Figure 1, via Medium.com

How Can a Municipal Sewer District Promote the Reduction of Stormwater Runoff Through Native Plant Landscaping and Green Roof Education?

Annie Lewis

The Benefits of Green Roofs on Stormwater Runoff

Faculty Advisor, Professor Stevie Famulari Gds

Bachelor of Science in Horticulture

Certificate in Sustainable Landscape Design

DAAP School of Planning, Horticulture Program

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"IF WE STEAL THE GROUND FOR A BUILDING, WE CAN GIVE IT BACK TO NATURE ON THE ROOF"- WOLFGANG ANSEL

lewisaf@mail.uc.edu / afslewis5@gmail.com

Previous Experience

2023-2024

Spring 2024

- DAAP 5062 Permaculture II, Professor Chris Smyth
  Common Orchard Project Permaculture Design
- HORT 3044 Urban Landscape IV: Roofs and Facades, Professor Wendy Ellis Gardner and Professor Rose Henry-Seger
  Projects include Chicago City Hall Green Roof Case Study
  John Weld Peck Federal Building Green Roof Design
- HORT 4092 Senior Project in Horticulture, Professor Stevie Famulari

Fall 2023

- HORT 2040 Sustainable Landscape Design I, Professor Stevie Famulari
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Abstract

Cincinnati has dealt with the effects of combined sewer overflows for decades. Although overflow levels are steadily improving, there is still more to be done. Since 2002, the city has been attempting to renovate their old system to meet the Environmental Protection Agency's Clean Water Act. This has proved extremely costly and difficult to complete with over 3,000 miles of public sewers with the antiquated combined sewer overflow system. Green roofs have become a proven tool in reducing combined sewer overflows. This project aims to explain how a municipal sewer district can promote the reduction of stormwater runoff through native plant landscaping and green roof education.

In 2010, the Metropolitan Sewer District, the agency responsible for waste water treatment in the Greater Cincinnati area, installed a green roof on one of their Mill Creek Plant buildings, however, it has been neglected and is not reaching its full potential. Through research on green roof's effects on combined sewer overflow, an improved green roof design, and educational signage this study aims to create an educational, visually pleasing, native focused, and functional green roof that still allows employees ease of access to necessary equipment. MSD can encourage an increase of green roofs throughout the city and this study creates a comprehensive plan to use green roofs as a promotional tool.

Key Words

Combined sewer overflow, green roofs, native plants, Cincinnati, Metropolitan Sewer District, MSD, storm water

Problem Statement

How Can a Municipal Sewer District Promote the Reduction of Stormwater Runoff Through Native Plant Landscaping and Green Roof Education?

Cincinnati has a combined sewer overflow system which causes pollution into the Ohio River when there is excess rain. The Metropolitan Sewer District has taken steps to improve the combined sewer overflow levels but there is still a long way to go. MSD have a green roof at their Mill Creek Plant that can be improved and highlighted for educational purposes.

Project Justification

As someone who has lived most of their life in the Greater Cincinnati area, I have seen the effects of the combined sewer overflow system on the Ohio River. A combined sewer overflow system means that both the wastewater and the storm water flow through the same pipes. This causes untreated sewage to be discharged directly into the Ohio River. Although the discharge levels have improved over the last 20 years, there is still a long way to go.

In 2002, the Environmental Protection Agency settled with the City of Cincinnati to "eliminate long-standing and significant sewage discharges from its sanitary system". This required the Metropolitan Sewer District of Cincinnati to spend millions of dollars to eliminate approximately 100 million gallons of raw sewage.

Green rooftop design is a helpful tool for managing storm water. The layer of plant material and growing media helps plants absorb excess water similar to a sponge as opposed to the immediate runoff of an impervious roof surface as it is commonly used. This research suggests that the city's job to promote alternative solutions to replacing our entire combined sewer overflow system. In 2010, the Mill Creek Plant installed a green roof but it has since been neglected. I aim to redesign the existing green roof to promote the reduction of combined sewer overflow and educate the public on the importance of it through additional signage and educational material surrounding the roof.

Client Description

Metropolitan Sewer District Employees

- Approximately 300 employees at the Mill Creek Treatment Plant
- Waste water operators, maintenance employees, and laborers all regularly access the rooftop to maintain and operate the surrounding equipment that is used for the grit removal facility.
- The roof is visible from ground level and all employees regularly drive by it.

Tour Groups

- 15-20 tour groups a year with an average of 10 people per group
- The tour groups are made up of people from elementary school age into adulthood
- A range of socioeconomic statuses, races, genders
- Most of the tour groups are college or high school students
- A majority of the guests are English speaking
- The groups are only accessing the roofs during guided tours as the space is not regularly open to public
- There is an accessible parking and a wheelchair accessible ramp to get to the roof

Major Project Elements

- A redesign of the current green roof at the Mill Creek Plant of MSD
    - Increase vegetative coverage by at least 50% to capture more rainfall, improve urban heat island effect, and improve aesthetic value
    - Diversify plant pallet for an increase in biodiversity as well as aesthetic improvement
    - Ensure that the new bed designs still allow access to equipment that are necessary for daily operation
    - Ensure that the bed designs are accessible to all abilities
- Create educational material
    - Create 3 major signs to be featured around the green roof with the purpose of educating visitors on green roofs
        - Sign 1: What is a combined sewer system?
        - Sign 2: What are green roofs and why are they beneficial?
        - Sign 3: What are other ways to reduce combined sewer overflow?
    - Ensure that signage is accessible
        - Include visual representation of concepts
        - Use language that is easily understood by most guests
        - Include a tactile map of the garden layout for people with visual impairments
        - Position the signage in areas that is accessible to people in wheelchairs

Site Information

Figure 2, An aerial photo of the Mill Creek Plant with the green roof building highlighted, via Google Earth

Region: Midwest

USDA Hardiness Zone: 6b

Site: Mill Creek Wastewater Treatment Plant, Grit Building Roof

1600 Gest Street, Cincinnati Ohio 45204

This site has an existing green roof that has not been upkept since its creation in 2010 and is not reaching its full potential. This research expands the scope of the green roof and update the design. The design will use the the roof as an educational and promotional tool for MSD to promote the reduction of stormwater runoff through green roofs. This building is unique because most of it is underground, with only one story being above ground. This makes the roof accessible to people and a useful educational tool about green roofs.

Inventory & Analysis

Topography

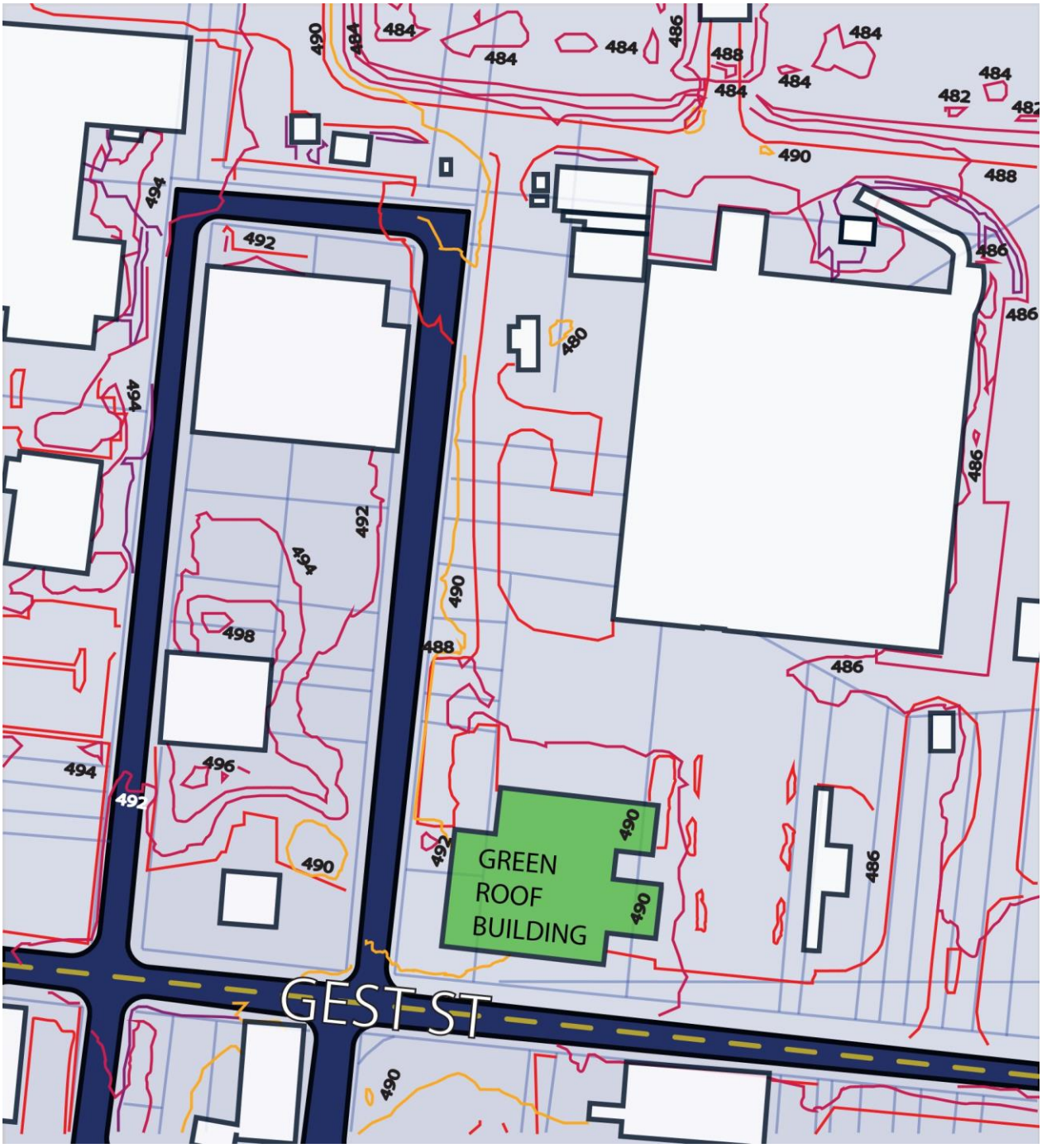

Figure 3, Topographical data via CAGIS

Existing Vegetation

Figure 4, Sedum kamtschaticum var. floriferum 'Weihenstephaner Gold'

Figure 5, Sedum reflexum 'Blue Spruce'

Figure 6, Sedum album

Figure 7, Sedum spurium 'Fuldaglut'

Figure 8, Sedum spurium 'John Creech'

Figure 9, Phemeranthus calycinus

Figure 10, Panicum virgatum 'Shenandoah'

Figure 11, Asclepias syriaca

Figure 12, Schizachyrium scoparium

Images from the Sight

Figure 13, Western facing view of Green Roof Taken by Annie Lewis 1/20/24.

