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French Drain Design for the Town of Edmonston

COURSE

ENST481: Ecological Design

PALS

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ABOUT PALS

The Partnership for Action Learning in Sustainability (PALS) is administered by the National Center for Smart Growth at the University of Maryland, College Park (UMD). It is a campus-wide initiative that harnesses the expertise of UMD faculty and the energy and ingenuity of UMD students to help Maryland communities become more environmentally, economically, and socially sustainable. PALS is designed to provide innovative, low-cost assistance to local governments while creating real-world problem-solving experiences for University of Maryland graduate and undergraduate students.

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EXECUTIVE SUMMARY

Flooding has been a continuing issue for the town of Edmonston, Maryland. Funding, space, and labor availability constrain efforts to address the issue. But a French drain system could be a solution, as detailed in this report. Specifically, the report focuses on assessing the feasibility of a proposed French drain design and its ability to reduce flooding in Edmonston.

The proposed design is fully passive, low-cost, adaptable, and low-profile. It promotes infiltration, prevents drain clogging, and can direct high volumes of water during storm events. These features meet the town's goals, which were set prior to the prototyping process.

Edmonston is located along the Northeast Branch of the Anacostia River, in a low-lying floodplain, downstream from College Park. Due to this proximity and as a highly urbanized area, the town faces significant amounts of runoff. Its flat topography contributes to water pooling. As a result, the drainage systems are overwhelmed, leading to repeated flooding events. Furthermore, the town also experiences drains clogged by gravel runoff from nearby gravel lots. Given these characteristics, a French drain system may be the best solution.

A French drain is a perforated pipe set on a gravel bed approximately six inches below the surface with the perforations facing down, to prevent clogging and promote natural infiltration. The pipe is wrapped in geotextile fabric to protect it, and cleanout points are located throughout the design to allow for maintenance. To implement this design, an approximately 24-inch tapered trench will promote water pooling in the bottom. The hole will be lined with geotextile fabric then filled with gravel.

This is an affordable solution based on calculations for 49th Avenue, which experiences regular flooding, according to town officials. The cost of ¾-inch gravel is $30 per cubic yard, six-inch PVC pipe is $8 per foot, and geotextile fabric is 35 cents per square foot (Home Depot), for a materials cost of $12.60 per linear foot. The cost for the 950 feet of 49th Avenue, the entire street, is $12,000.

Installing a French drain here can manage 100% of a 0.25- and 0.5-inch storm. The system would be able to manage 20,459.22 gallons of water, and if the drain is installed on both sides of the street, the capacity will double. While this design may not be able to eliminate the flooding issue, it will provide significant reductions.

Based on the analysis, a French drain design is recommended for Edmonston. French drains meet the outlined goals by being low-cost, low-energy, low-maintenance, and versatile, while reducing flooding and promoting infiltration. One potential issue is plant roots clogging the perforations. However, wrapping the piping in geotextile fabric, providing sufficient gravel coverage, and implementing cleanout points throughout the system will help prevent this.

For larger scale installations on public property, funding, permits, and community engagement will be essential. Smaller installations, for example in backyards, can be

done more easily, and as a result risk prone areas can be addressed immediately. Overall, this solution offers a practical and scalable solution for the town of Edmonston's flooding issue.

INTRODUCTION

Edmonston is a small, tight-knit community, less than a half-square mile, two and a half miles from Washington D.C. in the Maryland suburbs, with a population of about 1,600 residents (U.S. Census). Town leadership has a strong focus on sustainability, seeking to solve problems in the most eco-friendly and cost-effective way.

The town has a long history of flooding stemming from the nearby Northeast Branch of the Anacostia River. Flooding is exacerbated by the town's low elevation, approximately 20-feet, and its location in the Chesapeake Bay Watershed. The town is toward the end of the watershed and flood waters accumulate and intensify as they travel toward the Bay, causing flood damage that could have been avoided if upstream communities had better stormwater management practices.

