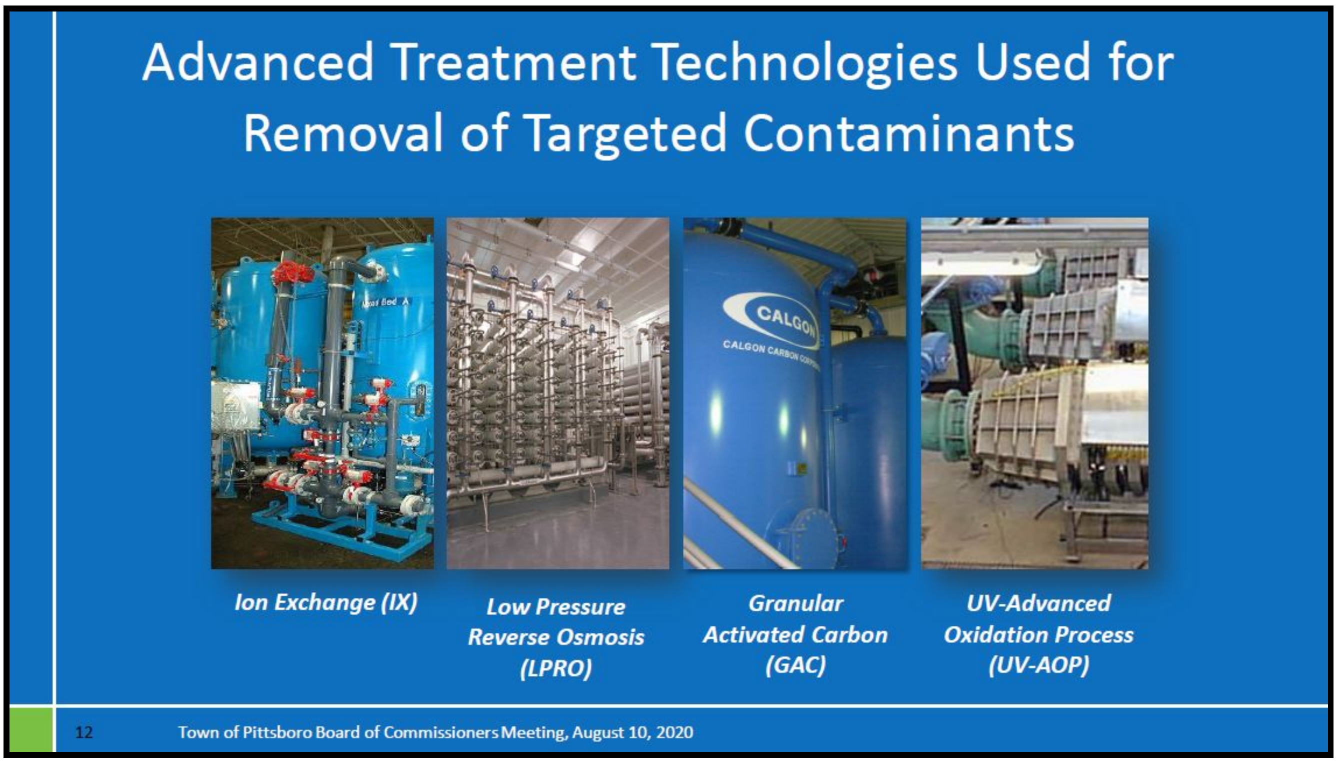
* Modeled assuming half-life of 3 months

Remediation Options

Source 6: CDM Smith Pilot Data

Background: CDM Smith is a private engineering consulting firm that was hired by the Town of Pittsboro to address the issue of contaminated water entering the Pittsboro Water Treatment facility. The slides below are from a series of presentations in which representatives from CDM Smith presented their findings and recommendations to the Mayor and Board of Commissioners after completing a pilot study at the treatment plant.

In the presentations, CDM Smith discusses four treatment options that are capable of filtering out several emerging contaminants, including PFAS. The first two slides below show a summary of the treatment types as well as their effectiveness at removing the contaminants of interest.