Figure 14, Northwestern facing view of Green Roof Taken by Annie Lewis 1/20/24

Figure 16, Northern facing view of Green Roof Taken by Annie Lewis 1/20/24

Figure 15, Western facing view from Ground Level of Grit Building Taken by Annie Lewis 1/20/24

Figure 18, Northwestern facing view from Ground Level of Grit Building Taken by Annie Lewis 1/20/24

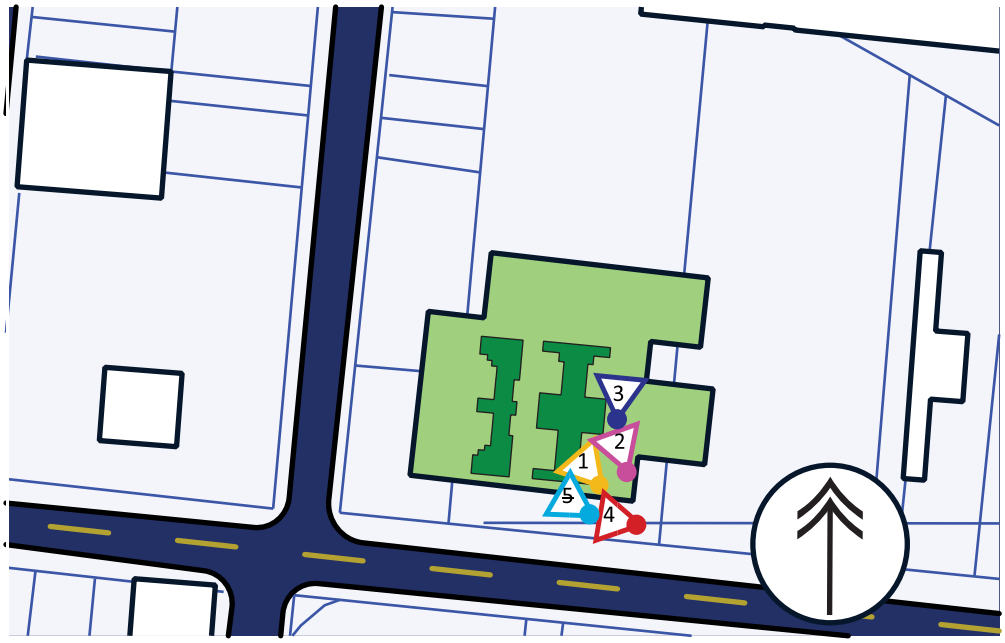

Figure 17, Location and perspective of Figures 12-17

Animal Habitat

Insects including pollinator species and birds visit the roof. The area is heavily populated by Canadian geese.

Opportunities & Challenges

Opportunities:

- Reduce the storm water runoff for this building.
- Educate the public on the importance of green roofs and other green infrastructure techniques.
- Improve wildlife habitat and biodiversity in an urban setting.
- Improve public image and change public perception of MSD.
- Assist urban heat island effect that is present in highly urbanized areas.

Challenges:

- Ensuring that the building can support additional green roof infrastructure.
- Ensuring that all areas are still accessible for employees that utilize the pumps and meters on the roof as well as accessible to guests on tours.
- Ensuring continual maintenance of the roof and care of plants.

Soil Conditions

There is no soil on the green roof, only soilless media that is commonly used on green roofs. The media is made up of 80% stalite and 20% compost. It has a weight of 80- 90 pounds per cubic foot when submerged in water, 60- 80 pounds per cubic foot when wet and drained, and 55-64 pounds per cubic foot when tamped damp. Temco provided a Green Roof Media analysis from Pennsylvania State University.

Green Roof Media Analysis

Results on dry weight basis unless specified otherwise

Analysis	Units	Result	FLL Guidelines for Intensive Sites[1]
Particle Size Distribution (See accompanying report)			
≤ 0.05 mm *(FLL reference value based on < 0.06 mm)*	mass %	4.4	≤ 20
Density Measurements			
Bulk Density (dry weight basis)	g/cm^3	1.19	—
Bulk Density (dry weight basis)	lb/ft^3	74.16	—
Bulk Density (at max. water-holding capacity)	g/cm^3	1.63	—
Bulk Density (at max. water-holding capacity)	lb/ft^3	101.91	—
Water/Air Measurements			
Moisture *(as received basis)*	mass %	10.9	—
Total Pore Volume[2]	Vol. %	47.8	—
Maximum water-holding Capacity	Vol. %	44.4	≥ 45
Air-Filled Porosity (at max water-holding capacity)	Vol. %	3.4	≥ 10
Water permeability (saturated hydraulic conductivity)	cm/s	0.018	≥ 0.0005
Water permeability (saturated hydraulic conductivity)	in/min	0.43	≥ 0.0118
pH and Salt Content			
pH ($CaCl_2$)		7.7	5.5 - 8.0
Soluble salts (water, 1:10, m:v)	mmhos/cm	0.12	—
Soluble salts (water, 1:10, m:v)	g (KCl)/L	0.86	≤ 2.5
Organic Measurements			
Organic matter content	mass %	4.2	≤ 6.0
Nutrients			
Phosphorus, P_2O_5 (CAL)	mg/L	95.3	≤ 200
Potassium, K_2O (CAL)	mg/L	333.1	≤ 700
Magnesium, Mg (CaCl2)	mg/L	128.8	≤ 160
Nitrate + Ammonium (CaCl2)	mg/L	12.2	≤ 80

Figure 19, This is a breakdown of the soil contents that was originally installed. This shows the potential bulk density at a minimum of 74.16 pounds per square foot. Via Trenco Incorporated

Green Roof Media
Particle Size Distribution

Particle Size Analysis		Sum of particles less than size specified				
Diameter -mm-	%		Diameter -mm-	Diameter -in-	Sieve size	% sum of particles
< 0.002	1.6	<	0.002	---	---	1.6
0.002-0.05	2.7	<	0.05	---	---	4.4
0.05-0.25	11.4	<	0.25	0.0098	60 mesh	15.7
0.25-1.0	33.3	<	1.0	0.0394	18 mesh	49.0
1.0-2.0	8.7	<	2.0	0.0787	10 mesh	57.7
2.0-3.2	7.3	<	3.2	0.125	1/8 inch	65.0
3.2-6.3	23.1	<	6.3	0.250	1/4 inch	88.2
6.3-9.5	11.8	<	9.5	0.375	3/8 inch	100.0
9.5-12.5	0.0	<	12.5	0.500	1/2 inch	100.0
> 12.5	0.0					

Figure 20, This graph shows the particle size of the soil that was originally installed. This shows how water will drain through the soil and how much water it can retain. Most particles are in the medium range between .05- 6.3 mm in diameter, meaning the soil has a medium drainage level. Via Tremco Incorporated

Weather Impacts

Annual average temperate, precipitation, and snow for the years 2022, 2021, 2020, 2019, and 2018. This data can be used to interpret how much rainwater is being diverted from the sewers each year based on the square footage of the roof. This information comes from the National Weather Service and is taken from the nearest airport location in Covington, Kentucky.

