The Edge of Victory

Abstract

The Victory Parkway campus at the University of Cincinnati sits at the top of an incline with an immense number of impervious surfaces and a lack of stormwater intervention to decrease the site runoff. Like 771 other cities in the United States, Cincinnati uses a combined sewer overflow for most of its stormwater. Because of this, 11 billion gallons of combined sewer overflows (CSO's) enter the local waterways, polluting the Ohio River and connected streams. This places Cincinnati in the top 5 cities in the country for CSO's. In 2011, Cincinnati entered a consent decree with the EPA and Federal Government to reduce this pollution. The city has since begun constructing green infrastructure (GI) projects throughout its watersheds. These projects will reduce the CSO's by 1.78 billion gallons each year, but there is still work to be done. In collaboration with the University of Cincinnati Facilities Department and the Cincinnati Municipal Sewer District, our team took a holistic approach to mitigating the Victory Parkway campus's contribution to CSO's while focusing on reducing heat stress, stabilizing the hillside, increasing educational opportunities, and providing multifunctional benefits. Our plan includes bioswales, green roofs, tree canopies, rainwater catchment, and invasive species replacement. These interventions will reduce stormwater runoff by 417,604 gallons per year, minimize the site's contribution to CSO's, and mitigate heat stress on the site. The proposed solutions can be utilized as a precedent for the other 771 cities in the country facing the challenge of reducing the CSO's.

Rainworks Challenge 2020

Team M43

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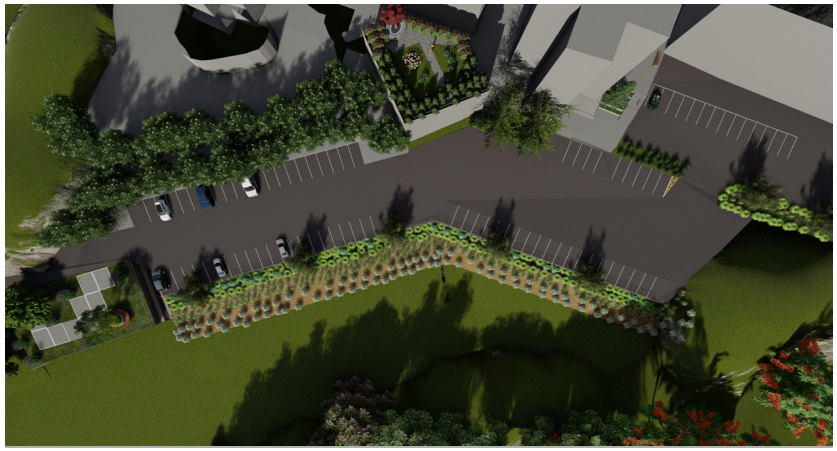

Figure 1. Edge of Victory Site Rendering

1. Introduction

The Edge of Victory is a green infrastructure site redesign approach conceptualized by an interdisciplinary team of five students enrolled in the Green Cities course at the University of Cincinnati (PLAN 6033) in collaboration with the University of Cincinnati Facilities Department and the Cincinnati Municipal Sewer District. To supplement in-class education material, students learned about various green infrastructure techniques by analyzing, developing, and proposing a design intervention at the University of Cincinnati campus. Out of each of the University of Cincinnati's locations, the Victory Parkway campus was chosen due to its proximity to multiple CSO's, the Ohio River, as well as the location's vulnerability to stormwater runoff. Conditions were determined based on independent research, site visits, and a guided tour with the University's Director of Facilities.

2. Cincinnati's Climate Concerns

Like most major cities across the United States, the city of Cincinnati faces several climate-related concerns related to stormwater and the threats of climate change, including the sewer district's combined sewer overflows well as a destabilized hillside.

2.1 Rainfall & CSO's

In the last 50 years, average annual precipitation in the region has increased by 5 – 10%, with the existing storms growing in severity (United States Environmental Protection Agency 2016). As the risks associated with climate change increase

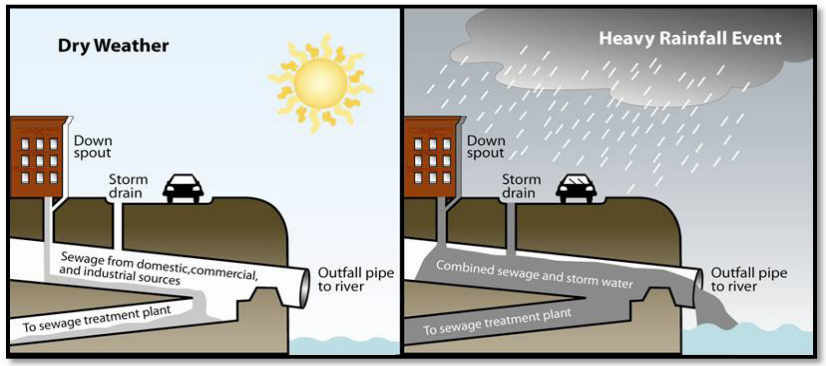

Figure 2. CSO Diagram (Combined Sewer Overflow n.d.)

and storms grow more frequent and severe, the Ohio River's annual water levels are predicted to increase by up to 25% by 2040. With heavy storms growing in frequency and duration, the amount of raw sewage and stormwater entering the Ohio River will increase as well (Project Groundwork 2020).

