

ENVS 50
Environmental Problem Analysis



Spring 2023 Report

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Chapter 1

Climate Migration and Resilience: A Case Study in Hartford, Vermont for the Upper Valley Climate Adaptation Workgroup



Connor Bishop, Ainsley Bryant, Destiny Hannon, Joanne Liu, Abigail Shepherd

Climate Migration and Resilience: A Case Study in Hartford, Vermont

Introduction

Climate change has been increasingly recognized as a driving force behind population displacement and migration worldwide. As Earth's climate continues to evolve, certain regions are witnessing an influx of individuals seeking refuge from the environmental challenges they face in their home communities. These challenges encompass not only the more visible consequences such as flooding caused by rising sea levels and frequent severe weather events but also the often overlooked long-term effects of heat, drought, and changes in air quality. The motivation behind these relocations then arises from diverse factors including incentives offered by the public sector, the necessity for infrastructure enhancements, land conversions, and the economic repercussions resulting from shrinking populations caused by the out-migration of others. This process of voluntary movement caused by climate-related motives is called climate migration. According to the United Nations, climate migration is “the movement of a person or groups of persons who, predominantly for reasons of sudden or progressive change in the environment due to climate change, are obliged to leave their habitual place of residence, or choose to do so, either temporarily or permanently, within a country or across an international border” (United Nations International Organization for Migration, 2020).

Related to climate migration is climate resilience. According to the Upper Valley Adaptation Workgroup, climate resilience is “the ability of a community to anticipate, prepare for, respond to and recover from climate impacts in a way that minimizes significant disruption to our lives and compromise of shared resources. This includes our health, safety, built environments, food availability, natural resources, wildlife, and financial strength,” (Vital Communities, 2023). Climate migration and climate resilience are connected to in-migration and housing pressure issues, as preparing for climate migration is necessary in order to make communities more climate resilient. However, there is still a great deal of uncertainty as to how to best plan for future development issues because projections of climate change’s impact on migration continue to fluctuate, and are fuzzy at best. As Linda Shi, an assistant professor in the Department of City and Regional Planning at Cornell University, states: “If you’re waiting for numbers, you’re not going to get them.” In other words, climate migration and climate resilience occur at such a large geographic and temporal scale that collecting concrete, quantitative data is nearly impossible.

A 2017 study funded and approved by the EPA attempted to develop a standardized climate resilience screening index (CRSI) at the county level to compare community resilience across the United States. The index is a composite measure of five categories (risk, governance, society, built environment, natural environment) calculated from 117 metrics spanning factors such as housing characteristics, socio-economics, demographics, and utility infrastructure capacity. Figure 1 reports the distribution of the final CRSI scores across the US and subsequently identifies the counties with the highest and lowest resilience to adverse climate events. Vermont, New Hampshire, and Maine consistently yield high resilience scores and are subsequently designated as targets for climate-related in-migration increases (Summers et al. 2017).

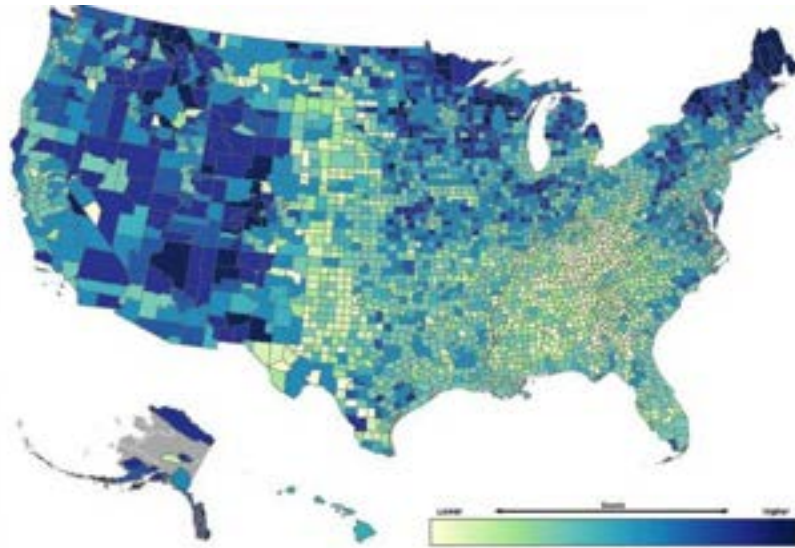


Figure 1: US distribution of CRSI scores (2000-2015) - dark colors indicating higher resilience scores.

Given the Northeastern US's high climate resiliency, as illustrated in Figure 1, we partnered with two regional organizations– Vital Communities and the Upper Valley Adaptation Workgroup (UVAW)– to study climate migration and resilience in this area. Vital Communities is an organization that represents 69 towns spanning the Connecticut River (TechTriad.com 2023). It aims to engage Upper Valley residents, organizations, and local governments to create equitable solutions to the region's civic, environmental, and economic challenges. UVAW, on the other hand, is an organization that deals solely with climate resilience. Their mission is to build and plan climate-resilient communities in the Upper Valley. Vital Communities is UVAW's fiscal sponsor and one of the group's 17 members, but both organizations operate independently of one another.

Vital Communities has been working with researchers at Cornell University to study climate migration and resilience in upstate New York. Our analysis aims to expand this research to New Hampshire and Vermont. We accomplish this by conducting a case study identifying the barriers and opportunities to address current and future climate migration to a specific town in Vermont. Ideally, our case study can be used to anticipate the needs of similar towns across New England as they prepare for the impacts of climate migration.

We chose to focus our research on the town of Hartford, Vermont (see Figure 2). Hartford is composed of five unincorporated small villages: Hartford, West Hartford, Quechee, White River Junction, and Wilder, and is the largest town in Windsor County. We chose Hartford as the subject of our case study as it is considered a large and growing town in the Upper Valley region. Vermont experienced a population growth of 2.8% (approximately 17,336 individuals) from 2010 to 2020. Around 6% of this population growth occurred in Windsor County (US Census Bureau - America Counts Staff, 2021). According to estimates released in March 2023, when accounting for in-migration driven by the Covid-19 pandemic, Vermont experienced around 2.5x its average annual growth between 2020 and 2021, seeing an increase of about 4,079 individuals. Approximately 15% of the growth was experienced in Windsor County (US Census Bureau, Population Division 2021). In short, Windsor County, and Hartford in particular, bears a large portion of the responsibility of housing new Vermont migrants. Because of this new growth, Hartford is now the 9th largest town in Vermont with around 11,000 residents.

Ultimately, we aimed to provide UVAW and Vital Communities with two different case studies conducted in conjunction with another research group. We chose to focus on a large and growing Vermont town, while our partner group focused on a smaller New Hampshire town (Plainfield, NH). This enables our partner organizations to compare climate migration across unique types of communities in the Upper Valley, specifically looking at 1) a high-density, primarily urban town (Hartford, VT) versus 2) a smaller, rural, more spread-out town (Plainfield, NH).



Figure 2: Town map of Hartford, VT including the five main villages: Hartford, Quechee, West Hartford, White River Junction, and Wilder.

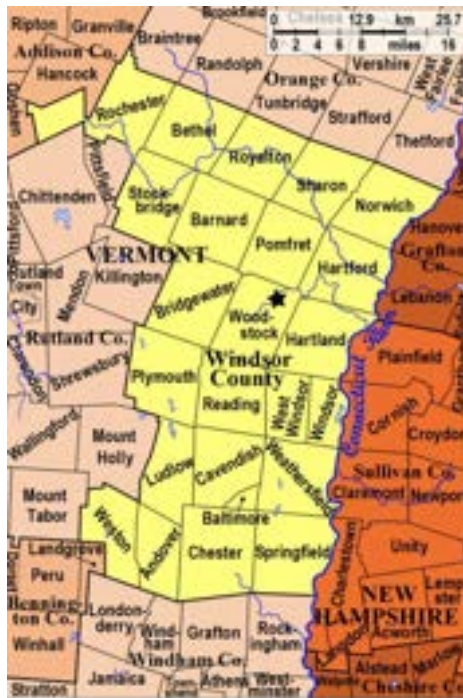


Figure 3: Windsor County (yellow) in relation to New Hampshire towns (red) and surrounding Vermont towns (orange)

The issue surrounding climate migration arises when population growth parallels a significant decrease in housing inventory while income inequality is exacerbated. According to monthly housing trend reports published by Realtor.com, the total of both active listings and pending listings in Windsor County decreased by 82.5% from April 2017 to April 2023 (Federal Reserve Bank of St. Louis, 2023). Additionally, from 2011 to 2021 the ratio of the mean income for the highest quintile (top 20 percent) of earners divided by the mean income of the lowest quintile (bottom 20 percent) of earners for Windsor County grew from 12.61 to 15.74 (Federal Reserve Bank of St. Louis, 2023).

A significant portion of Vermont's population, including BIPOC communities, older residents, and those with low incomes face housing insecurity due to high housing costs. Over 24% of households and a majority of renters are now considered “cost-burdened” (spending greater than 30% of income on housing). Rising rent prices resulting from increased in-migration and limited housing supply also contribute to homelessness in the state. While recent legislative efforts have allocated \$195 million to address homelessness, sustained action is necessary to find lasting solutions to Vermont's housing challenges (Vermont Climate Council et al. 2021). Achieving inclusive housing, racial justice, and eliminating discriminatory barriers are vital for creating a welcoming environment in the state.

In this paper, we attempt to identify common inhibitors to climate resilience and potential solutions to these challenges by comparing interviews of community leaders operating in capacities ranging from energy/utilities, zoning, housing, and economic services. Through these interviews of key stakeholders in the Hartford community, we conclude that the influx of non-residents to Vermont during the COVID-19 pandemic, along with the transformation of second homes into primary residences, offers a glimpse into a potential wave of climate-driven migration to the region. This has resulted in a housing shortage, escalating prices, and an exacerbation of equity and justice concerns. Insufficient infrastructure in some cases, particularly wastewater and water systems, presents challenges for compact settlement. Our results highlight the urgent need for effective land use planning and regulations that prioritize housing development, compact settlement, and just transition policies.

Methods

We attended the “World Cafe”, organized by Vital Communities’ Upper Valley Adaptation Workgroup in West Lebanon, New Hampshire, that aimed to bring together diverse community stakeholders from surrounding towns to collect opinions regarding sentiments surrounding climate in- and out-migration. Per suggestion by UVAW, our study builds off of the “World Cafe” by broadening our scope to interview more community leaders in the Upper Valley, using Hartford as a case study. We sought to find common themes in the opinions of community leaders regarding what must change in hopes of unifying the resiliency efforts of the Upper Valley. We did this by conducting ‘snowball sampling’, contacting individuals from the Upper Valley World Cafe conference and pursuing their referrals to other relevant figures knowledgeable about development in Hartford. We asked each individual questions based on a previously devised question bank and left room for flexibility as the conversation developed. Each interview was tailored to the role and knowledge of the interviewees.

From our interviews and snowball sampling process, we identified that there were several key stakeholder groups, including the TRORC (the Two Rivers-Ottawaquechee Regional Commission), the Upper Valley Adaptation Workgroup, and the Hartford Energy Commission, among others. The interviews were primarily conducted via Zoom, and we attended two in-person events: the UVAW Climate Migration World Cafe in West Lebanon, NH (3/29) and the Antioch University’s Local Solutions

to Climate Change conference in Keene, NH (5/17). We interviewed two members of the Two Rivers-Ottawaquechee Regional Commission, 1) Kevin Geiger and 2) Peter Gregory, Harford town planner Matt Osborn, members of the Hartford Energy Commission, 1) Dana Clawson, 2) Ellen Hender, 3) John Haffner, and 4) Jesse Pollard, Lauren Oates from the Nature Conservancy, Alice Ely from the executive board of the Upper Valley Public Health Council, and former Dartmouth Professor Bill Fischel, conducting at-length interviews with a total of 10 stakeholders, not including information gathered at the two conferences.

We began interviews with a short brief regarding the nature of the project, identifying it as a case study focused on in-migration in Hartford and the resulting development pressures within the community. We expressed that the overall goal was to help identify how the community can better prepare to be more resilient to future climate migrants while coexisting with current residents amid a serious housing crisis. We also shared how their input would be implemented in our final product. Finally, we asked the following questions (depending on relevance) and geared the interview toward the interviewee's responses:

1. What do you believe is the biggest hurdle to developing a climate-resilient community in Hartford?
2. What is your role/your organization's role in mitigating or adapting to climate migration in the area?
3. What is your opinion regarding the balance between conserving the Upper Valley's environment and increasing residential development to keep up with increased housing pressure? Are they necessarily opposing interests?
4. What are your thoughts on Act 250 and the appeals process? Where do you see opportunities for change and modernization?
5. How do you work with different community stakeholders, who might be strongly opposed to development and an additional influx of migrants, versus the interest in private-sector commercial and residential development?
6. How do you support a town whose population is growing in size, providing the necessary infrastructure (such as wastewater and public utility management) while preventing rural sprawl?

Results

A. Similarities Across Interviews

1) Act 250 is outdated: Act 250 is one of Vermont's land use and development laws, enacted in 1970 at a time when Vermont was undergoing significant development pressure. The law provides a public, quasi-judicial process for reviewing and managing the construction of major developments. Projects that are large enough to qualify under Act 250 require permits granted by the Natural Resources Board of Vermont if the project satisfies the ten environmental criteria outlined in the legislation.

According to the Vermont Planners Association (VPA), Act 250 has not been effective at meeting statewide land use and development goals. This is mainly due to environmental criteria applying holistically (state-wide) rather than on a local basis. Additionally, criteria are dated, as they don't reflect changes since 1970 regarding evolving state policies, permit requirements, scientific knowledge, or emerging environmental concerns. The vast majority of interviewed stakeholders agreed when asked if Act 250 was outdated and said that it played at least some role in inhibiting development projects.

However, we want to acknowledge the degree of its effect in Hartford did vary based on who was being interviewed.

We found that it is likely that people living in urban areas of Vermont, like Hartford, tend to be against Act 250 as they believe that the environmental criteria should not apply to areas that are already developed but instead to areas that are more rural and have aspects of the environment that should be conserved. The S.100 bill was brought up on multiple occasions as a step in the right direction to address this issue. S.100 aims to amend Act 250 and allow more housing development in already existing towns. Additionally, it hopes to limit appeals (the character of the neighborhood can't be an issue appealed under Act 250) and improve definitions of environmental criteria to also address the problem of frivolous appeals filed on grounds that are only somewhat related to environmental concerns.

All Hartford town planners and developers acknowledged that the appeals process under Act 250 is flawed in the sense that it has been used on multiple occasions to filibuster development projects that would potentially alleviate the housing pressure in Hartford or contribute economically to the area. However, it must be acknowledged that interviewees did see Act 250 as a necessary piece of legislation in the sense that it serves to protect wildlife habitats, farmland, wetlands, etc. Also, for many small towns, the process of reviewing projects and requiring a development plan under Act 250 is necessary as they lack the staff to conduct the proper planning on their own.

2) Staffing is an issue: Interviewees mentioned the issue of Hartford facing challenges retaining and attracting staff because local officials are often not paid and are typically volunteers. Due to its large size, Hartford is one of the few towns with town staff and coordinators, but it remains an issue. Because these positions are on a volunteer basis, Vermont towns exhibit problems of representation, as most of these positions are filled by individuals who have the financial means and time to do the work. This leads to some small towns having one individual trying to handle all town managerial work. This is a bad omen for future development as the housing crisis is a time-sensitive issue and understaffed municipalities may have trouble approving or appropriately vetting projects. For example, we spoke to members of the Hartford Energy Commission who reported having to handle projects outside of their job descriptions, distracting them from their actual work. Additionally, we recorded concern about drawing upon the plethora of federal and state funding aimed at encouraging economic development in the area because offices are so understaffed that there would be insufficient manpower necessary to manage these funds.

3) Workforce shortage: Hartford, like many towns, is facing a workforce crisis. Unprompted by our questioning, almost all interviewees mentioned that the type of out-of-staters moving to Hartford are wealthy individuals moving because they have the means to do so. Parties cited increasing amounts of residential cash purchases, second homes, as well as increased housing prices as evidence of this. This type of migrant is not filling the open positions in the job market, resulting in increased housing prices while not contributing to the workforce. A few interviewees mentioned that, although some people would think this would be beneficial to the local economy, the strain it produces outweighs any of the potential benefits. This also decreases Hartford's resiliency once people start moving to the area for climate reasons rather than by choice.

The workforce shortage has a significant effect on Hartford's economic growth and places particular strain on the public health sector. The workforce crisis in Hartford is also tied to changing demographics mainly in the form of an aging population. This is potentially why we now see significant decreases in school enrollment, declining about 25% from the 2017 school year to the present. Hartford is

attempting to address the issue of a workforce shortage in necessary industries (particularly the trades) through programs such as the Hartford Trailblazers, a seven-week training program in construction and renewable energy skills for women.

4) Community engagement and public infrastructure: All parties stressed the importance of community engagement when speaking about development projects in the Hartford area. Hartford does take steps to try and accomplish this, but, to some extent, it results in slow change, for instance, when deciding to amend zoning ordinances to permit Accessory Dwelling Units or ADUs. However, Hartford has taken measurable steps to incorporate community input through programs like the recent bylaw modernization project and “Homes for Hartford” which sought out input on solutions for the housing crisis and deployed multimedia booths about the issue in public buildings. Hartford also has resources that smaller towns do not, for instance, town staff and coordinators, a larger tax base than some towns, town water, and sewer as well as knowledge of their capacities, and workforce development programs.

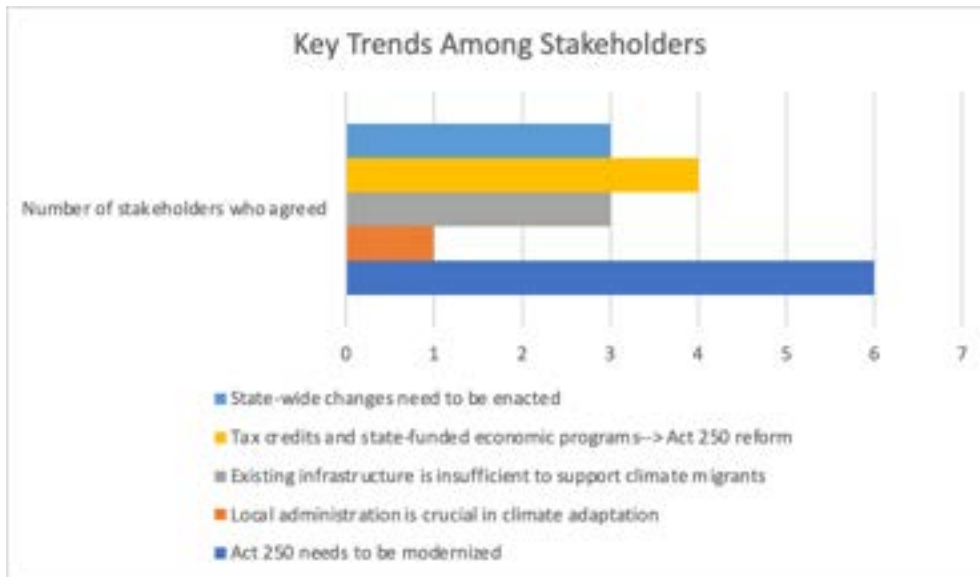


Figure 4: Key Trends are based on the following categories of stakeholders: Academics (1 interviewed formerly from Dartmouth Economics department), Public Health officials (1 from Upper Valley Public Health Council), Utilities (4 from Hartford Energy Commission), Planners & Developers (2 from Two Rivers-Ottauquechee Regional Commission, 1 from Hartford Town Planner), Nonprofits (1 from the Nature Conservancy).

B. Points of Disagreement Across Interviews

When comparing the perspectives of key stakeholders, representing nature conservation NGOs, public planning, or even more high-level urban planners, they diverged in several distinct ways in terms of barriers to action and opportunities for change concerning climate migration.

1) Access to Information: Hartford Energy Commission Chair, Jesse Pollard, sees an information bottleneck when decision-makers need to get information out to citizens quickly. For example, they may need to inform the public about a town grant or funding opportunity and require a quick turnaround time. The challenge, however, is that the mandatory open town meetings require public notice and occur only

on a monthly basis. Therefore, funding proposals and planning initiatives either get dragged out, or someone has to bear the extra workload to gather all the information required for applying for grants in a timely manner. With many towns being primarily staffed by volunteers, there is often insufficient bandwidth to both provide information quickly to the public and to enable them to respond promptly. There is no town energy efficiency website that would otherwise provide a centralized information source. It would be able to inform citizens in a timely manner about current grants, subsidies, and tax incentives made available to weatherization adaptation programs and efforts.

On the flip side, however, former Public Economics professor Bill Fischel believes that people's decisions on where they live illustrate their revealed preferences. Arguing from economic theory on "voting with one's feet", people have already revealed their preferences for a more- or less- well- climate migration-adapted town based on the home they purchased and the town they chose to live in. Residents also want to preserve their home values and so, given their awareness of climate migration pressures, they are incentivized to adapt sufficiently to climate change and to preserve their property/home values.

2) Tax Credits: Tax credits are able to create "designated downtown" and "village center" areas that might mimic the Central Business District of a city, providing mixed-use amenities and businesses selling goods and services, interspersed with residential-use spaces. Tax credits incentivize businesses to move into a town which generates additional capital inflow, allowing towns to fund more housing, public infrastructure, and energy efficiency programs. For example, Hartford was a major beneficiary of Department of Energy grants, Vermont state grants, and Efficiency Vermont funding for home weatherization and retrofitting initiatives.

On the other hand, others argue that towns should instead aim to capture organic growth. They argue that dangling tax credits to "lure people and businesses in" is a very old-school, economically inefficient way of bringing businesses to the area. It diverges funds away from making downtowns more liveable towards businesses that cannot say how much job creation and economic activity they actually generate. Additionally, some interviewees argue this system hasn't historically proven to be very effective and so the link between tax credits and economic revitalization is speculative at best, while significantly reducing the town's tax base.

3) ADUs as a solution: We encountered a few vocal supporters of ADUs, particularly Matt Osborn, who works in Hartford town planning, as well as the Hartford Energy Commission and related interviewees. They see that ADUs are a great compromise in getting residents on board with increased development because of their minimal impact on the visual integrity and character of the town and their ability to allow for a modest increase in housing supply to soften an incredibly tight housing market.

However, it is also important to acknowledge that ADUs are at best short-term solutions. They don't systematically increase the housing supply in a meaningful way, and they are constrained by existing house limitations, such as the lot size the ADU was built on, and not being able to exceed 75% of the size of the original house. Zoning ordinances will still limit the density of ADU development, and the cost of an ADU home will still remain high from a per-square-footage point of view. Ultimately, they are not the high-density, affordable housing that migrants and existing residents are in dire need of.

Discussion

Peter Gregory and Kevin Geiger

Peter Gregory and Kevin Geiger both work for Two Rivers-Ottawaquechee Regional Commission (TRORC) as the Executive Director and the Director of Planning, respectively. TRORC serves as a regional planning agency for 30 towns in Vermont, including Hartford. Both Kevin and Peter see climate migration as a significant issue that is currently impacting and will continue to impact the Upper Valley region. They both acknowledge that there is a housing crisis and that balancing development and conservation is creating tension within and among communities. One point Kevin and Peter both make is that the state and towns of Vermont need to invest in local infrastructure, both new and existing, to support current and incoming residents alike. The two seemed to differ in terms of their ideas for the best solutions to the climate migration issue. Kevin emphasized the economic forces that cause, and could therefore alleviate, the issue, such as the potential for tax incentives (equity taxation, conservation taxes). He identifies the wealth disparity between new residents (upper-class, non-minority, remote work) and the old residents as a driving force behind the housing crisis and believes it is the result of the free market. Kevin believes that it is the job of the Vermont state and local governments to step in and facilitate the moving process of climate migrants. He sees the biggest hurdle to climate resilience in Hartford as the ambiguity of the government's role in the process. Peter also believes that Vermont needs to anticipate the needs of climate migrants. However, he thinks that Vermont should invest in its strengths: upgrading existing infrastructure, drawing business to Hartford, making downtown areas more liveable, and supporting the creative economy (food, breweries, art, tourism).

Matt Osborn

Matt Osborn serves as the AICP planner for the Hartford Planning & Development Department. His background primarily centers around economic development and small-business support for town centers, and focuses on initiatives and programs that seek to revitalize New England small towns' downtown areas. The Hartford Planning Commission's goal is geared towards building a "resilient Hartford", where members work on sourcing alternative food sources, building a conservation commission, and developing programming to help reduce the reliance on and consumption of fossil fuels. The Planning Commission's role is primarily long-term urban planning and economic development, as opposed to climate resilience. From a legal and procedural perspective, Matt looks at how the town of Hartford can modernize its zoning regulations and bylaws to create more housing opportunities. For example, Hartford's 2008 change in zoning reduced sprawl, while encouraging habitat preservation through the Conservation Commission's pushing for amendments in these zoning regulations to protect riparian buffers.

In terms of community input, the planning and development department seeks creative ways to engage residents, for instance, through interactive multimedia booths in town centers and the "Homes for Hartford" project. Matt sees the town of Hartford as having ample infrastructure, including water and sewage systems, to support a larger population and therefore does not foresee major challenges on that front. Matt also supports reforming Act 250 to apply more to rural areas as opposed to more urban, higher-density towns such as Hartford. He sees Act 250's appeals process as problematic, resulting in development project delays. Matt believes that the key to encouraging climate resilience lies in developing the local economy, namely through financial incentives such as tax credits to local businesses, planning incentives, and designating village centers. Finally, the push to create mixed-use downtown areas and ADUs (accessory dwelling units) are viable strategies to address housing pressure while preserving the town's character.

Bill Fischel

Bill Fischel, a retired Dartmouth economics professor, spoke about his experience on the Hanover Zoning Board. He mentioned ADUs being one of the main ways in which New Hampshire has dealt with housing deficiencies caused by zoning rigidity. He spoke specifically about difficulties in keeping home ownership affordable for the children who grow up locally, but are forced to migrate out of their communities to find affordable properties in adulthood. The ADU requirement was applied evenly across participatory towns, distributing costs and benefits and thus making the idea more digestible to communities adopting the project. Effectively, the innovative project abolished single-family zoning – a regulatory measure that has long been lambasted as a barrier to sufficient housing capacity.

Professor Fischel also asserts that the attempts under Act 250 to reduce sprawl are outdated. He notes that a significant transformation occurred in 2004, where the rural residential minimum lot size increased from 3 acres to 10 acres, effectively impeding suburban housing expansion through a process referred to as 'downzoning.' Additionally, Fischel highlights limited internet access as an additional hurdle to augmenting housing capacity.

He addresses the point that every zoning change in certain towns is subject to a town meeting. However, Act 250 contains a provision for a “double veto” – through this process, town consensus can be vetoed through an appeal based on Act 250 standing. Professor Fischel asserts that no authority other than the select board that is appointed by town residents should have the final say in zoning matters. He posits that a policy-oriented planning board must be elected by residents to make such decisions. Communities are already incentivized to care about climate migration because their property is invested in the future. He believes a lack of information on zoning and migration/development is not the issue here– “you have to put your head in a hole and keep it there to avoid this”.

Making Room Conference: Funding and Local Case Studies

Lauren Oates, The Nature Conservancy VT, also sits on the Vermont Climate Council

Lauren states that the impacts of climate change, and the externalities that exacerbate them include physical damage, community cohesion, town capacity and turnover, planning, grants, etc. We need grid-based resilience related to energy demand, though the bigger issue will be days of extreme heat.

She believes small towns will bear the brunt of the planning, grant applications, and response to these issues. Lauren argues for the need to build communities with the capacity to absorb floodwaters, mitigate local hazards, meet energy demands, and incorporate community input. She posits that regional communities face notable challenges in accessing funding and that this is a problem at the legislative and executive levels.

Ethan Widrick, Resilience and Adaptation Manager for Wastewater Engineering Bureau

Widrick views wastewater as the key to resilience, and that communities need to prioritize infrastructure going forward when addressing climate resilience as a whole. He argues that people should “get to know” their utilities and understand that they are historically understaffed and underfunded. Ethan states that communities like Hartford need to be as proactive as possible with identifying issues, completing vulnerability assessments, and then implementing planning assessments and programs. This includes using the framework of the asset management program (AMP), climate vulnerability assessments, and targeting existing (aging) infrastructure and their lack of capital.

Bonnie Waninger, Vermont League of Cities and Towns

Waninger discussed the federal funding assistance program and the billions of dollars available for development-related concerns for those who know how to get it, including through the American Rescue Plan Act, the bipartisan infrastructure law, and the inflation reduction act (IIJA). She mentions the opportunity to book an appointment with the Vermont League of Cities and Towns which will provide municipalities in writing a list of grants they can apply for.

World Cafe

Stakeholders noted that the recent increase in migration to Vermont and New Hampshire's Upper Valley region was primarily driven by pandemic-related migration out of city centers, primarily by affluent white individuals. The stakeholders observed that many people were moving to the region by choice mainly for lifestyle reasons and possessed the financial means to do so. The area's housing crisis was identified as a key factor in pricing out current residents, with limited availability of affordable housing leading to outmigration. Stakeholders also highlighted a rise in second homes and rental properties. While climate was recognized as a motivation for some migrants, it was acknowledged that there were multiple other factors influencing their decision. Concerns were raised about the upper valley community's hostility towards migrants, citing instances of racism and discrimination. Additionally, the stakeholders pointed out that the existing sewer and water infrastructure was not well-equipped in certain rural areas to support increased development. Current residents viewed migration as a potential threat to the area's agriculture and natural resources. Additionally, participants in the climate café noted the strain on social services, which cannot accommodate the growing population. Finally, some community members, particularly those with zoning or development knowledge, called for loosening Act 250 to address the challenges posed by migration and potential limits to developing housing to accommodate them.

Alice Ely

Alice Ely, the Executive Director of the Upper Valley Public Health Council, acknowledges that climate-related in-migration poses both obstacles and opportunities for Vermont and the Hartford area. She recognizes the need for communities to openly discuss and think differently about this issue, beyond just economic benefits and accommodating well-resourced individuals. Alice emphasizes that some migrants will arrive with limited resources and different needs, such as those fleeing war or environmental devastation. The current population spike and housing crisis in Vermont present immediate public health challenges that require attention. Alice emphasizes the interconnectivity between housing, transportation, living wages, and other social determinants of health. She advocates for a comprehensive approach that involves partnerships between the Public Health Council, local government, community organizations, and stakeholders to address the housing crisis and improve public health in the region. Additionally, Alice advocates for increased public health funding and a shift in policy perspective from controlling development to implementing equitable and realistic approaches. By addressing the workforce crisis and promoting regional planning and zoning, she believes that the burden of housing can be shared more evenly across communities.

Hartford Energy Commission & Related Members

We interviewed four individuals: Jesse Pollard (Chair of Hartford Energy Commission), John Haffner and Ellen Hender (Program Managers of Housing and Transportation for Vital Communities), and Dana Clawson (Environmental Coordinator for Town of Hartford). We intended to interview the entire Energy Commission but given that other community leaders exhibited an interest in the project, we decided to conduct a larger group-style interview.

Interviewees mentioned the housing shortage as a top concern and discussed rewriting the housing chapter of the town plan to address this issue. However, there are challenges, including political pressures and NIMBYism, which hinder the construction of new housing.

Regarding resilience to climate-related in-migration, the interviewees highlighted the importance of increasing population density and urbanization, as outlined in the town's Climate Action Plan. They recognized the need for structural and institutional changes, such as paying people for their time and opinions to ensure diverse voices are represented. Collaboration and resource sharing between towns, especially in terms of workforce development programs, were seen as crucial for addressing the challenges posed by climate change and population growth. They mentioned that Hartford, in particular, could share initiatives like workforce development programs and similar resources with surrounding smaller towns that lack the municipal staff and resources to address in-migration on their own.

The interviewees acknowledged the trade-off between environmental goals and timely development. They discussed the tension between different perspectives on issues like solar installations and tree preservation. While development was seen as necessary, the interviewees emphasized the need to make informed decisions now to avoid burdening future generations.