General Treatment Performance Trends

	Typical Removal Performance [Excellent (>90%), Good (70-90%), Moderate (30-60%), Poor (<30%), Unknown)]				
Treatment Technology	Short Chain PFAS	Long Chain PFAS	1,4 Dioxane	Bromide	EDCs / PPCPs
Reverse Osmosis	Excellent	Excellent	Good	Excellent	Excellent*
Nanofiltration	Good*	Excellent	Moderate	Moderate	Excellent*
Advanced Oxidation Process - UV	Poor	Poor	Good	Poor	Moderate*
Advanced Oxidation Process - Ozone	Poor	Poor	Good	Poor	Moderate*
Ozone – Biofiltration	Poor	Poor	Moderate	Poor	Excellent*
Ion Exchange*	Excellent**	Excellent	Poor	Good*	Poor*
Granular Activated Carbon*	Good**	Excellent	Poor	Poor	Excellent*

* Varies pending the compound ** Performance depends on change-out frequency

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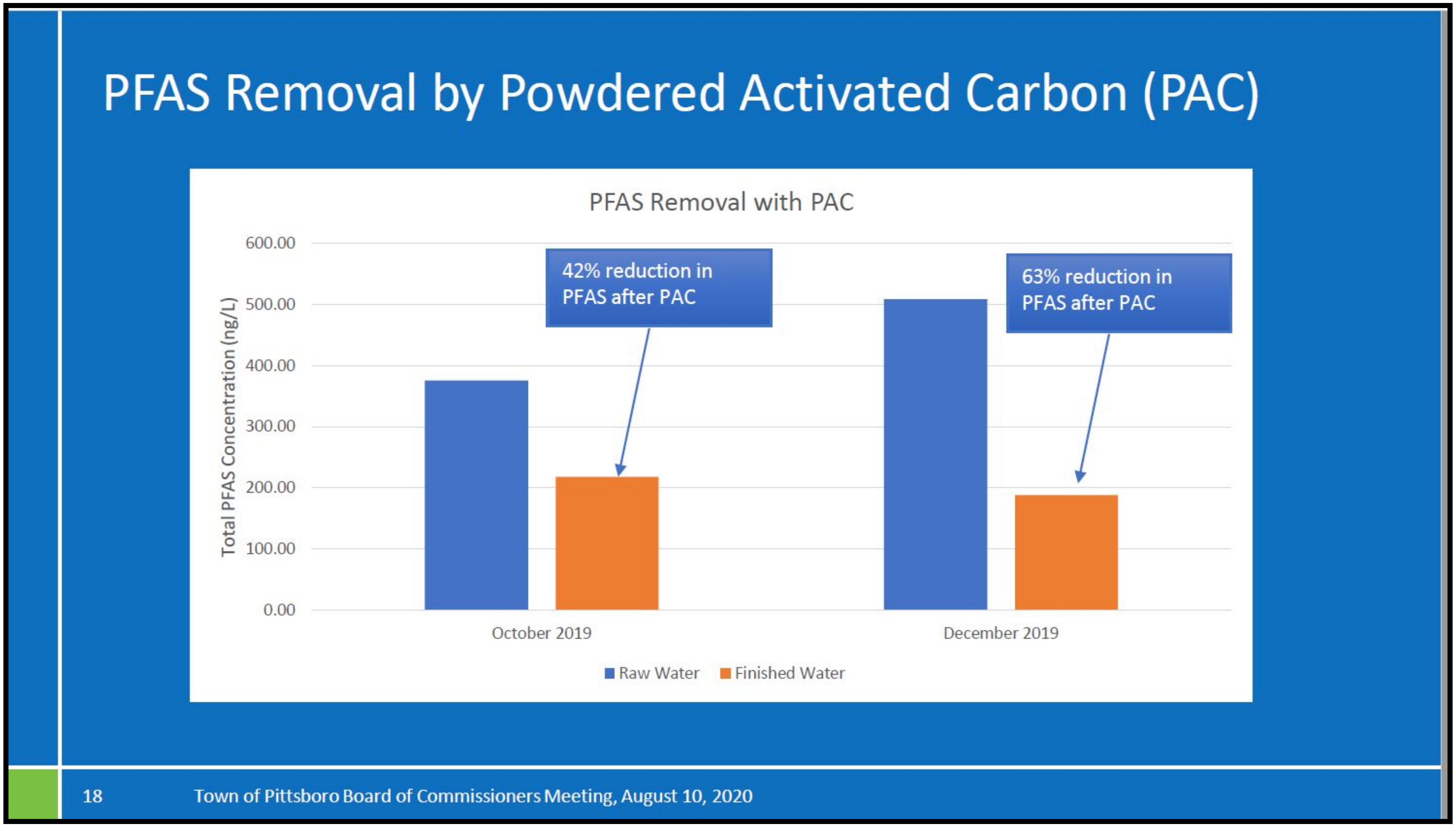
The slide below shows the impact of an ongoing treatment (from 2016), Powdered Activated Carbon (PAC), which is effective at reducing PFAS to a certain degree.



