Down the Drain: Stormwater Management effects on the Quality of the Westhampton Lake

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Abstract:

This paper examines incidents of illicit discharges on the University of Richmond campus as outlined by the City of Richmond's MS4 permit. Illicit discharges contaminate the Westhampton Lake by flowing from our storm drains directly into the Westhampton Lake. I detected incidents of illicit discharges by performing visual inspections as guided by numerous scholarly articles. The visual inspections were done with a special consideration of land use on campus. Along with the visual inspections, I inspected the storm drains during a dry weather event to find whether there was any flow during this period. In this study, I found several incidents of illicit discharges in the following area: animal feces, construction debris, litter, and flow on dry weather days. Animal feces, which adds *E. Coli* to water, was found throughout campus and especially near the Westhampton Lake where the geese reside. Construction runoff, which increases sediment, was found near Modlin, on New Fraternity Row, and near Marsh hall. Litter, which disrupts species and depletes oxygen, was found all around campus and even in a storm drain. Finally, I found one incident of dry weather flow near Weinstein Hall. The University of Richmond should improve education and regulation of these common incidents of illicit discharge to improve the quality of the Westhampton Lake.

INTRODUCTION AND BACKGROUND

The Westhampton Lake provides ecological and aesthetic benefits to the University of Richmond campus. The lake is a part of the larger James River Watershed. The quality of the lake affects both the ecology and its aesthetics. By protecting the water quality, we will be able to ensure the long-term productivity and overall health of Westhampton Lake. The University "face[s] unique constraints in achieving stormwater regulatory compliance" (Pierce et al., 2021). The University acts as a city within a city; its actions have broader effects on the world. In this research, I will investigate the MS4 legalities and understand the relationship between the University of Richmond and surrounding localities concerning stormwater management. My research question is: To what extent does the University of Richmond comply with the MS4 permit set by the city of Richmond?

Illicit discharges, managed by localities, are instances of contaminated stormwater. Illicit discharges can "degrade water quality, lead to fish kills and loss of species diversity, stimulate algae blooms, and create public health risks" (Steinman, 2015). Illicit discharges can occur from accidental spills and illegal pumping. Overflow of trash, dirt piles from construction, large amounts of pesticide use, and yard debris are all forms of illicit discharge. Walsh (2012) states that stormwater runoff alters water quality as it "degrades streams through altered volume, pattern and quality of flow, presents a problem that challenges dominant approaches to stormwater and water resource management, and to environmental flow assessment." These pollutants alter water quality, ecosystems, and the storm drains themselves. MS4 stands for the municipal separate storm sewer system. The MS4 permit falls under the Clean Water Act to manage and decrease pollutants in the stormwater (Keene, 1995).

In the 19th century, a system for wastewater management was proposed for it to be "collected in urban areas and disposed of outside of the urban environment as quickly and as fully as possible" (Chocat et al., 2001, 62). The system was put in place to protect the sanitation and health of city dwellers. This framework sets the foundation for modern stormwater management. Chocat et al. (2001) discuss the modern goals of urban drainage systems including public hygiene, flood reduction, minimizing pollution, and stormwater retention (63). Increased urbanization makes it exceedingly important to have efficient storm management infrastructure (Bender, 2016, 1). The city of Richmond states that "The MS4 carries stormwater runoff away from streets and neighborhoods directly to streams and the James River. This runoff is not treated before it empties into the water bodies." (citation)

We have numerous storm drains both on and off-campus that lead into Westhampton Lake. In addition to stormwater, these drains pick up leaves, litter, dirt, and anything else that can fit into them, all of which lead directly to the lake. Pollution affects water quality in a variety of ways based on the specific nature of individual pollutants. This process directly affects Westhampton Lake's water quality.VDOT relies on clean-ups, or the " removal of accumulated material from the storm drains… and other infrastructure that make up the MS4" (VDOT, 2021). However, Owusu-Asante (2021) illustrates that inspection and documentation are a no- or low-cost alternative to other methods of detecting illicit discharges. Inspecting sources of pollution can "guide local municipalities whose task it is to control polluted non-stormwater entries into the stormwater drainage system" (Owusu-Asante, 2021, 235). VDOT emphasizes this message in their best management practice: "noting when material is removed from specific storm drains during clean-outs and adding the MS4 service area to the geographic database used to schedule

and report these activities" (VDOT, 2021). Proper monitoring of what is entering our storm drains will promote water quality health in Westhampton Lake.

