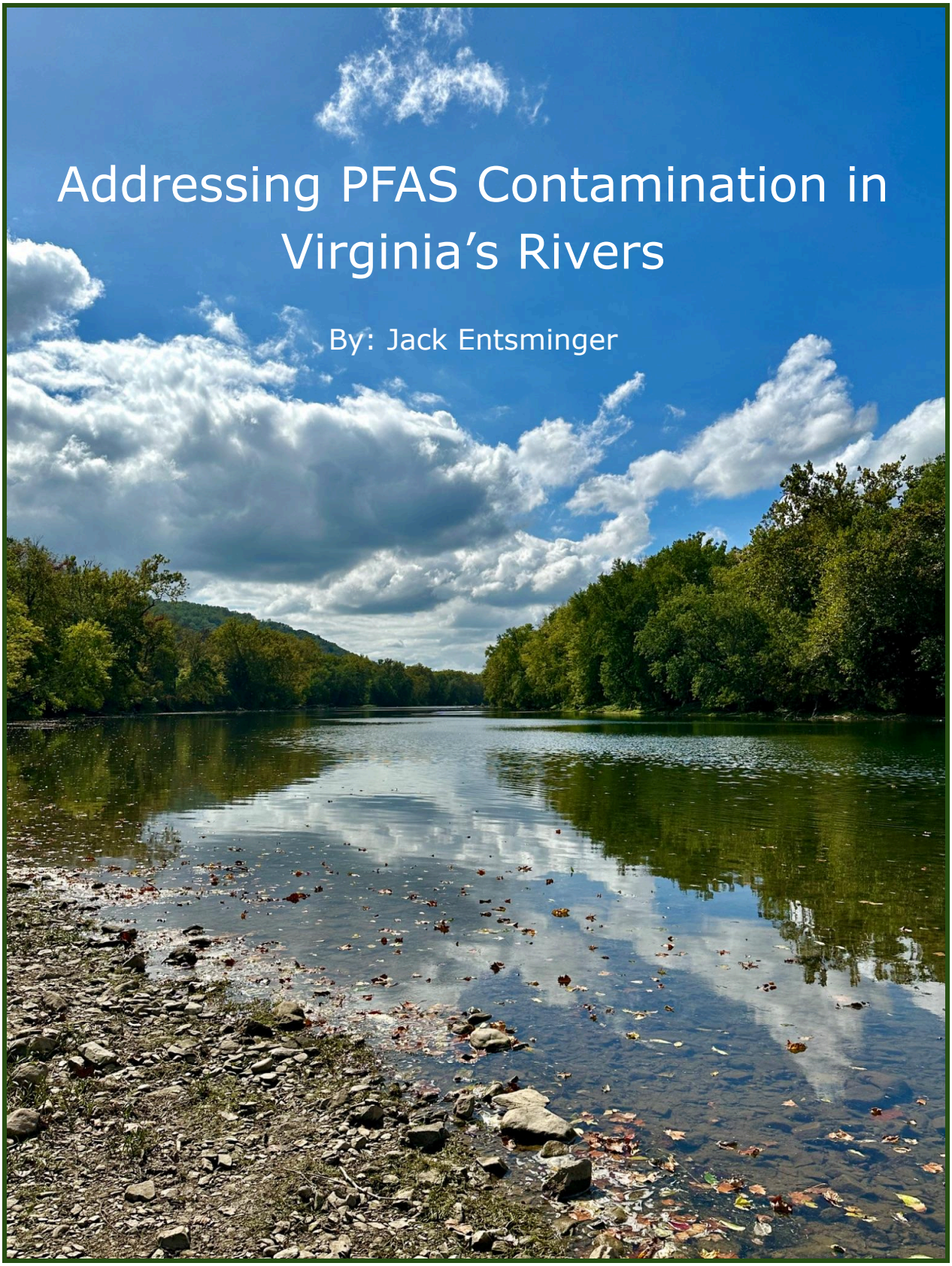
Addressing PFAS Contamination in Virginia's Rivers

By: Jack Entsminger



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Prepared for:
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SIERRA CLUB
VIRGINIA CHAPTER

UNIVERSITY of VIRGINIA
FRANK BATTEN SCHOOL of
LEADERSHIP and PUBLIC POLICY

"The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency."

Acknowledgements

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Finally, I would like to thank Sarah Lykins Entsminger, of Studio at Rippling Waters, for providing all of the photographs in this report.

Honor Statement

On my honor as a student, I have neither given nor received unauthorized aid on this assignment.
In addition, there is no generative AI use in this entire report.

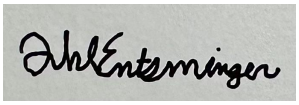

Table of Contents

Acknowledgements 3

Abbreviations and Key Terms 5

Executive Summary 6

Problem Statement and Contextualization 8

Discussion of Client and Why PFAS? 9

Background 11

Literature Review 15

Potential Alternatives 22

Evaluative Criteria 25

Analysis of Alternatives
- Alternative one: Status Quo (let present trends continue) 27
- Alternative two: Strategies for Education Outreach 29
- Alternative three: Strategic Litigation 31
- Alternative four: Community Initiatives and Biomonitoring 33

Alternatives Matrix 35

Theory of Change 36

Policy Recommendation 37

Policy Implementation 39

Appendix 41

References 45

Abbreviations

CDC → Centers for Disease Control and Prevention

DCR → Virginia Department of Conservation and Recreation

DEQ → Virginia Department of Environmental Quality

EPA → United States Environmental Protection Agency

PFAS → Per- and polyfluoroalkyl substances

USGS → United States Geological Survey

VDH → Virginia Department of Health

WQS → Water Quality Standards

Key Terms

Analytes → a substance whose chemical constituents are being identified and measured

Forever chemicals → another name for PFAS and other similar chemical compounds due to their long half-lives

Microplastics → small pieces of plastic found in the environment due to pollution

Non-point source pollution → contamination from many sources; such as stormwater runoff and erosion

Point source pollution → contamination from one source

Transboundary pollution → contamination from one country reaching into waters of another

Executive Summary

Virginia's rivers are currently contaminated with PFAS and other "forever chemicals". In the future, it is likely more PFAS will enter critical sources of drinking water in the Commonwealth as well as diminish other natural spaces. Additionally, PFAS have been proven to cause negative health effects such as increased cancer risk in humans. It is important for the commonwealth of Virginia to both remove current PFAS contaminants in our rivers and prevent more PFAS contaminants from entering the water.

The state government is responsible for PFAS legislation as well as enforcing PFAS regulations, but may need assistance in tackling this issue. Many environmental organizations want to assist the state government and local authorities in their efforts to reduce PFAS pollution, but lack the tools or information to address the issue. A thorough analysis and plan for organizations, such as the Sierra Club Virginia Chapter, is necessary to understand where they can make lasting change.

In this report, I provide background knowledge, analysis, and a recommendation to Connor Kish, Executive Director of the Sierra Club Virginia Chapter, regarding the available options for addressing PFAS contamination in Virginia's rivers. I propose four policy alternatives which have potential to address the problem:

1. Status Quo (let present trends continue)
2. Strategies for Education Outreach
3. Strategic Litigation
4. Community Initiatives and Biomonitoring

In order to assess the potential merits of each alternative, I used four evaluative criteria to determine the best option for the Sierra Club Virginia Chapter to implement. The evaluative criteria used included (a) cost, (b) administrative feasibility, (c) political feasibility, and (d) harm reduction. The final recommendation is the alternative that provides the greatest benefits in these four criteria.

