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Windmill Ridge Park: A Sustainable Park Design

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Windmill Ridge Park

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Executive Summary

This plan proposes designing and developing a plan for a new park in Chesterfield County that will promote sustainability. The purpose of this plan is to assist the Chesterfield Parks and Recreation Department in developing a sustainable park at the site located off Windmill Ridge Drive and Old Hundred Road. This plan seeks to assist the Parks and Recreation department in developing a sustainability master plan for a community park by addressing how sustainability may be integrated into park design—according to current literature.

A sustainable framework includes three main elements:

1. Environmental quality—preservation of the natural environment while minimizing the impact from development
2. Social equity—improving accessibility to parks, designing for specific locations/groups, being authentic to the community and adaptable to future changes in community needs, and functioning in a way that the community wants and needs
3. Economic opportunity—the inclusion of efficient building and management practices that can be maintained in a cost-effective manner for the long-term

This plan fills multiple needs as presented in the Comprehensive Plan for Chesterfield County and the Parks and Recreation Comprehensive Master Plan. The County's comprehensive plan calls for a future need of a community park near Old Hundred Road, and Windmill Ridge Park will fill that need. Community parks have a service radius of three miles, and the site for Windmill Ridge Park is 2.5 miles away from any other parks in Chesterfield, making it a great location to fill the needs of nearby residents. Community parks can be athletics focused or include a variety of active and passive outdoor recreation opportunities, and a recreation/community center. A sustainable framework permits these uses; however, the park will not have an athletics focus.

The property for the park in question was surplus property that was recently given to Chesterfield Parks and Recreation for development. Because of this, the park is not currently planned for in the Parks and Recreation master plan, which makes this the perfect opportunity for developing a sustainable park from the ground up.

Observations from site visits, case studies, additional online research, a focus group, and a survey were collected and analyzed to produce research findings. The focus group consisted of six staff from the Chesterfield County Parks and Recreation Department, and the survey was distributed among all Parks and Recreation employees. The survey focused on demographic information, how to access the park, desired facilities, and volunteering opportunities within the park. The focus group mainly discussed current sustainable practices and programs for the

design and construction of a park and informing the public and staff about those same practices.

From the research findings, 3 goals and 11 objectives were created to guide the design and development of Windmill Ridge Park into a sustainable park:

- **Goal 1: Maintain Environmental Integrity**
    - Objective 1.1: Design with nature to determine and enhance the identity of the park
    - Objective 1.2: Preserve the native plant and animal species in the park
    - Objective 1.3: Reduce stormwater runoff and filter its pollutants
    - Objective 1.4: Inform staff and the public on concepts and care of a sustainable park
    - Objective 1.5: Protect and maintain the Resource Protection Area (RPA)
- **Goal 2: Promote Social Equity**
    - Objective 2.1: Make Windmill Ridge Park accessible to as many residents as possible
    - Objective 2.2: Design a park that is specific and authentic to the community
    - Objective 2.3: Be adaptable to the changing needs of the community and future development
    - Objective 2.4: Provide a park that is functional for the community by including a variety of uses
- **Goal 3: Be Economically Efficient**
    - Objective 3.1: Shift to an adaptive management method that can adjust to community needs
    - Objective 3.2: Provide multiple recycling options

Introduction

This project proposes designing and developing a plan for a new park in Chesterfield County that will promote sustainability in its design and implementation, as well as provide a stepping stone to promote these practices throughout Chesterfield County parks. The purpose of this plan is to assist Chesterfield Parks and Recreation Department in developing a sustainable park by providing research and concept designs for the future Windmill Ridge Park. The site in question, located at 2222 & 2230 Windmill Ridge Drive, Midlothian, VA, was surplus property owned by the Chesterfield County Utilities Department and was transferred to the Parks and Recreation Department in 2018. As such, this site is unaccounted for in the Parks and Recreation Comprehensive Master Plan, thereby providing a great opportunity for developing a sustainable park from the ground up.

Chesterfield Parks and Recreation is in the process of developing a sustainability plan, and their mission statement, as stated in their 2018 master plan, is “to enhance the quality of life for citizens and visitors through First Choice recreation opportunities, experiences, and partnerships” (Chesterfield Parks and Recreation, 2018). The proposed new park would help enhance the quality of life by creating sustainable parks that preserve natural and native environments and the resources they produce, as well as provide accessible greenspace to nearby residents.

The plan first looks at existing literature on sustainable park practices and then evaluates existing site conditions and the community the park will service. The plan also presents methods to determine the best sustainable practices for the site. However, due to the infancy of the project and the lack of public knowledge on the park’s existence, public outreach has been placed on hold until the county can properly plan for and introduce the site to the public.

Background Research

Sustainability is often broadly defined and does not maintain one universally accepted definition, but it generally refers to the efficient use of today's resources so that there is enough for future generations (Moulay et al., 2017; Sanyal et al., 2012; United Nations, n.d.). Sustainability is built upon three pillars, or "the three Es—social equity, environmental quality, and economic opportunity" (Gough, 2015, p. 146).

The term "sustainable park" likewise does not have one accepted definition. Some researchers define sustainable urban parks entirely by their environmental quality (Dizdaroglu, 2022), while others say that one single definition should be avoided so as to not inhibit innovation; however, they also feel that too broad of a definition does not serve as a good "guide to action" and should be specific to the bioregion where the park will be located (Cranz & Boland, 2004).

The following literature review will explore the environmental, social, and economic elements of sustainable park development along with the many benefits they provide as presented by existing literature. The environmental quality section will discuss native plants and animals, park planning in sensitive areas, and providing educational opportunities to the community. The social equity section will discuss providing accessibility and inclusivity in parks to diverse populations, along with various activities and facilities to be included in parks. The economic efficiency section will discuss sustainable management practices for parks. The final section on park benefits discusses some of the many environmental, economic, and health benefits greenspaces can provide.

Environmental Quality

Preserving environmental quality is one of the most frequently discussed aspects of sustainability. This section will discuss how the preservation of native plants and animals aids in maintaining the health of an ecosystem. This section will also address approaches to park planning in sensitive areas by discussing energy-efficient and eco-friendly design and construction methods, best stormwater management practices, and providing educational opportunities to the community about native species and sustainable practices.

Native Species

Sustainable parks need to be designed for the preservation or restoration of the natural environment. One way this is done is through the preservation, or reintroduction of native plant and animal species (Bark et al., 2011; Brown et al., 2015; Caldwell, 2014; Cranz & Boland, 2004; Dizdaroglu, 2022). Native plants and animals contribute to the overall health of the environment and allow for "self-sufficiency" of its natural resources (Cranz & Boland, 2004; Dizdaroglu, 2022). Incorporating native plants, especially trees and flowers, provides food,

shade, and a place for native animals and insects to make their homes; in addition, the use of low-maintenance native grass species or meadows instead of turf or other impermeable surfaces will help treat city wastewater and stormwater and prevent erosion and flooding while also providing fresh water for the ecosystem (Brown et al., 2015; Cranz & Boland, 2004; Dizdaroglu, 2022).

Soils

Understanding the soils of the site is important to understanding water infiltration rates and the potential for runoff. Sand and loamy soil generally have a higher infiltration rate, while clay has a low rate that can result in higher potential runoff and ponding (Alsobrooks, n.d.). Soils are separated into four hydrologic groups (A-D) that provide a quick reference to the potential type of soil and its runoff and infiltration rates. Group A has the highest infiltration rates and the lowest potential runoff, and each proceeding group has lower infiltration rates than the previous with higher potential runoff—Groups C and D have varying levels of clay in the soil, and therefore have the lowest infiltration rates and highest potential runoff (Purdue Engineering, n.d.).

The drainage class of a soil details how quickly water drains out of the soil, or "the degree, frequency, and duration of wetness" (CT ECO, 2010). There are seven drainage classes: Excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. Excessively drained soils drain so rapidly that they very rarely have water on or near the ground surface during the growing season, whereas very poorly drained soils drain so slowly that they frequently have water on or near the surface of the ground (CT ECO, 2010).

Knowing which soils you will be working with is important as this can affect the plant and animal life that can survive in the area, as well as determine the materials that are used in some design and development. For example, areas with soils that have low infiltration rates, high potential runoff, and are poorly drained, are inadequate for the use of permeable pavement, since they can lead to ponding underneath the pavement (Alsobrooks, n.d.).

Design with Nature

Ian McHarg, in the late 1960s, presented the idea of the ecological method in planning and design that is centered on designing with nature. The method is fairly simple and includes two main parts (McHarg, 1995, p. 185):

1. "Search for the basis of the identity of the city"
2. "The selection of elements (natural and created) that are expressive and valuable, that exercise constraints and that proffer opportunities for new development"

Although the method itself is simple, the explanation of it parts is more complicated. First, everything that exists is unique. Every person, plant, animal, site, and city is unique; there is none other exactly like it. In the case of parks, every site is different because its combination of history, climate, physical geography (physiography), soils, plants, and animals are different from any other. That uniqueness is the basis of identity, and so we must determine which physiographic elements make up the identity of the site, then ensure their preservation and enhancement. This is achieved in the form and fitness of nature and of urban development within the environment (McHarg, 1995).

Form and Fitness in Design

McHarg poses three questions regarding fitness and form: "Is the environment fit for man? Is the adaptation that is accomplished fit for the environment? is the fit expressed in form?…Fitness is then by definition creative and will be revealed in the form of fitness that is life-enhancing" (McHarg, 1995, p. 173).

Fitness refers to how fitting something is to its environment. The fitness of a bird is shown in its physical form. There are many types of birds with differing wings, beaks, talons, etc., and their specific form shows how fit they are to exist in their environment, or in other words, their form shows how they have adapted to their environment. "Form then is communication, the presentation of meaning" (McHarg, 1995, p. 169). A bird that has adapted its form to its surroundings, and thrives there, is therefore "fit" for its environment.

Likewise, urban development fitness should conform to the surrounding environment and be made to fit that specific environment. The basic character of urban development comes from the site, and its character is improved when this is recognized and enhanced. Buildings, places, and spaces, in harmony with the site, add to its value, can add to its resources, and determine new form that is fit for the environment. With time, the environment will change on its own, but it can be changed to make it more fitting for people, however, "to do this one must know the environment, its creatures and their interactions—which is to say ecology" (McHarg, 1995, p. 52). Pierre L'Enfant, the plan designer for Washington D.C., was very aware of the form of the land—he used the Renaissance city style in his design, but he adapted it to the location—and speaking of the site he said, "Nature has done much for it, and with the aid of art it will become the wonder of the world." (McHarg, 1995, p. 181).

Social Values and Costs

The different parts of a site's environment provide a social value, and any development on the site will have some social cost. If construction is inevitable, find where it will destroy the least.

There are ways of measuring different areas of nature to compare which are better than others for development. The best spot for development "is the one that provides the maximum social benefit at the least social cost." The most convenient spot is not necessarily the best option (McHarg, 1995, p. 32). Costs are unavoidable in changing land use, so we should seek proposals that would exceed the costs incurred and add value to the area, while always avoiding costs that would cause irreversible losses (McHarg, 1995).

Approaches to Park Planning in Sensitive Areas

Any structures on the site should be designed in a way that they add to the social value of the environment. Energy-efficient buildings do this by being solar facing and using as much natural light and ventilation as possible; furthermore, the structure's ecological cost can be reduced by using durable, natural, and recycled materials throughout the design (Caldwell, 2014; Cranz & Boland, 2004).

The State of Virginia has 15 stormwater best management practices (BMPs) that aid in reducing negative impact to the environment by improving water quality (Virginia Department of Environmental Quality, 2013):

1. Rooftop (impervious surface) disconnection
2. Sheet flow to vegetation filter strip/conserved open space
3. Grass channels
4. Soil compost amendment
5. Vegetated roof
6. Rainwater harvesting
7. Permeable pavement
8. Infiltration practices
9. Bioretention
10. Dry swales
11. Wet swales
12. Filtering practices
13. Constructed wetlands
14. Wet ponds
15. Extended detention (ED) ponds

These BMPs provide different options for reducing annual stormwater runoff and reducing pollutant concentrations as they move through the BMP. Some of the techniques used in BMPs provide connections or paths from impervious surfaces to pervious surfaces that allow filtration, while others may create a buffer around large impervious surfaces—such as roads or parking lots—that help to slow runoff or reduce pollutant concentrations. Some of these BMPs

are useful in reducing both runoff and pollutant concentration on their own, while others are effective at reducing only one or the other; therefore, multiple BMPs may need to be implemented in development (Virginia Department of Environmental Quality, 2013).

Educational opportunities should also be provided to park staff and community members, especially children and youth. The education of sustainable development and native plant and animal life can be done through various classes and programs, which will encourage community members to be a part of the park's sustainability and will affect how visitors use the park (Cranz & Boland, 2004; Dizdaroglu, 2022; J. R. Wolch et al., 2014).

Social Equity

Sustainable parks are not just about preserving the environment, but also maintaining cultural diversity, equality, and equity through access to, and use of the parks and their amenities (Blokland, 2009, p. 5). Melissa A. Currie presents five design principles of urban parks, that were also featured in an article about social equity by the National Recreation and Parks Association (NRPA); those principles are accessibility, specificity, authenticity, adaptability, and functionality (Currie, 2016; National Recreation & Park Association, 2023). This section will discuss how parks can be socially equitable by improving accessibility to parks, designing for specific locations/groups, being authentic to the community and adaptable to future changes in community needs, and functioning in a way that the community wants and needs.

Accessibility and Inclusivity

Accessibility refers to the existence of "easy, nearby access…for a greater number of people" (Currie, 2016, p. 81). Many people lack quick or easy access to parks, or any greenspace, and therefore lack access to the environmental, economic, and health benefits they provide (Cirruzzo, 2021; Rinn, 2021; The Trust for Public Land, n.d.-a). "Studies show that racial/ethnic minorities and low-income people have less access to green space, parks, or recreational programs than those who are White or more affluent" (J. R. Wolch et al., 2014, p. 236). Some localities, like the City of Richmond, Virginia, are addressing this problem by planning to develop parks so that everyone in the locality is within a 10-minute walking distance of a park (*Richmond 300*, 2020). However, pedestrian infrastructure is needed in the surrounding neighborhoods to make parks easily accessible by walking or biking (Adlakha et al., 2016; Dizdaroglu, 2022; Montgomery, 2013; Moulay et al., 2017; Stafford & Baldwin, 2017).

Obstacles

Various obstacles have been found to stand in the way of walkability or biking. Adlakha et al. (2016) presents several obstacles to walkability—based on pedestrian surveys—including, a lack of pedestrian infrastructure, high traffic volumes, and government policies favoring

automobiles. These obstacles can be minimized with the installment of pedestrian infrastructure, bike paths, and traffic calming measures (Adlakha et al., 2016; Dizdaroglu, 2022).

Most pedestrian infrastructure is designed with healthy adults in mind, but there are multiple factors that should be considered for pedestrians or cyclists. People of varying ages or with disabilities, as well as their walking speeds, should be considered when determining the timing of traffic lights or the placement of rest points and other related infrastructure elements (Stafford & Baldwin, 2017). Further factors that may influence "walking thresholds" include the gradient, topographical features, and climate of the area (Stafford & Baldwin, 2017).

Social Interaction

Public parks are important spaces for social interaction, and their design can influence the accessibility and inclusivity of that space; some of these elements include how loud the park is, if it has a variety of recreational options, and if there are good places to rest (Moulay et al., 2017). People tend to "gravitate naturally towards the edges of public spaces," so the edges need to have "natural places to linger" that attract people and avoid visual obstacles (Moulay et al., 2017, p. 59). Visual obstacles can include actual physical obstacles—such as a wall that acts as a barrier and impedes visibility—or large open space between points of interest that create a visual disconnect; activities and facilities should be situated close together in a way that creates a "sense of continuity and comfort of use" (Moulay et al., 2017, p. 62).

Social interaction within the park is also important for the development of a community feeling, while a "lack of any face-to-face contact and feeling disconnected from the neighbors" can cause the loss of this community feeling (Adlakha et al., 2016, p. 10; Montgomery, 2013). Social interaction can be enhanced by incorporating multiple forms of active and passive recreation into the park (Moulay et al., 2017, p. 62). Active recreation may include strolling, hiking, or biking, while passive recreation may include relaxing on a bench or bird watching (Cranz & Boland, 2004; Mehta & Mahato, 2021).

A community feeling creates trust among neighbors and can help to enhance feelings of safety, which are necessary for increased accessibility to parks (Adlakha et al., 2016; Cirruzzo, 2021; Montgomery, 2013). Safety concerns, particularly with gender-based violence, often prevent accessibility for women and girls to public spaces (Adlakha et al., 2016). Adlakha et al. suggests making public spaces "busy, surrounded by shops and stores with movement of people, and open on all sides with good lighting" to help them feel safer (2016, p. 10).

Specificity and Authenticity

Specificity refers to the specific and unique design of a park to its specific location. According to Currie, the uniqueness can be influenced by "such things as historic, cultural, or geographic significance" (2016, p. 81). Every location is unique; every site has a unique combination of plants and animals, history, climate, and landforms (McHarg, 1995). A site lacks specificity if it follows a cookie-cutter design, rather than being unique in its design and specific and relevant to the location (Currie, 2016). As an example, a new skate park would be specific to its location if it were placed near a middle school or high school, or an area with a large youth population; however, if that park were to do well and the decision was made to build another one, it would not be specific to its location if it were designed the exact same way as the first or placed in the middle of a retirement community.

Authenticity is very similar to specificity. "It reflects the user's values and needs in the design process" (Currie, 2016, p. 81). Like specificity, authenticity avoids replicating patterns and forms without carefully considering the unique environment and demographic characteristics of the community. Domino Park in Florida, is located in a majority Cuban-American community, and it is a natural part of the community because it provides activities the population wants. The authentic park must also draw back those that encounter it regularly to provide opportunity to create collective memory as a community (Currie, 2016). An authentic park doesn't just say it is part of the community, it actually is a part of the community, when it is used for its intended purpose by its intended population on a regular basis. The needs of the community must be known, in order to design the park so that it will be unique to its location and used by the community.

Adaptability

Adaptability moves beyond the initial needs of the community during the design process, and into the future needs of the community. Or, in other words, the park must provide a flexible model that allows for adapting to the changing needs of the community over time (Currie, 2016). Currie describes a park like a living organism that can grow or shrink and change form with time as life progresses (2016). Marc Treib makes an important point, that there is no single way to design the landscape at any point in time, and the design will always reflect current values and attitudes (2001). A park is adaptable if it is able to change alongside the changing needs of the community. Adaptive management methods are an important part of adaptability, and will be discussed further in the "Economic Efficiency" section

Functionality

The functionality of a park is very closely tied to inclusivity. A park is functional when it provides a wide variety of activities that meet the needs of the surrounding community (Currie, 2016).

Activities and facilities are important to a park as they can determine its success (Aly & Dimitrijevic, 2022, p. 6). Many activities and other amenities have been found in studies to attract diverse groups of people. Mehta and Mahato (2021) studied two parks in Cincinnati where they observed and mapped out which park amenities were most commonly shared among different racial and ethnic groups. Their results showed that children's play areas, active water play areas (e.g., splashpads), swings, picnic areas, spaces under tree canopies, formal seating—like benches—and informal seating—like steps, were used the most by diverse groups of people (Mehta & Mahato, 2021). When including benches, or other formal seating in the park, Moulay et al. suggests aligning them so they are "face-to-face" to further create opportunities for social interaction (2017, p. 62). A more direct research approach was taken by Chiesura (2004) who surveyed visitors in a park in Amsterdam on their motives for visiting urban parks. The top three overall results, in order, are to relax, to be in nature, and to escape the city. However, when age was taken into account, youth visited parks mostly for sporting and meeting other people, while adult and elderly people were motivated by relaxing, staying with children, and contemplating nature (Chiesura, 2004, p. 133).

To provide social equity in parks, public involvement is needed throughout the design process to address the community's concerns, needs, and desires and to avoid a standardization of design criteria that is used for every park (Byrne, 2013; Chiesura, 2004; Stafford & Baldwin, 2017; J. R. Wolch et al., 2014). Byrne suggests a "needs based" approach that considers the community's "socio-demographic composition, their leisure and recreation preferences, and the type and number of facilities required to serve those needs" (2013, p. 3). Additionally, public involvement is needed beyond just the design process, but also in the policy and management of the park; this is discussed more in the following section, "Economic Efficiency."

Economic Efficiency

Economic efficiency is obtained in a sustainable park through the proper and efficient use of its resources and the management of the park (Aly & Dimitrijevic, 2022; Cranz & Boland, 2004; Takyi & Seidel, 2017). No matter how beautifully designed a park may be it will eventually fall to ruin if it is not managed properly (Aly & Dimitrijevic, 2022).

According to researchers that have studied this topic specifically, there is not one exact best method of managing a park in order to sustain it for the long term, nor should there be. Generalized standards—that often include large amounts of maintenance, supported almost entirely on government funding—are not sustainable due to the large differences between each park and the communities they service (Aly & Dimitrijevic, 2022; Cranz & Boland, 2004). Most researchers propose different management systems, but they all agree that some form of

community or stakeholder involvement should be included (Aly & Dimitrijevic, 2022; Cranz & Boland, 2004; Dizdaroglu, 2022; Mehta & Mahato, 2021; Takyi & Seidel, 2017).

Other researchers suggest public-private partnerships that will provide funding to the park through private organizations but will be maintained by community organizations, such as "friends of" groups, or volunteers (Aly & Dimitrijevic, 2022; Cranz & Boland, 2004). Others suggest more "evolutionary" or "adaptive" management that changes along with the ever-changing socio-economic characteristics of the community (Aly & Dimitrijevic, 2022; Cranz & Boland, 2004; Takyi & Seidel, 2017). Adaptive management will require interacting with the community and receiving continuous feedback in order to adjust to their needs and desires and remain relevant, while also providing greater social equity (Aly & Dimitrijevic, 2022; Mehta & Mahato, 2021). For adaptive management to be possible, multiple methods need to be implemented that allow for residents to submit feedback and suggestions, then the locality needs to follow-up on the feedback; additionally, regular meetings can be held with the public to discuss any issues or concerns they may have. The process can be made smoother through partnerships with the community, such as with "friends of" groups, as was mentioned earlier (Aly & Dimitrijevic, 2022).