Accordingly, the town must take extra measures to protect residents from water damage to their properties. Currently, the town plans to construct more than 100 rain gardens by the end of 2025, a large number given the town's small size (Green Street Project).

With growing concerns of climate change impacts on low lying communities like Edmonston, how susceptible is it to the impact of more intense storms and rising sea levels? A study by the Pacific Northwest National Laboratory found in a simulation that increased global temperatures indicated a 43% increase in tropical cyclones (Lalo, N.). These results are relevant to the Town of Edmonston because 95.4% of its properties are at risk of flooding in the next 30 years. Overall, the town is assessed to have a severe flooding risk (First Street). Edmonston has had extensive damage caused by past flooding, including a particularly devastating flood in September 2020, when rainfall accumulation was reported to be almost six inches (Samenow, J.). Given this past record and future predictions, it's safe to assume that the Town of Edmonston is particularly prone to climate change induced damage.

Considering this, a French drain system, which is a cost effective, sustainable, low-profile solution to flooding, could be implemented by homeowners without the help of contractors or special resources. French drains comprise a trench filled with gravel and river rock to promote infiltration, set with a perforated PVC pipe covered in geotextile fabric to move excess stormwater when the water table rises.

A Florida Department of Transportation study highlighted the advantages of a French drain system in urban areas, stating that they are "especially useful when there is limited land area to devote to storm water management" (Nam, B.H.). Dealing with limited land area is essential in Edmonston, as any proposed stormwater solution would need to work for residents on small lots.

The French drain's perforated bottom covered by geotextile fabric is particularly appealing. One sustainability leader in the town noted that stormwater systems often experience sedimentation and gravel clogs. As well, French drains promote natural infiltration of stormwater before the pipe drainage system is activated. Stormwater runoff flows through the trench into the ground until the water table reaches the level of the pipe. At this point, stormwater is diverted to the main stormwater system, which should be experiencing a decreased volume of stormwater runoff because of the natural infiltration from the French drain system. These benefits align with Edmonston's sustainability goals and its desire to protect the environment while also protecting residents.

OBJECTIVES

The goal of this project is to create a low-cost, low-maintenance design for Edmonston to reduce flooding issues and promote infiltration. The feasibility study to meet this goal includes determining the locations most vulnerable to flooding, evaluating low-cost and low-maintenance designs, evaluating the designs' potential to reduce stormwater burden though passive infiltration, and assessing the scalability and fit for the town.

French drain designs are nature based, low energy use, and adaptable to storm conditions, which aligns with the sustainable infrastructure and climate resilience clauses of the Green New Deal (Sierra Club, 2018). Furthermore, these drains design address the Green New Deal's environmental protection clause because they can reduce nutrient pollution and runoff through infiltration. As well, this project's focus on serving a diverse community facing environmental and social struggles by reducing flooding with low-cost strategies and creating local job opportunities, aligns with the equity and justice and the job creation potential clauses of the Green New Deal (Sierra Club, 2018).

METHODS

Ecological Design

The ecological design goal is to promote infiltration and prevent flooding and pooling. This occurs using the gravel void that increases the infiltration rate and decreases the retention time. A French drain can filter water by using a biofilter or geotextile fabric that improves water quality recharged into the soil.

Flood prevention occurs through the perforated overflow pipe that can capture and direct water if the water level gets too high. The pipe has holes on the underside so that water enters from the bottom. The water level must reach a certain height before the passive overflow system activates. The overflow can be routed to existing

stormwater management infrastructure or even other control practices like rain gardens or bioretention cells.

Scale

This project focuses on 49th Avenue, which has been identified as a flood prone area. This street was selected due to its high use, high flooding risk, the presence of impervious surfaces, and its proximity to the Northeast Branch. The cost analysis and runoff calculations were made for this 950-foot-long street. Focusing on 49th Avenue allowed for realistic cost estimates and stormwater capacity modeling.