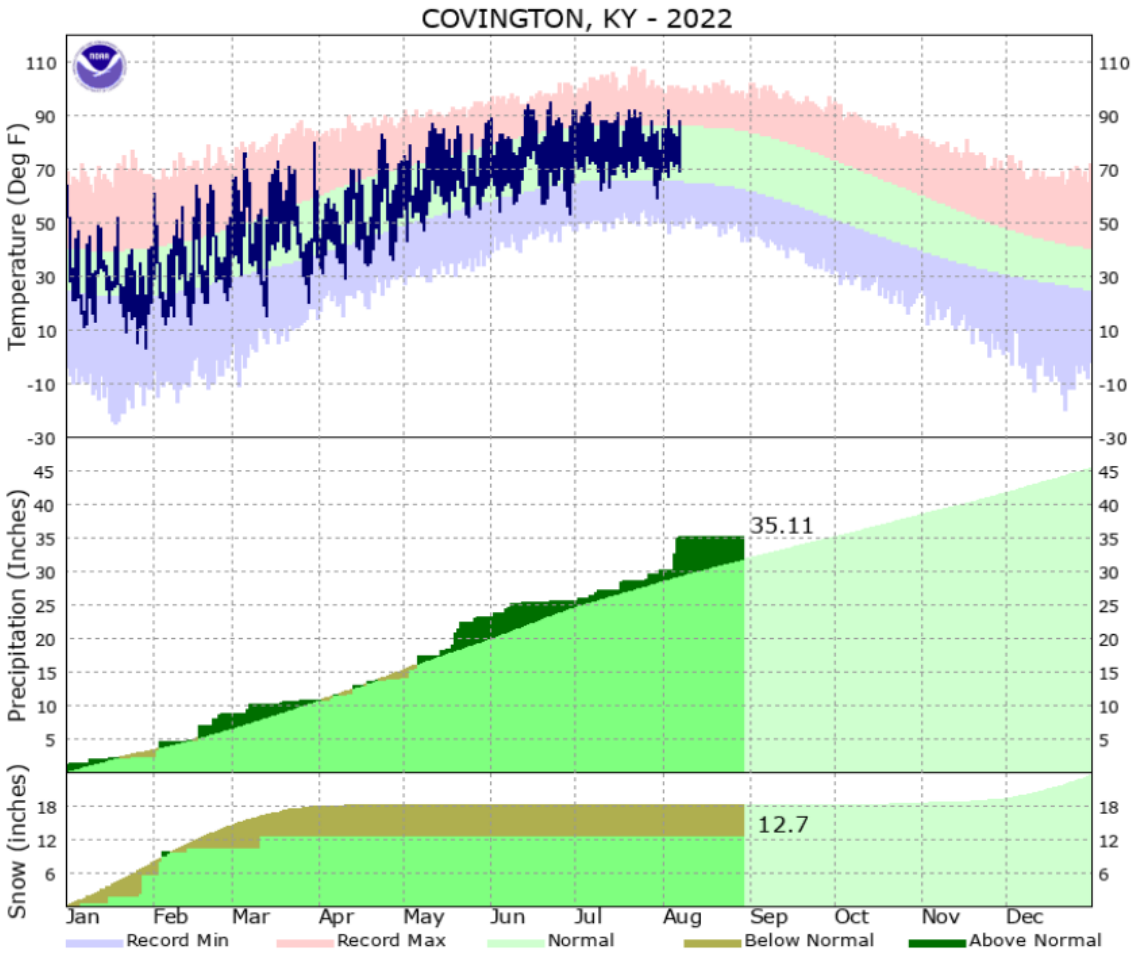

Figure 21, via National Weather Service

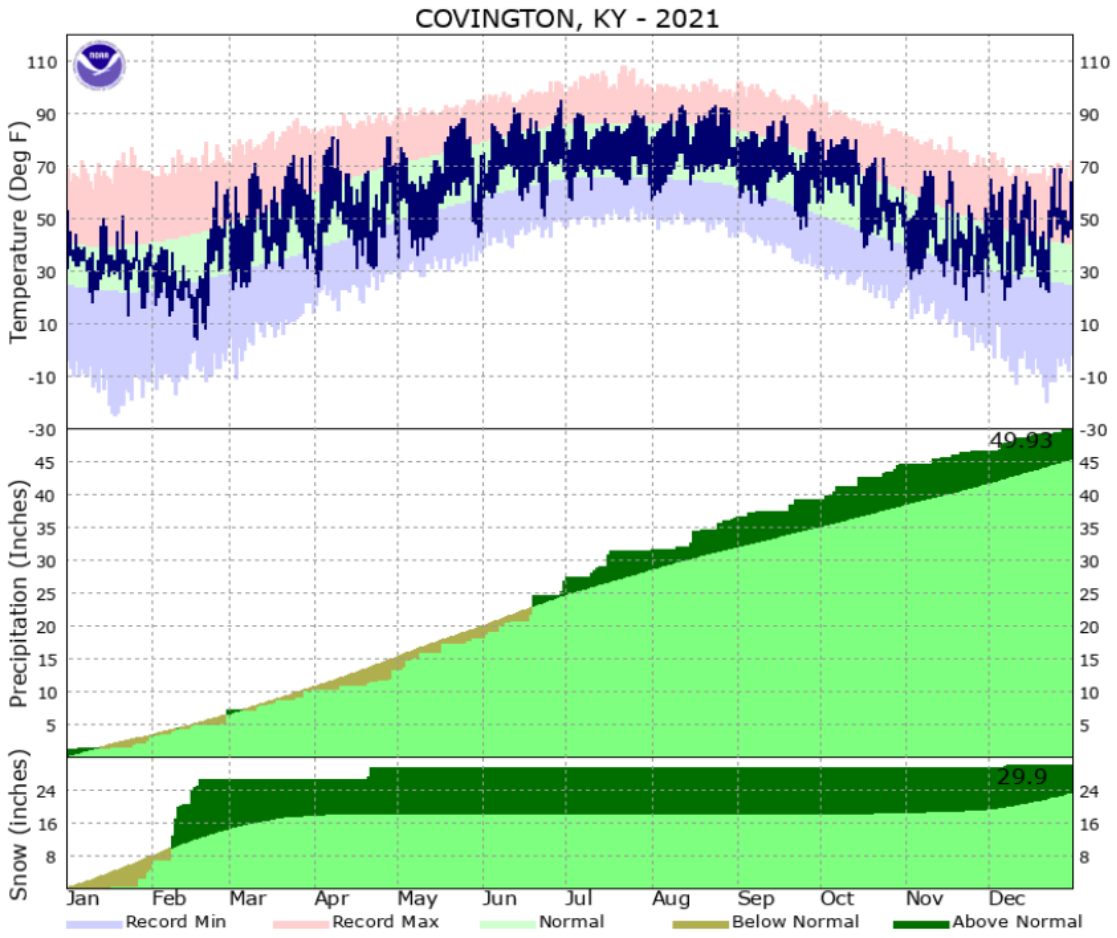

Figure 22, via National Weather Service

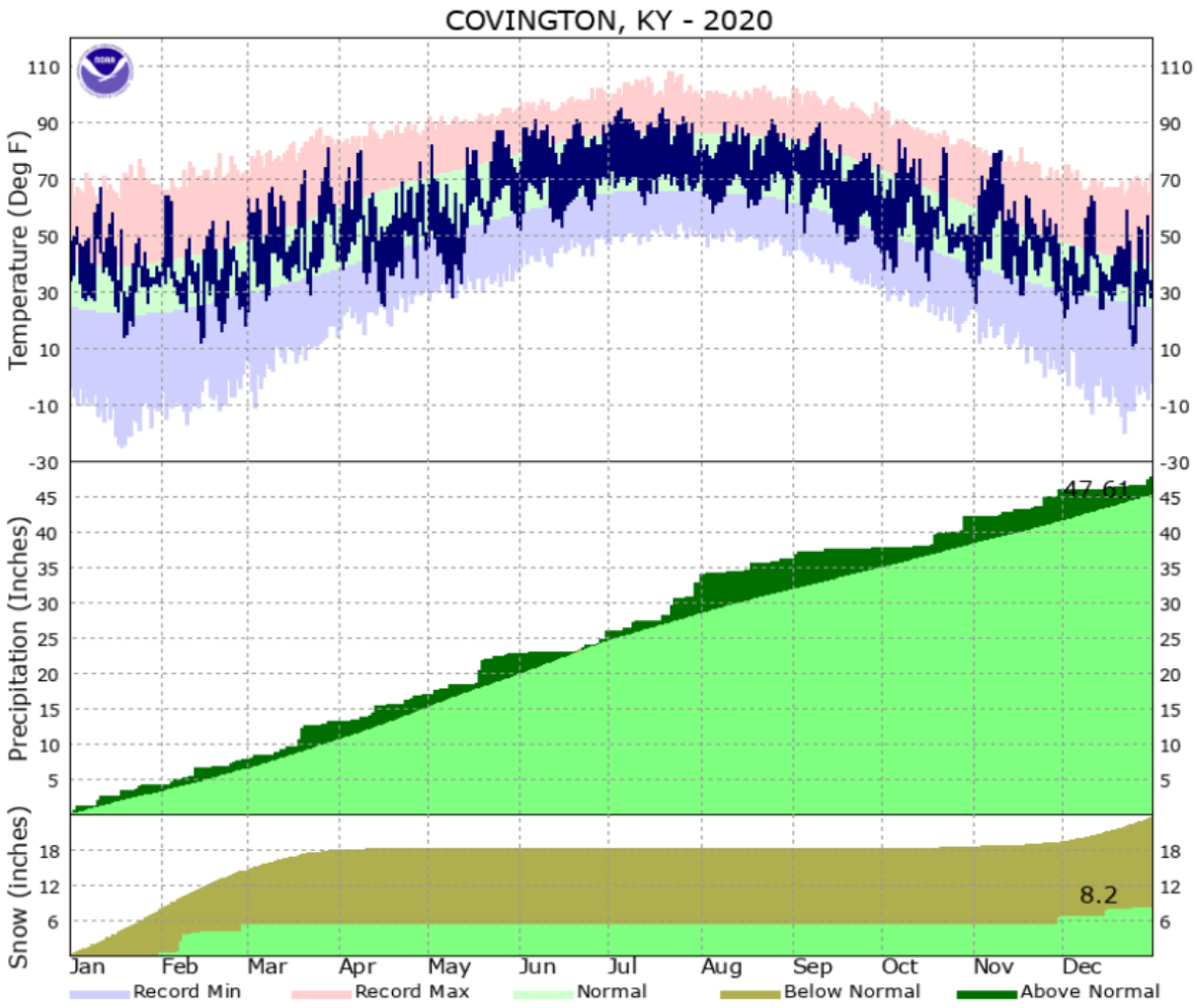

Figure 23, via National Weather Service

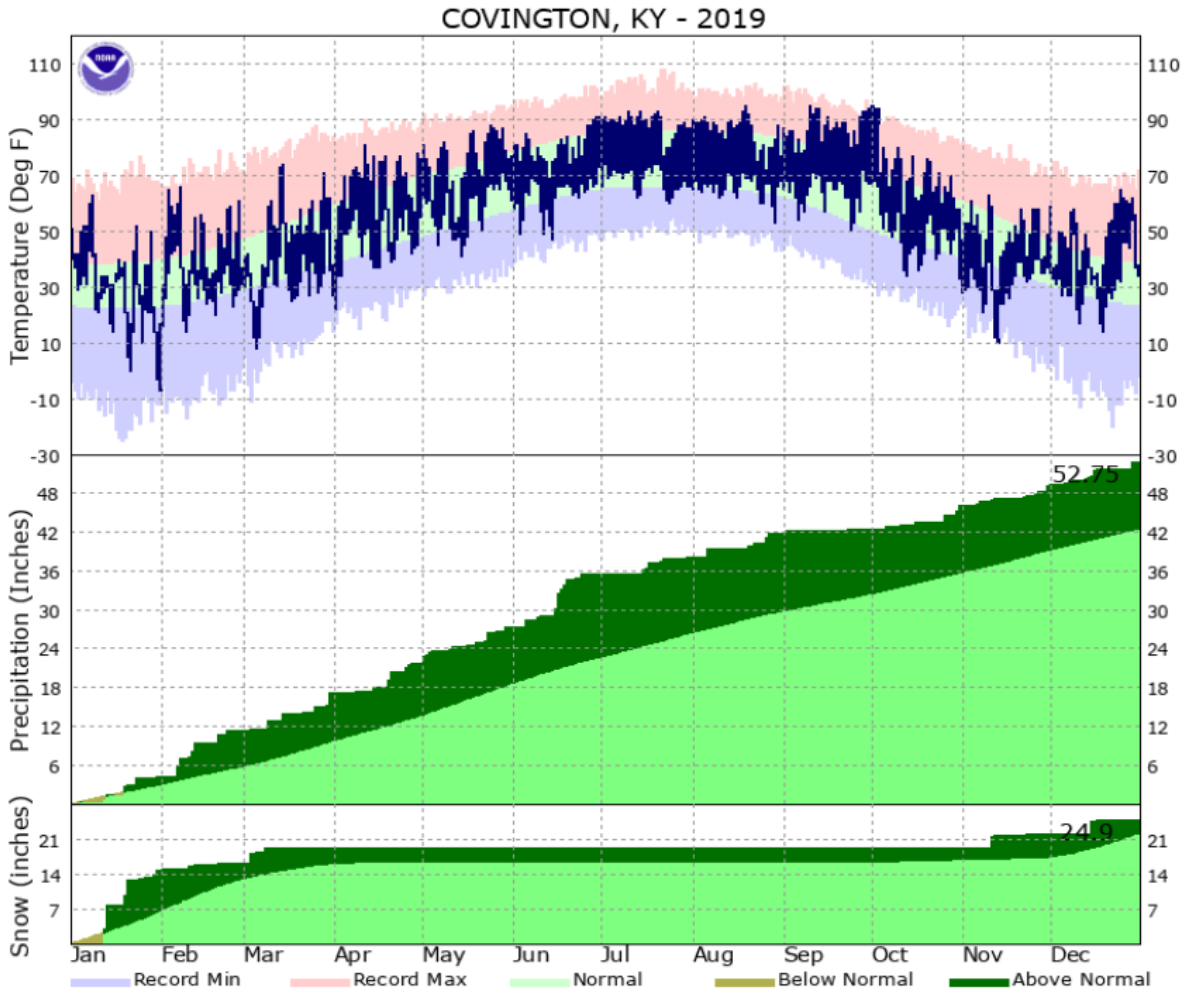

Figure 24, via National Weather Service

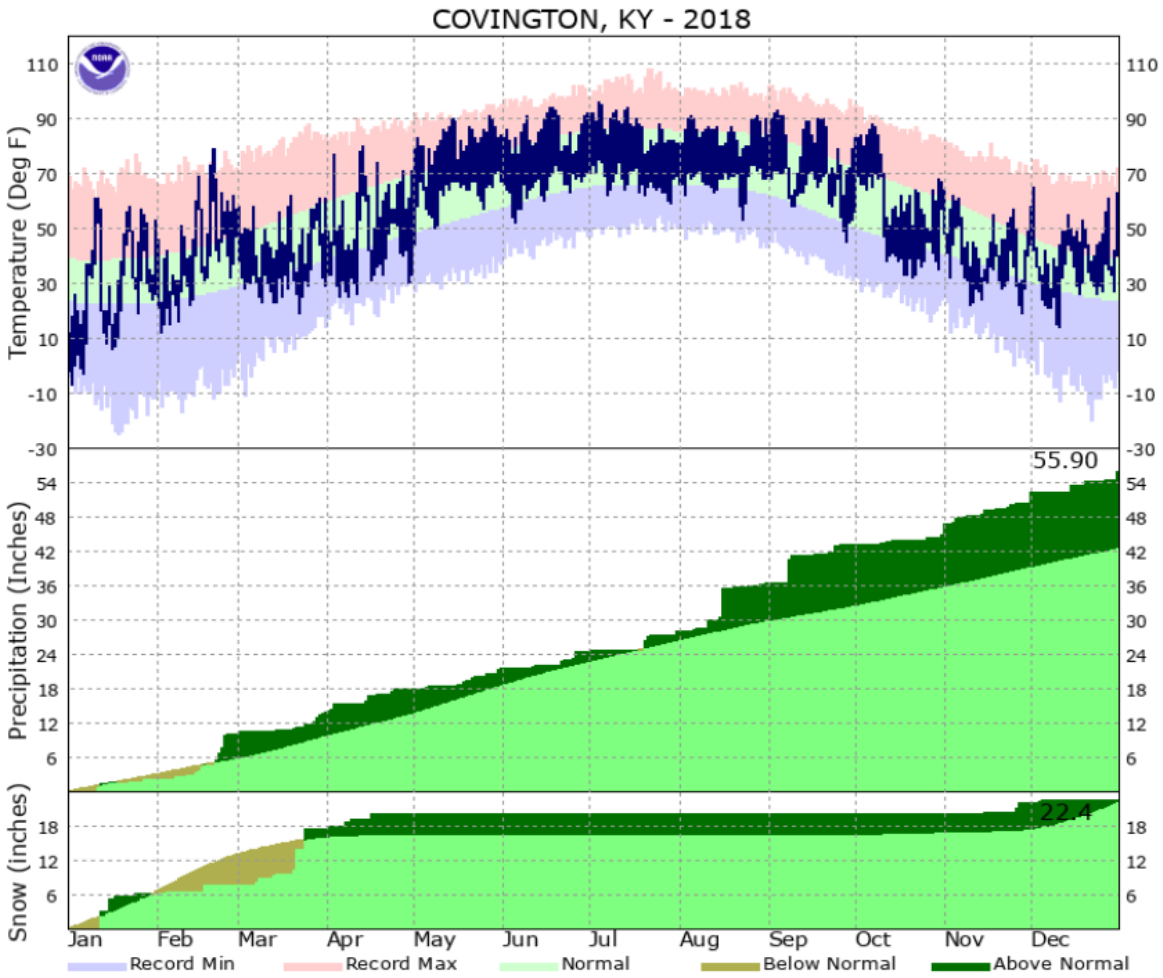

Figure 25, via National Weather Service

Noise Pollution

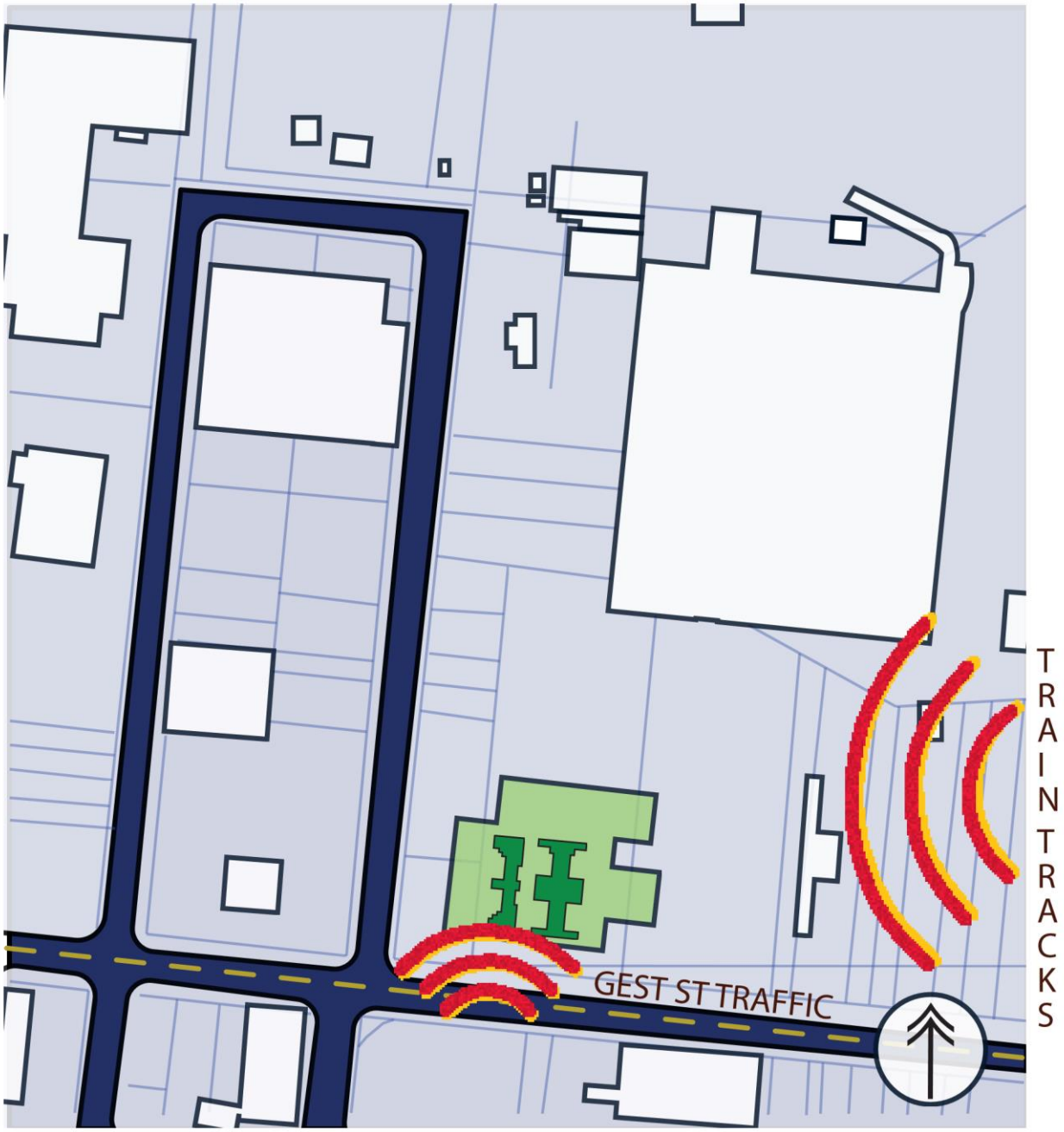

Figure 26, Noise Pollution Graphic. The two main sources of noise pollution are traffic from Gest St. which is moderate and the nearby train tracks which is intermediate.

Solar Exposure

The roof is in full sun with a taller building to the north of it. The shadow of the building does not cast onto the roof. There are no other objects that block the roof from the sun. Due to the urban heath island effect, the surrounding area can experience higher temperatures. "Urban heat islands occur when cities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. This effect increases energy costs, air pollution levels, and heat-related illness and mortality." (Environmental Protection Agency). NASA researchers found that "the Cincinnati and Covington area is 8.32°F warmer during the day and 4.97°F warmer at night compared to non-urban areas" (LaJoie et. al). With the current green roof, most of the concrete is exposed. The areas of the two garden beds are 2,919 ft and 1,452.75 ft with a combined total of 4,371.75 ft. The total area of the grit building roof is approximately 18,000 ft.