Some useful practices for economically efficient management can be found in the effective use of community assets and in the recycling of its resources (Caldwell, 2014; Cranz & Boland, 2004; Dizdaroglu, 2022); this can be achieved in multiple ways. One way to recycle resources would be in the building of the park by using resources that are taken from one spot and using it in the development of something else in the park: for example, soil that is dug up for one amenity in the park can be used to fill in holes or elevate other amenities within the park, instead of dumping it offsite (Cranz & Boland, 2004). Another option for recycling resources is to provide composting stations for food and leaves that can then be accessed by maintenance crews or community members (Caldwell, 2014; Cranz & Boland, 2004; Dizdaroglu, 2022; New York City Department of Parks and Recreation, 2011; *Richmond Compost Initiative*, n.d.).

Park Benefits

There is a large amount of literature that explores the benefits provided by parks. The most apparent are the benefits for the environment. The literature shows that the building of parks reduces stormwater runoff by providing more permeable surfaces for water to seep into the ground instead of hard surfaces, like asphalt, that repel water and contribute to flooding (Dolesh, 2021; The Trust for Public Land, n.d.-b). Replacing those hard surfaces with vegetation also reduces outdoor temperatures, especially if the area is at least 1 hectare in size (Dolesh, 2021; Jamali et al., 2021). The vegetation in parks also reduces air pollution, thereby improving the air quality for us to breathe and reducing other negative effects like acid rain (Ayala-

Azcárraga et al., 2019; The Trust for Public Land, n.d.-b). Parks also provide safe spaces for local flora and fauna to thrive (*Top 10 Reasons Parks Are Important*, 2009).

There are also a multitude of health benefits (physical, psychological, and social) that come from enjoying parks. Some of the many physical benefits provided by increased physical activity associated with proximity to parks are decreased risk of diabetes, obesity, and asthma, lower blood pressure, increased longevity, and an increased immune system (Ayala-Azcárraga et al., 2019; Chapman et al., 2021; Ji et al., 2019; Rinn, 2021; The Trust for Public Land, n.d.-a; J. Wolch et al., 2011). Psychological benefits of access to parks include reduced stress hormones, anxiety, and depression, and improved concentration and memory (Ayala-Azcárraga et al., 2019; Chapman et al., 2021; Cirruzzo, 2021; Hunter et al., 2019; Ji et al., 2019; Li et al., 2019; Rinn, 2021; The Trust for Public Land, n.d.-a; *Top 10 Reasons Parks Are Important*, 2009; University of Melbourne, n.d.). Furthermore, parks provide opportunities to develop social connections and serve as a place for community events or other social gatherings (Chapman et al., 2021; Gaikwad & Shinde, 2019) that promote feelings of trust among neighbors (Cirruzzo, 2021; Montgomery, 2013).

Lastly, parks provide economic benefits to the surrounding areas. The first and most prominent economic benefit is the increase of property values and property tax revenue of surrounding neighborhoods, but some parks also provide economic revenue by attracting tourists and subsequent businesses to support those tourists' needs (Bark et al., 2011; The Trust for Public Land, n.d.-b).

Theoretical Framework

The theoretical framework for this plan is a sustainable framework. Designing a park around sustainable principles is a difficult task. A sustainable framework must include the preservation of the natural environment—while minimizing the impact from development—it must include residents of the community by engaging them in the design process and making the end use accessible, and it must include efficient building and management practices that can be maintained in a cost-effective manner for the long-term. As the Chesterfield County Parks and Recreation Department develops a sustainability plan, the Windmill Ridge Park plan will serve as a steppingstone to guide their implementation of sustainable practices.

Context

This section discusses the park's specific location, relevant comprehensive plans, demographics, environmental factors, and other existing conditions of the site and its surrounding area. The purpose of this section is to provide the context of the proposed park site from which data and insight was gained for its development into a sustainable park.

Study Area

Location

The proposed site for Windmill Ridge Park is in Chesterfield County, Virginia (see Figure 1). The site consists of two parcels located off Watermill Parkway and Old Hundred Road (Route 652) in the northwestern end of the county. There are ten different schools within three miles of the site, ranging from elementary schools to a community college. The site is also within a five-minute drive of Bon Secours St. Francis Medical Center and about a seven-minute drive from the fire department (see Figure 2).

Figure 1:
Windmill Ridge Park, Chesterfield, VA Map

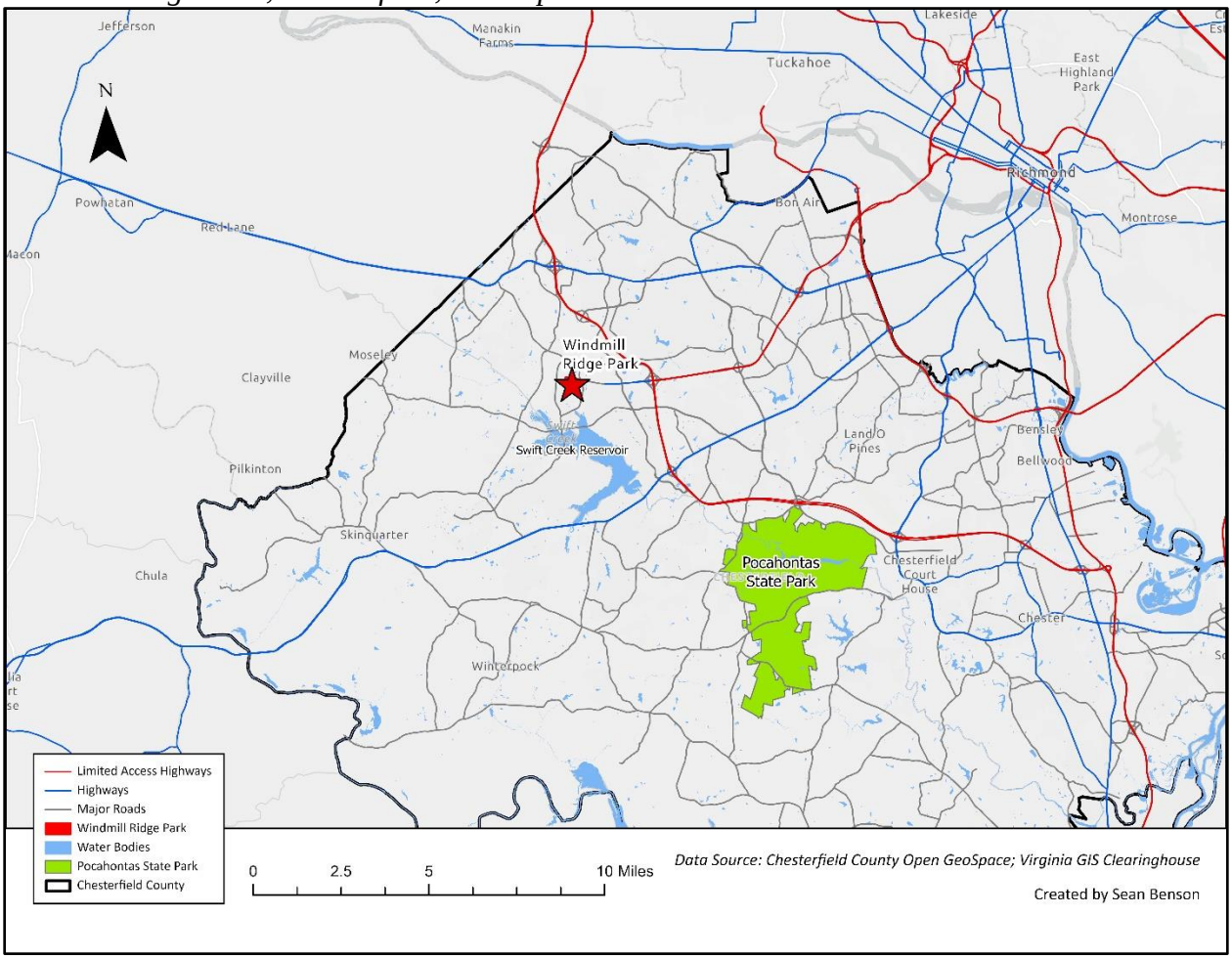
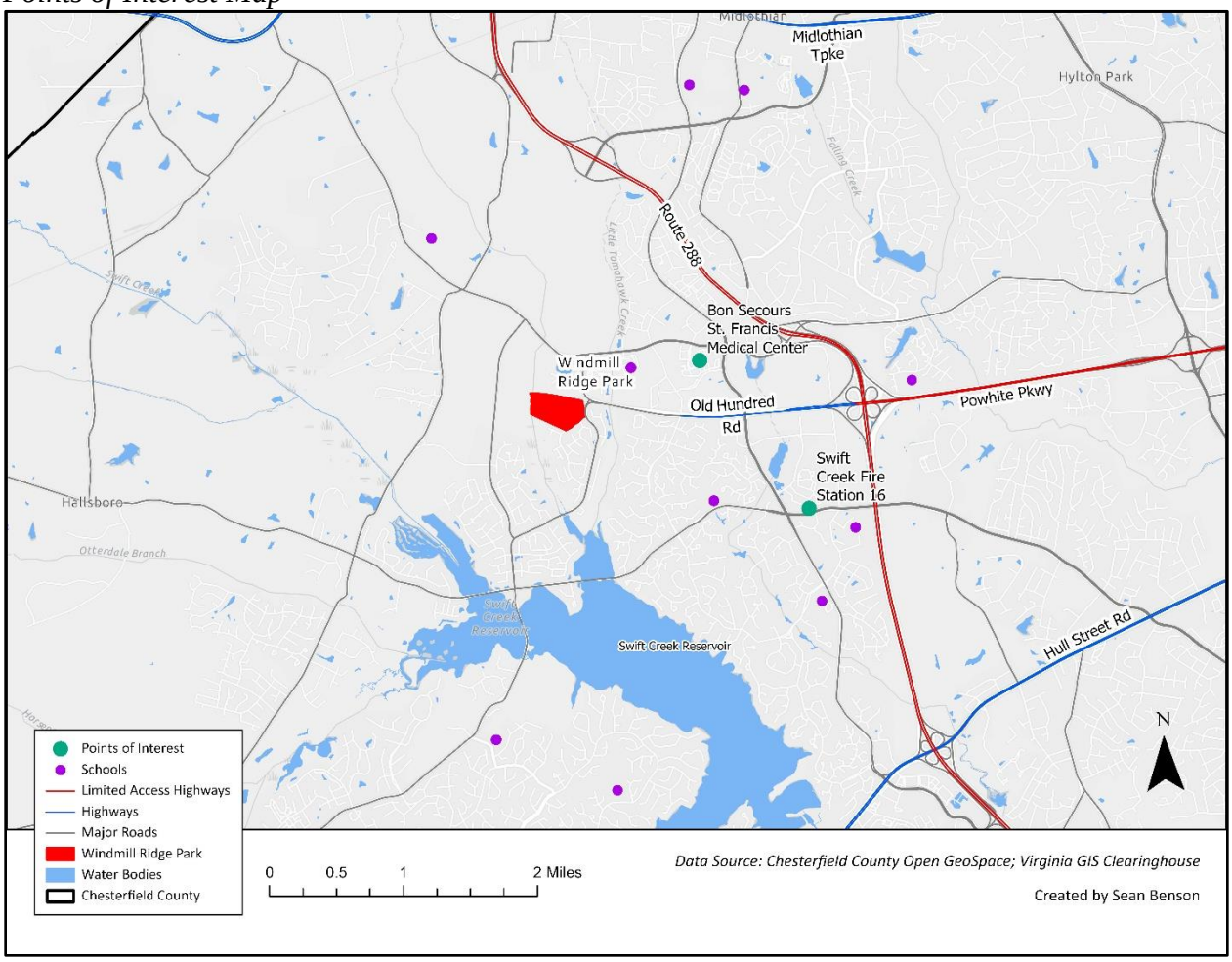


Figure 2:
Points of Interest Map



Precedent Plans

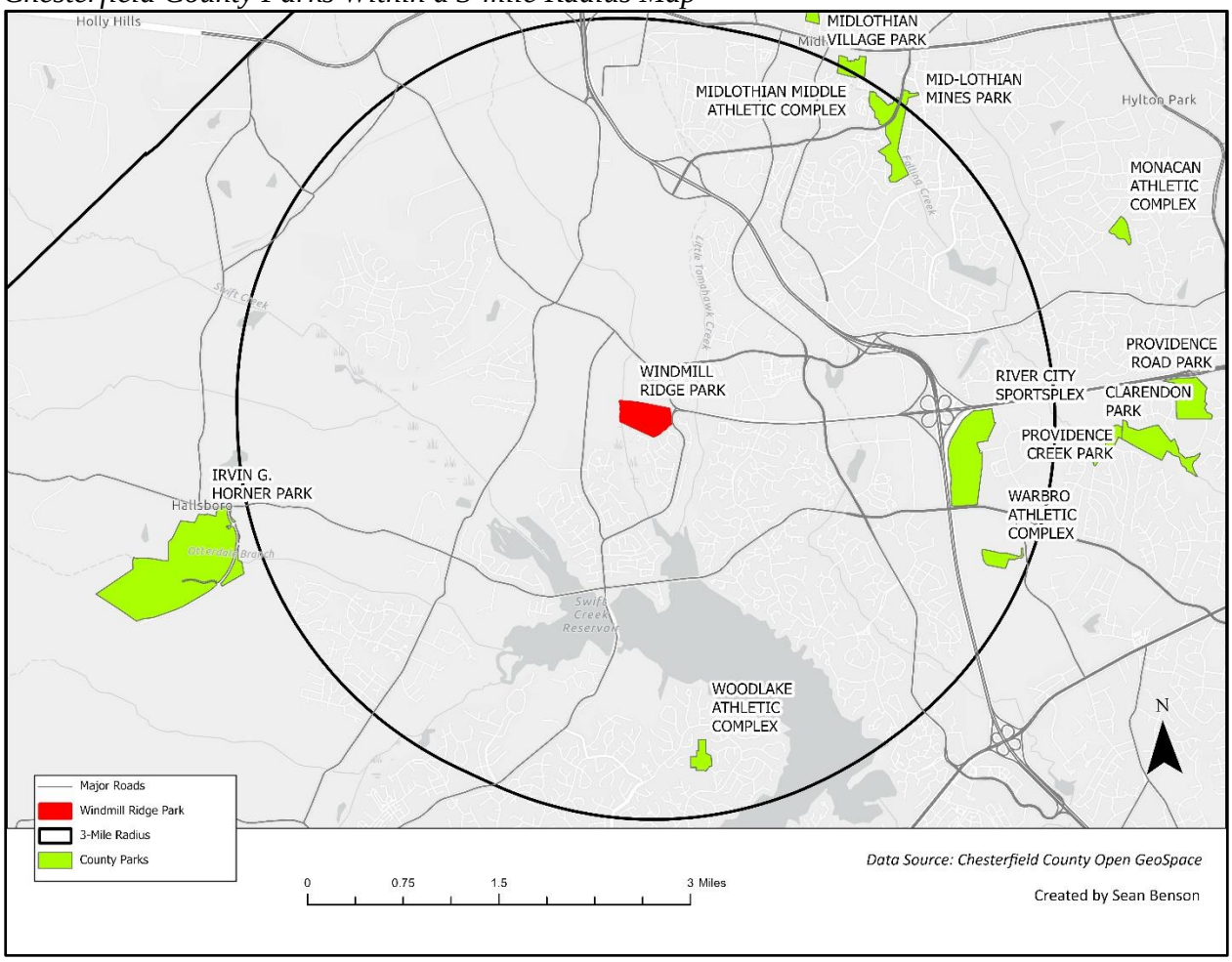
Other states and municipalities have already been implementing some of the sustainable practices mentioned previously in the research section of this plan. Oregon's Statewide Comprehensive Outdoor Recreation Plan includes a sustainability component that provides goals for each of the three E's of sustainability—including using sustainable/recycled materials in facilities, improving access to public spaces, working with private park foundations for long-term maintenance, and many other goals (Gallagher, 2012). New York City Parks, likewise has a sustainability plan, and theirs is heavily focused on environmental practices, such as recycling/composting and educating the public and staff (New York City Department of Parks and Recreation, 2011). Both plans have useful insights as to how sustainable practices are already being implemented, and therefore, should be referenced in the development of Windmill Ridge Park.

The Comprehensive Plan for Chesterfield County and the Parks and Recreation Comprehensive Master Plan likewise provide important guidance for development of the area generally and of community parks specifically. Both plans lay out the criteria for regional (100+ acres), community (21-99 acres), neighborhood (5-20 acres), and urban parks (0.5-5 acres). Windmill Ridge Park is considered a community park with 47 acres (Chesterfield County, 2019; Chesterfield Parks and Recreation, 2018). The county comprehensive plan calls for a future need of two community parks near Old Hundred Road and Route 288. Windmill Ridge Park will fill one of those two slots along Old Hundred Road (Chesterfield County, 2019).

Community Parks

Community parks are designed with a service radius of three miles, or a drive time of 10 minutes. The site for Windmill Ridge Park is 2.5 miles away from any other parks in Chesterfield, making it a great location to fill the needs of nearby residents. Community parks can be athletics focused or include a variety of active and passive outdoor recreation opportunities. They may also include a recreation/community center (Chesterfield County, 2019). Five other county parks are at least partially within the three-mile radius of Windmill Ridge Park, and four of them are an athletic complex or sportsplex (see Figure 3). The Parks and Recreation Comprehensive Master Plan states that in recent years mixed use parks that include multiple forms of passive and active recreation have seen the highest rates of use (Chesterfield Parks and Recreation, 2018). To avoid having too many athletics focused parks near each other, and to maintain a sustainable framework, it is recommended that Windmill Ridge Park not be athletics focused, but rather provide multiple opportunities for passive and active recreation.

Figure 3:
Chesterfield County Parks Within a 3-mile Radius Map



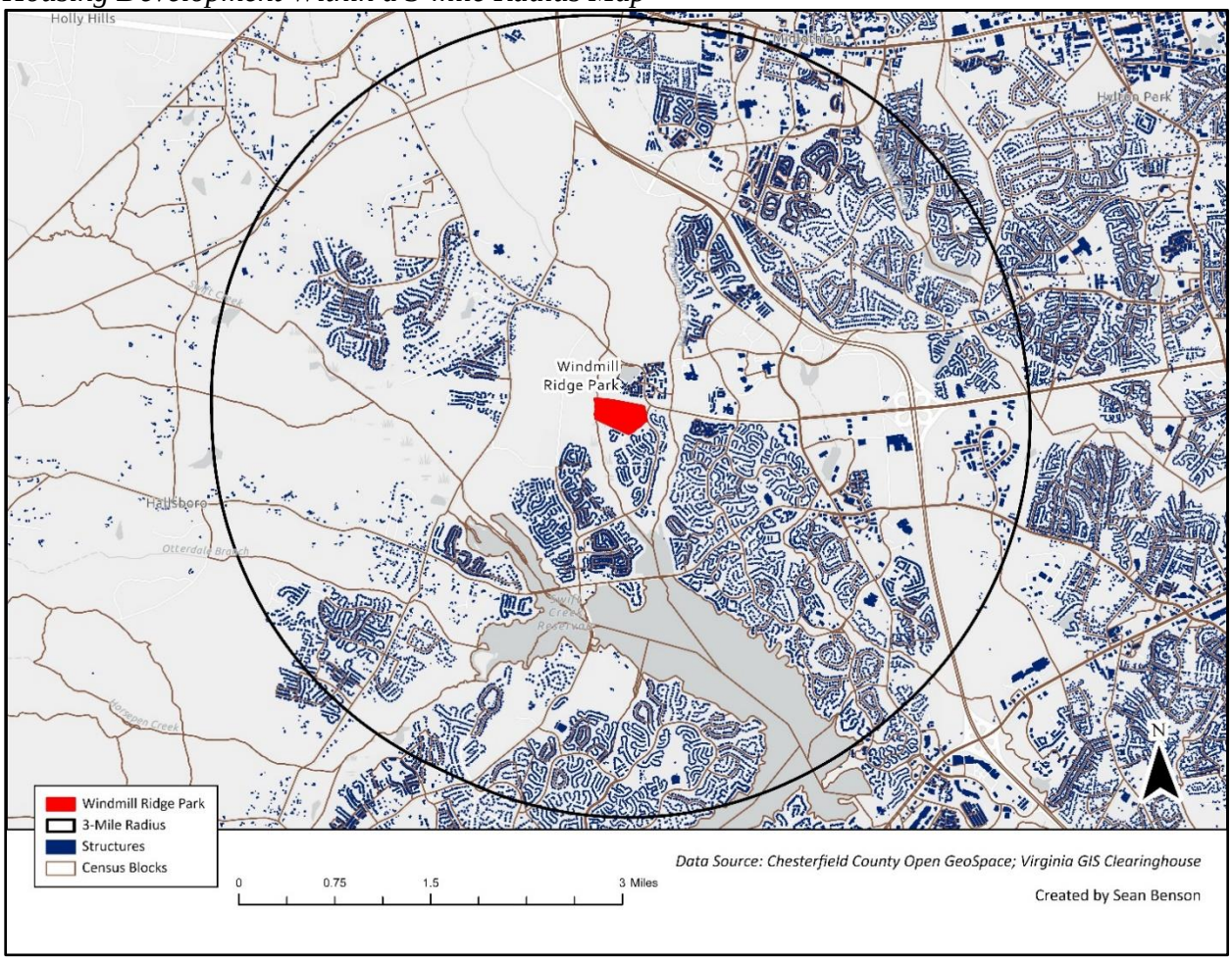
Demographics

Demographic data is not provided by the United States Census Bureau at an individual address level, as such the demographic data presented here is shown at either a county level, or a census block or block group level within three miles of the site. A three-mile radius is used because that is the service radius determined by the County in their comprehensive plan for a community size park (Chesterfield County, 2019; Chesterfield Parks and Recreation, 2018).

Housing

At the census block level, 19,185 housing units are within a 3-mile radius of the site. 18,552 are occupied and 633, or 3.3% are vacant (U.S. Census Bureau, 2021). The majority of the homes are single-family homes with some nearby multifamily homes. The land directly to the west of the park is undeveloped (as seen in Figure 4) aside from a single road running through the land. Development is spreading into the western part of the county where parks are more sparse, and as such, additional parks are needed in this area (Chesterfield Parks and Recreation, 2018).

