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Cover Page Footnote

Appendix VII: Acknowledgments I would like to extend my sincere thanks to my project peers Oliver Bhamani, Hanna Fulford, Conner Poort, and Garrett Moran. I also wish to thank Dr. Lindsey Payne, my writing mentor and our faculty project supervisor as well as our community partners at Lafayette Renew, Scott Ahlersmeyer and Vanessa Rainwater. Thank you to Purdue University for providing our team with a grant to pursue and install this project.

SERVICE-LEARNING IN ACTION

Lafayette, Indiana, Rain Garden Installation

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STUDENT AUTHOR BIO SKETCH

Elizabeth McCleery is a first-generation Boilermaker from Greenfield, Indiana. She received her BS in environmental and ecological engineering with a minor in environmental politics and policy in 2022. Her experience includes public-sector energy diversification, health care sustainability, COVID-19 tracking via wastewater, and infrastructure design. Elizabeth plans to pursue a career in sustainability and has accepted a position at an engineering consulting firm, CDM Smith.

ABSTRACT

Indiana's Wabash River is being polluted with contaminated water runoff from precipitation events. A lack of pervious land cover has led to an accumulation of fertilizer, sediment, and waste in the river. Green infrastructure, a stormwater management practice that mimics the natural ecosystem, is one of the most effective ways to prevent pollution from stormwater runoff and benefit the community. This project consisted of a rain garden installation at the Lafayette Fueling Station, a site where frequent water drainage and water runoff into the Wabash occurs. The rain garden will allow on-site water infiltration during rain events and promote natural pollutant removal underground. Further, students had the opportunity to engage with community partners at Lafayette Renew, the City of Lafayette's division in charge of stormwater management. This experience and its challenges and successes can be used as a reference for others pursuing community volunteer efforts. While this rain garden is a positive addition to the city's green infrastructure projects, more installations in this course and beyond that utilize best management practices are recommended in order to protect the Wabash River and promote sustainable development. The rain garden will prevent pollution from contaminating the Wabash and downriver bodies of water such as the Gulf of Mexico. This project has allowed me to reflect on the impacts that community service can provide to communities not only near the site of the project but also hundreds of miles away. The project has also allowed me to reaffirm my commitment to making the world a cleaner place through my work and volunteer efforts alike.

INTRODUCTION

The Wabash River is a symbol of Hoosier culture and is a vital aspect of the Greater Lafayette community (Lafayette/West Lafayette, n.d.). The state song, "On the Banks of the Wabash, Far Away," is an ode to this river (Indiana Historical Bureau, 2020). Even its name, derived from the Miami Indian term for "water over white stones," is a reminder of the significance of the river to those who inhabited these grounds centuries ago (Indiana Historical Bureau, 2020). Unfortunately, Indiana's state river is no longer "pearly white." The Wabash is heavily polluted by stormwater that brings sediment, salt, excess nutrients from fertilizers, and pet waste off of the surrounding watersheds and into the river (Kilbane, 2014). The Wabash River watershed is 33,000 square miles and includes over 4,366,000 people (Tippecanoe County, n.d.). Further, communities of color and low-income communities are 40% more likely to experience health issues as a result of polluted bodies of water and unsafe drinking water conditions (Natural Resources Defense Council, 2019).

The Greater Lafayette community is heavily impacted by pollution coming from the combined sewer overflow systems of both Lafayette and West Lafayette (Kilbane, 2014). In a combined sewer overflow system, stormwater runoff flows down storm drains and is carried to the local wastewater treatment plant by pipes that also carry sewage. The stormwater runoff that makes its way into the storm drain picks up sediments, salts, excess nutrients from fertilizers, and pet waste. In the event of heavy precipitation during extreme weather events, the sewage and polluted stormwater overflows directly into the Wabash River, threatening aquatic life (Environmental Protection Agency, n.d.). Climate change is causing an increased frequency of these extreme weather events and thus increased pollution levels. Implementing practices to ensure natural water infiltration is key to preventing further pollution, protecting vulnerable communities, and revitalizing the Wabash River.

