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The Green Infrastructure Network: Mapping Hopewell's Social & Natural Assets

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Introduction

Plan Purpose:

The City of Hopewell sits at the confluence of the James and Appomattox Rivers, which feed directly into the Chesapeake Bay. Hopewell's location within these major watersheds can contribute to the vulnerability of residents through flooding and coastal erosion (Kulp & Strauss, 2019), as well as result in waterway degradation from issues like pollution, stormwater runoff, and other negative impacts of human development (Arnold & Gibbons, 1996). These issues are exacerbated by climate change and the increase in the frequency and intensity of weather events (Stott, 2016). Climate change, along with industry and development patterns, contribute to environmental concerns with negative health effects like urban heat islands, poor air quality, access to green space, food security, and urban flooding (Singh et al., 2020; Brink et al., 2016). Many of these issues, especially urban flooding, and heat islands, are magnified when observed in lower-income and minority neighborhoods (Saverino et al., 2021; Capps & Cannon, 2021).

Confluence of the James & Appomattox Rivers

An emerging approach to combating these issues is resilience planning. Urban resilience is the ability of an urban area or community to achieve normal operations through reasonable buffering and responses to disturbances (Shi et al., 2021). Significant efforts have been made regionally and at the state level to address and plan for resilience. The "Virginia Coastal Resilience Master Plan" creates a resilience framework and acts as a call to action for localities to create and implement their resilience strategies at a local level (DCR, 2021). While the Virginia Coastal Resilience Master Plan is primarily focused on coastal flooding due to climate change across the state, the Resilience Adaptation Feasibility Tool's (RAFT) Crater resilience report contributes a more local understanding of resilience, through a significant research project focused on the Crater region, including the cities of Hopewell and Petersburg (RAFT & CPDC, 2022). Recognizing the urgency of resiliency planning, the Commonwealth of Virginia has recently adopted regulations that require local governments to assess the impacts of climate change and sea-level rise on any proposed land development in the Chesapeake Bay Resource Protection Areas (9VAC25-830-155).

The Green Infrastructure Network Plan (GINP) builds on concepts from RAFT's Crater Resilience study and the Virginia Coastal Resilience Master Plan. These plans prioritize the use of nature-based solution strategies; protection, and enhancement of green infrastructure (DCR, 2021); and measure resilience success by the number of green infrastructure

projects (RAFT & CPDC, 2022). Green infrastructure (GI) can be defined as planned or unplanned green spaces integrated to provide benefits or "ecosystem services" (Parker & Simpson, 2018). The GINP provides a map of the network of physical GI and the actors involved in GI projects in Hopewell. Green Infrastructure is mapped spatially with GIS and distinguishes between the various forms of GI present in the city. A network map visualizes the relationships between actors, and their relationships with GI in Hopewell.

While the GINP is not a resilience plan on its own, it fosters resilience in Hopewell by connecting actors like city departments, state agencies, residents, business owners, and local and regional stakeholder organizations for all aspects of GI projects including maintenance, funding, planning, volunteering, and installation. The network mapping platform Kumu, and the spatial distribution of GI throughout the city provides knowledge and visualization of these social interactions and acts as a tool for future use.

Client Description:

The client, the City of Hopewell, is represented by two departments: The Department of Development and the Department of Public Works (DPW). The Department of Development is represented by Kelly Davis, who currently works as the Senior Planner for the City of Hopewell. The department guides the development of Hopewell through processes that promote safety in the design and construction, rehabilitation, and re-use of buildings. The department also uses public engagement and research analysis to serve as a guide, not only for development but also for the creation of long-range plans like the city's Comprehensive Plan.

The DPW is represented by Michael Campbell, who currently works as the director of Hopewell's DPW. The DPW is responsible for maintaining city infrastructure, and vitally important to this plan, managing the city's solid waste and stormwater systems. The multifunctionality of GI and its range of ecosystem benefits is what fosters collaboration between departments for this proposal.

Outline:

This plan analyzes Hopewell's GI network of social-ecological assets and their relative interactions. By applying "systems" thinking (Ridder et al., 2017), and an Asset-Based Community Development (ABCD) (García, 2020) theoretical framework to resilience concepts, social and ecological assets related to GI were identified in Hopewell. To ensure a comprehensive understanding of the social actors involved, a wide variety of content has been analyzed, and a diverse range of participants interviewed. Actors interviewed included members of city departments, local and regional organizations, city representatives, and residents. Ecological, or natural assets include the physical GI and its location, and range in scales from regional to local and site scale GI. Notable GI in Hopewell ranges from stormwater greenways and riverside buffer parks to pocket parks, rain gardens, and larger city parks. Interactions between assets are visualized through the

KUMU platform, and interactions range from installation, funding, planning, and maintaining GI; and interactions between social assets, like the collaboration efforts made between the Chesapeake Bay Foundation and several city departments.

To provide context for the theories and concepts, a literature review was conducted in the next section. The subsequent section provides an analysis of the planning framework. For additional local context, an existing conditions report follows with relevant information on Hopewell. The following section documents the methodological approach to the research questions presented from the ideas of the proposal and their corresponding data sources, with the following section presenting research findings. Recommendations are grounded in the findings from the research, and the final sections involve the goals, objectives, and actions recommended to the City of Hopewell, including an implementation timeline and potential funding sources. Interview protocols and survey questions can be found in the Appendix, and the final sections outline the project timeline for completion.

Background

Literature Review:

Green Infrastructure is a method to combat the negative impacts of climate change, as well as to increase the resilience of vulnerable populations and urban areas through an array of ecosystem services (ES) (López-Valencia, 2019; Gómez-Baggethun & Barton, 201). GI is multifunctional (Meerow & Newell, 2017), and because of this, has the opportunity to provide more services or benefits to the community, than an initial project may anticipate or plan for (Rogers, 2013). ES are a direct component of the Social-Ecological System (SES) (Folke et al., 2016), like the City of Hopewell's Green Infrastructure Network. ES are products of the natural capital in a system where the social capital contributes by means of production or reception of the benefits (Ekins et al., 2003). The GINP documents interactions between the social and ecological assets of the system and contributes to Hopewell's resilience through the ES provided by GI, as well as enhancing the resilience of the system by increasing its adaptability.

Crystal Lake

To support this argument, a comprehensive review of the literature is necessary to break down key concepts and understand the plan's direction in the evolving discourse between GI, vulnerability, resilience, and SES. To understand GI in this context, the

literature review will begin by breaking down GI, its multifunctionality, and the ES it provides. Resilience and its related concepts will be addressed in relation to ES and how they contribute to a city's resilience. Systems can also be resilient (Ridder et al., 2017), which brings in SES concepts and properties of resilient systems and how they explain Hopewell's network of GI through interactions between social and natural assets.

Resilience through Green Infrastructure

While GI has an extensive range of uses and definitions, for this plan, GI is described as a network of green space, both naturally occurring and built systems, which contributes to human benefits through an array of ecosystem benefits [(Panagopoulos, 2019), (Demuzere et al., 2014)]. In this plan, ecosystem benefits and ecosystem services will be interchangeable terms, with the general definition being the benefits provided to humans by an ecosystem (Cornell, 2010). These services can be broken down into four categories: provisioning, regulating, habitat, and cultural (Gómez-Baggethun & Barton, 2013). Provisioning services are the physical products produced by natural capital and directly received like fresh water or food and produce (Kumar, 2012). Regulating services are indirect benefits that come from the regulation of ecosystem processes like climate regulation and water purification (Ekins et al., 2003). Habitat services are those that contribute to biological and genetic diversity by providing refuge and reproduction habitats for wildlife (Ekins et al., 2003). Environmental education, recreational activities, and social relationships are examples of cultural services obtained through human-nature interactions (Kumar, 2012). A review of the literature presents differing classifications of ES, but many of them similarly distinguish services. For example, Meerow & Newell use the term "supporting services" instead of "habitat services", and De Groot uses the term "Information function" with a definition similar to "cultural services" (De Groot, 1992).

City Park

GI has the opportunity to provide a wealth of ES because of its multifunctionality, for example, while GI projects are often installed for a priority solution, like a tree trench to manage stormwater, many additional benefits can be derived from these projects (Meerow & Newell, 2017). GI includes a wide range of designs and elements from rain gardens, street trees, and community gardens, to tree trenches, green roofs, and community parks (Christman et al., 2018). A stream channel restoration project may be designed for stormwater management and pollution control, however increasing native species, and planting additional trees increases an area's resilience through urban heat island amelioration and increased biodiversity (Blau et al., 2018). The desire for increased

tree canopy, as evidenced by recent CBF projects in Hopewell, provides numerous benefits to the community ranging from immediate shade relief to stormwater management, water filtration, and carbon sequestration (Parson, 2022).

Benefits like reducing urban flooding, addressing extreme temperatures, and improving air quality, are just a few examples of why GI can have a positive impact on vulnerable populations (López-Valencia, 2019; Suen, 2022). In general, vulnerability encompasses the conditions in which individuals or groups are more likely to experience negative consequences from external disturbances (Müller et al., 2011). Vulnerability research is extensive, and can include social, ecological, urban, environmental, and physical vulnerability (Müller et al., 2011). The common indicators for socio-economic vulnerability can be derived from census data and usually include income, race, age, employment status, educational attainment, and housing quality (Lin et al., 2023). Also important are vulnerability indicators related to health and the local environment. Neighborhoods with large percentages of impervious surface are more prone to urban flooding, leaving the residents vulnerable to its associated damages (López-Valencia, 2019). The EPA uses several indicators to assess vulnerability by census tracts like lifetime cancer risk from inhalations of air toxins, low-life expectancy, and percentage of adults with asthma (EPA, 2023).

Because of the multifunctionality of GI and its wide array of ES, GI is frequently being used as a strategy to mitigate the impacts of climate change, and increase the resilience of urban areas and communities (Demuzere et al., 2014). Urban resilience is not a new concept, and the current state of literature available represents an evolving theory with plenty of names attached to similar ideas such as disaster and hazard mitigation, and risk reduction (McGill, 2020). Broadly, urban resilience is characterized as an urban area's ability to adapt, regenerate, and respond to changes and disturbances (Reynolds et al., 2022), as well as anticipate potential events (Cysek-Pawlak et al., 2022). These disturbances and events range from natural disasters and economic failures to terrorist attacks and environmental hazards. (Parker & Simpson, 2020).

For this plan, urban resilience and its definition will be grounded in its relation to negative health consequences of a community, as well as the impacts of climate change. Urban resilience, in the context of Hopewell, can be broken down further to provide an understanding of how resilience is related to Hopewell's coastal zone management priorities for protecting its watersheds and protecting the residents from weather events associated with its location to waterways. GI contributes to coastal resilience in numerous ways like providing vegetative buffers for riverine flooding and storm surges, or providing waste removal through natural filtration processes of wetlands (Gómez-Baggethun & Barton, 2013). Effective urban resilience in Hopewell is more than just protecting the waterways, it increases the community's resilience to rising temperatures from the urban heat island effect, improves air quality from industry, automobiles, and rising temperatures, decreases urban flooding from frequent heavy rainfall events, provides access to green space, and reduces food insecurity.

Resilient Systems

Hopewell's GI network can be understood as a complex social-ecological system (SES). The theoretical framework behind systems and SES will be analyzed in the subsequent sections. For now, suffice to say that SES is a complex, adaptive system comprised of dynamic interactions between its components, and consists of bio-geo-physical units and associated social and institutional actors (Glaser, 2012). SES include several types of capital including natural capital (urban gardens, street trees, rain gardens); social and cultural capital (social networks, institutional arrangements); human capital (human capabilities, knowledge, skill development); and built capital (transportation infrastructure, buildings) (Constanza, 2013). Research among SES and its related capital has varied definitions; for instance, Reynolds et al. consolidates "Human" and "Social" capital into one type of capital (Reynolds et al., 2022). While these terms have similarities and subtle differences; terms like ecological capital, natural capital, and environmental capital are all used in varying capacities throughout the natural capital research. The use of the term "capital" is interchangeable with "assets", like social and natural assets (Chiesura & De Groot, 2003). For this plan, and to maintain consistency with the planning framework, the term "asset" will be used in place of "capital".

Appomattox River View

Interactions between social and natural assets, including non-linear feedback and tradeoffs associated with ecosystem service provisioning, are observed through the SES framework (Reyers et al., 2013). In Hopewell's GI network for example, the system comprises physical green spaces (natural assets), and the humans or organizations (social assets) using, planning, building, funding, and maintaining GI. These interactions, tradeoffs and non-linear feedback loops include the ES provided by GI, as well as the relationship between how they are received, and who receives these services.

While cities, rightfully, focus on nature-based solution strategies and resilience plans that are hyper focused on coastal flooding or stormwater management, arguably an integrated and interdependent SES is an equally important factor in determining a city's resilience (Mcgill, 2020). Resilient SES are those that are able to buffer, adapt, and transform in the presence of disturbances (Reynolds et al., 2022; Herrero-Jáuregui et al., 2018). This idea of resilient systems allows flexibility because the system is constantly changing. When disturbances occur, they are absorbed to enable the system to retain its functions, structures, and feedback without creating a new system operation (Walker & Salt, 2006). One of the key properties of a resilient system is its adaptability, which is the capacity of the system to adjust responses and interactions among its variables to changing external drivers and internal processes which allows system functions and

development to continue along the same trajectory. This is only possible when the system is not disturbed or disrupted to the point of a complete breakdown, when it remains within the current stability domain (Folke et al., 2010).

Conclusion

Understanding the dynamic definitions of resilience is important because GI is being used to mitigate common issues that urban areas are facing. These include urban heat island effect, urban flooding, and polluted runoff. These and related issues such as coastal flooding and rising sea levels are being addressed with resilience plans. GI or nature-based solutions are prioritized in these plans for their mitigation abilities and the wide range of ES they provide. Hopewell's GI network also benefits from a systems approach, where all of the assets, social and natural, are mapped to understand the dynamic relationships and interactions between assets. A deeper understanding of the actors, location of GI, and the opportunities to expand interactions to different actors or green spaces, helps to increase the adaptability of the system by better responses to changing external drivers.

Theoretical Framework:

The GINP is nested in Complex Adaptive Systems (CAS) theory and the understanding that urban areas are complex social-ecological systems (Frank, 2017), as this provides context for the application of Hopewell's assets in the system, and provides an understanding for the interactions between assets. Planning theory helps facilitate thorough and productive processes and outcomes, and because of this it is vital to ground planning work in theory. In addition to systems (CAS) theory and SES, the GINP focuses on Asset-Based Community Development (ABCD) principles as an applicable process for creating proactive community engagement through the identification of social and natural assets (Nel, 2020). Systems thinking conceptualizes the idea that in a system, everything is connected to everything (Meadows, 2009), like "humans in nature". Resilience is not just defined by a city's ability to adapt to weather events, but an emergent property of an entire system (Herrero-Jáuregui et al., 2018). While the systems framework provides the conceptual understanding of the GI network as a system, and the base for system resilience, the ABCD framework provides real world application and community engagement.

Complex Adaptive Systems (CAS) & Social-Ecological Systems (SES) Theory

In the CAS theoretical framework, systems are complex, and comprised of many assets and components and their dynamic interactions within the system. They are usually open systems, continuously interacting with their environment and permitting feedback (Ridder et al., 2017). In CAS, a "system" is a broad term defined by its parameters and the idea of what can be considered a system is limitless. For example, cities, ecosystems, governments, traffic layouts, human

body components and social networks could all be observed as systems (Burger et al., 2021). The parameters for Hopewell's green infrastructure system is its network, made up of actors and physical GI scaled regionally down to the site scale.

CAS are adaptive in that the components or variables in the system adapt through mutations or self-organizing abilities when presented with changes and interactions with other variables (Ridder et al., 2017). These systems are also hierarchical, and scale is an important consideration (Egerton-Warburton et al., 2013). For example, Hopewell is in the Chesapeake Bay Watershed, the largest estuary in the US, and this watershed can be observed as a system. Systems are hierarchical because larger systems are comprised of smaller subsystems. Larger systems can be scaled down to a central location, where subsystems work inside of the larger system. For example, Hopewell can be considered a subsystem of the Chesapeake Bay Watershed system, with multiple watersheds within its 11 square mile boundary, and these watersheds themselves can be studied as their own system, or as a sub-system of the larger watershed systems. This leads to interactions having scaling impacts, where the Hopewell GINP may produce interactions leading to subsystems of its own system, or providing interactions into larger systems, where Hopewell's GI network falls into the subsystem class.

The idea that interactions among actors or variables foster adaptability within the system is critical to understanding how the CAS theoretical framework applies to Hopewell's system of social and natural assets. SES theory is an offset of CAS theory, in that the SES system is comprised of an ecological or biophysical element and its interacting social or human characteristics. SES are still complex adaptive systems also defined by parameters, which in the context of Hopewell, is defined by GI and the human or social actors participating in GI projects. Humans are considered one with nature, and interactions within an ecosystem can be observed as a flow of resources or services (Herrero-Jáuregui et al., 2018; Folke et al., 2016). ES or benefits are the interactions received by the social or human variables of the system. These benefits range from products or natural assets, like produce from an urban garden and fish from the James River, to ES, like carbon sequestration and climate regulation (Guerry et al., 2015).

The SES framework is beneficial to Hopewell's GI network because it coordinates all variables related to GI into one system to observe their interactions.

Asset-Based Community Development (ABCD)

Asset-Based Community Development (ABCD) contrasts many conventional theories which focus on the needs (deficiencies) of a community, by instead focusing on a community's assets and building on the available resources a community has in place (García, 2020). ABCD provides a framework for the GINP that highlights and identifies social and

natural assets in Hopewell, as well as gaps and missing connections. The ABCD framework requires a collaborative and thorough process necessitating the involvement of the local community.

Hopewell historically has suffered from disinvestment, health and environmental disasters, and high poverty levels, and these issues are commonly the catalyst as well as the forefront of plans and policies in place in Hopewell. Embracing the ABCD process for the GINP utilized a different approach by focusing on social and natural assets, and helped guide GI network recommendations through a participatory approach where the actors are involved in the process (Scott et al., 2018).

In addition to expert knowledge, local knowledge was applied to create a broader understanding of the assets available in Hopewell's GI network. There is a technical aspect to GI, especially when dealing with green stormwater infrastructure or measuring air pollution and temperature readings across neighborhoods. The GINP process utilizes expert knowledge through spatial planning tools like GIS to identify green space and GI locations (natural assets), and to identify the social assets. Local knowledge provides context for interactions with GI network actors in Hopewell, and how residents interact with green space in Hopewell.

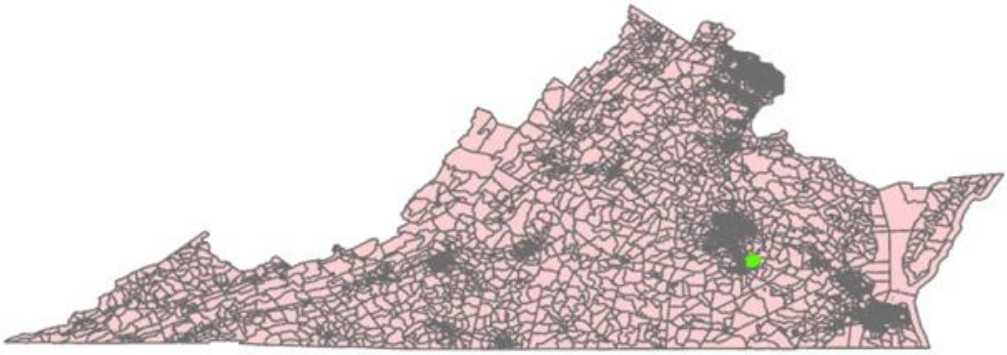
Context

Existing Conditions:

Study Area

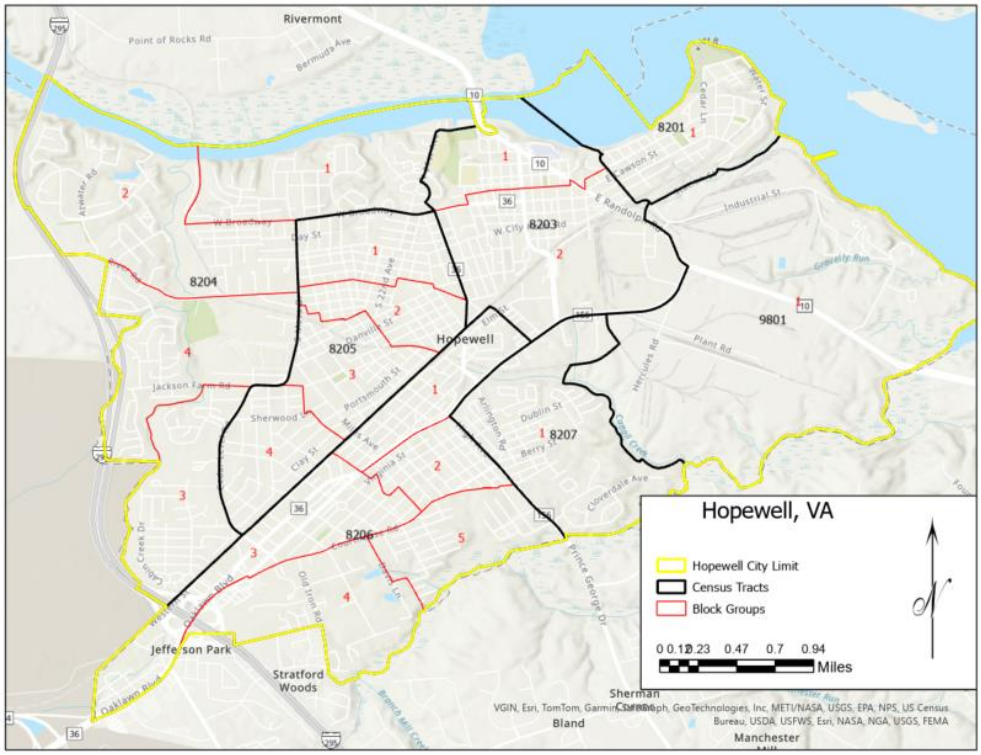
Hopewell sits at the confluence of the James and Appomattox Rivers, located roughly 20 miles south of the City of Richmond. It is bordered by Fort Gregg-Adams to the west, Prince George County to the south, the Appomattox River to the north and the James River to the east. Hopewell is nearly 11 square miles in size, with a population of about 23,000. Hopewell's location within the Commonwealth of Virginia is shown in Figure 1. Hopewell and its census tracts and block groups are shown in Figure 2. Census tract 9801 is the only tract without meaningful demographic data, as it is solely an industrial census tract. The remaining tracts in the City of Hopewell all contain various land uses including residential.

Figure 1. Location of Hopewell in Commonwealth of Virginia



Source: US Census Bureau TIGERLine 2020 Data

Figure 2: Census Tracts and Block Groups in the City of Hopewell



Source: US Census Bureau TIGERLine 2020 Data

History

Founded over 400 years ago, the settlement of City Point would go on to thrive as one of the busiest ports in the world during the Civil War. Hopewell maintained historic significance during times of war, playing a part in not only the civil war, but also the revolutionary war, as battles were fought right on its banks (City of Hopewell (N.d.). Hopewell was officially incorporated in 1916 by the DuPont Company, which was largely responsible for the character and residential layout of development through construction of worker housing during the 20th century (Bullis, 2011). DuPont originally produced dynamite but eventually switched to manufacturing guncotton during the first World War. DuPont was the first of many manufacturing giants, and specifically chemical manufacturers, to call Hopewell home. Hopewell proudly claimed its title as the "Chemical Capital of the South" with a sign displayed at the city entrance, until well into the 1970's (Fletcher, 2020).