Figure 4:
Housing Development Within a 3-mile Radius Map



Race

Census data by race was obtained at the block level from 2020. Table 1 shows the racial makeup of the population within a three-mile radius of the site with a total population of 51,163. The population is overwhelmingly a White majority with 39,952 people, which makes up approximately 78.09% of the total population. Black/African American is the second largest population with 4,265 people, or about 8.34%, followed closely by the multi-racial population at 3,427, or 6.70% and the Asian population at 2,783, or 5.44% (U.S. Census Bureau, 2021). Although the majority population is White, over 11,000 people in the area are not. Racial minorities are frequently neglected during the planning process (Loh & Kim, 2021; Williams, 2020), so to achieve social equity within this park, those that are not White need to be involved in the design process and policy making, and need to be provided accessibility to the park.

Table 1: Population by Race, Windmill Ridge Park Service Area

Race	Number	Percentage
Total	51,163	
White	39,952	78.09%
Black/African American	4,265	8.34%
Native American/Alaskan Native	93	0.18%
Asian	2,783	5.44%
Native Hawaiian/Other Pacific Islander	23	0.04%
Other	620	1.21%
Multi-racial	3,427	6.70%

Source: U.S. Census Bureau, 2020

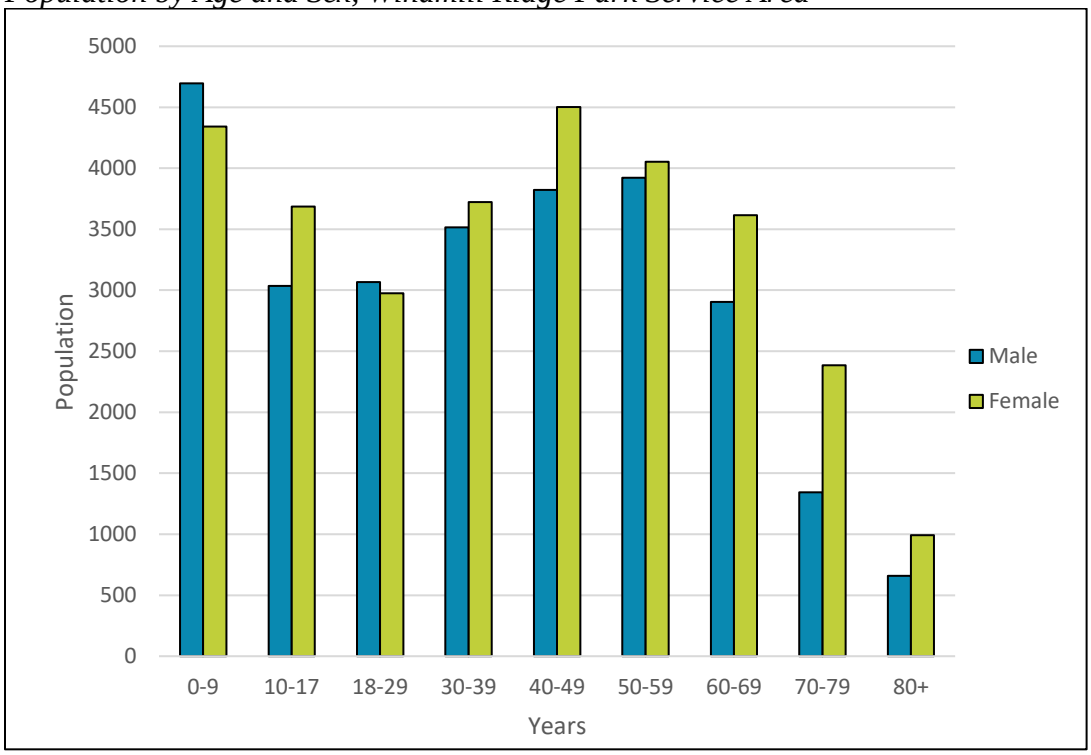
Age and Sex

Data used for the age and sex of the population are from 2020 census block groups. This means the population numbers will be slightly higher than the actuals within the service area, however, most are still within the boundary. Figure 5 shows the distribution of the population age and sex. About 57,239 people live in a block group that is at least partially within the three-mile radius. The majority of the population is female and/or an adult between the ages of 18 and 59 years. Of the total population, 26,963, or 47% are male, and 30,276, or 53% are female. About 27.5% of the total population are youth/children under the age of 18 years. Just over half of the population–51.7%–are adults between the ages of 18 and 59 years. The remaining 20.8%

are over the age of 60 years (U.S. Census Bureau, 2021). As of 2017, the population of the entire county was expected to grow by 27% by the year 2040, and 34% of that population is expected to be over the age of 55 (Chesterfield Parks and Recreation, 2018).

A large population of females, children/youth, and older adults will affect the design of the park. Elements like high visibility, open space, and good lighting will encourage feelings of safety, while paths and benches will provide opportunities for passive recreation and resting for those unable to participate in active recreation such as sports. These factors will also affect development of pedestrian infrastructure to the park and paths within it. Flat surfaces and small inclines make it easier for children, older adults, and people with strollers, wheelchairs, or other disabilities to access the park and its different uses.

Figure 5:
Population by Age and Sex, Windmill Ridge Park Service Area



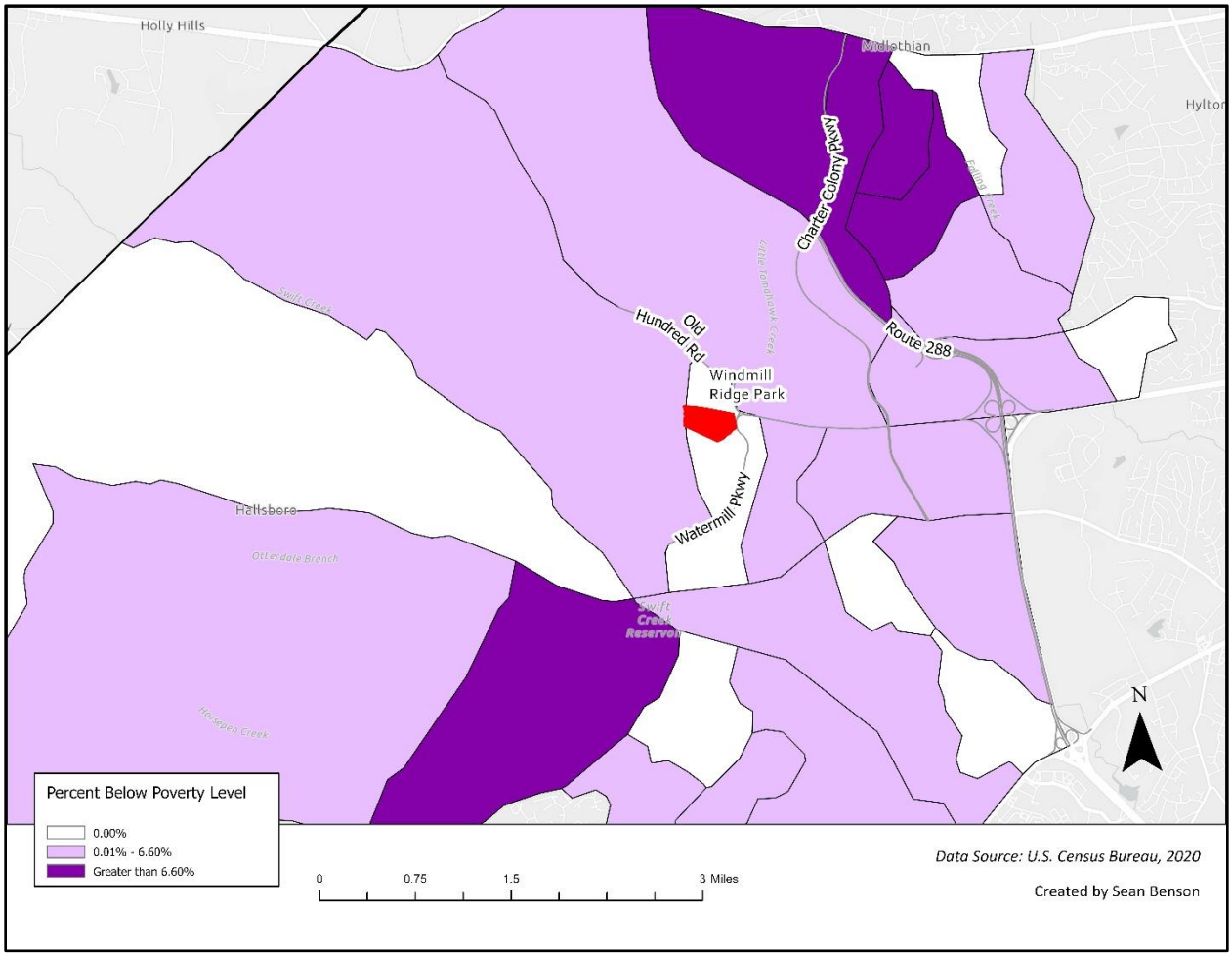
Source: U.S. Census Bureau, 2020

Economics

The service area around Windmill Ridge Park is an affluent area, with the majority of block groups having incomes higher than the County's and Nation's poverty levels. According to 2020 American Community Survey (ACS) census data, 6.6% of people living in Chesterfield County had incomes below the poverty level, while 11.4% of people in the U.S. were below the poverty level (US Census Bureau, 2021). At a census block group level, only five out of twenty-five block groups within the park's service area had percentages higher than the county's 6.6% (as seen in

Figure 6), with the lowest of the five being 8.47% and the highest being 13.92%. Only two of those block groups have percentages higher than the nation's 11.4%. The rest of the service area had percentages lower than 5%, with some block groups reporting 0% of households below the poverty level (U.S. Census Bureau, 2021). The five block groups with high poverty rates should be a focus for increasing accessibility, since areas with high poverty rates tend to have less access to personal vehicles and public transportation (Sanchez, 2008).

Figure 6:
Percentage of Population Below Poverty Level Map



Accessibility

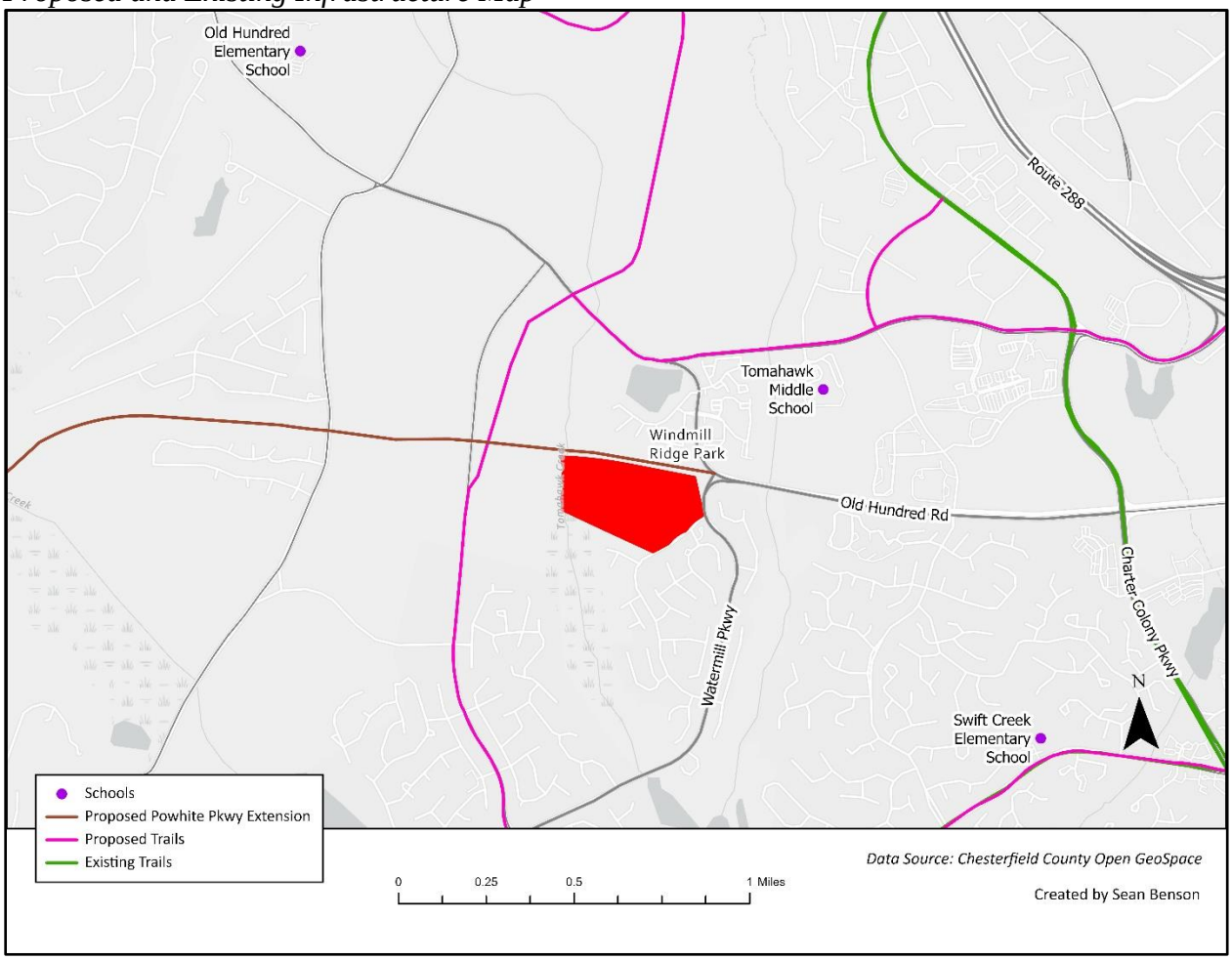
Infrastructure

The site is easily accessible by car from Watermill Parkway and Windmill Ridge Drive; however, it is not accessible by pedestrians and cyclists without safety risks, as there is currently no pedestrian infrastructure or bike paths to the site, and there is no public transportation in place for those that are unable to walk, bike, or drive themselves. The County's comprehensive plan includes a proposed bike path and trails plan, but none of the paths go to the site. One

proposed bike path runs almost parallel to the site on its western side and is only 0.25 miles away (see Figure 7). An extension could be added from this proposed path to the park.

The county's comprehensive plan also provides recommendations for improving pedestrian infrastructure by adding new sidewalks that can be between 5-10 feet wide, adding buffered/protected bike lanes, or adding paved shared-use lanes that would provide better access for cyclists and pedestrians, specifically people with wheelchairs or strollers. Additional improvements would include pedestrian signals, crosswalks, and other similar infrastructure at intersections (Chesterfield County, 2019). The Brandermill Community, which is just on the other side of Watermill Parkway from the site, has an extensive set of trails throughout the community (see Appendix D)—these could also be extended to the park to provide easier access for members of the Brandermill Community (Brandermill Community Association, n.d.).

Figure 7:
Proposed and Existing Infrastructure Map



One area of potential conflict to pedestrian and cyclist accessibility, as well as the overall sustainability of the park, is the county's proposed thoroughfare plan. This part of the comprehensive plan proposes an extension of Powhite Parkway, which would run parallel to the northern edge of the park, between the park and the homes directly north of it (see Figure 7). This would create a barrier that would hinder pedestrian access for anyone living north of the park and could have negative environmental impacts on the park and the resource protection area—discussed later in the environment section—of Tomahawk Creek. To prevent Powhite Parkway from becoming a barrier, infrastructure—such as pedestrian overpasses or underpasses—could be included to provide safe access.

Schools

Ten schools are within the three-mile radius of the site (see Figure 2), and three of those schools are less than two miles away (see Figure 7). Tomahawk Creek Middle School is only 0.5 miles away from the site and would be a great place to connect to by bike path and trail; thereby, providing a great outdoor destination for the youth to gather after school. One issue here is the paths would have to cross all four lanes of Old Hundred Road in a 45mph zone.

Environmental Factors

Tree Cover and Other Vegetation

The site is heavily wooded throughout, except for a 50 foot wide clearing around a gas line that cuts through the center of the entire site. Approximately 45 of the 47 total acres of the park currently have tree cover (see Figure 8). Various other native plant species populate the site, so a site evaluation will need to be scheduled with a Chesterfield Park Naturalist to determine which species are present and the best practices to use in development of the area. Native plant species are important in maintaining the natural ecosystem and reducing stormwater runoff and filtering out pollutants in the water; this is especially important in the wetlands that act as a buffer to Tomahawk Creek. According to the County's comprehensive plan, only 30% of the park is generally assigned as natural areas during development (Chesterfield County, 2019), but it is likely that more will be retained for this site in order to maintain the sustainable goals for the park.

Topography and Soils

The eastern end of the park begins at an elevation around 250-260 feet and gradually decreases to 195 feet as you move west across the park toward Tomahawk Creek (see Figure 8). The elevation does increase to form a hill with an elevation of 245 feet, just before the southern border of the park. Any slope 8% or above is considered steep and is usually avoided in Chesterfield parks. Grading and infill of the land may be required in areas of the park for improved drainage or where a flat surface is needed for building recreational fields and courts,

but this should be avoided as much as possible. Soil that is removed from one area of the site should be used for any necessary infill.

A preliminary analysis of the existing soils for the park was done using the U.S. Department of Agriculture's (USDA) Web Soil Survey—this is an online tool that allows the user to select an area within the U.S. and receive a detailed report of the soils and potential slopes (see Appendix C). A GIS file is also provided to download that contains a rough estimate of the soil distribution across the site and the categorization used by the USDA of each soil type that is present (U.S. Department of Agriculture, n.d.).

Figure 8:
Windmill Ridge Park Tree Cover and Topographic Map

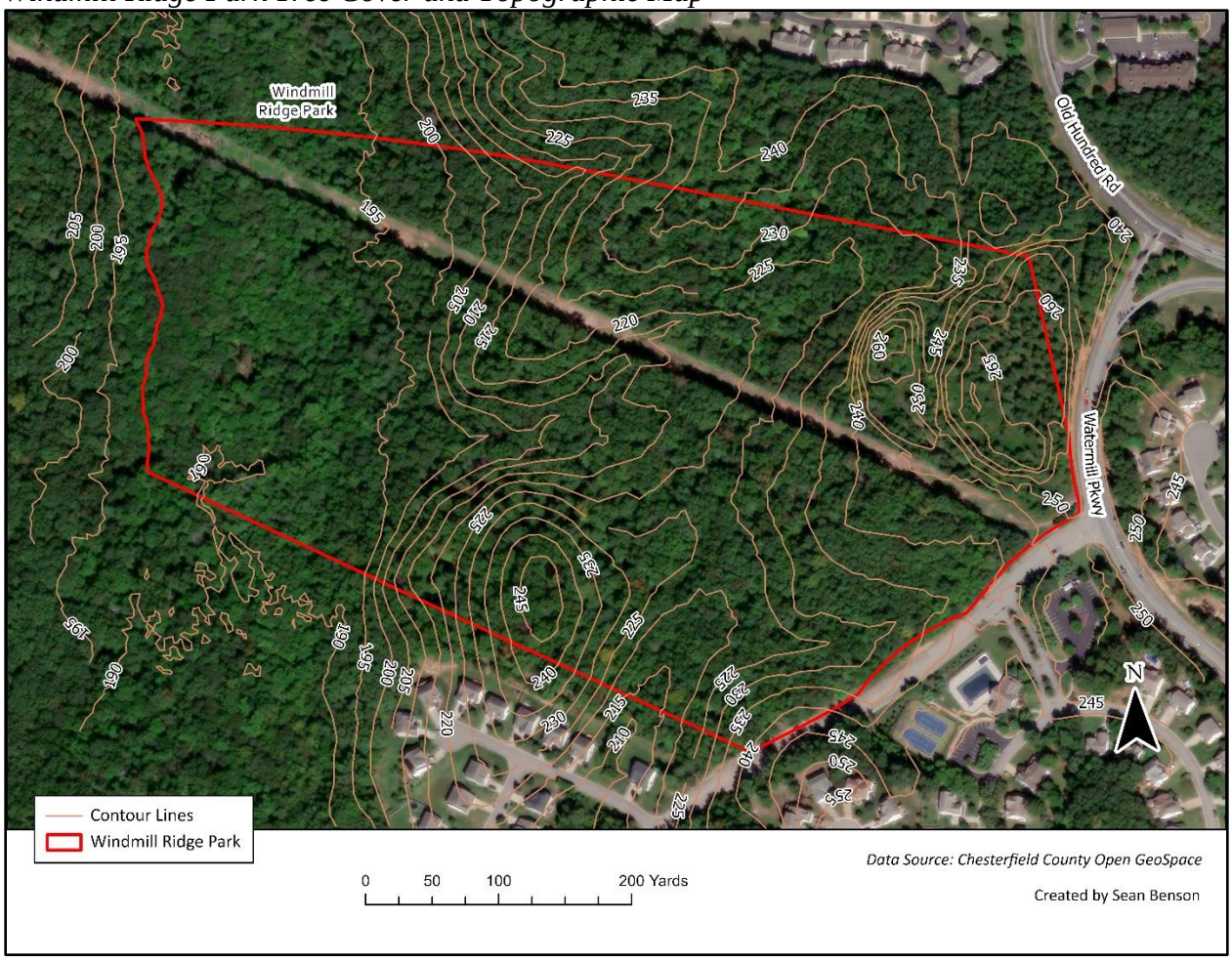
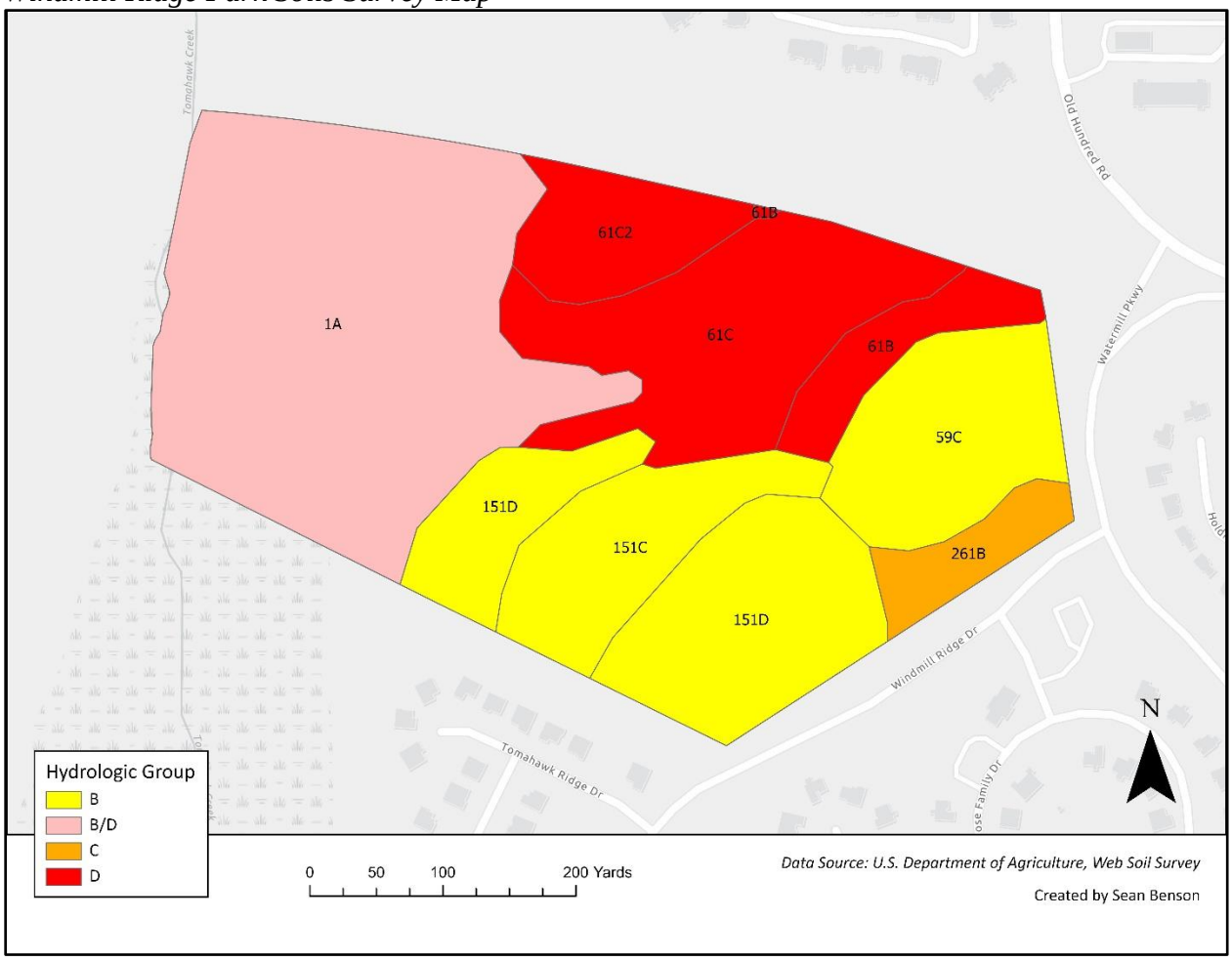


Figure 9 shows the approximate distribution of soils throughout Windmill Ridge Park, which are all labeled based on their classification that corresponds with the report in Appendix C. In the map labels, the number represents the type of soil, the letter represents the approximate slope, and any other numbers after the letter tell additional information—the letter that

references the slope ranges from ‘A’ having the lowest slope (0 to 2 percent) to ‘D’ having the highest slope (12 to 20 percent; see Appendix C). Soil 61C2 will be used as an example (see Figure 9): the number 61 refers to the soil ‘Creedmoor fine sandy loam,’ the C means the slope is 6 to 12 percent, and the 2 means the soil is eroded.