One notable practice for achieving these goals is the installation of green infrastructure. This method of pollution prevention is an approach to water management that protects, restores, or mimics the natural water cycle. Types of green infrastructure include best management practices (BMPs) such as rain gardens and bioswales as opposed to gray infrastructure such as pipes and culverts. Utilizing BMPs can reduce the amount of untreated water entering the Wabash River by naturally diverting it from running off, instead infiltrating it directly on-site into the ground. As a result, green infrastructure increases the health of local waterways and in this case the Wabash River.

This project will install a rain garden at the City of Lafayette Fueling Station and take a small step toward securing a clean and healthy future for both the Wabash River ecosystem and the Lafayette community. The project will also aim to educate the general public on the benefit of rain gardens and green infrastructure. This educational aspect is an integral part of the project. In a recent urban residential survey, although 82% of Greater Lafayette residents agreed that it is their personal responsibility to protect water quality, only 91% of respondents were somewhat familiar with rain gardens (Gao & Church, 2016). Thus, it is important to not only implement rain gardens in Lafayette but also involve the community, thereby nurturing public support for future green infrastructure installations.

This project was made possible through a community service-based course at Purdue University, "Environmental and Ecological Engineering 495: Urban Water Projects." Purdue students interested in bettering the local community through volunteerism are encouraged to take this course. In this course, a team of students collaborate with community partners to design and implement small-scale urban water projects, such as rain gardens and bioswales, and gain professional engineering experience—design, communication, teamwork, grant writing, budget management, and leadership—as they oversee a project from inception to implementation. Learning outcomes include working with stakeholders, becoming an active member of the community, and taking responsibility for the social, economic, and environmental impacts of a real-world project.

DESCRIPTION

Community Partner and Site Description

This course project was implemented with Dr. Lindsey Payne and community partner Lafayette Renew, which is the City of Lafayette's division in charge of stormwater management serving over 72,000 citizens. Scott Ahlersmeyer, stormwater foreman, and Vanessa Rainwater, green infrastructure manager, from Lafayette Renew worked directly on this project. Renew's goals in protecting water quality and the environment as well as its application of sustainable practices were in line with the course's goals in creating green stormwater infrastructure. Both Ahlersmeyer and Rainwater had extensive knowledge and experience in implementing green infrastructure projects, specifically in Lafayette.

The Lafayette Fueling Station is located at 111 S. 2nd St. in Lafayette, Indiana. The fueling station site was a unique opportunity for furthering education and usage of green infrastructure in Lafayette. Due to its high-traffic roads and the fueling station's use by city employees, this was a site with potential to demonstrate and communicate the importance of BMPs in the community. The main structure on the site is an open-roof building containing fuel tanks. The building is surrounded by a grassy area where the rain garden will be located. Figure 1 shows an aerial view of the site with the rain garden area circled in red. The grassy area is slightly sloped toward the location of the proposed rain garden.

Figure 1. Aerial Site View with Marked Rain Garden Area

A hose leads out from the building to this area. After one or more rain events, the open-roof building housing the fuel tanks is drained and releases all water into the grassy area, where it runs off into storm drains down the road. Erosion is apparent on the site from this runoff.

Project Collaboration

The initial design charette with community partners Ahlersmeyer and Rainwater of Lafayette Renew set the stage by establishing the main project objective: managing the range of water volumes that are irregularly drained from the fueling station while connecting with city employees to educate them on the importance of green infrastructure. The design also provided an opportunity to discuss team and partner capabilities. Due to differing levels of expertise and experience, a transdisciplinary approach was established for the project. The team handled the overall design of the project, such as determining site specifications, creating a site-specific design, and creating educational outreach material. Renew used its experience managing rain gardens to set project goals and provide design feedback. Additionally, during implementation Renew handled the construction side of the project and used its materials, experience, personnel, and equipment to ensure a successful installation. These complementary skills allowed the project to be designed in a way that reduced cost and maximized design effectiveness.

