Mitigating misfortune.

by

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A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECUTRE

Department of Landscape Architecture
College of Architecture, Planning, and Design

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2023

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Abstract

As flooding continues to be a major issue in cities across the United States, there is an increasing need to manage stormwater on private property rather than allowing the water to run off into sewer systems. This project explores why homeowners should retrofit their single-family residential property to manage stormwater to meet this increased need. To do this, the best vegetated and unvegetated residentially-scaled features are selected based on upfront cost, maintenance hours per year, and potential for captured stormwater volume to score the overall effectiveness of each feature. Selected stormwater features are proposed to capture runoff on the Kansas State University's President's Residence site during a storm event. These findings were then used to estimate the runoff on large lot (1.25-5 acres) properties in the Sharingbrook Neighborhood in Manhattan, Kansas, to model how much stormwater could be captured rather than drain into Little Kitten Creek and, eventually, Wildcat Creek. The project also identifies three cities with exemplary residential stormwater management incentive programs: Minneapolis, Minnesota, Portland, Oregon, and Washington D.C. The chosen properties in the Sharingbrook Neighborhood were evaluated based on the projective design to show how the design could benefit Manhattan, Kansas assuming it adopted the strongest incentive program.

Mitigating Misfortune

Residential Stormwater Management

Retrofitting large-lot single-family
residences to manage stormwater to
reduce urban and suburban runoff

Figure 0.1. Flowering shrub. Sam Wolkey.

Abstract

As flooding continues to be a major issue in cities across the United States, there is an increasing need to manage stormwater on private property rather than allowing the water to run off into sewer systems. This project explores why homeowners should retrofit their single-family residential property to manage stormwater to meet this increased need. To do this, the best vegetated and unvegetated residentially-scaled features are selected based on upfront cost, maintenance hours per year, and potential for captured stormwater volume to score the overall effectiveness of each feature. Selected stormwater features are proposed to capture runoff on the Kansas State University's President's Residence site during a storm event. These findings were then used to estimate the runoff on large lot (1.25-5 acres) properties in the Sharingbrook Neighborhood in Manhattan, Kansas, to model how much stormwater could be captured rather than drain into Little Kitten Creek and, eventually, Wildcat Creek. The project also identifies three cities with exemplary residential stormwater management incentive programs: Minneapolis, Minnesota, Portland, Oregon, and Washington D.C. The chosen properties in the Sharingbrook Neighborhood were evaluated based on the projective design to show how the design could benefit Manhattan, Kansas assuming it adopted the strongest incentive program.

Acknowledgments

I express my appreciation to the following for assisting me with this research and report:

Major Professor Lee R. Skabelund
Committee Member Kirby Barrett
Committee Member Dr. Trisha Moore
Washington D.C. Department of Energy and Environment

Figure 0.2. Flowering eastern redbud. Sam Wolkey.

For my parents who have given me the opportunity to be my best self.

Table of Contents

Table of Contents

List of Figures

List of Figures

List of Tables

Chapter 1 -

Introduction

Introduction

Project Rationale

Residential stormwater management is especially important in cities since a significant amount of land use is residential. The local neighborhood I studied has significant amounts of impervious surface. If many homeowners can be incentivized to manage the stormwater that falls on their property, rivers and streams would not have the volume of water running through them that leads to damaging erosion and flooding. The project examined how much a residence could subtract from the flooding volume by implementing designs on a few properties in the Sharingbrook Neighborhood in Manhattan, Kansas. By also analyzing the President's Residence at Kansas State University (K-State), the possibility for stormwater BMP implementation is more likely. Using the appropriate ratios for a residential property, the project used data from the K-State President's Residence to examine the impact of using similar stormwater features or BMPs (best management practice) at the Sharingbrook Neighborhood in Manhattan, Kansas. Once this was done I explored the types of incentive programs that could be implemented to allow property owners and city staff and officials to better understand how achievable a shared goal of reduced flooding can be.

Research Questions

How can designers encourage private homeowners to retrofit their single-family large-lot property to manage stormwater?

What incentive program in the U.S. is most likely to encourage homeowners to implement stormwater management features on their properties?

What residential-scale vegetated and unvegetated features are "best" based on upfront costs, maintenance hours per year, and stormwater volume potential?

Research Goals

The first goal of this research was to determine why a private homeowner should retrofit their property to manage stormwater.

The second goal of this research was to find an incentive program in the United States that is most likely to encourage participation and implementation of stormwater management features on large-lot residential property.

The third goal of this research was to identify residentially-scaled features that are "best" based on cost, maintenance considerations, and stormwater volume capacity.

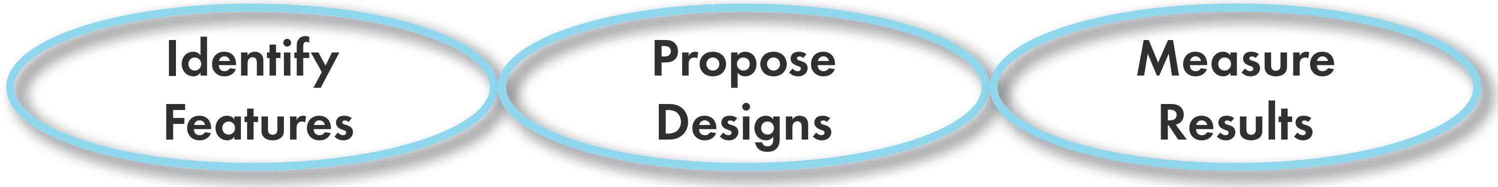


Figure 1.1. Project sequence. Sam Wolkey.

Introduction

Dilemmas - Flooding

When there is a large rain event, conventional, developments design for stormwater to be moved quickly away from the site through swales and drains which rapidly send stormwater to nearby rivers and streams. All of these can be overrun with stormwater following a storm event and cause flooding, leading to property damage and expensive clean up.

Flooding has been affecting the Manhattan area for decades. Prolonged storm events, such as the ones in September of 2018 and the summer of 1993, cause streams and rivers to breach their banks, leading to property damage and expensive cleanup efforts by property owners and cities (KMAN 2018; The Watchers 2018).

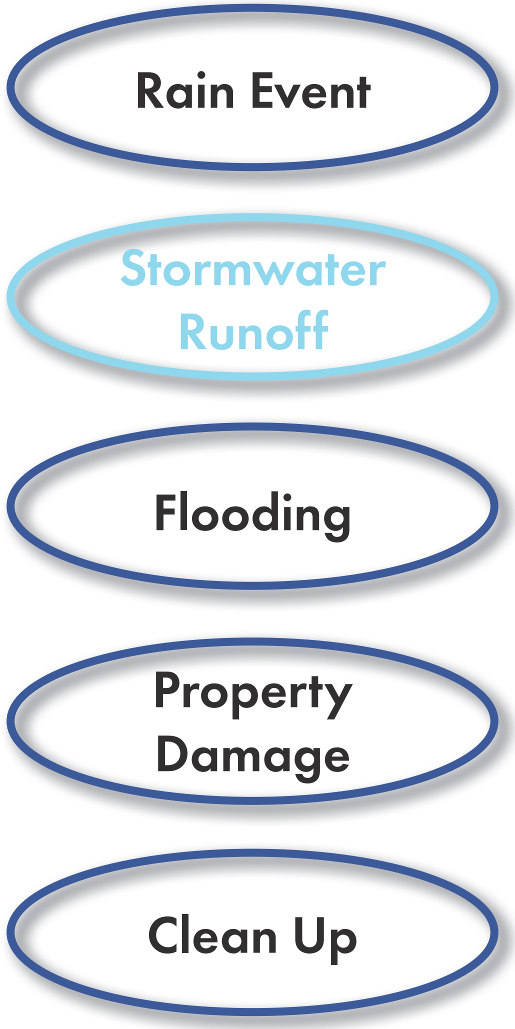


Figure 1.2. Flooding sequence. Sam Wolkey.

Stormwater Management

With the implementation of effective stormwater management instead of rapid stormwater runoff, rain events would not cause as much flooding and reduce property damage and other misfortunes.

The effects of flooding are not always obvious to every homeowner, especially if they live outside of flood hazard zones. Stormwater management will not eliminate flooding but will mitigate the negative effects.

Property owners that live outside flood hazard zones might not think stormwater management is important because their property will not be impacted. They fail to recognize the people living in or near the flood zones and how the damage from flooding can ruin homes and cost a family lots of money. Human health and safety is also endangered.

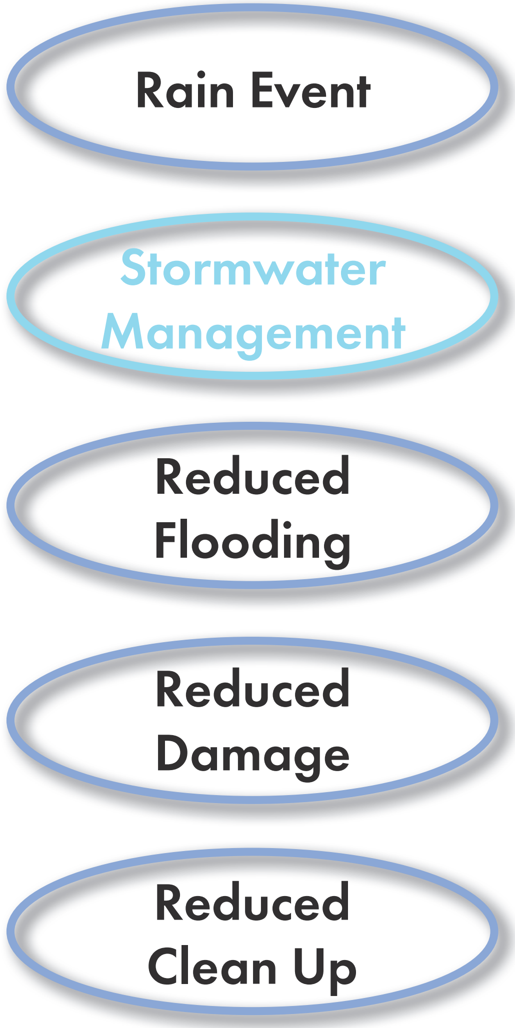


Figure 1.3. Management sequence. Sam Wolkey.

Introduction

Site Background

100 Wilson Court, Manhattan, KS 66502. This is the address that contains a piece of history dating back to the 1920s—the President's Residence. The house was originally built for $31,000, which was donated by Mrs. Mehitable Calef Coppenhagen Wilson, the widow of a state legislator and one of Manhattan's founders. The home was designed to appear as a family's home but match the existing aesthetics of Kansas State University's buildings. Kansas State's seventh president moved in upon completion of the residence, and seven other university presidents have since lived there. The home and site have been renovated over the years to adhere to new needs for hosting events for students, alumni, dignitaries, and even celebrities. The President's Residence has been an important landmark on campus for 100 years and, hopefully, will continue to be revered for 100 more (Kansas State University 2022). However, due to poor drainage and plenty of impermeable surfaces, basement flooding has been an ongoing challenge. Shown to the right, is a lot of impermeable surface that leads to runoff. Managing this runoff is crucial to prevent flooding, erosion, and water pollution.

Figure 1.4. President's Residence Entrance. Sam Wolkey.

Figure 1.5. President's Residence (Front). Lee R. Skabelund.

Figure 1.6. President's Residence (Back). Lee R. Skabelund. Note: the tall hackberry close to the back of the home (seen here at the far left of the image) was removed in Feb 2023 as windfall management.

Introduction

Site Background

According to Dan Devlin, a resident of Sharingbrook since July of 2016, the community at Sharingbrook is made up of professors, doctors, business owners, and others that are both still working or retired. The community is tight-knit and has a "everybody knows everybody" feel. The neighborhood first started in the late 1980s and there are still a few owners that have lived there since the beginning. Sharingbrook has a low turnover rate, according to Devlin, as only one or two new families or couples move in per year to replace homeowners that move away. Devlin sits on the Board of Directors for the neighborhood's homeowner's association (Devlin, Sharingbrook Narrative. Interview March 2023).

Figure 1.7. Lawn in Sharingbrook. Lee R. Skabelund.

Figure 1.8. Major outlet corridor. Lee R. Skabelund.

Figure 1.9. Sharingbrook Drive Looking north. Lee R. Skabelund.

Chapter 2 -
Background

Background

Stormwater Management

When discussing stormwater management, the United States Environmental Protection Agency (US-EPA) uses the definition Congress enacted in the Water Infrastructure Improvement Act of 2019: “the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspire stormwater and reduce flows to sewer systems or to surface waters” (US-EPA 2022b).

The US-EPA discusses how stormwater runoff occurs when rain or melted snow moves through impervious surfaces and ends up in waterways rather than infiltrating into the ground. This causes flooding, erosion, increased sedimentation in streams and rivers, loss of habitat, overflows in storm and sewer pipes, infrastructure damage, and polluted waterways (US-EPA 2022a). The United States Federal Emergency Management Agency (US-FEMA) has slightly different terminology for stormwater management and calls it floodplain management. FEMA’s approach to stormwater management is providing community-based programs to manage a community’s risk of flooding (US-FEMA 2022b). For this report, I define stormwater management as the process by which vegetated or unvegetated features allow for water caused by storm events such as rain or snow to be managed by mimicking natural systems (US-EPA 2022a; US-FEMA 2022b; Holm et al 2014).

Figure 2.1. Top of the world at Marlatt Park, looking west, Manhattan, Kansas. Sam Wolkey.

Background

Stormwater Management Features

Features are categorized in two ways: vegetated and unvegetated. Vegetated features use plants and other landscape systems to manage stormwater, while unvegetated features are products that are engineered to harvest and mitigate runoff. Both types of features are designed to mimic the natural environment by how they retain and clean runoff (Coleman et al 2018; Holm et al 2014). It is also important to note that while these features provide benefits related to runoff and flooding, some have secondary benefits that “include erosion control, temperature control, carbon sequestration, pollinator habitat, food production, as well as aesthetic, recreational, cultural, and social benefits” (Coleman et al 2018, 2). These benefits are discussed on pages 46-53. Figure 3.2 shows an existing driveway that includes pavers. This driveway may or may not include subsurface rock and gravel that could provide for underground storage and some subsurface infiltration. Such subsurface storage areas for rainfall and stormwater runoff from nearby rooftops and concrete surfaces would help reduce runoff to Little Kitten Creek.

Figure 2.2. Existing partially-permeable driveway in Sharingbrook. Sam Wolkey.

Background

Vegetated Features

On residential scales, vegetated features are very important to the visual appeal and sensory qualities of a property. Taller forms of vegetation also offer privacy to homeowners.

Rain gardens are effective examples of vegetated residential stormwater management, because they help retain water and therefore recharge groundwater supply and capture pollutants. Rain gardens are depressions in the landscape planted with specific plants to survive drought but also tolerate flood conditions until the water can infiltrate the ground or evaporate (Freeborn et al 2012, 10; Holm et al 2014 ; Morash et al 2019, 2). Vegetated stormwater management such as native plant rain gardens do not require regular mowing and fertilization.

Another simple method of vegetated stormwater management is planting trees. Planting trees on site can help reduce the amount of stormwater runoff significantly over the course of a year (Freeborn et al 2012, 10). Different trees have different capabilities depending on their size and rooting structure, but trees have more than just stormwater benefits; they can protect homes from the harsh winds during the colder months and the sun's rays during the warmer months, as well as so much more (Freeborn et al 2012, 10).

Figure 2.3. Rain garden accepting run off from lawn.
Washington DC Department of Energy and Environment.

Figure 2.4. Rain garden partially screening a chain-link fence.
Washington DC Department of Energy and Environment.

Figure 2.5. Backyard pond with plantings.
Lee R. Skabelund.

Figure 2.6. Rain garden partially screening utilities.
Lee R. Skabelund.

Background

Grassed or partially vegetated swales with rock and other natural, regionally-sourced materials are another method of managing stormwater on a site that may have topographical or other obstacles. Bioswales are paths for water in areas that slope gently; bioswales are vegetated and can look aesthetically pleasing when there is no rainwater. The goal of a bioswale is to provide a path for water and give it the chance to infiltrate into the ground by slowing the velocity of the water before it flows into storm drains, retention and detention areas, or into other created or natural features. Vegetated swales are an effective way to move water on a site without the use of underground pipes and they give plants and other features the opportunity to filter out harmful pollution like chemicals and trash (Freeborn et al 2012, 12; US-EPA 2022c; Holm et al 2014). Naturalized areas are spaces with native vegetation that may include a broad range of native plants of different types. Mulched beds are spaces that have vegetation with a layer of mulch to insulate the soil and roots. These features promote healthy soil and, therefore, allow more runoff to infiltrate the ground when compared to areas with more compacted soils often found in conjunction with the traditional regularly-mowed lawn. Naturalized vegetation such as meadows and prairie-like areas can also hold and infiltrate large amounts of rainfall, snowmelt, and upslope stormwater runoff (Freeborn et al 2012).

Figure 2.7. Native Plantings.
Washington DC Department of Energy and Environment.

Figure 2.8. Rain garden next to permeable patio.
Washington DC Department of Energy and Environment.

Background

Unvegetated Features

Unvegetated features mimic some functional aspects of natural systems, but they do not require plants to do so. The first example of a unvegetated feature is permeable paving. Permeable paving is a broad term used to describe some products, such as pavers and pavement, that allow for rainfall, snow, and nearby stormwater runoff to infiltrate the ground. These products can include diverse types of pavers that have filtering material to remove larger pollutants and allow water to pass through cracks. This is similar to permeable concrete, which can be mixed to allow for runoff to pass through small surface openings. Although these methods are effective, they can be quite maintenance intensive due to erosion, settling, and freeze-thaw cycles that can buckle pavements if they are not installed properly. On the residential scale, these features are best used for patios, driveways, and walkways that do not collect a lot of sediment-laden water from other upslope areas (Freeborn et al 2012; US-EPA 2022c).

Downspout alternatives are important to allow for runoff from roofs to be managed in a more sustainable fashion and can allow home owners to entirely disconnect their property from storm drains. Integrated stormwater management is important. As an example, downspouts can flow into rain barrels, which can overflow into drywells, permeable paving, vegetated swales, rain-gardens, and naturalized vegetation.

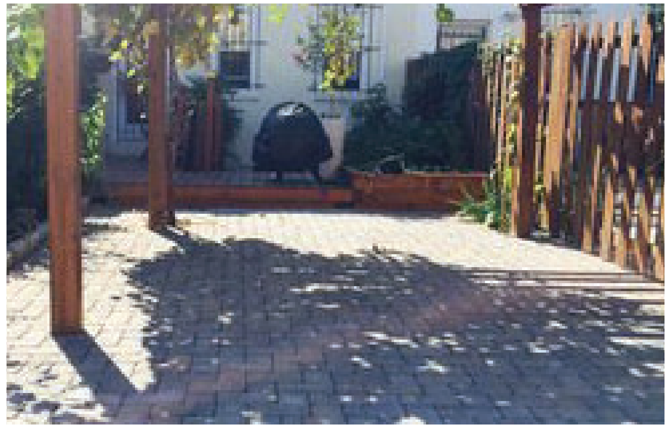


Figure 2.9. Permeable Patio.
Washington DC Department of Energy and Environment.

Figure 2.10. Rain barrel.
Washington DC Department of Energy and Environment.

Background

Products like rain chains allow stormwater from roofs to move down a chair to reduce runoff velocity and fall into a feature like a drywell or rain garden. Another method is simply disconnecting a downspout from the drain connection and allowing it to flow elsewhere, like a capturing feature such as a rain garden. Rooftop disconnection reduces runoff and is one of the simplest methods to keep runoff out of storm drains and nearby streams and ponds. By disconnecting the downspout and replacing it with an elbow and extension away from the house it provides the water a chance to infiltrate the ground (Freeborn et al 2012, 5-6).

Rainwater harvesting, like cisterns, is the most effective way to capture stormwater, but it is the costliest method as it requires draining and bypassing in cold winter months if they are located aboveground outside to avoid damage due to freezing. Captured water in cisterns and rain barrels can be released slowly later or be used for graywater in irrigation systems and toilets where this is allowed by local codes (Freeborn et al 2012; US-EPA 2022c). Both vegetated and unvegetated features are effective in their own ways, some more so than others. In a later section, the literature review discusses additional benefits of these features.

