



PROJECT GROUNDWORK  
your pipeline to clean water

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI



# COARSE EVALUATION LOWER MILL CREEK WATERSHED



november  
2009



Human Nature provides land analysis, planning, design and management services to our client base of municipal, institutional, commercial and private clients. Human Nature has place-specific planning experience with many individual communities, and comprehensive green infrastructure planning experience with multiple-county regions. At both scales, Human Nature incorporates place-specific design as a way to help communities and regions express themselves through a celebration of their unique cultural and natural resources.

**990 St. Paul Place**  
**Cincinnati, Ohio 45206**  
**513.281.2211**  
**[www.humannature.cc](http://www.humannature.cc)**



Strand Associates, Inc. is a multi-disciplinary engineering firm with approximately 380 employees, eleven offices, and projects completed in 46 states. The mission of Strand Associates is "Dedicated to Helping Our Clients Succeed Through Excellence in Engineering". In addition to traditional engineering services, Strand Associates possesses a diverse array of green infrastructure capabilities, and has become a national leader in green infrastructure and sustainable engineering practices.

**615 Elsinore, Suite 320**  
**Cincinnati, Ohio 45202**  
**513.861.5600**  
**[www.strand.com](http://www.strand.com)**



# CONTENTS

INTRODUCTION..... 1

METHOD..... 5

OVERVIEW: LOWER MILL CREEK WATERSHED..... 13

WEST FORK SUB-BASIN..... 21

CLIFTON SUB-BASIN..... 41

MITCHELL SUB-BASIN..... 59

KING’S RUN SUB-BASIN..... 73

DENHAM SUB-BASIN..... 93

GEST SUB-BASIN..... 111

SUMMARY OF COARSE OPPORTUNITIES..... 121

REFERENCES..... 131

# INTRODUCTION

Human Nature Inc. and Strand Associates Inc. created a series of coarse-level opportunity plans for the Metropolitan Sewer District of Greater Cincinnati (MSD). With the overarching goal of reducing the frequency and volume of combined sewer overflows (CSOs) in the Lower Mill Creek (LMC) watershed, the opportunity plans contain recommendations for removing stormwater runoff and natural stream base flows from the combined sewer system.

Combining Geographic Information System (GIS)-based inventory and analysis with knowledge of local conditions, the project team proposed wet weather strategies, in the form of opportunity plans, at the watershed and site levels. At both scales the opportunity plans focus on three categories of wet weather strategies:

(1) **Direct Projects:** Wet weather strategies (e.g., sewer separation or detention) that require direct investment by MSD for planning and long-term maintenance.

(2) **Enabled Projects:** Wet weather strategies (e.g., downspout disconnection and reforestation) that represent a leveraged infrastructure investment. Enabled Projects present opportunities for cost sharing and collaboration among MSD and key watershed stakeholders.

(3) **Inform & Influence Projects:** Programmatic elements that engage and educate watershed partners and the broader public in making sustainable decisions that provide water quantity and quality benefits.

While not the specific focus of this coarse evaluation, a set of holistic principles should guide future refinements to coarse-level opportunities. More specifically, watershed projects and stormwater management strategies should, whenever possible, aim to:

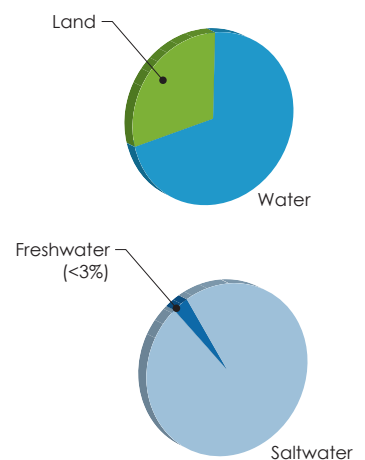
- Reconnect stormwater to natural systems
- Improve and restore terrestrial and aquatic habitats, as well as wildlife corridors
- Restore natural hydrologic patterns and increase natural base flows
- Improve regional water quality
- Build upon community connectivity

*NOTE: The purpose of this document was to identify a comprehensive list of site-specific wet weather strategies in the Lower Mill Creek watershed. Both Human Nature and Strand Associates developed the recommendations described herein. Not all of the recommended projects have been adopted or endorsed by MSD.*

## PROBLEM

Seventy-one percent of the surface of the earth is covered by water. Of this amount, less than three percent is fresh water, with two percent located in glaciers and the polar ice caps, and less than one percent found in surface waters, groundwater and water vapor combined (Nadakavukaren 2006, 459).

Human activities of industry, agriculture, development, and consumption pose constant threats to freshwater resources, as these activities produce wastewater and contribute to greater volumes of stormwater runoff. Maintaining and operating stormwater and wastewater infrastructure is a monumental challenge for local and regional governments. Providing constant and adequate levels of service, while anticipating future changes in demand and financial abilities, places a significant burden on these communities. In the United States, wastewater is transferred to a system of centralized



**Although the majority of the Earth is covered by water, less than one percent is freshwater. Freshwater resources are constantly threatened by development, industry, and agriculture.**

(municipal) treatment systems, decentralized treatment systems, or a combination of both. Within the former, underground sewer networks transport raw wastewater from the source (e.g., households) to treatment facilities. Treatment reduces contaminants through physical and mechanical methods before discharging treated wastewater (effluent) to surface waters. Centralized systems treat slightly less than eighty percent of domestic wastewater in the United States (NSFC 1995).

Stormwater is an integral component of the hydrologic cycle. In a natural landscape, systems like forests, streams, and wetlands naturally filter, cleanse and recycle stormwater. As cities and regions grow, however, natural systems are replaced by roadways, parking lots and rooftops. Because these surfaces are impervious, they affect the rate and volume of stormwater runoff that occurs during rainfall events. In the past, the primary objective of stormwater management was to remove rainfall as quickly as possible without jeopardizing safety, often through surface storage and underground pipe networks. This method of stormwater management can, however, have significant impacts on the environment. For example, stormwater flow from urbanized areas can contribute to combined sewer overflows; degrade natural habitats; increase sedimentation, turbidity, toxicity, temperature and bacterial contamination in streams; deplete oxygen resources; and lead to excessive aquatic plant growth that harms aquatic life and limits recreational uses.

In more than 700 cities across the country, wastewater and stormwater management is further complicated by combined sewer systems (U.S. EPA 2009). Combined sewer systems are sewers that are designed to collect stormwater runoff, domestic sewage, and industrial wastewater in the same pipes. Most of the time, combined sewer systems transport all of their wastewater to a centralized plant, where it is treated and discharged to a water body (e.g., the Mill Creek or Ohio River). During certain rain storms, pipes are overloaded and stormwater and sanitary sewage combine and overflow into the region's streams and rivers. This is called a combined sewer overflow, or CSO. Combined sewer overflows are point-source discharges to the waters of the United States, and are therefore subject to Section 301(a) of the Clean Water Act and the implementing regulations for the National Pollutant Discharge Elimination System (NPDES).

## SOLUTION

MSD is making necessary improvements to its sewage systems, particularly those with combined sewers that carry both sewage and storm water in the same pipes. Our current sewer system is old, parts of it are deteriorating, and portions are not large enough to handle the mixture of sewage and storm water that enters it during heavy rains. During wet weather, billions of gallons of raw sewage mixed with storm water overflow into local rivers and streams and back up into basements.



As one of the top five CSO dischargers in the country, MSD is under a federal Consent Order to resolve this problem. The U.S. EPA has mandated that MSD capture and treat or remove 85 percent of the 14 billion gallons of combined sewer overflows. The solution to this problem is [Project Groundwork](#), one of the largest public works projects in the history of our community. This two-phased, multi-year initiative is comprised of hundreds of sewer improvement projects across our area, with the local community investing over a billion dollars over the next ten years.

MSD is faced with finding solutions that are affordable to ratepayers and also meet the environmental, social and economic needs and desires of affected communities. The multi-billion-dollar construction initiative will result in significant sewer improvements and will provide economic, environmental, and social benefits for our communities, now and in the future. Under this initiative, MSD will use a blend of both "gray" infrastructure and "green" infrastructure that will create the most sustainable solutions for our region's infrastructure needs.

Conventional, gray engineering solutions such as sewer pipe upgrades and overflow storage facilities are often used to comply with federal Consent Decrees; however, planners and engineers have alternatives for managing stormwater runoff. Green stormwater management, commonly referred to as green infrastructure, focuses on retaining and treating stormwater as close to the source as possible; allowing it to infiltrate into the ground or evaporate into the atmosphere; and rediscovering and restoring natural systems to receive stormwater.

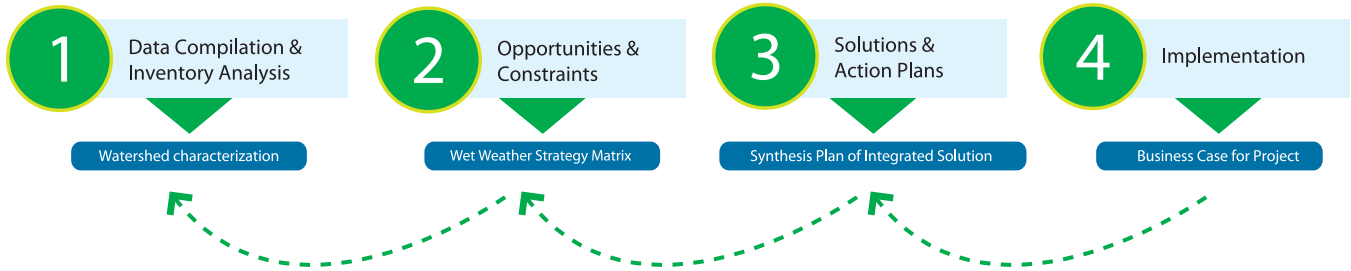
*"The average sewer pipe serves 400 residences.  
If **one inch** of rain infiltrates this same pipe...  
it will only serve **8 homes.**"*

- Sanitation District No. 1 of Northern Kentucky



## SUSTAINABLE WATERSHED EVALUATION PROCESS

A formal planning process is essential to achieving the goals and objectives of Project Groundwork. This process, known as MSD's Sustainable Watershed Evaluation Process (SWEP), involves four broad steps:



Similar to comprehensive planning, the SWEP identifies and analyzes the important relationships among the environment, infrastructure, the economy, transportation, communities and neighborhoods, and other components. It does so on a watershed-wide basis and in the context of a wider region and objective.

The coarse evaluation for the Lower Mill Creek watershed was a first step in the broader SWEP. Specifically, the coarse evaluation focused on Step 1, watershed characterization, and portions of Step 2, potential wet weather strategies.

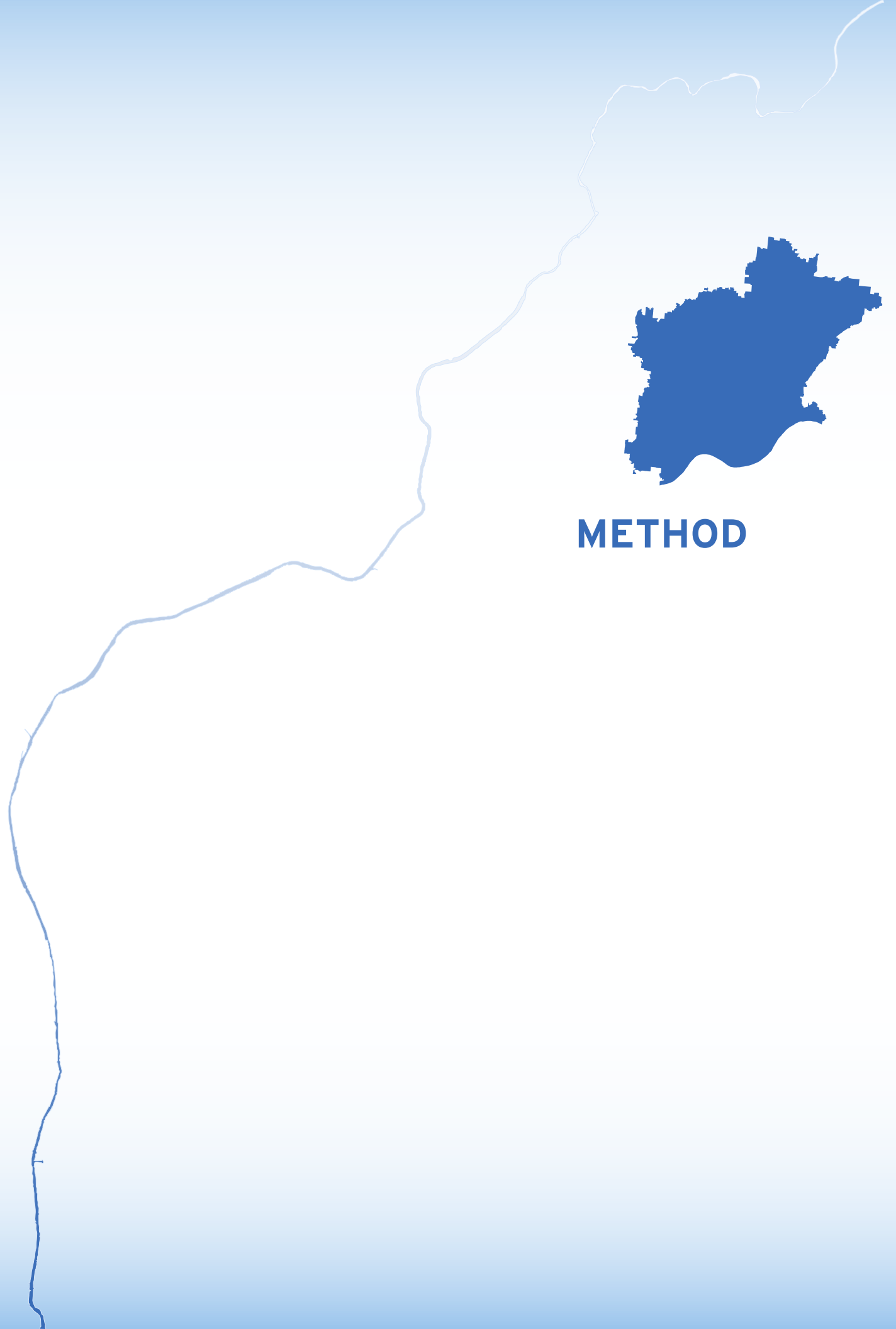
## COMMUNITIES OF THE FUTURE

As a way to maximize the social, economic and environmental benefits for watershed communities through Project Groundwork, MSD has developed a framework called **Communities of the Future**. This framework integrates economic development and urban renewal opportunities with sustainable, community-based wet weather solutions. MSD focuses on sustainable wet weather solutions, and serves as a catalyst for urban redevelopment opportunities and strategic partnerships. This document focuses on the initial phase of this process, which may later identify potential Communities of the Future projects.

MSD needs the support and assistance of agencies, organizations and community leaders. If the community chooses to utilize the consent decree requirements as opportunities to create Communities of the Future, we must work together towards a common solution, specifically in areas of the Lower Mill Creek watershed, where we face our most challenging problems.







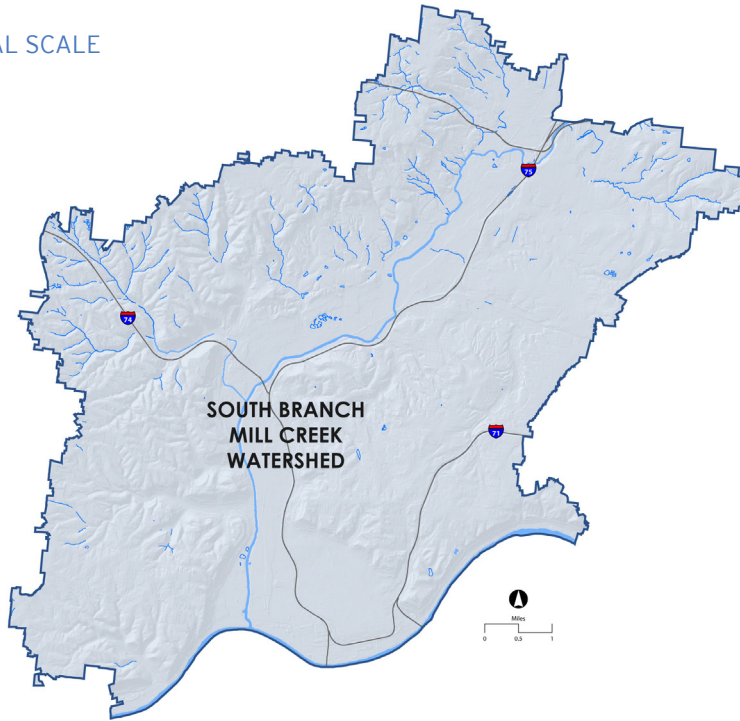
**METHOD**



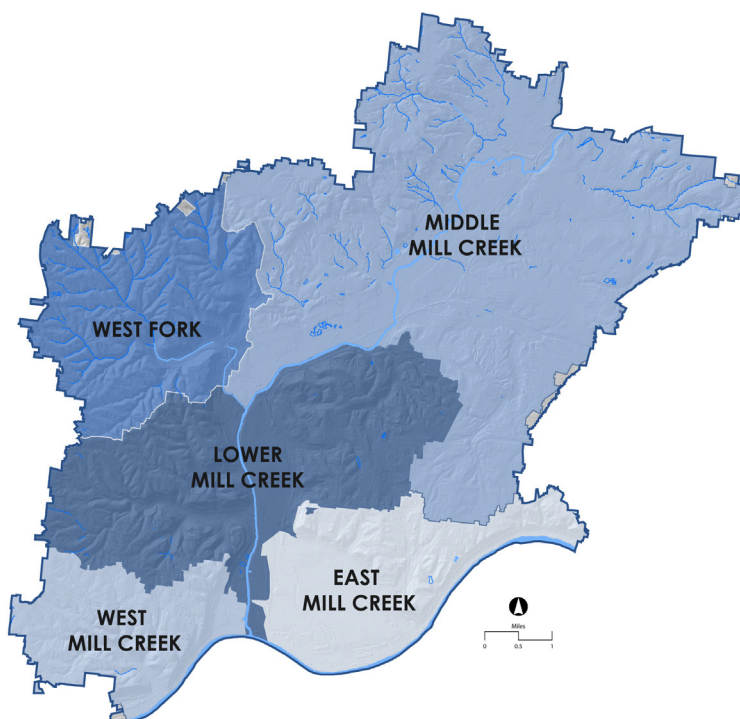
# METHOD

As part of the coarse evaluations, the project team critically analyzed the Lower Mill Creek watershed's natural and built systems. This inventory/analysis phase examined the watershed in its broader spatial and temporal contexts, providing a solid foundation for not only the subsequent phases of the evaluations, but also for future phases of MSD's Sustainable Watershed Evaluation Process.

## ANALYTICAL SCALE

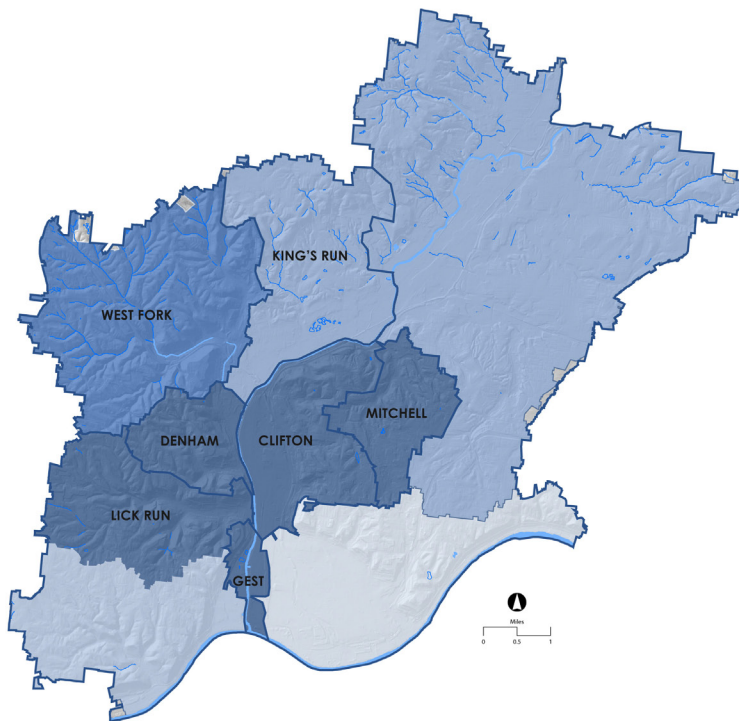


The South Branch Mill Creek watershed covers approximately 40,000 acres (62.5 square miles) within the heart of Hamilton County. The watershed contains the Mill Creek, West Fork Creek and the Ohio River as its major hydrologic features. Interstate 74, Interstate 75, and Interstate 71 comprise the watershed's major transportation infrastructure.



The Lower Mill Creek watershed, part of the South Branch Mill Creek watershed, covers approximately 8,712 acres (13.6 square miles). This watershed contains the southern portion of the Mill Creek and an eastern portion of the West Fork Creek. While the coarse evaluations focus mainly on the Lower Mill Creek watershed, they also included an evaluation for West Fork (5,524 acres) and the western portion (3,846 acres) of the Middle Mill Creek.

## SOUTH BRANCH MILL CREEK SUB-WATERSHEDS AND SUB-BASINS



The Lower Mill Creek watershed, West Fork watershed, and a portion of the Middle Mill Creek watershed were divided into seven different sub-basins - Lick Run, West Fork, Clifton, Mitchell, King's Run, Denham, and Gest - based on natural sub-watershed and sewer catchment boundaries. The first sub-basin, Lick Run, was evaluated as part of an earlier project and is therefore not included in the coarse evaluation of the Lower Mill Creek watershed. Coarse evaluations for the remaining sub-basins can be found in subsequent chapters of this document.

## WATERSHED CHARACTERIZATION

GIS is an integral tool for a watershed-wide inventory/analysis. With GIS, it is possible to combine information about location with descriptive data about contextual surroundings. For example, information such as where a point is located on a map, the length of a roadway, the area of commercial properties in a neighborhood, or the extent of landslide-prone soils in a watershed can all be stored in digital format - often times in layers - in a GIS. By combining a range of spatially-referenced data and analytical tools, GIS technology enables one to identify and assess watershed conditions, consider and prioritize alternatives, and reach viable conclusions about infrastructure projects.