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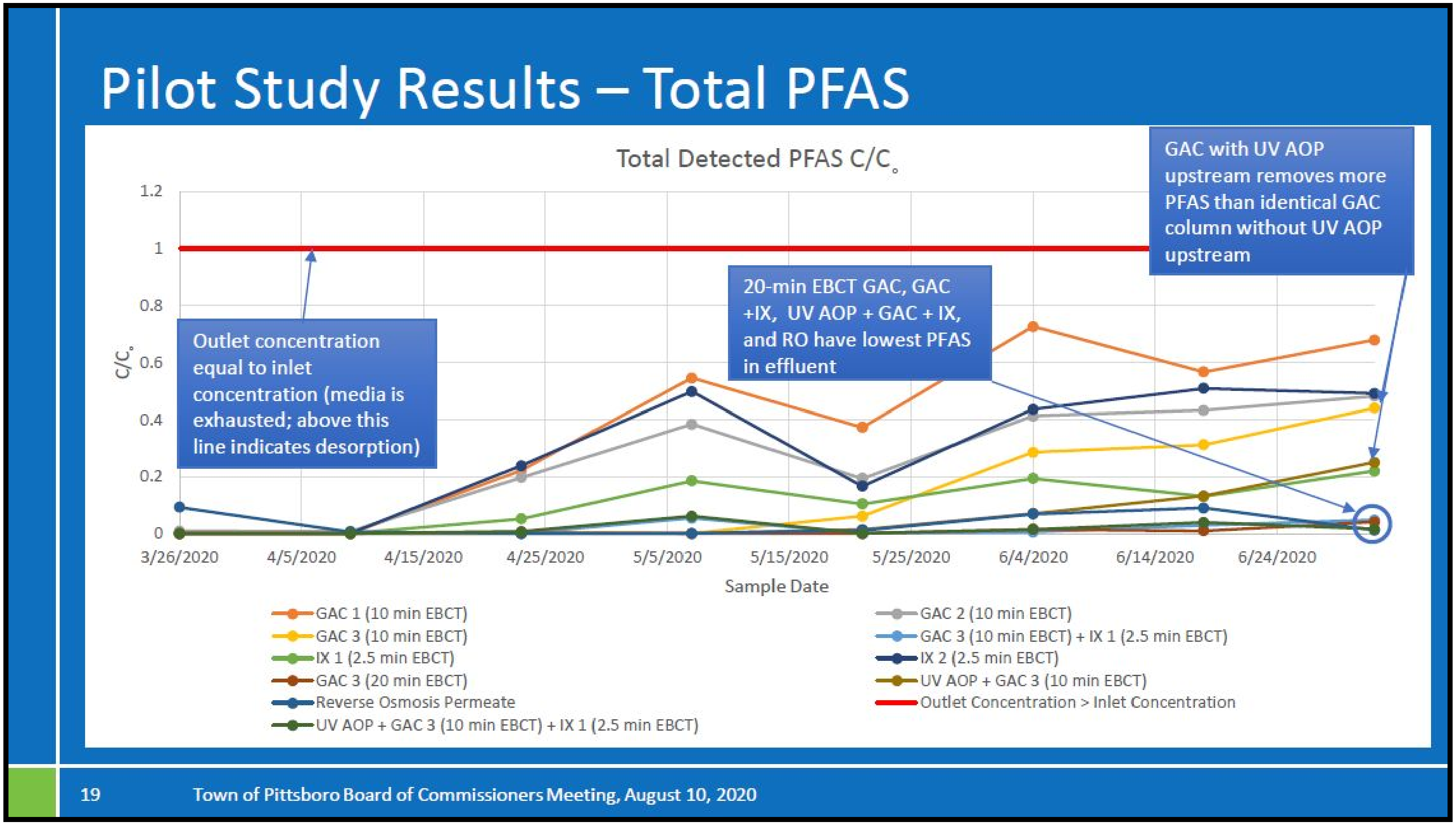
The slide below shows the results of all four treatment options. Each line shows how well each treatment option removes total PFAS. The red line at 1 represents the point at which the system is “exhausted”. In other words, the technology is no longer effective. So, the lower the line, the better.



