Cody Rouge Neighborhood | Detroit, MI

PRIORITIZING VACANT PROPERTIES FOR GREEN INFRASTRUCTURE

A Landscape Analysis, Spatial Planning, and Design Approach for Siting Green Infrastructure in Moderately to Highly Vacant Urban Neighborhoods

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ABSTRACT

This project focuses on the spatial planning, analysis, and design of a green infrastructure (GI) strategy for the Cody Rouge neighborhood in western Detroit. The Cody Rouge neighborhood is an ideal setting for this work because, like most neighborhoods in the city, it has experienced dramatic landscape change over the last sixty years as it has grappled with issues of blight, poverty, and vacancy. Specifically, the prevalence of vacant lots and abandoned properties, which cover approximately 25% of the landscape, contribute to neighborhood instability while creating a disconnected network of unused open space. Numerous studies that have examined future planning scenarios for "shrinking cities" have adopted GI for its multifunctional potential as a method for not only addressing blight caused by vacancy and abandonment but also as a long-term strategy for promoting urban ecology by enhancing ecosystem services and having a positive effect on human health and well-being.

Through the development of spatial models that synthesize opportunities for stormwater management and vacant lot feasibility, green infrastructure prioritization and design strategies are recommended for the Cody Rouge Neighborhood. This project aims to provide a neighborhood planning approach that integrates ongoing efforts for citywide greening, compliance for water management, and vacant land stabilization. Additionally, through an overview of topics related to green infrastructure, landscape planning, spatial modeling, urban ecology, and cultural landscape values, the transdisciplinary nature of this work is emphasized and an accessible, legible, and well-documented strategy for landscape modeling and green infrastructure site prioritization is provided for the Cody Rouge Neighborhood.

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INTRODUCTION

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Problem Definition

This project focuses on the spatial planning, analysis, and prioritization of a green infrastructure (GI) strategy for the Cody Rouge neighborhood located on the far west side of Detroit. The Cody Rouge neighborhood is an ideal setting for this work because, like most residential neighborhoods in the city, it has experienced dramatic landscape change over the last sixty years as it has grappled with issues of blight, poverty, and vacancy. The prevalence of vacant lots and abandoned properties, which cover approximately 25% of the landscape, contribute to neighborhood instability while creating a disconnected network of unused open space. Numerous studies that have examined future planning scenarios for "legacy cities" have adopted GI for its multifunctional potential as a method for not only addressing blight caused by vacancy and abandonment but also as a long-term strategy for promoting urban ecology by enhancing ecosystem services and having a positive effect on human health and well-being.

Since the 1950's, the city of Detroit has experienced an unprecedented 61% population decline, shrinking from nearly 1.8 million residents at its peak in 1950 to less than 714,000 residents in 2010 (U.S. Census Bureau 2010). Similar to other Midwestern rust-belt cities, Detroit quickly grew to maturity as a single-industry town through rapid manufacturing of the automobile. With the rise of the automobile industry, Detroit developed into an expansive city of low-density, residential neighborhoods comprised predominantly of single-family homes, many of them owner occupied (Dewar & Morrison 2012). In 1967, during the midst of economic prosperity, the auto industry began to restructure operations and decentralize its production, moving new manufacturing plants to suburban "greenfields" and small towns in the upper Midwest. Detroit lost more than 130,000 manufacturing jobs to deindustrialization and the migration of investments lead to the migration of middle-class residents to the suburbs, and thus a growing inventory of vacant land and abandoned structures (Sugrue 1996). Today, more than a quarter of Detroit properties are vacant or abandoned, making up more than 100,000 properties, approximately 20 square miles or 14% of the city's total land area, which is an area greater than all the city's parks and open spaces combined (City of Detroit 2012).

The term "shrinking city" is often used to describe industrial cities that have experienced significant and sustained population loss (25% or greater over the last 40 years) (Schilling 2008), it is often conceptually misleading because cities do not shrink spatially (Nassauer & Raskin 2014). This notion is especially relevant in the case of Detroit, whose expansive city limits could contain the entire cities of Boston, San Francisco, and the borough of Manhattan. As wealthy and middle-class residents moved to the surrounding suburbs, the decreasing city population became proportionately poorer, resulting in a declining tax base that is inadequate for maintaining and improving the existing citywide infrastructure (Nassauer & Raskin 2014). Detroit's archaic and predominantly combined sewer infrastructure is a primary example of a system that is in dire need of maintenance.

While traditional planning approaches tend to manage cities for anticipated growth and development, the prevailing conditions of disinvestment and abandonment are a reality for Detroit and adaptive alternatives that acknowledge landscape change and reduce the burden on conventional infrastructure must be considered. Schilling and Logan (2008) recommend a "right-sizing" strategy for stabilizing cities with dysfunctional markets and distressed neighborhoods. This approach attempts to align a city's built environment with the needs of existing and foreseeable future populations by adjusting the amount of land available for development. Green infrastructure offers a "right-sizing" opportunity for converting surplus vacant land into green space.

Definitions of Green Infrastructure

Green infrastructure definitions by a range of agencies, planning frameworks, and researchers:

The US EPA defines green infrastructure as:
{"practices that mimic natural hydrologic processes to reduce the quantity and/or rate of stormwater flows into the combined sewer system (CSS)…through the processes of infiltration, evapotranspiration, and capture and use (rainwater harvesting) (EPA 2014)."}

SEMCOG defines green infrastructure as:
{"parks, lakes, wetlands, and trees, as well as constructed green roofs, bioswales, and rain gardens… [that contribute] not only to environmental quality, but also to placemaking, economic values, and healthy communities (SEMCOG 2014)."}

Schilling and Logan (2008), define green infrastructure as:
{"an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations such as recreation, aesthetics, and flood control."}

Hoornbeek and Schwarz define green infrastructure as:
{"the use of green spaces, wetlands, parks, forest areas, and native vegetation to manage stormwater naturally, reduce flooding risk, and improve water quality"}

Tzoulas, Konstantinos, et al. define green infrastructure as:
{"[comprising] of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales … emphasiz[ing] the quality as well as quantity of urban and peri-urban green spaces, their multifunctional role, and the importance of interconnections between habitats".}

The Detroit Future City Framework Plan makes a distinction between blue infrastructure, which is used to capture and clean stormwater while minimizing the contribution of runoff to the combined sewer system, and green infrastructure, which is described as forested landscapes and greenways that can improve air quality (City of Detroit 2012).

Green infrastructure is a broad and flexible term that has been applied ubiquitously when referring to green space planning initiatives. It is commonly used by planners, designers, scientists, engineers, etc., to describe specific and generalized disciplinary and multidisciplinary goals for a range of projects. Because there is not one consistent definition of green infrastructure, standard models for the siting, design, and implementation of green infrastructure strategies vary widely. Additionally, the concept of green infrastructure is relatively new and much remains unknown about its impact and potential. The broad range of planning initiatives and research on green infrastructure is still in its infancy and perfect solutions do not currently exist. For this reason, projects exploring the concept should continue to embrace diverse and creative approaches while remaining objectively watchful of ongoing research and pilot programs.

While the definition of green infrastructure varies, it is commonly understood to be functional green space that provides both ecological and human benefits. It has particular implications for the management of stormwater, mimicking natural hydrologic functions to reduce the quantity of flow that enters a sewer system. In urban areas, stormwater management is of particular concern due to the expansive quantity of impervious surfaces (streets, roofs, parking lots), which prevent water from infiltrating into the ground. Engineered collection systems are designed to efficiently remove water from impervious surfaces into piped system, which typically discharge into nearby water bodies, introducing trash, bacteria, heavy metals, and other pollutants from the urban landscape that degrade water quality. During heavy rain events, an increased quantity of flow can contribute to erosion, flooding, and combined system overflow (EPA 2014).

Green infrastructure employs distributed source controls throughout a region that use vegetation, soils, and other natural processes to mitigate stormwater runoff quantity and quality before it reaches piped infrastructure systems, providing treatment to the associated pollutants (NRC 2009).

For the Cody Rouge neighborhood, this project anticipates the implementation of green infrastructures source controls that provide detention, retention, and bioretention/bioinfiltration to mitigate the impact of stormwater quality and quantity during storm events. This project does not propose site-based designs but rather a neighborhood based green infrastructure strategy for prioritizing implementation. Building on the work of Austin et al. (2013), "Green Infrastructure Analysis, Design, and Application in Detroit's Lower East Side," the source control interventions recommended for the Lower East Side, which exhibits similar patterns of residential vacancy, are also recommended for Cody Rouge.

Project Objectives

The primary objective of this project is to recommend a prioritization strategy for siting green infrastructure on vacant and abandoned residential properties in the Cody Rouge neighborhood. A prioritization strategy is developed through two spatial models: (1) the Catchment Prioritization Model and (2) the Vacant and Abandoned Parcel Prioritization Model. The Catchment Prioritization Model assesses landscape conditions that indicate the greatest need for green infrastructure to manage and mitigate stormwater. An additional goal for this model was to explore the influence of vacancy on baseline stormwater runoff calculations through a sensitivity analysis. This step was critical for demonstrating the effects of standardized modeling in highly vacant neighborhoods. The results of the Catchment Prioritization Model are developed through a landscape index in order to make recommendations for priority green infrastructure *areas* in the Cody Rouge Neighborhood.

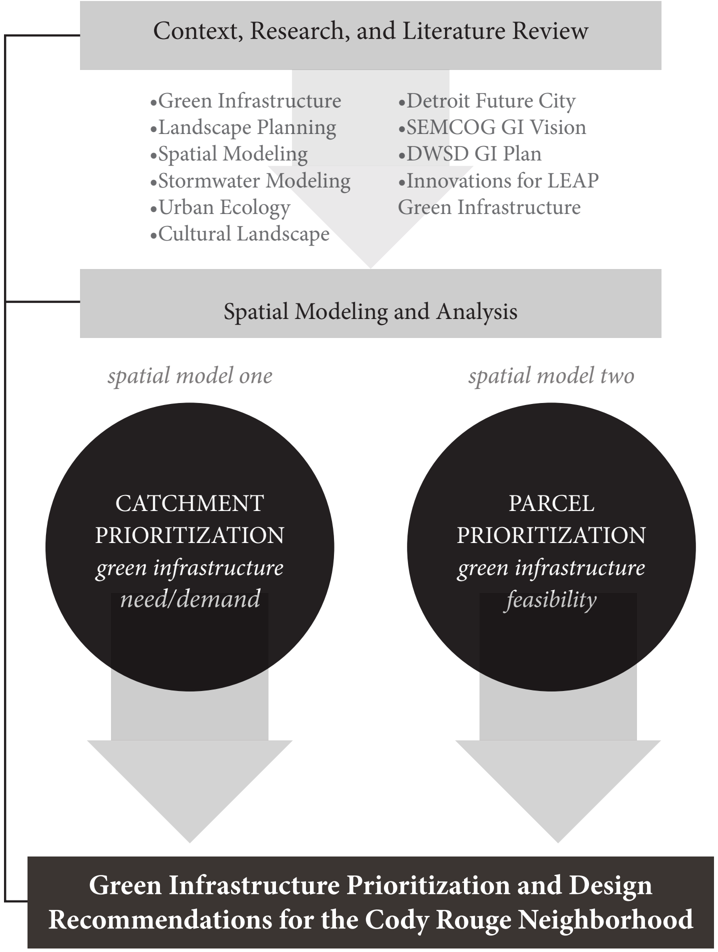
The Vacant and Abandoned Parcel Prioritization Model assesses parcel conditions that indicate greatest opportunities for green infrastructure. This model has three phases. The first phase identifies clusters of vacant parcels in order to recommend GI strategies that are dependent on available area. The second phase identifies vacant parcels that exhibit the greatest potential for providing ecosystem services and the third phase identifies vacant parcels that exhibit the greatest potential based on social characteristics. These three phases are combined to form the Vacant and Abandoned Parcel Prioritization Index, which is used to make recommendations for priority green infrastructure *parcels* in the Cody Rouge Neighborhood. The spatial results of all models are visually assessed to make specific recommendations for prioritizing green infrastructure in the Cody Rouge Neighborhood.

A secondary objective for this project is to explore and integrate a range of disciplinary and recommended approaches to green infrastructure design through the development of the green infrastructure prioritization model. Specifically, this project aims to balance the disciplinary goals of engineers, landscape planners, ecologists, social scientists, and designers. Additionally, because planning approaches for the city of Detroit have often been criticized for their lack of integration, this project considers several ongoing citywide and neighborhood planning frameworks, including the Detroit Future City Framework Plan, the SEMCOG Green Infrastructure Vision, and the DWSD Green Infrastructure Plan, to provide a neighborhood strategy that is consistent with widely accepted city and regional visions.

In order to develop an integrated and multidisciplinary framework for Cody Rouge, a planning approach that uses spatial landscape pattern indices was used to evaluate priority locations for green infrastructure. According to Corry and Nassauer (2005): "landscape pattern indices have two potentially attractive attributes for planners and designers: (1) they are relatively efficient tools that can be applied quickly to several different alternative plans (as opposed to more complex models that may have prohibitive computing requirements, expensive calibration requirements, or be discipline-centered and (2) they are accessible tools, easily acquired, fully documented, and applicable to digital data representing alternative plans and designs." While these characteristics suggest that landscape pattern indices could be a useful tool for siting green infrastructure in the Cody Rouge Neighborhood, Corry and Nassauer caution that these attributes may allow them to be used incorrectly. In order to be appropriately employed for decision-making, landscape pattern indices must only be used when data inputs are appropriately-scaled and have been evaluated with great intellectual and methodical care.

One of the greatest strengths of this project is that for all Cody Rouge landscape models, data input and their foundational underpinnings are thoroughly evaluated and documented, both ensuring a comprehensive understanding of the output results and providing a replicable process for other neighborhoods exhibiting similar landscape characteristics.

Figure I-1: Conceptual Flow of Project



II.

CONTEXT

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The Cody Rouge neighborhood is a primarily residential neighborhood that developed between the years of 1920 and 1950 to house workers in Detroit's then thriving manufacturing industry. Today, it is home to approximately 36,849 residents and is geographically located on the far west side of the city (Cody Rouge Neighborhood Profile 2012). It is bordered on the East by the Southfield Freeway and on the West by the western city limits of Detroit. The Northern border is Fullerton Street and Interstate-96 and the southern city limits, along M-153, are adjacent to the city of Dearborn. Anchored by the city's largest public park, Rouge Park, which extends more than 1,000 acres between the north-south neighborhood boundaries, the Cody Rouge neighborhood is currently experiencing active community transformation through initiatives such as Skillman's Good Neighborhoods and Downtowns of Promise from Michigan State Housing Development Authority. The Cody Rouge Community Action Alliance (CRCAA) maintains a strong community presence and is significantly involved with a number of planning and development initiatives that aim to "revitalize and sustain a healthy community where residents have access to and promote a high quality of life…. implementing plans for safety and forming plans for economic revitalization (CRCAA 2014)." While these community characteristics are likely to facilitate a receptive environment for developing a residential GI Siting and Prioritization strategy, a thorough understanding of the social and ecological context is critical for any neighborhood planning approach.

Figure II-1: Cody Rouge Neighborhood - Citywide Context

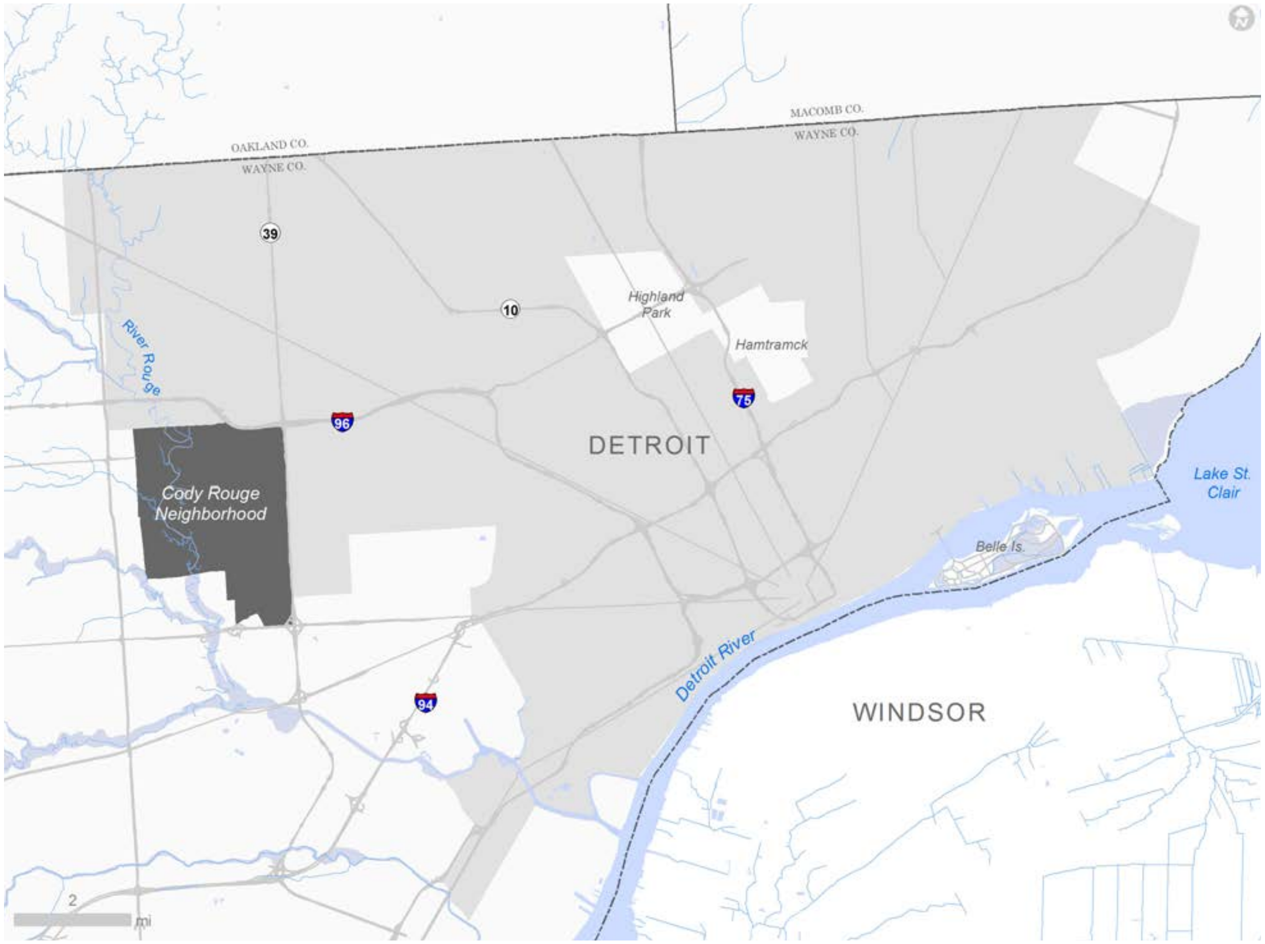
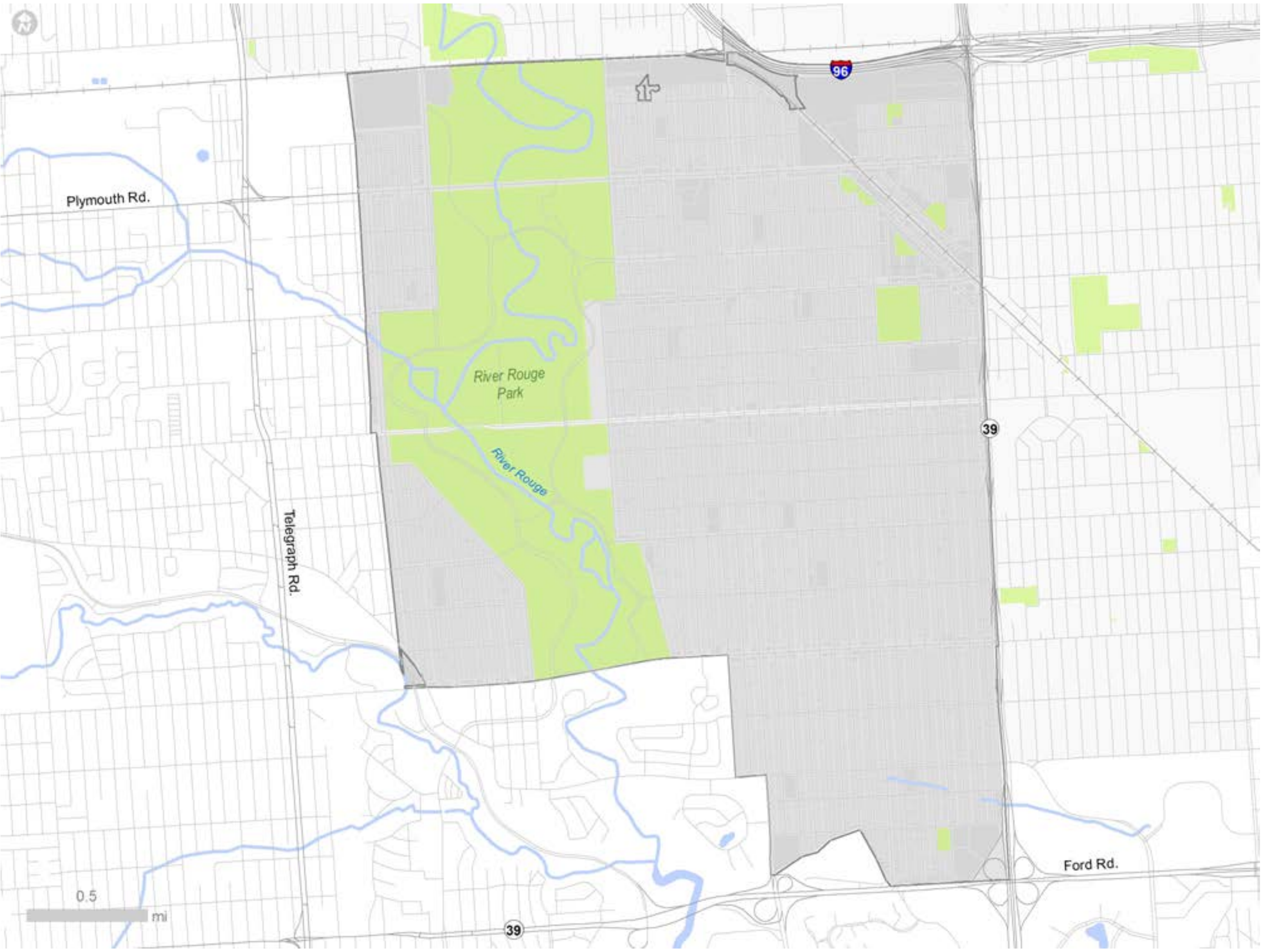


Figure II-2: Cody Rouge Neighborhood Study Area



Social Context: Overview, Problems, and Opportunities

General Population Trends

The 2010 Census shows a total population of 36,849 residents living in the Cody Rouge neighborhood. This figure represents an 18% decline in residency since the year 2000. Additionally, the total population of children and youth living in the area saw a marginally greater population decline during the same time period, at approximately 20%. These trends nearly mirror those of the entire city of Detroit, which experienced a 25% general population loss and a 34% population loss for the 0-18 demographic. A data analysis conducted by Data Driven Detroit concludes that the citywide exodus of urban residential neighborhoods over the last decade was led by families, which displays an overall shift in family structure. From 2000 to 2010, nearly 50% of married couples with school-age children left the Cody Rouge neighborhood while single-parent families decreased at lower rates. Additionally, beyond the age of 18 years, the only age groups to experience population growth in this neighborhood were the baby boomers (55-69) and the elderly (85+) (Cody Rouge 2012).

Racial/Ethnic Composition and Socioeconomic Demographics

Similar to the rest of the city, the Cody Rouge neighborhood has experienced significant emigration of the white population. Between 2000 and 2010, the community saw a 12% decline in white population and a 14% increase in African American population. Despite this change in racial/ethnic composition, the neighborhood has maintained a relatively diverse community structure. According to the 2010 Census, African-Americans make up 78% of the total population, followed by whites at 15%. Approximately 4% of the community is Hispanic/Latino and 2% is Multiracial (Cody Rouge 2012).

Compared to the city-wide average, Cody Rouge has fewer households living below the poverty line and more households with an average income of $50,000+ per year. Additionally, while the percentage of residents without a high school diploma is still considerably high at 20%, it is the lowest among the six Skillman Good Neighborhoods and below the city average, which is 24% (Cody Rouge 2012).

Housing Characteristics and Vacancy

More than 20% of the Cody Rouge neighborhood is made up of vacant and abandoned parcels (MCM 2014), which is on par with the city average of 23%. Since 2000, the rate of residential vacancy in Cody Rouge has quadrupled, rising from approximately 935 housing units to 3,627 (Cody Rouge Neighborhood Profile 2012). While vacancy and blight are a reality that put a great deal of pressure on community stability, the neighborhood is also home to an above average percentage of homeowners. Approximately 60% of the neighborhood remains owner occupied, which is high compared to the city average of 50% (Cody Rouge 2012).

Community Resources and Opportunities

Through several initiatives catalyzed by support from the Skillman Foundation and the Michigan State Housing Development Authority, many spearheaded by the Cody Rouge Community Action Alliance, the neighborhood has developed realistic planning goals that have increased continuity and collaboration within the community (CRCAA 2014). Through family assistance programs, investment in education and block clubs, and planning strategies that engage stakeholders for increased safety and economic revitalization, the Cody Rouge Community Action Alliance has been particularly successful in creating social cohesion and promoting positive neighborhood change. An above average rate of long-time homeowners, further reveals that residents in the Cody Rouge neighborhood are invested in their community. The Cody Rouge neighborhood also has a significant number of community resources and facilities, including fourteen open and active schools (eleven are public) (Data Driven Detroit 2014), seventeen churches, several historic structures and landmarks, the Thomas A. Edison Detroit Public Library, and seven public parks, including the expansive River Rouge, which hosts a plethora of recreational opportunities and community projects, such as the seven-acre D-Town farm.

Figure II-3: Cody Rouge Schools, Churches, Parks, and Historical Sites

Opportunities

In general, the prevalence of vacancy combined with the population, socioeconomic, demographic, and housing characteristics in Cody Rouge exemplify a typical urban residential neighborhood in the city of Detroit, making it a useful context for this project. An integrated model for siting and prioritizing green infrastructure on vacant land in Cody Rouge is transferable and could be applied to other neighborhoods exhibiting similar characteristics in the city. Additionally, because the financial capital for managing and maintaining vacant land in Detroit is limited, identifying neighborhood characteristics that display some degree of social cohesion may present opportunities for more successful GI design interventions (Nassauer & Raskin 2014). The Cody Rouge neighborhood exhibits many strong signs of social cohesion and it is these distinctive characteristics that provide conditions that may be more receptive to a long-term GI planning approach that connects community resources, provides useful neighborhood space, and helps to stabilize vacant properties. Further discussion of social cohesion and cultural ecosystem services in Section IV.

Urban Ecological Context: Overview, Problems, and Opportunities

The Cody Rouge neighborhood is immediately adjacent to the River Rouge and the 1,100 acre River Rouge Park. The neighborhood also contains six other public parks that contribute an additional 50 acres of open green space. These areas provide tremendous social, aesthetic, and ecological benefits to the Cody Rouge neighborhood. Additionally, more than 240 acres of scattered vacant land across the neighborhood results in a spatial pattern that could be described as patchy and heterogeneous.

Water Quality

In addition to concerns of flooding, the Cody Rouge neighborhood contributes to water quality issues as because it contains contributing watershed s to combined sewer overflow (CSO) outlets along the River Rouge, including six permitted sites within the neighborhood boundaries. The combined sewer and stormwater infrastructure does not have adequate transport and treatment capacity for stormwater runoff, resulting in untreated sewage discharge at CSO locations along the river that pose concerns for water quality.

Infrastructure

As mentioned previously, the citywide sewer infrastructure is deteriorating and in 2009, DWSD terminated a highly publicized contract to develop a seven-mile tunnel along the upper Rouge River, extending through the Cody Rouge neighborhood, due to lack of funding. This project was designed to reduce the frequency of overflow events from about 50 a year to less than one a year, reducing the overflow from an average of 1.3 billion gallons to 250 million gallons annually (Wallis 2009).

Urban Heterogeneity and Vacancy

Within the Cody Rouge neighborhood, there are more than 3,000 parcels that are classified as either vacant or abandoned, contributing to neighborhood instability as part of a disconnected network of unused open space (MCM 2014). The spatial pattern exhibited by these parcels is largely heterogeneous, some areas are uniformly occupied while others are uniformly vacant (Nassauer & Raskin 2014). Without a formal strategy for managing, maintaining, and creating connectivity among these parcels, they are less likely to support true ecological benefits.

Further, without visual evidence of human maintenance, overgrown patterns of spontaneous urban vegetation can appear “messy,” evoking negative landscape perception and contribute to concerns for safety (Nassauer 1995, 2011). Urban ecology recognizes the relevance of patch dynamics in the vacant residential landscape and can offer substantial knowledge for managing these parcels with a strategy that can promote ecological health and cultural sustainability (Nassauer & Raskin 2014).

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Landscape Ecology

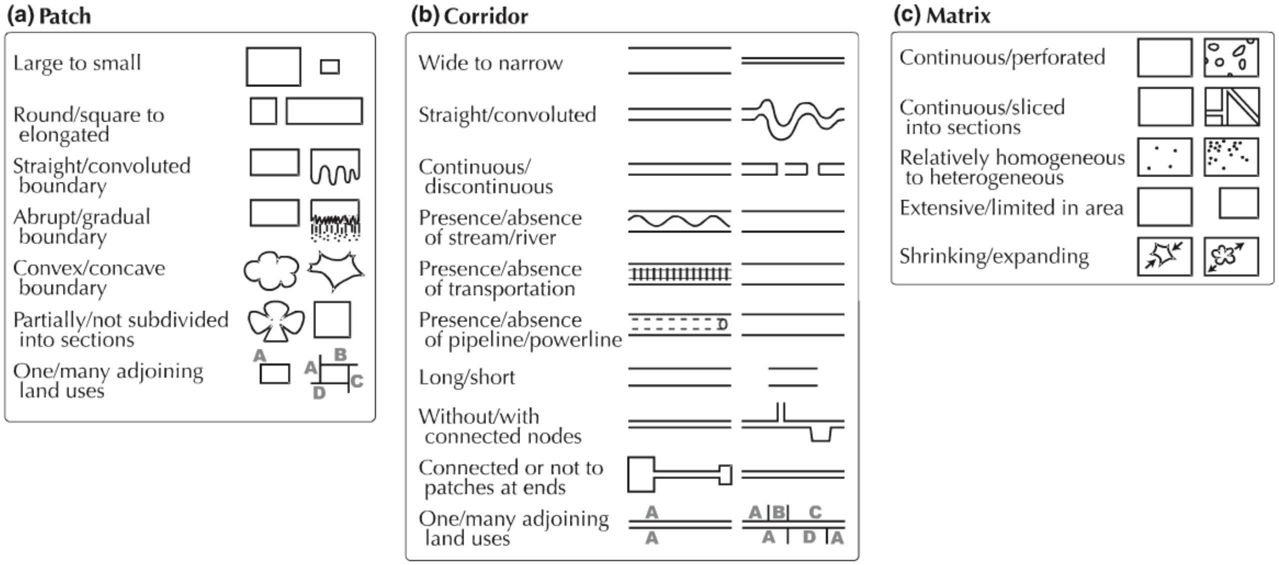
Urban landscapes are mosaics that can be conceptualized and represented by elements in a categorical map pattern known as the patch-corridor-matrix model. The arrangement of patches, corridors and matrix directly influence landscape flows and connectivity (Forman & Gordon 1995).

- *Patches* are spatial units at the landscape scale, typically surrounded by the matrix and connected by corridors.

- *Corridors* are elongated patches that connect other patches together.

- The *Matrix* is usually the most extensive and connected landscape element present and the element in which patches and corridors are imbedded.

Figure II-4: Patch-Corridor-Matrix Characteristics of a Land Mosaic
Retrieved from: Forman, Richard TT. Urban Ecology: Science of Cities. Cambridge University Press, 2014, p. 45



Connectivity is a measure of how physically connected or spatially continuous the patch, corridor, and matrix elements are within a landscape. A “spatial connection” means that patches are close to one another and that movement can occur among them or that they are connected by a corridor, along which landscape flows can occur. Urban green space that is considered “ecologically optimum” is dependent on the degree of connectivity and ideally comprised of large patches of natural vegetation that are supplemented with smaller patches of vegetation scattered within the matrix. Porosity is a measure of the density of patches in a landscape. Increasing connectivity and decreasing porosity provides a suitable strategy for countering fragmentation and enhancing landscape flows

Three spatial design concepts that can assist landscape planners in applying landscape ecology principles to their work are:

1. To maintain large patches of vegetation that has habitat function
2. To maintain wide riparian corridors
3. To maintain connectivity for the movement of key species among large patches (Leitao, 2002)

In urban landscapes, these concepts should be extended as part of a holistic planning approach that is driven by transdisciplinary concerns to link nature and human society (Naveh 2000). Because the framework of the patch, corridor, and matrix represents landscape elements at the human scale, it offers great opportunities for both ecological and cultural sustainability (Nassauer 1995).

Opportunities

To help mitigate flooding and manage stormwater runoff, a green infrastructure prioritization strategy for the Cody Rouge neighborhood will explore connectivity between open spaces, including vacant and abandoned lots, under the principles of urban ecological theory. Additionally, the Cody Rouge neighborhood is bordered by four major corridors: the River Rouge and the River Rouge Park to the west, I-96 to the north, the Southfield Freeway to the east, and M-153 (Ford Rd.) to the south. These corridors provide opportunities for investigating flows of water through the neighborhood. They also provide multifunctional opportunities for promoting human and animal movement through the area.

III.

MODEL ONE DEVELOPMENT

Catchment Prioritization for Stormwater Management

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Catchment Prioritization for Stormwater Management

Model Purpose

A common driver for the municipal implementation of green infrastructure is the need to comply with regulatory requirements (Dunn 2010). In legacy cities, such as Detroit, where financial resources are scarce and concentrated stormwater runoff regularly contributes to combined sewer overflow (CSO) events, there is a pressing need for the implementation of low-cost source control measures that reduce stormwater loading. Urban runoff carries significant amounts of pollution to nearby streams, rivers, and waterbodies, posing a serious threat to water quality. In addition to containing oil and grease products, bacterial pathogens, heavy metals, salts, nutrients, and sediment; urban runoff drives sewer overflows of untreated human waste during wet weather events (Hill 2009). In response to federal regulation, such as the National Pollution Discharge Elimination System (NPDES) Program, mandated by the Clean Water Act, municipalities are required to limit discharge of combined sewage at permitted locations and reduce pollutant loading into national waterways through stormwater management programs (Hill 2009, NPDES 2011). In order to demonstrate compliance with federal regulation, municipalities are often required to quantify the costs and benefits of all measures taken to improve the stormwater system (Dunn 2010). This requirement demonstrates a need for incorporating quantifiable goals and measurement strategies into the development of green infrastructure planning, design, and management. In order to significantly change urban hydrologic performance, Kristina Hill recommends an integrated framework for planners, designers, and scientists that simply categorizes hydrologic function and landuse within urban drainage basins, or catchments (Hill 2009). Additionally, Pickett et al., recommends a watershed approach for its ability to link and hierarchically organize social and ecological components as part of an integrated human-ecosystem framework (Pickett et al. 1997).

As a response to the literature on integrated planning approaches and the pressing need to meet federal regulation requirements, the Catchment Prioritization model for Cody Rouge aims to understand hydrologic performance at the neighborhood scale by quantifying stormwater runoff, landuse conditions, and relative contribution to combined sewer overflow at the catchment level. Through the development of a critical spatial analysis, primarily concerned with surficial hydrologic flow, the Catchment Prioritization model results represent a synthesized prioritization scheme for targeting the most suitable neighborhood catchments for green infrastructure based on *runoff reduction need* or *green infrastructure demand*. Essentially, the catchment prioritization model identifies neighborhood catchments-that contribute most significantly to stormwater runoff in the Cody Rouge neighborhood and would most benefit from targeted green infrastructure strategies.

Integration

The Detroit Future City Framework Plan, the SEMCOG Green Infrastructure Vision for Southeastern Michigan, and especially, the Detroit Regional Water and Sewer District (DWSD) Green Infrastructure Program, prioritize citywide stormwater management through blue or green infrastructure planning strategies.

A strategy outlined by The Detroit Future City (DFC) Framework is to rethink landscapes as citywide infrastructure. DFC recommends adapting available, open land to serve the wastewater and stormwater infrastructure systems. This approach promotes a “right-sizing” strategy that will optimize city water management and reduce the burden on conventional infrastructures that are quickly approaching the end of their productive life expectancy. Making a distinction between blue infrastructure, which is used to capture and clean stormwater while minimizing the contribution of runoff to the combined sewer system, and green infrastructure, which is described as forested landscapes and greenways that can improve air quality, DFC highlights the opportunity for combining these systems to serve as productive multifunctional and recreational landscapes that can provide a new identity for the city of Detroit (City of Detroit, 2012). The comprehensive DFC plan describes green/blue infrastructure types, functions, and strategies for citing landscape elements that reduce stormwater loading and improve water quality across the city.

Similar to the DFC Framework, SEMCOG’s regional green infrastructure vision imagines a connected system of existing parks, lakes, wetlands, and trees, as well as constructed green roofs, bioswales, and rain gardens across the seven-county region of Southeastern Michigan. While SEMCOG’s framework boasts the social, environmental, and economic benefits of green infrastructure, it emphasizes opportunities for improving water quality by reducing stormwater runoff, flood mitigation, and improvement to the regional water supply (SEMCOG 2014). According to SEMCOG, the primary focus of the Green Infrastructure Vision is to address water quality challenges in the river systems, focusing on urban areas and the extent of impervious cover (SEMCOG 2014). Additionally, the SEMCOG-framework recommends a watershed-based approach to water quality improvement that prioritizes impaired waterbodies or Areas of Concern (AOC) for green infrastructure implementation. The state of Michigan has 14 AOCs, which are defined as areas on the Great Lakes that have beneficial use impairments (BUIs). This designation was part of an amendment to the 1978 Great Lakes Water Quality Agreement. The River Rouge, which runs through the Cody Rouge neighborhood, is included in the list of AOCs and urban storm water, CSOs, nonpoint source pollution, and municipal and industrial discharges all contribute to beneficial use impairments (BUIs), which include:

- Restrictions on fish and wildlife consumption
- Eutrophication or undesirable algae
- Degradation of fish and wildlife populations
- Beach closings
- Fish tumors or other deformities
- Degradation of aesthetics
- Degradation of benthos
- Restriction on dredging activities
- Loss of fish and wildlife habitat (USEPA 2013)

The goals for stormwater management outlined in the Detroit Water and Sewerage District (DWSD) Stormwater Management Program Plan (SWMPP) and Green Infrastructure Program are most closely aligned with the development of the Catchment Prioritization Model. The Stormwater Management Program Plan (SWMPP) was developed in order to fulfill the requirements of a National Pollution Discharge Elimination System (NPDES) permit issued in 2003 for stormwater discharged from the Municipal Separate Stormwater System (MS4), which consists of 18 storm sewer outfalls along the River Rouge. The discharge permit requires the City of Detroit to develop, implement, and enforce a plan that reduces discharge from the stormwater system to the Maximimum Extent Practicable (MEP). As part of this plan, the city must include measurable goals for Best Management Practices (BMPs) and demonstrate that those goals are met. The BMPs are required to address the following:

- Public education Program - Education and outreach on storm water impacts
- Public involvement and participation
- Illicit discharge elimination program
- Post-construction Storm Water Management Program for new development and redevelopment projects
- Construction storm water runoff control

Most of the stormwater runoff in the City of Detroit is conveyed through the combined sewer system, which serves the entire city and encompasses an area of nearly 100,000 acres. More than half of this acreage is tributary to the River Rouge where combined sewage is discharged at more than 26 NPDES permitted locations. Six of the permitted NPDES locations are within the Cody Rouge Neighborhood, making it a primary target for stormwater management and water quality improvement (City of Detroit, 2013).

In 2011, DWSD received funding from SEMCOG and the Michigan Department of Environmental Quality (MDEQ) to integrate green infrastructure as part of the Alternative Rouge River CSO Control Program (DWSD 2011). This program is designed "to restore water quality and protect public health while staying within its financial means by controlling rate increases that will be needed to pay for new projects (DWSD 2011)." Through tree planting, demolition, greening of vacant lots, residential downspout disconnection, and the implementation of GI strategies in roadways and on municipally owned properties, the ultimate goal of the Green Infrastructure Plan is to implement "right-sized" source control measures that reduce urban runoff and its associated pollution while meeting regulatory compliance standards with low-cost landscape interventions (DWSD 2011, DWSD 2014).

While the DWSD Green Infrastructure Plan describes priority areas and proposed pilot projects, it does not provide a methodology for siting priority areas at the neighborhood scale. The Catchment Prioritization Model aims to respond to the vision and goals outlined by DFC, SEMCOG, and DWSD by providing a prioritization scheme for siting green infrastructure in the Cody Rouge Neighborhood.