Literature Review

The literature review for this report was conducted using the website Science.gov, which provides access to authoritative scientific research results from US federal agencies. Keywords used to search this database were: “French drain” and “flooding.” These keywords yielded thousands of results in research data and reports, so they were filtered to only include the most relevant and recent studies. From the most relevant results five sources were used in this report to provide additional information to the prototyping stages and site visit.

RESULTS

Figures 1 through 3 depict two module versions, with images on the left showing a cleanout, on the right with no cleanout. For both modules the design uses a ¾-inch gravel particle void at a depth of 22 inches, contained by geotextile fabric on a 12-inch base with walls extending diagonally upward at 97.13 degrees reaching a depth of 17.5-inches.

The gravel void is capped with two inches by 17.5 inches of decorative river rock, flush with the ground and contained by stainless steel dividers. A six-inch diameter PVC pipe with bottom perforations is placed 12 inches from the bottom. The pipe is wrapped in geotextile fabric to prevent the entry of foreign substances.

The cleanout module is a four-inch diameter PVC pipe that extends perpendicular from the side of the six-inch pipe for 2.85 inches. At a 90-degree bend, the cleanout pipe is directed to the surface. After the bend, the pipe extends eight inches, leaving one inch of clearance horizontally between the side of the trench surface and one inch vertically between the ground surface. The cleanout is capped with a removable piece, one-inch high and 4.5-inches in diameter.

The materials listed are: ¾-inch gravel, decorative river rock, geotextile fabric, stainless steel dividers, four-inch and six-inch diameter PVC piping.

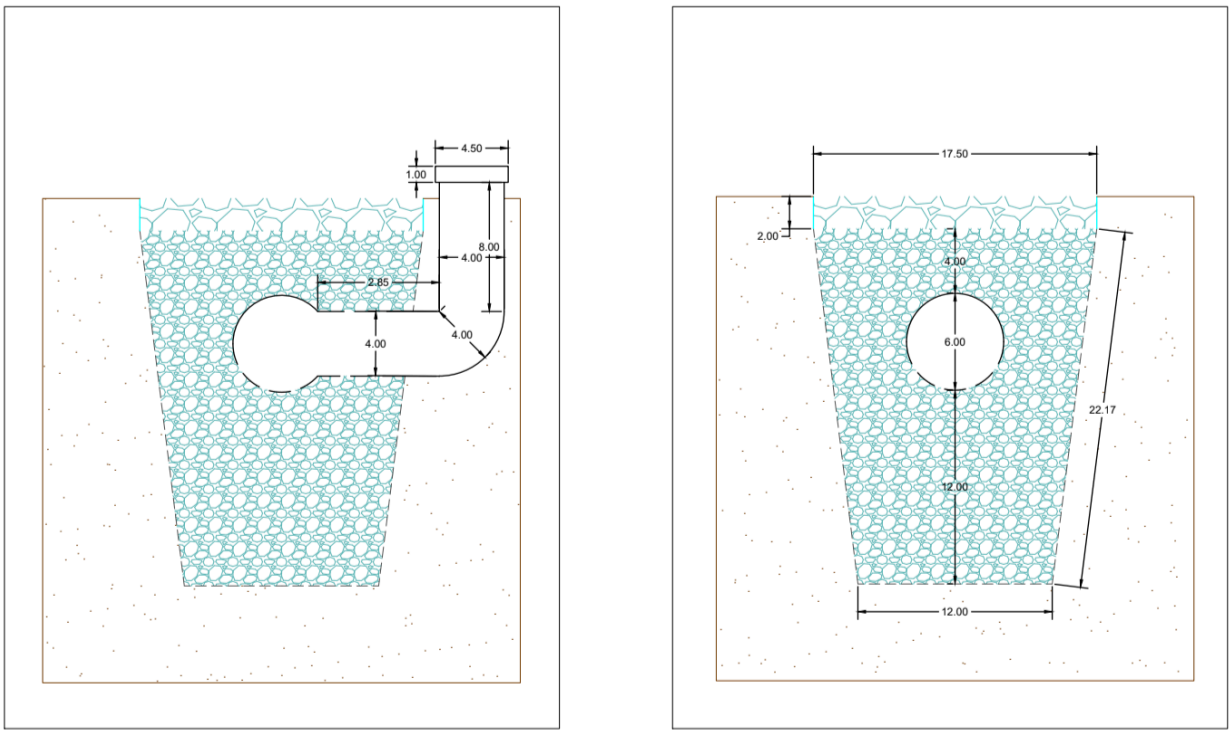


Figure 1. AutoCAD rendering of the front-facing cross section of the trench drainage system, including dimensions.