Conclusion

There are numerous limitations to the case study approach that could be addressed in further research. Firstly, the case study takes a micro approach to studying real-world issues. In our case study, we investigated climate resilience by studying the relatively small town of Hartford. This means that our results may not be generalizable, especially considering the unique geographic and demographic characteristics of the Upper Valley. Secondly, we found it difficult to gain a truly local perspective on climate migration. We mainly interviewed regional experts – board members, zoning officials, scientists, and others. This means that the human impacts of in-migration as it relates to climate may not be entirely captured in our report. In the future, we would like to survey a more randomized population to capture a greater breadth of perspectives and approaches to climate resilience. The perspectives and needs of a small, rural community, versus a more densely populated and larger town such as Hartford, are distinct from one another. While Hartford is not fully representative of all of the Upper Valley, by grounding our case study in this town, we could explore the challenges of balancing in-migration with limited resources and infrastructure.

Furthermore, as is the case with climate migration in any context, we came across the problem of a lack of causal certainty. For example, when we examined housing pressures, we found that the COVID-19 crisis was the foremost factor in the view of local experts, rather than potential climate migration pressures. While it may be argued that COVID-19 was exacerbated by a warming climate, this argument may not be strong enough to justify initiatives – and associated costs – geared at strengthening climate resilience. Hartford, as evidenced by our interviews, is acutely aware of the housing-related pressures brought about by external factors, including climate migration, so this could also be a factor that drew an influx of migrants in recent years. The COVID-19 crisis is only one among a host of confounding

variables that confuse causal certainty, thus creating a barrier to climate resilience action. A body of empirical, statistically significant evidence will be needed to prove causality and urge policymakers, urban planners, zoning boards, and residents to consider climate migration safeguards.

Group reflection

On April 4th, Dr. Bieluch presented ideas on how to better collaborate as a group through communication, organization, and clear expectations. We first sought to create an environment of psychological safety, cognizant of the fact that some people may not feel comfortable or safe speaking up in a group setting, for fear of vocalizing their ideas, getting shut down, or being critiqued in another way. Therefore, we first sought to establish ground rules: we ensured candor and openness in our conversations, by making sure we expressed appreciation for ideas that others volunteered to share, and instead of shutting down an idea that we felt would not work, sought to modify or adapt from them, to reach a compromise. This was especially important for us when we were trying to speak with stakeholders that sometimes disagreed with one another, or whom we disagreed with during our conversations.

We aimed to be intentional with our work by participating in weekly in-person group meetings and by setting boundaries with our work. These meetings, as well as consistent communication over group chat, were incredibly helpful in keeping everyone on the same page so that no one ended up doing the same work and so that we could each pick up the slack as needed. Clear communication was one of our strengths as a group, not just in terms of the project itself but in terms of our capacities to contribute to the project. The intention we made to accommodate and adapt to people's commitments outside of this class allowed us to maintain a positive working environment throughout the project. While it would be unfair to say that everything always runs smoothly, communicating clearly to the group about how much work the group member was putting in generally ended up being a pretty good way to encourage others to step up to contribute more work to 'match' the energy of those taking the work seriously. It was through this communication, direction, and regular meetings that we were able to hold each other accountable for the work we were putting in, and we made a better product because of it.

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Chapter 2

Climate Migration at the Crossroads: Investigating Plainfield, New Hampshire's Capacity to Welcome Newcomers for the Upper Valley Climate Adaptation Workgroup



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Climate Migration at the Crossroads: Investigating Plainfield, New Hampshire's Capacity to Welcome Newcomers

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Abstract:

Climate change and climate-related disasters are driving migration nationwide, resulting in significant internal displacement in the United States and globally. There is currently little data and empirical evidence surrounding the impacts of climate migration on receiving communities, and overall action to prepare communities for these future migratory patterns is limited. Because of relatively low susceptibility to climate change, the Northeast has been targeted as a desirable location or “climate refuge” for migrants, and data suggests that climate-induced migration to the Northeast will continue to increase in coming years. In our study, we work alongside the Upper Valley Adaptation Work Group and A Northeast Safe and Thriving for All (NEST) to prepare a case study on the town of Plainfield, New Hampshire. We are adding to their body of work in understanding how cities and towns throughout the Northeast may be impacted by an influx of climate migrants. By conducting interviews with town residents and local professionals, analyzing town archives, and attending regional conferences discussing the broader context of NEST’s work, we attempt to provide insight on how Plainfield housing, zoning, and residential perspectives may provide transferable lessons for how towns in the Northeast can best prepare for climate migration. We find that issues facing many Upper Valley communities, such as rising housing costs, a lack of infrastructure conducive for high density development, and NIMBY-ism from long-term residents, are prevalent in Plainfield and provide challenges for creating an environment that is receptive to climate migrants. We conclude that internal discourse and education about community-based zoning and infrastructure, as well as a broader focus on regional cooperation, is necessary for the Northeast to adapt to expected migratory changes.

I. Introduction

Climate change and climate-related disasters are driving migration nationwide, resulting in significant internal displacement in the United States and globally. As explained by Ama Francis, a project strategist at the International Refugee Assistance Project (IRAP), “climate displacement is movement, in part due to climate-related disasters, both sudden and slow-onset disasters...within countries or across borders” (Greenfield, 2022). According to World Bank estimates, by the year 2050 more than 140 million people across Sub-Saharan Africa, South Asia, and Latin America may be forced to move due to climate change and related disasters (“Groundswell”, 2018). Migration patterns within the United States also follow this trend: in 2017, environmental disasters displaced at least 1.7 million people in the US alone, representing the 6th highest rate of new internal displacements in the world (Perls, 202).

While climate change is projected to have tremendous consequences in the next 30 years and beyond, the exact nature of these consequences, specifically those related to migration, are difficult to predict. Although some of the impacts of climate change on migration patterns will be clear, as in the case of sea level rise causing clear-cut displacement of coastal communities, questions about *where* people will go, *why* they will choose to go there, and *how* those communities will receive them are less straightforward. Further, the degree and character of movement caused by other natural disasters such as wildfires, hurricanes, droughts, and heat is still uncertain. More precise modeling and quantifiable data on displacement and movement patterns will not come for some time and will be difficult to predict (Shi, 2023).

Much of the prevailing research on climate migration has been conducted on *sending*, rather than *receiving*, communities. Our research thus focuses on the potential of communities to receive climate migrants, guided by the understanding that past large-scale migrations have resulted in great degrees of trauma, harm, and inequality due to a lack of preparedness in receiving towns. Local populations are often resentful of the lack of systems in place to support migration, rather than migrants themselves, but this frustration is often mistakenly ascribed to migrating individuals and communities. However, despite the need for adequate preparation, many potential receiving communities remain complacent and unprepared, or even resistant, in the face of future waves of migration.

Regionally, much of the resistance against climate migration comes from the fact that municipalities are already overburdened by problems affecting current residents. Therefore, they perceive that preparing for migration would divert resources from their current constituents and needs in order to address a hypothetical future problem. However, without adequate preparation, climate migration will likely exacerbate current political, cultural, economic, and structural difficulties, rather than create new problems in itself. Therefore, we propose the understanding of climate migration as a secondary issue that can be ameliorated by resolving current inequalities, including the lack of availability of affordable housing, NIMBYism, and infrastructure deficits.

Communities burdened with structural and administrative difficulties that affect their current constituents will likely resist reform prioritizing hospitality to future climate migrants. The perception that climate migration is a “future” problem is especially strong in upper Northeast regions that are not facing climate-specific migration, because of a housing crisis that prevents all but wealthy migrants from moving for nearby economic opportunity. However, the resolution of pre-existing community issues and the impacts of climate change not only focus on similar root problems, but also exist on decadal timescales that extend far beyond a single election cycle. Thus, we seek not to divide these issues, nor to ignore current realities and inequalities in favor of problems that climate migration will present. Instead, we project that

the resolution of present problems will be mutually beneficial in preparing for a future that could see an increase in climate-driven migration to the region. Additionally, rather than framing the climate migration problem as one that will help to fix pre-existing community problems, as it has been presented in much of the literature (Marandi and Main, 2021), we seek to focus our research on present community difficulties and their potential solutions, which will ultimately support communities' potential to be hospitable to migration through the creation of long-lasting infrastructure, affordable housing, and development.

It is also important to note that, like most environmental issues, climate change and migration will disproportionately impact lower-income and BIPOC communities, as lower-income communities tend to be disproportionately affected and displaced by climatic events and disasters. Because identity influences our perception of reality, and social differences are key to shaping experiences of vulnerability to climate change, we must pay particular attention to current inequalities that exist in communities and seek to include all voices in the decision-making process. This is rarely a central part of the conversation when focusing on more concrete measures like city planning and zoning, but the fact that certain voices are not included in the decision-making and planning processes is one of the reasons for the mismatch between policy and on-the-ground need.

Different groups have begun to work to understand and prepare for the impacts of climate migration. A Northeast Safe and Thriving for All (NEST) is an organization dedicated to examining the consequences of migration to the Northeast as climate change makes other areas less habitable. The organization's work involves preparing towns in the Northeast for climate migrations, balancing development with wilderness conservation priorities, assessing infrastructure and transportation needs, and managing potential conflict between migrants and current residents. The Northeast in particular is a pertinent focus region, as it has been targeted as a potential "climate haven" relatively less susceptible to the impacts of global warming (Hurdle, 2022; "The Editorial Board", 2022). In order to better understand the impacts of climate migration and assist communities in their preparation for future changes, NEST has worked to facilitate research and discussions between experts, amplify community voices, and increase awareness about potential impacts of climate migration throughout New England, represented in a series of case studies of individual towns. The Upper Valley Adaptation Work Group, a bi-state organization working to help build climate resilient communities in New Hampshire and Vermont, has operated alongside NEST to host World Café roundtable-style discussions and work with community leaders to discuss obstacles and solutions.

To contribute to this body of literature, we are conducting a case study on Plainfield, New Hampshire, as it relates to climate migration and migratory patterns in the Northeast. This case study will contribute to NEST's series of climate migration-focused case studies in other New England towns. Our case study of Plainfield addresses a gap in existing literature in its focus on geographies that may receive climate refugees (Shi, 2023). In analyzing the town's preparedness to accept new residents, we also contribute to a small, but growing, body of literature on housing affordability in New England (Shi, 2023; Matheis & Sorens, 2020; Cadorette, 2009; Carr, 2022). By tracking the trends of migration into Plainfield, as well as assessing their capacity to adapt to this migration, we provide NEST with an additional data point on the dynamics in the region. This includes transferable lessons from Plainfield's response to business migration which provides a relevant area for future study, specifically in discussion of the migration of businesses in response to climate changes. By helping to build a more holistic view of the multitude of factors influencing migratory obstacles and responses, NEST will be able to better identify opportunities for regional collaboration.

II. Case Study Background

One of the most pressing problems incoming migrants face when arriving to the Northeast is a severe lack of affordable housing. Housing prices have risen faster in this region than the national average, as have rents. A review of existing literature suggests that supply-side factors dominate the lack of affordable housing in the region., which include high building costs and local land-use regulations. New Hampshire is a particularly worthwhile state to study in the case of municipal land use regulations, as it is one of the most regulated states in the nation in terms of land use (Matheis and Sorens, 2020). Matheis and Sorens (2020) identify three main factors contributing to this highly regulated landscape. First, they hypothesize that current landowners face an incentive to regulate land-use and construction in order to maintain their property's value. Moreover, political institutions in the Northeast are "designed to encourage local participation in land-use decisions" in order to "combat excessive developer influence." In their book *Neighborhood Defenders: Participatory Processes and Affordable Housing*, Einstein et al (2019) find that the selectboard governance models, which encourage public participation, of small New England towns can empower vocal minorities to delay development and ultimately reduce housing supply. Third, public opinion and a desire to protect the culture and history of hundred-year-old communities also contributes to land-use regulations. The phenomenon where current residents acknowledge the need for increased affordable housing, yet oppose the introduction of new developments in their own communities, is called "NIMBYism" (Not-In-My-BackYard). Homeowners are more likely to display NIMBY attitudes by opposing high-density housing interventions like condominiums.

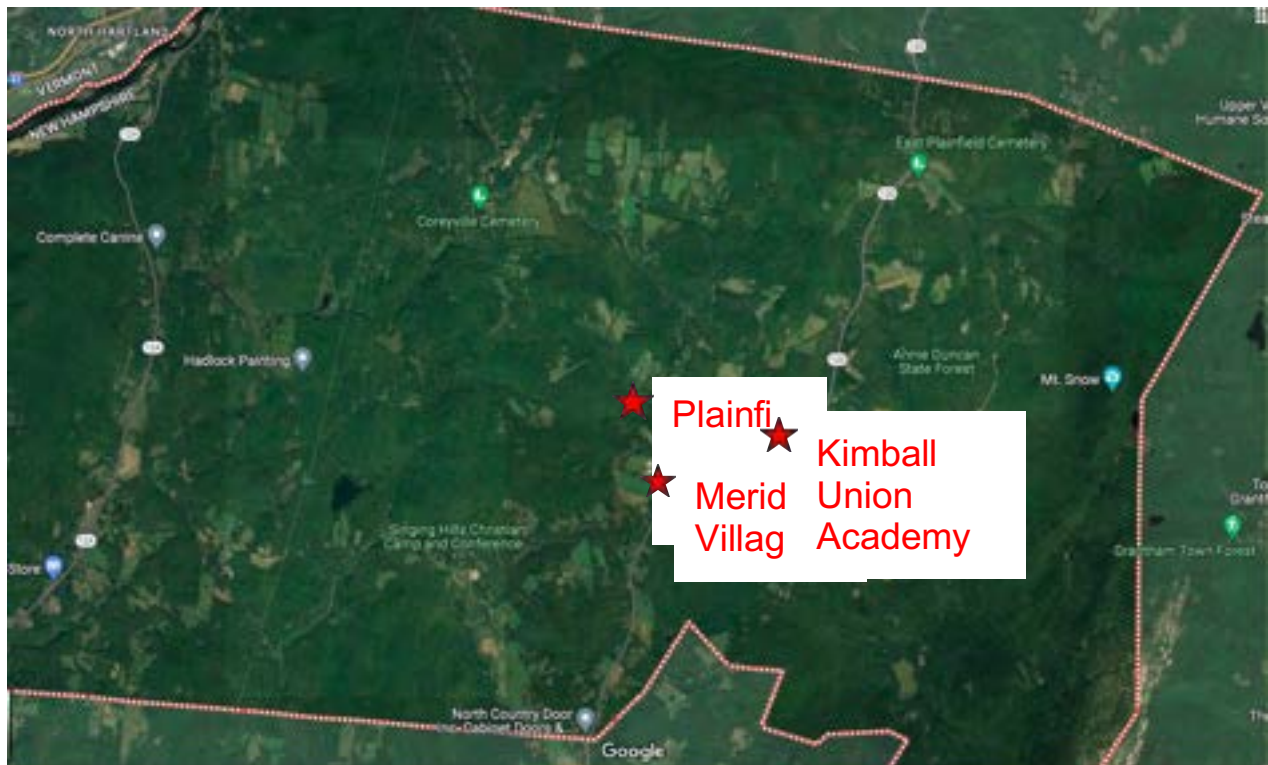
In line with regional and state-wide trends, we can learn from historical migrations to Plainfield, and attempt to place our case study within the context of the broader struggle for affordable housing in the midst of migration to the region. Incorporated in 1761, Plainfield's early economy and population was inextricably linked to agriculture. In 1780, due to an increase of population and the construction and improvement of infrastructure and roads, the town of Plainfield was divided into two "parishes" or villages. The first was the western parish, which included Plainfield village and other lands along the river, and the second was the eastern parish, which was named Meriden Village. Resident Steve Taylor recalls that historical migrations to Plainfield followed patterns of agricultural booms and busts until the 1970s. In that year, the population reached an all-time trough, with remaining residents working in manufacturing or in agriculture. The population of the town has since doubled, growing from 1,322 residents in 1970, to 2,430 in 2020. All of the residents interviewed attribute this growth to economic opportunities from a shift in agriculture and manufacturing to healthcare and education. While most of this population growth took place in the 70s and 80s, In 1991, the relocation of Dartmouth Hitchcock Medical Center (DHMC) from Hanover, NH to Lebanon, NH, "opened" Plainfield as a housing opportunity for hospital and Dartmouth College faculty, increasing the general affluence of residents in the town. From 1990-2010, almost 70% of the increase in Plainfield population came from in-migration, compared to 33% coming from a natural increase of excess resident births over deaths ("Population", 2010). More recently, town Administrator Steve Halleran has cited the COVID-19 pandemic as a pull-factor to Plainfield for White Collar professionals able to work from home, and current migration trends across the country reflect a reversal of densification towards smaller, more rural communities like Plainfield (Johnson, 2022).

Our research centers primarily on the question of how these current and historical migration trends in Plainfield, NH, inform potential for the town's adaptability to future climate migration. Specifically, we focus on how more recent migration, driven by employment opportunities at DHMC, has impacted the availability of affordable housing. From this, we can better understand how climate migration might impact

Plainfield, how this may apply to broader climate-based migratory patterns, and what steps can be taken to help towns adapt to an influx of residents.



Figure 1: A map of Plainfield, New Hampshire, with respect to the Dartmouth-Hitchcock Medical Center¹



¹ Taken from: <http://www.usbeacon.com/New-Hampshire/Plainfield.html>

Figure 2: A map of Plainfield, New Hampshire, which includes Kimball Union Academy (KUA), Plainfield Village and Meriden Village²

III. Methodology

In order to address these questions, we conducted a series of interviews with town residents. We used “snowball sampling” (asking current interviewees to recommend future interviewees) in order to generate a sample of seven town leaders or experts. Though “snowball sampling” may not yield a representative sample of a population, this methodology allowed us to reach various long time residents who represent different social and economic interests, ranging from librarians, to real estate agents, to former business owners and town administrators (see Appendix A for a list of interviewees and their titles). Interviews were fairly unstructured to prevent us, as the researchers, from asking leading questions. However, our main areas of interest included changes to the town within a resident’s lifetime, attitudes towards changing demographics, and attitudes towards town legislation. The goal was to examine historical economic and social trends driving demographic changes to provide insight on how future migration may be received by the town.

To support and further contextualize interview responses, we conducted research through town records, local media reports, and resident autobiographies. For instance, the Plainfield town tax records and zoning ordinances were instrumental in understanding the specific policies that dictate the process of developing new housing. Likewise, local news reports provided us with background information on public opinion surrounding controversial developments such as the Bean-Gleason road subdivisions and the construction of the Meriden Public Library. News reports were also an important resource in sourcing potential interviewees. Finally, we attended several World Café-style conferences specifically focused on local solutions to climate migration in the Northeast. These conferences allowed us to hear from local and expert representatives, inspired new directions for our research, and served to ground our case study in an understanding of the migratory dynamics already occurring within the Northeast.

IV. Results

Increased household incomes coupled with a relatively stagnant supply of housing has led to an unprecedented increase in property values in Plainfield over the last 30 years. In Plainfield, the median listing home price is \$649,000—more than double the median home price in the surrounding Sullivan County at \$225,900 (“Realtor.com”, n.d). The resulting affordable housing crisis displaces youth who were raised in the town and are now struggling with the high cost of living. Without high-profile jobs, “they just can’t compete with doctor and lawyer money,” says Selectman Halleran, unless their families are able to give them land through purchase or through subdivision of their own lots. Moreover, the high property values pose a barrier to those seeking to move into Plainfield. The high cost of living in Plainfield, specifically as a result of the high tax bill, also poses problems for some retired residents who lack income and rely on social security. Selectman Halleran notes a trend of displacement in spite of statewide assistance programs that aim to reduce property tax burden for pensioners.

The next sections will explore in-depth the factors that contribute to this lack of available and affordable housing in Plainfield, which include both demand-side factors like high incomes and high quality

² Taken from: <https://www.google.com/maps>

public schools (funded by higher than average property taxes), and supply-side variables like weaknesses of municipal water and sewer systems, zoning regulations, and community attitudes. Figure ii in the appendix presents a summary of interviewee responses.

Housing Crisis: Demand-Side Factors

Our interviews with Plainfield residents and governance officials overwhelmingly cite Dartmouth-Hitchcock Medical Center, which currently employs more than 8,000 staff, as the major catalyst for the large demographic shift in the town since the 1990s. In the past 30 years, there has been a shift away from the predominance of agricultural families and workers in the manufacturing sector to a primarily upper-middle or upper-class community of doctors and Dartmouth College faculty. This change has resulted in a dramatic increase in the affluence of the community and a corresponding increase in property values. Thus, the opening of DHMC in Lebanon in 1991 can be considered the primary “pull factor,” in attracting residents to the town. As the economic engine that fitted Plainfield into a “bedroom community” for affluent individuals (defined as a residential suburb inhabited by those who commute for work), the opening of DHMC was described as the primary demand-side driver of the town’s housing crisis.

Another factor that raises de facto housing costs in Plainfield are the town’s stellar public schools, which are in turn funded by high taxes. Because Plainfield is a small, sparsely populated residential town that provides a full slate of municipal services, residents face a higher tax burden than other neighboring towns, which may be more densely populated or dominated by second homes (meaning they would not require the high taxes required to support residential services). The Plainfield 2021 Tax Rate per \$1,000 of value was \$26.55, compared to a per-town average in New Hampshire of \$20.45 (“2021 New Hampshire Property Tax Rates”, n.d). Thus, the resulting tax bill presents an especially high burden for pensioners and low-income families, and it may also prevent families and individuals who could potentially afford a house in Plainfield from being able to live there sustainably. In support of this idea, Selectman Halleran notes that many young people are moving to places within New Hampshire that boast lower tax rates, such as Cornish and Canaan.

Housing Crisis: Low Supply

Affordable housing in Plainfield is also restricted by low supply. The town is home to 1,078 housing units, of which 964 are single-family units (“New Hampshire Employment Security”, n.d). The number of homes in Plainfield increases modestly each year, with about 12 new building permits approved annually, but this stands in clear contrast to the explosive growth seen in towns directly surrounding the hospital. Further, while some moderate to high-income housing development occurs in Plainfield through the subdivision of lots for single-family homes, the town generally lacks subdivision that creates small lots, as well as higher-density, more affordable housing developments like those which have been built in neighboring Lebanon. Although New Hampshire’s workforce housing law requires every municipality to provide a “fair share” of its region’s need for workforce housing (“Workforce Housing”, n.d), Plainfield satisfies these requirements with its two mobile home parks and is therefore not required by the state to build more affordable housing. In the rest of this section, we outline the supply-side factors that prevent both higher-density housing as well as subdivision of smaller parcels of land for single-family homes.

Obstacle: Lack of Municipal Water and Sewer

Perhaps the most influential factor that discourages the development of affordable, higher-density housing is the lack of municipal water and sewer systems in Plainfield that lead to prohibitively high

building costs. In fact, lack of public water and sewer are consistently cited in our interview samples as the most prominent issues preventing higher-density development. Plainfield is home to two water districts and a single wastewater district that primarily covers the large private boarding school in town, Kimball Union Academy. Of the 1,078 housing units in Plainfield, an estimated 350 are connected to town water in Meriden Village and Plainfield Village. The sewage system serves approximately 80 homes. Thus, private water and sewage systems, or shared wells, are often required for individual developments. Therefore, even if a form of high density housing ordinance were enacted that permits lower-cost, high-density development and re-development in particular zones, the cost of a private septic system often renders investment and building prohibitively expensive and thus unattractive for private developers (for context, it is estimated that the construction of a 12 unit condominium would require a \$250,000 septic system). By contrast, the proliferation of development in areas directly surrounding the hospital can be attributed to the availability of public water and septic systems that can be connected to new developments.

It is important to note that the term “prohibitively” expensive applies primarily to private developers seeking secure investments and maximal profits, rather than to individuals buying or building homes. The requirement of private water and sewer in most of the town, while it does present an economic burden for all seeking to build, may not deter an individual with economic means as it would a developer. Because individuals are influenced by factors beyond financial return on investment, the extra cost may be outweighed by the presence of amenities like good schools or aesthetic value. Conversely, developers are more likely to be discouraged by this cost, especially because it may not be as significant a variable in a town like Lebanon.

The lack of municipal water and sewer systems not only presents a barrier to private high-density development, but it also dissuades state programs for affordable housing or senior housing from building in Plainfield. As described by Jane Stephenson, president of this historical society, this is exemplified by the attempted construction of a senior housing unit in town that was ultimately turned down due to high development costs. She further notes that, because Plainfield is a wealthy town in a relatively poor county, state funds are often allocated to towns of greater apparent need.

Obstacle: Zoning Regulations

Plainfield’s zoning regulations also deter development in certain areas and thus contribute to the shortage of housing supply. The town is divided into 5 development zones: Village Residential (VR), Rural Residential (RR), Rural Conservation I (RC-I), Rural Conservation II (RC-II), and Conservation (CON) zones, which are progressively more restricted for development by lot size and conservation requirements. The minimum lot size requirement for the VR zone is 1 acre; RR is 3.5 acres; RC-I is 7 acres; RC-II is 14 acres; and CON is not available for development. As seen in Figure 3, only a very small percentage of the town is currently zoned as VR, with the vast majority of Plainfield being dominated by zoning that requires a minimum lot size of at least 3.5 acres. This effectively requires that few homes are spread across a large geographic area and greatly limits the potential for clustered residential development.

More intensive, higher-density developments are also constrained by an additional requirement of land per family unit for developments over two units. In VR zones, the minimum requirements for projects involving either multifamily dwellings or accessory dwelling units include an additional 20,000 square feet of land for each additional proposed dwelling unit. In R, RC-I, and RC-II zones, an additional acre of land is required for each unit over two. These regulations greatly reduce opportunities for clustered development and the subsequent availability of housing.

Subdivision provides a potential avenue for increasing housing availability and decreasing lot size,

exemplified by the town’s recently approved a 9-lot subdivision proposal. While Plainfield seeks to not impede property owners’ ability to subdivide, the minimum required lot area does limit subdivision potential by determining the size of individual lots within a subdivision. Furthermore, within the area of a subdivision, contiguous developable land must constitute at least 50% of the minimum lot area specified in the VR and RR Zones and 2 acres in RCI and RCII Zones as specified by the Plainfield Zoning Ordinance.

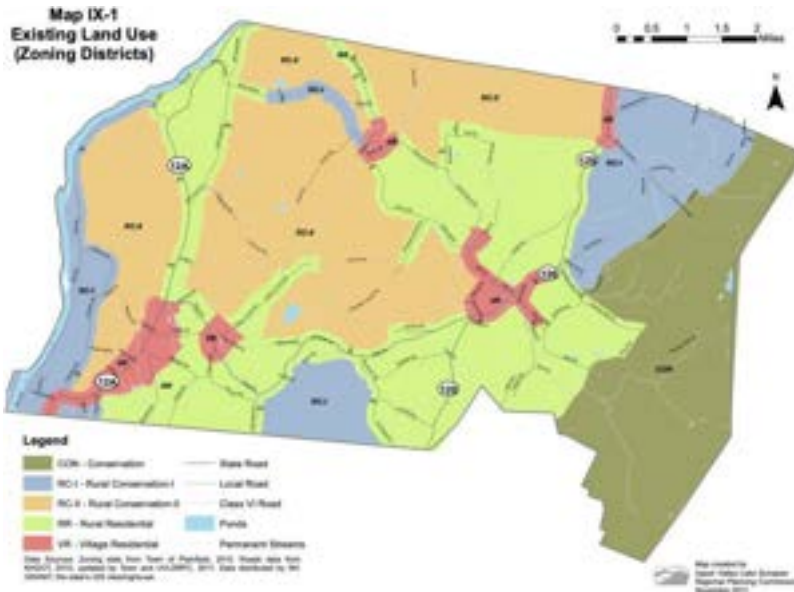


Figure 3: Zoning Map of Plainfield, New Hampshire by Land Use District³

Despite the specifications in the local zoning ordinance, state zoning incentives often take precedence over the local ordinances, and encourage larger lots and fewer subdivisions. First, Selectman Halleran describes that through the state of New Hampshire, subdivided lots larger than 5 acres are not required to undergo the costly and time-consuming process of working with the state to prove septic system suitability, a requirement for lots smaller than 5 acres. For this reason, Halleran notes that many owners ensure that subdivided lots in the RR zone are at least 5 acres, as opposed to the minimum required 3.5 acres. Secondly, the New Hampshire Current Use tax incentive is another mechanism that discourages subdivisions by incentivizing “the preservation of open land throughout the state.” To qualify for this tax reduction, lots must be 10 acres or more of forest, farm, or unproductive land (“New Hampshire Fish and Game Department”, n.d). This further discourages the subdivision of lots into smaller parcels and has led to the domination of 10-acre lots in the RC-I zone, despite the 7 acre minimum. Both of these incentives, which make larger plots more desirable in the form of lower effort and lower taxes, result in the preeminence of state zoning in the area. As a result, potential changes to Plainfield’s zoning ordinance may be less impactful when competing with state-level incentives that favor larger lots and open space over more clustered, higher-density housing.

Another state-imposed barrier to development comes from the New Hampshire state building code’s requirement of sprinkler systems for developments of greater than three units. Due again to Plainfield’s high costs of water and private water systems, mandating sprinkler systems significantly

³ Taken from: <https://www.plainfieldnh.org/pview.aspx?id=56125&catid=0>

reduces the likelihood of building developments with greater than three units. In fact, according to Steve Halleran, Plainfield is currently anticipating the construction of an additional apartment complex, but its viability hinges on high water costs associated with sprinkler implementation.

Despite barriers that arise from restrictions in Plainfield's zoning ordinance, as well as difficulties posed by state incentives and requirements, two provisions exist within the town ordinance that provide encouraging special exemptions for higher-density development. First, the Approved Combination of Related Uses provision, provides a vehicle to convert large houses into apartments by approving a mix of compatible uses on a single lot. This special exemption allows for more intensive residential use while preserving the essential character of buildings built before 1995. Further, it reduces the number of additional requirements, such as off-street parking, dimensional requirements and the requirement of an additional 20,000 sq feet of land for each additional dwelling unit. Second, the Planned Residential Development/Conservation Design exception allows residents to cluster homes closer together, as long as part of the land on the property is held in conservation. According to Halleran, there has been discussion of adding a bonus number of units based on a particular formula, though this has not been implemented. However, despite exceptions, it is important to remember that private septic systems would be required and limit development potential.

Land Use Conflicts, Aesthetic Value, and NIMBYism

Plainfield's landscape is dominated by rolling green fields, vistas, and abundant open land – relics of an agricultural past to which long-time residents feel strongly connected. Indeed, beyond Plainfield's proximity to the hospital, the role of aesthetic beauty was consistently posited as one of the town's primary attractions, which residents are deeply inclined to preserve. Selectman Halleran, referring to the town's open fields and remote agricultural atmosphere, stated plainly that “people move to Plainfield for this,” indicating that both long-time and newer residents are interested in preserving its rural character. Land-use conflicts are another reason residents may resist the idea of increasing population density through subdivisions or high-density development, as a higher population inherently increases the demand on recreational services provided by the land, such as public trails.

These attitudes and inclinations towards the preservation of open land underlie Plainfield's resistance to development. While our interviews suggest that residents are aware of the dire need to develop housing structures, residents are simultaneously reluctant to host development, particularly high density development, within their own community. Jane Stevenson summarizes the attitudes of many members of the town, stating, “Everyone knows we need [affordable housing], but when it comes down to practice it's challenging...[clustered development] is not what people coming here want.” Building off of our earlier discussion, it is clear that, as posited by Matheis and Sorens, NIMBYism is a factor that contributes to stringent town housing regulation in Plainfield. Furthermore, Plainfield is home to a community of liberal, white, politically influential families that Einstein et al (2019) might label as “neighborhood defenders.”

These prevailing attitudes result in a lack of public will to subdivide individual lots to sell for development, even if restrictions were to be reduced through changes to the zoning ordinance. This public consciousness is also underscored by language in the zoning ordinance itself. Under the Innovative Land Use Controls section, the ordinance seeks “to create neighborhoods with direct visual access to open land, with amenities in the form of neighborhood open space” as well as “to conserve scenic views and elements of the Town's rural character, and to minimize perceived density, by minimizing views of new developments from existing roads” (p. 26). Long-time resident Steve Taylor anecdotally confirms that these

statements in the zoning ordinance are aligned with town preferences, remarking, “If I took a survey, none of the owners would be willing to sell for a housing development.”