My analysis shows alternative two has many strengths in the chosen categories. In particular, its ability to achieve long-term harm reduction at a

reasonable cost. I therefore conclude that the Sierra Club Virginia chapter should adopt strategies for education outreach to address PFAS contamination in Virginia’s rivers.

Problem Statement and Contextualization

Half of Virginia's rivers sampled are significantly contaminated with PFAS, imperiling the drinking water of millions of Virginians. Statewide PFAS sampling between 2021 and 2024 tested for 40 PFAS analytes in surface water, sediment, and fish tissue – with results showing at least half (51%) of samples had one or more PFAS analytes detected above the minimum level of quantitation (Virginia DEQ, 2021).

Per- and polyfluoroalkyl substances (PFAS) are two types of synthetic chemical compounds used primarily in non-stick coatings and waterproof clothing with half-lives ranging up to eight years (CDC, 2024). PFAS are increasingly being used in the manufacturing process of everyday products and are ending up in landfills, causing these pollutants to soak into the soil and drinking water (Ryan et al., 2022). Some of the currently known effects of PFAS include increased risk of some cancers, increased cholesterol levels and/or obesity, reduced strength of immune systems, developmental effects, and reproductive effects (EPA, 2024). The James River remains susceptible to contamination, as seen by treated water from the Scottsville sewage treatment plant containing 178 nanograms of PFAS per liter of water, which is 44.5 times more than the EPA's maximum contamination level of only 4 nanograms (Hausman, 2024). Additionally, many people living in the watershed are concerned about pollution in the James and the potential of forever chemicals irreversibly altering ecosystems (Deluna, 2023).

Discussion of Client

My client for the applied policy project is the Sierra Club Virginia Chapter. The Sierra Club is a national environmental organization focused on a variety of issues relating to conservation and preservation of the natural environment. Each state in the US has a chapter of the organization which allows for addressing environmental issues in a focused and specialized manner at the state level. As a resident of Virginia, I felt drawn to the Virginia Chapter to help identify a problem affecting Virginia residents and complete further research on a chosen problem. Sierra Club Virginia Chapter does not have any dedicated staff working on water issues, so it made sense that the problem I would work on would be related to water. After an initial assessment of current issues faced by Virginia's waterways, it was determined that PFAS would be a meaningful problem to learn more about and develop possible alternatives for the Sierra Club Virginia Chapter to address the contamination of Virginia's rivers.

Why PFAS?

One benefit attached to addressing PFAS is how new it is relative to traditional causes of water quality issues. The Virginia General Assembly has passed a bill as recently as earlier this year regarding PFAS in drinking water and the EPA has released regulations for PFAS in 2024 as well (Pipkin, 2024). Plenty of research has already been done on how to deal with traditional sources of pollution from agriculture, manufacturing, stormwater runoff, and wastewater (Virginia SOS, 2014). By choosing to focus on PFAS, I am involved in discovering solutions for an issue that has not garnered much attention. I hope the policy alternatives I suggest will be innovative and useful for Sierra Club Virginia Chapter in the rapidly changing future.

Another benefit in centering PFAS in an analysis is the possible connections to microplastics, industrial waste, and sewage/wastewater treatment. Research on microplastics in landfills leaching into the groundwater will be useful in comparisons for PFAS, as they are entering our groundwater in similar manners (Cook & Steinle-Darling, 2021). Approaching the issue from the PFAS angle will allow me to incorporate information on wastewater treatment and industrial waste pollution, due to a large source of PFAS being linked to concentrated pollution released in industrial wastewater

(Trejo-Angeles, 2024). It will be vital to link PFAS to other causes of water pollution in Virginia to explain how PFAS became a problem and devise policy alternatives.

Background

Historical Trends of PFAS and Water Quality Issues

Pollution from industry, agriculture, and urban areas have contributed to the diminishing water quality in water sources across the United States (USGS, 2019). Water quality is assessed using national water quality standards (WQS) established by the Clean Water Act (EPA, 2014). The Environmental Protection Agency (EPA) monitors and evaluates quality based on these standards and three elements: designated uses, criteria or thresholds, and an anti-degradation policy (EPA, 2015). Traditional sources of water pollution may include agricultural pollution, sewage and wastewater, oil pollution, and more. Industry and household production whether by farming, treating water, or oil drilling are sources of pollution causing recurrent issues in water quality. There are three main types of pollution: point source (contamination from one source) pollution, non-point source (contamination from many sources such as stormwater runoff and erosion) pollution, and transboundary (contamination from one country reaching into waters of another) pollution (Denchak, 2019).

While people may be familiar with the usual suspects of mismanaged waste from farming and wastewater being dumped by factories into our water sources, they might be unfamiliar with PFAS being more prevalent in our waterways. PFAS were created in the 1940s for use in things like non-stick kitchen cookware, cosmetics, packaging, and as of the 1970s have also been seen in firefighting foam and in use by the military (Coulson, 2024). These everyday items with PFAS are disposed of in landfills or flushed into the sewer, causing the chemicals to reach our rivers directly through wastewater or by leaching into the environment down to the groundwater (Coulson, 2024).

There were significant reductions in pollution in the James River during the 90s, but there has been little to no progress recently and some sources even believe we are going in the wrong direction (Deluna, 2023). Additionally, many people living in the watershed are concerned about pollution in the James and the potential of PFAS and other long-lasting chemicals irreversibly altering ecosystems (Deluna, 2023).

Current and Anticipated Future Effects of PFAS

In the 2000s and 2010s, there have been studies detailing how PFAS have been seen in an increasing number of people and animals with adverse health effects caused by these "forever chemicals" (another name for PFAS due to the long half-lives mentioned previously) being present (Beans, 2021). Some of the currently known effects include increased risk of some cancers, increased cholesterol levels and/or obesity, reduced strength of immune systems, developmental effects, and reproductive effects (EPA, 2024). PFAS harm both animals and humans, with more research needed to see how women and children may be more sensitive to the effects of these chemicals (EPA, 2023). More recently there has been treated water coming from sewage plants entering the James, which often has exponentially more than the suggested limit of PFAS and is contributing to the decline of water quality (Hausman, 2024). An upward trajectory in the amount of PFAS in our drinking water over time signals the need for a response.

Factors Contributing to PFAS Pollution

One of the largest contributors to PFAS in rivers in Virginia is the increasing amount of plastic pollution globally. Microplastics and PFAS are intricately linked, exacerbating health issues as more plastic is used and disposed of in our waterways (Wee and Aris, 2023). This link can be seen by the presence of microplastics being shown to increase toxicity of PFAS as well as them acting as vectors for PFAS long-range transport in water (Wang & Good, 2024). Virginia, like other states, has a lot of single-use plastic products such as utensils, containers, bottles, and cigarette butts being manufactured and discarded daily (York River Group of the Virginia Sierra Club, 2021). Without managing our plastic usage, it will be difficult to address the issue of "forever chemicals" in our drinking water.