Relevant Ohio Building Codes

- 1607.12.3 Occupiable Roofs: Areas of roofs that are occupiable, such as vegetative roofs, roof gardens or for assembly or other similar purposes, and marquees are permitted to have their uniformly distributed live loads reduced in accordance with Section 1607.10.
- 1607.12.3.1 Vegetative and Landscaped Roofs: The weight of all landscaping materials shall be considered as dead load and shall be computed on the basis of saturation of the soil as determined in accordance with ASTEM E2397. The uniform design live load in unoccupied landscaped areas on roofs shall be 20 psf. The uniform design live load for occupied landscapes areas on roofs shall be determined in accordance with Table 1607.1.

Use Patterns

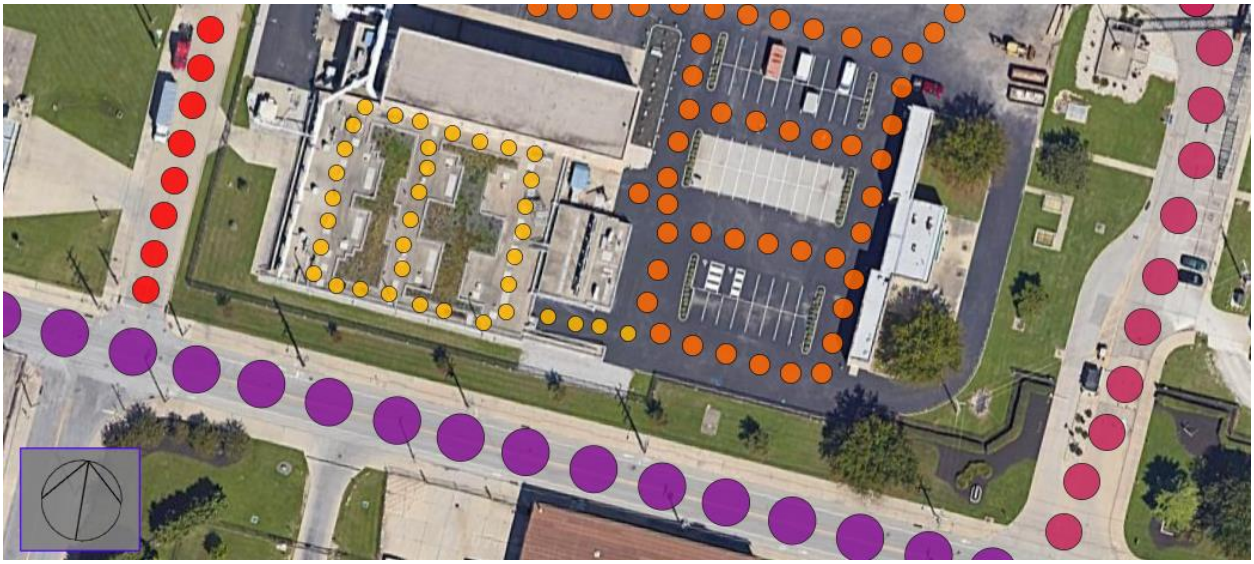

Figure 27, Usage Patterns, Satellite Image via Google Earth

Impacts of Development

If the green roof was to be expanded from its current square footage of 4,371.75 to cover more of the roof, it could have more of a positive impact on storm water retention. In a rainfall event that reaches 1", the whole roof receives 11,263.84 gallons. The vegetative portions of the roof receive 2,723 gallons. In an entire year with an average rainfall of 40", it will receive 108,944 gallons of rain. In the months of April-October where the average rainfall is 23.5" the roof has a water storage capacity of 90%. Therefore, the roof will absorb 57,591.45 gallons of rainwater. In the months of November- March the average rainfall is 17.2" with a water storage capacity of 40%. Therefore, the roof will absorb 18,738.36 gallons of rainwater. The combined total of this is 76,329.8 gallons in a year with a 40" average rainfall. If the square footage of the vegetative portion were to double, the total amount of gallons saved would reach 152,685 in a year with 40" of rainfall.

Drainage

Green roofs typically have a drainage mat underneath the plants and growing media. This roof has a composite drainage mat system that also acts as a root barrier, WaterDrain VR. The bottom layer is a geotextile fabric made of polypropylene and is treated with copper hydroxide to inhibit the roots from growing through the drainage mat. The top layer is made up of conical-shaped reservoir cups that can hold water for plants.

Physical Performance Characteristics

WaterDrain VR

Property	Typical Value		Test Method
Thickness	½" (12.7 mm)	1" (25.4 mm)	
Compressive Strength	15,000 lbs/ft² (732 kN/m²)	9,500 lbs/ft² (460 kN/m²)	ASTM D 1621
Water Storage Capacity	0.06 gal/ft² (92.4 L/ m²)	0.11 gal/ft² (4.51 L/ m²)	-
Horizontal Flow Gradient = 1.0	16 gpm/ft² (200 Lpm/m²)	100 gpm/ft² (1240 Lpm/m²)	ASTM D 4716
Horizontal Flow Gradient = 0.1	6 gpm/ft² (75 Lpm/m²)	21 gpm/ft² (260 Lpm/m²)	ASTM D 4716

Figure 28, Drainage Mat Data via Tremco Incorporated

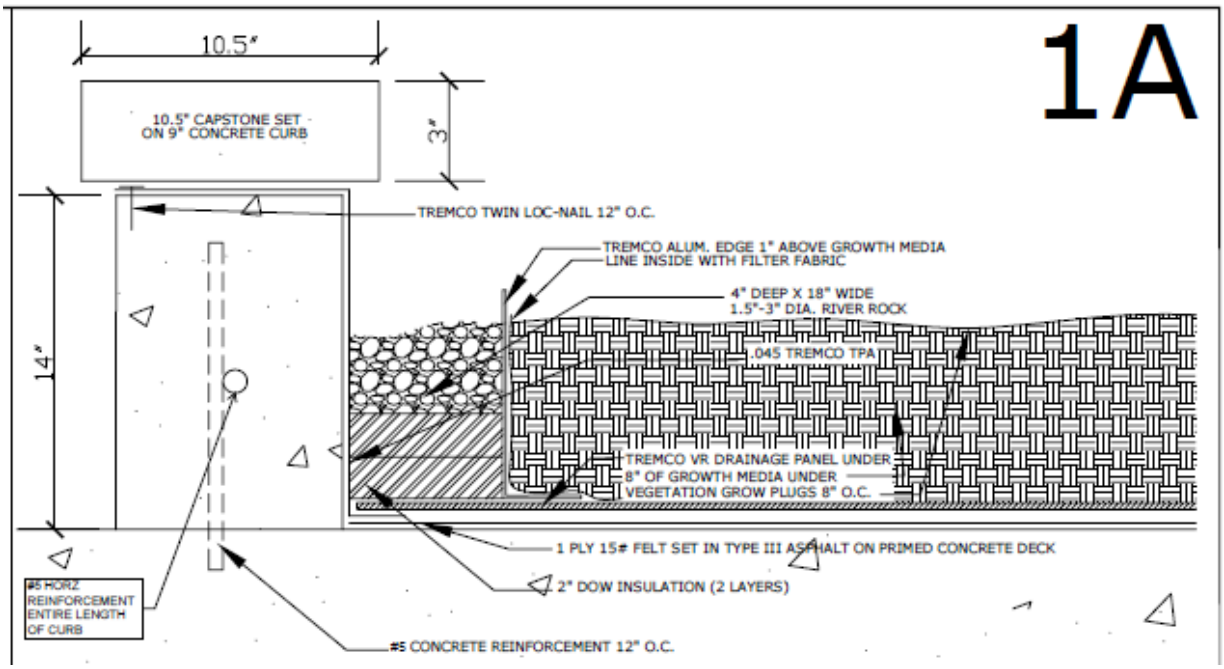

Figure 29, This graphic shows the current drainage system from side view. It is a French style drain that runs along the edge of the garden bed. Drainage Diagram via Industrial First Inc

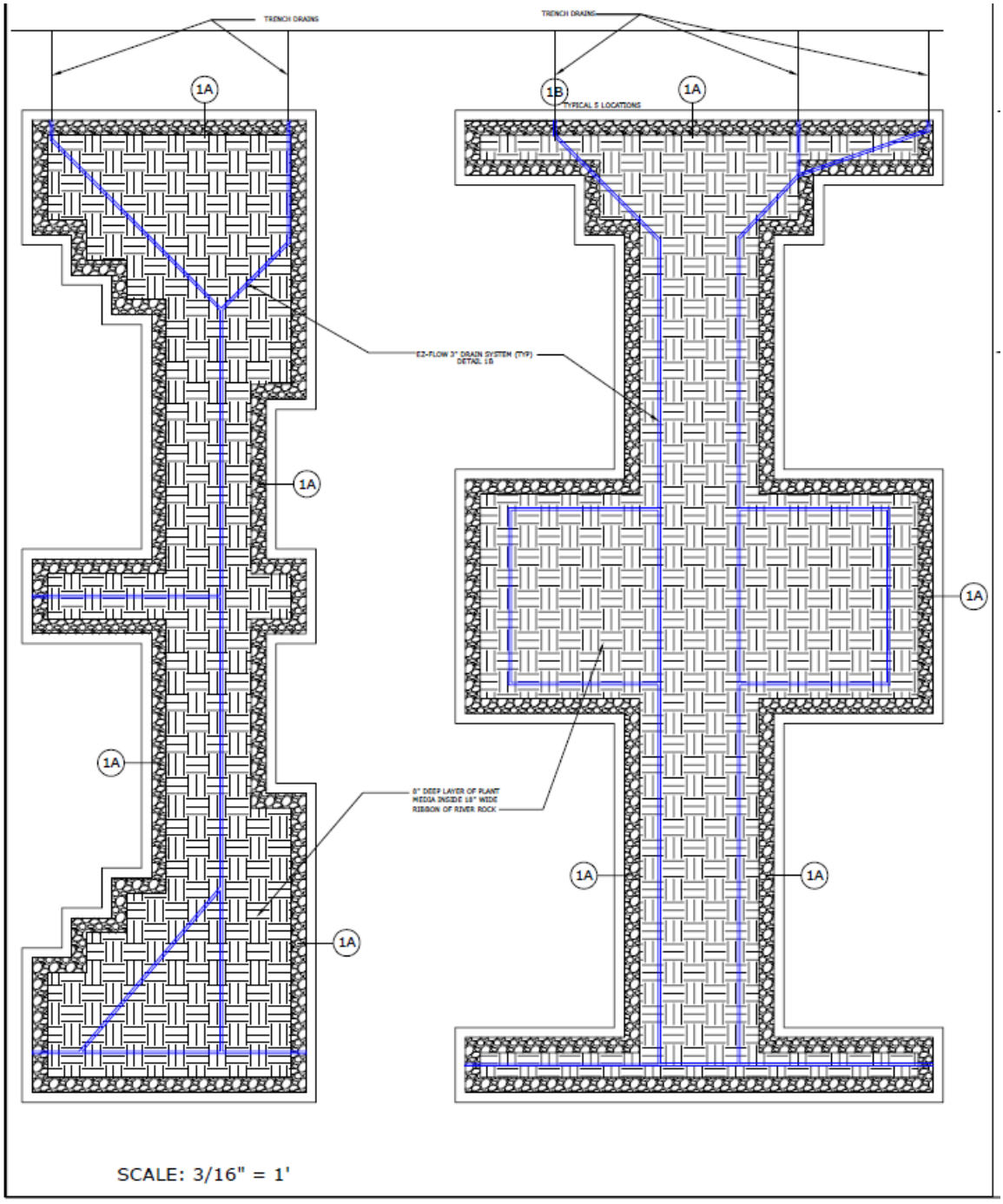

Figure 30, Drainage Diagram via Industrial First Inc

The drain is a gravel-free French drain, EZ- Flow, that runs through the beds.