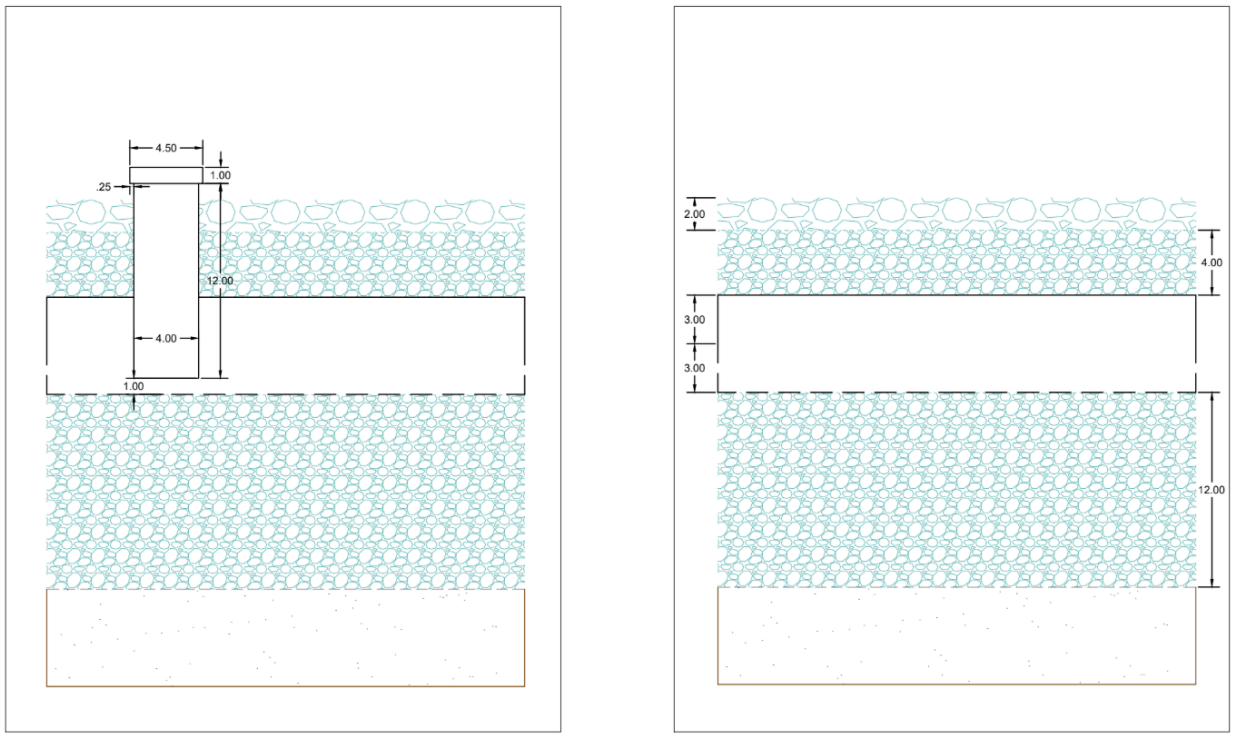


Figure 2. AutoCAD rendering of the side-facing cross section of the trench drainage system, including dimensions.