Some communities have been dealing with the effects of PFAS for decades, because of necessary products like firefighting foam, finding their way into town wells (Taylor & Fleming, 2021). Zooming out, pollution in general has been damaging ecosystems in Virginia's rivers for decades. The James River remains susceptible to contamination, as can be seen by treated water from the Scottsville sewage treatment plant containing 178 nanograms of PFAS

per liter of water, which is 44.5 times more than the EPA's maximum contamination level of only 4 nanograms (Hausman, 2024).

Legal and Regulatory Environment

Like most other environmental issues, water pollution is addressed by many different laws and regulatory agencies at both the federal and state level. One of the major players in Virginia, is the Department of Environmental Quality (DEQ). The DEQ relies heavily on State Water Control Law to create regulations and enforce laws regarding water quality in the Commonwealth (Virginia DEQ, 2024). They manage wastewater and stormwater, protect wetlands, issue permits, and create measures to protect and enhance the quality of water in Virginia (Virginia DEQ, 2023).

In cooperation with the DEQ, the Department of Conservation and Recreation (DCR) also plays a role in maintaining the health of Virginia's sources of water. Much of the DCR's work revolves around preventing nonpoint source pollution from degrading water quality in Virginia through pollution control programs and best practice guides for individuals or local governments (Virginia DCR, 2024). Primarily, if there are any laws or regulations preserving our water, it is enforced by these two state agencies.

Additionally, the Virginia Department of Health (VDH) also has the goal of fostering healthy, connected, and resilient communities, which implies a possible role for helping protect against the impacts of PFAS in our waterways (Virginia Department of Health, 2024).

Ecosystem Surrounding PFAS Contamination in Virginia

In order to understand the relevant stakeholders in the issue of PFAS contamination in Virginia's rivers, I created an Ecosystem Map – as shown in Figure 1 in the Appendix. The components of the ecosystem map includes Sierra Club, Virginia Chapter, as well as the issue we are addressing (PFAS contamination in Virginia's rivers), centered in the middle of the map surrounded by relevant stakeholders. Sierra Club Virginia Chapter and our issue are in dark green, environmentally conscious groups are in light green, state government is in red, federal government is in orange, local authorities are in pink, and other community members are in black. Many of the

stronger connections between different stakeholders are mapped with double-sided arrows in black.

The first major group of stakeholders in the PFAS contamination of Virginia rivers issue is the state government. There are two primary agencies in charge of regulations regarding PFAS, as well as testing and monitoring bodies of water in the state; the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Health (VDH). DEQ is concerned with water quality generally, whereas VDH has a particular vested interest in maintaining clean drinking water for Virginia's residents. Both the DEQ and VDH are often collaborating on the issue of PFAS contamination as their interest overlaps in addressing them. These two agencies report directly to the governor of Virginia, currently Glenn Youngkin, who is in charge of all state agencies and sets the policy agenda for the administration. Additionally, the DEQ and VDH also report to the Virginia General Assembly, the state body in charge of legislation.

On the federal level, the Environmental Protection Agency (EPA) is in charge of PFAS contamination regulations on a national scale. Legislation, such as the Clean Water Act, gives the EPA authority to regulate and enforce water standards across the United States.

In terms of water quality at the municipal or county level, there are many different local water and sewer authorities responsible for ensuring clean water across Virginia. These authorities manage water quality, engage in testing the water for PFAS and other chemicals, and treat wastewater.

The largest group of stakeholders is what I have classified as environmentally conscious groups. There are many different types of environmental groups working on PFAS issues in the state of Virginia through methods such as education, service, community outreach, advocacy, and legal means. Sierra Club Virginia Chapter is also an environmental group and collaborates with other groups in the state and region on many different types of environmental issues. Universities and colleges in the state of Virginia play a role in the issue mainly through education and research opportunities. Environmental consulting companies are often paid by private organizations or by the state government to develop potential solutions for addressing PFAS contamination.

Finally, is the group of stakeholders encompassing the rest of the members of the community associated with PFAS contamination. Industry, generally, as well as agriculture, have obligations to keep PFAS out of our water and be responsible stewards of the land. Additionally, Virginia residents as a whole are affected by PFAS and rely on the government to provide clean water.

The creation of this map has shown the importance of the state government and NGOs working together to address the issue. While the state is ultimately in charge of regulating PFAS pollution, it also needs input from other outside organizations to understand the issue and its consequences so it can make fair and accurate regulations.

Literature Review

Introduction and Brief Summary of Technical Solutions

People in the United States and around the world are concerned with the issue of water quality broadly, as clean water is necessary for a healthy population. Beginning with the Federal Water Pollution Control Act of 1948 and the Clean Water Act in 1972, the United States established water quality standards and used the Environmental Protection Agency to enforce them (U.S. EPA, 2018). Different types of pollution have been targeted for their impact on water quality such as industrial waste, sewage and wastewater, or agricultural runoff (Robinson, 2022). PFAS, while only recently gaining public awareness as a threat to water quality, have been known to be dangerous to human health for decades (Hayes, 2019). Given the current increased interest in PFAS, many people want to know how and understand why these chemicals reaching our drinking water is so critical and how it might be possible to mitigate their potential impacts.

Most literature regarding PFAS and their mitigation comes from the last few years, which could signify the lack of existing foundational literature or could just be a sign of renewed interest in their effect on water quality. One area of PFAS research is scientific solutions to remove existing PFAS from the water. The discussions include disagreements over which methods may be more cost-effective, efficient, or environmentally friendly. Some of the main treatment methods for PFAS include biochar, activated carbon, metal-organic frameworks, ion exchange resins, nanofiltration, reverse osmosis, foam fractionation, bubble fractionation, and destruction techniques - all of which are scientific structured solutions for how to clean our water (Amen et al., 2023; Itumoh et al., 2024). Much of the research is specifically focused on which types of sorbents (insoluble material capable of absorbing liquids or gasses) work the best, with some studies preferring metal-organic frameworks, some preferring nanomaterials, and others preferring different other materials (Fitzgerald et al., 2022; Ambaye et al., 2022; Lei et al., 2023). Additionally, some of the research has been used to discuss which methods of treating or mitigating PFAS are not as good as initially believed, such as watershed comprehensive management or PFAS incineration (Xu et al., 2024; Vollet Martin et al., 2023).

This previous section of quantitative information on PFAS removal and testing will serve as the foundation for understanding the general themes found in the research. The rest of this literature review will be focused on PFAS prevention, awareness, and accountability methods, as this is the area of the issue where the Sierra Club Virginia Chapter can make a difference. Sections following this introduction are centered around specific themes; letting present trends continue, strategic litigation for environmental concerns, biomonitoring and environmental community initiatives, and environmental education.

Status Quo (Let Present Trends Continue)

Letting present trends continue, there are some options for how PFAS contamination may change in the future. Currently, there is legislation, as well as regulations, guiding PFAS prevention and removal at both the federal and state levels. The status quo would be to use these current guidelines from the government to keep addressing PFAS at a similar level as to how it is being done already.

