The Nelson A. Rockefeller Center at Dartmouth College

The Center for Public Policy and the Social Sciences

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ASSESSING THE LAKE CHAMPLAIN SEWER OVERFLOW PROBLEM IN VERMONT

A Methodological Design

Presented to the Senate Committee on Natural Resources and Energy

PRS Policy Brief 1819-03
May 24, 2019

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EXECUTIVE SUMMARY

Lake Champlain is one of the most frequently visited recreation areas by Vermont residents and visitors alike. The lake generates in millions of dollars from its tourism and fishing industries alone. However, the main wastewater treatment facilities in the state have been leaking semi-treated wastewater into the Lake, due to outdated sewage treatment systems and use of combined sewage overflows (CSOs). These systems cannot handle the heavy precipitation that Vermont has encountered in recent years. The Vermont Senate Committee of Natural Resources and Energy is interested in understanding patterns of leakage in the state and how best to generate funds to mitigate the cost burden of pollution on the environment and recreational economy.

1. INTRODUCTION

Lake Champlain is the sixth largest freshwater lake in North America, extending from New York to Quebec. Fifty-six percent of the lake resides within Vermont, with Vermont residents comprising 72 percent of the United States population living in the basin. [1] The Lake Champlain Basin has a relatively wet climate, averaging 37.5 inches of precipitation a year. On average, more precipitation falls in the summer and autumn than winter and spring months, resulting in more wastewater treatment overflow in June to September. The Vermont sector of the lake has experienced over 38,000,000 gallons of sewage and stormwater released into it by wastewater treatment facilities between October 2017 and October 2018, alone. The leakage breakdown is 95 percent stormwater and five percent sewage.[2]

The 92 municipal wastewater treatment facilities in Vermont process more than 15 billion gallons of wastewater per year.[3] Municipal wastewater, originating from a combination of domestic, commercial, and industrial activities, is conveyed to centralized wastewater treatment facilities. In the treatment facilities, the water is treated to established standards before it is discharged into the lake. Some towns in Vermont utilize combined sewers where stormwater and wastewater are merged together through the sewer system to the treatment facility. After heavy rainfall, the current municipal treatment systems, which use combined sewage overflows (CSOs), cannot handle the excess amount of water and release untreated or semi-treated water. Of the nineteen towns that still use combined sewage overflows for the sewage treatment systems, nine have had multiple major sewage spills in the past year. The last plant to be updated was the Burlington Main Plant in 1994.[4] Many of these systems are severely outdated.

Due to climate change, Vermont will likely continue to experience an increase in rainfall in the coming years. Bacterial and nutrient pollution has escalated this year with a reported 125 major spills.[5] Seven of these leakages released over one million gallons of wastewater into the lake. The negative ramifications affect both the ecological and economic health of the Lake Champlain basin.

Urbanized areas contribute to the bacterial and nutrient pollution problem in Lake Champlain disproportionately more than rural areas. Sources of bacteria and excess nutrients accumulate on land between storms and move to a body of water with stormwater runoff. Water moves greater distances over paved surface of urbanized areas, thus having more opportunity to pick-up bacteria as compared to grasses, fields or forests of rural areas, where the water can seep into the ground.

While many of the larger cities and towns utilize the municipal water treatment systems, approximately 55 percent of Vermont homes have decentralized wastewater systems, which is the highest of any state in the United States. Decentralized wastewater systems consist of a septic household wastewater treatment system. These are found in the rural areas of Vermont, as urbanized areas use wastewater treatment plants more than rural areas.[6]