Model One: Process, Methods, and Assumptions

1. Delineate catchments for the Cody Rouge Neighborhood

2. Calculate peak stormwater runoff for each catchment during two, ten, and one-hundred year storm events for original and modified landuse datasets

3. Conduct sensitivity analysis to assess the impact of vacant land on peak stormwater runoff

4. Determine Priority Catchment opportunities and visually assess results

Catchment Delineation

The purpose of the Catchment Prioritization Model is to assess and quantify the relative contribution of stormwater runoff generated by each neighborhood catchment. The USEPA recommends a planning and modeling approach for green infrastructure that uses a Geographic Information System (GIS) to categorize sewersheds, or catchments, into groups, based on land use, soils, and topography (EPA 2014). The Catchment Prioritization Model focuses on the surficial flow of water using the best available spatial data to incorporate these landscape conditions.

Topographic Conditions

Catchments were delineated using ArcHydro 10.1, an extension of hydrologic modeling tools developed for ArcGIS. The primary input for this model was a three-meter digital elevation model (DEM), a subset from the National Elevation Dataset (NED) obtained from the U.S. Geological Survey (USGS). The three-meter DEM is the highest resolution dataset available to the public and free of charge. It represents bare-earth conditions as a raster dataset based on a survey of the terrain. Unlike high resolution and high cost LiDAR data, the DEM does not account for landscape subtleties and manmade structures such as tree height, buildings, towers, and power lines. The three-meter DEM does, however, accurately represent elevation change based on USGS quad contours (USGS 2015). Additionally, the Flood Emergency Management Agency (FEMA) states that a three-meter DEM is suitable for a detailed flood risk study in areas with a relatively low population and minimal anticipated growth (FEMA 2007).

Infrastructure and Surficial Flow

The American Water Works Association estimates that the restoration of existing water infrastructure systems will cost more than one trillion dollars over the next twenty-five years (Wyckoff 2012). In "legacy cities", including Detroit, maintaining existing infrastructure is complicated by fragmented population loss and excess infrastructure capacity, which has provoked interest in decommission and reconfiguration options. Hoornbeek and Schwarz (2009), investigated an approach for sustainable infrastructure in legacy or "shrinking" cities and found both decommission and removal to be costly and difficult to project entire system impact. In Detroit, where urban growth is uncertain, these options are also ethically challenging as they will require the relocation of residents who are either unable to move or don't want to (Wyckoff 2012). The agencies responsible for these systems, DWSD in the case of Detroit, do not have the resources to maintain them and lack the tools for reducing the system scale, requiring them to bear service costs without adequate revenue (Hoornbeak 2009, Wyckoff 2012). Hoornbeek and Schwarz, given their research findings, recommend an approach for sustainable infrastructure in shrinking cities that promotes asset/data management, integration and coordination across infrastructures, and optimizes the use and function of existing infrastructure to reduce current costs while preserving opportunities for growth and future development (Hoornbeak 2009). While this project and the Catchment Prioritization Model acknowledge the effects of the aging infrastructure in Detroit, the goal is not to reconfigure the existing sewer network. Instead, this project aims to optimize the system based on surface landscape conditions, reducing the infrastructural burden while proposing a flexible holding strategy for vacant land in an uncertain future.

With the exception of the River Rouge, the Cody Rouge neighborhood has few surficial streams and data for sewer infrastructure was unavailable. The overall terrain of the region is relatively flat and the three-meter DEM does not represent all landscape and manmade subtleties. Because this project aims to optimize the functions of the existing water infrastructure, the influence of these features are critical for representing the movement of stormwater. In order to enhance the model and to better simulate surficial flow, the DEM was modified to include the Michigan Department of Transportation (MDOT) linear road network. For this analysis, the surficial flow of stormwater is assumed to follow these linear corridors, which represent an artificial infrastructure for water movement across the landscape. This strategy is well-suited for the city of Detroit where the existing infrastructure is degrading and -

future patterns of reconfiguration are uncertain. Additionally, this approach provides an opportunity for the city to shift from a solely infrastructure-based logic to one that incorporates the broader influence of the watershed. This strategy complements the goals of DFC, SEMCOG, and DWSD to provide multifunctional landscapes that integrate both social and ecological influences.

For catchment delineation, the modified DEM was used to generate flow accumulation, flow direction, a drainage network, inlet locations, and 115 neighborhood catchments for the Cody Rouge study area. Figure III-1 graphically depicts the process for generating these datasets. The average neighborhood catchment size is approximately 40 acres but the size of catchments range from 5 to 200 acres across the study area. The final catchment dataset provides a basic mapping unit for quantifying peak stormwater runoff, comparison and prioritization, and the opportunity to compare stormwater capacity of different green infrastructure strategies across the neighborhood.

Figure III-1: Catchment Delineation Processing with ArcHydro

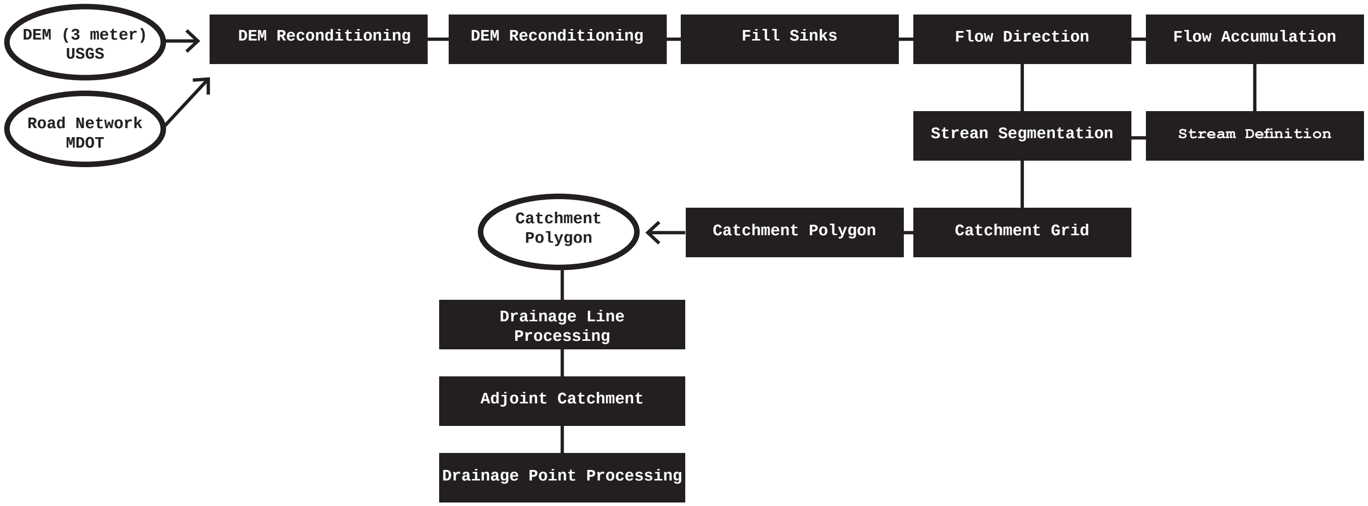
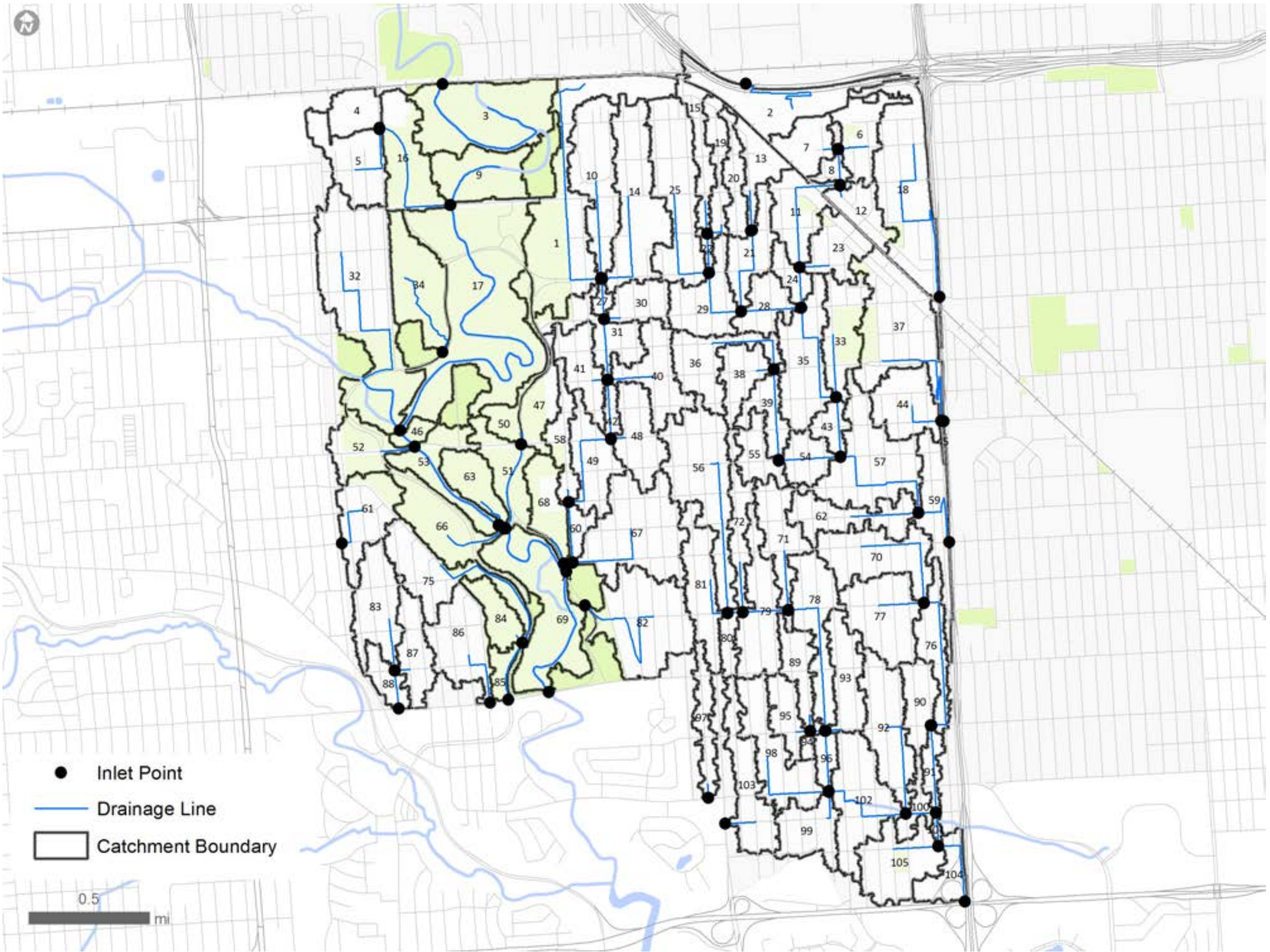


Figure III-2: Cody Rouge Neighborhood Catchments and Drainage Network



**Catchments labeled by catchment ID*

Quantifying Peak Stormwater Runoff by Catchment

Complex models often require highly specialized technical knowledge, expensive calibration techniques, and tend to be discipline-centered (Corry and Nassauer 2005). Leitao and Ahern recommend an approach to landscape planning that utilizes a landscape pattern index. This approach is useful to planners and designers because it allows for alternative patterns to be modeled efficiently while using accessible tools that are easily acquired, fully documented, and applicable to digital data representing plans and designs.

Soils and Geomorphology

The Natural Resources Conservation Service (NRCS) does not classify soils for urban areas in the most recent and comprehensive Soil Survey (SSURGO). Because these areas, which include the urban boundaries of Detroit, have been subject to construction, development, compaction (compression), and surface sealing, their soil properties are dramatically different from those in rural areas. Common disturbances to urban soils result in a reduced ability to perform the critical functions or activities of natural soils (USDA 2005). In order to appropriately target locations for the implementation of source control measures for stormwater management in Cody Rouge, an understanding of the urban soil characteristics and geomorphology is critical. In 1982, a survey of Michigan's Quartenary Geology by the Michigan Department of Natural Resources classified the majority of the Cody Rouge neighborhood as predominantly lacustrine clay and silt (MDNR 1998). In the 1977 General Soils Map for Wayne County, the U.S. Department of Agriculture classified most of the soils in the Cody Rouge Neighborhood as part of the Hoytville-Nappanee soil association. These soils tend to be located on nearly level or gently sloping terrain and are described as being very poorly or poorly drained with a fine textured subsoil. Along the River Rouge, soils that occur within the floodplain were classified as part of the Pewamo-Selfridge-Corunna association, also located on nearly level or gently sloping terrain. These soils are described as very poorly drained to somewhat poorly drained and have moderately fine to coarse textured subsoil (Larson 1977). While the availability of vacant land in the Cody Rouge neighborhood provides opportunities for land-based green infrastructure, the historic soil characteristics combined with the influence of development minimizes the potential for existing soils to support infiltration-based source control measures for stormwater management. This project proposes green infrastructure opportunities that combine retention, detention, and small-scale infiltration that improve water quality while slowing the introduction of water into the sewer system and reducing high flows during storm events. Site scale designs will likely require amended soils to promote infiltration designs that maximize the volume of water that can be held in the soils (NRC 2009).

Additionally, the contaminant burden and degree of concentration in urban vacant soils is largely unknown and likely influenced by the legacy of the landuse and the landscape context (Nassauer & Raskin 2014). When targeting vacant land for green infrastructure source controls, the soil contaminants that are present due to existing or demolished structural elements, the dumping of unknown materials, and the proximity to roads, highways, and industrial sources must be acknowledged before implementing site-scale designs (Nassauer & Raskin 2014). Before committing to a site, soil testing should be administered and evaluated by qualified professionals to minimize human and environmental health impact of green infrastructure.

Groundwater mapping of the Cody Rouge neighborhood indicates that groundwater is relatively shallow, approximately 1 to 24 feet below grade. Despite a shallow water table, the predominately clay soils in the neighborhood will likely minimize the effects of contaminant leaching into groundwater due to slow infiltration rates. This also indicates that strategies relying on a combination of green infrastructure strategies, rather than solely infiltration-based controls, will be most effective in this area.

This project acknowledges the importance of soils and geomorphology for the siting and design of green infrastructure through a comprehensive evaluation of soils in the Cody Rouge neighborhood based on available data and information. For the Catchment Prioritization Model, however, soils were not directly incorporated into the calculation of peak stormwater runoff due to the lack of a recent and detailed soil survey. Additionally, because the catchments generated for the study area were less than 200 acres, the Rational Method provided a simple process for estimating peak stormwater runoff. The Rational Method, which is described in some detail in the following sections, requires a landuse coefficient that incorporates general assumptions about the soil characteristics

Figure III-3: 1982 Survey of Michigan's Quartenary Geology (MDNR)

Figure III-4: 1977 General Soils Map for Wayne County (USDA)

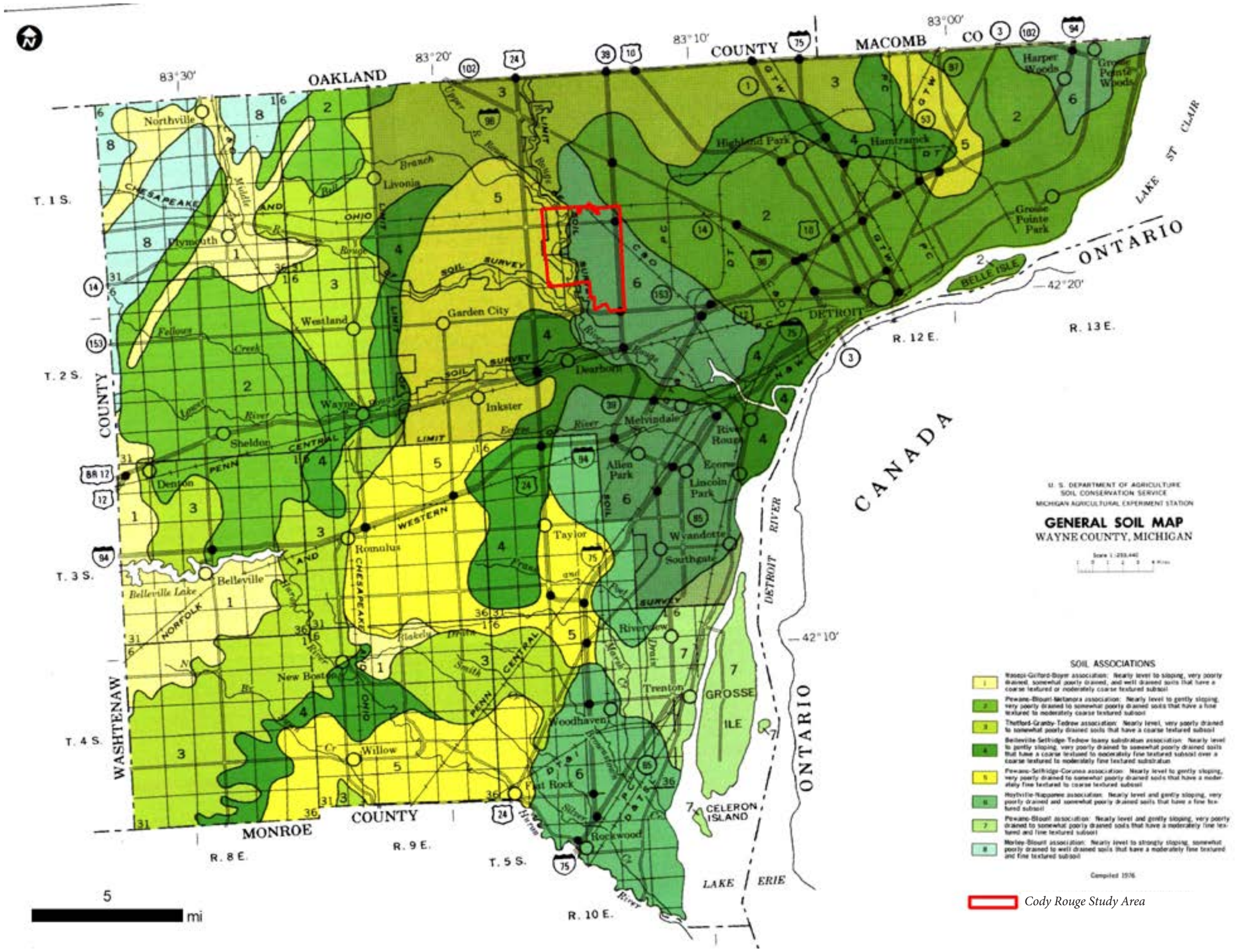
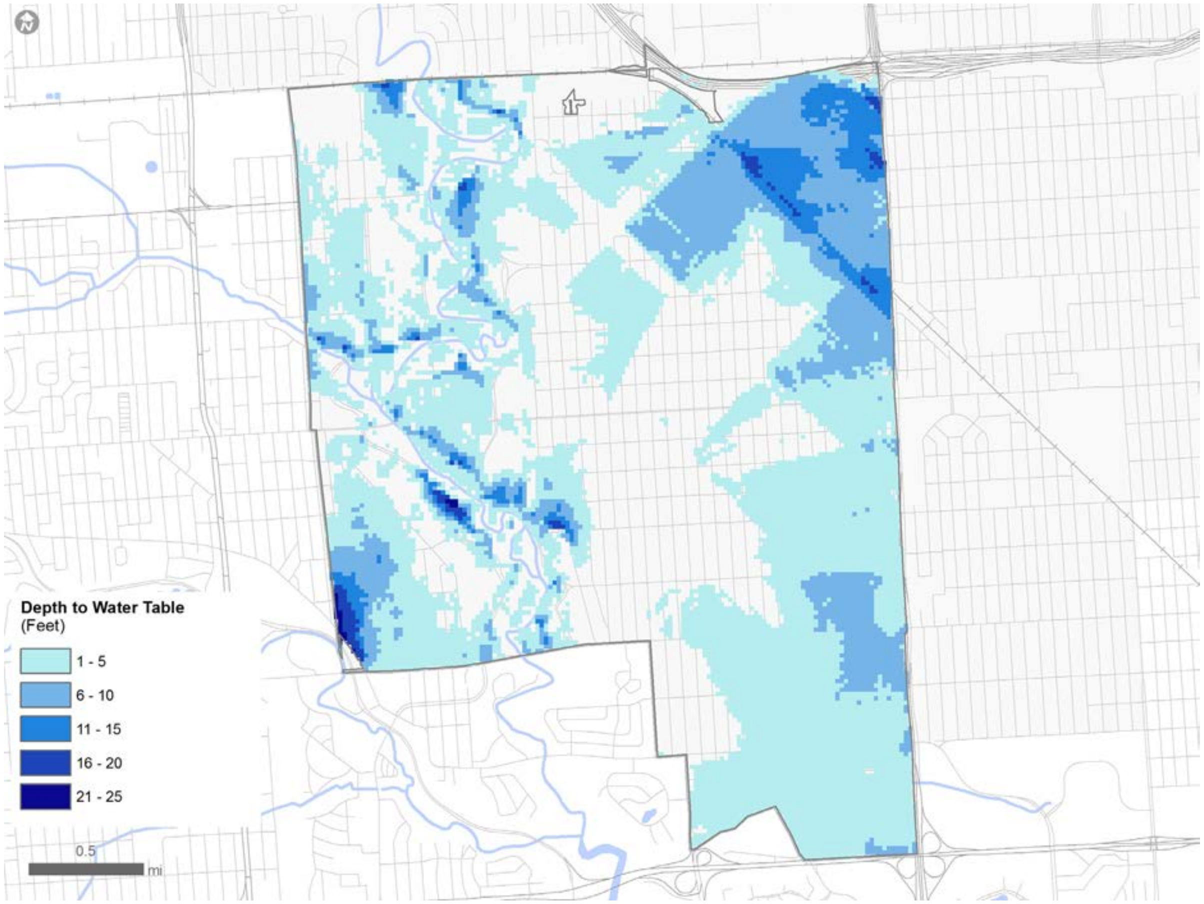


Figure III-4: Cody Rouge Neighborhood Depth to Water Table

**Groundwater Inventory and Mapping data was produced through a cooperative effort between the Water Bureau - Michigan Department of Environmental Quality, USGS - Michigan Water Science Center and Michigan State University - Institute of Water Research, RS&GIS and Biosystems and Agricultural Engineering. This project was mandated by P.A. 148 (Michigan Acts of 2003). Majozr funding was provided by MDEQ, supplemented with additional funds from the USGS Cooperative Water Program.*



Land Use

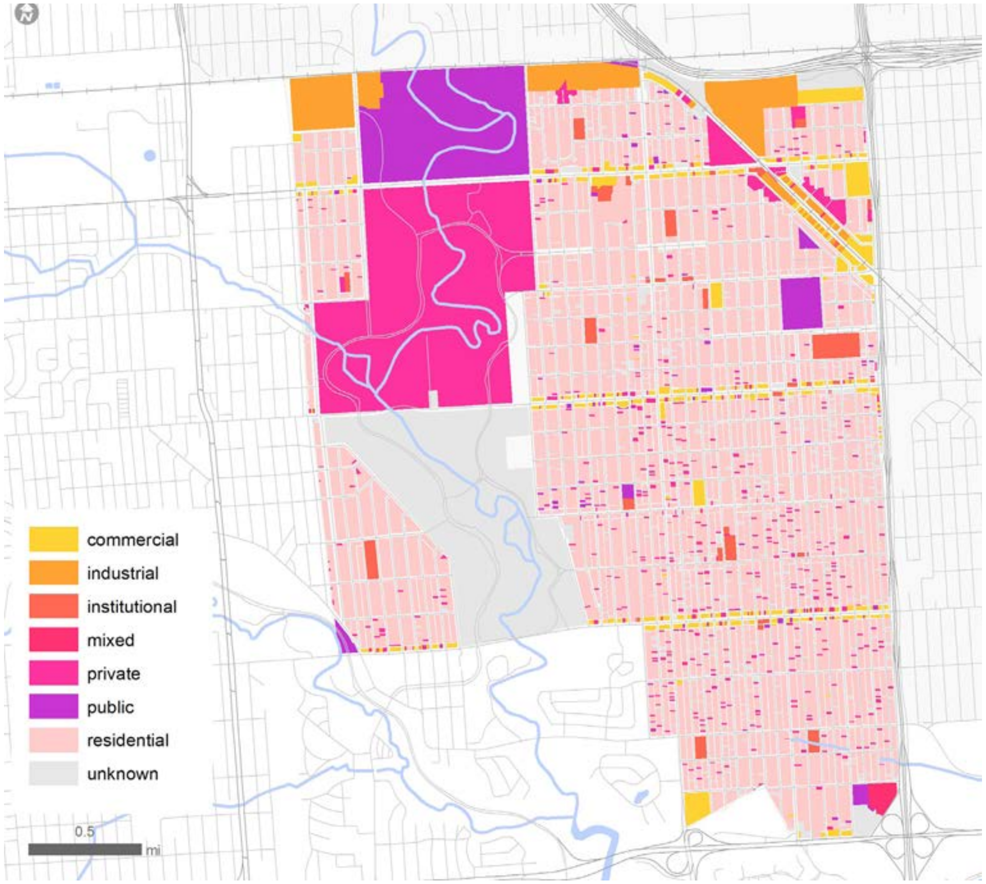
The level of urbanization or development, defined by the land use or zoning characteristics, largely reflects the quantity of impervious surfaces in a given area. Standard approaches to stormwater modeling typically require some measure of imperviousness in order to anticipate the movement of surficial water flow. The final Catchment Prioritization Model incorporates imperviousness into the prioritization index through a land use dataset. This approach uses land use classifications to represent relative imperviousness and uses the Rational Method to quantify peak stormwater runoff. This project provides an integrated approach to green infrastructure siting that is legible and multidisciplinary. Complex stormwater modeling techniques are considered but not applied, as described in the overview of standard modeling approaches. Instead, the oldest, simplest, and most widely accepted approach for quantifying stormwater runoff (Chow 1976), the Rational Method, was used to calculate a baseline estimate of peak stormwater volume by catchment. The Rational Method, described in the next section, uses a runoff coefficient (C) determined by land surface type to estimate outflow (NRC 2009). Strom et al. (2009) recommend runoff coefficients (C) for urban areas based on the land use categories described in Table III-1. In order to most effectively apply the Rational Method in the Catchment Prioritization Model, a land use dataset that most closely represents these categories was selected. Several available spatial datasets were mapped and evaluated, including the 2014 Motor City Mapping (MCM) Parcel Survey, the 2010 Detroit Works Zoning Classifications, the 2011 National Landcover Dataset (NLCD), and the 2008 SEMCOG Land use Classifications. The spatial pattern and distribution statistics for these datasets are mapped in the following figures and tables.

Table III-1: Recommended Runoff Coefficients for Urban Areas

Source: Strom et al., 2009; Table 11.1 Recommended Runoff Coefficients (C)

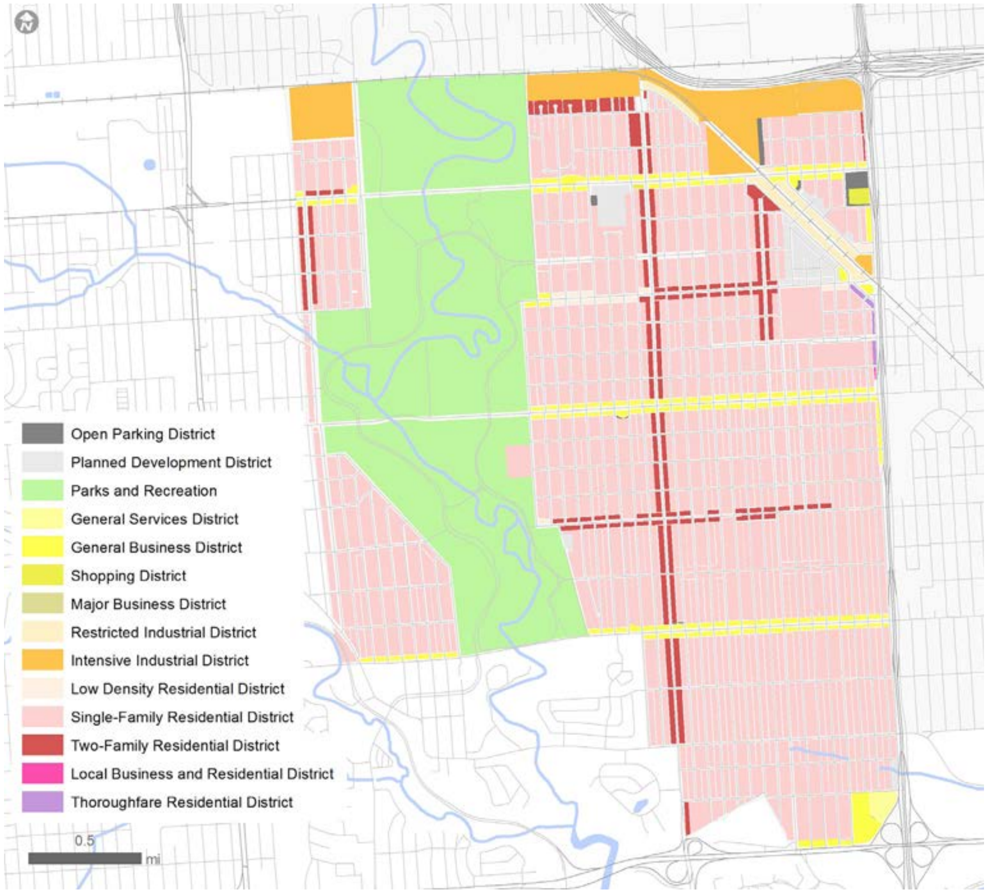
Landuse Classification	*Recommended Coefficient*
Downtown Business	0.70-0.95
Neighborhood Business	0.50-0.70
Single-Family Residential	0.30-0.50
Detached Multiunit Residential	0.40-0.60
Attached Multiunit Residential	0.60-0.75
Suburban Residential	0.25-0.40
Apartment	0.50-0.70
Light Industrial	0.50-0.80
Heavy Industry	0.60-0.90
Parks, Cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad Yards	0.20-0.35
Unimproved	0.10-0.30

Figure III-5: 2014 MCM Parcel Survey Land Use Map and Summary Table



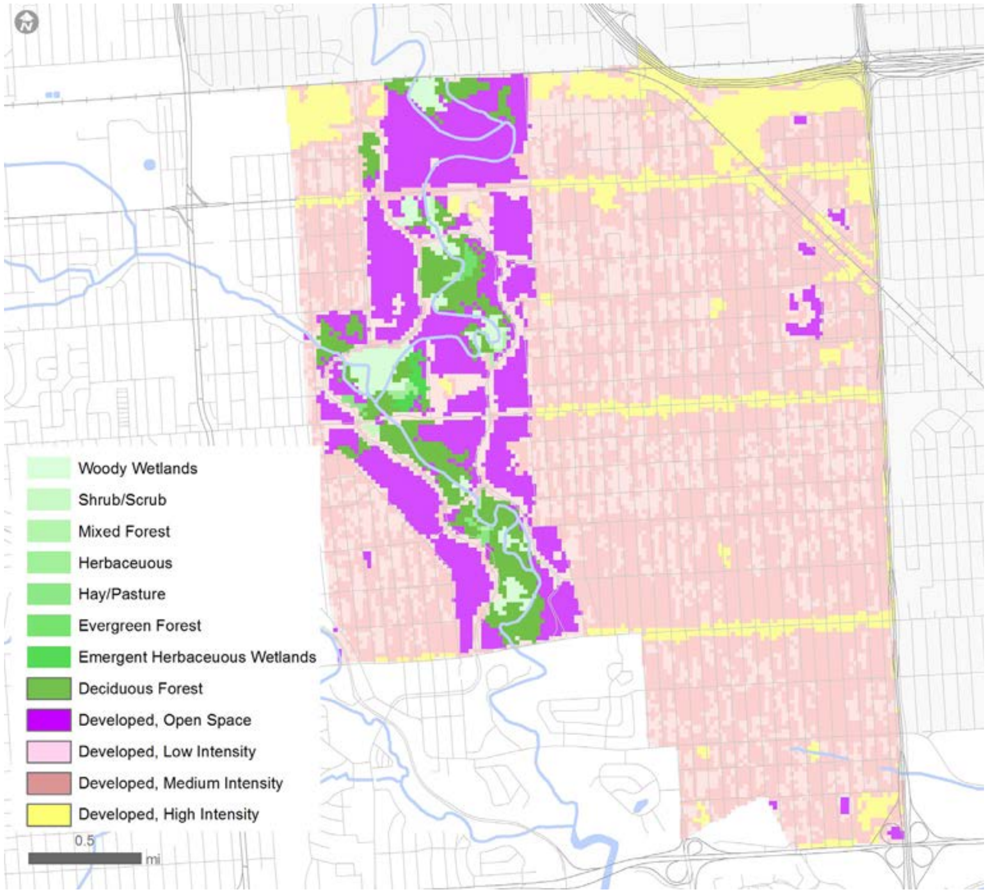
Landuse	*Area (acres)*	*% Parcel Dataset*	*% Cody Rouge Study Area*
Residential	1,847.05	52.0%	39.7%
Private	585.99	16.5%	12.6%
Unknown	511.43	14.4%	11.0%
Public	268.68	7.6%	5.8%
Industrial	151.46	4.3%	3.3%
Commercial	120.90	3.4%	2.6%
Institutional	59.19	1.7%	1.3%
Mixed	9.22	0.3%	0.2%

Figure III-6: 2010 Detroit Works Zoning Classification Map and Summary Table



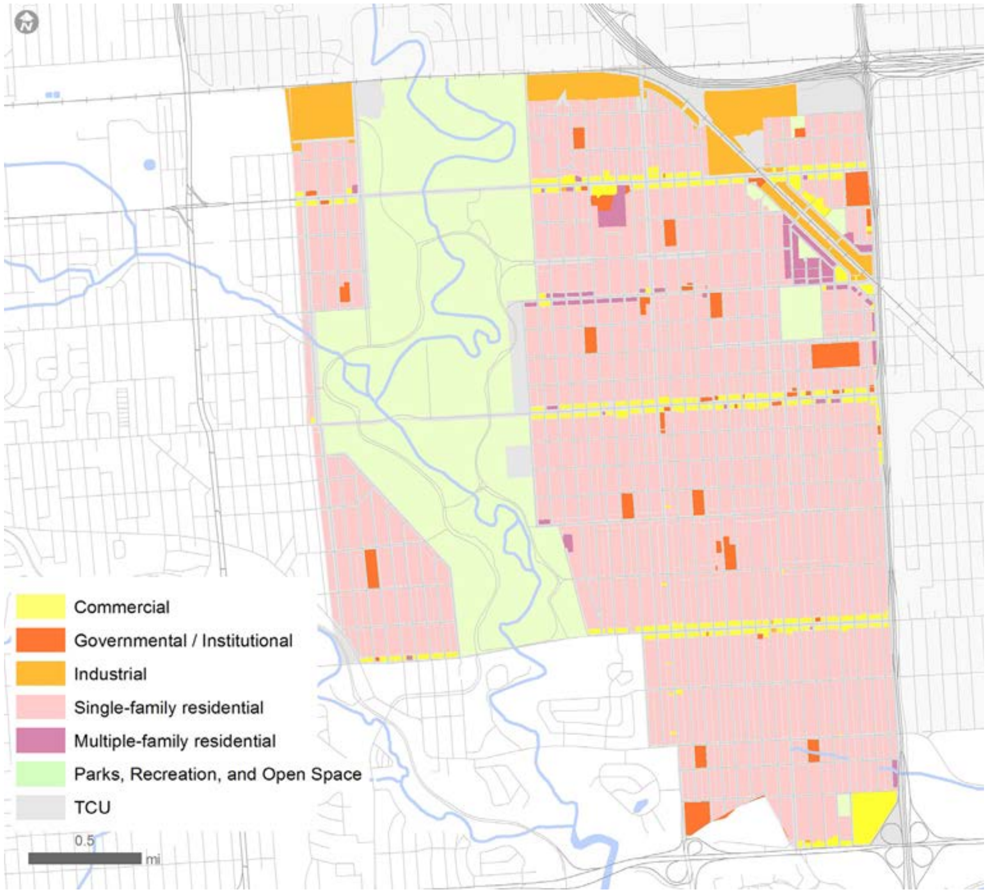
Zoning Class	*Area (acres)*	*% Parcel Dataset*	*% Cody Rouge Study Area*
Single-Family Residential District	1,894.7	52.83%	40.76%
Parks and Recreation	1,139.5	31.78%	24.52%
Intensive Industrial District	182.9	5.10%	3.94%
Two-Family Residential District	149.5	4.17%	3.22%
General Business District	107.9	3.01%	2.32%
Planned Development District	47.0	1.31%	1.01%
Restricted Industrial District	28.0	0.78%	0.60%
Open Parking District	10.2	0.28%	0.22%
Low Density Residential District	9.8	0.27%	0.21%
General Services District	8.3	0.23%	0.18%
Shopping District	4.6	0.13%	0.10%
Thoroughfare Residential District	3.3	0.09%	0.07%
Local Business and Residential District	0.2	0.01%	0.00%
Major Business District	0.1	0.00%	0.00%

Figure III-7: NLCD 2011 Landcover Classification Map and Summary Table



Landcover	*Area (acres)*	*% Cody Rouge Study Area*
Developed, Medium Intensity	2,129.64	45.81%
Developed, Low Intensity	1,107.52	23.82%
Developed, Open Space	618.70	13.31%
Developed, High Intensity	463.25	9.96%
Deciduous Forest	217.95	4.69%
Woody Wetlands	79.39	1.71%
Emergent Herbaceuous Wetlands	10.23	0.22%
Mixed Forest	6.00	0.13%
Hay/Pasture	5.78	0.12%
Evergreen Forest	4.67	0.10%
Shrub/Scrub	3.11	0.07%
Herbaceuous	3.11	0.07%

Figure III-8: 2008 SEMCOG Land Use Map and Summary Table



Landuse	*Area (acres)*	*% Cody Rouge Study Area*
Single-family residential	1,919.93	41.30%
Parks, Recreation, and Open Space	1,151.49	24.77%
Transportation, Communication, Utility (TCU)	1,151.07	24.76%
Industrial	168.50	3.62%
Commercial	115.55	2.49%
Governmental / Institutional	92.09	1.98%
Multiple-family residential	50.19	1.08%

The 2008 SEMCOG Land Use dataset was ultimately selected to represent land surface types in the calculation of peak stormwater runoff by catchment. This dataset most closely represents landuse classifications outlined by Strom et al. (2009) (Table III-1) and provides the highest level of coverage for the Cody Rouge study area.

The following coefficients were initially selected from Table III-1 to represent the 2008 SEMCOG land use classes determine peak runoff using the Rational Method:

Table III-2: 2008 SEMCOG Landuse Runoff Coefficients

SEMCOG 2008 Landuse Class	*Runoff Coefficient*
Commercial	0.6
Governmental	0.6
Industrial	0.8
Multi-Family Residential	0.65
Parks and Open Space	0.2
Single Family Residential	0.4
Transportation, Communication, and Utilities	0.85

Modified Land Use

While the 2008 SEMCOG Land Use designations are useful, they do not accurately represent the conditions of a moderately to highly vacant residential neighborhood. Vacant parcels that do not contain structures are predominantly classified as 'Single Family Residential' and occasionally 'Multi-Family Residential', 'Commercial', or 'Governmental'. When calculating peak runoff values, these parcels are attributed with runoff coefficient values of 0.4, 0.65, or 0.6, which assumes that a parcel contains impervious structures and/or surfaces that influence interception, infiltration, and evaporation. The distribution of these parcels from the 2014 MCM Parcel Survey can be observed in Figure III-9. The Cody Rouge neighborhood covers an area approximately 4,648.13 acres. It contains 1,381 vacant properties with no structure, which amounts to 241.7 acres or 5.2% of the study area. In order to more accurately represent landscape conditions in the Cody Rouge study area, a modified land use dataset was produced to incorporate vacant lots into the final runoff calculations. Vacant parcels without structures are likely to capture a higher volume of stormwater, resulting in a lower runoff coefficient value, similar to 'Parks and Open Space'. The process for creating a modified land use dataset is described in Figure III-10 and modified runoff coefficients are described in Table III-3. Vacant parcels were represented by runoff coefficient values of 0.2 and 0.3 to reflect open space conditions with compacted soils and impervious surfaces that were not fully removed during the demolition process. The effects of vacancy and vacancy coefficients on peak stormwater runoff were assessed in a sensitivity analysis, described in Phase Three.