This asks the question of whether what is currently being done is enough to avert crisis levels of PFAS contamination. Previously, the Biden Administration had made PFAS pollution a new priority for their time in office – with new regulations targeting maximum contamination levels. However, the new Trump Administration is deprioritizing PFAS pollution among other environmental issues moving forward. Concerns arise from this deprioritization, as the progress made on the issue is easily reversible given new legislation or the changing of regulations. In general, it is difficult to know whether meaningful change will be made on this issue in the future given the polarization of environmental issues and reliance on political momentum to make progress on reducing PFAS pollution.

Strategic Litigation for Environmental Concerns

The first theme in the existing evidence is the use of strategic litigation against corporations who are damaging the environment. When the literature refers to strategic litigation, it generally means citizen groups bringing targeted lawsuits against bad actors (usually larger organizations). Strategic litigation primarily serves two purposes; stop the harmful action

and procure money to help fix the outcomes caused by the action. This method is being used in many different types of environmental issues, such as climate change broadly and in natural resource governance. One source using strategic litigation for natural resources issues details strategic litigation as a strategy to bring social change and ensure accountability when the government lacks the capacity to do so (Gargule, 2022). Also mentioned are some of the challenges of strategic litigation, including the high cost of bringing these suits, as well as the public spotlight or exposure brought to the issue.

This challenge of public spotlight brought by strategic litigation can also be seen as a benefit in some cases, as it can bring awareness to a lesser known environmental issue through news headlines. This can be seen in some of the successful suits that have already occurred against 3M and DuPont – which have resulted in billions of dollars in settlements for the purpose of cleaning PFAS out of the sources of water they have contaminated (Flesher, 2023; Maruf, 2023). Accountability seems to be a harder objective to reach, as both of these settlements do not include an admission of liability – instead focusing on the financial compensation required to ensure clean drinking water.

PFAS litigation is an already existing field, but is developing rapidly as new scientific information regarding PFAS becomes more readily available (Roppolo, 2023). Some sources detail challenges and obstacles of PFAS litigation, particularly when trying to prove causation and in instances in which the defendant is a government entity (Snow, 2024). Additionally, sources also take the perspective of manufacturers looking to protect themselves from being liable for PFAS contamination and how they can better navigate a changing regulatory space surrounding the issue of PFAS (Quinn Emanuel, 2023). Most relevant to Sierra Club Virginia Chapter are sources detailing how environmental groups can get involved in PFAS litigation through guidebooks, analysis of key steps, and introductions to the environmental litigation landscape (SL Environmental Law Group, 2024; DiGiannantonio, 2024; Environmental Law Institute, 2024). Understanding the interplay between litigation, regulation, and legislation will be critical in determining where an environmental organization can make the most impact.

Biomonitoring and Environmental Community Initiatives

The next theme in the existing evidence is a group of different nature-based solutions to the PFAS issue. This section of literature looks at the ways our ecosystem interacts with PFAS and if there are animals or plants that might be able to help prevent, identify, and address PFAS contamination in bodies of water. One of the common ways scientists are utilizing our ecosystem to know more about PFAS is through biomonitoring. When the literature refers to biomonitoring, it means the use of certain organisms in an ecosystem to measure contamination of a body of water – either by studying observable changes in the organism or measuring the level of chemical contamination in their tissues. One source shows fish might have specific physiological responses to PFAS contamination in their habitat, including measurable stress responses in particular species of fish as a sign of PFAS being prevalent in the water (Schumann et al., 2022). Many sources suggest a multi-species approach to biomonitoring and comparison between individual species across multiple habitats to gather as much information as possible to determine levels of PFAS contamination (Groffen et al., 2024). Methods of passive biomonitoring, active biomonitoring, and identifying accurate thresholds of contamination are also being tested (Byns et al., 2024).

Relatedly, another facet of nature-based solutions is the use of plants to remove PFAS from water. There are a few sources discussing the effects of certain types of rice cultivation, as well as planting reed grasses, both as potential ways to decontaminate water (Yamashita et al., 2024; Ferrario et al., 2022). While nature-based solutions have a large gap in current research, the prospect of being able to use the environment to help address PFAS is an interesting idea. If more research becomes available on plants useful for PFAS removal, it may provide an opportunity for non-governmental organizations to implement community planting initiatives throughout the state.

Environmental Education Strategies

The last theme to discuss in the existing evidence is different methods of environmental education, both broadly for the environment, and specifically for PFAS issues. The research is relatively mixed on environmental education in general. Some sources think it has the ability to bring environmental

awareness and inspire action (Oe et al., 2022). In contrast, other sources show changed beliefs and attitudes from environmental education initiatives only in the short-term with very little evidence of long-term behavioral change (Gralton et al., 2004). Educating people on environmental issues seems to have varying results depending on the method and the context.

Overall knowledge of the PFAS problem in the United States seems relatively low, but if more people become aware of the issue, more action could be taken to help the situation. A study in Maine revealed that when people know about PFAS, they are willing to fund actions to fix the issue and change their own personal behavior to mitigate the spread of PFAS (Zimmerman et al., 2022). There are many different challenges and approaches to mitigating PFAS effects, which could be shared with people less familiar with the issue to get them up to speed (Lukić-Bilela et al., 2023). Other sources provide community outreach resources on PFAS to promote a participatory approach to addressing the problem (Powers et al., 2020). Additionally, there have been initiatives specifically targeting small or disadvantaged communities to help them understand the issue and what they can do themselves to deal with PFAS (US EPA, 2024).

There are many different scholarly sources available detailing PFAS, but very few are accessible to people who are not already highly educated in chemistry, policy, and water issues. This leaves a gap in the research of easy-to-explain, common-sense information that people from all backgrounds can access and use to make sense of PFAS contamination in their community. This creates opportunities for non-governmental organizations to translate the highly dense material into educational material accessible for anyone who might be interested in the issue. Centers such as the PFAS Project Lab at Northeastern University are attempting to remedy this by creating a centralized website of PFAS information available to everyone with the link (Northeastern University, 2024).

Conclusion

Even though PFAS contamination has recently become better known, it has been an existing problem for decades. There are many technical solutions proposed and created to address removing PFAS from our water sources and for testing water for PFAS. Non-governmental organizations, like the Sierra

Club Virginia Chapter, are better suited for considering less technical approaches for how they can contribute to PFAS prevention, awareness, and accountability methods. The relevant literature reviewed revolved around three main themes; strategic litigation, biomonitoring and nature-based solutions, and environmental education. These three areas will be critical for non-governmental organizations to consider when determining different policy alternatives suitable for their goal of mitigating the harmful effects of PFAS water contamination.

Potential Alternatives

Status Quo (let present trends continue)

Sierra Club Virginia Chapter would remain uninvolved in the current landscape of PFAS water quality issues. Current legislation and regulations would still guide PFAS prevention and removal in the state of Virginia. Without engagement in PFAS issues by non-governmental organizations, the problem could continue to get worse over time. Waiting to address the issue until it becomes more urgent could also create additional difficulty for Virginians.

Current trends on the federal level show an increasing deprioritization of PFAS regulation. In recent months, President Trump has put out an executive order withdrawing the EPA's proposed limit on PFAS chemicals in industrial wastewater (Kelleher, 2025). Without EPA support in regulating PFAS, state governments will become the main enforcers against PFAS pollution. If this alternative is chosen, Sierra Club Virginia Chapter would continue working on other environmental issues and rely on the state government and other environmental NGOs in the space to address the issue of PFAS contamination.