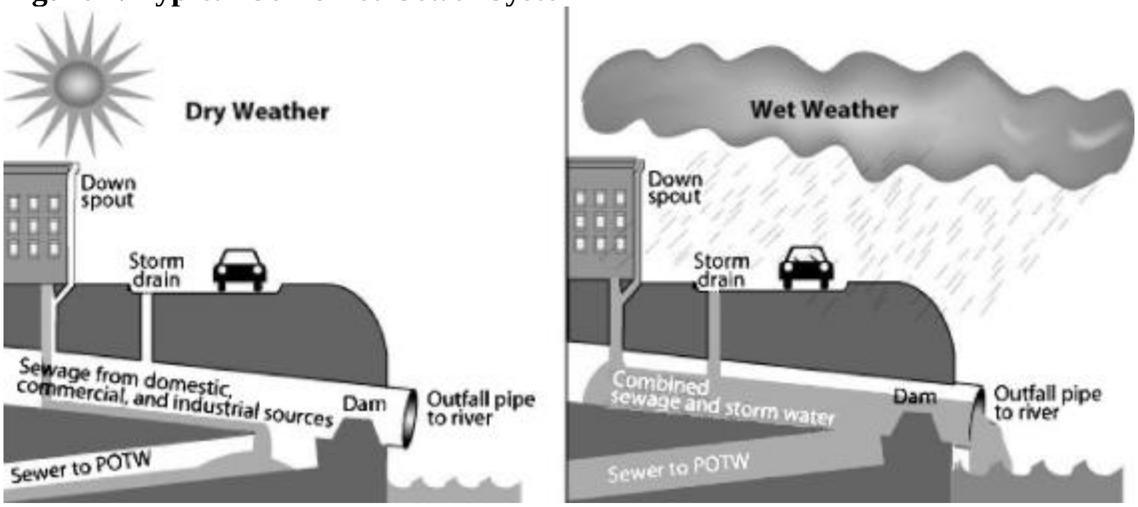
2. BACKGROUND

As the occurrences of sewer overflows become more frequent and reach the attention of lawmakers, the media, and the residents of Vermont, it becomes increasingly imperative to establish what exactly is being leaked into Lake Champlain when the sewage systems cannot adequately process the high levels of inflows properly. Because of this, the project will detail the different kinds of pollutants present when these overflows occur.

2.1 Combined Sewer Overflows

Combined sewer overflows (CSOs) occur when combined sewer systems (CSSs) overflow. CSSs are sewer systems in which storm runoff and domestic, commercial and industrial sewage are combined into one sewer system that transport the water to a publicly-owned treatment works (POTW), or a water treatment facility.[7] Overflows often occur during heavy periods of precipitation or snowmelt. Due to state regulations on combined sewer systems, overflows need to be less likely to occur under dry weather conditions.[8] Points where CSSs can overflow are called combined sewer overflow outfalls (CSO outfalls).[9] As of 2017, there were 63 CSO outfalls present in Vermont. Any CSO event that occurs in Vermont is required to be reported within 12 hours from its discovery.[10]

Figure 1. Typical Combined Sewer System



Source: *https://www3.epa.gov/npdes/pubs/csossoRTC2004_chapter02.pdf*

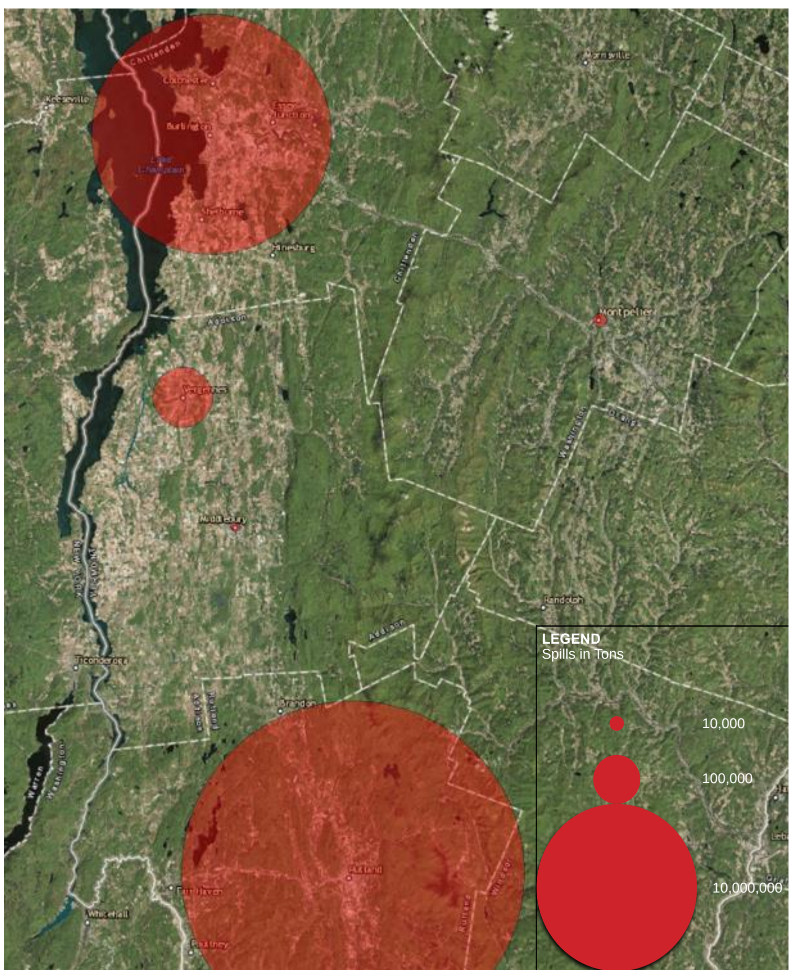
Through the Clean Water Act, the Environmental Protection Agency (EPA) regulates CSO discharges; such discharges are subject to technology-based and quality-based clarity. Its CSO Control Policy represents a comprehensive national strategy that allows municipalities to engage in a comprehensive and coordinated effort to achieve cost-effective controls that meet health and environmental objectives. The nine minimum controls set by the EPA are:[11]

- Characterization, monitoring, and modeling of the CSS
- Public participation
- Consideration of sensitive areas
- Evaluation of alternatives
- Cost/performance considerations
- Operational plan
- Maximization of treatment at the POTW treatment plant
- Implementation schedule
- Post-construction compliance monitoring program

Vermont regulates CSOs thorough its Combined Sewer Overflow Rule, implemented by the Agency of Natural Resources and the Department of Environmental Conservation in 2016. The rule entails a two-phased process to implement CSO controls.[12] During Phase I, municipalities are required to implement the technology-based minimum controls, which include a prohibition of CSOs during dry weather and maximum use of the collection system for storage without endangering public health, or property. During Phase I, municipalities are also required to comply with water quality requirements under state law.