Source: Chesapeake Bay Foundation

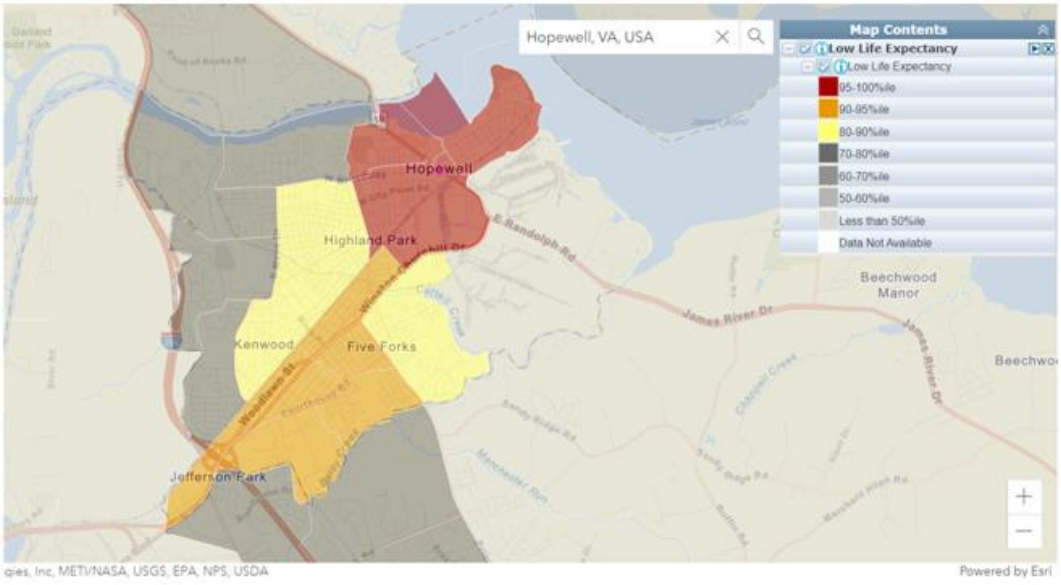
Lack of environmental regulations has resulted in increased environmental pollution from chemical manufacturers in Hopewell. This trend ultimately culminated in what is now known as the "Kepone Disaster" in which the highly toxic chemical, Kepone, was illegally disposed of through the sewage system, eventually feeding into the James River. It is estimated that over 200,000 pounds of Kepone were dumped into the river between 1966 and 1975 (Daly, 2023). Allied Chemical, the manufacturer of Kepone, was forced to shut down their facility as workers from a neighboring plant began to exhibit severe symptoms related to its exposure. Not only was the facility shut down, but a James River fishing ban went into effect lasting up to 13 years in certain areas. Kepone is an endocrine disruptor and carcinogen which accumulates in the fatty tissue of fish, and unfortunately trace amounts were still discovered in fish caught in the James River within the last six years (Wilson & Maroon, 2017).

Environmental efforts looked promising following the Kepone disaster, including river revitalization through the Clean Water Act and the Virginia Environmental Endowment (Wilson & Maroon, 2017). Unfortunately, severe environmental degradation through manufacturing pollution is still a critical concern for Hopewell residents to this day. AdvanSix, the offspring company of Allied Chemical, has been flagged more than 66 times in the last eight years for violations of the Clean Air Act and the Clean Water Act (Powell, 2023a). In September of 2023, the plant workers were forced to "shelter in place" over a leak of oleum (a fuming sulfuric acid), which was its fourth similar leak in the last year (Daly, 2023). Plants are leaking hazardous toxins not only into the air but into the water and environment in Hopewell, and what makes this issue more concerning is the location of some of the plants. AdvanSix for example, is situated less than one mile from residences, including public housing (Powell, 2023b).

Community Health & Demographics

The health statistics align with the problems Hopewell residents face from pollution, as three out of the six observed census tracts rank in the 90th percentile or higher for low-life expectancy compared to the nation. For perspective, census tracts 8201, 8203, and 8207 border the industrial census tracts with heavy manufacturing plants located adjacent to these tracts. These tracts have a life expectancy at birth of 69.2, 69, and 75.3, respectively. Low-life expectancy data is based on 5-year estimates from 2010-2015 where the mean life expectancy at birth for the U.S. was 78.8 in the midyear 2013 (NVSS, 2022).

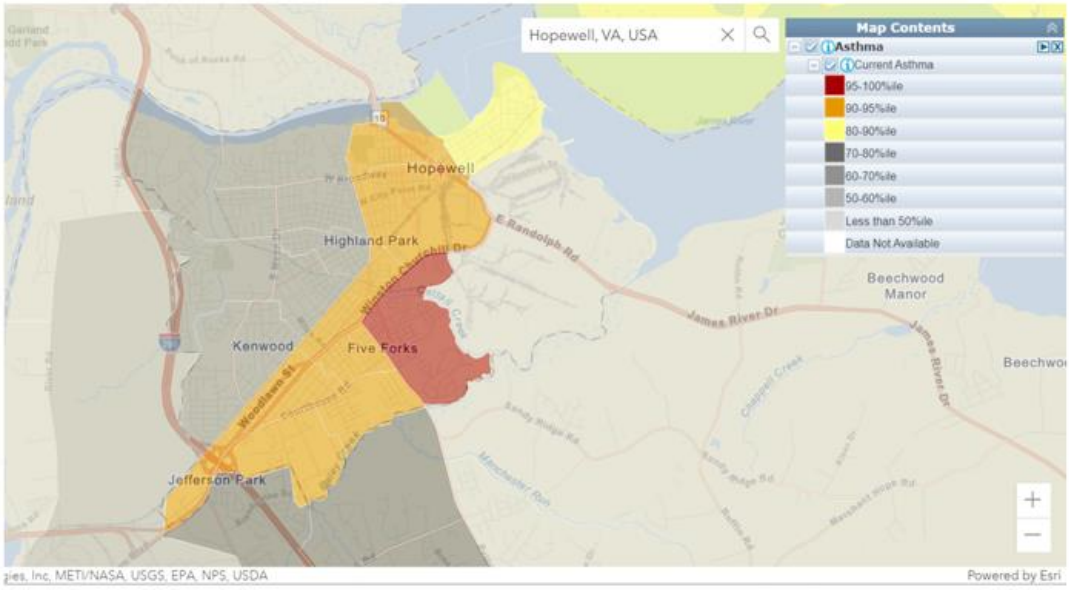
Figure 3. Percentile of Low Life Expectancy



Source: EPA EJ Screen

The Environmental Protection Agency has an interactive mapping service called the Environmental Justice EJScreen, which applies vulnerability indicators to census tracts to help identify areas impacted by environmental injustices. A similar trend among census tracts is seen when visualizing related health data including percentile for asthma and lifetime cancer risk from the inhalation of air toxins. Again, it should be noted that the census tracts bordering the tract without data are in relatively close proximity to heavy industry and chemical manufacturing.

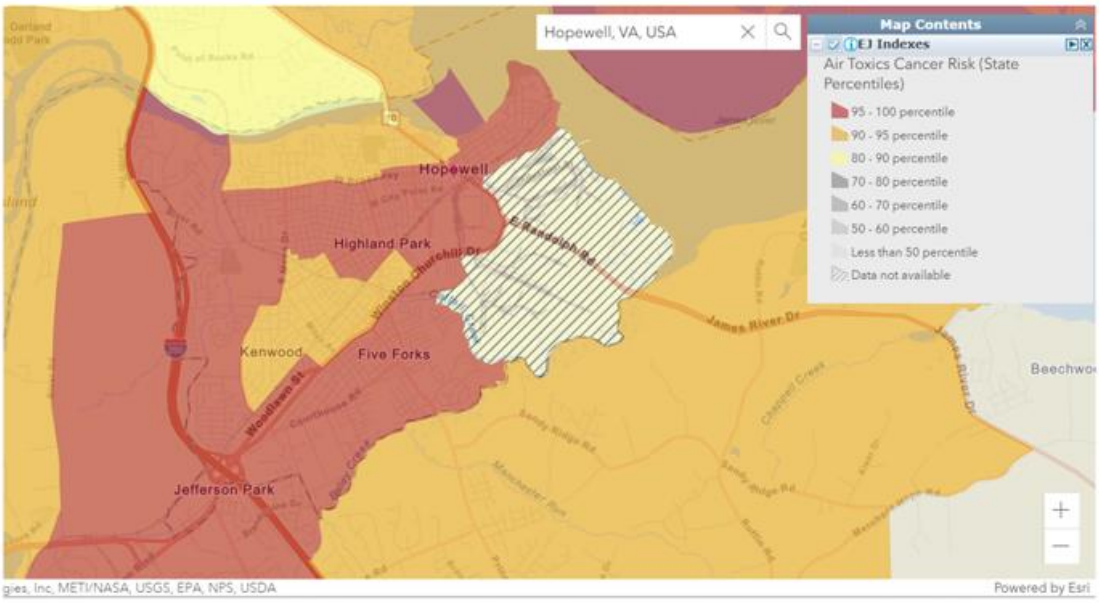
Figure 4: Percentile of Residents with Asthma



Source: EPA EJ Screen

Asthma data represents the prevalence of asthma among adults over the age of 18, at the census tract level. This data is applied and compared to national statistics. The three census tracts closest to Hopewell's industry, tracts 8201, 8203, and 8207 all have 12% or more of its residents over 18 with asthma according to the CDC's "Places" data.

Figure 5: Percentile of Lifetime Cancer Risk Due to Inhalation of Air Toxics



Source: EPA EJ Screen

Every census tract in Hopewell is in the 90th percentile or higher for air toxics related to cancer risk. Air toxics are screened using an assessment method by the EPA that reviews air pollution data and how its correlation to cancer and noncancer hazard indexes for the human body (EPA, 2018). This data does not visualize residents with cancer from toxics, but shows the possible exposure by census tract of residents to air toxics known to cause cancer.

Hopewell also ranks poorly in other key vulnerability indicators such as median income level, percentage of persons in poverty and educational attainment. Table 1 compares key demographic statistics between Hopewell, Richmond, and Virginia. Hopewell's median income of $44,209 is nearly $10,000 less than Richmond's, and almost half of the state average of $80,615. While the state average is heavily skewed from localities surrounding Washington D.C., Hopewell's median income of $44,209 creates a burden on the residents and tax base, especially considering one in four Hopewell residents live in poverty. The percentage of Black or African American population is comparable to the City of Richmond, but is much higher than the state average. Hopewell's three census tracts cited earlier for poor health statistics, 8201, 8203, and 8207, have 63%, 61%, and 74% people of color as their total population, respectively (EPA EJScreen). The lower income rate and higher percentage of minority population compared to the state are reason enough for Hopewell to prioritize equitable outcomes, as neighborhoods with minority populations tend to bear the brunt of environmental concerns like urban flooding and heat islands (Saverino et al., 2021; Capps & Cannon, 2021), as well as lack of green space (Wolch et al., 2014).

Table 1: 2022 Census Bureau Data Comparing Hopewell, Richmond & Virginia

2022 Population Data			
	Hopewell city, VA	**Richmond city, VA**	**Virginia**
Population Estimates, 2022	22,962	229,395	8,683,619
Race and Hispanic Origin			
White alone, percent	47.4%	44.8%	68.5%
Black or African American alone, percent	44.3%	45.2%	20.0%
Education			
High school graduate or higher, percent of persons aged 25 years+, 2017-2021	85.2%	87.7%	90.8%
Bachelor's degree or higher, percent of person age 25+, 2017-2021	11.4%	43.1%	40.3%
Income & Poverty			
Median household income (in 2021 dollars), 2017-2021	$44,209	$54,795	$80,615
Per capita income in past 12 months (in 2021 dollars), 2017-2021	$23,314	$38,132	$43,267
Person in poverty, percent	24%	19.8%	10.6%

Source: US Census Bureau 2022 Vintage Data

Precedent Plans

Hopewell has garnered significant attention over the years for projects ranging from downtown revitalization, food access improvements, street tree installations (CBF, 2020), marina redevelopments, brownfield developments, and resilience studies, along with other studies, proposals, and plans listed in Table 2 below. Hopewell's location along two rivers, with opportunities for regional trail connectors (FOLAR, 2017) makes it an ideal location for green space development, and there is an emphasis to locate projects on the water (Parson, 2022).

Precedent plans are beneficial for context, even plans that have yet to be completed, or plans yet to be approved or adopted. Plans like Hopewell's Marina Park Master Plan, which was not approved by council (Thrasher, 2022), provides enticing green space designs for a key piece of property in Hopewell, the City Marina. The green space designed for the

Marina Park Master Plan would serve as a connector between the current Hopewell Riverwalk and the conceptual Hopewell connections to the Appomattox Riverside Trail Master Plan (FOLAR, 2017). The Brownfield Redevelopment Plan, while incomplete in certain areas, provides valuable research into neighborhoods deemed acceptable for green space installations through redevelopment of brownfield sites in tract 8203 where commodities like tree canopy coverage are scarce (SGA, 2016).

Qualitative data, like public perception of local green space, or social institutions participating in urban gardening initiatives, is valuable information gathered through analysis of precedent plans like the Crater Region Resilience Plan (RAFT & CPDC, 2022) or the Hopewell Food Access Report & Recommendations for The City of Hopewell, Virginia (VCU, 2020). Information, like community survey data from previous plans, provides an understanding of perspectives on some of the recent projects like access to green space and community health. Information about social actor involvement, and what their roles may be, can be gathered through precedent plans like the Hopewell Community Action Plan. This identifies key social assets in facilitating green space development focused on community health like the HEAL Hopewell Alliance, Hopewell Downtown Partnership, and the Virginia Cooperative Extension, all of which have played a collaborative role in previous urban garden initiatives in the city (EPA 2018).

Table 2 below displays a list of precedent plans and studies related to green infrastructure, green space, or development plans with a significant GI attribute.

Table 2: Hopewell Precedent Plans

Hopewell Precedent Plans	
Plan Name	Plan Preparer
Marina Park Master Plan	Timmons Group
Hopewell Community Action Plan	EPA
Hopewell Food Access Report & Recommendations	VCU
Appomattox Riverside Trail Master Plan	Friends of the lower Appomattox River
Riverside Greenway Park	Hopewell
Hopewell Waterfront Plan	ULI
B Village / Waterfront Plan	Hopewell
Brownfields Redevelopment Plan	Stromberg Garrigan & Associates
Building Resilience in Virginia's Crater Region	RAFT
City Point Road Plan	VCU
City Point Historic District Plan	VCU
Hopewell Resilience Plan	Hopewell DPU
Downtown Hopewell Area Plan	Downtown Hopewell
Poythress Street Design Guide	Hopewell
Poythress Alleyway Plan	Hopewell

Methodology

Research Questions:

A mixed-method approach was used to identify social assets, their roles, and their interactions between natural assets, and other social assets. Natural assets were identified spatially, and their functions or services were documented accordingly. The following research questions guided research, data collection, surveys, and interviews.

Table 3: Research Questions

Research Questions
What are the social-natural assets in Hopewell? • Where is GI located in Hopewell? • What are the various types of GI in Hopewell? • Who are the human actors involved in GI projects, and what are their roles? • What are the interactions between social-natural assets? • Where are the opportunities for GI in Hopewell? **Is there a current framework to prioritize vulnerable neighborhoods for GI enhancements?** **How can the GIN be used as a tool for actors in the future?**

Community Engagement

To engage the community, and create a comprehensive database of assets from the community perspective, key informant interviews were conducted, and a community survey was distributed. A "Google Forms" community survey was created and distributed with the help of several respondents who participated in the informant interview process. A community survey flyer was created for distribution, with a scannable QR code, and a direct link to the survey. The survey was posted on the Hopewellva.gov website, Hopewell's Facebook page, and shared by the Hopewell Downtown Partnership. Survey flyers were posted at Hopewell public parks, Waves Sandwich Co., and the Appomattox Public Library. In conversations with actors, several pointed to a low response rate stemming from survey fatigue from residents. The research for this project has highlighted three VCU projects in Hopewell including this capstone that implemented surveys, while another Hopewell capstone was taking place concurrently. This, coupled with the community outreach performed for the CBF projects and the Crater Resilience Plan all within the last four years can cause fatigue from residents in participation. The full survey can be found in the appendix.

An initial key informant interview list was prepared using conversations with client contacts, and a preliminary actor network map was created by researching websites of potential GI actors in the region or with a history of working in

Hopewell. The interview process provided context to information gathered through site observations, spatial datasets, and the various sources listed in the subsequent sections. Key informant interview respondents not only provided insightful responses about the research questions, but through a snowballing technique, identified additional survey respondents and actors in the network. Several respondents also provided crucial secondary data, including spatial datasets, and executive summaries of previous Hopewell GI projects.

Table 4. Interview List

Respondent	Title & Affiliate
Chris Ward	Director, Department of Development
Rita Joyner	City Councilor; Wonder City Garden Club member
Michael Campbell	Director, Public Works
Josh Sementelli	Manager, Hopewell Stormwater
Kathy S.	Hopewell Resident, City Point
Kit Friedman	Planner, Crater PDC
Tabitha Martinez	Director, Recreation & Parks
Derrick Gooden	VSU Small Farm Outreach Program
Heather Barrar	Friends of the Lower Appomattox River (FOLAR)
Ann Jurczyk	Chesapeake Bay Foundation
Heather Lyne	Hopewell Downtown Partnership
Chip Bowman	Bowman Construction
Justin Doyle	James River Association
Kelly Davis	Senior Planner, Department of Development
Jessica Huang & Kendall Topping	Green Infrastructure Center (GIC)

Data Sources

1.1 Where is Green Infrastructure located in Hopewell?

1.2 What are the various types of Green Infrastructure in Hopewell?

Spatial datasets: Datasets were obtained from various sources including the 2021 National Land Cover Database (NLCD), 2021 Virginia satellite imagery from VGIN, Stormwater best management practices (BMPs), and Chesapeake Bay Preservation area datasets from the City of Hopewell. NLCD datasets included tree canopy coverage and impervious surface coverage layers. Overlaying recent satellite imagery with NLCD and Preservation areas made it possible to identify green spaces and green alleys identified in the GIS map. GI identified through satellite imagery was cross-referenced through site observations or interviews when possible. Stormwater BMPs provided geospatial locations of BMPs that the City of Hopewell regulates across the city. Friends of the Lower Appomattox River (FOLAR) provided spatial datasets for the Regional River Trail plan, including conceptual networks.

Site Observations: Site observations provided additional context and the ability to cross-examine green spaces for specific GI elements. Table 5 on page 34 provides green infrastructure typology and local examples at different scales. For example, a visit to City Park identifies several GI elements that are not identifiable through satellite imagery, or web sources, like the native meadow and stream restoration. Knowledge of these elements is beneficial in interviews and can help facilitate conversation into roles that actors may have played in installing or maintaining these specific elements.

Web sources: Several of the organizations interviewed have project information readily available online to better understand the location of GI projects. The Chesapeake Bay Foundation and James River Association document their projects with the locations of some of the GI installations on the website. Other web sources included Hopewell's recreation & parks website, which documents all of the public parks in Hopewell. Webpages for larger GI sites like city and regional park systems provided location and information for site scale GI elements within larger GI and parks.

Interview: Key informant Interviews started with a presentation of the GIS-based network map at its present state at the time of the interview, and informant interview respondents were encouraged to identify locations of GI that were not currently mapped. The following questions from the informant interview were intended to provide information for research question 1.1 and 1.2:

- What type of work have you been involved with, in relation to green infrastructure?
- Where is the green infrastructure located that you have worked with?
- What are the different types of green infrastructure that you have worked with?

Survey: The following community survey questions were meant to provide information for the research questions 1.1 and 1.2:

- What is your favorite green infrastructure in Hopewell, and where is it located?
- What neighborhood do you live in?
    - Can you walk to any of the following green infrastructure from home?

1.3 Who are the human actors involved in Green Infrastructure projects, and what are their roles?

1.4 What are the interactions between social-natural assets?

Site Observations: Site observations provided supplemental information for actors participating in GI projects, specifically funding. Placards could be found in several parks and green spaces showcasing the groups or organizations responsible for supplying funds or grants to pay for the projects. Site scale GI elements, and information gathered through site observations related to actors, like funding sources, can be found in the network map and on the Green Infrastructure layer.

Web sources: Web sources for the different actors provided baseline information for the actor network map including organizational duties, activities, and participating organizations. Project profiles from actor websites not only provide descriptions of the project, but identify other actors engaged in similar projects or the groups that have also worked on the project, through funding, donating time, installation, planning, or any of the roles found through this research.

Interview: The following questions were meant to provide information for research questions 1.3 and 1.4:

- What is the name of the company you work with?
- What type of work have you been involved with, in relation to green infrastructure?
- Is long term maintenance of green infrastructure a concern?
    - Are there any other perceived issues associated with green infrastructure?

Preliminary conversations with the Client regarding the difficulties of long-term maintenance of GI lead this question to be included in the informant interview to understand the complexities of the issue.

- What other actors have you worked with, in relation to green infrastructure?
- What benefits have you experienced from green infrastructure in Hopewell?

Survey: The following questions were meant to provide information for research questions 1.3 and 1.4:

- What green infrastructure benefits do you enjoy?
- How do you typically use green infrastructure?
- Do you perceive any of the following issues with green infrastructure? (Maintenance; Access; Crime; Problems with nature)

Preliminary conversations with the Client regarding issues associated with GI lead this question to be included in the community survey to understand the complexities of the issues.

1.5 Where are the opportunities for GI in Hopewell?

Precedent Plans: Information from previous designs, studies, and plans from Table 2 were used to identify possible GI locations.

Spatial Datasets: VGIN satellite imagery, parcel datasets, USGS 2022 hydrography, and land cover datasets provided spatial data for analysis of opportunity locations. Satellite imagery was paramount in identifying opportunity sites for potential GI, as it helped to identify vacant lots when overlayed with city-owned parcel data. NLCD datasets were used in conjunction with satellite imagery as well to identify locations lacking tree canopy coverage, or areas with high impervious surface coverage for possible depaving. Hydrography layers were analyzed spatially with the point layer created from stormwater complaints to understand the possible relationship between localized flooding and adjacent waterways.

Interviews and Survey: The following questions were used to provide information for research question 1.5:

- Where would you like to see more green infrastructure?
- What green infrastructure would you like to see more of in Hopewell?

2. Is there a current framework to prioritize vulnerable neighborhoods for GI enhancements?

Spatial Datasets: Spatial datasets for the EPA EJscreen tool (p.18), and Climate and Economic Justice Screening Tool (CEJST) were downloaded, and the respective layers were created and added to the spatial map. The CEJST tool is another tool, similar to the EJScreen tool, and it maps vulnerability characteristics spatially at the census tract level, while the EJscreen tool can map vulnerability characteristics at the block group level. A wide range of vulnerability characteristics or attributes are downloaded along with census shapefiles, and are able to be symbolized depending on the vulnerability characteristic like low-life expectancy or percentage of asthma among adults.

Interview: The following questions were used to provide information for research question 2.1:

- Do you know of any processes in place to prioritize vulnerable neighborhoods for green infrastructure?
    - What do you consider to be a vulnerable neighborhood, and where are they?