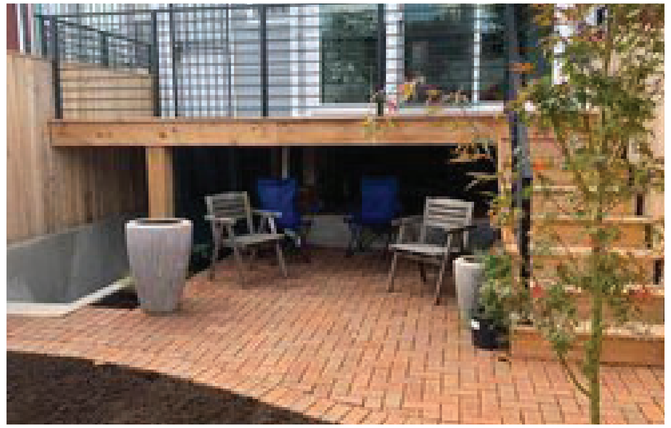


Figure 2.11. Permeable patio under a deck and near a mulch bed. Washington DC Department of Energy and Environment.

Figure 2.12. Rain barrel next to a drywell. Washington DC Department of Energy and Environment.

Background

Social Benefits

Since flooding has become a problem that has only gotten worse in many parts of the world, old ways of more effectively managing stormwater through sewer systems is a minimum requirement and best management practices (BMPs) need to be implemented to help mitigate runoff (Thurston 2012, v). Commercially, some cities require businesses and new developments to implement stormwater BMPs through ordinances and codes. On existing private residential property, there needs to be a program that includes incentives to make managing stormwater worthwhile for the homeowner (Thurston 2012, v-vi). This may include financial subsidies, tax breaks, technical support, and other types of assistance.

Flooding is not just an issue that homeowners have been dealing with recently. In 1993, fifty people died and seventy-thousand people were left homeless during a continuous storm that affected most of the Midwest. Thankfully, Manhattan, Kansas did not have any deaths, but the storms led officials to open the spillways leaving the Tuttle Creek dam, located northeast of Manhattan, Kansas, to release water into parts of the city east of Tuttle Creek Boulevard (KMAN 2018).

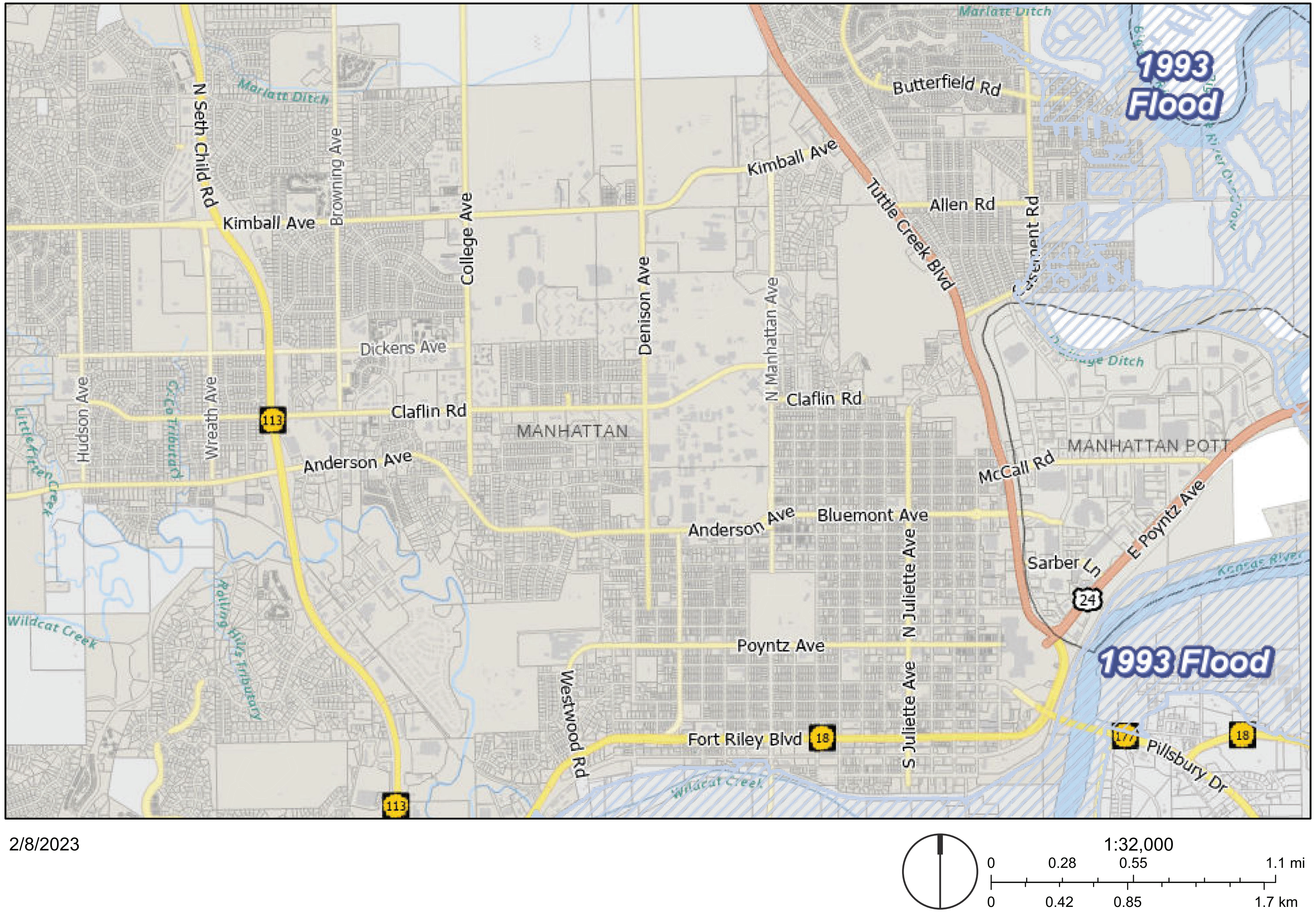


Figure 2.13. Represents observed flooding extents of the Kansas and Big Blue Rivers that occurred in the summer of 1993. Map adapted from Riley County GIS Community Viewer.

Background

More recently, Manhattan faced the inundation of buildings, parking lots, streets, and landscapes when Wildcat Creek flooded in 2007, 2011, 2012, and again in September 2018. On Labor Day in 2018,nine inches of rain in less than twenty-four hours forced students and permanent Manhattan community members to evacuate their homes. Three hundred people were told to evacuate, and three thousand customers lost power during the flood event (The Watchers 2018). The map to the right shows the flooding dangers the community faces. Socially, mitigating stormwater runoff as a community and region —to reduce flooding that impacts neighbors — is why stormwater management is so important. Implementing stormwater management features on residential sites will reduce the runoff entering waterways such as Wildcat Creek in Manhattan, Kansas, and has the potential to reduce flooding and the displacement of people during serious flooding events, because the water will be managed on site rather than being shed elsewhere.

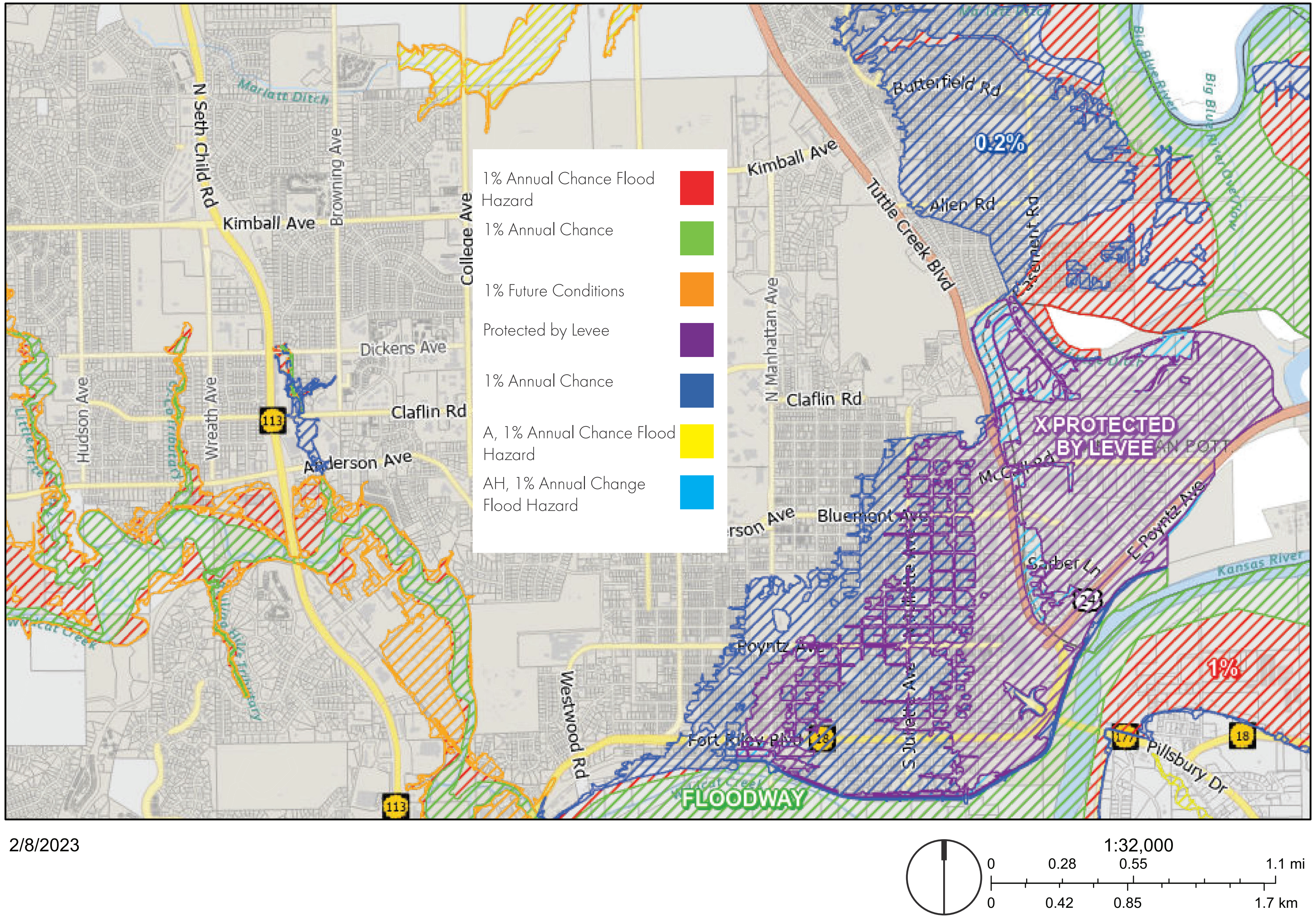


Figure 2.14. Manhattan, Kansas Flood Map. Observed flooding hazards and present and potential change. Map adapted from Riley County GIS Community Viewer.

Background

Economic Benefits

Economically, stormwater management on a residential site can be beneficial for a homeowner as it may reduce the likelihood of flood damage on their property. In Johnson County, Kansas, the City of Merriam has repeatedly had to deal with flooding that totaled millions in damage since 1970 (US-FEMA 2021c).

Two floods in Merriam, one in 1977 and the other in 1993, cost homeowners and businesses totaled $11.6 million after Turkey Creek could not handle the volume of water being put through it (US-FEMA 2021c). After assessing the damage, Johnson County received funding to acquire a few properties and turn them into open space to manage flood water and seek to prevent severe flood events from happening again. In a more recent and similar flood event in Merriam, the open space was able to manage flood waters where the homes would have otherwise had over $100,000 worth of damage (US-FEMA 2021c).

Implementing effective stormwater BMPs (including well-designed vegetated and unvegetated features) has direct financial benefits for property owners. For instance, there are programs that provide incentives for residents to manage their stormwater on-site in cities across the United States. However, some programs do not make sense for residential projects because fees and rebates are not available in a specific area or seen as financially beneficial by home owners. Thurston (2012) provides an example of what policy makers should consider when creating worthwhile incentive programs for homeowners interested in BMPs. Thurston (2012) calculated the value of a homeowner's land using hedonic price methods by finding how much of the land is worth to the landowner per square foot and then using that information to steer the kind of incentive that is worth most to the landowner — fee and rebate or tradable allowances. If policymakers were to invest in programs that gave homeowners an opportunity to implement features on their property, flood events would cause less damage because less water would need to be managed by the city infrastructure.

Note: A hedonic model is a method in which researchers find unbiased and real sales data to inform prices associated with land use decisions.

Background

Thurston (2012) discusses how in reality different sites have different opportunities and can cost less or more depending on the site.

"To ensure that on-site BMPs installed under a policy are cost-effective, the following must be true: (1) installed on-site management must be less expensive than equivalent incremental additions to regional runoff management, and (2) on-site requirements must be structured so that the incremental cost of the added runoff management capacity is approximately equal across sites" (Thurston 2012, 196).

Kertesz et al (2014) studied simulated residences in four cities and found the total runoff volume in the model directly correlated to the percentage of impervious surface that resulted in stormwater running off to a bioretention cell. The study also found that there was a gap between the reduction of annual runoff and a reduced fee (Kertesz et al 2014, 1746). This means there is often no true correlation in programs, either the agency is incentivizing more than they should or not enough based on the discount provided and the captured runoff.

Speaking of financial costs, the 2018 flood in Manhattan, Kansas not only displaced three hundred residents, but it also caused $17.2 million in damages (Jones 2018). Jones (2018) cited the City of Manhattan Manager, Ron Fehr. "Fehr told the Manhattan City Commission on Sept. 18 that four commercial and eight residential properties suffered substantial damage" (Jones 2018). More than 50% of the damage was sustained during the main storm and later an additional 25% or more was sustained by later storms and flooding (Jones 2018). While $17.2 million is significant, it will be interesting to see if the City of Manhattan and Riley County, Kansas will invest a generous sum of money to incentive programs like those discussed by Thurston (2012) to help mitigate flooding at the source, namely upstream farmland areas and the mix of residential and commercial properties in the Wildcat Creek Watershed, to reduce flooding in the future. Flooding along Wildcat Creek also occurred in 2007, 2011, and 2012 and many residential developments contribute to flooding.

Background

Ecological Benefits

Ecologically, well planned, designed, and implemented stormwater management can be very helpful at all scales. In residential areas, stormwater features can have more benefits than just harvesting and capturing stormwater. Vegetated features, such as bioswales, rain gardens, native plant areas, mulched beds, and trees, provide clean air, reduce pollutants, offer flood prevention, and create habitat. A typical residential turf yard provides very few ecosystem services and typically increases air and water pollution due to the way most lawns are maintained.

Jacobson (2009) identifies twelve methods of planting in a residential setting that provide for native species of insects and wildlife. 1) Plant trees to provide shade, which cools the area around them. This results in lower utility bills and a reduction in the heat island effect as well as numerous other ecological benefits, such as capturing and sequestering carbon dioxide, which is reduced by new growth and stored in roots and undisturbed soils and aided by increasing stormwater infiltration. 2) Reduce or eliminate lawn because they are over used, require too many inputs, and create too many harms. In many locations, irrigation is expensive and wasteful. Management of lawn also produces increased greenhouse gas emissions. 3) Use mostly native plants, because they will provide a habitat for other native species (including pollinators which are vital to human and ecosystem health) and will support an ecosystem better than close-cropped, fertilizer-and-herbicide-dependent lawns and non-native vegetation are able to.

Figure 2.15. Bee on an inflorescence. Sam Wolkey

Background

4) Use drought-tolerant and climate-adaptive plants, because they are most likely to survive spurts of little to no rain and will survive without irrigation. 5) Use edible plants for a crop that can be used by a family and provide for the ecosystem. Less money would be spent at a grocery store, but these gardens can be time-consuming. 6) Use mulch wisely (especially green mulch/living vegetation) to insulate the soil around plants to keep moisture from evaporating and protect the roots from stressful heat. 7) Irrigate appropriately and conscientiously to reduce water consumption and ensure that watering takes place when the likelihood of evaporation is at a minimum. 8) Reduce impermeable surfaces because those areas do not contribute to stormwater infiltration. Impermeable surfaces include areas like concrete or roofs. 9) Use permeable paving to allow stormwater to infiltrate the ground and provide moisture for nearby roots growing under the surface. 10) Direct runoff from impermeable surfaces into well-vegetated retention and filtration areas to slow stormwater flows and allow for plants to soak up water and transpire water molecules. 11) Use swales and bioswales to slow and direct water from impermeable surfaces and allow for infiltration. 12) Design appropriately so that everything works cohesively and does not need to be redone or maintained constantly (Jacobson 2009 7-15).

Figure 2.16. Colorful highlights. Sam Wolkey

Background

Researchers at Michigan State University note how most of the water during a rain event does not infiltrate into the ground, but instead, flows into storm sewers and ends up finding its way unfiltered to waterways (Michigan State University n/d). Features such as well-designed and implemented native plant areas work to reduce runoff by giving the stormwater a chance to infiltrate rather than fall on an impermeable surface and runoff into a pipe and similarly, rain gardens are often installed to capture the runoff (Michigan State University n/d). Capturing this water is important because aquifer levels and stream baseflows are increased by the infiltration of stormwater in some areas and if not, reducing water volume in city storm sewer systems is important. When water is allowed to infiltrate the ground, the quality of the water improves. The reason this is important is because bringing native plants and features that mimic natural systems into the landscape helps mimic how the landscape performed before the Industrial Revolution. This helps mitigate flooding and habitat loss by implementing small to medium sized native plant gardens, especially in residential settings.

Figure 2.17. Rain garden with native plants on campus. Sam Wolkey.

Background

To increase the capacity of an aquifer and improve the quality of surface waters like streams and ponds, effective stormwater management practices must be implemented (Larson and Safferman 2008, 126). Additionally, vegetated native stormwater management features "offer a large potential variety of plant sizes, flower colors and bloom periods and, once established, may need less watering and care than non-native species. Adding native ground covers or expanding perennial flower borders can also reduce the proportion of your property that is turf and thereby reduce fuel use and CO2 emissions" (Michigan State University n/d).

As discussed previously, using native plants and non-invasive, well-adapted plant communities for vegetated stormwater management features in an integrated system will increase effectiveness and provide a range of ecosystem services by producing habitat other vital environmental benefits.

Figure 2.18. Butterfly on an inflorescence. Sam Wolkey.

Background

Incentive Programs

Stormwater management incentive programs are initiatives created by governmental entities to promote involvement within a community focused on implementing stormwater management features on private property. Different entities employ different methods to incentivize residents and other property owners. These include but are not limited to rebates, grants, cost sharing, credits, and loans (Nattress 2017). Portland (Oregon), Washington D.C., and Minneapolis (Minnesota) are cities that have exceptional examples of stormwater management incentive programs. The examples were chosen because of their clear criteria and benefits, diversity in geographical locations (west, east, and central United States), and diversity in the kind of incentives.

A more thorough description of each incentive program appears later in the book. The following is an abbreviated introductory discussion.

Figure 2.19. Minnesota backyard with native plantings and a permeable paving driveway. Lee R. Skabelund.

Background

Portland, Oregon

Clean River Rewards is a program that can provide discounts of up to $130 a year on the property's stormwater fee. The property owner qualifies by implementing functioning features that can reduce their runoff. Examples of features eligible are rain gardens, swales, lawns, landscaped areas that have at least 10% of the roof's surface drain to them, drywells/French drains, rain barrels, cisterns, stormwater planters, ponds, detention facilities, and ecoroofs (City of Portland 2022).

Figure 2.20. Portland and surrounding area. Aerial from Google Earth.

Background

Washington D.C.

RiverSmart is a program that provides several avenues that property owners can utilize. RiverSmart Homes is a program that property owners can use to pay a small co-payment and have the organization come to their property, assess the property, and help implement features that manage stormwater. RiverSmart Rebates is a similar program, but instead of the work being done by someone else, the feature is implemented by the property owner who then gives proof that the feature exists before receiving a rebate. Finally, RiverSmart Rewards is a program that helps assess existing features on a property and the property owner is then given a discount on their stormwater fee (Washington D.C. DOEE a,b,c, 2022).