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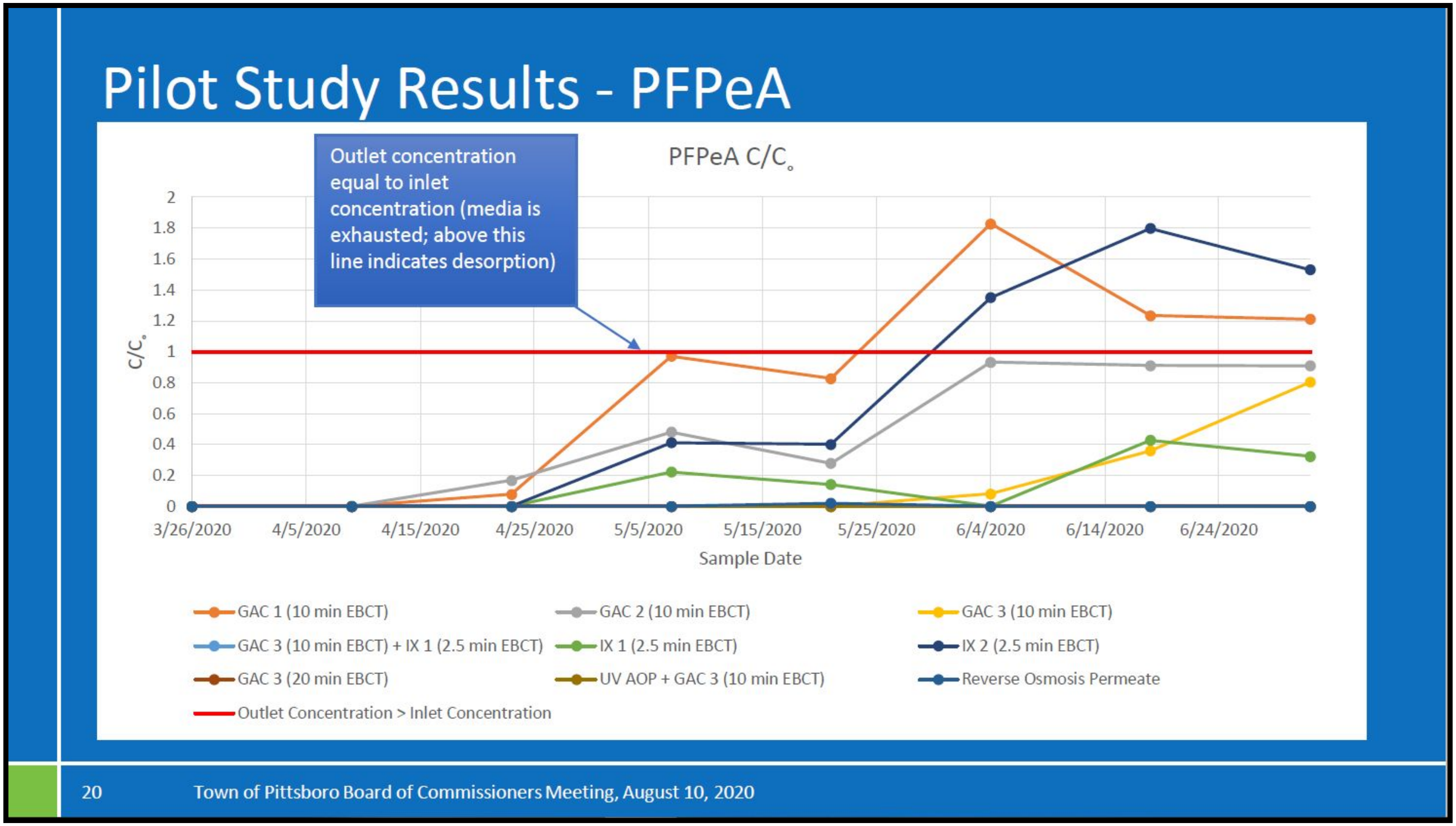
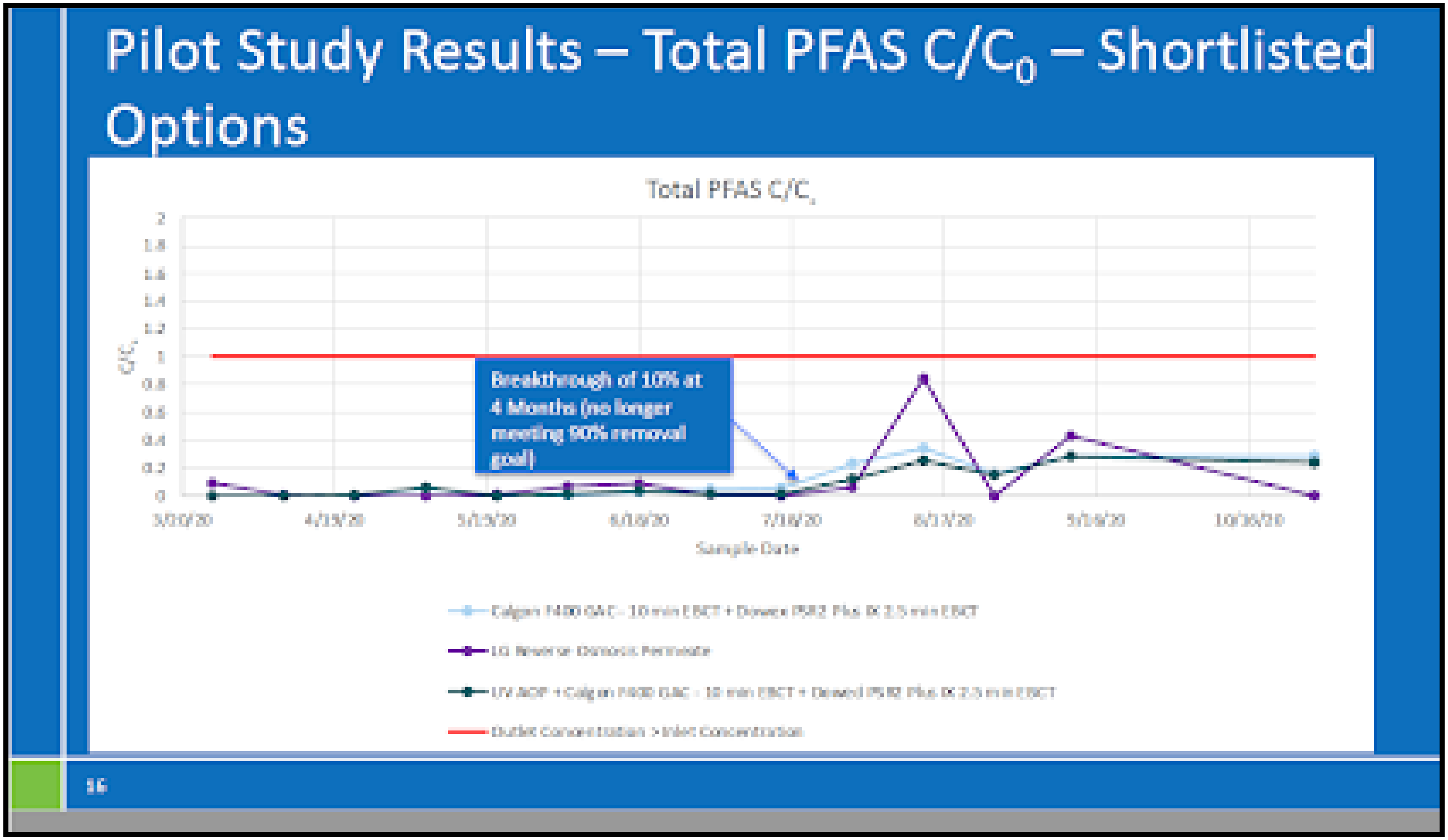
The slide below is similar, but only shows effectiveness against one type of PFAS called "PFPeA", which is a shorter-chain PFAS compound. Studies suggest that short-chain PFAS compounds are becoming more common in industry. They are also more difficult to detect.