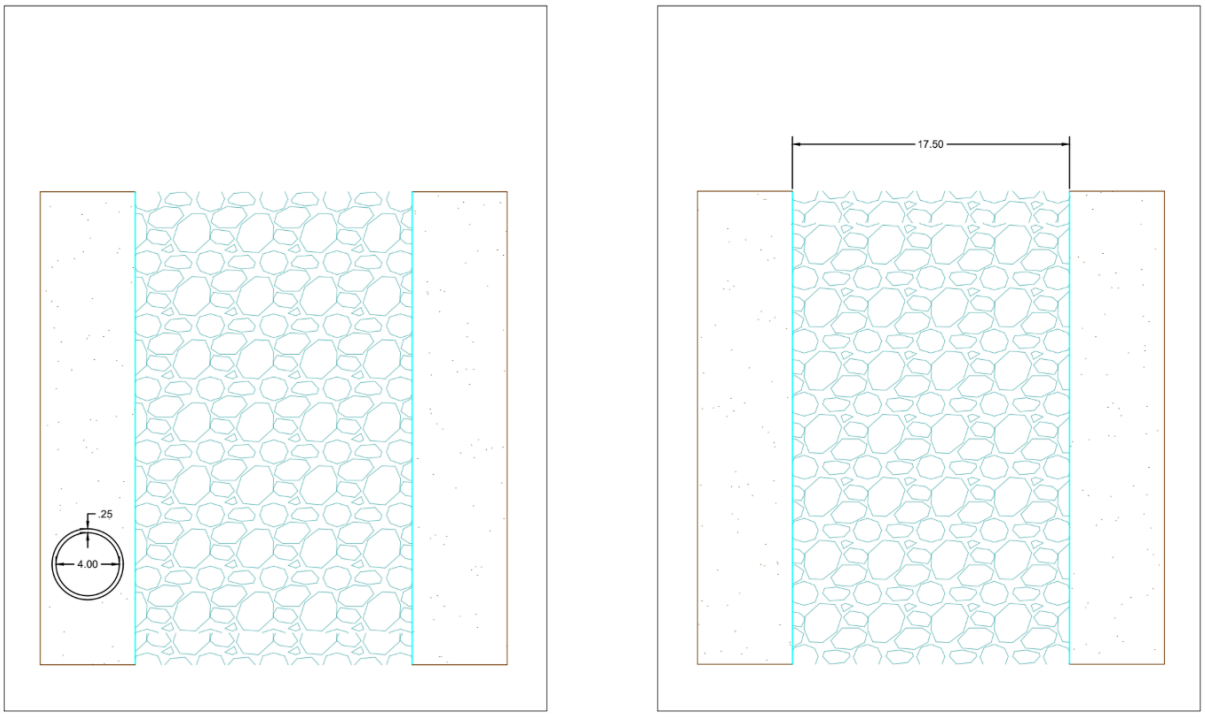


Figure 3. AutoCAD rendering of the top-down view of the trench drainage system, including dimensions.



Figure 4. SketchUp three-dimensional rendering of the PVC piping system, including the cleanout.

Figure 4 shows the perforations on the downward facing sides of both the main six-inch pipe and the four-inch perpendicular cleanout pipe. The perforations are ½-inch holes, sized to block gravel particles from the piping system. The perforations are spaced every four inches. Note the size difference between the main six-inch pipe and

the four-inch cleanout pipe, as well as the 90-degree corner bend. As a modular system the main pipe can extend indefinitely, whereas the cleanout module should be placed every 100 feet or closer as necessary.

This proposed drainage system is composed of eight parts: ¾-inch gravel, decorative river rock, six-inch PVC SDR 35 pipe, four-inch PVC SDR 35 pipe, four-inch pipe cap, four-inch 90-degree pipe bend, geotextile fabric, and steel edging. In this modular system the cleanout module is placed every 100 feet or less. Most of the system is composed of only five parts: ¾-inch gravel, decorative river rock, six-inch PVC SDR 35 pipe, geotextile fabric, and steel edging.