However, while the spring and fall will grow wetter with more frequent and severe heavy rainfalls, there will also be an increase in intense drought periods during the summertime. These dramatic fluctuations between heavy rain and severe droughts put Cincinnati at a higher risk of flooding (U.S. Army Corps of Engineers and Ohio Basin Alliance 2017).

2.3 Destabilized Hillsides

Cincinnati's existing infrastructure is currently facing significant issues with its destabilized hillsides, resulting in increasing landslides in urbanized areas. Cincinnati, the "City of Seven Hills," is praised for its varying landscape, consisting of numerous hillsides and valleys that provide beautiful views. However, as these hillsides were built upon, the crucial vegetation was replaced with pavement, roadways, and other impervious development. Cincinnati has among the highest frequency of landslides in the United States and one of the highest per capita costs for prevention and mitigation (Potter, et al. 2013).

Not only does the increasing volumes of the stormwater flood the sewage system and the river, but it also floods the hillsides as well. Cincinnati's geology includes swelling soils that fluctuate heavily during wet and dry periods, which are predicted to strain existing gray infrastructure.

2.4 Current Mitigation Efforts

Cincinnati was one of the top five combined sewer overflows (CSOs) dischargers in the nation (Metropolitan Sewer District of Greater Cincinnati 2012) at the start of the 21st century, entering into multiple federal Consent Decrees with the United States EPA, Ohio EPA, as well as the Ohio River Valley Water Sanitation Commission. The Metropolitan Sewer District incorporated a multi-billion-dollar Wet Weather Improvement Plan, which outlined the efforts to reduce combined and sanitary sewer overflows into local rivers and streams. In the last two decades, the city has invested over $1 billion into infrastructure improvements and has reduced the total volume of sewer overflows by 6 billion gallons (Metropolitan Sewer District of Greater Cincinnati 2020). However, given the age of the sewer and project costs, it is expected to take several decades to achieve full compliance.

Given the increasing amount of wet weather and frequency of landslides, Cincinnati has approved a $17 million stabilization project along one of the city's primary thoroughfares, Columbia Parkway. These efforts include new retaining walls and soil nail solutions, and the mitigation efforts are expected to take two years to complete (City of Cincinnati 2020). Though there is mention of the deforestation of the hillside being a contributing factor to the frequency of landslides along this roadway, the Columbia Parkway Landslide Report does mention that the solution to these landslides should also include "possible other green solutions" (City of Cincinnati Transportation and Engineering 2019).

Figure 3. Destabilized Hillside on Columbia Parkway directly south of the site (City of Cincinnati Transportation and Engineering 2019)

3. Site Conditions

3.1 Location

Located along the city's southeastern hillside, the University of Cincinnati's Victory Parkway campus provides its visitors and administrators with a quiet campus and beautiful Ohio River views. With a steep hillside backing up to Columbia Parkway to the southern side, the rest of campus is otherwise surrounded by a mix of single and multi-family residential housing and office spaces. Additionally, the campus shares the hillside with the Edgecliff Point Condominiums, a luxury residential apartment high rise, and residents frequently cut through the campus' back parking lot to get to the building's parking garage.

3.2 History & Current Use

Currently, the campus is housing the University's College of Applied Sciences and the Office of Professional and Continuing Education. The Victory Parkway campus also houses administration or faculty that may be moving buildings. The University's "overflow" campus was once known as Edgecliff College, an all-girls catholic college founded in 1935 and was purchased by the University of Cincinnati at the end of the 20th Century. Currently, the campus houses various administrators, overflow faculty, and hosts non-traditional learning opportunities through the Osher Lifelong Learning Institute (OLLI).

3.3 University Planning Precedent

There are currently no long-term plans in place for the University's Victory Parkway Campus. However, increasing the sustainability of campuses is not a new concept for the University. UC's facility management has seen ongoing sustainability success for the last several years at its main campus, including reducing greenhouse gas emissions by 39%.

UC's Office of Planning, Design, and Construction has prioritized both energy usage and stormwater management, requiring all new construction and renovations to be certified LEED Silver or higher, as well as encourage all new construction projects to develop methods of reducing stormwater runoff (Schefft 2017).