The contingent of residents who are especially inclined to resist development is enabled by a selectboard style of governance that allows them to voice their concerns publicly, which further delays the implementation of new development. The process of approval of subdivisions and zoning changes requires multiple steps and public approval. For example, the Plainfield Planning Board grants subdivisions through an application process in accordance with the Master Plan and Zoning Ordinance (2013), accompanied by notification of abutters and the public and a public hearing. Approval or disapproval of a plan, along with proposed changes to the ordinance, however, are ultimately up to the Planning Board’s deliberation and voted on by the town (“Master Plan”, 2013). Along the lines of Einstein et al.’s theory of “neighborhood defenders,” this participatory governance model creates a potential arena through which vocal minorities can delay development.

We further note in our interviews a particular concern with the maintenance of unobstructed views, rather than the explicit mention of preservation of land for conservation purposes. Thus, even if the construction of an apartment building largely preserved open land for conservation purposes, many would consider the landscape to be irreparably tarnished if it obstructed a clear vista. Selectman Halleran notes that because of this, the planning board encourages people not to build in the middle of fields or other areas that would present a visual burden. While the aesthetic value of the open space that defines Plainfield represents a clear pull factor in encouraging people to move to Plainfield, for existing residents and those who can afford to purchase larger tracts of land, it can secondarily be considered a limiting factor in attracting residents as it ultimately reduces the availability of housing.

Conservation

Resistance to development is also motivated by a secondary desire for conservation. The section of the town’s Master Plan that pertains to Land Use states that “future development of the Town should be directed and limited by the ability of the environment to support that development.” Land trusts and conservation easements are one avenue for conservation in Plainfield, and Steve Taylor mentions that many conservation-minded generational landowners choose to use land trusts in order to restrict what happens to the land they sell. They allow for the conservation of land in perpetuity based on an agreement between a property owner and a land trust, incentivized by income tax, estate tax, and gift tax benefits (“Conservation Easements”, n.d). However, the use of land trusts and conservation easements can be controversial because they remove land available for development indefinitely. Steve Taylor believes that these trusts should be balanced by high-density development, hypothetically proposing that 10% of a plot to be conserved in trust should be allocated for development purposes.

In the early 2000s, the Plainfield Conservation Commission focused on creating a Natural Resource Inventory to track natural resources in the community, with the intention of helping set priorities for town conservation use and provide information for land use planning (“Land Use”, 2014). While this Natural Resource Inventory was never brought past the first stage, it recognized several natural constraints to development in Plainfield, such as high slopes, shallow bedrock soils, wetlands, and floodplains. Overall, Plainfield has largely succeeded at protecting land from development, but it has largely been in response to a desire to preserve “green space” for aesthetic purposes. Around the same time, the Plainfield Conservation Commission worked to survey Plainfield residents in order to summarize opinions on development. In analyzing the survey responses, many share a strong resemblance to our interview responses from current residents. For instance, a majority of residents agreed that Plainfield should remain “principally a residential

community” and there was an overwhelming amount of support specifically highlighting the “rural character” of the town as a priority for protection (“Land Use”, 2014). Other popular areas of emphasis included “open spaces, nature, [and] natural beauty.”

Reception to Cultural and Social Differences

There are also interpersonal elements that we must consider that relate not only to the process of increasing capacity, but to the creation of a cohesive community. We noted in our introduction that climate change and climate migration will disproportionately impact lower-income and BIPOC communities, and spoke to the importance of including diverse voices in the decision-making process. However, in the overwhelmingly white and wealthy town of Plainfield, it is difficult to concretely imagine what integrating diverse voices could look like when structural realities exclude those voices from the town altogether. Brenda Chien, a teacher and one of three Asian faculty members of the Plainfield School District, was able to provide important insight on dynamics of inclusion and social and racial justice in Plainfield. She notes that the town is “very welcoming and inviting,” especially to her, and she further points out indications of an inclusive attitude through Black Lives Matter signs throughout town and pride flags outside of the local church. Further, she states that the Plainfield schools are approaching introducing diversity well through their Diversity, Equity, and Inclusion committee. However, though these indicators may demonstrate a degree of openness to marginalized identities and an interest in promoting equity and diversity, these attitudes may change if Plainfield were structurally able to host large contingents of climate migrants that look different from Plainfield’s largely white population. The same NIMBY attitudes that prompt residents to resist high-density development while acknowledging its necessity could also apply to questions of racial and socioeconomic diversification in the town.

V. Discussion

Application and Generalizability

Because this case study largely focuses on economic and business-driven migration centered around DHMC, we predict that the most directly applicable lessons from our study of Plainfield will pertain to the climate-related movement of businesses. Much of the research thus far has focused on individuals, but climate change may also drive movements of employers. While the “tipping points” that determine whether businesses will move in response to climate disasters are difficult to quantify, movement is likely in coming years (Shi, 2023). For example, the increasing cost of flood insurance may drive a business to seek a region where it can operate without this expense (Shi, 2023). The migratory patterns in Plainfield resemble those that we may see in response to the movement of businesses for climate reasons. As this case study makes clear, the relocation of businesses will be a large driver of individual (largely economic) migration. Thus, this dynamic further complicates the discussion of climate-based migration and is therefore important to consider in a holistic understanding of how climate change will affect movement patterns within the US.

It will also be important to consider the range of factors determining why employers move, what features they are looking for, and why they would choose to migrate to the Northeast. However, the dynamics driving the selection of Lebanon as the location for DHMC is not a broadly applicable case study, since it is connected to a long-established institution and its movement was geographically limited as a result. Future research should focus not only on the consequences of business migration, as this study did, but also on the factors that make a region an attractive choice for businesses.

The basic narrative of Plainfield’s housing crisis that emerged from our findings aligns with previous literature and expectations about current trends in the Northeast. The similarities between our case study and existing literature create avenues for comparison and motivate the creation of policies that can be applied throughout the region. Our interview-based research aligns with data from the housing crisis throughout New England, especially in New Hampshire and Vermont. These housing issues, driven primarily by low supply stock, have led to increasing housing costs and the “pricing out” of typical residents. To illustrate, the median listing price for a house in Plainfield is three times the Sullivan County average. The trend of rapidly increasing housing prices appears to be a key feature of the New England housing market, as home prices have increased faster in New England than in the rest of the country since 1995 (“New England Center for Public Policy”, 2020). One of the primary factors contributing to rising housing prices on the supply side is the highly regulated landscape of New England, and New Hampshire in particular.

A high degree of land use regulations has proven politically popular in both Plainfield and New Hampshire more broadly, because residents oppose high density development. In Plainfield, we found NIMBY-ism primarily played out through individuals’ resistance to subdivide or promote higher density housing on their property in order to protect natural “green spaces,” which attracted many to the town in the first place. Our findings on NIMBY-ism align with Matheis and Sorens’ 2020 paper, which suggests that homeowners in New Hampshire are more likely to resist high density developments in their neighborhoods.

NIMBY-ism, especially as it pertains to the affordable housing crisis, is not specific to New Hampshire and the Northeast. In California, for example, New York Times Opinion writer Binyamin Appelbaum posits that seemingly “liberal” residents are not “living their values” (Harris & Appelbaum, 2021). Appelbaum cites the dynamics in Palo Alto, where the fast-growing job market is leading to a population increase that outpaces housing construction. While many democrat controlled communities argue that they are prioritizing affordable housing (or at least understand its necessity), in reality residents of single-family housing neighborhoods like Palo Alto are voting down zoning changes prioritizing high-density, affordable development because it poses a threat to property values.

Potential Policy Prescriptions

From our research and findings on Plainfield, there are a few future policy prescriptions that we think would help benefit and support climate migration in this town. As depicted in the Appendix, residents agree that housing density must increase in order to support affordable housing. A majority of respondents support methods that align with current town legislation, such as the continued construction of Accessory Dwelling Units (ADUs). However, a minority of respondents mentioned that they were proponents of strategies that involved reforms to legislation. Nonetheless, we present policy prescriptions pertaining to support of ADUs, as well as zoning reform.

First, the town should continue to support residential ADUs, which as noted in the results section, provide a feasible immediate avenue to modestly increase housing density in a way that is compatible with the zoning ordinance and does not require the approval of high-density development. ADUs are secondary units at the site of a primary dwelling unit that owners are able to rent out, which generates income for homeowners while simultaneously increasing housing availability (Hamilton & Houseal, 2023). Given the significant zoning restrictions outlined above, increasing the number of available ADUs appears to be the most politically feasible immediate measure to address the town’s housing crisis. In fact, Selectman

Halleran considers ADUs to be “the most important tool in [Plainfield’s] toolbox,” in confronting the housing crisis, because they fit with current town policies and can slowly increase the quantity of housing units. Though the process may be slow, their potential for increasing the housing stock can be substantial, especially in light of the high cost of building to which there are no viable short-term solutions. However, it is important to note that ADUs cannot be considered “affordable housing,” as they are not subsidized and thus listed at high market value. Further, ADUs should not be considered a sustainable or complete solution to address the housing crisis, nor should their success limit focusing on a range of changes to address the crisis holistically, such as addressing zoning restrictions and encouraging the construction of multi-family structures.

Reforming zoning legislation may also confer some moderate benefits to individuals seeking to move into Plainfield by reducing restrictions on lot size, thereby encouraging more clustered development. However, many interviewees hesitated to propose zoning reform as a solution to the housing crisis, due primarily to perceived lack of feasibility. In the town’s Master Plan located in Chapter III – Housing, one of the goals put forth by the Planning Board to reform zoning legislation was to enact some form of “grow housing” ordinance, permitting low cost high-density development and redevelopment in the Village Residential zones (p. 6). While the particulars of such an ordinance are unclear, Selectman Halleran did discuss the realistic potential to expand the (minimum 1-acre) Village Residential Zone in town, which would result in a smaller required lot sizes over a larger area. He states that this may be “the only way to loosen up some additional land for new housing.” Secondly, the Master Plan proposes re-invigorating and extending multi-unit development ordinances to permit higher density development in rural residential (RR) zones. Multi-unit development refers to a development of *no less* than 5 residential units on a piece of land that is already occupied by a building or buildings, and intended to share amenities, facilities, and services. Expanding this multi-unit development ordinance into rural residential areas can thus enable higher density development by providing more choices and units for incoming families and individuals. Finally, encouraging individuals to take advantage of special exemptions that allow for apartment construction in converted homes and greater clustered development will continue to be essential. It is important to note that changes to the zoning ordinance are outlined and presented by the Planning Board and then voted on by the town, meaning that residents have the power to encourage or deter clustered development.

Lastly, from our research and interviews, we find continued investment in upgraded infrastructure to be a beneficial strategy. This includes both “attractive infrastructure” and “third spaces,” which describe social spaces such as libraries, cafes, or parks, as well as basic, necessary infrastructure like grocery stores and public transportation. Plainfield currently has neither a grocery store nor a robust system of public transportation in town. Such infrastructure would support present and future residents and will prove increasingly vital if the town seeks to expand its residential capacity. Thus, investing in infrastructure can be considered a necessary prerequisite to support higher-density housing. Not only would it support those moving into the town, but both necessary and “attractive” infrastructure can also serve to attract developers seeking lucrative investments. Plainfield appears to be dedicated to this strategy (at least with the goal of supporting current residents), as evidenced by their commitment to constructing and opening a second town library in the township of Meriden and their pledge to transition to 100% renewable energy by 2050 in all sectors.

Further recommendations

The most critical infrastructure investment would be in increasing the capacity and reach of the town’s water and sewer systems, though this may present residents with an impossibly high tax burden that

may not prove reasonable, and updating the system would also require some residents to vacate their homes in Village Residential zones. Given Plainfield's profound lack of infrastructure and capacity, it would be unrealistic to expect the town to become a destination for *large-scale* climate migration now, or in the future. Rather, it may be more valuable to consider neighboring communities, such as Lebanon, more appropriate destinations for migrants given their availability of vital infrastructure such as sewage systems. This suggestion motivates the importance of regional cooperation, as well as the resilience of specific communities.

Limitations

We recognize that our findings may be limited both through our methodology and through the availability (or lack thereof) of data and diversity of interview subjects. Much of our data is anecdotal, as it was obtained principally through individual interviews. Due to time and resource constraints, we were unable to comprehensively survey Plainfield's population to gauge the opinions of a more complete sample of the community. Furthermore, interviews are an inherently imperfect data collection method (Hofisi et al., 2014). The interview process is often fraught with biases and subjectivities, and data is reviewed and then discriminately selected. Further, data from interviews may not always be perfectly reliable, as interviews draw from an interviewee's reconstruction of events rather than recollection of events exactly as they occurred. At the same time, however, it is important to note that apparent bias also became an important part of the data we collected, as it informed our discussion of NIMBYism and the inclinations of town residents regarding certain contentious subjects.

Several times in this report, we noted that climate change and migration will disproportionately impact lower-income and BIPOC communities, and it will be critical to integrate these voices into the decision-making process. We recognize that centering those whom climate migration will affect should also mean incorporating those voices into the narratives and research on climate migration. However, our data was limited in this respect by the fact that the town is overwhelmingly white and wealthy, reflecting less of a limitation of our methods than one presented by the town's demographic. The socioeconomic profile of those currently migrating into Plainfield will likely be very different from those of future climate migrants (specifically climate refugees, for whom migration is not a choice, but a necessity) moving throughout the United States. This inherently limits the capacity of our case study to contribute to the literature on social responses to climate migration, as we predict unforeseen social and economic frictions that we don't observe now given the current affluence of residents.

VI. Conclusion

Selectman Halleran reflects that, "We're up against a system of codes and rules intended to protect certain things. Now we have to decide if we still value those things." His sentiment lies at the crux of Plainfield's, and New England's, affordable housing crisis. Under the current system, Plainfield faces a difficult contradiction. Residents of the town are aware of the housing crisis it faces and proclaim an interest in creating an environment in which available, affordable housing is possible. However, many also seek to prevent development which jeopardizes clear views, natural areas, or necessitates a high expenditure of public funds for supplying municipal services. Overall, our findings determine that due to these factors, as well as rising affluence, increasing property values, stagnant development, and a lack of town resources and capacity, Plainfield has a very low potential to become a "climate haven."

Teacher Brenda Chien recognizes that “the focus on tradition can be a barrier to progress.” It is this balance between tradition and progress, and the value Plainfield places on each, which the town will need to determine so as to effectively direct policy now and in the future. However, it may be the case that the values of tradition and conservation supersede those of “progress,” either because of political will or lack of resources to direct towards progress. Namely, increasing receptivity and capacity for greater housing supply. Because of the barriers that may prevent community-based action in preparing towns for climate migration, we find that this case study supports the idea of a regional, collaborative committee to coordinate action on climate migration or support towns with resources to address preparedness and capacity.

VII. Appendix

Figure i: Tabulation of Interviewee responses. Cells are colored blue if the respondent identifies

	Obstacles Identified							Solutions Identified					
Role/ Occupation	COVID	Zoning	Septic	Vacation Rentals	DHMC	Taxes	Land Use	Increase Density	Update Sewers	Tax breaks	Responsible Conservation	Invest in infrastructure	Support of ADUs
Zoning Board (Steve Halleran)	Blue	Blue	Blue		Blue	Blue	Blue	Blue		Blue			Blue
Former Commissioner of Ag. (Steve Taylor)		Blue	Blue		Blue		Blue	Blue			Blue	Blue	Blue
Valley News (Molly Shimko)		Blue									Blue	Blue	
Historical Society (Jane Stevenson)		Blue	Blue				Blue	Blue	Blue				Blue
Library Director (Mary King)		Blue			Blue			Blue				Blue	
Teacher (Brenda Chien)							Blue	Blue					
Real Estate Agent (Susan Cole)					Blue	Blue	Blue	Blue					

Figure ii:

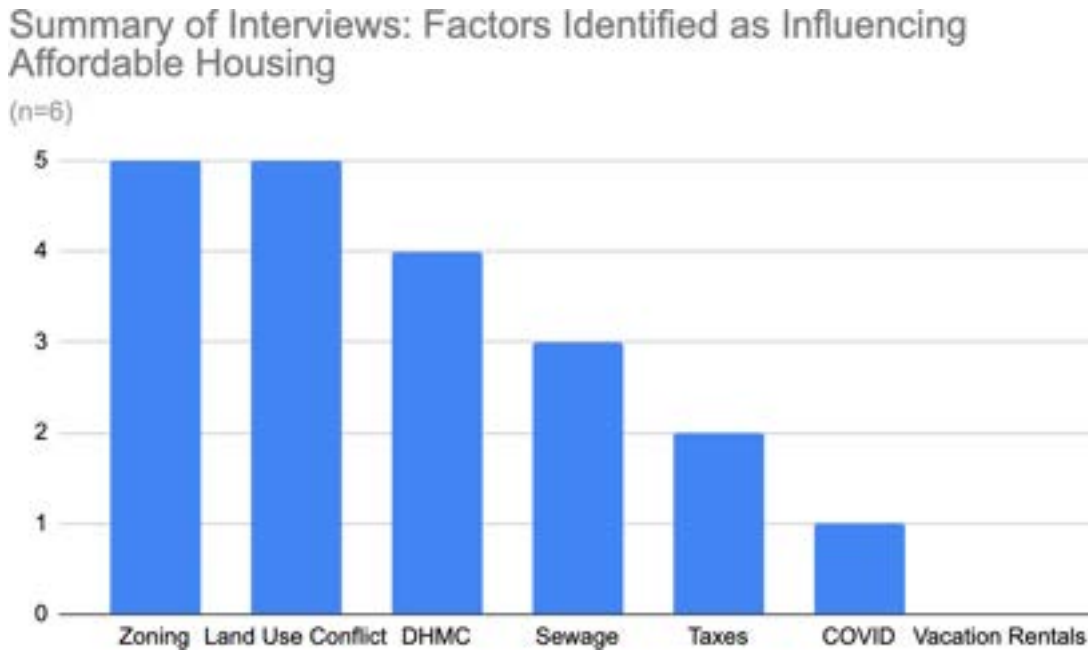
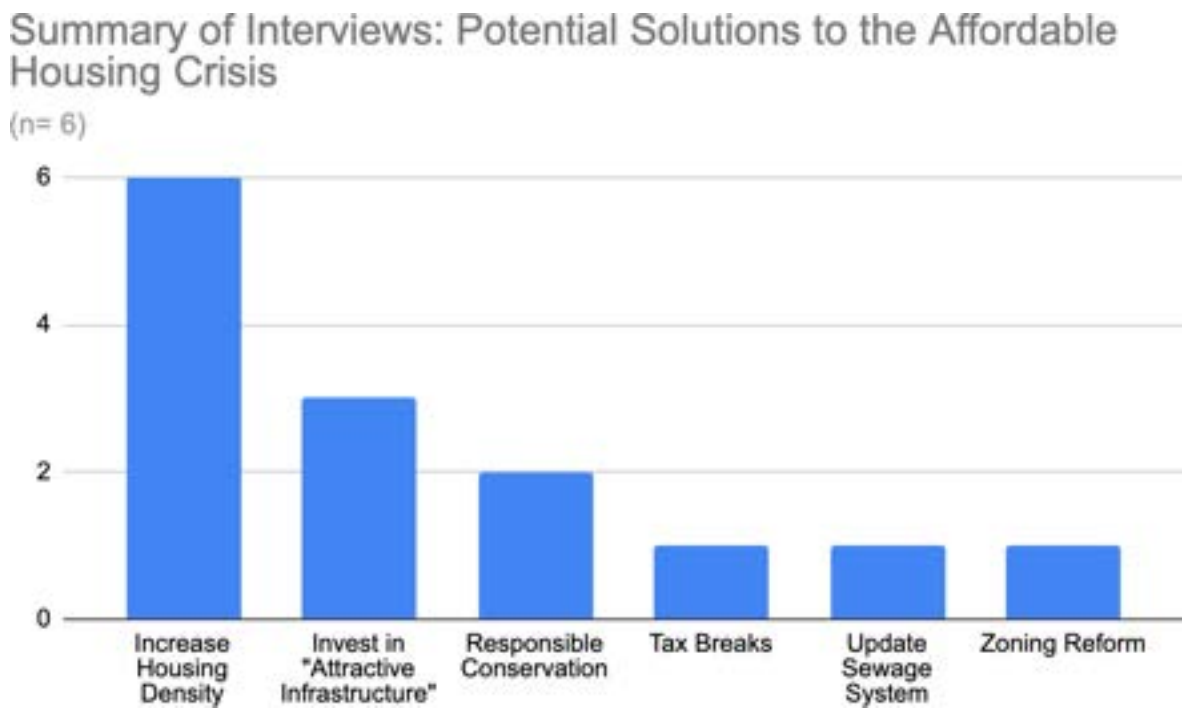


Figure iii:



VIII. Group Reflections

We think our group was very successful in implementing the ideas about collaboration discussed in class on April 4. As a group, our biggest strength was our communication and desire for everyone to get involved and do their part for the project. We made a group chat early on and never hesitated to check in with questions, comments, or concerns about the state of our work. We invested in developing our group relationships outside of the assignments as well, and took multiple trips to Plainfield, World Cafes, and other parts of New Hampshire. We developed trust and respect for everyone in the group, and because there were only four of us, we were able to spend a significant amount of time getting to know each other as more than just partners on a class project. Another great thing about our group was the fact that we were all on the same page about taking pride in our work and putting in the time to produce high quality assignments. It can be scary in a culminating class during senior spring that some group members may be academically checked-out, and not feel the need to put in work for a strong final product. But whether it was conducting interviews, researching historical context, or practicing for our presentation, our group put in the time, and we were all on the same page about feeling proud of the work we submitted. Traveling to Plainfield and talking to long term residents made us all feel a little connected to the town, and we took a genuine interest in learning more about Plainfield and analyzing what its future may look like.

Just like with any successful group or team, there must be people who take the lead in organizing and implementing the project. Cypress and Sacha definitely stepped up into that role, and did an incredible job of keeping everyone on track, taking personal responsibility in making sure assignments got done on time, and delegating tasks to other members of the group. All while providing positive, constructive feedback and leading by example to do more than their fair share of work when necessary. Cypress and Sacha led the way in diving through countless pages of Plainfield zoning regulations and town meeting minutes, and early on were able to provide a strong, background understanding of town issues that informed many of our research-steps moving forward. Charlotte and Brody followed the lead of Cypress and Sacha and stepped in to fill important roles when necessary. They were there for every step of the way, writing notes during meetings, traveling to World Cafes, taking initiative to reach out and conduct interviews, and working on specific sections of the paper and presentation. All members of the group had an important part in contributing to the final product, and especially in contributing to positive team dynamics. We're grateful to have been grouped up for this project, and are proud of the work we've done throughout the term.

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Chapter 3

Septic Policy Working Group for the Connecticut River Conservancy



***Tennison Brady, Trey Cormier, William Johnson,
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Introduction

Individual septic systems dominate municipal wastewater treatment in Vermont and New Hampshire. Mary Clark, environmental program manager for the Drinking Water and Groundwater Protection Division of the state of Vermont, estimated about 55 percent of residential homes rely upon onsite systems; “That’s the highest rate [of septic system usage] reported in the entire country.” For New Hampshire, this figure jumps to 60 percent (Hookset, 1).

Given the myriad challenges of building and maintaining centralized wastewater treatment facilities in rural areas; septic systems have become vital to communities. In the Upper Valley, septic systems have been the primary source of wastewater management for over one hundred years. In the 1950’s and 60’s the Upper Valley experienced a wave of migration, and as a result many septic systems were installed to manage the waste from these new homes. While this development forged ahead, regulative policy lagged behind. As a result, septic systems have become a major source of pollution in VT and NH’s Connecticut river watershed.

When properly regulated, decentralized water treatment can offer an array benefits; The EPA states that “if a system is properly installed, sited and maintained it can protect public health, preserve valuable water resources, and maintain economic vitality in a community.” Specifically, septic systems serve as an effective and cost efficient solution for treating waste water in less densely populated areas, such as the Upper Valley (U.S. Environmental Protection). Centralized wastewater treatment plants are incredibly costly, both to erect and maintain. Many municipalities in NH and VT cannot support this infrastructure, even with extensive federal federal funding.

With proper septic maintenance, communities benefit from decreased exposure to disease and pathogens. The surface water can be protected from contamination, while still replenishing groundwater reserves (EPA Types of Septic Systems). Septic systems are complex and varied. Accordingly, policy recommendations must be informed by a robust understanding of the mechanisms behind and variations within the systems themselves. Furthermore, septic tank upgrades vary depending site-specific needs. To improve the function of systems, regulators can recommend different courses of action depending on current state of the system, geological features of the area, and other factors such as soil composition.

Our report recognizes that there is a disconnect between the care needed to properly maintain the systems and legislation enforcing this maintenance. This issue leads to significant problems related to public and environmental health, especially burdening those living in low income rural areas (U.S. Environmental Protection). Our community partner, the Connecticut River Conservancy (CRC) is a non-profit organization that brings “people together to prevent pollution, improve habitat, and promote enjoyment of the river and its tributary streams” (Connecticut River Conservancy, 2023). This report provides the CRC with an overview of existing policy histories around septic regulation and explores potential policy steps for VT and NH to remedy this issue. In crafting these policy recommendations, we held the values and mission of the CRC at the forefront of our concerns; seeking to find policy solutions that benefit communities and the river “from source to sea.”

Methods

The policy overview and recommendation for our partners at the CRC are based on empirical evidence of nutrient pollution sources, interviews with key stakeholders and legislators, background information from our partner, and existing state legislation on septic systems.

First, we reviewed legislative records in Vermont and New Hampshire. This involved studying relevant laws, regulations, and policies related to wastewater treatment that our partners provided us, and looking online at the agencies designated with regulating either septic systems or bodies of water. For Vermont, this is the Vermont Agency of Natural Resources and Vermont Department of Environmental Conservation; for New Hampshire, this includes the New Hampshire Department of Environmental Services, the New Hampshire Fish and Game Department, and the Subsurface Systems Bureau. For both states, we reviewed applicable legislation from the U.S. Environmental Protection Agency (EPA). This review, along with our partner's background information, made it apparent that VT and NH septic policies overlooked instances that could lead to nutrient pollution. For example, the fact that there was no mechanism to ensure regular checkups on septic systems leads to enough septic system leakages for a significant amount of pollution in Connecticut.

To recommend steps for the CRC to take, we sought already existing policies to model our recommendations after. We then researched states with stronger legislation, and contacted our VT and NH representatives that have previously introduced stronger septic law. By scraping laws on gencourt.state.nh.us and legislature.vermont.gov (provided by our partners at the Connecticut River Conservancy) using the keyword “wastewater,” we examined all septic legislation from 2015 to now, the dates picked by our partners as containing the most relevant recent action.

We then found the bills related to improving individual septic systems and their sponsors. By contacting and interviewing those sponsors (for example, Senator Dianne Snelling and Representative Sarita Austin), we learned that the sponsors of progressive bills modeled their legislation off of existing septic laws in other states, specifically Massachusetts Title 5, the New Jersey Administrative Code (NJAC), and Title 27 of the California Code of Regulations (OWTS). We provide examples from these “bright spots” that our partners at CRC can use when crafting new policies for their home states. We contacted all representatives that we could find for relevant bills, including both the main sponsor and sub co-sponsors. We talked with any representative that responded to our email queries.

Additionally, we contacted journalists who have covered nutrient pollution and septic system laws, and NGO representatives from other water quality advocacy groups. From our legislative review, it became apparent that Massachusetts Title 5 was an exemplary law that NH and VT legislators were already looking at. Thus, we reached out to Barbara Moran from the WBUR-FM, who covered proposed septic regulations in Massachusetts and voter sentiment—another focus of our research, as we found that many progressive septic bills in VT and NH that would ameliorate the gaps we identified have not made it past the first vote.

Reviewing septic policies in other states also helped to inform a cost-benefit analysis. Our comprehensive cost-benefit analysis involved calculating various scenarios under different septic policies, helping us evaluate the potential economic implications

of implementing different policies. By weighing the costs and benefits associated with each scenario, we aimed to determine the most effective and efficient approach to address the issue. Finally, to gather firsthand information, we conducted interviews or correspondence with local representatives. By engaging in these discussions, we gained insights into the practical challenges, considerations, and potential solutions related to the issue we were studying. These interactions also helped us to get a better understanding of the current policy work that is being done on septic issues.

By employing these methods, we aimed to ensure a comprehensive and well-rounded approach to our project. Each method provided us with unique perspectives and data that contributed to our analysis and informed our final recommendations.

Results and Discussion

Existing Vermont Legislation

In Vermont, three main programs cover homeowner septic systems: the Wastewater Systems and Potable Water Supplies Rule (1977, updated in 2019), the Healthy Homes Initiative On-Site program (2022), and Vermont Water Quality Standards (2022).

The Wastewater Systems and Potable Water Supplies Rule, implemented by the Vermont Department of Environmental Conservation (DEC), outlines the design, construction, and maintenance requirements for septic systems ("Wastewater System and Potable Water Supply Rules," 2023). Though it doesn't require septic system inspections at the time of property sale, it does allow the state to inspect systems if there's reason to believe they're malfunctioning. These rules also define technical standards by which the design and installation of septic systems must comply with. If a septic system is found to be failing, the property owner is required to repair or replace it in accordance with the state's rules.

During the pandemic, the Vermont Agency of Natural Resources (ANR) leveraged its \$16 million allocation from the American Rescue Plan Act to create the Healthy Homes Initiative On-Site program, which funds low and moderate income Vermont homeowners to replace their home water or wastewater systems (Vermont Agency of Natural Resources, 2023). The ANR is also providing \$24.75 million in ARPA funding to help manufactured housing communities (also known as mobile home parks) fix water infrastructure issues related to drinking water, wastewater, stormwater, and drainage systems (Vermont Agency of Natural Resources, 2023).

Finally, the Vermont Water Quality Standards, established by the Vermont Water Resources Board, set water quality objectives for surface waters in the state. They include provisions for septic systems to prevent pollution and maintain water quality (Vermont Agency of Natural Resources 2022, 14-15).

Legislation Gaps In Vermont's Septic Policy

Though comprehensive, Vermont legislation is still lacking. Regular inspections, maintenance and pump-out requirements, certification of septic system professionals, tiered requirements that acknowledge different types of homeowner situations, records

of septic installations, and better management of agricultural runoff could be included in future bill sponsorships. Vermont lawmakers have made strides in these directions, with Representative Sarah Austin introducing H.144 in 2021 to require the inspection of home wastewater systems. Though it did not pass, it will be reintroduced during the 2024 cycle. Although it also did not pass, bill S.70 sponsored by Senator Diane Snelling in 2015 leveraged the mechanism of real estate transfers to require notice of wastewater treatment.

Beyond these bills, Vermont lawmakers could turn toward the Massachusetts State Environmental Code, specifically the section referred to as “Massachusetts Title 5,” which governs the design, construction, inspection, and maintenance of on-site sewage disposal systems. This section, along with the New Jersey Administrative Code Section 7:9A-3.19 (NJAC) and Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy) in Title 27 of the California Code of Regulations, serve as bright spots that allies of Austin and Snelling could emulate in their efforts to reduce septic-sourced pollution and target those gaps mentioned above.

Table 1: Models To Improve Vermont’s Septic Legislation

Gap	Bright Spot	Addresses
Regular Inspections	Massachusetts Title 5, or HB. 426	The former the mechanism of home sales to mandate septic tank inspections. The latter mandates inspection for systems older than 20 years.
Maintenance And Pump-Out Requirements	New Jersey Administrative Code (NJAC)	Designates a time period for certain capacities of septic tanks.
Certification Of Septic System Professionals	NJAC	By giving incentives to certify septic professionals, the NJAC ensures that they have the necessary training and expertise to do the job correctly
Tiered Requirements	Title 27 of the California Code of Regulations, California Onsite Wastewater Treatment Systems Policy (OWTS)	Ensures that septic systems that pose more environmental harm (based on location near water, state of the system, capacity) are treated more severely from those that do not have those requirements.
Records Of Septic Installations	NJAC + OWTS	Require homeowners to keep a record of septic installations, upgrades, and maintenance.
Bureau and Commission for	New Hampshire Subsurface Systems	Creating a commission to study septic-related water issues and to

Septic Systems	Bureau and H.B. 475	regulate permits.
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*Table illustrates the gaps in current Vermont legislation (left column) and specific codes from other states that Vermont legislators could emulate (right column).
Note: VT and NH are separate tables as the information covers too much for one.*

For regular inspections, Massachusetts Title 5 stipulates that inspections of home septic systems must occur within a window of two years prior to transfer to six months after the transfer ("310 CMR" 2019, 75) For shared systems, they should be inspected at least every three years by a System Inspector and pumped on an as-needed basis ("310 CMR" 2019, 93).