Site Summary

In the Spring of 2024, the roof is not being used to its full potential. This roof design is a unique opportunity to create a green roof that is relatively accessible to the public due to the frequent tour groups that visit the site as well as its location being low to the ground. With limited plant diversity, a relatively small size compared to the rest of the roof, and little to no public knowledge of the roof, MSD is missing out on an educational tool to help impact their combined sewer overflows. The site already has an existing green roof. This shows that MSD is willing to install a green roof and that the space is a hospitable environment for green roofs. There is full sun exposure, high annual rainfall, and previously installed drains that all make the space compatible for a green roof.

Literature Review & Case Studies

The Benefits and Challenges of Green Roofs on Public and Commercial Buildings: A Report of the United States General Services Administration

This study, authorized by the United States Congress, goes over the costs, benefits, challenges, and opportunities of green roofs on public and commercial buildings. It amassed data from around 200 research studies and includes a cost-benefit analysis. This study highlights how government agencies are promoting green roofs because of their environment and economic benefits. They state that the "green roofs provide a payback (based on a 50-year average annual savings) of approximately 6.2 years nationally" (General Services Administration).

The study finds that "installing a green roof can help reduce wastewater treatment costs in area with combined sewers" (General Services Administration). This can help reduce the costs for taxpayers. In Washington DC, where GSA is located, installing green roofs "throughout the combined sewer area could potentially have an annual operations savings of $1.4-$5.1 million dollars" (General Services Administration).

Estimating the Environmental Effects of Green Roofs: A Case Study in Kansas City, Missouri

Kansas City is a midsize city in the Midwest that is located on a river that flows into the Mississippi River. "Since 2002, the city has discharged approximately 6.4 billion gallons of untreated sewage each year into local streams and rivers" (Environmental Protection Agency). Kansas City has also reached a settlement with the EPA to reduce its "5.4 billion gallons of annual combined sewer overflow discharges to comply with the Clean Water Act" (Environmental Protection Agency). The Green Roof Energy Calculator that they utilized in this study estimates that "green roof systems could retain up to 29 inches of stormwater per year on average" (Environmental Protection Agency). The EPA estimated that there would be between 700,000-800,000 square feet of green roofs by the year 2020 and used that data to determine their calculations. The green roof calculators utilized in this study was created by the University of Toronto and Portland State University. It can be used to determine the "electricity savings, heat flux, evapotranspiration, and net stormwater runoff of a building with a green roof against existing office buildings and apartments buildings with conventional roofs. They created a methodology that is applicable and evidence-based to create tangible data to demonstrate the benefits of green roofs to decision-makers who will be implementing the green roofs.

Green Cities Great Lakes: Using Green Infrastructure to Reduce Combined Sewer Overflows

This study goes into the various green infrastructure technologies and how they can reduce combined sewer overflows in The Great Lakes Basin. This study suggests other strategies besides green roofs to use, including downspout disconnection programs, permeable pavements, rain gardens, and road swales. This is all useful information for the educational aspects of this project as the average homeowner is not capable of installing a green roof. Using a variety of different techniques is crucial when reducing combined sewer overflows. This "relieves the

strain on hard infrastructure so that stormwater runoff volumes can be reduced" (Ecojustice). The main point of this research project is to highlight the rigidity and difficulty of solving the CSO issue. This study explains how green infrastructure is flexible and can be applied in many different scenarios. "Green infrastructure solutions can be used almost anywhere soil and vegetation can be incorporated into the urban landscape, and the benefits are particularly significant in urban areas where there is limited green space and a high degree of environmental degradation" (Ecojustice).

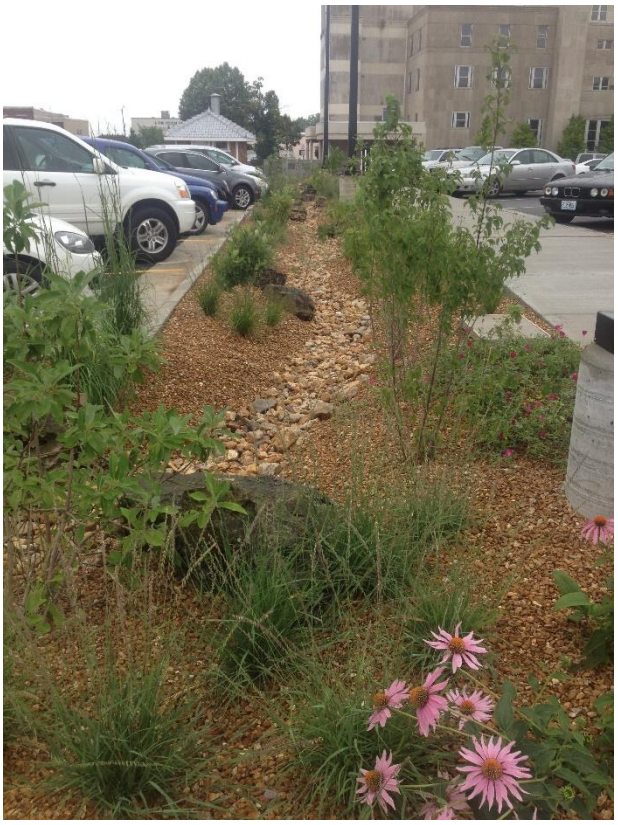

Figure 31, Bioswale in an urban parking lot located in Missouri

Interpretation design: an integrative, interdisciplinary practice

This study focuses on the practice and goals associated with interpretation design when used in public spaces like museums, zoos, and heritage sights. The author, Toni Roberts, explains interpretation design as design for communicating ideas in a way that is attractive and engaging for visitors. "Interpretation design is the strategic application of one or more design forms to shape visitor experiences that communicate specific ideas, values and messages. Interpretation design seeks to engage visitors through cognitive, affective and physical means; visitors co-create their individual experiences through prior knowledge, motivations and actions to learn and make meaning over time. Interpretation design aims to coordinate and integrate elements into a holistic, coherent visitor experience." (Roberts). Roberts goes on to explain the importance of interpretation design in public spaces to "communicate complex, layered messages, ideas, and information" and for "encouraging visitor engagement" (Roberts). The goals of interpretation design are to spark the interest of the audience and create analogy with everyday experiences to help the audience relate to the information.

Through interviews with public spaces that use interpretation design, two different nature preserves located in Australia, Roberts highlights how interpretation design should be multilevel in its execution. On one level is communication with the audience through education. On a

deeper level is the need to “create a coherent environment that supports the interpretive messages, sense of place, intuitive way finding, and integrated content” (Roberts).

Case Study Summary

Green roofs reduce combined sewer overflows, the focus of this project, but they have many other benefits including improved air quality, reduced energy consumption, reduced sound pollution, and improving water quality. Kansas City bears a lot of similarities to Cincinnati. Two out of three of these case studies were done by the federal government, including the EPA. The EPA highly encourages green roofs as a solution to combined sewer overflow as well as urban heat island effect, reduction of air pollution, and as a wildlife corridor for threatened species. These studies have given concrete ways to synthesize the data that is needed to prove the importance of green roofs through online calculators, cost analysis, and research-based evidence. These type of tool and data would be useful in determining the data for Cincinnati. This type of data is needed to educate the public about the benefits of green roofs and to include in the educational signage around the proposed design. They have shown other successful measures of green infrastructure that can be used in addition to green roofs and how to discuss them in an easily digestible way. This is all useful information when creating educational tools for the public.

The research study on interpretation design study helps highlight the importance of creating intentional educational signage, which is a main goal of this project. The main takeaways from this research paper include the importance of relating to the audience through analogies, catering to various learning styles, and creating cohesion between learning tools. It also highlights the importance of using various design methods including signage, art, and landscape. These are all aspects that will be included in the overall design.

If the agency that is responsible for constructing, managing, and preserving government buildings is recommending green roofs for publicly owned buildings, it is logical that the City of Cincinnati can do the same through the installation and promotion of green roofs on city owned properties. MSD has made news in the recent past for mishandling taxpayer money. By promoting green roofs as an opportunity for a reduction for taxpayers, this can be a selling point in their promotion of green roofs.

Historical Context

In 2002 the City of Cincinnati reached a partial settlement with the Environmental Protection Agency that they will "eliminate long-standing and significant discharges from its sanitary sewer system". The EPA states that these discharges violate the Clean Water Act and are illegal. They estimated that this agreement would cost the city more than $450 million dollars and take up to 2016 to assess and complete a comprehensive plan to eliminate their raw sewage discharge.

Figure 32, A sign posted at the Mill Creek warning people of potential combined sewer overflow

In 2016, MSD was found to be giving money to a charity that had little to do with sewers. "Project Rebuild Foundation, a privately- run nonprofit, relied heavily on public money from the Metropolitan Sewer District to subsidize both its operations and its mission" (Horn). The sewer district's ratepayers, the constituents whose taxes go towards MSD funds, paid more than $800,000 to provide services to high school students on basic life skills. It was largely labeled as a mismanagement of money during a multimillion-dollar plan to revamp the sewers to comply with the Clean Water Act.