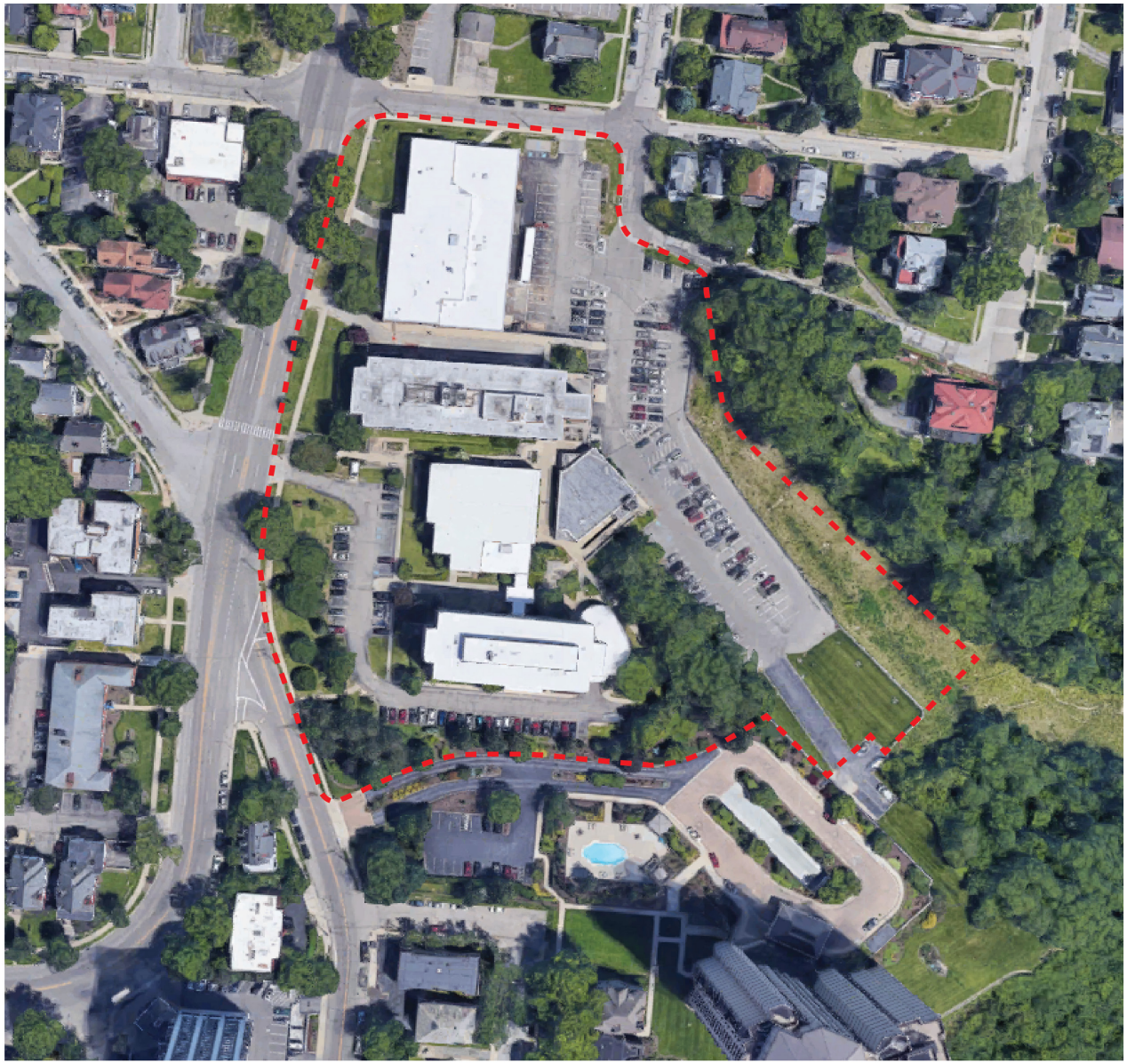

Figure 4. Existing Site

4. Site Challenges

4.1 Hillside and Slope

Though providing visitors with a beautiful view of the Ohio River, the Victory Parkway campus' hillside comes with unique challenges. The five buildings on campus are located along the western portion of campus, running along Victory Parkway, a road heavily used to connect the surrounding neighborhoods. Looking past the buildings, the University-owned parcels extend South, ending at Columbia Parkway. As previously discussed, Columbia Parkway has faced an increasing number of landslides in the past few years. The roadway is undergoing a significant stabilization project, with the two miles on either side of campus seeing the most considerable amount of landslide mitigation efforts. The southern hillside is made up of a continuous steep slope and the elevation plateaus at the retaining wall surrounding the eastern perimeter of the campus. The first level of flat elevation is an 83,607 square foot parking lot perched upon a retaining wall overlooking the hillside at an elevation of approximately 750 feet.