In addition, Title 5 instructs inspections must be performed at least once every three months for any system serving a facility with a design flow of 2,000 gallons per day or greater, and annually for any system serving a facility with a design flow of less than 2,000 gallons per day, verified by submission to an "Approving Authority annually" ("310 CMR 15.000: Title 5" 2019, 82).

The NJAC would help Vermont grow its septic support through incentives of certifying septic system professionals. The NJAC requires that professionals who design, install, and maintain septic systems must be certified by the state. This ensures that they have the necessary training and expertise to do the job correctly (New Jersey Administrative Code, 2023).

California has a tiered set of regulations for onsite wastewater treatment systems, stipulated by the Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy), which is part of Title 27 of the California Code of Regulations. More stringent requirements apply to systems that are larger, located in environmentally sensitive areas, or pose other higher risks. The policy establishes a risk-based, tiered approach (Tier 0 to 4) to regulate OWTS installations and replacements (California Code of Regulations 2023, 1). For example, Tier 1 septic tanks conform to basic OWTS policy, not near public water sources. New or replacement systems in this tier are subject to permitting and inspection by local agencies, but are not generally subject to detailed technical reviews or operating permits ((California Code of Regulations 2023, 10)). In contrast, Tier 4 fail the OWTS and are located near "Areas of Special Concern"; systems in this tier require immediate corrective action or replacement. This might include upgrading the system to a more advanced treatment system, connecting the property to a public sewer system, or relocating the system to a more suitable location on the property (California Code of Regulations 2023, 41).

Though the state of Vermont mandated that new septic systems must apply for a Wastewater System and Potable Water Supply Permit, there is no mandate for septic systems to have a record of maintenance. In contrast, both California and New Jersey require homeowners to keep records of septic system installations, repairs, inspections, and maintenance. These records can be important for homeowners, potential buyers, and regulatory authorities. In New Jersey, this is covered in N.J.A.C. Section 7:9A-3.19, which discusses the records that must be kept (New Jersey Administrative Code 2023, 26).

Beyond homeowner septic, "a major source of runoff pollution is agriculture. The spreading of excess fertilizer and manure leads to nitrogen and phosphorus being

washed into streams and rivers and feeding algal blooms" (Environmental Integrity Project 2019, 12). Vermont could also focus its efforts on curbing this source, given that 22% of its land is used for farming ("State Agriculture Overview: Vermont" 2023, 1). This area might be of interest to allies of Snelling and Austin who are looking to propose new legislation, as the historical lack of successful bills regulating septic systems may indicate that educating constituents and canvassing voters may yield better results than reproposing bills that fill the current gaps in Vermont's legislation.

Existing New Hampshire Legislation

New Hampshire's (NH) first relevant piece of legislation over septic systems and groundwater quality was the Subsurface System Law, enacted in 1967. Before this, NH kept no records of subsurface systems or how they affected groundwater, and from 1967 to 1971, NH only kept track of septic systems within 1,000 feet of surface water. In 1975, NH established the Subsurface Systems Bureau, responsible for overseeing septic system regulations, ensuring compliance with state and federal laws, providing permits, inspecting systems, and enforcing regulations (NH General Assembly, 1975). In 1984, NH took another step forward in defining and regulating the balance of wastewater and groundwater with the Subsurface System Rules regulating the design, installation, and maintenance of subsurface wastewater disposal systems (commonly known as septic systems) in the state (NH General Assembly, 1984).

These rules aim to protect groundwater health by ensuring that septic systems effectively treat and dispose of wastewater, preventing contamination of groundwater sources. The rules outline specific requirements for septic system design, sizing, setback distances from wells and water bodies, soil evaluations, and construction standards. They also address proper maintenance practices, including periodic inspections and pumping of septic tanks. By implementing these rules, the state of New Hampshire has taken steps to safeguard groundwater quality. Effective septic system management helps prevent the release of harmful pathogens, nutrients, and chemicals into the groundwater, which is a vital source of drinking water for many communities in the state. The regulations under the NH Subsurface Rules have contributed to improved protection of groundwater health by promoting responsible design, installation, and maintenance practices for septic systems.

The Shoreland Water Quality Protection Act, enacted in 1991 by the New Hampshire General Court, builds upon the foundation established by the NH Subsurface Rules to further protect water quality in shoreland areas (NH General Court, 1991). This act focuses specifically on the preservation and conservation of water bodies near shorelands, such as lakes, ponds, rivers, and tidal waters. The act establishes regulations and guidelines for development, construction, and land use activities within designated shoreland areas. It incorporates elements from the NH Subsurface Rules, such as setback distances and soil evaluations, and expands upon them to address the unique challenges and concerns related to shoreland development.

By combining the requirements of the NH Subsurface Rules with additional provisions, the Shoreland Water Quality Protection Act aims to prevent water pollution, protect natural vegetation along shorelands, control runoff and erosion, and promote responsible land use practices. It emphasizes the importance of maintaining water quality and the ecological balance of shoreland areas. The act acknowledges the

interconnectedness of septic systems, land use, and the health of water bodies in shoreland areas. It recognizes that protecting water quality requires not only well-functioning septic systems but also responsible land development practices that minimize the impact of human activities on the environment.

The regulations governing septic tanks and water quality in New Hampshire aim to protect public health and the environment. These regulations can be found in the New Hampshire Code of Administrative Rules, specifically sections Env-Wq 100 through Env-Wq 1600. These rules cover various aspects related to septic systems and water quality.

Regarding septic tanks, the regulations address system design and installation, operation and maintenance requirements, and procedures for repair and replacement. They ensure that septic systems are properly designed, installed, and maintained to prevent any adverse impacts.

In terms of water quality, the New Hampshire Department of Environmental Services (DES) enforces regulations to control pollution sources and establish standards. The regulations encompass pollution prevention and control measures, water quality standards for different water bodies, and monitoring and assessment programs. Compliance with these regulations is essential for effective wastewater management and the preservation of water quality in New Hampshire. Adhering to these rules helps protect public health, maintain the integrity of water resources, and ensure sustainable management of septic systems.

Table 2: Models To Improve New Hampshire’s Septic Legislation

Gap	Bright Spot	Addresses
No mandated inspection requirements	Massachusetts Title 5, CT public health code (S. 19-13-B100)	Mandates septic inspections done by professionals during owner turnover.
No mandated maintenance	New Jersey Administrative Code (NJAC), RI Individual Sewage Disposal System Code	Mandates continual maintenance of septic tanks to prevent backup or use-related degradation.
No mandated pumping	VT Wastewater System and Potable Water Supply Rules (3 to 5 years), CT public health code	Mandates professional pump outs at certain time intervals.
Lack of state assistance/information	CT Department of Energy and Environmental Protection, MassDEP, VT DEC (env. conservation)	Helps and informs homeowners navigate the rules and resources of maintaining and replacing their septic tanks.

This table illustrates the gaps in current NH policy (left column), the states and legislation that address the same gaps (middle column), and what specifically they address (right column).

Comparison Of The Two States

Both VT and NH have an act to regulate surface waters: Vermont Water Quality Standards and the Shoreland Water Quality Protection Act, respectively. Vermont could learn from New Hampshire's dedicated Subsurface Systems Bureau, which created an agency specifically to regulate septic systems. Creating a bureau could be helpful to prioritize .

Similarly, NH recently signed an act to establish a shoreland septic system study commission (Establishing A Shoreland Septic System Study Commission 2019, 1). This act recognized issues with achieving upgrades of private property septic systems and established a commission to study the potential impairment of surface waters in New Hampshire by inadequate residential septic systems. A commission could similarly increase the legitimacy and prioritization of septic leakages as a state issue.

Vermont and New Hampshire have both had their share of unpassed legislation: HB. 426 in New Hampshire regulates shoreland septic systems, focusing on systems not approved by the department or the department's approval is older than 20 years. This law would require those systems to be inspected by New Hampshire permitted septic system designer or evaluator (Relative To Shoreland Septic Systems 2021, 1) and did not make it past the House.

Though NH's septic website does redirect to a federal grant list (USDA Single Family Housing Repair Loans & Grants in New Hampshire, Province Lake Association), it requires more hurdles to jump through for a homeowner to apply for a grant. NH could also add a program similar to VT's Healthy Homes Initiative On-Site program, alleviating the cost for low-income households to upgrade their septic tanks.

Cost Benefit Analysis

It will be helpful to discuss the benefits of proper septic systems when we convert these harmful environmental effects into monetary values. To begin, a proper ecosystem service valuation of the Connecticut River would allow a proper comparison between costs and benefits of possible alternatives to the septic problem of pollution. It should be understood that the goal of this section is not to establish these alternatives as realistic solutions (because the feasibility of such scenarios to come are not practical) but rather to illustrate the importance of the Connecticut River as an invaluable economic utility. Through preliminary research we were able to conclude that the ecosystem service valuation of the Connecticut River for water quality regulation (filtration capabilities) is at least \$2.5B annually. Put more plainly, this means that the implementation cost to completely replace the ecosystem service the Connecticut River system with artificial filtration would cost at least \$2.5B per year.

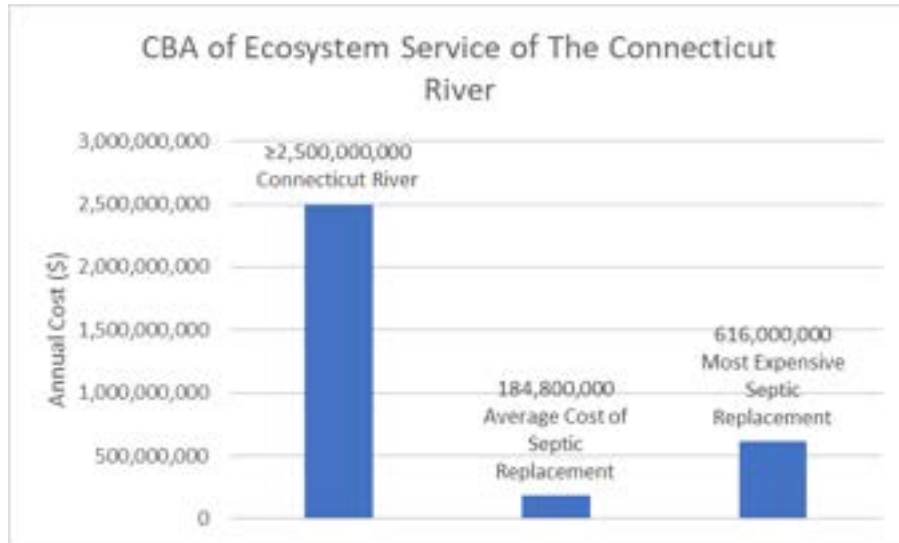
Now that the ecosystem service is properly valued in economic terms, we then turned our attention to the task of valuing septic replacement costs around the CT river basin to gain an insight on comparative values. The replacement cost valuation of septic systems vary greatly, (depending on the tank technology that is used) therefore, we have provided three different scenarios to fully understand an economic reflection that provides a broader range of quantification that retains more confidence. For all

scenarios we decided to overestimate values to avoid underestimating the cost of septic replacement. For instance, in these scenarios we are assuming that all septic systems around the CT river basin are failing and need complete replacement (which is highly unlikely to be representative of reality). The scenarios imagined are as follows:

1. All existing septic systems are replaced using the average costs of septic system replacement in the US (\$7,000).
2. All existing septic systems are replaced using the most expensive tanks available in the US (\$20,000 - BAT).

The techniques used to properly quantify these scenarios were challenging. The lack of septic system regulation or documentation forced us to use various resources to create a comprehensive list of the number of septic systems around the CT river basin. To do so, we used the population size that surrounds the river basin. This was around 2.4 million people. Next, we then compared that to the average household size (2.6) to estimate the number of homes in the area. Finally, we used the average percentage of homes with a septic system (50%) in the New England area to estimate the total number of septic systems around the CT river basin. Once this was completed, it was possible to estimate the cost of replacing all septic systems in both scenario 1 and 2. However, the total cost did not reflect the lifespans of the septic systems. Therefore, we then divided the total cost of the septic system replacements by 15 years, which is the short end of lifespans for septic systems. This allowed us to properly compare the annual cost of septic system replacement in both scenarios to the annual valuation of the CT river ecosystem service. By doing so, scenario 1 came out to be \$184,800,000 and scenario 2 was \$616,000,000. Both scenarios are far less than the \$2.5B valuation of the CT river's water quality regulation ecosystem service. The cost of replacing all existing septic systems is far outweighed by the benefit of retaining the ecosystem capacities of the CT river.

It should be noted that there were many limitations within this cost-benefit analysis. The valuation of an ecosystem service is difficult to solely be displayed using a monetary lens. More so, the ecosystem services that the CT river provides are vast and therefore, almost impossible to fully appreciate in an economic evaluation. The valuation of the CT ecosystem service is likely far greater than the value reflected in our research. More so, the costs to implement septic systems varies greatly not only on geographic location but also on the infrastructure which surrounds each home. Taking these limitations into consideration, all valuation of septic system replacement utilized the more extreme cost possibilities while the ecosystem service of the CT river was likely far underestimated. This allowed us to properly illustrate that even while we took these limitations into account, the CT river has a far greater economic value than the costs associated with septic system replacement.



Conclusion

New England has the greatest proportion of single-family homes served by septic systems in the country with 55% of households in Vermont alone relying on septic – the highest rate of any state in the country. New Hampshire and Maine follow closely with nearly half of all households using septic systems. Being more economical than municipal wastewater treatment systems thanks to reduced infrastructural demands, decentralized wastewater treatment is generally preferred for rural New England communities given their lower population density and smaller median household incomes.

However, when improperly regulated, the ostensible cost savings of using decentralized wastewater treatment come at a greater, more insidious price. Nonpoint phosphorus and nitrogen pollution originating from septic system effluent is the leading cause of nutrient loading in the Connecticut River watershed, causing eutrophication as far downstream as Long Island Sound. In New Hampshire, the Connecticut River affords \$12.5 billion in annual ecosystem services from municipal water provision, bioremediation, and recreational opportunities alone, excluding the untold intrinsic value provided by the watershed's ecological function (State Agriculture Review: Vermont). As limiting nutrients in freshwater ecosystems, nitrogen and phosphorus inputs from septic tank leakage feed harmful algal blooms that toxify the water supply, devaluing the provisioning and cultural ecosystem services that support local economies.

When underregulated, decentralized wastewater treatment often imposes public costs on local and state governments from pollution mitigation and economic loss that negate any savings they accrue. Florida set's a sobering precedent for this reality as the state faces \$20 billion in ecosystem remediation costs thanks to historically laissez-faire regulation for its 2.7 million residential septic systems. Similar case studies abound in the Chesapeake Bay watershed where septic effluent has compounded persistent toxic algal blooms attributed to agricultural runoff. Such long-term costs can be avoided through proactive state policy mandating septic system compliance with minimum performance standards.

Despite an extensive record of legislative revision, regulatory frameworks for septic tank maintenance in Vermont and New Hampshire continue to lag behind more progressive measures taken by other New England states, including Massachusetts in the lower reaches of the Connecticut River watershed. While both states mandate permitting for septic installation and outline standards for system function and construction, neither state requires recurring inspections to ensure these standards are met. With little regulatory oversight to inform homeowners of damaged or outdated septic systems, Vermont and New Hampshire households are frequently unaware of the status of their systems, and even when they are aware, homeowners have few incentives to solicit professional advice.

Without provisions requiring regular inspections, Vermont and New Hampshire residential real estate markets are rife with moral hazard. Buyers typically lack any information on septic system integrity when purchasing homes because sellers are neither required nor incentivized to provide it to them. As a result, malfunctioning septic systems often go undetected for years even as ownership changes hands, unwittingly allowed to continue leaching nutrient-laden effluent into groundwater and surface water flows that ultimately reach the Connecticut River. Property conveyances therefore serve as opportune times for the Vermont and New Hampshire state governments to mandate septic tank inspections to identify and repair faulty systems, helping lessen nutrient loading in the Connecticut River while protecting homebuyers from unforeseen liability. The following policy amendments are recommended in Vermont and New Hampshire to this end:

Vermont: Vermont is encouraged to resurface either bill S.70 (failed 2015) or bill H.144 (failed 2021), both of which called for mandated septic system inspections during real property conveyance. Sellers would be required to provide buyers with a certificate of inspection filed by a licensed inspector confirming septic system compliance with minimum standards of functionality. Such a bill would amend Chapter 64 of “Title 10: Conservation and Development” which currently includes permitting provisions but neglects reference to inspections. Of particular relevance to this recommendation is Rep. Sarita Austin’s (D-Chittenden-9-2) intent to reintroduce a version of H.144 modeled after Massachusetts’s progressive Title 5. Rep Austin’s first attempt to pass H.144 in 2021 unfortunately never received a vote on the house floor. Furthermore, Vermont could create new legislation modeled off the bright spots to bridge the gap of Maintenance And Pump-Out Requirements, Certification Of Septic System Professionals, and Tiered Requirements.

Table 3. Recommendations for Vermont Legislation

Gap	Bright Spot	Addresses	Recommended Legislation
Regular Inspections	Massachusetts Title 5, or HB. 426	The former the mechanism of home sales to mandate septic tank inspections. The latter mandates	Resurface H.144

		inspection for systems older than 20 years.	
Maintenance And Pump-Out Requirements	New Jersey Administrative Code (NJAC)	Designates a time period for certain capacities of septic tanks.	New legislation.
Certification Of Septic System Professionals	NJAC	By giving incentives to certify septic professionals, the NJAC ensures that they have the necessary training and expertise to do the job correctly	New legislation.
Tiered Requirements	Title 27 of the California Code of Regulations, California Onsite Wastewater Treatment Systems Policy (OWTS)	Ensures that septic systems that pose more environmental harm (based on location near water, state of the system, capacity) are treated more severely from those that do not have those requirements.	New legislation.
Records Of Septic Installations	NJAC + OWTS	Require homeowners to keep a record of septic installations, upgrades, and maintenance.	Resurface S.70
Bureau and Commission for Septic Systems	New Hampshire Subsurface Systems Bureau and H.B. 475	Creating a commission to study septic-related water issues and to regulate permits.	See NH's H.B. 475

New Hampshire: Unlike Vermont, New Hampshire has less of a precedent for progressive septic policy in the state's legislative record. New Hampshire is encouraged to amend "Env-Wq 1000: Subdivisions; Individual Sewage Disposal Systems" to direct the Department of Environmental Services (DES) to enforce real property conveyance inspections similar to those recommended in Vermont. Sellers would be required to present buyers with proof of a successful inspection accredited by a DES-approved technician during property sales. Inspections would only qualify as "successful" if compliance with minimum standards of septic system functionality was documented.

Provided the Connecticut River is a shared resource between Vermont and New Hampshire, it's advised that both states work in close coordination to develop similar, if not functionally identical regulations. Critical elements of such a "joint bill" should include 1) financial assistance for sellers required to hire inspectors or upgrade their system, 2) clearly-defined minimum standards of compliance, 3) enforceable consequences for noncompliance, and 4) designated Nitrogen Sensitive Areas (NSAs) where river or tributary-adjacent homes are subjected to more stringent compliance standards. A number of existing Vermont and New Hampshire programs and statutes could support these elements, and Massachusetts's progressive Title 5 provides ample precedent for inspiration.

Hiring inspectors and refurbishing septic systems when necessary are costly endeavors, especially in lower income rural communities. Cost concerns have been a primary obstacle to the adoption of septic inspection policy, but a variety of existing grants and cost-share assistance resources could be deployed to alleviate this economic burden. For instance, New Hampshire created the Septic System Replacement and Repair Fund in 2013 to provide cost-share assistance to qualifying homeowners undertaking costly repairs on their septic systems. Although such a fund would have to grow considerably to accommodate a greater volume of demand, revenues from noncompliance penalties (discussed further below) could be used to finance this growth without having to draw from tax revenue.

Inspections will be most costly when septic systems are found to be noncompliant, but how should noncompliance be defined? Massachusetts' Title 5 serves as an excellent blueprint for minimum performance standards that could be adopted by Vermont and New Hampshire. Most importantly, Title 5 requires residential septic systems to have a minimum capacity of 1000 gallons and be equipped with effluent filters attached to distribution boxes. Capacity minimums help prevent system overflow while effluent filters and distribution boxes prevent solid wastes from entering the leach field and ensure effluent is distributed evenly across the field, respectively. These measures significantly reduce nutrient discharge from septic systems, helping limit ground and surface water contamination.

Given the technicality and potential costliness of such standards, homeowners may be incentivized to avoid compliance. To discourage noncompliance, state programs should levy strict punishments on sellers who fail to obtain proof of inspection. Massachusetts' Title 5 imposes \$1,000 fines on sellers who fail to perform inspections, ratcheting these fines up by \$1000 for each subsequent offense. The fines for failing to upgrade a noncompliant system are even steeper, totaling up to \$25,000 *per day* beyond pre-agreed deadlines. As previously noted, Vermont and New Hampshire could design a self-subsidizing law whereby the revenues from these penalty fees could be allocated to cost-share assistance programs to reduce cost burdens on lower income households.

Equally important as preventing noncompliance is ensuring that residences in high priority areas are subjected to greater scrutiny. Vermont has experimented with designating certain riparian regions as Nitrogen Sensitive Areas (NSAs) due to their outsized sensitivity to nutrient runoff. Construction activities in NSAs are subject to more rigorous standards designed to account for their inherently riskier nature. NSA designation could be extended to the entire Connecticut River main stem as well as its tributaries, and separate minimum standards of septic performance could be applied to residences in these regions. Residences would fall into a tiered taxonomy of compliance standards in accordance to their risk profile, with homes at greater risk of nutrient leaching (e.g. those that are riverfront) facing the most stringent compliance standards.

In aggregate, cost-share assistance, tiered performance standards, stiff noncompliance penalties, and NSA designations comprehensively account for many of the implementation and effectiveness challenges a mandated inspection bill would face in Vermont and New Hampshire. Nonetheless, questions persist regarding the political viability of this legislation, particularly given similar bills' record of failure in the Vermont house and senate. The national landscape of state septic policy reflects divided

partisan attitudes over the necessity of regulation, and such disputes undoubtedly bear relevance among the purple political constituencies of Vermont and New Hampshire.

However, framing the septic policy dialogue in the terms of cost avoidance could alleviate critics' concerns that a mandated inspection bill would be excessively burdensome. Such a bill could save Vermont and New Hampshire taxpayers from costly pollution mitigation projects while also shielding them from high septic system replacement costs through regular maintenance and inspection. Moreover, the policy could be partly self-subsidizing through creative financing mechanisms such as allocating penalty revenues to cost-share assistance programs, helping reduce inspection costs and tax liabilities for individual households. The economic logic of a mandated inspection bill, as well as the relative infrequency of property conveyance, therefore create a strong case for the political palatability of this legislation in purple voting blocs.

Reflection

Throughout the course of this project, our group actively invested in developing effective communication strategies. We met regularly to discuss strategy both in and outside of class. We communicated in person and across virtual mediums; messaging regularly in a Groupme chat, commenting on Google documents, drafting shared documents, and hosting work sessions via zoom. Having lots of different channels for communication helped to keep connected when we separated into different tasks.

For different phases of the project, we adopted different approaches. We conducted most of our initial research as a group. As we conducted this initial research, it became clear that we each had different aspects of the project that struck us as particularly engaging. From there, we divided ourselves according to interests for drafting the actual report. Throughout this process, we continually communicated across sections, and divided a large portion of our editing into bringing the sections into cohesion. For the policy debate, we maintained a similar approach, where, even after we divided into affirmative and negative, we helped each other devising arguments and compiling evidence.

During our meetings, we crafted a safe space for group members to share constructive feedback and discuss potential ideas. All of our interactions held core values of mutual respect, and were approached maintaining a friendly, open disposition.

The long term nature of the project allowed us to adopt a flexible approach to our workflow. This meant that if any group members were ill or otherwise incapacitated, other group members carried more of the workload for a period of time while the member recovered. After they were well, they could make up the work that they missed while unwell. We found that this flexibility worked really well for each of our schedules, and allowed us to produce our best quality work.

Reflecting on our responses during the first group dynamic classroom discussions at the beginning of the term, we learned through this group project how important delegation is. When one of our team members suggested we split work up by section, it gave members agency and ownership over their work. Our conversation at the beginning of the term was important in setting norms for group work and conflict resolution. Thankfully we didn't have any conflicts to resolve, and the ample time in class to collaborate was part of that reason.

Overall, we genuinely enjoyed working together. For many of us it was our last opportunity to collaborate at Dartmouth, so we savored the experience!

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Chapter 4

Residential Septic Pollution Education and Outreach for the Connecticut River Conservancy



Jake Dalton, Quintin George, Susie Goodell, Liam Jamieson, Sarah McWhirter, and Claire Mitchell

Residential Septic Pollution Education and Outreach for Connecticut River Conservancy

Final Report

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McWhirter, and Claire Mitchell

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INTRODUCTION

Residential septic systems, particularly outdated or poorly maintained systems, are a significant contributor to nitrogen and phosphorus nutrient loading in New England watersheds, as older, uninspected systems experience gradual leakage over time ([US EPA, 2022](#)). An alarming consequence of this pollution is algal blooms, which diminish dissolved oxygen levels in bodies of water, like the Connecticut River, leading to the death of aquatic life and unsafe waters for recreational activities. At the turn of the century, the Long Island Sound experienced extremely high levels of nitrogen and phosphorus due to nutrient loading from septic systems and agricultural runoff. This has major impacts on the water quality and aquatic life, as algal blooms appeared over large swaths of the Sound. 90% of the Long Island Sound's freshwater comes from the Connecticut, Thames, and Housatonic Rivers, which cross state lines, creating a legislative challenge. So in 2001, institutions collaborated cross-jurisdictionally to establish Total Maximum Daily Loads (TMDLs) for nutrients responsible for the ecological damage to the Sound. TMDLs mandate a 58% reduction in nitrogen concentrations, which led to a reduction in the area of hypoxia by more than a factor of two over the years following the TMDL enactment.

While residential septic was *part* of the issue for the Long Island Sound, it's a large issue in Vermont. For instance, Vermont's rural poverty rate of 9.8% is 32% higher than Connecticut's rate ([Connecticut, 2023](#)), and it boasts the highest percent of homes served by residential septic systems than any other state at 55% ([Septic Systems Overview, 2015](#)). With a larger rural poverty rate and higher prevalence of residential septic, it's likely that the state's waters face a significant challenge due to pollution from poorly-maintained residential septic systems. When the "links between private septic systems, well water contamination, and health are poorly understood", New Englanders have reason to be concerned with the state of their local lakes and rivers ([Fizer et al., 2018](#)). With no laws in Vermont requiring septic pumping or routine inspection when selling properties, these important responsibilities end up on the bottom of homeowners' priority lists. Homeowners also sometimes lack resources to fully understand the benefits of a working septic system, including healthy water quality, increased or maintained home value, and overall savings when comparing inspection and pump costs to complete replacement, which can be necessary if the system is old and failing.

The core of this pollution problem is that many homeowners do not feel incentivized or informed enough to properly maintain their septic systems. The factors to blame are often elevated perceived financial costs and relatively low perceived health and water quality risks, which keep a homeowner satisfied with the status quo. Even if a homeowner *is* aware of these risks, in the end, septic maintenance is not free. A key issue, then, is informational asymmetry, not one of greed or deliberate ignorance of a homeowner's community. Homeowners are often not aware of the large long-term financial and health costs associated with no maintenance, nor are they fully aware of the water quality degradation cost to their community, the Connecticut River watershed, or the Long Island Sound. It is crucial that homeowners understand the impact that their malfunctioning septic systems can have on their local communities and far beyond. This communication disconnect presents an opportunity to improve water quality by educating homeowners on the importance of maintaining septic systems.

To solve this issue and fulfill their mission statement to "bring people together to prevent pollution, improve habitat, and promote enjoyment of the river and its tributary streams", the Connecticut River Conservancy (CRC) can build an education and outreach campaign for Vermont homeowners focused on septic systems and their impact on the health of the Connecticut River watershed. In this Report, we outline a plan for CRC to address septic pollution by reaching out to homeowners and community members.

Through frequent communication with the CRC, interviews with a wide range of Connecticut River watershed stakeholders, and review of relevant scientific literature, we devise a strategic outreach plan focused on 1) clear, factual information, 2) descriptive social norms, 3) actionable steps, and 4) the most effective channels of communication. We provide rationale for these four tenets in the “peer-reviewed research and institutional publications” section. This plan features action items for the CRC, as well as a brochure containing sample figures, which they can use as part of the plan. We hope our plan can increase awareness of the importance of septic system maintenance, encourage more homeowners to regularly maintain and inspect their septic systems, and ultimately improve the water quality in the Connecticut River watershed.

METHODS AND ACTIVITIES

To ensure the best possible outcome for the CRC in solving the issue of communication disconnect to homeowners about the importance of septic upkeep, we used three main research and data-gathering methods:

- Frequent, clear communication with our community partners at the CRC, Kate Buckman and Kathy Urffer
- Interviews with a wide range of stakeholders in the Connecticut River watershed, and
- A comprehensive review of peer-reviewed literature and institutional publications.

This three-pronged methodological framework provided a balance to our data collection and research, allowing our team to tap into local knowledge on pertinent, timely issues as well as grounding our recommendations with research-backed findings.

Communication with community partners

To ensure the most clarity and efficiency throughout our project, our team prioritized frequent communication with Kate and Kathy from the CRC. Serving as consultants to help them strive toward fulfilling their mission statement and solving septic pollution, it was paramount to keep Kate and Kathy in the loop during all steps of our process. On a practical level, this communication took the form of weekly email updates, Zoom meetings every other week, and email threads asking for feedback as needed.

Not only was it likely helpful for the CRC to know exactly what our plans were on a weekly basis, but it was also useful for our team to receive feedback from the CRC to create a better work-product. For example, after finishing the first few drafts of our “Septic Smart” educational brochure, the CRC’s Communications Director Diana Chaplain provided invaluable feedback to help us make sure the brochure’s layout and “look and feel” matched with that of the CRC’s published materials. These quick formatting changes might have taken us several more iterations to dial in if we hadn’t maintained a constant stream of communication with our community partners, but since we were proactive in asking the CRC for feedback, it saved both our team and our community partners time and effort.

Similar examples played out several times throughout the course of our project. In the first week of our project – as our team acclimated to how septic systems work and learning as much as possible about relevant local issues (like the success stories in the Long Island Sound over a decade ago or ongoing problems like phosphorus and nitrogen leaching in freshwater systems) – we were unsure about how we could be the most impactful with choosing the scope of our project given our time constraints in a ten-week term. After deliberating as a group, we were still unsure about whether to focus on both Vermont and New Hampshire, one particular

state, both municipal and residential, or just residential systems, so we spoke with Kate who, in a 25-minute meeting on a Friday afternoon, discussed with us the strengths of focusing on residential septic systems in Vermont. Had we not simply asked for the meeting, we might have waited the full weekend to deliberate or, worse, focused on something that the CRC didn't think was important.

Interviews with relevant stakeholders

A crucial part of our research was conducting interviews with a variety of stakeholders in the Connecticut River watershed. We received guidance from Kate and Kathy from the CRC as well as Dr. Karen Bieluch, a supervising guide throughout this process, as to what types of stakeholders to which it would be most beneficial to reach out. Two interviewees work in personal septic system installation and maintenance; two work in Vermont state and municipal departments that cover water/wastewater systems and water treatment plants; two work at nonprofits that support Vermont's water sectors (drinking, storm, and waste); one interviewee is a Vermont homeowner with a two-tank residential system; and one interviewee is a homeowner in Hanover, NH and a recreational fly-fisher in the Upper Valley region of the Connecticut River.