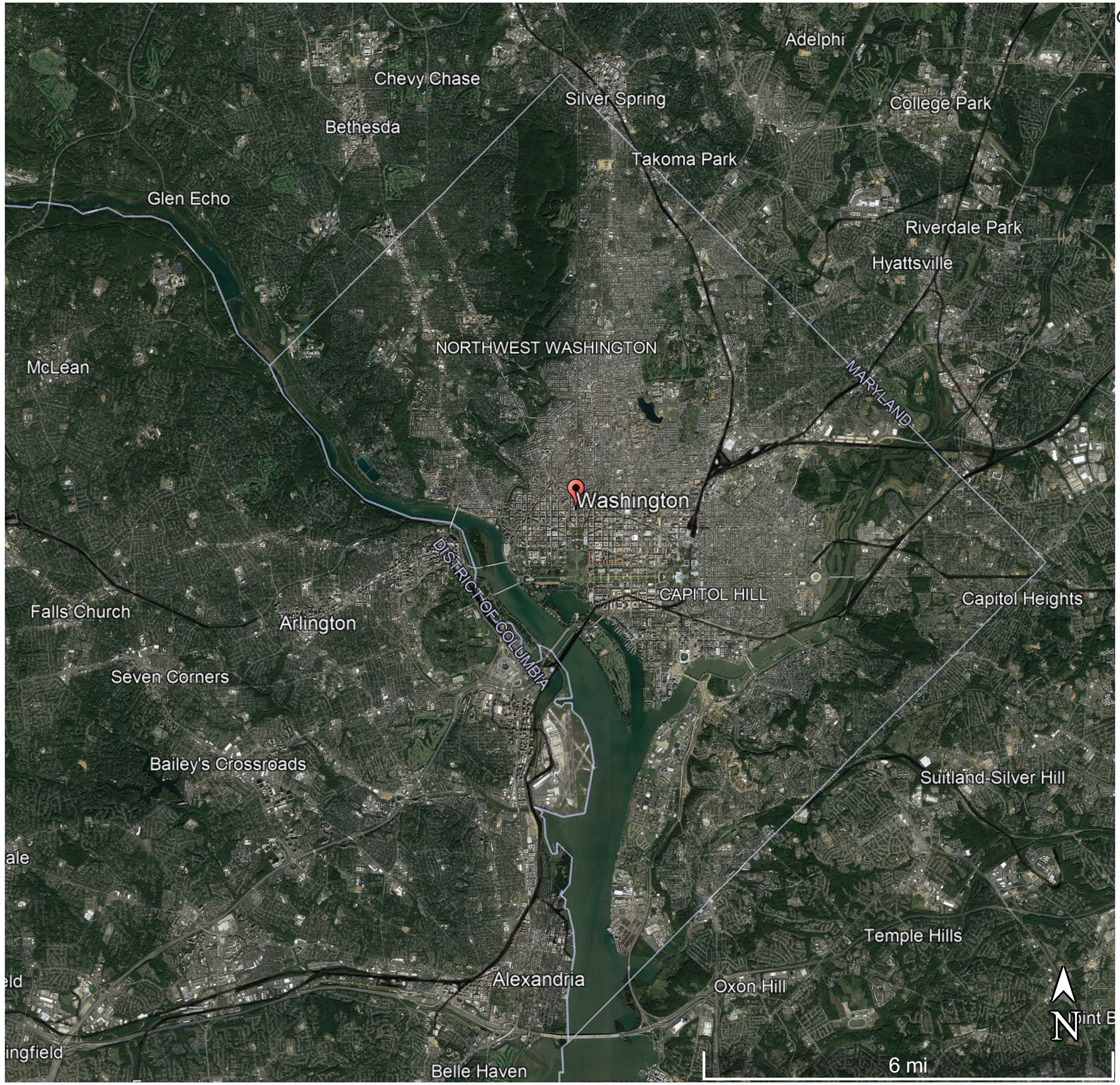


Figure 2.21. Washington D.C. and surrounding area. Aerial from Google Earth.

Background

Minneapolis, Minnesota

Residential stormwater credits are used to reduce a utility fee up to 45% or 35% (depending on where you live within the city) for implementing the following types of features: rain garden, pervious pavement, green roof, or stormwater reuse. Applicants apply online by showing what feature they have on site and can thus prove that they are removing pollutants from the stormwater that falls on their property (City of Minneapolis 2022).

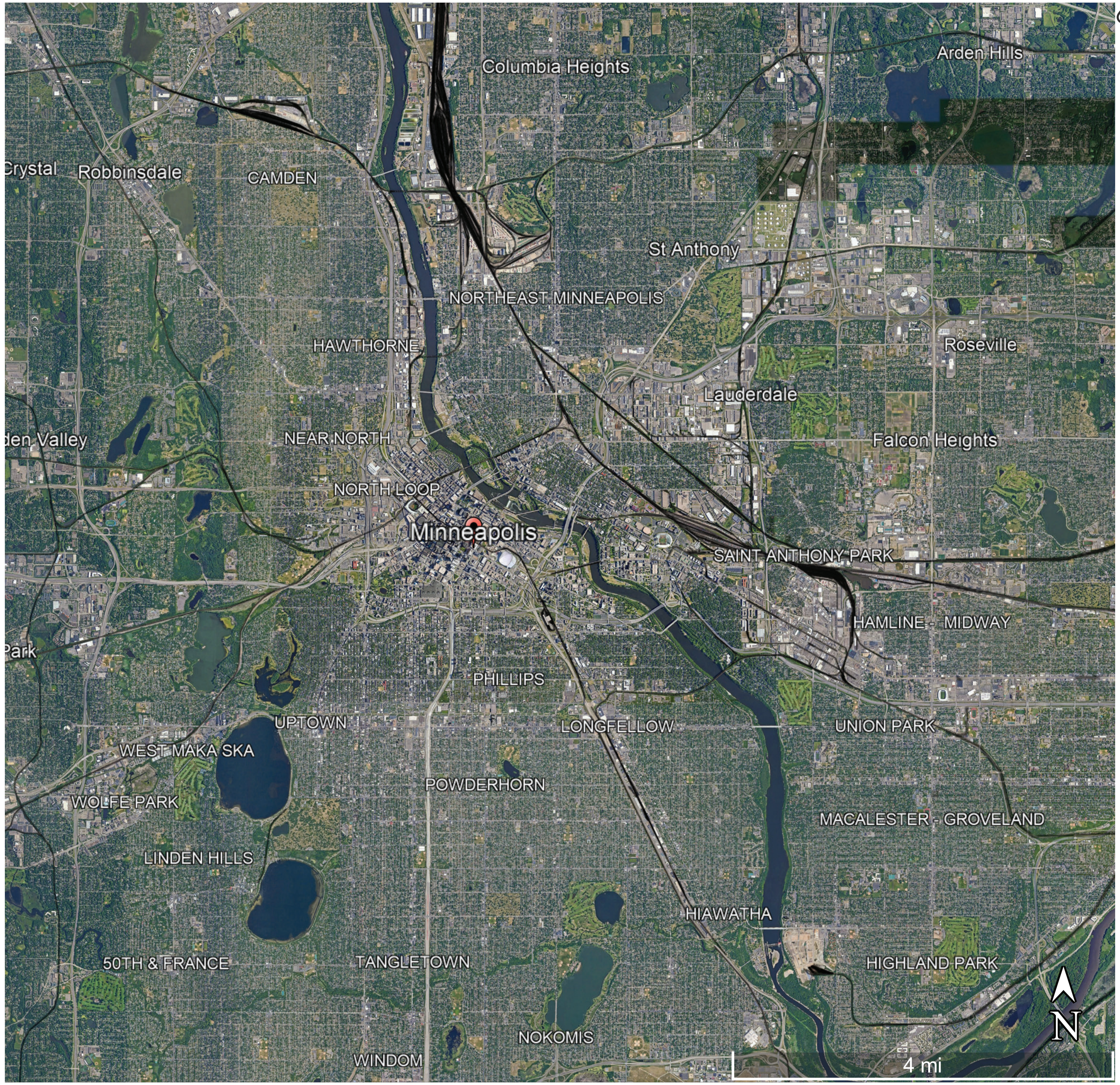


Figure 2.22. Minneapolis and surrounding area. Aerial from Google Earth.

Chapter 3 -
Methodology

Methodology

Introduction

Three methods were used to answer the research questions: How can designers encourage private homeowners to retrofit their single-family large-lot property to manage stormwater, what incentive program in the U.S. is most likely to encourage homeowners to implement stormwater management features on their properties, and what residential-scale vegetated and unvegetated features are "best" based on upfront costs, maintenance hours per year, and stormwater volume potential?

The first method analyzes stormwater management features by studying them based on cost, maintenance considerations, and their potential volume capacity. The second method shows how features can be implemented into a design to effectively manage stormwater on a large-lot residential site. Finally, the third method measures the kind of incentives a homeowner would benefit from if they were to implement a set of selected stormwater features.

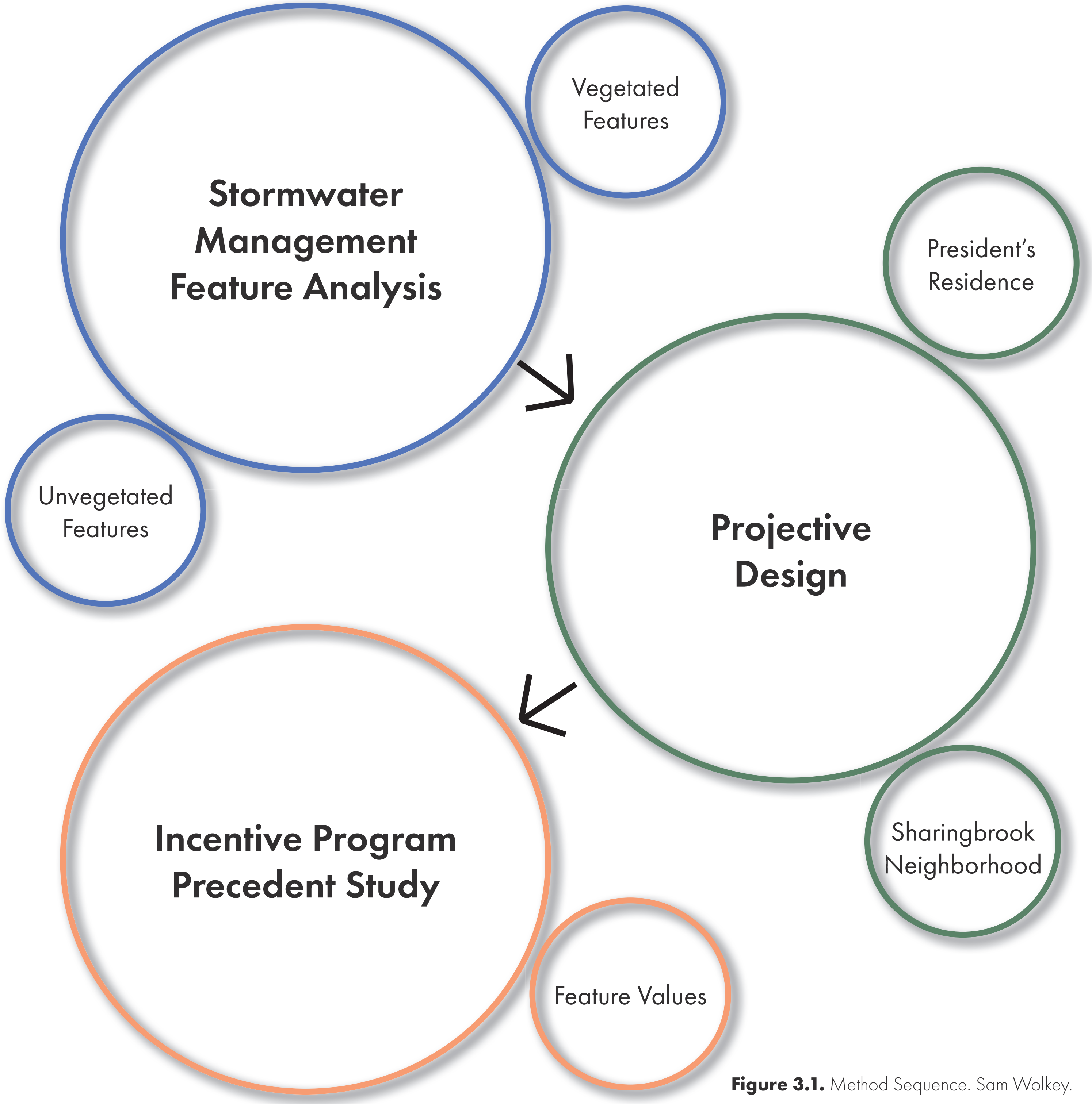


Figure 3.1. Method Sequence. Sam Wolkey.

Method 1

Stormwater Management Feature Analysis

This method was used to produce a matrix that was used to evaluate stormwater management features and then to identify the features that can hold the most based on cost, maintenance considerations, and capacity for runoff storage. The features analyzed must meet four criteria: 1) common in retrofit design, 2) available on a residential scale, 3) goal must be to capture or harvest stormwater, and 4) potentially implementable at the President's Residence at Kansas State University.

Given the high degree of variations possible for each of these vegetated and unvegetated features, construction details of certain features were prepared to establish a standardization to facilitate quantity calculations for these BMPs and allow for comparison in the matrix. This analysis was used to identify features that would work well in a large lot (1.25-5 acre) residential site.

Figure 3.2. Before stormwater management features were implemented.
Washington DC Department of Energy and Environment.

Figure 3.3. After stormwater management features were implemented.
Washington DC Department of Energy and Environment.

Method 1

Research into the costs of vegetated and unvegetated features was done to identify the least expensive to the most expensive feature. The costs of unvegetated features were identified by visiting the websites of stores that carry such products. In the case of rain gardens and other vegetated features, an average cost per square foot was calculated by finding the costs of plants and amended soil. The cost of implementation was accounted for as this fee is dependent on who is installing the feature: the homeowner themselves, a hired gardener, or a hired landscape contractor.

Research on maintenance was conducted to identify how many hours in a year the feature needs to be maintained (e.g., cleaning out, weeding, trimming, etc.) and how expensive maintaining the feature would be. Maintenance research excluded the effects of improper use or impacts due to equipment failure, as each feature was analyzed assuming proper installation with proper use.

Volume was measured based on how much runoff the feature has the capacity to harvest/capture. The features were ranked based on cost — with the lowest costing feature assigned the lowest number and to the highest costing feature the highest number. The feature that requires the least amount of maintenance was given the lowest number and the feature that requires the most amount of maintenance was given the highest number. The feature that can hold the most amount of water volume was given the lowest number and the features that hold the least amount of water volume were given the higher numbers. If two features had the same metric for one of the criteria, they were assigned the same number in that column.

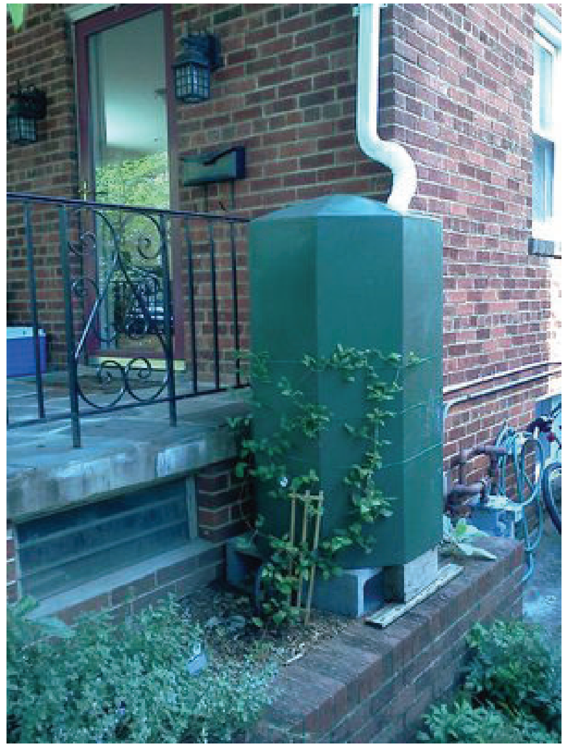


Figure 3.4. Rain barrel connected to plantings.
Washington DC Department of Energy and Environment

Figure 3.5. Permeable paving and rain garden.
Washington DC Department of Energy and Environment

Method 2

Projective Designs

Using the projective design process I selected sites, determined how to analyze them, and then developed a conceptual design for each selected residential property. The test site needed to be a single-family residence with a lot size of 1.25-5 acres. The site needed to allow access for the designer/researcher to perform a good-faith site analysis. The secondary site needed to be at a neighborhood scale. The homes in the neighborhood needed to have lot sizes that are 1.25-5 acres. This neighborhood also needed to have up-to-date aerial imagery on Google Earth or other satellite imagery databases. Both sites needed to have mostly open lawn with scattered trees and a few planting beds around the property.

Figure 3.6. Back of residence. Sam Wolkey.

Figure 3.7. View from the middle of the backyard Sam Wolkey.

Figure 3.8. Front driveway. Sam Wolkey.

Method 2

Projective Designs

During the site analysis of the neighborhood site, hydrology was studied on one site visit which was made to experience the site from a windshield and pedestrian perspective to complement ArcGIS and Google Earth plan and street views. For hydrology, the designer and researcher examined the topography, site drainage, location of downspouts, how the space is used and traveled on, what surfaces were permeable, and what surfaces were impermeable.

During the design phase, the test site identified stormwater management features that could be readily and effectively implemented at the K-State President's Residence. Areas where features like prairie or savanna and rain gardens could potentially be implemented were areas found to be underutilized or could replace unused lawn space. Areas that have the potential to collect water and are far enough away from existing trees to not harm root systems are good areas for rain gardens. It was important to take into account existing conditions such as trees, paths, and views when considering opportunities for designed interventions.

Figure 3.9. Residence in Sharingbrook. Sam Wolkey.

Figure 3.10. Open lawn and prairie. Sam Wolkey.

Figure 3.11. Sharingbrook has homes with a lot of lawn. Sam Wolkey.

Method 2

Projective Designs

Finally, using a replacement ratio found by comparing the amount of lawn at the test site and the amount of lawn replaced by a feature, or the amount of impermeable surface converted to pervious surface, the designer/researcher could use those ratios to design them for the homes in the neighborhood. The ratio used is shown in the following equation:

Total Lawn Space in Test Site (square feet) / Prairie or Savanna Space Replacement in Test Site (square feet) = Total Lawn Space in Neighborhood Property (square feet) / Prairie or Savanna Space Replacement in Neighborhood Property.

Once these ratios were found, a quick site analysis was performed on each of the properties to be used in the neighborhood to ensure the design was done in good faith. Finally, each property was analyzed to find how many gallons could be captured rather than sent downslope or downstream as stormwater runoff.

Figure 3.12. Drain outlet lawn swale from existing stormwater management technique. Sam Wolkey.

Figure 3.13. Riparian zone for stormwater to flow through before reaching Little Kitten Creek, shown here going under the road with lawn surrounding the area. Sam Wolkey.

Figure 3.14. Riparian zone with extreme erosion near lawn. Sam Wolkey.

Method 3

Incentive Program Precedent Study

Through this method, the designer and researcher studied incentive programs that include a form of rebate, grant, credit, or cost sharing in different parts of the country. These cities were found by searching for "residential stormwater management incentive programs" online and assessing them based on their user-friendliness and how much information was available online. The types of incentives that were deemed to be most practical for the homeowners in the neighborhood as identified via Method 2 were examined more closely. Each precedent study explains what the program offers to the citizens in their respective reach. After the most practical incentive program was identified using the properties in the Sharingbrook Neighborhood designed for using Method 2, it was estimated how the design would impact the homeowner financially or in any way applicable to the incentive program by the creation of a chart specifying the units or square feet of the features, how much potential stormwater volume they can hold, and other applicable information.

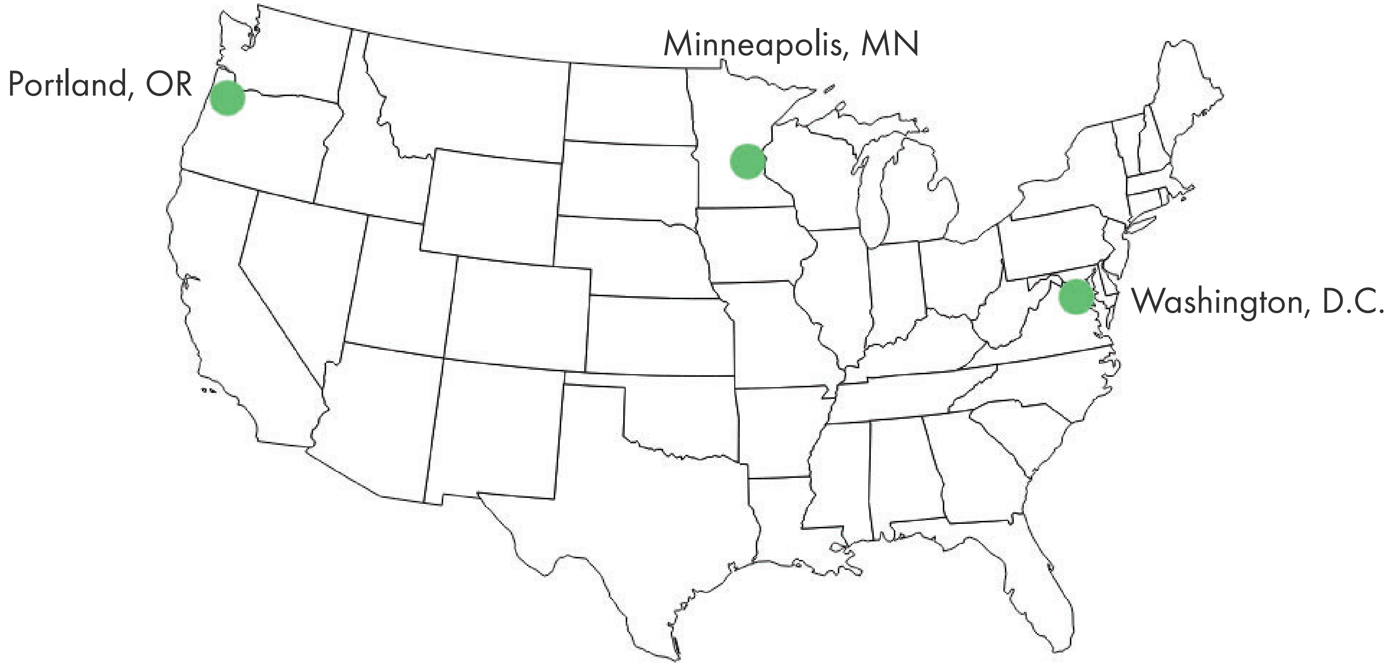


Figure 3.15. Locations of the three selected precedent cities. Sam Wolkey.