Source 7: CDM Smith Cost Analysis

The slides below were presented to the Board of Commissioners on January 11, 2021. The first shows the performance of the three “shortlisted” treatment options. The light blue line is GAC and Ion Exchange, the purple line is Reverse Osmosis, and the dark green line is GAC and Ion Exchange with an additional Ultraviolet treatment. Recall, the lower the line, the more effective the treatment option.


Pilot Study Results – Total PFAS C/C0 – Shortlisted Options
Total PFAS C/C0
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Breakthrough of 10% at 4 Months (no longer meeting 90% removal goal)
Sample Date
LG Reverse Osmosis Permeate
Outlet Concentration > Inlet Concentration
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PFAS Conclusions

- Combined GAC+IX and RO demonstrated superior performance, and can achieve a 90% PFAS removal goal
- GAC as a treatment method by itself is less desirable than GAC+IX for some short-chain PFAS
- UV-AOP extended life of GAC for Total PFAS by only 2 to 4 weeks

The following slides show CDM Smith's Total Capital Cost estimates for the three treatment options (GAC + Ion Exchange, GAC + Ion Exchange + UV, and Reverse Osmosis), as well as a Cost Comparison with Advantages and Disadvantages.

Preliminary Conclusions - Total Capital Costs

Post-Treatment	Capital Cost Advanced Treatment to 6 MGD (million $)	Capital Cost Conventional Expansion to 6 MGD (million $)	Total Capital Cost (million $)
GAC + IX	$ 11 - 13	$ 31	**$ 42 - 44**
GAC + IX + UV/AOP	$ 14 - 17	$ 31	**$ 45 - 48**
LPRO	$ 23 RO (plus $ 5-13 for Concentrate)	$ 31	**$ 59 - 67**

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NOTE: "6 MGD" refers to the productivity of the treatment facility based on population size. Since Pittsboro is projected to grow over time, the amount of treated water the town will need is projected to increase over time.

Advanced Treatment Costs and Comparison

Advanced Treatment (Post Filtration)	Capital Cost at 6 MGD (million $)	20-Year Life Cycle Cost (million $)	Advantages	Disadvantages
Combined GAC+IX	$11 - 13 (low end uses outdoor contactors)	$42 - 44	▪ Lowest Cost ▪ Effectiveness ▪ Schedule (3-4 years) ▪ Can Fast-track	▪ Frequent changeout required
Combined GAC+IX+UV/AOP	$14 - 17 (low end uses outdoor contactors	$50 - 53	▪ Moderate Cost ▪ Effectiveness ▪ Schedule (3-4 years)	▪ Frequent changeout required
LPRO	$23 RO $5 - 13 Conc. $28 - 36 Total	$55 - 62	▪ Best Technology ▪ Effectiveness	▪ Higher Cost ▪ Concentrate ▪ Schedule (5+ years) ▪ Site Space

*Costs to expand the existing conventional WTP systems are not included in the table.
** Costs shown in 2020 present worth dollars

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Closing Remarks and Recommendations from CDM Smith

Treatment Recommendations

- Combined GAC+IX is recommended for the Pittsboro WTP
  - It provides superior performance, and can achieve a 90% PFAS removal goal
  - It can be incorporated into the existing WTP most readily, requiring less space
  - It does not require an NPDES permit to be issued by NCDEQ and can be implemented on a shorter timeline when compared to RO
  - It is the lower capital and lifecycle cost option, when compared to RO
  - More efficient use of energy; less wasted water in treatment process, when compared to RO

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References

(In order of appearance in the Data Packet)

Herkert, N., Merrill, J., Peters, C., Bollinger, D., Zhang, S., Hoffman, K., Ferguson, P., Knappe, D., and Stapleton, H. 2020. Assessing the Effectiveness of Point-of-Use Residential Drinking Water Filters for Perfluoroalkyl Substances (PFASs). *Environmental Science & Technology Letters*, 7 (3), 178-184

Haw River Assembly Website and Presentations:
http://hawriver.org/river-issues/industrial-contaminants/

Feb. 2019:
https://pittsboronc.gov/vertical/sites/%7B512CE168-4684-4855-9CD9-7D209FE775E3%7D/uploads/Emily_Suttons_PPT_021119.pdf

Sept. 2018:
https://pittsboronc.gov/vertical/sites/%7B512CE168-4684-4855-9CD9-7D209FE775E3%7D/uploads/_ECC.Haw.TownBoC92F24.pdf

Heather Stapleton and Detlef Knappe Feb. 2019 Presentation to the Pittsboro Board of Commissioners: (Google Drive link: https://drive.google.com/file/d/1IfZx1xoiZRvRqVQthMTv1ku1iPYL4QCH/view?usp=sharing)

Stapleton Lab, Duke University, NC PFAS Exposure Study:
~~https://sites.nicholas.duke.edu/stapletonlab/research/pfas-research/pfas-exposure-nc/~~

CDM Smith, August 2020 presentation:
~~https://pittsboronc.gov/vertical/sites/%7B512CE168-4684-4855-9CD9-7D209FE775E3%7D/uploads/2020-08-10_CDMSmith.pptx~~

CDM Smith, January 2021 presentation:
~~https://pittsboronc.gov/vertical/sites/%7B512CE168-4684-4855-9CD9-7D209FE775E3%7D/uploads/CDMSmith_Pittsboro_BOC_PPT_2021-01-11_FINAL.pdf~~