Another important aspect in understanding how pollutants affect water quality is land use. Steinman et al. (2015) conducted a study in Michigan on stormwater runoff "because of concerns that increased impervious land cover in the watershed… would result in greater stormwater runoff and pollutant loads." Impervious surfaces increase the amount of runoff and allow pollutants to accumulate and be washed directly into water sources. The addition of impervious surfaces decreases the water from being filtered through drainage into the soil (Cambridge, 2020, 1). Our impending climate crisis will exacerbate this issue. Higher precipitation will increase runoff which "can increase the risk of sewage overflows, contaminate local recreational waters, decrease the productivity of agricultural lands, and increase the risk of human illnesses" (Steinman et al., 2015). Other land uses on and near campus include the golf course, eco-corridor, steam plant, and nearby shopping center. Gunawardena et al. (2017) suggest that by identifying land uses, we can identify the nature of the pollutants and equip planners to predict water quality given mathematical modeling.

In my project, I will investigate the University of Richmond’s campus to detect instances of illicit discharges. I hypothesize that there will be instances of water found in storm drains during dry events and there will be instances of illicit discharges on the campus including poop, construction materials, litter, and discoloration of water on rainy days.

METHODS AND MATERIALS

To achieve my goals, I used the University of Richmond's campus to detect incidents of illicit discharges per the city of Richmond's MS4 permit guidelines. I had a two-pronged approach to detecting illicit discharges on the University's campus. I first did this by physically walking through the campus to detect incidents of illicit discharge. I based my visual inspection on common land usages on campus. This includes litter, discoloration in rain water, construction debris, and animal feces. Next, I walked by storm drains and man covers on dry days to see if I could detect discharges from the sewage system itself. I prioritized dry days as literature has shown that "the stormwater network that occurs as dry weather flows are a more significant contributor than wet weather stormwater pollution" (Bender, 2016, 2). This did not show point sources but gave evidence on whether unwarranted substances are entering the storm drains.

Hachad et al. (2022) discuss the many ways to detect illicit discharges including public complaints, visual inspections, changes in temperature, and changes in ammonium. Of these methods, I relied on visual inspections to detect instances of illicit discharges on the University of Richmond campus. I walked around campus three times during April 2022 to detect any incidents of illicit discharges. This gave me insight into what kinds of illicit discharges were present on campus. To analyze my data I will couple the information from the incidents of illicit discharges and storm drain walkthroughs with the outlined legalities in the MS4 permit and the guidelines set by the Environmental Protection Agency (EPA) to understand how the Westhampton Lake fits in with the City of Richmond’s permit. Additionally, I used the data to get a better grasp of what sources need to be tackled to mitigate illicit discharges and decrease the amount of pollution that is entering the Westhampton Lake and thus altering its water quality.

RESULTS

On April 1, 2022, I examined the Richmond side of campus for incidents of illicit discharge. I did a walk through of the campus on April 8, 2022 and on April 12, 2022. There are four main categories of illicit discharges that I checked for based on the University of Richmond campus demographics and land use. The four categories include: animal feces, construction, litter, and impervious surfaces. Next, I checked the storm drains on dry weather days. I did this on April 14, 2022 and April 15, 2022.

Animal feces contributes to the amount of E. Coli pollution in the lake. I found instances of both dog and geese poop throughout the campus on both the Westhampton and Richmond side. The Westhampton side of campus had fewer incidents of poop and mostly that from dogs. I believe this could've been due to the increased usage of campus by non-campus members for both inauguration events and general admissions events. However, there was a large amount of geese poop throughout the Richmond side of campus due to the amount of geese that live on the Westhampton lake and venture near that side of campus.

The EPA lists construction runoff as an illicit discharge due to the amount of sediment that pollutes water sources: "During a short period of time, construction sites can contribute more sediment to streams than can be deposited naturally during several decades… can cause physical, chemical, and biological harm to our nation's waters" (EPA, 2005, 1). Construction debris was something that I found throughout campus with no accordance to significant specific locations. Places where I found construction piles included: near Modlin Center for the Arts, on New Fraternity Row, outside of the Weinstein Recreation Center, and near Marsh Hall. Although I found few instances of runoff (build up of sediment away from the pile) these large piles have potential to run off and pollute water sources especially during high precipitation events.

Litter can cause illicit discharges as "Any trash or pollutants on the streets or lawns travel with the stormwater runoff into our streams and rivers" (City of Richmond, n.d.). The process of breaking down the litter in the lake exhausts oxygen in the river which depletes overall water quality. I found many incidents of litter throughout the University of Richmond campus. Most of this trash included beer cans, cups, pieces of paper, and plastic. Another potential source of litter is overfilled trash cans that can easily sweep litter away by the wind or from animals. I found litter inside of a storm drain, near a lidless trash can, outside of the Weinstein Recreation center. On the Westhampton side of campus, most of the trash cans are tier-2's which are enclosed bins. However, on the Richmond side of campus, especially near the lake, there are many brutes, black, metal bins, and bins with wooden stakes around them. The Gazebo on the Westhampton Lake has a bin with the wooden stakes around them but no top or lid to prevent litter from leaving the trash can. On 12 April 2022, the Boatwright Library had an overflowing landfill bin that was made of the black, metal material with no top to enclose trash.