Chapter 4 -

Site Analysis

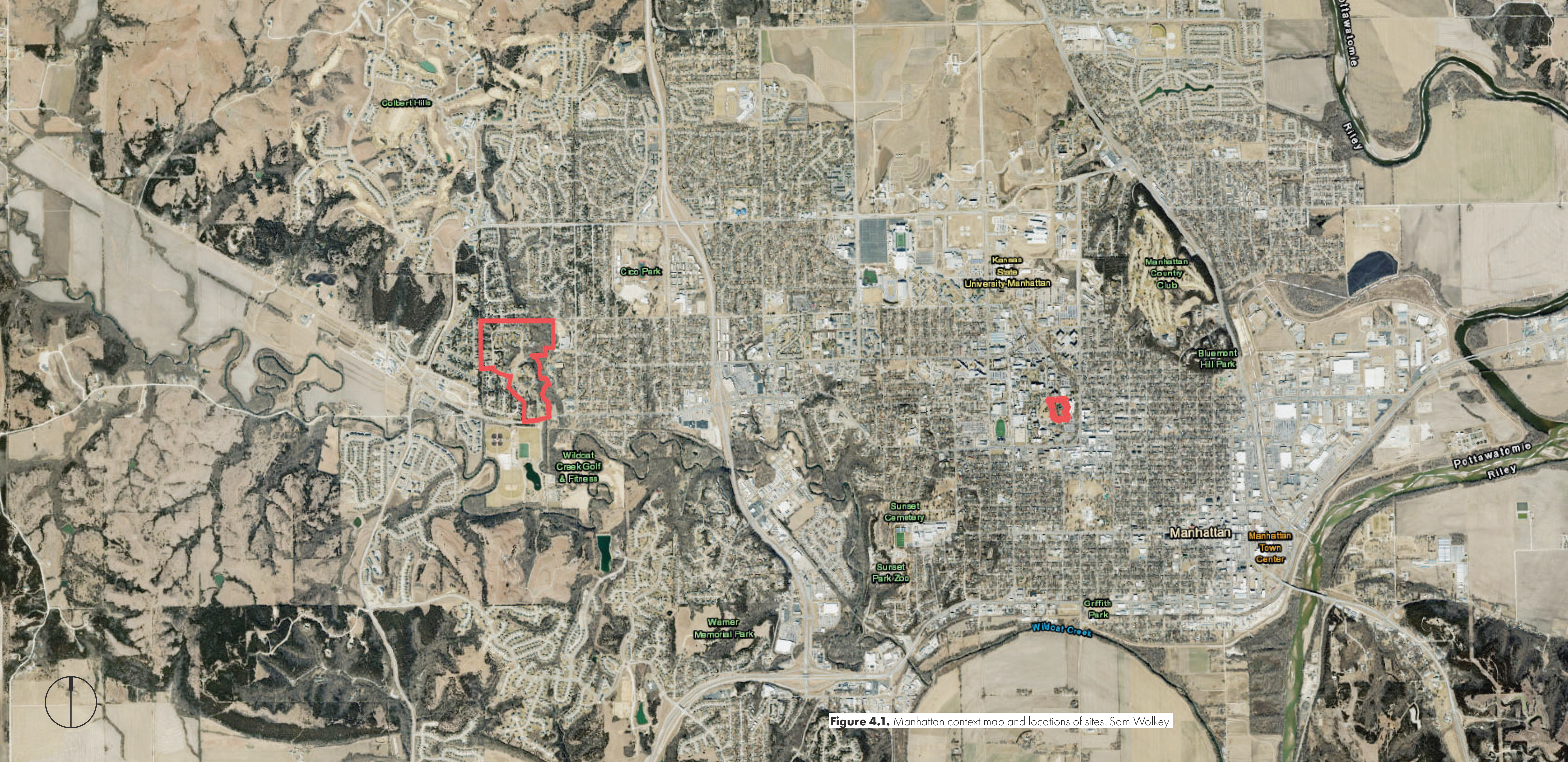


Figure 4.1. Manhattan context map and locations of sites. Sam Wolkey.

Site Analysis

K-State's President's Residence

The Kansas State University President's Residence has multiple existing on-site amenities. For starters the almost 5,400 square feet of floor space provides the President and their spouse with lots of opportunity to entertain guests. In addition, the loop driveway and nearby parking allows easy access for visitors to be dropped off or stop for a quick visit. Surrounding the home are multiple mulch beds for plantings. Around the property, there are sidewalks to pass by the residence on the way to class, work, or for visitors on campus for an activity or for a casual stroll through campus.

The almost 5-acre site is made up of a few different land cover types, including open lawn, woodland-like areas, gardens, mulch beds, and various impervious surfaces. The site has a rose garden just east of the house and another garden just west of the house. This site is unlike normal large-lot single-family residences because a private property owner would have to pay for any additions or maintenance on the site and would only have to deal with typical residential utilities. This site has university utilities on site and a trained crew of professionals hired by the university to maintain the property at no cost to the President.

Note: Maps with Riley County GIS Community Viewer are more up to date that the rest of the aerial imagery. The Community Viewer imagery was taken in the winter of 2022 and the rest were taken in winter 2020.

Figure 4.2. President's residence site. Sam Wolkey.

Site Analysis

Context - President's Residence

The President's Residence is situated towards the southeast corner of Kansas State University's main campus. Directly north of the site are Justin and Bluemont Hall. East of the site is one of the newest buildings on campus, the College of Business. South of the President's Residence is parking for the College of Business as well as open lawn and the Danforth/All Faiths Chapel. West of the site is Anderson Lawn, an open lawn setting with scattered trees closest to the street west of the President's Residence. Importantly, to the north, west, and south, there is a curb surrounding the site where there are streets and parking lots.

Students, faculty, staff, and visitors use the sidewalks in the area to move from the buildings to the north to the parking lots to the south. The parking lots to the south may be an eye-sore and especially bothersome if someone pulls into this lot with their headlights on at night. With Anderson Lawn directly to the west, it is possible for this area to be used by the President's family and visitors to the home.

Figure 4.3. President's residence context map. Sam Wolkey.

Site Analysis

Surface Typology - President's Residence

At the President's Residence there are four different kinds of surfaces or land cover types. The first is shown on the adjacent map in light gray, impervious surfaces. These surfaces are defined as an area in which stormwater like rain or snow would not be able to penetrate. At the President's Residence, these surfaces include parking and sidewalks (concrete), the driveway (asphalt), and the house. The second land cover type is the lawn. Lawn covers a majority of the site and, although better than impervious surfaces, does not promote good infiltration because of the compacted soil from regularly mowing the site and cool-season grass root systems that do not penetrate deep into the soil. The third land cover type on site are the woodland-like areas. These areas include a more "natural" look with a variety of plants from trees, understory plants, and ground cover such as vines. These areas are more likely to promote infiltration because of the vast root structure and less compacted soil. Finally, the last land cover type includes the mulch beds that surround the residence. These areas have a few plantings in them but are not as large as the woodland areas.

Figure 4.4. Woodland-like areas. Sam Wolkey.

Figure 4.5. Mulch beds. Sam Wolkey.

Figure 4.6. Site typology and canopy coverage. Sam Wolkey

Site Analysis

Drainage - President's Residence

The K-State President's Residence is located in the Eureka Lake - Kansas River Watershed. The site, as seen on the map, slopes from the northwest to the southeast. It is important to note that surrounding the site to the north and west are roads that have curbs so as to not allow stormwater from the street to enter the site. ***Given its context, this site primarily manages stormwater that falls on site*** with a small amount of stormwater added from the sidewalk and landscape areas west of the Business Building walkway/service drive. The site is generally flat gently sloping in the front, and proceeds to become very level at the east edge and southeast corner of the property. Knowing this, a significant amount of stormwater will end up in low-lying areas.

Figure 4.7. Saturated lawn after rainfall in the backyard. Sam Wolkey.

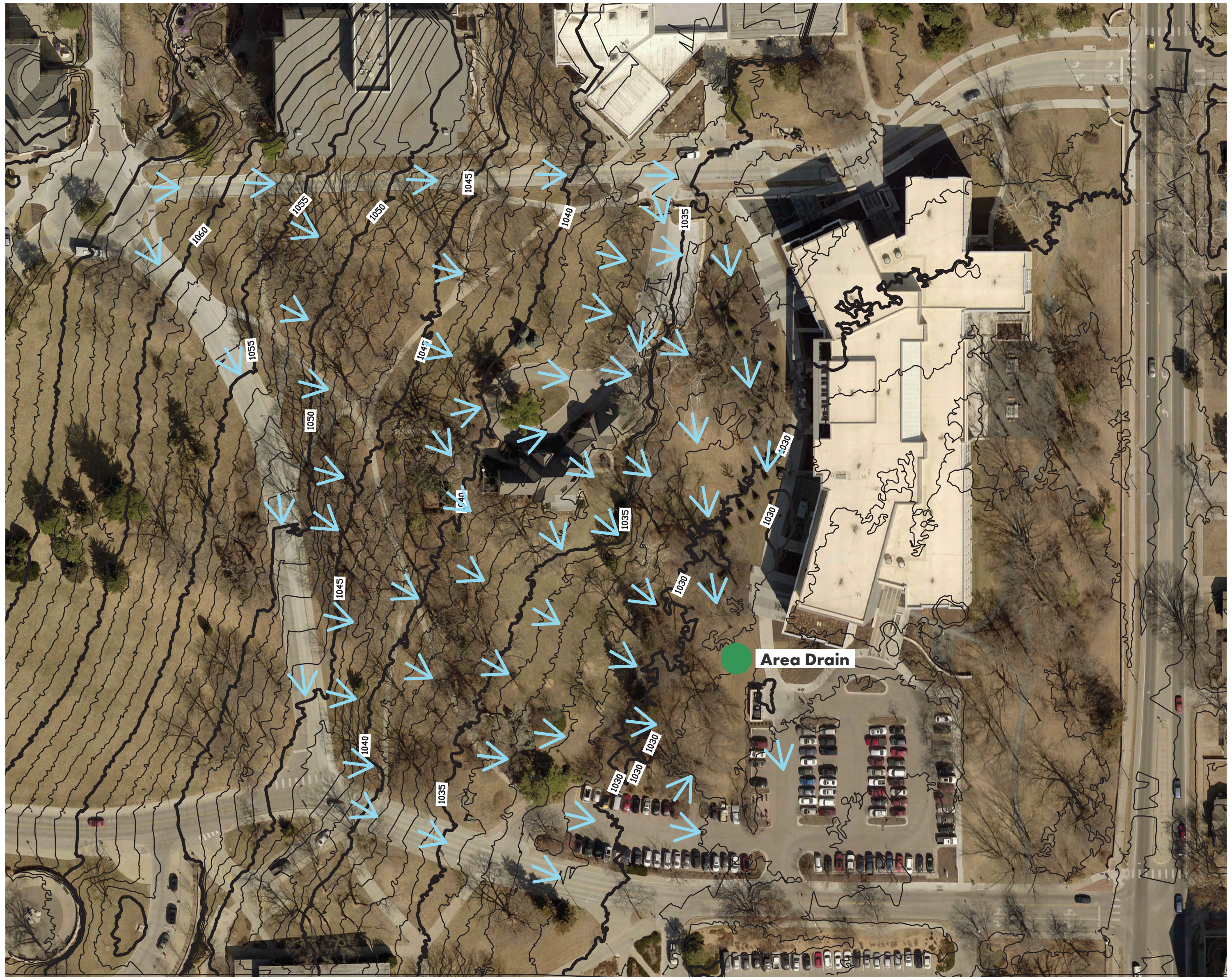


Figure 4.8. Topographical Map with arrows showing the direction of stormwater flows. Data from LiDAR flown by Riley County in 2018. Sam Wolkey.

Site Analysis

Storm Sewer - President's Residence

The President's Residence does not have a lot of infrastructure when it comes to storm sewers. There are a few drains near the home and are piped to a drain where the stormwater is then released into the backyard starting on the east side of the site.

Because of this, the few drains that do exist can be overrun with stormwater during storm events. And, frustratingly, stormwater has entered the basement a number of times. Thus, getting water safely away from the house is very important.

Figure 4.9. Drain near the northeast corner of the residence. Lee R. Skabelund.

Figure 4.10. Partially clogged drain in the front yard on the west side of the entry drive, where stormwater collects from the large front lawn. Lee R. Skabelund.

Figure 4.11. Storm Sewer Infrastructure. Map created with Riley County Community GIS Viewer.

Site Analysis

Sharingbrook

During the interview with resident Dan Devlin, he made a point to say Little Kitten Creek has been a constant problem. More recently, there has been so much erosion that it is hard for people to get to it. There used to be a bridge that connected the neighborhood to the school but has since been closed because of the danger. The erosion caused by flood waters is putting some homeowners at great risk of home damage. Devlin talked about since there has been more development to the north, the erosion and volume of water during storm events has only gotten worse causing trees to fall.

Another point of conversation during the Devlin conversation was the lack of sidewalks. It is often discussed among the neighbors that if the neighborhood was constructed again, sidewalks would be an important addition.

The neighborhood's homeowners association has no rules nor regulations about stormwater management features.

Figure 4.12. Sharingbrook Neighborhood site. Sam Wolkey.

Site Analysis

Context - Sharingbrook

Sharingbrook is a neighborhood west of campus, just north of Anderson Rd. Directly to the south of the site is Frank Anneberg Park. The park is home to many amenities such as a golf course, pond, soccer fields, baseball fields, walking trails, and much more. East of the site are single level office buildings, single family residential homes, a small recreation center, and Amanda Arnold Elementary School. North of the site are more single-family residential properties. Also, north of the site is the Colbert Hills Golf Course and Neighborhood which shed water into Little Kitten Creek during substantial rainfall and snowmelt events. West of the site are more single-family residential homes.

Figure 4.13. Sharingbrook Neighborhood context. Sam Wolkey.

Site Analysis

Surrounding Creeks - Sharingbrook

There are two major creeks in the area around Sharingbrook. The larger Wildcat Creek is to the south of Sharingbrook, and prone to flooding. The creek that is directly to the east of the neighborhood is called Little Kitten Creek. All of the Sharingbrook Neighborhood drains to Little Kitten Creek and is leading to a significant amount of erosion and flooding.

The Little Kitten Creek Watershed, encompasses all of the site boundary and spans as far north as the Colbert Hills Neighborhood. Since the watershed covers more than just the site boundary, it can be reasonably assumed that there will still be flood waters during rain events after a significant (medium to large depending on soil saturation and geographic extent) storm event.

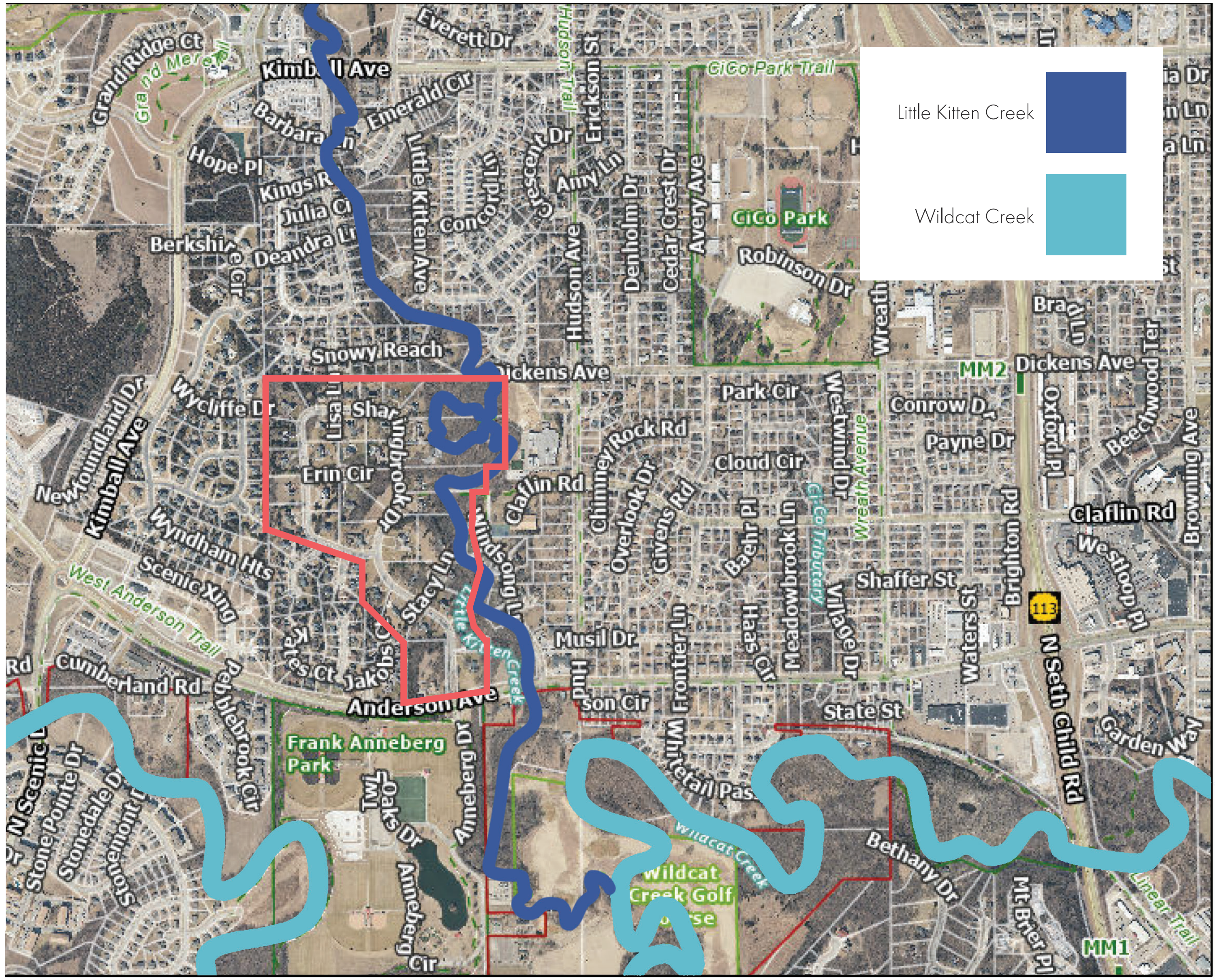
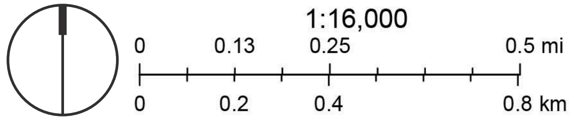


Figure 4.14. Surrounding Creeks. Map adapted from Riley County Community GIS Viewer.



Site Analysis

Drainage - Sharingbrook

Sharingbrook lies in the Little Kitten Creek Watershed which is a part of the larger Wildcat Creek Watershed. The image to the right shows Little Kitten Creek to the east of the neighborhood. It is important to note that the properties on the eastern-most portion of the site are the most vulnerable to flooding.

The large arrows on the map show the major thoroughfares that feed stormwater runoff to Little Kitten Creek. The areas pointed out have deeper trenches that could mean there is significant flooding that will only get worse if the volume of water is not mitigated or at least slowed. In the images shown to the right, riparian zones and drainage ways are used throughout the site to guide stormwater to drains and Little Kitten Creek.

The small arrows show what direction the runoff flows.

Figure 4.15. Riparian zone. Sam Wolkey.

Figure 4.16. Drainage way. Sam Wolkey.