A watershed-wide inventory and analysis is the first opportunity for integrating GIS into MSD's comprehensive SWEF. During the inventory phase, data are displayed to simply show the location and extent of landscape features. An inventory of watershed hydrology would show rivers, streams, lakes, and wetlands. During the analysis phase, GIS data are used to integrate different layers into one composite data set. For example, separate data for buildings, roadways, parking lots, and driveways are combined into one layer representing impervious surfaces.

Local data for natural and built systems can be obtained from Cincinnati Area Geographic Information Systems (CAGIS), MSD, and several national, state, and local agencies. Specifically, GIS data sources included the following:

### National-Level Data Sources

- National Land Cover Database (NLCD)
- US Geologic Survey (USGS)
- National Resource Conservation Service (NRCS)
- National Hydrography Database (NHD)

### State-Level Data Sources

- Ohio Environmental Protection Agency (OEPA)
- Ohio Geological Survey (OGS)
- Ohio Department of Natural Resources (ODNR)

### Local-Level Data Sources

Cincinnati Area Geographic Information Systems (CAGIS)  
Hamilton County Auditor  
Metropolitan Sewer District of Greater Cincinnati (MSD)  
Cincinnati Park Board

The following sections describe the variables that were relevant to the Lower Mill Creek inventory/analysis.

### Natural Systems

Natural systems not only form the structure of a watershed, but of an entire regional landscape. The hillsides, valleys, waterways and vegetation have influenced how the landscape developed over time; however, many of the region's original natural systems have been altered. For example, many of our stream and waterways have been directed into pipe networks on top of which we build and develop. While a wholesale deconstruction of these features is not feasible, much can be learned by studying the remnant natural systems, how they have been altered and what pieces remain.

What is vital to sustaining watershed integrity is not just the overall quantity of land area lost to development, but also the pattern or configuration of what remains. A watershed's natural systems include, but are not limited to, topography, hydrology, soils and geology, and tree canopy. An assessment of these systems will identify opportunities and constraints for a range of infrastructure alternatives.

### Topography & Slopes

Topography defines the shape and character of the landscape and influences hydrologic patterns, vegetation and habitat, and can even constrain land uses. For example, hillsides influence natural drainage patterns and landslide susceptibility, while low-lying basins can increase the risk of flooding. Specific variables related to topography included:

- Slope characterization
- Steep hillsides
- Flood-prone areas
- Historical stream channels

### Hydrology

Although the term "hydrology" includes both groundwater and surface water features, the type and extent of surface water features was the most applicable during the watershed inventory and analysis phase. An inventory of surface hydrology included the following:

- Existing rivers, streams and creeks
- Historical rivers, streams, or creeks
- Lakes
- Floodplains

### Geology and Soils

Geology and soils are important factors in determining many of the physical attributes of an area, including the physical appearance of the environment, local flora, water quality and land use. During the inventory and analysis phase, it was important to assess a range of geologic and soil variables, including:

- Type of geologic structure (e.g., alluvium, sand, gravel, shale, limestone)
- Hydrologic soil group\*
- Erosion potential
- Drainage potential

\* Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four hydrologic soil groups - group A, B, C or D - according to their minimum infiltration rate. Group A soils consist of well- to excessively-drained sand or gravel and have a high rate of water transmission (*i.e.*, greater than 0.30 in/hr). Group B

soils consist of moderately well to well-drained soils with moderately fine to moderately coarse textures and have a rate of water transmission between 0.15- 0.30 inches per hour. Group C soils consist of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (*i.e.*, 0.05-0.15 in/hr). Group D soils have high runoff potential and consist of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (*i.e.*, 0-0.05 in/hr).

### **Tree Canopy Cover**

Tree canopy cover is an important component of natural systems. In addition to improving air quality, native trees cover can intercept, absorb, and filter stormwater. Data for the area and extent of tree canopy cover were obtained from land cover characteristics and from city departments (*i.e.*, the Cincinnati Park Board).

## **Built Systems**

Built systems are the products of urbanization and development. While built systems are essential to the strength of and quality of life in our urban areas, they have undoubtedly influenced the natural conditions of our landscapes and watersheds. In the context of a watershed inventory and analysis, these systems include land use and land cover types, impervious surfaces, infrastructure (*e.g.*, sewer, transportation, and other utility infrastructure), and property.

### **Land Use**

Land use is the documentation of human uses of the landscape. It shows the general distribution, location, and characteristics of current and future land uses and urban form. Land use plans include color-coded maps showing exclusive land use categories (*e.g.*, residential, commercial, industrial, institutional, public, open space, recreational, and agricultural uses). The display of land use information followed standards established by the American Planning Association (APA), specifically the Land-based Classification Standards (LBCS).

### **Impervious Surfaces**

Impervious surfaces include pavements, parking lots, roadways, sidewalks, rooftops, and bridges. These surfaces limit or prevent the natural infiltration of stormwater into local soils, and exacerbate stormwater runoff into underground sewer infrastructure. Characterizing the area and extent of impervious surfaces was important for identifying appropriate strategies for integrated stormwater management.

### **Macro Sewer Infrastructure**

Macro sewer infrastructure relates to the larger-scale infrastructure components and included the following:

- Type of underground sewer infrastructure (*e.g.*, combined, sanitary, and/or storm sewers)
- Relative size of underground infrastructure (*i.e.*, pipe size and length)
- Connections of different sewer types (*e.g.*, separate storm sewer connected into combined sewer)
- Location and severity of combined sewer overflows

An early assessment of these systems helped to identify initial priority areas during later stages of analysis.

### **Micro Sewer Infrastructure**

Micro sewer infrastructure relates to smaller-scale infrastructure components and included the following:

- Sewer manholes
- System inlets (*e.g.*, stormwater catch basins)
- Detention basins

### **Right-of-Way**

Right-of-way includes publicly-owned land adjacent to transportation infrastructure (*e.g.*, interstates, roadways, or railways), and is reserved for purposes of maintenance or expansion of existing services in these areas. Right-of-way can often be integrated with gray or green wet weather strategies that capture stormwater runoff from nearby impervious surfaces.

### **Neighborhood Boundaries**

Watersheds span jurisdictional and community boundaries. For example, the city of Cincinnati contains over 52 different

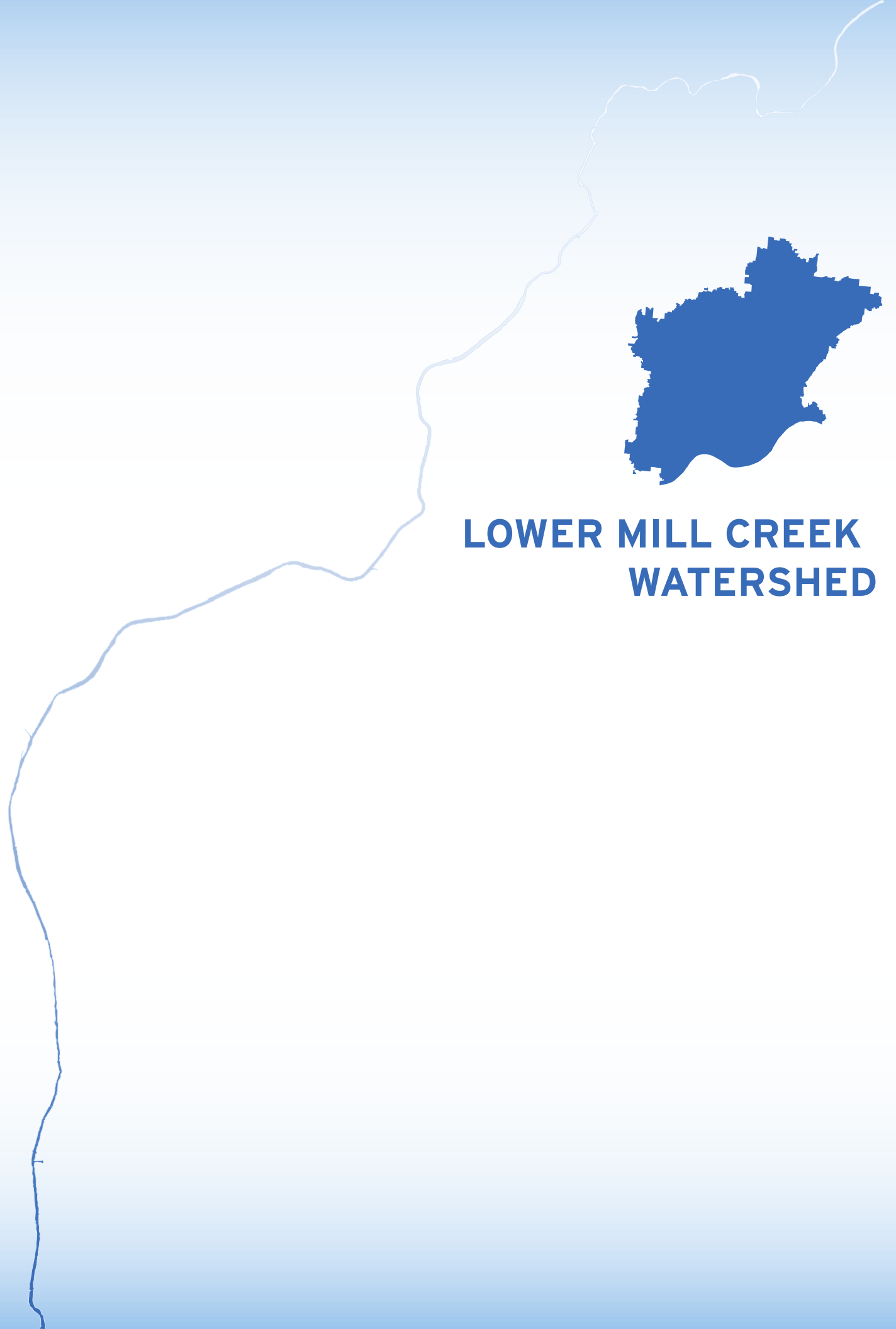
neighborhoods, each having different demographics, characteristics, and levels of public involvement. It was important to identify the neighborhoods contained within the watershed boundary and each respective sub-basin boundary.

### **Property Data**

Property lines, property ownership, and the shape, pattern, and size of parcels are key factors in the appearance of the built environment. Specific property variables included:

- Parcel area
- Parcel ownership (*i.e.*, private, institutional, public)
- Parcel area by land use type



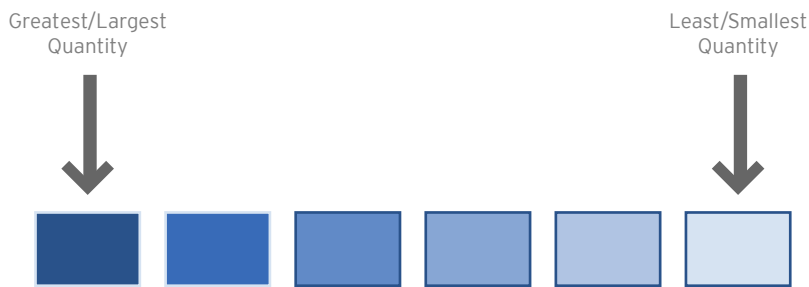


**LOWER MILL CREEK  
WATERSHED**

# OVERVIEW: LOWER MILL CREEK WATERSHED

The Lower Mill Creek watershed, part of the South Branch Mill Creek watershed, covers 8,712 acres. The watershed was divided into seven different sub-basins - Lick Run, West Fork, Clifton, Mitchell, King's Run, Denham, and Gest - based on natural sub-watershed and sewer catchment boundaries. The first sub-basin, Lick Run, was evaluated as part of an earlier project and is therefore not included in the summary of coarse evaluations. The King's Run sub-basin, although part of the Middle Mill Creek, was included as part of the evaluation.

The following sections provide an overview of the priority sub-basins based on land area, total runoff volume, combined sewer overflows, and coarse-level opportunities. Note that the sub-basins are coded by graduated colors as follows:

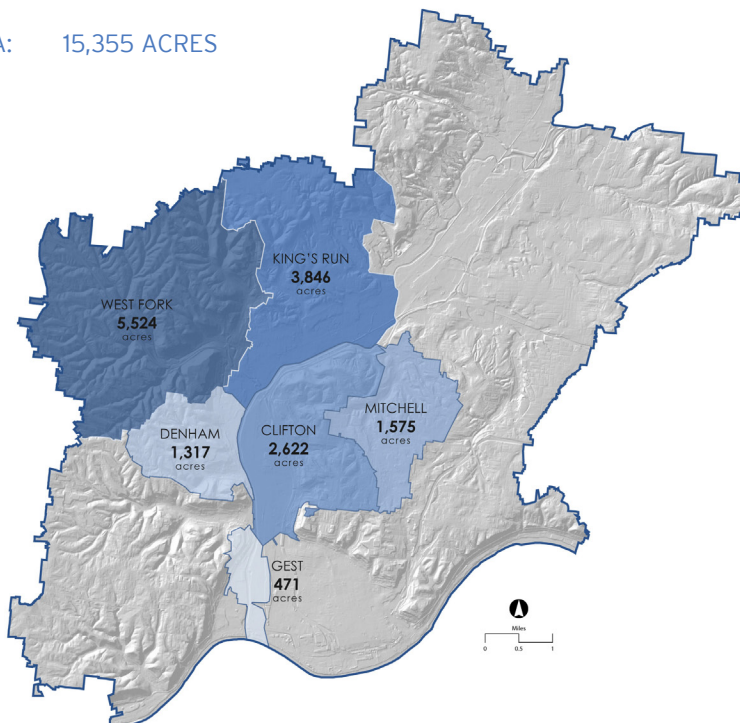


This chapter summarizes the results of the proposed Direct, Enabled, and Inform & Influence coarse-level opportunity evaluations. Based on preliminary calculations, these project areas contribute roughly:

**3,192 million gallons**  
of stormwater runoff each year.

Subsequent chapters of this document provide a detailed breakdown of the inventory/analysis results and coarse-level opportunities for each sub-basin.

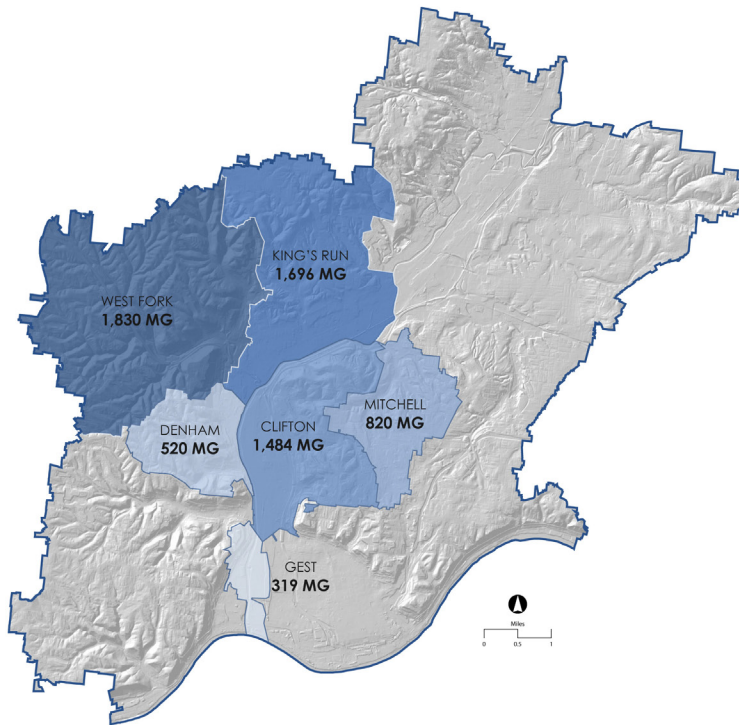
LAND AREA: 15,355 ACRES



The Lower Mill Creek sub-basins cover 15,355 acres. West Fork is the largest, spanning 5,524 acres, and the Gest sub-basin is the smallest, covering only 471 acres.

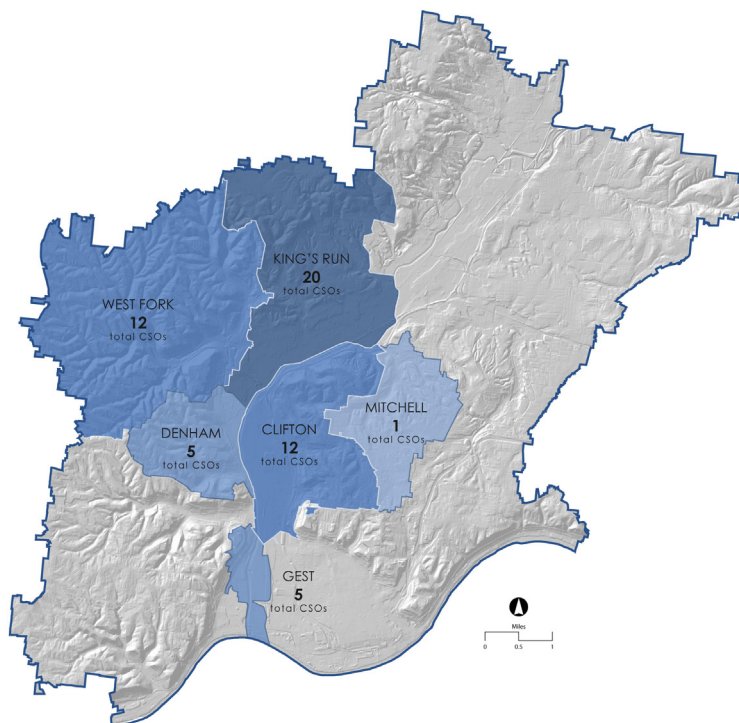


ANNUAL RUNOFF VOLUME: 6,670 MG



Based on typical year of rainfall, the West Fork sub-basin has the greatest volume of annual runoff with 1,830 million gallons (MG), representing 27 percent of the total runoff volume in the Lower Mill Creek. The Gest sub-basin has the smallest volume of runoff, with 319 MG annually.

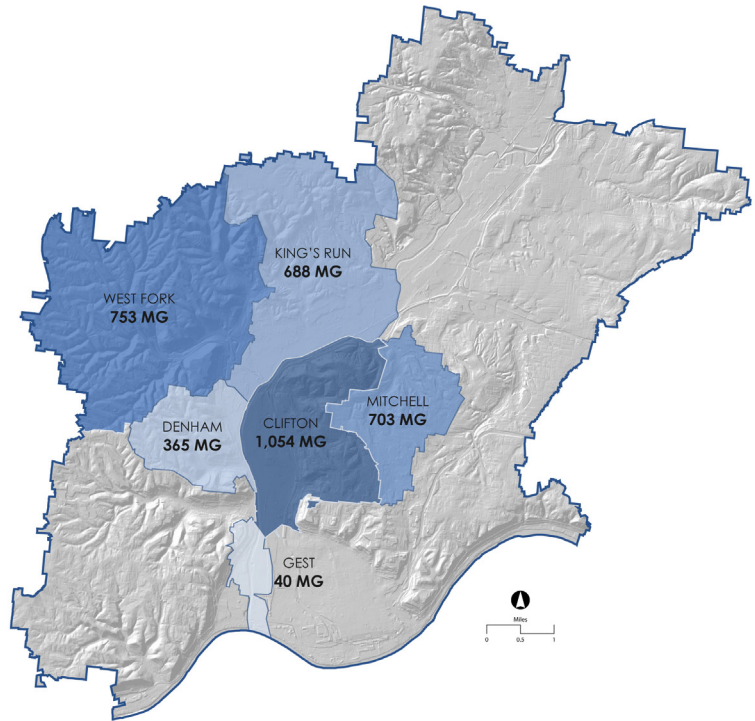
TOTAL NUMBER OF CSOs: 55



King's Run sub-basin has the greatest number of CSOs (20) and the Mitchell sub-basin has the fewest with only one.

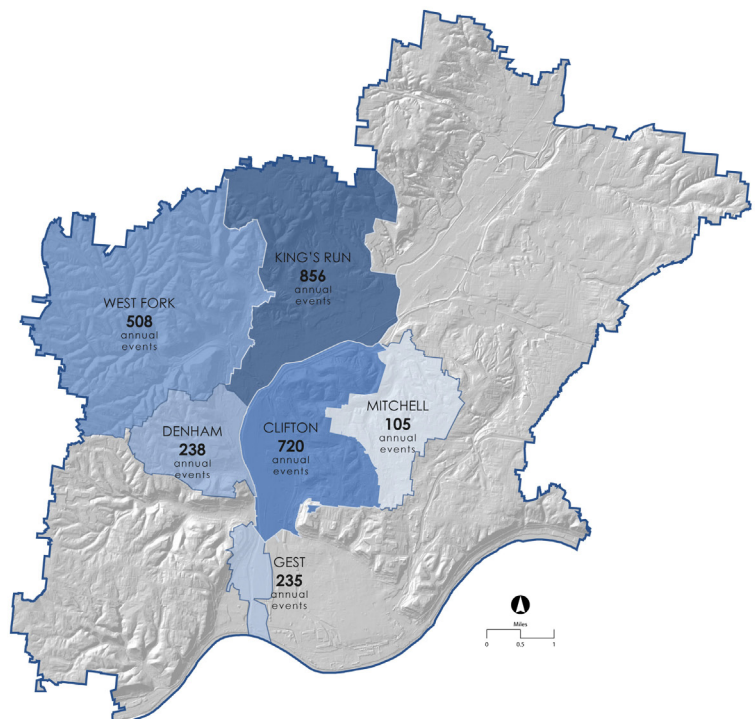
ANNUAL CSO VOLUME: 3,603 MG

The Clifton sub-basin has the largest CSO volume with 1,054 MG, representing 29 percent of the total overflow volume in the Lower Mill Creek watershed. The Gest sub-basin has the smallest volume, with 40 MG annually.