The colors in Figure 9 represent the hydrologic groups of the soils—the legend shows each hydrologic group with its corresponding color. The lettering used to classify the hydrologic groups does not necessarily correspond with the lettering used in the soil type—the soil 61C2, referenced earlier, is in hydrologic group D. For simplicity, the labels refer to the soil type, and the colors refer to the hydrologic group. As was mentioned in the literature review, the hydrologic group is determined by the soil’s water infiltration rate and runoff potential.

Figure 9:
Windmill Ridge Park Soils Survey Map



About a third of the park site is in the hydrologic group B, which has a good infiltration rate and a lower runoff potential, but these areas also have some of the highest slopes in the park.

Another third of the park is in hydrologic group D, which has really poor infiltration rates and high runoff potential. The last third of the park is mostly within the RPA and floodplain (soil 1A), and is part of two hydrologic groups, B and D, which may be influenced by Tomahawk Creek (see Figure 9). Knowing the types of soils and where they are located is important in determining the locations for each use/facility—such as putting a basketball court with impermeable pavement in an area with soil that already has high runoff rates. A more detailed evaluation of existing soil types and slope of the terrain is needed, however, due to the simplicity of the data from the USDA Web Soil Survey—this data is meant to provide a preliminary understanding of the potential soils in the area.

Resource Protection Areas (RPA)

RPAs are 100-foot natural buffers that run alongside streams, rivers, lakes and reservoirs (Department of Environmental Engineering, n.d.). RPAs protect these sensitive water sources in multiple ways, such as naturally filtering pollution from stormwater runoff, lessening runoff volume, and preventing erosion. Therefore, to protect these resources, very few activities and uses are permitted in an RPA, such as trails and pathways.

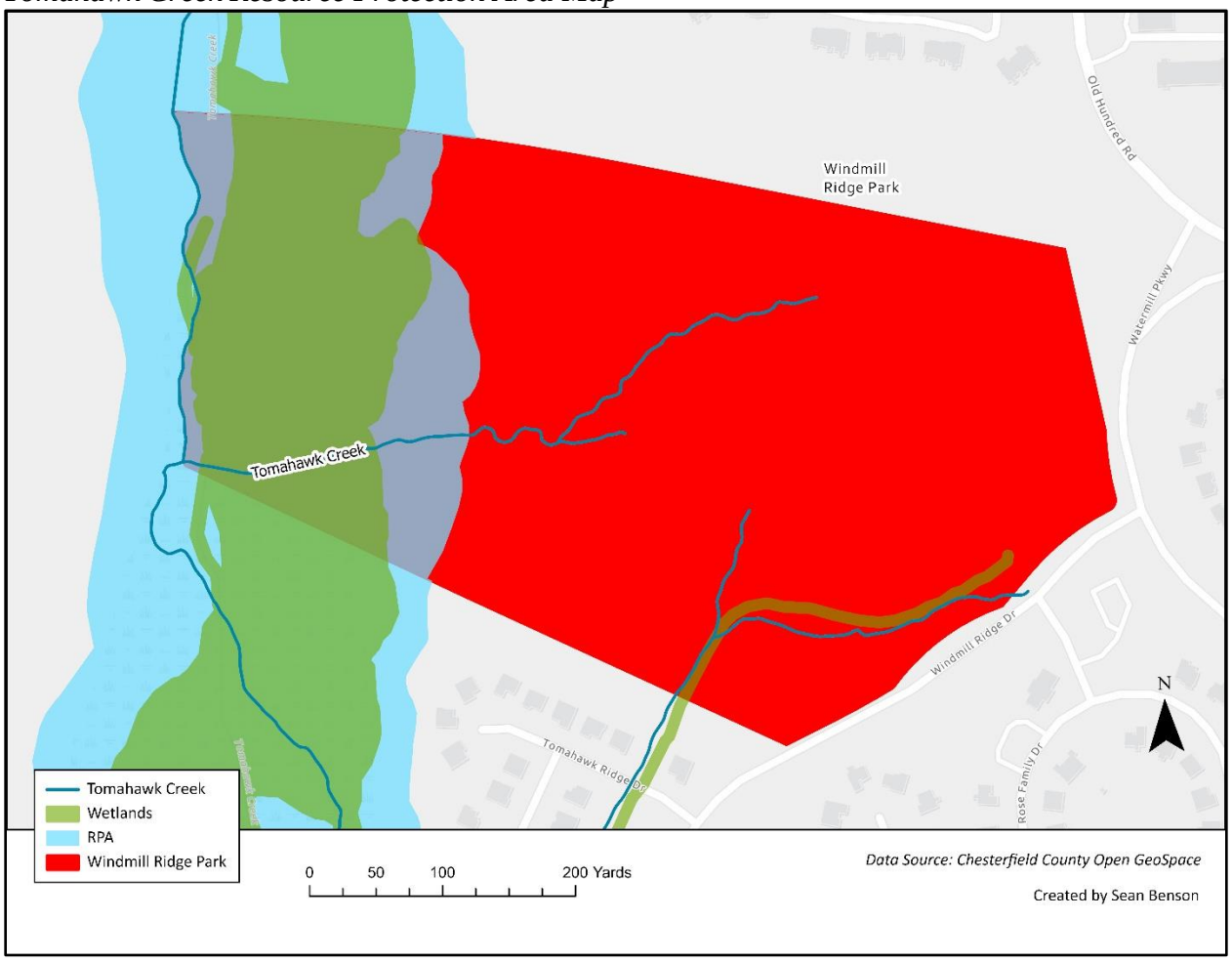
The site for Windmill Ridge Park includes about 13 acres of RPA around Tomahawk Creek, which feeds into Swift Creek Reservoir–a major water source for Chesterfield County (see Figure 10). Any development in or near Tomahawk Creek will need to be minimally invasive and environmentally friendly. Maintaining the site as a sustainable park, instead of allowing for further housing or commercial development, is a much better option for protecting the water quality of the creek and reservoir.

According to the Department of Environmental Engineering, bike paths and pedestrian trails are permitted within the RPA. If the proposed bike path from the County's comprehensive plan—mentioned previously in the infrastructure section—were to be extended to the park, it would need to cross over Tomahawk Creek. A bridge is allowed in an RPA, but it needs to be above the base floodplain elevation (BFE) to prevent being washed away or becoming an unintentional dam to the rest of the creek in the event of a flood. The Federal Emergency Management Agency (FEMA) has determined that Tomahawk Creek is in BFE Zone AE. Information as to how FEMA zoning designations are defined is lacking on FEMA's website; however, the Montana Department of Natural Resources and Conservation website states that AE zones have flooding elevations of less than three feet (FEMA, 2012).

If a select few trees need to be cleared for "reasonable sight lines" along paths, it must first be approved by the Department of Environmental Engineering, and the trees need to be replaced with other vegetation that provides equivalent water quality protection; if possible, it is

recommended that branches be pruned instead of removing entire trees (Department of Environmental Engineering, n.d.).

Figure 10:
Tomahawk Creek Resource Protection Area Map



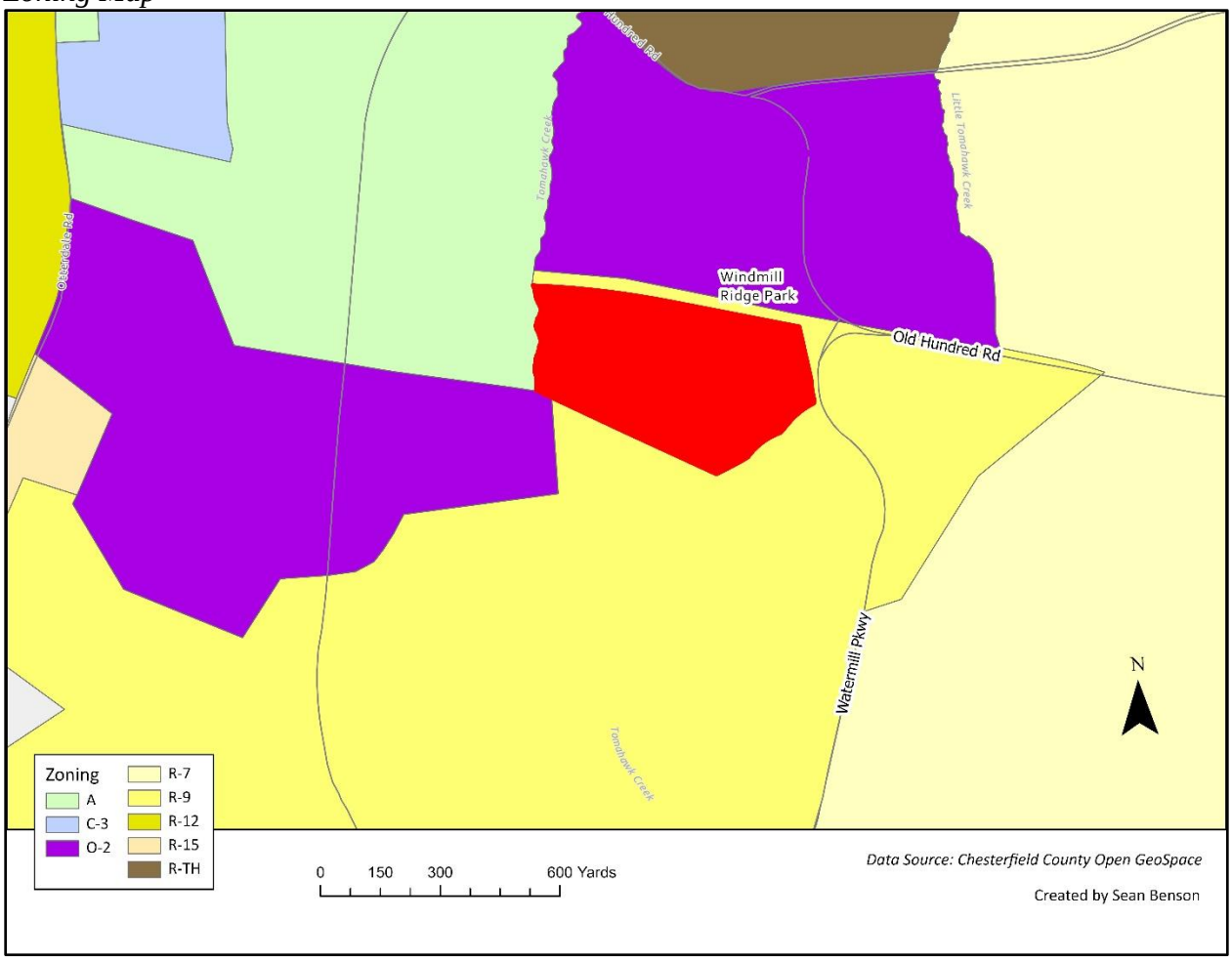
Trails and bike paths should not be paved, except to prevent erosion in areas that have a steep incline; generally, the trails can either be natural leaf-litter trails or can be covered with crushed stone or stone dust to allow for better maneuverability for bikes, strollers, etc. Benches are also permitted along any paths within the RPA.

Because Windmill Ridge Park is in the Swift Creek watershed, any treatment for stormwater from the park must be done on-site, but outside of the RPA. This may be done using the 15 BMPs discussed previously in the Environmental Quality section of the literature review. However, since there is a high volume of existing native vegetation already on site, the native plants can be preserved and used for natural stormwater treatment, thereby requiring less construction/hardscaping onsite.

Zoning & Land Use

The existing zoning for the site is R-9, or single family residential (see Figure 11). A park is permitted by right in any "R" district, but as it is a non-residential use it must follow non-residential standards; parks typically follow "O" district requirements. A setback of 50-75 feet with perimeter landscaping is required along major arterial roads and 25-40 feet with perimeter landscaping is required along local roads. When bordering a residential use, a setback must be a minimum of 10-40 feet with a landscaped buffer.

Figure 11:
Zoning Map

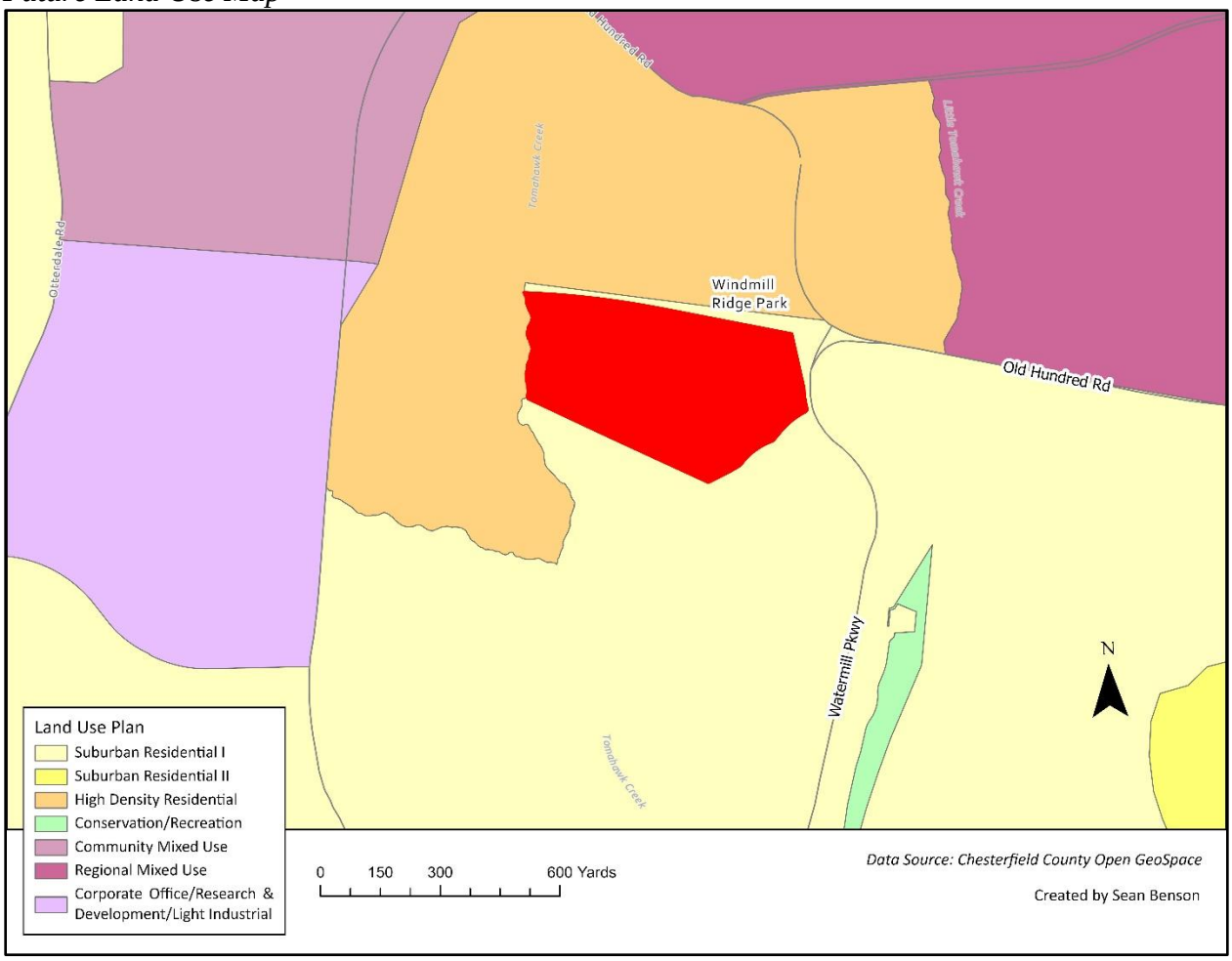


Current zoning also requires sufficient off-street parking on site for all uses. The number of parking spaces required is based on the types of uses included in the park. For outdoor sports playfields without fixed seats, 30 spaces are required per field. Tennis, racquetball, squash, and handball courts require 4 spaces per court, and volleyball courts require 12 per court. Other

indoor facilities, such as a community center, need 1 space for every 200 square feet of the gross floor area (Chesterfield County, n.d.). To best maintain the sustainable framework of the park, some form of pervious pavement or pavers should be considered for the parking lot.

The neighboring zoning districts are O-2 (corporate office district) and A (Agriculture); however, there is no current development within either of these districts directly adjacent to the site (see Figure 11 and Figure 4). Although these two districts don't directly affect the development of the park, the changes that are proposed in the County's future land use plan may influence its design.

Figure 12:
Future Land Use Map



The future land use for the site, according to the County's comprehensive plan, is Suburban Residential I, which won't create any significant changes for the site where the park is already permitted. The proposed land use for the neighboring zones will change to high density residential, corporate office/research and development/light industrial, and community and

regional mixed-use, which will make the site the ideal location for a new regional center (see Figure 12). The land use plan maps out locations for regional and community centers, and the site for Windmill Ridge Park is located within one of these regional centers. The plan states that these centers are intended to become high density, mixed-use areas that "are built around unique and attractive social gathering spaces that are utilized by residents, businesses and visitors alike." The social gathering spaces should be deliberately designed to stand out in the mixed-use development, and focus should be placed on connecting the uses, especially to provide access for pedestrians and cyclists, connecting "projects internally and to adjacent uses where appropriate" (Chesterfield County, 2019). The park site is in the ideal location to be developed as the social gathering space for the mixed-use regional center.

Methods

This section addresses how the designing and developing of a plan for a new sustainable park in Chesterfield County was accomplished. This was done by presenting research questions to be answered and suggesting methods to be used in gathering information relevant to sustainable park design for the Windmill Ridge Park site.

Research Questions

The research questions for this plan were intended to guide the design of the park around a sustainable framework and answer the overarching question, "how can the site be designed in a sustainable way?" The questions helped define sustainability for Windmill Ridge Park and addressed each of the "three E's" of sustainability.

1. What does the research suggest for best sustainable design practices?
    a. Which amenities should be included?
    b. What has already been done in other parks outside of Chesterfield County?
2. What does the community want from the park?
3. What is the best management method for this site?
    a. Will the responsibility be mainly on the county?
    b. Is a public/community partnership, such as a "friends of" group, feasible?
    c. What funding is available for park development and implementation?
4. What strategies can promote accessibility to the park?
    a. Is bicycle and pedestrian infrastructure feasible?
        i. Is there a desire within the community for bicycle and pedestrian infrastructure?
        ii. Is there a demand for E-scooter and bike share amenities?
        iii. Will increased accessibility minimize needed parking?
5. What are the best environmental practices for park design?
    a. If BMPs are needed, which ones should be implemented for stormwater management?
    b. Where should permeable pavers be implemented and what kind?
    c. Which design elements would be most appropriate for the park (i.e., benches, shelters, lighting, trees, shrubs, and ground cover)?

Stakeholder Outreach Methods

As was mentioned in the introduction to the plan, due to the infancy of the project, public outreach is on hold until a future date when the County can properly introduce the site and inform the public of its plans. Therefore, to supplement stakeholder feedback, an online survey was provided to Chesterfield County Parks and Recreation employees using Google Forms; a

focus group with select employees from the department was also held. The focus group was hosted online through Zoom, to allow for easier gathering of participants and the ability to record the meeting for future reference. Sustainable concepts were presented to the group, then the participants were asked questions to facilitate conversation and provide expert advice on what concepts would be possible at the site, as well as how these concepts might reflect other priorities of the Parks and Recreation Department. Questions and results used in the survey and focus group can be found in the "Research Findings" section of this plan, as well as in Appendices A and B.