If they are not in compliance, municipalities are required to submit a Long-Term Control Plan (LTCP).[13] Requirements for an LTCP include drafting reports to apply for state funding, enforce a public participation process, include an analysis that evaluates costs and performance of CSO control alternatives such as flow metering system and adding storage tanks, a prioritization of CSO control projects, measures to address recurrent instances of sewage backups or raw sewage discharges onto ground surface, include a financing plan. During Phase II, municipalities will continue implementing the minimum controls, implement controls identified in its LTCP approved by the Agency of Natural Resources, and establish compliance schedules.[14] Nineteen towns in Vermont still use CSOs for the sewage treatment systems. Nine of these have had multiple major sewage spills in the past year.

Figure 2. Magnitude of Spills in Vermont in the Past Year



Burlington has been in many headlines this past year for their leakages of high magnitude. Large urban areas, such as Burlington, have more runoff than rural areas, leading to more pollutants in nearby bodies of water. However, Rutland, a rural town, has had 87 spills in the last year, the most of any municipality in the state. While in Burlington spills totaled 11 million gallons, Rutland had a disproportionately higher amount of over 24 million gallons in the last year. Rutland is typical of older municipalities in the upper Midwest and Northeast that developed wastewater and stormwater systems together back in the 1800s; whereas Burlington has the most recently updated system.

2.2 Pollutants

The leakage from wastewater treatment facilities pollutes Lake Champlain with bacteria and nutrient pollutants that have a detrimental impact on the water quality, fish ecosystem and tourism industry. Escherichia Coli (E. Coli) and phosphorus levels are of particular concern.

Satisfactory water quality is imperative for Vermont residents. Many Vermonters get their drinking water from Lake Champlain, as 73 water systems in the state draw from it. Roughly 20 million gallons of water are pumped from the Lake each day to supply drinking water to about 145,000 people (or about 20 percent of the Basin's population).[15] Harmful bacteria and viruses from wastewater leakage can cause people to become sick, or in rare cases, die. The water of Lake Champlain is becoming too contaminated with E. coli and toxins by an abundance of blue-green algae to be potable.

The excessive levels of E. coli, giardia and cryptosporidium are regulated and monitored differently by New York, Vermont. and the Canadian province of Quebec. Each of these government entities have different standards for determining when bacterial levels are high enough to close beaches and even for how frequently beaches should be tested. State agencies in Vermont regularly test the water quality at public beaches around Lake Champlain during the swimming season for bacteria such as E. coli and other fecal coliform (bacteria that comes from animal and human waste). If the E. coli level exceeds 77 colony-forming units per 100mLs, Vermont beaches close. Since 1994, many beaches, especially those clustered in Chittenden and Addison counties, have experienced excessive levels of E. coli.[16]

Eight of the major beaches on Lake Champlain were closed in 2018 due to the bacterial pollution found in the lakes. These beach closures are mostly due to the E. Coli presence in the shallow waters near the beach, which are more susceptible to high bacteria counts than the cold, deep waters. The peak beach closures in the summer of 2018 also coincide with peak rain season, which occurs in the month of July.

Figure 3. E. Coli Levels in Burlington Swimming Areas

	30-May	5-Jun	8-Jun	12-Jun	15-Jun	21-Jun	25-Jun	28-Jun	2-Jul	5-Jul	9-Jul	11-Jul (AM)	11-Jul (PM)	12-Jul	17-Jul	19-Jul
North Beach (N)	1	5.2	2	2	10.9	2	0	0	3.1	2	1	-	-	2	0	0
North Beach (S)	0	0	1	10.6	11	2	0	1	11.8	3.1	1	-	-	1.25	0	0
Leddy Beach (N)	23	4.1	0	2	30.1	2	1	0	1	1	4.1	-	-	1.11	0	0
Leddy Beach (S)	0	3.1	0	0	26.5	4.1	1	0	2	1	1	-	-	2.18	0	6.3
Blanchard/Oakledge Beach (N)	0	3.1	0	1	0	27.5	12.1	1	5.2	1	1	32.3	10.9	0.5	0	2
Blanchard/Oakledge Beach (S)	0	7.4	2	0	0.5	52	2	1	5.2	1	1	122.3	3.1	0.5	1	0
Cove/Oakledge Beach	2	1	0	1	4.1	123.6	36.9	24.9	1	1	1	13.4	19.9	1.11	2	1
EPA/VT Standard	235	235	235	235	235	235	235	235	235	235	235	235	235	235	235	235