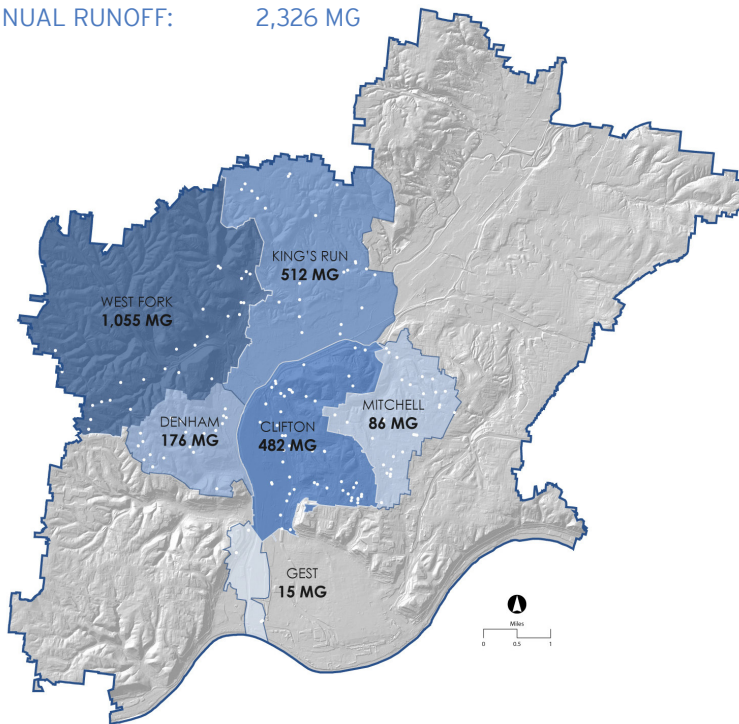
ANNUAL CSO EVENTS: 2,622

The greatest number of CSO events occurs in the King's Run sub-basin (856), while the fewest number occurs in the Mitchell sub-basin (235).



DIRECT ENTRY POINTS: 143

ANNUAL RUNOFF: 2,326 MG



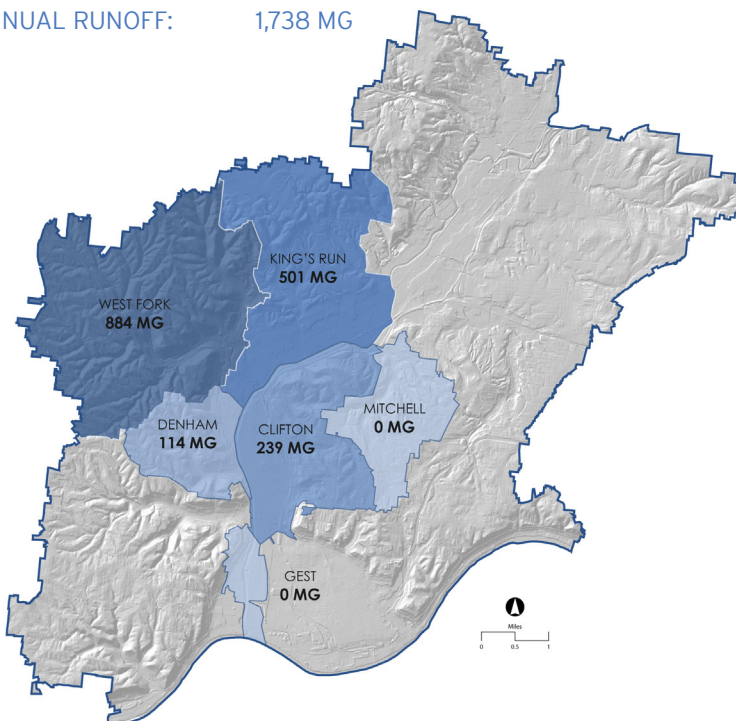
Direct entry points are points at which natural drainage features (e.g., streams) or large areas of separate storm sewer enter the combined sewer system. The project team identified 143 total direct entry points within the Lower Mill Creek sub-basins.

The Clifton sub-basin has the greatest number of direct points (44) and the Gest sub-basin has the fewest (4).

Natural drainage areas were delineated for each direct entry point to determine the approximate volume of stormwater runoff entering the combined sewer system each year (2,326 MG). With 1,055 MG, the West Fork sub-basin has the greatest volume of annual runoff flowing to direct entry points. The Gest sub-basin has the least volume of annual runoff flowing to direct entry points with 15 MG.

DIRECT PROJECTS

ANNUAL RUNOFF: 1,738 MG



As part of the coarse evaluation, some natural drainage areas were classified as direct project areas. Direct projects are wet weather strategies that require direct investment by MSD for planning and long-term maintenance.

Within the Lower Mill Creek sub-basins, direct project areas contribute approximately 1,738 MG (75 percent of the total runoff to the combined system) of annual stormwater runoff to the combined sewer system.

Direct project areas within the West Fork sub-basin contribute approximately 884 MG (51 percent of the total runoff contributed by direct projects) of runoff to the combined system each year. Direct projects were not proposed for the Mitchell or Gest sub-basins.

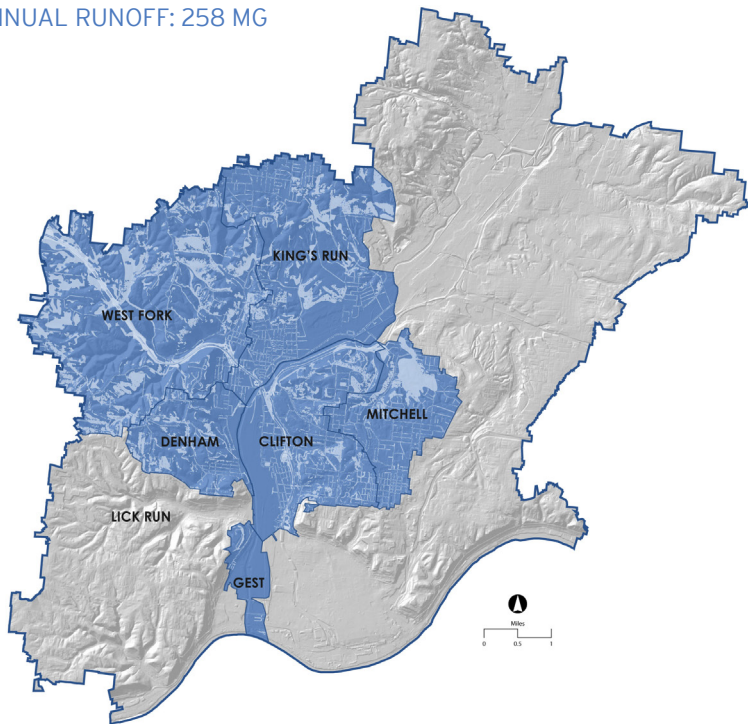
## ENABLED PROJECTS

ANNUAL RUNOFF: 258 MG

Enabled projects are those that present opportunities for cost sharing and collaboration among MSD and key watershed stakeholders. Enabled projects identified during the coarse evaluation included reforestation of steep hillsides and right-of-way; stormwater offloading and water quality opportunities along interstate right-of-way; and recreational opportunities along the Mill Creek Greenway.

A CITYgreen analysis of reforestable areas in the Lower Mill Creek sub-basins showed a potential annual benefit of 130 MG if 1,187 acres (60 percent of existing canopy-deficient areas) were reforested.

Within the Lower Mill Creek watershed, Interstates 74 and 75 cover 120 acres and generate 128 MG of stormwater runoff annually. It is imperative that future construction within these interstate corridors integrates both water quantity and water quality opportunities.



## INFORM & INFLUENCE PROJECTS

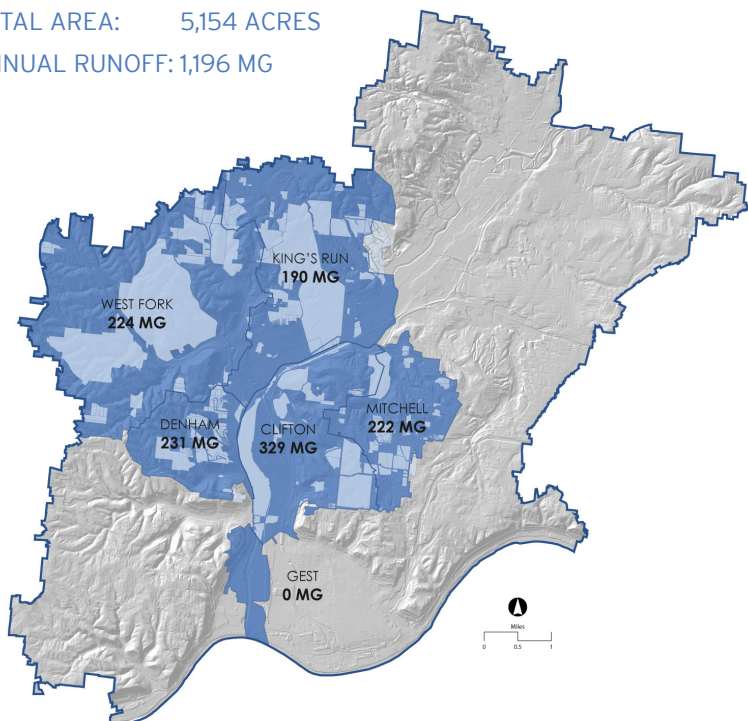
TOTAL AREA: 5,154 ACRES

ANNUAL RUNOFF: 1,196 MG

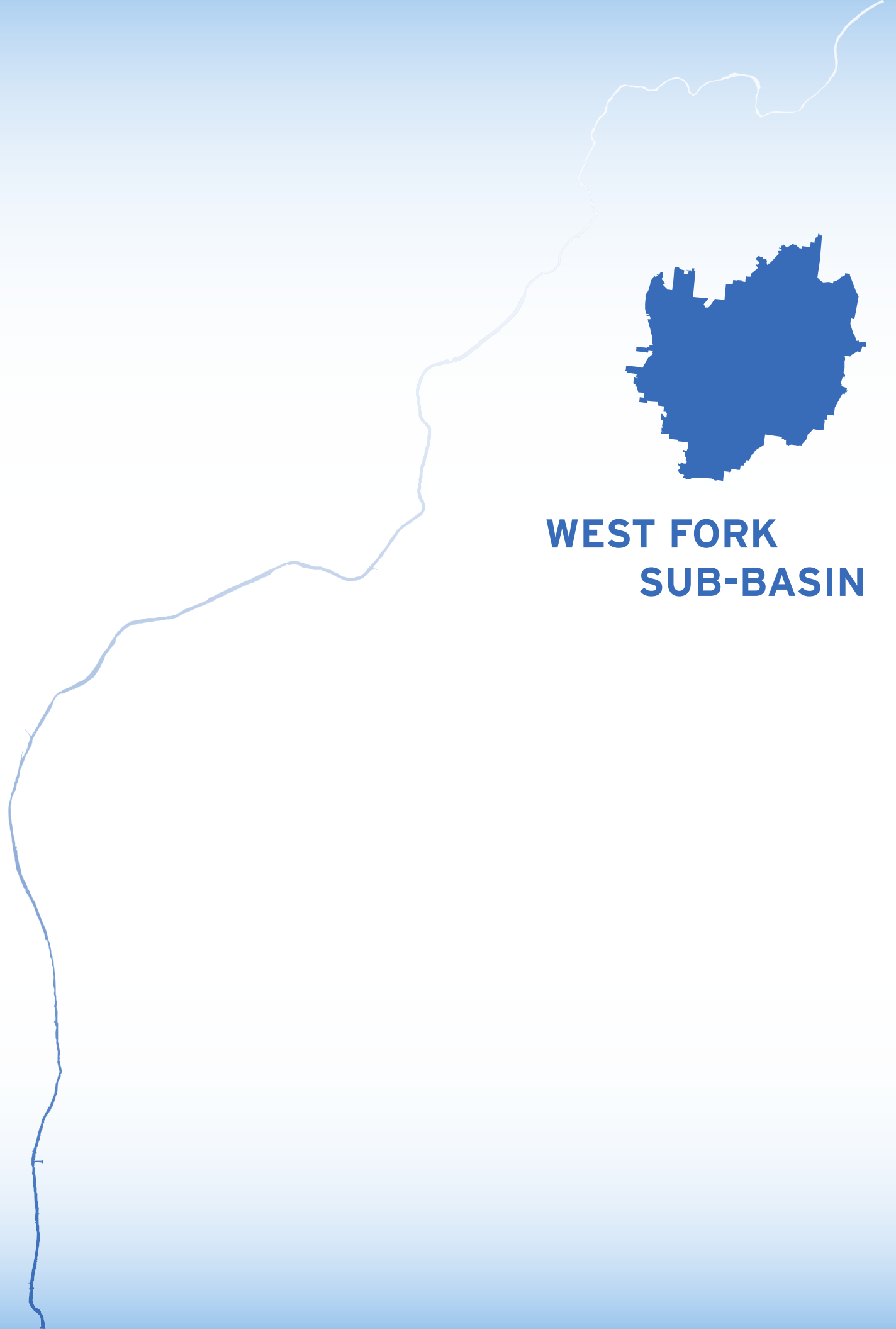
Inform & Influence projects are programmatic elements that engage and educate watershed partners in making sustainable decisions that provide water quantity and quality benefits.

Watershed partners include schools, parks and open spaces, institutional properties, public and even large private properties. These areas present opportunities for site-specific stormwater management and the potential for CSO volume reduction.

There are approximately 5,154 acres (33 percent of the LMC watershed) of Inform & Influence project areas, which generate approximately 1,196 MG of annual runoff. To avoid misrepresentation, the annual runoff calculations do not include the Inform & Influence project areas that overlap with Direct Project areas.

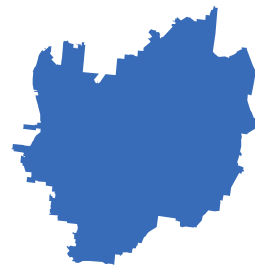






**WEST FORK  
SUB-BASIN**

# WEST FORK SUB-BASIN



## LOCATION

The West Fork sub-basin covers approximately 5,524 acres (13.8 percent of the Lower Mill Creek watershed) and overlaps seven neighborhoods within the City of Cincinnati (*i.e.*, Mt. Airy, College Hill, Northside, South Cumminsville, Fay Apartments, East Westwood, Westwood) and two other jurisdictions (*i.e.*, Green Township and Cheviot). The main transportation routes include Interstate 74, Hamilton Avenue, Colerain Avenue, West Fork Road, Westwood Northern Boulevard, Montana Avenue, and North Bend Road. There are two key property owners within the West Fork sub-basin, which include the Cincinnati Park Board (Mt. Airy Forest) and the Cincinnati Board of Education.

## CHARACTERIZATION OF PROBLEM

There are 12 CSO locations within the West Fork sub-basin, contributing an annual overflow volume of 753 million gallons. Direct project areas identified during the coarse evaluation contribute approximately 884 MG of stormwater runoff annually.

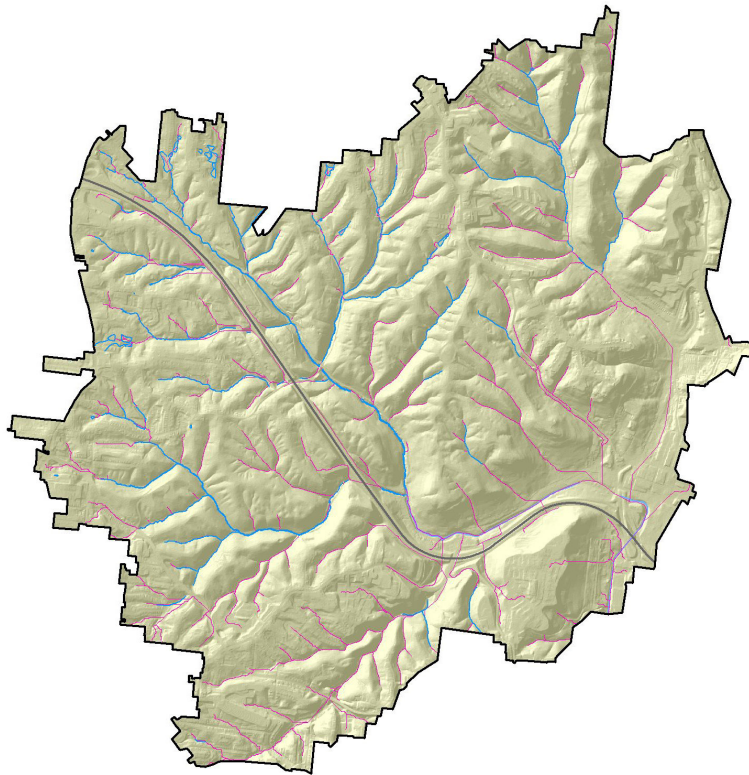
ANNUAL CSO STATISTICS <sup>1</sup>							
CSO NUMBER	NAME	EVENTS	OVERFLOW (MG)	CONTROL (%)	DIRECT PROJECT <sup>2</sup> (MG)	CSO CONTROL STRATEGY <sup>1</sup>	BUNDLE CLUSTER
117	Dreman Grating	56	31	51	84	Tunnel at Mill Creek (12,600' of 84" sewer)	West Fork Creek
123	Hoffner Grating	19	0	100	0	Partial separation	West Fork Creek
125	Badgeley Run Grating	58	227	51	0	Tunnel at Mill Creek (12,600' of 84" sewer)	West Fork Creek
126	Todd No. 1 Grating	70	148	33	193	Tunnel at Mill Creek (12,600' of 84" sewer)	West Fork Creek
127	Hays Grating	74	80	19	29	Partial separation	West Fork Creek
128	Todd No. 2 Grating	54	28	60	25	Partial separation	West Fork Creek
130	Butte Grating	65	206	45	246	Tunnel at Mill Creek (12,600' of 84" sewer)	West Fork Creek
194	Highpoint Grating	22	6	80	307	Partial separation (community priority)	Westwood Northern
195	Westwood Northern Grating	38	13	63	307	Partial separation (community priority)	Westwood Northern
203	Twin Grating	26	8	77	84	Tunnel at Mill Creek (12,600' of 84" sewer)	West Fork Creek
525	Mt. Airy Grating	22	6	83	307	Partial separation (community priority)	Westwood Northern
527	Powers No. 1 Grating	4	0	94	84	Regulator Improvement (4.6 cfs)	West Fork Creek
<b>TOTAL</b>		<b>508</b>	<b>753</b>		<b>884</b>		





<sup>1</sup> Volume II CSO LTCP Update Report, 2006; 2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report, 2008; Final Wet Weather Improvement Program, 2009.

<sup>2</sup> Represents preliminary annual stormwater runoff contributing to direct project areas identified in the Coarse Evaluation; Total number does not consider runoff from drainage areas that are tributary to multiple CSO points

The GIS inventory of natural systems investigated the sub-basin's hydrologic network, soil characteristics, slopes, tree canopy cover, and geology. The GIS inventory of built systems investigated the impervious surfaces, combined sewer system, existing land use, neighborhoods, and road right-of-way. Descriptions of and maps for these systems are included in the following pages.

### hydrologic network

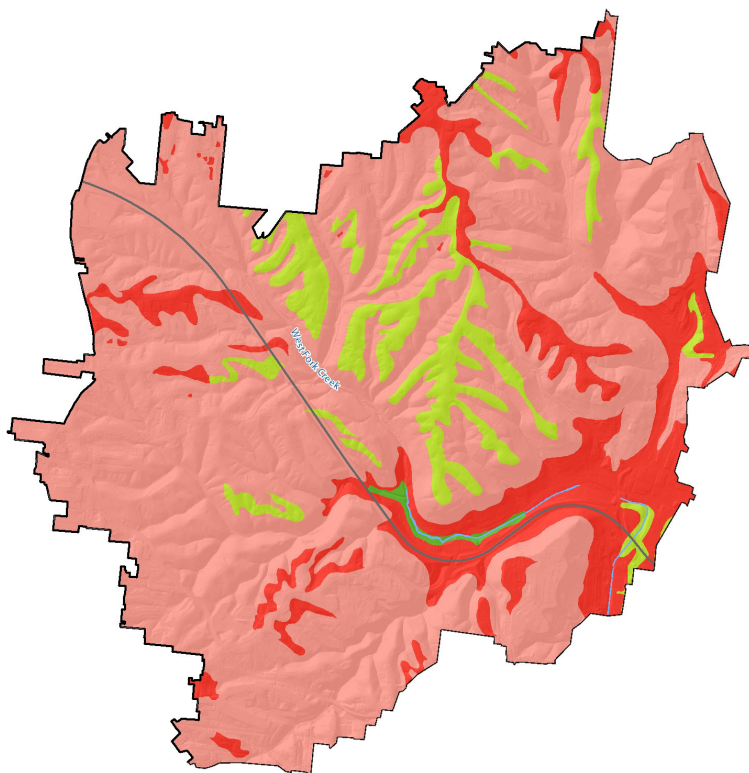








-  Sub-basin boundary
-  Interstate
-  Historical streams
-  Existing streams

The pre-development hydrologic network shows an extensive system of creeks and streams within the sub-basin. This network naturally conveyed stormwater runoff to the Mill Creek. Today underground sewer systems have replaced much of this stream network.

Data source: CAGIS, historical USGS maps

### hydrologic soil groups










-  Sub-basin boundary
-  Interstate
-  Group A
-  Group B
-  Group C
-  Group D

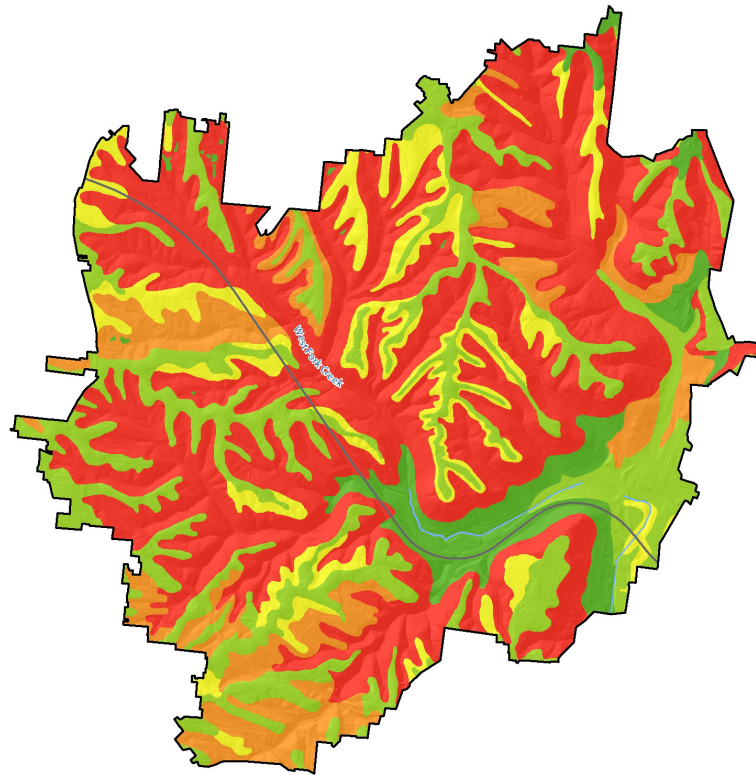
In the West Fork sub-basin, 76% of soils are Group C (4,175 acres), with 15% in Group D (856 acres). There are opportunities for shallow infiltration within Group A and B soils, which are located along the West Fork Creek and hilltops in Mt. Airy forest, respectively.