In 2019, Federal regulators got involved in an ongoing battle between the City of Cincinnati and Hamilton County over Metropolitan Sewer District. Hamilton county owns MSD, but the city runs it, resulting in a power struggle on coming up with next steps for reducing sewer overflows into local streams and rivers. "The county submitted a five-year plan worth $616 million. The city wanted a 10-year plan worth $1.01 billion" (Wartman). If the federal judge agreed with the county's plan, it could result in major increases in yearly payments for Cincinnati residents. From 2006 to 2016 , "the average annual sewer bill went from $250 to $1000" (Horn) due to the massive overhauls. The lack of agreement on a plan demonstrates how the city is not taking necessary steps to "bring MSD into compliance with the federal Clean Water Act" (Hanselman).

Since 2018, the levels of combined sewer overflow has stayed consistently in the multi-billion gallon range, showing that there is still improvements that can be made. Promotion of alternative methods, like green infrastructure, is in the best interest of MSD.

Solutions

How Can a Municipal Sewer District Promote the Reduction of Stormwater Runoff Through Native Plant Landscaping and Green Roof Education?

By Annie Lewis

In 2010, the Metropolitan Sewer District, the agency responsible for waste water treatment in the Greater Cincinnati area, installed a green roof on one of their Mill Creek Plant buildings, however, it has been neglected and is not reaching its full potential. Through research on green roof's effects on combined sewer overflow, an improved green roof design, and educational signage this study aims to create an educational, visually pleasing, native focused, and functional green roof that still allows employees ease of access to necessary equipment. MSD can encourage an increase of green roofs throughout the city and this study creates a comprehensive plan to use green roofs as a promotional tool.

A Dirty History

In 2002 the City of Cincinnati reached a partial settlement with the Environmental Protection Agency that they will "eliminate long-standing and significant discharges from its sanitary sewer system". The EPA states that these discharges violate the Clean Water Act and are illegal. They estimated that this agreement would cost the city more than $450 million dollars and take up to 2016 to assess and complete a comprehensive plan to eliminate their raw sewage discharge.

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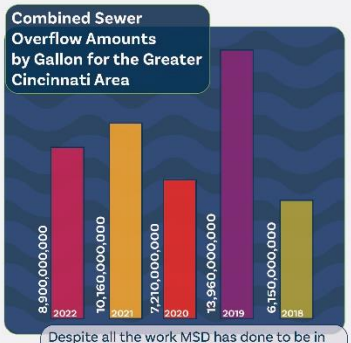


Despite all the work MSD has done to be in compliance, the numbers are still staggering. *Data via Metropolitan Sewer District Consent Decree Quartlery Reports*

A sign by the Mill Creek CSO location warning people not to come into contact with the water. *Image via Metropolitan Sewer District of Greater Cincinnati*

Inspiration

Image via Recreation and Park Commission for the Parish of East Baton Rouge

Image via San Juan Island National Historical Park

Image via Pannier Graphics

The green roof design is focused on the decrease in stormwater runoff, creating aesthetically pleasing and native plant focused green roof raised beds, and ensuring the roof is still functional for employees.

The design is informed by research studies conducted by government agencies including Environmental Protection Agency and General Services Administration. These studies highlight all of the benefits of increasing vegetative space on roofs including reduction in urban heat island effect, added insulation from outside weather and sound, and reduction in storm water runoff. One of the main goals of the design is to increase vegetative square footage by 50% to increase the effect of these stated benefits.

The design for the signage is informed by many examples of interpretation that are design focused on native plants and green infrastructure. Interpretation design focuses on communicating ideas and information with the goal of sparking the audience's curiosity.

The green roof's signage incorporates this by creating visual representations and analogies of everday experiences, communicating directly with the audience, and creating a cohesive design environment. The signs are placed throughout the space along with seating. This invites guests to spend more time with the surrounding landscape and create an inviting environment for tour groups.

Image via Botanical Concepts Chicago

Tour Guide Teaching Outline

This outline will be given to employees offering tours to visitors. This adds another layer to the communication methods of the interpretation design as it is important to have a variety of different methods to cater to various learning styles. These are the general talking points and facts for tour guides to bring up to help spread MSD's positive green roof image.

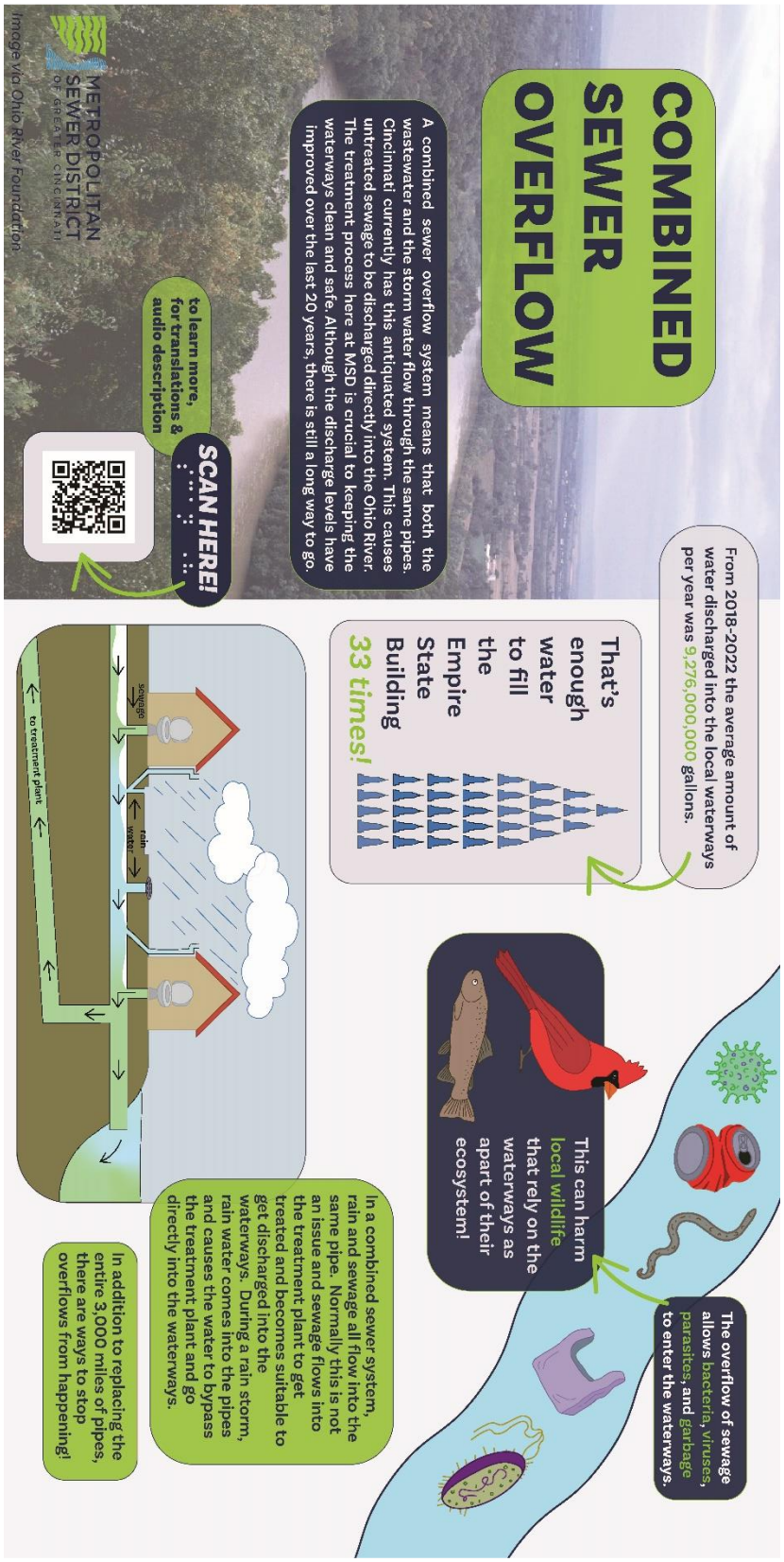
- **MSD's progress towards CSO elimination since 2009.**
- 7.8 billion gallons of sewer overflows eliminated
- Improved water quality in 114 miles of local streams, including Mill Creek
- 175+ wet weather projects completed
- 72 CSOs eliminated or controlled
- 69 SSOs eliminated or controlled
- **The Green Roof Loan Program**
- MSD offers low interest loans to property owners to install green roofs
- This also includes on-ground stormwater controls like cisterns, bioswales, rain gardens, pervious pavers, and rain barrels
- **Biodiversity**
- This roof contains over 20 native plant species.
- Biodiversity is important, especially in urban areas, because it offers habitat and food for many different bird and insect species

Faculty Advisor Stevie Famulari Gds
HORT 4092: Senior Project
Spring 2024

Green Roof Redesign

- The vegetative area of the green roof has been increased by 17%. The original vegetated area was 4,371,75 square feet. The new design includes 720 additional square feet. The estimated amount of rainfall collected in a year with 40 inches of rain is 126,892.64 gallons. This is increased from the estimated amount of 76,329.8 gallons.
- The plant palette has been diversified from 8 species to 20. These plants are a majority native and will increase biodiversity by attracting native insects and plants. The species included are the following:
    - *Agastache* 'Blue Fortune', Blue Fortune Hyssop
    - *Allium* 'Millenium', Millenium Ornamental Onion
    - *Amsonia tabernaemontana* 'Blue Ice', Blue Ice Blue Star
    - *Ascelpias syriaca,* Common Milkweed
    - *Asclepias tuberosa,* Butterfly Weed
    - *Baptisia australis* 'Lemon Meringue', Lemon Meringue False Indigo
    - *Bouteloua gracilis,* Grama Grass
    - *Coreopsis verticillata,* Threadleaf Coreopsis
    - *Echinacea purpurea,* Purple Coneflower
    - *Gaillardia aristata,* Blanket Flower
    - *Liatris spicata,* Dense Blazing Star
    - *Monarda fistulosa* 'Claire Grace', Claire Grace Wild Beebalm
    - *Panicum virgatum* 'Shenandoah', Shenandoah Switch Grass
    - *Phlox* 'Fashionably Early Crystal', Fashionably Early Crystal Garden Phlox
    - *Rudbeckia hirta,* Black-eyed Susan
    - *Schizachyrium scoparium* 'Standing Ovation', Standing Ovation Little Bluestem
    - *Symphyotrichum novae-angliae,* New England Aster
    - *Symphyotrichun oblongifolius* 'Raydon's Favorite', Raydon's Favorite Aster
- The redesign is limited to a 17% increase to allow access to necessary equipment on the roof and allow it to stay accessible with paths at least three feet wide.