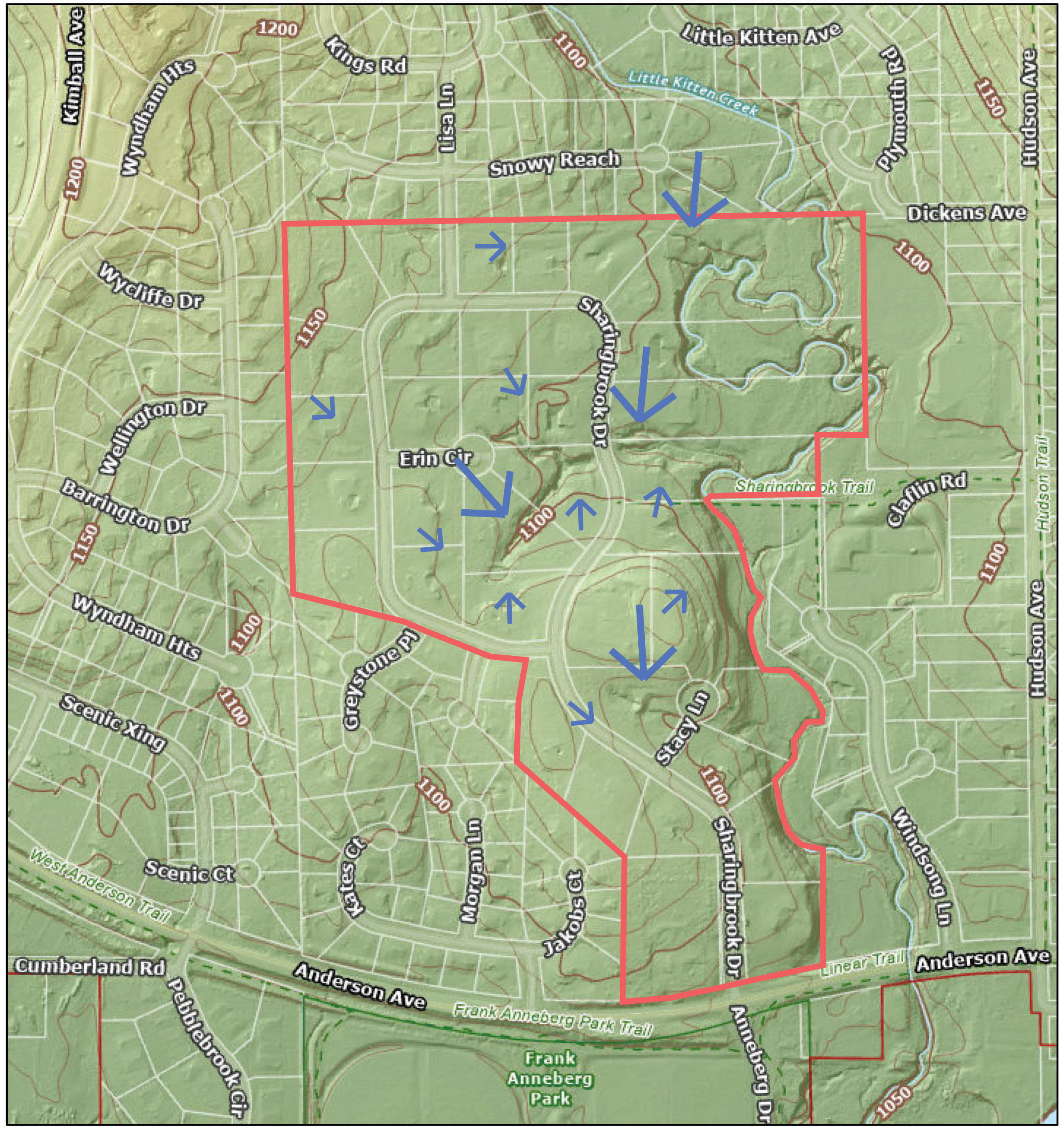


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Figure 4.17. Topographical Shadow Map. Map created with Riley County Community GIS Viewer.

Site Analysis

Parcels of Interest - Sharingbrook

The properties shown in green to the right are of special interest to this project and were looked at in a more in-depth way than the rest of the properties. These properties were chosen based on their property size (1.25-5 acres), amount of impermeable surface, potential of stormwater management, and general diversity of existing features like lawn, parking, patios, and trees. Each property in green was designed with stormwater management features and assessed as if the City of Manhattan had a stormwater incentive program to figure out how the property owner would benefit financially from implementing stormwater management features.

The properties shown in blue are properties that are in danger of being partially flooded during medium to large storm events because of their proximity to Little Kitten Creek, shown on the next page.

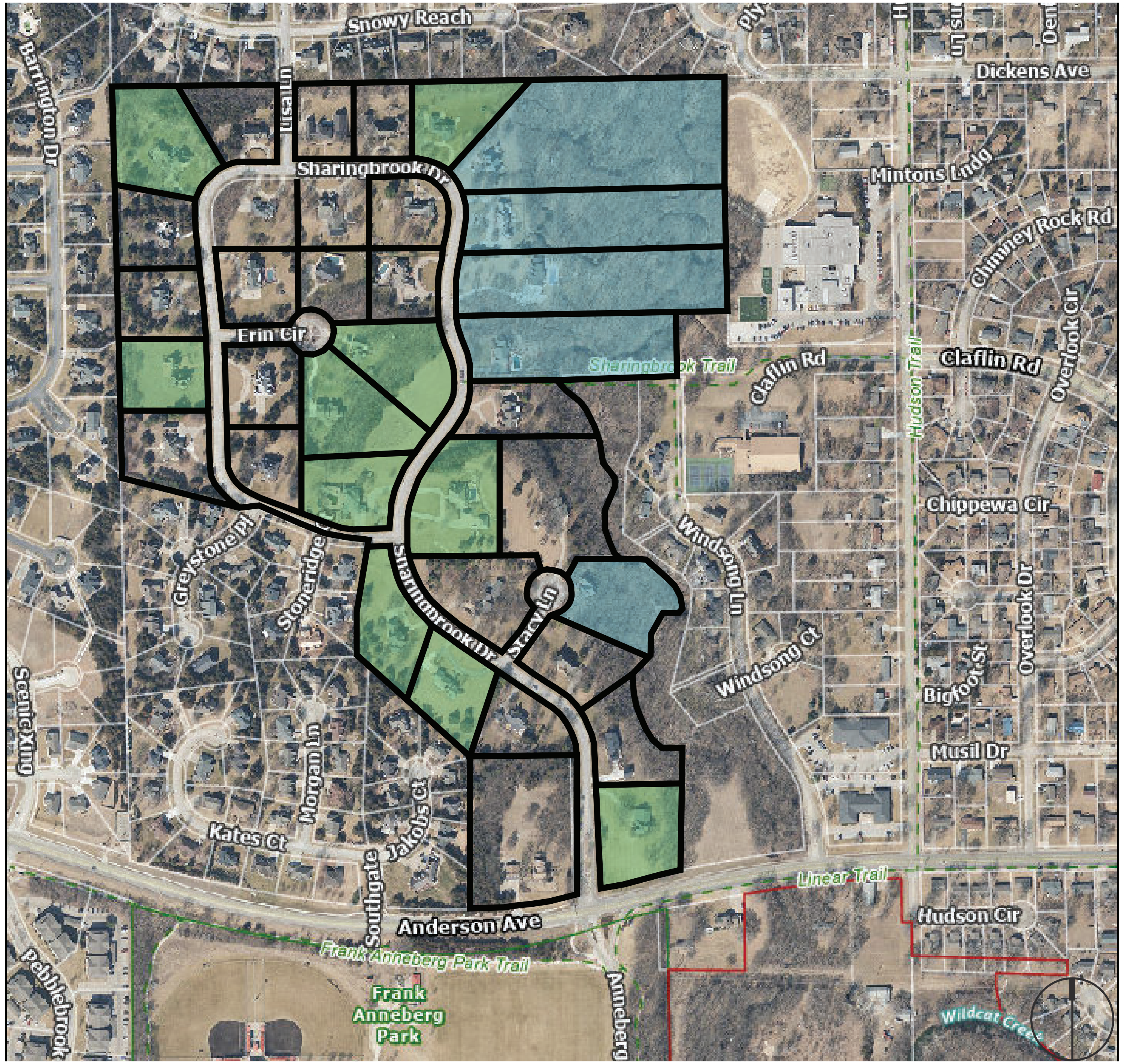

Figure 4.18. Parcels. Map created with Riley County Community GIS Viewer.

Site Analysis

Flood Hazard - Sharingbrook

As studied in the research, flooding is a continuous issue in cities across the United States. Manhattan, Kansas is no exception. Referenced in the "Background," Wildcat Creek is prone to flooding. Part of the Wildcat Creek watershed is Little Kitten Creek, the creek that runs to the east of the Sharingbrook Neighborhood. The map shows the flood hazard areas along Little Kitten Creek. Note the homes on the east side of the neighborhood and their proximity to the hazardous zones. As concluded before, it is the responsibility of the property owners upstream to pay careful attention to how their stormwater management techniques could be impacting those downstream. Figure 5.21 to the right shows the riparian zone and three different flood hazards. Future flood hazards are projected to be a greater concern along both creeks.

Figure 4.19. Eroded drainage way. Sam Wolkey.

Figure 4.20. Flood plain east of the site. Sam Wolkey.

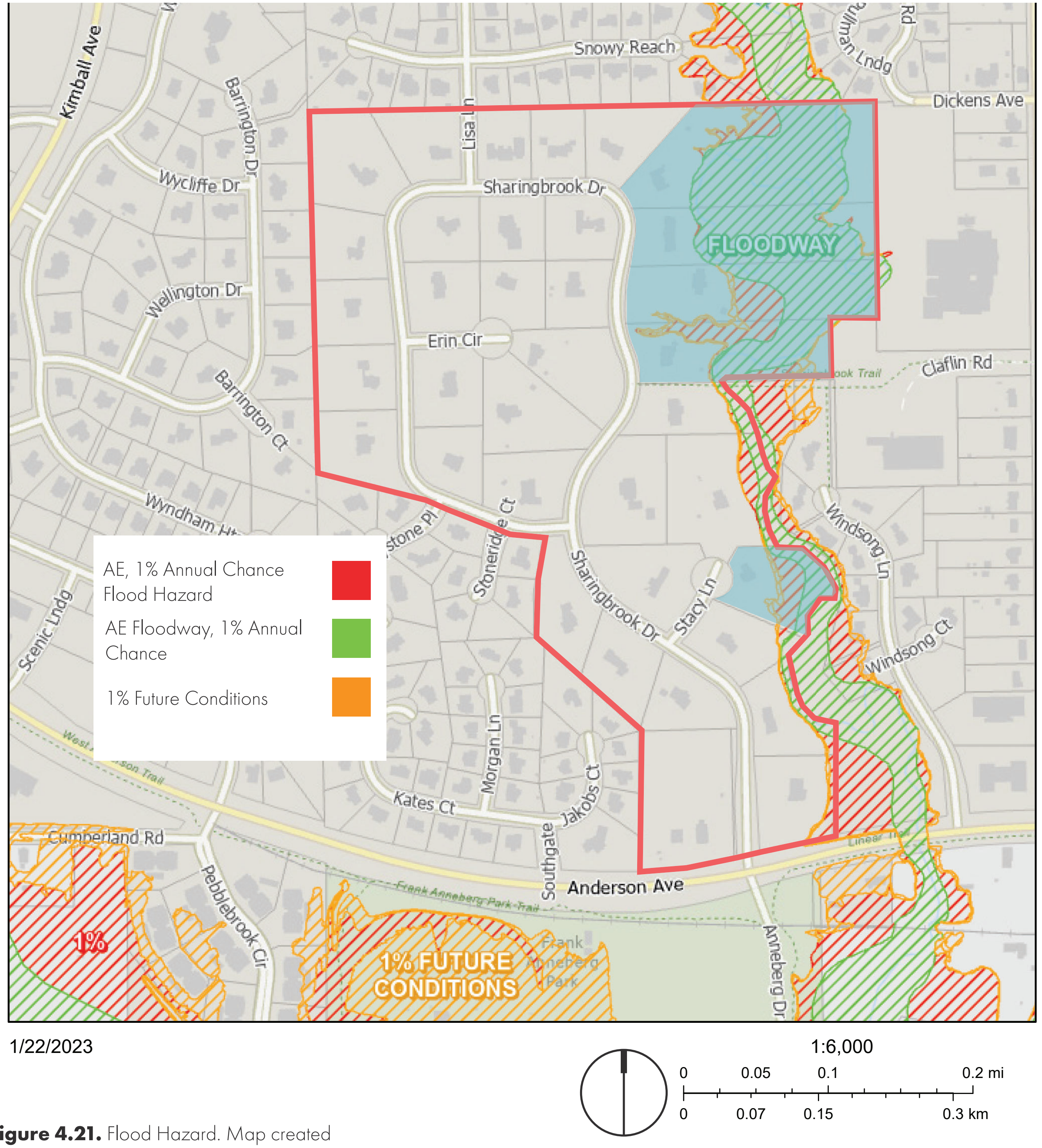

Figure 4.21. Flood Hazard. Map created with Riley County Community GIS Viewer.

Site Analysis

Storm Sewer - Sharingbrook

Shown here is a map of Sharingbrook and the storm inlets, discharge points, and drains. As seen before, there is a significant amount of topography on site and the discharge points are in key areas to allow for stormwater to move through riparian zones before entering the creek.

A lot of these outlets are allowing water to run through private property and with erosion, could cause damage. It is likely that the less water that runs through the outlets, the less erosion there would be. Since there are so few, it is likely that the inlets that do exist are overrun during a large storm event and cause large puddles around them and if there was less water running towards them, the issue would not exist.

Figure 4.22. Stormwater inlet. Sam Wolkey.

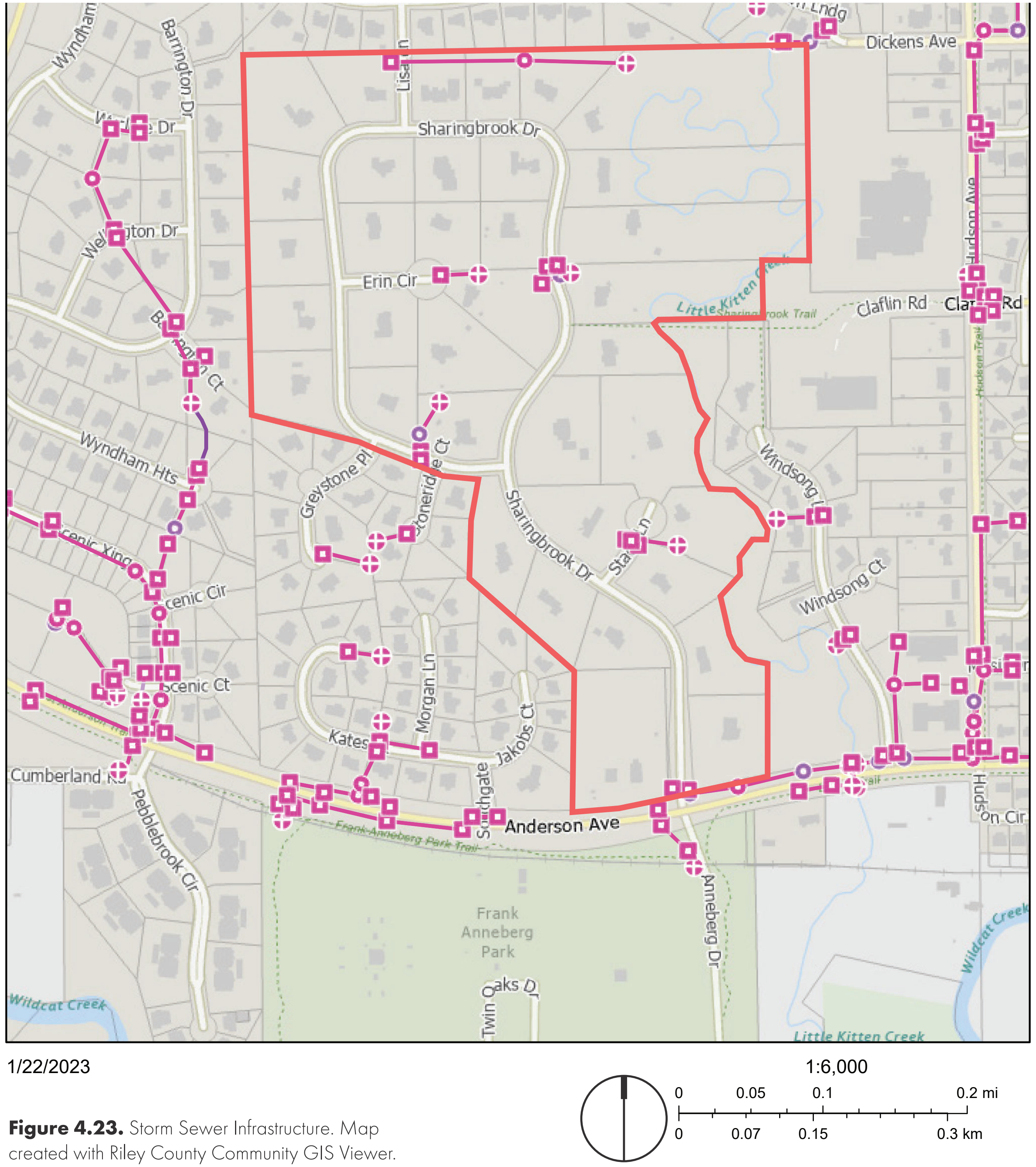

Figure 4.23. Storm Sewer Infrastructure. Map created with Riley County Community GIS Viewer.

Chapter 5 -

Feature Analysis and Matrix

Feature Analysis

Introduction

The feature matrix analysis is designed to identify the best stormwater management features based on cost, maintenance requirements, and potential volume capacity. As discussed before, there are two different typologies of stormwater management features, vegetated and unvegetated. In each matrix, they are split in two groups, features that can be measured by cost per square foot and those that are per unit cost.

Prairie/savanna gardens can come in a lot of different forms. The projective design introduces pocket native gardens of species of tallgrass and other species found in a Kansan prairie and savanna setting. Less compaction and more fibrous root systems foster ideal soil health and allow for more stormwater to infiltrate the ground making these areas great for stormwater management. Prairie and savanna gardens that are small enough can be implemented by using a tarp to "sterilize" an area to kill off undesirable species. After the site is prepped, the space can be seeded if there is no need for immediate aesthetic appeal, or planted with container plants if the desired aesthetic is wanted immediately. Plant spacing would be at each owners' discretion.

Figure 5.1. Existing prairie on a private property in Sharingbrook. Sam Wolkey.

Feature Analysis

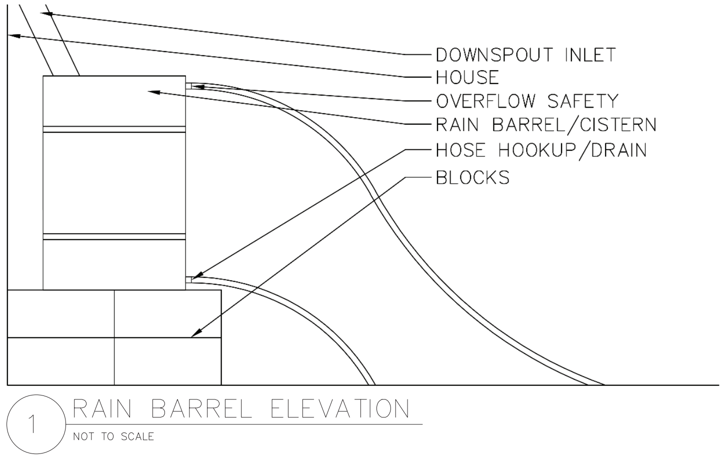

Figure 5.2. Rain barrel detail. Sam Wolkey.

Rain barrels, also known as rain harvesting systems, are storage vessels that hold stormwater during and after storm events. Rain barrels can come in many sizes. They are installed by attaching the downspout of a rain gutter to the vessel. If during the storm event, the barrel is filled, there would be a valve at the top to allow water to escape without backing up the downspout. The water harvested can be used to irrigate nearby areas or drained after a storm event.

Figure 5.3. Rain Barrel.
Washington DC Department of Energy and Environment.

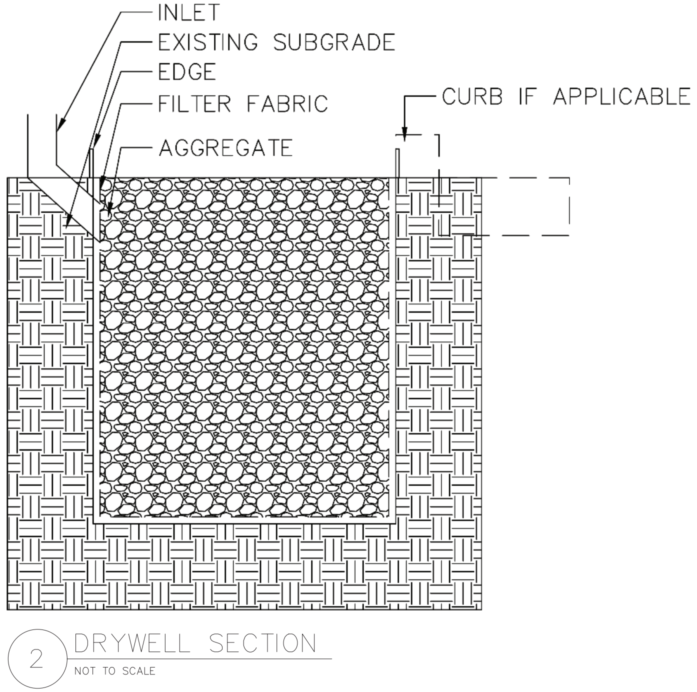

Figure 5.4. Drywell detail. Sam Wolkey.