Data source: Hamilton County Soil Survey






-  Sub-basin boundary
-  Interstate
-  0-3 percent
-  3-8 percent
-  8-15 percent
-  15-25 percent
-  25+ percent

slope ranges

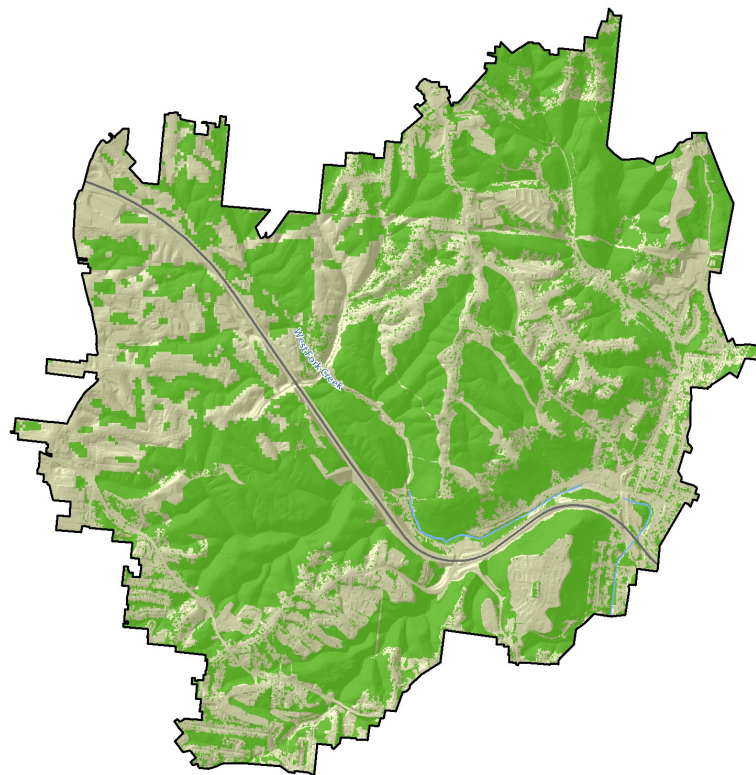


50% (2,748 acres) of land in the West Fork sub-basin has slopes greater than 25 percent.

Data source: Hamilton County Soil Survey

-  Sub-basin boundary
-  Interstate
-  Existing tree canopy

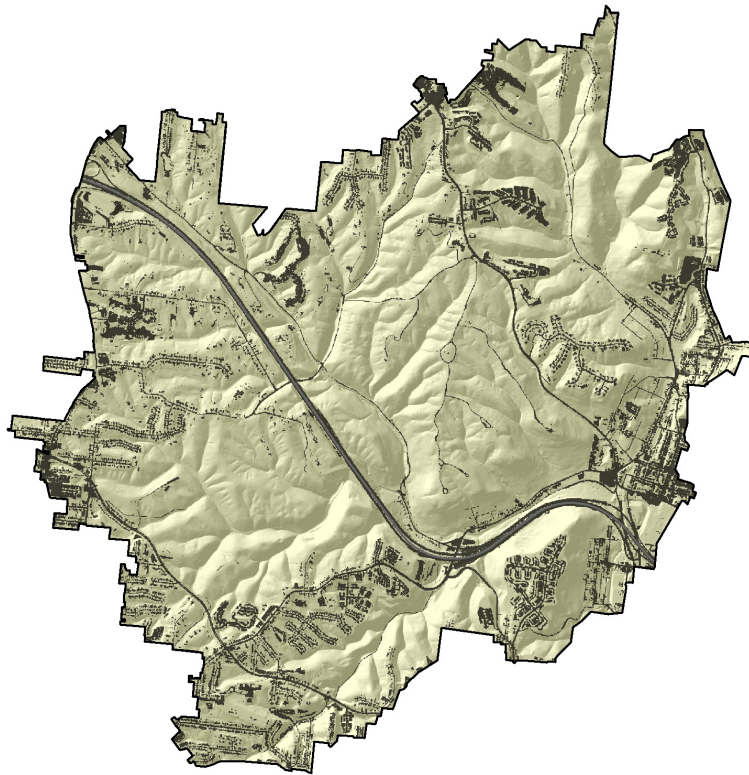
tree canopy cover



There are 3,098 acres of existing tree canopy in the West Fork sub-basin, representing 56% of the total land area.

Data source: Cincinnati Park Board, ODNR

## impervious surfaces

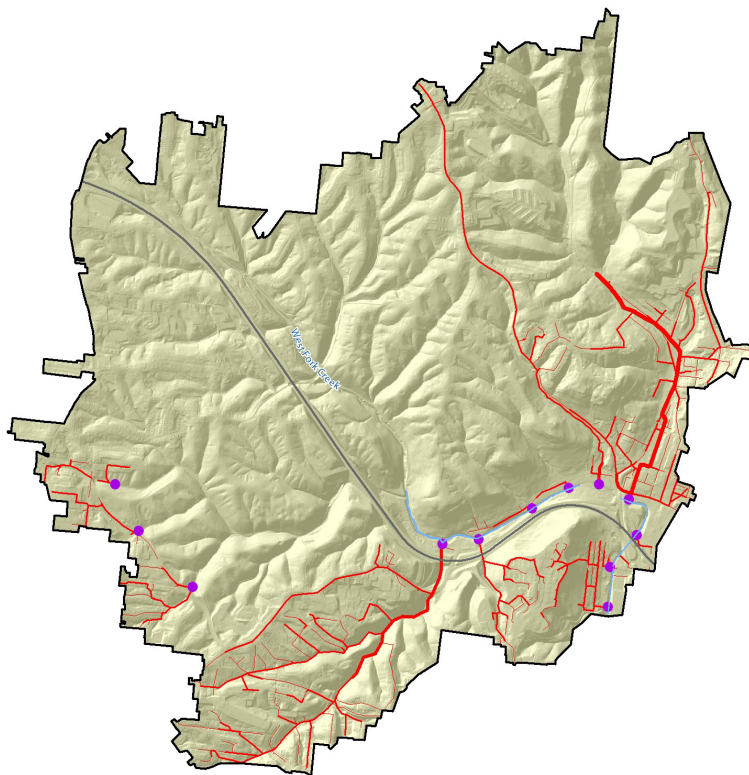


- Sub-basin boundary
- Interstate
- Impervious surfaces

There are 887 acres of impervious surfaces in the West Fork sub-basin, representing 16% of the total land area.

Data source: CAGIS









## combined sewer system

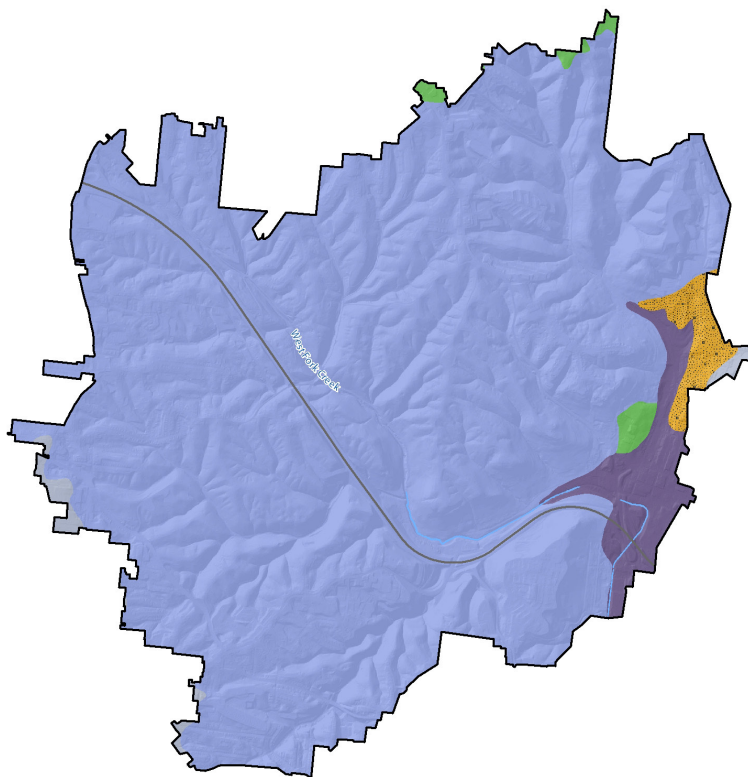


- Sub-basin boundary
  - Interstate
  - CSO
- Combined sewers (pipe size)
- < 12 inches
  - 12-48 inches
  - 48-72 inches
  - > 72 inches

There are 36 miles of combined sewers (100% of sewer infrastructure) in the West Fork sub-basin.

Data source: MSD

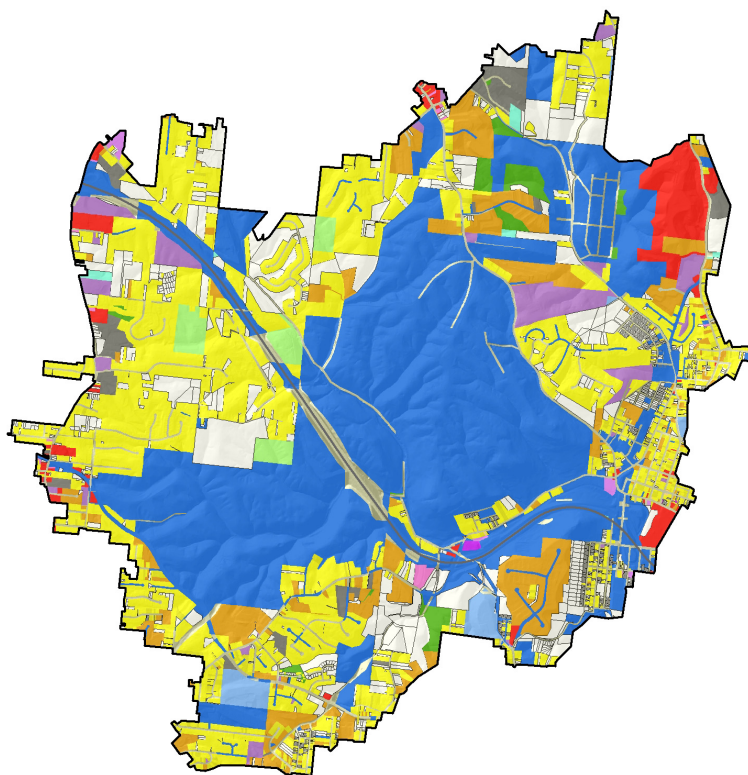
-  Sub-basin boundary
-  Interstate
-  Sand
-  Clay-loam till
-  Limestone
-  Loam till
-  Shale
-  Silt



The vast majority of land in the West Fork sub-basin is underlain by limestone geology. Deep infiltration opportunities may exist in sand deposits, which may be present in the eastern portion of the sub-basin

Data source: Ohio Geological Survey

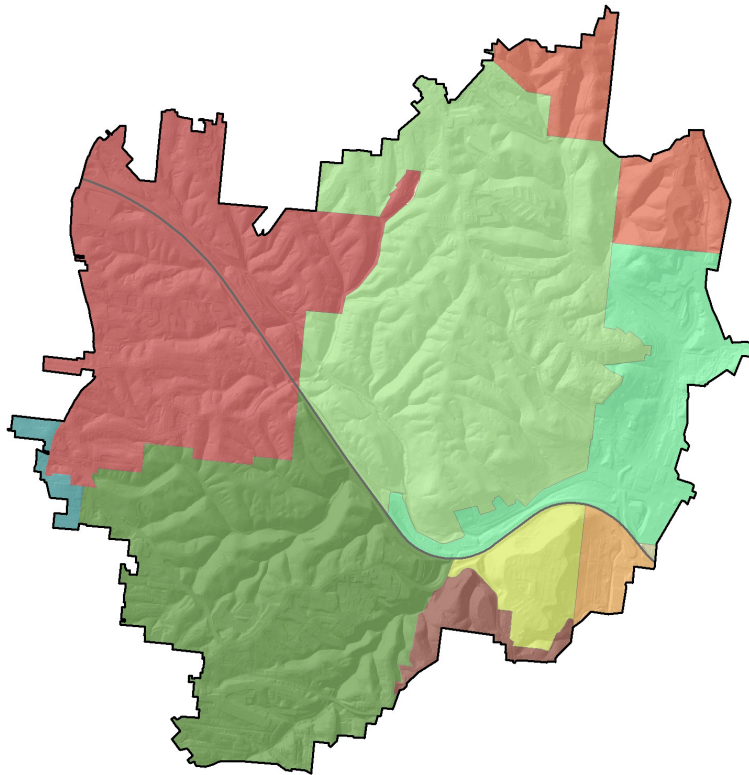
-  Sub-basin boundary
-  Interstate
-  Commercial
-  Educational
-  Industrial
-  Institutional
-  Light industrial
-  Multi-family
-  Mixed-use
-  Office
-  Parks & recreational
-  Public space
-  Public utilities
-  Single-family
-  Two-family
-  Vacant
-  Unknown



Publicly-owned property comprises the greatest percentage (39%) of land within the West Fork sub-basin.

Data source: Hamilton County Auditor

## neighborhoods

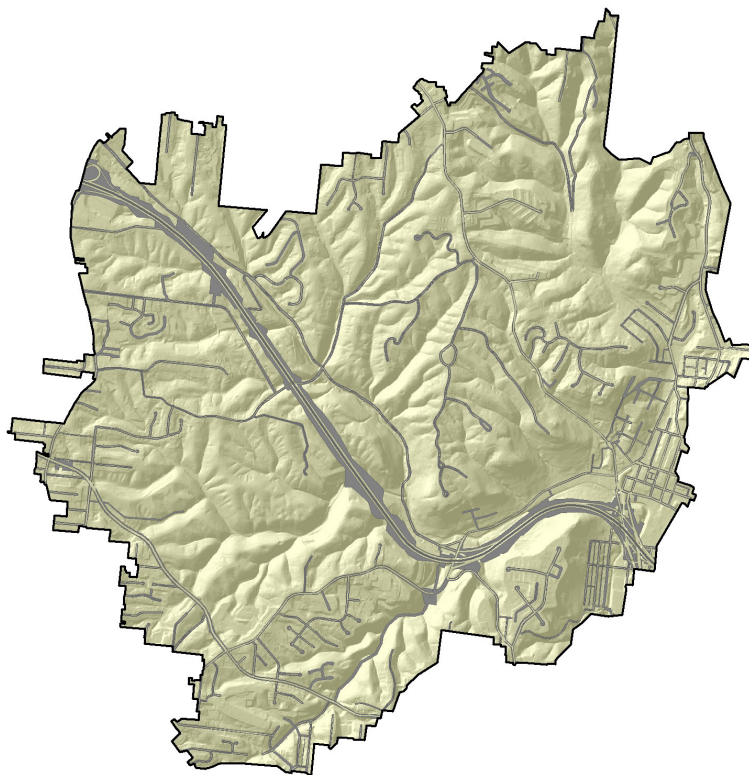


- Sub-basin boundary
- Interstate
- Cheviot
- College Hill
- East Westwood
- Fay Apartments
- Green Township
- Mt. Airy
- Northside
- South Cumminsville
- Westwood

The West Fork sub-basin is comprised of 7 different neighborhoods within 3 different jurisdictions.

Data source: CAGIS

## right-of-way (ROW)



- Sub-basin boundary
- Interstate
- Impervious surfaces

There are 365 acres of ROW in the West Fork sub-basin, which is 7% of the total land area.

Data source: CAGIS

## COARSE-LEVEL OPPORTUNITIES

The project team identified several opportunities for reducing the volume of stormwater runoff entering the combined sewer system and the resulting CSO volume. Coarse-level opportunities in the West Fork sub-basin include Direct Projects, Enabled Projects, and Inform/Influence Projects. Direct projects are wet weather strategies that require direct investment by MSD for planning and long-term maintenance; Enabled Projects are wet weather strategies that represent a leveraged infrastructure investment and present opportunities for cost sharing and collaboration among MSD and key watershed stakeholders; and Inform/Influence Projects are programmatic elements that engage and educate watershed partners and the broader public in making sustainable decisions that provide water quantity and quality benefits.

### Direct Projects

With the objective of reducing combined sewer overflows in the West Fork sub-basin, the project team first identified major direct entry points to the combined sewer system and their tributary natural drainage areas (**See Existing Conditions Overview**). Direct entry points represent areas where stormwater runoff and/or natural stream flows enter the combined sewer system.

Natural drainage basins that contained coarse-level opportunities became “direct project areas” (**See Direct Project Areas Overview**), allowing the team to narrow its focus within the sub-basin. The direct projects include large-scale retention, large-scale detention, stormwater separation, flood mitigation, and stream restoration.

#### Large-Scale Retention/Detention in Mt. Airy Forest (Direct Project Area 1)

A large-scale retention basin is proposed in the western portion of Mt. Airy Forest, near Interstate 74. This retention basin covers approximately 15.3 acres and lies within a 970-acre drainage area that produces approximately 307 million gallons of stormwater runoff each year. Stormwater runoff will be offloaded from the combined sewer system and directed to the proposed retention area with the potential to eliminate three CSOs (#525, #195, and #194). This retention feature will not only reduce downstream flooding and peak flows, but also will provide a community and recreational amenity.

#### Large-Scale Retention/Detention in Mt. Airy Forest (Direct Project Area 2)

Two large-scale detention basins are proposed in the northern section of Mt. Airy Forest. Detention Basin 1 covers approximately 13.6 acres and lies within a 373-acre drainage area that produces roughly 117 million gallons of stormwater runoff each year. Detention Basin 2 covers approximately 17 acres and lies within a drainage area of 247 acres with an annual runoff volume of 76 million gallons. These detention features will reduce downstream flooding and CSO volume (CSO #125).

#### Stormwater Separation in Fay Apartments (Direct Project Area 3)

A comprehensive stormwater separation opportunity is proposed in the Fay Apartments neighborhood. This opportunity includes disconnecting and offloading stormwater runoff from the combined sewer system to separate storm sewers which lead to West Fork Creek. The proposed stormwater separation area lies within a 207-acre drainage area which produces approximately 85 million gallons of stormwater runoff each year. This separation strategy will reduce CSO volume in CSO #203 and potentially eliminate CSO #527 and #117. This strategy will also improve water quality and offer community improvement (e.g., through open space utilization).

#### Flooding Mitigation, Stream Restoration & Stormwater Separation (Direct Project Area 4)

This opportunity area lies within a drainage area of approximately 207 acres which produces roughly 84 million gallons of stormwater runoff each year. The proposed mitigation, restoration and separation will disconnect and offload stormwater from the combined sewer to a restored natural drainage feature, thereby reducing flooding, restoring floodplain/natural habitat, and improving water quality. These opportunities have the potential to reduce CSO volume in CSO #127, #128, and #203.

#### Stormwater Offloading/Separation in Mt. Airy (Direct Project Area 5)

This separation opportunity lies within a 647-acre drainage area that produces approximately 246 million gallons of stormwater runoff each year. The proposed separation will disconnect and offload stormwater from the combined sewer system and direct it to natural drainage areas, separate storm sewers, and West Fork Creek thereby reducing CSO volume (CSO #103) and flooding, restoring stream and natural habitat and historical hydrologic patterns, and improving water quality.

## Enabled Projects

### **Reforestation (Enabled Projects: Reforestation)**

There are currently 3,098 acres of existing tree canopy in the West Fork sub-basin, representing 56 percent of the total land area. This canopy network provides valuable benefits in regard to natural stormwater runoff management and air quality improvement. Based on a CITYgreen analysis, the team was able to recommend not only protecting the existing canopy within the sub-basin, but reforesting 60 percent of the canopy-deficient areas along major interstate corridors, road right-of-ways and steep slopes. Reforestation efforts should focus on the 511 acres of canopy-deficient hillsides and 85 acres of right-of-ways present within the West Fork sub-basin. According to the CITYgreen analysis, such reforestation has the potential to remove approximately 59.5 million gallons (53.7 and 5.8 million gallons respectively) of stormwater runoff from the combined sewer each year.

### **Interstate 75 Expansion**

An enabled opportunity has been identified with the reconstruction of the Interstate 75 and 74 corridor and several of its interchanges within the LMC watershed presents an opportunity to form partnerships (inform and influence) with the Ohio Department of Transportation and the City of Cincinnati (specifically Cincinnati's Department of Transportation and Engineering). As impervious pavement increases, so will the amount of stormwater runoff unless efforts are made to capture the excess water. There are currently 60 acres of impervious surface along the I-74 corridor within the West Fork sub-basin, which generate roughly 64 MG of stormwater runoff each year.