Survey: The following questions were used to provide information for research question 2.1:

- Does your household have access to a car?
    - What neighborhood do you live in?
        - Can you walk to any of the following GI?
- Rank the quality of green infrastructure in Hopewell:

3. How can the GIN be used as a tool for actors in the future?

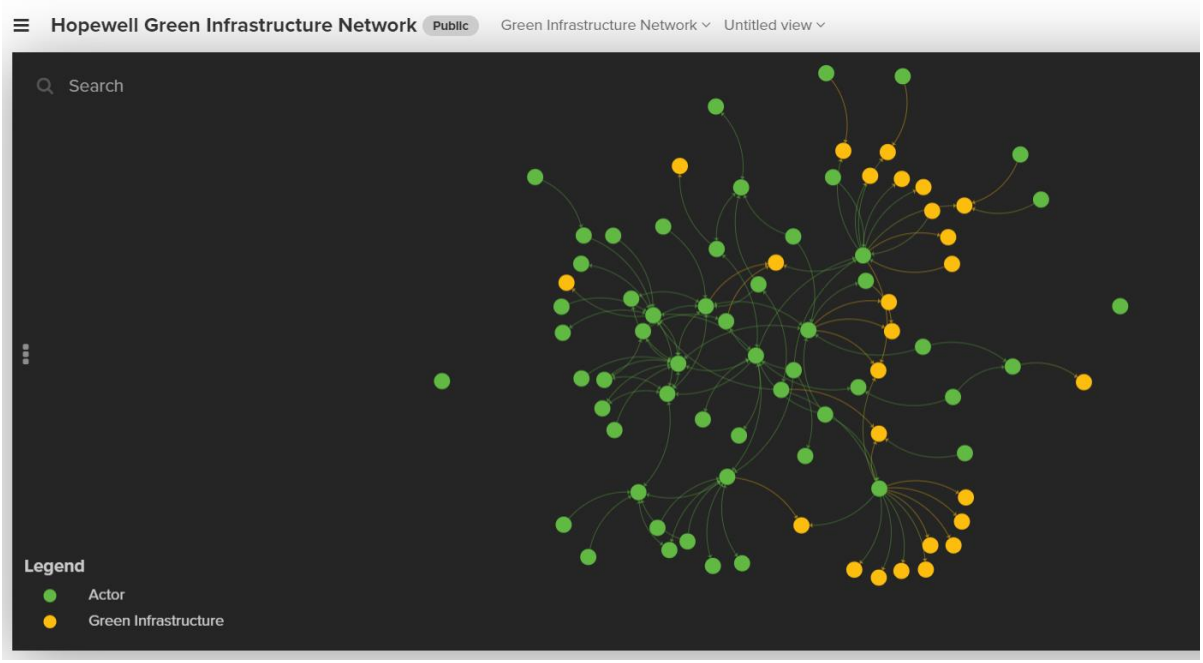
Interviews: The following questions were used to provide information for research question 3.1:

- How can you benefit from a better understanding of the actors participating in green infrastructure projects?
- How can you benefit from an interactive GIS map of green infrastructure in Hopewell?

Analytical Methods

Network Mapping through Kumu, and Spatial Analysis through ArcGIS are the two primary methods of analysis for the data gathered. A Kumu network map was created initially through preliminary conversations with actors working in Hopewell and information pulled from actor websites, as well as information gathered from precedent plans. Interviews supplemented this information by providing context into the roles of these actors, and the roles of the collaborating actors. Interviews added insight into the nuances of GI installation and planning, especially the obstacles. Respondents not only helped identify social assets but helped identify natural assets as well by identifying the location of GI in Hopewell and sites with the potential to add or increase GI. The Kumu network map can be accessed by the link below. The network map displays actors, GI, and the interactions and connections between them. Click on the interaction arrows or the actor/GI nodes for additional information.

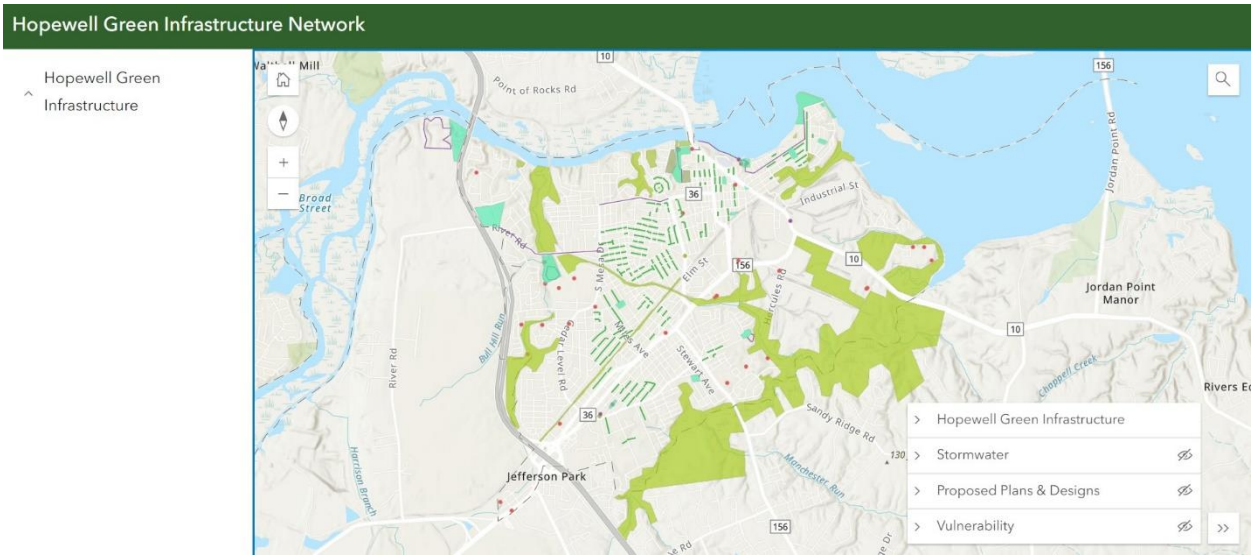
Figure 6. Kumu Network Map



Hopewell Actor Network Map

Information related to the location of GI was included in the spatial analysis of Hopewell. Using ArcGIS, five green infrastructure layers were created at various scales, including: Green Alleys; Green Space; Trails & Greenways; and Site Scale green infrastructure. Other layers created include Stormwater Complaints; Proposed Plans & Designs; and three different vulnerability layers. Follow the link below to use the interactive and public map. Map layers can be toggled either by clicking layers in the legend on the left, or with the small legend icon in the bottom right-hand corner. Several raster layers were created for the City of Hopewell that are not included in the online map, including 2021 tree canopy coverage, 2021 impervious surface coverage, and 2021-2022 VGIN satellite imagery.

Figure 7. ArcGIS Online Map



[Hopewell Spatial Map]

Fifteen interviews were conducted in total, representing various groups and departments from Hopewell's planning department and public works to stormwater management, the city council, several regional environmental non-profit organizations, and residents. These interviews were recorded with the participant's permission and transcribed using Zoom and Microsoft software to review the information later. The full interview list can be found in the appendix. Several themes emerged, which are outlined in the following section, however, any information that was relevant to the network map or spatial maps was added to their respective outlet. The community survey was not as successful, with only seven respondents, however, there is still value to several responses which are also accounted for in the following section.

Research Findings

Findings Summary

- The proximity to Richmond has increased the capacity of the adjacent localities to collaborate with regional and local environmental nonprofit groups like the Chesapeake Bay Foundation and James River Association. Petersburg, for example, has several ongoing green infrastructure projects with regional environmental groups that have a history of working in Hopewell, but are not currently working on green infrastructure in Hopewell.
- Funding, or lack thereof, is a roadblock in the planning and implementation process of GI in Hopewell.
- Hopewell's ecological patches and corridors complement green space GI in Hopewell, like parks, and the smaller site scale GI like rain gardens, native meadows, and constructed wetlands. The following section elaborates further on green infrastructure typologies, and the scaling of green infrastructure in Hopewell.
- Hopewell's downtown lacks significant tree canopy coverage from historic development patterns and an overwhelming amount of impervious surface coverage. Hopewell's industrial tract, and the Winston Churchill corridor are two other areas with a poor ratio of tree canopy coverage to impervious surface.
- Mapping proposed plans, future projects, and conceptual ideas adds a comprehensive GI layer with information gathered from previous research, funding, and energy.
- Respondents from interviews and the survey pointed to several locations within City Point to target new GI.
- Maintenance, as well as crime, were both cited as contributing to a negative perception of GI in Hopewell at times.

Interview Themes

Maintenance:

A common theme was the burden of maintenance, and the possible confusion surrounding maintenance responsibilities. Several interviewees referred to maintenance issues as a reason they did not support adding green infrastructure, like street trees, to potential sites. Lack of maintenance was also cited as an issue, creating aesthetically unappealing areas, potentially creating more harm than good by either making an area look uninviting, or potentially dangerous by not maintaining tree limbs. Interviews with DPW, and Rec & Parks, and Development point to the lack of outside support for long term maintenance from neighborhood or civic groups, like those that are active in Richmond such as Southside ReLeaf, Capital Trees, and the numerous gardening clubs active in Richmond greening initiatives. When speaking with

regional and local organizations that have experience working in Hopewell, as well as neighboring localities, the lack of stewardship or involvement by local groups, and the absence of neighborhood associations, in maintenance of street tree projects or other green infrastructure projects constricts the support to increase GI.

Funding:

Maintenance issues are related to funding issues in Hopewell. A major source of assets for Hopewell comes in the form of grants, and when the capabilities are there to apply for grants, this funding supports many projects that Hopewell is able to carry out. This is evidenced by Hopewell's DEQ Tree Canopy Grant, the Chesapeake Bay Stewardship Fund Grant, and the Virginia American Water Grant. These grants have funded a majority of recent GI projects in Hopewell. Grant applications and a lack of municipal funding were recurring themes throughout the interviews. Actors pointed to grants from the USDA, EPA, IRA, VDOT, USDH, and many other localized grants from organizations like the Virginia Outdoors Association, John Randolph Foundation, and the Virginia Cooperative Extension. Hopewell's network is filled with actors pursuing grant opportunities and knowledge of available funding outside of basic government spending. The pursuit of grant funding is competitive just as much as it is collaborative locally and regionally. Hopewell is financially handcuffed, and GI is not a priority for city spending. These two components, chasing grants and lack of municipal funding, lead projects to stall out after completion. For a GI project to be successful there needs to be a concerted effort to not only install and implement projects, but to spend the money to maintain GI properly so that it provides long-term ecosystem services and creates an aesthetically appealing city.

Regional Collaboration:

Outside of city departments and residents, the majority of the actors participating in GI projects in Hopewell are involved in projects regionally and even at the state level. The Chesapeake Bay Foundation, and the Friends of the Lower Appomattox River (FOLAR) have been major contributors to Hopewell's GI network, with FOLAR investing financial and sweat equity into building City Park into what it is today by increasing access, restoring eroded stream channels, and enhancing biodiversity and stormwater management with a native's meadow. The Chesapeake Bay Foundation, which works at a multistate regional level, spent four years in Hopewell, planting 250 trees, installing rain gardens, rain barrels, and stormwater BMPS, and restoring stream channels and wetlands. Other regional groups have put effort into stewardship, planning and GI education in Hopewell, however there is a need to translate this regional collaboration into local buy-in and localized stability. A theme through several conversations was the concern of regional groups coming in and adding GI, only for the momentum to die down after project completion and the organization moves out of town.

Hopewell's public schools have proven to be stewards of the land, with Woodlawn's Learning Center being a prime example, taking care of a vegetable garden and dozens of trees planted through the CBF's time in Hopewell.

Findings Continued

1.1 Where is Green Infrastructure located in Hopewell?

1.2 What are the various types of Green Infrastructure in Hopewell?

Research findings for questions 1.1 & 1.2 were consolidated together because of the overlap in analysis methods for each question.

The following table provides examples of Hopewell's GI typology at different scales, from regional to site-scale. An expanded GI reference table can be found in the appendix. The spatial map, available under the Analytical Methods section, allows for an interactive display of Hopewell's scaled GI, and is meant to be used primarily with the table below supplementing information. Full green infrastructure tables can be found in the appendix with all mapped GI by typology and acreage of green space GI.

Table 5. Hopewell's Green Infrastructure Scale

Scale	Green Infrastructure	Hopewell Examples
Regional	Ecological Corridors & Patches, Regional Parks & Trails	Protected Wetlands, Appomattox Regional River Trail, Appomattox Regional Park
Local	City Parks, Ecological Corridors & Patches, Green Space, Athletic Fields, Cemeteries, Riparian Buffers, Urban Forest	Wetlands, Appomattox Cemetery, Mathis Field, City Point Green Space, Utility Corridors, Riverside Park
Site-Scale	Green Stormwater Infrastructure, Gardens, BMPs, Greenways, Bioswales, Green Roofs, Trees	Bioretention Ponds, Native Meadows, Urban Gardens, Green Alleys, Constructed Wetlands, Street trees, Rain Gardens, Permeable Pavers, Stream Restorations, Greenways/Trails

Hopewell Green Infrastructure GIS Map

1. Hopewell's ecological patches line up with the designated Chesapeake Bay Preservation Areas (CBPA). There are two types of CBPAs in Hopewell, Resource Management Areas (RMAs) and Resource Protection Areas (RPAs). RPAs are more restrictive, only allowing a limited type of development, while RMAs are less restrictive, and allow most development to occur if proper steps are taken to prove the development will not cause significant water quality damage or degradation. Generally, the RPA protects the 100-foot landward area or buffer of any Chesapeake Bay watershed stream or waterway, and the RMA protects up to a 500-foot land buffer from the same waterways. The protection afforded by the Chesapeake Bay Act, and the CBPAs, provides Hopewell with its most dense areas of ecological integrity and biodiversity. Comparing the maps of Ecological Corridors in Figure 7 to the CBPA areas in Figure 6, illustrates the lack of dense ecological patches or spaces outside of the CBPA areas within Hopewell's municipal limits. Train tracks and utility right of ways present opportunities for creative GI techniques, but the CBPA protections allow for some of the most productive ecosystem services in the City. VGIN satellite imagery was used with other spatial datasets to map ecological corridors and patches, with a rough estimate of 941 acres of ecological corridor and patches within Hopewell's city limits.

Figure 8. Hopewell's CBPA Areas

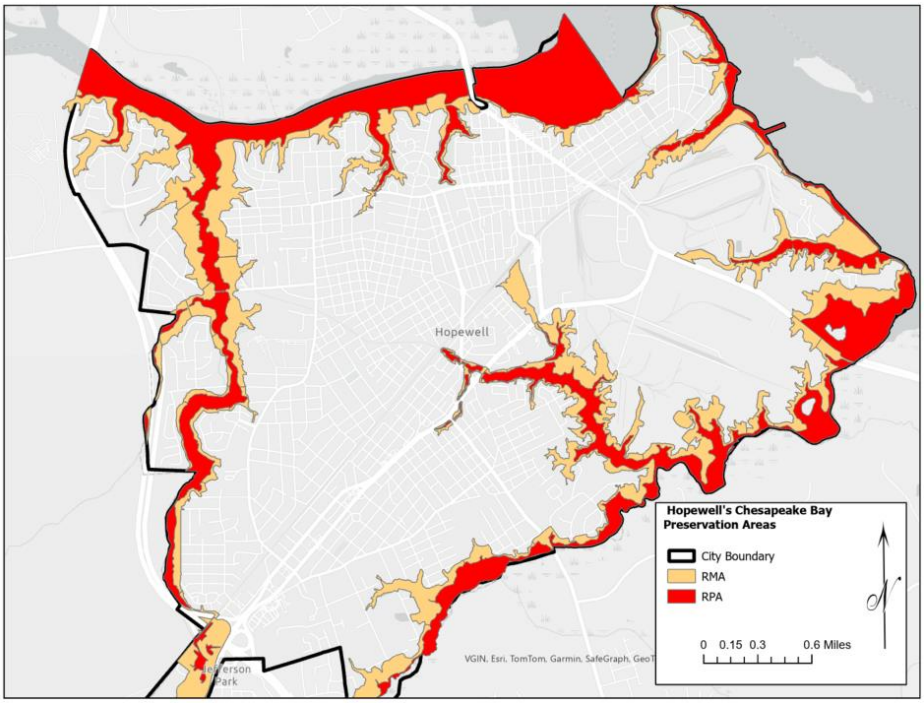
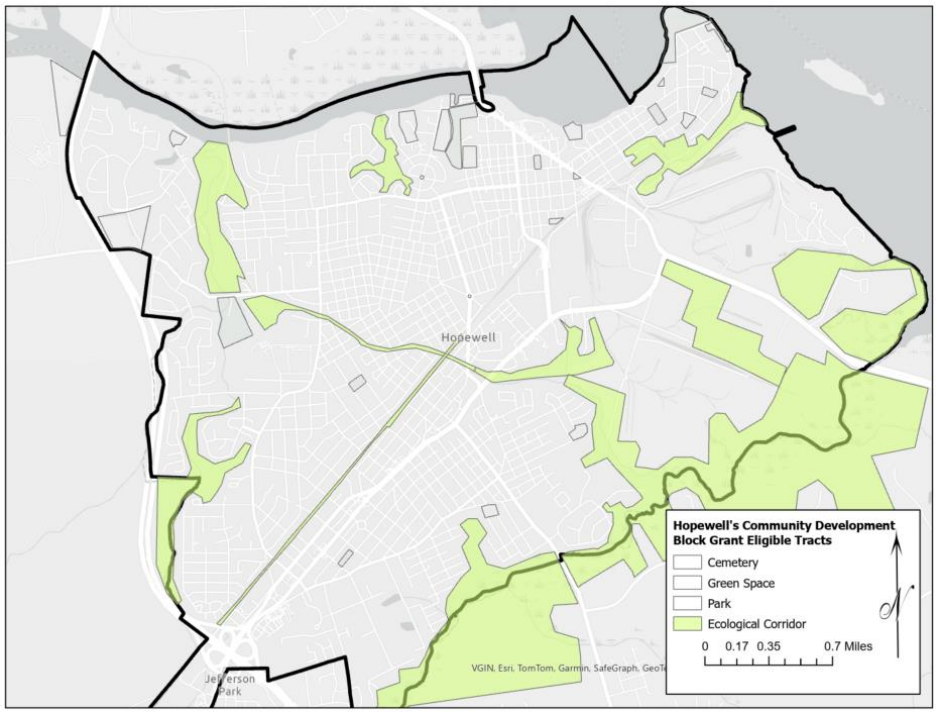


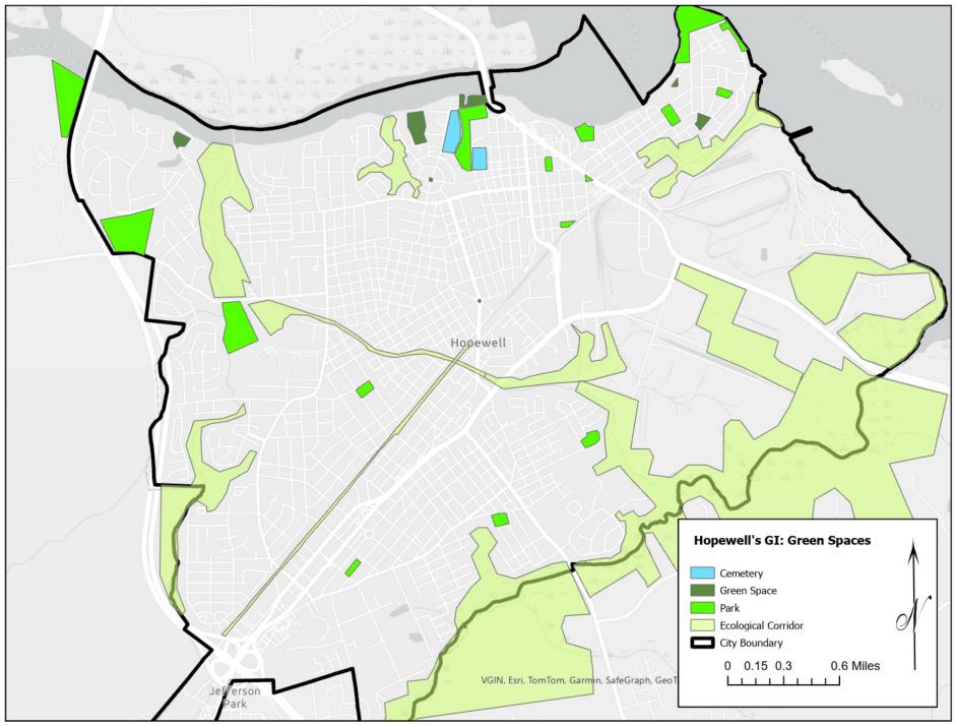
Figure 9. Ecological Corridors & Patches



2. Hopewell's park system includes city parks, as well as regional park connections to the Appomattox River Regional Park, and the Appomattox River Trail. City parks range from larger complexes with athletic fields, to small neighborhood parks, and riverfront parks or trails. Other local green spaces include cemeteries, informal, and formal green spaces. According to information gathered for this plan, there are sixteen parks, two cemeteries, and seven formal green spaces in Hopewell. This information should be updated regularly, and there may be GI missed throughout the research finding phase of the plan process. Total acres of parks in Hopewell is about 117. Informal green spaces can be found around Hopewell's wetlands, as well as utility and transportation corridors. Examples of formal green spaces include lots like the one in City Point, which receive regular maintenance and offer a bench for seating underneath the tree canopy. Interviews with the Wonder City Garden Club, and Hopewell residents pointed to these locations as green infrastructure activated by the public, and not just city-run green space. Total acres for green space is about 19, and there are about 15 acres of cemetery space. While Hopewell has parks throughout the city, interviews, survey responses, and field observations made it apparent that Hopewell's most popular parks are the two along the river, City Park, and Old City Point Waterfront Park.

The parking lots, and foot traffic were consistently busier at these two parks than any of the other parks during site visits. Both parks provide spectacular views of the James and Appomattox Rivers, and the close proximity to downtown make them obvious choices for recreational funding or municipal spending.