The largest material cost is the ¾-inch gravel, which can be acquired in bulk for as low as $39 per ton (Noel). The decorative river rock costs $36 per cubic foot (Home Depot). Six-inch PVC SDR 35 can be found for $6.10 per linear foot (Saber Sales). Non-woven geotextile fabric costs about $0.70 per square foot (Sandbaggy). The two-inch steel edging completes the assembly at $1.70 per linear foot (Lowes). The total cost is estimated to be $21.95 per linear foot.

The additional parts costs for a cleanout module are: four-inch PVC SDR 35 pipe at $1.65 per linear foot, four-inch removable pipe cap at $13.60, and a four-inch 90-degree pipe bend at $4.95 making the total cost for the cleanout assembly $20.04. The combined cost for one linear foot of the cleanout module is $41.99. Given these costs, a cleanout module placed every 100 feet along a 1,000- foot trench will total $21,930.90.

This proposed system is similar to a traditional French drain, a system with widespread implementation, so existing installation data can be used to estimate the labor cost, including trench excavation, laying perforated pipe, adding gravel, and backfilling. Based on sites like HomeAdvisor that compile data on installations there is an established national average of $25 to $50 per linear foot. The proposed system is designed for individual sites along previously graded roadways, so it should fall into the low-end estimate of $25 to $30 per linear foot (“How Much Does It Cost to Install a French Drain?” [2025 data]). This includes markups for profit margins.

A construction timeline can be estimated by looking at historical projects. Consultant sites such as Drainage First and Bioclean CT claim a short installation time, from two to seven days for systems between 50 to 1,000 feet in residential areas (DrainageFirst) (John). This assumes the customer has acquired permits and defined the area. Trenching can take between two to three days at 300 to 500 linear feet per day (Lonestar) The timeline also needs to account for site preparation, bedding the gravel, installing the pipe, and backfilling (Lonestar).

The primary objective of the proposed system is to mitigate stormwater runoff through retention and conveyance. Based on the porosity of ¾-inch gravel and an area of 2.2535 cubic feet per linear foot, the retention capacity is estimated to be 5.92 gallons per linear foot. To determine the system’s conveyance, we applied Manning’s formula

for flow rate in open channels (Oregon State University). The cross-sectional area of a six-inch diameter pipe is 0.1963 square feet, the weighted perimeter per linear foot is 1.5708 feet, and the hydraulic radius is 0.125 feet, for a conveyance of 14,542.12 gallons per hour.

Using the spatial constraints of a typical urban right-of-way—a 30-foot-wide roadway with five-foot sidewalks on both sides (MDOT)—an estimate for runoff per 1,000 feet can be determined. These measurements along 1,000 feet of roadway create 40,000 square feet of impervious surface. Using the Rational Method for runoff, with a coefficient of 0.95 (California State Water Resources Control Board), per inch of rain on 40,000 square feet of impervious surface there is an expected 23,688.31 gallons of runoff. Across 1,000 feet the system's retention is 5,917.09 gallons, and the conveyance is 14,542.12 gallons per hour, a combined 20,459.22 gallons per hour. This means 86.37 percent of runoff from each inch of water per hour can be retained or conveyed by the drain system.

DISCUSSION

The expected outcome of the proposed French drain system is to promote natural infiltration so that heavy rain doesn't cause pooling or flooding and then allow for the excess water in heavy storms to be directed out of the system through the pipe. This system would accommodate runoff from most smaller storms without the help of the pipe and in an entirely natural process, while still ensuring a safety measure to handle more water. This is especially important in Edmonston given the town's well-documented history of flooding.

A French drain system is designed to use natural water flows along the path of least resistance, using gravity for natural infiltration and capturing excess water in a pipe once its level rises high enough (Dale, 2024).

This system is easy to scale up, the only issue is permits, which came up in the presentation to the Green Team and town administration. Costs are reasonable. Based on projected dimensions, materials would cost around $21.95 per linear foot. For 49th Avenue, the materials would cost around $12,000.

This prototype could be extended through small installations in yards that have water pooling. The work can be done by the individual or a contractor, but the town could incentivize it or pay for it to support less overall flooding.