## Inform & Influence Projects

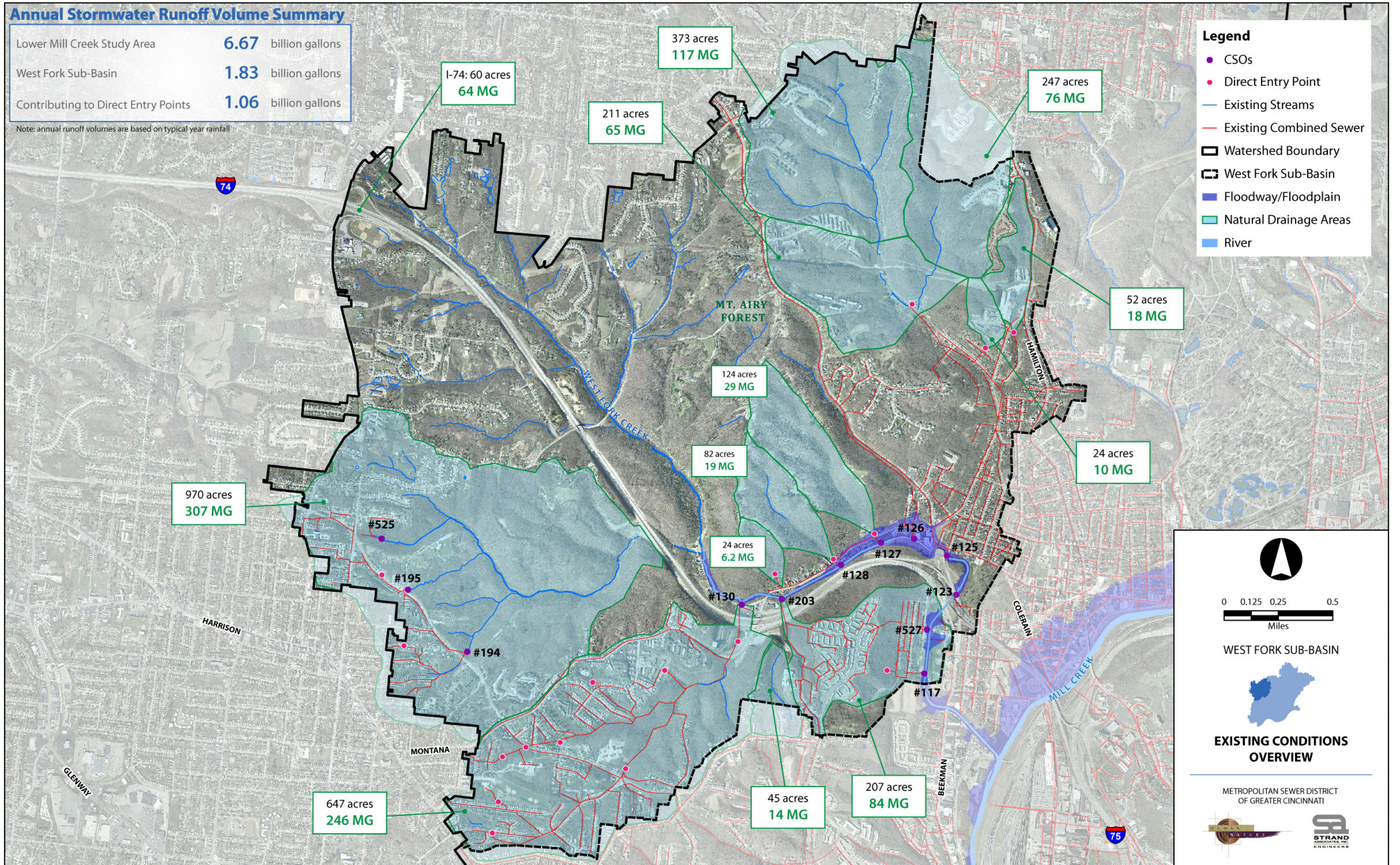
### **Watershed Partners (Inform & Influence Projects: Watershed Partners)**

Several partners within the West Fork sub-basin have been identified as opportunities to inform and influence the implementation of various direct and enabled wet weather strategies or opportunity projects (i.e. detention/retention basins, stormwater separation and reuse, water quality BMPs, and reforestation). Partner properties include schools, parks, open spaces, institutional properties, road right-of-way, and vacant, abandoned and foreclosed properties. As potential areas for public-private partnerships, these land uses can integrate multiple stakeholders, thereby increasing public involvement and improving public perception of infrastructure projects. For example, forging partnerships with institutional and educational properties can create highly-visible projects within the community, and foster long-lasting, inter-agency relationships. The Watershed Partner map depicts the identified partners within the West Fork Sub-basin. The largest partner located in the West Fork sub-basin is the Cincinnati Park Board, which owns Mt. Airy Forest and Bradford-Felters Tanglewood Park.

# Annual Stormwater Runoff Volume Summary

Lower Mill Creek Study Area	6.67 billion gallons
West Fork Sub-Basin	1.83 billion gallons
Contributing to Direct Entry Points	1.06 billion gallons

Note: annual runoff volumes are based on typical year rainfall



0 0.125 0.25 0.5 Miles

WEST FORK SUB-BASIN

EXISTING CONDITIONS OVERVIEW

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

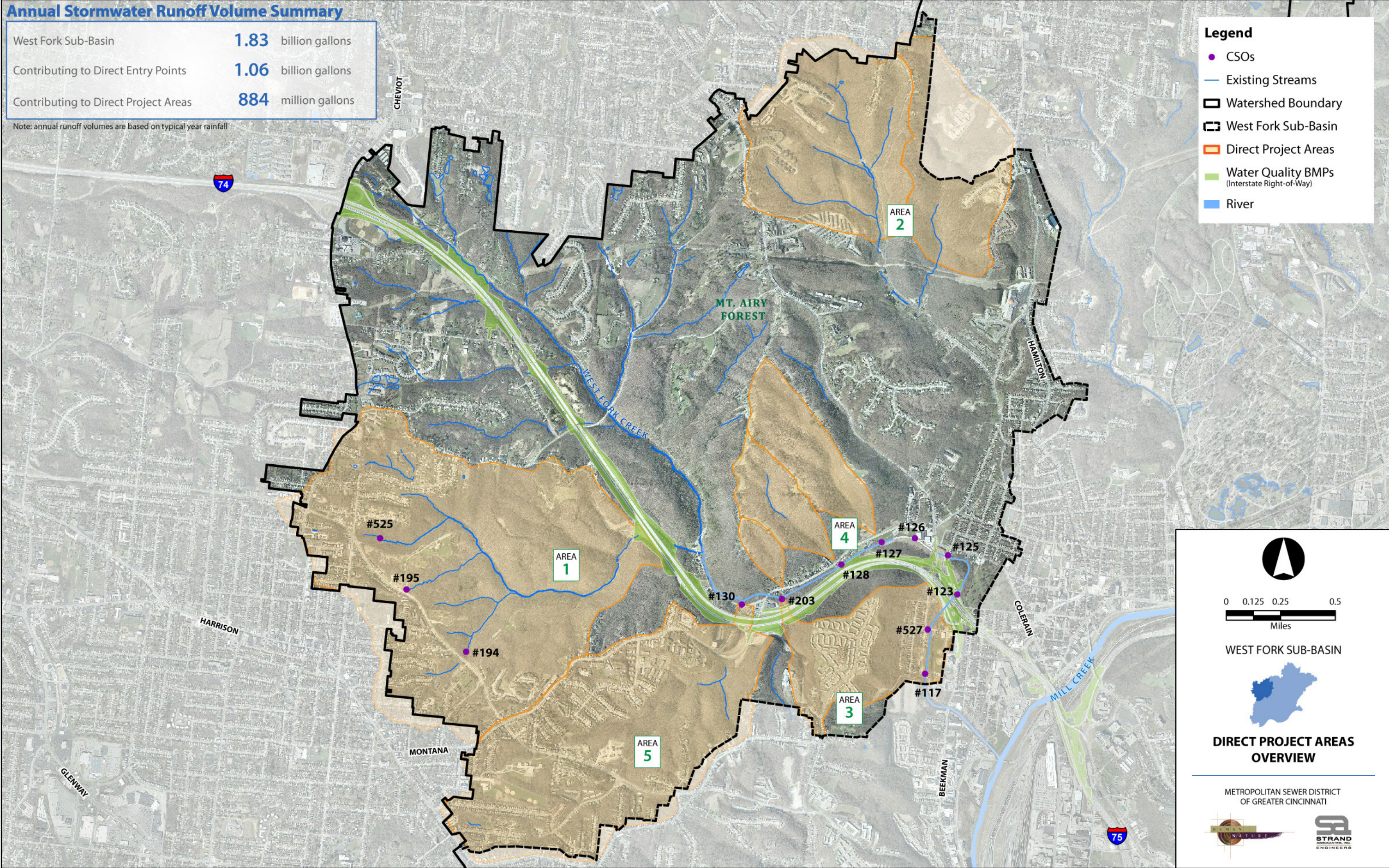
# Annual Stormwater Runoff Volume Summary

West Fork Sub-Basin	<b>1.83</b> billion gallons
Contributing to Direct Entry Points	<b>1.06</b> billion gallons
Contributing to Direct Project Areas	<b>884</b> million gallons

Note: annual runoff volumes are based on typical year rainfall

**Legend**

- CSOs
- Existing Streams
- ▭ Watershed Boundary
- ▭ West Fork Sub-Basin
- ▭ Direct Project Areas
- ▭ Water Quality BMPs (Interstate Right-of-Way)
- ▭ River



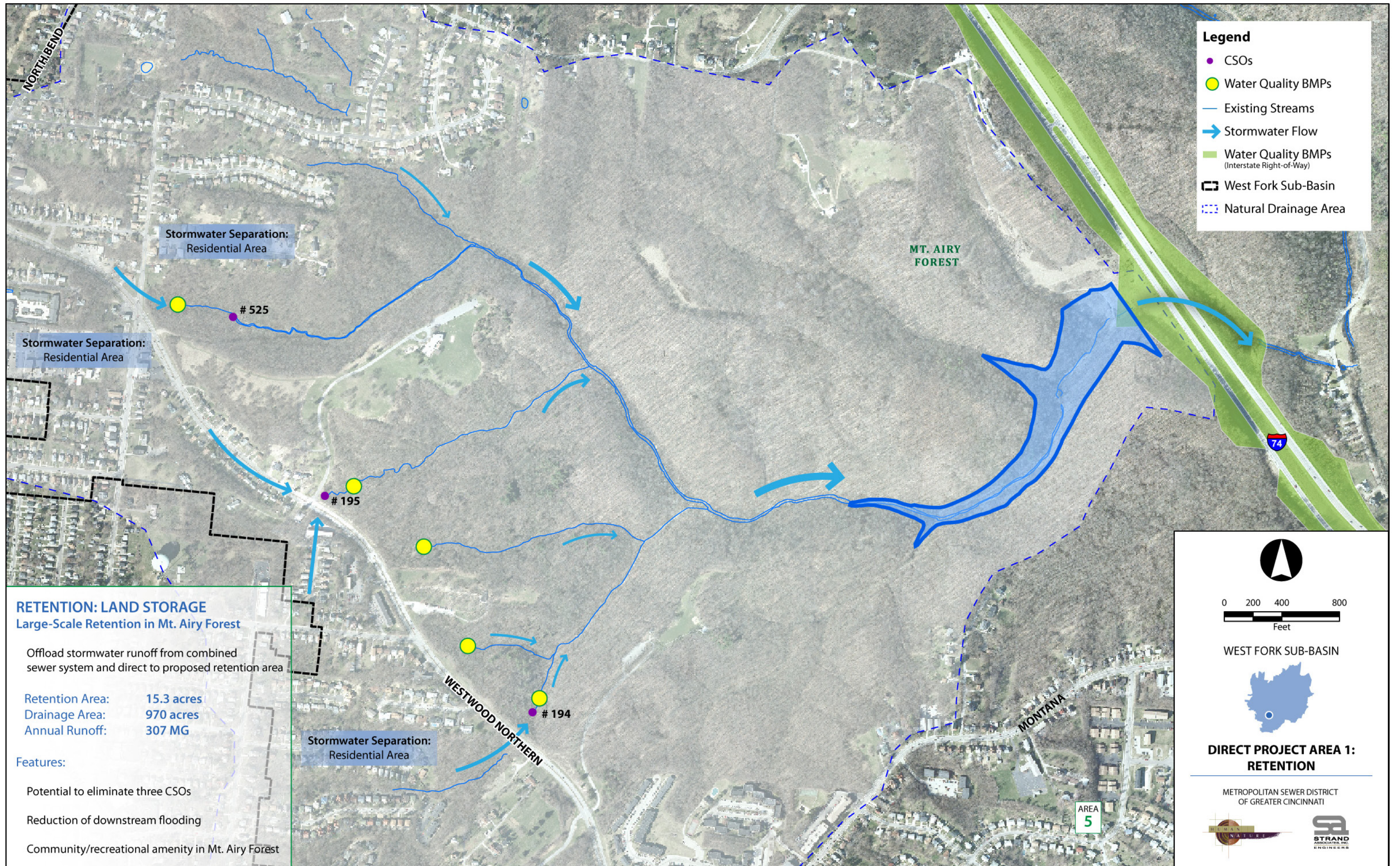
0 0.125 0.25 0.5  
Miles

WEST FORK SUB-BASIN

**DIRECT PROJECT AREAS OVERVIEW**

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI





**Legend**

- CSOs
- Water Quality BMPs
- Existing Streams
- ➔ Stormwater Flow
- Water Quality BMPs (Interstate Right-of-Way)
- ▭ West Fork Sub-Basin
- ⋯ Natural Drainage Area

**RETENTION: LAND STORAGE**  
 Large-Scale Retention in Mt. Airy Forest

Offload stormwater runoff from combined sewer system and direct to proposed retention area

Retention Area: 15.3 acres  
 Drainage Area: 970 acres  
 Annual Runoff: 307 MG

Features:

- Potential to eliminate three CSOs
- Reduction of downstream flooding
- Community/recreational amenity in Mt. Airy Forest

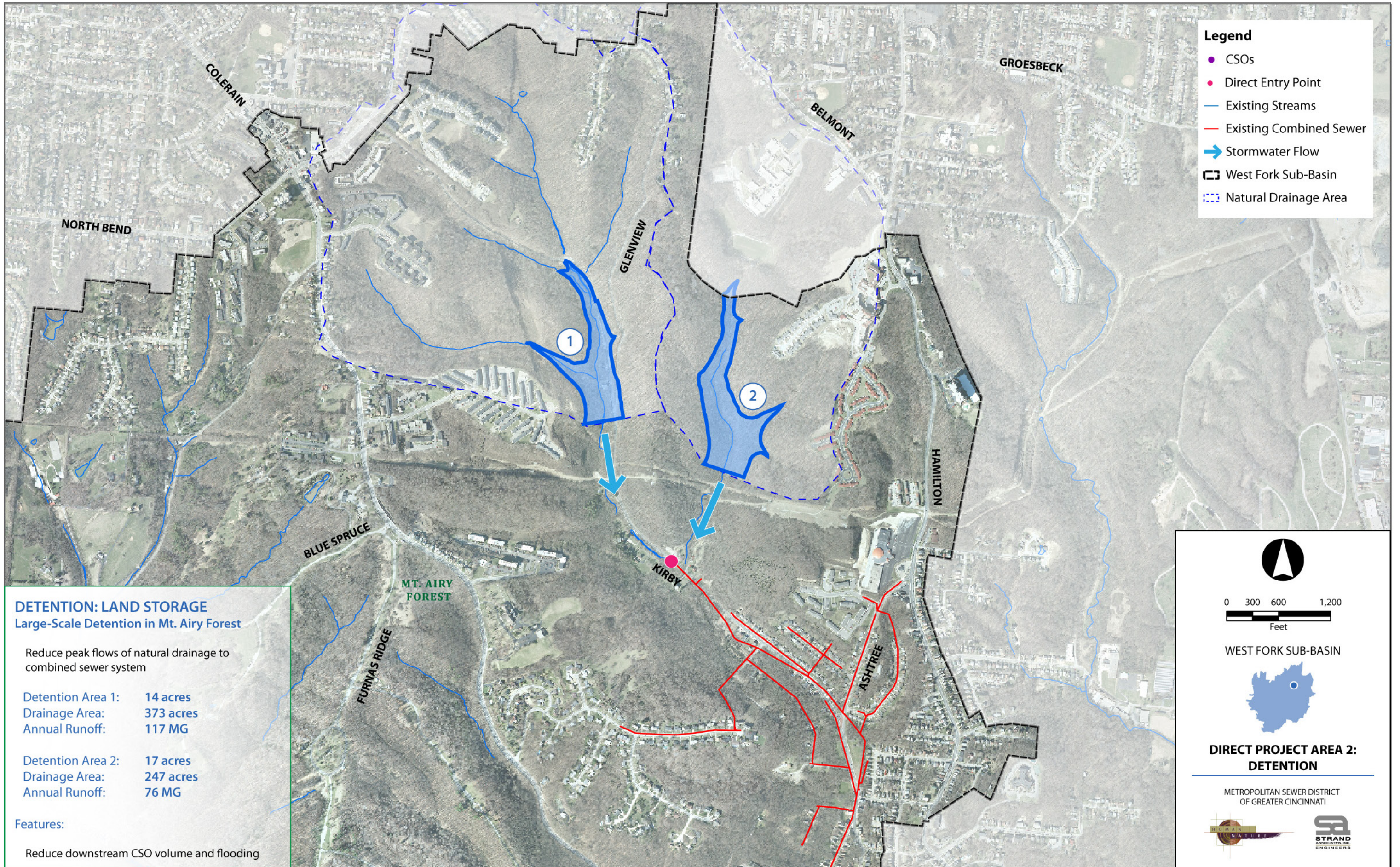
0 200 400 800  
 Feet

WEST FORK SUB-BASIN

**DIRECT PROJECT AREA 1: RETENTION**

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

STRAND ASSOCIATES INC. ENGINEERS





**STORMWATER SEPARATION**  
Fay Apartments

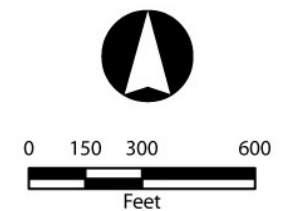
Offload stormwater runoff from combined sewer system and direct to separate storm sewers and West Fork Creek

Drainage Area: 207 acres  
Annual Runoff: 84 MG

**Features:**

- Reduce CSO volume (#203)
- Potential to eliminate two CSOs (#527, #117)
- Water quality improvement

- Legend**
- CSOs
  - Direct Entry Point
  - Existing Streams
  - Existing Combined Sewer
  - Existing Storm Sewer
  - ➔ Proposed Separate Storm Sewer (to natural drainage features)
  - Water Quality BMPs (Interstate Right-of-Way)
  - ▭ West Fork Sub-Basin
  - ⋯ Natural Drainage Area



WEST FORK SUB-BASIN



**DIRECT PROJECT AREA 3:  
SITE-SPECIFIC SOLUTIONS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI



# FLOODING MITIGATION & STREAM RESTORATION West Fork Creek

Separate dry weather flows from combined sewer interception

Drainage Area: 230 acres  
Annual Runoff: 55 MG

## Features:

- Stream flow offloaded from combined sewer system
- Flooding mitigation
- Floodplain/habitat restoration
- Water quality improvement

Drainage Area: 124 acres  
Annual Runoff: 29.2 MG

Drainage Area: 82 acres  
Annual Runoff: 19.3 MG

Drainage Area: 24 acres  
Annual Runoff: 6.2 MG



**Legend**

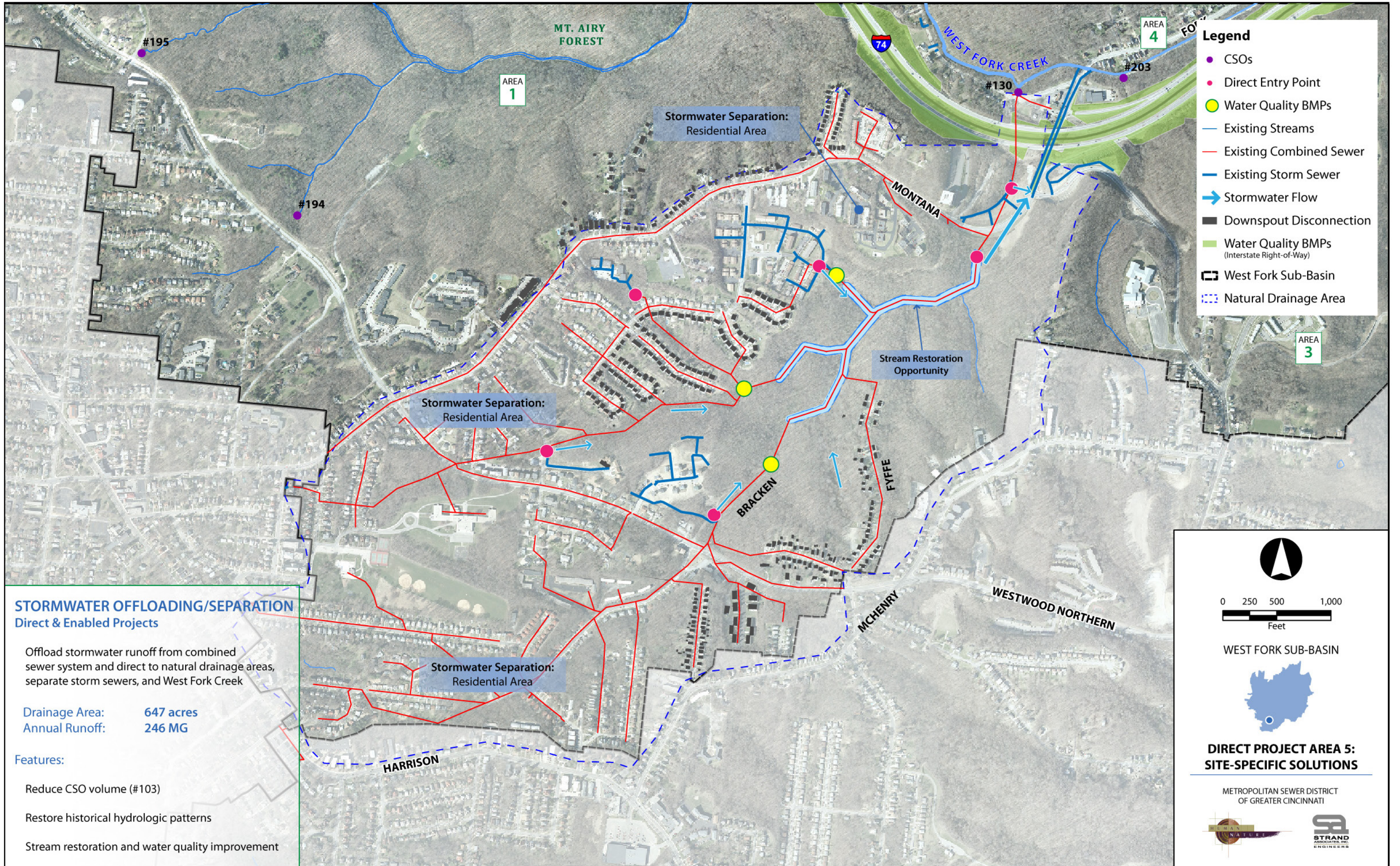
- CSOs
- Direct Entry Point
- Existing Streams
- Existing Combined Sewer
- ➔ Proposed Separate Storm Sewer (to natural drainage features)
- Water Quality BMPs (Interstate Right-of-Way)
- Floodplain Restoration (West Fork Creek)
- ▭ West Fork Sub-Basin
- ⋯ Natural Drainage Area