Table 2: Research Questions and Methods Used

Research Question	Methods Used
1. What does the research suggest for best sustainable design practices?	Gathered feedback from county staff through the online survey and focus group.
	Researched case studies and other articles related to sustainable park design.
2. What is the best management method for this site?	Met with Chesterfield Parks and Recreation staff to discuss their usual management methods and the feasibility of partnering with a friends of the park group.
	Included a question in the survey about community member interest in participating in the friends of group.
	Reviewed the County's Capital Improvement Program for funding opportunities.
3. What strategies can promote accessibility to the park?	Researched case studies of existing parks and other resources to determine useful accessibility practices.
	Included questions in the survey regarding desire for bicycle and pedestrian infrastructure, and demand for bike share systems.
4. What are the best environmental practices?	Met with the Department of Environmental Engineering for general information on RPAs, best design practices within RPAs, and the use of BMPs.
	Researched different options for permeable pavers to be used in parking and/or paths.
	Researched different options for design elements.

Analytical Methods

Survey results were analyzed quantitatively to determine the most desired uses for the park, based on the answers that have the highest frequency of selection. These were then compared to current literature on sustainable parks and case studies—including visiting parks outside of Chesterfield County—that have implemented sustainable practices to determine design

recommendations for Windmill Ridge Park. Feedback from the focus group was likewise analyzed to make any necessary adjustments. A concept design was presented to the client as part of this plan, and a sketch of the design is included at the end of the plan.

Research Findings

This section discusses the findings that guided the concepts and recommendations for this plan. Data was collected from site visits, case studies, additional online research, a focus group, and a survey.

Site observations

Site observations and photos were obtained by visiting the park in person. Some observations and recommendations for the park were discussed with the client during site visits.

Image 1:
Hill at Entrance to Windmill Ridge Park

Photo Credit: Sean Benson

The site has multiple hills (see Images 1&2), which can generally make development more difficult due to the amount of grading and infill that would be required, however, the terrain provides the opportunity for a unique sustainable design for the park that can attract visitors and reduce disturbance to the natural environment. This can be accomplished by following the guidelines mentioned previously from Ian McHarg on designing with nature (1995).

Image 2:
Hill of Debris from Previous Construction

Photo Credit: Sean Benson

The tallest of the hills looks as if it is a debris pile that was deposited on the site when one of the roads adjacent to the site was built (see Image 2); some kind of filter fabric surrounds the base of this hill (see Image 3), and likely continues beneath it.

Image 3:
Filter Fabric at the Base of Debris Hill

Photo Credit: Sean Benson

For most trails and pathways, the hills are not an issue as they can provide variety to a nice stroll, particularly since most of the hills have a very gradual incline. The hills can be used to design with nature and create a unique park, as was discussed previously in the Background Literature section of this plan.

Image 4:
Vegetation at Windmill Ridge Park

Photo Credit: Sean Benson

Aside from the cleared section where the gas pipeline is found (see Image 1), the entire site is covered with trees and other vegetation. The natural tree cover is an asset that can serve as great natural shading during the summer months while allowing for sunlight during the winter months. Image 4 shows what the vegetation looks like throughout most of the park.

Image 5:
Gully at Windmill Ridge Park

Photo Credit: Sean Benson

South of the gas pipeline, running through the middle of the park, is a gully that is likely the result of water flowing through during heavy rainfall. Some sections of the gully have a gradual incline, while other sections have a several foot drop; a wooden plank was found spanning

across the gully, likely to be used as a small, makeshift bridge. No water was observed in the gully during the site visits, but that may change during rainy weather (see Image 5).

Image 6:
Park Boundary Without Sidewalks

Photo Credit: Sean Benson

There are no sidewalks or paths along the perimeter of the park or leading to it (see Image 6). The adjacent Watermill community has a one sidewalk that extends along Windmill Ridge Drive, but it's on the opposite side of the street from the park and there are no crosswalks.

Case Studies

Information from case studies was obtained while visiting parks outside of Chesterfield County and from online research of sustainable parks.

Inclusivity

Miracle Park, Rock Hill, SC

A visit was made to Miracle Park in Rock Hill, SC, which is not designed with sustainable practices in mind, but it has a few features that can be considered sustainable. Part of social equity involves not only having access to a park, but also having amenities that appeal to a large variety of people. Miracle Park was built as an inclusivity park that allows for people with a variety of special needs to enjoy park life. The play area has a playground that is wheelchair accessible and provides a wide range of play equipment (see Images 7&8). Restrooms are close to the play area and other areas with expected high rates of use (see Image 9).

Images 7&8:
Miracle Park Playground

Photo Credit: Sean Benson

Image 9:
Miracle Park Restrooms

Photo Credit: Sean Benson

Image 10:
Miracle Park Benches

Photo Credit: Sean Benson

Image 11:
Miracle Park Tables

Photo Credit: Sean Benson

Miracle Park also provides a variety of spaces to sit throughout the park with different types of benches and tables (see Images 10&11). The park also includes recycle bins next to the trash cans instead of in their own place, which helps encourage people to recycle (see Image 12). The materials used for some of the seating and the recycle bins and trash cans are sustainable because they use metal and wood. The metal is durable and will last a long time and is usually recycled and recyclable too, while the wood is natural and won't pollute the environment as it degrades (Gallagher, 2012).

Image 12:
Miracle Park Trash and Recycle Bins

Photo Credit: Sean Benson

Miracle Park provides accessibility by including sidewalks and crosswalks for nearby residents to walk to the park, and it even includes a bus stop in the parking lot (see Images 13&14). The Comprehensive Plan for Chesterfield County plans for adding pedestrian infrastructure throughout the county, however, there is no public transportation available for the county.

Image 13:
Sidewalk Entering Miracle Park

Photo Credit: Sean Benson

Image 14:
Bus Stop in Parking Lot

Photo Credit: Sean Benson

Using Natural Topography

Freedom Park, Charlotte, NC

Freedom Park in Charlotte, NC was also visited, which is not a sustainable park, but it did have one feature that's useful to the design of Windmill Ridge Park. Freedom Park has a stage/amphitheater area, and the natural hill was terraced to provide step-like seating on the grass (see Image 15).

Image 15:
Freedom Park Amphitheater Seating in Hillside

Photo Credit: Sean Benson

Environmentally and Economically Friendly

New York City Parks and Recreation

New York City Parks and Recreation has been implementing sustainable practices in their parks for several years now—in particular, various recycling projects and green roof systems. They chip and reuse forestry wood, and some of the chipping is done within Cunningham Park; some of the wood chips are then used to generate energy at Flushing Meadows Corona Park pool.

Another simple recycling option that they provide is locations for battery recycling (New York City Department of Parks and Recreation, 2011).

New York City has also designed a variety of different green roof systems that are gradually being implemented on their recreational centers, including a walkable system—a green roof you can walk through—and green wall system—a section of wall with plants (*Green Roofs : NYC Parks*, 2013).

Discovery Green

A lot can be learned from Discovery Green—a park in Houston, Texas. It is located in a dense urban setting with access to public transportation and facilities for pedestrians and cyclists. Park construction included methods to prevent pollution during construction, such as using regional sources for materials and recycling materials that were used (*Why Discovery Green Is "Green,"* n.d.); additional practices may include hiring construction companies that use electric tools and vehicles (Batten, 2022). Mature trees were planted to provide shade and buildings were designed to maximize natural air flow and access to daylight. The park also uses renewable energy sources, like wind and solar. Groundwater is recycled, and high-tech, highly efficient restroom fixtures are used to minimize water usage. The park also provides education programs and conservation education experiences for the community (*Why Discovery Green Is "Green,"* n.d.).

Additional Research

Permeable Surfaces

Parking lots, sidewalks, and trails will need to be included in the development of the park, which would typically include a lot of traditional asphalt and concrete, thereby resulting in large amounts of stormwater runoff; however, there are multiple alternative, permeable options that not only reduce the amount of stormwater runoff but also aid in the filtration of pollutants carried by the runoff—porous/pervious concrete, pervious asphalt, interlocking pavers, and plastic grid pavers (US EPA, 2015).

A study done by the United States Environmental Protection Agency (EPA), tested the surface infiltration rates of three parking rows—each made of a different permeable pavement—in a parking lot over a six-month span. Porous concrete, porous asphalt, and interlocking pavers were used, and although they are all an improvement over traditional pavement, the porous concrete had a significantly higher average rate of surface infiltration of 4,000 cm/hr., compared to 2,400 cm/hr. for the pavers, and 200 cm/hr. for the porous asphalt. The porous concrete was also the only pavement to increase in its infiltration rates over the six month period (Office of Research & Development, 2010).

RI NEMO, from the University of Rhode Island, is participating in multiple projects involving low impact development, a part of which involves permeable pavement. Image 16 shows some parking in East Greenwich, Rhode Island after a rainfall, that has pervious asphalt and regular asphalt; it's clear from the photo that the pervious asphalt allows for greater water infiltration, while the regular asphalt retains the water on its surface, which can lead to greater risk of flooding and slippery road conditions (*RI NEMO*, n.d.).

Image 16:
Pervious Asphalt with Conventional Asphalt

Note: "Conventional asphalt on the left, porous asphalt on the right at Cottages on Greene in East Greenwich. Photo courtesy of Jonathan Ford." *Source*: (*RI NEMO*, n.d.) https://dem.ri.gov/sites/g/files/xkgbur861/files/ri-stormwater-solutions/documents/factsheet_porous.compressed.pdf

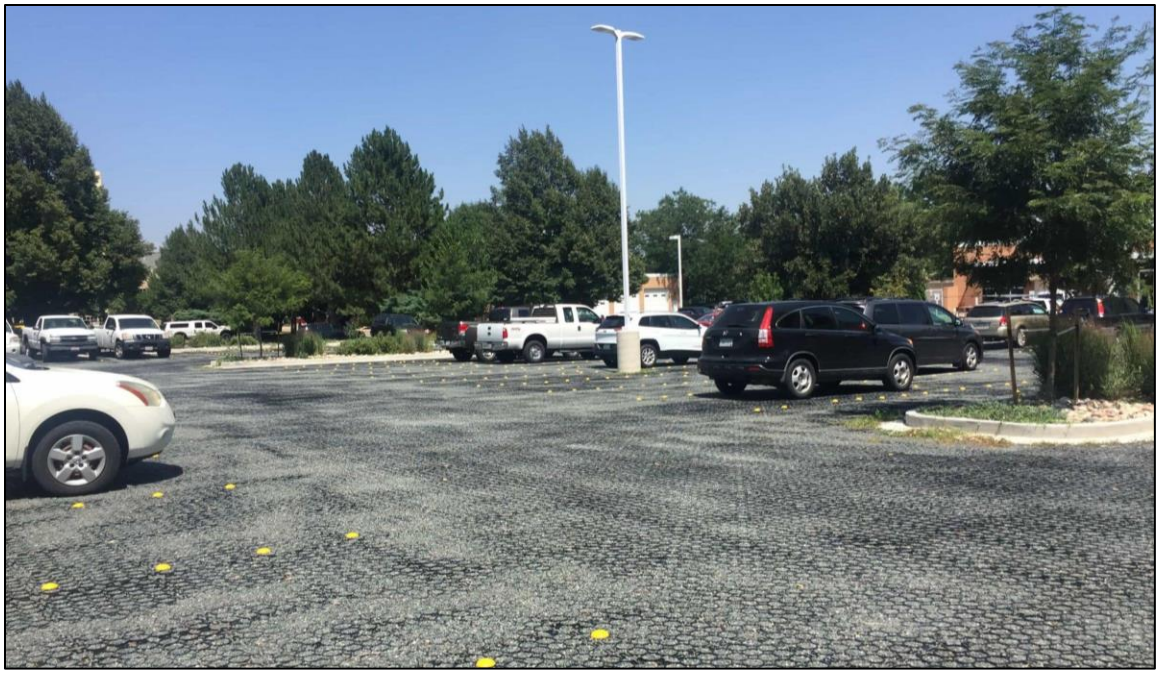
There are also a variety of manufactured plastic grid pavers available that provide options for parking lots that are generally easy/cheap to install and require less maintenance than concrete or asphalt (TRUEGRID, 2017). A section of these pavers is made of a plastic grid that is filled

with a permeable material—such as sand or gravel—after a layer of the pavers is laid across the desired area (see Image 17).

The Chesapeake Bay Trust states that permeable pavements can be used in most locations, but a drainage system may need to be put in place underneath the pavement depending on the type of soil in the desired location. Sand and loam allow for quick infiltration of stormwater, whereas clay does not provide very easy infiltration and would require an underdrain to prevent ponding (Alsobrooks, n.d.). Permeable pavement also has a lower loadbearing capacity than conventional pavement, so it shouldn't be used in areas that experience excessive loads or high-speed traffic (Alsobrooks, n.d.); however, the Chesapeake Bay Trust only includes porous asphalt, pervious concrete, and permeable pavers, they don't mention plastic grid pavers.

Costs for permeable pavement tend to vary by type and construction company. According to the Chesapeake Bay Trust, the cost of pervious concrete or porous asphalt can be as high as 50% more than conventional pavement, and paving stone and manufactured grass can cost up to 20% more than concrete pavers (Alsobrooks, n.d.). Other sources provide a range of initial construction costs, putting regular asphalt at $7-$13 per square foot and porous asphalt at a similar rate. Pervious concrete is around $8-$15 per square foot, plastic grid pavers are about $5-$9 per square foot, and permeable stone pavers are $10-$30 per square foot (Crail, 2023; Flannery, 2022; HomeAdvisor, 2022a, 2022b; Noel, 2023; TRUEGRID® Paver, 2021b).

Image 17:
Plastic Grid Pavers



Source: TRUEGRID (TRUEGRID® Paver, 2021a) https://www.truegridpaver.com/permeable-hardscape/

Lighting

Light pollution can be an issue when including outdoor lighting. Increased amounts of lighting at night can affect the health, among other things, of wildlife and even humans. The International Dark-Sky Association (IDA) provides information on best outdoor lighting practices, including free access to a research database containing over 4,000 articles that discuss these practices and their effects on wildlife and humans. Some of the best lighting practices are to use downward directed lighting and minimize blue light usage—use low color temperatures/"warm" colors. While the IDA does not sell lighting, their website does include a page with recommended products and retailers (*International Dark Sky Association*, n.d.).

Unique Identity

Public spaces provide an opportunity to create a unique identity for neighborhoods. "The result of strengthening neighborhood ties and celebrating their unique identities produces stronger communities and cities" (National Recreation & Park Association, 2023).

Sankofa Community Orchard

Sankofa Community Orchard in Richmond, VA, has created an identity for itself by providing murals (see Image 18) that represent the surrounding community. The orchard also includes community gardens that allow the nearby residents to grow their own food and further increase the community feeling.

Image 18:
Sankofa Community Orchard Murals

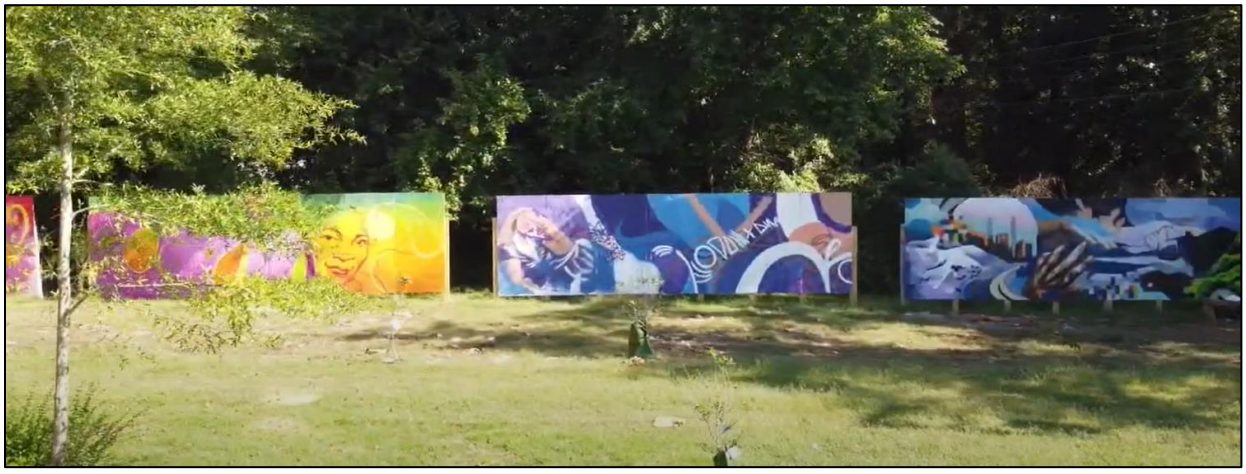


Photo Credit: Southside ReLEAF, https://www.southsidereleaf.org/events

Survey and Focus Group Results

The survey and focus group were very informative. Both provided useful insight into what may be possible within the park design, as well as adjustments that can be made for future public outreach. The survey focused on demographic information, how to access the park, desired facilities, and volunteering opportunities within the park. The focus group mainly discussed sustainable practices and programs for before and after the construction of a park, and informing the public and staff about those same practices.

Survey Results

The survey provided limited insight into what amenities should be included in the park design and served more as a preliminary test to surveying the public on sustainable park design. The results were heavily biased due to all the respondents working for the Chesterfield County Parks and Recreation Department, and the majority age among respondents being over 40 years of age. Overall, though, the demographics were somewhat representative of the actual population demographics of the service area. For the purposes of these findings, "population" will refer to the residents that live within the service area of Windmill Ridge Park.

Survey Demographics

Approximately 100 staff work for the Parks and Recreation Department, however, about 60 of those work in the field—and were unlikely to respond to the survey—and the other 40 work in the County offices. Twenty-three people responded to the survey, creating a response rate of just over 50%. Regarding the sex of respondents, 56.5% were female (see Figure A1 in Appendix A), which is close to the 53% female distribution of the population in the park's surrounding community. The racial distribution of respondents was 78% White, 13% Black/African American, and 8.7% multiracial (see Figure A3), which closely matches the population racial distribution for Whites, but doesn't closely match any of the other races (see Table 1).

The greatest difference between the population and the respondents was in age. Of the respondents, 47.8% were in the age range of 40-59, and 34.8% were age 60 or older, coming to a total of 82.6% of respondents being 40 years of age or older (see Figure A2). Comparatively, only 28.5% of the population is in the age range of 40-59, and only 20.8% is age 60 or older (see Figure 5), coming to a total of 49.3% of the population being 40 years of age or older. The number of respondents 40 years old or older does not properly represent the population, so the survey questions not related to demographics will likely be very biased.

Park Access

The fourth question in the survey asks respondents to rank, in order from first to third, how they would like to access the park—walk, bike, drive. The responses showed 76% chose 'drive'

as their first choice (see Figure A4), which may be due to the age bias. However, there may simply have been a misunderstanding of the question, because the fifth question asks if the respondent would walk or bike to the park if pedestrian infrastructure was built, and 69.6% responded that they would (see Figure A5). The high response rate for wanting to drive in the fourth question may further be influenced by the fact that there is not currently pedestrian infrastructure, or that many of the respondents may live outside of the service area of the park and were considering it to be too far for them to walk to. Nonetheless, a clear majority of the respondents would want to walk or bike to the park if the proper infrastructure were available, thereby providing a good support for adding the infrastructure.

The sixth question asked if respondents would be interested in a bike share system—assuming the infrastructure to support it were provided—and aside from the three people that didn't know what bike share is, the rest of the results were evenly split—half for it and half against it (see Figure A6). Educational opportunities of bike share systems may need to be provided to the public to increase their understanding of what it is and the benefits they offer to health and accessibility.

Desired Uses from the Park

Questions seven and eight asked which types of passive and active recreational facilities they would like to be included in the park. For passive recreation, 100% of respondents wanted trails, followed closely by 87% wanting picnic areas, and 69.6% wanting playgrounds (see Figure A7). For active recreation, basketball courts and pickleball courts tied for the most at 43.5% of respondents wanting each, and the next being tennis courts at 39.1%. Under the 'other' option of the question, a few people stated that they don't want any active recreation facilities at the park; however, these types of facilities should be included to attract more people to the park (see Figure A8). Soccer fields were the next most wanted after tennis courts, but they shouldn't be needed in the park due to the site's proximity of about a 5-7 minute drive to River City Sportsplex, which has 12 synthetic turf fields for soccer, lacrosse, field hockey, and other sports—and the Parks and Recreation Department plans to add 4 more fields in the future (Chesterfield Parks and Recreation, n.d.-b).

Question nine asked respondents to rank their top three reasons for visiting parks, and 'to relax' was consistently one of the top picks for the first, second, and third choices, with 'observing nature' and 'to escape the home/urban life' being very frequent choices as well (see Figure A9). A large number of people don't necessarily go to parks for the opportunity to exercise as much as they go to get out of the house and get some fresh air.

Volunteering

The final question asked if respondents would be interested in being involved in a friends of the park group. The respondents very clearly didn't want to participate in a friends of the park group with 56.5% responding 'no' and 30.4% responding 'maybe' (see Figure A10). Although the respondents don't want to be a part of a volunteer group, a similar question may yield different responses from the population living near the park. These results may also be biased because the respondents work in Parks and Recreation—they may not want to volunteer to work at the parks they already get paid to work on full time.

Focus Group Results

The focus group was held online on 3 March 2023, using the Zoom platform, and lasted for about 50 minutes. The meeting was recorded to allow for full attention given to the participants during the meeting and for a more thorough analysis afterwards. The focus group began with a brief introduction of the six attendees—including the department director, one of the assistant directors, two people from the planning sector of Parks and Recreation, the GIS specialist, and the County Naturalist. Following the introductions, a brief presentation was given to the group that introduced the site location and some of its existing conditions, as well as the main sustainable concepts that have appeared in the research so far. The goal of the focus group was then presented, and questions were asked to encourage discussion about the concepts presented and the current priorities of the Parks and Recreation Department. The focus group agenda, which includes a list of questions prepared for the group, can be found in Appendix B.

Concerns with Implementing Sustainable Practices

The focus group presented a narrower view on sustainability that focused on how the park is constructed—what goes there and what materials are used. Management feels "it's a difficult line to balance, between the practicality of getting something built and using sustainable concepts." The site is in a great location to meet priorities for both the County and the Parks and Recreation master plans, so they don't want sustainability to "get in the way" of getting development done. One example that was used was with regards to permeable pavement, which is a good idea, but the soil conditions have to be right. If the soil is such that it doesn't absorb water well, then permeable pavement isn't as useful. The assistant director was involved in a project where this was the case, so they had to construct a large tub underneath the parking lot to gather and drain the water. Before a plan can move forward, a thorough site analysis of the slopes and soils needs to be done.

There is also conflict between the different departments and ordinances involved, regarding goals and requirements, that make it difficult to be fully sustainable. For example, if the roads

in the park are to be maintained by VDOT or CDOT then they have to be built to their standards, which may or may not be sustainable. Departments and processes need to be aligned for sustainability to work.