Figure III-9: Cody Rouge Neighborhood Distribution of Vacant (No Structure) Parcels

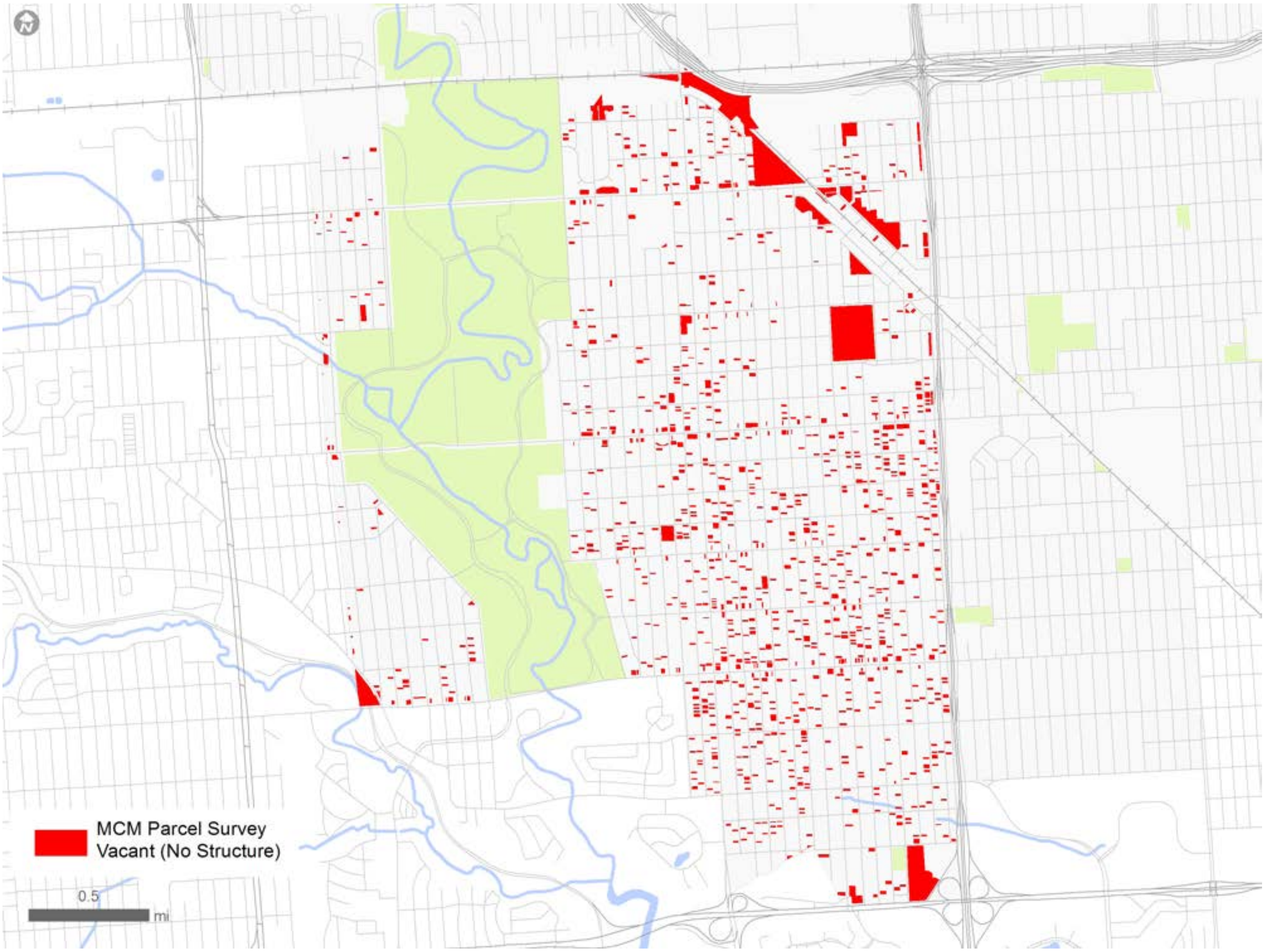
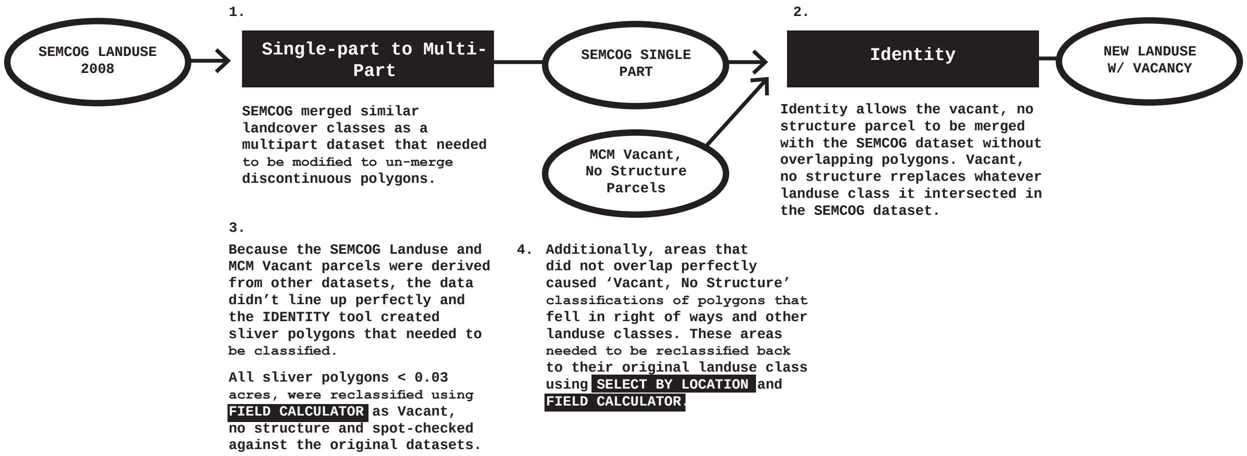


Figure III-10: Development of Modified Land Use Data



1. SEMCOG merged similar landcover classes as a multipart dataset that needed to be modified to un-merge discontinuous polygons.

2. Identity allows the vacant, no structure parcel to be merged with the SEMCOG dataset without overlapping polygons. Vacant, no structure rreplaces whatever landuse class it intersected in the SEMCOG dataset.

3. Because the SEMCOG Landuse and MCM Vacant parcels were derived from other datasets, the data didn't line up perfectly and the IDENTITY tool created sliver polygons that needed to be classified.

   All sliver polygons < 0.03 acres, were reclassified using **FIELD CALCULATOR** as Vacant, no structure and spot-checked against the original datasets.

4. Additionally, areas that did not overlap perfectly caused 'Vacant, No Structure' classifications of polygons that fell in right of ways and other landuse classes. These areas needed to be reclassified back to their original landuse class using **SELECT BY LOCATION** and **FIELD CALCULATOR**.

Table III-3: Modified Land Use Runoff Coefficients

SEMCOG 2008 Landuse Class	*Runoff Coefficient*
Commercial	0.6
Governmental	0.6
Industrial	0.8
Multi-Family Residential	0.65
Single Family Residential	0.4
Parks and Open Space	0.2
Transportation, Communication, and Utilities	0.85
Vacant, No Structure	**0.2/0.3***

**As part of the sensitivity analysis described in Section XXX, the original 2008 SEMCOG landcover data was compared to different values representing the land use coefficient for vacant land.*

Figure III-11: Cody Rouge Neighborhood Modified Land Use Map

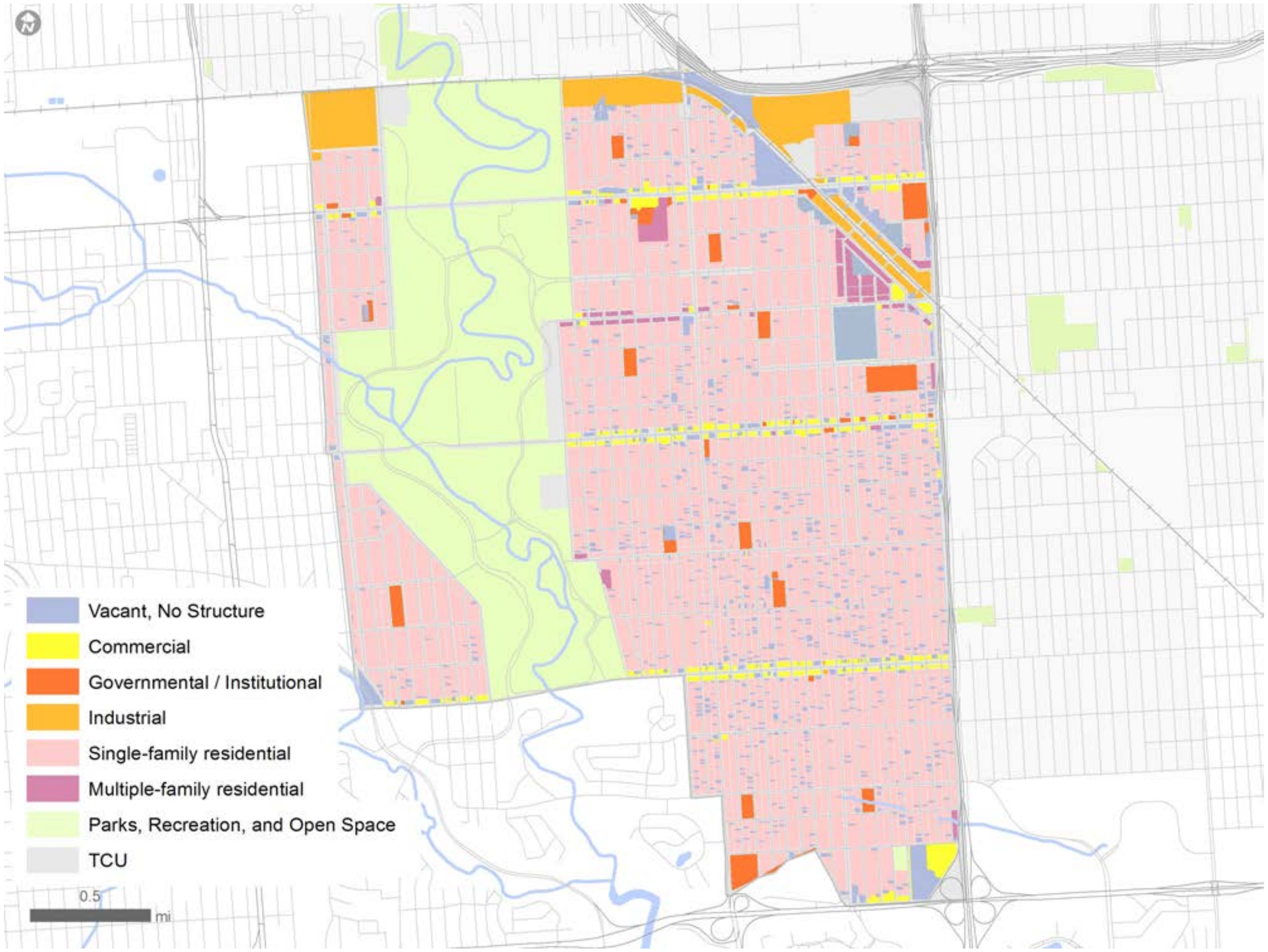


Table III-4: Cody Rouge Neighborhood Modified Land Use Comparison Table

Modified Landuse	*Area (acres)*	*% Cody Rouge*	*% Cody Rouge*	*Percent Difference*
		Modified Landuse	*SEMCOG 08 Landuse*	
Single-family residential	1,818.39	39.01%	41.30%	2.29%
Multiple-family residential	47.35	1.02%	1.08%	0.06%
TCU	1,130.65	24.26%	24.76%	0.50%
Parks, Recreation, and Open Space	1,113.49	23.89%	24.77%	0.88%
Industrial	149.17	3.20%	3.62%	0.42%
Governmental / Institutional	83.25	1.79%	1.98%	0.19%
Commercial	77.35	1.66%	2.49%	0.83%
Vacant, No Structure	241.74	5.19%	0.00%	5.19%

Application of the Rational Method

The Rational Method is widely used because it is a highly simplified model for calculating peak runoff in small, urban watersheds (NRC 2009). While it is often criticized for its simplicity, no other method for calculating fine-scale drainage has evolved to such a level of general acceptance among engineering and planning professionals. Because this project attempts to provide a simplified and well-documented approach for green infrastructure siting in small neighborhood catchments, ranging from 5 to 200 acres, it was selected as an appropriate strategy for determining baseline runoff volume. The Rational Method determines peak runoff by combining rainfall intensity, watershed area, and land surface condition, represented by standard coefficient values. Outflow is determined by multiplying inflow (rainfall intensity times drainage area) and an averaged coefficient value that represents the combined land use classifications occurring within a given catchment.

The following equation is used to determine peak runoff volume:

$$Q=(C)(i)(A)$$

Where:
Q = Peak stormwater runoff in cubic feet per second (cfs);
C = Average coefficient of runoff; determined by 2008 SEMCOG Landuse Classifications;
i = Average rainfall intensity in inches per hour (iph) for the design storm frequency and the time of concentration for a drainage area;
A = Catchment area in acres

The coefficient of runoff (C) is a dimensionless value between 0 and 1 that represents the ratio of runoff to rainfall. It can roughly be related to a catchment's landscape characteristics, representing interception, infiltration, evaporation, and degree of imperviousness. Large coefficient values represent land use/landcover and soil characteristics that cause a higher proportion of runoff during any given storm event (Austin et al. 2013). As described in the previous section on landuse, the values for (C) were determined based on Strom et al. (2009) recommended runoff coefficients for urban areas (Table III-1). For each catchment in the Cody Rouge Neighborhood, the total area of each land use type, obtained from the 2008 SEMCOG land use dataset, was multiplied by the appropriate coefficient value. The (C) value for each catchment represents an area-weighted average of combined land use characteristics.

For each delineated catchment, the peak runoff volume was calculated for two, ten, and one hundred year storm events based on Hershfield (1961) and using Austin et al. (2013) as a precedent. For each storm event, storm durations of 30 minutes and one hour were used to calculate average rainfall intensity (i). Table III-5 provides a summary of the (i) values used to calculate peak stormwater runoff for three storm events and two storm durations.

Table III-5: Average Rainfall Intensity (Inches per Hour) by Storm Frequency and Duration

		Storm Duration	
Storm Event		30 min	60 min
	2 Year	2	1.27
	10 Year	2.8	1.8
	100 Year	3.8	2.6

The Rational Method is widely used because it is a highly simplified model for calculating peak runoff in small, urban watersheds (NRC 2009). While it is often criticized for its simplicity, no other method for calculating fine-scale drainage has evolved to such a level of general acceptance among engineering and planning professionals. Because this project attempts to provide a simplified and well-documented approach for green infrastructure siting in small neighborhood catchments, ranging from 5 to 200 acres, it was selected as an appropriate strategy for determining baseline runoff volume. The Rational Method determines peak runoff by combining rainfall intensity, watershed area, and land surface condition, represented by standard coefficient values. Outflow is determined by multiplying inflow (rainfall intensity times drainage area) and an averaged coefficient value that represents the combined landuse classifications occurring within a given catchment.

Average rainfall intensity values were kept constant for all catchments in the Cody Rouge Neighborhood and the influence of adjacent catchments was not represented in the runoff calculations, producing non-dynamic model results. Dynamic stormwater modeling for the Cody Rouge Watershed would require advanced expertise and calibration methods that were outside of the project scope. Because this project aims to provide a simplified process for prioritizing the spatial location of green infrastructure based on the relative contribution of stormwater, a non-dynamic estimation of stormwater volume provides reasonable baseline values that were used to develop the Catchment Prioritization Model.

As mentioned previously, the Rational Method is often criticized for its simplified approach and is limited in its ability to provide accurate data for comprehensive stormwater inlet and piping designs (NRC 2009). Additionally, it is solely an assessment of peak stormwater volume by catchment and does not consider the time distribution of a storm across more complex drainage systems where the inflow and outflow of sub-catchments are influenced by one another (Chow 1976). Essentially, the non-dynamic output for this calculation provides information for a single point along the runoff hydrograph and should only be used for assessing basic drainage conditions in small urban watersheds.

Example Calculation: Application of the Rational Method on Catchment 56, 10-Year, 30 and 60 Minute Storms

Table III-6: Catchment 56; 2008 SEMCOG Land Use Area (Acres)

Catchment ID	*Commercial*	*Governmental/ Institutional*	*Industrial*	*Multi-Family Residential*	*Single-Family Residential*	*Parks, Open Space, Recreation*	*Transportation, Communication, Utilities*	***Total Area***
56	*5.32*	*1.46*	*0.00*	*0.00*	*52.25*	*0.00*	*27.65*	***86.68***

For each catchment, the land use classification area (acres) was multiplied by its respective land use runoff coefficient (Table III-2). These values were then summed and divided by total catchment area to provide an area-weighted, average coefficient value for each catchment.

Total Area **(A)** for Catchment 56:

= 86.68

Average Runoff Coefficient **(C)** for Catchment 56 :

(5.32 (0.6) + 1.46(0.6) +0.00(0.8) +0.00(0.65) +52.25 (0.4) +0.00(0.2) +27.65(0.85))/ 86.68

= 0.559

*For the ***10-year 30 minute storm, i= 2.8*** inches per hour (iph) in 30 minutes, so the 10-year, 30 minute peak rate of runoff:

Q= CiA = C x 2.8 x A =2.8AC cfs

The storage volume required for 10-year 30 minute storm event is:

Volume (10-year, 30min) = 2.8ACx 30 min x 60 sec/min
= **5,040 AC ft3**

The untreated peak runoff volume for Catchment 56 (10 year storm, 30 minute duration) is:

Q= CiA = (**0.559**) x (**5,040**) x (**86.68**)
= ***244,208.765 cfs***

*For the ***10-year 60 minute storm, i= 1.8*** inches per hour (iph) in 60 minutes, so the 10-year, 60 minute peak rate of runoff:

Q= CiA = C x 1.8 x A =1.8AC cfs

The storage volume required for 10-year, 60 minute storm event is:

Volume (10-year, 60min) = 1.8ACx 60 min x 60 sec/min
= **6,480 AC ft3**

The ***untreated peak runoff volume*** *for Catchment 56 (10 year storm, 60 minute duration) is:*

Q= CiA = (**0.559**) x (**6,480**) x (**86.68**)
= ***313,982.698 cfs***

Incorporation of Vacant Land and Sensitivity Analysis for Untreated Stormwater Runoff

Nearly half of the Cody Rouge Neighborhood is classified as 'Single Family Residential' by the 2008 SEMCOG land use dataset, making it a typical representation of an urban residential neighborhood. Approximately 25% of the neighborhood parcels, however, are classified as either having abandoned structures or as vacant, where structures have been demolished. There are more than 1,300 vacant lots in Cody Rouge, making up 5% of the study area. While these vacant lots present opportunities for more formal green infrastructure designs, their influence on existing landscape conditions and their un-designed and unmaintained impact on stormwater runoff is rarely measured. Many hydrologic models, including the Rational Method, rely on standard datasets that are readily available and can be easily implemented into an existing model framework. Often, these models do not consider atypical urban characteristics, including the prevalence of vacant land in legacy cites like Detroit. This project differs from a standard approach to stormwater modeling through the development of a modified landuse dataset that incorporates vacant land, described in Phase Two.

In order to assess the effects of vacant land on peak stormwater runoff, a sensitivity analysis was conducted. Peak runoff volume was calculated for each catchment during two, ten, and one hundred year storm events at both 30 and 60 minute storm durations. The sensitivity analysis compares catchment peak runoff values for each storm event and duration using the original 2008 SEMCOG landuse dataset, where vacant land is predominantly classified as 'Single Family Residential' with a coefficient (C) value of 0.4, and the modified landuse dataset, which incorporates vacant lots using two different coefficients, values of 0.2 and 0.3. For the sensitivity analysis, peak stormwater runoff was calculated for each catchment using the Rational Method in eighteen scenarios. Example calculations for Catchment 56 are described below:

Table III-7: Catchment 56; Modified 2008 SEMCOG Land Use Area (Acres)

Catchment ID	*Commercial*	*Governmental/ Institutional*	*Industrial*	*Multi-Family Residential*	*Single-Family Residential*	*Parks, Open Space, Recreation*	*Transportation, Communication, Utilities*	*Vacant, No Structure*	***Total Area***
56	*3.82*	*0.99*	*0.00*	*0.00*	*47.56*	*0.00*	*27.67*	*7.14*	***86.68***

First, the average runoff coefficient was calculated with vacancy runoff coefficients of 0.2 and 0.3:

Modified Average Runoff Coefficient **(C)** for Catchment 56 =
Vacant, No Structure represented by (C) value of 0.2

(3.82 (0.6) + 0.99(0.6) +0.00(0.8) +0.00(0.65) +47.56 (0.4) +0.00(0.2) +27.67(0.85) +**7.14(0.2))**/ 86.68
= **0.541**

Modified Average Runoff Coefficient **(C)** for Catchment 56 =
Vacant, No Structure represented by (C) value of 0.3

(3.82 (0.6) + 0.99(0.6) +0.00(0.8) +0.00(0.65) +47.56 (0.4) +0.00(0.2) +27.67(0.85) +**7.14(0.3))**/ 86.68
= **0.549**

Average rainfall intensity was derived from the values in Table III-7 and storage volume was calculated for each storm event and duration based on the methods described above. The following eighteen equations were then calculated for comparison of stormwater runoff by catchment in the sensitivity analysis:

2-year Storm Event
Volume (2-year, (C) from Original Landuse, 30 min) = 3600* 0. 559*A (acre) ft3
Volume (2-year, Vacancy (C) = 0.2, 30 min) = 3600* 0. 541*A (acre) ft3
Volume (2-year, Vacancy (C) = 0.3, 30 min) = 3600* 0. 549*A (acre) ft3
Volume (2-year, (C) from Original Landuse, 60 min) = 6480* 0. 559*A (acre) ft3
Volume (2-year, Vacancy (C) = 0.2, 60 min) = 6480* 0. 541*A (acre) ft3
Volume (2-year, Vacancy (C) = 0.3, 60 min) = 6480* 0. 549*A (acre) ft3

10-year Storm Event
Volume (10-year, (C) from Original Landuse, 30 min) = 5040* 0. 559*A (acre) ft3
Volume (10-year, Vacancy (C) = 0.2, 30 min) = 5040* 0. 541*A (acre) ft3
Volume (10-year, Vacancy (C) = 0.3, 30 min) = 5040* 0. 549*A (acre) ft3
Volume (10-year, (C) from Original Landuse, 60 min) = 6408* 0. 559*A (acre) ft3
Volume (10-year, Vacancy (C) = 0.2, 60 min) = 6408* 0. 541*A (acre) ft3
Volume (10-year, Vacancy (C) = 0.3, 60 min) = 6408* 0. 549*A (acre) ft3

100-year Storm Event
Volume (100-year, (C) from Original Landuse, 30 min) = 6840* 0. 559*A (acre) ft3
Volume (100-year, Vacancy (C) = 0.2, 30 min) = 6840* 0. 541*A (acre) ft3
Volume (100-year, Vacancy (C) = 0.3, 30 min) = 6840* 0. 549*A (acre) ft3
Volume (100-year, (C) from Original Landuse, 60 min) = 9360* 0. 559*A (acre) ft3
Volume (100-year, Vacancy (C) = 0.2, 60 min) = 9360* 0. 541*A (acre) ft3
Volume (100-year, Vacancy (C) = 0.3, 60 min) = 9360* 0. 549*A (acre) ft3

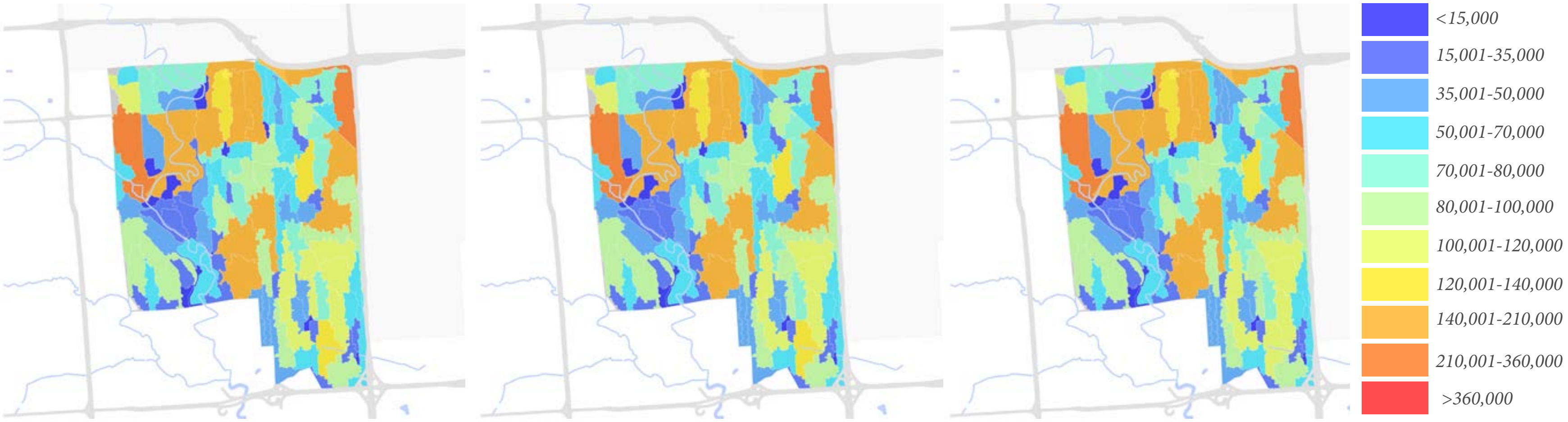
Sensitivity Analysis and Results

Untreated stormwater runoff volume was assessed for all 115 neighborhood catchments in the Cody Rouge study area. Peak stormwater runoff volume by catchment was analyzed for 18 different scenarios and distributed across 11 classes. For each storm event (2 year, 10 year, and 100 year), there are 6 scenarios that compare duration and vacancy runoff coefficients. Because peak runoff results were visually compared across all storm events to assess variation in the sensitivity analysis, the same classification scheme needed to be applied to all scenarios. The 10 year, 30 minute, original 2008 land use coefficient, scenario was chosen as the baseline scenario for the identifying the classification scheme. For this scenario, peak runoff volume by catchment was classified into 10 classes using the Natural Breaks/Fisher-Jenks algorithm, also known as the goodness of variance fit (GVF). This classification scheme determines the “best” arrangement of data into a user-specified number of classes. Values are placed in each class to minimize deviation from the class mean while maximizing deviation from the means of other classes in order to reduce the variance within classes and maximize the variance between classes. In other words, like values are placed in the same class based on the position of values along the number line (Slocum et al. 2005). For the other 17 scenarios, the classification scheme of the first 10 classes is the same and an 11th class is added to represent runoff greater than the baseline maximum (360,000 cfs). For the baseline scenario, 0 catchments fall into the 11th class. Figures III-12 – III-17 show the maps of catchments using this classification scheme for each scenario. The results are also represented by a table and line graphs that indicate the distribution of stormwater runoff among the catchments. The peaks in the line graphs represent the most common quantities of runoff for each storm event scenario.

In general, for all 18 storm scenarios, catchment runoff volume tends to cluster between 50,000-360,000 cfs. In order to better represent the spatial distribution of catchment peak runoff volume, a second set of maps was created using an aggregated classification scheme, merging 11 classes to 7, where runoff values tend to cluster across catchments. In Figures III-18 – III-20, catchments that are represented by colors closer to red, generate a higher volume of stormwater runoff while catchments represented by colors closer to blue generate a lower volume of stormwater runoff. Changes in storm duration and surface imperviousness, represented by average land use coefficient, account for variation within the sensitivity analysis for each storm event.

Figure III-12: Two Year Sensitivity Analysis Results – 11 Classes (Spatial Distribution)

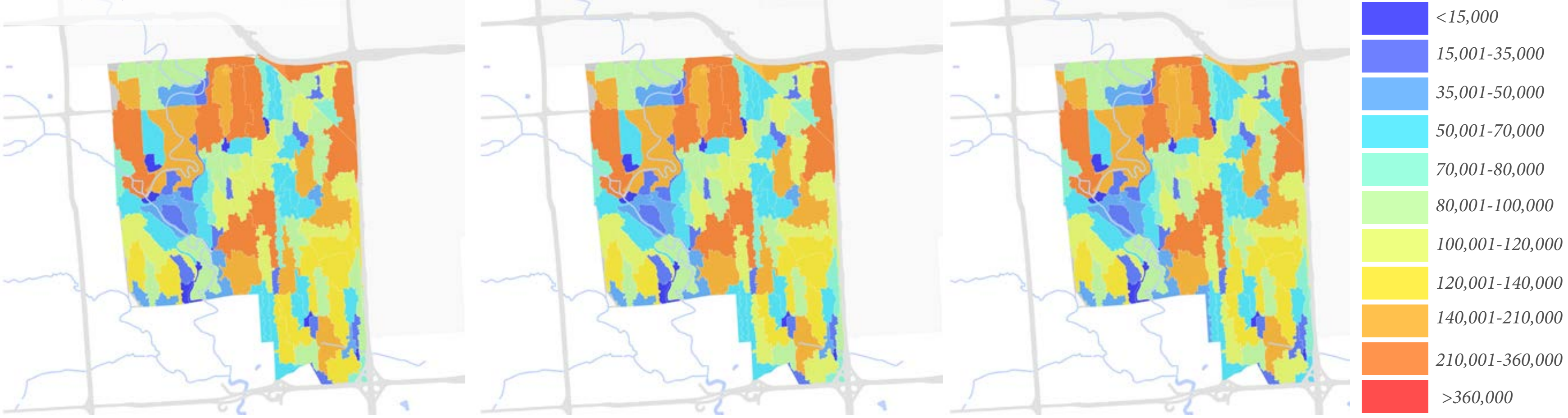
30 MIN, 2 YEAR *peak stormwater runoff volume (cfs)*


original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

60 MIN, 2 YEAR *peak stormwater runoff volume (cfs)*

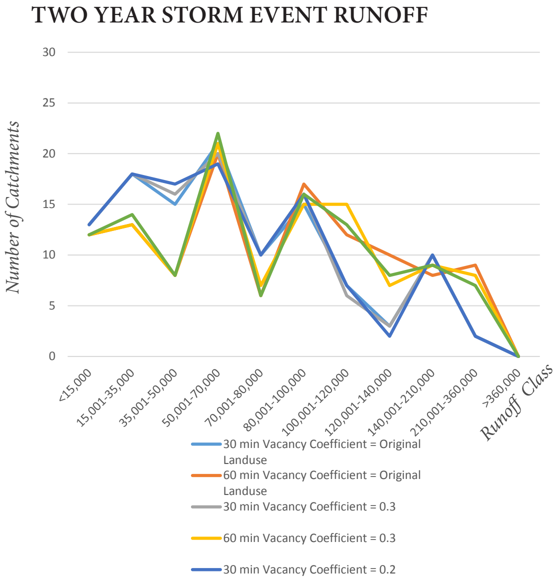

original landuse,
no vacancy coefficient

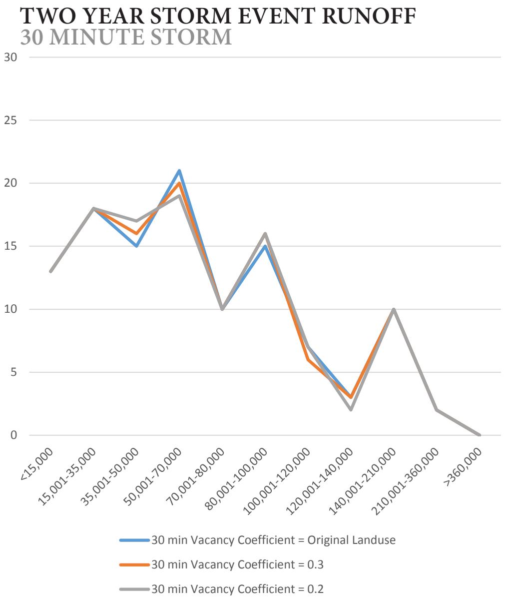
modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

Figure III-13: Two Year Sensitivity Analysis Results – 11 Classes (Summary Tables)

Categories	Runoff Class (cfs)	30 min	60 min	30 min	60 min	30 min	60 min
		Vacancy Coefficient = Original Landuse	Vacancy Coefficient = Original Landuse	Vacancy Coefficient = 0.3	Vacancy Coefficient = 0.3	Vacancy Coefficient = 0.2	Vacancy Coefficient = 0.2
1	<15,000	13	12	13	12	13	12
2	15,001-35,000	18	13	18	13	18	14
3	35,001-50,000	15	8	16	8	17	8
4	50,001-70,000	21	20	20	21	19	22
5	70,001-80,000	10	6	10	7	10	6
6	80,001-100,000	15	17	16	15	16	16
7	100,001-120,000	7	12	6	15	7	13
8	120,001-140,000	3	10	3	7	2	8
9	140,001-210,000	10	8	10	9	10	9
10	210,001-360,000	2	9	2	8	2	7
11	>360,000	0	0	0	0	0	0





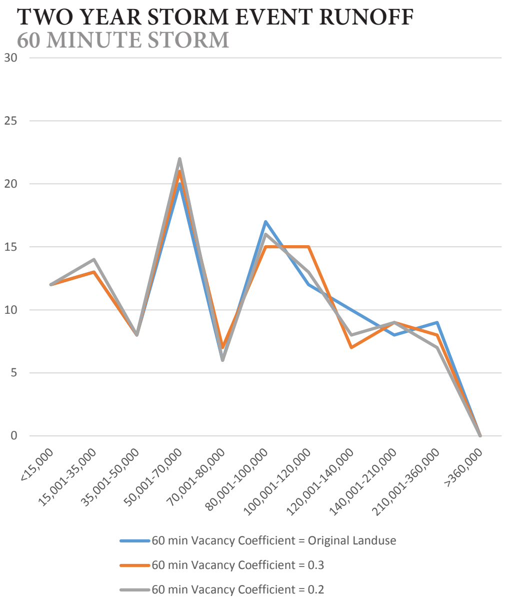
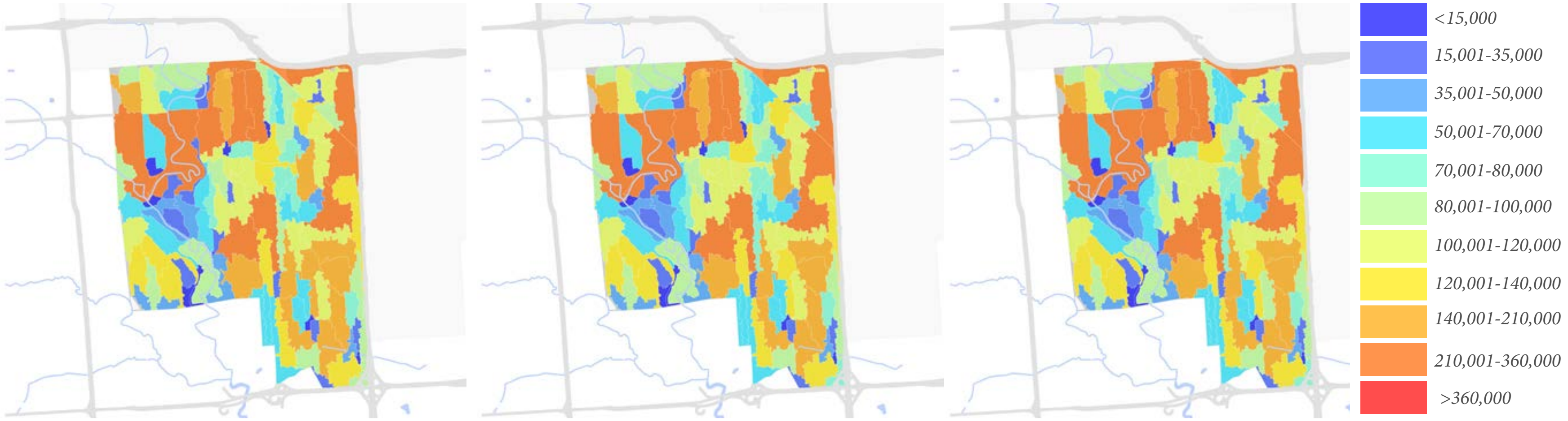


Figure III-14: Ten Year Sensitivity Analysis Results – 11 Classes (Spatial Distribution)

30 MIN, 10 YEAR *peak stormwater runoff volume (cfs)*

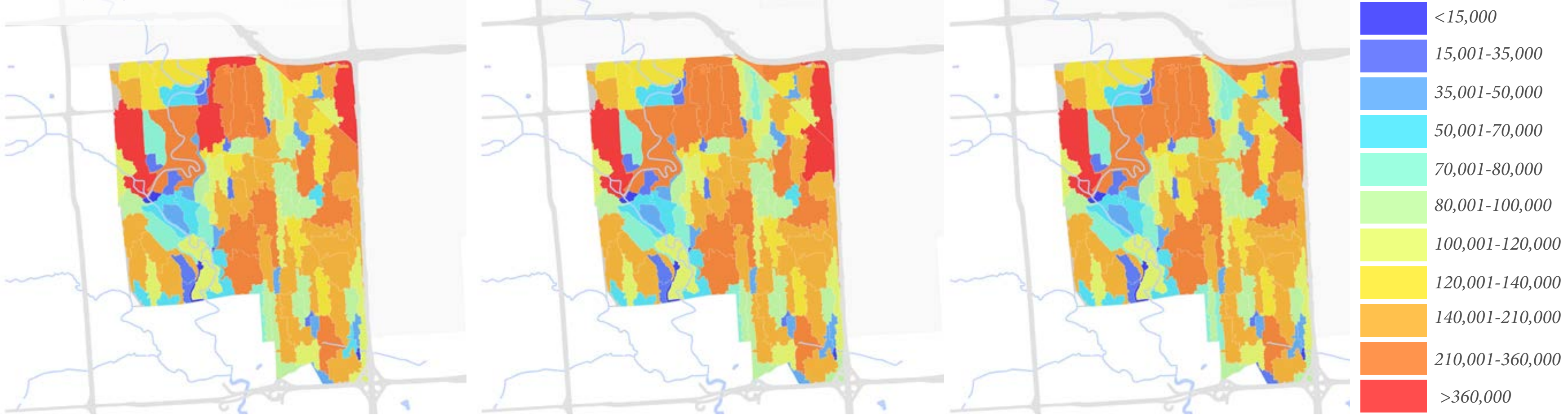


original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

60 MIN, 10 YEAR *peak stormwater runoff volume (cfs)*



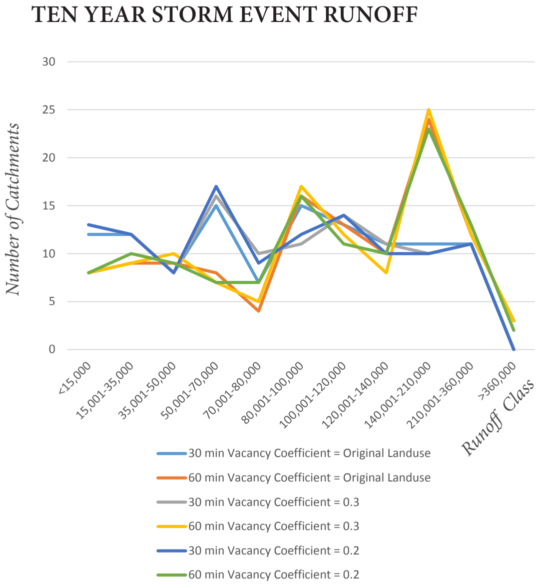
original landuse,
no vacancy coefficient

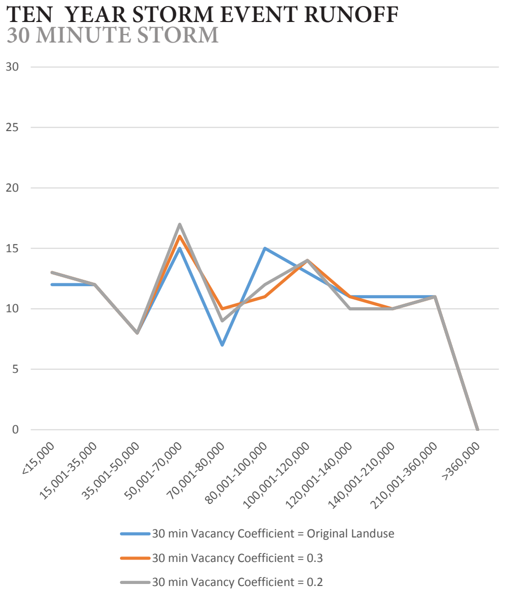
modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

Figure III-15: Ten Year Sensitivity Analysis Results – 11 Classes (Summary Tables)

Categories	Runoff Class (cfs)	30 min Vacancy Coefficient = Original Landuse	60 min Vacancy Coefficient = Original Landuse	30 min Vacancy Coefficient = 0.3	60 min Vacancy Coefficient = 0.3	30 min Vacancy Coefficient = 0.2	60 min Vacancy Coefficient = 0.2
1	<15,000	12	8	13	8	13	8
2	15,001-35,000	12	9	12	9	12	10
3	35,001-50,000	8	9	8	10	8	9
4	50,001-70,000	15	8	16	7	17	7
5	70,001-80,000	7	4	10	5	9	7
6	80,001-100,000	15	16	11	17	12	16
7	100,001-120,000	13	13	14	12	14	11
8	120,001-140,000	11	10	11	8	10	10
9	140,001-210,000	11	24	10	25	10	23
10	210,001-360,000	11	12	11	12	11	13
11	>360,000	0	3	0	3	0	2