0 150 300 600  
Feet

WEST FORK SUB-BASIN

**DIRECT PROJECT AREA 4:  
FLOODING MITIGATION**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI



**Legend**

- CSOs
- Direct Entry Point
- Water Quality BMPs
- Existing Streams
- Existing Combined Sewer
- Existing Storm Sewer
- ➔ Stormwater Flow
- Downspout Disconnection
- Water Quality BMPs (Interstate Right-of-Way)
- ▭ West Fork Sub-Basin
- ▭ Natural Drainage Area

**STORMWATER OFFLOADING/SEPARATION**  
Direct & Enabled Projects

Offload stormwater runoff from combined sewer system and direct to natural drainage areas, separate storm sewers, and West Fork Creek

Drainage Area: 647 acres  
Annual Runoff: 246 MG

- Features:
- Reduce CSO volume (#103)
  - Restore historical hydrologic patterns
  - Stream restoration and water quality improvement

0 250 500 1,000  
Feet

WEST FORK SUB-BASIN

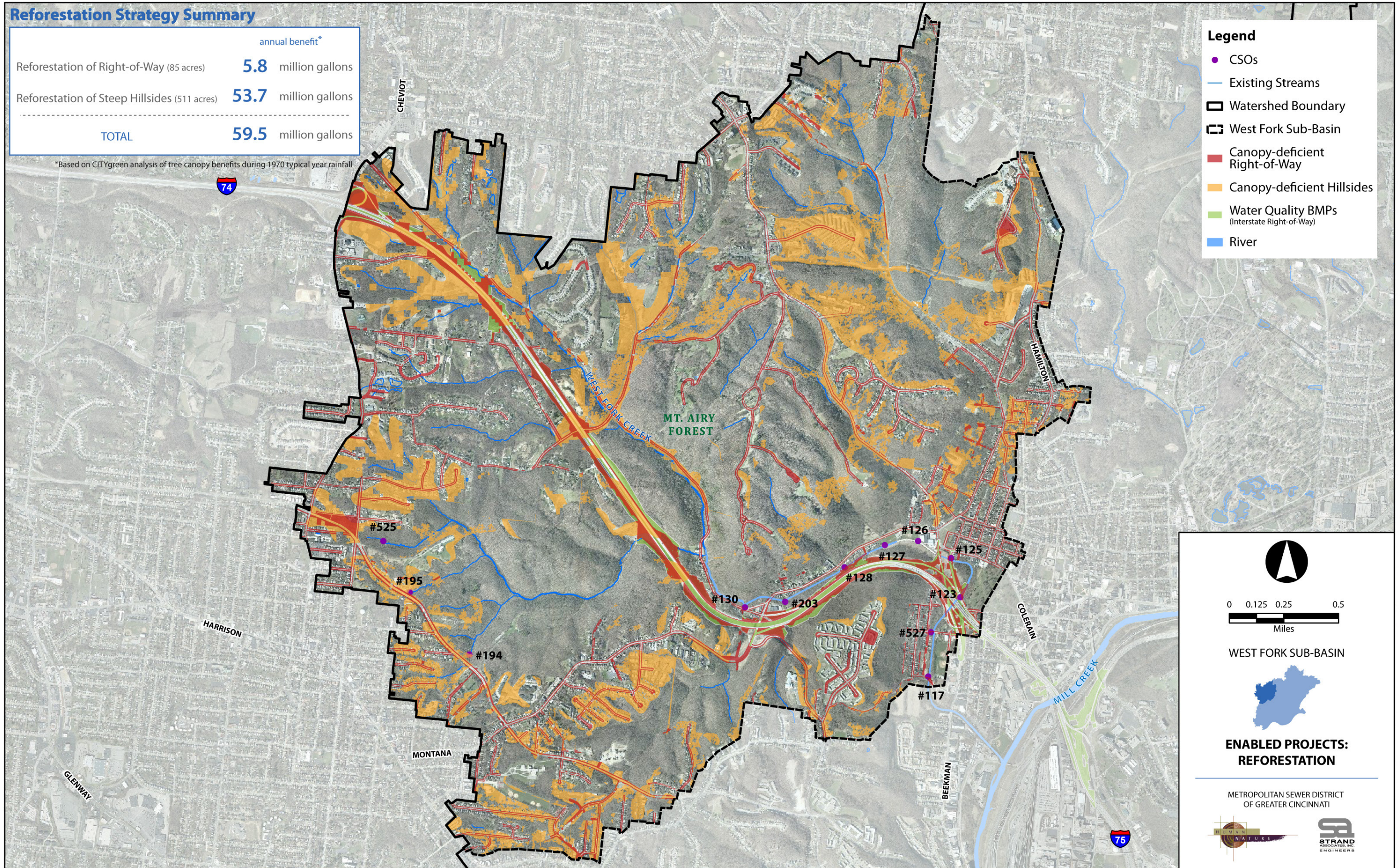
**DIRECT PROJECT AREA 5:  
SITE-SPECIFIC SOLUTIONS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI

## Reforestation Strategy Summary

	annual benefit*
Reforestation of Right-of-Way (85 acres)	5.8 million gallons
Reforestation of Steep Hillsides (511 acres)	53.7 million gallons
<b>TOTAL</b>	<b>59.5 million gallons</b>

\*Based on CITYgreen analysis of tree canopy benefits during 1970 typical year rainfall



**Legend**

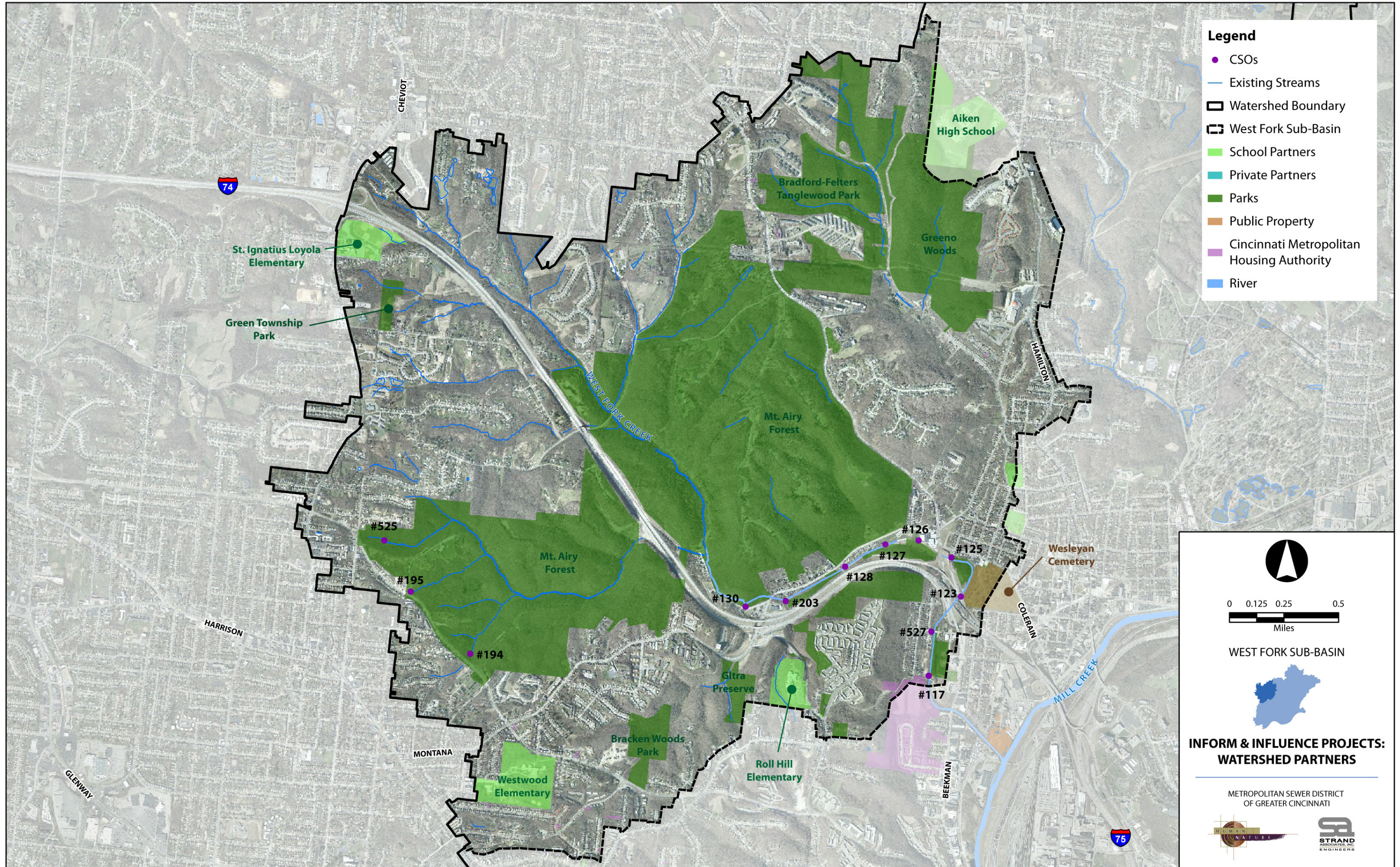
- CSOs
- Existing Streams
- ▭ Watershed Boundary
- ▭ West Fork Sub-Basin
- ▭ Canopy-deficient Right-of-Way
- ▭ Canopy-deficient Hillsides
- ▭ Water Quality BMPs (Interstate Right-of-Way)
- River

0 0.125 0.25 0.5  
Miles

WEST FORK SUB-BASIN

**ENABLED PROJECTS:  
REFORESTATION**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI



- Legend**
- CSOs
  - Existing Streams
  - ▭ Watershed Boundary
  - ▭ West Fork Sub-Basin
  - School Partners
  - Private Partners
  - Parks
  - Public Property
  - Cincinnati Metropolitan Housing Authority
  - River

0 0.125 0.25 0.5  
Miles

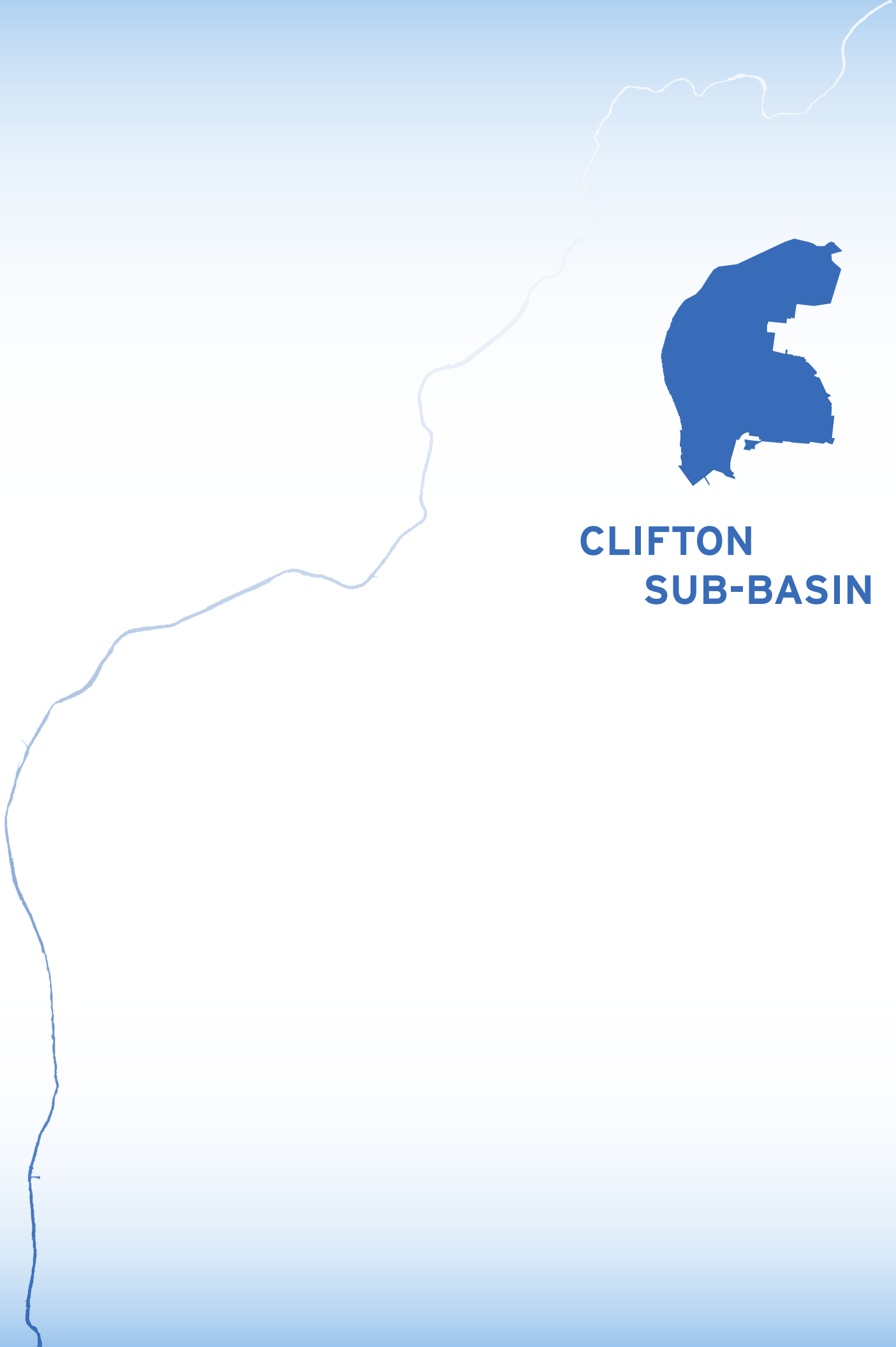
WEST FORK SUB-BASIN

**INFORM & INFLUENCE PROJECTS:  
WATERSHED PARTNERS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI







**CLIFTON  
SUB-BASIN**

# CLIFTON SUB-BASIN



## LOCATION

The Clifton sub-basin covers approximately 4.1 square miles (6.6 percent of the Lower Mill Creek watershed) and overlaps ten neighborhoods within the City of Cincinnati (i.e., Camp Washington, Clifton, CUF (Clifton Heights, University Heights and Fairview), Clifton Heights, Northside, Winton Place, Corryville, South Fairmount, Queensgate, West End and a contested area). The main transportation routes include Interstates 74 and 75, Central Parkway, Martin Luther King Jr. Drive, Clifton Avenue, Spring Grove Avenue, Hopple Street, Western Hills Viaduct, and Harrison Avenue. Key property owners include CSX (Railroad property), the Cincinnati Park Board, the City of Cincinnati, the State of Ohio (University of Cincinnati and I-75 right-of-way), Vine Street Hill Cemetery Association, Cincinnati State, Cincinnati Board of Education, Good Samaritan Hospital, The Union of American Jewish Congregation (Hebrew Union College), and the United States Environmental Protection Agency.

## CHARACTERIZATION OF PROBLEM

There are 12 CSO locations within the Clifton sub-basin, contributing an annual overflow volume of 1.05 billion gallons, which accounts for about 16 percent of Cincinnati's total combined sewer overflow volume. Direct project areas identified during the coarse evaluation contribute approximately 239 MG of stormwater runoff annually.

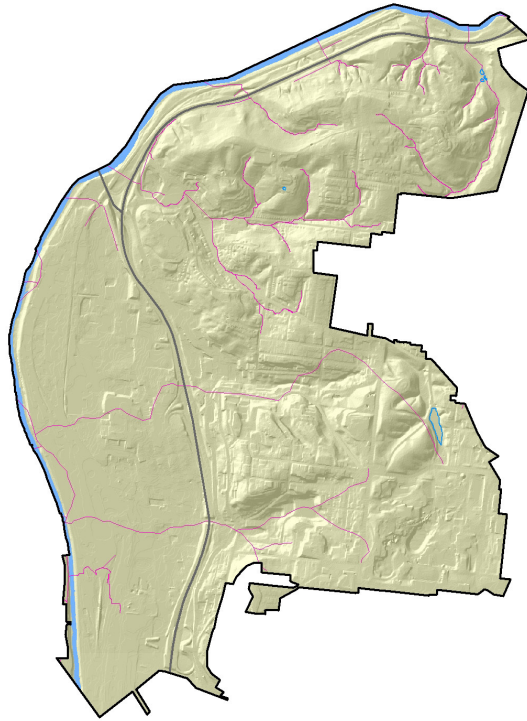
CSO NUMBER	NAME	ANNUAL CSO STATISTICS <sup>1</sup>			DIRECT PROJECT <sup>2</sup> (MG)	CSO CONTROL STRATEGY <sup>1</sup>	BUNDLE CLUSTER
		EVENTS	OVERFLOW (MG)	CONTROL (%)			
4	Harrison and State East Regulator	74	37	18	0	HW/DW protection	Western Hills Viaduct
6	Queen City East Regulator	70	52	25	0	Tunnel	Western Hills Viaduct
7	Draper St. Regulator	77	92	19	0	Tunnel	Western Hills Viaduct
9	Marshall Ave. Regulator	49	162	67	10	Tunnel	Hopple Street Viaduct
11	Hopple St. Regulator	65	28	37	0	Tunnel	Hopple Street Viaduct
12	Bates Run Regulator	68	325	36	136	Tunnel	Hopple Street Viaduct
15	Arlington St. Regulator	35	39	79	0	Tunnel	Hopple Street Viaduct
19	Geringer St. Grating	13	1	92	0	Regulator Improvement (7.6 cfs)	Northside
21	Streng St. Diversion Dam	73	156	27	71	Tunnel	Northside
28	Clifton Ave. East Grating	64	36	48	0	Tunnel	King's Run
30	Lafayette Cir. Grating	59	66	60	0	Tunnel	King's Run
179	Scarlet Oaks Regulator	73	60	13	23	Partial separation	Northside
<b>TOTAL</b>		<b>720</b>	<b>1,054</b>		<b>239</b>		

<sup>1</sup> Volume II CSO LTCP Update Report, 2006; 2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report, 2008; Final Wet Weather Improvement Program, 2009.

<sup>2</sup> Represents preliminary annual stormwater runoff contributing to direct project areas identified in the Coarse Evaluation; Total number does not consider runoff from drainage areas that are tributary to multiple CSO points

The GIS inventory of natural systems investigated the sub-basin's hydrologic network, soil characteristics, slopes, tree canopy cover, and geology. The GIS inventory of built systems investigated the impervious surfaces, combined sewer system, existing land use, neighborhoods, and road right-of-way. Descriptions of and maps for these systems are included in the following pages.

## hydrologic network

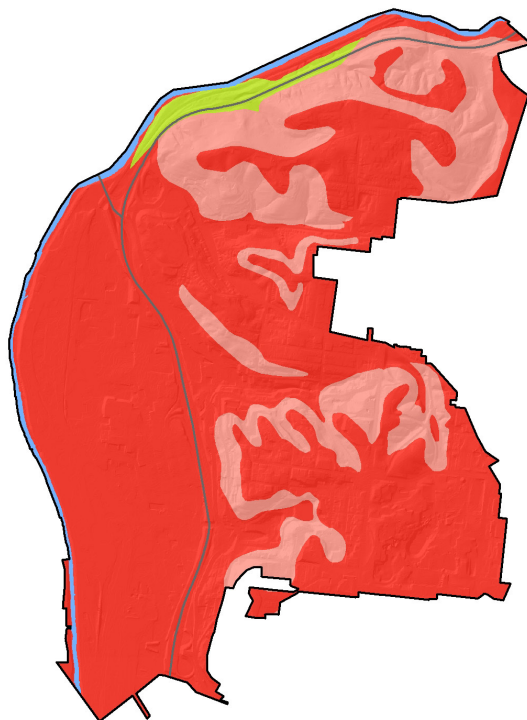


- Sub-basin boundary
- Interstate
- Historical streams
- Existing streams

The pre-development hydrologic network shows an extensive system of creeks and streams within the sub-basin. This network naturally conveyed stormwater runoff to the Mill Creek. Today underground sewer systems have replaced this stream network.

Data source: CAGIS, historical USGS maps








## hydrologic soil groups



- Sub-basin boundary
- Interstate
- Group A
- Group B
- Group C
- Group D

In the Clifton sub-basin, the majority of soils are hydrologic group C or D, having limited potential for infiltration.

Data source: Hamilton County Soil Survey




-  Sub-basin boundary
-  Interstate
-  0-3 percent
-  3-8 percent
-  8-15 percent
-  15-25 percent
-  25+ percent

slope ranges



The majority of land in the Clifton sub-basin has slopes of 8 percent or less.

Data source: Hamilton County Soil Survey

-  Sub-basin boundary
-  Interstate
-  Existing tree canopy

tree canopy cover






There are 801 acres of existing tree canopy in the Clifton sub-basin, representing 31% of the total land area.

Data source: Cincinnati Park Board, ODNR

## impervious surfaces

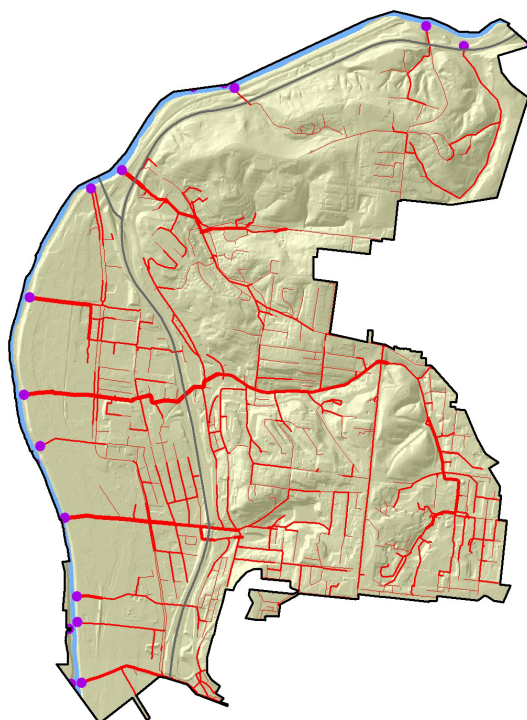









-  Sub-basin boundary
-  Interstate
-  Impervious surfaces

There are 1,362 acres of impervious surfaces in the Clifton sub-basin, representing 52% of the total land area.