Current Recycling Situation and Practices

Currently, Chesterfield County is in the process of ending subsidized, curbside pickup recycling for residents, and is planning to add six new recycling drop-off locations. The Parks and Recreation Director said there is a lot of politics behind this, but the Chesterfield County parks are being considered for these new drop-off locations. Some see parks as convenient locations to the neighborhoods for drop-off centers, but this can cause problems because you need to remove trees and put down a lot of concrete, and people will start dumping waste that is not recyclable. The parks that will become these drop-off locations have not been chosen yet, however, it is possible that Windmill Ridge Park would become one of them.

The Parks and Recreation Department is already involved in some recycling practices, one of which is similar to the New York City example mentioned previously. The department removes diseased and dead trees then cuts them up to provide free firewood for the community or mulches it to be used in the parks. During the construction of Government Center Trail near the County offices, trees that were cut down were mulched and used as temporary erosion mats—instead of hauling all of them out—and when they were finished, they spread it all into the woods.

Priorities in Sustainability

During the focus group, a poll was distributed through Zoom that asked which components of sustainability the participants thought were most important to sustainable parks. Nine options were provided: pedestrian access, recycling, variety of activities, use of sustainable materials in construction, stormwater runoff reduction and filtration, volunteer groups, design efficiency, unique/specific to location, and all of the above (see Table B1 in Appendix B). One of the focus group attendees did not participate in the poll, but of the five that did participate, all chose pedestrian access and stormwater runoff reduction as important, and four of the five chose design efficiency. Each of the other options were chosen as important by only one or two participants. The results provided insight within the County, that there is a focus in the environmental aspect of sustainability and pedestrian access to parks.

The County has a few priority areas in sustainability, such as energy efficiency, functionality, and use of sustainable materials in structures. Currently, all county departments are involved in energy tracking. In Parks and Recreation specifically, they are trying to use lower energy equipment, such as switching athletic lighting over to LED sources that are more efficient and

use less energy and less maintenance. They also have some design practices built into some of their building programs, mostly energy efficiency and sustainability that are required in major structures; Parks and Recreation doesn't have very many major structures, mostly smaller structures like restrooms and concessions, but they still consider efficiency and sustainability in their designs. Besides just looking at functionality, they are looking at materials that will last the longest and require the least amount of maintenance to keep them safe and functional. They have also been working on letting the natural grasses grow by not fertilizing and by mowing less—too much mowing can promote erosion, and less mowing means less machinery being used and less potential for damage. In some cases, they are looking at going back to natural forested situations as opposed to open areas.

Informing the Public

The final question asked was regarding how to better inform the public and staff about sustainability. The department is already making efforts to have more public engagement, which are not only opportunities to gather their input on design but can also serve as opportunities to inform them about sustainable practices. The County Naturalist is also in parks programming, and they use their programs to inform people. As part of their education programs, they take people to conservation areas to help them understand why we have conservation areas. People may understand sustainability, but it's a broad term, and educators can help bring it into focus—it may be an abstract concept until you bring them to the park and then it becomes a concrete thing. The County Naturalist feels this is something that can easily be done in their programming.

This focus group provided useful information for the design and development of Windmill Ridge Park, but it also served to inform the participants. The assistant director said he is considering a broader lens of sustainability as put forth in the presentation at the beginning—he is looking at what defines a sustainable park from a more complex view, rather than just what kind of materials you use and how you design it.

Strengths, Weaknesses, and Opportunities

The strengths, weaknesses, and opportunities (SWO) of Windmill Ridge Park are derived from the existing conditions and research findings discussed previously. This section is important in analyzing and narrowing down the special opportunities for this site that will help inform the Recommendations section that follows.

Strengths

Ideal Location

The first and biggest strength for the site is its location. It is near a medical center and multiple schools and businesses, and it's adjacent to three different neighborhoods. It is easily accessible due to its proximity to major roads like Old Hundred Road, Route 288, and Powhite Parkway. The park also fills the County need of having a park near Old Hundred Road, and it falls within one of the Future Land Use Plan's regional center nodes.

Clean Slate

The site for the park is previously undeveloped land, so it provides a nice clean slate from which to build the park on sustainable practices. The site is already covered in native vegetation and animals.

Growing region

The site is in a growing developmental region. The land to the west of the site is expected to grow to include more businesses, housing, and entertainment. This growth will bring more people to the park.

Natural Vegetation

The site has a very large percentage of tree cover, which serves as a great source of natural shade. The current zoning code requires landscape buffers along park borders that are adjacent to housing or major roadways. The already existing vegetation also serves as a buffer, which will lessen the amount of work required.

Weaknesses

Lack of Transportation Options

The site does not have pedestrian and bicycle infrastructure leading to it, nor is there any public transportation that could assist. The park is accessible only by car, which severally limits who can access the park.

Powhite Parkway Extension

The Powhite Parkway Extension is expected to run directly adjacent to the northern border of Windmill Ridge Park. This can cause multiple problems: increased stormwater runoff, increased pollution of stormwater, the disturbance of nature, and creating a barrier to pedestrian access.

No Large Open Spaces

The lack of wide-open spaces may seem like a good thing for sustainability, but in this case it means that large sections of trees will need to be removed for parking, recreational fields/courts, and other facilities.

Lack of County Goal Alignment

There is a lack of alignment of sustainable goals between county departments and state departments. Parks and Recreation has different ideas and goals regarding sustainability than the Environmental Engineers, Utilities, or VDOT, which creates conflict and makes sustainability more difficult to attain.

Lack of Public Engagement

There is currently a lack of public engagement, with regards to Windmill Ridge Park, which means all recommendations within this plan are based entirely on principles and good practices from case studies and other professional literature/recommendations. None of the recommendations are based on what the community wants, which inhibits the ability to properly address social equity.

Opportunities

Extensions of Proposed and Existing Trails

Chesterfield County has a proposed bikeways and trails plan, and the Brandermill Community has an extensive trail network, both of which provide a great opportunity to connect with Windmill Ridge Park. With a proposed bike path to the West of the park and the Brandermill trails to the East, there is an opportunity to extend both sets of trails to the park, providing increased access for pedestrians and cyclists.

Prepare for Future Development

While future development, such as the Powhite Parkway Extension, may be a weakness for Windmill Ridge Park, we have an opportunity to plan and prepare for it. The park can be designed in a way that when the extension comes, the park will already be set up to allow for increased stormwater runoff or allow for pedestrian access over or under the extension. The park can also be designed to accommodate the population growth that will come with the expected new, nearby business and housing developments.

Hilly Terrain

The several large hills in the park provide the opportunity for a unique park that utilizes the hills, rather than flattening them out. Playgrounds or a community center can be built into the side of the hills, or one can be used for an amphitheater.

Unique Gathering Space

The County's comprehensive plan calls for unique gathering spaces within its proposed regional centers, and Windmill Ridge Park is located in one of those nodes. This is an opportunity to design Windmill Ridge Park as the desired unique gathering place for the regional center.

Resource Protection Area

Windmill Ridge Park contains 13 acres of Resource Protection Area (RPA). Because this area is limited in its allowed development, it provides an opportunity for the public to interact with and relax in nature, and it can be used as a place to teach about sustainability and conservation.

Ideal Concepts

This plan lacks community engagement, but there is an opportunity here to provide concept designs and ideas that are based entirely on solid sustainability concepts and principles. These concepts can then be modified to meet the needs of the community later, after public outreach is completed.

Recommendations

The following recommendations are derived from the research presented in this plan, as well as the focus group and survey. The recommendations present three main goals that follow the three Es of sustainability, and each goal contains multiple objectives and actions for those objectives.

Goal 1: Maintain Environmental Integrity

Objective 1.1: Design with nature to determine and enhance the identity of the park

Action 1.1.1: **Define the unique identity of the site through analyzing its environmental characteristics and community**. Characteristics to consider include the native plant and animal species, soils, history, physiography, climate, and community demographics. Each of these is part of the park's identity and should inform its design. Part of this analysis should include Virginia's Department of Conservation and Recreation (DCR), as well as the Department of Historic Resources (DHR) to assure no harm is done to any endangered species or historic/archeological sites that may exist in the park.

Action 1.1.2: **Design and place structures so that their form fits the surrounding environment to utilize natural ventilation and maximize efficient heating and cooling**. Orient and design buildings to utilize as much natural airflow as possible for increased efficiency in heating and cooling. Include operable windows that can be opened and closed for increased circulation. Some additional ventilation examples include solar chimneys, wind towers, and trickle ventilators (Atkinson et al., 2009). Spring Lake Park Visitor's Center in Santa Rosa, California is a great example of designing the structure to fit the environment (see Image 19).

Image 19:
Spring Lake Park Visitor's Center, Santa Rosa, CA

Source: Obie G. Bowman, https://obiebowman.com/spring-lake-park-visitors-center/

Action 1.1.3: **Orient structures to utilize as much natural light as possible**. The design of the building, particularly the placement of windows, allows for maximum daylight exposure and use of natural light. Windows can be used to reflect light into a room, or to focus light on a specific space. The Exeter's Library in New Hampshire (see Image 20) frames the windows in a way that directs daylight onto individual study spaces for students (Pun, 2020).

Image 20:
Natural Lighting of The Exeter's Library

Source: Rethinking the Future, https://www.re-thinkingthefuture.com/rtf-fresh-perspectives/a1059-10-examples-of-innovative-use-of-natural-light-in-architecture/

Objective 1.2: Preserve the native plant and animal species in the park

Action 1.2.1: **Retain as much existing, native tree coverage as possible to be used for natural shading throughout the park**. The trees on-site are primarily hardwood and will allow much desired sunlight through during the colder months, after their leaves have fallen. These trees also provide homes for many animals that live in the park; removing them could indirectly cause the removal of some native animals. This action should be continually addressed throughout the lifespan of the park.

Action 1.2.2: **Use native grass species in place of turf for any open spaces or sports fields**. The use of native grass assists in reducing stormwater runoff and filtration of pollutants.

Action 1.2.3: **Use warm temperature, downward facing lighting throughout the park**. Increased lighting at night can ruin the day/night cycle of many animals, which can have negative effects on their health, human health, and the overall environment. Refer to the International Dark-Sky Association's website for sources to obtain appropriate lighting (https://www.darksky.org/our-work/lighting/lighting-for-industry/fsa/fsa-products/).

Objective 1.3: Reduce stormwater runoff and filter its pollutants

Action 1.3.1: **Include various types of vegetation adjacent to any impermeable surfaces**. The best and most efficient way of doing this would be to utilize the existing vegetation that already covers most of the site. Virginia's 15 BMPs should also be included when appropriate.

Image 21:
Example of a Virginia Stormwater BMP, Dry Swale

Source: Marshall Landscaping, https://www.marshalllandscapingllc.com/7-water-management-solutions-for-proper-drainage

Action 1.3.2: **Construct parking lots using porous asphalt or pervious concrete where possible**. The site contains multiple large sections of land, near the park entrance, that have sand or loamy soils and are part of the hydrologic soil group 'B.' These soils have a moderate infiltration rate and should be suitable for accommodating permeable pavement.

Objective 1.4: Inform staff and the public on concepts and care of a sustainable park

Action 1.4.1: **Provide a community center in the park that can hold various programs and classes**. These classes can be made available to the public and to staff. The community center can also host other community events as necessary. Programs and

classes should be worked on closely with the Recreation side of the Parks and Recreation Department to ensure that sustainable concepts continue to be taught and practiced after the construction of the park.

Action 1.4.2: **Hold lunch and learn sessions for Department staff to provide educational opportunities about current sustainable practices in parks**. Programs, classes, and lunch and learn sessions should be coordinated with the County Naturalist and should continue even after the park is completed.

Action 1.4.3: **Implement a walkable green roof system on the community center**. Make the green roof accessible to the public and provide opportunities for interactive classes. The vegetation grown on the roof can include a variety of natives species for the interactive classes or just for observation and relaxation; this space could also be used for a community garden. The green roof will also assist in stormwater management and the reduction of the urban heat island effect. Image 22 shows an example of how New York City Parks has implemented walkable green roof systems.

Image 22:
NYC Parks Walkable Green Roof System

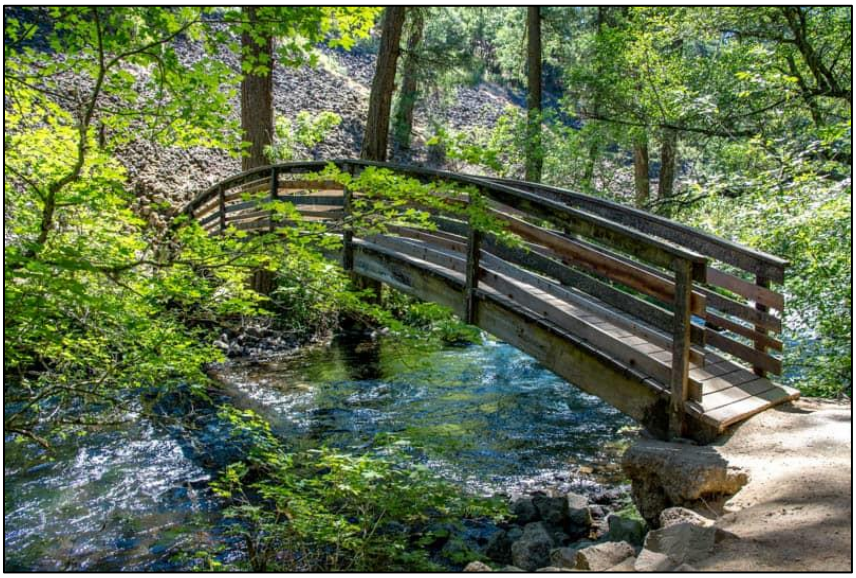
Source: Greenroofs.com, https://www.greenroofs.com/projects/nyc-parks-five-borough-5-boro-administrative-building/

Objective 1.5: Protect and maintain the Resource Protection Area (RPA)

Action 1.5.1: **Include a simple trail system throughout the RPA**. Trails are one of the very few uses permitted within an RPA, and they should remain unpaved except for cases when prevention of excessive erosion is necessary. Any development within the RPA must first be approved by the Department of Environmental Engineering.

Action 1.5.2: **Construct a bridge over Tomahawk Creek that connects to the County's proposed bike path to the west of the park**. Connecting the proposed bike path to the park would provide an important, additional access point for pedestrians to Windmill Ridge Park. An additional bridge could be included across the gully found in the middle of the park and can also be part of the trails system. Both bridges would likely only be 10-20 feet long, depending on where they are built, and should be about 8 feet wide. The bridge should be more than three feet above the creek to avoid potential damming and flooding of the creek. An extension to the County's bike paths and trails should be coordinated with the Bikeways and Trails Committee in the Planning Department. Image 23 shows an example of a simple bridge that can be included over the creek.

Image 23:
Precedent Image of Rainbow Bridge at Burney Creek, CA



Source: https://roadtrippingcalifornia.com/burney-falls-hike/

Goal 2: Promote Social Equity

Objective 2.1: Make Windmill Ridge Park accessible to as many residents as possible

Action 2.1.1: **Construct sidewalks and crosswalks in the adjacent Watermill Community and around the site**. There are currently no sidewalks—or any other pedestrian infrastructure—leading to the park; there is one sidewalk across Windmill Ridge Drive from the park (see Image 24), but it only extends along the one side of Windmill Ridge Drive, and there are no crosswalks from the sidewalk to the park. A sidewalk should be installed along Windmill Ridge Drive that is on the same side as the park, along with periodic crosswalks (see Figure 13). Adding additional pedestrian

infrastructure to this neighborhood would provide safer access to the park for pedestrians, especially children that live close enough to walk. New pedestrian infrastructure in or near the Watermill Community should be planned with CDOT and VDOT.

Image 24:
Single Sidewalk in the Watermill Community

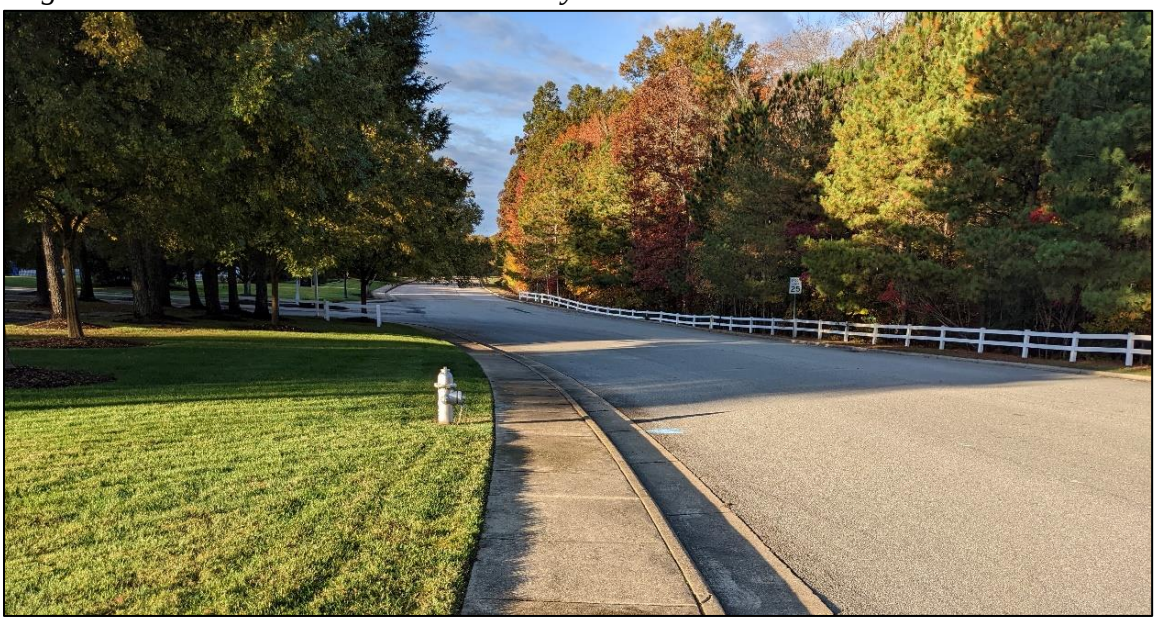


Photo Credit: Sean Benson

Action 2.1.2: **Meet with the Brandermill Community Association (BCA) to discuss the possibility of connecting their trails to the new trails and pedestrian infrastructure in the park**. The Brandermill Community has an extensive trails system throughout (see Appendix D for a map of their trails obtained from the BCA website), and part of the community borders Watermill Parkway, directly across from Windmill Ridge Park. Additional pedestrian infrastructure, such as flashing crosswalk lights, can provide added safety for crossing Watermill Parkway by alerting drivers of pedestrian crossings (see Figure 13). Connecting trails and providing pedestrian lights would provide easier, safer access for residents of Brandermill to the park. Any connections made should be discussed with the BCA and the Bikeways and Trails Committee. Discussing connections with the BCA is particularly important as their trails are HOA owned and operated and are not open to the public. Steps may need to be taken to connect the trails that provides easier access for Brandermill residents to the park while also discouraging non-residents from using the BCA trails.

Figure 13:
Map of Existing and Proposed Pedestrian Infrastructure

Action 2.1.3: **Extend pedestrian infrastructure further out to areas not directly adjacent to the park, such as Tomahawk Creek Middle School**. The service radius of the park is three miles, which includes neighborhoods and schools beyond the Watermill and Brandermill communities; these additional areas need and deserve better access to county parks as well—especially the areas with higher poverty rates mentioned previously in the Existing Conditions section. Trails can extend from the park to connect with Tomahawk Creek Middle School, the neighborhood directly to the north of the park, and the County's proposed trail that runs along Woolridge road (see Figure 13). This action may take longer than others, but it can be achieved with the help of PlanRVA, CDOT, and Safe Routes To Schools (SRTS). SRTS is a program under VDOT that provides grant assistance in developing pedestrian infrastructure to and from schools, and teaching children safe pedestrian/cycling practices. Since Windmill Ridge Park is surrounded by homes and is near schools, like Tomahawk Creek Middle School, the County's Parks and Recreation Department can work in a joint effort to provide trails and paths that connect residents to the park and the schools.

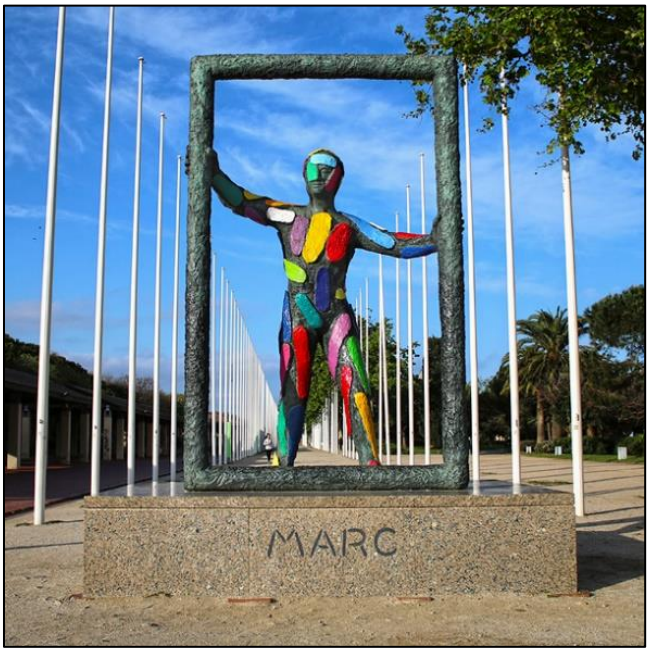
Objective 2.2: Design a park that is specific and authentic to the community

Action 2.2.1: **Perform extensive public outreach to learn what the community wants and needs from Windmill Ridge Park**. One recommended method of doing this is by running pop-up public engagement sessions where the people can visit and explore the site, then provide their ideas and feedback of preliminary concepts. Public outreach can also serve as opportunities to teach the public about sustainable park design. Outreach should continue periodically after the park is completed to learn of any changing needs from the community—this can be made easier by implementing Action 2.3.1.

Action 2.2.2: **Avoid the use of generalized design standards used in other county parks**. Due to the uniqueness of every site, a design standard that works in one park may not work in others. It is highly recommended that custom designs be used for equipment, rather than picking from a catalog. To make Windmill Ridge Park specific and authentic, it must be designed to fit the environment of its specific site and the needs of the community. Consider also contracting with a firm the Parks and Recreation Department doesn't normally work with, that also has sustainability practices and goals.