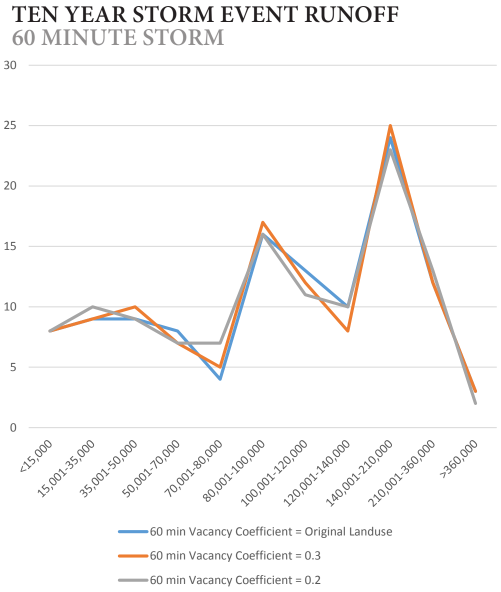
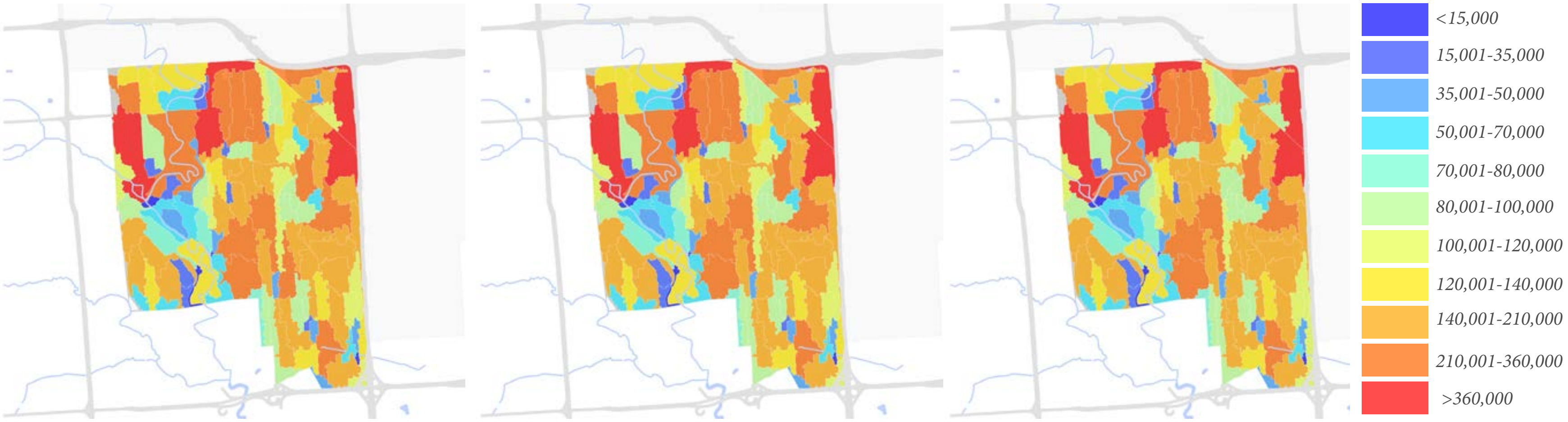


Figure III-16: One Hundred Year Sensitivity Analysis Results – 11 Classes (Spatial Distribution)

30 MIN, 100 YEAR *peak stormwater runoff volume (cfs)*

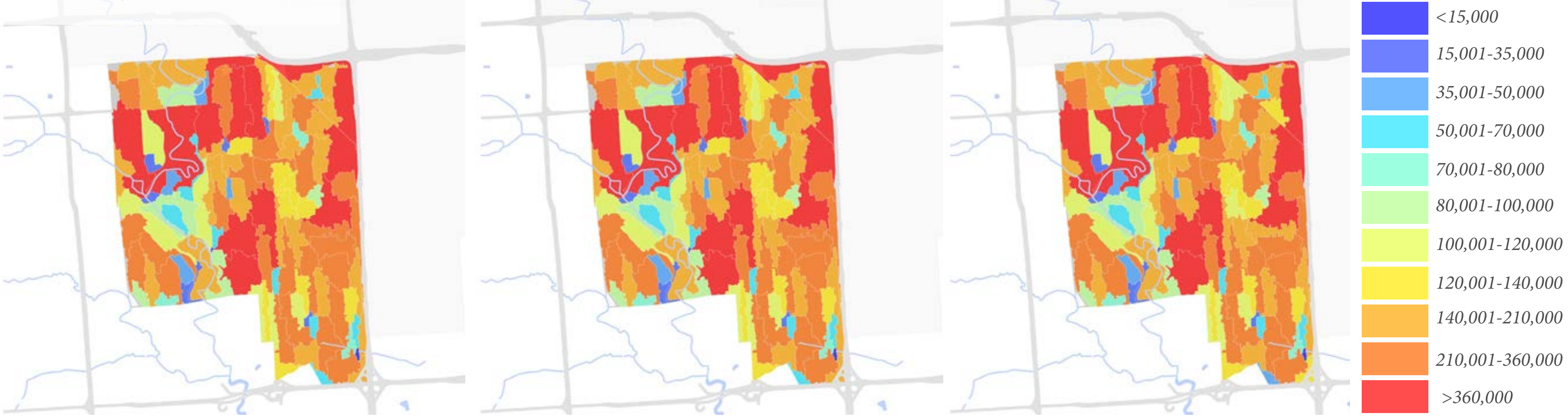


original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

60 MIN, 100 YEAR *peak stormwater runoff volume (cfs)*



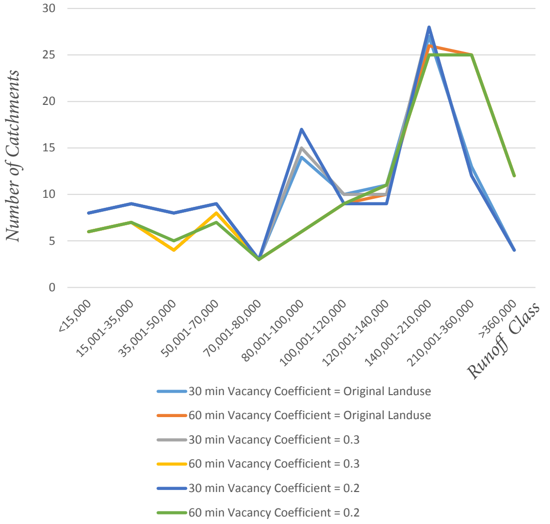
original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

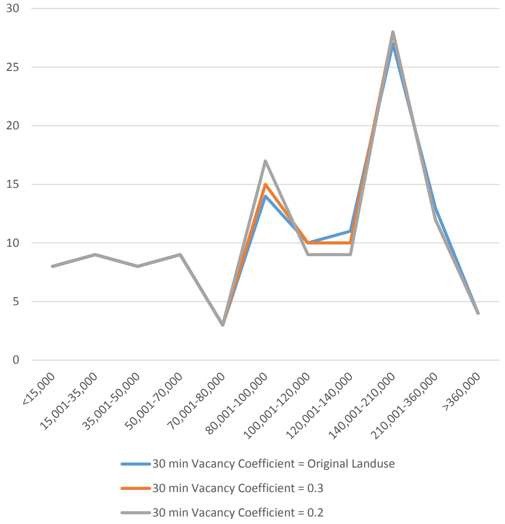
modified landuse,
vacancy coefficient 0.2

Figure III-17: One Hundred Year Sensitivity Analysis Results – 11 Classes (Summary Tables)

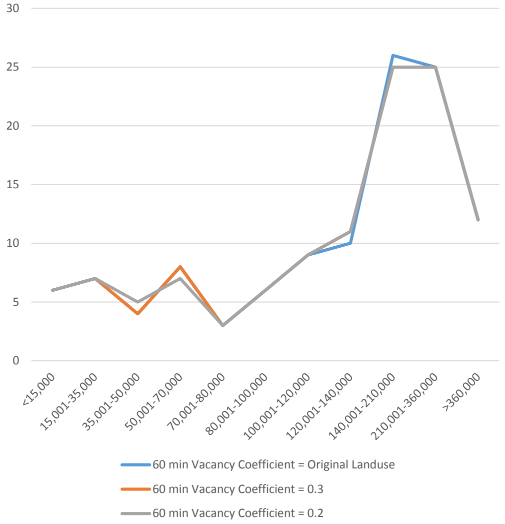
Categories	**Runoff Class (cfs)**	**30 min**	**60 min**	**30 min**	**60 min**	**30 min**	**60 min**
		Vacancy Coefficient = Original Landuse	**Vacancy Coefficient = Original Landuse**	**Vacancy Coefficient = 0.3**	**Vacancy Coefficient = 0.3**	**Vacancy Coefficient = 0.2**	**Vacancy Coefficient = 0.2**
1	<15,000	8	6	8	6	8	6
2	15,001-35,000	9	7	9	7	9	7
3	35,001-50,000	8	4	8	4	8	5
4	50,001-70,000	9	8	9	8	9	7
5	70,001-80,000	3	3	3	3	3	3
6	80,001-100,000	14	6	15	6	17	6
7	100,001-120,000	10	9	10	9	9	9
8	120,001-140,000	11	10	10	11	9	11
9	140,001-210,000	27	26	28	25	28	25
10	210,001-360,000	13	25	12	25	12	25
11	>360,000	4	12	4	12	4	12



ONE HUNDRED YEAR STORM EVENT RUNOFF



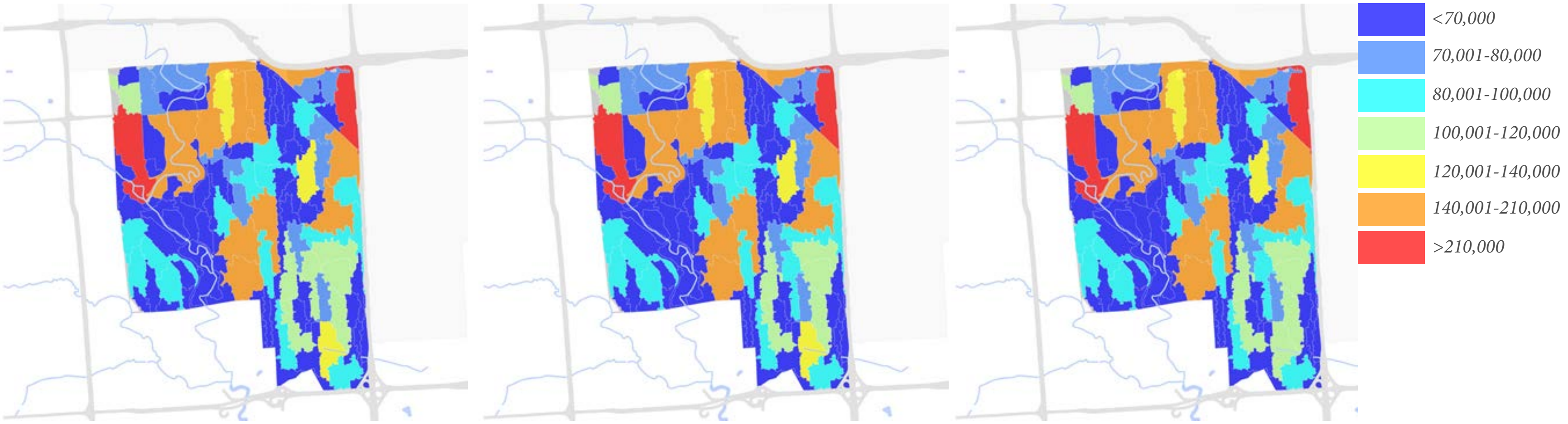
ONE HUNDRED YEAR STORM EVENT RUNOFF
30 MINUTE STORM



ONE HUNDRED YEAR STORM EVENT RUNOFF
60 MINUTE STORM

Figure III-18: Two Year Sensitivity Analysis Results – 7 Classes (Spatial Distribution)

30 MIN, 2 YEAR *peak stormwater runoff volume (cfs)*

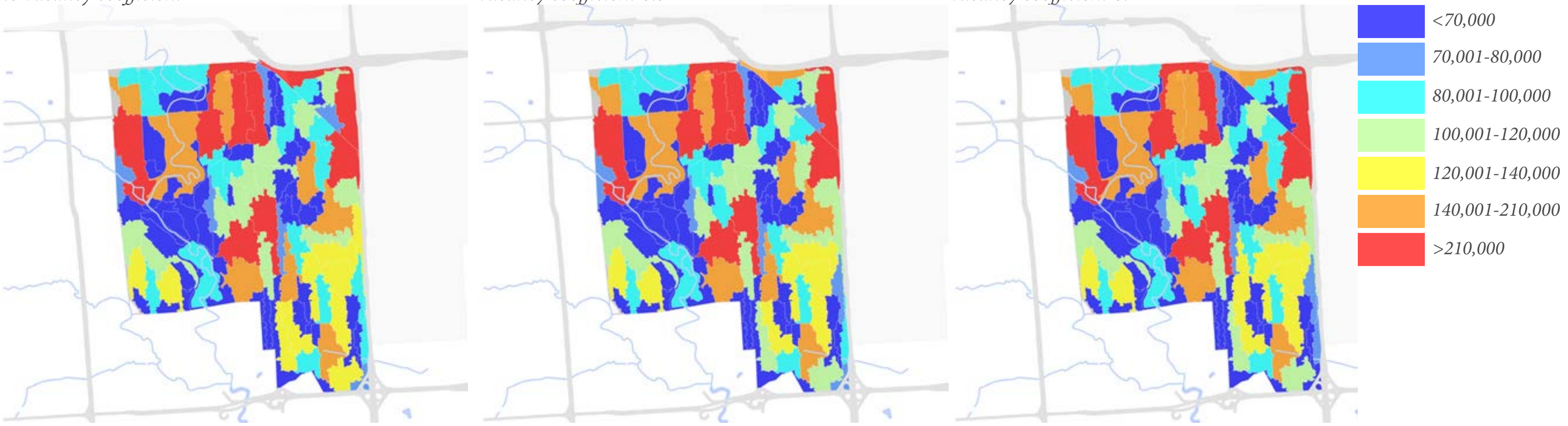


original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

60 MIN, 2 YEAR *peak stormwater runoff volume (cfs)*



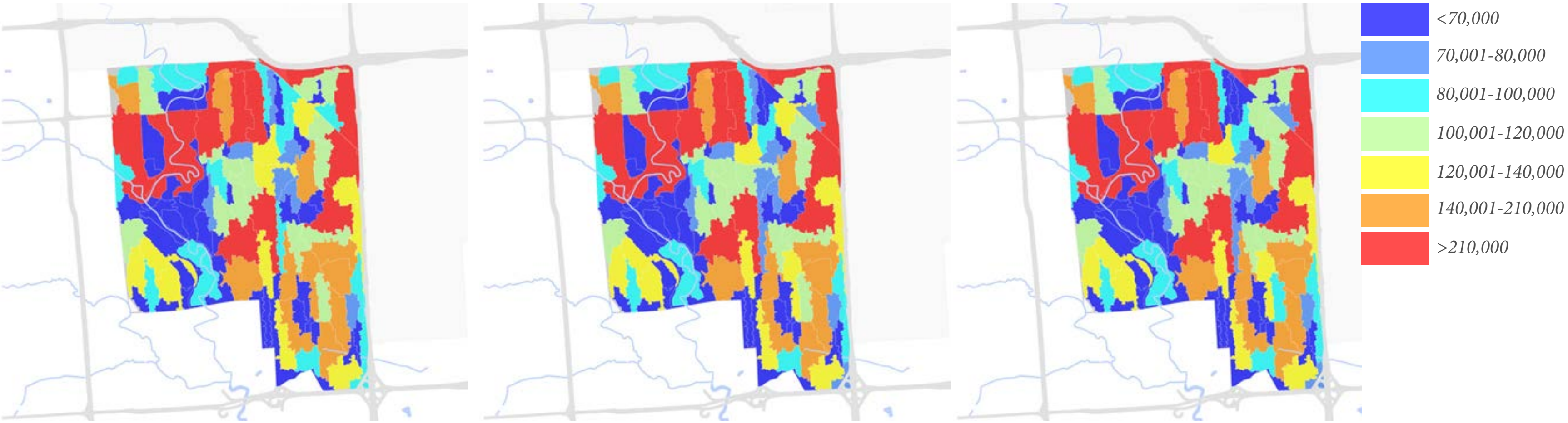
original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

Figure III-19: Ten Year Sensitivity Analysis Results – 7 Classes (Spatial Distribution)

30 MIN, 10 YEAR *peak stormwater runoff volume (cfs)*

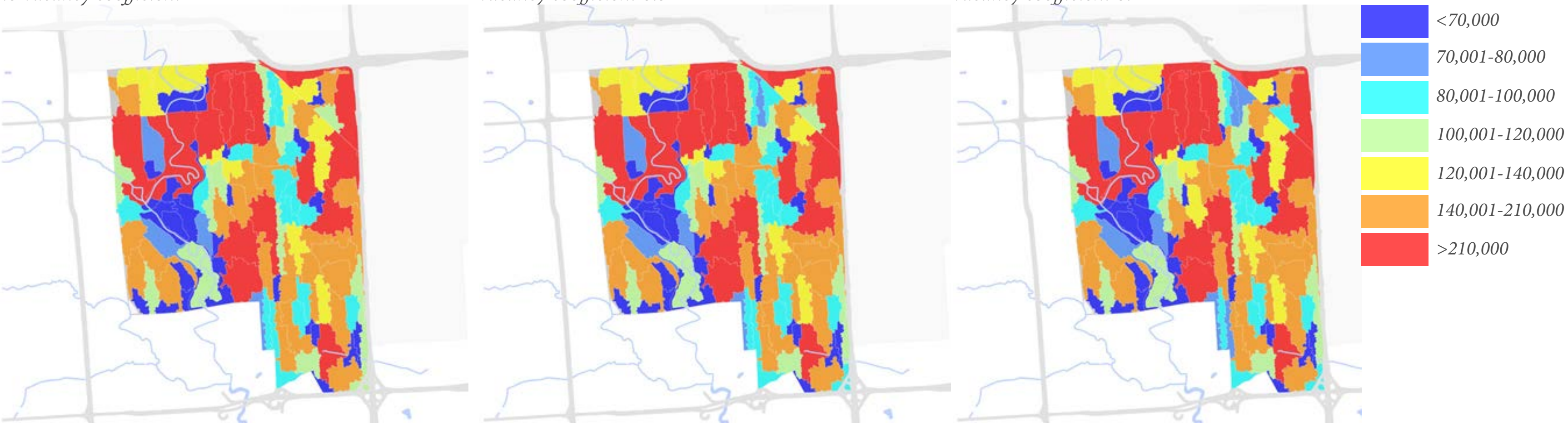


original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

60 MIN, 10 YEAR *peak stormwater runoff volume (cfs)*



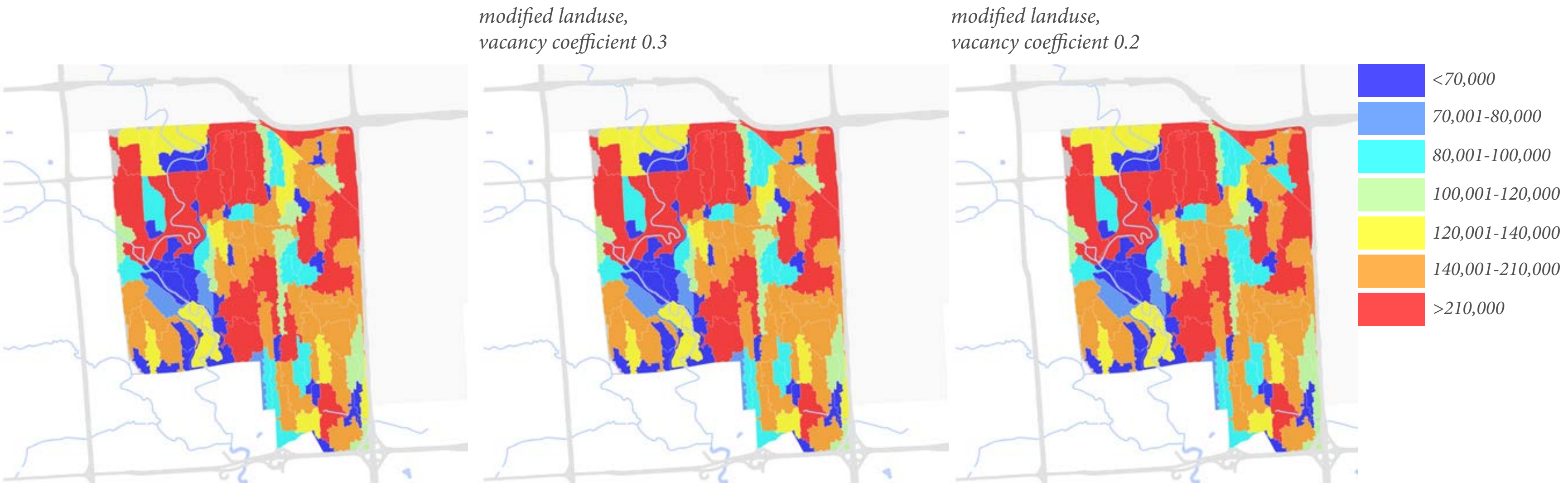
original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

Figure III-20: One Hundred Year Sensitivity Analysis Results – 7 Classes (Spatial Distribution)

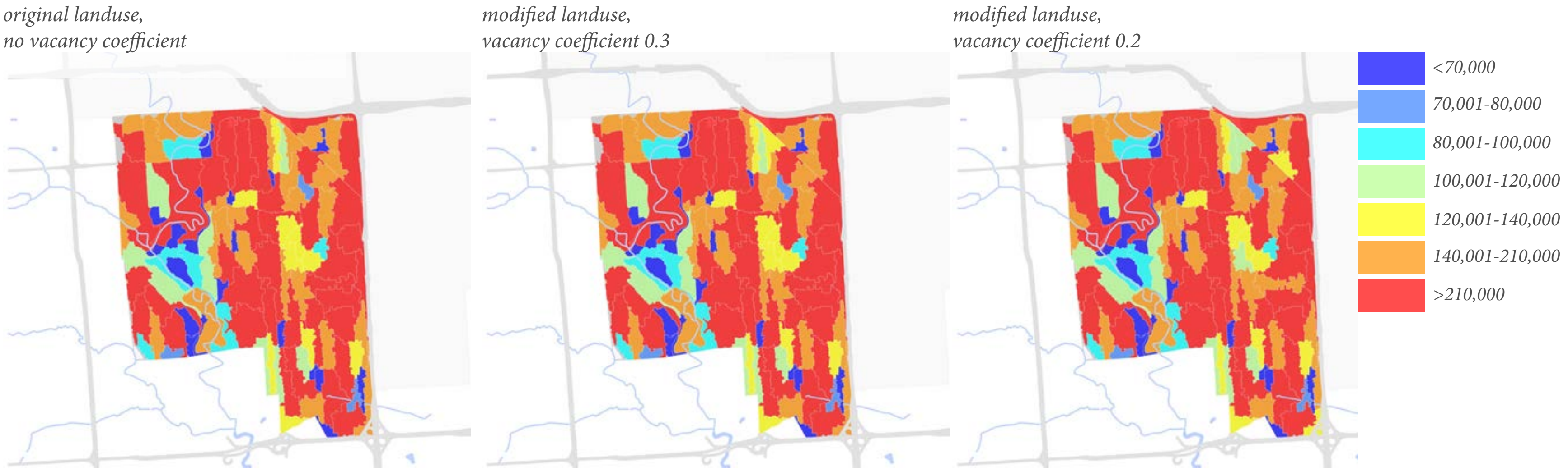
30 MIN, 100 YEAR *peak stormwater runoff volume (cfs)*



modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

60 MIN, 100 YEAR *peak stormwater runoff volume (cfs)*



original landuse,
no vacancy coefficient

modified landuse,
vacancy coefficient 0.3

modified landuse,
vacancy coefficient 0.2

Further Assessment of the Effects of Vacancy

The maps and tables shown in Figures III-12 – III-17 display peak runoff volume across 11 data classes with similar breakpoints and the maps in Figures III-18-20 display peak runoff volume across 7 data classes with similar breakpoints. From each set of figures, where the class distribution and breakpoints are similar, the spatial change across the three storm event groups (2 year, 10 year, and 100 year) is clear but the subtleties that indicate the effect of vacant land as part of the modified landuse dataset, is less so. While the charts and line graphs from the sensitivity analysis indicate that several catchments are affected by an alternative landuse coefficient for vacancy, further exploration is required.

To further assess the effects of vacancy on peak stormwater runoff, the differences between the three landuse coefficient scenarios were calculated for the 10 year, 30 minute storm (baseline scenario). The following equations were calculated using Field Calculator in ArcGIS:

1. Difference between peak runoff volume (cfs) for 2008 SEMCOG **original** landuse coefficients and peak runoff volume (cfs) for modified landuse with vacancy coefficient of **0.3**:
(Volume (Q) (10-year, (C) from Original Landuse, 30 min)) - (Volume (Q) (10-year, Vacancy (C) = 0.3, 30 min, 30 min))

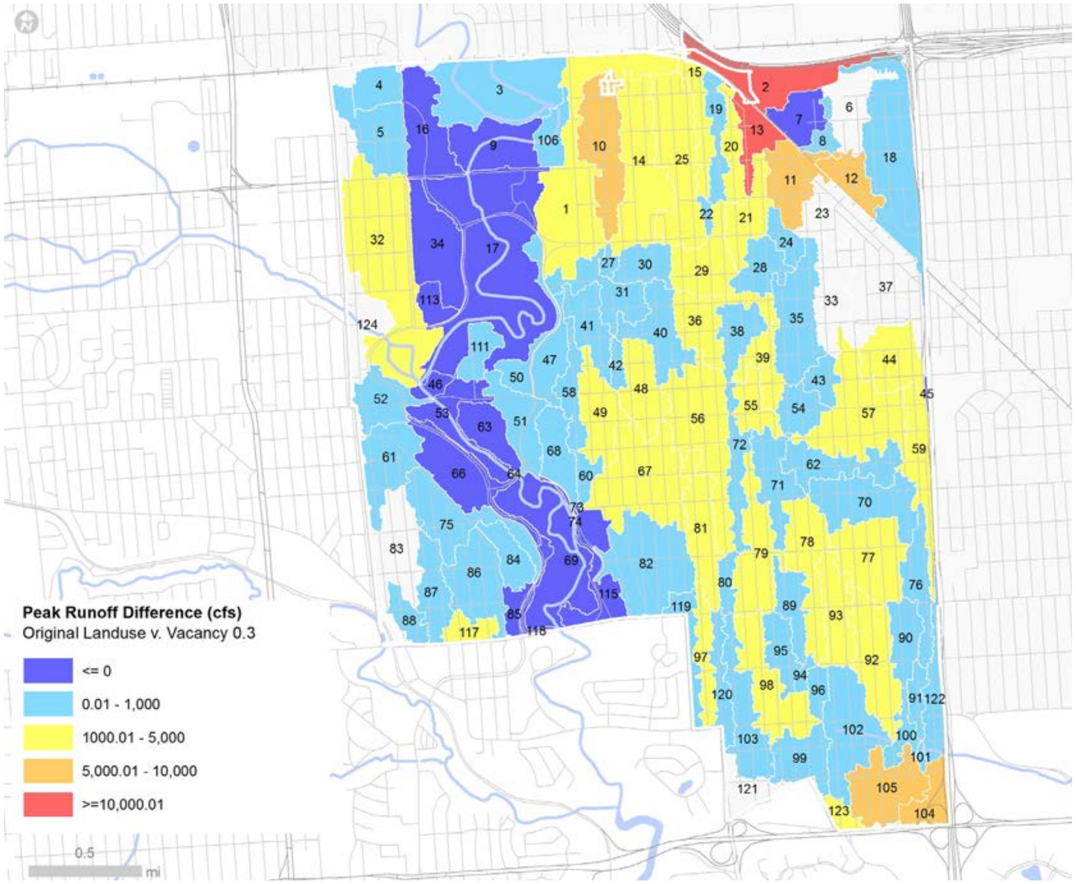
2. Difference between peak runoff volume (cfs) for 2008 SEMCOG **original** landuse coefficients and peak runoff volume (cfs) for modified landuse with vacancy coefficient of **0.2**:
Volume (Q) (10-year, (C) from Original Landuse, 30 min)) - (Volume (Q) (10-year, Vacancy (C) = 0.2, 30 min, 30 min))

3. Difference between peak runoff volume (cfs) for modified landuse with vacancy coefficient of **0.3** and peak runoff volume (cfs) for modified landuse with vacancy coefficient of **0.2**:
(Volume (Q) (10-year, (Vacancy (C) = 0.3, 30 min)) - (Volume (Q) (10-year, Vacancy (C) = 0.2, 30 min, 30 min))

These spatial distribution of these differences can be observed in Figures III-21 – III-23.

Figure III-21: Original SEMCOG 2008 Coefficient v. Modified Landuse (Vacant 0.3) Coefficient

Runoff by Catchment, 10 year, 30 min

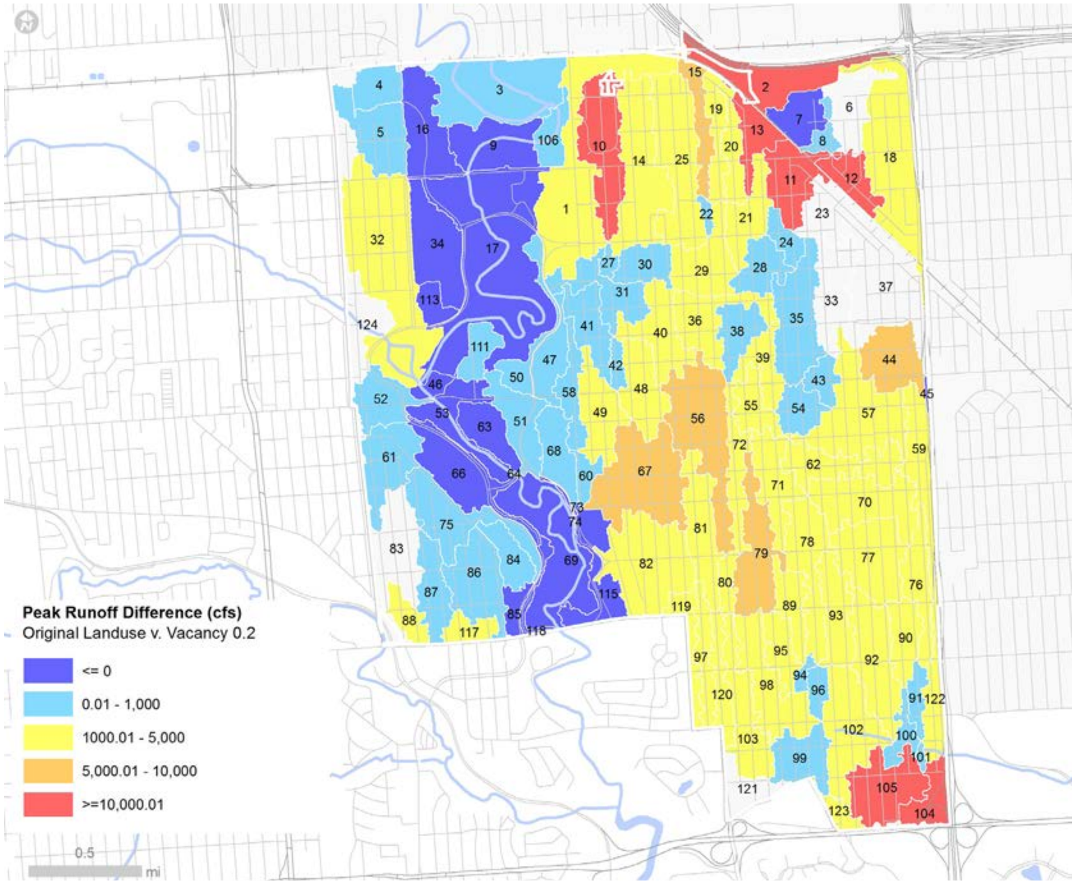


**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*

Difference Class	*Number of Catchments*
<=0	19
0.01-1,000	55
1,000.01-5,000	28
5,000.01-10,000	5
>10,000.01	2

Figure III-23: Original SEMCOG 2008 Coefficient v. Modified Landuse (Vacant 0.2) Coefficient

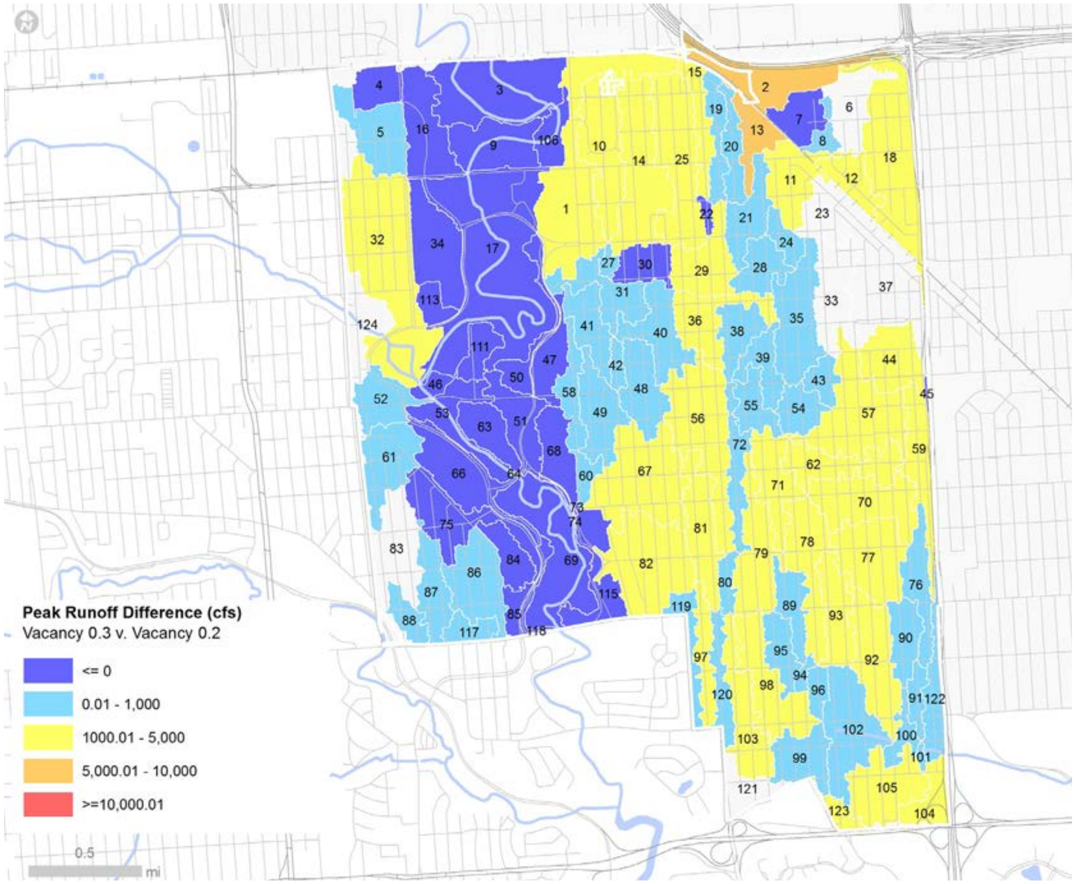
Runoff by Catchment, 10 year, 30 min



Difference Class	*Number of Catchments*
<=0	19
0.01-1,000	36
1,000.01-5,000	42
5,000.01-10,000	5
>10,000.01	7

**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*

Figure III-23: Modified Landuse (Vacant 0.3) v. Modified Landuse (Vacant 0.2) Coefficient
Runoff by Catchment, 10 year, 30 min



Difference Class	*Number of Catchments*
<=0	31
0.01-1,000	44
1,000.01-5,000	32
5,000.01-10,000	2
>10,000.01	0

**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*

Limitations/Data Inconsistencies

Table III-8: Land Use Comparison Table

New Landuse	***Area (acres)***	***% Cody Rouge Study Area***	***% Cody Rouge Study Area***	***Percent Change***
		Modified Landuse	*SEMCOG 08 Landuse*	
Single-family residential	1,818.39	39.01%	41.30%	2.29%
TCU	1,130.65	24.26%	24.76%	0.50%
Parks, Recreation, and Open Space	1,113.49	23.89%	24.77%	0.88%
Vacant, No Structure	241.74	5.19%	0.00%	5.19%
Industrial	149.17	3.20%	3.62%	0.42%
Governmental / Institutional	83.25	1.79%	1.98%	0.19%
Commercial	77.35	1.66%	2.49%	0.83%
Multiple-family residential	47.35	1.02%	1.08%	0.06%

The SEMCOG 2008 Land Use data was derived from a different source than vacant parcels, which were extracted from the 2014 MCM Parcel dataset and embedded into the Modified Land Use dataset. This resulted in some inconsistencies based on projection/data conflicts and classification strategies. Where MCM parcel data was classified as vacant, no structure, the modified land use dataset was classified as vacant. In some cases, this resulted in the reclassification of land use classes that were not residential. Industrial, Governmental, and Commercial parcels that were reclassified as Vacant tend to be large and thus have a greater impact on model results. In a few cases, parcels that were classified by SEMCOG as parks, recreation, and open space, were classified as vacant, which significantly impacted the average landuse coefficient value. The tables and figures below describe these situations.

Table III-9: Data Inconsistencies by Catchment

Catchment ID	*Issue*	*Explanation*	*Solution*
6	SEMCOG parcel classified as park, MCM parcel classified as vacant; Difference between Original and Vacant 0.3 runoff volume is -1,000 cfs and difference between Original and Vacant 0.2 runoff volume is 2,332 cfs - catchment has high residential vacancy as well	Vacant 0.3 coefficient is higher than Park coefficient (0.2) while vacant 0.2 coefficient is the same as Park coefficient	(1) Keep SEMCOG classification for park parcel (2) Remove catchment from analysis
23	2 SEMCOG parcels classified as park, MCM parcels classified as vacant; Difference between Original and Vacant 0.3 runoff volume is -1,043 cfs and difference between Original and Vacant 0.2 runoff volume is 339 cfs	Vacant 0.3 coefficient is higher than Park coefficient (0.2) while vacant 0.2 coefficient is the same as Park coefficient	(1) Keep SEMCOG classification for park parcel (2) Remove catchment from analysis
33	SEMCOG parcel classified as park, MCM parcel classified as vacant; Difference between Original and Vacant 0.3 runoff volume is -14,739 cfs and difference between Original and Vacant 0.2 runoff volume is 116 cfs	Vacant 0.3 coefficient is higher than Park coefficient (0.2) while vacant 0.2 coefficient is the same as Park coefficient	(1) Keep SEMCOG classification for park parcel (2) Remove catchment from analysis
37	2 SEMCOG parcels classified as park, MCM parcels classified as vacant; Difference between Original and Vacant 0.3 runoff volume is -5,471 cfs and difference between Original and Vacant 0.2 runoff volume is 7,956 cfs - catchment has high residential vacancy as well	Vacant 0.3 coefficient is higher than Park coefficient (0.2) while vacant 0.2 coefficient is the same as Park coefficient	(1) Keep SEMCOG classification for park parcel (2) Remove catchment from analysis
83	Unknown; Difference between Original and Vacant 0.3 runoff volume is -55 cfs and difference between Original and Vacant 0.2 runoff volume is 92 cfs	Unknown - could be related to data edge effects, catchment located at outer boundary of study area	Remove catchment from analysis
121	Unknown; Difference between Original and Vacant 0.3 runoff volume is -1,272 cfs and difference between Original and Vacant 0.2 runoff volume is -931 cfs	Unknown - could be related to data edge effects, catchment located at outer boundary of study area	Remove catchment from analysis
124	Unknown; Difference between Original and Vacant 0.3 runoff volume is -317 cfs and difference between Original and Vacant 0.2 runoff volume is 640 cfs	Unknown - could be related to data edge effects, catchment located at outer boundary of study area	Remove catchment from analysis

Table III-10: Data Inconsistencies by Catchment – Landuse Area Differences

Catchment Id	Commercial	**Modified Commercial**	Governmental / Institutional	**Modified Governmental/Institutional**	Industrial	**Modified Industrial**	Multiple-family residential	**Modified Multi-Family Residential**	Single-family residential	**Modified Single-Family Residential**	Parks, Recreation, and Open Space	**Modified Parks, Open Space, Recreation**	TCU	**Modified TCU**	**Vacant, No Structure**	Catchment Area	**Mod Catchment Area**
6	0.9	0.7	1.2	1.1	3.5	3.4	0.0	0.0	11.8	11.2	2.6	0.0	15.1	15.1	3.6	35.0	35.0
23	0.0	0.0	0.0	0.0	4.6	4.6	7.1	7.1	9.5	9.3	1.3	0.0	10.7	10.7	1.5	33.1	33.1
33	0.0	0.0	0.0	0.0	0.0	0.0	5.3	5.3	12.4	12.3	16.3	0.5	10.5	10.5	15.9	44.5	44.5
37	3.4	3.1	4.6	4.6	5.4	5.1	10.4	9.6	23.4	22.0	11.5	0.2	32.9	32.9	14.3	91.7	91.7
83	0.0	0.0	3.8	3.8	0.0	0.0	0.0	0.0	31.6	31.5	0.0	0.0	14.0	14.0	0.2	49.4	49.4
121	0.0	0.0	9.4	9.4	0.0	0.0	0.0	0.0	7.5	7.2	0.0	0.0	5.8	5.8	0.4	23.0	22.7
124	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	8.7	15.1	15.1	11.0	11.0	1.0	37.2	36.8

The catchments with data inconsistencies were removed from Figures III-21 –III-23 and were not evaluated as part of the Catchment Prioritization Model.

Discussion and Summary Assessment of Vacant Land in Stormwater Modeling

A primary goal of the stormwater modeling was to explore the influence of vacant land as part of a non-dynamic hydrologic model that evaluates peak runoff volume. Existing model frameworks for hydrologic modeling require a variety of standard data inputs. Most of these model frameworks include a measure of imperviousness, often represented by a land use/landcover component that can be sourced from a local or national spatial database. Land use classes are typically assigned at the parcel level using a generalized land use classification scheme based on a combination of aerial imagery interpretation and property assessment. This is true of the SEMCOG 2008 land use data for the city of Detroit, which was used in this analysis. Because municipalities and government organizations often make these datasets available to the public, the standard zoning codes have become useful criteria for building model frameworks that are used in planning and natural resource management. In the SEMCOG 2008 Land Use dataset, urban residential areas are designated at the parcel level as either single-family or multi-family residential. Strom's urban land use coefficients for calculating peak runoff using the Rational Method are based on similar land use classifications but they do not consider atypical urban areas that contain high rates of vacancy and therefore do not provide a sufficient runoff coefficient for vacant land. As a result, hydrologic models in highly vacant urban areas often lump vacant lots into a land use class that does not accurately represent the landscape characteristics.