Initial data collection for the project included a neighborhood immersion walk in which the team assumed the role of participant observers and explored the area to gain a better understanding of the community and infrastructure around the site. This activity prompted the idea of art to engage the community and connect to the "Wabash Walls" art installations. A percolation test was performed to measure the infiltration of water over a period of time to establish an infiltration rate. A rain garden calculator provided in the course used the infiltration rate to calculate the necessary surface area and depth of the rain garden. Modifications such as reduced depth and increased surface area were made to overcome simplifications made by the calculator. Site measurements were then taken to fit the preliminary rain garden design to the site. The location of the water output from the building and obstacles, such as a spigot and a manhole cover, greatly influenced the rain garden's location and shape. This also helped determine the placement of the educational materials to maximize visibility toward the city workers and general public based on available space around the rain garden.

Regular meetings and communication with the community partners through email were necessary to keep the project moving forward throughout the design process. When more information was needed, Ahlersmeyer and Rainwater were able to connect the team with outside resources, such as city engineers who could provide the building's maximum water capacity. As the design phase concluded, Lafayette Renew has reduced project costs by supplying materials such as soil and stone and providing in-house labor and equipment. By working together to draft a comprehensive installation plan, those participating in this project ensured a successful installation of the rain garden by the end of the semester.

Rain Garden Design

The primary goal of this project was to absorb and filter water output from the Lafayette Fueling Station to divert it from the Wabash River and infiltrate it directly into the ground. The water is also not tested for contaminants before release, meaning that pollutants such as volatile organic compounds (VOCs) could be present. Installing a rain garden that could manage the irregular pattern of water is a novel problem that required distinct strategies for water management, placement, plant type, and maintenance. The volume of water being released was the primary motivation behind choosing a rain garden for this site. Rain gardens can handle 30% more water absorption and filtration than a lawn of the same size (San Francisco Baykeeper, 2020). In Lafayette, the annual average rainfall is 43.63 inches, or 3.64 inches per month (National Weather Service, 2022). However, the rainfall amount alone is insignificant compared to the volume of water that could be expelled from the enclosure. This volume is, at maximum, 14,759 gallons.

The rain garden design shown in Figure 2 features a dry riverbed to channel the water away from the building. The riverbed curves around the spigot and runs along the driveway. Replacing the currently used hose with a dry riverbed will eliminate the issue of clogging. Because the design will be gravity powered, no additional equipment with maintenance needs will be required. The dry riverbed will empty water into the rain garden's preliminary native grass section, which should remove any VOC contamination. A slope from this section leads the water into the flowering area of the rain garden. The dimensions for the rain garden are shown in Figure 2. Native plants for the garden were chosen with the following criteria in mind: available at local Spence's Nursery, weather-resilient, variable in look and bloom time, and VOC tolerant. These flowers chosen were purple coneflower, blue false indigo, heath aster, and black-eyed susan. Their characteristics are shown in Table 1.