Action 2.2.3: **Include murals, sculptures, or other artwork that showcases the unique identity of Windmill Ridge Park**. Adding artwork to the park can play a useful part in addressing the specificity and authenticity of sustainable design by creating a place that represents the community. The artwork should be unique, not a replication of already existing art (see Image 25). When possible, provide priority to artwork created by the park community in order to represent its members. Make the artwork possible to be rotated out with new artwork over time to better represent the changing community. The artwork, especially sculptures, should be available to be interacted with, whether that be as a form of seating or simply a gathering spot and point of discussion.

Image 25:
Public Art in Barcelona, Spain



Source: https://art-barcelona-streets.blogspot.com/

Objective 2.3: Be adaptable to the changing needs of the community

Action 2.3.1: **Create an advisory board that is run by community members and reflects community demographics**. The advisory board will act as a liaison between the community and the County for the park; they will do this by informing the community of any upcoming changes or events and likewise informing the County of the community's wants and needs. They will also help determine the policies and management of the site. The board members will serve for a specific predetermined amount of time, near the end of which an analysis of community demographics will be performed to see if any major changes have happened—such as a major increase or decrease in the percentage of any racial groups—and new board members will then be selected accordingly. This board could potentially serve as a branch of the Parks and Recreation Advisory Commission (PRAC). PRAC is a group of county citizens that act as a liaison between the public, the board of supervisors, and County Administration—with regards to parks and recreation facilities (Chesterfield Parks and Recreation, n.d.-a). PRAC's purpose is very similar to the advisory board, but there are some key differences: PRAC members are appointed by the Board of Supervisors, but Windmill Ridge Park's advisory board would be chosen by the community; the advisory board would represent just Windmill Ridge Park; and the advisory board demographics would reflect the community's demographics.

Action 2.3.2: **Terrace one of the many hills in the park to provide amphitheater style seating and a multi-use space for the community**. This amphitheater style space can be adapted for multiple uses such as outdoor classes/programs or small community events (see Image 26). The amphitheater also provides a great space to include some of the artwork recommended in Action 2.2.3. Keep trees around the amphitheater to provide shade.

Image 26:
Precedent Image of a Small, Open-air Amphitheater

Source: iStock. https://www.istockphoto.com/photo/open-air-theater-gm474316541-34932720

Objective 2.4: Provide a park that is functional for the community by including a variety of uses

Action 2.4.1: **Include a small selection of athletic courts, based on what the community wants most**. There are five other county parks that are within a couple miles of Windmill Ridge Park that are athletics focused, so Windmill Ridge Park should not be athletics focused; however, in order to attract a larger variety of people, a few options should be made available, such as basketball, pickleball, and tennis. Soccer—or other field sports such as lacrosse—should not be included due to the park's proximity to River City Sportsplex that has 12 fields designed for these sports.

Action 2.4.2: **Construct a unique playground and adjacent splash pad or other water feature**. A playground and splashpad will attract children and their parents, especially during the more pleasant times of the year when people want to escape their homes and be outdoors. A splash pad will be particularly useful and unique, since Chesterfield County lacks public splash pads, or other free water features. Residents with children that want to cool off and have fun during the hot summer months frequently have to drive to Henrico or Richmond to play or relax in the water, if they don't have access to a

gated community pool. One potential option for a unique playground is a natural play area, such as those found at James River State Park or James Madison University Arboretum (see Image 27). Consider working with a company such as All Recreation, that has experience making unique playgrounds that are also accessible for people with disabilities.

Image 27:
Natural Play Area at the James Madison University Arboretum

Photo Credit: Meghan Gough

Action 2.4.3: **Provide many spaces to relax and observe nature or socialize**. This can include an extensive trail network and a variety of seating options such as benches, picnic areas, or even some of the art mentioned in Action 2.2.3 can be designed with the intent to have people sit on and interact with it. The most common responses to the online survey for this park, and from surveys performed by other researchers, were to relax and observe nature—an extensive trail system encourages exploration of the park's more than 40 acres of nature while a variety of seating options allows people to choose the spaces that make them most comfortable.

Goal 3: Be Economically Efficient

Objective 3.1: Shift to an adaptive management method that can adjust to future needs

Action 3.1.1: **Design the first plan for the park to be adjustable for future planned development**. An area on site can be reserved to be one of the future recycling drop-off locations the County is planning to place in their parks, which should be coordinated with the Waste and Resource Recovery Division. The park should also be designed to accommodate an increased number of visitors over the years, since the County expects increased development and population growth just to the west of Windmill Ridge Park.

Action 3.1.2: **Minimize potential impacts from the Powhite Parkway extension.** The County is planning an extension for Powhite Parkway, which will run along the northern edge of Windmill Ridge Park (see Figure 13 under Action 2.1.2); athletic fields and courts can be placed along that same northern edge, since they will require the removal of large areas of vegetation, which will minimize the amount of additional vegetation that will need to be removed when the extension is built. The extension would also cut off a proposed trail that would connect the park to the neighborhood just to the north of it. To prepare for this, an underpass could be constructed that would serve two purposes: to provide additional pedestrian access to the park and to provide a space for additional artwork in the form of murals along the underpass walls. The underpass could be similar in length and design to the one located at Midlothian Mines Park (see Image 28).

Image 28:
Midlothian Mines Park Underpass

Photo Credit: Sean Benson

Action 3.1.3: **Organize a friends of the park group to assist in park management**. A friends of the park group will be a volunteer based group that is run by the advisory board recommended in Action 2.3.1. The volunteer group will provide needed care and management of the park, and the advisory board will provide the connection to the County to obtain resources needed by the volunteer group.

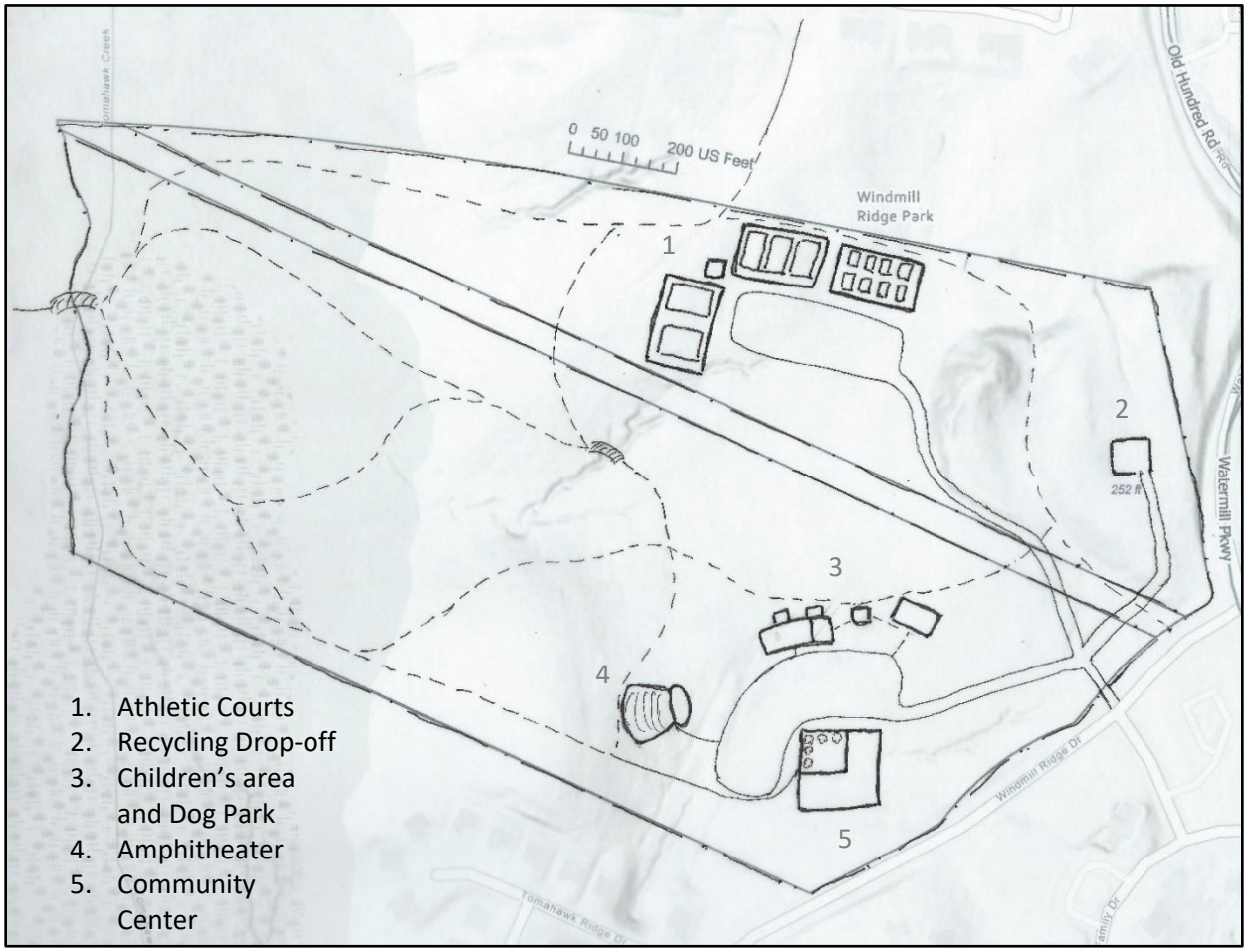
Objective 3.2: Provide multiple recycling options

Action 3.2.1: **Mulch or chop up trees that are removed for construction, and trees that are dead or diseased**. The Parks and Recreation Department already has experience doing this, so this process should be familiar and easy to implement. Mulching the trees during construction and spreading it throughout the construction site can help reduce erosion, then it can be spread back into the wooded areas to decompose. Some mulch can be set aside, as well as chopped up wood, for residents to use in home projects or as firewood.

Action 3.2.2: **Provide free, public composting stations for leaves and food waste**. Composting stations provide a space for park staff and community residents to drop-off leaves or food waste that can then be accessed for free by anyone to use in park or home projects. This can be particularly helpful if community gardens are included in the park, and the compost station could be placed in the recycling drop-off location that was recommended in Action 3.1.1. These and any other recycling efforts can be implemented with the help of the Waste and Resource Recovery Division.

Concept Design

Figure 14:
Concept Map of Windmill Ridge Park



There is no single perfect design for Windmill Ridge Park, but Figure 14 shows one potential, concept design. The darkened area in the western quarter of the map represents the RPA and wetlands. The total amount of tree cover that would need to be removed for this design is approximately 5 acres, or about 10.6% of the site.

In Figure 14, Area 1 is for athletic courts—this design shows basketball, pickleball, and tennis courts, which were the top 3 active recreational facilities chosen from the survey. Area 2 is a recycling drop-off location that can also include a composting station. Area 3 includes a playground, attached splash pad and adjacent pavilions or picnic areas, as well as a dog park. Area 4 is a small amphitheater built into the side of one of the park's hills. Area 5 is a community center and small courtyard, where different classes, programs, or events can be held. The roof should be a green roof that can either be a way to provide interactive classes that teach about native plants, conservation, and sustainability, or can include community gardens.

The dashed lines are trails with a bridge over the gully found in the middle of the park, and a bridge at the western end of the park over Tomahawk Creek (see Figure 14). The trails should contain periodic resting points or gathering spaces with benches, or some other form of seating. Artwork can also be included along the trails at the gathering spots—this design includes almost 2 miles of trails.

The parking and roads in the northern end of the park around the athletic courts should be conventional asphalt, due to the poor soil conditions; however, the parking and roads around the children's play area, amphitheater, and community center should have soil suitable for permeable pavement (see Figure 14).

Implementation

The implementation section of this plan provides a timetable for development phases. Each recommended action is to be completed either short-term (1-2 years), mid-term (3-5 years), long-term (more than 5 years), or continuous. Suggested stakeholders and partner organizations have also been included with each action in the timetable. The actions were shortened and abbreviations of partner organizations are used to make everything easier to fit in the table. Full descriptions of the actions can be found in the Recommendations section, and a legend is provided below for the abbreviations and their corresponding organization; the implementation timetable follows on the proceeding pages.

	Partnership Legend	**CN**	County Naturalist
AR	All Recreation	**CRC**	Capital Region Collaborative
BCA	Brandermill Community Association	**EE**	Environmental Engineering
BTC	Bikeways and Trails Committee	**IDA**	International Dark-Sky Association
CC	Chesterfield County	**P&R**	Parks and Recreation
CEV	Community Engagement and Volunteerism	**SRTS**	Safe Routes To Schools
CM	Communications and Media	**WRRD**	Waste and Resource Recovery Division

Table 3: Implementation Timetable

		Short	Mid	Long	Partnering
Goal 1: Maintain Environmental Integrity					
Objective 1.1: Design with nature to determine and enhance the identity of the park	Action 1.1.1: Determine the unique identity of the site				P&R, DCR, DHR
	Action 1.1.2: Design structures to utilize natural ventilation				Consultant
	Action 1.1.3: Orient structures to utilize as much natural light as possible				Consultant
Objective 1.2: Preserve the native plant and animal species in the park	Action 1.2.1: Retain as much existing, native tree cover as possible	Continuous			P&R, DCR
	Action 1.2.2: Use native grass species in place of turf				P&R
	Action 1.2.3: Use warm temperature, downward facing lighting throughout the park				IDA, Utilities
Objective: 1.3: Reduce stormwater runoff and filter its pollutants	Action 1.3.1: Include various types of vegetation adjacent to any impermeable surfaces				EE, P&R
	Action 1.3.2: Construct the parking lot using porous asphalt or pervious concrete				Consultant
Objective 1.4: Inform staff and the public on concepts and care of a sustainable park	Action 1.4.1: Provide a community center in the park that can hold various programs and classes				Consultant
	Action 1.4.2: Hold lunch and learn sessions for staff	Continuous			CN, P&R
	Action 1.4.3: Implement a walkable green roof system on the community center				P&R, CN, Consultant
Objective 1.5: Protect and maintain the Resource Protection Area	Action 1.5.1: Include a simple trail system throughout the RPA				EE, Consultant
	Action 1.5.2: Construct a bridge over Tomahawk Creek that connects to the County's proposed bike path				EE, BTC, Consultant

Goal 2: Promote Social Equity					
Objective 2.1: Make Windmill Ridge Park accessible to as many residents as possible	Action 2.1.1: Construct sidewalks and crosswalks in the adjacent Watermill Community and around the site				PlanRVA, VDOT, CDOT
	Action 2.1.2: Connect the Brandermill Community's trails to the park				BCA, BTC, P&R
	Action 2.1.3: Extend pedestrian infrastructure further out to areas not directly adjacent to the park				VDOT/SRTS, CDOT, PlanRVA
Objective 2.2: Design a park that is specific and authentic to the community	Action 2.2.1: Perform extensive public outreach	Continuous			CEV, CM, P&R, Consultant
	Action 2.2.2: Avoid the use of generalized design standards	Continuous			AR, Consultant
	Action 2.2.3: Include murals, sculptures, and other artwork				CRC
Objective 2.3: Be adaptable to the changing needs of the community	Action 2.3.1: Create an advisory board that is run by community members and reflects community demographics	Continuous			CC, P&R
	Action 2.3.2: Terrace one of the many hills in the park to provide amphitheater style seating and a multi-use space				Consultant
Objective 2.4: Provide a park that is functional for the community by including a variety of uses	Action 2.4.1: include a small selection of athletic courts				P&R, Consultant
	Action: 2.4.2: Construct a unique playground and adjacent splash pad				AR, P&R
	Action 2.4.3: provide many spaces to relax and observe nature or socialize				P&R, Consultant
Goal 3: Be Economically Efficient					
Objective 3.1: shift to an adaptive management method that can adjust to community needs	Action 3.1.1: Design the first plan for the park to be adjustable for future planned development				P&R, WRRD, Consultant
	Action 3.1.2: Organize a friends of the park group to assist in park management				P&R
Objective 3.2: Provide multiple recycling options	Action 3.2.1: Mulch or chop up trees that are removed from the park	Continuous			P&R
	Action 3.2.2: Provide free, public composting stations for leaves and food waste				P&R, WRRD

Summary

The sustainable concepts presented in this plan should continue to be thoroughly researched and then implemented, not only in Windmill Ridge Park, but throughout Chesterfield Parks and Recreation's plans and designs for all County's parks. The concepts discussed and the recommendations made in this plan provide a solid framework for Chesterfield County moving forward in implementing sustainable practices.

Windmill Ridge Park is an excellent site for a sustainable park. With the land being already owned by the Parks and Recreation Department, being undeveloped land, and due to it being currently unplanned for in the department's master plan, it can be designed on a clean slate from the ground up, around sustainable practices. The Parks and Recreation Department should strive to expand its current sustainable practices beyond just the environment to include promoting social equity and economic efficiency. This will require new, creative, and innovative ways of thinking, but will not only be good for the environment but also beneficial to the community and the County as a whole.