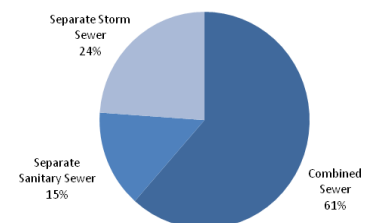
Data source: CAGIS

## combined sewer system










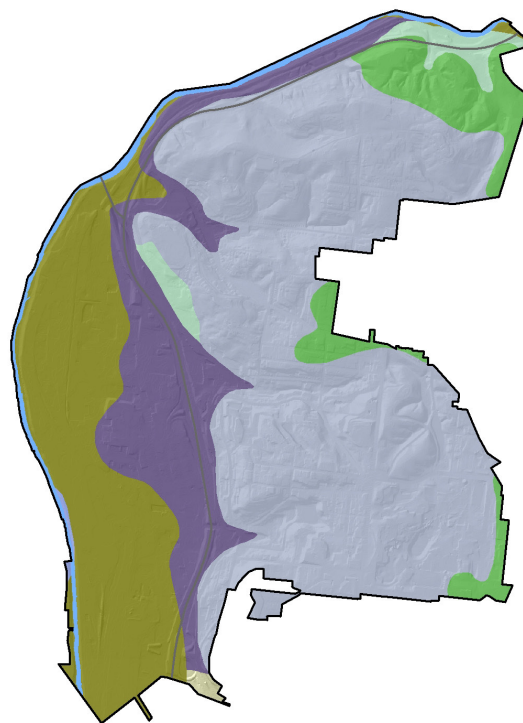
-  Sub-basin boundary
  -  Interstate
  -  CSO
- Combined sewers (pipe size)
-  < 12 inches
  -  12-48 inches
  -  48-72 inches
  -  > 72 inches

There are 56 miles of combined sewers in the Clifton sub-basin.



Data source: MSD

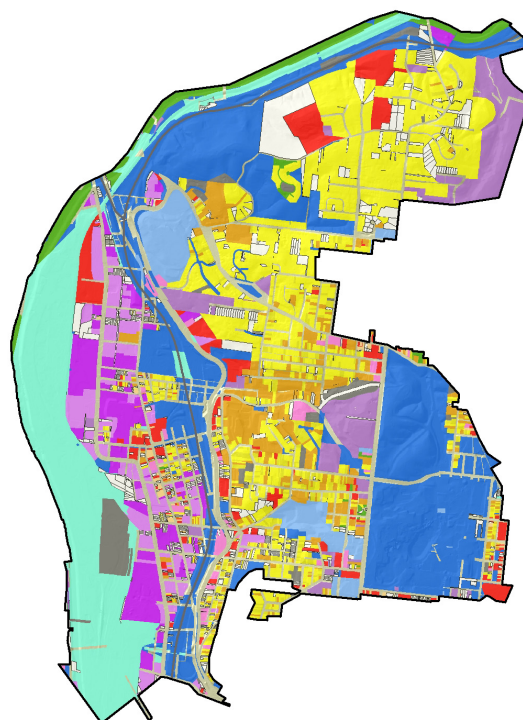
-  Sub-basin boundary
-  Interstate
-  Alluvium
-  Clay
-  Loam till
-  Shale
-  Silt



The majority of land in the Clifton sub-basin is underlain by shale, silt, and clay geologic formations. Deep infiltration opportunities may exist in alluvium, which may be present in the western portion of the sub-basin along the Mill Creek.

Data source: Ohio Geological Survey

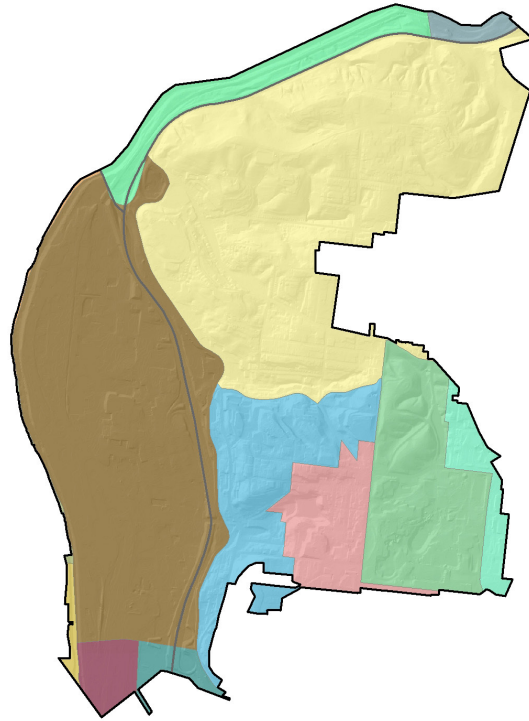
-  Sub-basin boundary
-  Interstate
-  Commercial
-  Educational
-  Industrial
-  Institutional
-  Light industrial
-  Multi-family
-  Mixed-use
-  Office
-  Parks & recreational
-  Public space
-  Public utilities
-  Single-family
-  Two-family
-  Vacant
-  Unknown



Publicly-owned property comprises the greatest percentage (22%) of land within the Clifton sub-basin.

Data source: Hamilton County Auditor

## neighborhoods

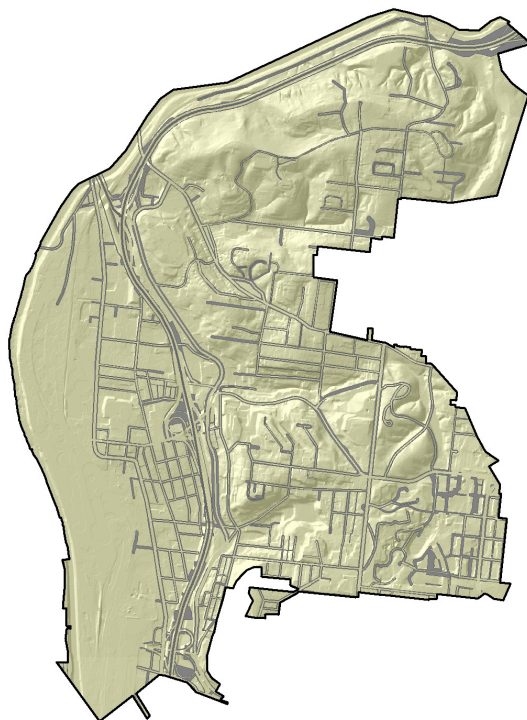


- Sub-basin boundary
- Interstate
- CUF
- Camp Washington
- Clifton
- Clifton Heights
- Corryville
- North Fairmount
- Northside
- Queensgate
- South Fairmount
- West End
- Winton Place
- Contested Area

**The Clifton sub-basin is comprised of 11 different neighborhoods.**

Data source: CAGIS

## right-of-way (ROW)



- Sub-basin boundary
- Interstate
- Impervious surfaces

**There are 205 acres of ROW in the Clifton sub-basin, which is 8% of the total land area.**

Data source: CAGIS

## COARSE-LEVEL OPPORTUNITIES

The project team identified several opportunities for reducing the volume of stormwater runoff entering the combined sewer system and the resulting CSO volume. Coarse-level opportunities in the Clifton sub-basin include Direct Projects, Enabled Projects, and Inform/Influence Projects. Direct projects are wet weather strategies that require direct investment by MSD for planning and long-term maintenance; Enabled Projects are wet weather strategies that represent a leveraged infrastructure investment and present opportunities for cost sharing and collaboration among MSD and key watershed stakeholders; and Inform/Influence Projects are programmatic elements that engage and educate watershed partners and the broader public in making sustainable decisions that provide water quantity and quality benefits.

### Direct Projects

With the objective of reducing combined sewer overflows in the Clifton sub-basin, the project team first identified major direct entry points to the combined sewer system and their tributary natural drainage areas (**See Existing Conditions Overview**). Direct entry points represent areas where stormwater runoff and/or natural stream flows enter the combined sewer system. Due to the prevalence of watershed partners in the Clifton sub-basin, runoff volumes were calculated for major Inform & Influence properties in addition to the natural drainage areas.

Natural drainage basins that contained coarse-level opportunities became “direct project areas” (**See Direct Project Areas Overview**), allowing the team to narrow its focus within the sub-basin. The direct wet weather strategies, or opportunity areas, include retention basins, detention basins, several different stormwater separation opportunities, and water quality BMPs.

#### Potential Separation in Mt. Storm Park (Direct Project Area 1)

The proposed separation will disconnect and offload stormwater from the combined sewer to natural drainage areas which will eventually flow into a separate storm pipe leading directly to the Mill Creek. This opportunity will improve water quality and potentially eliminate CSO #21 with an average annual overflow volume of 156.1 million gallons each year. The proposed separate storm sewer is approximately 7,630 feet and has the potential to remove approximately 93 MG of stormwater runoff from the combined sewer each year.

#### Stormwater Separation in Stratford Heights/Coy Field (Direct Project Area 2)

A stormwater separation opportunity is proposed in the Stratford Heights community across from the University of Cincinnati. This opportunity includes disconnecting and offloading stormwater runoff from the combined sewer system and redirecting it to an underground storage facility in Coy Field. This opportunity may provide community improvement (e.g., through open space utilization). The proposed stormwater separation area is approximately 26.8 acres. The underground storage area underneath Coy Field is 2.8 acres and has the potential to hold much of the 10 million gallons of annual stormwater runoff generated by Stratford Heights separation area.

#### Retention, Stream Daylighting, and Detention in Burnet Woods (Direct Project Area 3: Burnet Woods)

The proposed opportunities proposed for Burnet Woods (as identified in the Burnet Woods Master Plan) will offload stormwater runoff from the U.S. EPA site and the University of Cincinnati’s West Campus and direct it to stormwater management features within Burnet Woods. These opportunities will reduce CSO volume (CSO #12 with an average annual overflow volume of 325.1 MG), reduce peak flows to the combined sewer system, and improve water quality. The proposed opportunities will contribute to the removal of approximately 136 MG of stormwater runoff each year.

### Enabled Projects

#### Reforestation (Enabled Projects: Reforestation)

There are currently 801 acres of existing tree canopy in the Clifton sub-basin, representing 31 percent of the total land area. This canopy network provides valuable benefits in regard to natural stormwater runoff management and air quality improvement. Based on a CITYgreen analysis, the team was able to recommend not only protecting the existing canopy within the sub-basin, but reforesting 60 percent of the canopy-deficient areas along major interstate corridors, road right-of-ways and steep slopes. Reforestation efforts should focus on the 84 acres of canopy-deficient hillsides and 50 acres of right-of-ways present within the Clifton sub-basin. According to the CITYgreen analysis, such reforestation has the potential to remove approximately 16.1 million



galons (10.5 MG and 5.6 million gallons respectively) of stormwater runoff from the combined sewer each year.

An enabled opportunity has been identified with the reconstruction of the Interstate 75 corridor and several of its interchanges within the LMC watershed presents an opportunity to form partnerships (inform and influence) with the Ohio Department of Transportation and the City of Cincinnati (specifically Cincinnati's Department of Transportation and Engineering). As impervious pavement increases, so will the amount of stormwater runoff unless efforts are made to capture the excess water. There are currently 59 acres of impervious surface along the I-75 corridor and 5 acres along the I-74 corridor within the Clifton sub-basin, which generate roughly 63MG and 5MG respectively of stormwater runoff each year.

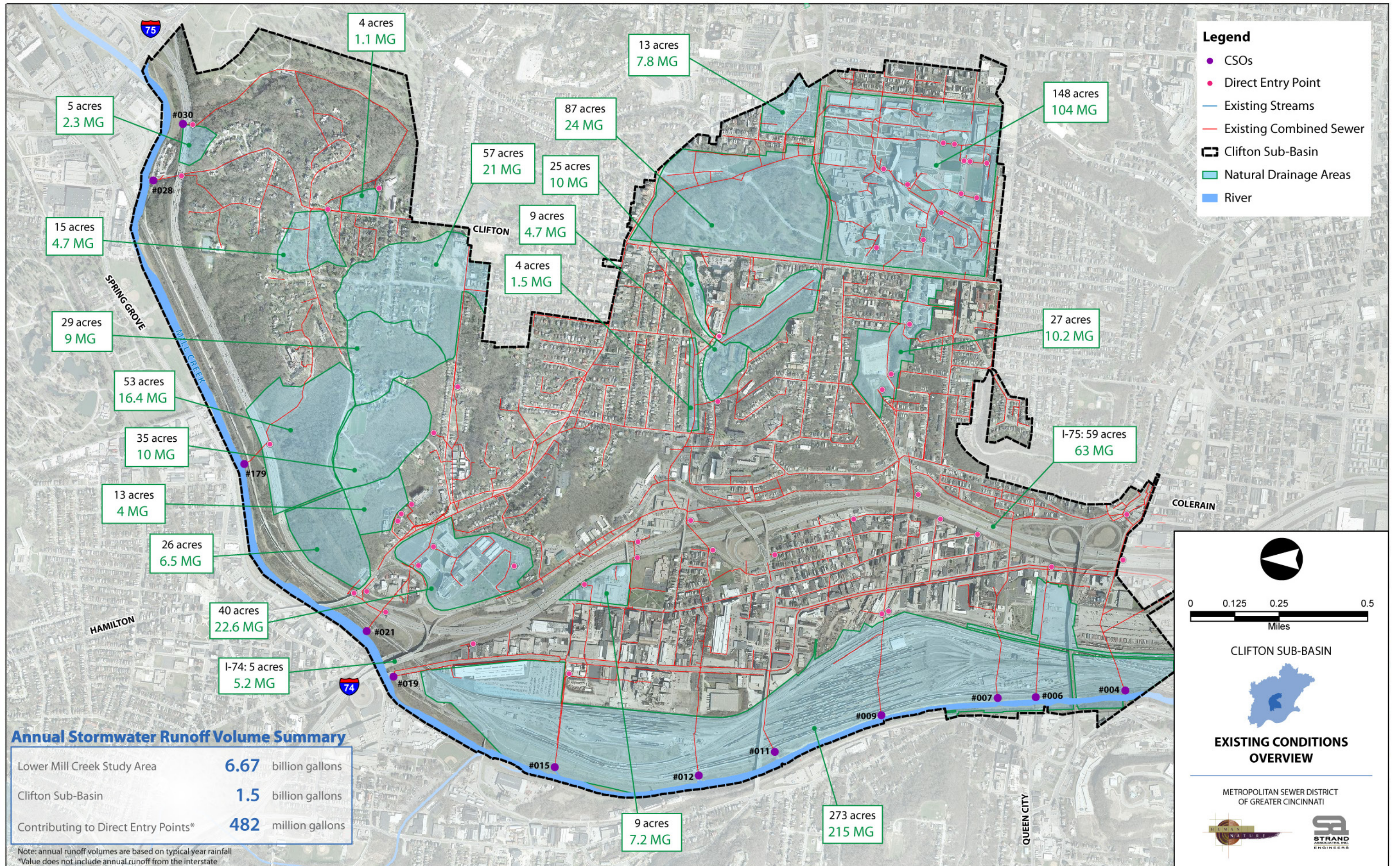
#### **Mill Creek Greenway Trail**

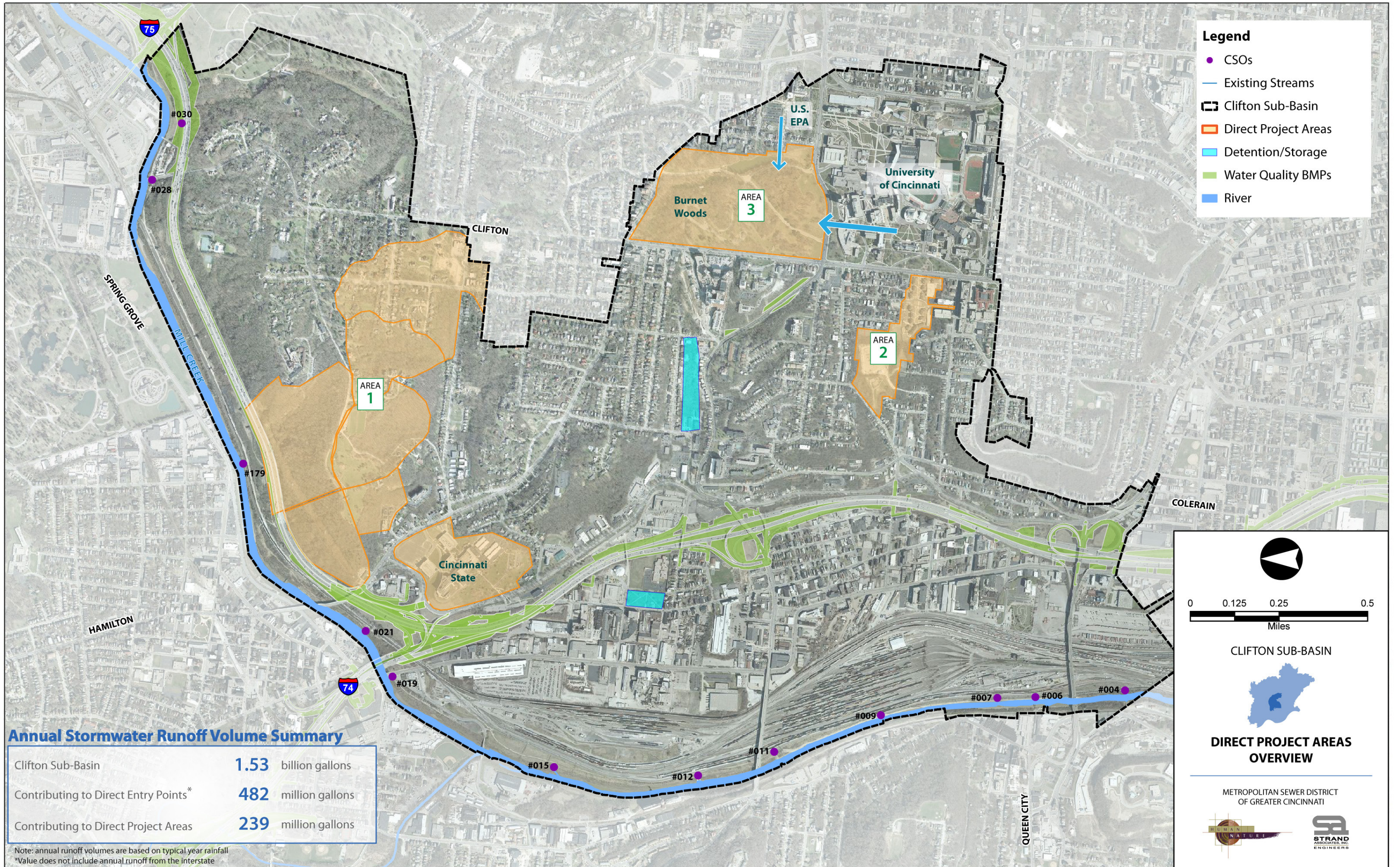
The construction of the Mill Creek Greenway trail presents the opportunity to integrate stormwater quality BMPs along the Mill Creek corridor.

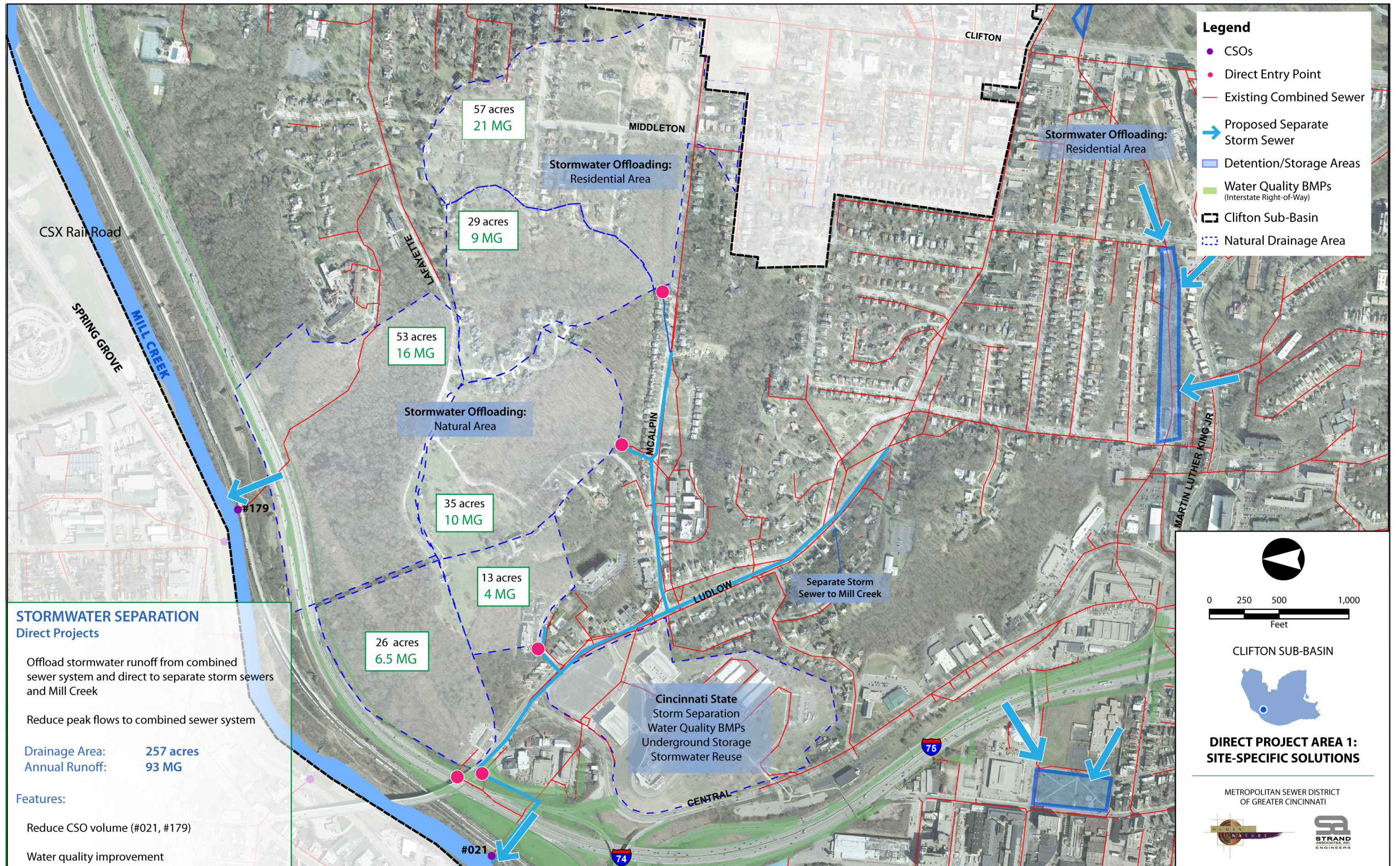
### **Inform & Influence Projects**

#### **Watershed Partners (Inform & Influence Projects: Watershed Partners)**

Several partners within the Clifton sub-basin have been identified as opportunities to inform and influence the implementation of various direct and enabled wet weather strategies or opportunity projects (i.e. detention/retention basins, stormwater separation and reuse, water quality BMPs, and reforestation). Partner properties include schools, parks, open spaces, institutional properties, road right-of-way, and vacant, abandoned and foreclosed properties. As potential areas for public-private partnerships, these land uses can integrate multiple stakeholders, thereby increasing public involvement and improving public perception of infrastructure projects. For example, forging partnerships with institutional and educational properties can create highly-visible projects within the community, and foster long-lasting, inter-agency relationships. The Watershed Partner map depicts the identified partners within the Clifton Sub-basin may include Cincinnati Park Board (Mt. Storm Park, Burnet Woods, and Central Parkway), University of Cincinnati, Cincinnati State University, US Environmental Protection Agency (US EPA), CSX Railroad, Good Samaritan Hospital, Hebrew Union College, City of Cincinnati's Strategic Program for Urban Redevelopment (SPUR), and the Mill Creek Greenway Trail.