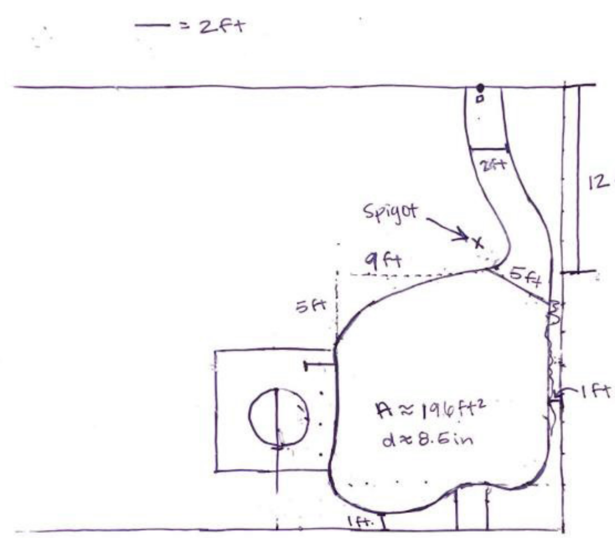

Figure 2. Rain Garden Design

Table 1. Comparison of Plant Characteristics

	Prairie Dropseed	Purple Coneflower	Blue False Indigo	Cream False Indigo	Bottle Gentian
Sunlight	full	full, partial	full, partial	full, partial	full, partial
Moisture	medium	medium wet	medium	medium	medium
Height	1–3 ft.	3–4 ft.	2–4 ft.	1 ft.	1–2 ft.
Bloom time	July–September	June–August	May–June	May	September–October
Bloom color	green, cream	pink, purple	purple	cream, yellow	blue, purple

The overall design of the rain garden and plant selection therein serve to maximize sustainability through green practices. The rain garden should capture and infiltrate all water from the building and prevent it from becoming runoff and entering a storm drain. VOCs should also be removed by the grass, improving the overall quality of the water. The native plants will help improve air quality and attract pollinators, which are critical for maintaining a healthy ecosystem and improving genetic diversity among plants in the area.

The maintenance plan given to Lafayette Renew was also designed to provide volunteers and city workers with the tools required to easily maintain the garden. Renew is planning to have an annual summer internship program that will focus on the maintenance of Lafayette's green infrastructure, ensuring maintenance for the summer months. For the purposes of this rain garden, the maintenance plan will be used for interns who are responsible for maintaining Lafayette's green spaces. The plan will also be used to help the next person who has Rainwater's position at Lafayette Renew. The maintenance plan includes information about the native plants including height, water requirements, sun requirements, color, bloom time, and any additional notes that are important to know. For example, the plan includes that prairie dropseed is a clumping grass, meaning that it is not likely to spread and take over the whole garden. The maintenance guide also includes pictures of the native plantings at different times of the year. This is to help with identification of natives to ensure they are not accidentally pulled as weeds. The maintenance plan also includes common weeds, including picture identification. This is also to help with identification and ensuring that the native plants are kept safe. Many weeds are shown at different stages so they will be identifiable even in early growth stages. The maintenance plan also includes best practices and tips for weeding, watering, and mulching the garden. Figure 3 shows the plant installation guide.

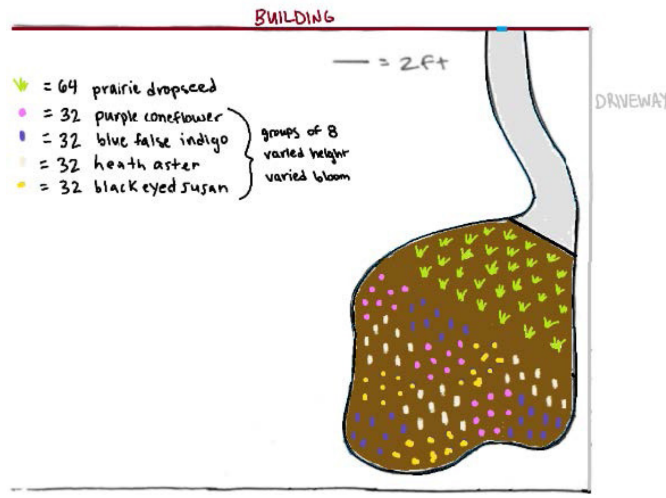

Figure 3. Plant Installation Plan

COMMUNITY IMPACT

Ultimately, the rain garden will divert 7,100 gallons of stormwater per year from the Wabash River as well as reduce nitrogen, phosphorous, and sediment loading by 0.48 pounds per year, 0.03 pounds per year, and 33.72 pounds per year, respectively. Another key impact of this project will be using the educational potential of this site to educate the city employees who fuel their vehicles at the station. The physical location of a sign can make a large difference in terms of whether it is viewed. Therefore, an educational sign faces the fueling station so that city employees can read the sign while fueling their vehicles. The fueling station team has also decided that it would be more beneficial to focus the educational content on why rain gardens are useful and important instead of how they work. The hope is that educating city employees on the importance of rain gardens will get them interested in learning more about the gardens. Items on the sign (Figure 4) include the amount of water the rain garden prevents from going into the Wabash River on a yearly basis, the importance of native plants, and the environmental harm caused by excess stormwater in the river.