Drywells are spaces in the ground filled with gravel or other course filler to allow underground storage and eventual infiltration to occur during and after storm events. Drywells can be many sizes and lined in areas with filter fabric to keep surrounding soil and gravel from mixing and clogging. The drywells designed for this project have course gravel used as the filler and filter fabric lining the sides. The top of the drywell is not covered by soil and instead allows for stormwater to overflow out of the storage space after it has reached it’s capacity. Drywells will need to be far enough away from the foundation and positive drainage away from the home are essential.

Feature Analysis

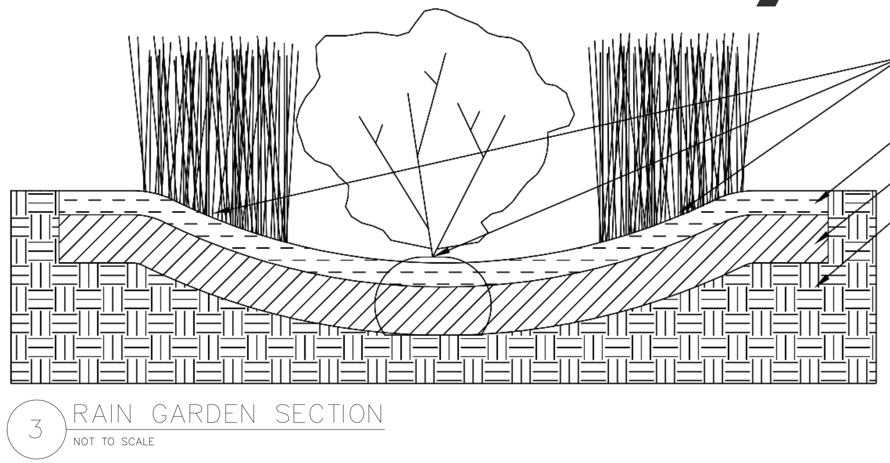

Figure 5.5. Rain garden detail. Sam Wolkey.

Rain gardens are small depressions in the landscape used to clean and hold stormwater. They are planted with a variety on plants ranging from ground cover to trees. These plants need to be able to handle drought and flood conditions. Rain gardens are designed to be filled with water after the soil beneath it is saturated and allow for infiltration within a few to 72 hours depending on soil saturation and the intensity and duration of storms. These rain gardens are designed to flow out after the capacity has been met.

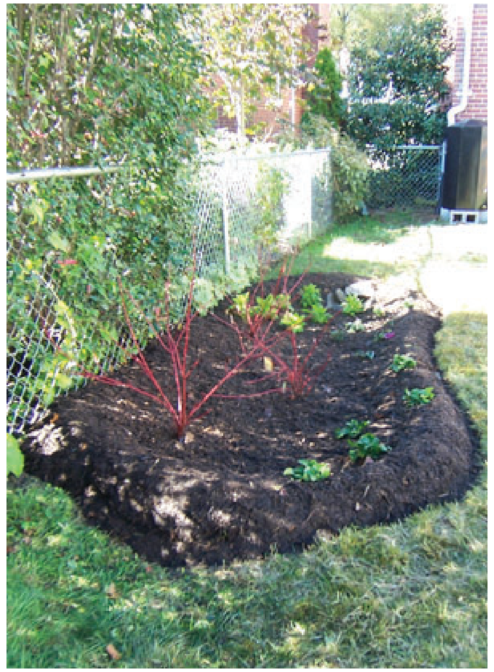

Figure 5.6. Rain Garden.
Washington DC Department of Energy and Environment.

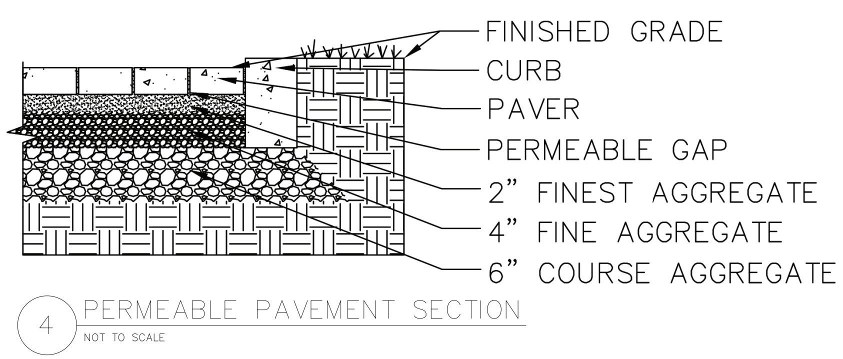

Figure 5.7. Permeable driveway detail. Sam Wolkey.

Pavers that allow for stormwater to infiltrate into the ground are called permeable pavers. Unlike concrete and other forms of impermeable surfaces, permeable pavers will not collect water and shed it elsewhere. They have small gaps between each paver to allow stormwater to fall below the paver and enter the ground. This is a great way to reduce runoff. Some permeable paving has storage underneath it in the form of compacted gravel and/or larger stone to allow for more water. Others might only have sand. Note that gravel is best since it is most permeable. Importantly, permeable paving needs to be located where sediment-laden water does NOT flow onto it.

Figure 5.8. Permeable Driveway.
Washington DC Department of Energy and Environment.

Feature Matrix

Group 1

Group 1 is made up of rain gardens, bioswales, mulch beds, native prairie restoration, and permeable pavers. To make them as equal as possible, each was evaluated per 100 square feet. Based on cost, maintenance hours per year, and possible volume captured/treated, native prairie restoration is likely the best option for stormwater management. Because of the lack of mulch and site preparation it makes the upfront cost less than others. These areas would be easily maintained each year with only a few hours of work once established, with either mowing or burning. Finally, because of enhanced soil health, stormwater can be directed to these areas in non-concentrated flows allowing for faster infiltration due to less compacted soil and deeper root growth.

Rain Garden	100 square feet avg. 12" depth
Bioswale	100 square feet avg. 12" depth
Mulch Bed	100 square feet 3" mulch depth
Prairie/Savanna Garden	100 square feet
Permeable Paving	100 square feet 12" avg. depth

Table 5.1. Group 1 features. Sam Wolkey.

Group 1 Features	Cost (Dollars)	Maintenance Hours/Year	Volume	Rating
Rain Garden	751-1000	16-20	Best	2
Bioswale	501-750	16-20	Poor	4
Mulch Bed	1001-2000	21-25	Fair	5
Prairie/Savanna	251-500	11-15	Better	1
Permeable Paving	2001-5000	6-10	Good	3

Table 5.2. Group 1 feature matrix. Sam Wolkey.

Feature Matrix

Group 2

Group 2 is made up of drywells, cisterns, and rain barrels. Based on unit cost, maintenance hours per year, and possible volume captured/treated, installing a rain barrel is the best option for a homeowner. The main factor at play here is cost. Installing a rain barrel is relatively low cost. Compared to the other features in this group, one could install a rain barrel that is higher-end for the starting price of what it would cost to install a drywell and a fraction of the cost it would take to install a cistern. Maintenance considerations are pretty even across the features with minimal maintenance. Because of the size of rain barrel, the volume compared to a cistern is quite different, fifty-five gallons is standard but there are other rain barrels that have more or less storage and could be used depending upon site conditions and financial limitations or possibilities.

Drywell	25 square feet 3′ depth
Cistern	1000 gal
Rain Barrell	55 gal

Table 5.3. Group 2 features. Sam Wolkey.

Group 2 Features	Cost (Dollars)	Maintenance Hours/Year	Volume	Rating
Drywell	501-750	1-5	Better	2
Cistern	1001-2000	6-10	Best	3
Rain Barrel	101-250	1-5	Good	1

Table 5.4. Group 2 feature matrix. Sam Wolkey.

Feature Matrix

Conclusion

In conclusion, due to the high variability in stormwater management features and the high variability in site conditions, it is very difficult to identify features as “the best”. Every site has different obstacles, and every feature can look and perform differently depending upon those obstacles making a direct comparison difficult to perform. For example, the amount of time required to maintain permeable paving will increase if there are lots of leaves and organic matter that blow on the pavers and if clogging occurs due to sedimentation. The amount of time required to tend to planting beds depends on the aesthetic interests of the property owner and the types of plants selected. In addition, depending on the financial capability of a homeowner, some features, although more expensive, may be “better” but were given a worse rating because of their cost.

Chapter 6 -
Projective Design

Figure 6.1. Drainage area map for the President's Residence. Sam Wolkey.

Projective Design

Feature Map with Drainage Areas

The features at the President's Residence were placed in areas that appeared to be in drainage ways and low areas to intercept the most amount of stormwater possible. These decisions were made after the site analysis and several site visits. To confirm the locations of these features, drainage areas were estimated to make sure the features were large enough to manage the amount of runoff each drainage area would generate during a one-inch storm event.

The Simple Method

Schueler's (1987) Simple Method for Runoff Volume:

$Rv = 0.05 + 0.9 * I_A$
Where: Rv = Runoff Coefficient (unitless)
I_A= Impervious Fraction (unitless)
0.05 = constant
0.9 = constant

$DV = 3630 * R_D * R_D * A$
Where: DV = Design Volume (cu ft)
R_D= Design Storm Depth (in)
A = Drainage area (acres)

"The Simple Method was developed by measuring the runoff from many watersheds with known impervious areas and curve-fitting a relationship between percent imperviousness and the fraction of rainfall converted to runoff (the runoff coefficient). It uses a minimal amount of information to estimate the volume of runoff" (NC Environmental Quality 2017).

The reason the Simple Method was used at the President's Residence is because it is typically more conservative in comparison to other methods such as the USDA-NRCS Curve Number method. This is because when using the Simple Method, it is less likely to over-estimate the storage potential of the BMPs (NC Environmental Quality 2017, Schueler 1987).

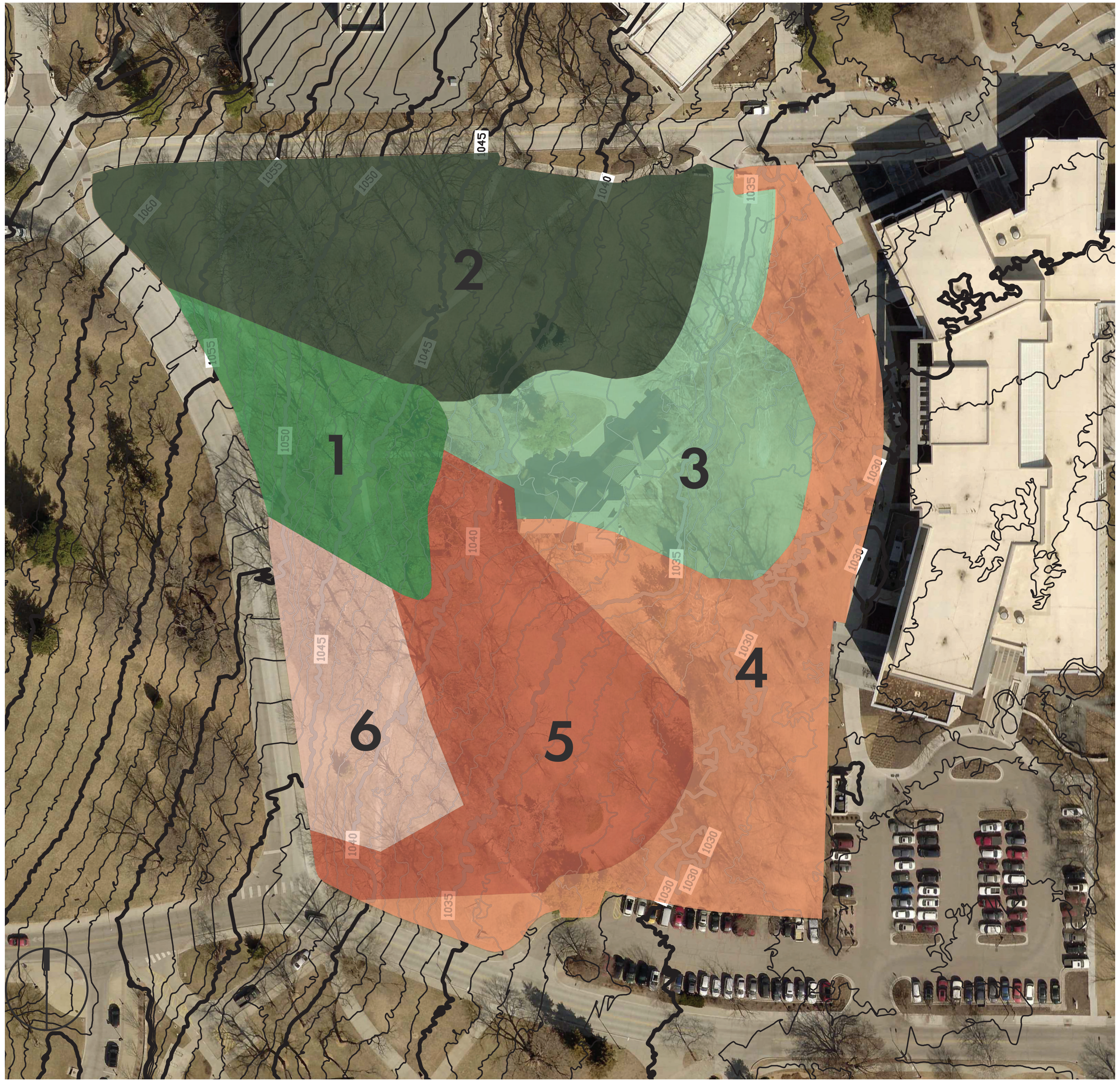

Figure 6.2. Drainage area map for the President's Residence. Sam Wolkey.

Projective Design

Watershed	Design Storm Depth (ft)	Impervious Fraction	Drainage Area (sqft)	Design Volume (gallons)
1	0.083	0.05	14,900	2,544
2	0.083	0.25	44,900	2,648
3	0.083	0.33	37,300	8,036
4	0.083	0.05	42,200	1,546
5	0.083	0.2	34,600	2,041
6	0.083	0.01	14,200	2,028

Table 6.1. Drainage area runoff calculation table. Sam Wolkey.

Projective Design

Figure 6.3. Rain garden locations. Sam Wolkey.

Rain Gardens

The 7,900 square feet of rain gardens are situated around the President's Residence in specific areas. The northernmost rain garden is designed to capture stormwater moving into the drain found on the north end of the site, west of the driveway. The easternmost rain garden is in an area that would capture the stormwater that comes from the drain to the east of the house. This area is often saturated with water and will be a good opportunity for water to be stored before flowing to the area drain southeast of it. The westernmost rain gardens are situated in areas that are already managing stormwater but instead of capturing it, the mater moves quickly through the space and is released into the woodland-like area to saturate the ground. Designing the rain garden to hold water before letting it into the woodland-like area was the intent of the design in this area. The trees used in the rain gardens shown are sycamores. Sycamores are good for absorbing stormwater that has infiltrated the ground and are native to this region. The trees used in the rain gardens, however, do not have to be sycamores. Any tree that is native or well-adapted to Kansas and that thrives in mesic-wet environments will work best. Note that because of their root structure and tendency for smaller branches to break in severe storms it is best to avoid planting sycamore near wastewater/sanitary sewage lines and within 50 feet of homes.

Note: Rain gardens and the process of implementing them can be harmful to surrounding trees because of root damage. Care must be taken to minimize damaging effects.

Figure 6.4. Prairie/savanna locations. Sam Wolkey.

Projective Design

Prairie/Savanna Gardens

Replacing existing lawn with native prairie/savanna gardens on the south side of the site gives the rest of the backyard a traditional residential look with the existing lawn. Since the south side of the site is where most of the stormwater is moving, it would be helpful in this instance to foster healthier soil and allow for quicker infiltration after severe events or a prolonged wet season. In addition to the hydrological benefits of placing the southernmost gardens where they are, because of the location of the parking lots, the gardens will provide a buffer for glare and eye sores during the day and headlights during the night. Layering of native trees, shrubs, and grasses can help block headlight glare. Grasses will need to be kept through fall and winter months to diminish headlight glare. The northernmost garden serves a similar purpose to the southernmost gardens. On the north end of the site, the garden provides a buffer between a walkway cutting across the front yard and the driveway. This would make for a similar experience to The Meadow near the Beach Museum. Replacing 37,000 square feet of lawn throughout the site gives the site potential to manage more stormwater by promoting healthier soil.

Figure 6.5. Drywell locations. Sam Wolkey.

Projective Design

Drywells

The three drywells are fed by downspouts from the house. The design proposes that parts of the existing mulch beds are replaced by decorative gravel to maximize the capacity of the drywells. The drywells are designed to be filled during storm events and drained from the top and flow away from the house into the yard or nearby drain. The reason they were located in the areas they were is because each location allows for the overflow to drain away from the building. Another reason was the existing areas were all mulched and the addition of decorative rock would help the aesthetics of the site. Note that gravel would be best (less prone to clog and more permeable).

Projective Design

Figure 6.6. Rain barrel locations. Sam Wolkey.

Rain Barrels

The four rain barrels are fed by downspouts from the house. The design proposes that four rain barrels are installed at the end of each downspout of the south-facing side of the house. The rain barrels are designed to be filled during storm events. The water from the rain barrels can be used to water the plants around them or just drained after a rain event a few days later to allow the rest of the stormwater to infiltrate the ground or evaporate. The reason they were put in the back of the house was to allow for the front of the house to maintain the "traditional" residence look. This area is also close enough to planting beds that can be irrigated be the stormwater. Overflow water would move to the two south drywells.

Projective Design

Figure 6.7. Permeable patio design. Sam Wolkey.

Permeable Paving - Patio

Shown on the south side of the house, there is room for future improvement should the current or future president of the university want an outdoor patio. This patio would be made from permeable pavers with gravel as the base and not add to the current impermeable surface total. Because of the current conditions, there would not need to be a drain because if the area became saturated enough, the topography would move the water away from the house and towards other proposed features on the southeast portion of the site. This area was chosen because of its proximity to the deck, smoker/grill, walkways, and entrance/exit to the sun room. Designers and contractors will need to make sure that the compacted subsurface of this permeable patio within at least 20 feet of the home slopes to the east of the home so that water moves safely away from the basement.

Figure 6.8. Permeable parking design. Sam Wolkey.

Projective Design

Permeable Paving - Parking

The only existing designated parking on site is located northeast of the residence. The parking is slightly raised allowing stormwater running along the drive to pass next to it. The goal of this space is to allow for stormwater falling in this space to be managed the same way a permeable garden would manage it by storing it under the pavers. There would not be a drain on this feature. If the storage reaches capacity it can start to flow out to the top and make its way into an existing drain. The feature in this proposed design converts 2,500 square feet of impervious surface to permeable surface. Once the current parking area needs to be replaced permeable pavers with subsurface storage should be implemented as this is and ideal location for such a feature.

Figure 6.9. Final design. Sam Wolkey.

Projective Design

Feature Locations - All

The proposed design suggests replacing a significant amount of introduced turf grass with features that provide more benefits to the site and its context. The prairie/savanna garden areas and rain gardens total 44,600 square feet. In total, the site is now capable of managing approximately 73,800 gallons of stormwater because of the proposed features. Since the site is approximately five acres, according to the United States Geological Survey, a five acre site would yield 135,770 gallons of water during a one inch storm event (USGS n/d). This means the features would manage over fifty percent of the site's stormwater during a one inch storm event. It is important to note that this calculation was done without including the interception rates from trees and other plant material. This was done because a significant amount of the trees on site are deciduous and the interception rates can vary based on if the trees have leaves on them or not.

Figure 6.10. Parcels of interest locations. Sam Wolkey.

Projective Design

Replacement Ratios

During the projective design for the President's Residence, a ratio was created to find how much of the existing lawn space or impermeable space was being replaced by stormwater management features. In this section, those ratios are applied to four parcels in the Sharingbrook Neighborhood. The four parcels chosen are 2, 4, 7, and 9. These properties were chosen because of the amount of impervious space, increased lawn, and opportunity for stormwater management features. In the case of trees, they should be planted at the property owner's discretion in areas that make the most sense. In two cases, they have been placed, but in another two it was hard to tell where they would be best.