The sensitivity analysis provides an initial assessment of vacant land and its impact on stormwater runoff by catchment. For the 10 year, 30 minute storm event, further evaluation of the differences in peak runoff volume for the original and modified land use datasets helped to identify catchments where runoff volume is most influenced by vacant land.

When using the modified land use dataset, where vacant land is given a land use coefficient of 0.3, peak stormwater runoff is greater than 1,000 cubic feet per second for 35 catchments when compared to the results calculated using the original 2008 SEMCOG Land Use classifications. Seven of these catchments experience a change in peak runoff greater than 5,000 cubic feet per second and of these seven catchments, five of them (Catchment IDs: 11, 12, 105, 104, and 10) are more than 25% residential. These results suggest that the influence of residential vacancy has a significant impact on untreated stormwater volume in these catchments. This influence is further emphasized in-the modified land use dataset where vacant land is given a landuse coefficient of 0.2. In this scenario, there are 54 catchments with a runoff volume greater than 1,000 cubic feet per second when compared to the runoff results from the original land use classifications. Of these 54 catchments, twelve experience a change in peak runoff greater than 5,000 cubic feet per second and ten (Catchment IDs: 10, 11, 12, 15, 44, 56, 67, 79, 104, 105) are more than 25% residential.

When comparing the difference in peak runoff between the two modified land use datasets, 34 catchments experience a change that is greater than 1,000 cubic feet per second. Of these 34 catchments, 32 are more than 25% residential and all experience a change in peak runoff that is less than 5,000 cubic feet per second. These results suggest that different vacancy coefficients applied to vacant land in the modified landuse dataset has fairly significant implications for model results.

In summary, for the entire Cody Rouge study area during the 10 year, 30 minute storm event, modifications to the 2008 SEMCOG Land Use dataset resulted in a reduced total peak runoff volume of 187,867.47 cubic feet per second where vacant land was given a landuse coefficient of 0.3 and 288,135.39 cubic feet per second where vacant land was given a landuse coefficient of 0.2. The total reduced difference in peak runoff between the modified land use dataset where vacant land received a coefficient value of 0.3 and the modified land use dataset where vacant land received a coefficient value of 0.2 was 100,267.92 cubic feet per second. For more intense storm events with longer durations, these values would significantly increase.

Urban residential neighborhoods represent an atypical situation for traditional approaches to urban stormwater modeling. Most hydrologic modeling frameworks require a measure of imperviousness, often represented by standard landuse classifications and coefficients. This is true for the Rational Method, which was used in this analysis. In order to calculate more accurate estimates of baseline peak stormwater volume, model input that represents the landscape condition must be evaluated appropriately for a given context. In the Cody Rouge neighborhood, more than 25% of parcels are classified as vacant or abandoned and vacant residential lots make up more than 5% of the landscape. Vacant lots are less likely to contain impervious structures and/or surfaces -

that inhibit interception, infiltration, and evaporation. The results of this analysis indicate that baseline values for untreated stormwater runoff would have been significantly underestimated without the incorporation of vacant land as part of the modified land use dataset. Further, in order to effectively evaluate the influence of more intensive green infrastructure projects/designs, often for regulatory compliance, the baseline or existing landscape conditions must be accurately characterized.

Additionally, the results of this analysis suggest that it is likely that un-designed and unmaintained vacant land or informal green infrastructure is offering some benefits for stormwater management in urban residential neighborhoods. With this knowledge, prioritization strategies for green infrastructure siting become more important. If all vacant lots provide some stormwater benefit, how do we decide which lots are most valuable as more intensive green infrastructure designs? Where are the most productive opportunities? In an attempt to address these questions, the second phase of this project aims to integrate the stormwater modeling results as part of a Catchment Prioritization Model. This model will ultimately be combined with the Vacant Land Prioritization Model to provide GI siting strategies for the Cody Rouge Neighborhood.

Synthesis/ Catchment Prioritization

The Catchment Prioritization Index represents a synthesized prioritization scheme for targeting the most suitable neighborhood catchments for green infrastructure based on runoff reduction need or green infrastructure demand. Essentially, the catchment prioritization model identifies neighborhood catchments that contribute most significantly to stormwater runoff in the Cody Rouge neighborhood and would most benefit from targeted green infrastructure strategies. The Catchment Prioritization Index combines the following input variables:

1. Model results for peak stormwater runoff
2. Impervious land cover
3. Tree canopy cover
4. Direct drainage to combined sewer overflows

For each input variable, a priority value is determined for each catchment that reflects a combination of the relative importance for stormwater management and the reliability of the spatial data. The sum of the five index values for each catchment is the Catchment Prioritization Index Score.

1. Peak Stormwater Runoff Priority:
Peak stormwater volume by catchment was evaluated for the three storm events (2 year, 10 year, and 100 year) at both 30 and 60 minute durations. The modified 2008 SEMCOG Land Use dataset was used as model input and vacant land was given a land use coefficient of 0.3. This value was chosen for this phase because it is a conservative characterization of vacant land parcels in the Cody Rouge neighborhood. In order to determine peak runoff index values, the seven class classification scheme in Figures III-21 - III-23 was used to determine priority. For each storm event and duration (6 scenarios total), peak runoff volume was assigned to a Catchment Class from 1 to 7. Class 1 reflects relatively low runoff volume (less than 70,000 cfs) and Class 7 reflects relatively high runoff volume (greater than 210,000 cfs). Depending on the storm intensity and duration, a catchment might fall into a different class. The number of times that a catchment fell into each Catchment Class was recorded and peak stormwater runoff priority values were determined. Table III-11 summarizes these results.

After determining catchment priority for runoff volume, an index score was specified. A higher index score reflects a higher priority while a lower index score reflects a lower priority. Because runoff volume represents the most important variable in the Catchment Prioritization Index, the index score values are much higher than the other variables in the combined index.

Table III-11: Peak Stormwater Runoff Priority - Summary Table

Catchment Runoff Class	*Catcment Runoff Class Volume (cfs)*	*Number of Times Catchment Falls in Class*	*Number of Catchments*	*Priority for Stormwater Management/Green Infrastructure**	***Runoff Volume Prioritization Index Score*****
7	>210,000	6	2	1st	***10***
7	>210,000	5	5	2nd	***10***
7	>210,000	4	3	3rd	***9***
7	>210,000	3	4	4th	***9***
7	>210,000	2	1	5th	***9***
7	>210,000	1	20	6th	***8***
6	140,000-210,000	3	1	7th	***8***
6	140,000-210,000	2	3	8th	***8***
6	140,000-210,000	1	17	9th	***7***
5	120,000-140,000	1 or more	10	10th	***7***
4	100,000-120,000	1 or more	9	11th	***7***
3	80,000-100,000	1 or more	6	12th	***6***
2	70,000-80,000	1 or more	3	13th	***6***
1	<70,000	1 or more	24	14th	***5***

**Figure III-24; **Figure III-25*

Figure III-24: Peak Stormwater Runoff Priority Rank Map

**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*

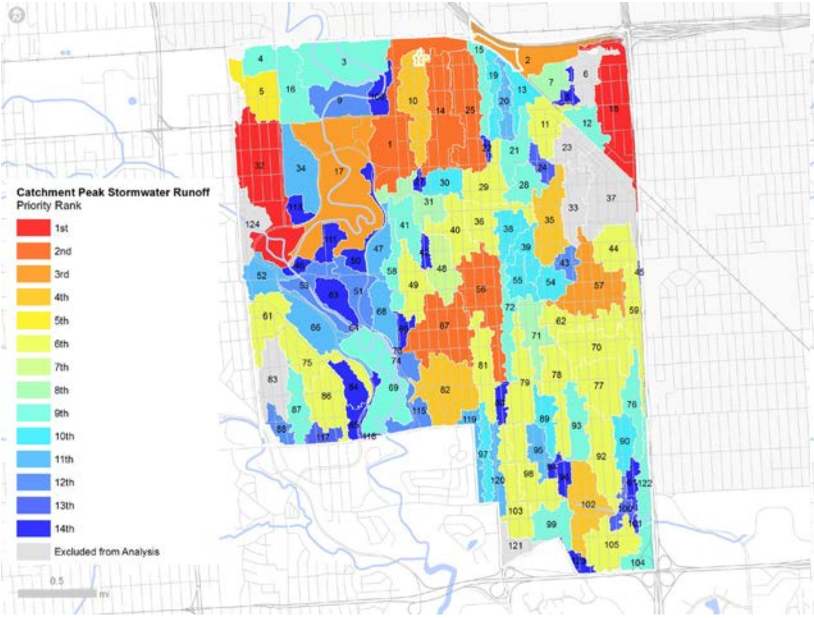
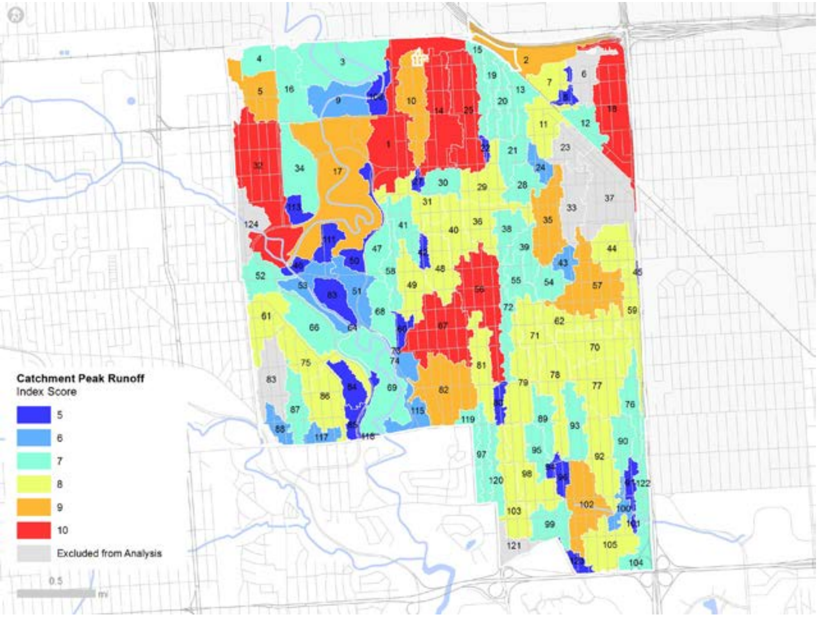


Figure III-26: Peak Stormwater Runoff - Index Value Map

**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*



2. Impervious land cover

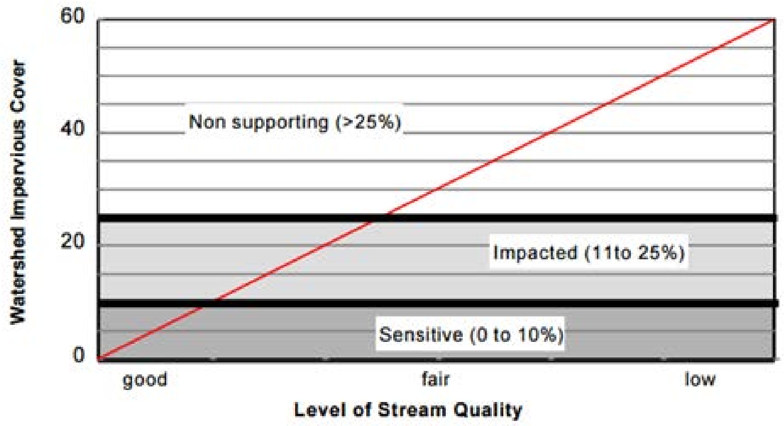
While stormwater modeling of peak runoff volume incorporates imperviousness as part of the land surface coefficient, it is an overly generalized representation of landscape condition based on the parcel landuse designations. To further emphasize the importance of imperviousness in stormwater management, remotely sensed land cover data was incorporated into the Catchment Prioritization Index.

The Multi-Resolution Land Characteristics (MRLC) Consortium is a consortium of ten federal agencies that administer the development of the National Land Cover Dataset (NLCD), which is based primarily on a remotely sensed decision-tree classification of Landsat satellite data. The 2011 NLCD Dataset is a 16-class land cover classification scheme that has been applied consistently across the United States at a spatial resolution of 30 meters (Homer 2015). In addition to providing national land cover data, the MLRC also develops a dataset for Percent Imperviousness and Percent Tree Canopy Cover. Both of these datasets were used in the Catchment Prioritization Index.

The 2011 Percent Imperviousness dataset classifies developed land cover based on the spectral brightness of the Landsat imagery at a spatial resolution of 30 meters. Each 30 meter pixel in this dataset represents an estimate of the average percent impervious (Xian 2011). While a more useful representation of impervious cover would classify spatial data as either impervious or not impervious, the 2011 NLCD dataset is the best available. In order to determine the area of impervious cover in each catchment, several methods for reclassifying the percent imperviousness data were explored by testing various break points in the 2011 NLCD Impervious dataset.

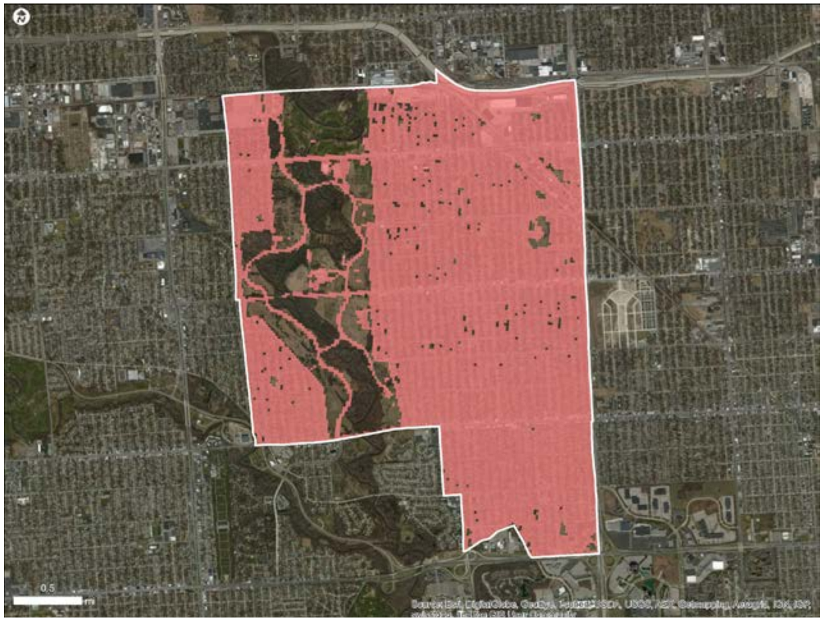
From a water quality standpoint, streams are determined to be negatively impacted when their watersheds contain more than 25% impervious cover (EPA 1999). Based on this logic, 25% was tested as an initial threshold value for determining impervious cover in the Cody Rouge Neighborhood.

Figure III-27: Relationship between Watershed Impervious Cover and Stream Quality
Schueler and Claytor, 1995



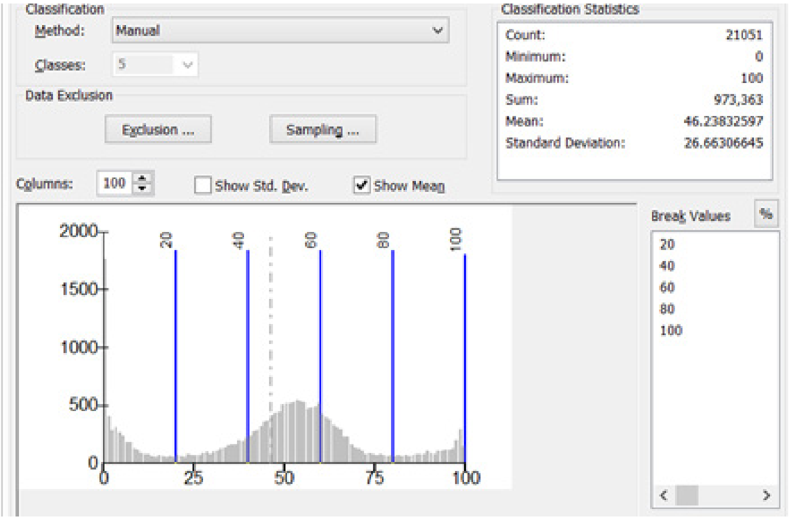
The 2011 NLCD impervious cover was first divided into two classes based on the 25% threshold for the Cody Rouge study area. This resulted in 3619.478 acres (16,275 30 meter cells) that were classified as high impervious cover and potentially detrimental to water quality. These results were visually assessed based on ESRI 2011 High Resolution imagery to evaluate the threshold and determine relative coverage of data (Figure III-28). While this threshold was able to distinguish large areas that were relatively pervious, smaller open spaces within residential blocks were not identified. This suggests a need for a more nuanced classification system that can better represent landscape conditions.

Figure III-28: Cody Rouge Impervious Cover at 25% Threshold



Due to the limitations of a two-class or binary classification scheme for impervious data, a more nuanced method was applied to the 2011 NLCD impervious data for Cody Rouge using natural breaks in ArcGIS. This scheme was chosen for its ability to characterize data that doesn't always exhibit a normal distribution. Five classes were chosen in order to use the median value as a measure of central tendency. Values closest to the median are placed in a mid-scoring class while values above and below the median are placed into two different high and low scoring classes. The break values for this scheme were slightly modified for ease of legibility in final map outputs. Numbers were rounded to the nearest ten value. The distribution of data is represented in Figure III-29.

Figure III-29: Cody Rouge Percent Impervious - Natural Breaks Classification Distribution



Classification

Method: Manual

Classes: 5

Data Exclusion

Columns: 100

☐ Show Std. Dev.

☑ Show Mean

Classification Statistics

Count:	21051
Minimum:	0
Maximum:	100
Sum:	973,363
Mean:	46.23832597
Standard Deviation:	26.66306645

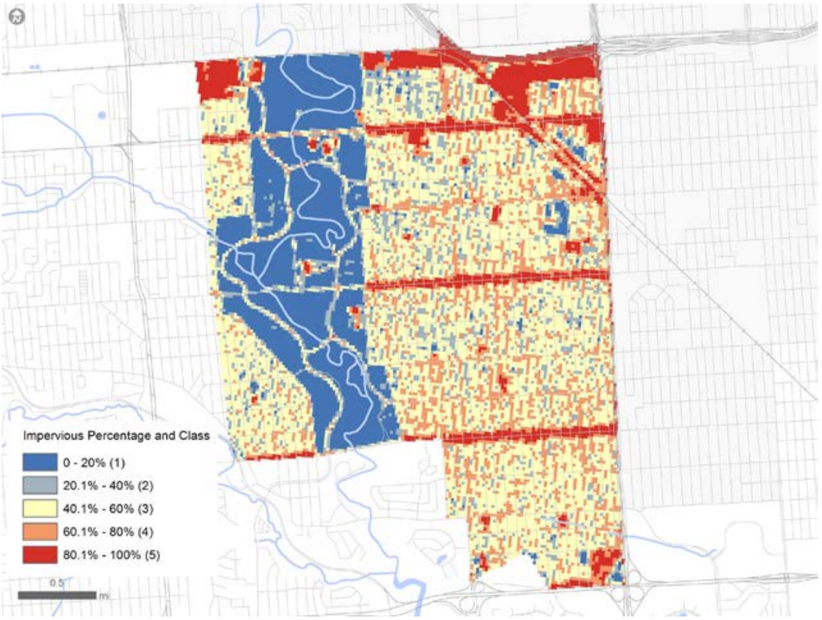
Break Values

20
40
60
80
100

Figure III-12: Cody Rouge Percent Impervious Classes

Impervious Percentage Range	*Impervious Class (Weight/Rank)*	*Number of 30 M Cells*	*Area (Acres)*
0-20	1	2,972	660.96
20.1-40	2	2,239	497.94
40.1-60	3	8,686	1,931.72
60.1-80	4	3,646	810.85
80.1-100	5	2,026	450.57

Figure III-30: Cody Rouge Percent Impervious - Natural Breaks Classification Map

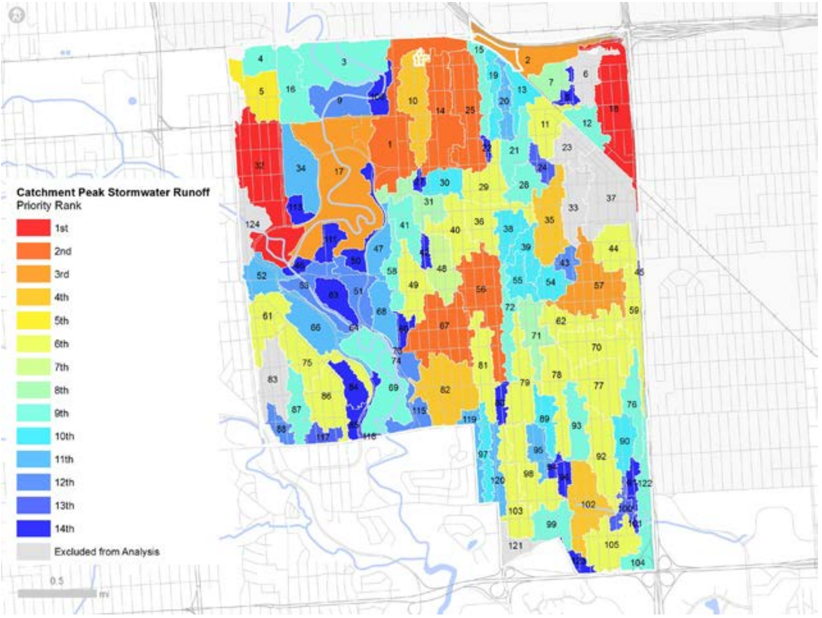


For each catchment, the average impervious percentage was calculated using zonal statistics in ArcGIS and then assigned an Imperviousness Priority Index Score. A higher score reflects a greater area of high percentage impervious cover and therefore a greater need for stormwater management and green infrastructure. These results are summarized and mapped in Table III-13 and Figure III-31.

Table III-13: Average Percent Imperviousness - Summary Table

Average Impervious Percentage Class	*Average Impervious Percentage Value (%)*	*Number of Catchments*	*Priority for Stormwater Management/Green Infrastructure*	*Average Impervious Percentage Prioritization* ***Index Score***
5	80-100	5	1st	**5**
4	60-80	38	2nd	**4**
3	40-60	37	3rd	**3**
2	20-40	12	4th	**2**
1	0-20	16	5th	**1**

Figure III-31: Average Percent Imperviousness - Index Value Map



**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*

3. Tree canopy cover

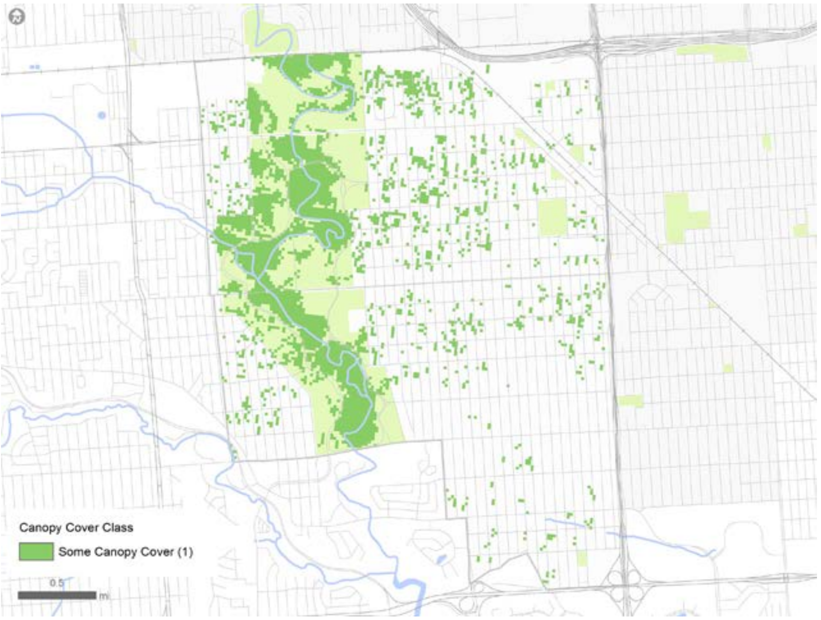
In addition to the National Landcover and the Percent Developed Imperviousness datasets, the MLRC also develops a Percent Tree Canopy dataset in cooperation with the USDA Forest Service Remote Sensing Applications Center (RSAC). The 2011 Percent Tree Canopy dataset quantifies per pixel tree canopy as a continuous variable from 1 to 100 percent and was developed using a Random Forests regression algorithm that combines imagery, modeled imagery, and forest inventory plot modeling. This dataset is intended to be used in rigorous analytical tasks that require a high degree of accuracy (MLRC 2015).

For the Catchment Prioritization Index, the percent canopy cover value for each 30 meter pixel was reclassified as either 1 or 0. Values of 1 represent some canopy cover and values of 0 represent no canopy cover. This assumption was based on the average planting area requirements for commonly planted street trees in the residential neighborhoods of Detroit (oaks, elms, and maples). On average, the canopy of these medium to large deciduous trees, covers approximately 100-150 square feet, roughly 30-50 meters. Assuming that each cell in the 2011 NLCD canopy cover dataset represents at least one tree, this reclassification scheme provides a reasonable estimate of tree cover in the Cody Rouge Study area, which can be observed in Table III-14 and Figure III-32. Based on this analysis, the Cody Rouge study area is less than 18% forested.

Table III-14: Cody Rouge Canopy Cover

Canopy Cover	*Canopy Cover(Weight/Rank)*	*Number of 30 M Cells*	*Area (Acres)*	*Percent*
No Canopy Cover	0	17,414	3,872.78	82.7%
Some Canopy Cover	1	3,637	808.85	17.3%

Figure III-32: Cody Rouge Canopy Cover

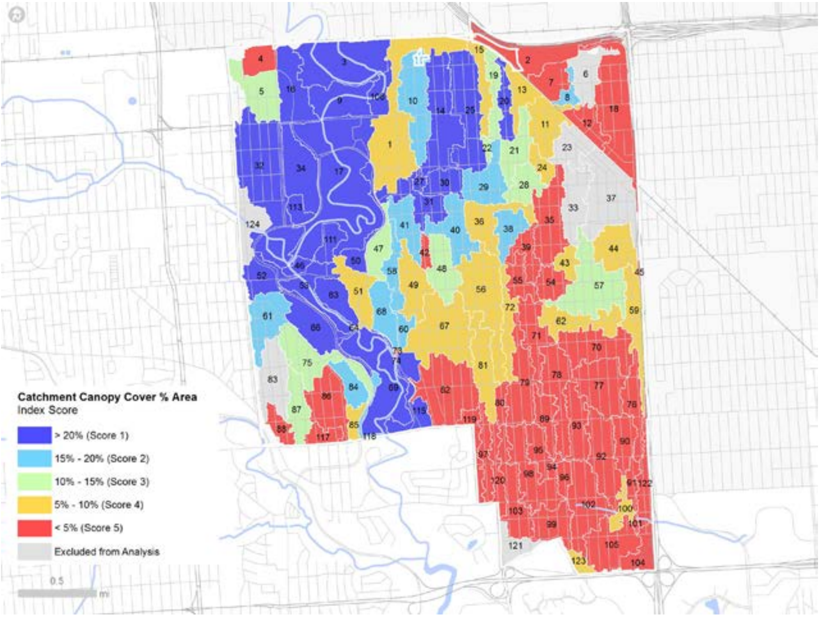


Because this model does not consider canopy overlap, it cannot be used to determine the exact number of trees but it can be used to approximate forested area by catchment. Using zonal statistics in ArcGIS, the number of cells containing 'Some Canopy Cover' were calculated by catchment and then divided by total catchment area to provide a measure of Percent Canopy Cover for each catchment. Percent Canopy Cover by catchment values were then aggregated into four classes using an equal interval classification method. Each class was assigned a Canopy Cover Priority Index Score. Because urban forests and street trees contribute significantly to stormwater management by intercepting rainwater in the tree canopy (Xiao and MacPherson, 2003), a higher score reflects low canopy cover and therefore a greater need for improved stormwater management and green infrastructure that includes tree plantings and urban forest design. These results are summarized and mapped in Table III-15 and Figure III-33.

Table III-15: Average Percent Canopy Cover by Catchment - Summary Table

Canopy Area Class	*Canopy Cover Area Percentage (%)*	*Number of Catchments*	*Priority for Stormwater Management/Green Infrastructure*	*Canopy Cover Prioritization* ***Index Score***
5	< 5	43	1st	**5**
4	5-10	19	2nd	**4**
3	10-15	11	3rd	**3**
2	15-20	12	4th	**2**
1	>20	23	5th	**1**

Figure III-33: Average Percent Canopy Cover - Index Value Map



**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*

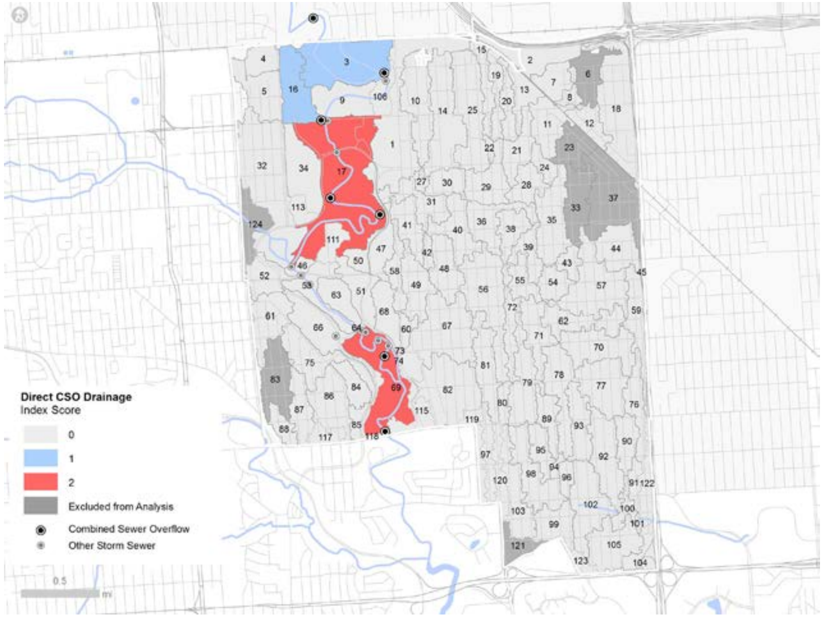
4. Direct drainage to combined sewer overflows

In 2011, more than 36 million gallons of untreated sewage and stormwater was discharged in to the River Rouge as a result of Detroit's combined sewer system (Lyandres 2012). There are six combined sewer overflow locations at the River Rouge in the Cody Rouge neighborhood that significantly contribute to water quality impairment and raise concerns about public health. DWSD, SEMCOG, and Detroit Future City emphasize stormwater management plans that prioritize the mitigation and elimination of CSOs in order to protect water resources, human health, and meet compliance with federal regulations. Upstream green infrastructure throughout the neighborhood can alleviate some of the sewage system's storage needs by infiltrating stormwater and pollution before it enters the combined system. Source control measures within catchments that contain overflow locations can provide further benefits. Because most of the catchments that contain CSOs are located on the River Rouge in the city owned park, they are less likely to be prioritized for green infrastructure in this model. In order to acknowledge the influence of direct drainage to combined sewer overflow locations, catchments containing one CSO were prioritized for stormwater management and given a Direct CSO Drainage Index score of 1 while catchments containing two CSOs were given a Direct CSO Drainage Index score of 2. The four catchments (Catchment IDs: 3, 16, 17, 69) containing one or more CSOs are mapped in Figure III-34. All other catchments were given a Direct CSO Drainage Index score of 0 and were not influenced by this index variable.

Table III-16: Catchments with Combined Sewer Overflows – Summary Table

Catchment ID	*Number of CSOs*	*Priority for Stormwater Management/Green Infrastructure*	*Direct CSO Drainage* ***Index Score***
3	1	2nd	**1**
16	1	2nd	**1**
17	2	1st	**2**
69	2	1st	**2**

Figure III-34: Catchments with Combined Sewer Overflows - Index Value Map

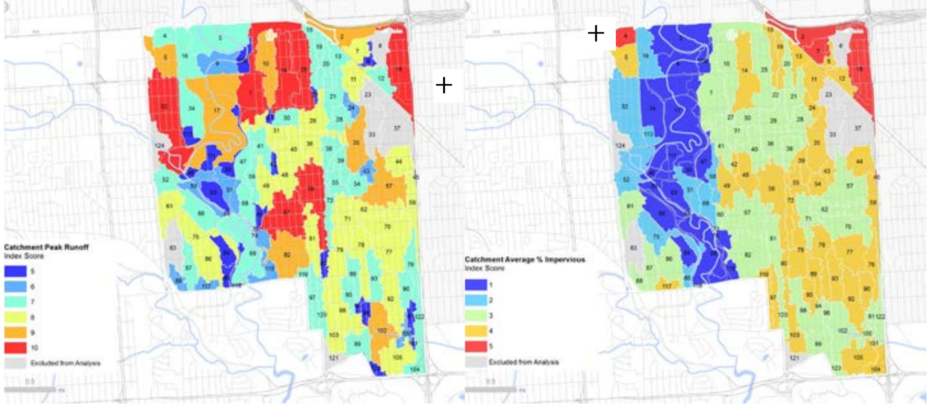


**Catchments (labeled by Catchment ID) with data inconsistencies removed from this map*

Figure III-35: Map and Table Summary of Input Variable Index Scores

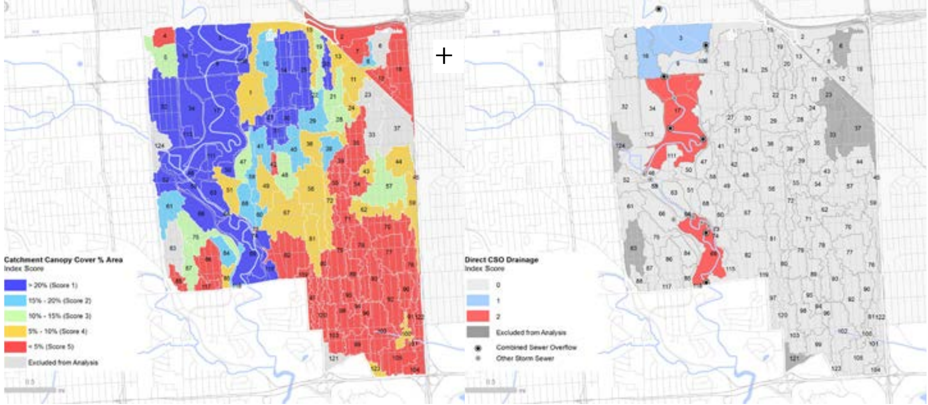
peak runoff score

impervious percent score



canopy percent area score

cso direct drainage score



Peak Runoff Volume Priority		**Index Score Value**
High	1st and 2nd Priority	**10**
	3rd - 5th Priority	**9**
Medium	6th - 8th Priority	**8**
	9th -11th Priority	**7**
Low	12th and 13th Priority	**6**
	14th Priority	**5**

Average Percent Impervious Priority		**Index Score Value**
High	1st Priority	**5**
Medium	2nd Priority	**4**
	3rd Priority	**3**
	4th Priority	**2**
Low	5th Priority	**1**

Percent Area Canopy Cover Priority		**Index Score Value**
High	1st Priority	**5**
Medium	2nd Priority	**4**
	3rd Priority	**3**
	4th Priority	**2**
Low	5th Priority	**1**

Direct CSO Drainage Priority		**Index Score Value**
High	1st Priority	**2**
Low	2nd Priority	**1**

Figure III-36: Final Catchment Prioritization Index – Raw Combined Index Score

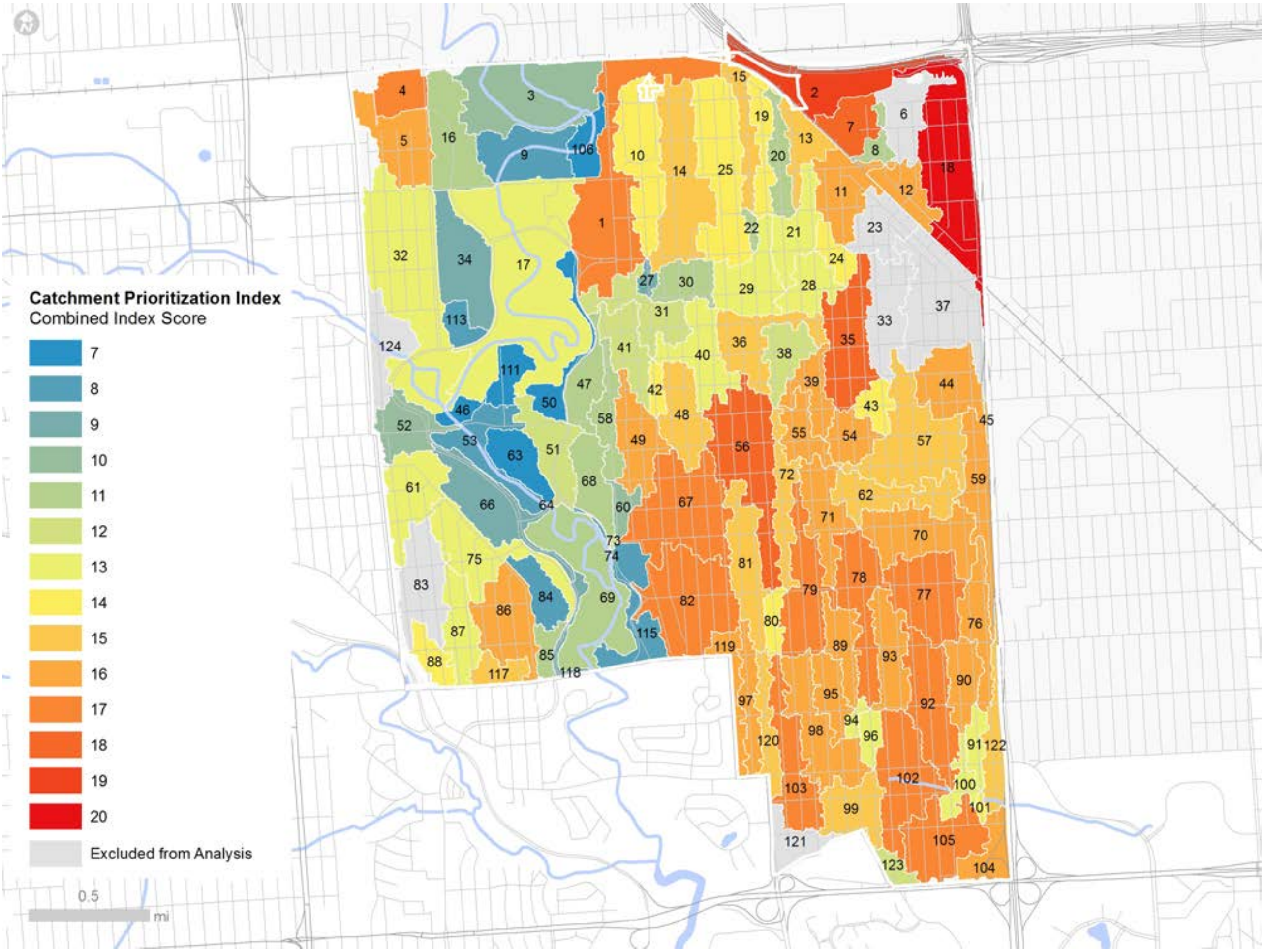


Figure III-37: : Final Catchment Prioritization Index – Aggregated Combined Index

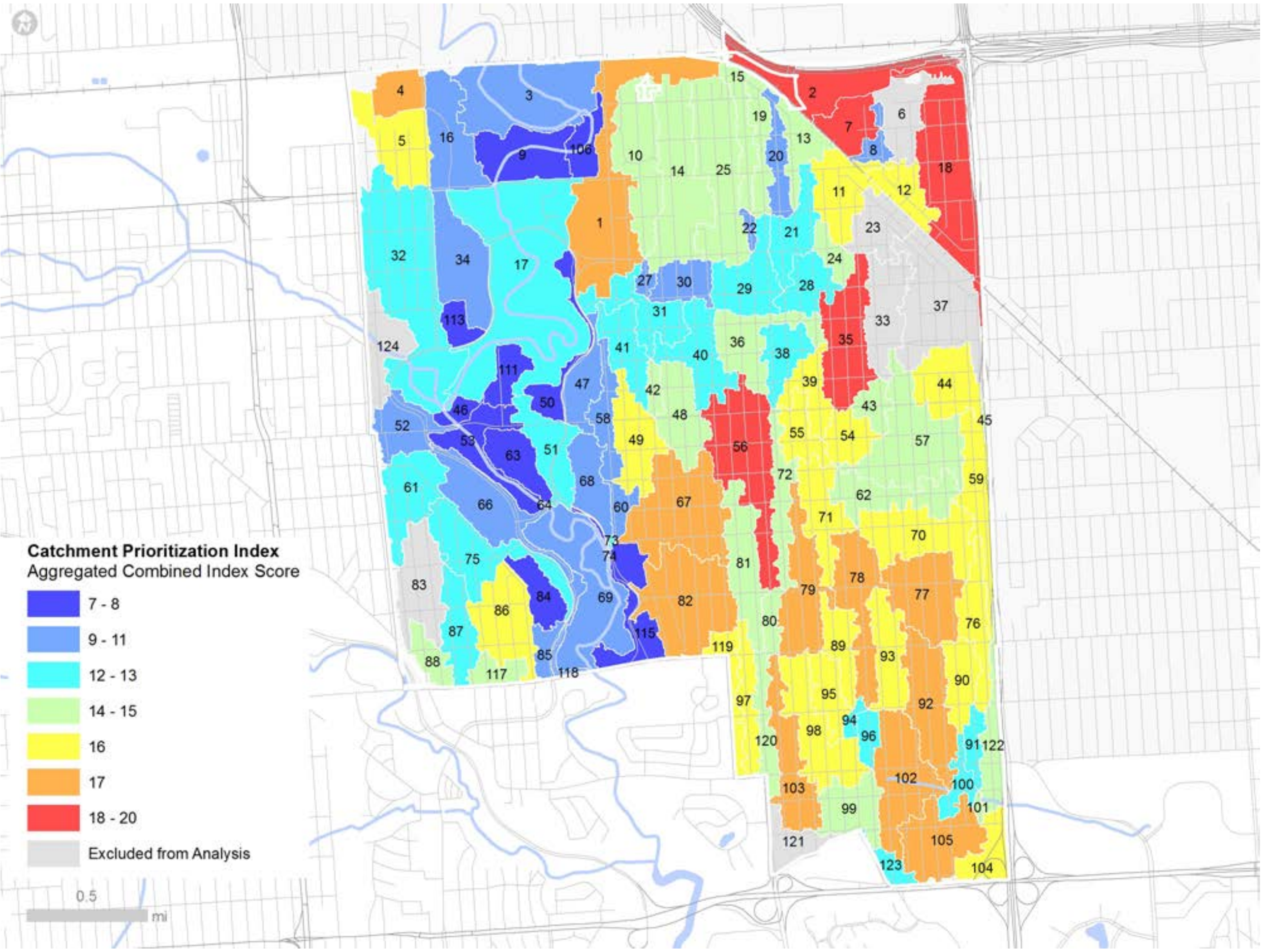


Figure III-38: Ranked Priority Areas

Because catchment boundaries are curvilinear, they do not correspond with areas within the residential block grid. To simplify these areas, first, second, and third ranked priority areas were developed to better evaluate block conditions.