Education Material



GREEN INFRASTRUCTURE

Green infrastructure is a series of alternative plant solutions to traditional grey infrastructure. Grey infrastructure is when water goes directly into the sewage systems. Green infrastucture utilizes plants, soil, landscaping, and hardscaping to divert rain water from the sewage system. This lessens the chance for an overflow or flooding incident to occur. Installing and maintaining green infrastructure is more affordable. It can be done on a very large scale like a green roof or small scale like a backyard rain barrel. When a whole community makes small changes to incorporate green infrastructure, it can stop a flooding from a rainstorm. Most people see green infrastructure in action everyday and do not even realize it!

BIOSWALES

Bioswales are shallow depressions made in the land and are designed to collect rain water. They are often found in parking lots or inbetween roads and sidewalks. Bioswales are used to break up the sleak, impervious concrete that often makes up urban areas.

Bioswales are beneficial because they improve the quality of rainwater as plants filter out the impurities in the water. They also reduce the quantity of water that is flowing into the sewers. Common plants that are put in bioswales are sedges, ornamental grasses, shrubs like dogwood and buttonbush, and water-loving plants like cardinal flower and swamp milkweed.

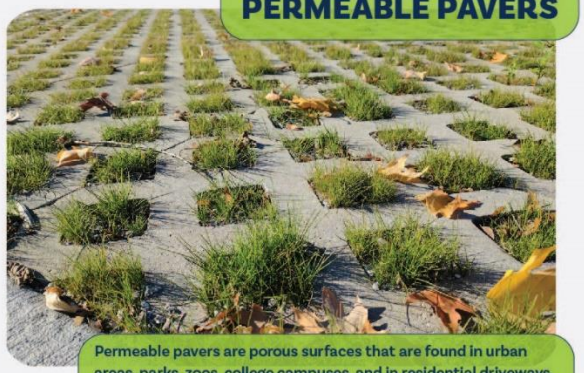
Image via Michigan State University Extension

RAIN BARRELS

Rain barrels are something a home gardener can install. Not only are they saving money on their water bill by repurposing rain water for watering plants, they are also keeping water out of the sewer system. Rain barrels are connected to the downspouts (such as gutters) and usually hold around 50 gallons. It is importnat to place a rain barrel as high as possible to allow gravity to feed the water through a hose.

Image via Michigan State University Extension

PERMEABLE PAVERS



Permeable pavers are porous surfaces that are found in urban areas, parks, zoos, college campuses, and in residential driveways. They are made up of individual bricks or concrete with space in between the bricks and a layer of gravel to allow for water to trickle and plants to grow. They are best used on slopes to allow the gravity to help the water flow.

Image via Mississippi Watershed Management Organization

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TYPES OF GREEN ROOFS

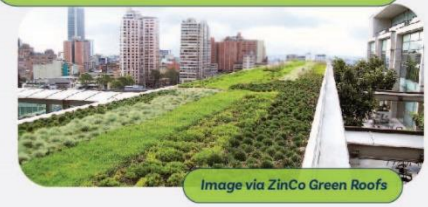
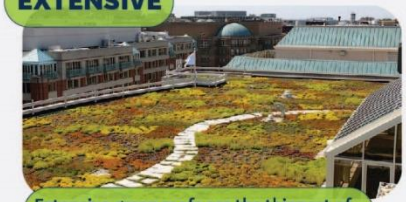


Image via ZinCo Green Roofs

EXTENSIVE



Extensive green roofs are the thinnest of the three green roof types. The soil is usually 2-6 inches deep and it is made up of small, hardy plants like sedums and ornamental onions. These roofs are the most are the most affordable option because they require little maintenance and less material than the other two.

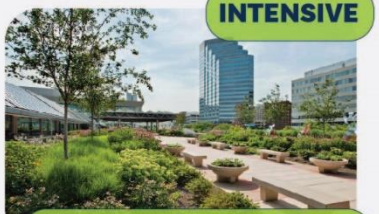
Image via Greenroofs.com

SEMI-INTENSIVE

Semi-intensive roofs are the median between extensive and semi-intensive. They have 6-12 inches of growing medium. They require moderate amounts of maintenance and can require irrigation. Perennials, grasses, and small shrubs can be found on a semi intensive roof.

Image via 3 River Wet Weather Rainways

INTENSIVE



Intensive roofs are the heaviest and thickest of the three roofs. These are more suitable for people to spend time on them and will feature seating areas and walking paths. The soil is typically 12-24 inches thick. Perrenials, shrubs, and trees can be found on these roofs.

Image via Pro Arkitects

Can you tell what kind of green roof this one is?

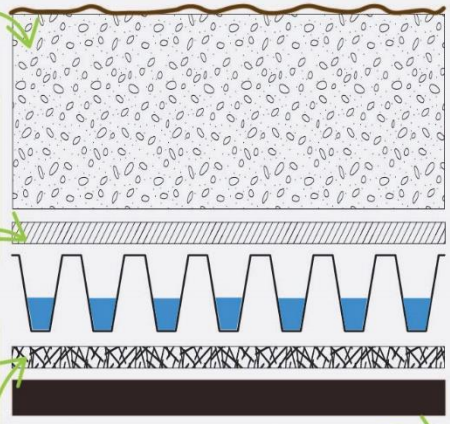
WHAT'S UNDERNEATH?

Green roofs are more than just plants growing on top of a roof. They are made up of many layers which keep water from leaking into the building, allow the excess water to drain, and make sure the roof has enough nutrients

Growing media is what the plants put their roots into to allow them to grow and uptake nutrients. It is like soil but is made up of things like tree bark, peat moss, and perlite. Soil is often too heavy to put on a roof. It is important to keep the roofs as light as possible because a heavy roof can cause structural issues for the building.

Drainage is a crucial part of a green roof system. WIthout a proper drainage system, the excess water from the roof would just sit, keeping the plants too wet. The drainage layer is made up of little cups and looks like an egg carton. This stores the water for when plants might need it. Whatever waterthe plants do not need evaporates.

Waterproofing is a thick layer of some kind of rubber or plastic that keeps water off of the roof below. The waterproofing can be rolled out or poured out as a liquid like tar. It's important to check the waterproofing periodically to ensure no rips or holes have formed.



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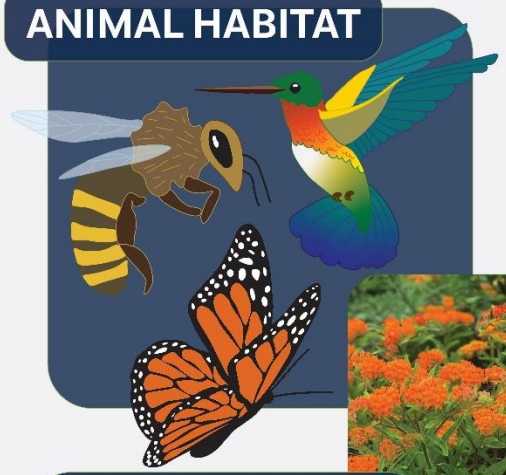
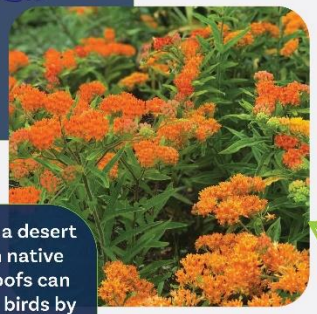
WHY INSTALL GREEN ROOFS?

ANIMAL HABITAT





Urban areas are often times like a desert for insects and birds that rely on native plants as a food source. Green roofs can provide an oasis for insects and birds by providing habitat and food sources, especially for migratory insects like monarch butterflys.

Monarchs rely on milkweed as their only food source as caterpillars.
Image via Garden for Wildlife

URBAN HEAT ISLAND

Ubran areas tend to be hotter than suburban and rural areas. This is because of the dense amount of pavement, buildings, and cars found in cities while also lacking trees and plants compared to suburban and rural areas. The higher temperatures cause people to use more energy to cool their buildings, it leads to more air pollution, and more heat related illness.

Green roofs help minimize the heat island effect. They insulate the building below which can help reduce energy use. Green roof temperatures tend to be 30-40° lower than traditional roofs and can reduce city ambient temperatures by up to 5°.Plants have a naturally cooling effect. They release moisture into the atmosphere which can help cool down the surrounding area.

RAINWATER RUNOFF

Green roofs are another tool in toolbox of green infrastructure. On a traditional roof, rainwater runs off immediately directly into the sewers. With a green roof the spongy layer of soil and roots absorbs excess rainwater. A majority of rainwater that comes in contact with green roofs completely avoids the sewer system.

This green roof saves an average of over 126,000 gallons of water annually.

That's the same amount of water than an average American household will use annually.

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- Four interpretation design signs have been created for educational opportunities for the intended audiences of tour groups ranging from elementary school-aged to adulthood.
- These signs cater to different learning styles by creating visual analogies, using bright colors, and using real-world examples.
- The signs are the based on the following topics:
    - Sign 1: What is combined sewer overflow?
    - Sign 2: What is green infrastructure?
    - Sign 3: Types of Green Roofs
    - Sign 4: Benefits of Green Roofs.
- The signs include the following accessibility features:
    - There is a QR code to scan for audio descriptions of the signs for people with visual impairments.
    - There is braille featured on the sign to allow people with visual impairments to locate the QR code.
    - They have a font of at least 18 point and feature contrasting colors for people with visual impairments.
    - The signs feature accessible language and images to allow the general population to understand the concepts.

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This outline will be given to employees offering tours to students and other groups. This adds another layer to the communication methods of the interpretation design as it is important to have a variety of different methods to cater to various learning styles. These are the general talking points and facts for tour guides to bring up to help spread MSD's positive green roof image.

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- Biodiversity
    - This roof contains XX amount of native plant species.
    - Offers habitat and food for many different bird and insect species

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