Strategies for Education Outreach

One of the major components of the PFAS pollution problem is the lack of education on the topic for policymakers, stakeholders, and the citizen population. Sierra Club Virginia Chapter would develop a comprehensive plan with strategies to educate people through grassroots initiatives, as well as, targeting key policymakers in the Virginia General Assembly with information regarding PFAS. When people become aware of a potential issue that affects them, they are more willing to mobilize on that particular issue, which would be the case if education on PFAS was more widely promoted.

This alternative would consist of hiring a policy analyst to examine water quality issues for the organization. They would research PFAS prevention and awareness strategies, create educational materials, and disperse these educational materials. The information gathered by the analyst would be made available online for the public and e-mailed directly to members on

Sierra Club Virginia Chapter e-mail lists. This information could also be presented to Virginia lawmakers, but the organization needs to remain aware of lobbying constraints due to their non-profit status. Education on PFAS would center around what PFAS are, how they enter our sources of drinking water, and what tools are available for people who want to help make change.

Strategic Litigation

There is a focus on preventing PFAS pollution by targeting pollution at the source. Sierra Club Virginia Chapter could either hire an in-house attorney or become part of a larger environmental working group to pursue lawsuits against businesses that are polluting Virginia's rivers with PFAS. Citizen groups can file lawsuits targeted toward organizations that are doing the most harm to our environment. Additionally, money awarded in settlements from these suits potentially goes toward implementing other PFAS removal techniques as a bonus on top of getting the businesses to stop polluting. PFAS litigation has already begun in different capacities across the United States and one suit against DuPont has had a film created about it called *Dark Waters*.

Sierra Club Virginia Chapter would become involved in PFAS litigation in this alternative. Hiring an environmental attorney to focus on PFAS and water quality issues more broadly would allow the organization to participate more actively in targeted lawsuits, stopping industrial wastewater from polluting Virginia's rivers. Legal advice from an attorney could help the Sierra Club Virginia Chapter have a better understanding of the tools that are available for them to prevent PFAS pollution by manufacturers.

Community Initiatives and Biomonitoring

Sierra Club Virginia Chapter could also focus on removal or testing of existing PFAS. Implementing different nature-based solutions, such as biomonitoring of fish and other wildlife to see if PFAS are present in our waterways, can occur while organizations wait for larger regulatory change. Additionally, different community initiatives such as planting grasses or trees that would help clean up rivers are part of this alternative. Community

initiatives targeted toward improving water quality in general, such as organized group outings for collecting litter, will also be helpful.

In this alternative, the Sierra Club Virginia chapter would hire a volunteer coordinator to organize water quality community events. Reed grasses, as mentioned earlier in the literature review section, are an effective way to mitigate pollutants (Ferrario et al., 2022). The volunteer coordinator would organize two reed grass community planting events per year at sites on PFAS contaminated rivers in Virginia. This alternative would leverage the existing volunteer network of the Sierra Club Virginia Chapter to make targeted, incremental attempts at PFAS removal and mitigation. The reed grass planting also can contribute to other environmental goals of pollution removal, habitat restoration, and protecting shorelines.

Evaluative Criteria

Cost

Examine alternatives based on the cost of the solution. How much does each alternative cost the Sierra Club Virginia Chapter and how well spent is the money for each?

Costs will include salaries of hired professionals as well as any potential costs for materials necessary for the alternative to be successful. One-year projections for cost will be how each alternative is assessed. Effectiveness will be assessed based on how much change can be created with the amount of money spent. It is important that the Sierra Club Virginia Chapter utilizes its resources efficiently.

Administrative Feasibility

Examine alternatives based on how administratively feasible they are for the Sierra Club Virginia Chapter. Does the organization have enough staff to implement the alternative? Is the technology available for the alternative? Does the Sierra Club Virginia Chapter have the authority to address the problem and the commitment to follow through?

In addition, most of the alternatives require hiring staff for the alternative to be successful. Part of this criteria will also be focused on how difficult it may be to find qualified staff for each alternative. Availability of current technology can be assessed by how difficult it will be to acquire new materials necessary for the alternatives, as well as whether the organization has existing resources for staff who will work on the alternatives. Lastly, alternatives will be evaluated under this criteria on whether Sierra Club Virginia Chapter has the capabilities to pursue an alternative more effectively than other potential organizations and if they are willing to commit to a potential alternative long-term.

Political Feasibility

Examine alternatives based on how politically feasible they are for the Sierra Club Virginia Chapter. Are the alternatives legal for the organization to

undergo? Are there regulations in place harming the effectiveness/possibility of the alternative? Is the alternative acceptable in the current political climate?

Alternatives need to be legal for Sierra Club Virginia Chapter to undertake and will be evaluated based on potential barriers to effective completion. The alternatives need to work with existing regulations and legislation to be feasible options. Looking at the current political climate, it will be important to determine if an alternative is able to be fully implemented with little backlash against the organization. Successful alternatives will not make Sierra Club Virginia Chapter at odds with the state government or at risk of potential retaliation.

Harm Reduction

Examine alternatives based on the extent of the harm reduction in terms of overall health markers, as well as reduction in disease for plants, animals, and people in the affected areas. Could the alternatives offer additional types of harm reduction? Are there opportunities for new or altered uses of the land and waterways with harm reduction or mitigation? Is there an increased use in the land and waterways for recreation purposes with the alternatives? How effective are the alternatives at preventing PFAS pollution or addressing current pollution levels?

Alternatives will be evaluated on the effectiveness of achieving the goal of less PFAS contamination in Virginia’s rivers. Expected outcomes will be measured by how much they achieve this goal, when they achieve this goal, and how long the alternatives will make lasting change in achieving this goal. Additionally, the alternatives will be evaluated on potential positive externalities and spillover effects they may have in addressing other environmental problems currently faced in Virginia.

Analysis of Alternatives

Alternative 1: Status Quo (let present trends continue)

Alternative one requires no costs be expended to hire any professionals to pursue the option. Letting present trends continue does not require staff or any new materials or resources not already at the Sierra Club Virginia Chapter. The estimated total cost of this alternative is $0, but this does not include the potential cost of donors concerned with water quality in Virginia giving their money to other organizations if they do not see progress made on PFAS or other water issues (Ryba et al., 2022). In terms of effectiveness, while there are no clear costs, there is also no clear progress made on working toward the goal of less PFAS contamination.

Regarding administrative feasibility, status quo does not need any additional staff for Sierra Club Virginia Chapter to pursue the alternative. There will be no difficult hiring searches necessary for the alternative as well. Current technology is effective for letting present trends continue and the resources needed for the alternative are already available at the organization. Sierra Club Virginia Chapter does not have a particular advantage over other organizations in letting present trends continue and may find difficulty committing to the status quo long-term. Administrative feasibility is high for this alternative.