The locations of the features were chosen based on how the stormwater on site flows and what made most sense. Rain gardens and the prairie/savanna gardens were located to capture potential runoff in swales, near impervious surfaces, or at the bottom of hills to capture possible pollutants found in lawn grass and on impermeable surfaces.

Figure 6.11. President's residence final design . Sam Wolkey.

Projective Design

President's Residence

Total Site Area: 216,000 square feet

Existing Impermeable Area: 29,000 square feet

Existing Lawn Area: 114,100 square feet

Existing Woodland Area: 72,900 square feet

1 Proposed Prairie/Savanna Area: 37,050 square feet

2 Proposed Rain Garden Area: 7,550 square feet

3 Proposed Permeable Paver Area: 3,700 square feet

4 Proposed Trees: 4

5 Proposed Sites for Rain Barrel or Dry Well: 4

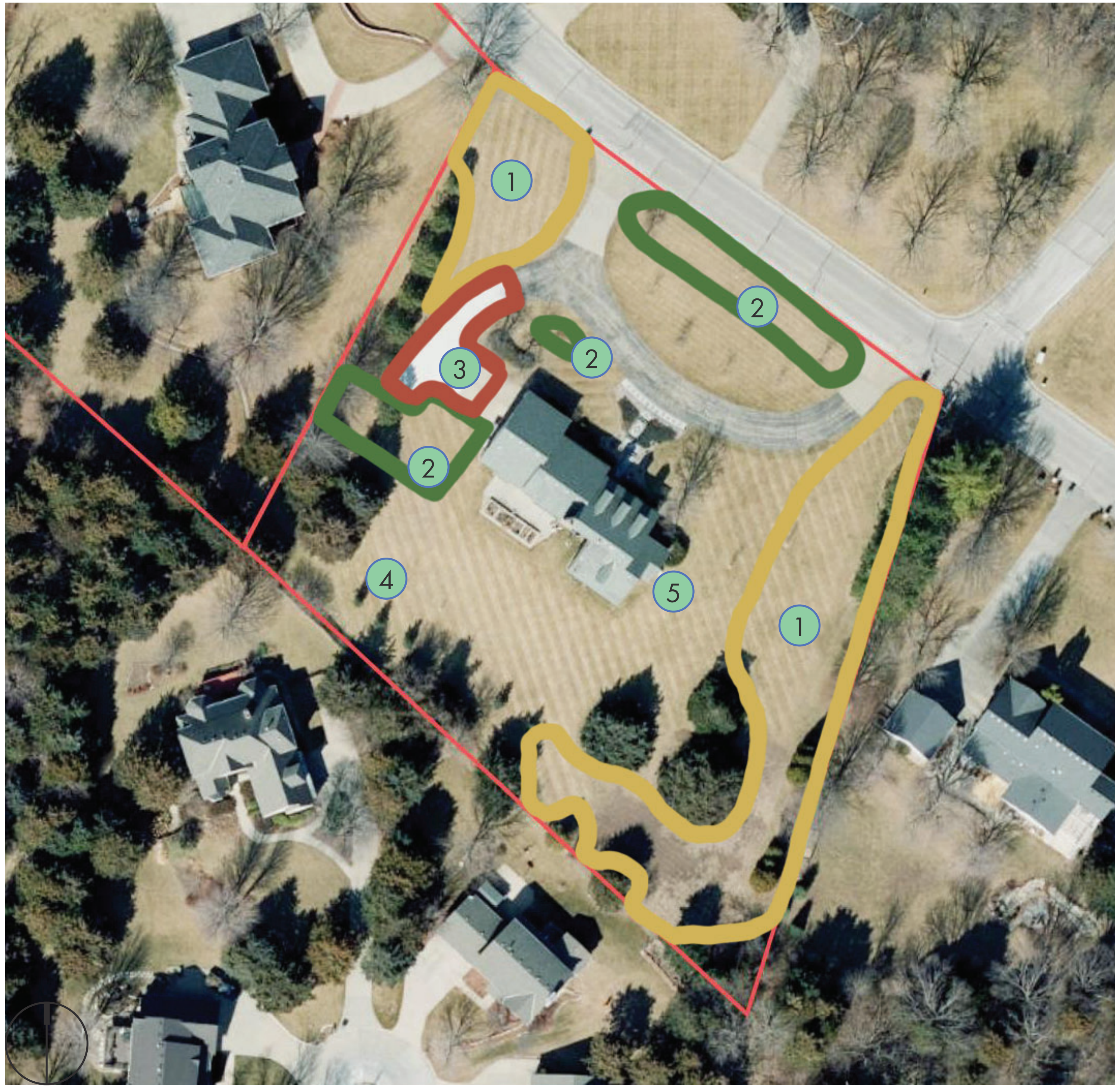

Figure 6.12. Sharingbrook Property 2 design. Sam Wolkey.

Projective Design

Sharingbrook Property 2

Total Site Area: 85,000 square feet

Existing Impermeable Area: 14,200 square feet

Existing Lawn Area: 70,800 square feet

Existing Woodland Area: 0 square feet

1 Proposed Prairie/Savanna Area: 23,000 square feet

2 Proposed Rain Garden Area: 4,700 square feet

3 Proposed Permeable Paver Area: 1,800 square feet

4 Proposed Trees: 4

5 Proposed Sites for Rain Barrel or Dry Well: 2

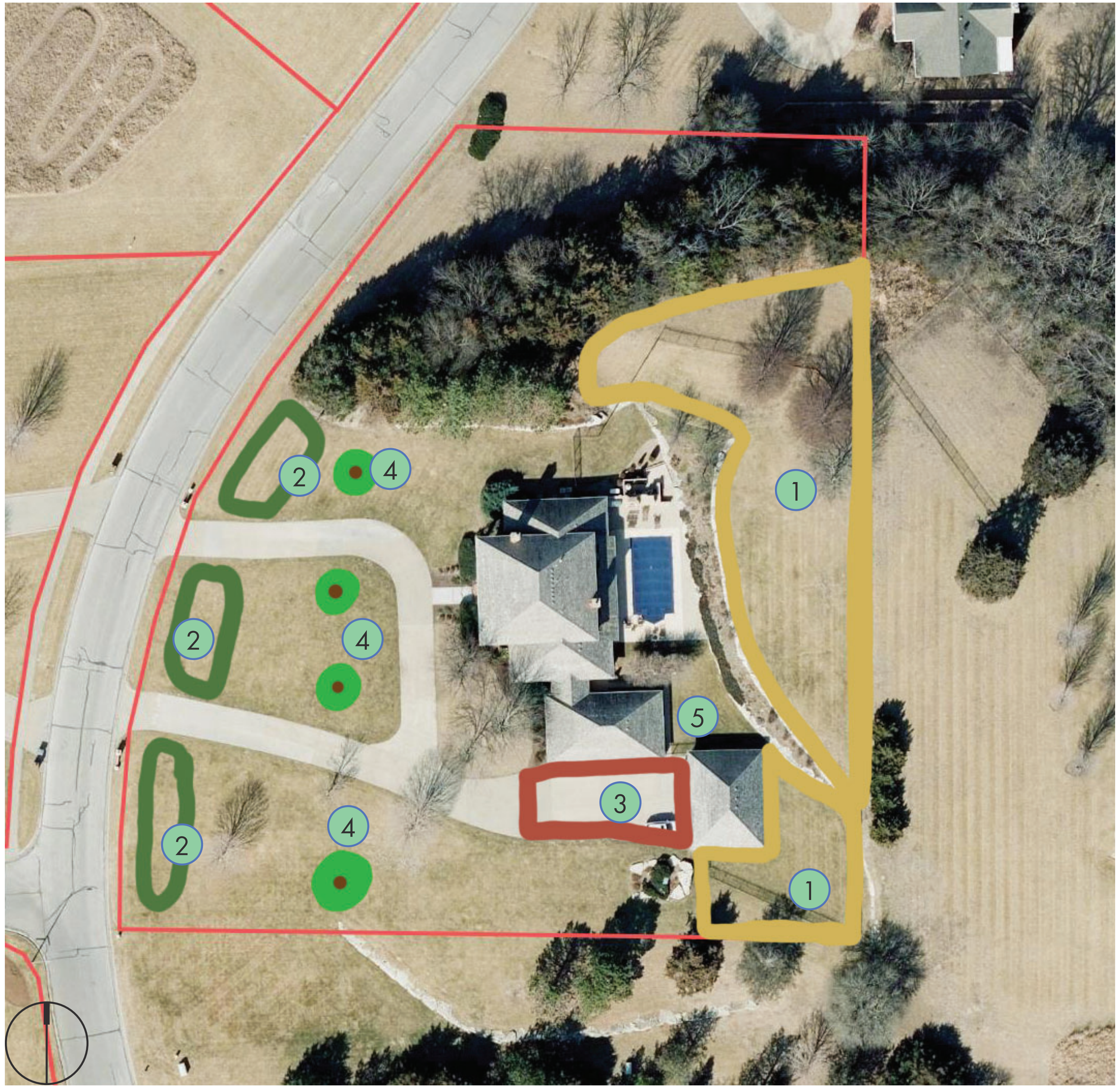

Figure 6.13. Sharingbrook Property 4 design. Sam Wolkey.

Projective Design

Sharingbrook Property 4

Total Site Area: 98,000 square feet

Existing Impermeable Area: 19,400 square feet

Existing Lawn Area: 4,700 square feet

Existing Woodland Area: 14,650 square feet

1 Proposed Prairie/Savanna Area: 19,000 square feet

2 Proposed Rain Garden Area: 3,900 square feet

3 Proposed Permeable Paver Area: 2,500 square feet

4 Proposed Trees: 4

5 Proposed Sites for Rain Barrel or Dry Well: 5

Figure 6.14. Sharingbrook Property 7 design. Sam Wolkey.

Projective Design

Sharingbrook Property 7

Total Site Area: 109,000 square feet

Existing Impermeable Area: 7,400 square feet

Existing Lawn Area: 53,600 square feet

Existing Woodland Area: 48,000 square feet

1 Proposed Prairie/Savanna Area: 17,400 square feet

2 Proposed Rain Garden Area: 3,500 square feet

3 Proposed Permeable Paver Area: 950 square feet

4 Proposed Trees: 7

5 Proposed Sites for Rain Barrel or Dry Well: 2

Figure 6.15. Sharingbrook Property 9 design. Sam Wolkey.

Projective Design

Sharingbrook Property 9

Total Site Area: 78,000 square feet

Existing Impermeable Area: 10,400 square feet

Existing Lawn Area: 46,300 square feet

Existing Woodland Area: 21,300 square feet

1 Proposed Prairie/Savanna Area: 15,000 square feet

2 Proposed Rain Garden Area: 3,000 square feet

3 Proposed Permeable Paver Area: 1,350 square feet

4 Proposed Trees: 2

5 Proposed Sites for Rain Barrel or Dry Well: 2

Chapter 7 -

Incentive Program and Application

Incentive Programs

Portland, Oregon

Clean River Rewards is a government-based incentive program that provides homeowners and renters the option to implement different features on the property to receive discounts on their stormwater fee up to $130 a year. The website has a discount calculator for residents to use for people to understand how much money they may be able to save. Residents have the option to register online, by mail, or email (City of Portland 2022). Property owners qualify for rewards by having one or more features that keep stormwater on their property. These features include rain gardens, swales, lawns, or landscaped areas that have at least 10% of the roof's surface area drain to them. Drywells, French drains, or soaking trenches are used to facilitate water into the ground. Rain barrels or cisterns are used to collect water from roofs and must be released into the ground when full. Stormwater planters, ponds, or detention facilities collect water until they are full and then release into the sewer with an overflow pipe. Ecoroofs, also known as green roofs, capture rainwater by having a layer of plant material and soil rather than conventional roofs. Property owners are eligible for the rewards if impermeable surfaces on their property do not exceed one thousand square feet and if a property owner has four or more fifteen-foot trees on their property (City of Portland 2022).

Washington D.C.

RiverSmart is a multi-opportunity program that allows homeowners to choose from several different incentive initiatives. RiverSmart Homes aids property owners technically and financially, encouraging them to install functional stormwater management features. These features include rain barrels, shade tree planting, rain gardens, native plant gardens, and revegetating previously impermeable space or replacing impermeable space with permeable paving. An auditor will schedule a site visit and determine what features are available (Washington D.C. DOEE a, 2022). RiverSmart Rebates provides property owners with the opportunity to install features themselves or hire a contractor. Trees, rain barrels, rain gardens, and permeable surfacing are all priced based on totals of non-required features. Residents can apply online and be partially or fully reimbursed (Washington D.C. DOEE b, 2022).

RiverSmart Rewards is another program the Washington D.C. area provides that encourages residents with existing stormwater management features to apply for water bill discounts of up to 55%. This program was implemented to protect the Anacostia and Potomac Rovers as well as Rock Creek. Discounts to the resident's water bill are based on how much stormwater can be retained on site (Washington D.C. DOEE c, 2022).

RiverSmart Rebates is a program similar to RiverSmart Homes but instead of having an auditor come to the property and receiving technical aid, the owner of the property is expected to "do-it-yourself" or hire a contractor. The property owner is liable for all upfront costs but able to submit a form for partial reimbursement for implementation costs (Washington D.C. b, 2022).

Incentive Programs

Minneapolis, Minnesota

Residential stormwater credits can reduce a utility fee up to 45%. Properties are eligible for credits if it has a rain garden, pervious pavement, green roof, or reuse BMP (not including rain barrels). The features must be on the property and not in the right-of-way. Applicants apply online and they must have a map with details on the location of the feature(s), how the property drains to the feature(s), and the total area of impervious surface drainage to feature(s). The applicant must also provide pictures and/or videos of the feature(s), their location, and paths (downspouts and swales) by which stormwater find its way to the feature(s) as well as the total area of impervious surfaces draining towards each feature. Overall, the credits (and associated partial utility fee waiver) are earned if the property owner can prove that they are removing pollutants from the stormwater that is falling on impervious surfaces on their property (City of Minneapolis 2022).

Incentive Application

Introduction

Based on the incentive program analysis, the Washington D.C. RiverSmart program was deemed to be best by me for this research application because of their ability to encourage homeowners to implement stormwater management features. This section will identify how the parcels of interest in the Sharingbrook Neighborhood would benefit from a program like Washington D.C.'s in Manhattan, Kansas by identifying what stormwater management features could be implemented on the site and how much it would cost in the RiverSmart Homes program, how much they could receive back from the RiverSmart Rebates program, and what kind of credits they would get in the RiverSmart Rewards program.

RiverSmart Homes Feature	Cost	Limit
Rain Barrels	$50	2 units
Shade Tree Planting	$0	0
Rain Garden	$100/50 sqft	2 units
Native Plant Garden	$100/120 sqft	2 units
Re-Vegetation	$5/1 sqft	$4,000.00
Permeable Pavers	$10/1 sqft	$4,000.00
RiverSmart Rebates Feature	**Rebate**	**Limit**
Trees	up to $100	1 unit
Rain Barrels	$2/1 gallon	$1,000.00
Rain Gardens	$3/1 sqft	$2,200.00
Re-Vegetation	$5/1 sqft	$4,000.00
Permeable Pavers	$10/1 sqft	$4,000.00
RiverSmart Rewards	**Max. Allowable Discount**	
Apply for Discount	55%	

Table 7.1. Washington D.C.'s RiverSmart Incentive Programs. Adapted from doee.dc.gov/riversmart.

Incentive Application

Figure 7.1. President's residence design. Sam Wolkey.

President's Residence

Total Site Area: 216,000 square feet

Existing Impermeable Area: 29,000 square feet

Existing Lawn Area: 114,100 square feet

Features	Units/ Square Feet	Co-payment Dollars	Rebate Dollars	Volume Gallons
1 Prairie/Savanna	37,050	200	N/A	7,400
2 Rain Garden	7,550	200	2200	53,600
3 Permeable Paving	3,700	4000	4000	12,400
4 Trees	4	0	N/A	Depends
5 Rain Barrel	4	100	220	440

Table 7.2. Feature usage and volume totals for the President's Residence. Sam Wolkey.

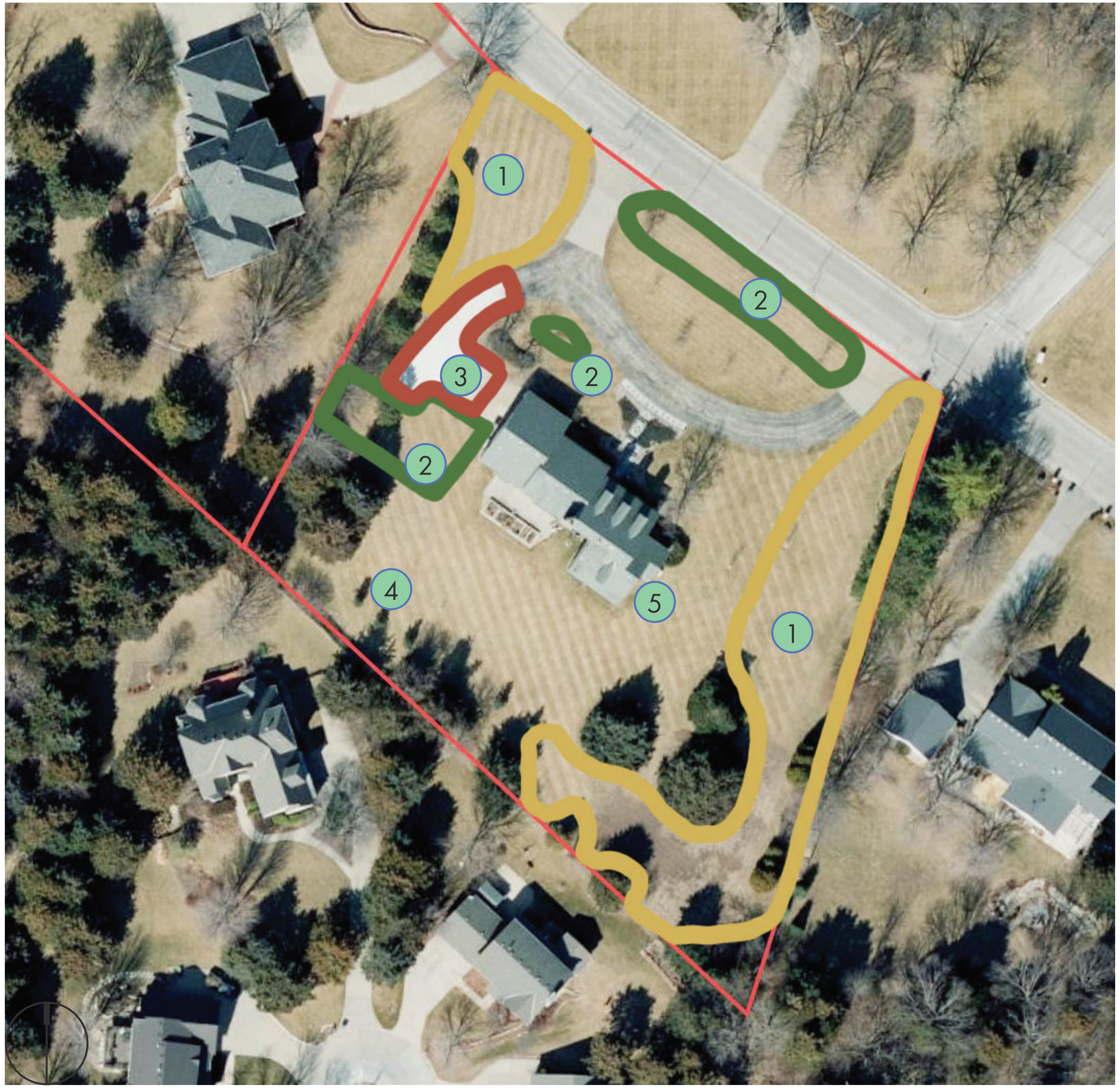

Figure 7.2. Sharingbrook Property 2 design. Sam Wolkey.

Incentive Application

Property 2

Total Site Area: 85,000 square feet

Existing Impermeable Area: 14,200 square feet

Existing Lawn Area: 70,800 square feet

	Features	Units/ Square Feet	Co-payment Dollars	Rebate Dollars	Volume Gallons
1	Prairie/Savanna	23,000	200	N/A	34,400
2	Rain Garden	4,700	200	2200	33,400
3	Permeable Paving	1,800	4000	4000	6,000
4	Trees	4	0	N/A	Depends
5	Rain Barrel	2	100	N/A	110

Table 7.3. Feature usage and volume totals for property 2. Sam Wolkey.