	24-Jul	27-Jul	28-Jul	31-Jul	3-Aug	7-Aug	10-Aug	14-Aug	20-Aug	23-Aug	27-Aug	30-Aug
North Beach (N)	0.5	101.9		1	14.6	5.2	5.2	1	4.1	1	1	0.5
North Beach (S)	1	10.9		1	8.6	12.1	0.5	0.5	9.5	0	2	0.5
Leddy Beach (N)	1	344.8	17.1	1	6.3	18.7	21.3	0.5	24.6	11	2	0.5
Leddy Beach (S)	1	8.6	12.2	1	1	0.5	4.1	0.5	5.2	1	0	0.5
Blanchard/Oakledge Beach (N)	0.5	770.1	80.1	7.4	1	1	39.8	0.5	1	3.1	0	10
Blanchard/Oakledge Beach (S)	0.5	185	38.8	0.5	2	0.5	21.1	0.5	1	0	2	24
Cove/Oakledge Beach	0.5	90.7		0.5	1	1	3.1	0.5	2	4.1	1	54
EPA/VT Standard	235	235	235	235	235	235	235	235	235	235	235	235

Source: https://enjoyburlington.com/resources/water-quality-public-notices/

In addition to the E. Coli presence, excessive phosphorus levels are also harming the ecosystem of the lake. Lake Champlain runs into problems when too much phosphorus enters the lake from sources such as wastewater treatment facilities. More than two-thirds of the problematic phosphorus overload in Lake Champlain comes from Vermont. Excess phosphorus in Lake Champlain often leads to nuisance plant growth and algae blooms, lowering oxygen levels in the water.[17] These low oxygen levels can result in dead fish and other aquatic wildlife. The algae blooms produce toxins called cyanotoxins, known to kill fish and dogs, and can make a person ill or worse if swam in or swallowed.

The EPA recently released its Total Maximum Daily Load (TMDL) for Lake Champlain and wastewater treatment facility discharges to Lake Champlain now have stricter phosphorus limits. Permits to 58 wastewater treatment facilities in Vermont determine how much phosphorus each facility can discharge into waterways. According to court documents, the new permits have lowered the pounds of phosphorus per year.[18]

Lake Champlain is one of the top tourist destinations of Vermont. The 54 beaches that surround the lake are used by almost one million people annually. The Agency of Commerce and Community Development stated that "approximately $300 million was spent in and around Lake Champlain [by tourists]."[19] The beaches play an integral role in the lives of Vermont residents and millions of tourists.

The fishing opportunities previously brought many tourists to the area. Yet, fish consumption is not supported in any Vermont portion of the lake due to elevated levels of mercury or polychlorinated biphenyls in fish tissue. With a total spending of $205 million per year for fishing in Lake Champlain, the economic significance of a clean lake and healthy fish population cannot be ignored. [20]Fishing is one of the most prominent sources of tourism; in the state, Lake Champlain is the its largest venue for it.

3. PURPOSE STATEMENT

The current sewage system in Vermont is not capable of processing the excess intakes and overflows that occur especially during the summer months. Furthermore, revenues necessary for reverting these problems are not readily identifiable. Part of process to resolve this issue revolves around acknowledging and understanding what the sewage problem really is. The other part lies in evaluating different taxation methods that would bring in enough revenue to support the damage being done. This work not only addresses an environmental question but also a welfare question.

With increasing levels of sewage being dumped on Lake Champlain every year, the state is seeing a decrease in its constituents' welfare as everyday tasks and leisure times are now being impaired by contaminated waters. The state must address the question of whether or not it truly understands the consequences of these spills on the environment and whether this information is being accurately disseminated to the public. As mentioned earlier by various media outlets, these events may not be accurate, which creates an issue of an uninformed public. Our first task will be to research and explain the different bacteria that can contaminate Vermont waters, and specifically Lake Champlain. This will require a deep understanding of the Vermont sewage system and what the system can or cannot process when those overflows occur.

Next, the project aims at examining different taxation methods that provide revenues to resolve and mitigate this problem. In doing so, multiple factors must be considered including the effects of taxation on the state and on its constituents. The policy must be effective in generating enough revenue that surpasses the financial and environmental burden that these overflows are causing. The project will aim to estimate the benefits and costs of individual taxation policies, taking into account what each taxation method does and the drawbacks associated with each.

Finally, we will analyze the difference between an individual septic system and a municipal sewage system in order to evaluate the potential benefits and costs of these practices. We will address the challenge of adopting these measures as Vermont has different soil types and one septic tank will not work for all household types and environments.