Interviews were conducted both in-person and over the phone. All interviews were recorded to ensure the accuracy of references in the report. The conversations and topics covered in interviews were varied for several reasons. First, interviews were conducted by different group members. Second, interviewees all had unique perspectives and interactions with the Connecticut River watershed and septic systems. While there was diversity in the interviewees and content of the interviews, we were able to categorize takeaways from these conversations to help establish trends and themes surrounding septic maintenance and community outreach through an interview table. In addition to two biographical columns, *Interviewee* and *Occupation or project objective*, we present three analytical columns: *Perceived homeowner motivators for maintenance or upgrades*, *Homeowner outreach strategies*, and *Challenges in motivation and outreach*.

Table 1: First two rows of interview table (full table included in Appendix)

Interviewee	Occupation or project objective	Perceived homeowner motivators for maintenance or upgrades	Homeowner outreach strategies	Challenges in motivation and outreach
Middle-aged owner of VT septic inspection, maintenance, and pumpout service	Inspect, maintain, and pump out residential septic systems in VT	Financial risk Health risks: "some people literally straight pipe their septic to their yard"	In-person home visits, phone calls Would provide educational materials if they had time	Hard to motivate low income households to act on environmental risks, and most "problem areas" are low income "People are unaware"
Middle-aged Senior VP Marketing, septic installer and pumpout service on Eastern Seaboard	Market, advertise, and "ensure customer's ability connect with" 16 local "legacy brands" of septic installers and maintenance providers	"Their pocketbooks" Balance of health and environmental risks: "if you live on the water..."	"Communicate the likelihood of long term financial risk" of improper maintenance Educational materials on social media, ad campaigns, direct communication to (potential) clients	Hard to motivate all households to act on environmental risks, unless their job depends on it (fishers) "Balancing environmental consciousness with budget in rural areas"

Table 1 displays the first two rows of the interview table (full table in the Appendix), highlighting the general setup of our interview framework. In the Results section, we present summary figures tabulating key takeaways from this interview table.

Peer-reviewed literature and institutional publications

To supplement our interpersonal communication with the CRC as well as interviews with relevant stakeholders, we conducted conventional research on peer-reviewed literature and other relevant sources. To cover multiple aspects of the project, we break down the scholarly research into two parts: septic science and effective outreach strategies, the findings of which we will discuss further in the *Results* section.

To better understand septic science and best prepare educational and outreach plans for the CRC, we referenced general educational materials from government agencies as well as university publications. An important resource in this part of our research was the Environmental Protection Agency's (EPA) [SepticSmart Education Materials](#), which details how septic systems work and best home practices. We also leveraged educational materials co-produced by the [University of Maryland and the EPA](#), which answers dozens of frequently asked questions by homeowners with septic systems. These sources focused on basic understandings of septic systems, which helped us produce a comprehensive figure tailored to the CRC's intended audience comparing functional residential septic systems to failing systems, which we highlight in the *Results* section.

We also looked at relevant peer-reviewed literature to inform our understanding of behavior change and effective outreach strategies. We searched Google Scholar using keywords related to these topics. For human behavior change, we entered search terms such as 'human behavior change "environment" OR "environmental change"', 'motivation for environmental conservation', and 'social norms behavior change "Cialdini"', after Dr. Bieluch recommended this particular author. We found Goldstein et al.'s [A Room With a Viewpoint...](#) (2008) paper particularly useful for this part of the research process. This paper provided concise but thorough empirical analysis on the dynamics that cause hotel guests to make a decision to reuse their towels for environmental reasons. The authors found that descriptive social norms – which influence behavior by informing people about what *others* do ([Bergquist and Nilson, 2019](#)) – can be an effective, powerful way to “motivate others to engage in the important real-world domain of environmental conservation” ([Goldstein et al., 2008](#)). A later synthetic literature review of the influences of social norms on environmental behavior, published in 2020, provided more insight into recent emerging trends in how norms can be effectively leveraged for positive environmental or social change ([Cialdini and Jacobson, 2020](#)).

On the outreach side, we searched terms like 'effective outreach strategies "environmental" OR "pollution"' and 'homeowner outreach success'. We reference Flanagan et al.'s paper on water well risk messaging, testing, and perceived risk ([Flanagan et al., 2020](#)). This paper provides important insight into the reality that motivating homeowners to improve their well water quality who perceive low risk to household health is difficult. We also drew heavily from environmental psychologist Douglas McKenzie-Mohr, who developed community-based social marketing (CBSM) ([McKenzie-Mohr](#)). This approach to human behavior change relies on identifying barriers to behavior change upfront and tailoring the outreach or behavior change program specifically around these barriers, selecting behavior change tools that face these barriers head-on ([McKenzie-Mohr](#)). CBSM has proved successful in educating homeowners on how they can reduce the environmental impact of home lawn care in Maine ([Stevenson, 2010](#)).

We also wanted to learn more about the importance of clear communication and exactly which communication channels to use in an outreach scheme. Searching Google Scholar for "facts and behavior change", we landed on a synthesis paper titled *Consumers and Trust*, which highlights several papers that spell out the importance of trust in behavior change ([Hobbs and Goddard, 2015](#)). These papers reiterate that not only does clear communication enhance trust, but interpersonal communication also builds trust, and more trust contributes to more rapid adoption of intended behaviors ([Hobbs and Goddard, 2015](#)).

RESULTS AND DISCUSSION

Informational findings & materials

In speaking with Kate and Kathy and researching septic pollution ourselves, we found it useful – for our own understanding, as well – to distill basic information about septic systems and pollution into easy-to-digest informational materials. Intended for use in the outreach plan, we create a brochure focused on clear, factual information, actionable steps, and the most efficient communication channels containing details specific to the audience’s local context. In this case, our brochure is intended to be distributed to Vermont residents, and presents and answers some of the most common questions about septic tanks and their impact on the environment.

Figure 1. “Septic Smart in Vermont” educational brochure.

What should I do to protect my family, lakes, and streams?

- 1) Hire a licensed professional to inspect your septic system for an assessment of pump-out frequency and potential long-term issues
- 2) Pump tank out as necessary (recommended every two years)
- 3) Follow EPA's SepticSmart practices:
 - Flush only septic-safe materials
 - stagger use of water-intensive appliances (washing machine, dishwasher, etc.) and shower and bath
 - don't "strain your drain" with oils or greases

Typical septic services prices

Service	Typical Price
Pumpout (recommended every two years)	\$275
Inspection (includes pumpout)	\$550
Clearing clogged lines from a "backlog"	\$500
Replacing a crushed pipe	\$1,500
Entire system replacement	\$6,000

What resources are available to reduce the cost of repair?

- 1) Individual projects can be funded by the EPA's Clean Water State Revolving Fund
- 2) Vermonters disproportionately affected by COVID-19 are eligible for funding under the American Rescue Plan Act
- 3) Non-profits can apply to receive Rural Decentralized Water Systems Grants through the USDA

However, the best way to save money is through preventative care. Maintenance costs are 10x less than repair costs.

Connecticut River Conservancy

About us

Since 1952, Connecticut River Conservancy has been a strong voice for the Connecticut River watershed, from source to sea. We collaborate with partners across four states - NH, VT, MA, CT - to protect and advocate for your rivers, and educate and engage communities. We bring people together to prevent pollution, improve habitat, and promote enjoyment of the rivers and streams. Healthy rivers support healthy economies.

15 Bank Row, Greenfield, MA 01301
413.772.2020

Your River Stewards!

Left to right: Kate Buckman (NH), Kelsey Wierling (MA), Kathy Uffler (VT), & Rhea Druzenko (CT)

Septic Smart in Vermont
Answering the most common questions asked by Vermonters about residential septic

- How does residential septic work?
- Why should I pump my septic system?
- How does my old septic system endanger the environment and my family?
- What should I do to ensure my household and community are safe?
- What resources are available to bring down costs of repair?

How does residential septic work? 3 Steps.

- 1) Wastewater enters your home's tank (situated right where you use toilets, sinks, & showers)
- 2) Bacteria decompose solids waste, which sinks to the bottom of the tank as sludge
- 3) Liquid waste flows to the leach field, leaving cleaner wastewater behind
- 4) Wastewater flows out into a leachfield, where it slowly soaks into the ground
- 5) Soak and slowly filter up to the tank until returned by a pump-out service

Why should I pump my tank?

Reduce risks to your home and community

- Financial risk
 - Avoid future repair and replacement costs of more than \$1000
 - Septic leaks decrease home value
- Water safety risk
 - Bacteria make waterborne drinking water
 - Reduced potential drinking water supply
 - Water damage (leaky tanks, oil, oil, mold, etc.) and other health risks

How does my old septic system endanger the environment and my family?

Functional residential septic system

Failing residential septic system

Are't nutrients good for local waters and the soil?

Manure and phosphorus are limiting nutrients in saturated soil. Excess nitrogen, often the result of a limiting nutrient, enters an ecosystem where the algae blooms and eutrophication.

Algae and excessive ground increases

When algae and phosphorus are abundant, they can result in eutrophication and long-term health of contaminated stream containing nitrogen and phosphorus are local waters (Source: modified from National Geographic, 2018)

Panels context – left to right: outside fold, back cover, front cover, inside fold (opens fully)

In this brochure, the title page highlights five frequently asked questions about home septic systems. We decided on these questions after our interviews and speaking and iterating on the brochure with Kate and Kathy. At a high level, the structure is as follows: we outline how residential septic systems work before explaining why homeowners should maintain them, focusing on financial and water quality risks. To depict this visually, we include an original diagram created using Adobe Illustrator showing how malfunctioning and leaking septic systems harm the environment. We provide a list of actionable steps that homeowners can take to maintain their septic systems, as well as the typical prices for septic services and other available resources.

Our interviews were especially useful for outlining the brochure, as we were able to hear from residents and other experts on what the most common questions and misunderstandings are on septic systems. We used this to create the list of questions that will be addressed in the brochure on the front page. The interior of the brochure includes our diagram, an explanation on how residential septic systems work, and how the environment is impacted when the systems are old and leaking and the consequent effects on the environment. We then provide a rationale for why homeowners should pump their tanks as well as dispel a common misconception about nutrient loading.

While the interior of the brochure answered the what and the why of septic pollution, the outside fold focuses more on the what to do now that you are informed. Our interviewees cared more about the financial and health risks of malfunctioning septic systems than the impact on the environment, which we discuss in further detail in the next section. We provide a list of actions that readers can take as well as a chart displaying typical prices for different septic system services, which we received from our interviews and confirmed with basic web searches to get quotes we could generalize across Vermont. To further inform our audience about cost (and cost mitigation), we provide a list of resources available to help homeowners pay for septic upkeep. In this section, we also highlight that these costs may seem steep now, but they will only increase in emergency situations that occur with outdated or malfunctioning septic systems.

This brochure meets three of the four key tenets of our outreach plan (more information in *Table 2*): (1) clear, factual information – the brochure relies heavily on unpacking complex systems and dynamics for a wide audience, (3) actionable steps – it provides concrete actions homeowners can take to maintain their systems day-to-day, and (4) most effective communication channels. Though descriptive social norms are a key tenet of our plan, we did not think it was necessary or relevant to leverage social norms in this brochure, given its informational nature. In an alternate version, though, perhaps the CRC could combine the second tenet, descriptive social norms, into a similar document by highlighting a “community champion” who has taken initiative to ensure their residential septic system is maintained. This could take the shape and form of occupying a full panel on the brochure, for example. This brochure serves as one element in our outreach plan. We hope this brochure can be adapted by the CRC to fit other mediums as well as local contexts – perhaps they want to narrow or broaden the scope to reach a more targeted or larger audience or they want to take some of the information to use in social media infographics. The brochure’s editable link has been shared with CRC so they can make updates as they see fit after our communications conclude.

Barriers to behavior change (interview results)

The most important takeaways from our interviews involved tabulating responses around barriers to changing behavior with respect to residential septic systems. In the context of Community-Based Social Marketing (CBSM), identifying barriers to behavior change upfront is a crucial step in the development of effective outreach strategies. CBSM is a research-driven approach that leverages an understanding of the target audience's perceived barriers to influence behavior change ([McKenzie-Mohr](#)). By pinpointing these barriers early on, we can tailor our strategies to address them directly, thereby increasing the likelihood of successful behavior change. Through our interviews, we highlight two central barriers to behavior change: first, a lack of information among homeowners; and second, low perceived environmental and health risks associated with not maintaining one’s septic system.

Figure 2. Interview response tabulations: lack of information

Almost all interviewees cited "lack of information" as a challenge in motivating homeowners to pursue septic upkeep

"Uninformed", "misinformed", or otherwise unaware



In Figure 2, we emphasize a key result of these interviews: almost all interviewees cited “lack of information” as a challenge in motivating homeowners to pursue septic upkeep. Responses we deemed to fit this description consisted of quotes containing “uninformed”, “misinformed”, or other ways of communicating that homeowners are unaware of the full extent of not maintaining their residential tanks. This confirmed our and the CRC’s hypothesis that there is significant opportunity for an outreach plan to alleviate informational asymmetries associated with residential septic systems. We felt even more motivated to continue with our outreach plan given this result.

Figure 3. Interview response tabulations: financial, health, and environmental risks

More interviewees cited financial and health risks than environmental risks as motivators for septic upkeep

Financial Risks



Health Risks



Environmental Risks



Figure 3 displays another significant barrier to behavior change: low perceived environmental risk of faulty septic systems. All interviewees cited financial risks, namely the much higher costs of large septic failures compared to routine septic maintenance, as a motivator for upkeep. Six out of eight interviewees further cited health risks, such as the risk of waterborne illnesses and contamination from per- and polyfluoroalkyl substances (PFAS), as a motivator for septic upkeep. Only four out of eight interviewees cited environmental risk, including phosphorus and nitrogen loading into local ecosystems, as a motivator for septic upkeep. These results indicate a crucial knowledge gap and a need for increased education and

awareness regarding the environmental impacts of septic pollution. Homeowners largely respond to immediate and personal risks, such as financial burdens and health hazards, but the under-emphasized environmental implications, like nutrient overloading causing harm to local ecosystems, appear to be less understood or prioritized. Bridging this gap between personal risks and broader environmental risks could potentially motivate homeowners to pursue a more proactive approach to septic system maintenance.

Tools to overcome these barriers: outreach plan

After frequent communication with the CRC, interviews with a wide range of Connecticut River watershed stakeholders, and synthetic review of relevant scientific literature, we present a strategic outreach plan for CRC focused on educating Vermont homeowners about proper care for their septic systems. Rooted in scholarly literature on behavior change and effective outreach, especially on community-based social marketing ([McKenzie-Mohr](#)), descriptive social norms ([Goldstein et al., 2008](#)), and trust-building ([Hobbs and Goddard, 2015](#)), this plan centers on four central tenets: 1) clear, factual information, 2) descriptive social norms, 3) actionable steps, and 4) the most effective channels of communication. The table below shows a summary of the complete plan (attached in Appendix), highlighting concrete actions the CRC can take to fulfill each tenet.

Table 2. Outreach Plan Tenets and Action Items for CRC

Central Tenet	CRC Action Items
1. Clear, factual information	<ul style="list-style-type: none"> • Develop informational material (we provide a brochure with sample figures) • Establish / maintain web presence
2. Descriptive social norms	<ul style="list-style-type: none"> • Highlight community stories • Commemorate community "champions"
3. Actionable steps	<ul style="list-style-type: none"> • Create step-by-step maintenance guide for homeowners and directory of local septic services
4. Most effective communication channels	<ul style="list-style-type: none"> • Organize community events / engagement ("septic socials") • Leverage local media (news, radio, TV) • Send informational materials directly to via mail • Engage with homeowners on social media and the web

Our outreach plan emphasizes clear, factual information first and foremost. To accomplish this, the CRC can consider developing informational material and establish and maintain a web presence focused on septic maintenance. CRC can serve as an outlet for homeowners or other community members seeking information on residential septic systems. In pursuit of this, the CRC can continue to establish trust, which is a crucial component for behavior change, as we cite previously in the peer-reviewed literature section. Second, since people are often influenced by the behavior of others, especially with respect to environmental and social change, showcasing good practices and community endorsements can encourage similar behavior. CRC can leverage social norms by highlighting community stories (good and bad) and commemorating "community champions". In celebrating people who treat their septic system the right way, the CRC can inspire others to act similarly and properly maintain their own septic systems. Third, it's not enough to tell people why they should do something; you must also tell them how. Providing easy-to-follow actions through maintenance guides or a directory

of local services is crucial to transforming intentions into actions. Last, to ensure the CRC is reaching as many homeowners as possible, it should consider engaging with community members face-to-face through “septic socials” or similar community-centered events. These events, which center around interpersonal communication, can also help build trust among the CRC’s outreach plan, which encourages more rapid adoption of better septic upkeep practices. CRC can supplement face-to-face community engagement with local media, direct mail, and online outreach. Through these channels, the CRC can carry out the other three tenets of the outreach plan.

It’s important to note that communication via an outreach plan is just one avenue of motivating behavior change. Incentives, regulatory legislation, or informal social influence are other methods of affecting behavior change especially in an environmental or sustainability context. However, while incentives provide rewards for desired behaviors, they “do not stimulate individuals’ awareness towards environmental problems” ([Grilli and Curtis, 2021](#)). According to the same paper, education and awareness schemes are more successful at long-term or ‘sticky’ behavior change because of this reason; the ultimate motivator of behavior change from education and outreach is oneself, after being educated ([Grilli and Curtis, 2021](#)). The other CRC workgroup from this class has looked at potential policy options that the CRC might consider supporting to help solve septic pollution issues. However, while regulatory legislation can induce behavior change by force, bills can be slow to pass and require deep tacit knowledge about policymaking to move them forward. In addition, regulatory legislation often makes concessions of components of the desired behavior change to achieve compromise, which can be necessary to pass a piece of legislation. Lastly, even if a law does get passed, making sure citizens adhere via enforcement can be an additional challenge, especially in rural areas. We highlight this to underscore the importance and large potential upside of this education and outreach plan that focuses directly on individual homeowners.

As we seek to bridge the informational gap between homeowners and their septic system responsibilities, it’s imperative to design an outreach plan that effectively communicates the risks of neglect and the benefits of maintenance. We hope the CRC can encourage proactive engagement in septic system care by providing clear, concise, and actionable information efficiently. Understanding that changing behavior is a gradual process, our plan emphasizes ongoing dialogue, education, and the promotion of positive social norms around septic upkeep.

CONCLUSION

Limitations

There were a few limitations to our project, the first being timing. The ten-week term constrained our ability to create the wide range of materials we had hoped we could. We brainstormed a long list of items that we could work on for the CRC during the course of our project, however, we had to be realistic and cut down our focus to only a few deliverables. We decided to focus on our outreach plan that outlines potential ways to expand on our work and continue the campaign and our brochure that can be adapted to other forms and be the foundation for materials that the CRC could make. We do include some of our other ideas for the CRC in the outreach plan as potential action items in case the CRC is interested in exploring these options as they continue to grow their septic education campaign.

Sampling bias may have influenced the results of our interviews in this report. Given the demographics of the interviewees (professionals involved in the septic industry, state and

municipal officials, and homeowners) perspectives on the topic may be skewed. While this group does provide a range of perspectives, it does not fully represent the diversity of the wider population of homeowners in the Connecticut River watershed. Nor was it intended to be a representative sample; interviewees were not chosen at random, but rather for specific insight into the issue and for some, expertise on outreach. While the professionals and officials may have a deeper understanding and awareness of the issues surrounding septic systems due to their occupational exposure, typical homeowners might lack this understanding; as a result, we could be underrepresenting the degree of the 'lack of information' barrier. Furthermore, one homeowner selected for interviews was selected due to previous knowledge about their residential septic system being in close proximity to their water source; as a result, this homeowner might be more careful than average, which might not reflect the experiences and attitudes of the general homeowner population. We also had a small interview sample size, which was a function of our timing constraints and contributed to potential sampling bias issues. Thus, while the interview results provide valuable insights, the potential sampling bias suggests caution in generalizing these findings to the broader community without additional research. In the future, the CRC could consider pursuing a survey striving for more robust random sampling to account for this issue.

Another limitation is that we focused on *rural* Vermont residents. It is more difficult to communicate with large groups of residents who live in rural areas as their homes are more spread out and it takes more effort to discuss in-person with groups. As such, our group faced issues finding effective methods of outreach to these types of communities. We initially hoped to survey Vermont homeowners with questions gathering data about their septic systems to get more accurate data. However, this proved difficult rather quickly, as designing a successful survey is a big task, let alone distributing that survey to a representative rural population. Additionally, in reality, the septic pollution issue in the Connecticut River Watershed extends beyond the Vermont boundary into other New England states. CRC could consider adapting a similar outreach plan for other states or geographies.

Final Remarks

Despite these limitations, we were able to create educational materials and a concrete outreach scheme rooted in Community-Based Social Marketing, descriptive social norms, and establishing and maintaining trust, key concepts we sourced from peer-reviewed literature. We are hopeful our work will help form a foundation for the CRC's efforts to engage with community members and efficiently reduce nutrient pollution from septic systems in the Connecticut River watershed. In our brochure, we synthesize information that is critical for residents to understand and that answers questions they are likely to have about septic systems and their impact on the environment. We hope the CRC can incorporate this information into a number of different forms, including flyers, social media content, and infographics. Our interviews revealed that social media is an emerging, very effective method of interacting with younger generations. CRC already has a social media presence, but we think the CRC has a great opportunity to explore this channel of communication even further in its septic education campaign. We also discussed the idea of the CRC hosting a "septic social" event for residents in Vermont watersheds. We agree that this could be an effective way of educating residents and having meaningful in-person conversations about this important topic. Our outreach plan includes these possible avenues of communication and more that we hope will guide the CRC as they continue their septic education and outreach campaign in Vermont.

GROUP REFLECTIONS

Our group's final work product and collaborative process were heavily influenced by past experiences with teamwork and theories about collaboration, especially those that Dr. Bieluch presented for this class. We incorporated many of the ideas about psychological safety and the importance of being a good leader and follower that were first brought to our attention through the preparatory materials for that presentation. The free writing exercise also helped our group think on the same page. These new conceptualizations of effective teamwork helped our group create measurable, achievable, and relevant goals that helped us reach our overall aim of generating a septic outreach and education plan and useful data for the CRC.

The first set of preparatory materials for Dr. Bieluch's presentation touched on the concept of psychological safety, which "enables candor and openness and, therefore, thrives in an environment of mutual respect" ([Edmondson, 2018](#)). In order for any collaboration to be effective, a group must set norms that ensure a safe working environment, which in turn allows for group members to speak their minds and hold each other accountable. There are several methods of accomplishing the creation of a psychologically safe group work environment, including setting the stage for collaboration, inviting participation, and responding productively to group members. Our group was united by a shared purpose, namely a desire to help the CRC in their important mission of improving water quality in the Connecticut River. Initially, we also framed the scope of our project so we had a clear idea of what deliverables we would be producing and how they would directly benefit the CRC, which created a shared group culture and expectations. Our group invited equal participation by all group members by partitioning the workload in a way that encouraged group members to own a particular work stream; however, we also often came together during in-class group work sessions to collaborate on the same deliverable. This group work structure allowed each individual group member to delve into a specific angle of septic education and outreach as we each interviewed various stakeholders to gain perspective on the issue. In terms of group processes, we harnessed collaborative technology, particularly Canva and Google Docs, in order to ensure that each group member's voice was heard. These kinds of software allowed us to simultaneously make changes to our deliverables in real time, which greatly eased group communication regarding shared aspects of the workstream. Further, the ability to suggest edits and comment on each other's individual contributions on shared deliverables created a spirit of constructive criticism, in which we each responded to each other with the aim of improving our final product to the greatest extent possible. In this way, we were able to help each other learn throughout the collaborative process.

The way that we aimed to provide each other constructive feedback was also rooted in one of the other preparatory materials for Dr. Bieluch's presentation on group work, namely the idea that great leaders are also great followers ([Waddell, 2019](#)). Great followers should bring out the best in their leaders and in their peers, and they should also be critical yet positive thinkers. Each group member in our group embodied this dual dynamic, as each of us took charge in specific aspects of creating a final product, while also keeping other members accountable for their own contributions. We each aimed to do our best work and make sure that our group mates held themselves to an equally rigorous standard. The end result of this collaborative mindset was a clear vision, achievable objectives, and a high quality final product— all with the end goal of aiding the CRC in improving septic education and outreach in order to reduce septic tank leakage into the Connecticut River and improve its water quality.

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Appendix

Appx. Figure 1. Complete Interview Table

Interviewee	Occupation or project objective	Perceived homeowner motivators for maintenance or upgrades	Homeowner outreach strategies	Challenges in motivation and outreach
Middle-aged owner of VT septic inspection, maintenance, and pumpout service	Inspect, maintain, and pump out residential septic systems in VT	Financial risk Health risks: 'some people literally straight-pipe their septic to their yard'	In-person home visits, phone calls Would provide educational materials if they had time	Hard to motivate low income households to act on environmental risks, and most "problem areas" are low income. "People are unaware"
Middle-aged Senior VP Marketing, septic installer and pumpout service on Eastern Seaboard	Market, advertise, and ensure customer's ability connect with 16 local "legacy brands" of septic installers and maintenance providers	"Their pocketbooks" Salience of health and environmental risks: 'if you live on the water...'	"Communicate the likelihood of long term financial risk" of improper maintenance Educational materials on social media, ad campaigns, direct communication to (potential) clients	Hard to motivate all households to act on environmental risks, unless their job depends on it (fishers) "Balancing environmental consciousness with budget in rural areas"
Middle-aged Southern District Supervisor and Regional Engineer with Vermont DEC Drinking Water and Groundwater Protection Division	Manage Rutland and Springfield Regional Office for the receipt, review, and permitting of non-public water systems and wastewater systems of less than 6,500 gallons per day	Financial risk of full replacement, especially as inflation/supply chain issues have made septic prices skyrocket	"Septic socials" in coordination with other offices of VT DEC Educate homeowners about financial resources available to them	Balancing economic concerns about septic with best environmental practices and tech Lack of information
Commissioner of Public Works for the City of Rutland Member of Green Mountain Water Environment Association (GMWEA)	Leading Maintenance on the state's largest Water Treatment Plant and public outreach to discourage flushing "flushable" wipes	Education of an unknown issue to homeowners, incentivized through the risk of a backup in their own home. Costs are both financial and health-based	Brochures airood at consumers of both municipal and personal systems; info on quarterly water bills. Informational letters to neighborhoods upstream of localized pump stations that had backups from "flushable" wipes Informational Facebook posts	Misinformation about "flushable" wipes Read-rate of paper mail
Executive Director of GMWEA	Executive director of GMWEA, a nonprofit membership organization that supports Vermont's drinking water, wastewater, and storm water sectors through a variety of outreach methods including conferences, public education, school programs, policy advisory, and publications.	Financial motivators: People will listen to their wallet. Long run costs of improper maintenance Education about the water cycle: understanding the risk of contamination of drinking water from a faulty septic system.	Low cost options/free public outreach. Diversity in outreach across different age groups Older generations: pamphlets/brochures, news releases in newspapers, local TV Middle generations: municipality or private sector websites Younger generations: social media. Humor and visuals on platforms like Twitter/TikTok	Infrastructure is buried: out of sight, out of mind. Challenging to educate people about something they cannot see. Discussing topics or aspects of an issue at too complex of a level for the "general public" Town hall meetings can get a bit out of control. Also requires approval from a town board member.

Appx. Figure 1 ctd. Complete Interview Table

Interviewee	Occupation or project objective	Perceived homeowner motivators for maintenance or upgrades	Homeowner outreach strategies	Challenges in motivation and outreach
Homeowner in Vershire, VT with garden and swimming pond downhill of home	Retired campus facilities supervisor	Long-term costs	Personal knowledge and word-of-mouth advice	Feels properly informed and motivated to maintain septic Others seem uninformed, "always asking me about their tank"
		Safe and healthy recreation on home property		
		Maintaining "beauty" of property		
		Preserving well water quality		
Homeowner in Hanover, NH, Dartmouth alumni	Recreational flyfisher in Connecticut River watershed	Occupational hazard: "Is septic pollution a danger to my job and the way I make a living?" "Also how much will I have to pay" to avoid emergencies or backups?	Social media	"Seems easier to motivate younger folks" over older "head-of-households"
		Recreational preferences	Online news coverage	"Not many people understand how their tank actually works"
Employee at the Vermont Rural Water Association (VRWA)	Source Water Specialist: Deals with protection of source water and people's drinking water. Works to combat contamination from private septic systems leaking into source water, both ground and surface water.	One of the biggest motivators for proper septic maintenance is cost-savings. Practicing proper maintenance saves money in the long-run.	Includes "Do your part be septic smart" EPA graphic in all of VRWA's community protection plans. Highlights source of water and how to avoid contamination.	Misinformation about what can go down drains into septic systems. Things like PFAS from floorwax or toilet bowl cleaning can leech and contaminate surrounding community wells; residents don't know where contaminants come from. Maintenance is low down on many homeowners' priority lists.

Appx. Figure 2. Brochure as of 5/31/23. Panels context – left to right: outside fold, back cover, front cover. Canva [linked here](#).

What should I do to protect my family, lakes, and streams?

- 1) Hire a licensed professional to inspect your septic system for an assessment of pump-out frequency and potential long-term issues
- 2) Pump tank out as necessary (recommended every two years)
- 3) Follow EPA's SepticSmart practices:
 - flush only septic-safe materials
 - stagger use of water-intensive appliances (washing machine, dishwasher, etc.) and shower and bath
 - don't "strain your drain" with oils or greases

Typical septic services prices

Service	Typical Price
Pumpout (recommended every two years)	\$275
Inspection (includes pumpout)	\$550
Clearing clogged lines from a "backup"	\$500
Replacing a crushed pipe	\$1,500
Entire system replacement	\$6,000

Prices quoted from small- to medium-sized Vermont septic service provider, May 2023.

What resources are available to reduce the cost of repair?

- 1) Individual projects can be funded by the EPA's **Clean Water State Revolving Fund**
- 2) Vermonters disproportionately affected by COVID-19 are eligible for funding under the **American Rescue Plan Act**
- 3) Non-profits can apply to receive **Rural Decentralized Water Systems Grants** through the USDA

However, the best way to save money is through preventative care. Maintenance costs are 10x less than repair costs.



About us

Since 1952, Connecticut River Conservancy has been a strong voice for the Connecticut River watershed, from source to sea. We collaborate with partners across four states - NH, VT, MA, CT - to protect and advocate for your rivers, and educate and engage communities. We bring people together to prevent pollution, improve habitat, and promote enjoyment of the rivers and streams. Healthy rivers support healthy economies.

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Your River Stewards!



Left to right: Kate Buckman (NH), Kelsey Wentling (MA), Kathy Urfler (VT), & Rhea Drozdenko (CT)



Quechee Gorge (No Home Just Room, 2019)

Septic Smart in Vermont

Answering the most common questions asked by Vermonters about residential septic

- How does residential septic work?
- Why should I pump my septic system?
- How does my old septic system endanger the environment and my family?
- What should I do to ensure my household and community are safe?
- What resources are available to bring down costs of repair?



How does residential septic work? 5 Steps.

- 1) Sewage enters your home's tank (pictured right) when you use toilets, sinks, & showers
- 2) Bacteria decomposes solid waste, which sinks to the bottom of the tank as **sludge**
- 3) Liquid waste floats to the top as **scum**, leaving cleaner wastewater in between
- 4) Wastewater flows out into a **leachfield**, where it slowly trickles into the ecosystem
- 5) Scum and sludge build up in the tank until removed by a **pumpout service**.

Why should I pump my tank?

Reduce risks to your home and community.