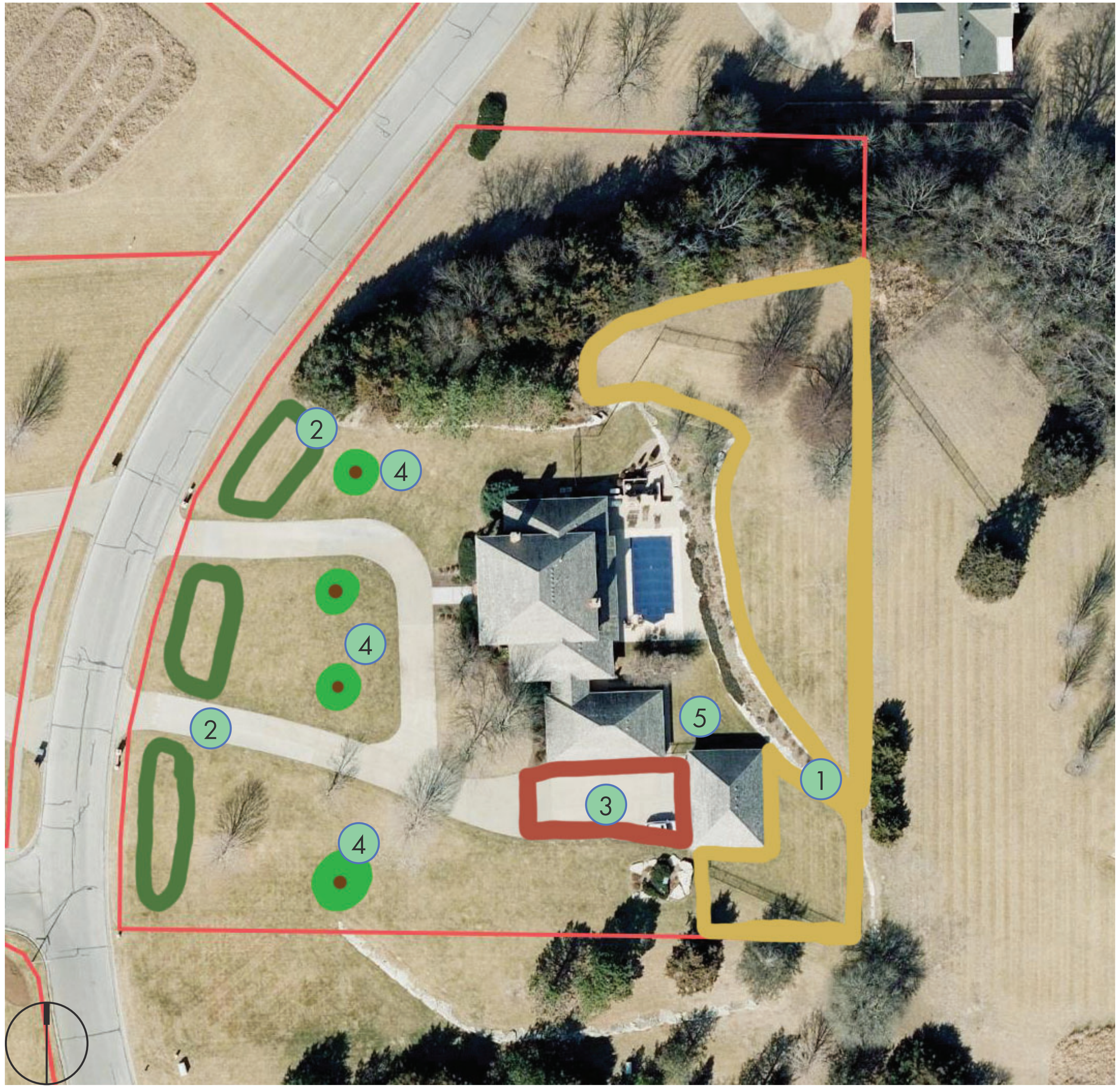

Figure 7.3. Sharingbrook Property 4 design. Sam Wolkey.

Incentive Application

Property 4

Total Site Area: 98,000 square feet

Existing Impermeable Area: 19,400 square feet

Existing Lawn Area: 4,700 square feet

	Features	Units/ Square Feet	Co-payment Dollars	Rebate Dollars	Volume Gallons
1	Prairie/Savanna	19,000	200	N/A	28,400
2	Rain Garden	3,900	200	2200	27,700
3	Permeable Paving	2,500	4000	4000	4,100
4	Trees	4	0	N/A	Depends
5	Rain Barrel	5	100	330	275

Table 7.4. Feature usage and volume totals for property 4. Sam Wolkey.

Figure 7.4. Sharingbrook Property 7 design. Sam Wolkey.

Incentive Application

Property 7

Total Site Area: 109,000 square feet

Existing Impermeable Area: 7,400 square feet

Existing Lawn Area: 53,600 square feet

Features	Units/ Square Feet	Co-payment Dollars	Rebate Dollars	Volume Gallons
1 Prairie/Savanna	17,400	200	N/A	26,030
2 Rain Garden	3,500	200	2200	24,900
3 Permeable Paving	950	4000	4000	3,200
4 Trees	7	0	N/A	Depends
5 Rain Barrel	2	100	N/A	110

Table 7.5. Feature usage and volume totals for property 7. Sam Wolkey.

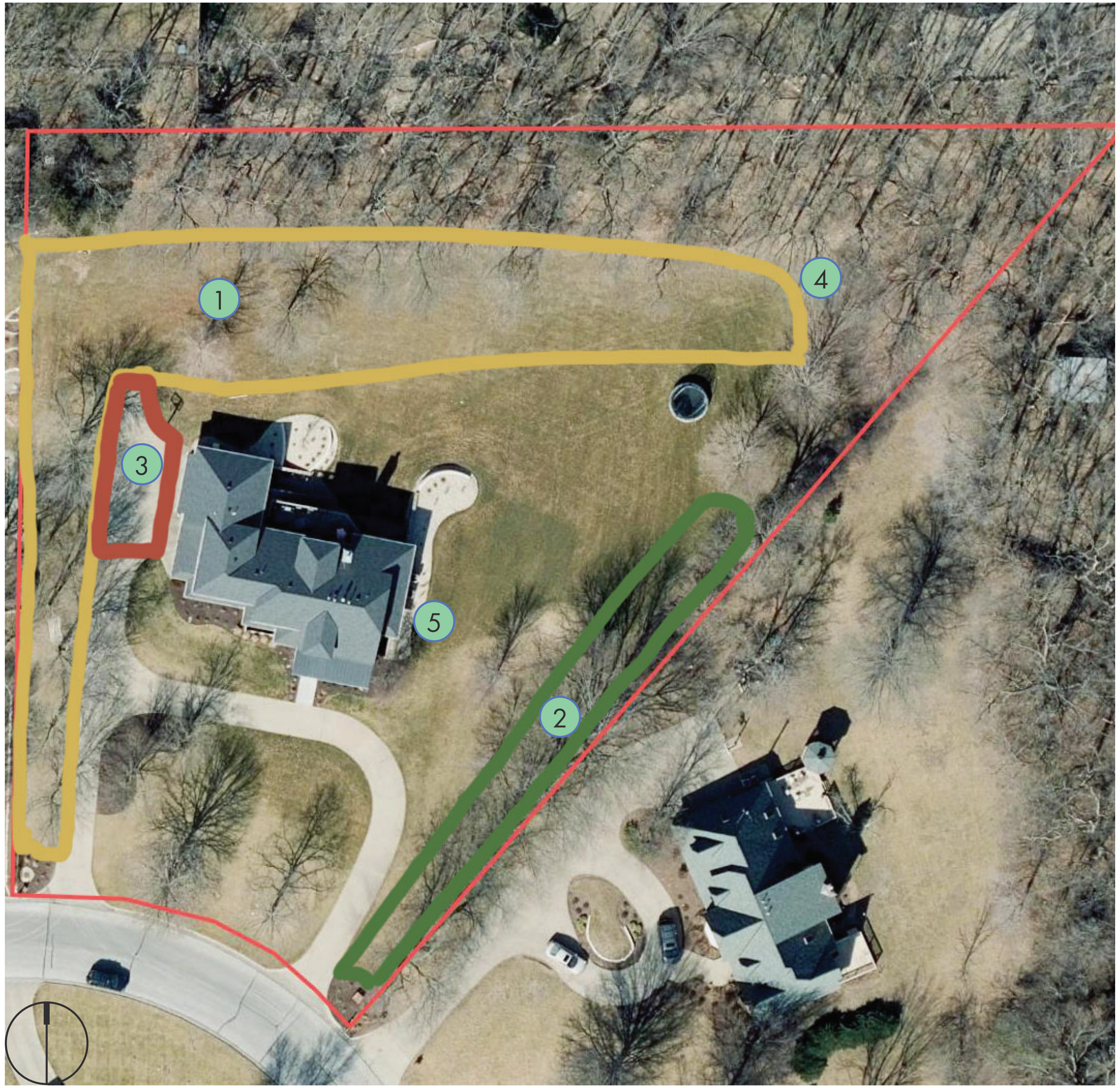

Figure 7.5. Sharingbrook Property 9 design. Sam Wolkey.

Incentive Application

Property 9

Total Site Area: 78,000 square feet

Existing Impermeable Area: 10,400 square feet

Existing Lawn Area: 46,300 square feet

	Features	Units/ Square Feet	Co-payment Dollars	Rebate Dollars	Volume Gallons
1	Prairie/Savanna	15,000	200	N/A	22,440
2	Rain Garden	3,000	200	2200	21,300
3	Permeable Paving	1,350	4000	4000	4,500
4	Trees	2	0	N/A	Depends
5	Rain Barrel	2	100	N/A	110

Table 7.6. Feature usage and volume totals for property 9. Sam Wolkey.

Incentive Application

Calculations

To find how much stormwater each feature could hold, the volume of each was calculated. In the case of soil and gravel, a porosity figure was used in the calculation found in Huffman et al. (2013) -- with 0.2 and 0.3 used as the porosity value depending on the material. Huffman et al. (2013) uses less-conservative values representative of the space in the soil that is "empty" during dry periods and would thus allow water to fill the space. The reason the value is used is because one foot beneath the surface will need to be saturated before a rain garden would be filled. The value "7.48" is what is multiplied to the cubic foot value to make it U.S. Gallons. The following formulas were used to find the values. It is important to note that in addition to the stormwater held on the ground, there is also potential for interception rates that are not being accounted for in this project. Interception rates are calculated as the stormwater that is intercepted by a plant before it hits the ground like when water is captured on the leaf of a tree.

Rain garden:
Volume in gallons = 7.48 (garden volume + volume of 1 foot of soil beneath garden*0.2)

Prairie/Savanna:
Volume in gallons = 7.48 (volume of 1 foot of soil beneath garden*0.2)

Permeable Paving:
Volume in gallons = 7.48 (volume of underground storage*0.3)

As an example, this is how Property 2 was calculated:

Rain garden:
Volume in gallons = 7.48 (garden volume + volume of 1 foot of soil beneath garden*0.2)
Volume in gallons = 7.48 (4,700 * 0.75 + 4,700 * 1 * 0.2)
Volume in gallons = 33,400 gallons

Prairie/Savanna:
Volume in gallons = 7.48 (volume of 1 foot of soil beneath garden*0.2)
Volume in gallons = 7.48 (23,000 * 1 * 0.2)
Volume in gallons = 34,400 gallons

Permeable Paving:
Volume in gallons = 7.48 (volume of underground storage*0.3)
Volume in gallons = 7.48 (1,800 * 1.5 * 0.3)
Volume in gallons = 6,000 gallons

Chapter 8 -
Design Findings

Stormwater Feature	Number of barrels, trees, or total area (sf)	Captured, temporarily stored, or treated stormwater in gallons
Rain Barrel	11	605
Trees	17	0
Rain Garden	15,100 sf	107,300
Prairie/Savanna	74,400 sf	111,270
Permeable Paving	6,600 sf	17,800

Table 8.1. Sharingbrook projective design totals. These figures represent the total capacity of each feature on all four properties combined and the number of rain barrels, trees, and square feet of the selected features. Sam Wolkey.

Design Findings

Totals

Each property of interest has its own opportunities and challenges related to implementing effective and aesthetically pleasing stormwater management features. Each property in the Sharingbrook Neighborhood was designed without a true site visit or proper inventory and analysis since I did not seek permission to visit properties. A quick windshield survey was completed from the road and aerial imagery was used for conceptual design work. It is also important to note that the designs are for educational purposes only and a more thorough design process should be completed before costly interventions are implemented for the purpose of mitigating downstream flooding.

However, if these designs were adapted and installed as designed, the four properties explored have the opportunity to replace almost 90,000 square feet of lawn area, 6,600 square feet of impervious surface, and implement seventeen additional trees and eleven rain barrels. All of these features capacities would contribute a total of almost 237,000 gallons of stormwater that would be stored or treated on site rather than quickly drained towards Little Kitten Creek.

Conclusion - 9

Conclusion

Feature Matrix

Stormwater management features are important in the effort to reduce flooding. Measuring their effectiveness in cost, maintenance considerations, and potential volume captured, however, makes it incredibly difficult to make one type of feature “better” or more preferred than the others. The high variability in the features themselves as well as their availability on a site or other obstacles make ranking one type of feature over another difficult. For instance, a rain garden might be able to store more runoff, but there is not enough room for a rain garden and instead permeable pavers can be implemented somewhere on site. Another example is if a cistern is within the financial capability of a property owner, but the idea is discouraged because it was “ranked” lower on the matrix because of the cost. Although this matrix and the research it took to make it is a good starting point, future research should be completed to look into each grouping of feature and how practical each one is in certain site situations as well as their performance.

K-State President’s Residence

The Kansas State University President’s Residence has a lot of potential for stormwater management. Currently, the site seems to effectively move stormwater in the large front yard to a swale in between the President’s Residence and the Business Building to an area drain southeast of the site. Although there are few attempts at managing the stormwater, it is possible to introduce the features proposed in the design to manage the stormwater on site and, most importantly, be an example to visitors (including faculty, staff and students) on the possibilities of a large-lot single-family residence to manage stormwater with vegetated and unvegetated features throughout the site. The design has the capacity to store almost 74,000 gallons of stormwater. According to the United States Geological Survey, a 5-acre site would see almost 68,000 gallons of stormwater during a half inch rain event, and 135,770 gallons during a one inch rainfall. The watershed calculations were done using a one inch storm.

Conclusion

Sharingbrook Neighborhood

The Sharingbrook neighborhood shows immense potential for mitigating stormwater runoff leaving this development after a storm event because of their capacity to implement features that help water soak into soils. The main takeaway during this exercise is that although one property, like the President's Residence, can do their part, it is really up to larger scale neighborhoods and groups to implement features on a scale that allows for normal usage of their property but will also manage stormwater that falls on their site. The more property owners that practice this, the more runoff will be captured and less ends up in creeks like Little Kitten Creek and Wildcat Creek. Some of the properties in this area, however, are owned by people who are being effected by the decisions, or lack thereof, by property owners north of the neighborhood who do not practice stormwater management and do not mitigate but rather add to the issues that cause erosion and downcutting. Although Sharingbrook is a unique neighborhood in Manhattan, Kansas that has thirty-six properties 1.25-5 acres, it is important to note that neighborhoods and homeowners that do not have the same scale of property can still help. Effective stormwater management can be implemented on all kinds and sizes of properties. Future research could be conducted to study how the implementation of stormwater management features across the entire Little Kitten Creek Watershed could mitigate flooding.

Incentive Program Precedent Study

The Incentive Program Precedent Study shows that Washington D.C. and their RiverSmart program is the most practical and usable for incentivizing stormwater BMPs on Sharingbrook properties in Manhattan, Kansas. Being able to reach homeowners on multiple levels allows for equitable usage like the RiverSmart Homes program, RiverSmart Rewards program and RiverSmart Rebates program. In addition to the great tools that come with the Homes and Rebates programs, using the Rewards program after the fact helps homeowners to continue to reap the rewards of their features. Similar to the conclusion of the Feature Matrix, it is hard to tell which is best because there are more factors like space, budget, and availability, but the RiverSmart program covers more than just a credit to a stormwater fee on a utility bill like the programs in Portland and Minneapolis.

A future study could research the cost of flood events on a city and compare how implementing a program like Washington D.C.'s might mitigate flooding and if the cost would be worth it in the long run. Research could be conducted to ask homeowners in different lower-density neighborhoods in Manhattan, Kansas and other cities with flooding issues if they would be willing to implement such features if a program such as Washington D.C.'s was implemented in their city.

Conclusion

Project Conclusion

Although there are not personal financial benefits to implementing effective stormwater management features onto private property (unless such feature help prevent basement or other types of flooding), the widespread implementation of features could prove to do a lot of good in the communities they are implemented in. As highlighted in the Background section, flooding can cause harm and financial hardship to people in the same community as those who are capable of implementing stormwater management features. The effects of flooding cause great misfortune to people who lose their cars, valuables, or home so mitigating the floods is something that, as neighbors, should be dealt with before the next flood-related disaster strikes. The reason private homeowners should retrofit their large-lot single-family properties to manage stormwater is to help mitigate the damage to their community. Simultaneously, as shown by projects like the following award-winning large-lot residential design projects -- artfully designed landscapes that integrate stormwater management into all aspects of a property can be stunningly beautiful and also provide habitat and sustenance for people and other creatures. Look and learn!

Maple Hill Residence, Westwood Massachusetts -
www.asla.org/2012awards/350.html
Stephen Stimson Associates Landscape Architects

Woodland Rain Gardens, Caddo Parish, Louisiana -
www.asla.org/2014awards/602.html
Jeffrey Carbo Landscape Architects

Quarry House, Park City, Utah -
www.asla.org/2022awards/5789.html
Design Workshop, Inc. (Landscape Architects & Planners/Designers)

Refugio - Santa Cruz, California -
www.asla.org/2022awards/6194.html
Ground Studio Landscape Architecture

Takeaways

There are a few major takeaways from this report. 1.) Lawn covers a huge percentage of residential property and a portion can be converted to a stormwater management feature and make a small difference. However, if an entire neighborhood does the same thing, the impact would be far greater. It is most important to not only get a few owners involved in a project like this, but an entire neighborhood. 2.) Stormwater management features come in many shapes and sizes. They can adapt to different site conditions and therefore they are difficult to compare sometimes which one is best overall instead of best for a specific condition. 3.) Incentive programs have great potential and the best kind are the ones that make the features more accessible financially and have am incentive to keep them from failing. A program like RiverSmart needs a great deal of funding but has great potential in a community like Manhattan, Kansas where incentives and support to manage stormwater on each property (residential or commercial) is really needed. Although funding and implementing such programs take lots of work, so does cleaning up after flooding. Ethics and compassion should compel us to act in ways that truly reduce downstream harms and misfortune.

Conclusion

Limitations

With limited time and resources, a complete site analysis for every site was not able to be performed and instead a more "good-faith" analysis was performed. Things like stakeholder interviews, soils tests, and budget evaluations could have been influential in the design phases to identify what designs were possible for the President's Residence and Sharingbrook properties. Most importantly, comparing "apples-to-apples" was difficult when it comes to comparing the different features. Because of the high variability in them and change in site conditions, no feature is the "best" and should be compared related to specific site conditions rather than side-by-side.

Future Research

Future research can include a large scale study on a neighborhood and how much stormwater such an area is are able to capture. This could be done with the ratios used in this study or a different replacement ratio. Other future research could study the soils in the areas designed for to more accurately estimate the amount of stormwater that each feature could hold. More studies could also be conducted on different features and how they could be implemented at these scales. Instead of studying the potential for residential stormwater management, could there be other types of developments that could benefit from the same type of project or incentive program?

Conclusion

Personal Reflection

Although I enjoy residential design, I find it hard to believe most people would implement it. Because of the cost and maintenance requirements, most people do not see the value of stormwater management unless it is helping their interests even with an incentive program like Washington D.C.'s. There are always exceptions, and the idea is great, but when it comes down to the bottom line, I would have to imagine things like this are the first to be cut. However, this small yard in Minneapolis, Minnesota is a water infiltration paradise -- and stunningly beautiful. Aesthetics and ecology (including stormwater management) can be integrated and also meet the property owner's budget.

Sites come in all different shapes and sizes. Rarely are two sites the same. I think this is what makes landscape architecture so interesting. Although there are the slow times, what I look forward to most is the next puzzle, challenge, obstacle, or hang-up. No matter what the issue is, it makes things more interesting. Not only this, but the potential impact I can have on the world is something I do not take lightly. It is my hope that this project and my future endeavors can make a positive impact on the world. I believe that each of us are handed the same world which when we look at it, looks different to each of us. We take this world how it is and try to make it better or worse. My decision to stay in this major and profession is an active attempt at making it better, not just for me, but my friends and family that have supported me through these past five years.

Figure 9.1. Minneapolis, Minnesota naturalized backyard. Lee R. Skabelund.

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