4. METHODOLOGY

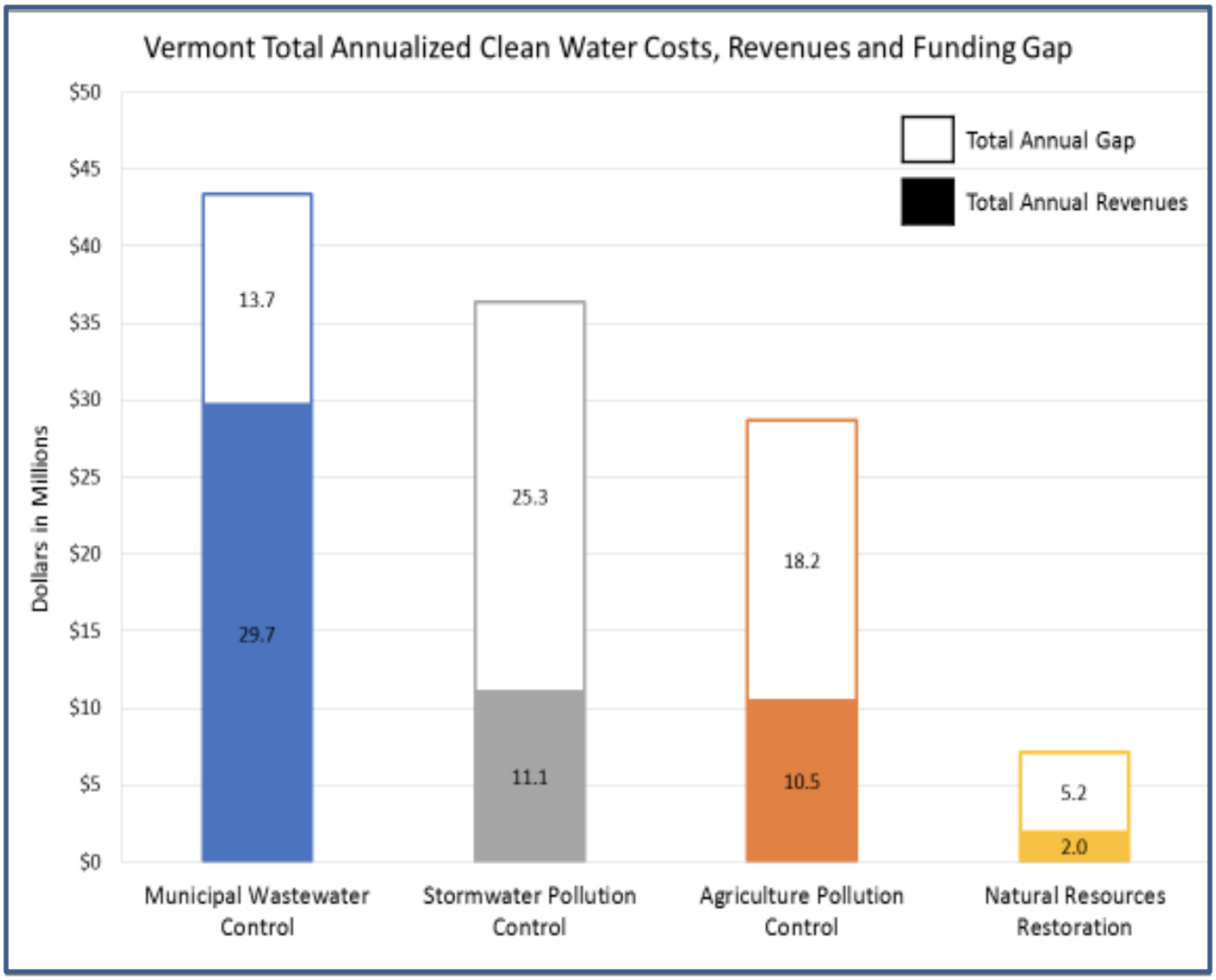
When tackling the sewage issue in Vermont, it is imperative to establish the source of the problem, its urgency, as well as an effective design to solve the problem. The key question to address is: how does Vermont design the best taxation policy to reduce the amount of sewage being dumped in Lake Champlain without burdening the state and its residents? In answering this question, different taxation policies must be evaluated including a uniform flat fee, a state tax, a statewide storm water utility or a pro-rated fee that takes into consideration an array of factors such as property size, amount of impervious land, and other factors.

4.1 Current Efforts to Clean Vermont's Waters

On January 15, 2017, the Office of the State Treasurer issued a report detailing urgent need of cleaning up the state's waters as a way to preserve the economic future of the state. Lake Champlain, being the major body of water in the state, plays a big role in this 20-year plan. Vermont, over numerous decades, has become a major tourist attraction for its waters and natural, rural landscapes.[21] With the increased rainfall and inadequate systems to process these overflows, Vermont is experiencing a greater amount of beach closures, bacterial contaminations and inaccessibility to the breath-taking nature that many are traveling miles to experience. Not only that, residents of Vermont are also experiencing the negative impacts of these contaminated waters. In 2015, reassessments of lakeside properties in Georgia, Vermont, resulted in a $1.8 million grand list drop due to severe water quality degradation.[22] For these reasons, the State Treasurer, in this report, laid out a series of measures to clean up the waters in Vermont, determining monetary cost and some revenue sources that can help overcome the financial burden.

The total new 20-year total clean water compliance costs are projected to be $2.3 billion. Revenues during that time are projected to be approximately $1.06 billion, creating a 20-year total gap of $1.3 billion. [23] Annually, it will cost the state $115.6 million to comply with these proposed measures; annual revenues are estimated at $53.2 million, leaving a gap of $62.4 million per year. The following table shows the different sectors that factor into the Clean Water plan, including the associated costs and estimated revenues of each of these.