4.2 Stormwater Management

The slope presents a challenge for stormwater volume as well. A residential neighborhood borders the northeastern side of the neighborhood, with intersecting streets sloping at a grade of approximately 25%. During heavy rains, stormwater runs down the slope and into the drain at the parking lot entrance. The current estimate for stormwater runoff on the site is 5,549,054 gallons per year.

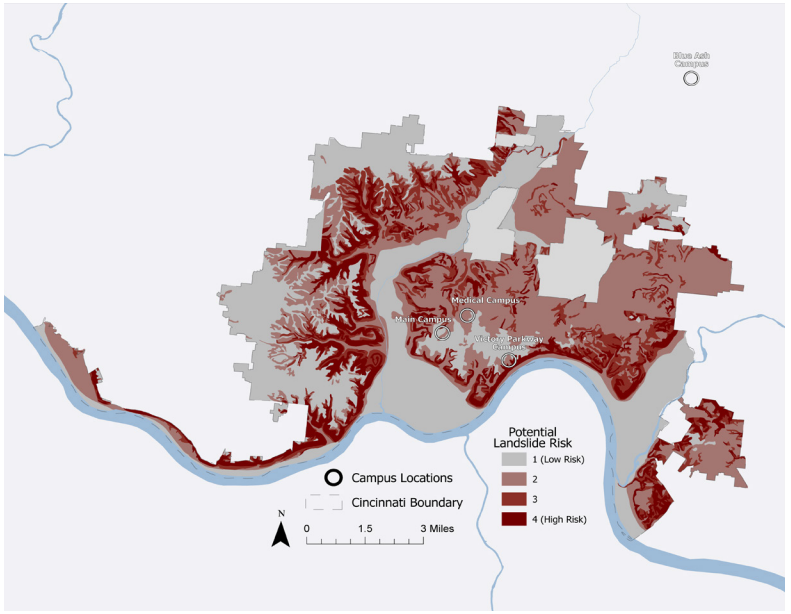

Figure 5. Landslide Risk

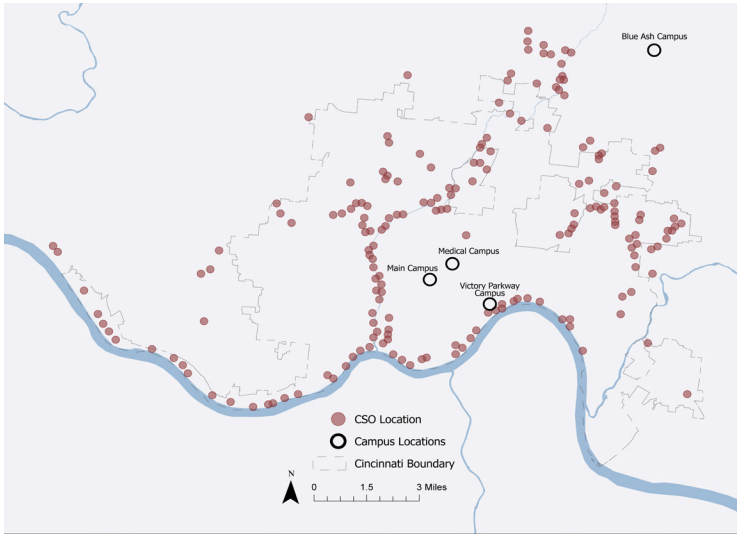

Figure 6. Cincinnati CSO Locations

5. Site Strengths

5.1 An Ideal Location

The campus, which is approximately 8 acres, is located in East Walnut Hills, a neighborhood seeing large amounts of new commercial and residential developments, and is less than a mile from the growing business district. The area is expected to continue to grow and see increased reinvestment. As the neighborhood surrounding the campus begins to grow and develop, the university's campus can position itself as a staple within the community. Though the hillside presents its challenges, the campus' clear views of the Ohio River enhance visitors' time on campus. With both an upper-level balcony and underused green space along the hillside, the site can serve various needs, including a venue for University-sponsored events or an outdoor community space.

5.2 Existing Community Engagement

One of the campus' primary departments is the Office of Professional & Continuing Education, which engages with Cincinnati residents through the university's Osher Lifelong Learning Institute (OLLI). OLLI provides various educational and social opportunities for a diverse, nontraditional audience and offers hundreds of non-credit courses for adult learning and personal enrichment through the university's Communiversity program. Classes range from traditional college subjects to wellness, music, philosophy, travel, and writing, with a hope of expanding knowledge and cultivating community through shared interests.

5.3 Flexible Space Provision

Over the next decade, the Victory Parkway campus will see a growth in its daily visitors as significant changes are made on the Main Campus. A sixteen-story building that holds various departments is expected to be demolished in 2025. According to Michael Hofmann, the University's Director of Utilities, other departments may be moved to the Victory Parkway campus.