In order to create more interest in the garden and the educational sign, garden gnomes that represent each of the city departments were placed in the garden. This artistic element features city department–themed gnomes, specifically the Fire, Police, Streets, and Parks Departments. This addition adds individuality to the rain garden and also attracts the attention of city employees using the Lafayette Fueling Station. Representation of the city workers at the site is likely to make them feel more a part of this project and want to learn more.

The team has also developed an educational game for Wabash Riverfest, an annual event attracting over 8,000 attendees and aimed at educating the public on the Wabash River and its importance. This activity is more directed at a younger audience, in contrast with the sign. The game is similar to hopscotch, and the participants will roll a die, hop to that spot, and answer a question relating to green infrastructure in order to stay on their spot. Incorporating a fun activity into learning will make the participants more eager to learn.

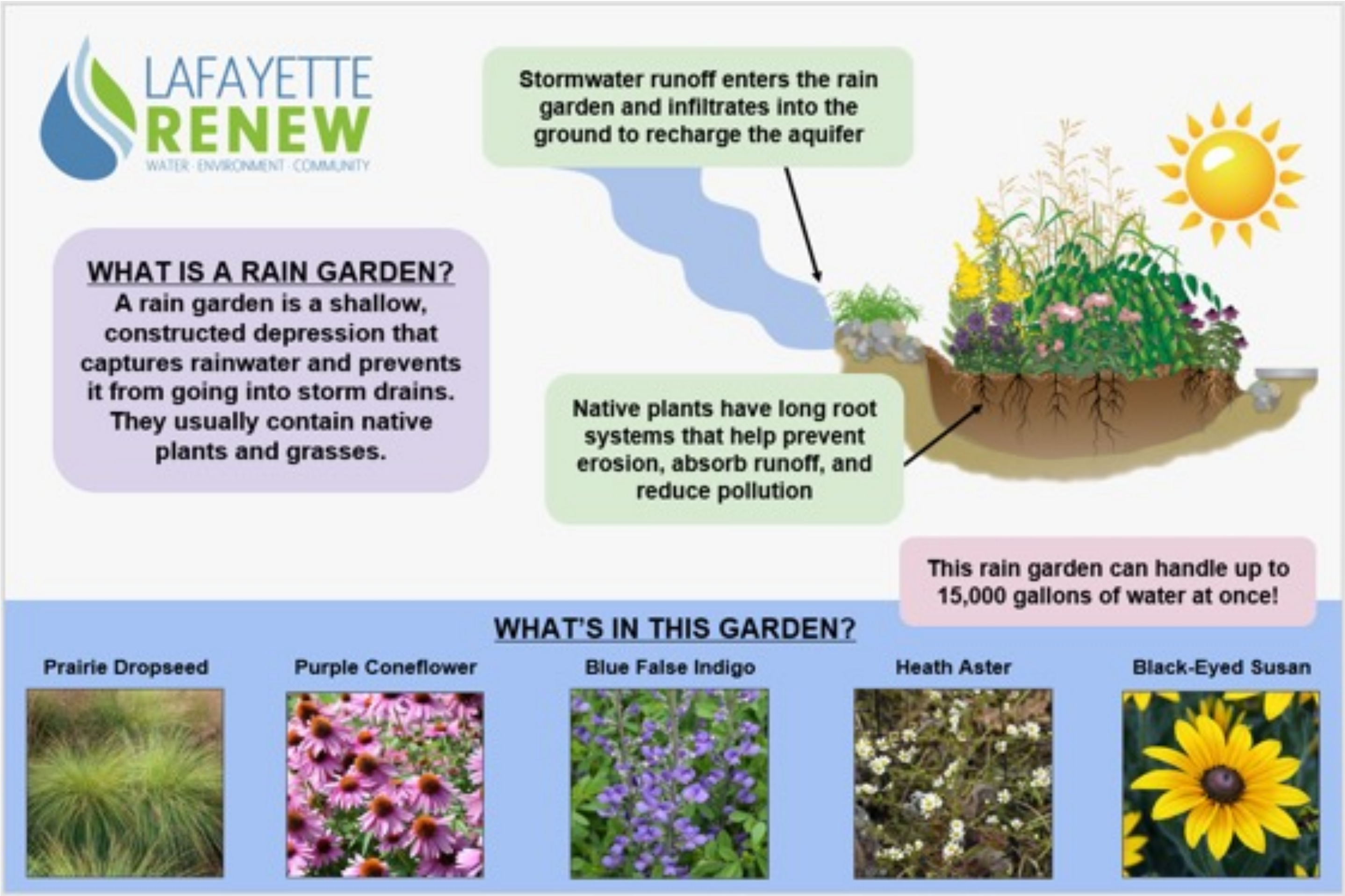

Figure 4. Educational Sign

AUTHOR IMPACT

In my time as a student at Purdue, I have had the opportunity to develop technical and soft skills that have prepared me for a career in environmental engineering. Relevant skills that I learned in prior courses include engineering economic analysis, agronomy, hydraulics, biology, and environmental policy. However, this course has allowed me to experience real project management ranging from the initial site visit to installing our project in the ground. Specific course learning objectives allowed my peers and I to add new skills to our arsenals, including the ability to display social responsibility, civic engagement, and leadership in addressing local water sustainability issues. For example, it is our job as community members to advocate for and become involved in environmentalism to prevent phenomena such as climate change and pollution. I learned to overcome challenges with flexibility, such as when our installation dates were moved due to inclement weather and when parts of the site had bad soil that necessitated replacement.