Evaluating the status quo alternative for political feasibility, it is well within legal frameworks of the state. Additionally, the Sierra Club Virginia Chapter would find very few political barriers should it move forward with this alternative. Letting present trends continue without Sierra Club Virginia Chapter involvement does not impede legislation or regulation activities from achieving their purpose. Examining the current political climate, this alternative protects the organization from any potential backlash from government entities and industry in the state of Virginia. Risk of retaliation is unlikely, but some donors or Virginia residents might take issue with Sierra Club Virginia Chapter’s perceived inaction on the issue of PFAS contamination of Virginia’s rivers. Political feasibility is high for this alternative.

Harm reduction is a weakness of the status quo alternative. By choosing to let present trends continue, Sierra Club Virginia Chapter does not contribute to making any progress toward achieving less PFAS contamination in Virginia’s rivers. The status quo alternative fails to address pollution levels or reduce harm, making any lasting change difficult. This alternative does not provide any other positive externalities or spillover effects. Harm reduction is low or absent from this alternative.

Analysis of Alternatives

Alternative 2: Strategies for Education Outreach

Alternative two requires hiring an environmental policy analyst and budgeting for potential printing and presentation material costs. Strategies for education outreach relies on this new staff member and the procurement of materials to aid them in accomplishing the goals of the alternative. The estimated total cost for one year of this alternative including salary and resource cost is $73,371, calculated using average yearly salary of environmental policy analysts in Virginia, plus a small stipend to cover materials (ZipRecruiter, 2025). Costs of already procured equipment, such as a work computer for the hired policy analyst, are not included in this estimate. In terms of effectiveness, there appears to be medium costs for this alternative to work toward the goal of less PFAS contamination.

Regarding administrative feasibility, strategies for education outreach will need staff to be hired to pursue the alternative. A moderate hiring search to fill the environmental policy analyst position will be necessary for Sierra Club Virginia Chapter should they choose this alternative. Current technology is effective for strategies for education outreach and most of the resources needed for the alternative are already available at the organization, with a small amount allocated to procurement of materials for printing and presentation of gathered information. Sierra Club Virginia Chapter, as an advocacy organization, has an advantage in strategies for education outreach. The organization likely would not find difficulty in committing to strategies for education outreach long-term. Administrative feasibility is high for this alternative.

Evaluating the strategies for education outreach alternative for political feasibility, the alternative is in-line with legal frameworks of the state and there would likely be very few political barriers to implementing this alternative. Strategies for education outreach will not impede legislation or regulation activities from achieving their intended purpose of PFAS prevention and removal. One factor to consider in political feasibility is the portion of the alternative dedicated to educating lawmakers. Lawmakers may have varying levels of receptiveness to the information provided by the policy analyst and there may be limited amounts of time the analyst can

provide the information to the lawmakers given the nature of the Virginia General Assembly's part-time legislature. In addition, this alternative should also consider the limited amount of lobbying that Sierra Club Virginia Chapter can do per year and how dedicating time to this issue may take away from other issues the organization is trying to address as well. The strategies for education outreach alternative is unlikely to create backlash from the state government, but the campaign may invite attempts from industry to challenge or deny some of the information provided. Risk of retaliation against the organization for this alternative is unlikely. Political feasibility is medium for this alternative.

Reduction in harm over the long-term is a focus of the strategies for education outreach alternative. By using strategies for education outreach, Sierra Club Virginia Chapter contributes to making progress toward achieving less PFAS contamination in Virginia's rivers. The strategies for education outreach alternative does not address current pollution levels or reduce harm in the short-term, but it attempts to change lawmaker and public opinion on addressing PFAS pollution to create lasting change in the long-term. An environmental education initiative can raise awareness of the problem, as well as enhance citizen engagement in addressing the particular issue in the future (Hnatuyk et al., 2024). This alternative can also provide a positive externality through the spotlighting of water quality issues as a whole in the state of Virginia. Meaningful harm reduction is possible in the long-term for this alternative.

Analysis of Alternatives

Alternative 3: Strategic Litigation

Alternative three requires hiring an environmental attorney and budgeting for potential legal expenses and filing fees. Strategic litigation relies on this new staff member and allotment of some financial support to aid them in accomplishing the goals of the alternative. The estimated total cost for one year of this alternative including salary and resource cost is $131,741, calculated using average yearly salary of environmental attorneys in Virginia, plus financial support to cover expenses and fees (ZipRecruiter, 2025). Costs of already procured equipment, such as a work computer for the hired attorney, are not included in this estimate. In terms of effectiveness, there are higher costs for this alternative to work toward the goal of less PFAS contamination.

Regarding administrative feasibility, strategic litigation does need new staff to be hired to pursue the alternative. A moderate hiring search to fill the environmental attorney position will be necessary for Sierra Club Virginia Chapter should they choose this alternative. Current technology is effective for strategic litigation and most of the resources needed for the alternative are already available at the organization. PFAS litigation has less of an extensive list of cases to reference compared to other environmental suits, so knowledge of its current landscape and information on best practices may need to be procured (SL Environmental Law Group, 2024). Sierra Club Virginia Chapter does not have a particular advantage over other organizations in strategic litigation, but the national Sierra Club organization does have experience in filing environmental lawsuits. The organization likely would not find difficulty in committing to strategic litigation long-term. Administrative feasibility is medium for this alternative.

Evaluating the strategic litigation alternative for political feasibility, the alternative utilizes existing state and federal legal frameworks. Sierra Club Virginia Chapter would find few political barriers to this alternative’s implementation, but will likely need to find more partners to work with to be successful in their lawsuits should they choose this alternative. Strategic litigation does not impede legislation or regulation from achieving their dual purpose of PFAS prevention and removal. Factors to consider in the political

feasibility of this alternative include the necessity of working partnerships with other litigation-minded environmental organizations, a receptive and open judiciary presiding over chosen cases, and continued support from the Sierra Club Virginia Chapter to maintain litigation efforts. Funding and attention directed toward PFAS litigation could also potentially take away resources from other issues the organization is trying to address. The strategic litigation alternative is unlikely to receive any backlash from the state government, but targeted manufacturers in potential suits would likely dedicate resources in opposition to Sierra Club Virginia Chapter's desired goal of less PFAS contamination in Virginia's rivers. Industry may spend more time trying to disprove claims against them, instead of trying to fix any potential PFAS issues. Risk of retaliation against the organization for this alternative is a possibility, with potential of alienating the private sector in future conversations on how best to address PFAS contamination in Virginia's rivers. Political feasibility is medium for this alternative.

Reduction in harm over the long-term is a focus of the strategic litigation alternative. By using strategic litigation, Sierra Club Virginia Chapter would contribute to progress toward achieving less PFAS contamination in Virginia's rivers. The strategic litigation alternative does not entirely address current pollution levels or reduce harm in the short-term, but it attempts to stop PFAS contamination from manufacturing sources and enforce the Clean Water Act to create lasting change in the long-term. Settlements and outright victories in strategic litigation have the ability to prevent pollution one case at a time (Gargule, 2022). This alternative in certain circumstances may provide a positive externality by informing state governments of their ability to enforce existing water and toxic substances legislation. Meaningful harm reduction is possible in the long-term for this alternative.