I found one incident of flow during a dry weather event on campus. This was located in a sewage drain near Weinstein Hall and was recorded on April 14, 2022 and April 15, 2022. Prior to this date, there hadn't been a significant rain event on campus since April 7, 2022. This means that something, other than stormwater, is entering and flowing in the storm drains.

DISCUSSION

Through the usage of case studies, I have found the best approaches to detecting illicit discharges in any given area. Hachad et al. (2022) found that "grab samples with appropriate sampling time (7 to 10 am) were easy to set up and were sufficient to detect and locate illicit discharges efficiently, which was the objective." This illustrates how constant monitoring is effective and efficient in detecting illicit discharges. Owusu-Asante (2021) emphasizes the importance of public education: "Enforcement and public awareness campaigns will be critical components of local government's plans to aect changes in human behaviors and practices that lead to many illegal discharges." These scholarly articles provide us with the justification needed to propose an educational resource that will promote campus-wide knowledge on high priority sources of illicit discharge and thus mitigate the pollution. Using these methods I found several incidents of illicit discharges dispersed throughout the University of Richmond campus including: litter, construction runoff, animal feces, and dry weather sewage flow.

The most important limitation to this study is the inability to identify point sources based on visual inspections. Moreover, Steinmen (2015): "Nonpoint sources of pollution, especially stormwater runoff, are notoriously difficult to manage given their diffuse nature" (Steinmen, 2015). Being unable to note exactly where certain pollutants are coming from, we are unable to get at the source of the issue. In addition to this, the lack of monitoring makes it impossible to know the exact impacts of individual illicit discharges. However, with widespread education we are better able to prevent incidents of illicit discharges. Moreover, if the campus is more knowledgeable about illicit discharges then we are better able to attack the issues that cause them in the first place.

I propose for widespread education on the University of Richmond campus in hopes that education will deter any intentional events of illicit discharges. However, Cambridge (2021) proposes forms of natural water capture to decrease reliance on storm drains. Green infrastructure "uses vegetation, soils, and water retention methods to mimic the natural processes required to manage rainwater and create a healthy environment" (Cambridge, 2021, 1). These methods include rain gardens, permeable pavement, rainwater harvesting, and shoreline stabilization. I believe that education in combination with Cambridge's natural recommendations would be successful in improving the overall quality of the Westhampton Lake and thus the James River watershed.

Keene (1995) lays out and critiques the Virginian permitting process, focusing on NPDES generally, and analyzes whether that is an efficient practice from a legal perspective. After my research, I would argue that the MS4 permit is not enforced heavily enough to truly improve the quality of Westhampton Lake. The permit often states that small scaled problems, such as those we find at the University of Richmond, should be enforced and monitored by the entity that owns the land. This means that there is no entity that is keeping the university accountable for the amounts of illicit discharge. Although they may be minute in the grand scheme, our contamination can accumulate and add to the overall pollution in the James River Watershed. I propose that the University of Richmond becomes more acquainted with the ideas and best management practices in how to effectively detect and prevent incidents of illicit discharge. The University of Richmond should follow the Best Management Practices set forth by the Environmental Protect Agency, Virginia Department of Environmental Quality, and even Virginia Department of Transport.

The next steps for this project would be to find a cost-efficient way to monitor the true effect of the listed illicit discharges on the water quality. This should be taken a step further than visual inspections to best eliminate incidents of illicit discharges. We would need to quantifiably measure levels of *E. Coli*, sediment, and oxygen levels. The outdoor brute trash cans should be replaced with the tier-3 trash cans which offer compost and recycling options. This decreases the amount of trash that goes to the landfill and prevents the wind from blowing overfilled trash cans away. Construction debris should be contained over tarps that help to prevent runoff and thus sediment accumulation in the Westhampton Lake. Geese management and dog litter bags will help to prevent the amount of animal feces and *E. Coli* in the lake. Moreover, the dry weather flow must be examined and the flow must be redirected out of our stormwater drains to be in compliance with the MS4 permit. Finally, there should be increased education and awareness of the common illicit discharge sources on campus. This education should be put out for the entire campus body including students and faculty, local residents, and all facilities staff.

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