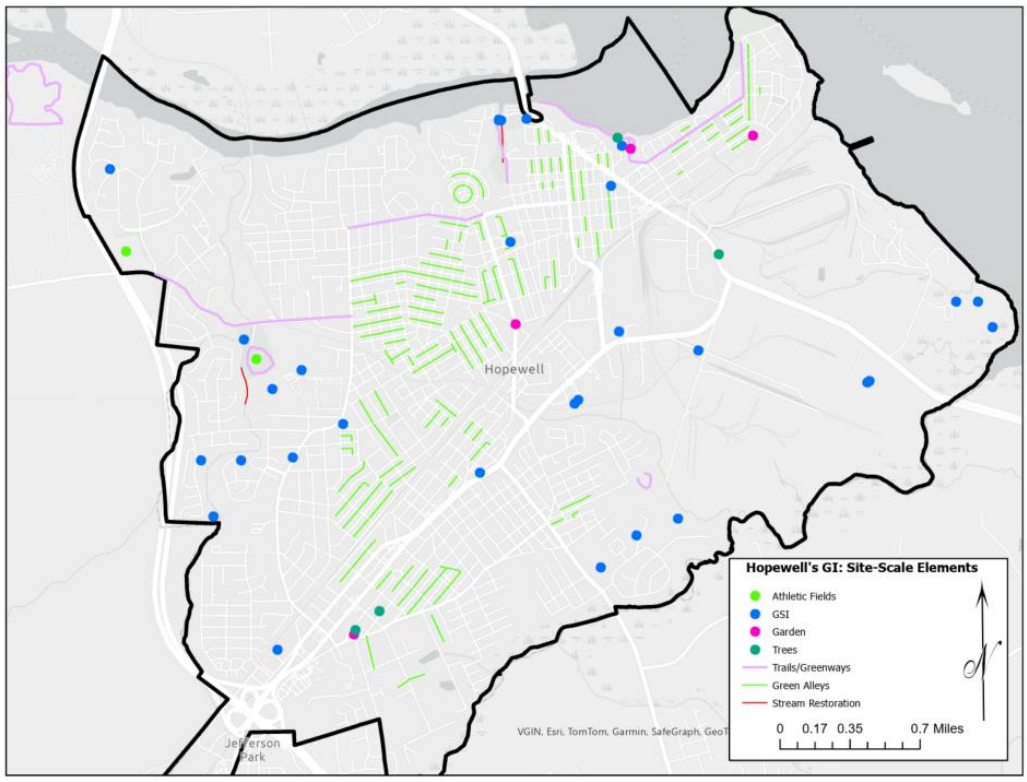
Figure 10. Hopewell's Green Spaces



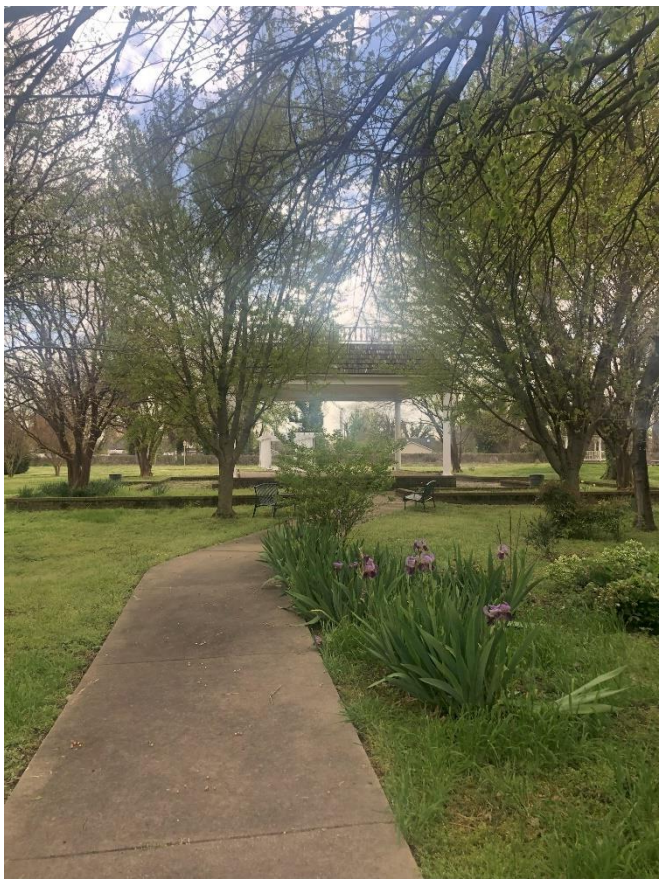
3. Hopewell's site-scale GI elements range from dry detention ponds, green alleys, constructed wetlands, and stormwater greenways, to street trees and urban gardens. The Chesapeake Bay Foundation pointed to several rain gardens installed in private residences, but for the purpose of this plan, site-scale GI on private property was not mapped. The map includes green stormwater infrastructure (GSI) elements that do not fall directly under the definition of GI for this project, but contribute to the same goals of GI through stormwater management and water quality improvement, like permeable pavers. Hopewell's DPW provided a GIS layer of BMPs maintained by the city, which is included in this analysis. Native meadows, like the garden mapped in City Park, not only increase biodiversity, and attract pollinators, but its strategic location in a basin, allows for increased stormwater management in large rain events, acting as a buffer to the restored stream channels downstream, and the eventual James River.

Green alleys are abundant in Hopewell, and while these alleys are basic green elements, as in they are grass as opposed to structured green alleys with permeable pavers or other installed GSI elements, they provide a distinct service by managing stormwater without impervious surfaces or overwhelming the current stormwater system, and filtering runoff before the water reaches the nearby rivers. Street trees mapped indicate locations of specific tree planting projects, either completed or planned.

Figure 11. Hopewell's Site Scale Green Infrastructure



4. Gardens in Hopewell provide aesthetic appeal especially in certain areas with low tree canopy and intense concrete, like Memorial Circle. Weston Circle is an example of another garden in Hopewell located in a roundabout circle with a pocket park. Heritage Gardens is another "garden" with success in the past, but is currently not a functional garden and is underutilized green space in the popular City Point neighborhood. Heritage Gardens is a nearly 3-acre plot of land, owned by the City of Hopewell located at 900 E. Broadway, presenting a great opportunity for urban farm space and ample room for gathering of community. As mentioned earlier, the garden mapped in City Park represents a native meadow which contributes to stormwater management and biodiversity along the riverfront.



Heritage Gardens

5. While the survey only yielded seven responses, the answer to the question: "Where is your favorite green infrastructure located in Hopewell?" identified the location of natural assets. Every response to this question was different, including City Point Park, the Riverwalk, Crystal Lake, and the Riverside Greenway.
6. Hopewell's Tree Canopy progress has included over 250 trees planted through the work with the CBF throughout the entire city, including along the James River near the riverwalk, at elementary schools Woodlawn and DuPont, the Woodlawn playground, and several other locations throughout the city. Hopewell's upcoming Tree Canopy Grant with Crater PDC stands to increase trees planted within the city limits.

1.3 Who are the human actors involved in Green Infrastructure projects, and what are their roles?

1.4 What are the interactions between social-natural assets?

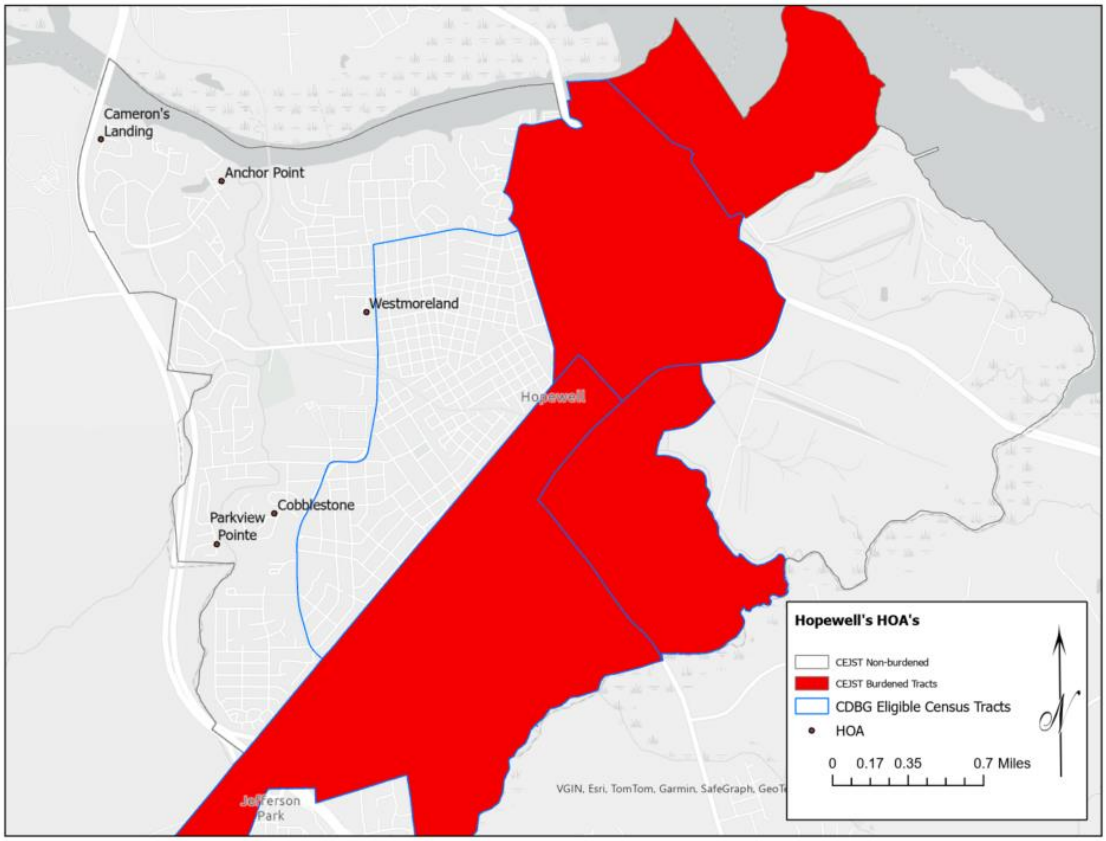
Research findings for questions 1.3 & 1.4 were consolidated together because of the overlap in analysis methods for each question.

Hopewell Green Infrastructure Actor Network Map

1. The Network Map provides a comprehensive analysis of the actors and GI elements in Hopewell, including their interactions, roles they play, and information about each piece of the system. Follow the link above to view this interactive analysis of Hopewell's GI network. Some of the key findings are summarized below. A table with all of the actors, their roles, and descriptions can be found in the appendix.
2. Environmental non-profits provide support to many of the localities in the region, acting as liaisons for funding between agencies, as well as facilitators of education, and GI materials. Interviews with the Chesapeake Bay Foundation, and the Green Infrastructure Center (GIC) illustrate several large projects, with different roles, interactions, goals, and processes. Organizations like the CBF and GIC wear many hats throughout the GIC process, serving several roles through the duration of a project, and with many interactions along the way. Some of the roles include grant administrators, planners, donors, and collaborators. Some of the interactions include installation of GI, community outreach and education, planning new projects, and maintenance of installed GI. These projects represent a significant amount of the GI work performed in Hopewell in recent years, along with work from groups like the James River Association (JRA) and Virginia Outdoor Foundation (VOF). There has been a dip in activity from similar groups working in Hopewell on GI projects, but working with other localities like Petersburg and Richmond. The Virginia Cooperative Extension and the James River Association are two examples of groups with ties to Hopewell, but no recent history of GI activities in the city, as interviews with the Hopewell Downtown Partnership and JRA point to connections between local groups, and even non-GI activities occurring in Hopewell with the JRA.
3. In recent history, maintenance has been a collaborative effort in Hopewell, with groups like the Wonder City Garden Club, the Lion's Club, and the Hopewell Tree Stewards participating in GI cleanups and tree maintenance activities. Unfortunately, the burden of maintenance is now shouldered mainly by Hopewell's Department of Public Works, and the Department of Recreation and Parks. These two departments are responsible for maintenance of all of the public GI in Hopewell. The inactivity and dissolving of certain groups has muddied up maintenance responsibilities, and while business owners and residents that were interviewed seem open to the idea of maintaining GI or participating in maintenance events, there is still a gap missing between implementation and maintenance strategies.

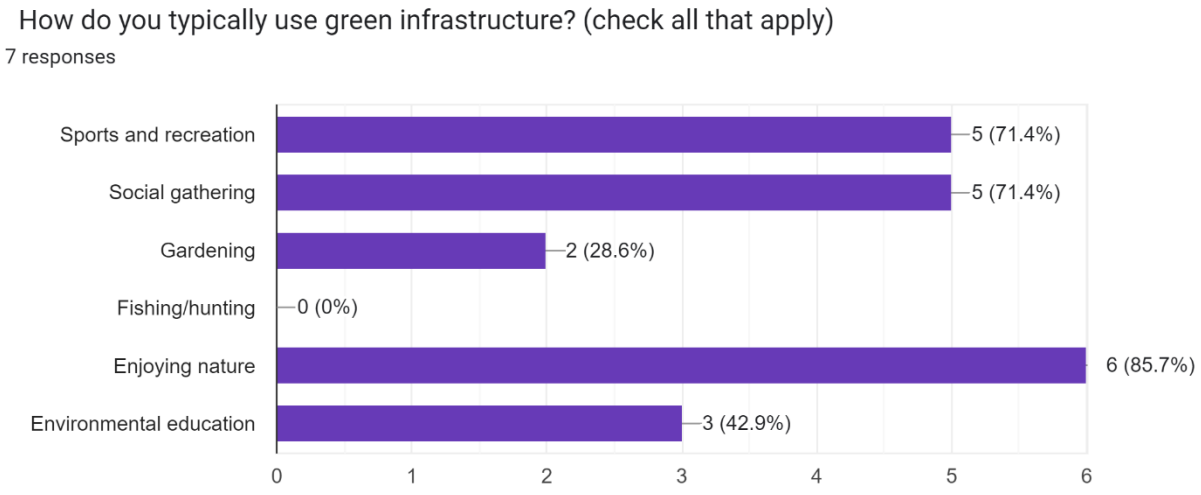
4. Hopewell's city departments contribute to the planning of green spaces, collaborating with actors like Crater PDC, the EPA, Keep Hopewell Beautiful, the Chesapeake Bay Foundation, VCU, and Hopewell Downtown Partnership, to plan for enhanced green space or to activate some of the underutilized spaces. Hopewell's DPW and Recreation & Parks have also worked with groups like the Chesapeake Bay Foundation to install GI, and stream restoration projects.
5. Hopewell relies heavily on the support of grant funding and the capacities of groups facilitating projects. Funding issues and small staff numbers leave the City handcuffed financially and capacity-wise. Interviewees, including CBF, HDP, and City representatives, mentioned the struggles of maintaining project momentum once outside support is gone. Projects like the CBF's are successful while being managed by the partnering organization, but a lack of interaction among local groups leads to the decaying of these support structures when the organization finishes its project scope. Hopewell has a lack of neighborhood organizations and local groups. Faith based organizations are influential, and there are several groups associated with health and well-being like the Hopewell Downtown Partnership, and One Hopewell. In Richmond, churches are looking to involve community and congregations in greening initiatives through urban gardens, and depaving for GI infill. Churches tend to have more underutilized space with the opportunity for community events, additional trees, or urban gardens. There are also several HOAs, however these are generally located in neighborhoods that aren't as vulnerable as the neighborhoods in need of representation or organization. HOAs identified through interviews include Cameron's Landing and Anchor Point. The website hoa-community.com was used to identify several other HOA's in Hopewell. While this list is not exhaustive, the mapped HOAs from the website list have been identified as either active or recently active. None of the HOAs mapped are located either in a CEJST vulnerable census tract, or a CDBG eligible census tract.

Figure 12. Hopewell HOA's



6. The question from the survey: "How do you typically use green infrastructure?" was meant to understand how residents interacted with public green infrastructure. While the limited survey responses restricts finding takeaways; of the seven respondents, more than five interact with GI through sports, recreation, social gatherings, or by simply appreciating nature.

Table 6. Survey Question: Human Nature Interactions



1.5 Where are the opportunities for Green Infrastructure in Hopewell?

Urban Farms in City Point and Downtown:

Interviews with city representatives and the Hopewell Downtown Partnership highlighted the progress made to organize a group to run Heritage Gardens as a full-time urban farm, producing food for the community, farm members, and possible outlets like the farmer's market. Interviews with HDP pointed to business owners downtown open to starting urban farms of their own. Several other interviewees mentioned Heritage Gardens as a location they would like to see more GI in the City.

Ecological Corridors:

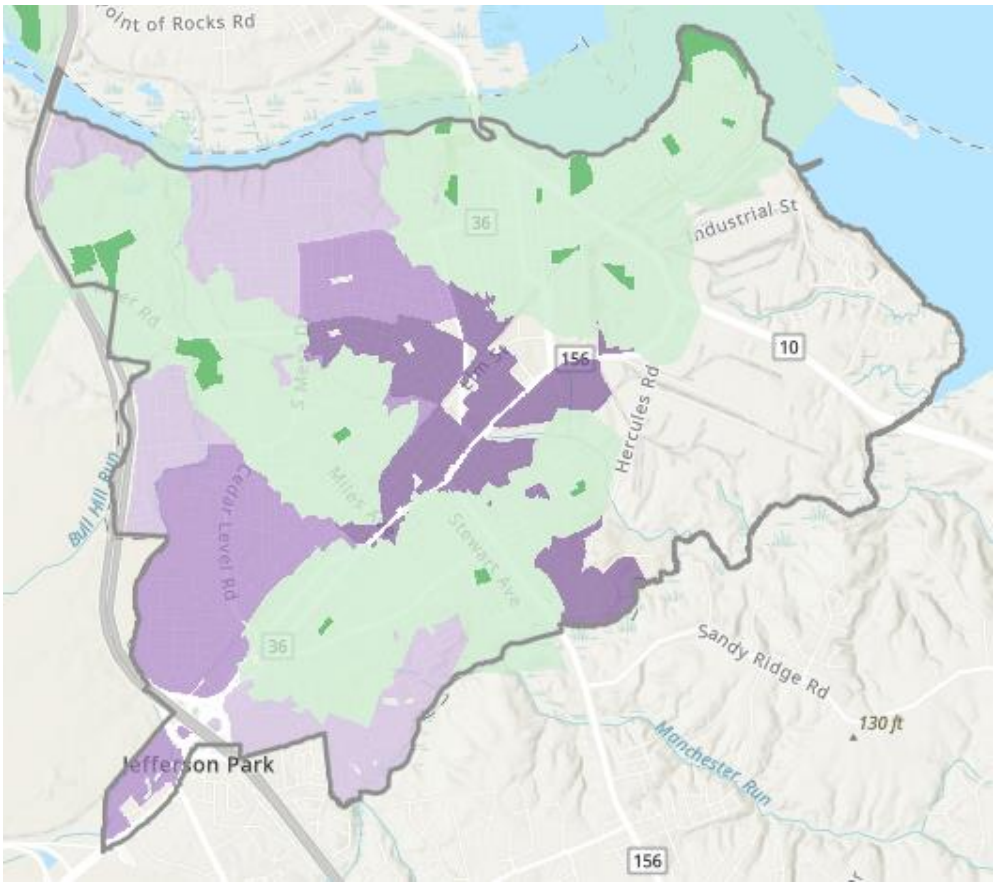
The Chesapeake Bay Preservation Act (CBPA) provides additional protection for land adjacent to active waterways in the Chesapeake Bay watershed through protection areas called RPA's and RMA's. Hopewell has ecologically rich areas that are undeveloped because of the protection afforded by the CBPA. These areas, along with easements for rails and utilities provide semi-undeveloped land with opportunities to increase the ecosystem services provided if approached in an innovative manner that increases the multifunctionality of these spaces while not altering its main function as a utility space or transportation corridor. An example would be to increase natives or pollinators along utility easements, where trees may not be appropriate but smaller plantings would fit. A larger scale example of this is Virginia's Wildflower and Pollinator Habitat Program, which utilizes state maintained green space along transportation corridors to increase

pollinators and other plantings. Rails to trails programs are another example of how localities are utilizing utility and rail easements to increase access, green space, and GI. It is important to note, a large portion of CBPA land resides on private property, limiting the City's ability to use the land for innovative processes.

Increasing Green Space & Tree Canopy:

Comparing maps using 2021 NLCD data highlights areas that are high in impervious surface coverage, while also lacking tree canopy coverage. Overlaying the GIN map highlights neighborhoods that lack access to parks within walking distance and using additional resources like ParkServe can provide additional context into park accessibility. The following map from ParkServe displays areas in Hopewell within a 10-minute walk from parks, and identifies areas for new parks. The light green area is the 10-minute walk service area, and the purple areas represent priority areas for new parks.

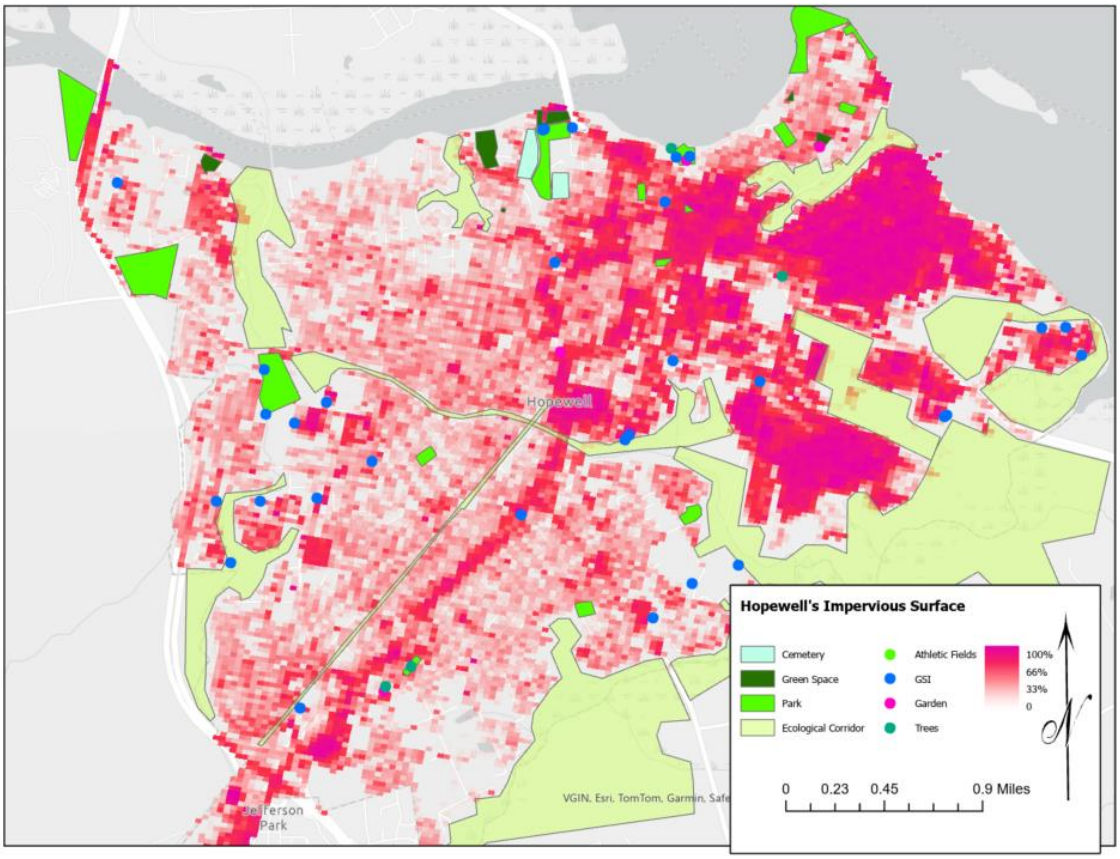
Figure 13. ParkServe Park Access Map



Source: ParkServe

Areas with high impervious surface coverage and low tree canopy coverage contribute to negative health consequences from the urban heat island effect, urban flooding, and poor air quality. The following map shows the spatial distribution of impervious surface in Hopewell in relation to natural assets from the previous maps.