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Appendices

Appendix A: *Survey Questions and Results*

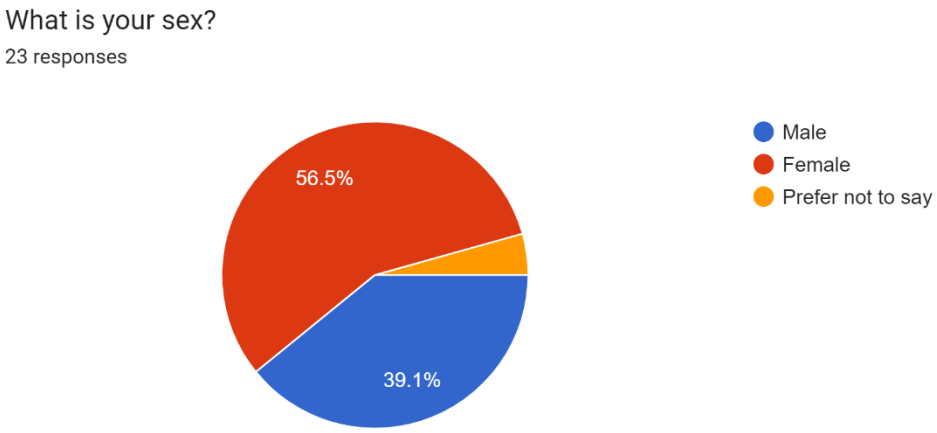


Figure A1: *Survey Respondents' Sex*

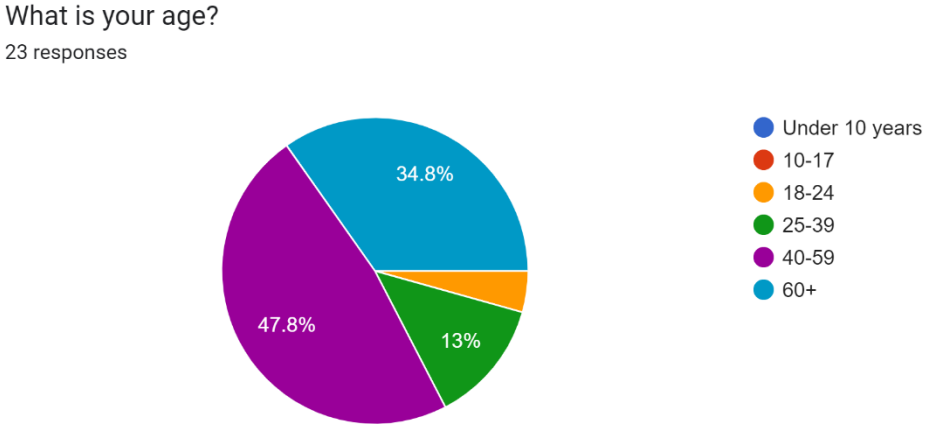


Figure A2: *Survey Respondents' Age*

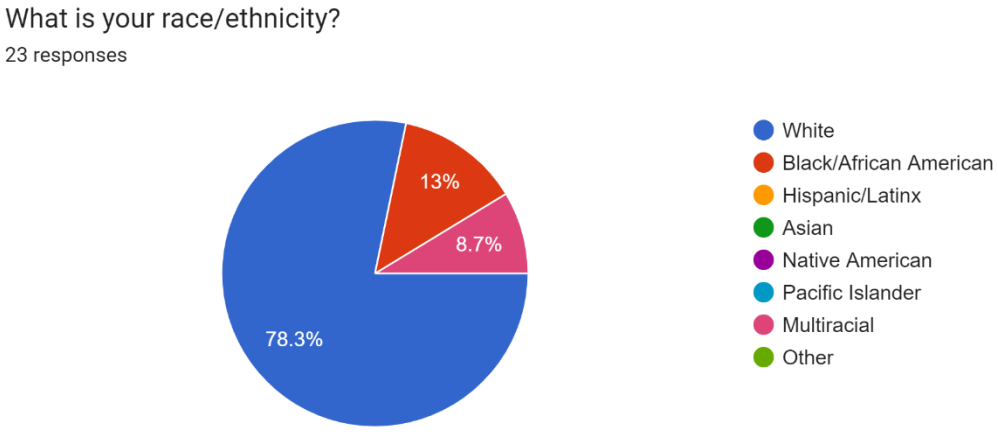


Figure A3: *Survey Respondents' Race/Ethnicity*

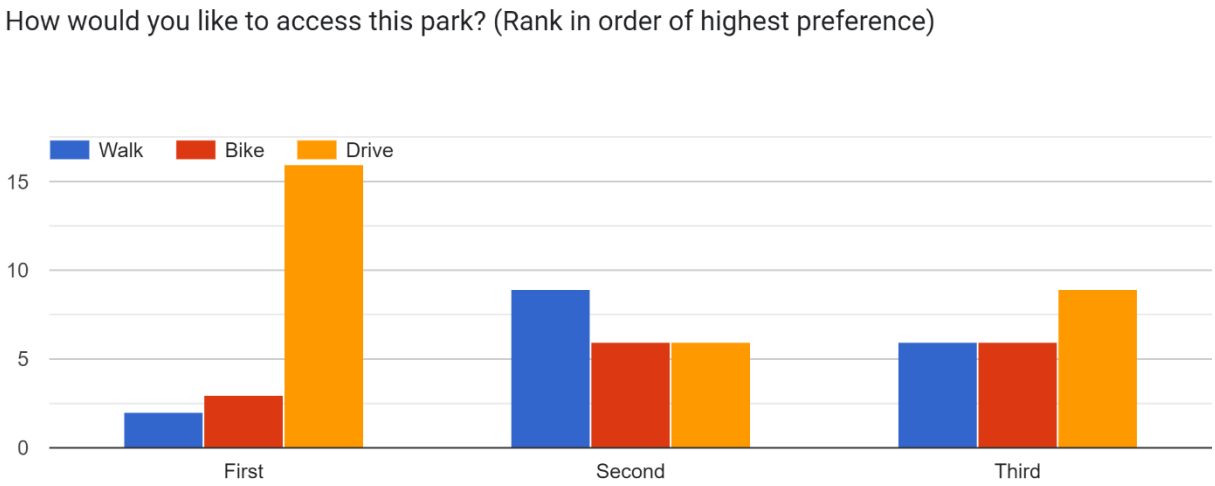


Figure A4: *How Respondents Prefer to Access Parks*

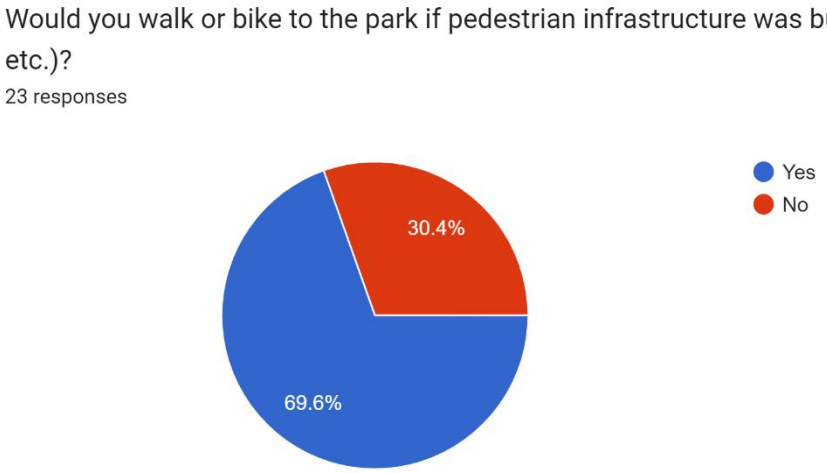


Figure A5: *Respondents' Desire to Walk to Parks*

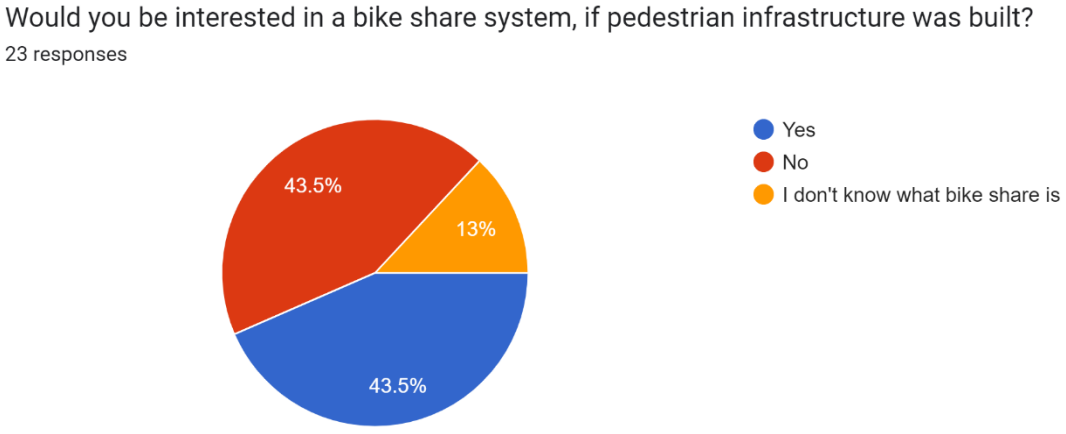


Figure A6: *Respondents' Interest in Bike Share*

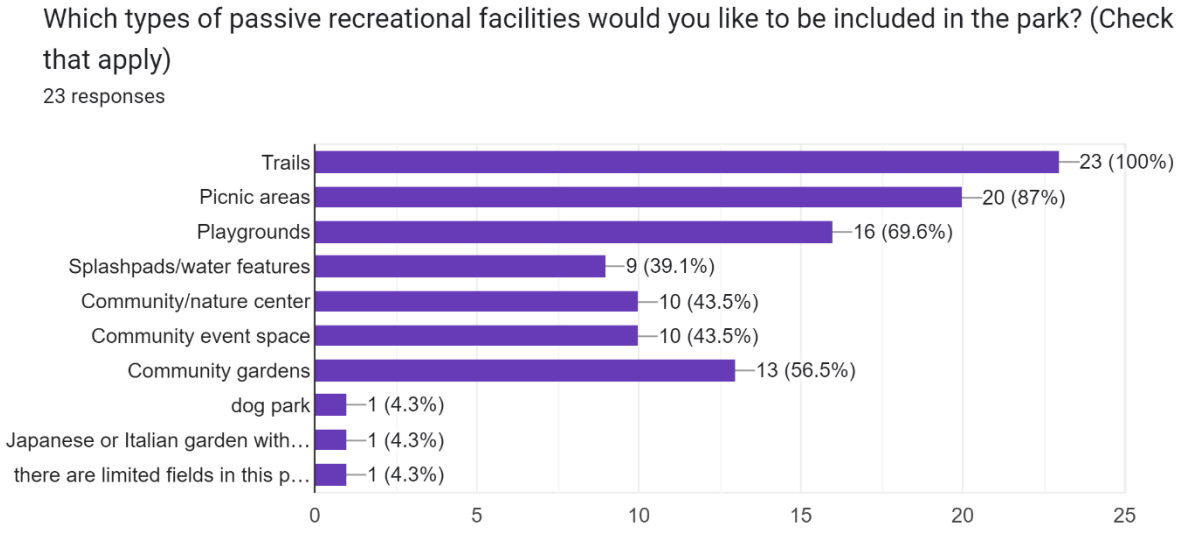


Figure A7: *Desired Passive Recreational Facilities*

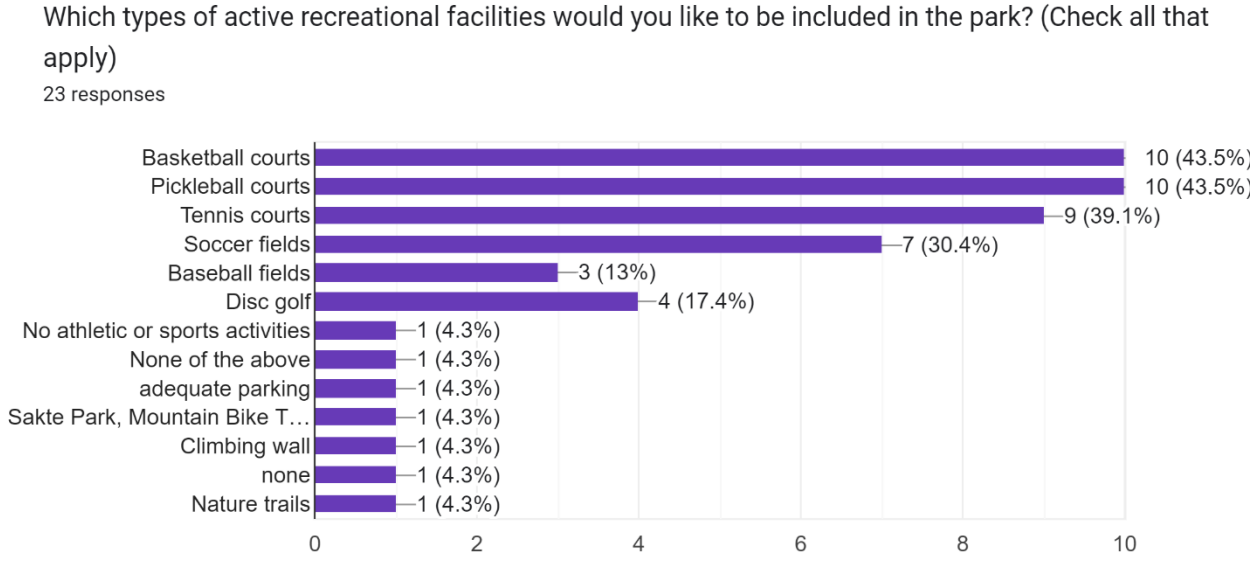


Figure A8: *Desired Active Recreational Facilities*

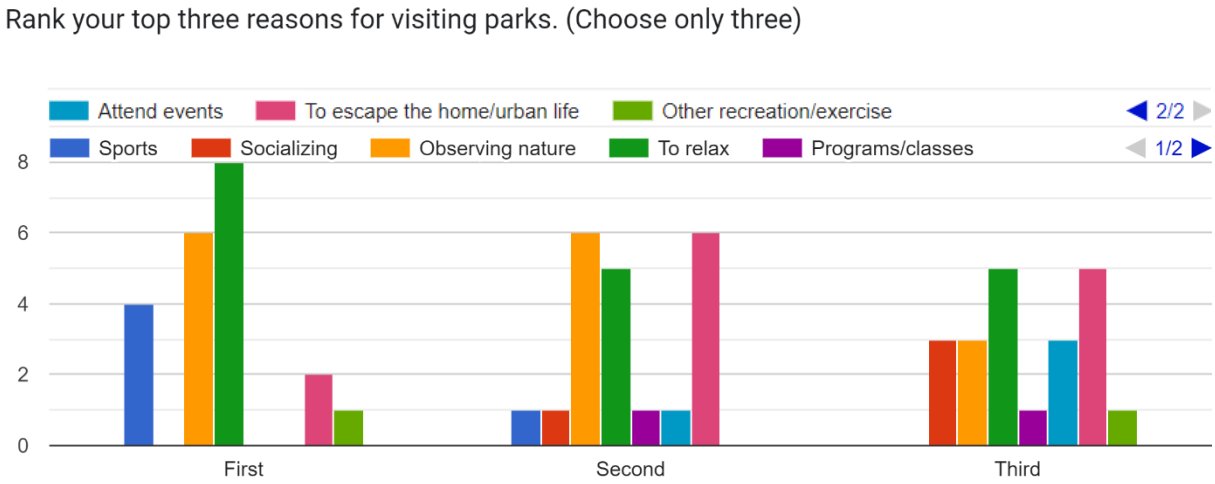


Figure A9: *Top Three Reasons for Visiting Parks*

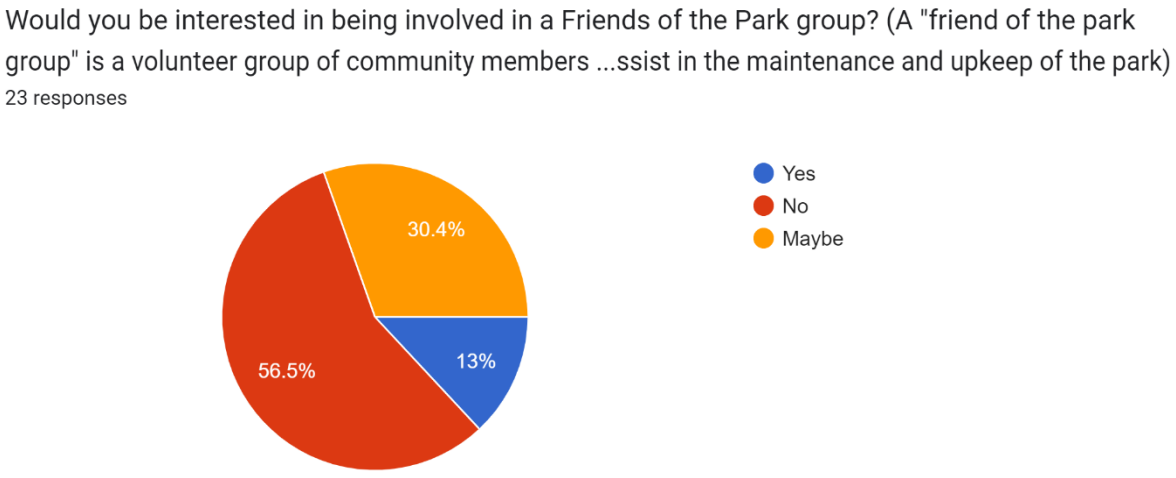


Figure A10: *Interest in a Friends of the Park Group*

Appendix B: *Focus Group Agenda and Poll*

Windmill Ridge Park Focus Group Agenda

Goal

To determine which sustainable design elements would be possible for Windmill Ridge Park, and which elements support current Parks and Recreation priorities.

Icebreaker/introductions:

Agenda

1. Introduce the site for Windmill Ridge Park
2. Present sustainable concepts
3. Ask questions/facilitate discussion

Questions

- Do you have any questions about the site?
- Do you have any questions about sustainability and what it means to park planning?
- Do you feel sustainability in parks is important?
- Has the County ever worked with a "friends of the park" group that assists with the maintenance/management of the park?
- Why doesn't the County have water features at any of their parks?
    - How feasible would it be to put in a splashpad or similar water features at this site?
- How can we improve County recycling programs in Windmill Ridge Park?
- Which components of sustainability do you think are most important to a sustainable park? (Do a poll/ranking in Zoom if they don't provide answers)
    - For example, is there a priority in purchasing materials that are sustainable? (use as a prompt)
    - Which sustainable concepts do you think the County would be the most interested in implementing?
    - Does the County have priority areas? – connection to Comp plan
- What do you see as the primary limitations to developing a sustainable park?
    - How can we inform staff on sustainability for parks?
    - What additional information could be helpful for the rest of County staff?
- How is the department adapting to changing needs of county residents?

Which components of sustainability do you think are most important to a sustainable park?						
	Person 1	**Person 2**	**Person 3**	**Person 4**	**Person 5**	**Person 6**
Pedestrian access	X	X	X	X	X	
Recycling	X		X			
Variety of activities	X	X				
Use of sustainable materials in construction	X		X			
Stormwater runoff reduction and filtration	X	X	X	X	X	
Volunteer groups	X					
Design efficiency	X	X	X	X		
Unique/specific to location	X	X				
All of the above	X					

Table B1: *Focus Group Poll Results*

Appendix C: *Soil Survey Report*

This soil report only contains the soils found within the Windmill Ridge Park site—the shape file obtained of the soils was clipped using the shapefile of the park boundary. Soil information was obtained from the USDA's web soil survey (U.S. Department of Agriculture, n.d.). The report from the USDA contains all information of each soil type in the area, but for simplicity in this plan, the report was trimmed to focus on the information related to the slopes, drainage class, runoff class, and hydrologic soil groups—full reports and explanations of each soil type and classification can be found on the USDA's website.

1A—Fluvaquents

Description of Fluvaquents

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 40 inches: silty clay loam *H3 - 40 to 50 inches:* sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches *Drainage class:* Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr) *Depth to water table:* About 0 to 12 inches
Frequency of flooding: NoneFrequent
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: B/D
Ecological site: F136XY600NC - Flood plain swamp forest, hydric soils
Hydric soil rating: Yes

59C—Mayodan sandy loam, clayey substratum, 6 to 12 percent slopes

Description of Mayodan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex

Across-slope shape: Convex
Parent material: Triassic clayey sandstone and shale

Typical profile

H1 - 0 to 12 inches: sandy loam
H2 - 12 to 16 inches: sandy clay loam
H3 - 16 to 44 inches: clay
H4 - 44 to 70 inches: clay

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F136XY420NC - Triassic basin upland forest, moist *Hydric soil rating:* No

61B—Creedmoor fine sandy loam, 2 to 6 percent slopes

Description of Creedmoor

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Triassic clayey sandstone and shale

Typical profile

H1 - 0 to 10 inches: fine sandy loam
H2 - 10 to 15 inches: sandy clay loam
H3 - 15 to 43 inches: clay
H4 - 43 to 60 inches: sandy clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches *Drainage class:* Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 12 to 30 inches
Frequency of flooding: None

Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: D
Ecological site: F136XY410NC - Triassic basin upland forest, seasonally wet
Hydric soil rating: No

Minor Components

Worsham

Percent of map unit: 3 percent
Landform: Depressions
Hydric soil rating: Yes

61C—Creedmoor fine sandy loam, 6 to 12 percent slopes

Description of Creedmoor

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Triassic clayey sandstone and shale

Typical profile

H1 - 0 to 10 inches: fine sandy loam
H2 - 10 to 15 inches: sandy clay loam
H3 - 15 to 43 inches: clay
H4 - 43 to 60 inches: sandy clay loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 12 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: F136XY410NC - Triassic basin upland forest, seasonally wet
Hydric soil rating: No

61C2—Creedmoor fine sandy loam, 6 to 12 percent slopes, eroded

Description of Creedmoor

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Triassic clayey sandstone and shale

Typical profile

H1 - 0 to 10 inches: fine sandy loam
H2 - 10 to 15 inches: sandy clay loam *H3 - 15 to 43 inches:* clay
H4 - 43 to 60 inches: sandy clay loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 12 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: F136XY410NC - Triassic basin upland forest, seasonally wet
Hydric soil rating: No

151C—Mayodan gravelly sandy loam, clayey substratum, 6 to 12 percent slopes

Description of Mayodan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Triassic clayey sandstone and shale

Typical profile

H1 - 0 to 12 inches: gravelly sandy loam
H2 - 12 to 16 inches: sandy clay loam
H3 - 16 to 44 inches: clay
H4 - 44 to 70 inches: clay

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F136XY420NC - Triassic basin upland forest, moist
Hydric soil rating: No

151D—Mayodan gravelly sandy loam, clayey substratum, 12 to 20 percent slopes

Description of Mayodan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Triassic clayey sandstone and shale

Typical profile

H1 - 0 to 12 inches: gravelly sandy loam
H2 - 12 to 16 inches: sandy clay loam
H3 - 16 to 44 inches: clay
H4 - 44 to 70 inches: clay

Properties and qualities *Slope:* 12 to 20 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F136XY420NC - Triassic basin upland forest, moist

Hydric soil rating: No

261B—Bourne-Colfax complex, 2 to 6 percent slopes

Description of Bourne

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy marine deposits

Typical profile

H1 - 0 to 11 inches: sandy loam
H2 - 11 to 22 inches: sandy clay loam
H3 - 22 to 44 inches: fine sandy loam *H4 - 44 to 72 inches:* clay

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches *Drainage class:* Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 12 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e *Hydrologic Soil Group:* C
Hydric soil rating: No

Description of Colfax

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy granite and gneiss

Typical profile

H1 - 0 to 8 inches: fine sandy loam
H2 - 8 to 24 inches: sandy clay loam
H3 - 24 to 40 inches: sandy clay loam
H4 - 40 to 86 inches: clay
H5 - 86 to 117 inches: sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Somewhat poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: F136XY810SC - Acidic upland forest, seasonally wet
Hydric soil rating: No

Minor Components

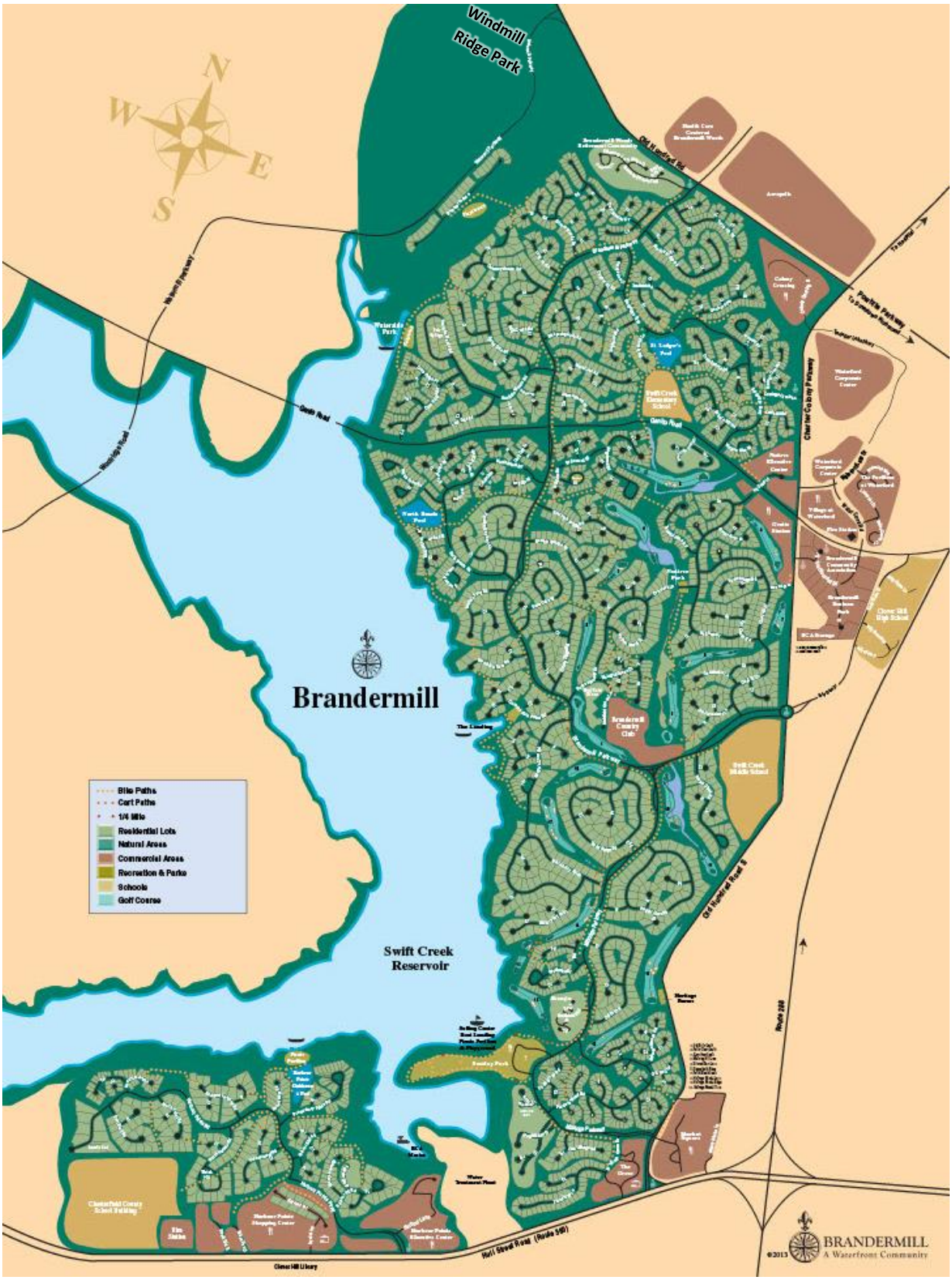
Worsham

Percent of map unit: 3 percent
Landform: Depressions
Hydric soil rating: Yes

Data Source Information

Soil Survey Area: Chesterfield County, Virginia
Survey Area Data: Version 15, Aug 24, 2022

Appendix D: *Brandermill Community Trails Map*



Source: Brandermill Community Association, https://brandermill.com/trails/