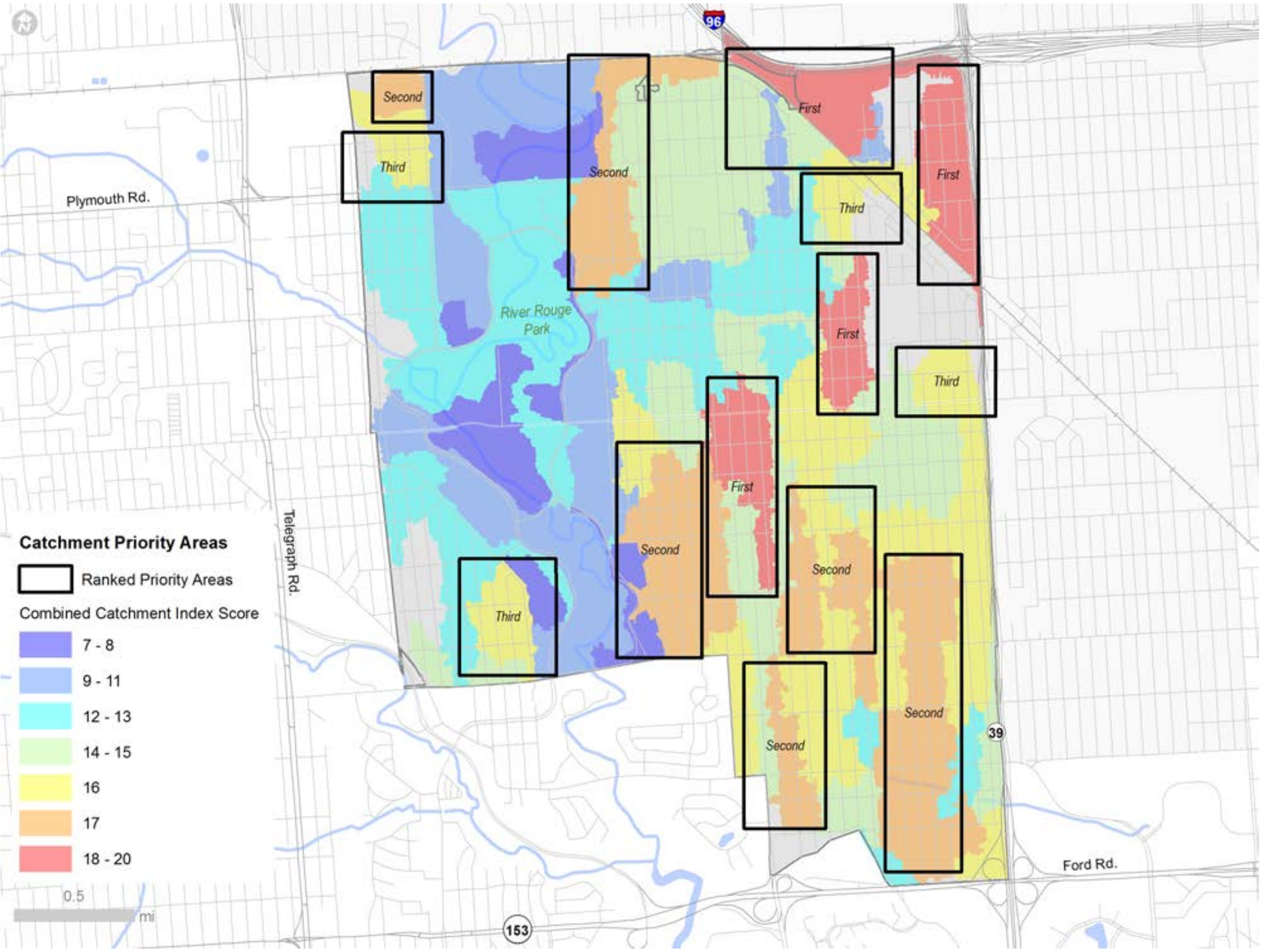


Figure III-39: Final Catchment Prioritization Index – Aggregated Combined Index Score for Shoreline Catchments

A few smaller residential areas fall within the low ranking shoreline catchments, which offer opportunities for green infrastructure along the River Rouge. These areas have the greatest potential for reducing stormwater at the source of the river and can assist in reducing stream bank erosion and sedimentation along the River Rouge. In order better evaluate green infrastructure opportunities in these areas, the catchments that are located immediately adjacent to the River Rouge were isolated and aggregated to show their relative priority.

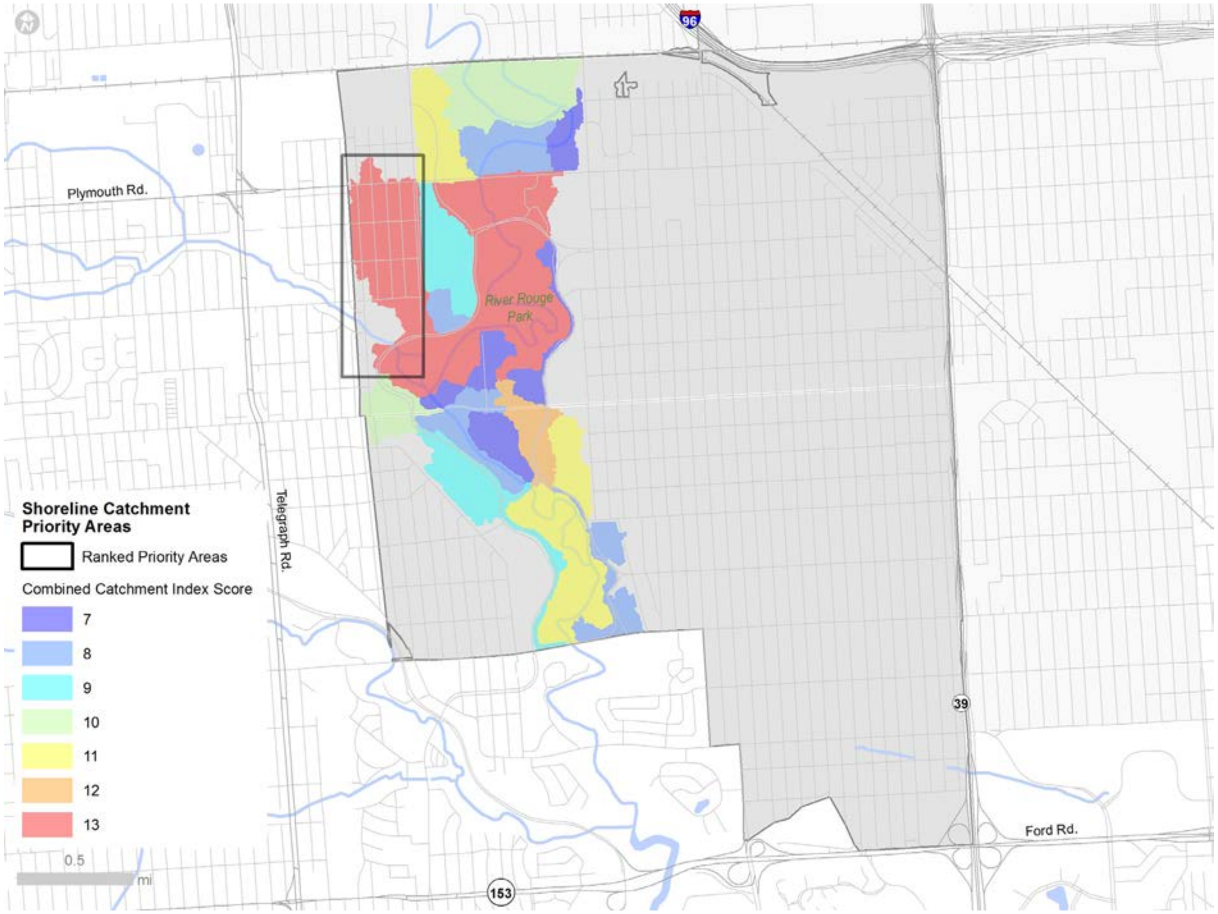
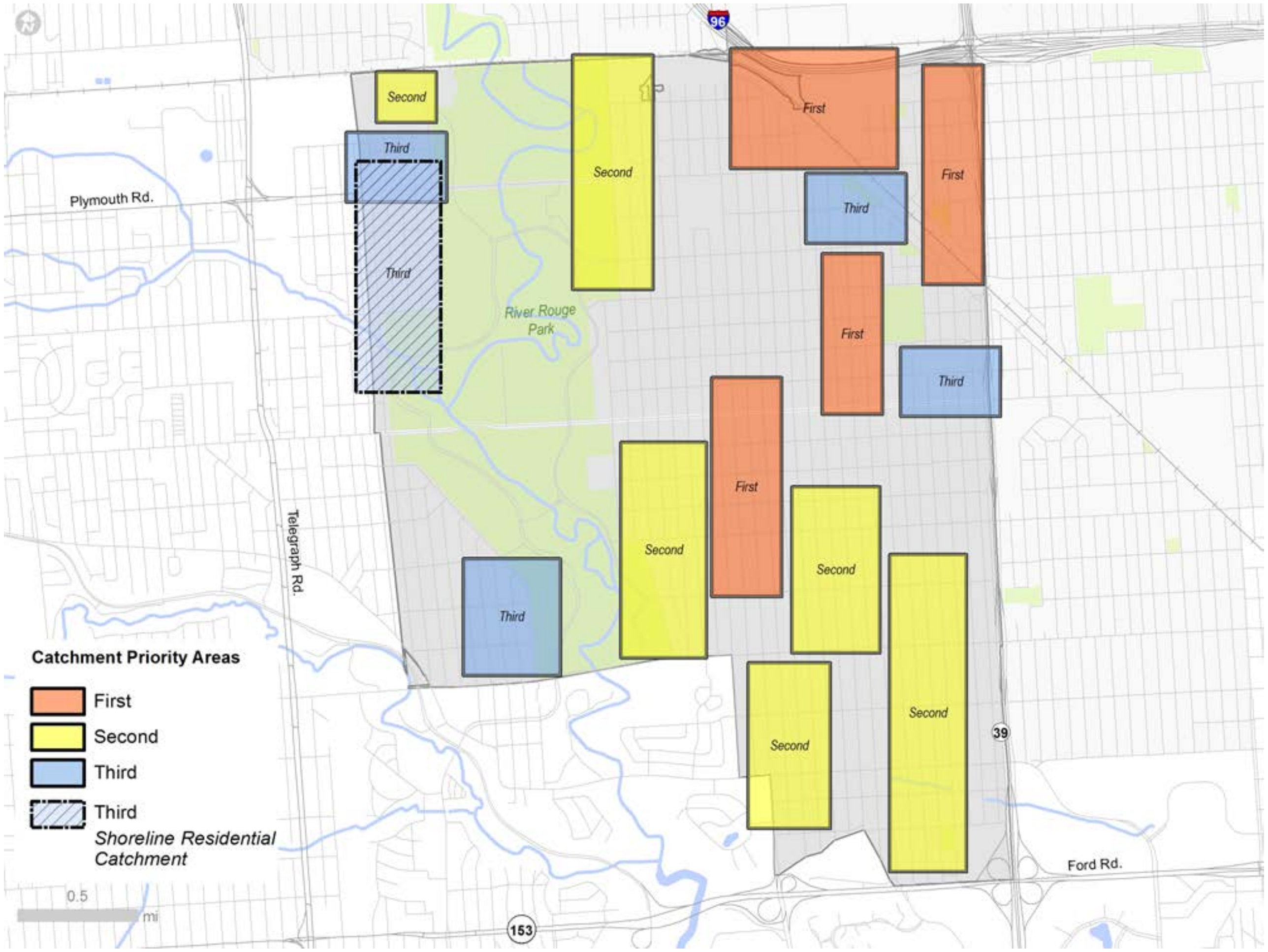


Figure III-40: Ranked Priority Areas without Catchments



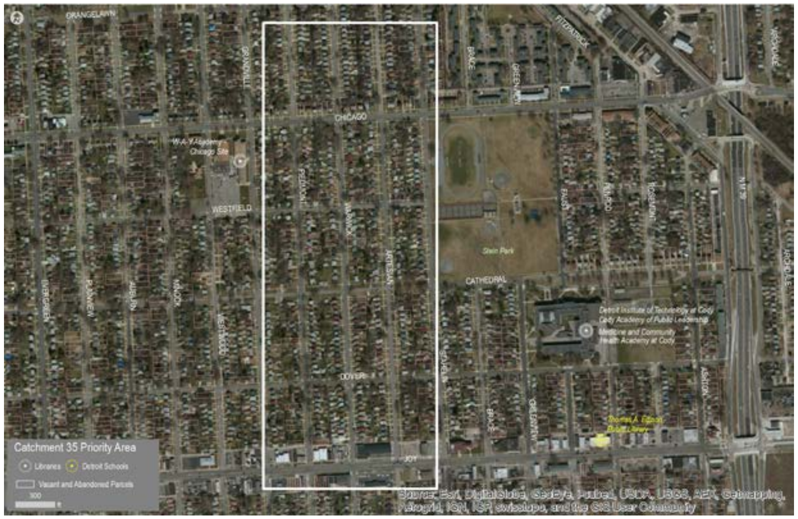
In order to visually assess the conditions of the priority areas, the first and second ranked zones were mapped at a finer scale.

Figure III-41: Fine Scale Priority Zone/Catchment Index

Figure III-42: First Ranking Priority Zone – Catchment 56

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure III-43: First Ranking Priority Zone – Catchment 35



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure III-44: First Ranking Priority Zone – Catchment 18

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

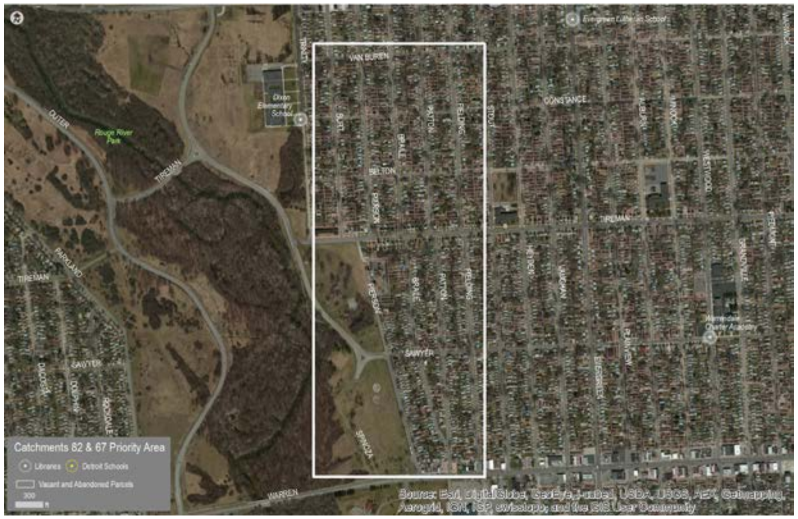
Figure III-45: First Ranking Priority Zone – Catchments 2 and 7

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure III-46: Second Ranking Priority Zone – Catchments 77, 78, 79, 92, 102, 103, and 105

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure III-47: Second Ranking Priority Zone – Catchments 67 and 82



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure III-48: Second Ranking Priority Zone – Catchment 1

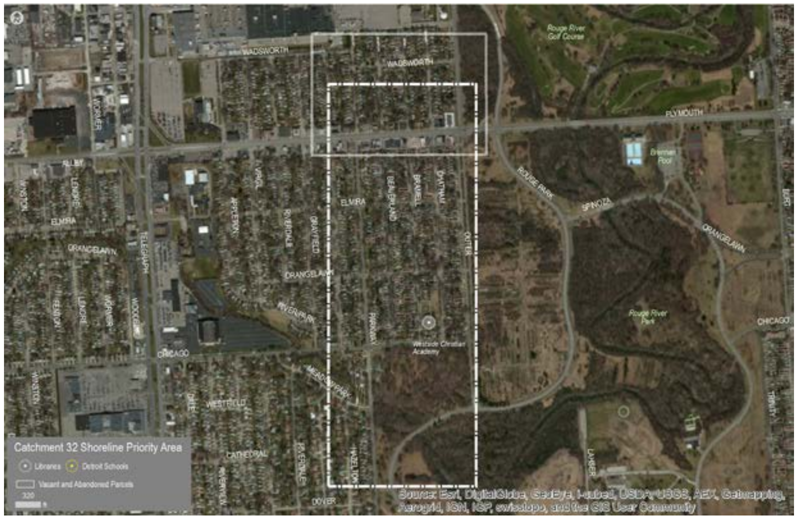
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure III-49: Second Ranking Priority Zone – Catchment 4

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

While the Catchment 4, second ranking priority is predominantly comprised of a parking lot near the automotive production facility on the northwest corner of the Cody Rouge study area, it is immediately adjacent to two predominantly residential areas and the River Rouge Park and Golf Couse. This massive expanse of impervious area is contributing a significant volume of stormwater to the system and source controls located within or near this area could provide some mitigation.

Figure III-50: First Ranking Shoreline Residential Zone



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

While this area represents a third ranking zone in the combined catchment prioritization index, it is a high-ranking shoreline area comprised of predominantly residential properties. Source control green interventions located in this area could provide significant erosion control and flood mitigation immediately adjacent to the River Rouge.

The priority zones determined by the Catchment Prioritization Model will be combined with the results from the second phase of this project, to make recommendations about specific green infrastructure interventions on vacant and abandoned parcels.

IV.

MODEL TWO DEVELOPMENT

Parcel Prioritization of Vacant and Abandoned Land

IV. MODEL TWO DEVELOPMENT
Parcel Prioritization of Vacant and Abandoned Land

Model Purpose

At its peak, development demand in Detroit was high and the city expanded with little regard for natural systems and ecological connectivity. Today, the results of Detroit's economic decline can be observed in the highly vacant residential neighborhoods across the city. These areas, including Cody Rouge, have limited potential to attract financial investment. Additionally, residents living in these neighborhoods are surrounded by large vacant areas and abandoned structures that pose legitimate concerns for safety and contribute to a sense of hopelessness, isolation, stigmatization, and undermine neighborhood social capital (Nasauer & Raskin 2014). Land planning strategies in Cody Rouge must consider approaches for stabilizing vacant land that are locally appropriate, realistic, economically feasible, and provide a higher quality of life for the remaining residents. Green infrastructure strategies guide planning frameworks to manage landscape change rather than growth and development in highly vacant neighborhoods. Building on this premise, surplus real estate or vacant lots can be utilized for their multifunctional potential to serve as productive landscapes to expand and connect parks and green spaces, restore urban tree canopy, reclaim badly damaged ecosystems, manage storm water, and optimize the function of deteriorating infrastructure (Schwarz 2011, Dewar 2012). Landscape interventions on vacant lots that appear to be managed and maintained for some functional purpose will likely signify order, care, neighborliness, and an ongoing human presence that can contribute to increased neighborhood stability (Nassaur & Raskin 2014). Additionally, green infrastructure strategies can respond to future uncertainty with long-term strategies and their form can be adapted to ongoing changes in real estate development demand as necessary (Schwarz 2011). Essentially, green infrastructure presents an opportunity to manage change toward the larger goal of achieving long-term ecosystem services at a time when real estate markets are weak (Nassauer 2008). It can be utilized as a flexible, low-cost holding strategy for that assists in neighborhood stabilization while improving citywide natural systems and providing ecosystem services that improve water management and reduce the burden on deteriorating infrastructure.

While the Catchment Prioritization Model identifies broad-scale priority areas for green infrastructure in the Cody Rouge neighborhood based on the need to manage and reduce stormwater loading, the Vacant Land Parcel Prioritization Model identifies finer-scale vacant and abandoned parcels and clusters of parcels within those areas.

The prioritization criteria for parcels attempts to integrate the vision of citywide and neighborhood planning initiatives with research on green infrastructure for vacant land management and the foundational principles for socio-ecological planning that consider urban ecology. Additionally, parcel size has implications for the type of green infrastructure intervention that can be implemented. Larger areas of land offer opportunities for more intensive green infrastructure and stormwater management while smaller parcels provide replicable opportunities for smaller scale infiltration. In order to recommend appropriately scaled green infrastructure, the development of the Vacant Land Parcel Prioritization Index includes a model for identifying adjacent clusters of vacant and abandoned parcels that can support varied green purposes.

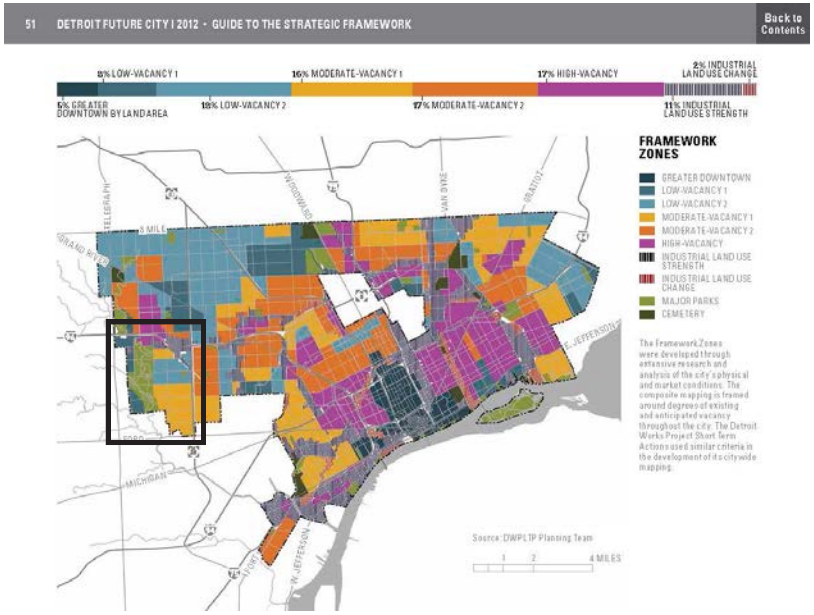
Integration

Parcel-based designs for green infrastructure are most effective when they can be aligned with a citywide vision (Schwarz 2011). The Detroit Future City Framework Plan, the SEMCOG Green Infrastructure Vision for Southeastern Michigan, the Detroit Regional Water and Sewer District (DWSD) Green Infrastructure Program, and the Skillman Good Neighborhood Initiative, prioritize planning strategies for the city of Detroit that provide recommendations for managing and stabilizing vacant neighborhoods.

The Detroit Future City Framework Plan recognizes vacant land as the city's greatest and most challenging asset (City of Detroit 2012). By addressing vacancy as part of a broad scale land use plan, this framework acknowledges the limitations of a centralized infrastructure that is deteriorating and unable to serve city inhabitants. By transforming vacant land in ways that increase value and productivity and promote long-term sustainability, Detroit Future City focuses on "right-sizing" strategies for a smaller population with surplus vacant land that are efficient, affordable, and better performing. Through the development of citywide Framework Zones determined by vacancy conditions, neighborhood identity, and physical separation created by major pieces of infrastructure or variations in land use, Detroit Future City provides a basis for developing land use strategies and citywide decisions. These zones are intended to be used when informing finer-grain analysis within city neighborhoods. Much of the Cody Rouge Neighborhood is defined as Low Vacancy 2 and Moderate Vacancy 1, both of which are characterized as predominantly residential neighborhoods that should be maintained but re-envisioned. The leading proposal for Cody Rouge is to -

transform the neighborhood into a land use typology defined as "Green Residential." Green Residential neighborhoods optimize vacant and underused land as a "canvas of green" that supports single- and multifamily residential with community maintained recreational spaces, productive landscapes, and blue/green infrastructure. Specific blue/green infrastructure strategies for Green Residential areas with low to moderate vacancy include: industrial buffers, carbon forests, stormwater boulevards, small retention, and low-lying lakes (City of Detroit 2012). Available land could also be developed as community open space and transitional landscapes (Figure IV-1).

Figure IV-1: Detroit Future City Framework Zones
Source: City of Detroit. (2012, December). Detroit future city: Detroit Strategic Framework Plan



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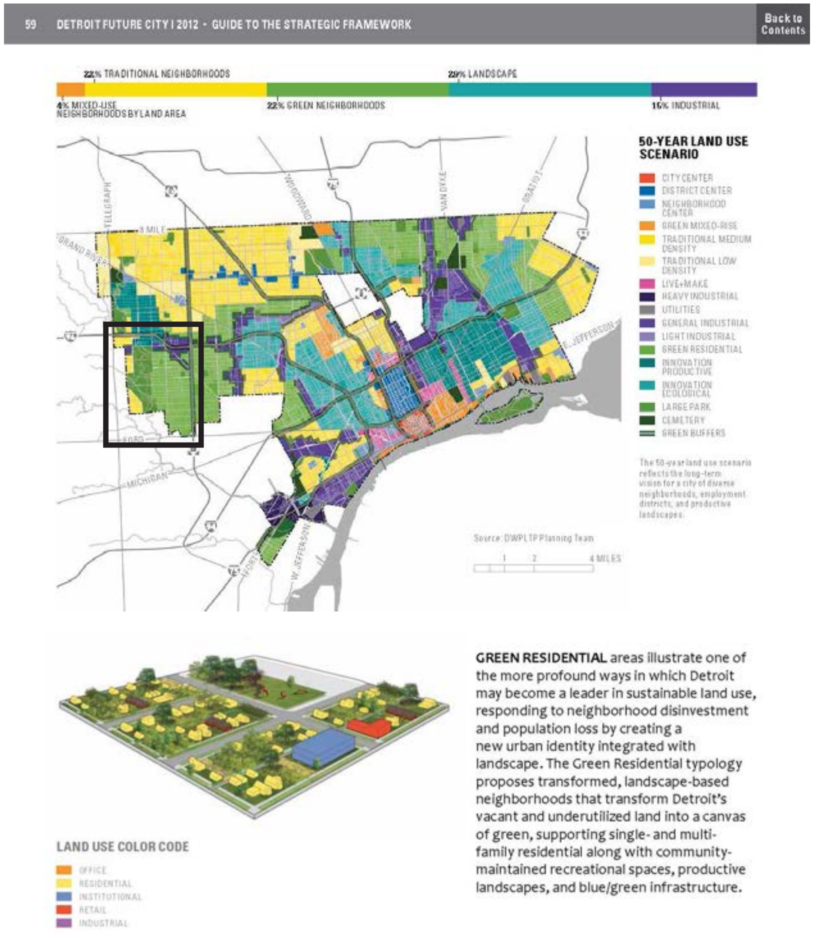
The Framework Zones were developed through extensive research and analysis of the city's physical and market conditions. The composite mapping is framed around degrees of existing and anticipated vacancy throughout the city. The Detroit Works Project Short Term Actions used similar criteria in the development of its citywide mapping.

Figure IV-2: Detroit Future City Proposed Land Use: Green Residential
Source: City of Detroit. (2012, December). Detroit future city: Detroit Strategic Framework Plan



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22% TRADITIONAL NEIGHBORHOODS

29% LANDSCAPE

4% MIXED-USE NEIGHBORHOODS BY LAND AREA

22% GREEN NEIGHBORHOODS

16% INDUSTRIAL

50-YEAR LAND USE SCENARIO

- 🟥 CITY CENTER
- 🟦 DISTRICT CENTER
- 🟦 NEIGHBORHOOD CENTER
- 🟧 GREEN MIXED-RISE
- 🟨 TRADITIONAL MEDIUM DENSITY
- 🟨 TRADITIONAL LOW DENSITY
- 🟪 LIVE+MAKE
- ⬛ HEAVY INDUSTRIAL
- ⬜ UTILITIES
- 🟪 GENERAL INDUSTRIAL
- 🟪 LIGHT INDUSTRIAL
- 🟩 GREEN RESIDENTIAL
- 🟩 INNOVATION PRODUCTIVE
- 🟦 INNOVATION ECOLOGICAL
- 🟩 LARGE PARK
- ⬛ CEMETERY
- ═ GREEN BUFFERS

The 50-year land use scenario reflects the long-term vision for a city of diverse neighborhoods, employment districts, and productive landscapes.

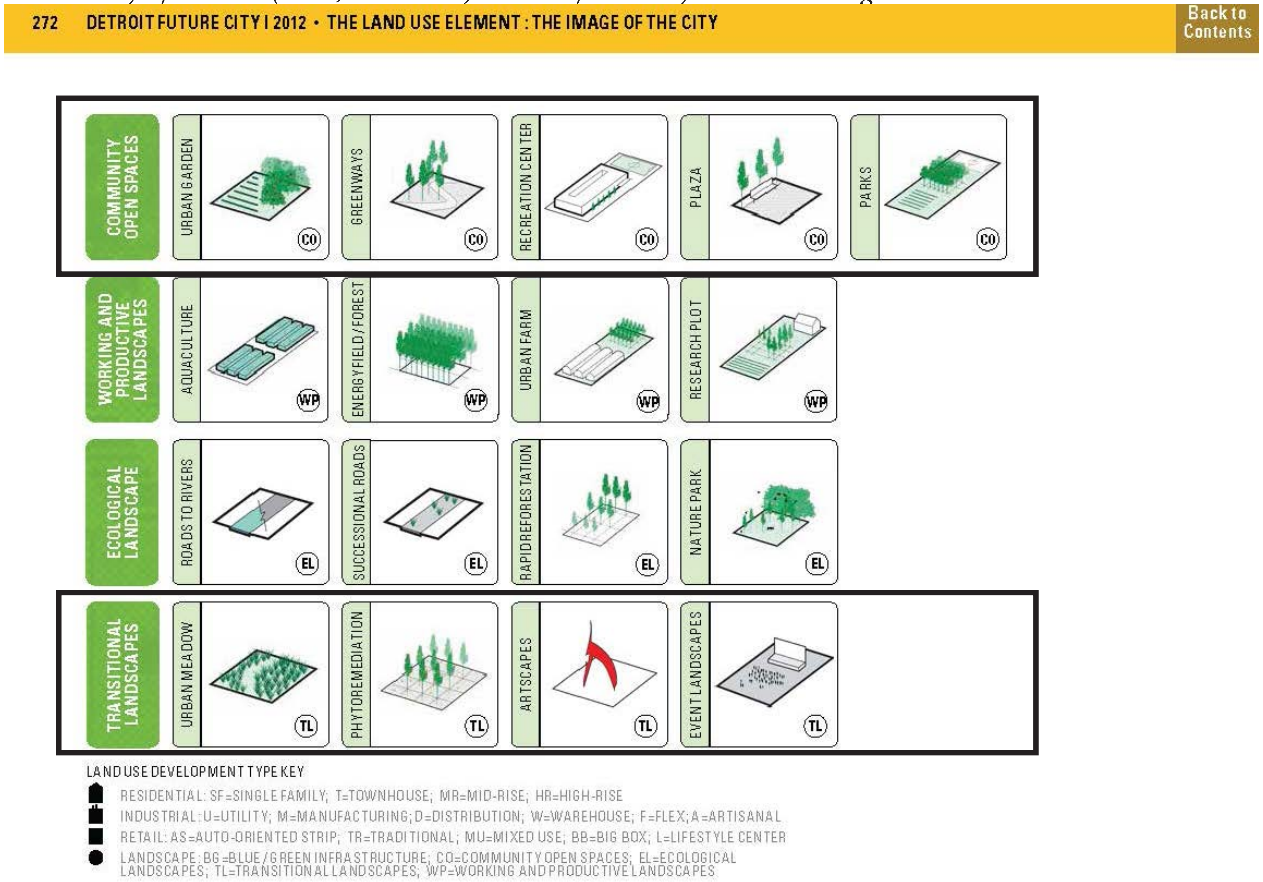
Source: DWPLTP Planning Team

GREEN RESIDENTIAL areas illustrate one of the more profound ways in which Detroit may become a leader in sustainable land use, responding to neighborhood disinvestment and population loss by creating a new urban identity integrated with landscape. The Green Residential typology proposes transformed, landscape-based neighborhoods that transform Detroit's vacant and underutilized land into a canvas of green, supporting single- and multi-family residential along with community-maintained recreational spaces, productive landscapes, and blue/green infrastructure.

LAND USE COLOR CODE

- 🟧 OFFICE
- 🟨 RESIDENTIAL
- 🟦 INSTITUTIONAL
- 🟥 RETAIL
- 🟪 INDUSTRIAL

Figure IV-3: Land Use Development Types
Source: City of Detroit. (2012, December). Detroit future city: Detroit Strategic Framework Plan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LAND USE DEVELOPMENT TYPE KEY

RESIDENTIAL: SF=SINGLE FAMILY; T=TOWNHOUSE; MR=MID-RISE; HR=HIGH-RISE

INDUSTRIAL: U=UTILITY; M=MANUFACTURING; D=DISTRIBUTION; W=WAREHOUSE; F=FLEX; A=ARTISANAL

RETAIL: AS=AUTO-ORIENTED STRIP; TR=TRADITIONAL; MU=MIXED USE; BB=BIG BOX; L=LIFESTYLE CENTER

LANDSCAPE: BG=BLUE/GREEN INFRASTRUCTURE; CO=COMMUNITY OPEN SPACES; EL=ECOLOGICAL LANDSCAPES; TL=TRANSITIONAL LANDSCAPES; WP=WORKING AND PRODUCTIVE LANDSCAPES

The SEMCOG Green Infrastructure Vision for Southeast Michigan (2014) prioritizes green infrastructure as a both a short and long term holding strategy for vacant land. Specific prioritization strategies for vacant parcels are outlined in this framework and include:

- Providing access to public waterways and increasing riparian corridors
- Buffering high-quality areas such as wetlands
- Increasing connectivity of the green infrastructure network through linking public parks
- Managing stormwater runoff from roadways by moving it into vacant lots
- Greening individual vacant lots
- Planning for large-scale green infrastructure that requires land assembly (SEMCOG 2014)

The SEMCOG Green Infrastructure Vision distinctly calls attention to the challenges of large-scale green infrastructure implementation in areas where there are multiple land owners. In order to efficiently implement and assemble green infrastructure in southeast Michigan, publicly owned land that is managed by a land bank or other entity that has taken on the role of land assembly, provides the greatest opportunity for green infrastructure development (SEMCOG 2014).

In coordination with the initiatives of both the Detroit Future City Framework and the SEMCOG Green Infrastructure Vision, The Detroit Water and Sewerage District (DWSD) is actively investing in vacant lots to reduce stormwater from entering the sewer system. As part of its agreement to meet federal regulatory standards provisioned by the U.S. Environmental Protection Agency (USEPA) and to protect the Rouge River, DWSD has developed a Green Infrastructure Plan as part of its Stormwater Management Program to supplement high-cost grey infrastructure initiatives with lower cost green infrastructure that assist in system optimization (City of Detroit, DWSD 2013). In partnership with Greening of Detroit, DWSD is currently working with residents to select and and transform vacant lots into green infrastructure. Three projects to date have been implemented in the Cody Rouge Neighborhood (Tireman Ave., Artesian St., and Keeler Ave.) but the process for selecting and prioritizing these sites has not been made publicly available. Additionally, DWSD has not provided a citywide or long-term strategy for targeting priority vacant lots. This project aims to provide a more strategic approach for meeting these goals.

Process, Methods, and Assumptions

Phase One:
1.Identify and isolate vacant and abandoned parcels in the Cody Rouge Neighborhood
2.Build Vacancy Cluster Model: identify vacant and abandoned clusters and define appropriate/feasible GI strategies

Phase Two:
3.Build Ecological Vacant Parcel Prioritization Index

Phase Three:
4.Build Social Vacant Parcel Prioritization Index
5.Build Combined Vacant Parcel Prioritization Index
6.Determine Priority Vacant Parcel opportunities and visually assess results

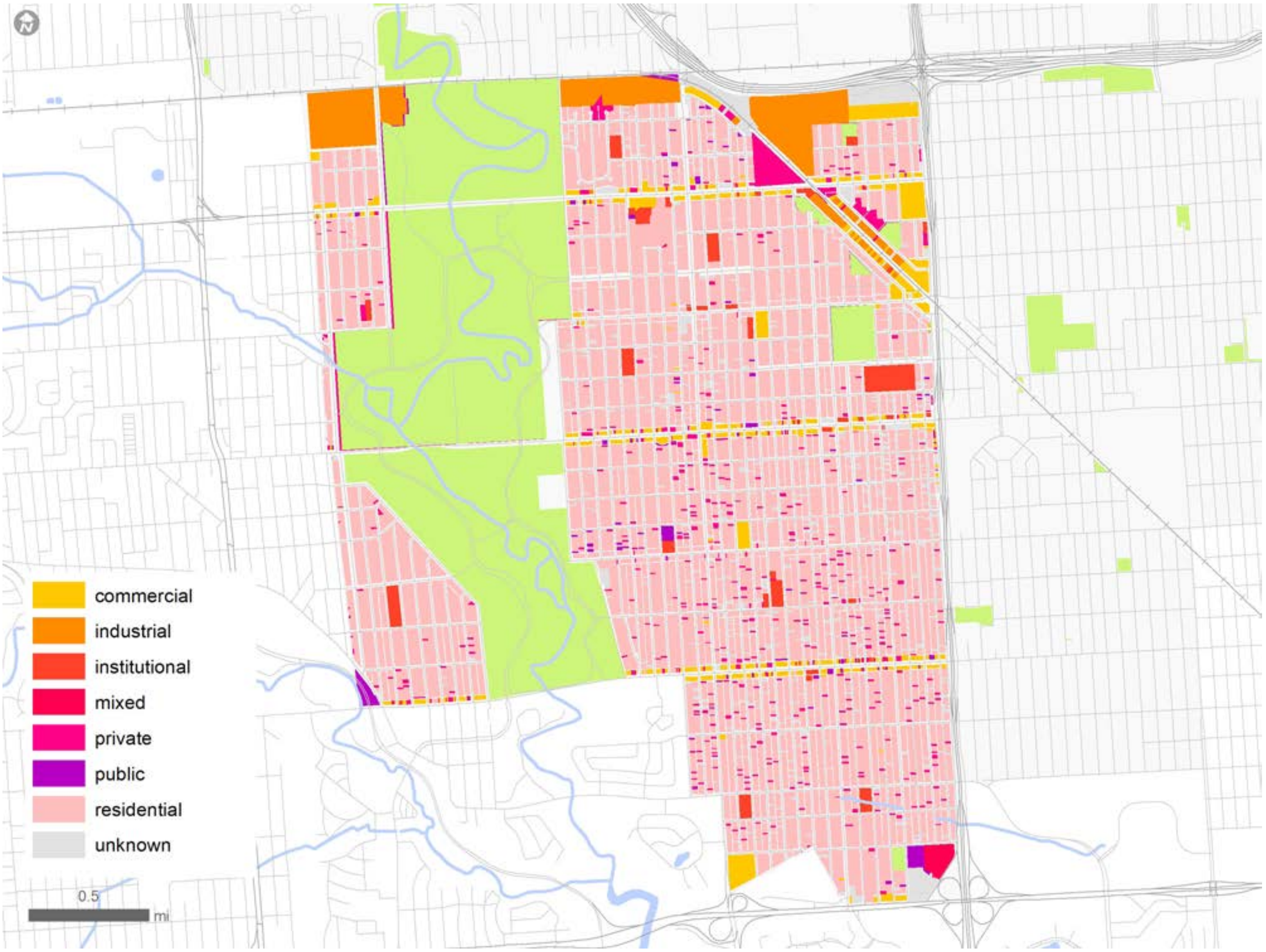
Phase One

Classification of Vacant and Abandoned Parcels

The parcel dataset used in this analysis was obtained from Data Driven Detroit (D3) and represents the official certified results from the Motor City Mapping (MCM) comprehensive parcel survey, conducted between December 2013 and February 2014. From the citywide dataset, vacant and abandoned parcels contained within the Cody Rouge neighborhood boundary were extracted.