Figure 14. Hopewell Impervious Surface Coverage

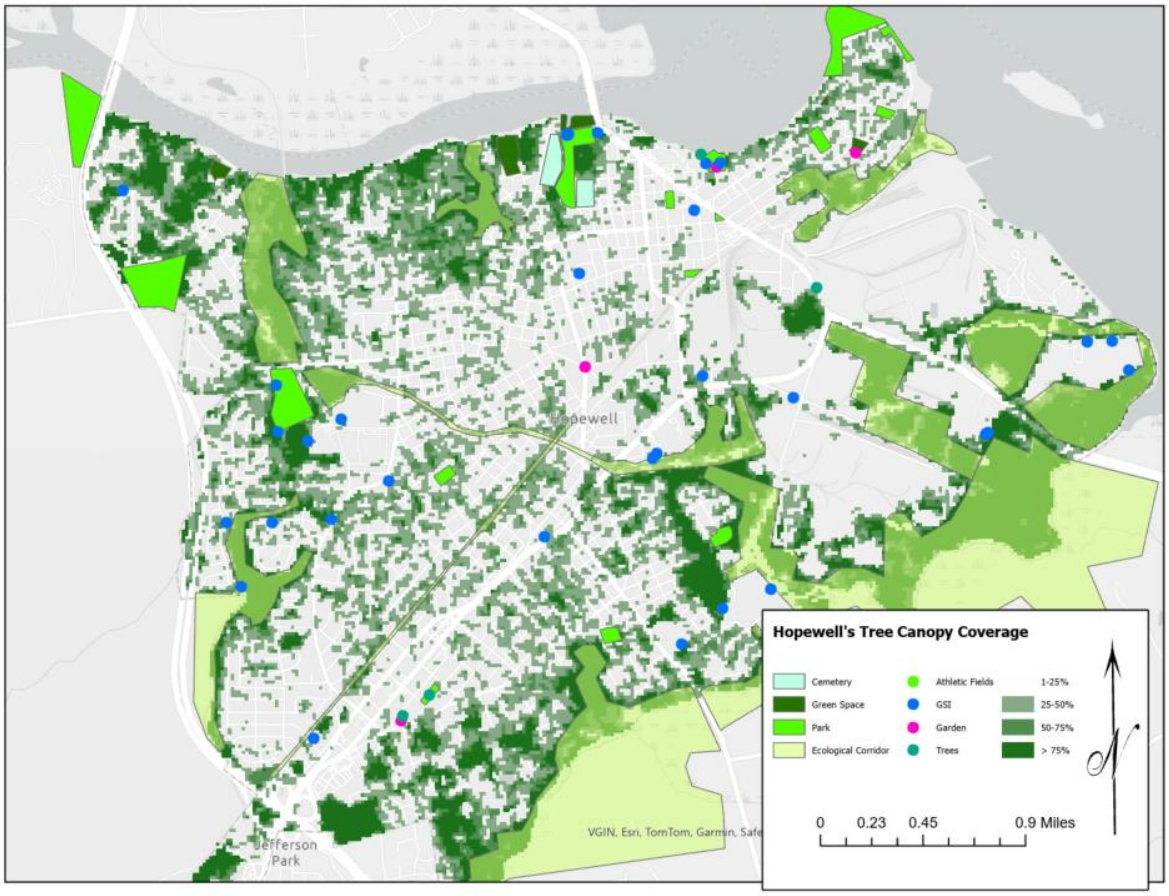


Source: 2021 NLCD

The following tree canopy map shows the spatial distribution of tree canopy coverage in relation to Hopewell's natural assets. While tree canopy coverage from the NLCD provides an understanding of the location of tree canopy, it is limited in mapping detailed tree coverage of a city. To symbolize the tree canopy data, coverage percentage is the percentage of a 144 square foot space with live trees in the FIA master tree species list. Using GIS analysis, a rough estimate of canopy coverage percentages was calculated for Hopewell. Hopewell has roughly 6,628 acres of total land space, and an estimated 1,796 are covered by 50% tree canopy coverage. Hopewell has 1,228 acres of land space covered by 25-50% tree canopy coverage, meaning there are a total of 3,024 acres covered by at least 25% tree canopy coverage. There are an estimated 1,651 acres of land space with 0% tree canopy coverage. Finally, there are 1,950 acres covered by 1-25%

tree canopy coverage. Hopewell's Tree Canopy Grant is currently targeting downtown parcels for tree plantings to increase canopy coverage in a highly impervious area.

Figure 15. Hopewell's Tree Canopy Coverage

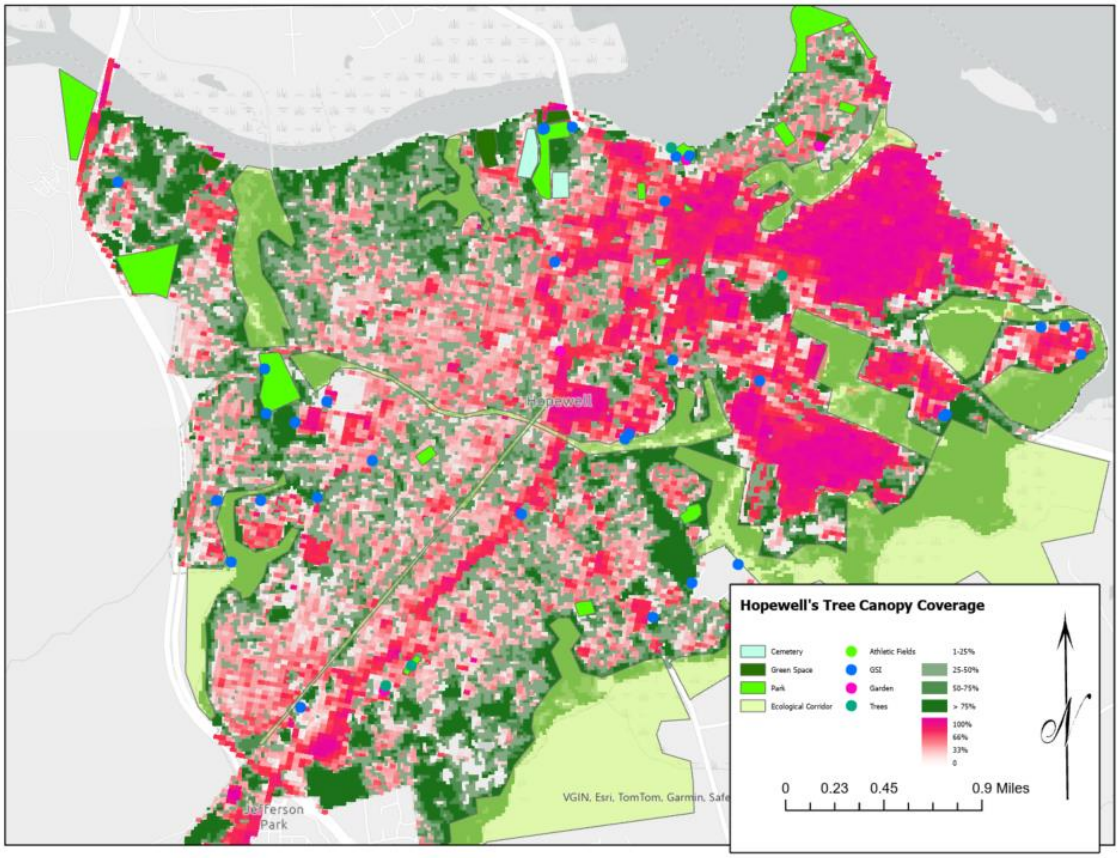


Source: 2021 NLCD

The following map combines the impervious surface coverage layer with the tree canopy coverage layer to highlight areas that may be suitable for additional tree plantings or GI improvements. These areas in grey are mostly athletic fields and cemeteries, but they still present opportunities for plantings in the future. While the areas with high impervious surface area do not offer much in way of available planting space, they do present the opportunity for future change. These areas should be targeted for infill GI, using a variety of approaches like complete streets models where GI is incorporated into an overall road diet by reducing vehicular lanes and replacing them with medians, and enlarged sidewalks with enough space to accommodate streets trees, tree wells, and rain gardens or bioswales. Parking areas, especially in shopping centers like Cavalier Square, represent large areas of impervious surface, with the opportunity to

infill with GI by adding streets trees and GSI in underutilized impervious areas. Transportation corridors like Winston Churchill Blvd. represent opportunities for infill development with underutilized parking spaces and road diets. As mentioned earlier, a sizable portion of the area with high impervious surface coverage is industrial land with heavy industry located on the properties, leaving little opportunity to increase GI in certain parcels. The CBF interview mentioned planting complications related to soil issues, and it is safe to assume this is a consistent problem throughout the city, especially in areas with decades of impervious surface coverage history. While this can be seen as a deterrent to exploring GI in these areas, remediating soil is a possibility, and would be welcoming for a future filled with increased urban green space. This will be more difficult in industry adjacent properties with a history of contamination, as remediation will involve extreme safety measures. These projects are also not impossible, and the EPA and DEQ are actively encouraging Brownfield remediation projects in Virginia.

Figure 16. Tree Canopy & Impervious Surface Coverage

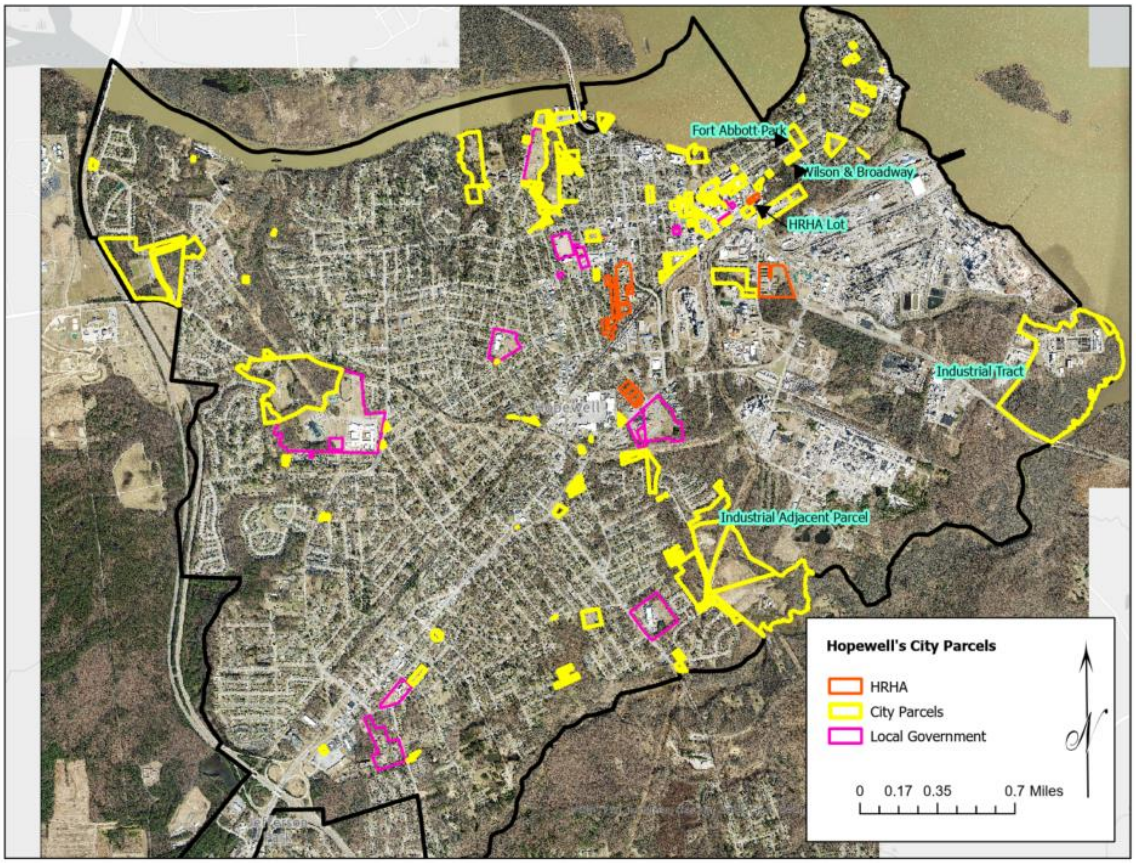


Source: 2021 NLCD

City-Owned Parcels:

The City of Hopewell owns property with a varying degree of ecological importance. Parcel layer data was overlayed with up-to-date VGIN satellite imagery to identify city parcels with ecological importance or the possibility of GI enhancements. City parcels include EDA, Public Schools, HHRA, and general City-owned property. Several city parcels in the industrial tract and parcels surrounding Cattail Creek near the southern city boundary are examples of undeveloped city owned property. Other city-owned properties like Fort Abbott Park, the lot adjacent to the Hopewell Housing & Redevelopment Authority, and the lot at the corner of Wilson St. and E. Broadway are examples of underutilized green space with an opportunity for enhanced GI. Several other spaces not labeled in the map below that are ideal candidates to increase GI through tree plantings or other site scale improvements include the Davisville field along Route 10, and the gravel lot adjacent to the Poythress Street public parking lot which has been identified through precedent plans and Hopewell's Tree Canopy Grant project for new tree plantings. Examples of GI elements to add to these sites include tree trenches and plantings, urban gardens, bioretention, and bioswales, or riparian buffers for land adjacent to waterways.

Figure 17. Hopewell's City Properties

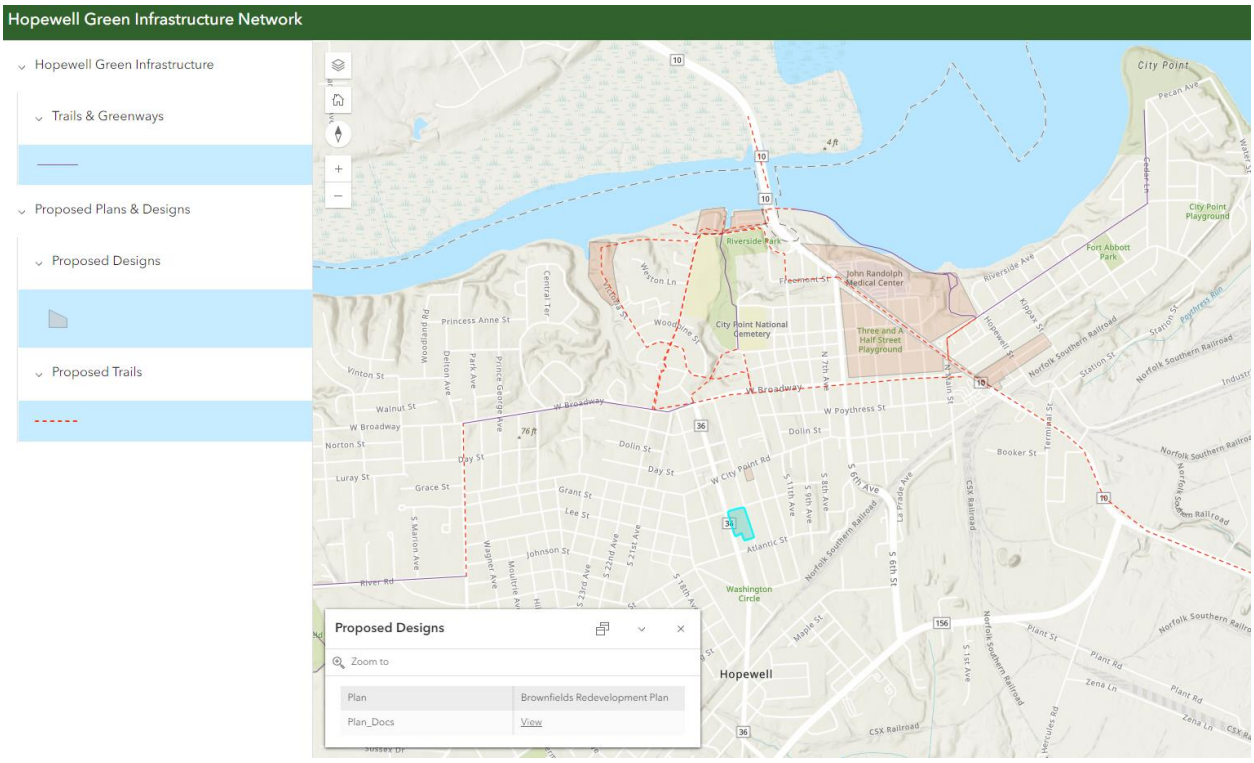


Sources: VGIN VBMP; Hopewell City Parcels Data

Previous & Current Plans:

The Hopewell Brownfield Plan, Food Access Report, Marina Plan, and Poythress Street Design are all examples of plans with green infrastructure elements that were either never adopted or have not been implemented. These plans highlight different areas of the city and point to specific locations suitable for GI and presumably desired in these locations. Information was pulled from these plans, along with GIS data from FOLAR, to create a proposed plans and designs GIS layer for the online spatial map. The online map provides different locations for each proposed development, as some of the plans have recommendations or designs for several locations. Each design attribute has a plan or document linked to it, allowing future actors like planners or developers to access previous research and design work for various popular locations around the city, expediting the planning, funding, and grant application process.

Figure 18. Hopewell's Proposed Trails, Designs, and Plans

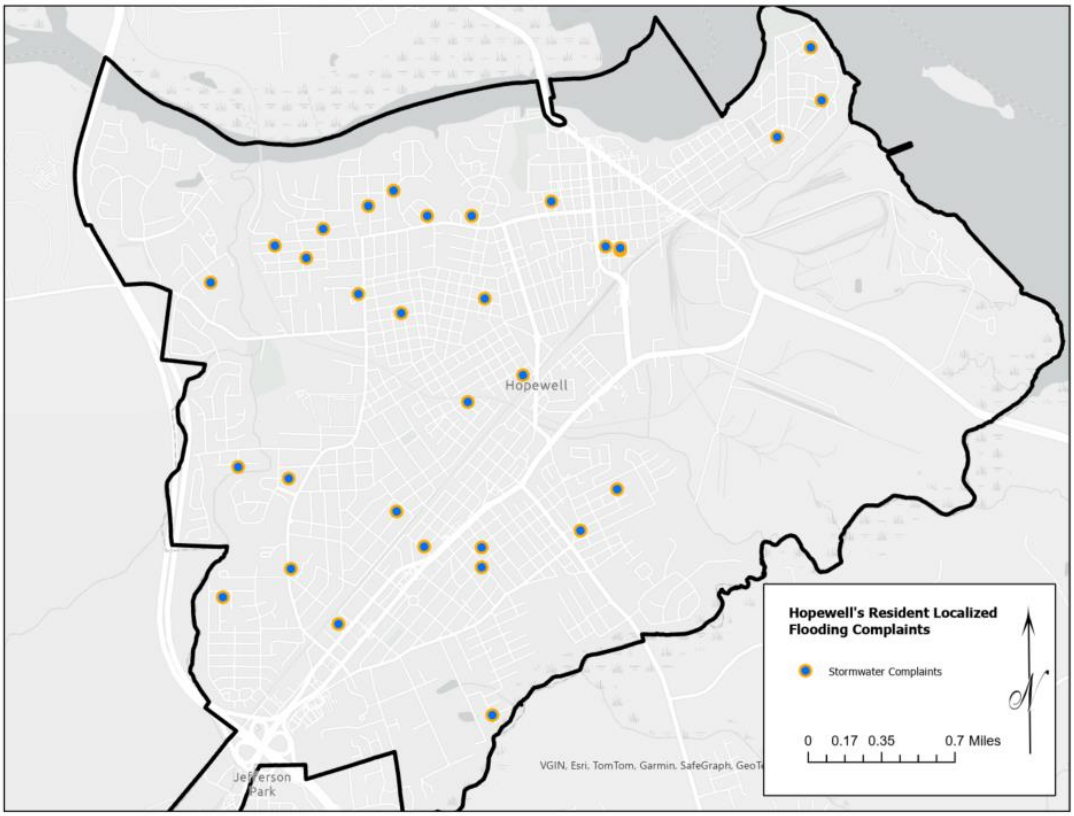


Source: ArcGIS Online GIN Map

Stormwater Management:

Complaints from residents of stormwater issues contribute to the Capital Improvement Projects that Hopewell funds through various grants and city spending to maintain its MS4 permit. Most of the projects involved grey infrastructure updates, however several projects involved a stream stabilization using natural materials, and a stream restoration project. Interviews with Stormwater and DPW provided additional details to the outcomes of these projects, and locations for stream restorations or BMPs, supplemented by the provided BMP GIS layer. Groupings of resident complaints lead to localized projects for stormwater improvements, and should be studied for the opportunity to supplement these improvements with GI designs. The following map shows the spatial distribution of localized flooding complaints from residents between January of 2023, and February of 2024. Stormwater complaints are included in the spatial map, with the current USGS hydrography layer, allowing complaints to be compared spatially to the location of local waterways.

Figure 19. Hopewell's Stormwater Complaints



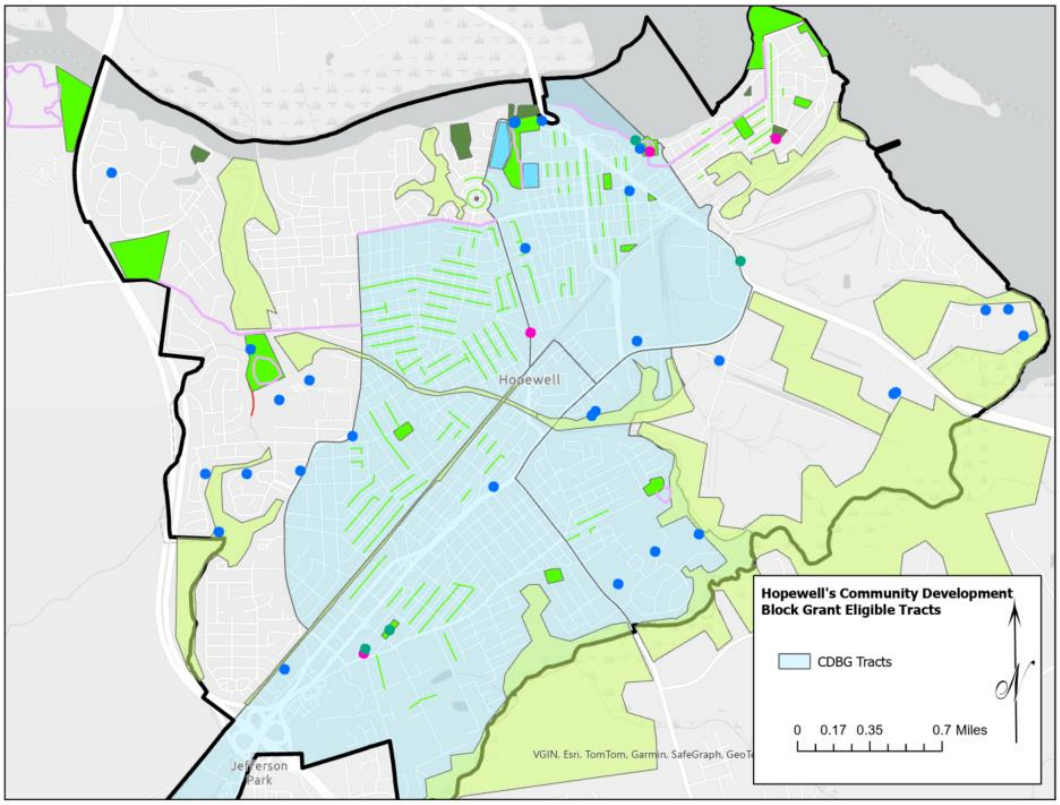
Source: Hopewell Department of Public Works

2.1 Is there a system in place to prioritize vulnerable neighborhoods for GI enhancements?

CDBG:

Interviews with the Development Department highlighted Community Development Block Grant funding as one of the main processes in place for prioritizing vulnerable neighborhoods for community development in Hopewell. Census tracts are deemed eligible for federal funding through these grants based on economic characteristics. These funds are predominately used for emergency home repairs for private property, and while this is extremely important for the residents able to receive funding, the funds don't usually translate to increase GI. CDBG funds have been used previously for park upgrades in eligible census tracts, including the 3 ½ street playground, and a proposal for upgrades at Westwood Park, but the project scopes are mostly limited to playground equipment. CDBG funds have not been used for any other GI improvements, but this funding can act as a method to prioritize certain census tracts. The following map shows the census tracts that are eligible for CDBG funding for city improvement projects. Eligible tracts are overlayed to Hopewell's GI assets to visualize the spatial relationship between potentially vulnerable census tracts and the location of natural assets.