I was able to directly apply my classroom knowledge to the real world in order to make a positive environmental impact. Further, we learned to approach problems from a transdisciplinary perspective to ensure the best outcome. We had to analyze the project from a social, environmental, and economic perspective, and I grew in my analytical abilities as a result. In the future, I would suggest that there be more involvement of those who live near the site of the installation rather than only those who directly use the site. This project and the process of engaging with the community amounted to a very fulfilling opportunity. I plan to not only stay involved with stormwater sustainability efforts in my community but also use my position as an environmental engineer to advocate for sustainable solutions.

CONCLUSION

The Wabash River is an important symbol and resource in the Greater Lafayette community. In order to protect the Wabash, BMPs can be used to reduce the amount of stormwater runoff that enters the river. This project

Figure 5. Final Rain Garden

designed and implemented a rain garden at the Lafayette Fueling Station with community partners Scott Ahlersmeyer and Vanessa Rainwater from Lafayette Renew. The project progressed using an iterative design process and involved frequent communication with the community partners and Purdue students. The relationship between Purdue students and community partners should be continually strengthened in order to promote further opportunities of this kind. This experience and its challenges and successes can be used as a reference for others pursuing community volunteer efforts.

Now finalized and installed (Figure 5), the rain garden will catch and infiltrate the irregular drainage of stormwater from the open-roof fuel tank storage building, which causes the main runoff issue on the site. Native plants in the rain garden will not only beautify the area but also help clean the water by removing potential hazards such as VOCs as the water infiltrates into the ground. While this rain garden is a positive addition to the city's green infrastructure projects, more installations utilizing BMPs in this area and beyond are recommended in order to protect the Wabash River and promote sustainable development. This project will not only revive the health of the Wabash River but also enrich the community with its natural beauty and provide Greater Lafayette with widespread education on green infrastructure. Being involved with this rain garden installation has allowed me to connect with the community and gain skills to better serve the neighborhoods in which I live.

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