Table 1. Vermont Total Annualized Clean Water Costs, Revenues and Funding Gap



Source:https://www.vermonttreasurer.gov/sites/treasurer/files/committees-and-reports/_FINAL_CleanWaterReport_2017.pdf

This bold initiative has in mind the welfare of the Vermont residents and economy thinking ahead in the next twenty years. Although this initiative does have gaps, the Office of the

Treasurer does recommend a structure in adjusting the financial burden of this plan. These include:

- Establish a long-term funding plan
- Establish a two-year interim funding plan for high priority projects to facilitate water quality implementation efforts and allow for the long-term plan to be built
- To the extent possible, use existing resources[24]

This plan, though not formalized and put into effect yet, offers a solution to the sewage overflow problem, in a 20-year time frame. Other solutions are needed to combat the immediate problems of pollution and sewage overflows into Vermont waterways, like Lake Champlain.

4.2 Benefits and Costs of Taxation Policies

Prior to determining which taxation method is the most appropriate and effective as a solution to the increased overflows into Lake Champlain, it will be useful to learn about the clear-cut benefits and costs of such policies. During this evaluation, the following questions must be addressed:

- What percentage of the population will be affected by this policy?
- What will the taxation of this policy look like? Will it relate to property size, amount of impervious land, or other factors that contribute to the problem? How will this be determined?
- What will be backlash of this policy and from which specific interests or targeted groups will it come from?
- What are the costs of implementing and enforcing this policy?
- How does the state plan on paying for the initial costs of the plan?
- What will be the methods of surveying and studying whether or not the population will support the policy?
- How much revenue will the policy bring in? How will it be allocated?
- How is the state going to advertise and educate the public about this plan? What form will this take? What are the costs associated with this?

These questions will aim to consider all affected citizens under the numerous different scenarios. It will also attempt to evaluate the burden that will fall on the individual citizen being taxed and on the state that is conducting the tax. The overall goal will be to choose the best policy design for all parties involved, keeping in mind that there will be a cost associated with solving Vermont's increasing sewage overflows problem.

4.3 State-By-State Comparisons

In order to obtain a more complete analysis of taxation policy design, it is helpful to evaluate different states/localities that have already implemented some sort of tax design to combat an overflow-related problem. From research already conducted, it seems clear that payment methods vary greatly.

Burlington, Vermont established a stormwater utility in 2009 and uses a fee to fund efforts to comply with the city's stormwater permit as well as to improve stormwater management and quality in the area. The fee is measured by the amount impervious area on a property (including driveways, rooftops and sidewalks) which is determined by an equivalent residential unit (ERU). The ERU calculates the average square feet of impervious surface on a typical single-family home. It has proven to be the most effective at reducing property taxes and minimizing administrative costs since it does not have to create a new and separate method for collecting payments. The revenue generated from the fee also goes directly towards fixing the problem at hand whereas other methods, such as a state tax, direct payments to the state which then decides how much to allocate to the issue. The service fee is also the most favorable design in the eyes of the public, even proving to be statistically less likely to face legal challenges.[25]

Atlanta, Georgia, in 1985, utilized revenue bonds to mitigate their issue regarding CSOs. In this instance, revenue bonds supplied $92 million of the estimated $110 million total cost. Revenue bonds are issued when permittees sell bonds to investment banks. Fees or service charges by users are used to pay back the investment bank. They are able to be used easily, payments spread out, it is not affected by local debt limits, and since fees are paid by the users of the system, it is more equitable. Nonetheless, it has high interest rates and requires the permitee to legally establish their authority to issue debt. The permittee will also likely need to have advanced financial management expertise.[26]

South Portland, Maine, adopted general obligation bonds in 1993 when they initiated an $8 million project to expand their water treatment facility.[27] General Obligation Bonds are bonds issued by a municipal government. This type of bond is most secure and has low interest rates. Payments can also be spread out, and it eliminates the need for separate bonding authorities and advanced financial management expertise. However, such bonds require voter approval, include a statutory limit on debt, and are not the most equitable.

Philadelphia, Pennsylvania enacted the Greened Acre Retrofit Program to provide funding, in the form of grants, to private landowners and developers for their construction of stormwater retrofit projects to divert stormwater out of the combined storm and wastewater system.[28] The project will need to consider the effectiveness because it was implemented recently. Nonetheless, privatization may be a path to consider in reducing CSOs.[29]

4.4 Differences Between Sewage System and Septic System

A potential alternative to combatting the CSO problem is to analyze the difference between a municipal sewage system and an individual septic tank usage. Septic tank systems are underground wastewater treatment structures, using a combination of nature and technology to treat wastewater from household plumbing produced by bathrooms, kitchen drains and laundry.[30] Water from a household runs from a drainage pipe into a septic tank, a water-tight container buried underground. It holds the water until the solid material settles to the bottom and the grease floats to the top as scum. The water then exits the tank through piping, and enters a drainfield, which supports a community of aerobic and anaerobic organisms to treat the wastewater by absorbing organic waste, removing pathogens and breaking it down into soluble byproducts. Finally, the wastewater percolates into the soil.[31]