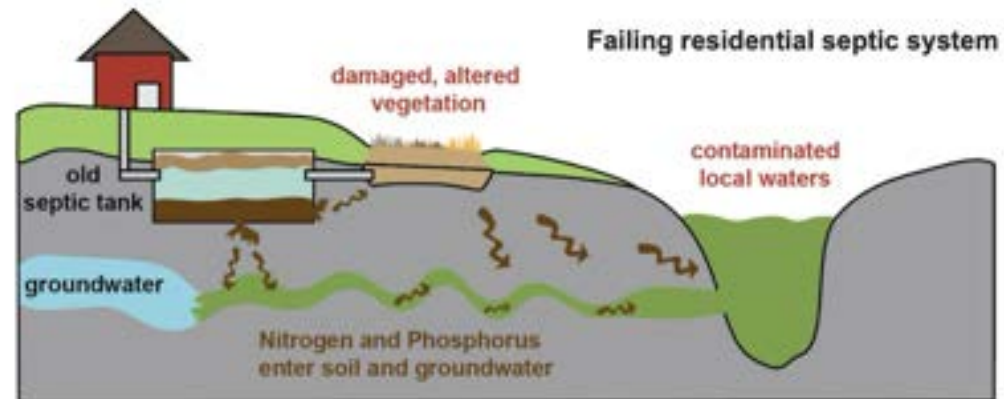
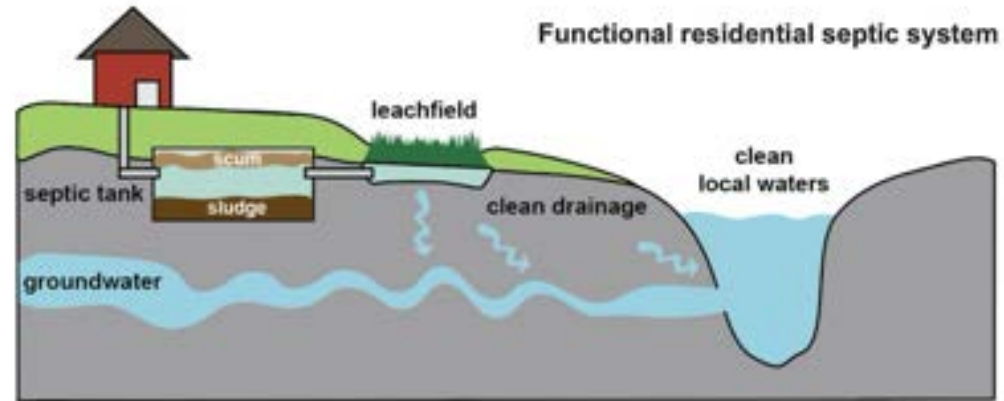
- **Financial risk**
 - Avoid future repair and replacement costs of more than \$6,000
 - Septic leaks decrease home value
- **Clean water risk**
 - Septic leaks contaminate drinking water
 - Nutrient pollution causes ecological issues like algae blooms and eutrophication

Aren't nutrients good for local waters and the soil?

Nitrogen and phosphorus are **limiting nutrients** in saltwater and freshwater systems. When too much of a limiting nutrient enters an ecosystem:

- **Algae and plankton** growth increases
- When algae and plankton die, **decomposers** use **dissolved oxygen** to break them down
- **Low dissolved oxygen levels** kill fish, crustaceans, and other aquatic wildlife

How does my old septic system endanger the environment and my family?



Functional vs. failing residential septic system. Failure to replace an old tank or regularly pump out a new one can result in emergency overflow and long-term leaks of unseparated sewage containing Nitrogen and Phosphorus into local waters (Source: created in Adobe Illustrator, 2023).

Appx. Figure 3. Outreach Plan (Screenshots). PDF [linked here](#).



Clean water. Healthy habitat. Thriving communities.

Connecticut River Conservancy

Septic Pollution Education Outreach Plan

Produced by ENVSSO team, May 2023

Quintin George, Susie Goodell, Liam Jamieson, Sarah McWhirter, Claire Mitchell, and Jake Dalton,

Rationale:

As we seek to bridge the informational gap between homeowners and their septic system responsibilities, CRC should consider an outreach plan that effectively communicates the risks of septic neglect and the benefits of maintenance. Our goal is to encourage proactive engagement in septic system care by providing clear, concise, and actionable information efficiently. Understanding that behavior change is a gradual process, our plan focuses on ongoing dialogue, community engagement, and the promotion of positive social norms around septic upkeep. To address the current knowledge asymmetry and incentivize proper maintenance, we suggest an outreach plan centered on 1) Clear, Factual Information, 2) Descriptive Social Norms, 3) Actionable Steps, and 4) Effective Channels of Communication.

1. Clear, Factual Information:

An outreach plan centered first on clear, factual information is crucial to establishing the CRC as an outlet homeowners can trust for information on septic systems. To accomplish this, CRC must develop informational material and establish and/or maintain a web presence focused on septic maintenance.

- *Develop Informational Material:* Create clear, easy-to-understand brochures, infographics, or other materials that present the facts about septic systems: their function, common issues, the risks of poor maintenance, and the benefits of proper care. This could include visual diagrams of how septic systems work and the potential impact on local water quality. We provide a brochure with some sample figures.
- *Web Presence:* Develop a dedicated section on the CRC website for septic system maintenance, including the same information as above in a web-friendly format. Also consider creating a FAQ section to answer common questions from homeowners.

2. Descriptive Social Norms:

People are often influenced by the behavior of others, especially with respect to environmental change, so showcasing good practices and community endorsements can encourage similar behavior. CRC can leverage social norms by highlighting community stories (good and bad) and commemorating "community champions".

Appx. Figure 3. Outreach Plan (Screenshots) ctd. PDF [linked here](#).

- *Community Stories:* Feature stories from local homeowners who have benefited from regular septic system maintenance either on the website or in local newsletters. This can help establish a norm for septic responsibility and encourage others to follow suit.
- *Community Champions:* Identify respected community members who can advocate for septic system maintenance. They can share their own experiences and influence others in their social circles.

3. Actionable Steps:

It's not enough to tell people why they should do something: you must also tell them how. Providing easy-to-follow actions through maintenance guides or a directory of local services is crucial to transforming intentions into actions.

- *Maintenance Guides:* Provide homeowners with a clear, step-by-step guide for septic system maintenance. This could be a part of the informational material mentioned in 1).
- *Directory of Local Services:* Offer a directory of local septic system service providers who can assist homeowners with maintenance and repairs. Include their contact information on the website and in print materials.

4. Most Effective Channels of Communication:

To ensure CRC is reaching as many homeowners as possible, it should consider community events primarily, and then local media, direct mail, and online outreach.

- *Community Events:* Attend local events such as farmer's markets, town fairs, or community gatherings to engage with homeowners face-to-face. Hand out informational materials and answer any questions people may have. CRC can also host events like "septic socials" with the goal of educating homeowners in person.
- *Local Media:* Utilize local newspapers, radio stations, and television channels to spread the message.
- *Direct Mail:* Send informational materials directly to homeowners via mail. This can be a very effective way of reaching your target audience.
- *Online Outreach:* Use social media platforms to share information and connect with homeowners. Regular posts with tips and facts about septic systems can reach a wide audience.

Chapter 5

Solar Feasibility Report for the Hanover Improvement Society



*Bror Magnus Sand, Cailey McVay,
Eric Sachleben, Hatley Post, Henrik Thorsby,
and Reece Lagerquist*

ENVS50: Hanover Improvement Society Solar Feasibility Report

Bror Magnus Sand, Cailey McVay, Eric Sachleben, Hatley Post, Henrik Thorsby, and Reece Lagerquist

INTRODUCTION

For this project we partnered with the Hanover Improvement Society, a local non profit that identifies, evaluates, supports, and funds “good works” opportunities and projects for the Hanover community. The organization currently owns and operates three areas: Storrs Pond Recreation Area and the Nugget Theater in Hanover, and Campion Rink in West Lebanon.¹ Jeff Graham is the general manager for the organization, and he worked as our partner for this project, asking us to investigate the feasibility of solar power at Storrs Pond Recreation Area and Campion Rink.

Solar power at these locations are of interest to the Hanover Improvement Society, hereafter referred to as HIS, for two main reasons: energy cost reduction and increased sustainability. The two local energy providers used by the HIS are Constellation Energy and Liberty Utilities. One of the key motivators for this exploration is Jeff’s feeling that these providers hold a monopoly over the area and are inaccessible to local residents when they have questions or concerns about their electricity bills; thus, he wants to explore solar power for greater energy independence and reduced long-term costs for the HIS. Additionally, the HIS cares about funding projects that improve the lives of members of the Upper Valley community. By investing in solar power, they can decrease their greenhouse gas emissions and increase Hanover’s sustainability.

INITIAL SITE EVALUATIONS

Jeff Graham was interested in the possibility of solar at both Storrs Pond and Campion Rink, with the hope that solar in either or both places could help reduce costs and improve sustainability. With this, we decided to do a site visit for both places, allowing us to get a sense of what the area looked like and what type of solar installation might be feasible. In our visit at Storrs Pond, we confirmed that ground mounted solar trackers would be the only option due to a lack of buildings with roof solar opportunities. Ground mounted solar trackers require large open areas to maximize their energy efficiency and output, as the panels follow the sun’s movement across the sky to ensure the maximum exposure possible.² Much of the area available for ground mounted solar trackers to be put in is covered or surrounded by tall trees that would decrease the

¹ “Mission Statement,” Hanover Improvement Society, accessed 2 June 2023, www.hanoverimprovement.org/mission/.

² Vanessa Peng, “Ground Mount vs Roof Mount Solar Cost: Which One Is Better for Your Facility?” WattLogic, October 11, 2022, wattlogic.com/blog/ground-mount-vs-roof-mount-solar-cost/.

energy output of the trackers due to their blocking of the sun. The only area that appeared potentially viable to us is the area where the new nordic trails are being built, leading us to rule out Storrs Pond as a location for solar power development at this time.

By contrast, the idea of solar development at Champion Rink seemed much more feasible. Champion Rink has a large roof with a great angle for the implementation of roof solar panels. Roof panels are less prone to sun blockage, take up less space that could be employed for other purposes, and are cheaper to install than ground mounted trackers.³ Furthermore, Champion Rink has incredibly high electricity costs, as it is open almost twenty-four hours a day from October to April. The high costs of electricity during this period are a major pain point for the HIS, and solar has the potential to greatly decrease the long-term energy bill of the rink. In our conversations with Jeff, we learned that the rink is currently under renovation, making this an attractive time for the addition of solar panels. The renovation of the rink should lead to increased energy efficiency, which would allow solar panels to make an even larger impact on the rink's fossil fuel energy usage and electricity bills.

RESEARCH DESIGN

Before discussing our research design and results, it is important to provide a list of key solar terms and their definitions. See appendix for all relevant solar and financial terminology.

Qualitative Research: Interviews

Our research method consisted of a combination of qualitative and quantitative methods. For our qualitative research, we conducted an interview with the HIS general manager, Jeff Graham. From that initial meeting we learned about his initial pain points with Champion Rink's electricity costs. He mentioned that there had been a brief investigation by ReVision Energy into the feasibility of solar for Champion Rink's roof. Additionally, he included that HIS is open to the idea of trackers being installed near Storrs Pond to produce solar energy. He introduced a figure with the most recent renovations of Champion Rink and mentioned that he is unsure of how the energy usage of the building will change. Lastly, he pointed us towards Solar Flect as a potential lead due to their work in the local area. However, Solar Flect only installs residential trackers, which does not align with our project's size. In addition to Jeff, we spoke with Amy Olaes from New England Clean Energy and Kim Quirk from Revision Energy.⁴

In our initial search for local solar energy experts, we found New England Clean Energy's services online and filled out a form to schedule a consultation. After examining our site on Google Maps, Amy Olaes reached out to us to schedule a free on-site consultation. Before

³ Ibid.

⁴ "Solar Panels Installation in MA, NH, RI, ME From New England Clean Energy," New England Clean Energy, accessed June 2, 2023, <https://newenglandcleanenergy.com/>; "Solar for Your Home," Revision Energy, accessed June 2, 2023, https://www.revisionenergy.com/solar-products/home?utm_medium=cpc&utm_source=google&utm_campaign=&utm_term=&gclid=CjwKCAjwpuaiBhBpEiwA_ZtfhbiWNvNxtl43icD6AKA8-er-E93qArvwRKoxZ0ef7NkpLg7JeF5fhoCY6gQAvD_BwE.

she agreed to meet with us, she asked us a list of questions to learn more about the property and project. Her questions included:

1. How old is your roof and what is the roof type?
2. What is the roof made of?
3. Why are we interested in solar?
4. Do we want to lease or own your solar energy system?
5. Which company is our utility provider?
6. Are there any battery backup systems?

We used these questions to guide an exchange with Jeff Graham who provided the majority of the answers. From that discussion, we learned that the roof was originally built in 1988. Currently, it is a metal roof and the building is a Varco Pruden product. Aside from the motivations, which we've already discussed, he additionally mentioned that the HIS would not be interested in battery back ups. Eventually, the on-site visit was canceled which we will discuss more in our section on limitations.

Our next interview we conducted was with Kim Quirk from Revision Energy. Kim provided an overview of Revision's process for assessing a site. First, Revision Energy calculated the total annual kilowatt (kW) usage of the site from past electric bills. Their next step included using PVWatts, a program that takes various inputs including system size, geographic location, azimuth, tilt, system type, and percent loss, and calculates a monthly yield for the system, to determine the potential of the site, to calculate the solar yield of the site and understand which metrics to use for the calculations. In addition to PVWatts calculations, Kim explained how monthly net metering rollover applies in NH and how it is considered when sizing an array. Monthly net metering rollover is more productive in the summer because the array produces the most surplus energy. In the case of Champion Rink, this means that the solar panels will be most effective during their off-season. Therefore, they will be selling more energy back when prices are somewhat lower in the summer. Kim also touched upon state and federal tax incentives that have changed recently and other budget items to be aware about. To start in 2022, the Inflation Reduction Act (IRA) allows qualified buildings with solar to be eligible for a tax credit up to 30% against the cost of the system.⁵ Finally, Kim projected that an assessment of the structural integrity of the roof would require a \$2000 consultation from a structural engineer.

Quantitative Analysis: Programming and Financial Analysis

For our quantitative analysis, we used two programs to model the projected output of our two solar arrays (the characteristics of which are explained later). First, we mapped the physical layout of the panels on the Champion Rink roof via Helioscope, a solar modeling software. Using standard specifications for Northeast solar projects of a similar size (described in the following section), we were able to estimate the capacity of various solar systems as well as their upfront costs. Once we had these outputs, we used PVWatts to calculate the monthly solar production for

⁵ "New Hampshire Solar Incentives: NH Solar Tax Credit," Sunrun, November 15, 2022, www.sunrun.com/solar-by-state/nh/new-hampshire-solar-incentives.

our two models. This monthly data allowed us to conduct a full financial analysis of the solar panel feasibility. From our monthly data outputs from PVWatts and Helioscope, we calculated the annual electricity production for the full and partial coverage scenarios mentioned below to determine the system's annual greenhouse gas reductions. In our financial model, we found the annual savings and revenue generated from selling electricity back to the grid, adjusted for inflation, of both the partial and full array models. We subtracted annual savings and revenue from the combined 2023 electric bills to estimate the future annual electric bill for each scenario. Lastly, we divided the upfront costs by the annual price savings to calculate the years to pay off the project. Furthermore, we found that HIS could boost its return on investment by acquiring debt to construct the PV system.

Next, to determine greenhouse gas emissions reductions we used Grafton County specific data from Find Energy, who compile data from various government agencies and directly from electricity companies, to determine the emissions in kilograms of CO₂ equivalent per kWh of electricity produced (kgs CO₂e/kWh) supplied by the grid.⁶ CO₂e is the EPA's standard metric for measuring greenhouse gas emissions.⁷ Within this data set, three of the eight electricity generation sources applied to only Bristol and Hanover, so we excluded them from our calculations because they do not supply Campion Rink. Of the other five electricity generation sources, four are renewable, and therefore produce no emissions.⁸ The last energy source, Bridgewater Power LP, is a wood chip fueled biomass power plant that has a high 1.476 kgs CO₂e/kWh. After weighting the energy sources based on their grid contribution and dividing it by the five sources, combined, the power plants supplying Grafton County have a .276 kgs CO₂e/kWh. The annual electricity produced from each solar scenario can be subtracted from the 2023 electricity usage to find the annual electricity savings. The annual electricity savings multiplied by Grafton county's kgs CO₂e/kWh gives us the annual emissions reductions for each solar scenario. Then, we inserted the annual emissions reductions into the EPA's Greenhouse Gas Equivalencies Calculator to contextualize the findings in terms of the number of houses it would take to emit an equivalent amount of CO₂e.⁹

OUR TWO SOLAR MODELS:

**All information regarding Campion Rink's electricity consumption is taken directly from the Hanover Improvement Society's electricity bills.*

Full Coverage Model: In this scenario, the entire roof of Campion Rink is covered in solar panels. Standard solar regulations (based on presets from Dynamic Energy, a company Eric worked for last summer) for an array of this size are followed, including those related to panel

⁶ Matt Hope, "Grafton County, NH: Electric Rates from Grafton County, NH: Electricity Rates & Statistics," Find Energy, accessed June 2, 2023, findenergy.com/nh/grafon-county-electricity/#production.

⁷ "Greenhouse Gas Equivalencies Calculator," *United States Environmental Protection Agency*, updated April 2023, <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results>.

⁸ Hope, "Grafton County, NH: Electric Rates from Grafton County, NH: Electricity Rates & Statistics."

⁹ "Greenhouse Gas Equivalencies Calculator," *United States Environmental Protection Agency*.

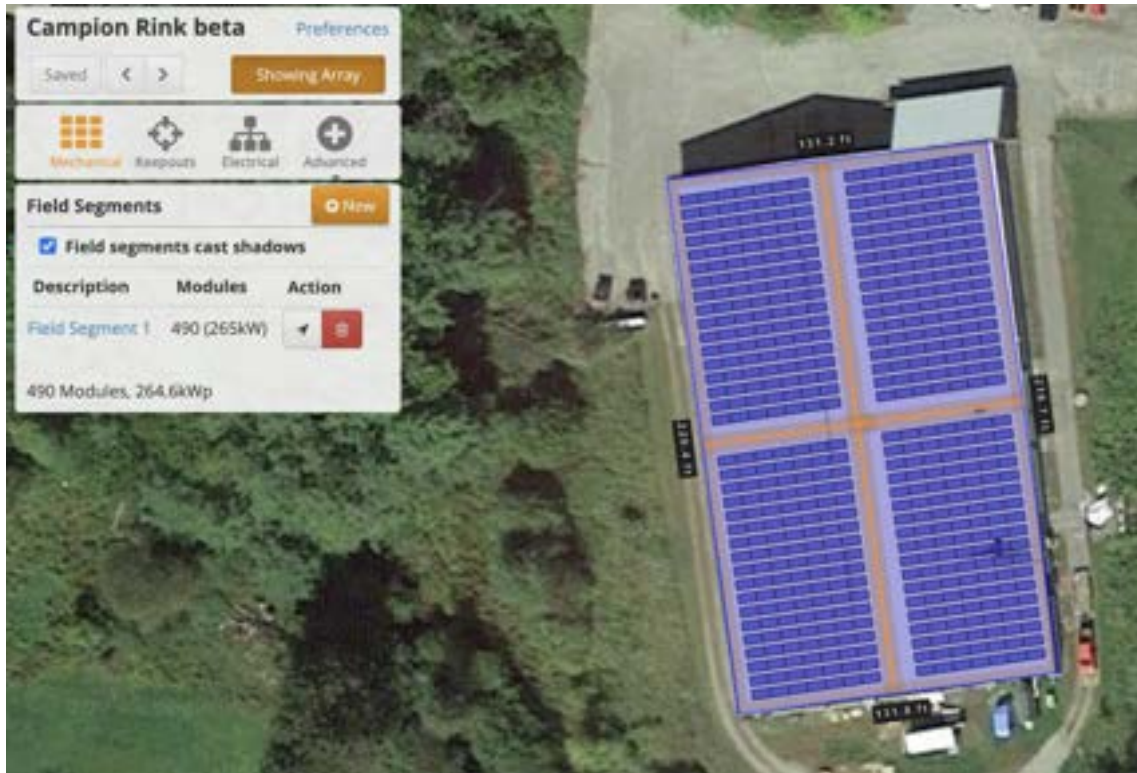
spacing, walkway requirements, and type of panel. We chose to tilt the modules at 10° because a lower angle allows for disproportionately better production in the summer months when the sun is much more powerful in New Hampshire. New Hampshire has state incentives that allow Campion Rink to take advantage of the strong summer sun despite only consuming a significant amount of energy in the winter. The most important of these programs is net metering with monthly rollover. Net metering allows a producer of renewable energy to get credit for excess energy produced even when it exceeds on-site demand.¹⁰ For solar, this means an owner can credit for production during the middle of the day (when output is highest) that goes towards their consumption during the evening. Monthly rollover is the same principle but applied to the monthly scale, so the excess generation in the summer (when production is highest) gets credited towards the rink's electricity usage in the winter. In our model, the array comes out to 490 modules with a capacity of 265 kW, meaning under peak conditions the system can produce a maximum of 265 kW of electricity.¹¹ This electricity is in the form of Direct Current (DC), because solar panels naturally produce this type of electricity (when selling to the grid, AC is used). For a bit of context, an average-sized refrigerator uses about .5 kW at any one time, so under peak conditions this system can be powering 530 refrigerators at any given time.¹²

¹⁰ "Database of State Incentives for Renewables & Efficiency," DSIRE: NC Clean Energy Technology Center, accessed June 2, 2023, www.dsireusa.org/.

¹¹ "HelioScope: Advanced Solar Design Software," HelioScope, app.helioscope.com/expired, accessed 2 June 2023.

¹² Jacob Marsh, "How Many Watts Does a Refrigerator Use?" EnergySage Blog, January 12, 2023, news.energysage.com/how-many-watts-does-a-refrigerator-use/.

Figure 1: Full Coverage Solar Model - 265 kW (Helioscope)



Once we had the capacity from this model, we used PVWatts to get an estimated monthly electricity output for the system. Below is a table of our inputs into PVWatts. For ease of comparison, we included our assumptions for the 100 kW model (discussed below) as well:

Table 1: PVWatts Input Comparison¹³

Model	System Size (kW)	Module Type	Array Type	System Losses (%)	Tilt (degree)	Azimuth (Degree)
Full Coverage	265	Standard	Fixed (Roof mount)	17.12	10	171.82
Partial Coverage	99.9	Standard	Fixed (Roof mount)	17.12	10	171.82

This table compares the PVWatts inputs for our two solar models. The difference in system size is highlighted in red.

Several categories affect the loss percentage. Our inputs for these are outlined in the table below. In the following paragraph, we explain how we chose these values.

¹³ "Solar Resource Data," PVWatts Calculator: NREL, pvwatts.nrel.gov/pvwatts.php, accessed 2 June 2023.

Table 2: PVWatts Loss Input Comparison¹⁴

Model	Soiling (%)	Shading (%)	Snow (%)	Age (%)	Light-induced Degradation (%)
Full Coverage	0	3	5	0.5	1.5
Partial Coverage	0	3	5	0.5	1.5

This table displays our inputs for various categories affecting system losses. For consistency, we used the same values for both models.

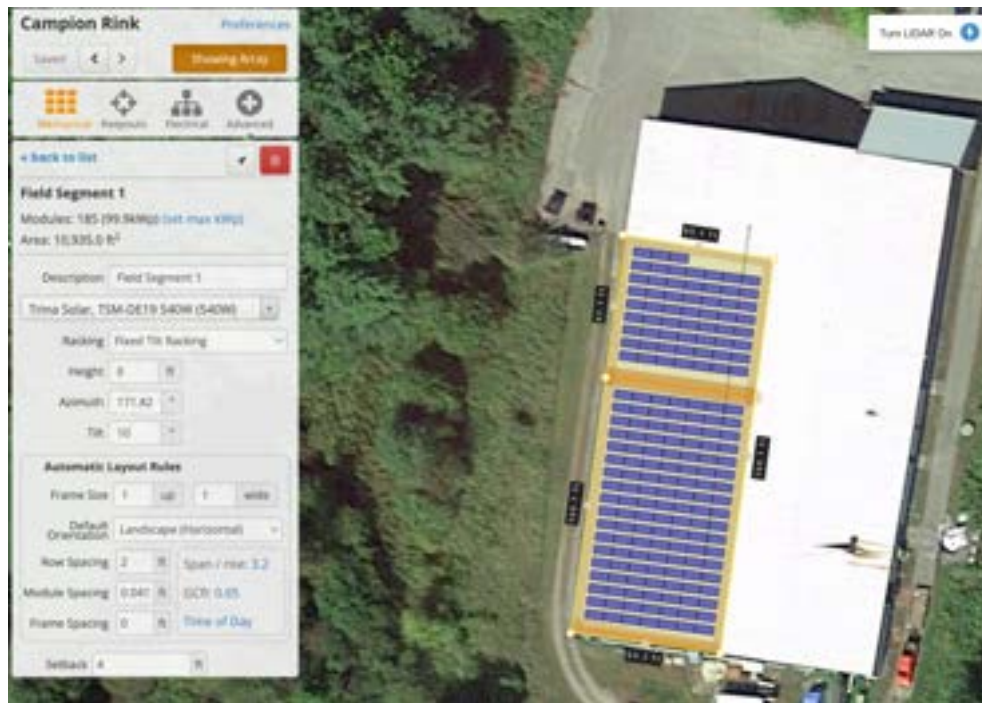
Highlighting a few of the system loss inputs, soiling, the accumulation of dust and dirt particles on the panels, is largely only a factor in cities, and as such is set to zero. At 3%, shading is also quite low, resulting from the clearing of surrounding trees during the current rink renovations. We only project shading to be relevant during the very early and late hours of the day, when the system is producing only a small amount of electricity. While 5% loss from snow coverage seems low for New Hampshire, the system is producing at such lower levels in the winter months anyway that the losses from snow are of little significance during that period. The rest of the loss values are based on industry standards (age and light-induced degradation.)

Partial Coverage Model: In this scenario, we limit the array to a capacity just below 100 kW. We did this for two reasons: First, the array itself is much cheaper in terms of upfront cost, so it acts as an alternative if the HIS does not have sufficient funds to purchase a full-coverage array. Second, there are additional incentives for systems under 100 kW. For these systems, net excess generation is credited at a rate equal to 100% of the retail energy and transmission charges plus 25% of the distribution charge, whereas larger systems only get retail energy charges. The financial analysis section will describe this in greater detail, but it works out to production credited at a rate of just over 50% of the total cost of electricity for the full coverage model and about 85% for the 100 kW model. Essentially, systems under 100 kW are considered “residential” and, due to lower costs associated with connecting them to the grid, buy back excess energy at a higher rate.¹⁵ Finally, a full structural analysis of the Campion roof is necessary to determine the maximum amount of weight it can bear. The roof is quite old and, while Jeff believed early tests suggested it could hold at least some panels, it is not clear if it could handle the full array. Such an analysis is likely to be conducted once current construction of the rink concludes. Below is the Helioscope model of our 100 kW scenario.

¹⁴ Ibid.

¹⁵ “Net Metering,” DSIRE: NC Clean Energy Technology Center, last updated February 14, 2023, <https://programs.dsireusa.org/system/program/detail/283>.

Figure 2: Partial Coverage Model - 100 kW Model (Helioscope)¹⁶



The PVWatts inputs for this model (displayed in the table PVWatts Inputs Comparison table above) are the same as for Full Coverage, with the exception of a system size of 99.9 kW. We chose to put the array on the Southwest side of the roof because it is more productive given the location and orientation of the Rink relative to the path of the sun.

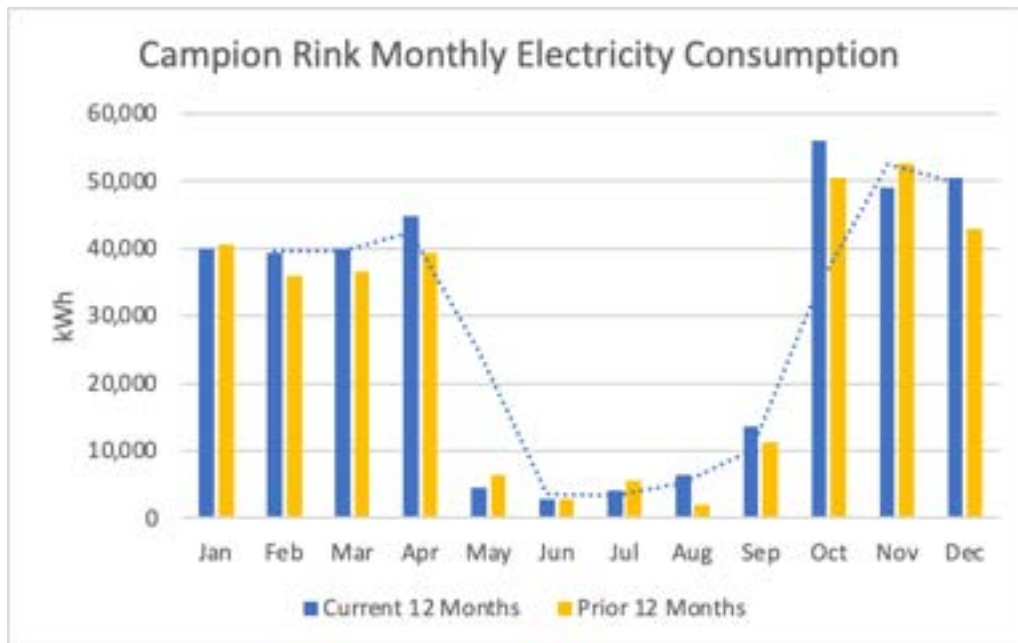
RESULTS FROM SOLAR ANALYSIS

Campion Rink’s electricity demand is massive. When the Rink is in operation (October-April), it uses 40,000-50,000 KWh per month, equivalent to around 50 homes.¹⁷ Below is a graph of Campion’s monthly electricity consumption over the past two years.

¹⁶ “HelioScope: Advanced Solar Design Software,” HelioScope, app.helioscope.com, accessed 2 June 2023.

¹⁷ Lindsay Wilson, “Average Household Electricity Consumption - 2023,” Shrink That Footprint, May 2023, shrinkthatfootprint.com/average-household-electricity-consumption/.

Figure 3: Campion Rink Monthly Electricity Consumption

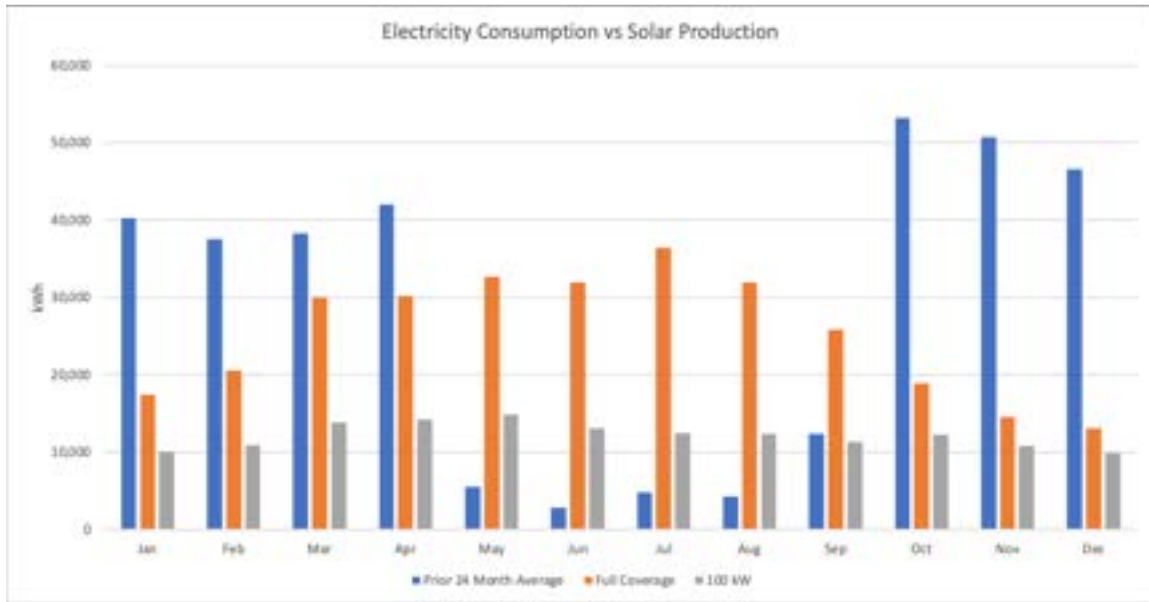


The graph shows the monthly electricity consumption for Campion Rink for the previous two years in operation. Consumption peaks from October to April when the Rink is active and is low in the summer.