Figure 20. CDBG Eligible Census Tracts (2024)



Other Grants:

Multiple interviewees including city representatives, GIC, and Crater PDC pointed to the prioritization of underserved communities in the grant application process. For example, several federally funded grants through the EPA were mentioned as requiring evidence of positive future impact on vulnerable populations through grant implementation. These grants include the Greenhouse Gas Reductions grants, Inflation Reduction Act grants, and the grant funding the tree canopy project being led by Crater PDC and Hopewell. All of these grants require evidence and supporting documentation that the proposed projects or work will positively impact underserved or vulnerable communities. EJscreen Tool and the CEJST are two tools federal and state agencies encourage applicants to use to understand which communities are vulnerable, and how they are vulnerable.

The Chesapeake Bay Foundation and the Green Infrastructure Center were the only groups interviewed with a process in place for targeting vulnerable neighborhoods or populations for new projects. In the process of identifying neighborhoods for tree canopy plantings, the CBF used data from the EJScreen tool, socio-economic census data, and data from the CDC to highlight census block groups in Hopewell that were vulnerable in different health, economic, and social statistics.

3.1 How can the GINP be used as a tool for actors in the future?

1. Missed connections

Interviews with FOLAR, JRA, and HDP point to actors currently working with local actors in Hopewell on projects unrelated to GI, or have previously worked in Hopewell on projects related to environmental education and recreation activities. The James River Association has recent experience hosting educational, recreational, and art events related to GI, but have not participated in specific GI projects in Hopewell recently. The Virginia Outdoor Foundation recently funded a trash collector in one of Hopewell's outfalls, and the Alliance for the Chesapeake Bay recently recognized a former Hopewell Mayor for a Virginia Watershed Champion Award (Miller, 2022). These are groups that are heavily involved in GI projects regionally, like JRA's green infrastructure initiative in Richmond and Petersburg, just miles from Hopewell. The Virginia Outdoor Foundation is involved with land acquisition for conservation regionally, and even in Hopewell's neighboring localities, working with FOLAR to acquire and conserve land for the connecting River trail, but not in Hopewell. Interviews with VSU point to their efforts with the Virginia Cooperative Extension, and their Small Farm Outreach Program, and is activity supporting small urban farmers in localities surrounding Hopewell. These actors can be found in the Network Map along with their connections to a number of regional groups, but a smaller number of connections to Hopewell's local groups active in the GI world.

2. Identifying funding sources

Almost every interview identified reoccurring grant or funding sources, but also added new sources for the network map. Grants from the EPA, DOF, and DEQ were common, but grant sources from VDAC, NFWF, Chesapeake Bay Trust, VDH, and local grant options like the Virginia Outdoor Foundation, Cameron Foundation, and John Randolph Foundation provided variety to some of the larger and more competitive grants. Diving deeper into network connections increases the capacity for funding sources or funding ideas. Acquiring funding for GI requires innovative thought processes, as municipal spending is often dedicated to necessary improvements like grey infrastructure, transportation, and housing. Innovation is a product of collaboration and increasing social capital, and the network map is a tool for realizing the social capital available to the local groups in Hopewell, as well as the connections they have both past, present, and future, to other actors with similar goals or ideas. A list of potential funding sources can be found in the implementation section, this list is a product of data gathered from interviews and the network map.

3. GI Inventory

Cataloging and documenting inventory of GI is valuable on multiple levels for Hopewell's network. At the regional level, documentation of larger parks can aid in the process of creating connections to regional trails or park systems. The FOLAR interview pointed to the "East Coast Greenway" as an example of a national trail route with the possibility of future trail spinoffs. Route 10, Hopewell's main highway, intersects with the future East Coast Greenway and could be an opportunity for a smaller regional trail connector. Having an inventory of GI and trails easily accessible through a mapping service can aid in planning for exciting new developments.

Locally, a resource with data mapped spatially at the site scale level is important to the actors involved in planning, installing, and maintaining new and current GI at the site scale level. Through Hopewell's four-year program with the Chesapeake Bay Foundation, 250 trees were planted throughout the city, and none of these trees were entered into a spatial database like ArcGIS. There was a sense of frustration in the CBF interview, that not having this data on hand would be a setback in the future to the long-term maintenance and health of the trees planted. The GIC interview turned out to be one of the most productive, as it opened the door for a new grant which Hopewell has since applied for, the Urban & Community Forestry Grant Program through the Department of Forestry. The GIC is administering the program to grant recipients in the region, and if Hopewell is awarded the grant, will expand on the tools of the GINP. The GIC is currently creating a GI inventory for the City of Petersburg, and mapping similar spatial characteristics like tree canopy coverage and identifying potential planting sites for new street trees and urban forests. The spatial maps and the GI

inventory created through the GINP act as a baseline of data for groups like the GIC, expediting the process by providing spatial datasets of locations of GI overlayed to tree canopy and impervious surface coverage in Hopewell.

4. Stormwater Management

Creating a spatial database of stormwater management issues and solutions has similar benefits to having access to a spatial database of GI. Stormwater and DPW interviews mentioned the city's MS4 permit several times, which requires standards, and planning for stormwater management. Some of these requirements include public outreach and education, a comprehensive stormwater management plan, and the use of best management practices (BMPs). Mapping stormwater complaints spatially allows departments like DPW to identify neighborhoods more prone to flooding, and with additional layers like GI, stormwater improvement projects can target neighborhoods or site-specific locations for green stormwater infrastructure. The spatial datasets apply to the studying of stormwater calculations for the MS4 permit, as the location of current and future GI can be analyzed for any impacts to runoff or stormwater flows during heavy rain events.

Recommendations

Recommendations are related to research findings from interviews, mapping data, and other relevant sources. Recommendations are broken down by goals, objectives, and actions. There are three goals, scaled like Hopewell's green infrastructure system, working from a regional perspective down to a localized perspective. Recommendations consider Hopewell's financial limitations, and that green infrastructure is not a top priority for municipal funds. In light of this knowledge, recommendations are meant to be cost effective, and identify ways in which the GINP's tools can be used for strategic funding and implementation strategies.

Goal 1: Establish Regional Asset Connections

The Crater and Richmond regions are rich in social and natural assets, with many groups working on similar projects in multiple localities. Previous efforts have been made to plan for major ecological connections like the Green Infrastructure Center's green infrastructure plans for the Crater and Richmond regions. Social assets like the James River Association, and the Chesapeake Bay Foundation have a history of working in Hopewell, and currently are working in adjacent localities. The following objectives and actions provide strategies for making connections between current asset gaps.

Objective 1.1 Bridge gaps between regional actors

Action 1.1.1: Reach out to regional actors for support creating green infrastructure events like tree plantings, rain barrel donations, and rain garden installations.

Hopewell should reach out to groups like the JRA, CBF, and Capital Trees to sponsor green infrastructure events. These groups have a history of working in Hopewell or with local groups, but have not supported any events in the last few years. Examples of recent events include JRA's tree planting event in Richmond, made possible through a partnership with the Arbor Day Foundation, and a grant from SageSurge.

Action 1.1.2 : Coordinate with high centrality groups in the network map when planning new GI projects.

The Green Infrastructure Center, FOLAR, and Crater PDC are examples of groups with a large number of regional connections to other GI actors. Crater PDC, for example, hosts a monthly Environmental Resources Management Task Force, bringing new ideas to the table with regional actors. By coordinating with these higher centrality groups, more opportunities become available for new group involvement, funding sources, and expanded education. The network map should be updated regularly, and consulted in the preliminary stages of GI planning.

Objective 1.2 Create opportunities for regional green infrastructure connections

Action 1.2.1 : Amend the zoning ordinance to create more restrictive development standards in the RMA.

Examples of this include James City County's 200-foot protected riparian buffer along tidal creeks within the Powhatan Creek Watershed.

Action 1.2.2 : Create incentive opportunities for residents to preserve their land through conservation easements.

Groups like the Virginia Outdoor Foundation provide support and guidance to residents and government entities in the conservation easement process. Partnering with a knowledgeable group can help facilitate protecting valuable land. FOLAR has used this strategy to conserve land for the Appomattox River Trail in the localities adjacent to Hopewell. While donating land for conservation easements is advantageous for the landowner through tax deductions and credits, this can be a minor blow to tax revenue for Hopewell. Understanding the future benefits from improved water quality, increased green space and possible connections to trails and regional parks lends an eye to the future and the economic potential that comes with prioritizing green space and parks in Hopewell. In Richmond, for example, property values increase by an average of $8,712 for every quarter mile the property is closer to the James River Park System. The James River Park System is Richmond's main park system focused on the James River and brings in millions of visitors per year, with an estimated thirty-three million in spending related to park tourism in 2016 (Shivy & Suen, 2017).

Action 1.2.3. Use traffic calming measures on streets intersecting ecological corridors to promote safe crossings for wildlife.

Complete streets principles can be applied to this action by decreasing travel lanes, or a "road diet," and replacing the space with GI like rain gardens or tree trenches, installing elevated crossings, decreasing the speed limit, and in wildlife crossing locations, eliminating unnecessary light pollution.

Action 1.2.4 : Amend the zoning ordinance to preserve Hopewell's ecologically rich city-owned land.

Hopewell currently has a conservation zoning district that protects environmental lands, and this strategy should be used in areas with high ecological integrity like those bordering RMA's, and other ecological patches or corridors.

Goal 2: Engage Social Assets Locally

Hopewell lacks a cohesive system of local groups in relation to green infrastructure planning, development, or maintenance. Hopewell relies heavily on outside support from grants and the grant providers, however, by creating a collaborative network of local groups engaged in green infrastructure enhancement like churches, garden clubs, PTAs, civic associations, and neighborhood associations, the local system can become more resilient and self-sufficient.

Objective 2.1 Strengthen Hopewell's network of actors

Action 2.1.1 : Create and hire a City Sustainability Coordinator position.

Financially, this position will require fiscal creativity from the city. By establishing a dedicated position, the burden of coordinating events, groups, meetings, funding, and grant applications will be eased from departments like Development, Public Works, and Recreation & Parks. Salary from this position can be included in the budget requirements for Tree City USA (*See Action 2.1.6*.)

Action 2.1.2 : Establish an urban farm collective with regular meetings.

Groups like the HDP, Virginia Cooperative Extension, VSU, and several business owners are in the process of revitalizing Heritage Gardens to support a fully functional urban garden. There is interest and support in using other sites downtown for urban agricultural sites.

Action 2.1.3 : Establish a green infrastructure committee to meet regularly.

There is a general interest locally in enhancing GI, from tree plantings to rain gardens, to urban gardens for food production, and stream restoration or bank stabilization. Connecting interested residents and community groups under the umbrella of GI will help facilitate ideas, and provide the opportunity to engage new community members.

Action 2.1.4 : Reach out to faith-based organizations to increase community engagement in neighborhoods lacking neighborhood associations or representation.

Hopewell is underrepresented by neighborhood and civic groups, but faith-based organizations tend to be prominent in Hopewell's neighborhoods. These groups should be engaged and included in the process of GI planning and community outreach initiatives.

Action 2.1.5 : Re-establish the Hopewell Tree Stewards

Engage interested community members to activate the dormant group, Hopewell Tree Stewards. Activities like tree maintenance, and tree pruning classes are examples of events to engage group members. Creating an agreement for long-term tree maintenance between City Departments and the Tree Stewards would satisfy the requirements for a "Tree Board" for the Tree City USA designation.

Action 2.1.6 : Commit to becoming a "Tree City USA" City.

Hopewell has attempted previously to obtain "Tree City USA" status. While this provides minimal support from the Arbor Day Foundation, participation and recognition alone come with a multitude of benefits. There is a four-step requirement process outlined in these recommendations.

1. Maintaining a tree board (Action 2.1.5)

A tree board requires legal responsibility for the care of all public trees, and can be any form of group responsibility, not limited to an agreement between City Departments and a group like the tree stewards to have annual tree care responsibilities.

2. Having a community tree ordinance (Action 2.2.1)

3. Spending at least $2 per capita on urban forestry – Cumulatively the spending through these recommendations, along with the salary of Hopewell's arborist, should reach the rough $46,000 requirements.

4. Celebrating Arbor Day (Action 2.2.2)

Objective 2.2 Educate the public on green infrastructure benefits and opportunities

Action 2.2.1 : Create a comprehensive urban forestry ordinance with a detailed process for community engagement & education.

This ordinance should be an all-encompassing forestry ordinance with landscaping and species standards, standards for tree removal, and a comprehensive framework for the City's tree planning canopy goals. Groups with experience in this

process like the Green Infrastructure Center can support this process and provide guidance on standards for Hopewell. The ordinance process should include an inventory of Hopewell's urban forest. ESRI software makes tree management easier to manage in a spatial database.

Action 2.2.2 : Partner with Hopewell Public Schools and environmental groups to host an annual tree planting day to celebrate Arbor Day.

CBF's previous projects with Dupont Elementary and Woodlawn Elementary should serve as a template for similar events in the future. Schools offer the opportunity to engage community through students and parents as PTAs and active children's groups like Girl and Boy Scout troops can increase awareness and education to other members of the community.

Action 2.2.3 : Establish regular educational GI events

These can include urban agricultural expos, and farming techniques. Events should incorporate the Hopewell Farmers Market, where GI committee members should rotate attendance to educate customers and visitors and different GI events, opportunities, and general information. These educational events are opportunities for Hopewell's DPW to satisfy MS4 community engagement requirements.

Action 2.2.4 : Create a green alley plan by coordinating groups among the neighborhoods with green alleys like City Point and West City Point.

VCU Capstone, The Green Alley Network Plan, by Dan Motta provides relevant ideas and recommendations for a green alley plan in Richmond City in a similarly urban neighborhood. The link to this plan can be found in the implementation table.

Goal 3: Increase & Maintain Natural Assets in Hopewell

Hopewell is filled with natural assets; however, some areas tend to be more asset rich than others. The following strategies aim at increasing GI in neighborhoods that are more vulnerable or lack adequate access to natural assets, or are rather void of them in general. Strategies also address maintenance, and help provide a framework for long term maintenance planning.

Objective 3.1 Employ a multi factored approach to long term maintenance of green infrastructure

Action 3.1.1 : Amend the site plan ordinance to require a long-term maintenance agreement for street trees in new developments.

Action 3.1.2 : Include multi-year warranty/maintenance agreements in contracts between the city and its green infrastructure contractors on public property.

Action 3.1.3 : Create a dedicated GI fund for future projects, grant matching, and long-term maintenance.

Take advantage of local industry, business owners, and regional donors that are interested in making Hopewell a greener city by creating a public GI fund.

Action 3.1.4 : Attract arborist certification programs by collaborating with regional localities and partners.

Tree Pittsburgh is an example of a successful regional arborist certification program that allows for career development opportunities while also managing the urban forests. Groups like the Mid Atlantic Chapter International Society of Arboriculture, and VSU are actors involved in arboriculture regionally. Create opportunities for those seeking certification to use Hopewell's urban forests and complete required work or hours.

Objective 3.2 Leverage policy to increase green infrastructure development standards

Action 3.2.1 : Create a Green Infrastructure Plan

A green infrastructure plan should include attainable metrics like percentage of tree canopy coverage increased, number of trees planted, acreage of green space increased, accessibility, and stormwater management metrics. The Green Infrastructure plan should dedicate funding and act as a phasing plan for GI development.

Action 3.2.2 : Enforce current development standards, specifically landscape requirements for street trees.

Currently properties in areas with low tree canopy coverage are not meeting minimum tree canopy requirements. Properties along Winston Churchill for example currently do not have any trees, and do not meet the current minimum 10% tree canopy coverage requirements.

Action 3.2.3 : Amend the site plan ordinance to increase green stormwater infrastructure BMPs requirement in the right of way for new developments.

Action 3.2.4 : Amend the zoning ordinance to include maximum lot coverage restrictions for zoning districts.

Objective 3.3 Use GIS layers to target neighborhoods for green infrastructure enhancement

Action 3.3.1 : Use available information from vulnerability layers to apply for grants.

Action 3.3.2 : Record all future stormwater complaints submitted to Hopewell's DPW on the newly created flood complaints layer.

Action 3.3.3 : Use proposed GI layer to guide future development and save resources by utilizing previous research and designs.

Action 3.3.4 : Maintain and update tree canopy coverage layers on the Hopewell green infrastructure page.

Action 3.3.5 : Use Tree Canopy Coverage and Impervious Surface Coverage layers to identify locations for infill GI, and complete streets strategies.

Innovative methods are necessary to increase GI in an urban setting like Hopewell, with limited land space and a desire to increase economic activity. Underutilized grey space like empty parking lots and streets with inappropriate amounts of travel lanes are ideal candidates for street trees, road diets, tree trenches and rain gardens.

Implementation

The GINP is not meant to have a completion date, but rather provide a set of tools for relevant actors in the pursuit and maintenance of GI projects in Hopewell. The tools are created for the City of Hopewell, specifically the departments of Development, and Public Works, but the accessibility of the created maps makes these tools a public resource too. The final section provides an implementation table, with different action timelines for the previous recommendations. Recommendations were made to be implemented in a timely manner, and meant to be on-going actions that are maintained just like the GI they're intended for. The timeline is broken down by short term actions (0-2 years), mid-term actions (2-5 years), long term actions (5+ years), and on-going actions. A potential partner's section identifies the departments, groups, and agencies either best equipped for the action responsibility, or with the most potential for supplementing an action for long-term success. The final section outlines potential funding sources, with a description of the funding option and source of funding. The funding sources are meant to be diverse, with a variety of loan and grant options, however the network map should serve as an on-going tool for collaboration and communication between actors for new or continuous funding opportunities.

Timeline

Goal 1: Establish Regional Asset Connections	Timeline	Potential Partners
Objective 1.1 Bridge gaps between regional actors		
Action 1.1.1. Reach out to regional actors for additional support in future green infrastructure events like tree plantings, rain barrel donations, and rain garden installations.	Short Term	James River Association, Chesapeake Bay Foundation, Alliance for the Chesapeake Bay, John Randolph Foundation, Arbor Day Foundation
Action 1.1.2. Coordinate with high centrality groups in the network map to plan new GI projects.	On-going	Crater PDC, FOLAR, Green Infrastructure Center
Objective 1.2: Create opportunities for regional green infrastructure connections		
Action 1.2.1. Amend the zoning ordinance to create more restrictive development standards in the RMA.	Short Term	Green Infrastructure Center, Development, City Council
Action 1.2.2. Create incentive opportunities for residents to preserve their land through conservation easements.	Short Term; Mid Term	Virginia Outdoor Foundation, DWR, DCR
Action 1.2.3. Use traffic calming measures on streets that intersect ecological corridors to promote safe crossings for wildlife.	Mid Term; Long Term	VDOT, DPW
Action 1.2.4 : Amend the zoning ordinance to preserve Hopewell's ecologically rich city-owned land.	Short Term	Development, City Council

Goal 2: Engage Social Assets Locally	Timeline	Potential Partners
Objective 2.1: Strengthen Hopewell's network of actors		
Action 2.1.1. Create and hire a City Sustainability Coordinator position.	Mid-Term	City Departments, City Council
Action 2.1.2. Establish an urban farm collective with regular meetings	Short Term	VSU, HDP, Line-X, Farmers Market Association, One Hopewell
Action 2.1.3. Establish a green infrastructure committee to meet regularly	Mid Term	Crater PDC, FOLAR, HDP, JRA,

Action 2.1.4. Reach out to faith-based organizations to increase community engagement in neighborhoods lacking neighborhood associations or representation	Short Term	Green Infrastructure Center, Crater PDC, City Departments, HDP
Action 2.1.5 Re-establish the Hopewell Tree Stewards	Short-Term	Arbor Day Foundation, GIC, City Departments, Cameron & John Randolph Foundation
Action 2.1.6. Commit to becoming a "Tree City USA" City	Mid Term	Arbor Day Foundation, JRA, Capital Trees, CBF, Alliance for the Bay
Objective 2.2: Educate the public on green infrastructure benefits and opportunities		
Action 2.2.1. Create a comprehensive urban forestry ordinance with a detailed process for community engagement & education	Short Term	Green Infrastructure Center
Action 2.2.2. Partner with Hopewell Public Schools and environmental groups to host an annual tree planting day	Short Term; Mid Term	James River Association, Hopewell Public Schools, City Departments, Keep Hopewell Beautiful
Action 2.2.3. Establish regular educational GI events	Short Term; Mid Term	VSU, Virginia Cooperative Extension, HDP, Line-X, HDP, Farmers Market Association, Business Owners, Ashford Civic Plaza Commission
Action 2.2.4 : Create a green alley plan by coordinating groups among the neighborhoods with green alleys like City Point and West City Point.	Long Term	Refer to previous VCU Capstone: Green Alley Network Plan for innovative ideas in enhancing green alley networks.

Goal 3: Increase & Maintain Natural Assets in Hopewell	**Timeline**	**Potential Partners**
Objective 3.1: Employ a multifactored approach to long-term maintenance of green infrastructure		
Action 3.1.1 : Amend the site plan ordinance to require a long-term maintenance agreement for street trees.	Short Term	Development, City Council
Action 3.1.2 : Include multi-year maintenance agreements in contracts between the city and its green infrastructure contractors on public property.	Short Term	City Departments, Hopewell Downtown Partnership
Action 3.1.3 : Create a dedicated GI fund for future projects, grant matching, and long-term maintenance.	Mid Term	GIC, City Departments, John Randolph Foundation, Cameron Foundation*, See funding options*
Action 3.1.4 : Attract arborist certification programs by collaborating with regional localities and partners	Long Term	MAC-ISA; VSU; Petersburg, Richmond, Colonial Heights
Objective 3.2: Leverage policy to increase green space development standards		
Action 3.2.1. Create a Green Infrastructure Plan	Mid Term	GIC, City Departments, City Council, JRA, HDP

Action 3.2.2. Enforce current development standards, specifically landscape requirements for street trees.	Short Term	Building Code
Action 3.2.3. Amend the site plan ordinance to increase green stormwater infrastructure BMPs requirement in the right of way for new development.	Short Term	Development Department, DPW, City Council
Action 3.2.4. Amend the zoning ordinance to include maximum lot coverage restrictions for zoning districts.	Short Term	Green Infrastructure Center, City Departments, City Council
Objective: 3.3: Use GIS layers to target neighborhoods for GI enhancements		
Action 3.3.1. Use available information from vulnerability layers to apply for grants.	Short Term	Crater PDC, City Departments, FOLAR, HDP, GIC
Action 3.3.2. Record all future stormwater complaints submitted to Hopewell's DPW on the newly created flood complaints layer.	On-going	DPW
Action 3.3.3. Use proposed GI layer to guide future development and save resources by utilizing previous research and designs.	On-going	City Departments
Action 3.3.4. Maintain and update tree canopy coverage layers on the Hopewell green infrastructure page.	On-going	Development, Crater PDC
Action 3.3.5. Use Tree Canopy Coverage and Impervious Surface Coverage layers to identify locations for infill GI, and complete streets strategies.	Short Term, Mid Term	City Departments

Potential Funding Sources

Virginia Clean Water Revolving Loan Fund (CWRLF)

The revolving loan fund, administered by Virginia's DEQ, provides financial assistance for water quality improvement projects, including stormwater BMPs, brownfield site remediation, land conservation, and living shorelines.

Clean Water Act Section 319 Grants

Federal grants administered by Virginia's DEQ can be used for nonpoint source management implementation projects.

Virginia Brownfields Restoration and Economic Redevelopment Assistance Fund (VBAF)

The Virginia Economic Development Partnership administers loans and grants to local governments to restore and redevelop brownfield sites and address environmental issues.

Virginia Cooperative Extension at VSU, Small Farm Outreach Program

The Small Farm Outreach Program provides connections, education, support, and assistance programs through the USDA for small urban farmers, or those interested in starting a small urban farm.

