Background Guide for Instructors
What's in the Water? Lesson 3: The Economic Challenges of Clean Water
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Introduction
This lesson will focus on two primary objectives:

1) What are the possible solutions for eliminating PFAS from the town's drinking water?
2) Who should bear the economic responsibility of making the water safer?

Background Information: Local remediation options
The EPA provides a broad overview of remediation options in their 2018 posting here. The three most common options to remove PFAS at the treatment-plant level are listed below. The table on the next page provides more details about each option. The engineering firm, CDM Smith, tested several options at the local water treatment plant in Pittsboro. We will focus on the three listed below only. Several tradeoffs must be addressed including, cost, effectiveness, waste, infrastructure limitations, and energy use.

Students will study a figure from their presentation to guide their discussion of the pros and cons of each option. The instructor should help students focus on the tradeoffs as they work their way through the pilot study data. Several topics related to environmental justice become relevant here. For example, more expensive options may be more effective at removing PFAS, but could result in higher water bills for residents. Without grants or other assistance, the town may have no choice but to pass the cost down to water consumers. A cheaper option may mean inequities in terms of water quality, as higher-income residents may opt to further treat their homes with RO or other filters, leaving those without such resources without additional options. Such discrepancies could disproportionately impact already marginalized populations (people of color and low income communities), who are already more likely to be subjected to Safe Drinking Water Act (SDWA) violations (see "Watered Down" report which students will explore in Lesson 4).

PFAS Removal Options:

- Activated carbon adsorption (e.g. **granular activated carbon**, or GAC)
- **Ion exchange resins**
- High-pressure membranes (e.g. **Reverse Osmosis**, or RO)

Table of Treatment Options

Treatment	Description	Mechanism	Benefits	Trade Offs
GAC	Highly porous raw organic material	Adsorption: provides a large	Most-studied, commonly used to	Does not work well on shorter

	(coconut shells, coal, etc.) that is heated to increase surface area	surface area to trap contaminants	treat other organic compounds Effective on long chain PFAS	chain PFAS (e.g PFBS, PFBA) Requires periodic replacement
Ion Exchange	Tiny beads made from hydrocarbons	Adsorption and ion exchange: Anion resins attract negatively charged PFAS molecules	No contaminant waste to handle or dispose	Product must be incinerated
Reverse Osmosis	Layer of permeable membrane	Size: exclusion:	Effective on wide range of PFAS, including short chain	Productes concentrated waste stream Most energy intensive

Helpful visuals of how granular activated carbon, ion exchange, and reverse osmosis work are available from ect$_2$, an environmental consulting firm and other resources. For Granular Activated Carbon, also see video from Scottsdale, AZ water treatment plant.

Overview of Data Sources for Students

CDM Smith Data: The town of Pittsboro commissioned an independent consulting firm to conduct a study of its current water treatment facilities. Initiated in 2015, the goal of their work was two-fold: (1) assess the infrastructural needs of the town in light of anticipated population growth and (2) consider solutions to filter several unregulated contaminants being detected in the town's water source, the Haw River. Contaminants of concern include 1,4 dioxane, bromide, and the PFAs family of chemicals. The information and data reported in the students' Data Packets provide information about a pilot study completed at the Pittsboro Water Treatment Plant. The study assessed the effectiveness of several filtration systems on removing the contaminants of concern. CDM Smith attended several Board of Commissioners meetings from 2018 through January of 2021 to discuss the results of the pilot study and to share a cost analysis with town leaders.

Pittsboro Mayor and Board of Commissioners: Several sources of information have been provided to the Mayor and Board of Commissioners about the exposure, risks, and remediation options available to protect residents from emerging contaminants. Some of that information is provided in the students' Data Packet, and the students may also benefit from looking at the information in its original location. (NOTE: this would be a wonderful place to discuss the role of

local government in proper disclosure of information, accessibility issues pertaining to the sharing of such information, etc.)