Septic tank systems may be advantageous in that it does not cause large, point source pollution events, but they are still a major factor in groundwater and surface water contamination if they malfunction. For instance, septic tanks should be pumped every three to five years to prevent solids from reaching the drainfield and clogging soil.[32] Furthermore, leachfields located in overly dense, clay composed soils limit percolation prone to flooding, which can serve as runoff into the local waterways. On the other hand, leachfields located in sandy areas allow water to percolate easily, which may end up contaminating the groundwater supply. [33]A typical septic tank system on a level site on an area with good soil would cost an estimated $1,500 to $4,000. [34]

Thus, an important aspect of conducting a feasibility study of septic tanks will be the cost of building a septic tank versus the cost of upgrading municipal sewer systems. The Vermont Department of Environmental Conservation has a database of designers of water supply and wastewater treatment systems who may be useful to consult with when considering the costs of upgrading existing municipal sewer systems. Furthermore, a database of septic tank permit specialists is also available on the Department of Environmental Conservation. These permit specialists may help identify concerns in various localities and the precautions needed to take for septic system installation.

A general study of geology that impact septic tank price may also be conducted through the study of Vermont soils. Important aspects of a surrounding environment include soil permeability, groundwater levels, depth to rock, sand or gravel, slope of the ground surface, nearness to streams, and local changes in soil type.[35] The United States Department of Agriculture has a soil survey that evaluates the soil types throughout various localities throughout the United States. After setting the Area of Interest to a specific area within Vermont, clicking on the Soil Data Explorer tool, proceeding to click on Water Management and exploring the Subsurface Water Management icons, the research team can evaluate why certain areas are well suited or ill-suited for septic tank usage and installation.

Some of these may be avoided through creative alternatives. For instance. The Sannock Woods Cluster Subdivision utilized a septic tank for 16 lots throughout 24 acres.[36] The total water consumption of these lots totaled 7, 200 gallons per day.[37] There were steep slopes in the area and the soil in this area was sandy, and each lot has its own private well, which made water contamination a major concern.[38] By centralizing the treatment system, the minimum land area for the treatment system was reduced.[39] It also reduced soil erosion, maintained scenic views, and protected drinking waters.[40] It furthermore protected individual drinking wells from contamination.[41]

4.5 Analysis of Cities Feeding into Lake Champlain

Rutland, VT

The city of Rutland, VT has a population of 15,440 people, according to the most recent United States Census estimates. It is the third largest city in the state and is home to 7,934 households. The median income for households in the city is $42,860; the median household has 5.1 rooms and a value of $150,900.[42]

The Rutland Wastewater Treatment Division is responsible for the operation and management of the largest municipal facility in the state of Vermont. It is comprised of ten pumping stations that serve from the peak of Killington all the way to East Clarendon. The division can often be considered a regional rather than a municipal one since it processes biosolids from six neighboring communities who do not have the capacity to do so.

The facility's method of operation includes, in a simplified version, separating heaviest of contaminants from the flow, removing the solids and landfilling them, breaking down compounds and stabilizing the sludge that results, removing as much phosphorus as possible from the system before discharging into the waters, hauling the stable sludge cake to Waste USA in Coventry, VT and finally neutralizing the water that is going to enter Otter Creek in order to protect the marine wildlife populations.[43]

Burlington, VT

The city of Burlington, VT has a population of 42,556 people, ranking it the 964th largest city in the United States. The city's population density is 4,129 per square mile which is 6246% higher than the Vermont average. [44] Currently, sewage from 16,067 households in the city end up in Lake Champlain. While the city's population experienced a 0.03% decline, its median household increased by nearly five percent in the same time period.[45]

Burlington is currently anticipating $8 million to $10 million in investments over the next three-to-four years to update existing equipment wastewater treatment plants (WWTPs) with the goal of avoiding future mechanical and facilities issues. These plans are part of the city's improvements to the WWTPs that began in the 1970s. Back then, much of the city had only one pipe that carried both sanitary waste and stormwater flow, as is typical of older cities. As seen above, this can create a sewage overflow problem once capacity is exceeded. Efforts have since been implemented to abate the CSOs. The city continues to pursue sewer separation and recently has shifted its focus towards managing stormwater in CSOs at its source. This involves reducing inputs through ground infiltration or by storing the stormwater and releasing back into the system in a controlled manner.[46]

Vergennes, VT

The municipality of Vergennes has a population of 2,631 people, where the median household income is $53,080. Between 2015 and 2016, Vergennes' median household income grew by nearly eight percent. There are 1,162 reported households with an average of 2.2 people per household.[47]

Its first wastewater plant was built in the early 1960s. Because of this, underground pipes are not very well sealed. Many sewer lines are still made of clay which results in openings in the pipes. Currently, the Vergennes wastewater system is not designed to collect stormwater. The current design does have the capacity to separate sewer which means that flows from businesses and homes feed directly into the sewage treatment plant and not mixing with rain runoff and stormwater in the system. The wastewater system is not designed as a combined sewer system but the state permits it as one. [48]

Montpelier, VT

Montpelier, VT has a population of 7,584 people, with a median household income of $60,793 which is slightly higher than the average American household income. Between 2016 and 2017, the population of Montpelier declined slightly by around one percent, whereas the median household income increased by around the same percentage.[49] The city is home to around 3,690 households whose waste feeds into Lake Champlain.