Environmental & Climate Justice Community Change Grant

Administered by the EPA, this grant benefits disadvantaged communities through projects that reduce pollution, increase community climate resilience, and build community capacity to address environmental and climate justice challenges.

Urban Waters Small Grant Program (UWSG)

Administered by the EPA, grants are awarded up to $60,000 and are meant to help restore urban waters in ways that benefit community and economic revitalization.

Community Development Block Grants Program

CDBG funding has supported several community projects in Hopewell, and countless emergency home repairs. Directing CDBG funding towards GI projects will support community development and help build stronger and more resilient communities.

Community Project Funding Grants (CPF)

Administered by HUD, CPF grants can be used for economic development projects related to resilience planning, parks, public facilities, and workforce development.

The Chesapeake Bay Trust

Dozens of annual grant opportunities specifically for non-profit and community organization applicants. Hopewell's stream restoration project was funded through money from the Chesapeake Bay Trust. **City of Hopewell is not an eligible applicant.**

National Coastal Resilience Fund

Administered by the NFWF, this fund restores, increases, and strengthens natural infrastructure to protect coastal communities. The fund focuses on nature-based solutions and protecting natural coastal resources.

Urban Agriculture & Innovative Production Competitive Grants (UAIP)

Administered by the USDA, grants are meant to support a range of production from community gardens and urban farms to rooftop gardens, with a wide variety of farming techniques and practices.

Virginia Outdoors Foundation (VOF): Conservation Funding

Three funds through the VOF provide funding for conservation easement: Preservation Trust Fund, Get Outdoors Fund, Targeted Environmental Remediation & Restoration Accounts program.

Safe Streets & Roads for All Grant (SS4A)

Administered by the USDOT, grants are meant to fund road safety projects, with complete streets being a primary example of safer street design. Complete streets can be used to incorporate more GI than traditional street design, and provide safer wildlife crossing points.

Virginia Food Access Investment Fund Grants (VFAIF)

Administered by the VDAC, grants are meant to increase access to healthy foods in underserved communities. This is an ongoing priority for Hopewell, and is exacerbated in Hopewell's food deserts. Innovative ideas are necessary for the VFAIF application to possibly incorporate new urban farming ideas and Hopewell's farmers market or a possible mobile market.

James River Water Quality Improvement Program

Administered on a rolling, biannual basis by the Virginia Environmental Endowment, grant funds are meant for projects involving water quality improvement, land conservation, environmental education and public awareness, or climate adaptation and emerging issues.

Public-Private Partnerships

Hopewell is filled with industry and businesses that depend on a healthy community, and attractive city for a workforce and economic development. Creating public-private partnerships can act as a catalyst for on-going funding opportunities and grant matching possibilities.

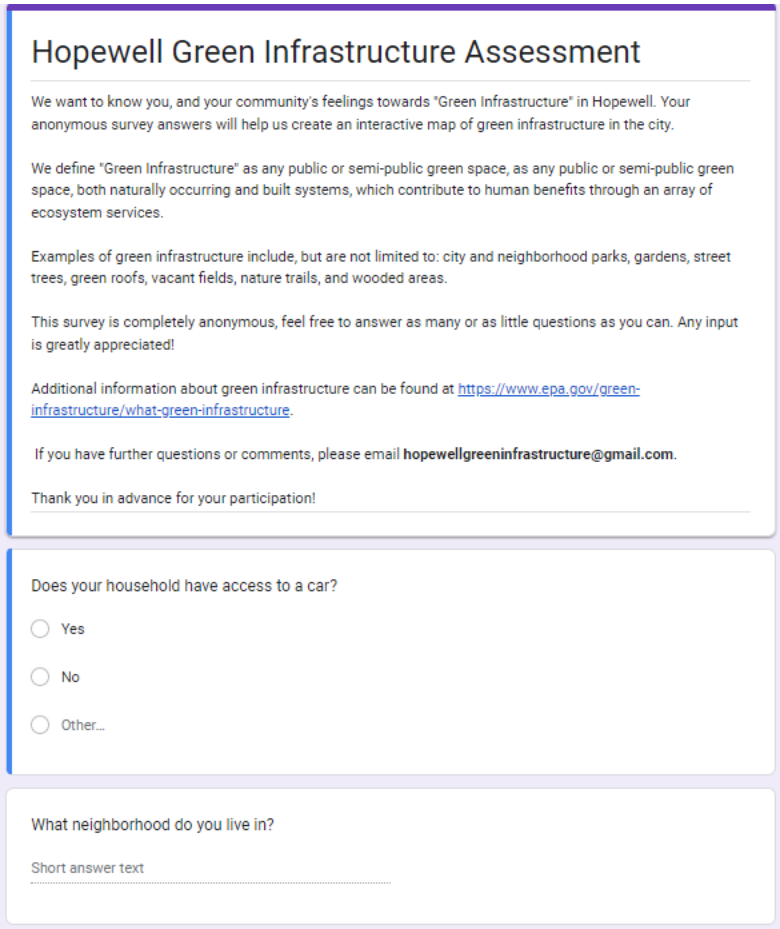
Conclusion

This plan addresses two priority components of most resilience plans: social and natural assets. Hopewell has the assets in place, and with a push to bridge gaps in connections, will have a more cohesive network to build on. The tools created from the GINP provide Hopewell with technological assets to acquire funding, pursue regional collaborations, and provide a spatial inventory to the actors working in Hopewell for the future. It is crucial to maintain and expand on the information so it stays up to date and can be used to create a comprehensive Green Infrastructure Plan. By establishing attainable goals and metrics, and creating a clear framework, Hopewell can expand the green infrastructure in place, reduce the impervious surfaces in town through creative and adaptive infill GI techniques, and engage community members to buy in and take pride in Hopewell's greening efforts and progress to increase resilience. As mentioned before, this plan's recommendations are meant to be on-going and cost-effective, as Hopewell navigates financial struggles, the tools created are supposed to help leverage opportunities and enhance the entire community with a concerted effort to equity and vulnerable neighborhoods.

Appendix

Community Survey

Link to survey: [Hopewell Green Infrastructure Assessment]



Hopewell Green Infrastructure Assessment

We want to know you, and your community's feelings towards "Green Infrastructure" in Hopewell. Your anonymous survey answers will help us create an interactive map of green infrastructure in the city.

We define "Green Infrastructure" as any public or semi-public green space, as any public or semi-public green space, both naturally occurring and built systems, which contribute to human benefits through an array of ecosystem services.

Examples of green infrastructure include, but are not limited to: city and neighborhood parks, gardens, street trees, green roofs, vacant fields, nature trails, and wooded areas.

This survey is completely anonymous, feel free to answer as many or as little questions as you can. Any input is greatly appreciated!

Additional information about green infrastructure can be found at https://www.epa.gov/green-infrastructure/what-green-infrastructure.

If you have further questions or comments, please email **hopewellgreeninfrastructure@gmail.com**.

Thank you in advance for your participation!

Does your household have access to a car?

- Yes
- No
- Other...

What neighborhood do you live in?

Short answer text

Can you walk to any of the following green infrastructure from home/work? (check all that apply)

- [ ] Parks

- [ ] Street trees

- [ ] Nature trails/green ways

- [ ] Woods or forests

- [ ] Athletic fields

- [ ] Cemeteries

- [ ] Riparian buffers (vegetated areas along creeks or rivers)

- [ ] Gardens

- [ ] Green alleys

- [ ] Vacant fields

- [ ] Green roofs/green walls

- [ ] Stormwater management areas (Rain gardens, Bioswales, Retention ponds)

What is your favorite green infrastructure in Hopewell, and where is it located?

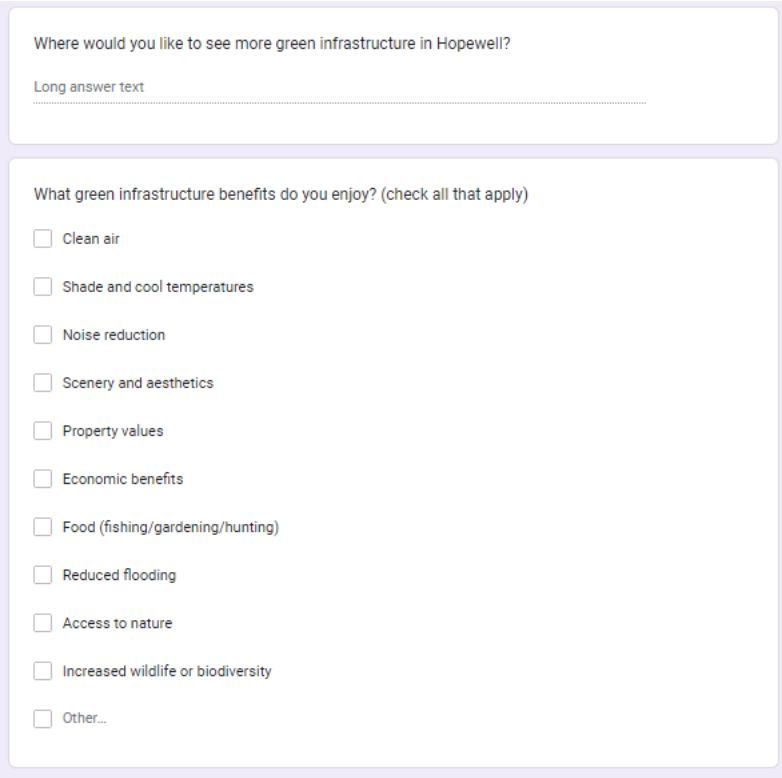
Short answer text

Rank the quality of green infrastructure in Hopewell

	Good	Adequate	Poor	Not Available
Parks	☐	☐	☐	☐
Gardens	☐	☐	☐	☐
Street trees	☐	☐	☐	☐
Woods or forests	☐	☐	☐	☐
Nature trails/green...	☐	☐	☐	☐
Athletic fields	☐	☐	☐	☐
Cemeteries	☐	☐	☐	☐
Green alleys	☐	☐	☐	☐
Vacant fields	☐	☐	☐	☐
Riparian buffers (v...	☐	☐	☐	☐
Green roofs/green ...	☐	☐	☐	☐
Stormwater mana...	☐	☐	☐	☐

What green infrastructure would you like to see more of in Hopewell? (check all that apply)

- ☐ Parks
- ☐ Food gardens
- ☐ Rain gardens
- ☐ Stream restoration for flooding & stormwater
- ☐ Street trees
- ☐ Green roofs
- ☐ Green walls
- ☐ Nature trails/green ways
- ☐ Riparian buffers
- ☐ Green alleys
- ☐ Athletic fields
- ☐ Stormwater management areas (bioswales, rain gardens, retention ponds)
- ☐ Other...


Where would you like to see more green infrastructure in Hopewell?
Long answer text
What green infrastructure benefits do you enjoy? (check all that apply)
Clean air
Shade and cool temperatures
Noise reduction
Scenery and aesthetics
Property values
Economic benefits
Food (fishing/gardening/hunting)
Reduced flooding
Access to nature
Increased wildlife or biodiversity
Other...

How do you typically use green infrastructure? (check all that apply)

- [ ] Sports and recreation
- [ ] Social gathering
- [ ] Gardening
- [ ] Fishing/hunting
- [ ] Enjoying nature
- [ ] Environmental education
- [ ] Other...

Do you perceive any of the following to be issues with green infrastructure? (check all that apply)

- [ ] Maintenance (weeds, overgrown trees, tall grass)
- [ ] Access
- [ ] Crime
- [ ] Problems with nature (animals, allergies)
- [ ] Other...

If you have any additional comments, we would love your input below.

Long answer text

Interview Protocol

Interview
Introduction: The Green Infrastructure Network Plan seeks to create a map of the network of physical green infrastructure and the actors involved in green infrastructure in Hopewell. We define *green infrastructure* as any public or semi-public green space, both naturally occurring and built systems, which contribute to human benefits through an array of ecosystem services. Examples of green infrastructure include, but are not limited to city and neighborhood parks, gardens, street trees, green roofs, vacant fields, riparian buffers, green alleys, bioswales. "Actors" includes, but is not limited to organizations, government agencies, neighborhood groups and associations, individuals, or residents. "Involved with", or "working with" includes, but is not limited to planning, funding, building, developing, planting, and maintaining green infrastructure.
What is the name of the group/company/agency you work with (if applicable), and how many years have you been associated?
What green infrastructure projects have you worked on in Hopewell?
Where is the green infrastructure located that you have worked with?
What are the different types of green infrastructure that you have worked with?
Is long term maintenance of green infrastructure a concern for you?
- Are there any other perceived issues?
What other actors have you worked with, in relation to green infrastructure?
- What are their roles, or what type of work are they involved with, in relation to green infrastructure?
What benefits have you experienced from green infrastructure in Hopewell?
Where do you see an opportunity to increase green infrastructure?
Do you know of any processes in place to prioritize vulnerable neighborhoods for green infrastructure?
How can you benefit from the green infrastructure network tool? - What is missing from this tool that would benefit you?

Hopewell Green Infrastructure Tables

Green Infrastructure	Type	Name
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Wet Retention Pond	
GSI	Wet Retention Pond	
GSI	Dry Detention Pond	
GSI	Bioretention	
GSI	Bioretention	
GSI	Bioretention	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	

GSI	Wet Detention Pond	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Bioretention	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Bioretention	
GSI	Permeable Pavers	
GSI	Wet Retention Pond	
GSI	Wet Retention Pond	
GSI	Wet Retention Pond	
GSI	Permeable Pavers	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Dry Detention Pond	
GSI	Stormwater	Riverside Greenway - Constructed Wetlands
Greenway	Greenway	Cabin Creek Nature Trail
GSI	Stormwater	Crystal Lake
Greenway	Greenway	Cattail Creek Nature Trail
Garden	Garden	Heritage Gardens
Garden	Garden	Memorial Circle
Garden	Garden	Native Meadow
Athletic Fields	Athletic Fields	Mathis Athletic Fields
Athletic Fields	Athletic Fields	Atwater Sports Complex
Trees	Trees	Woodlawn Tree Installation
Trees	Trees	Riverwalk Tree Installation
Trees	Trees	Route 10 Tree Canopy
Garden	Garden	Woodlawn School Garden
Trees	Trees	CBF Tree Canopy Plantings
GSI	Stream Restoration	City Park Stream Restoration
GSI	Stream Restoration	Cabin Creek Stream Restoration

Green Infrastructure Type	Name	Acres
Park	Mathis Park	22.05
Park	Atwater Park	28.86
Park	Riverside Park	16.26
Park	3 1/2 Street Park	1.72
Park	Fort Abbott Park	3.84

Park	City Point Playground	2.00
Park	Petersburg National Battlefield	21.55
Park	City Point Waterfront Park	3.07
Green Space	Heritage Gardens	2.49
Park	City Park	4.66
Park	Ashford Civic Plaza	0.50
Park	Community Center	1.15
Cemetery	City Point National Cemetery	5.74
Cemetery	Appomattox Cemetery	9.55
Green Space	Weston Manor	8.70
Green Space	Anchor Point Marina	3.15
Park	Woodlawn Park	1.96
Park	Arlington Park	3.13
Park	King's Court Playground	3.72
Park	Westwood Playground	2.86
Green Space	Weston Circle	0.22
Green Space	Washington Circle	0.14
Green Space	City Point Green Space	0.57
Green Space	City Point Marina	4.18
Ecological Corridor	Anchor Point Ecological	92.08
Ecological Corridor	Cabin Creek Ecological	48.63
Ecological Corridor	Weston Ecological	26.79
Ecological Corridor	Gravelly Run Ecological	145.32
Ecological Corridor	Poythress Run Ecological	62.41
Ecological Corridor	Cattail Creek Ecological	48.70
Ecological Corridor	Utility Ecological	29.64
Ecological Corridor	Route 10 & 156	98.44
Ecological Corridor	Hummel Ross Road	84.05
Ecological Corridor	Rail line	19.38
Ecological Corridor	Southeast City Limit	285.60

Actor Table

Actor	Role & Responsibility	Website
Chesapeake Bay Foundation	Organization. 4 Year Green Infrastructure Project in Hopewell, planting over 200 trees, installing rain gardens, constructed wetlands, stream restorations, community education & engagement, and other GSI	https://www.cbf.org/about-cbf/our-mission/
Virginia American Water	Funding. Picture from City Park. Funded several City Park GI elements	

Hopewell Tree Stewards	Organization. Dormant group created through the partnership with CBF, aided in tree planting efforts from 2016-2020.	https://www.rootedinhopewell.org/
Friends of the Lower Appomattox River	Organization. Non-profit Organization. Environmental conservation, land stewardship, GI planning	https://folar-va.org/
Green Infrastructure Center	Organization. Environmental Protection Organization Planning, grant application assistance, stewardship	https://gicinc.org/
James River Association	Organization. Non-Profit Organization. Roles: environmental conservation, stewardship and community engagement, education, increasing access options, river-related projects, maintenance and planning	https://thejamesriver.org/about-the-james-river-association/
Environmental Protection Agency	Federal Agency. Funding options - Current grants include tree canopy grant administered through DEQ and Crater PDC. Possible future grants with DPW	https://www.epa.gov/grants
Hopewell Department of Public Works	City Department Responsible for maintenance of all GI on public property excluding parks. Active in grant application process and the pursuit of outside funding through VDOT, EPA, etc	
Hopewell Recreation & Parks	City Department Responsible for maintenance of all park space GI. Active in previous projects with CBF including stream restorations, constructed wetlands, and tree plantings. Actively pursues grant opportunities	
National Fish & Wildlife Foundation	Non-Profit Organization Regional organization with numerous grant options annually - awarded grant to CBF for the project in Hopewell	https://www.nfwf.org/
Wonder City Garden Club	Non-Profit Organization Local gardening club committed to plant education, and supporting local gardens like Memorial Circle	https://www.facebook.com/p/Wonder-City-Garden-Club-100069893119016/
Lions Club	Organization Civic group with history maintaining the garden at Weston Circle and possibly other GI maintenance events	https://e-clubhouse.org/sites/hopewellpg/index.php
Hopewell Department of Development	City Department	
United States Department of Agriculture	Federal Agency. Funding Options - urban agriculture and small farm grants with the help of VSU, HDP, Cooperative Extension	https://www.usda.gov/
Virginia State University	University. Small Farm Outreach Program, Possible arborist certification collaboration	https://www.ext.vsu.edu/#gsc.tab=0
AgrAbility Virginia	Organization Partners with Cooperative Extension, VT, VSU	https://agrability.alce.vt.edu/

SARE	Organization Professional Development Program coordinated by VT and VSU	https://www.sare.org/
Department of Environmental Quality	State Agency. Funding Options. Coastal zone management program; watershed improvements plans	DEQ Funding/Grants
Department of Conservation & Recreation	State Agency Funding Options. Community flood preparedness fund allows Crater PDC to sign off on special projects	https://www.dcr.virginia.gov/dam-safety-and-floodplains/dsfpm-cfpf
Virginia Outdoors Foundation	Non-Profit Organization Small green space and conservation specific grants. Worked with Crater and FOLAR on previous projects	https://www.vof.org/
Department of Forestry	Federal Agency. Funding Options. Grant opportunity with community change grant administered by the GIC from IRA funding. Possible maintenance grant options	https://dof.virginia.gov/
PlanRVA	Planning District Commission. Green Infrastructure Project with Crater PDC	https://planrva.org/
Crater PDC	Planning District Commission. Regional planning commission - planning (natural resource management, grant implementation, watershed implementation plans), grant application assistance	https://craterpdc.org/
Bowman Properties	Business & Property Owner Willing to install and maintain street trees along right of way of property, and in privately owned business parking lots	
Arbor Day Foundation	Organization Foundation that oversees Tree City USA status and certifications	https://www.arborday.org/
Keep Hopewell Beautiful	Organization	
Hopewell Downtown Partnership	Non-Profit Organization Planning, grant application assistance, Organizer (farmers market and downtown events), Leading Heritage Gardens group	https://hopewelldowntown.com/
Timmon's Group	Engineering Firm Consulting firm with several projects submitted to Hopewell, including Marina Park Plan (not adopted)	https://www.timmons.com/service/engineering/infrastructure-design/stormwater/
Petersburg	Government adjacent jurisdiction - government entity is recognized as one and may encompass different departments within the city	
Woodlawn Learning Center	Elementary School Stewards for multiple GI projects including an urban garden and tree canopy	

Virginia Cooperative Extension	Partnership Works closely with VSU and the Small Farm Program - provides training, education, assistance, and offers grant opportunities to small farmers or urban ag initiatives. Experience in urban forestry and arborist certifications	https://www.ext.vsu.edu/#gsc.tab=0
Virginia Department of Health	State Agency Funding Options Community health grant opportunities especially urban ag, and health through GI	https://www.vdh.virginia.gov/environmental-health/onsite-sewage-water-services-updated/organizations/
Virginia Commonwealth University	State University Research provided to the city and previous plans and designs - especially with GI related themes or ideas	https://wilder.vcu.edu/programs/urban-and-regional-studies-planning/
Virginia Department of Agriculture & Consumer Services	State Agency Funding Opportunities related to urban ag and small farms	https://www.vdacs.virginia.gov/agriculture-afid-planning-grants.shtml
Virginia Department of Transportation	State Agency Transportation agency with funding opportunities through grants. Hopewell DPW has a history of receiving grant funds from VDOT - can be used for complete streets model to increase GI in right of way	https://www.vdot.virginia.gov/
Virginia Department of Wildlife Resources	State Agency Funding/Grant Opportunities Grants tend to be focused on larger scale conservation projects and could be used for the trail network or future IDA properties along the river	https://dwr.virginia.gov/virginia-wildlife-grant-program/
Capital Trees	Non-profit Organization Primarily focused on Richmond with some reach outside - major contributors to some of Richmond's more prominent GI like the lowline and great ship lock park	https://capitaltrees.org/
Virginia Farmers Market Association	Non-Profit Organization Focused on farmers market collaboration and has worked with HDP. Potential to partner with urban ag events	https://vafma.org/
Methodist Men's Group	Faith Based Organization	
Community Heart & Soul Group	Civic Group	
Petersburg League of Urban Growers	Community Group Located in Petersburg, active in local urban agriculture	https://www.facebook.com/p/Petersburg-League-of-Urban-Growers-100068292693300/
Petersburg Healthy Options	Community Partnership funded through CDC to support healthy food options (urban ag possibilities)	https://cphpr.publichealth.vt.edu/phops.html
John Randolph Foundation	Local Non-Profit Organization Local Grant and Funding Option	https://johnrandolphfoundation.org/grants/
Cameron Foundation	Local Non-Profit Organization Local Grant and Funding Option	https://camfound.org/

Groundwork RVA	Non-Profit Organization Primarily in Richmond, focused on community engagement, education and stewardship in the long term installation and maintenance of GI	https://www.groundworkrva.org/
Richmond Tree Stewards	Organization Richmond branch of the tree stewards, committed to increasing tree canopy and providing long term maintenance support to Richmond urban forest	https://www.richmondtreestewards.org/
Crater Health District	Regional health district Grant application assistance and involvement in community health initiatives especially food access and possible urban agriculture projects	https://www.vdh.virginia.gov/crater/
Rotary Club	Civic Association	
Hopewell Parks Advisory Commission	City Commission: acts as board to recreation and park decisions	
Alliance for the Chesapeake Bay	Non-Profit Organization Regional organization focused on green infrastructure installation, grant application assistance, community stewardship & engagement. Collaborating with Richmond departments to create a green infrastructure plan for Richmond	https://www.allianceforthebay.org/project/cleaner-water-faster/
Tree's Virginia	Virginia's Urban Forest Council Tree Steward Mini Grants. Oversees Virginia Tree Stewards Program	https://www.treesvirginia.org/about/trees-virginia
RAFT		
Southside ReLeaf	Non-Profit Organization Focused on southside Richmond, with an emphasis on increasing tree canopy coverage, community education and stewardship, long-term maintenance and policy reform	https://www.southsidereleaf.org/
Hopewell Department of Economic Development	City Department	
Wetlands Watch	Virginia nonprofit committed to wetland conservation - funding and grant opportunities	https://wetlandswatch.org/our-history