5.4 No Plan? No Problem.

As the campus has been historically underutilized by the University, primarily housing administration and evening classes, there is no existing campus plan. However, the culmination of discussed strengths suggests that now is the ideal time to look towards the site's future. With an enthusiastic and knowledgeable facilities team, strong partnerships with the local sewer district, and increasing university-wide interest in green infrastructure, leadership and stakeholders can develop the campus to showcase solution-focused innovation.

6. Proposal

6.1 Goal 1: Contribute to the existing city-wide efforts to manage stormwater runoff, reducing the volume entering the sewer system

- Reduce the amount of impervious surface coverage and compacted soils on the site, replacing them with water retaining natural and permeable land cover
- Capture and filter stormwater following wet-weather events in bioswales and green roofs before it reaches drainage systems
- Plant large, native shade trees to absorb and clean stormwater runoff from nearby streets and impervious surfaces

6.2 Goal 2: Support proposed city landside mitigation techniques

- Remove invasive plant species along the hillside, replacing them with native species to conserve and revegetate the hillside
- Advocate for greenspace and hillside conservation by showcasing the critical views that make the existing campus a desirable learning location

6.3 Goal 3: Grow the existing relationship with the surrounding community centered around innovation and green infrastructure

- Provide an accessible public space to nearby residents and campus visitors, increasing UC's integration in the growing community
- Engage with programs such as the Osher Lifelong Learning Institute to provide educational opportunities about the benefits of Green Infrastructure
- Develop education-oriented signage to showcase and explain the proposed mitigation techniques

Figure 7. Proposed Site Plan Design

7. Methods

The team used several tools to analyze the site's hydrology and stormwater runoff mitigation techniques. Of the tools used, Rainwater+ and the CNT's Green Values National Stormwater Management Calculator were the most vital to the site design.

7.1 Rainwater+

Rainwater+ is a tool used with Grasshopper, an add-on for the 3D modeling software, Rhino. The existing terrain of the site was analyzed using this tool. The results showed significant amounts of runoff draining to the eastern side of the parking lot. Because of this, bioswales and vegetated filter strips were placed on both sides of the retaining wall. Figure 8 is a snip of the model the team created to perform this analysis. The arrows in Figure 9 illustrate this water flow.

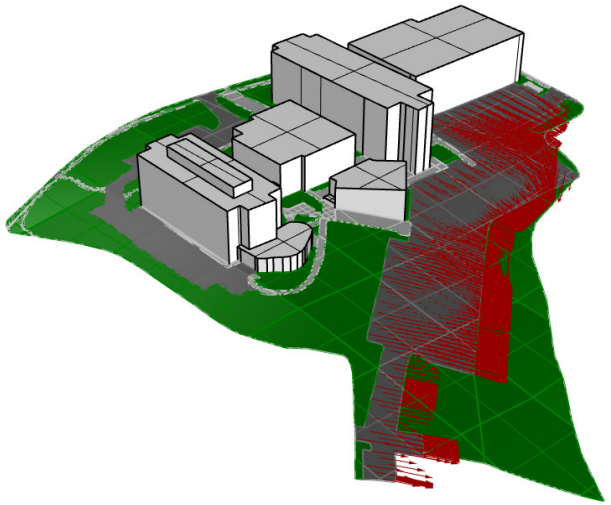

Figure 8. Rhino model with Rainwater+ Results

7.2 CNT Green Values National Stormwater Management Calculator

Upon analyzing the best locations for green infrastructure implementation using Rainwater+, the team chose to compare several mitigation techniques. This was completed by using the Center for Neighborhood Technology's Green Values National Stormwater Management Calculator (GVC). This calculator provides comparison estimates of stormwater runoff, land use, costs, and benefits.

Figure 9. Site water flow

8. Mitigation Techniques

8.1 Bioswales

Given their ability to provide both stormwater treatment and retention, bioswales were chosen as a primary mitigation strategy to deal with the high runoff volume within the parking lot and along streets. Bioswales are an appropriate and attractive opportunity to introduce beautiful, native plants to spaces lacking in biophilic interaction and provide an opportunity for pollinators. Additionally, bioswales were the most cost-effective LID on the site and yielded substantial life-cycle cost savings.

Native plant varieties have been chosen to fill the bioswales, including Feather Reed Grass, Beebalm, Echinacea varieties, and Spice bushes.