Within the Cody Rouge neighborhood, there are 17,034 parcels. The map below shows these parcels characterized by MCM land use categories.

Figure IV-4: MCM Parcel Distribution - Cody Rouge Land Use



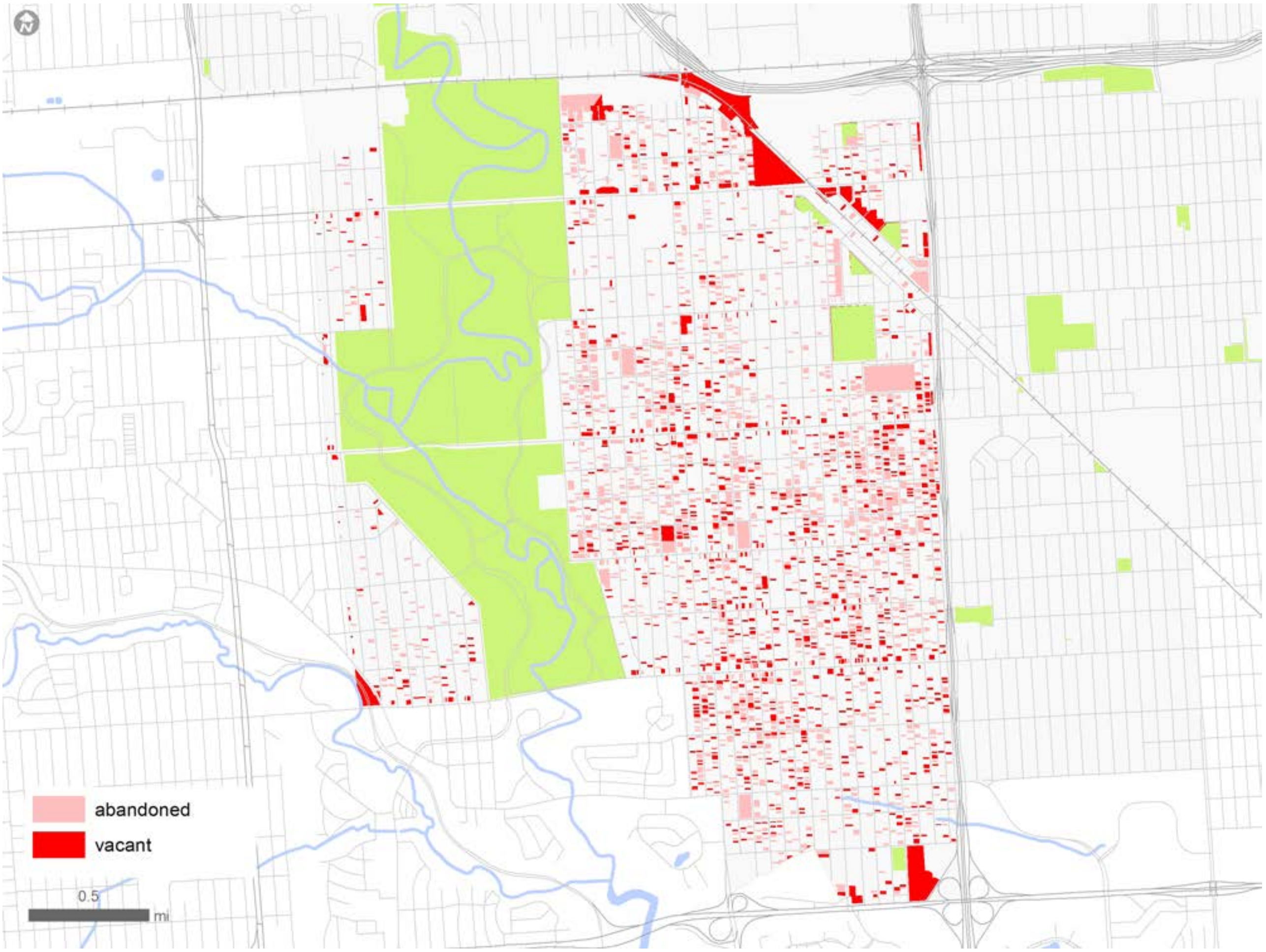
Parcels containing vacant lots and abandoned structures were extracted from the complete parcel dataset and functioned as the primary input for the analyses involving green infrastructure siting and feasibility.

Abandoned parcels were classified based on the MCM 'Structure' and 'Occupancy' designations. From the MCM parcel database. All parcels containing a 'Yes (Permanent structures or buildings, including garages and sheds, that are not moveable)' designation for 'Structure' and an 'Unoccupied (Common characteristics are: neglected facades, eviction notices, empty interiors, substantial physical or structural damages, extensive security measures, uncut or tall grass, weeds, scrub trees, trash or debris accumulated over time, accumulated flyers on the porch or door, and so on)' designation for 'Occupancy' were classified as abandoned. This resulted in 2,412 abandoned parcels within the Cody Rouge neighborhood.

Vacant parcels were categorized based on a 'No (The lot is empty of structures, but it may be paved or have fences, a swimming pool, cars, or any other movable object) designation for the 'Structure' category. This resulted in 1,381 parcels within the Cody Rouge neighborhood. These two groups of parcels were merged to form a single green infrastructure opportunity dataset that **3,79**5 parcels. The following map shows the occurrence of these designations in the Cody Rouge neighborhood.

The vacant parcels extracted from the MCM Parcel dataset are typically empty lots that could be described as open space. Abandoned parcels, which contain 'unoccupied' structures, are characterized by the MCM survey as having "neglected facades, eviction notices, empty interiors, substantial physical or structural damages, extensive security measures, uncut or tall grass, weeds, scrub trees, trash or debris accumulated over time, accumulated flyers on the porch or door, and so on." These parcels will likely be considered for demolition and reclassified as part of the open space network, presenting additional opportunities for green infrastructure.

Figure IV-5: Cody Rouge Vacant and Abandoned Parcels – Green Infrastructure Opportunities



Development of Vacant Land Cluster Model

Parcel size has implications for the type of green infrastructure intervention that can be implemented. Larger areas of land offer opportunities for more intensive green infrastructure and stormwater management while smaller parcels provide replicable opportunities for smaller scale infiltration. In order to recommend appropriately scaled green infrastructure, the development of the Vacant Land Parcel Prioritization Index includes the identification of contiguous clusters of vacant and abandoned parcels that can support varied green purposes.

The functional goals of green infrastructure, for the purposes of this project, are to maximize infiltration, evapotranspiration, detention, and retention of stormwater using vacant and abandoned parcels in the Cody Rouge neighborhood. Proposed green infrastructure strategies are recommended for their ability to reduce urban contaminants in air, water, and soil while minimizing implementation costs and maintenance as part of a long-term strategy for stormwater management.

A multidisciplinary project by Austin et al. (2013), developed six best management practices (BMPs) specific for vacancy and abandonment in the Lower East Side neighborhood of Detroit. These BMPs were designed to provide appropriately scaled stormwater management strategies that respond to the quantity of "within block" contiguous vacant parcels. Smaller aggregations of vacant parcels within relatively populated areas are characterized by mown lots with colorful flowers, while larger expanses of vacant property efficiently capture, infiltrate, and transpire stormwater through well-organized urban woodlots, but could also provide space for alternative designs that require more land area. Because this project aims to integrate existing proposals and build on academic research to provide a prioritization strategy for green infrastructure siting, the Austin et al. BMP designations are used to identify contiguous parcels of vacant land in the Cody Rouge neighborhood.

Building on the work of the Austin et al. (2013), contiguous groups of vacant or abandoned parcels were classified in the Vacant Land Cluster Model, based on size, as one of the seven BMP types listed below:

- Bioretention 1: A singular vacant lot or abandoned property with structure with a minimal design intervention that requires re-grading and planting and is estimated to capture approximately 1,774 cubic feet of stormwater.

- Bioretention 2: Two contiguous vacant lots or abandoned properties with structures with minimal design interventions that require re-grading and planting and are estimated to capture approximately 4,807 cubic feet of stormwater.

- Bioretention 3: Three contiguous vacant lots or abandoned properties with structures with minimal design interventions that require re-grading and planting and are estimated to capture approximately 7,840 cubic feet of stormwater.

- Infiltration Garden: A singular vacant lot containing an abandoned property with a structure that could be demolished. The design intervention utilizes the foundation of the demolished structure for temporary stormwater retention during peak flow rain events and is estimated to capture approximately 2,560 cubic feet of stormwater through re-grading and planting, similar to bioretention interventions.

- Small Lot: Four to nine contiguous vacant lots or abandoned properties with structures that can be used for more intensive stormwater management while providing open space and/or recreational opportunities.

- Medium Lot: Ten to twenty contiguous vacant lots or abandoned properties with structures that can be used for more intensive stormwater management while providing open space and/or recreational opportunities.

- Large Lot: Twenty-one or more contiguous vacant lots or abandoned properties with structures that can be used for more intensive stormwater management while providing open space and/or recreational opportunities.

In order to classify the Cody Rouge vacant and abandoned parcels into these seven types, the Vacant Land Cluster Model was built using ArcGIS and the 2014 MCM vacant and abandoned parcel dataset. The flow chart below describes this process:

Figure IV-6: Vacant Land Cluster Model Development

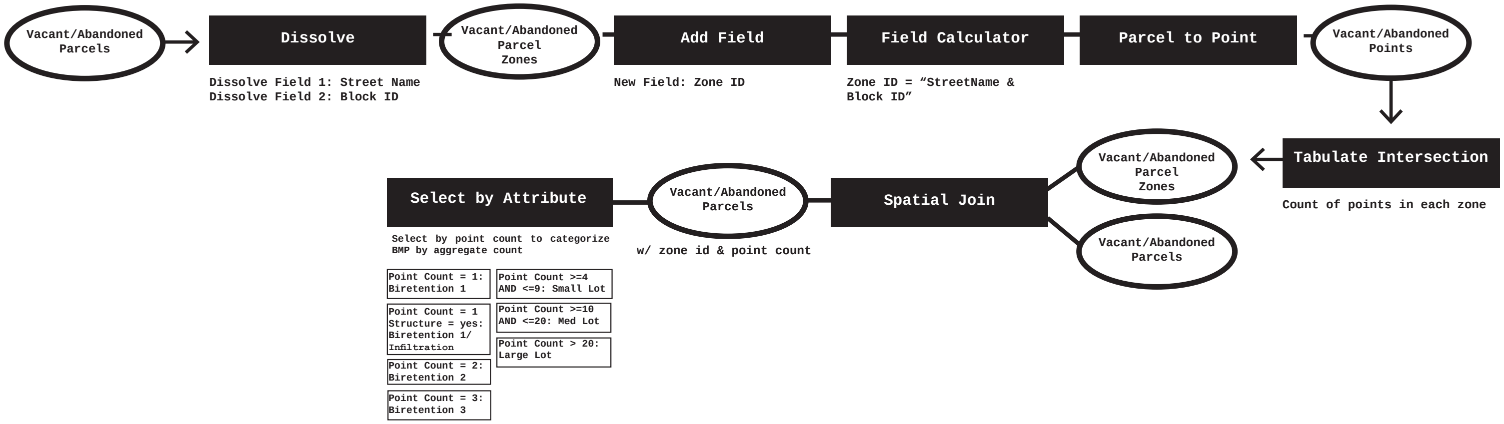


Figure IV-7: Distribution of GI Types - Vacant Land Cluster Model

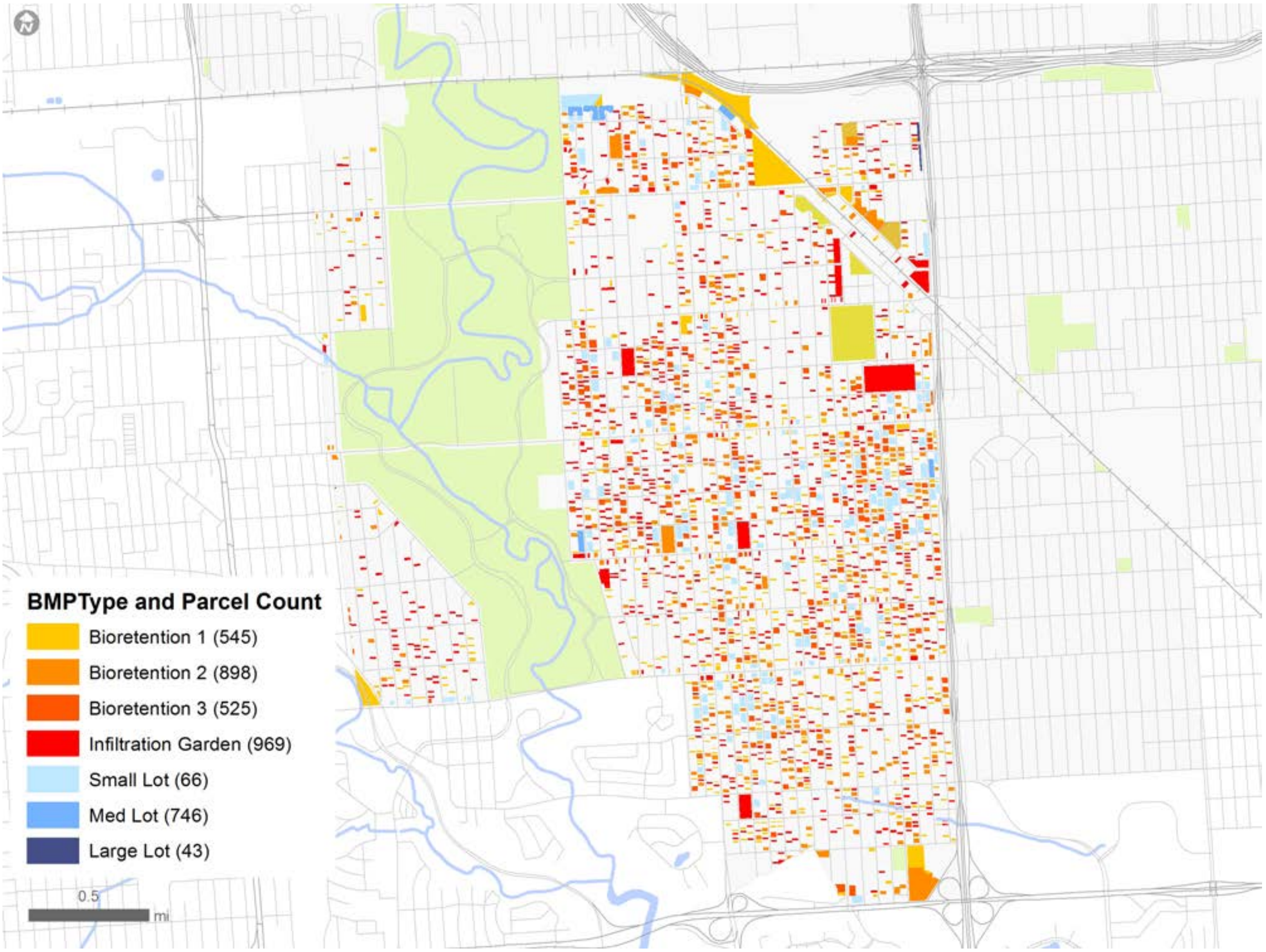


Table IV-1: Parcel Count and Total Area by GI Type - Vacant Land Cluster Model

BMP Type	Parcel Count	Area Cody Rouge Neighborhood (acres)
Bioretention 1	545	137.28
Bioretention 2	898	130.14
Bioretention 3	525	59.33
Infiltration	969	150.88
Small Lot	746	82.30
Medium Lot	66	7.89
Large Lot	43	1.05

The BMP designations identified by the Vacant Land Cluster Model are combined with the results of the Vacant Land Prioritization Index to make recommendations about green infrastructure siting in Cody Rouge.

Phase Two

An Overview of Ecosystem Services

Ecosystem services can be generally described as the benefits that people obtain from ecosystems, linking frameworks for conservation and development by relating environmental health to human health, security, and well-being (Brauman et al. 2007). The EPA more specifically defines ecosystem services as "the many life-sustaining benefits we receive from nature—clean air and water, fertile soil for crop production, pollination, and flood control (USEPA 2012).

Brauman et al. (2007) classify ecosystem services into four main categories: provisioning, regulating, cultural, and supporting services.

1. *Provisioning services* provide goods such as food, freshwater, timber, and fiber for direct human use. These ecosystem services are a familiar part of the economy.

2. *Regulating services* maintain a world in which it is biophysically possible for people to live and provide benefits such as pollination of crops, water damage mitigation, and climate stabilization.

3. *Cultural services* make the world a place in which people want to live; they include recreation as well as aesthetic, intellectual, and spiritual inspiration.

4. *Supporting services* are the underlying ecosystem processes that produce the direct services described above, including the preservation of options. These are intermediate services that include: waste decomposition and treatment, water supply regulation, and conservation for plant and animal diversity.

The Vacant Land Prioritization Index considers all four ecosystem service categories. When developing this model, ecosystem services that provide hydrologic services were of particular importance for prioritizing green infrastructure. Hydrologic services can improve the extractive and in-stream water supply, mitigate urban water quality, and provide additional cultural services and amenities. They can be defined by quality, quantity, location, and flow. Additionally, green infrastructure relies heavily on the ecosystem services provided by vegetation to support hydrologic services, including pollutant removal from overland flow to physically trap water and sediments, reducing water speed to enhance infiltration, biochemical transformation of nutrients and urban contaminants, and by absorbing water at the root zone to stabilize eroding stream banks (Brauman et al. 2007).

Cultural ecosystem services are also highly emphasized in the development of the Vacant Land Prioritization Index. While other ecosystem services are useful for justifying green infrastructure, they often exaggerate productive landscape potential, overshadowing the importance of cultural sustainability in landscape management. In the short-term, it is unlikely that large capital investments will be made in the Cody Rouge neighborhood to provide extensive landscape services, such as flood control or regional water management. The quality of life for residents, however, is an immediate concern that can be addressed by making changes to more flexible neighborhood services (Nassauer & Raskin 2014). In this project, the cultural services that are prioritized include: the perception and feasibility of landscape maintenance, attractiveness, safety, and visibility.

In Cody Rouge, extensive vacant land and blighted structures have a negative effect on landscape aesthetics, contributing to resident concerns for safety and undermining neighborhood social capital (Nasauer & Raskin 2014).

Green Infrastructure on vacant lots that is managed and maintained for some functional purpose will likely signify order, care, neighborliness, and an ongoing human presence that can contribute to increased positive landscape perception. Landscapes that evoke enjoyment or approval are likely to be culturally sustainable or, maintained over time. This in turn and over time, can lead to landscapes that are likely to be ecologically sustainable as well (Nassauer 1997).

Highly vacant landscapes should be conceptualized as socio-ecological systems. The Combined Vacant Parcel Prioritization Index for Cody Rouge merges variables that represent both social and ecological values in order to provide a holistic strategy for developing neighborhood green infrastructure.

Ecological Vacant Parcel Prioritization Index

Vacant and abandoned parcels were prioritized for their ability to support green infrastructure, provide ecosystem services, and enhance urban ecology. This assessment combined the following variables: topographic wetness, proximity to existing parks and green space, proximity to the floodplain, proximity to historical streams and wetlands, and proximity to approximated drainage inlets. Each variable is described in some detail pertaining to the relevant literature and characterized by the frequency distribution (histogram) of un-weighted, normalized values. These distributions were used to assist in the determination of ranking class break points for the Vacant Parcel Prioritization Index.

Topographic Wetness Index

The topographic wetness index (TWI) combines local upslope contributing area and slope based on the elevation, slope, flow accumulation, and flow direction values obtained from the 3-meter USGS digital elevation model (DEM). It is used to quantify topographic control on hydrological processes and predict landscape potential for soil surface saturation (Sörensen et al. 2006). Topographic wetness can be determined by combining upland catchment area with slope steepness using the following equation:

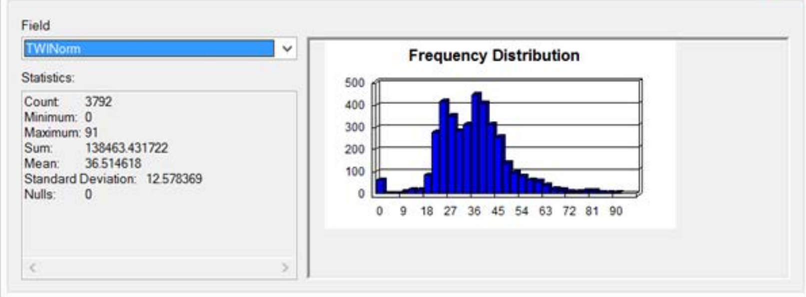
$$w = \ln(AS / \tan\beta)$$

Where:

w = the wetness index
ln is the natural logarithm operation
AS = upland catchment area (determined using flow accumulation and flow direction)
ß = slope steepness (in degrees)

For the Cody Rouge neighborhood, topographic wetness values were calculated using Raster Calculator in ArcGIS to produce a continuous raster surface for the study area. For each vacant and abandoned parcel, an average topographic wetness value was determined using Zonal Statistics. In order to combine these values with other variables in the Vacant Land Prioritization Index, the TWI values were rescaled and normalized as values between 0-1 using the Slice tool in ArcGIS. High values represent parcels where water is expected to accumulate and are therefore more feasible and for green infrastructure.

Figure IV-8: Cody Rouge Normalized Topographic Wetness Index Values – Distribution

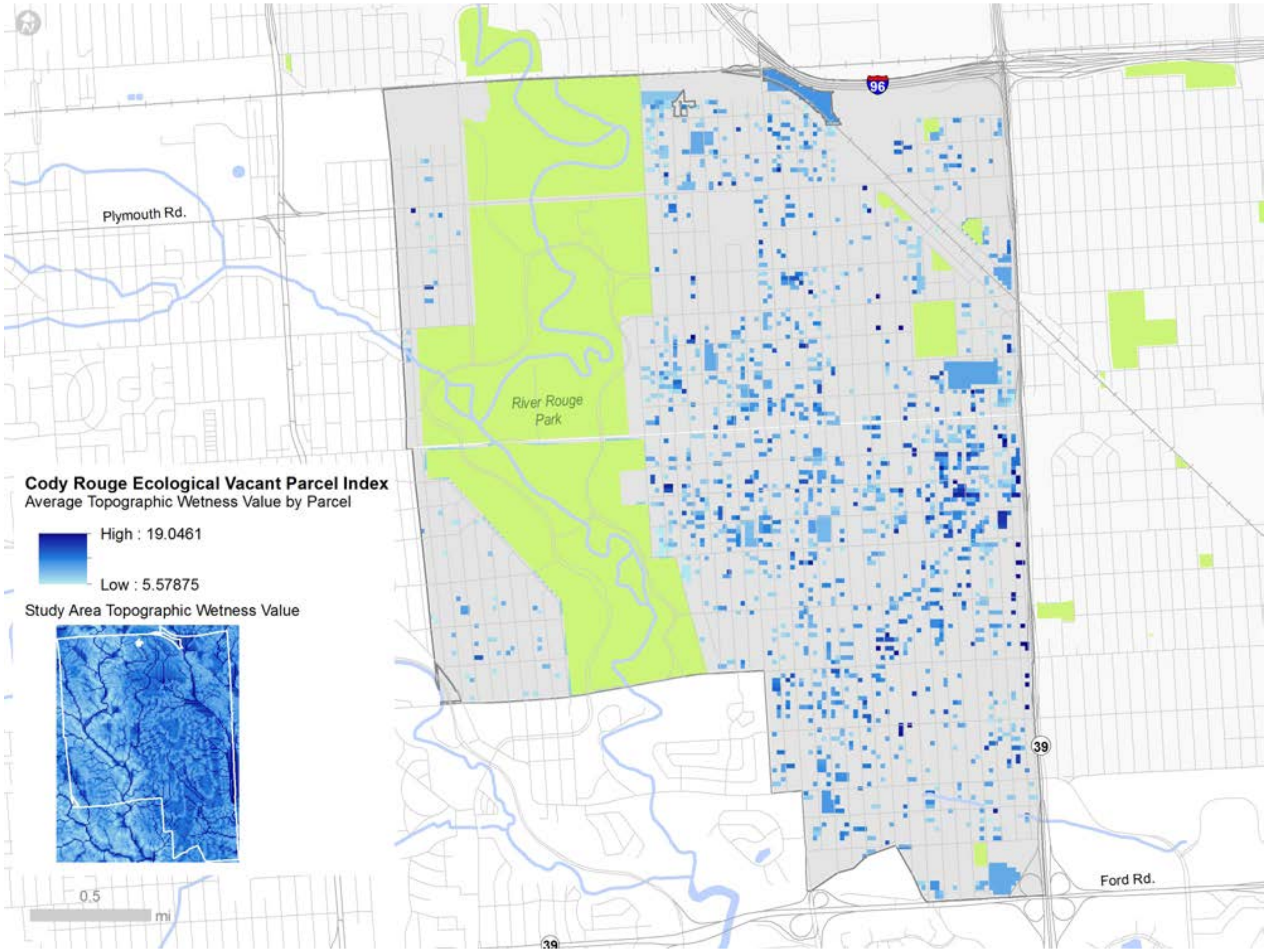


Field: TWINorm

Statistics:

Count: 3792
Minimum: 0
Maximum: 91
Sum: 138463.431722
Mean: 36.514618
Standard Deviation: 12.578369
Nulls: 0

Figure IV-9: Cody Rouge Map of Topographic Wetness



Proximity to parks and green space

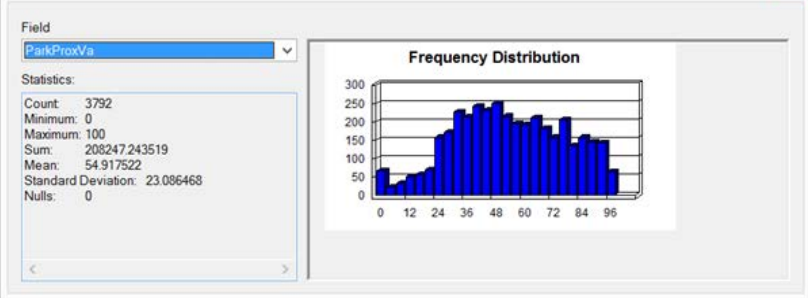
In order to maximize the ecological potential of green infrastructure, proposed interventions on vacant and abandoned parcels must be integrated with a regional network of green space. Such a network would attempt to connect green infrastructure patches on vacant land with corridors and other typical urban patches, such as parks, cemeteries, woodlots, open space, conservation areas, school grounds, etc. (McGuckin et al. 1995). Forman and Gordon (1986), arguably the founders of landscape ecological theory, recommend decreasing the porosity, or density of landscape patches, in order to enhance connectivity and reduce landscape fragmentation. These principles are consistent with the SEMCOG Green Infrastructure Vision for Southeast Michigan, which advocates for a regional green infrastructure strategy that prioritizes opportunities for green infrastructure near parks and other open spaces and natural areas (SEMCOG 2014).

In Cody Rouge, vacant and abandoned properties were assessed based on their proximity to existing parks and open space. In order to accurately represent the regional distribution of parks and open space, the 2008 SEMCOG Regional Parks dataset was clipped to the SEMCOG regional boundary, beyond the Cody Rouge study area, and converted to a raster dataset in order to evaluate the average park proximity for each vacant and abandoned parcel.

Proximity to parks and green space was attributed to the vacant and abandoned parcels through the following process:

1. Convert Feature to Raster (Parks to Raster)
2. Euclidean Distance on Parks Raster
3. Slice to normalize distance values on a scale between 0-1. Higher values are closer to parks, making them more suitable for green infrastructure
4. Zonal statistics to attribute vacant and abandoned parcels with average park proximity value

Figure IV-10: Cody Rouge Normalized Park Proximity Index Values – Distribution



Field
ParkProxVa

Statistics:

Count: 3792
Minimum: 0
Maximum: 100
Sum: 208247.243519
Mean: 54.917522
Standard Deviation: 23.086468
Nulls: 0

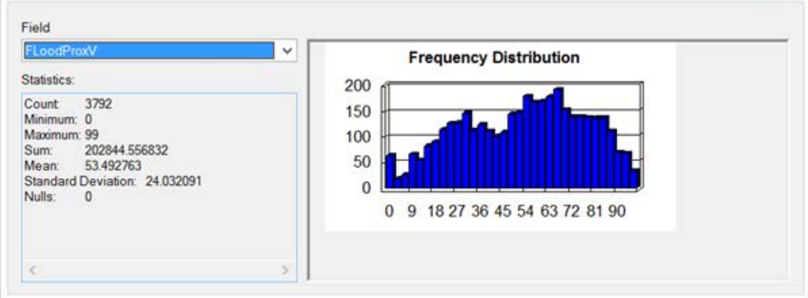
Proximity to floodplain

Flooding in the Cody Rouge neighborhood is a primary concern that can be alleviated by the implementation of green infrastructure. Residential parcels within and closest to the floodplain are most vulnerable. Prioritizing green infrastructure on vacant and abandoned parcels closest to the floodplain can reduce flood potential by absorbing and slowing floodwaters (Brauman et al. 2007).

In Cody Rouge, vacant and abandoned properties were assessed based on their proximity to 2008 SEMCOG River Rouge floodplain. Proximity to the floodplain was attributed to the vacant and abandoned parcels through the following process:

1. Convert Feature to Raster (Floodplain to Raster)
2. Euclidean Distance on Floodplain raster
3. Slice to normalize distance values on a scale between 0-1. Higher values are closer to floodplain, making them more suitable for green infrastructure
4. Zonal statistics to attribute vacant and abandoned parcels with average floodplain proximity value

Figure IV-11: Cody Rouge Normalized Floodplain Proximity Index Values – Distribution



Field
FLoodProxV

Statistics:
Count: 3792
Minimum: 0
Maximum: 99
Sum: 202844.556832
Mean: 53.492763
Standard Deviation: 24.032091
Nulls: 0

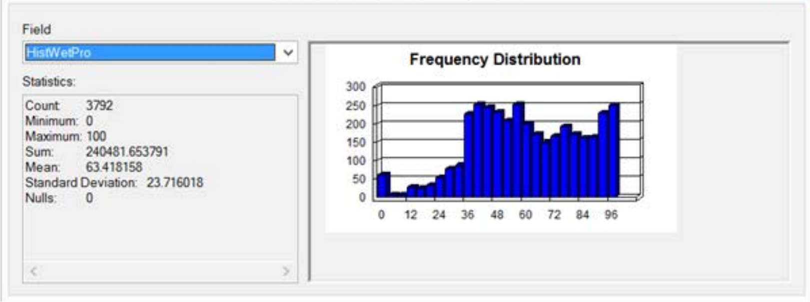
Proximity to historical streams and wetlands:

While the cost of daylighting streams is prohibitive and unlikely to occur in the Cody Rouge neighborhood, aggregating green infrastructure on vacant parcels along or near actual (or approximate) historic stream networks and wetlands can be a useful restoration strategy. Underground culverts are likely to remain but intermittent strands of vegetation on vacant land would direct stormwater along more natural paths of hydrology, allowing infiltration into the soil rather than the sewer system (Schwarz 2011).

In Cody Rouge, vacant and abandoned parcels were assessed based on their proximity to historical streams and wetlands. Historical streams were georeferenced and digitized in ArcGIS using a map from the Urban Streams Restoration Technical Memorandum (Farmer 1889). Historical wetlands were extracted from the Historical Landcover dataset (1800) compiled by the Michigan DNR and obtained from the Michigan Geographic Data Library. Similar to parks and the floodplain, proximity to the historical streams and wetlands was attributed to the vacant and abandoned parcels through the following process:

1. Convert Feature to Raster (Historical streams and wetlands to Raster)
2. Historical Streams and wetlands merged
3. Euclidean Distance on Historical Streams and Wetlands
4. Slice to normalize distance values on a scale between 0-1. Higher values are closer to historical streams and wetlands, making them more suitable for green infrastructure
5. Zonal statistics to attribute vacant and abandoned parcels with average historical stream and wetland proximity value

Figure IV-12: Cody Rouge Normalized Historic Stream and Wetland Proximity Index Values – Distribution



Field: HistWetPro

Statistics:

Count: 3792
Minimum: 0
Maximum: 100
Sum: 240481.653791
Mean: 63.418158
Standard Deviation: 23.716018
Nulls: 0

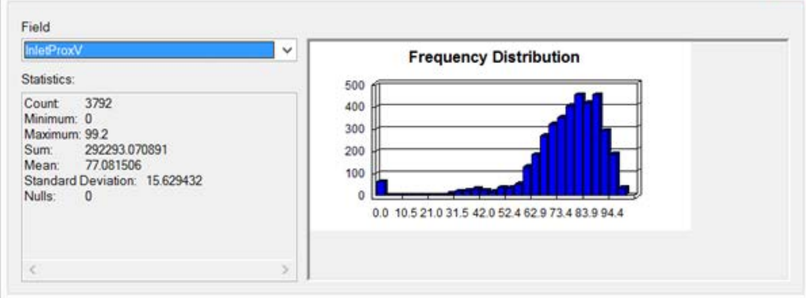
Figure IV-13: Map of Floodplain and Historic Streams and Wetlands

Proximity to drainage inlets

Approximate locations for drainage inlets were determined as part of the Catchment Delineation Model using ArcHydro 10.1, an extension of hydrologic modeling tools developed for ArcGIS. These locations represent discharge points for multiple catchments within the study area. It can be assumed that water collection at these locations is significant. Siting green infrastructure near the approximated drainage locations will likely reduce stormwater entering the system. Proximity to these locations was attributed to the vacant and abandoned parcels through the following process:

1. Convert Feature to Raster (inlet to Raster)
2. Euclidean Distance on inlet raster
3. Slice to normalize distance values on a scale between 0-1. Higher values are closer to inlet, making them more suitable for green infrastructure
4. Zonal statistics to attribute vacant and abandoned parcels with inlet proximity value

Figure IV-14: Cody Rouge Normalized Drainage Inlet Proximity Index Values – Distribution

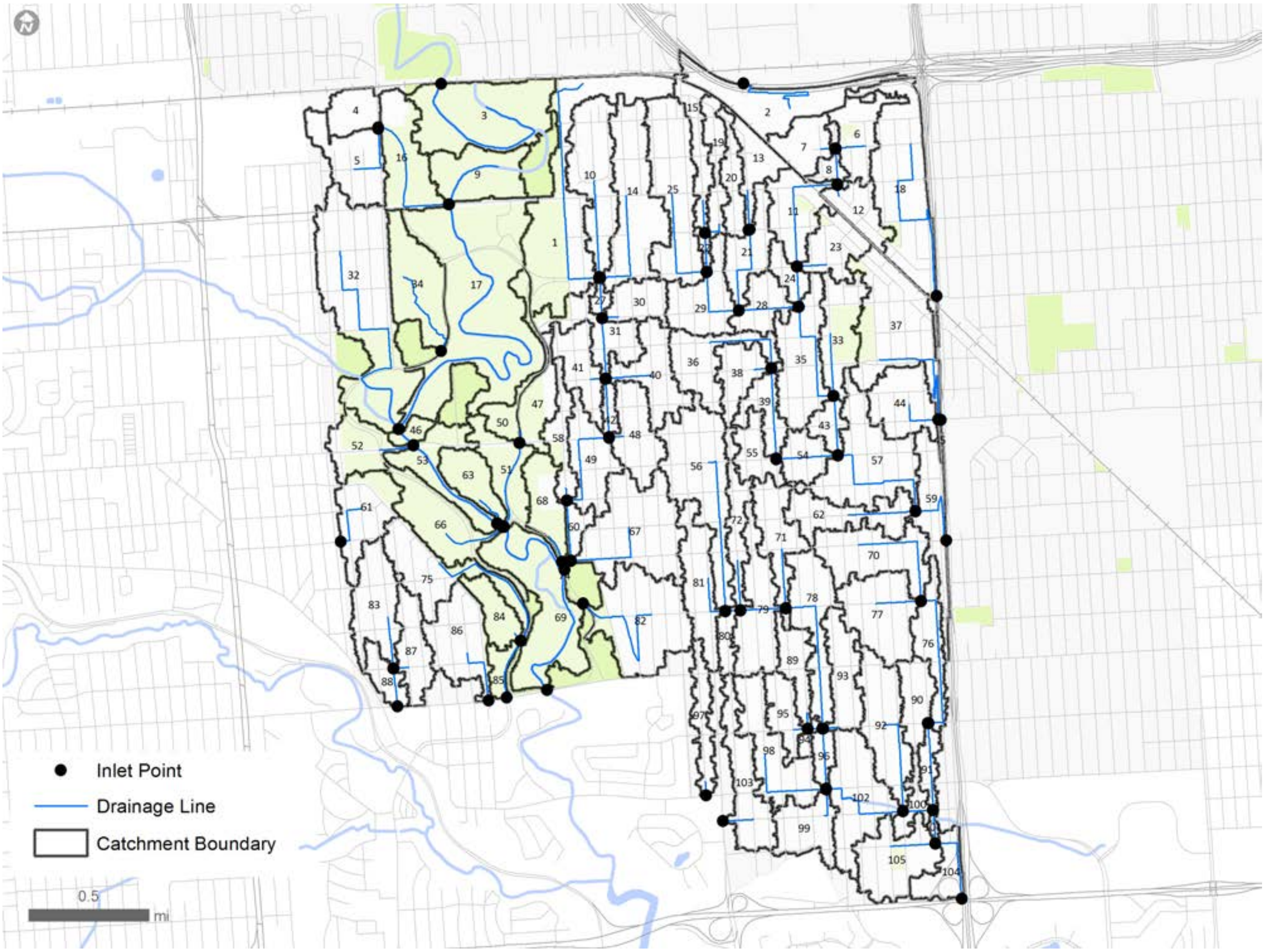


Field: InletProxV

Statistics:

```
Count:    3792
Minimum:  0
Maximum:  99.2
Sum:      292293.070891
Mean:     77.081506
Standard Deviation:   15.629432
Nulls:    0
```

Figure IV-15: Map of Cody Rouge Drainage Network



Phase Three

Social Vacant Parcel Prioritization Index

The Social Vacant Parcel Prioritization Index is qualitatively different than the Ecological Vacant Parcel Prioritization Index, because it prioritizes social conditions that reflect cultural values and provides opportunities to enhance neighborhood social cohesion and reduce maintenance demands. This index makes the assumption that green infrastructure will have long-term sustainability in areas where social cohesion already exists. It also assumes that maintenance will be more feasible in areas that are closer to publicly owned land that is either already being maintained by the city and/or in areas where ongoing community initiatives and resources can support it. Finally, in order to implement neighborhood green infrastructure, land acquisition must be feasible. Vacant and abandoned parcels that are publicly owned and/or managed by the Detroit Land Bank Authority (DLBA) are more likely to be efficiently obtained and converted to green infrastructure.

Proximity to public institutions

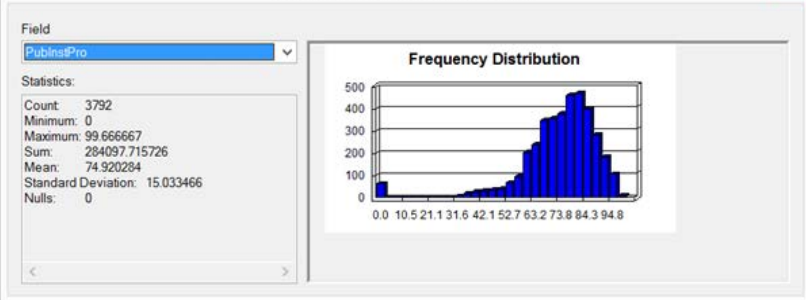
The public institution dataset for Cody Rouge is comprised of the Detroit Schools dataset and the Detroit Public Library Dataset. Detroit School data was geocoded and referenced by Data Driven Detroit (D3) using the Michigan Center for Educational Performance and Information, Educational Entity Master (2014). The Public Library Dataset was also geocoded by Data Driven Detroit (D3 2014).

Schools and libraries represent opportunities in the neighborhood where social cohesion is likely to exist. Additionally, because schools and libraries are publicly owned, they are likely maintained by the city. Green infrastructure located near these anchor institutions will be more likely to receive regular maintenance and neighborhood approval, promoting long-term cultural and ecological sustainability.

Schools and libraries are the primary public institutions within the Cody Rouge neighborhood. There are 14 open and active schools (public and private) and 1 public library (Thomas A. Edison) in the Cody Rouge study area. These layers were merged and analyzed in a method similar to the water quality proximity criteria. The main difference relates to the processing extent, which was limited to the Cody Rouge neighborhood boundary for this analysis.