The Montpelier Resource Recovery Facility treats approximately 1.8 million gallons of sewage daily. This operation consists of sewer collection system maintenance, sludge disposal, water treatment and laboratory work. This task is accomplished by five employees who work in conjunction with the local Waste Management company, and the Central Vermont Solid Waste Management District.[50] In 2015, a federal grant of $89,000 was awarded to the District in order to finance a series of presentations, workshops, webinars to help residents and businesses located in the area learn to recycle, compost and discover the process of waste management in their region. This educational program came at the same time as discussions regarding a new waste facility location that would serve as a materials recovery facility as well as a district-run composting operation designed to handle both household hazardous waste as well as construction demolition debris. [51]

Middlebury, VT

Home to 7,024 people, Middlebury, VT is one of the younger towns in Vermont, with a median age of 23.8, sharply lower than the average median age of 38 years old across the state. There are 2,210 households, with the largest share of them having an income ranging from $75,000 to $100,000. The largest industries in Middlebury include educational services, health care and social assistance and accommodation and food services.[52] This is a result of having Middlebury College located in the heart of the city. The wastewater division manages the wastewater treatment facility for the town and operates an extra 20 pump stations around the community. The Wastewater Facility treated over 360 million gallons of wastewater in 2016. There are currently no infrastructure projects.[53]

5. CONCLUSION

The aim of this paper is to identify the risks of combined sewer overflows and to identify methods to mitigate them. This is important because Lake Champlain provides a substantial source of income to Vermont through its tourism and fishery industries. Overflows may also cause health and environmental hazards and decrease property prices around the lake. This paper discusses the various ways in which municipalities can upgrade their sewer systems to limit overflows. It also discusses ways in which they can secure funding, and ways in which Vermont legislature can aide municipalities in the abatement of their overflows.

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APPENDIX

Taxation Method	**What it is**	**Benefits**	**Drawbacks**
Revenue Bonds	Bonds sold by permittees to investment banks and paid back using fees to system users	Accessible, payments spread out, unrestricted by local debt limits, equitable	High interest rates, requires advanced financial management expertise, requires permittee to legally establish authority to issue debt
General Obligation Bonds	Bonds issued by a municipal or county government	Low interest rates, eliminates the need for separate bonding authority and advanced financial management capabilities, and payments are spread out	Debt requires voter approval and faces a statutory limit on debt, and is not equitable
Moral Obligation Bonds	Bonds paid back by non-binding pledge from community to cover payments	Lower interest rates, easier to obtain bonds, unconstrained by government debt limitations	Requires approval by elected officials, interest rates are slightly higher than general obligation bonds because it is not legally binding
Double Barrelled Bonds	Bond that is backed by the government and by the revenue from system users	Lower interest rates, easier to market	Constrained by debt limitations, and some governments have limitations on its use

State Bond Bank	Pooled bonds of smaller communities	Lower interest rates, allows smaller communities to access bonds	Involves administrative fees
State Revolving Fund Loans	Provides funding for wastewater treatment projects. Can be seen as grants with interest	Low interest rates	Limited funding
Clean Water State Revolving Fund	Provides funding for Vermont's clean water projects, including CSO abatement, monitoring, or elimination projects	Low or no interest rates	Involves administrative fees, limited funding
Federal Grants (including the Rural Utilities Service Grant Program, Economic Development Administration Grant program, and Community Development Block Grants)	Non-repayable funds issued given by the government	No repayments and reduce user fees	Lengthy application project, and conditions may add to project cost. Are also primarily targeted toward small, economically disadvantaged communities.
Privatization	Full or partial sale of federally funded infrastructure assets	Generate capital for future CSO controls without increasing debt, provide an influx of specialized skills, stimulate innovations, and more effectively control costs	Reduces permitee's control over operations

Estimated Prices of Septic System Installation in Localities with High Rates of Overflows

Municipality	**Estimate**
Burlington	$10,000-$30,000
Middlebury	$20,000-$50,000
Montpelier	$15,000-$20,000
Rutland	$8,000-$30,000
Vergennes	$20,000-$50,000

1. Estimate obtained from Brian Trebeck.
2. Estimate obtained from Larose Surveys.
3. Estimate obtained from Chase Craig.
4. Estimate obtained from Andrew Roy.
5. Estimate obtained from Larose Surveys.