Green Infrastructure Reference Table

Brief description	Object type	Object category	Food provision	Air pollution removal	Noise mitigation	Heat mitigation	Water quality mitigation	Water flow management	Maintaining carbon stocks	Supporting physical activity	Supporting social interactions	Restoring capacities - stress reduction and cognitive restoration	Supporting biodiversity
Mainly private space linked to dwellings	Gardens	Balcony	Low	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low	High	Low
		Private garden	Medium	Low	Low	Medium	Medium	Medium	Low	Very high	Medium	Very high	High
		Shared common garden area	Medium	Low	Low	Medium	Medium	Medium	Low	Medium	High	Medium	Low
Mainly public space, but some access restrictions may apply	Parks	Pocket park	Low	Low	Low	Low	High	Medium	Low	Medium	Very high	High	Medium
		Park	Low	High	High	High	High	Medium	High	Very high	Very high	Very high	High
		Botanical garden	Low	High	Very high	Very high	High	Medium	High	Medium	High	Very high	Very high
		Heritage garden	Medium	Medium	High	High	High	Medium	Medium	Medium	High	Very high	High
		Nursery garden	Medium	Medium	Low	Low	High	Medium	Medium	Low	Medium	Medium	Low
Areas designed primarily for specific amenity uses	Amenity areas	Sports field	Negligible	Low	Low	Low	Low	Low	Low	Very high	High	Medium	Negligible
		School yard	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Very high	Very high	Medium	Negligible
		Playground	Negligible	Negligible	Negligible	Negligible	Low	Low	Negligible	Very high	Very high	Medium	Negligible
		Golf course	Negligible	Medium	Low	Low	Negligible	Medium	Low	Medium	High	High	Medium
		Shared open space (e.g. square)	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Medium	Very high	Low	Negligible
Areas designed primarily for specific uses (not leisure); some access restrictions may	Other public space	Cemetery	Negligible	Medium	Medium	Medium	Medium	Medium	High	Low	Low	Very high	High
		Allotment/other growing space	Very high	Medium	Low	Low	Negligible	Medium	Negligible	High	High	Very high	High
		City farm	Very high	Medium	Low	Low	Negligible	Medium	Negligible	Medium	Medium	High	Medium
		Adopted public space	Low	Medium	Low	Low	Low	Low	Negligible	Negligible	Low	Medium	Low
Linked to routeways, geographical features and boundaries	Linear features/routes	Street tree	Low	High	Low	High	Low	Low	Medium	Negligible	Low	High	Medium
		Cycle track (as green/blue corridor)	Low	Low	Low	Low	Low	Low	Low	Very high	Medium	High	Low
		Footpath (as green/blue corridor)	Low	Low	Low	Low	Low	Low	Low	Very high	Very high	High	Low
		Road verge	Low	Low	Low	Low	Medium	Medium	Low	Negligible	Negligible	Low	Low
		Railway corridor	Negligible	Very high	Very high	Very high	Low	Medium	High	Negligible	Negligible	Low	Very high
		Riparian woodland	Low	Very high	Very high	Very high	Very high	High	Very high	High	High	Very high	Very high
		Hedge	Low	Medium	Low	Low	High	High	Medium	Negligible	Negligible	Medium	Medium
Constructed green and blue space, added to infastructure	Constructed GI on infrastructure	Green roof	Negligible	Low	Negligible	Low	Low	High	Low	Negligible	Negligible	Low	Low
		Green wall	Negligible	Medium	Medium	Low	Negligible	Low	Low	Negligible	Negligible	Medium	Low
		Roof garden	Medium	Medium	Low	Medium	Low	Low	Medium	Low	High	Very high	Medium
		Pergola (with vegetation)	Negligible	Medium	Low	High	Low	Low	Medium	Negligible	Low	High	Low
Infrastructure designed to incorporate some GBS components	Hybrid GI (for water)	Permeable paving	Negligible	Negligible	Negligible	Negligible	High	High	Negligible	Low	Negligible	Negligible	Negligible
		Permeable parking/roadway	Negligible	Negligible	Negligible	Negligible	High	High	Low	Negligible	Negligible	Negligible	Negligible
		Attenuation pond	Negligible	Low	Low	Low	Very high	Very high	Medium	Negligible	Low	Medium	High
		Flood control channel	Negligible	Low	Negligible	Low	Low	Very high	Low	Negligible	Low	Negligible	Medium
		Rain garden	Low	Medium	Negligible	Low	High	High	Medium	Negligible	Negligible	High	Medium
		Bioswale	Negligible	Medium	Low	Low	Medium	Very high	Medium	Negligible	Negligible	Low	Medium
Bluespace features	Waterbodies	Wetland	Negligible	Medium	Low	Medium	Very high	Very high	Medium	Low	Medium	Very high	High
		River/stream	Low	Low	High	High	Medium	High	Low	Medium	High	Very high	High
		Canal	Low	Low	Low	Medium	Low	Medium	Low	Medium	High	Very high	Low
		Pond	Negligible	Low	Low	Low	Low	High	Medium	Low	High	Very high	High
		Lake	Medium	Low	Medium	High	High	High	Medium	High	High	Very high	Very high
		Reservoir	Low	Low	Medium	High	High	Very high	Medium	High	High	Very high	Medium
		Estuary/tidal river	High	Low	High	High	High	N/A	Medium	Medium	High	Very high	Very high
		Sea (incl. coast)	High	Low	High	Very high	High	N/A	Very high	Very high	Very high	Very high	Very high
Other un-sealed features without specified use, often on private land	Other non-sealed urban areas	Woodland (other)	Low	Very high	Very high	Very high	High	High	Very high	High	High	Very high	Very high
		Grass (other)	Low	Low	Low	Low	Medium	Medium	Low	Very high	High	Medium	Medium
		Shrubland (other)	Low	Medium	Low	Low	High	High	Medium	Medium	Medium	High	High
		Arable agriculture	Very high	Medium	Low	Low	Negligible	Low	Negligible	Low	Negligible	Low	Low
		Sparsely vegetated land	Negligible	Negligible	Low	Negligible	Low	Low	Negligible	Medium	Medium	Medium	Low

(Jones et al., 2022)

References

Arnold, C. L., & Gibbons, C. J. (1996). Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. *Journal of the American Planning Association*, *62*(2), 243–258. https://doi.org/10.1080/01944369608975688

Blau, M., Luz, F., & Panagopoulos, T. (2018). Urban River Recovery Inspired by Nature-Based Solutions and Biophilic Design in Albufeira, Portugal. *Land*, *7*(4), 141. https://doi.org/10.3390/land7040141

Brink, E., Aalders, T., Ádám, D., Feller, R., Henselek, Y., Hoffmann, A., Ibe, K., Matthey-Doret, A., Meyer, M., Negrut, N. L., Rau, A.-L., Riewerts, B., Von Schuckmann, L., Törnros, S., Von Wehrden, H., Abson, D. J., & Wamsler, C. (2016). Cascades of green: A review of ecosystem-based adaptation in urban areas. *Global Environmental Change*, *36*, 111–123. https://doi.org/10.1016/j.gloenvcha.2015.11.003

Bullis, R. K. (2011). *Hopewell and City Point*. Arcadia Pub.

Burger, A., Kennedy, W. G., & Crooks, A. (2021). Organizing Theories for Disasters into a Complex Adaptive System Framework. *Urban Science*, *5*(3), 61. https://doi.org/10.3390/urbansci5030061

Capps, K., & Cannon, C. (2021, March 15). Redlined, Now Flooding. *Bloomberg*. https://www.bloomberg.com/graphics/2021-flood-risk-redlining/

CBF. (2020, November). Major Hopewell Tree Planting Effort Continues This Fall. *Chesapeake Bay Foundation*. https://www.cbf.org/news-media/newsroom/2020/virginia/major-hopewell-tree-planting-effort-continues-this-fall.html

Chiesura, A., & De Groot, R. (2003). Critical natural capital: A socio-cultural perspective. *Ecological Economics*, *44*(2–3), 219–231. https://doi.org/10.1016/S0921-8009(02)00275-6

Christman, Z., Meenar, M., Mandarano, L., & Hearing, K. (2018). Prioritizing Suitable Locations for Green Stormwater Infrastructure Based on Social Factors in Philadelphia. *Land*, *7*(4), 145. https://doi.org/10.3390/land7040145

City of Hopewell (N.d.). City History. https://hopewellva.gov/460/City-History.

Constanza, R. (2013). *Building a sustainable and desirable economy-in-society-in-nature*. Australian National University E Press.

Cornell, S. (2010). Valuing ecosystem benefits in a dynamic world. *Climate Research*, *45*, 261–272. https://doi.org/10.3354/cr00843

Cysek-Pawlak, M., Krzysztofik, S., & Makowski, A. (2022). Urban regeneration and urban resilience planning through connectivity: The importance of this principle of new urbanism. *European Spatial Research and Policy*, *29*(1), 111–133. https://doi.org/10.18778/1231-1952.29.1.06

Daly, C. (2023, September 18). Chemical leak at AdvanSix plant triggers shelter-in-place in Hopewell, Virginia. *World Socialist Web Site*. https://www.wsws.org/en/articles/2023/09/18/ecmy-s18.html

DCR. (2021). *The Virginia Coastal Resilience Master Plan*. https://www.dcr.virginia.gov/crmp/document/VirginiaCoastalResilienceMasterPlan.pdf

De Groot, R. S. (1992). *Functions of nature: Evaluation of nature in environmental planning. management and decision making*. Wolters-Noordhoff.

Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Bhave, A. G., Mittal, N., Feliu, E., & Faehnle, M. (2014). Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. *Journal of Environmental Management*, *146*, 107–115. https://doi.org/10.1016/j.jenvman.2014.07.025

Egerton-Warburton, L. M., Querejeta, J. I., Allen, M. F., & Finkelman, S. L. (2013). Mycorrhizal Fungi. In *Reference Module in Earth Systems and Environmental Sciences* (p. B978012409548905226X). Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.05226-X

Ekins, P., Simon, S., Deutsch, L., Folke, C., & De Groot, R. (2003). A framework for the practical application of the concepts of critical natural capital and strong sustainability. *Ecological Economics*, *44*(2–3), 165–185. https://doi.org/10.1016/S0921-8009(02)00272-0

EPA. (2018). *2018 AirToxScreen: Assessment Results*. https://www.epa.gov/AirToxScreen/2018-airtoxscreen-assessment-results

EPA. (2018). *Community Action Plan for Hopewell, Virginia*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ams.usda.gov/sites/default/files/media/LFLPHopewellVA.pdf

EPA. (2023, July). *Overview of Environmental Indicators in EJScreen*. https://www.epa.gov/ejscreen/overview-environmental-indicators-ejscreen

Fletcher, K. (2020). *In Richmond, Trees Will Battle Extreme Heat, Pollution, and Injustice in Greening Southside Initiative*. https://www.cbf.org/news-media/newsroom/2020/virginia/in-richmond-trees-will-battle-extreme-heat-pollution-injustice.html

Fletcher, K. (2020, November). Transforming Hopewell: From Chemical Spills to Community Trees. *Chesapeake Bay Foundation*. https://www.cbf.org/blogs/save-the-bay/2020/11/transforming-hopewell-from-chemical-spills-to-community-trees.html

FOLAR. (2017). *Appomattox River Trail Master Plan*. Friends of the Lower Appomattox River. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.craterpdc.org/environment/documents/AppRiverPlan2017/ART%20Master%20Plan%20Part%20I-Front%20Section%201-4-Final-Final-4-9-2017.pdf

Folke, C., Biggs, R., Norström, A. V., Reyers, B., & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society*, *21*(3), art41. https://doi.org/10.5751/ES-08748-210341

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society*, *15*(4). http://www.jstor.org/stable/26268226

Frank, B. (2017). Urban Systems: A Socio-Ecological System Perspective. *Sociology International Journal*, *1*(1). https://doi.org/10.15406/sij.2017.01.00001

García, I. (2020). Asset-Based Community Development (ABCD): Core principles. In R. Phillips, E. Trevan, & P. Kraeger (Eds.), *Research Handbook on Community Development*. Edward Elgar Publishing. https://doi.org/10.4337/9781788118477.00010

Glaser, M. (Ed.). (2012). *Human-nature interactions in the anthropocene: Potentials of social-ecological systems analysis*. Routledge.

Gómez-Baggethun, E., & Barton, D. N. (2013). Classifying and valuing ecosystem services for urban planning. *Ecological Economics*, *86*, 235–245. https://doi.org/10.1016/j.ecolecon.2012.08.019

Guerry, A. D., Polasky, S., Lubchenco, J., Chaplin-Kramer, R., Daily, G. C., Griffin, R., Ruckelshaus, M., Bateman, I. J., Duraiappah, A., Elmqvist, T., Feldman, M. W., Folke, C., Hoekstra, J., Kareiva, P. M., Keeler, B. L., Li, S., McKenzie, E., Ouyang, Z., Reyers, B., … Vira, B. (2015). Natural capital and ecosystem services informing decisions: From promise to practice. *Proceedings of the National Academy of Sciences*, *112*(24), 7348–7355. https://doi.org/10.1073/pnas.1503751112

Herrero-Jáuregui, C., Arnaiz-Schmitz, C., Reyes, M., Telesnicki, M., Agramonte, I., Easdale, M., Schmitz, M., Aguiar, M., Gómez-Sal, A., & Montes, C. (2018). What do We Talk about When We Talk about Social-Ecological Systems? A Literature Review. *Sustainability*, *10*(8), 2950. https://doi.org/10.3390/su10082950

Jones, L., Anderson, S., Læssøe, J., Banzhaf, E., Jensen, A., Bird, D. N., Miller, J., Hutchins, M. G., Yang, J., Garrett, J., Taylor, T., Wheeler, B. W., Lovell, R., Fletcher, D., Qu, Y., Vieno, M., & Zandersen, M. (2022). A typology for urban Green Infrastructure to guide multifunctional planning of nature-based solutions. *Nature-Based Solutions*, *2*, 100041. https://doi.org/10.1016/j.nbsj.2022.100041

JRA. (2024). *James River Association, Arbor Day Foundation, and SageSure Team Up to Host Community Tree Planting Event*. https://thejamesriver.org/pr-jra-adf-sage/

Kulp, S. A., & Strauss, B. H. (2019). New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. *Nature Communications*, *10*(1), 4844. https://doi.org/10.1038/s41467-019-12808-z

Kumar, P. (Ed.) (2012). *The economics of ecosystems and biodiversity: ecological and economic foundations*. Routledge.

López-Valencia, A. P. (2019). Vulnerability assessment in urban areas exposed to flood risk: Methodology to explore green infrastructure benefits in a simulation scenario involving the Cañaveralejo River in Cali, Colombia. *Natural Hazards*, *99*(1), 217–245. https://doi.org/10.1007/s11069-019-03736-8

Lin, J., Zhang, H., Chen, M., & Wang, Q. (2023). Socioeconomic disparities in cooling and warming efficiencies of urban vegetation and impervious surfaces. *Sustainable Cities and Society*, *92*, 104464. https://doi.org/10.1016/j.scs.2023.104464

McGill, R. (2020). Urban resilience – An urban management perspective. *Journal of Urban Management*, *9*(3), 372–381. https://doi.org/10.1016/j.jum.2020.04.004

Meadows, D. H. (2009). *Thinking in systems: A primer*. Earthscan.

Meerow, S., & Newell, J. P. (2017). Spatial planning for multifunctional green infrastructure: Growing resilience in Detroit. *Landscape and Urban Planning*, *159*, 62–75. https://doi.org/10.1016/j.landurbplan.2016.10.005

Miller, A. (2022, September). Recognizing 2022 Virginia Watershed Champion Awardee—Jasmine Gore. *Alliance for the Chesapeake Bay*. https://www.allianceforthebay.org/2022/09/recognizing-2022-virginia-watershed-champion-awardee-jasmine-gore/

Müller, A., Reiter, J., & Weiland, U. (2011). Assessment of urban vulnerability towards floods using an indicator-based approach – a case study for Santiago de Chile. *Natural Hazards and Earth System Sciences*, *11*(8), 2107–2123. https://doi.org/10.5194/nhess-11-2107-2011

Nel, Hanna. (2020). Stakeholder engagement: asset-based community-led development (ABCD) versus the traditional needs-based approach to community development. *Social Work* , *56*(3), 264-278. https://dx.doi.org/10.15270/52-2-857

NVSS. (2022). *Provisional Life Expectancy Estimates for 2021*.

Panagopoulos, T. (2019). Special Issue: Landscape Urbanism and Green Infrastructure. *Land*, *8*(7), 112. https://doi.org/10.3390/land8070112

Parker, J., & Simpson, G. D. (2018). Public Green Infrastructure Contributes to City Livability: A Systematic Quantitative Review. *Land*, *7*(4), 161. https://doi.org/10.3390/land7040161

Parker, J., & Simpson, G. D. (2020). A Theoretical Framework for Bolstering Human-Nature Connections and Urban Resilience via Green Infrastructure. *Land*, *9*(8), 252. https://doi.org/10.3390/land9080252

Parson, W. (2022, September). Between two rivers, a city's hopes are tied to healthy waters. *Chesapeake Bay Program*. https://www.chesapeakebay.net/news/blog/between-two-rivers-a-city-has-tied-its-hopes-to-healthy-waters

Powell, L. (2023, April 7). Hopewell plant AdvanSix flagged by feds for repeated chemical releases. *Richmond Times-Dispatch*. https://infoweb-newsbank-com.proxy.library.vcu.edu/apps/news/document-view?p=WORLDNEWS&t=pubname%3ARTDWE%21Richmond%2BTimes-Dispatch%253A%2BWeb%2BEdition%2BArticles%2B%2528VA%2529&sort=YMD_date%3AD&fld-base-0=alltext&maxresults=20&val-base-0=kepone&docref=news/190BFF4AD9883588#copy

Powell, L. (2023, September 16). Plastics plant has another gas leak. *Richmond Times-Dispatch*. https://infoweb-newsbank-com.proxy.library.vcu.edu/apps/news/openurl?ctx_ver=z39.88-2004&rft_id=info%3Asid/infoweb.newsbank.com&svc_dat=WORLDNEWS&req_dat=E25D26F9985744EDB7C4A61154F7F782&rft_val_format=info%3Aofi/fmt%3Akev%3Amtx%3Actx&rft_dat=document_id%3Anews%252F194164B51C1A1780

RAFT, & CPDC. (2022). *BUILDING RESILIENCE IN VIRGINIA'S CRATER REGION: COMMUNITY PERSPECTIVES FROM HOPEWELL AND PETERSBURG ON CHALLENGES AND OPPORTUNITIES*.

Reyers, B., Biggs, R., Cumming, G. S., Elmqvist, T., Hejnowicz, A. P., & Polasky, S. (2013). Getting the measure of ecosystem services: A social–ecological approach. *Frontiers in Ecology and the Environment*, *11*(5), 268–273. https://doi.org/10.1890/120144

Reynolds, H. L., Mincey, S. K., Montoya, R. D., Hamlin, S., Sullivan, A., Thapa, B., Wilson, J., Rosing, H., Jarzen, J., & Grove, J. M. (2022). Green infrastructure for urban resilience: A trait-based framework. *Frontiers in Ecology and the Environment*, *20*(4), 231–239. https://doi.org/10.1002/fee.2446

Ridder, D. D., Stöckl, T., To, W. T., Langguth, B., & Vanneste, S. (2017). Noninvasive Transcranial Magnetic and Electrical Stimulation: Working Mechanisms. In *Rhythmic Stimulation Procedures in Neuromodulation* (pp. 193–223). Elsevier. https://doi.org/10.1016/B978-0-12-803726-3.00007-9

Rogers, J. (2013). *Green, brown or grey: Green roofs as 'sustainable' infrastructure*. 323–333. https://doi.org/10.2495/SDP130271

RVA Mag. (2020). *Urban Farming at Edens Community Garden*. https://rvamag.com/news/environment/urban-farming-at-edens-community-garden.html

Saverino, K. C., Routman, E., Lookingbill, T. R., Eanes, A. M., Hoffman, J. S., & Bao, R. (2021). Thermal Inequity in Richmond, VA: The Effect of an Unjust Evolution of the Urban Landscape on Urban Heat Islands. *Sustainability*, *13*(3), 1511. https://doi.org/10.3390/su13031511

Scott, H., Smith, B., & Schaedler, B. (2018). Disaster recovery towards resilience: Contributions of an assets-based community development approach. *Australian Journal of Emergency Management*, *33*(1), 55–60.

SGA. (2016). *Hopewell Brownfields Redevelopment Plan*. Stromberg/Garrigan & Associates. file:///C:/Users/oscar/Downloads/2016_0118_HPWL_Brownfields%20Report%20reduced.pdf

Singh, N., Singh, S., & Mall, R. K. (2020). Urban ecology and human health: Implications of urban heat island, air pollution and climate change nexus. In *Urban Ecology* (pp. 317–334). Elsevier. https://doi.org/10.1016/B978-0-12-820730-7.00017-3

Shivy, V., & Suen, I.-S. (2017). *Economic Impact of the James River Park System*. VCU Psychology. https://scholarscompass.vcu.edu/cgi/viewcontent.cgi?article=1040&context=psyc_pubs

Shi, Y., Zhai, G., Xu, L., Zhou, S., Lu, Y., Liu, H., & Huang, W. (2021). Assessment methods of urban system resilience: From the perspective of complex adaptive system theory. *Cities*, *112*, 103141. https://doi.org/10.1016/j.cities.2021.103141

Stott, P. (2016). How climate change affects extreme weather events. *Science*, *352*(6293), 1517–1518. https://doi.org/10.1126/science.aaf7271

Suen, I.-S. (2022). Assessment of Urban Heat Islands and Land Cover Types in Relation to Vulnerable Populations. *Earth*, *3*(2), 733–747. https://doi.org/10.3390/earth3020041

Thrasher, T. (2022, March 2). The future of the Hopewell City Marina could see some key upgrades. *ABC 8 News*. https://www.wric.com/news/local-news/the-tri-cities/the-future-of-the-hopewell-city-marina-could-see-some-key-upgrades/

US Census Bureau. (2020). *TIGERLine* [dataset].

US Census Bureau. (2022). *Vintage Dataset*.

Walker, B. H., & Salt, D. (2006). *Resilience thinking: Sustaining ecosystems and people in a changing world*. Island Press.

Wilson, G., & Maroon, J. (2017, September 28). Wilson and Maroon column: The Kepone disaster: History, reflection, and relevance. *Richmond Times-Dispatch*. https://infoweb-newsbank-com.proxy.library.vcu.edu/apps/news/document-view?p=WORLDNEWS&t=pubname%3ARTDWE%21Richmond%2BTimes-Dispatch%253A%2BWeb%2BEdition%2BArticles%2B%2528VA%2529&sort=YMD_date%3AD&page=1&fld-base-0=alltext&maxresults=20&val-base-0=kepone&docref=news/1673F1D2158B6180#copy

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough.' *Landscape and Urban Planning*, *125*, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017