The following graph takes the average of each of these monthly consumption values (the blue bars) and compares them to the projected month by month production for the Full Coverage and Partial Coverage systems.¹⁸

¹⁸ “PVWatts - NREL.” PVWatts Calculator, pvwatts.nrel.gov/pvwatts.php. Accessed 2 June 2023.

Figure 4: Electricity Consumption vs Solar Production

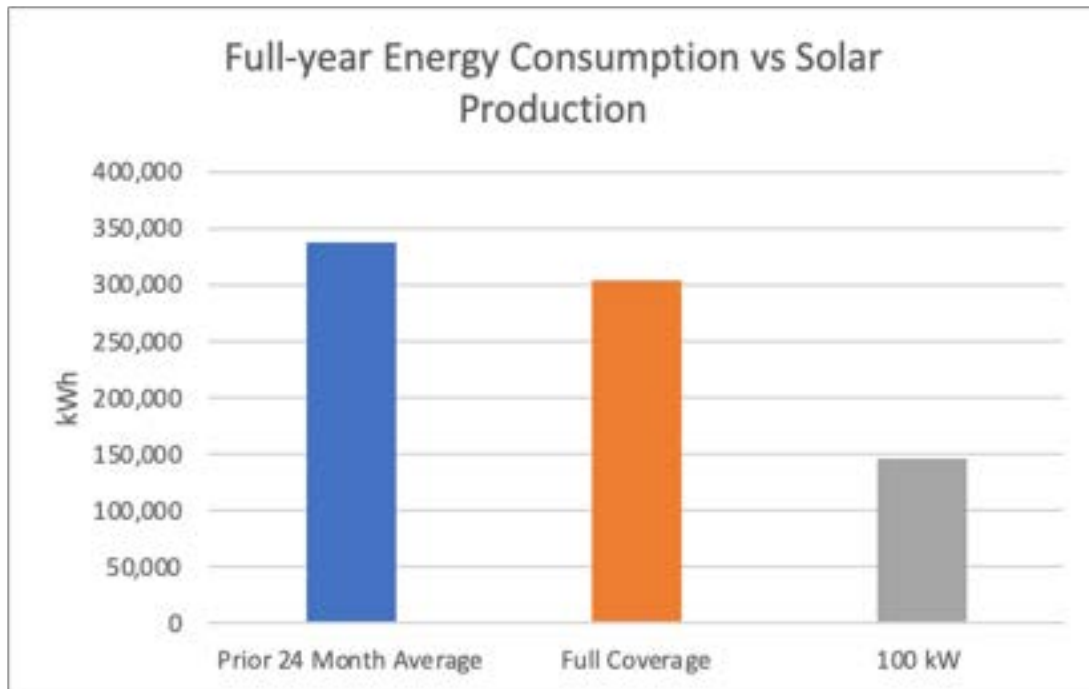


This figure compares the two year average monthly electricity consumption with the projected monthly output for our two models. While peak production and consumption occur at opposite times of year, monthly rollover for net metering allows Campion to get credit for the excess energy produced, which goes towards the Rink’s winter energy bill.

To make the potential overall impact of the two systems more tangible, the following graph compares the total annual electricity demand, 338,400 kWh, with the total annual projected production of the two systems, Full → 303,639 kWh and Partial → 146,099kWh.¹⁹

¹⁹ Ibid.

Figure 5: Full Year Comparison of Energy Consumption



This graph compares total annual Campion Rink electricity consumption (taken as an average of the past two years) to projected annual solar production for our two models.

FINANCIAL ANALYSIS

In order to determine the financial viability of the Campion Rink solar project, we used a financial model to calculate the net present value based on projected cash flows. The financial model is built upon industry benchmarks and meticulous analysis of various factors influencing solar projects. It takes into account both the operational and financial aspects of the project to provide a holistic perspective on its potential profitability. Furthermore, the model allows us to run different scenarios in which we can tweak variables such as PV system size, capital expenditures, and financing. When evaluating the financial viability of a project, the most important outputs are the net present value of cash flows (NPV) and internal rate of return (IRR). Financial terminology can be found in the appendix. The full financial model is attached to our Canvas submission.

Inputs and Sources

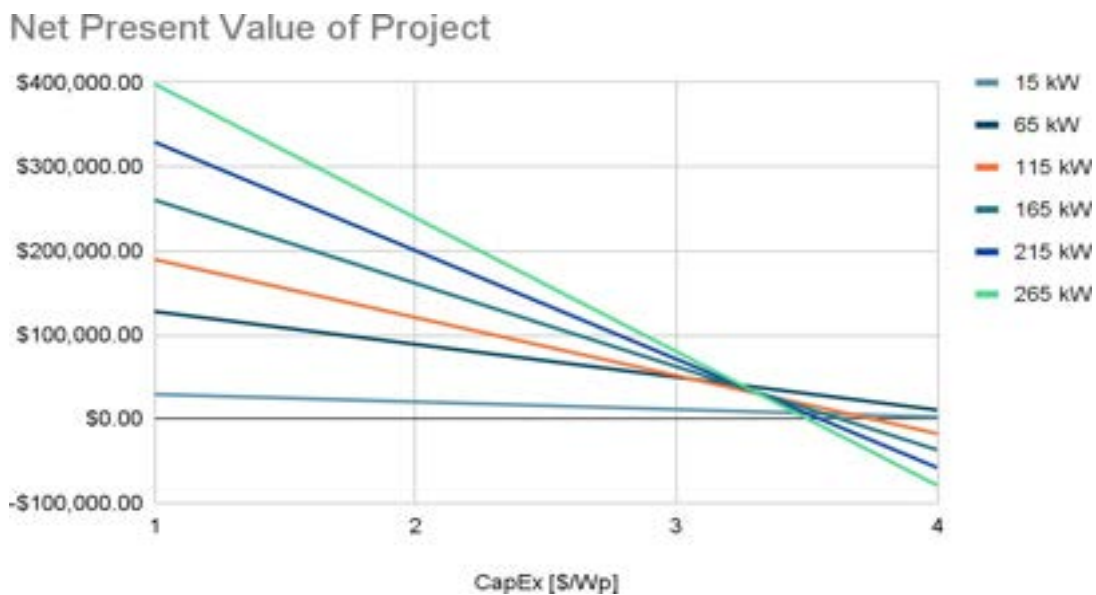
- **System lifetime** → 25 years based on industry standards.
- **CapEx** → The pre-tax cost of \$500,000, or ~\$1.90/Wp is based on an estimate by Dynamic Energy (a commercial/residential solar company.) A tax incentive of 30% brings the CapEx down to ~\$350,000, or ~\$1.34/Wp.

- **OpEx** → Bloomberg New Energy Finance has projected the operations and maintenance costs of solar PV systems per kWp from 2020 to 2060. Prices are real and to be adjusted by an average inflation rate of 2.0%.
- **Financing** → Base case inputs are 50% senior debt leverage at 4% interest rate. Corporate tax rate is set at 29% and the required return on equity is set at 10% (average financial market return). This results in a weighted average cost of capital of 6.43% for which the project cash flows are being discounted.
- **Power prices** → Based on average monthly prices of electricity in New England from 2018 to 2022. Projected average monthly electricity price is adjusted for inflation at 2%/year.
- **Power charge portions** → Based on invoices from Liberty.
- **Power generation** → PVWatts estimates a yearly production of 1,108 kWh AC per kWp of installed PV solar panels at Campion Rink. Calculations are based on AC electricity generation as the solar system is expected to send surplus electricity into the grid.
- *Note:* power prices and electricity generated by the PV system are matched on a monthly basis to ensure a more rigid financial analysis.

System Size and CapEx

System size is an uncertain variable in our analysis as an engineer inspection is required in order to evaluate how many solar panels the roof of Campion Rink can support. Therefore, we run a financial sensitivity analysis on system size and CapEx in \$/Wp.

Figure 6: Net Present Value of the Project, Sensitivities on System Size and CapEx



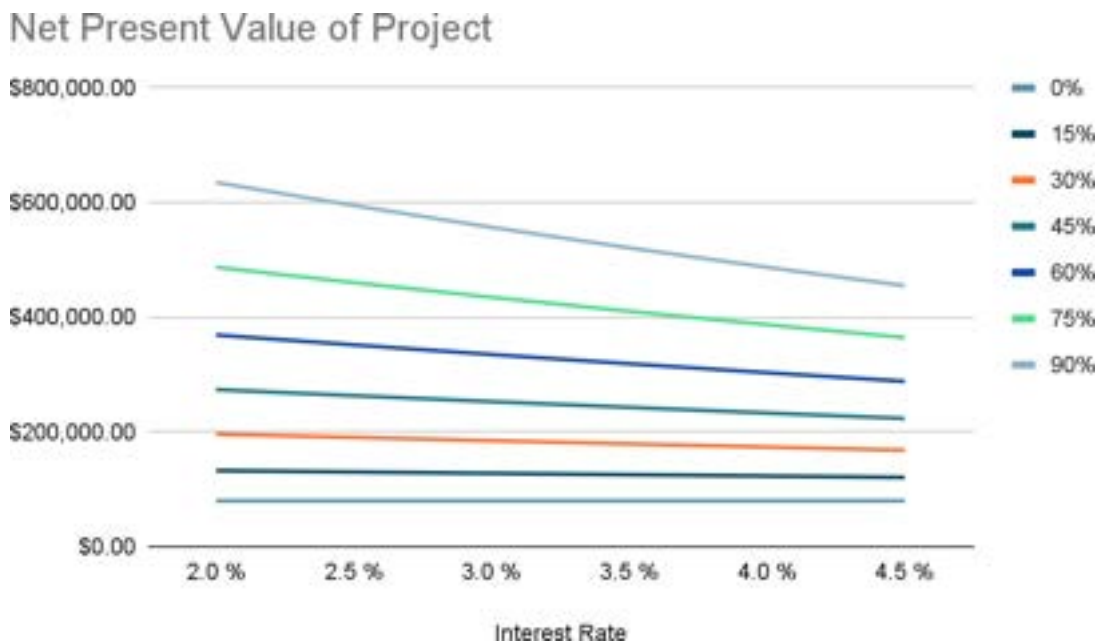
This graph reflects the net present value of the project while controlling for sensitivities of system size and capital expenditures denoted in \$/Wp.

In order for the NPV of the project to be positive, CapEx in \$/WP has to be below ~\$3.50, which infers an initial investment of \$927,500. The quota from Dynamic Energy is well below this threshold at ~\$500,000 pre-tax incentives. From the graph, it is apparent that the project NPV increases with the size of the PV system if the CapEx is held below ~\$3/Wp, or \$795,000 pre-tax incentives. Therefore, it is advisable to go with the largest system size possible. Indicated projected cost of \$350,000 post-tax incentives results in an NPV of \$255,000 and a project IRR of 12.5%, which is higher than the average financial market returns of about 10%.

Financing

We believe it is imperative to acquire debt to fund the solar project in order to boost equity returns. There are four key reasons why that is. First, if the project generates positive cash flows and returns exceeding the cost (interest rate) of borrowing, the equity investors can benefit from the increased return on their invested capital. Second, interest payments on debt are often tax-deductible, meaning they reduce taxable income. This tax shield can lower the overall tax liability of the project, which results in higher net cash flows and improved equity returns. Third, the HIS can preserve their equity capital by using debt, which allows them to allocate less of its money to the project. Four, By introducing debt capital, the HIS can limit their exposure to downside risks. In the case of bad years with lower solar power generated or limited cash flows on a corporate basis, the burden of repayment primarily falls on the debt holders.

Figure 7: Net Present Value of Project, Sensitivities on Leverage and Interest Rates



This graph reflects the net present value of the project while controlling for sensitivities of leverage in percent of capital expenditures and interest rates.

In the graph, sensitivities of how much debt is being raised and the interest rates are presented. It is imperative that the HIS fund portions of the solar project with debt in order to have higher returns on invested capital. Even with interest rates as high as 4.5%, the project NPV will still be boosted by leverage as the cash flows generated by the project exceeds the interest payments. This allows the HIS to use the funds saved from electricity bills and the revenue generated by selling electricity back to the grid to pay down the debt as soon as possible in order to minimize interest payments. In the base case of 50% leverage at a 4% interest rate, the HIS would eliminate its debt by year-end of year 5 if it was to allocate all of its cash flow from the project to pay down debt. The boost in project NPV is represented by the difference between lines in the graph. For instance, 0% leverage would result in a project NPV of ~\$82,000 while 90% leverage would result in a project NPV of ~\$490,000. However, it is important to note that it is not recommended to acquire excessive amounts of debt as they increase the financial risk, burden cash flows with interest expenses, limit flexibility, and negatively impact market perception.

Residential vs Full-Coverage

Given the uncertainty of system size and the difference in the excess power supply sales price, it is beneficial to compare the residential-scale system of 100 kW and the full-coverage system of 265 kW using the same base case assumptions.

Table 3: Residential-Scale and Full-Coverage Financial Comparison

Item	100 kW	265 kW
CapEx [\$]	\$133,670	\$354,450
OpEx (Yearly Avg. Nominal) [\$]	\$641	\$1,717
Yearly Prod. Without Degradation [kWh] ²⁰	109,733	293,731
Excess Power Supply Sales Price	85.9%	52.7%
LCOE [kWh]	\$0.11	\$0.11
NPV	\$132,894	\$255,155
Project IRR	14.9%	12.5%

This table compares the residential-scale and full-coverage scenarios in terms of capital expenditures, operational expenditures, yearly production, excess power supply sales price and key financial metrics to evaluate profitability.

The most important items to note in this comparison are the excess power supply sales price, NPV and Project IRR. If HIS decides on a residential-scale project, the excess power

²⁰ Yearly electricity production for alternating current.

supply sales price will be ~33 percentage-points higher than with a full-coverage project. However, the trade-off is naturally that the system will generate lower output and revenue. Due to the higher sales price of electricity, the project IRR of the residential-scale system is 14.9% compared to 12.5% for the full-coverage system. However, the NPV of the full-coverage project is almost twice that of the residential-scale system. Given that a full-coverage system is technically feasible at the Champion Rink, the HIS needs to carefully weigh in on the financial risks, project goals, and other factors associated with the scale options in order to make a more informed and strategic decision.

CONCLUSIONS

We received an estimate of \$500,000 as the cost of the full coverage array from Dynamic Energy Solutions, a solar installation company based in Philadelphia, which Eric worked for this past summer. Their estimate was based upon the helioscope models and current market conditions, and gave a basepoint with which to calculate the costs of the installations.

With the IRA subsidies, we found the upfront cost of the **full coverage array (265 kW)** to be \$354,450. This is still quite expensive on the front end, but reduces the electricity bill of Champion Rink from its current \$78,800 per year to just \$26,200 per year, giving the HIS an annual savings of \$52,600 per year. Under this scenario, the HIS would recoup their investment in just 6-7 years, leading to a substantial decrease in long-term costs. For the **partial coverage array (100 kW)**, the upfront cost is reduced to \$133,670 with the IRA subsidies. The yearly electricity bills decrease to \$55,100/year, giving the HIS an annual saving of \$23,707 and the upfront cost is recouped in 5-6 years.²¹

As discussed in the introduction, reduced costs are not the only motivator for the installation of solar. Therefore, we also calculated the reduction in greenhouse gas emissions that would occur with the installation of solar. Using .276 kg of CO₂/kWh (see the Methods section for a discussion of how we arrived at this number), we calculate that the **full coverage array (265 kW)** reduces the grid electricity consumption by ≈ 90%, which corresponds to an elimination of 83,804 kg of CO₂ – which is equivalent to the annual electricity usage of 16.3 households. The **partial coverage array (100 kW)** reduces their grid electricity consumption by 43%, which corresponds to an elimination of 40,323 kg of CO₂ emissions – which is equivalent to 7.8 homes annual electricity usage.²²

With the mix of qualitative and quantitative methods employed, we were able to model the two different scenarios discussed above to give the HIS an idea of the costs and benefits of solar installation at Champion Rink. This being said, we encountered a few complications that

²¹ The numbers in our presentation were different because of an error in the average kilowatt/hour price – numbers were originally based on a source we have not been able to find again, and we redid the calculations using the figure (\$.233/kWh) from our financial model.

²² The household equivalency numbers also differ from our presentation as we put the greenhouse gas equivalency for homes' energy usage for one year, rather than electricity usage. However, after discussion with the group, we changed the numbers to reflect electricity usage instead as it is a better comparison for this project.

limit the exactness of our analysis. First, we have been working as an intermediary between the HIS and some different solar companies in the Upper Valley/Northeast to explore the costs and benefits of solar. We reached out to several different companies, and struggled to get in contact with them due to lack of responses via email and answering via phone calls. These general struggles are exemplified in one instance where we had a site visit scheduled with a solar company. Our status as students means that we lack the funds to implement the project, leading some companies to be unwilling to meet with us.

We were able to work around this issue in part due to Revision Energy's willingness to speak with us. They had done a complete site workup prior to COVID, and provided us with a significant amount of information discussed in the qualitative methods discussed earlier in the report. Critically, they told us about the difference between a residential and non-residential array size, which led us to provide the two different solar models for the HIS. Secondly, Eric reached out to the company he worked for last summer and we were able to get a second opinion on the scope of the project. Each of these opinions is limited by the lack of up-to-date site visit, and our two models represent what we assume to be true based upon the conversations we have had and where we believe they could go from here.

Finally, the rink is currently under construction and so structural integrity components of a site survey are not possible right now. Although we have not been able to get the complete picture we would have liked, we have been able to get enough information to allow us to create two scenarios for the HIS to consider what size array they would like to install. Based on our NPV and sustainability calculations we would recommend the HIS build a 265kW array. Furthermore, we believe it is imperative for the HIS to finance the solar project using a moderate amount of debt in order to boost its returns on investment. The amount of debt is contingent on terms arranged with a bank.

NEXT STEPS

Present our findings to the HIS and encourage them to get into contact with one of the solar providers in the Upper Valley to get a complete site evaluation to implement the project. Based upon the previous connection with Revision Energy and their willingness to speak with us, continuing to talk with Revision about the installation of the panels would likely make sense. There are also plenty of other potential solar power companies to work with, so talking to multiple companies would be good for the increase of competition for the project. All Energy Solar, Energy Shield of New Hampshire, and Granite State Solar are just a few examples of companies that work with solar in the Hanover area.²³

²³ "Solar Power in New Hampshire," All Energy Solar, accessed June 2, 2023, www.allenergysolar.com/company/service-areas/new-hampshire/; "Solar Energy," Energy Shield of New Hampshire, June 1, 2022, www.energyshieldnh.com/solar/; "New Hampshire's Award-Winning Solar Company," Granite State Solar, accessed June 2, 2023, lp.granitestatesolar.com/request-a-quote/?utm_term=nh+solar&utm_source=adwors&utm_medium=ppc&utm_campaign=2021%2BGSS%2BWinter%2BSearch2BCampaign&hsa_cam=15133877958&hsa_g

We have found a series of financial incentives and subsidies, and need to ensure that these are clearly communicated to the HIS (for example, the difference between the partial array (100kW) and full coverage (265 kW) options) so they can make the best possible decision with their current budget and goals.²⁴ The HIS will also have to seek financing options depending on the project size they pick with banks in order to find the most competitive interest rates.

APPENDIX:

Solar Terminology:

Array / System → a set of solar panels on a property (terms used interchangeably)

Capacity → under peak conditions, the maximum amount of electricity the system can be producing at a given time

Azimuth → The direction the panels are angled towards

Tilt → The degree to which the panels are angled towards the azimuth

Net Metering → A solar financial incentive that allows a system owner to get credit for excess electricity generated by their panels when production exceeds demand

Monthly Rollover → The credits towards future bills that accumulate when an array produces more energy than the building consumes.

Direct Current (DC) → Flow of electric current in one direction. For solar, this is the electricity produced by the array before interacting with the grid.

Alternating Current (AC) → Flow of electric current that alternates direction periodically. For solar, DC energy is converted to AC because it is more efficient to transmit to the grid.

Financial Terminology:

CapEx → Capital expenditures, the initial investment of solar project

OpEx → Operational expenditures, yearly maintenance, etc., of solar project

NPV → Net present value, the net value discounted cash flows of project

IRR% → Internal rate of return of project in percent

Leverage → Debt

LCOE → Levelized cost of electricity, cost of electricity throughout project lifetime

Excess power supply sales price → Percent of retail price of electricity achieved by selling power back to grid

IRA subsidies → The Inflation Reduction Act is a \$370 billion investment in clean energy development in the United States signed by President Biden in August 2022. The IRA covers a wide range of initiatives related to clean energy development, from modernizing the electricity

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²⁴ “Net Metering,” DSIRE: NC Clean Energy Technology Center, last updated February 14, 2023, <https://programs.dsireusa.org/system/program/detail/283>.

grid, expanding public transit, improving system resilience, cleaning up pollution, and working to ensure an equitable energy transition. Immediately relevant to our project are tax incentives in the IRA for the development of solar, which greatly reduce the total cost of solar installation .
2023 Real Value of Money → The inflation adjusted value of money in 2023.

GROUP REFLECTIONS

We think that we have done a good job as a group in implementing the ideas about collaboration that Dr. Bieluch discussed on April 4. As a class, we discussed that critical elements of successful collaboration included clear communication, trust, a division of labor and inclusive leadership. As a group we understood each other's schedule demands, trusted others with their work, and clearly set expectations and divisions of labor. We emphasized inclusive leadership over the planning and execution of the project, and provided a space for people to discuss concerns and give constructive criticism. All of these practices reflected “psychologically safe teams,” a term that we broke down as a class.

Throughout this term, our group’s communication has been very strong, both in person and via our group text message we set up on the first day of class. This has allowed us to clearly communicate with one another about the division of work and the quality of work expected, as we could reach out to each other with questions or prompts as we each came to the project. In tandem with this, our group has done a good job of understanding the different time constraints caused by other classes and outside activities. One example of this is that both Bror and Hatley had large demands on their time due to thesis writing. The group accommodated these demands during different deadlines, and Bror and Hatley picked up their part of the load after some of these demands passed. Furthermore, our group was very much a space where questions and concerns could be raised without fear of judgment. This was perhaps best exemplified in our debate preparation as we developed the affirmative/negative sides. We worked to ensure that both sides had understandable and coherent arguments. Overall, we have had a very successful group dynamic, and one that has fostered not only good work but also good times.

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Chapter 6

Waste Management Team for the Hanover Improvement Society



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Final Report: Hanover Improvement Society—Waste Team

Gannon McCorkle, Hillary Davis, Leandro Giglio, Macklin Ayers, Paridhi Kapadia, TJ Bryan

Introduction

The Hanover Improvement Society (HIS) is a local non-profit that was founded in 1874 as the “Ornamental Tree Association” to enhance the desirability of the village with shade trees. Today, HIS owns and manages three local facilities: Storrs Pond Recreation Area (SPRA), The Nugget Theater, and the James W. Campion III Ice Skating Rink. Its primary mission is to fund "good works" projects that quietly maintain and improve the Hanover community. It has provided seed money for various projects in and around the Upper Valley, such as expanding the Howe Library, constructing the Hanover Parking Facility, and constructing the Richard W. Black Community Center. The society's sources of funding include revenue from operating the three aforementioned facilities, as well as from rental properties, investments, and private contributions.

As part of ENV5 50: Environmental Problem Analysis and Policy Formation, our team was tasked with helping the Hanover Improvement Society reduce improper and excessive waste disposal at SPRA and The Nugget Theater, as well as reduce the costs associated with such waste disposal.

STORR’S POND RECREATION AREA

Issue

SPRA is a community recreation area with various facilities, including a 13-acre pond, disc golf, a heated pool, a splash pad, tent and RV sites, pavilions, tennis courts, and a trail system. People can access the area by purchasing memberships or daily admission passes. However, the increasing use of the recreation area in recent years has resulted in issues such as increased trash production and the associated fees for removing it. Additionally, community members have been caught bringing household trash into SPRA to dispose of in the dumpsters on-site, which suggests a deeper level of abuse of the waste management system at Storr’s Pond, resulting in heightened costs for trash removal for the Hanover Improvement Society. To remedy these issues, we recommend a three-tiered approach: (1) implement a pay-as-you-throw system, (2) offer free recycling services, and (3) offer free composting services.

Methods

1. Data Collection and Interviews

To address the issues identified by the Hanover Improvement Society for waste management at Storr’s Pond, we first organized meetings, over the phone and in-person, with the General Manager, Jeff Graham, to get an overall perspective of what priorities are highest and what has been done in the past. For our in-person meeting with Jeff, we conducted a site visit at SPRA in order to evaluate the current trash system at the campsites and discuss what has worked well and what still needs improvement.

Once priorities were set and the site visit was conducted, we began to brainstorm a plethora of viable solutions that either reduce volume of garbage, curb customer behavior, or change the current system in place. In this phase of work, we interviewed Willy Phillips, a Dartmouth ‘20 who worked with Jeff at SPRA last summer and who originally suggested the centralized trash

system at the RV campsites, and we asked him for any ideas he had left unfinished to further improve the waste management system at SPRA. We also interviewed ENVIS Professor Erich Osterberg, who is a frequent visitor of SPRA's recreation facilities and campsites, to ask him about the feasibility of our ideas and ask if he had any ideas for further reducing the amount of waste generated. Finally, we interviewed Amber Boland, the owner of a local business, The Nest, to gain insight into their waste management system. While the purpose of the interview with Amber was mainly to address potential solutions for waste management issues identified at the Nugget Theater, which will be discussed later, this interview provided valuable insight into waste management costs of composting, which is a program that could be implemented at SPRA.

Once we had gathered data and identified the three-tiered approach, we conducted a cost benefit analysis to determine if the savings gained would be worth implementing. We did this using waste disposal cost data in an Excel sheet obtained from Jeff, which allowed us to calculate total cost savings and display the data visually for our final report.

2. Cost Benefit Analysis

First, we aggregated the monthly waste disposal costs at each HIS site to determine the total cost of waste disposal for the 2022 fiscal year. Despite only being open for seven months, from May to November, and having no costs documented for the month of June 2022, SPRA had by far the highest trash removal costs. We believe our three-tiered approach will significantly reduce net costs, and to provide evidence for this, we estimated cost savings or cost additions for each. While the pay-as-you-throw system generates additional revenue to reduce costs, the free recycling and free composting programs focus on reducing trash going to landfills, which reduces *trash* removal costs but increases costs of recycling and composting disposal. Using the 2022FY costs as a comparison, we used estimated inputs such as the percentage of campers who will pay the fee and continue to throw and the amount by which monthly recycling and composting fees will increase to deduce the net savings of our recommendations for SPRA. The solutions and the results of the cost benefit analysis for Storr's Pond will be discussed below.

Results

1. Interviews

In our initial meetings with Jeff, he expressed a desire to both lower the amount of waste at SPRA and lower the costs associated with removing it. One step that has already been taken to reduce excess trash at the campsites at SPRA is a centralized trash system, which was suggested by Willy when he worked at SPRA last summer. This system involves centralized trash bins throughout the campsites, instead of trash bins at each campsite. This system was implemented on the RV camping side of the campground, and Jeff expressed a desire to implement it on the tent camping side as well, since the system has proven successful in reducing excess waste and making trash collection at the campsites easier for the SPRA staff.

During our interview with Willy, he introduced us to the idea of a pay-as-you-throw waste disposal system, which has been implemented at other campgrounds and in several towns and cities across the United States, including Seattle, WA, Berkeley, CA, Austin, TX, and Portland, ME. Pay-as-you-throw is a waste management policy that charges system participants for the amount of waste they throw out. This is sometimes referred to as variable-rate waste pricing. According to the World Economic Forum, in Massachusetts, towns with pay-as-you-throw

systems achieved a 30% waste reduction compared to towns without pay-as-you-throw systems in 2020 alone, evidencing the potential success of this type of program.¹

A pay-as-you-throw system would internalize costs for those creating the garbage to disincentivize behavior while offsetting the cost of garbage removal for HIS through the income it generates. Based on Jeff's description of the sources of most of the trash generated at SPRA—large events and the campground— as well as typical fees charged at other campsites employing pay-as-you-throw systems, we suggest a two-pronged approach. For large groups hosting events on-site, SPRA can include a flat fee, which would be built into the event contract. For campers, SPRA could impose a per-bag fee on campers disposing of trash at the campsites. When we ran this idea by Jeff, he suggested that a \$25 flat fee for large events of more than 100 people and a \$5 per bag fee for campers would be a reasonable place to start. With this revenue, the pay-as-you-throw system would provide HIS with significant cost savings, and it would likely make community members more conscious of how much trash they generate at SPRA.

Our interview with Professor Osterberg proved helpful in gaining feedback from a community member who uses SPRA often on the pay-as-you-throw system and also further brainstorming ways to reduce the amount of waste generated at SPRA. Given the context we provided of the history of abuse of the waste management system at SPRA, Professor Osterberg thought the pay-as-you-throw system would be reasonable, but difficult to enforce through more than just an honor system, which might still allow for abuse of the system. In terms of reducing waste generated, Professor Osterberg suggested pairing the pay-as-you-throw system with free recycling and free composting programs, which would encourage community members to properly dispose of recyclable materials and food waste in a way that reduces the amount of waste going to landfills. This would reduce the volume of trash being generated at SPRA, thus reducing the cost of waste disposal for HIS, however, it would increase costs for recycling and composting pick-up.

Finally, during our interview with the owner of The Nest, we learned that the composting service they use costs \$25 per 55-gallon bin to pick up each week, and The Nest generates about two full bins of compost each week for a total of about \$200 per month in composting costs. The Nest utilizes a company called Nordic Waste to pick up their compost.

2. Cost Benefit Analysis

During our data collection phase, we learned that the dumpsters at SPRA fit about 15 trash bags, and Casella Waste Systems charges \$98 per dumpster for pickup. We also learned that HIS pays \$165 per month for recycling pickup at SPRA. Finally, Jeff told us that about 37.5% of trash comes from large events, about 37.5% of trash comes from campsites, and about 25% comes from other operations, such as pool deck and pond usage. Events tend to generate about ½ of a dumpster, or about 7-8 bags of trash. In our cost-benefit analysis, we used these inputs, along with the fees Jeff suggested for the pay-as-you-throw system. For the 37.5% of trash generated by large events, we factored in a \$25 charge per dumpster, and for the 37.5% of trash generated by campers, we factored in a \$5 fee per bag and a low and high scenario for the percentage of community members who would continue to throw their trash out at SPRA even with the fee.

¹ World Economic Forum. "What is pay-as-you-throw? A waste expert explains."
<https://www.weforum.org/agenda/2022/01/pay-as-you-throw-waste-expert-pollution-trash/>

The low-throw scenario assumes that the number of trash bags thrown out by campers at SPRA would be 50% of the 2022 total, while the high-throw scenario assumes it would be 75%. The results of this cost benefit analysis suggest that during peak months, August through October, SPRA could save about \$150 per month in pickup costs in the high-throw scenario and about \$200 per month in pickup costs in the low-throw scenario, with the additional revenue from the pay-as-you-throw system offsetting pickup costs and bringing total savings during peak summer months to \$160-\$351 per month in the high-throw scenario and \$165-\$362 per month in the low-throw scenario, compared to 2022.

Inputs			
Cost per dumpster	\$98.00	Percentage of waste from events	37.50%
Recycling cost per month	\$165.00	Percentage of waste from campers	37.50%
PAYT Event fee	\$25.00	Percentage of waste from other	25.00%
PAYT Fee per bag	\$5.00	Percentage who throw-- low	50.00%
Bags per dumpster	15.00	Percentage who throw-- high	75.00%
# of dumpsters per event	0.50	Low-R&C Cost Increase	\$140.00
		High-R&C Cost Increase	\$240.00



Figure 1: This table and graph provide the inputs and results of our cost benefit analysis of the pay-as-you-throw policy alone, with high-throw meaning that 75% of campers would continue to throw and low-throw meaning that 50% of campers would continue to throw, yielding total annual savings in net trash and recycling costs for SPRA of around 50%, or between \$1,500 and \$1,550, compared to the 2022 fiscal year.