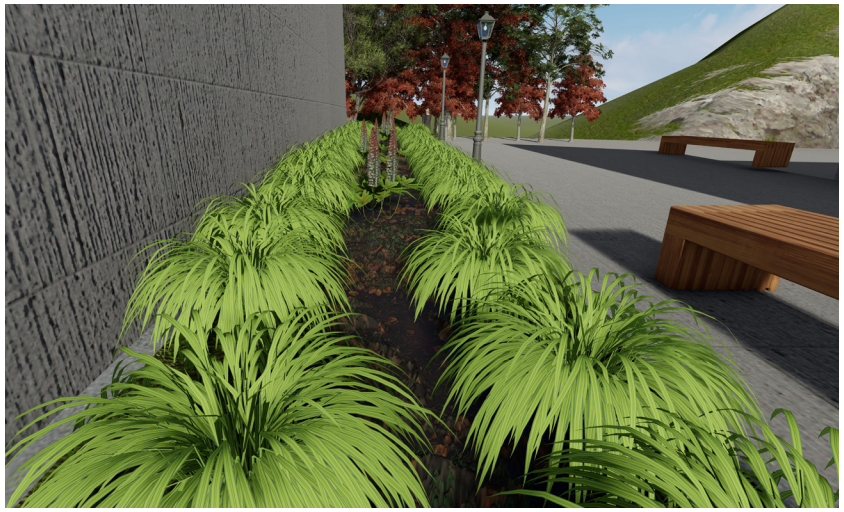

Figure 10. Bioswale

8.2 Green Roof

Green Roofs are popular green infrastructure interventions as the plants assist in neutralizing heat absorbed by the building from sunlight, further helping sequester stormwater runoff, introduce clean air and capture airborne pollutants, and often become a source of pride for the individuals who operate in the space beneath them. Given the buildings' wide and flat roofs positioned at a higher elevation than the rest of campus, green roofs are a cost-effective mitigation strategy. The location of this green roof has been chosen because of its flat surface and small cost add. Additionally, this green roof will provide savings in energy costs, assist in the mitigation of the city-wide Urban Heat Island Effect, and serve as a precedent for the rest of the Victory Parkway campus. Upon its success, it can be replicated on the other roofs.

Figure 11. Green roof

8.3 Permeable Pavement

Located in the southernmost area of campus overlooking the hillside is a small grass area as the only vegetative coverage. Though the grass provides a nice break from the asphalt parking lot, the space is highly underutilized, and visitors wade through water to reach the overlook. Pervious pavement tiles will assist the drains in rainwater dispersal because of the relatively low cost and little to no maintenance feature that will freshen up the neglected outlook, introducing new visitors to the ample outdoor space that has been undervalued and underutilized.

8.4 Hillside Conservation & Revegetation Efforts

Currently, a large amount of existing vegetation on the victory parkway campus is comprised of invasive species doing little to retain stormwater. Plant species identified as invasive species are nonnatives typically introduced to a region with the goal of beneficial impact. New species show promise in rigorous growth and vegetative production and are often low maintenance, so they are heavily promoted. However, problems occur when these species are far too successful by demonstrating reproduction and survival rates that out-compete local, native flora. Healthy ecosystems thrive on biodiversity to sustain the circle of life.

Native plants, like Southern Magnolia trees and Bottlebrush Buckeye shrubs, are better for reducing stormwater volume and erosion control due to their deeper root systems and superior water filtration (Alliance for the Bay 2020). Having evolved in the southern Ohio climate, native plants can naturalize and flourish when planted appropriately while simultaneously requiring minimal maintenance.

Figure 12. Permeable Pavement

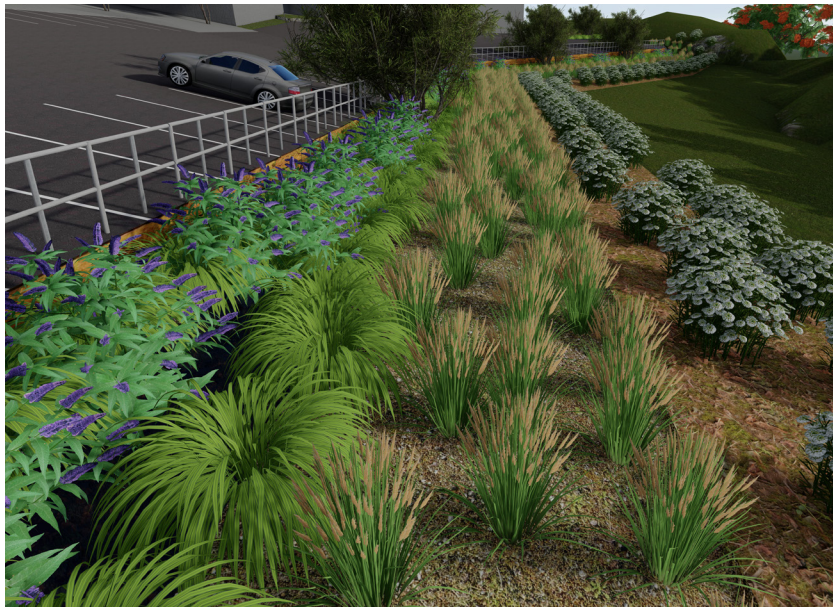

Figure 13. Revegetation efforts

9. Finances + Timeline

The costs, benefits, land use, and coefficients and runoff were determined using the CNT's Green Values National Stormwater Management Calculator (GVC). These values are discussed throughout this section.