Analysis of Alternatives

Alternative 4: Community Initiatives and Biomonitoring

Alternative four requires hiring a volunteer coordinator and budgeting funds for seeds for community plantings and other workday materials. Community initiatives and biomonitoring relies on this new staff member and the procurement of materials to aid them in accomplishing the goals of the alternative. The estimated total cost for one year of this alternative including salary and resource cost is $53,184, calculated using average yearly salary of volunteer coordinators in Virginia, plus funding for seeds and other workday materials (ZipRecruiter, 2025; Seed World 2025). Costs of already procured equipment, such as a work computer for the hired volunteer coordinator, are not included in this estimate. In terms of effectiveness, there appears to be low-to-medium costs for this alternative to work toward the goal of less PFAS contamination.

Regarding administrative feasibility, community initiatives and biomonitoring do need staff to be hired to pursue the alternative. A moderate hiring search to fill the volunteer coordinator position will be necessary for Sierra Club Virginia Chapter should they choose this alternative. Current technology regarding community initiatives and biomonitoring is not fully developed, as many of these scientific interventions have not been extensively tested. The organization will also have to procure reed grass seeds for these community plantings and potentially any workday equipment, such as shovels and gloves, to achieve the goal of the alternative. Sierra Club Virginia Chapter, as an organization with an extensive volunteer network, has an advantage in community initiatives and biomonitoring. The organization likely would not find difficulty in committing to community initiatives and biomonitoring long-term. Administrative feasibility is medium for this alternative.

Evaluating the community initiatives and biomonitoring alternative for political feasibility, the alternative is legal and has almost no political barriers to implementation. Pending permission and approval of communities with proposed sites for community plantings, this alternative should be able to be pursued as soon as personnel is hired and materials are procured. Explaining to communities the purpose of the planting and its benefits will be crucial in securing the ability to implement this alternative. Community initiatives and

biomonitoring do not impede legislation or regulation, as they will be projects which target reaching lower levels of contamination outlined by existing regulation. Funding for community initiatives and biomonitoring could cause the Sierra Club Virginia Chapter to scale back on other community projects for other areas of interest of the organization. Community initiatives and biomonitoring are unlikely to cause any potential backlash against the organization from state entities or industry. Risk of retaliation against the Sierra Club Virginia Chapter is extremely low in this alternative. Political feasibility is high for this alternative.

Reduction in harm over the short-term is a focus of the community initiatives and biomonitoring alternative. By using community initiatives and biomonitoring, Sierra Club Virginia Chapter contributes to making progress toward achieving less PFAS contamination in Virginia's rivers. The community initiatives and biomonitoring alternative does not entirely address lasting change in PFAS contamination in the long-term, but it does address current pollution levels and reducing harm in the short-term. Reed grass planting has the potential to mitigate PFAS contamination in bodies of water, which can lead to better health outcomes for people in targeted areas (Ferrario et al., 2022). Positive externalities can arise from reed grasses addressing other water quality issues, volunteers feeling more involved in helping their community, and potential stabilizations of river ecosystems. Meaningful harm reduction is possible in the short-term for this alternative.

Alternatives Matrix

Criteria	Alternatives			
	Status Quo	*Education Outreach*	*Strategic Litigation*	*Community Initiatives*
Administrative Feasibility	High	High	Medium	Medium
Political Feasibility	High	Medium	Medium	High
Harm Reduction	Fails to reduce harm	Long term reduction in harm	Long term reduction in harm	Short term reduction in harm
Cost	$0	$72,371	$131,741	$53,184

Matrix Guide

In this matrix I have evaluated the proposed alternatives with the chosen criteria. A high, medium, low scale was used for administrative feasibility and political feasibility. The harm reduction criteria utilized a determination of when the criteria will be met and how effective the alternative is at achieving the ultimate goal of reducing harm. Cost is the total estimated cost for one year of each alternative.

The matrix shows the expected grades of each alternative in the chosen criteria and how likely they are to address the issue of PFAS contamination of Virginia’s rivers. Further research on the effectiveness of each alternative could be useful for future implementation of any of these alternatives.

Theory of Change

This section describes the causal chains linking the alternatives to the ultimate goal of reducing PFAS contamination in Virginia's rivers. The structure will be connections from the alternatives to intermediate steps and progress, to the desired outcome. It will include narratives of how the alternatives would play out, should they be chosen by the Sierra Club Virginia Chapter.

In alternative one, status quo would lead to Sierra Club Virginia Chapter allowing other current actors to continue the work already being done to address PFAS contamination in Virginia's rivers. In alternative two, strategies for education outreach would lead to the organization educating the public and lawmakers, changing public perception of PFAS as an issue, and hopefully result in lasting legislation or regulation addressing PFAS contamination in Virginia's rivers. In alternative three, strategic litigation would lead to Sierra Club Virginia Chapter filing suits to prevent industry PFAS pollution in water bodies, utilize settlements for recovery efforts, and hopefully result in more regulatory enforcement to address PFAS contamination in Virginia's rivers. In alternative four, community initiatives and biomonitoring would lead to the organization coordinating volunteer community plantings, stabilizing impaired ecosystems, and hopefully result in removal of existing PFAS contamination in Virginia's rivers.

The hope and expectation is that all alternatives are capable of making progress toward reducing PFAS contamination in Virginia's rivers, but this section serves as an explanation for why these particular alternatives may achieve said goal.

Policy Recommendation

The Sierra Club Virginia Chapter should begin utilizing PFAS strategies for education outreach to help address PFAS contamination in Virginia's rivers. Specifically, they should consider hiring an environmental policy analyst to continue researching PFAS and water quality issues in Virginia for the purpose of creating educational materials to distribute and present to Virginians.

Sierra Club Virginia Chapter could best contribute to reducing PFAS contamination in Virginia's rivers by leaning into their strengths as an advocacy organization and focusing on educating people across the state on PFAS issues. In evaluating the alternatives, consideration was given to cost, administrative feasibility, political feasibility, and harm reduction. Alternative two (strategies for education outreach) had high administrative feasibility, medium political feasibility, an expected long-term reduction in harm, and a cost of $73,371. This alternative's reasonable cost, as well as its commitment to long-term harm reduction, made it stand out as having the best potential for the Sierra Club Virginia Chapter to address PFAS contamination in Virginia's rivers.

Alternative one (status quo) was not recommended due to its failure to reduce harm in either the short-term or long-term. The status quo alternative having low cost, high administrative feasibility, and high political feasibility makes it an easier alternative to implement, but it fails to achieve the main goal of reducing harm from PFAS contamination. Choosing to not address PFAS contamination is risky given the current political climate and lack of existing positive progress toward PFAS prevention and removal in Virginia. Federal regulations for PFAS have recently been scaled back, so now is the time to step forward in tackling the issue instead of stepping backward.

Alternative three (strategic litigation) was not recommended due to several reasons. Strategic litigation has only a medium score in both administrative feasibility and political feasibility. Hiring an attorney for the organization solely to work on water quality issues does not seem to fit the rest of the organization's structure and the potential administrative concerns with becoming an active participant of an environmental litigation working group

are significant. Sierra Club Virginia Chapter can act as an advisor and provide information to other groups filing lawsuits, instead of becoming involved directly. Additionally, it is the highest cost option of all of the alternatives at an estimated $131,741, making it a comparatively larger investment than other alternatives The long-term harm reduction makes the alternative a strong option, but there appeared to be more value gained per dollar from other alternatives.