Haw River Assembly: Spearheaded by the Haw Riverkeeper, Emily Sutton, the Haw River Assembly has continuously monitored the presence of emerging contaminants in the Haw and have worked to education both the Board and the residents that use the Haw River for drinking water and recreation about the dangers of exposure to such emerging contaminants. Data from their monitoring efforts are included in the students' Data Packet

Duke/NC State Data: Drs. Heather Stapleton and Detlef Knappe have led efforts to quantify PFAS in the Cape Fear and Haw Rivers, and have documented exposure over the past several years. Presentations and research papers shared in this lesson include the concentration of PFAS chemicals in various towns and cities in the region, PFAS profiles (the specific types and concentration of PFAS chemicals) in various municipal and/or household sources both upstream and downstream from known industrial polluters, and blood serum data showing the concentration of PFAS in the blood of NC residents. Their labs are among several that have been vocal about the levels of PFAS being detected in the region. They work in collaboration with other research labs as part of the NC PFAS Testing Network.

Glossary of Important Terms

upstream: pertaining to an area situated opposite the flow of a stream or river

downstream: pertaining to an area situated in the direction of the flow of a stream or river

ppt (parts per trillion): refers to the concentration of a substance in a liquid. THe concentration of chemical contaminants in bodies of water are often described using these terms. May also be referred to as **ng/L (nanograms per Liter)**

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ion exchange (IX) - the removal of a molecule or compound from a substrate due to its attraction to an oppositely charged material

granular activated carbon (GAC) - highly porous organic material capable of adsorbing to compounds of interest

UV-Advanced Oxidation Process (UV-AOP) - a chemical treatments used to disinfect and treat contaminant

reverse osmosis (RO)

- Note: may also be referred to as LPRO (low-pressure reverse osmosis)

References

EPA: “Reducing PFAS in Drinking Water with Treatment Technologies”
https://www.epa.gov/sciencematters/reducing-pfas-drinking-water-treatment-technologies

Town of Pittsboro, NC:

- Water Quality Task Force Final Report (also saved in our Google Folder): https://pittsboronc.gov/index.asp?Type=B_BASIC&SEC={E3E5DE9C-8AA7-4D9F-BFF4-6C78E6B4044B}
- Other public access documents related to emerging contaminants: https://pittsboronc.gov/index.asp?Type=B_BASIC&SEC={E3E5DE9C-8AA7-4D9F-BFF4-6C78E6B4044B}

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

Natural Resources Defense Council (NRDC), Coming Clean, and the Environmental Justice Health Alliance (EJHA), “Watered Down Justice”
https://www.nrdc.org/sites/default/files/watered-down-justice-report.pdf

NC PFAS Testing Network: https://ncpfastnetwork.com/

Lesson 3: The Economic and Regulatory Challenges of Clean Water
Lesson Overview and Timeline

Materials/Resources: ● Lecture slides ● Student devices to access web resources (Data Packet) ● Markers/whiteboards or large sketch paper	
Learning Objectives ● Analyze the costs and benefits of local efforts to treat water contamination	
Timeline (80 minutes) 1. Opening Lecture/Discussion (25 Minutes) 2. Activity 1 (25 Minutes) 3. Synthesis/Reflection (10 Minutes) 4. (open-ended capstone project work time) 5. Announcements/Closing (5 Minutes)	**Notes**:
Deliverables: ● HW Reflection on Haw River data ●	

Pre-class Assignment

Introduction:
In order to have a meaningful discussion about how best to deal with emerging chemicals in the Haw River and their impacts on Pittsboro residents, we need to better understand the extent to which the residents are being exposed. The purpose of this assignment is to provide an opportunity for you to view PFAS data collected by local scientists in order to decide the severity of the problem in Pittsboro.

Task:
You will be provided a Data Packet that includes a variety of data and information about PFAS in the area. Use the data from Sources 1-5 to reflect on the questions below. Be sure to reference at least three specific figures/tables from the Data Packet to back up your ideas (2 figures/tables can come from the same source, but you should investigate at least two different sources):

- What patterns do you see in the data regarding the location, concentration, and makeup of PFAS chemicals in the Haw River?
- What do we know about the "profile" of the PFAS chemicals being detected in the Haw River? Is it similar to the types of PFAS being detected elsewhere? How might the profile help us understand the origin of the contamination?
- Based on the data, is there cause for concern regarding the presence of PFAS in the Haw River?