9.1 Costs

The costs for this project were split up into three sections: construction, maintenance, and life cycle costs. For construction costs, the proposed design was compared to a conventional design to assess the savings if the University would have originally chosen a green design. For annual maintenance costs and life cycle costs, these two designs were compared again. The results show a 4% savings in construction costs, 16% savings in maintenance costs, and 8% savings in life cycle costs. Over its lifespan, the proposed design has the potential to save the University $211,504.

	Construction Cost ($)				Annual Maintenance Cost ($)				Life Cycle Cost ($, NPV)			
	Conventional	Green	Difference	%	Conventional	Green	Difference	%	Conventional	Green	Difference	%
Concrete Sidewalk	$125,062	$125,062	$0	0%	$699	$699	$0	0%	$174,381	$174,381	$0	0%
Curbs and Gutters	$0	($84,232)	($84,232)	0%	$0	($732)	($732)	0%	$0	($125,745)	($125,745)	0%
Street	$0	($84,574)	($84,574)	0%	$0	($1,074)	($1,074)	0%	$0	($136,992)	($136,992)	0%
Parking Lot	$460,675	$425,984	($34,691)	-8%	$12,541	$11,597	($944)	-8%	$958,177	$886,022	($72,155)	-8%
Conventional Stormwater Storage	$273,703	$0	($273,703)	-100%	$711	$0	($711)	-100%	$355,707	$0	($355,707)	-100%
Standard Roof	$468,833	$439,766	($29,068)	-6%	$3,126	$2,932	($194)	-6%	$669,754	$628,229	($41,525)	-6%
Green Roof	$0	$61,042	$61,042	0%	$0	$97	$97	0%	$0	$77,377	$77,377	0%
Turf	$23,972	$0	($23,972)	-100%	$10,274	$0	($10,274)	-100%	$354,730	$0	($354,730)	-100%
Native Plants	$0	$8,436	$8,436	0%	$0	$4,218	$4,218	0%	$0	$143,930	$143,930	0%
Trees	$0	$2,750	$2,750	0%	$0	$200	$200	0%	$0	$9,685	$9,685	0%
Swales in Parking Lot	$0	$64,440	$64,440	0%	$0	$516	$516	0%	$0	$94,779	$94,779	0%
Roadside Swales	$0	$292,980	$292,980	0%	$0	$2,344	$2,344	0%	$0	$430,916	$430,916	0%
Vegetated Filter Strips	$0	$43,197	$43,197	0%	$0	$2,085	$2,085	0%	$0	$118,663	$118,663	0%
Total	**$1,352,245**	**$1,294,851**	**($57,394)**	**-4%**	**$27,350**	**$22,880**	**($4,470)**	**-16%**	**$2,512,749**	**$2,301,244**	**($211,504)**	**-8%**

Table 1. Cost Summary

9.2 Benefits, Land Use, and Coefficients + Runoff

The benefits, land use, and coefficients + runoff are respectively shown in Table 2, Table 3, and Table 4. In Table 2, the multifunctional benefits of the proposed design are presented. It can be seen that the addition of trees added quite a large "green benefit": $2,750 per year. In Table 3, there is an addition of 25,828 sf pervious surfaces added to the project. This will help reduce the urban heat island effect. In Table 4, there is an annual 8% reduction in stormwater runoff. This will help significantly in local CSO reductions and support Cincinnati's plan to reduce pollution to the Ohio river.

9.3 Timeline

In Table 5, a timeline is provided. This shows the year and season in which the mitigation techniques will be implemented. While some techniques are less constrained for what season they should be implemented in, others are (native plants, for example). All mitigation techniques were strategically scheduled to not interfere with classes.

	Annual Benefits ($) Green Benefits	Life Cycle Benefits ($, NPV) Green Benefits
Reduced Air Pollutants	2	57
Carbon Dioxide Sequestration	1	38
Compensatory Value of Trees	2,750	87,141
Groundwater Replenishment	69	2,193
Reduced Energy Use	698	22,106
Reduced Treatment benefits	38	1,216
Total	**3,558**	**112,751**

Table 2. Benefits Summary

	Conventional Area (ft²)	Green (Using BMPs) Area (ft²)
Conventional Roof	62,511	58,635
Green Roof	0	3,876
Swales in Parking Lot	0	4,296
Roadside Swales	0	19,532
Lawn	114,152	0
Native Vegetation	0	84,361
Filter Strips	0	29,791
Total Impervious	**170,215**	**140,511**
Total Pervious	**114,152**	**139,980**