Alternative four (community initiatives and biomonitoring) was not recommended due to a few reasons. First, the administrative feasibility concerns of having to organize the volunteer network, as well as procure workday equipment, potential workday meals, and more may drain resources from elsewhere in the organization. Sierra Club Virginia Chapter also already has a volunteer coordinator, who may be able to take on the new community planting ideas with their current responsibilities. Secondly, the short-term harm reduction makes it difficult for the alternative to create lasting change in addressing PFAS contamination in Virginia's rivers. Thirdly, the community plantings focus on helping specific geographic locations in Virginia, while strategies for education outreach address PFAS contamination throughout all rivers in Virginia.

Based on my analysis, I recommend the Sierra Club Virginia Chapter use strategies for education outreach to address PFAS contamination in Virginia's rivers.

Policy Implementation

The strategies for education outreach alternative will only be successful if it is implemented properly by the organization. There are a few key themes and best practices necessary for this alternative to be implemented to the best of its ability. The next few paragraphs highlight some of the most important considerations for implementing strategies for education outreach.

Continued Research

As new technology and information on PFAS testing, removal, and prevention arise, it will be important to be up to date on them. The policy analyst will need to be keenly aware of new PFAS developments and incorporate them into their base of knowledge and create updated educational materials accordingly. New legislation and regulations will need to be tracked to understand the direction of PFAS contamination in Virginia's rivers moving forward.

Engaging the Network of Sierra Club Virginia Chapter Members

One of the largest components of this alternative are the members of the Sierra Club Virginia Chapter. Strategies for education outreach will rely on engaging these members through e-mailing lists, community events, and social media. It will be key to connect to a larger base of support in the state of Virginia, not only to educate them on PFAS contamination issues, but also to gain assistance in pressuring Virginia lawmakers to pass new PFAS legislation. The more people aware and engaged in PFAS, the more likely this alternative will reach the goal of achieving long-term harm reduction.

Creating Interesting and Explanatory Materials

Much of the strategies for education outreach alternative relies on educational materials that will be dispersed to the public, members of the organization, and lawmakers in Virginia. It is vital these materials are not only informative, but also interesting and eye-catching for readers. PFAS contamination is a complex issue, so it is important to be able to explain the intricacies of it in plain language. The policy analyst will need to be able to get the point across, have supporting factual information, and make the

material visually appealing in order for the strategies for education outreach alternative to have the best effect.

Connecting with Virginia Lawmakers

Ultimately, the strategies for education outreach alternative relies on long-term harm reduction as one of its goals. The central intermediate step in this process is convincing Virginia legislators to address the issue by passing new laws safeguarding against PFAS contamination in our water sources. The policy analyst will need to be able to connect with members of the Virginia General Assembly and effectively communicate both the issue of PFAS contamination and the potential tools legislators have available to them to address the issue. Since Sierra Club Virginia Chapter is not a legislative or regulatory body, it is key to gain the support of people in these positions to make lasting change.

Appendix

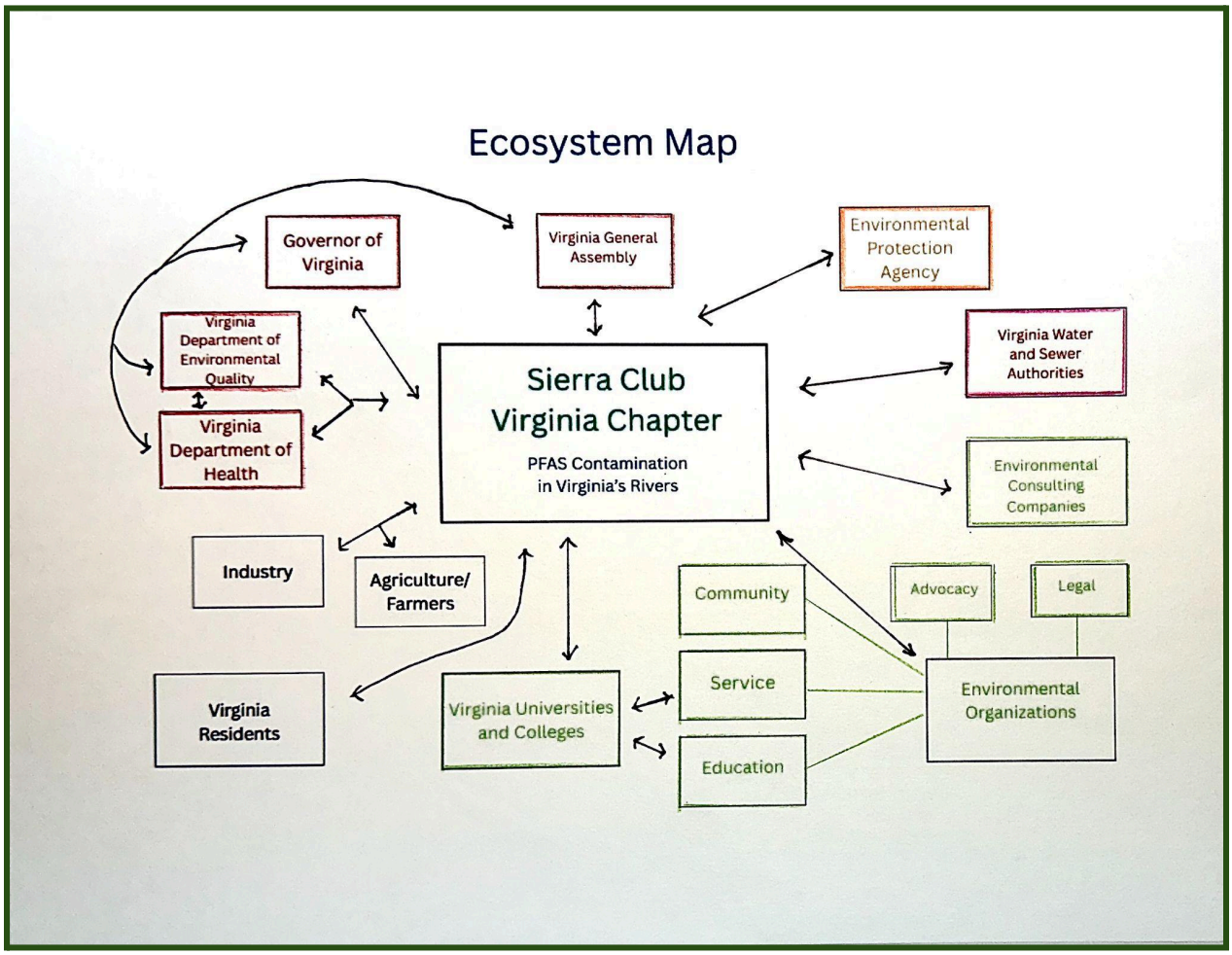

Figure 1. Ecosystem Map: Sierra Club Virginia Chapter and the issue of PFAS Contamination in Virginia's Rivers

Costing for Alternatives

Expected Cost (Salary + Resource Cost = Final Cost for One Year)

Status Quo: $0 + $0 = $0

Strategies for Education Outreach: $72,221 + $150 = $72,371

Strategic Litigation: $131,241 + $500 = $131,741

Community Initiatives and Biomonitoring: $52,384 + $800 = $53,184

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