As you can see in the chart, the cost savings are substantial when you offset trash pickup costs with the pay-as-you-throw revenue, however, pairing the pay-as-you-throw system with free recycling and free composting would inevitably increase recycling and composting pick up costs, which need to be factored in to complete the cost-benefit analysis. Assuming the pay-as-you-throw system could increase the amount of recycling by no more than 25%, this could result in an increase in recycling pickup costs of up to 25%, or about \$40 per month. While we have no basis for the amount of food waste generated at the SPRA campsites each week given that there is no composting program currently in place, we estimate that SPRA would generate no more than The Nest generates, which is two bins of compost per week, given that most campers would pack out excess, unused food. However, we estimate that SPRA campsites would likely generate at least one bin of compost full of cooked, uneaten food per week, since campers would likely not pack out leftovers. Thus, using the same service for compost pickup as The Nest does, composting costs would probably range from \$100-\$200 per month.

We conclude that the total increase in recycling and composting costs would probably range from \$140 to \$240 per month, with various amounts of recycling and compost generated, for a total cost range of \$305-\$405 for recycling and composting combined. Combining the low-throw versus high-throw scenarios with the low versus high recycling and composting costs (low-R&C and high-R&C), the table below shows the possible savings for each month compared to 2022FY trash and recycling pickup costs.

Month	May	June	July	August	September	October	November
Low-throw/Low-R&C Scenario							
Trash Pickup	(\$57.14)	\$0.00	(\$120.54)	(\$263.06)	(\$263.06)	(\$263.06)	(\$172.98)
Recycling and Compost Pickup	(\$305.00)	\$0.00	(\$305.00)	(\$305.00)	(\$305.00)	(\$305.00)	(\$305.00)
PAYT Revenue Generated	\$45.67	\$0.00	\$96.35	\$210.27	\$210.27	\$210.27	\$138.27
Net Cost	(\$316.47)	\$0.00	(\$329.19)	(\$357.79)	(\$357.79)	(\$357.79)	(\$339.71)
Total Savings Compared to 2022	(\$49.89)	\$0.00	\$50.10	\$274.88	\$274.88	\$274.88	\$132.81
Low-throw/High-R&C Scenario							
Trash Pickup	(\$57.14)	\$0.00	(\$120.54)	(\$263.06)	(\$263.06)	(\$263.06)	(\$172.98)
Recycling and Compost Pickup	(\$405.00)	\$0.00	(\$405.00)	(\$405.00)	(\$405.00)	(\$405.00)	(\$405.00)
PAYT Revenue Generated	\$45.67	\$0.00	\$96.35	\$210.27	\$210.27	\$210.27	\$138.27
Net Cost	(\$416.47)	\$0.00	(\$429.19)	(\$457.79)	(\$457.79)	(\$457.79)	(\$439.71)
Total Savings Compared to 2022	(\$149.89)	\$0.00	(\$49.90)	\$174.88	\$174.88	\$174.88	\$32.81
High-throw/Low-R&C Scenario							
Trash Pickup	(\$66.66)	\$0.00	(\$140.63)	(\$306.91)	(\$306.91)	(\$306.91)	(\$201.81)
Recycling and Compost Pickup	(\$305.00)	\$0.00	(\$305.00)	(\$305.00)	(\$305.00)	(\$305.00)	(\$305.00)
PAYT Revenue Generated	\$52.96	\$0.00	\$111.72	\$243.83	\$243.83	\$243.83	\$160.33
Net Cost	(\$318.70)	\$0.00	(\$333.90)	(\$368.08)	(\$368.08)	(\$368.08)	(\$346.48)
Total Savings Compared to 2022	(\$52.12)	\$0.00	\$45.39	\$264.59	\$264.59	\$264.59	\$126.04
High-throw/High-R&C Scenario							
Trash Pickup	(\$66.66)	\$0.00	(\$140.63)	(\$306.91)	(\$306.91)	(\$306.91)	(\$201.81)
Recycling and Compost Pickup	(\$405.00)	\$0.00	(\$405.00)	(\$405.00)	(\$405.00)	(\$405.00)	(\$405.00)
PAYT Revenue Generated	\$52.96	\$0.00	\$111.72	\$243.83	\$243.83	\$243.83	\$160.33
Net Cost	(\$418.70)	\$0.00	(\$433.90)	(\$468.08)	(\$468.08)	(\$468.08)	(\$446.48)
Total Savings Compared to 2022	(\$152.12)	\$0.00	(\$54.61)	\$164.59	\$164.59	\$164.59	\$26.04

Figure 2: This table provides monthly waste management net costs and total savings compared to 2022 after factoring in increased recycling and composting costs in both low and high scenarios. The low-throw and high-throw scenarios are as described in Figure 1. The low-R&C category represents a \$140 increase in recycling and composting costs, and the high-R&C category represents a \$240 increase in recycling and composting costs. Highest savings are in the high-throw/low-R&C scenario, achieving about a \$250 reduction in net costs during peak months.

Disclaimer: In the data Jeff gave us, June 2022 showed zero costs. Thus, we could not make cost savings calculations for the month of June, as everything was compared to the 2022 fiscal year.

Adding the monthly cost savings together, the annual savings results for each scenario are as shown in Figure 3 below. The results in part (A) show that the pay-as-you-throw system using a \$5 per bag fee and \$25 per event fee, paired with free recycling and free composting, offers a range of cost savings scenarios. However, one scenario, the high-throw/high-R&C scenario, provides less than \$100 in cost savings. To increase cost savings in the high-R&C scenarios, we recommend raising the fixed fee for large events from \$25 to \$40, which would be consistent with the per-bag fee imposed on campers considering that events tend to generate 7-8 bags of trash. The annual cost savings with this increase in the fixed fee for large events are shown in part (B). Increasing the large event fee would ensure that HIS is achieving both its goals: *significantly* reducing waste management costs while also reducing the amount of trash going to landfills and increasing the waste stream feeding into recycling and composting systems, thereby reducing the negative environmental impact of HIS' waste management system at SPRA.

(A)

Annual Cost Savings	Low-R&C	High-R&C
Low-throw	\$725.03	\$125.03
High-throw	\$680.45	\$80.45

(B)

Annual Cost Savings	Low-R&C	High-R&C
Low-throw	\$957.65	\$357.65
High-throw	\$913.07	\$313.07

Figure 3: These tables show annual cost savings provided by the proposed waste management system, with a \$25 per event fixed fee in part (A) and a \$40 per event fixed fee in part (B), a \$5 per bag fee for campers across both parts, and high and low scenarios for both the percentage of campers who continue to throw and the increase in recycling and composting costs, as described in Figures (1) and (2).

THE NUGGET THEATER

Issue

The Nugget Theater is a historic movie theater located in Hanover, New Hampshire. Situated on South Main Street, it has been a cultural landmark in the town since it first opened its doors in 1916. Even with its storied history, The Nugget Theater has not been immune to a number of market challenges, including decreased demand and profits due to the rise of streaming services. One way to combat this issue is through targeted cost management. Here we specifically examine the cost of solid waste removal for The Nugget Theater, which presents an issue of exorbitant cost because Casella Waste Systems, the trash removal company employed by HIS, charges for removal based on volume, not weight. The major source of waste for the Nugget Theater is empty popcorn buckets that do not weigh significant amounts, but do take up significant volumes in trash bags, due to their inability to be crushed and packed tightly. To remedy this, we recommend replacing the popcorn buckets with paper popcorn bags.

Methods

1. Interviews

During our initial meetings with Jeff, we asked about HIS' goals and priorities for The Nugget Theater, specifically surrounding popcorn buckets. Next, we interviewed with the owner of The Nest, Amber Boland, to ask about the business' food and food-container disposal practices and costs, which helped us evaluate our ideas regarding The Nugget Theater. We also reached out to a trash compactor company to inquire about costs of buying and installing one at The Nugget Theater in order to reduce the volume of the waste generated. Finally, we used our interview with community member and Dartmouth Professor Erich Osterberg to ask for feedback our idea of shifting to paper popcorn bags at The Nugget Theater.

2. Research and Analysis

The Nugget Theater workstream required more research than the SPRA workstream, which involved looking into biodegradable, recyclable, and reusable popcorn container options. We collected information on a plethora of options, and then we zeroed in on one idea to conduct a cost benefit analysis to assess potential cost savings.

The cost benefit analysis used inputs such as the upfront cost of popcorn buckets, the upfront cost of paper bags, and the quantity of each size sold to calculate the potential cost savings associated with buying paper bags. It also used an estimate about the distribution of The Nugget's trash to SPRA and Campion and an estimate of by how much shifting to paper bags instead of buckets would reduce trash generation to calculate potential cost savings on the back-end.

Additionally, we conducted a student survey on popcorn consumption habits and the likelihood of popcorn consumption to change following our recommendation, in order to evaluate the feasibility of our recommendation in the eyes of the Dartmouth student population, who make up a portion of The Nugget's customer base.

Results

1. Interviews

During our initial meetings with Jeff, we learned that HIS desires to reduce waste disposal costs at The Nugget Theater, much like at SPRA. Additionally, Jeff mentioned that it would be great to find a way to recycle or reuse the popcorn containers, which are disposed of covered in butter and thus difficult to recycle. While we ruled out the recyclable and reusable options due to high upfront costs, we decided that shifting from popcorn buckets to paper popcorn bags would reduce both waste generated and waste disposal costs for The Nugget Theater. The analysis done to reach this recommendation will be discussed later, in the Cost Benefit Analysis section.

In addition to providing information about composting practices, our interview with Amber Boland, manager at The Nest, yielded more information about this neighboring business's waste disposal practices and costs. We learned that The Nest spends approximately \$800 monthly (\$200 weekly) on waste removal with Casella Waste System. The business participates in a community dumpster with other downtown Hanover businesses, but they and other businesses have not been informed if they are charged by weight or volume for disposal in the community dumpster. Meanwhile, when talking to Jeff about the community dumpster, we learned that The Nugget Theater used to participate, but has since saved \$15,000 annually in waste management costs by allocating its waste to SPRA and Campion Rink.

Our inquiry into buying a trash compactor helped us rule out that option due to the high cost. While a trash compactor would be useful in crushing the popcorn buckets to reduce the volume of waste generated, Harmony Enterprises, the company we reached out to, gave us an official quote for one unit, including packaging and shipping from Minnesota, of \$10,355. Seeing that HIS spends less than \$4,000 a year on trash disposal (and will spend even less given the implementation of our recommendations), this investment did not seem to be economically viable, and we did not proceed.

Finally, during our interview with Professor Osterberg, we asked him how a shift from popcorn buckets to popcorn bags at the Nugget might affect his purchasing behavior—specifically, we wanted to know if taking away popcorn buckets would deter community members from buying popcorn. He responded that, while he does prefer a bucket to a bag, if the Nugget substituted bags for buckets *and* properly marketed the motivation for such a shift being to reduce waste for environmental reasons, he would still be likely to buy popcorn. This feedback was important, as Jeff expressed multiple times that popcorn is The Nugget’s “cash-crop,” and the business would suffer greatly if people stopped buying popcorn. This feedback also provides helpful direction for a marketing campaign, which could be a continuation of this project.

However, Professor Osterberg raised a potential concern for the shift to popcorn bags instead of buckets, saying that popcorn bags are not as sturdy and are more likely to be knocked over, especially by small children. If people knock over their popcorn bags and ask for free refills, the shift to popcorn bags could not only create more waste and cleanup for Nugget Theater employees, but also cause a financial loss for the business if they grant free refills of their most valuable product. This user feedback, while helpful, did not provide us with certainty that a shift to popcorn bags *alone* would be effective in reducing waste and waste disposal costs for The Nugget Theater. Thus, we suggest this as an area for further research towards the end of the report.

2. Research

As mentioned previously, we researched biodegradable, reusable, and recyclable alternatives to popcorn buckets but were unable to find any cost effective solutions that fit these criteria. A couple front-runner ideas included custom-printed biodegradable buckets and reusable buckets with disposable liners in them. The biodegradable buckets had extremely high upfront costs and would still present the high-volume issue when disposing of them, thus not providing any cost savings upfront or on the back-end. The liners, while space-efficient and thus cost-reducing in terms of disposal, also had very high upfront costs, along with the necessary investment in reusable buckets to go with them. Thus, our idea to replace popcorn buckets with paper popcorn bags of the same size is the only alternative we found that reduces both upfront and back-end costs.

On the front end, paper bags are less expensive than popcorn buckets, as they use less material and have significantly lower shipping costs. We looked into many different paper bag options to find deals that offer the Nugget the most size flexibility, so they don’t have to change their product pricing, and the best savings.² On the back end, paper bags are more spatially efficient, filling up far fewer trash bags than their bucket counterparts. This offers a win-win scenario where the Nugget pays less in trash removal, and the use of less material offers strong environmental gains.

Through our communication with Jeff, we learned that The Nugget Theater has been using popcorn buckets for a number of years and has not fully considered moving away from them, as

² WebstaurantStore. “EcoCraft Popcorn Bag.”

<https://www.webstaurantstore.com/bagcraft-papercon-300614-7-1-2-x-3-1-2-x-11-3-4-170-oz-ecocraft-popcorn-bag-case/150300614.html>

HIS believes that popcorn buckets offer a more “authentic movie theater experience.” To address this concern, we conducted a campus survey to see if The Nugget’s customer base, at least the portion of it who are Dartmouth students, would genuinely purchase less popcorn if the packaging were to change. Of the 34 students who responded, 9 said they would reduce popcorn consumption, 19 said they would not change their popcorn consumption, and 6 even said they would increase their popcorn consumption given this shift. The 25 responses we got suggesting either no change or increased consumption, along with Professor Osterberg’s feedback, suggests that HIS would not lose significant popcorn sales if they implemented the shift to paper bags, especially with the right messaging.

3. Cost-Benefit Analysis

The popcorn buckets currently used by The Nugget come in three sizes, with the largest size being 170 oz. The small size costs \$0.32 to purchase, the medium size costs \$0.55 to purchase, and the large size costs \$0.60 to purchase. The largest size is the most popular size at The Nugget, as they sell about 1,349 units each year. They sell 503 of the medium size and 856 of the small size. Total upfront cost for the amount of units sold is about \$1,360. Paper bags, on the other hand, are cheaper upfront, provide the same size flexibility, and have a lower environmental impact. These bags are “100% chlorine-free, made of natural kraft paper, contain a soy-blended eco-wax that provides a barrier against butter and grease, and the largest size holds 170 oz. of popcorn.” There are large (170 oz.), medium (130 oz.), and small (85 oz.) sizes to fit any of The Nugget’s needs. These paper bags are much cheaper than the current buckets as well, with the largest size costing only \$0.26, the medium bags costing \$0.23, and the small bags costing \$0.18. Thus, in upfront costs alone, this alternative will save The Nugget a significant amount of money moving forward. As seen in Figure 4, for each size, the paper bags save about 50% in upfront costs, for total cost savings of \$743.59.

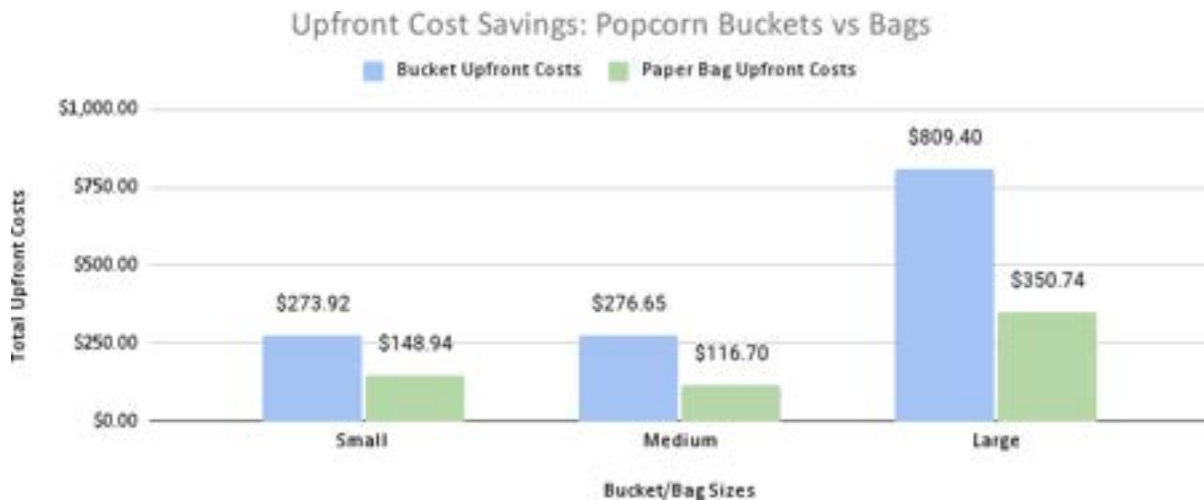


Figure 4: This figure represents 2022FY Nugget Theater costs of purchasing small, medium, and large popcorn buckets (in blue) and projected costs of purchasing the same 2022FY quantities of small, medium, and large popcorn bags (in green), which will reduce the total upfront costs by about 50%.

In terms of waste disposal costs on the back-end, The Nugget Theater produces around 5-6 bags of trash on an average week, and 8 on a busier week with more popular movies. For calculation

purposes, we decided to use 6 bags per week as our input, which accounts for the greater amount of trash generated on more popular weeks. This puts the total number of trash bags generated at The Nugget annually at about 312. In the summer, these bags of trash are taken to the dumpster at Storrs Pond. In the winter, the trash from The Nugget is taken to Campion Rink. As previously mentioned, these dumpsters hold about 15 bags of trash and cost \$98 per pick up. Assuming half of The Nugget’s trash goes to SPRA and half goes to Campion Rink, this means that The Nugget generates ten dumpsters full of trash at each facility, costing a total of \$2000 to pick up annually. By implementing paper bags as opposed to the larger, bulkier popcorn buckets, we conservatively estimate that The Nugget will fill up half the number of trash bags, thus costing half the amount in terms of trash removal. By saving \$743.59 in upfront costs and about \$1000 in back-end costs (\$500 each at SPRA and Campion Rink), the paper bag alternative to the current popcorn buckets is expected to decrease yearly costs by approximately \$1,743.59.

Additionally, due to their lower material usage, paper popcorn bags have lower environmental impact in production and shipping and generate less waste going to landfills, and the lack of a PFAS coating reduces the harmful chemicals that are leached into the environment once the waste reaches the landfill. These two benefits can help The Nugget achieve its goal of reducing the environmental impact of their waste management system.

Conclusion

1. Our final recommendations are as follows:
 - At SPRA, we recommend implementing a two-tiered pay-as-you-throw waste management system, imposed on both individual campers and large events, coupled with free recycling and free composting programs. This will reduce the amount of waste generated and waste disposal costs, while encouraging positive environmental practices.
 - At The Nugget Theater, we recommend replacing cardboard popcorn buckets with paper popcorn bags of the same size. This will reduce both upfront and waste disposal costs, while reducing the facility’s environmental impact.

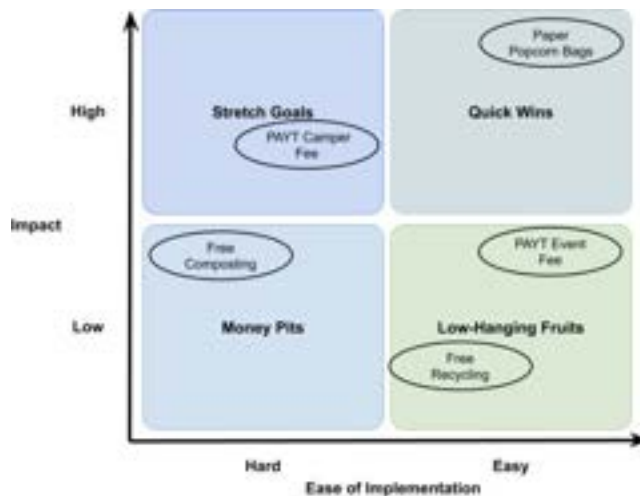


Figure 5: This matrix displays our recommendations against the scales of ease of implementation and potential impact.

These recommendations are placed above on a matrix representing the ease of implementation versus the potential impact of each recommendation. At SPRA, when comparing the two tiers of the pay-as-you-throw system, the \$5 per-bag fee for campers has a higher potential impact than the \$25 event fee because it generates greater revenue, but it is harder to implement, due to its reliance on an honor system rather than a contracted upfront fee. Increasing the per-event fee to \$40 would bring up the impact of the PAYT Event Fee to be on par with the PAYT Camper Fee in the diagram. Additionally, providing free composting services to campers has a high potential impact in reducing waste given that SPRA currently does not have a composting program, however the composting costs create difficulty of implementation compared to the lower-impact and less expensive free recycling program. Additionally, a composting program would require investment in special composting receptacles in order to keep food waste from attracting larger animals to the campsites. Finally, at The Nugget Theater, replacing popcorn buckets with paper popcorn bags not only has a high potential impact in reducing waste volume, as more popcorn buckets can be packed into a trash bag than popcorn buckets, but it is also cheap to implement, as paper bags cost less than popcorn buckets.

Our recommendations for both facilities result in significant cost savings for HIS. Taking the cost savings from the paper popcorn bag solution, including both the upfront and back-end savings, and combining them with the average of the four cost saving scenarios from the PAYT system with the \$25 event fee in the low-savings scenario and the average of the four cost saving scenarios from the PAYT system with the \$40 event fee in the high-savings scenario results in a dramatic reduction in aggregate costs. Figure 7 shows this reduction.

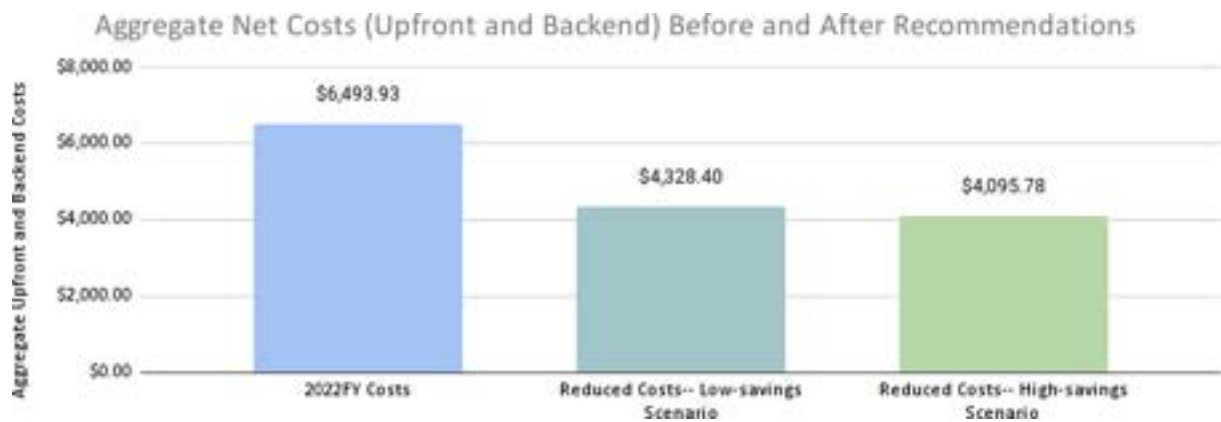


Figure 6: This chart shows aggregate upfront and backend waste management costs after factoring in cost savings from reduced waste at SPRA and The Nugget and lower upfront costs at The Nugget, additional revenue from the pay-as-you-throw scheme at SPRA, and added costs from the free recycling and composting programs at SPRA. The low savings scenario reduces costs by about 33%, while the high savings scenario reduces costs by about 37%.

Finally, our recommendations at SPRA and The Nugget Theater all reduce the negative environmental impact of the Hanover Improvement Society, and together, we suspect that these actions will have an added environmental benefit: when community members see more sustainable practices being implemented at well-known and frequently-visited local facilities, hopefully there will be a ripple effect on the actions they take in their own lives to live more sustainably.

2. Limitations

There were several limitations with the study conducted. First, our recommendations at SPRA were based on estimates that predicted people's willingness to pay for our pay-as-you-throw system. While evidence of waste reduction from pay-as-you-throw systems across Massachusetts is promising, we struggled to find data from recreational facilities and campsites regarding how many people actually continue to throw out their trash and pay the fee. We also could not find consistent data for a “reasonable” fee to charge per bag. Our interview with Erich Osterberg proved helpful in this regard, but he is only one community member, and thus the scope of our community feedback is very limited. The fees we used in Scenario (A) of the cost-benefit analysis—\$5 per bag and \$25 per event—were suggested by Jeff, but without extensive market research or case studies it is difficult to accurately judge an appropriate price point to push onto customers.

Our recommendation to replace popcorn buckets with paper bags at The Nugget also relies on unpredictable consumer standards and potential changes in consumption. While our survey sought to address the concern that movie-goers may reduce popcorn consumption without the “authentic movie theater experience” of the popcorn bucket, it was limited in the sample, which was composed of only students, and in the number of responses, which was relatively low at 34 responses. If we had more time to work on this project, we would make it a priority to expand the demographics surveyed in order to get accurate information on whether or not our recommendation would hurt The Nugget’s popcorn sales.

Next, the cost benefit analyses were conducted using limited cost-data. We based all calculations off of only one fiscal year of waste cost data, and it was unclear exactly how much cost was attributed to the waste generated at each facility, because the Hanover Improvement Society distributes trash and recycling generated at The Nugget to Campion Rink and SPRA, depending on the season. Thus, cost savings attributed to each facility were based on rough estimates of this distribution that we received from Jeff. The 2022 fiscal year cost data was also affected by seasonality of the three facilities, with SPRA only being open for the six warm months of the year, and Campion Rink only being open for the six cold months of the year.

In terms of our recommendations themselves, there are a few limitations regarding implementation. Firstly, our recommendation of the pay-as-you-throw system is difficult to enforce. With the centralized trash system at SPRA campsites, there would be a strong reliance on campers holding themselves accountable through the honor system. Due to the community engagement at SPRA, we do not believe this would become a prevalent issue, nevertheless, it is a possibility. There are ways to overcome this through charging credit cards kept on file, but, on the tent-camping side of SPRA, this can lead to conflict between employees who clean each campsite and the campers, resulting in a “He said, She said” scenario, and on the RV-camping side of SPRA, there is no way to keep track of how many bags of trash each party is putting into the centralized containers.

Additionally, our recommendation suggesting the substitution of popcorn buckets to bags has lower environmental benefits than originally desired, as it still generates waste instead of providing a recyclable or reusable alternative. While the paper bags reduce waste because of their lower material usage, we would have liked to have found a greener alternative but were

limited by the high upfront costs of those options. Finally, there is also the previously mentioned concern brought up by Professor Osterberg, which is that popcorn bags are more easily knocked over than buckets.

Areas for Future Research

1. Marketing and Messaging

There were more ideas we as a group wanted to pursue if we had more time to work with the Hanover Improvement Society. A root of the issues with waste management that is experienced at Storrs Pond is tied with the customers actions and behaviors on how they dispose of trash at the site. This behavior could be due to the fact that people are not educated on the issues at hand or unaware how they can do better. We believe that creating clear signage that would be posted around the park could equip customers with information they need to make choices with their waste that would make the management of Storrs easier.

We briefly looked into the case study of the “Don’t Mess with Texas” Campaign that reduced roadside litter in Texas through signs and advertisements. In brief, this campaign that began in 1986 has been very effective at reducing roadside waste. They used Texas icons, or in other words, people that Texans can resonate with, to advocate the reduction of roadside waste. Celebrity names such as Willie Nelson, George Strait, and Dallas Cowboy football players are just a few of the “staple” Texans that have starred in ads and signage helping create a change in the public’s actions. The litter rate has significantly dropped and “98% of Texans say that they recognize the slogan.”³ Using strategies from this case, we could have effectively crafted signs that would resonate with the public in and around the area, and ultimately change their behaviors. We would encourage those who work on this project in the future to consider placing signs at each campsite. If that would be too much signage for the management’s liking, signs at entrances, roads along campsites, and by the pond itself would also be very beneficial. We would recommend using some wordage that really resonates with the community and the ethos the community is looking for. Some preliminary thoughts for the wordage were (1) Do Not Litter...Keep Storr’s Scenic, (2) Keep Storr’s Sparkling, Do Not Litter, (3) Clean Storr’s = Beautiful Shores: Be Litter-Free, (4) Save Storr’s for Future Generations... Pick Up Your Trash, and (5) Only You Can Keep Storrs Part of the Beautiful Outdoors. Undoubtedly, these can be improved upon and implemented to make the community truly feel like they are a valued part of the solution. This will make attendees of Storr’s Pond feel a personal responsibility for the health and cleanliness of the area. We believe that marketing deliverables created through a continuation of our project can have a major impact at Storr’s Pond when implemented next season, along with our recommendations.

Additionally, a continuation of our project could create marketing materials describing the environmental motivation for switching from popcorn buckets to paper popcorn bags at The Nugget Theater, due to Professor Osterberg’s suggestion that this shift must be paired with appropriate messaging. Simple signs with phrases such as “Did you know popcorn bags generate 50% less trash than popcorn buckets?” could be effective at communicating this motivation.

³ Karmout, Kaitlyn. ““Don’t Mess with Texas’ Finds a New Anti-Litter Jingle for a New Generation.” <https://www.kxan.com/news/texas/dont-mess-with-texas-finds-a-new-anti-litter-jingle-for-a-new-generation/>

There is also the opportunity to create educational resources that advise community members of where their trash goes and how they can be more vigilant in creating less waste. Through TJ's internship with Casella Waste Systems, we learned that the company conducted a project where they converted a school bus into an interactive workshop that showed school children how the garbage system works. While HIS might settle on a less elaborate educational tool, we recommend that a future project team at least create pamphlets or flyers that shed light on the garbage collection systems at HIS facilities.

2. Further Potential Waste Management Solutions

One area we did not explore in great detail when doing the cost benefit analysis of the three-tiered approach at SPRA is the breadth of options available when it comes to implementing a composting system. Our CBA rested on the assumption that HIS would use the same compost pick-up service as The Nest, with total costs per month between \$100 and \$200, but there may be cheaper alternatives. Namely, HIS may be able to participate in the municipal composting system at the Lebanon town dump or even partner with local farms to donate or sell compostable waste to those farms so they can use it as organic fertilizer. The main issue with these two ideas is that transportation of the compostable waste to the dump or to the farms would fall on HIS employees, whereas using a pick-up service such as Nordic Waste would eliminate that responsibility. A future iteration of this project would have to run a more in-depth cost-benefit analysis using a range of options for the composting system to determine the highest cost savings possible.

At The Nugget Theater, one issue we did not get to address over the course of this project is the large amount of popcorn that goes unsold or littered in the theater at the end of each day. It is a good step that they use the leftover popcorn as chicken feed, but we would have liked to examine ways to create less waste in the first place or create ways to reduce the impact of this waste in disposing of it.

To address the issue of popcorn being spilled in the theater, especially with the implementation of paper popcorn bags, we recommend that a future iteration of this project look into design solutions in the theaters at The Nugget themselves. To achieve this, students from Dartmouth's ENVS department could partner with students in the Human-Centered Design department of the Thayer School of Engineering to create a product that better holds the popcorn bags in the theaters so they do not get knocked over.

Finally, depending on the success of the composting system at SPRA, HIS could also compost food waste from The Nugget.

Group Reflection

At the beginning of the term, Dr. Bieluch posed some crucial questions and ideas for our group to think about heading into this project. The main theme throughout was collaboration. We had to figure out how six people were going to make such a broad project successful. Throughout the term, we learned each other's skill sets and utilized individual niches every step of the way. Certain group members were better at writing, others were better at speaking, and others were better with data. We used this wide-range of skills from different group members to our advantage, allowing them to flourish in fields they were familiar with. However, at the same

time, most of us collaborated on everything. We understood the reasoning and thought behind every single part of the project, even if that part was not our “duty.” That is why when it came time to assign final slides for our presentation, mostly everyone felt comfortable taking any slide; that is how collaborative we were as a group.

In all, our group was very successful at implementing Dr. Bieluch’s message of collaboration. Throughout the term most of us carried this message with us, listening to group mates, challenging assumptions, and suggesting ways to improve the work that each of us were doing. Perhaps the most important outcome of our collaboration as a group was the strong bond we built with one another in such a short amount of time. We are no longer just fellow students anymore, but rather friends. We have formed meaningful relationships that will last much longer than this group project. That is why after finishing our project, we can all say, with full confidence, that psychological safety was at the forefront of the work we did together, and hopefully that shines through in our work.

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