1. Convert Feature to Raster (Public institutions to Raster)
2. Euclidean Distance on public institution raster
3. Slice to normalize distance values on a scale between 0-1. Higher values are closer to public institutions, making them more suitable for green infrastructure
4. Zonal statistics to attribute vacant and abandoned parcels with public institution proximity value

Figure IV-16: Cody Rouge Normalized Drainage Social Institution Proximity Index Values – Distribution



Field: PubInstPro

Statistics:

Count: 3792
Minimum: 0
Maximum: 99.666667
Sum: 284097.715726
Mean: 74.920284
Standard Deviation: 15.033466
Nulls: 0

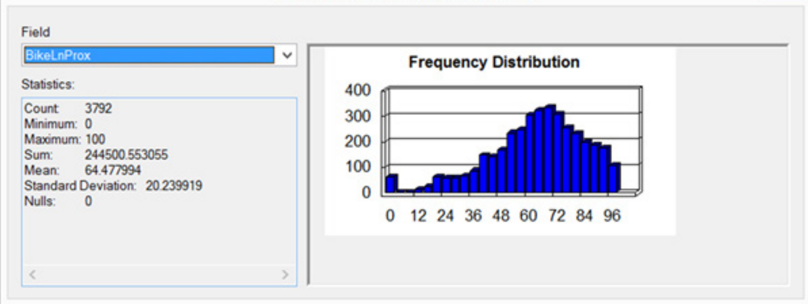
Proximity to bike lanes

Bike lane data (2014) was compiled by the City of Detroit Department of Public Works, Traffic Engineering Division and obtained from Data Driven Detroit (D3).

Bike lanes and bus routes represent landscape corridors that are likely to be traveled by pedestrians, making them highly visible to many residents at the scale of human experience. These publicly owned assets are also more likely to be maintained by the city. Prioritizing and aggregating green infrastructure along these linear corridors increases the likeliness of maintenance and enhances resident perception and visibility. Proximity to these locations was attributed to the vacant and abandoned parcels through the following process:

1. Convert Feature to Raster (Bike lanes to Raster)
2. Euclidean Distance on bike lane raster
3. Slice to normalize distance values on a scale between 0-1. Higher values are closer to bike lane, making them more suitable for green infrastructure
4. Zonal statistics to attribute vacant and abandoned parcels with bike lane proximity value

Figure IV-17: Cody Rouge Normalized Drainage Bike Lane Proximity Index Values – Distribution



Field: BikeLnProx

```
Statistics:
Count     3792
Minimum:  0
Maximum:  100
Sum:      244500.553055
Mean:     64.477994
Standard Deviation:  20.239919
Nulls:    0
```

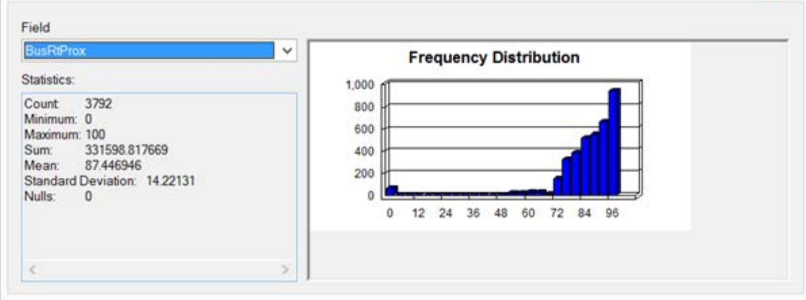
Proximity to bus routes
Bus route data (2012) was produced by the City of Detroit, Department of Transportation (DDOT) and obtained from Data Driven Detroit (D3).

Proximity to these locations was attributed to the vacant and abandoned parcels through the following process:

1. Convert Feature to Raster (Bus routes to Raster)

2. Euclidean Distance on bus route raster
3. Slice to normalize distance values on a scale between 0-1. Higher values are closer to bus routes, making them more suitable for green infrastructure
4. Zonal statistics to attribute vacant and abandoned parcels with bus route proximity value

Figure IV-18: Cody Rouge Normalized Drainage Bus Route Proximity Index Values – Distribution

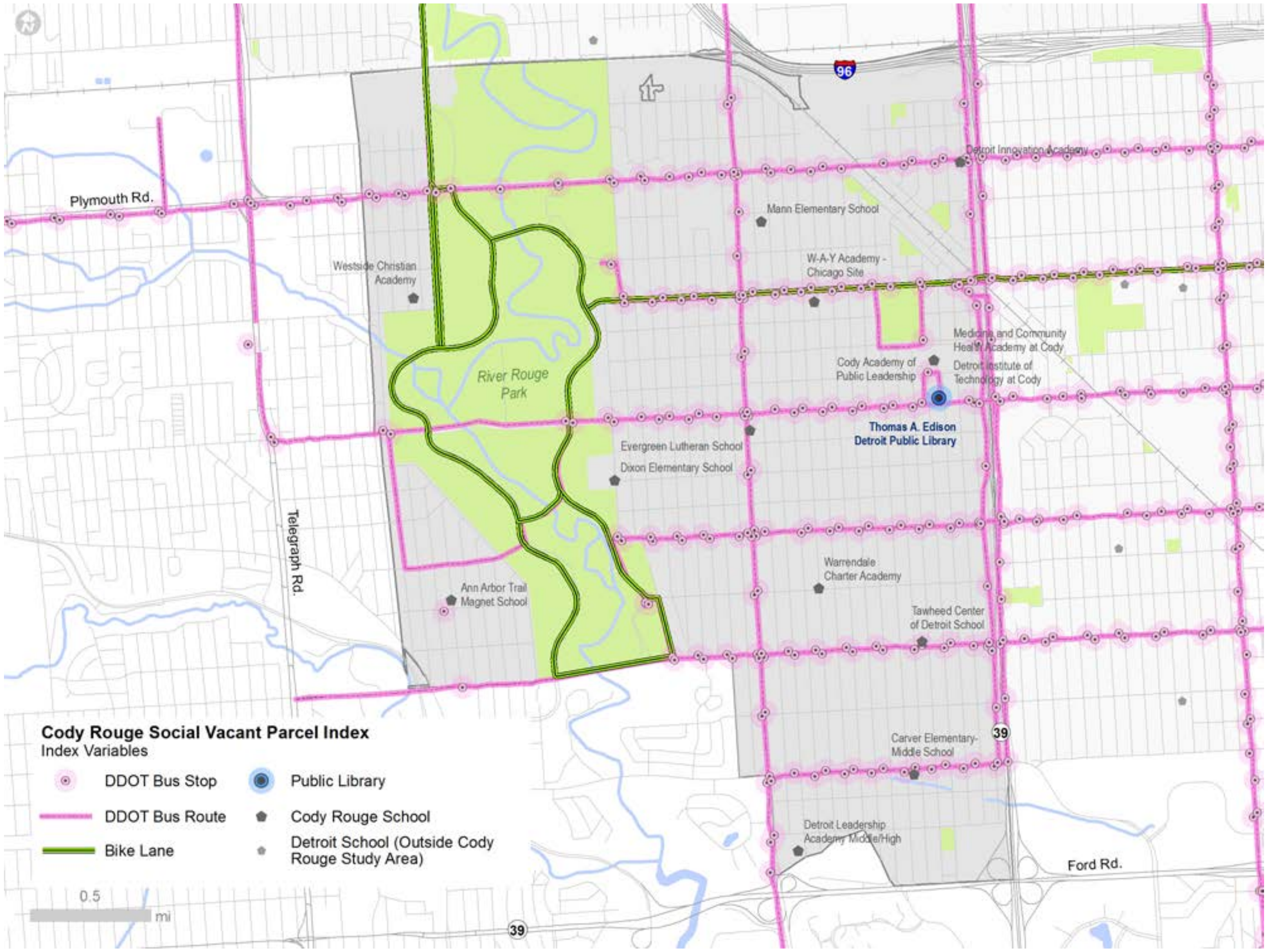


Field: BusRtProx

Statistics:

```
Count:    3792
Minimum:  0
Maximum:  100
Sum:      331598.817669
Mean:     87.446946
Standard Deviation:  14.22131
Nulls:    0
```

Figure IV-19: Social Vacant Land Prioritization Index Variables - Map
Excludes Land Ownership (Figure IV-20)



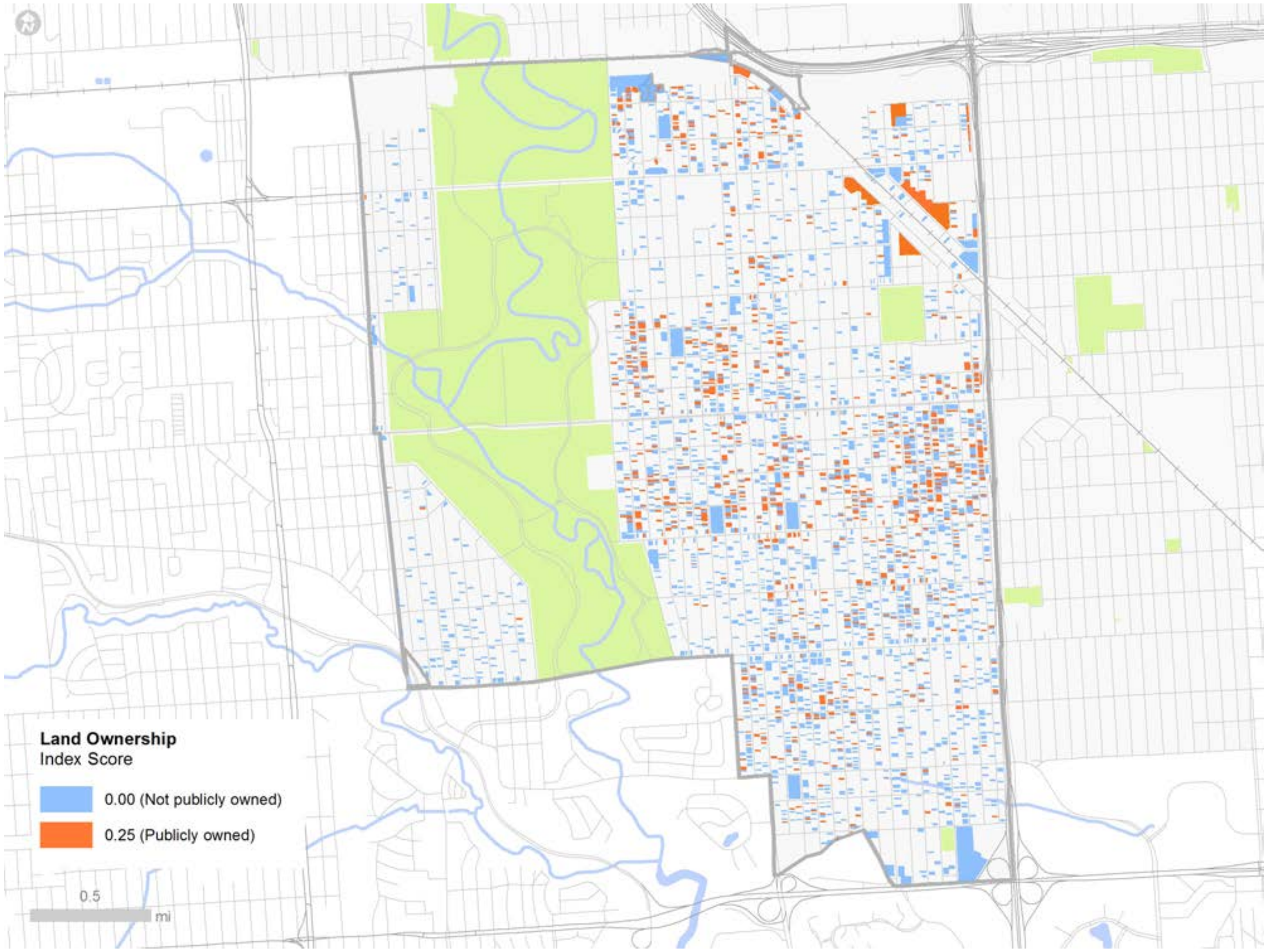
Land Ownership

In order to efficiently implement and assemble a green infrastructure network in Cody Rouge, publicly owned vacant land that is managed by a land bank or other public entity that has taken on the role of land assembly, provides the greatest opportunity for green infrastructure development (SEMCOG 2014). These parcels will likely be more efficiently obtained and converted to green infrastructure. The 2014 MCM Parcel Survey designates publicly owned parcels and this attribute was used to assess the land ownership variable.

Vacant and abandoned parcels that are publicly owned can be more efficiently converted to green infrastructure and were given an index weight of 0.25. Vacant and abandoned parcels that are not publicly owned will likely be more challenging to obtain and were therefore were given an index weight of 0.00. Because vacant and abandoned parcels can only be designated to one of two classes, this variable is essentially binary. A conservative weight of 0.25 was chosen to influence the total index score only slightly. These data are not complete and are therefore subject to some inaccuracy.

Within the Cody Rouge study area, there are 1,001 vacant and abandoned parcels that are publicly owned. This equates to 26.4% of the total vacant and abandoned parcel dataset.

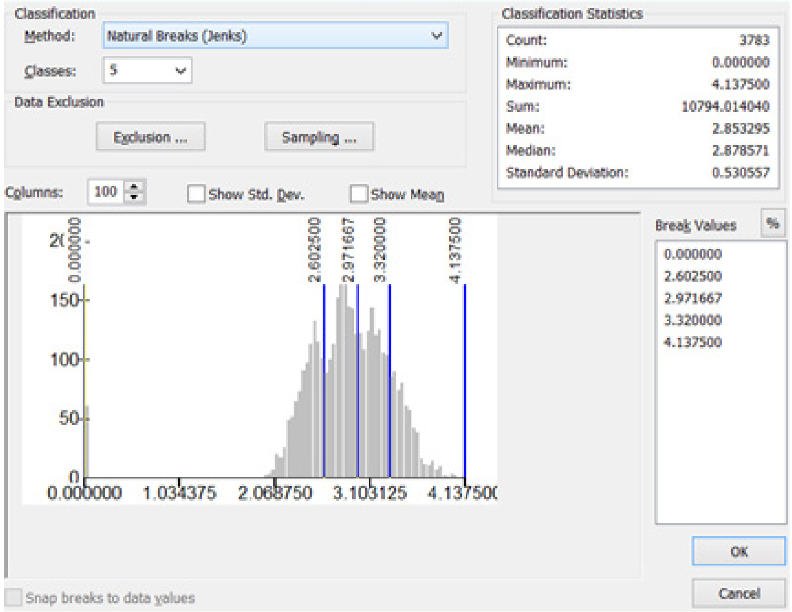
Figure IV-20: Cody Rouge Land Ownership Index Values – Distribution Map



Synthesis and Model Output

Results: Highest Priority Ecological Parcels
The distribution of un-weighted, normalized values for all ecological variables attributed to the vacant and abandoned parcels in the Cody Rouge Study Area were evaluated and then aggregated into five classes using Natural Breaks in ArcGIS. The distribution (histogram) and mapped results are shown here.

Figure IV-21: Distribution of Ecological Vacant Parcel Prioritization Index - Histogram



Classification
Method: Natural Breaks (Jenks)
Classes: 5

Classification Statistics

Count:	3783
Minimum:	0.000000
Maximum:	4.137500
Sum:	10794.014040
Mean:	2.853295
Median:	2.878571
Standard Deviation:	0.530557

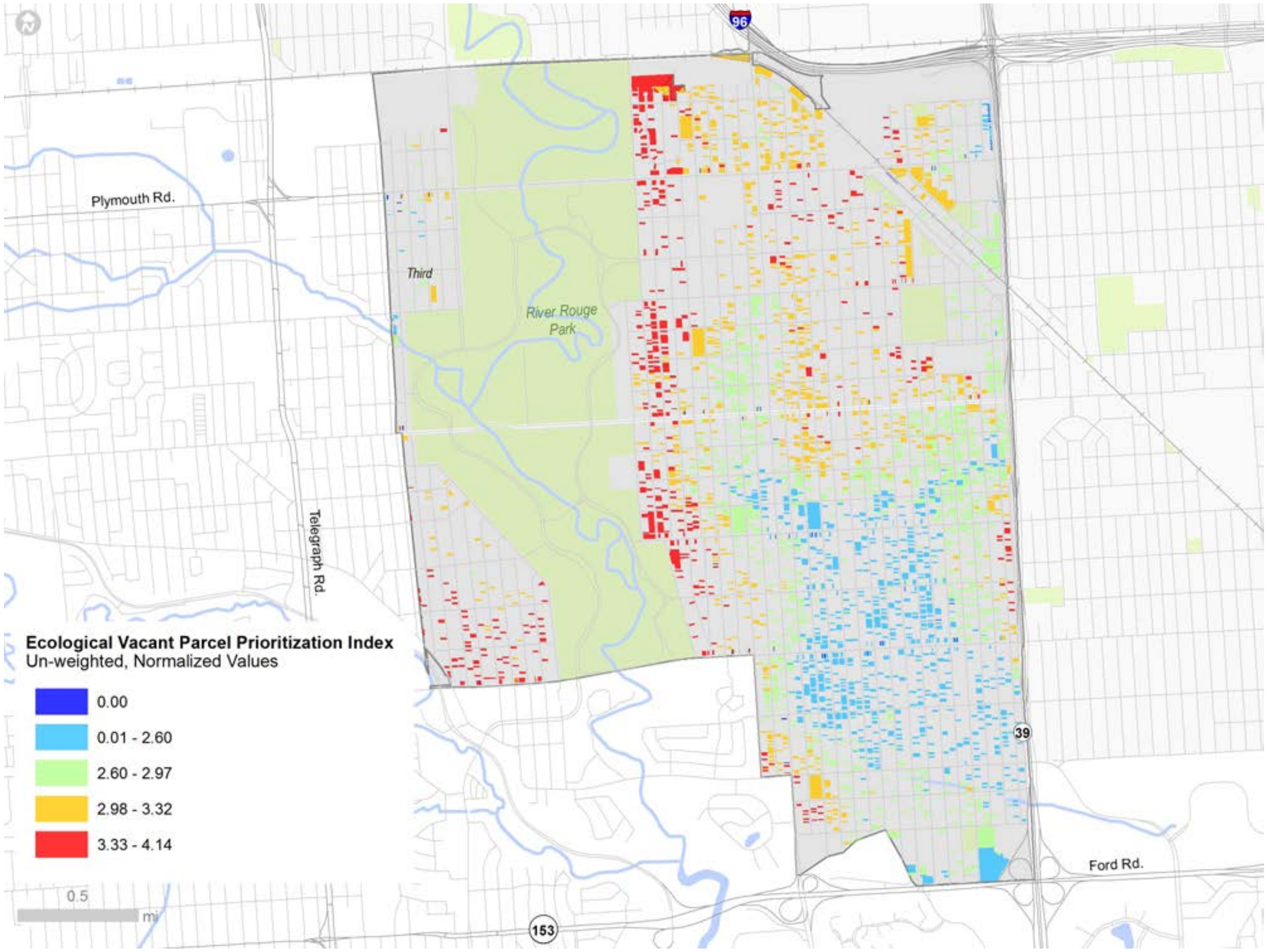
Columns: 100
☐ Show Std. Dev.
☐ Show Mean

Break Values
0.000000
2.602500
2.971667
3.320000
4.137500

☐ Snap breaks to data values

Figure IV-22: Distribution of Ecological Vacant Parcel Prioritization Index - Map

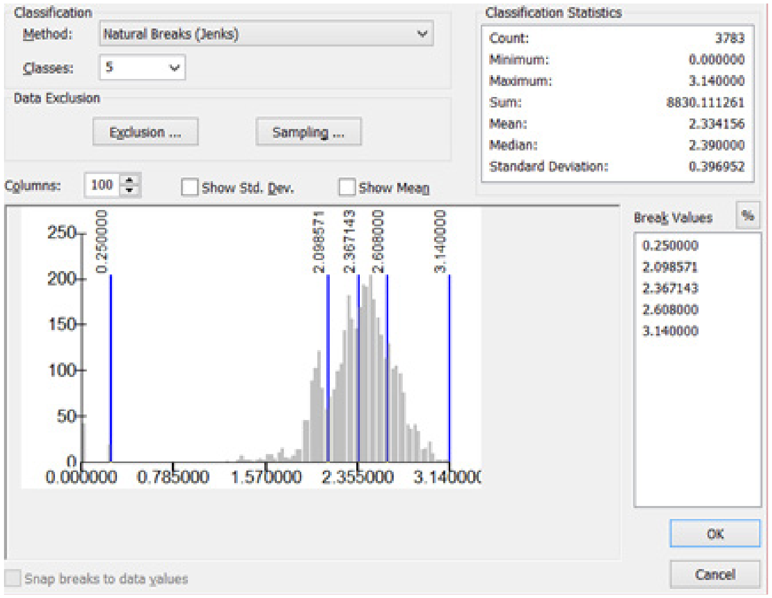
Red and orange parcels represent the highest ranking vacant and abandoned parcels for ecological priority.



Results: Highest Priority Social Parcels

The distribution of un-weighted, normalized values for all social variables attributed to the vacant and abandoned parcels in the Cody Rouge Study Area were evaluated and then aggregated into five classes using Natural Breaks in ArcGIS. The distribution (histogram) and mapped results are shown here.

Figure IV-23: Distribution of Social Vacant Parcel Prioritization Index – Histogram



Classification

Method: Natural Breaks (Jenks)

Classes: 5

Classification Statistics

Count:	3783
Minimum:	0.000000
Maximum:	3.140000
Sum:	8830.111261
Mean:	2.334156
Median:	2.390000
Standard Deviation:	0.396952

Columns: 100

☐ Show Std. Dev. ☐ Show Mean

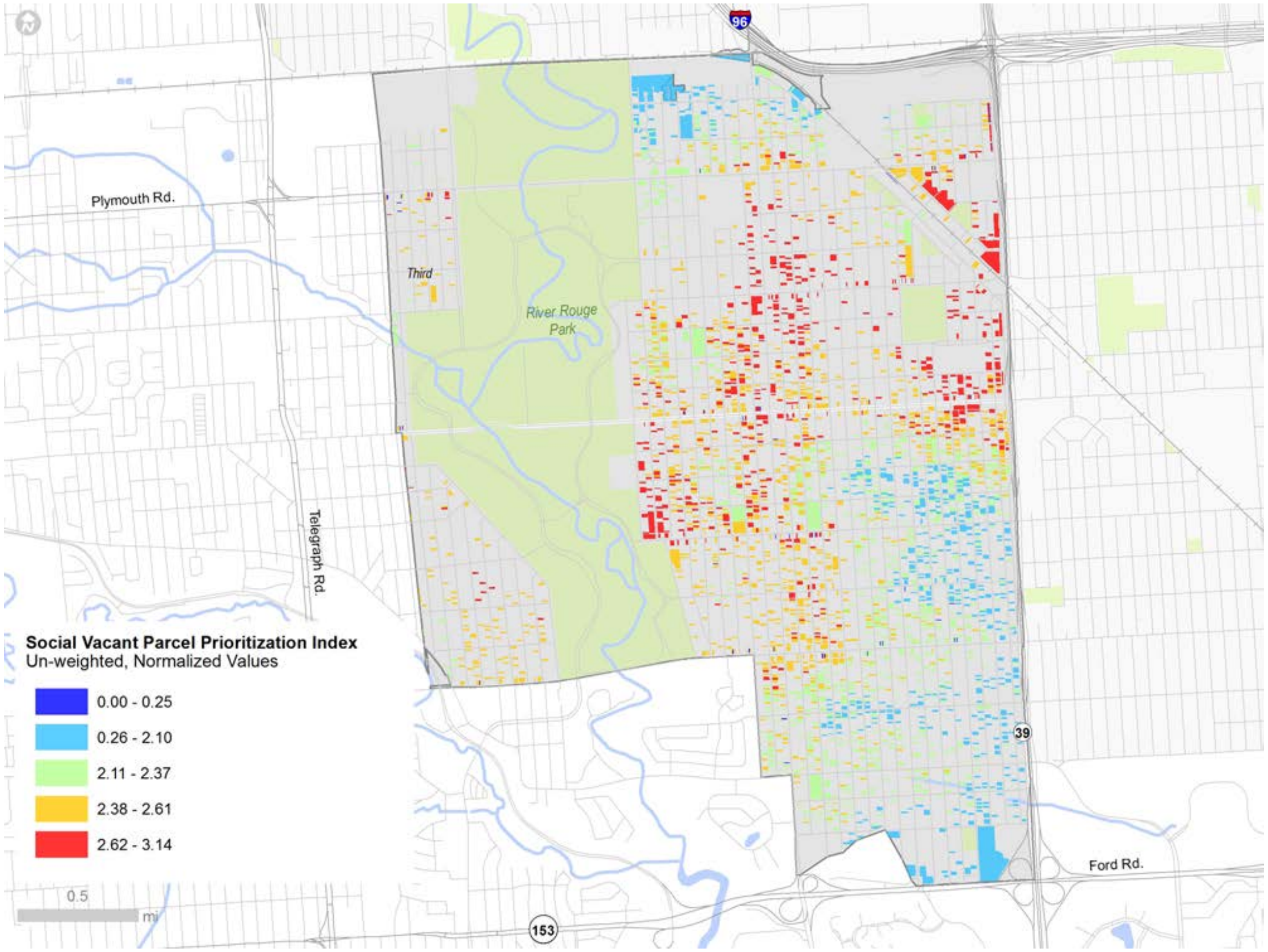
Break Values

- 0.250000
- 2.098571
- 2.367143
- 2.608000
- 3.140000

☐ Snap breaks to data values

Figure IV-24: Distribution of Social Vacant Parcel Prioritization Index – Map

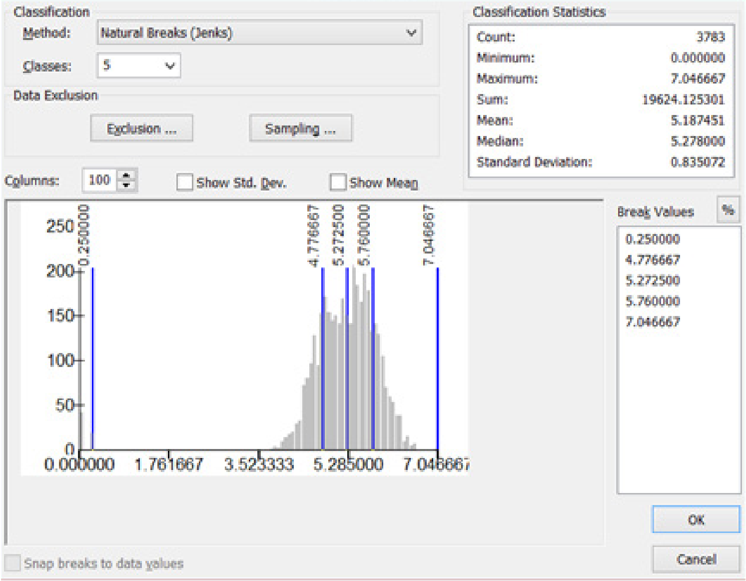
Red and orange parcels represent the highest ranking vacant and abandoned parcels for ecological priority.



Results: Highest Priority Combined Index Vacant Parcels

The un-weighted, normalized index values from the Ecological Vacant Parcel Prioritization and Social Vacant Parcel Prioritization Indices were summed. These distribution scores of the combined index were then evaluated and aggregated into five classes using Natural Breaks in ArcGIS. The distribution (histogram) and mapped results are shown.

Figure IV-25: Distribution of Combined Vacant Parcel Prioritization Index – Histogram



Method: Natural Breaks (Jenks)
Classes: 5
Columns: 100

Classification Statistics

Count:	3783
Minimum:	0.000000
Maximum:	7.046667
Sum:	19624.125301
Mean:	5.187451
Median:	5.278000
Standard Deviation:	0.835072

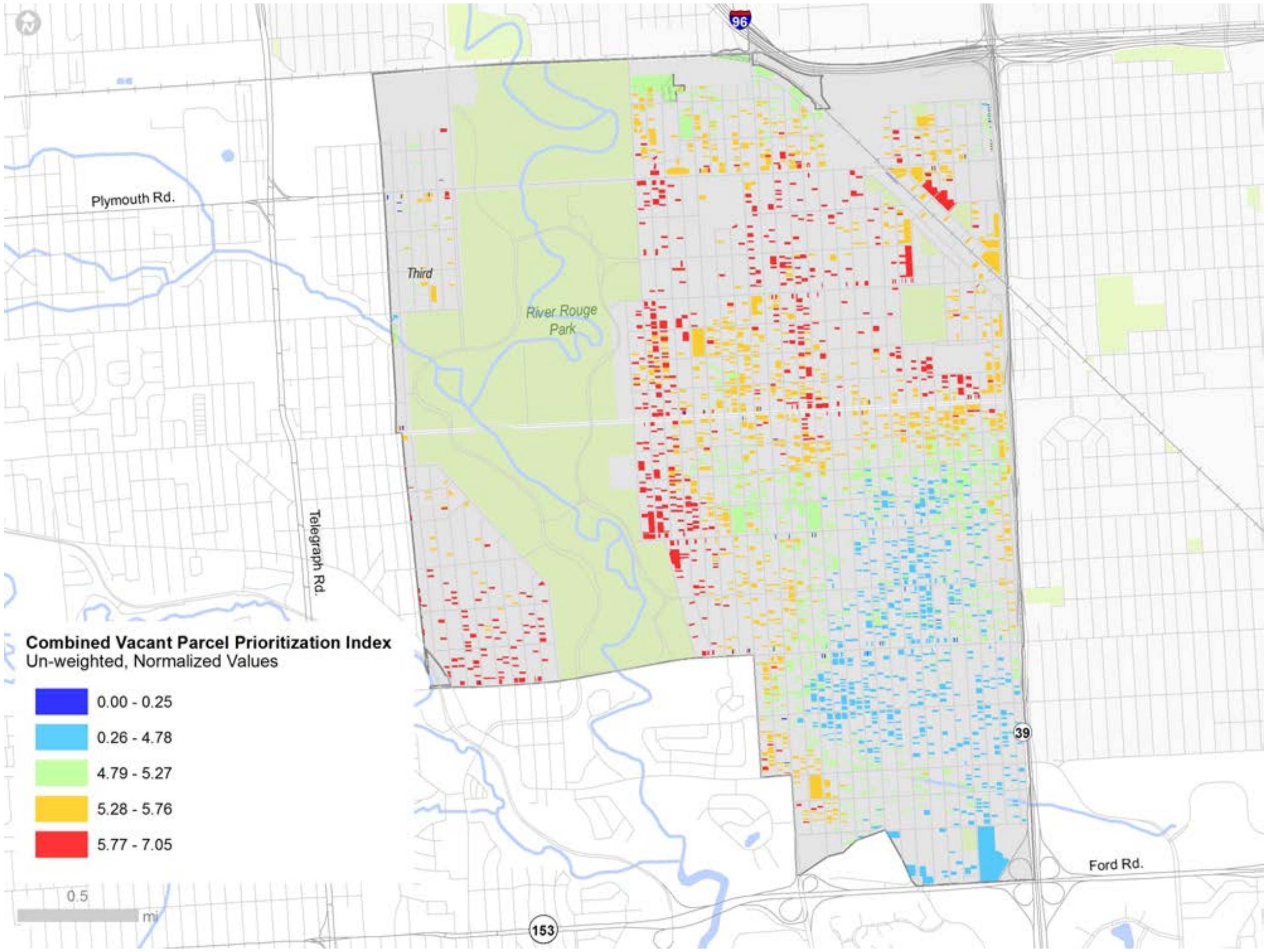
Break Values
0.250000
4.776667
5.272500
5.760000
7.046667

Table IV-2: Summary Table of Combined Vacant Parcel Prioritization Index

Prioritization Class	*Index Values*	*Number of Parcels*	*Percentage of Vacant and Abandoned Parcel Dataset*
5	0.00-0.25	52	1.37%
4	0.2-4.78	735	19.38%
3	4.79-5.27	1,094	28.85%
2	5.28-5.76	1,193	31.46%
1	5.76-7.05	718	18.93%

The vacant and abandoned parcels from the Combined Vacant and Abandoned Parcel Index have values ranging from 0.00-7.05. These values represent the sum of the un-weighted, normalized scores from both the ecological and social prioritization indices and are represented in the map above. The highest priority parcels, depicted in red and orange, represent opportunities for green infrastructure that are likely to provide both ecological and social benefits to the Cody Rouge Neighborhood, approximately 50% of the vacant and abandoned parcels fall into these two classes. The highest scoring parcels are represented in red and range in index values from 5.77-7.05. These parcels make up approximately 19% of the dataset and represent the most promising opportunities in the study area.

Figure IV-26: Distribution of Combined Vacant Parcel Prioritization Index – Map



V.

CONCLUSIONS AND RECOMMENDATIONS

V. CONCLUSIONS AND RECOMMENDATIONS

Utilizing a Landscape Heuristic for Decision-Making
Three distinct model outputs were generated during the development of this project:

1. *Priority Areas based on Catchment Prioritization Index*
These areas were identified based on landscape conditions that exhibit the greatest need for stormwater management or green infrastructure demand.

2. *Priority Vacant and Abandoned Parcels based on Vacant Parcel Prioritization Index*
These parcels were determined based on the combined results for a selection of variables that indicate greatest potential for green infrastructure feasibility and reflect a range of ecological and social priorities for the Cody Rouge neighborhood.

3. *Aggregated Parcel Clusters by Recommended BMP Type/Green Infrastructure Strategy*
Depending on the size of available land exhibited in clusters of vacant and abandoned parcels, BMP or green infrastructure strategies were recommended and provide a baseline volume for stormwater infiltration capacity.

Each model could function as a standalone pattern index for making neighborhood recommendations about green infrastructure siting in the Cody Rouge Neighborhood. The usefulness of this project, however, is that the three models can be used together as part of a landscape heuristic that will allow decision makers to narrow down the overwhelming range of opportunities to a few site-specific locations and interventions. Additionally, the calibration techniques that were used to develop each model can be modified by decision-makers to respond to different goals and changing circumstances in the neighborhood. For example, the Priority Vacant and Abandoned Index does not prioritize the input variables using ranks or weights to reflect relative importance. If certain variables to this index are more important than others, they can be attributed with specific weights to reflect higher or lower priority.

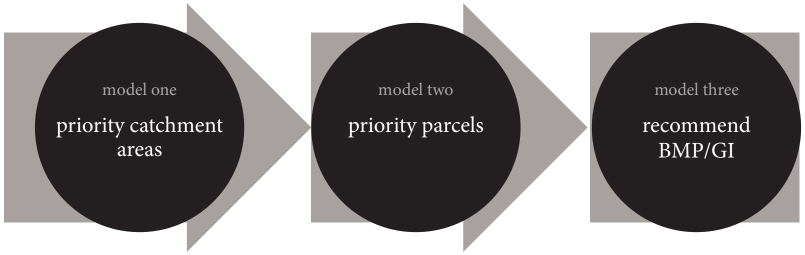
To provide recommendations for the Cody Rouge neighborhood, this project uses the three un-weighted models as part of a landscape heuristic that narrows down the range of choices using the following logic:

1. Use top-ranking priority catchment zones to determine broad areas for landscape intervention

2. From the top ranking priority catchment zones, identify top-ranking vacant parcels from the combined index (values of 5.28 – 7.05)

3. Within top-ranking catchment zones, make recommendations for the top-ranking vacant parcels that occur in the largest aggregated clusters (defined by BMP/GI Type) to provide the greatest reduction in stormwater volume.

Figure IV-27: Landscape Heuristic for Recommended Green Infrastructure



The prescribed logic can be modified endlessly to reflect alternative goals and preferences but for simplicity's sake, these parameters were chosen to recommend one site-specific priority location for green infrastructure in the Cody Rouge Neighborhood.

Example: Recommended Priority Green Infrastructure Site using Landscape Heuristic

Small Lot near intersection of Joy Road and Vaughan Street

1. Priority Catchment Area: Catchment 56

Figure IV-28: Priority Catchment Area 56

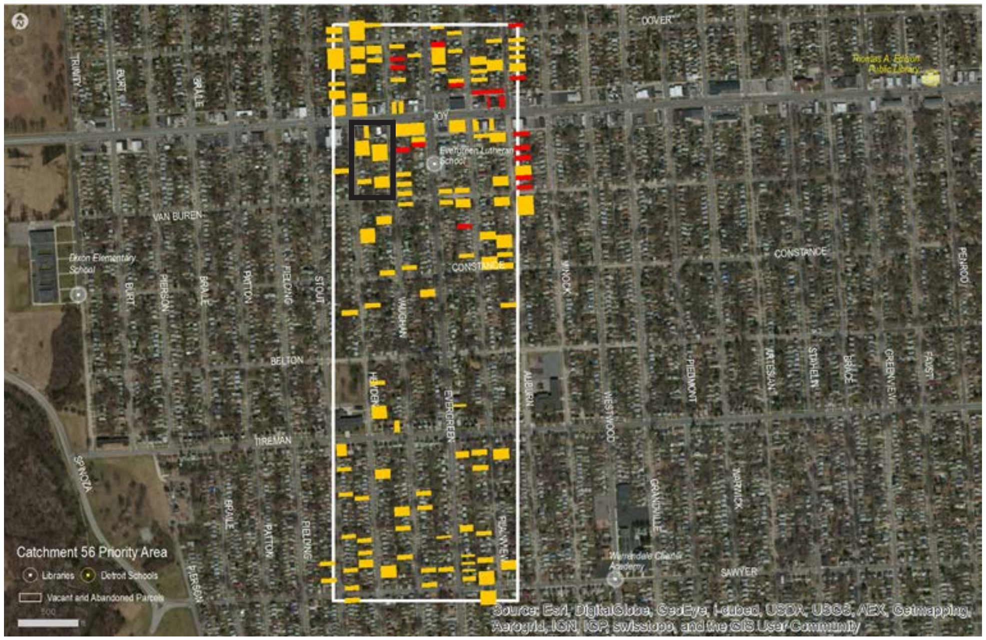
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

2. High-Scoring Vacant Parcels – Priority Parcels

Table IV-3: High-Scoring Parcels in Priority Catchment Area 56

Prioritization Class	*Index Values*	*Number of Parcels*
2	5.28-5.76	180
1	5.76-7.05	20

Figure IV-29: High-Scoring Parcels in Priority Catchment Area 56



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

3. BMP Type

Table IV-4: BMP Cluster Types in Priority Catchment Area 56

BMP Type	*Number of Parcels*
Bioretention 1	41
Bioretention 1/Infitration Garden	70
Biretention 2	96
Biretention 3	54
Small Lot	91

Figure IV-30: BMP Cluster Types in Priority Catchment Area 56

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

4. Site Location

Figure IV-31: Recommended 'Small Lot' GI Location

This 'Small Lot' site near the intersection of Joy Road and Vaughan Street was chosen as a recommended green infrastructure site in the Cody Rouge neighborhood. It occupies four parcels, approximately a total area of approximately 0.4 acres or 17,763.4 square feet. Based on size and location, this site is suitable for moderately intensive stormwater management and could be developed as a small urban woodlot or large infiltration garden.

Concluding Remarks

Through integrated landscape planning and spatial analysis, three spatial models were developed to prioritize siting strategies for green infrastructure in the Cody Rouge neighborhood. The first model identifies priority neighborhood catchment areas that exhibit the greatest need for stormwater management or green infrastructure demand. The second model identifies vacant and abandoned parcels that exhibit a range of desirable ecological and social priorities, indicating the greatest potential for green infrastructure feasibility. The third and final spatial model recommends BMP types or green infrastructure strategies dependent on the size of available land exhibited in clusters of vacant and abandoned parcels. These models utilize landscape pattern indices, which are useful to planners and designers because they allow for alternative patterns to be modeled efficiently while using accessible tools that are easily acquired, fully documented, and applicable to digital data representing plans and designs. These models can function as standalone tools for neighborhood decision-making or they can be combined as part of a landscape heuristic for prioritizing green infrastructure.

Landscape pattern indices are used widely but the assumptions about data inputs are often misunderstood. A primary goal of this project was to thoroughly evaluate all model input and provide a detailed record of how data was developed, interpreted, and applied. As part of this data evaluation, a sensitivity analysis was conducted on the results of stormwater modeling for the Catchment Prioritization Model in order to assess the effects of vacancy on urban residential neighborhoods. Nearly half of the Cody Rouge Neighborhood is classified as 'Single Family Residential' by the 2008 SEMCOG Land Use dataset, making it a typical representation of an urban residential neighborhood. Approximately 25% of the neighborhood parcels, however, are classified by the MCM Parcel Survey (2014) as either having abandoned structures or as vacant. While these vacant and abandoned parcels present opportunities for green infrastructure, their influence on existing landscape conditions are rarely measured. The results of the Catchment Prioritization sensitivity analysis concluded that baseline conditions for stormwater modeling are inaccurately calculated using the standard land use data as part of model input. This suggests a need for improving urban stormwater models in moderately to highly vacant neighborhoods. For best results, existing conditions should be accurately represented based on the landscape context.

While citywide planning frameworks are useful for broad-scale decision-making, recommendations for site-based design should be developed through a finer-scale analysis to adequately represent the local landscape. This project acknowledges both citywide and neighborhood visions that were applicable to green infrastructure in Cody Rouge. Cody Rouge is an ideal context for the development of this project because the prevailing condition of urban residential vacancy is similar to many neighborhoods in the city of Detroit. Additionally, the Cody Rouge neighborhood exhibits unique characteristics, such as its adjacency to the River Rouge Park and a number of community action initiatives that make green infrastructure more feasible for ecological and cultural sustainability. The models developed through this project are replicable, making this green infrastructure prioritization strategy transferable to other neighborhoods in the city.

Finally, this project focuses highly on a transdisciplinary approach for siting green infrastructure by combining the goals of planners, engineers, ecologists, social scientists, and designers. In addition to serving as a flexible mid to long term holding strategy for vacant land that can stabilize distressed neighborhoods, prioritizing vacant and abandoned parcels for green infrastructure contributes to a “right-sizing” framework that can assist in the clean and capture of stormwater to optimize city water management and improve water quality. A neighborhood and citywide vision that promotes the development of a connected system of productive, multifunctional, and recreational landscapes can ultimately provide a new identity for urban residential neighborhoods in the city of Detroit.

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