Opening Lecture/Discussion

Hook/Engagement: Our PBO resident is growing more concerned, and frustrated, about the water issue in town. She speaks with neighbors and business owners to give mixed information.

Frustrated, she fumbles around on the Towns website, hoping for a clue. She stumbles upon a timeline from the Mayor's office (attached), which suggests that the town leaders have been aware of the problem for several years.

It's been almost a year since she received the vague note in her water bill, and she's anxious for an update. She heard about a pilot study being conducted by an engineering firm, CDM Smith to look into the feasibility of putting in some type of filter at the drinking water facility just north of town. She notices that the Board of Commissioners has a meeting planned for the following week to hear about the results of the pilot study. She decided to attend the meeting to hear the latest updates.

During the meeting, she learns that CDM Smith has been conducting a pilot study at the local water treatment facility for the past year. She tries her best to follow along, but the graphs and jargon make it difficult for her to take notes. She finds a copy of their presentation on the town's website. Let's take some time to review the data from CDM Smith (view Source 6 in the Data Packet as a class)

Discussion Questions:

- Based on the data, which treatment option makes the most sense?

Activity 1

Instructor Notes

Students will work in small groups to study and discuss the information from CDM Smith's presentation to Pittsboro's Board of Commissioners (Sources 6 and 7). Groups should work towards two goals: (1) evaluate CDM's claims based on earlier data and data from other sources in the Data packet. (2) draft a list of questions that would help the town decide which option to chose

- Groups do not have to produce a physical deliverable for this activity. Depending on the number of groups and the level of engagements, students could compile their thoughts on a shared doc/slide and/or share orally once everyone is ready.

Wrap up/Reflection of Activity 1: Once everyone is ready, have groups share their thoughts. Ask them to compare and contrast data from multiple sources to evaluate the results of the pilot study. Are the treatment options effective? Are there any perceivable issues (does the treatment effectively address the specific PFAS profile in Pittsboro, can it reduce the amount of PFAS to an acceptable limit (e.g. 70 ppts), Do we agree with CDM Smith's recommendations? Why or why not?, etc.). This is a great opportunity to bring in questions about environmental justice. How might the town's decision disproportionately impact marginalized populations?

Time estimate: 20-25 minutes

Student Resources:

- Data Packet

Student Instructions for Activity 1

Introduction:

The Board of Commissioners has a difficult decision to make soon. They now have pilot data in hand that provides options about how best to deal with PFAS in Pittsboro's Drinking Water. CDM Smith has returned to share their recommendations with the Board in order to help them make a decision. In their presentation, they included a summary of the Pilot study, an estimate of the cost for each treatment, and a list of advantages and disadvantages. You will look at a section of their most recent presentation and discuss the best next step for the town.

Task:
Study the data provided under Source 7 in the Data Packet with your small group. Discuss the following, and be prepared to share your insights with the class.

Discussion Prompts:

- Glance at the graph showing the Pilot Study results. Based on your understanding of the data, which of the three treatment options is the most effective?
- Skim through the remaining slides of their presentation. As a Commissioner hearing the presentation, what thoughts/questions might be running through your mind? What are your main priorities and how can you balance them with other considerations?
- Do you agree with the CDM Smith's recommendations? Why or why not?

Synthesis/Reflection
The following questions and discussion posts may be helpful as you conclude the lesson.

● In your opinion, what are the primary responsibilities of Pittsboro's Mayor and Board of Commissioners pertaining to the water issue?
● Do you feel the treatment options are sufficient? Why or why not? Is it possible to completely avoid contamination?
● POV Statements: write a statement from the point a Pittsboro resident based on what you know so far. You could write a reflection expressing your feelings about the water issue (what bothers you the most), your concerns about yourself and others in the community, or something else. In your opinion, what should happen next?

Capstone Project working time
Announcements/Closing