Table 3. Land Use Summary

	Conventional	Green	Conventional to Green Difference (%)
Average Annual Rainfall			
Total Runoff (in)	31.3	28.95	-8%
Total Runoff Volume (gal)	5,549,054	5,131,450	-8%
Cumulative Abstractions (in)	1.27	3.18	151.2
99% Storm			
Total Runoff (in)	1.12	0.42	-62%
Total Runoff Volume (gal)	198,471	75,266	-62%
Cumulative Abstractions (in)	0.78	1.03	32.52
CN	88	74	
Initial Abstractions (in)	0.26	0.71	167.96

Table 4. Coefficients and Runoff

	Construction Cost	Timeline
Native Plants	$8,436	Year 1, Spring
Vegetated Filter Strips	$43,197	Year 1, Summer
Trees	$2,750	Year 1, Fall
Swales in Parking Lot	$64,440	Year 1, Winter
Roadside Swales	$292,980	Year 2, Summer
Green Roof	$61,042	Year 2, Winter
Total	**$472,845**	

Table 5. Timeline

10. Conclusion

The Edge of Victory should serve as a precedent for the University of Cincinnati's future green infrastructure projects. This project contributes to the existing city-wide efforts to manage stormwater runoff by reducing the volume entering the sewer system, supports the proposed city landside mitigation techniques, and grows the existing relationship with the surrounding community centered around innovation and green infrastructure. In order to reduce the amount of CSO's entering the Ohio River, the city must incentivize interventions like the proposed design. While the Edge of Victory is only one example of what can be done at a site scale, there is plenty more work to be done.

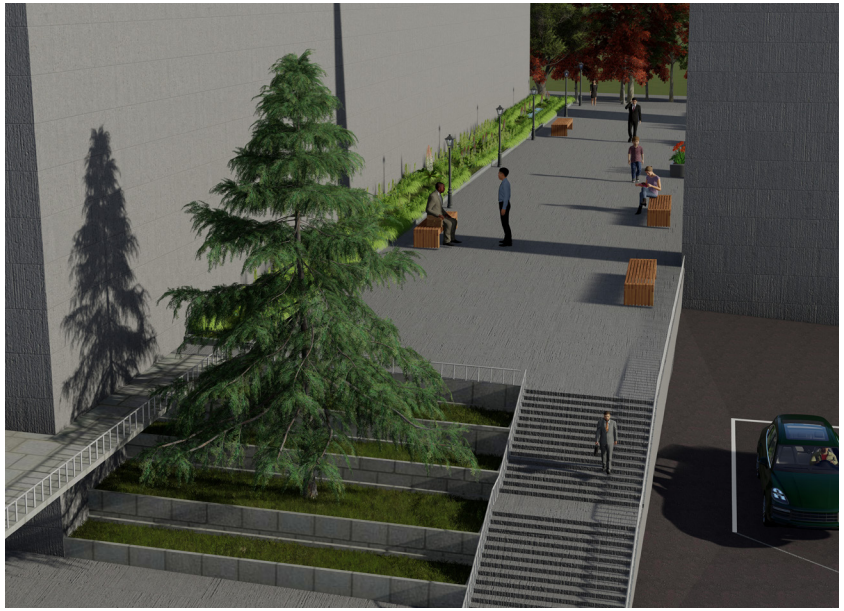

Figure 14. Invasive Species Removal

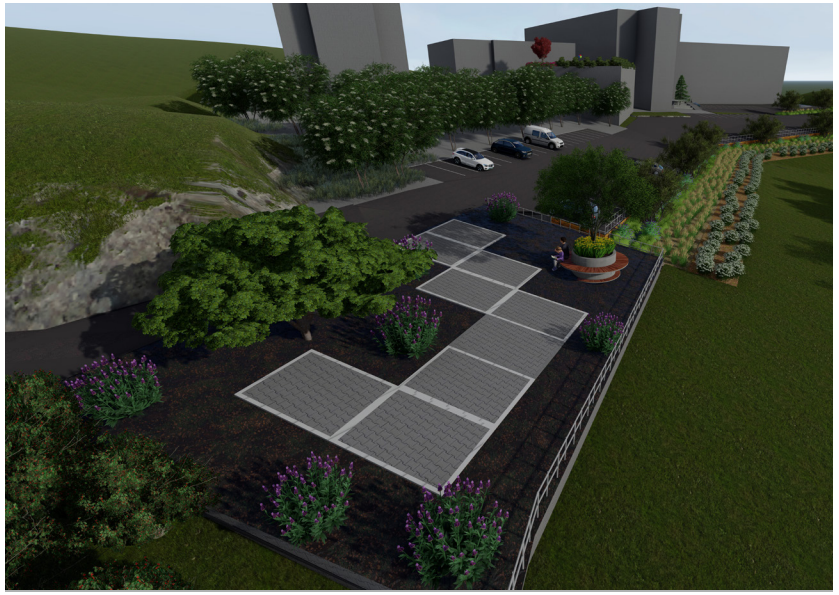

Figure 15. Site Perspective

Figure 16. Vegetated Filter Strip

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