This system can be seamlessly integrated with the surrounding environment. The surface can be finished with river stones, mossy grass, or even native plants to blend in and look attractive. It is both a functional and aesthetically pleasing solution. French drains are easy to install compared to other stormwater best management practices and can be installed without professional help.

There are some unknowns in the installation process. The costs estimates here are based on bulk purchasing, but what about the backyard scale solution? It would be

more cost effective for the town to purchase bulk materials and pass the lower costs to homeowners. The town should also investigate a sustainability grant, or other type of grant, which could fund the town's purchase of materials. Any solution should not burden property owners, especially if they want professional installation. The town should provide this service because flooding on private property affects the whole community.

The implementation of French drains in other communities are primarily small-scale designs installed by private property owners. Scaling up this prototype is a way for a large-scale French drain system to be installed throughout Edmonston to address flooding. With potential grants and town budgeting, buying materials in bulk will help keep this a cost-effective solution.

As the calculations indicate, if the length of 49th Avenue were fitted with a French drain system on just one side, there would be no flooding from rain events up to just over one inch. This appears to be the best solution at this scale.

RECOMMENDATIONS

Based on this report's information and results, the proposed design is a good fit for Edmonston. The low-cost and low maintenance design makes it a simple flooding solution to implement, and it will not require much upkeep. Furthermore, the design's versatility makes it simple to apply in a variety of places, whether a backyard or along a street. This versatility means that the flooding will be directly addressed since the French drain can be placed in the most flood prone places.

One issue with the system are plant roots potentially clogging the pipe's drainage holes. It would take at least a year to appear, and wrapping the pipe in geotextile fabric can protect the piping while allowing water to pass through. Furthermore, during installation creating a sufficient gravel bed can help block roots.

Also, sediment can build up in the piping. While the gravel and river rock will help mitigate clogging from leaves or larger particles, sediment may still accumulate. Cleanout points along the length of pipe will allow for inspections and maintenance, such as cleaning out sediment. These cleanout points can be placed at any point throughout the design.

Before constructing French drains in large public areas, permits and funding will be necessary. For smaller areas, like a backyard, pre-approval isn't necessary, and the design can be implemented once funding has been acquired and the installation process has been determined. To implement this system in public areas, such as a street, permitting and zoning approval is required. Additionally, mapping flood-prone areas and engaging with the local community can be helpful in determining which areas to prioritize, ensuring the solution is implemented where it is most needed. Submitting grant proposals to acquire funding will also be another crucial step for this project to come to fruition.

TEAM CONTRIBUTIONS

Jacob Amster

Over the semester, I helped with the brainstorming process when we were trying to decide if we wanted to work on a solution for Edmonston. I also helped build the prototype as well as fulfilling my part for all group activities, like PowerPoints, websites, and presentations. On average I spent about one and a half hours both in class and lab and outside of class on this project. For this paper, I wrote the Discussion section and part of the Methods section.

Masha Berezina

During the semester, I helped develop and decide on the final idea, determined the tasks, and delegated work assignments. Each week, including lab and independent work time I averaged about two and a half hours on this project. For this report I worked on the Executive Summary, Objectives, Methods, and Recommendations sections.

Hannah Johnson

For this project I focused on the Town of Edmonston and how our solutions could best benefit the community, as well as on the cost analysis and applicability of the prototype. I took extensive notes on the field visit about the different areas of town, and how we could provide the most flooding relief in the least intrusive, and most cost-effective way. On average, between class time, labs, and independent work, I spent about two hours a week on this project. For this paper, I wrote the Introduction, conducted the literature review, and wrote a portion of the Methods section.

John McDermott

For this project I was responsible for leading the technical aspects of budgeting, visualizing, and data management for the prototype and the ideal real-world system. Most of my time was spent in AutoCAD and SketchUp visualizing the product as we progressed through the iterative design process and running calculations for each iteration to determine the capability and capacity of each version. I contributed to budgeting and assembling the prototype and was responsible for leading the demonstration during the final presentation. In this paper, I expanded on those roles in the Results section.

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