**Legend**

- Direct Entry Points
- Existing Combined Sewer
- Existing Storm Sewer
- ➔ Proposed Separate Storm Sewer (to underground storage)
- Water Quality BMPs (Martin Luther King Drive)
- ▭ Clifton Sub-Basin
- ⋯ Natural Drainage Area

**DETENTION: UNDERGROUND STORAGE**  
**Coy Field**

Offload stormwater runoff from combined sewer system and direct to separate storm sewers (existing and proposed) and underground storage tank

Reduce peak flows of stormwater runoff to combined sewer system

Drainage Area: 27 acres  
 Annual Runoff: 10 MG

Features:

- Reduce CSO volume (#009)
- Water quality improvement

0 100 200 400  
 Feet

CLIFTON SUB-BASIN

**DIRECT PROJECT AREA 2:  
 SITE-SPECIFIC SOLUTIONS**

METROPOLITAN SEWER DISTRICT  
 OF GREATER CINCINNATI

In Collaboration with:

**Uptown Consortium, Inc.  
&  
Cincinnati Park Board**

**Uptown Parks & Neighborhood Revitalization Plan**

**Burnet Woods & Clifton Study Area  
Final Master Plan**

**BURNET WOODS  
Stormwater Master Plan**

Offload stormwater runoff from the U.S. EPA site and the University of Cincinnati's West Campus and direct to stormwater management features within in Burnet Woods

Drainage Area: **248 acres**  
Annual Runoff: **136 MG**

**Components:**

- AREA A** Retention forebay/bioinfiltration
- AREA B** Stream daylighting opportunity
- AREA C** Detention opportunity

**Components:**

- Reduce CSO volume (#012)
- Reduce peak flows to combined sewer system
- Water quality improvement

**"The Oasis"**

**Park Elements:**

- 1 Improved Linkages to / from Digg's Plaza
- 2 Ludlow Gateway
- 3 New Street Trees Along Ludlow
- 4 Streetscape Linkages to / from Zoo
- 5 Restored Stream Corridor with Trail Interpretive Stops: Stormwater BMP's
- 6 Clifton Gateway: Realigned with Dixmyth
- 7 Bandstand
- 8 Improved Parking & Picnic/Play Rental Area
- 9 Realigned Street with Parking, Pedestrian Promenade, & Connecting Gardens
- 10 Enhanced Trailside, Boathouse, & Terrace
- 11 Existing Shelter and Playground
- 12 Existing Road Removed to Strengthen Forest & Stream Linkage
- 13 Terrace, Cafe, and Restaurant on Clifton
- 14 Park Drop-Off & Parking
- 15 Enhanced Lake Promenade
- 16 New Scenic Drive Alignment
- 17 "Green" Park Maintenance Building
- 18 Enhanced Streetscape Along Clifton Avenue
- 19 UC Permit Parking
- 20 Expanded Disc Golf Course
- 21 Native Landscape Restoration & Biofiltration
- 22 Entry Plaza & Improved Intersection
- 23 Landscape Gallery
- 24 Enhanced Streetscape Along Martin Luther King Avenue
- 25 King Gateway
- 26 Cul-de-sac Alternative



**Boulevard Streetscape Enhancements:**

- Landscaped Median with Trees
- Boulevard Lighting
- ADA Curb Ramps
- Curb Extensions ("Bulb-Outs")
- Bike Lanes (Space Permitting)
- Crosswalk Enhancements

**Residential Streetscape Enhancements:**

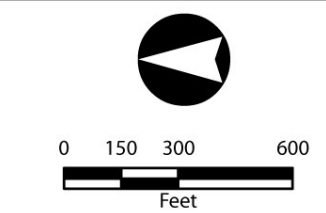
- ADA Curb Ramps
- Curb Extensions
- Traffic Calming Elements
- Crosswalk Enhancements

- KEY:**
- IN** New Institutional Development Opportunities
  - MU** New Mixed-Use Development Opportunities
  - ★** Park/Neighborhood Gateway
  - Major Uptown Gateway
  - \*** Interpretive Element
  - Emergency Call Kiosk
  - Park Property Line



**December 20, 2006**

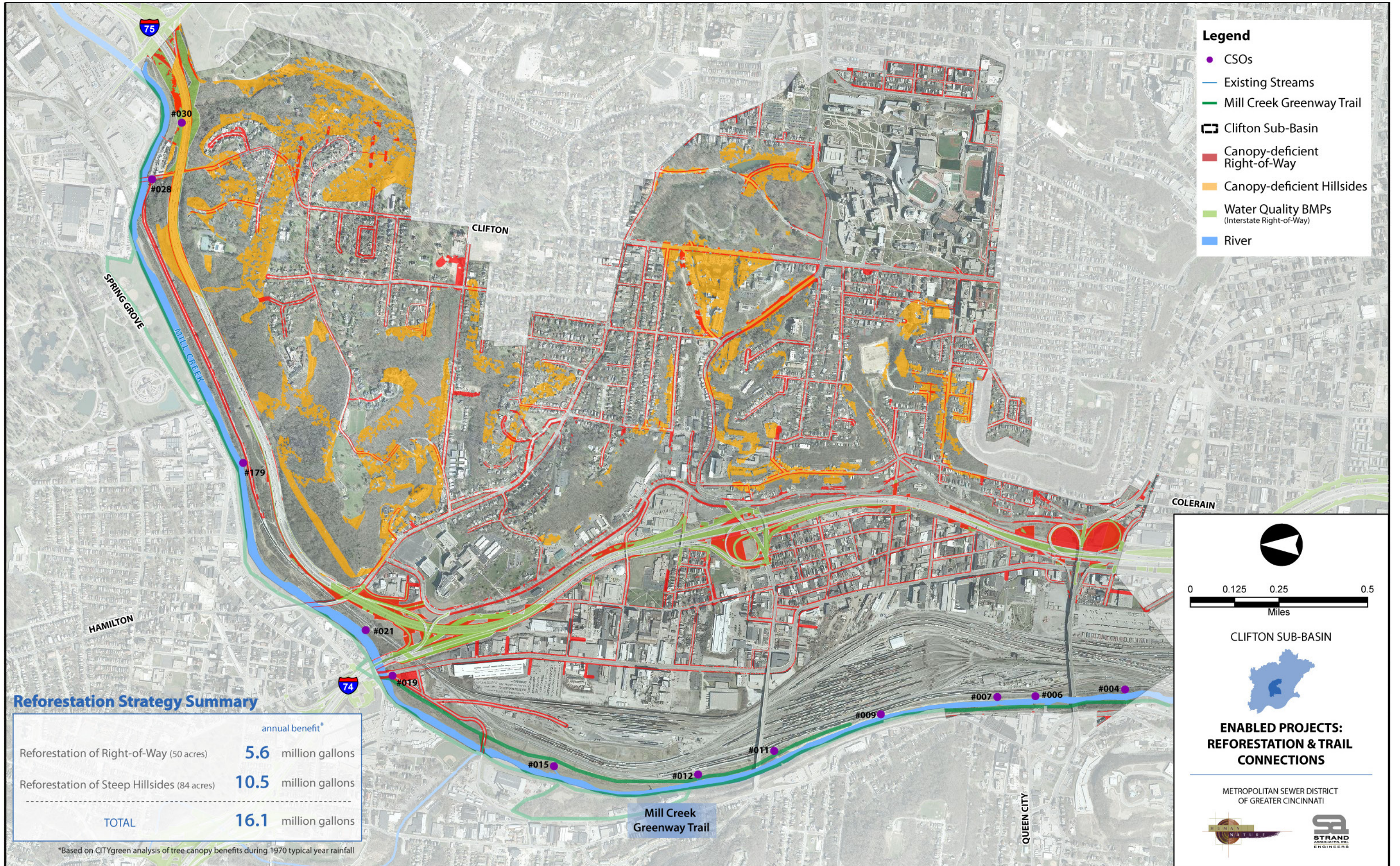
**DESIGN TEAM:** Human Nature Goody Clancy | ZHA, Inc. Fearing + Hagenauer | Kolar Design Leisure Services Management | Davey Resource Group LISC



**CLIFTON SUB-BASIN**

**DIRECT PROJECT AREA 3:  
BURNET WOODS**



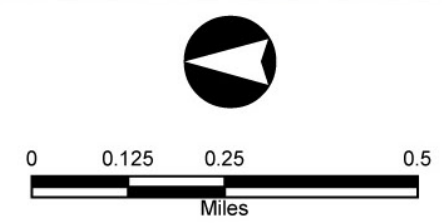


- Legend**
- CSOs
  - Existing Streams
  - Mill Creek Greenway Trail
  - ▭ Clifton Sub-Basin
  - ▭ Canopy-deficient Right-of-Way
  - ▭ Canopy-deficient Hillside
  - ▭ Water Quality BMPs (Interstate Right-of-Way)
  - ▭ River

**Reforestation Strategy Summary**

	annual benefit*
Reforestation of Right-of-Way (50 acres)	5.6 million gallons
Reforestation of Steep Hillside (84 acres)	10.5 million gallons
<b>TOTAL</b>	<b>16.1 million gallons</b>

\*Based on CITYgreen analysis of tree canopy benefits during 1970 typical year rainfall



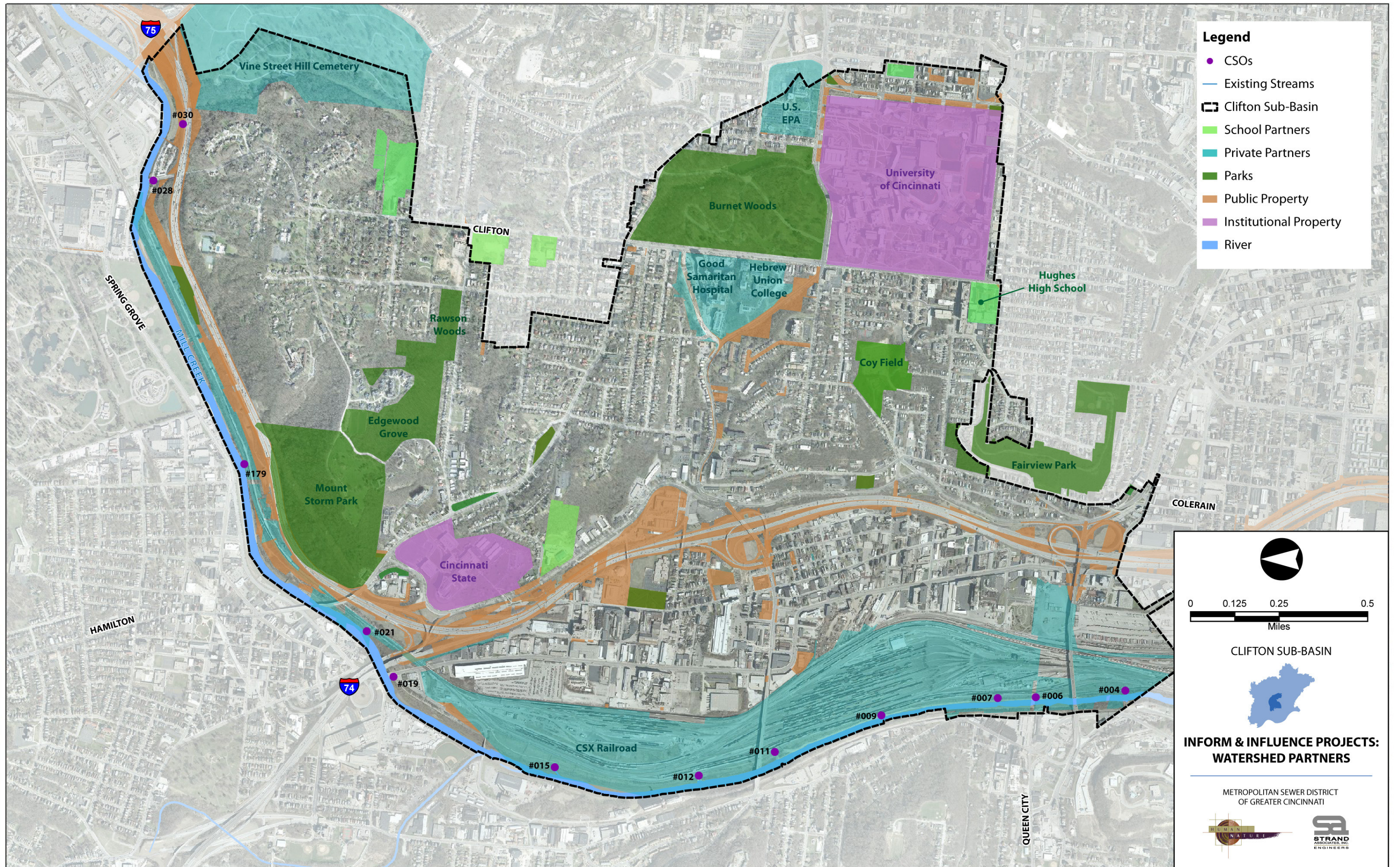
CLIFTON SUB-BASIN



**ENABLED PROJECTS:  
REFORESTATION & TRAIL  
CONNECTIONS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI





**Legend**

- CSOs
- Existing Streams
- ▭ Clifton Sub-Basin
- School Partners
- Private Partners
- Parks
- Public Property
- Institutional Property
- River

0 0.125 0.25 0.5  
Miles

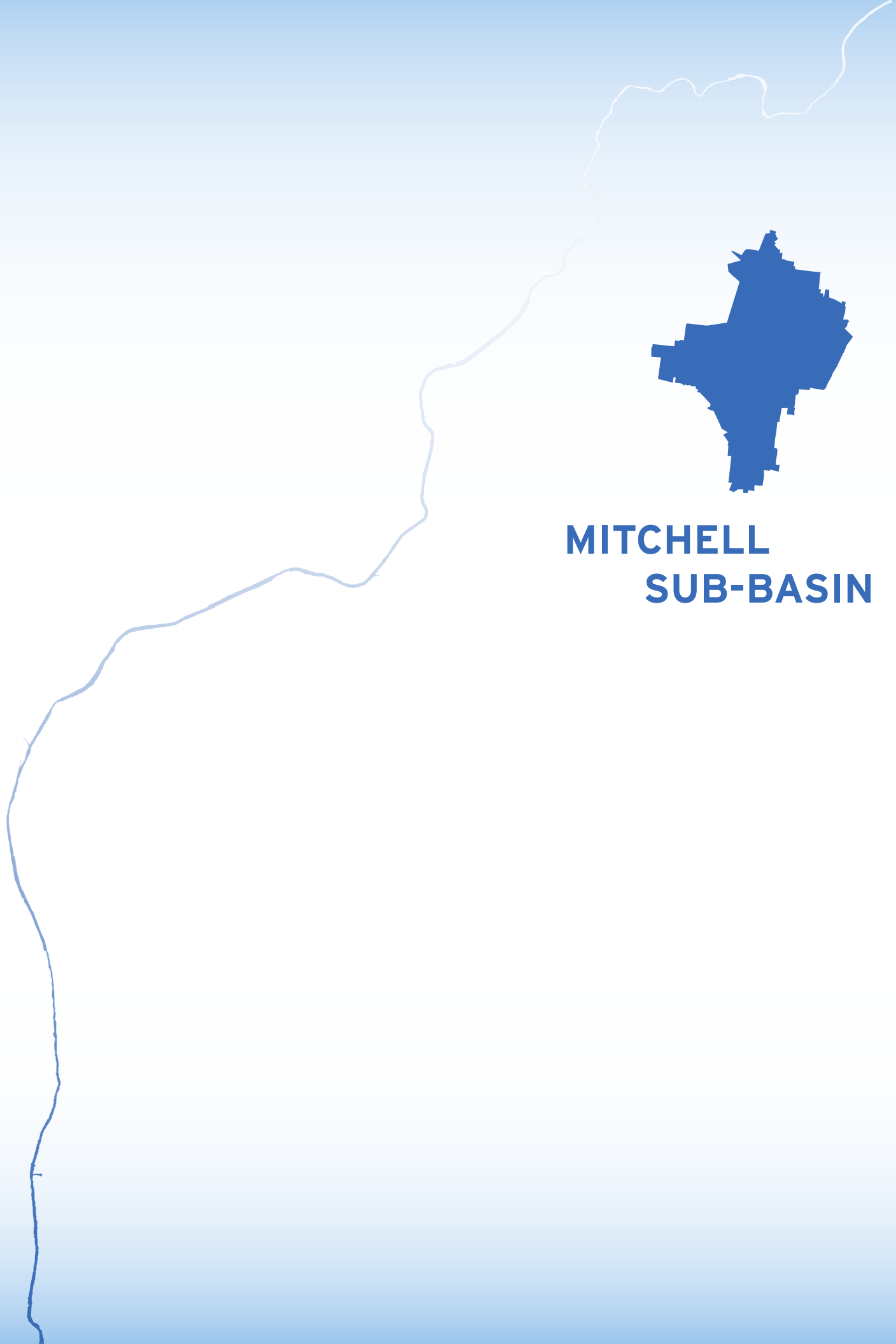
CLIFTON SUB-BASIN

**INFORM & INFLUENCE PROJECTS:  
WATERSHED PARTNERS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI







**MITCHELL  
SUB-BASIN**

# MITCHELL SUB-BASIN



## LOCATION

The Mitchell sub-basin covers approximately 2.4 square miles (3.8 percent of the Lower Mill Creek watershed) and overlaps five neighborhoods within the City of Cincinnati (i.e., Mitchell, Corryville, Avondale, North Avondale, Mt. Auburn, Winton Place and a contested area) and Saint Bernard. The main transportation routes include Interstate 75, Vine Street; Mitchell Avenue; Martin Luther King Jr. Drive; Ludlow Avenue; William Howard Taft Road; Reading Road; and Mitchell Avenue. There are several key property owners within the Mitchell sub-basin, which include the Cincinnati Zoo, The State of Ohio (University of Cincinnati and I-75 right-of-way), United States of America (US EPA), Children’s Hospital; University Hospital, Cincinnati Metropolitan Housing Authority, Vine St Hill Cemetery, and Cincinnati Board of Education.

## CHARACTERIZATION OF PROBLEM

There is one CSO location within the Mitchell sub-basin, contributing an annual overflow volume of 703 million gallons.

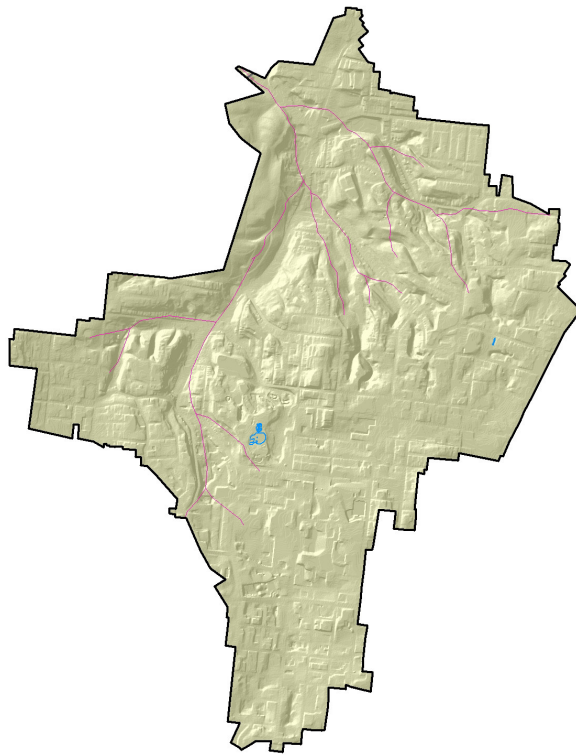
**ANNUAL CSO STATISTICS<sup>1</sup>**

CSO NUMBER	NAME	EVENTS	OVERFLOW (MG)	CONTROL (%)	CSO CONTROL STRATEGY <sup>1</sup>	BUNDLE CLUSTER
482	Mitchell Ave. Regulator	105	703	4	Tunnel	King's Run
<b>TOTAL</b>		<b>105</b>	<b>703</b>			

<sup>1</sup> Volume II CSO LTCP Update Report, 2006; 2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report, 2008; Final Wet Weather Improvement Program, 2009.

The GIS inventory of natural systems investigated the sub-basin’s hydrologic network, soil characteristics, slopes, tree canopy cover, and geology. The GIS inventory of built systems investigated the impervious surfaces, combined sewer system, existing land use, neighborhoods, and road right-of-way. Descriptions of and maps for these systems are included in the following pages.

## hydrologic network

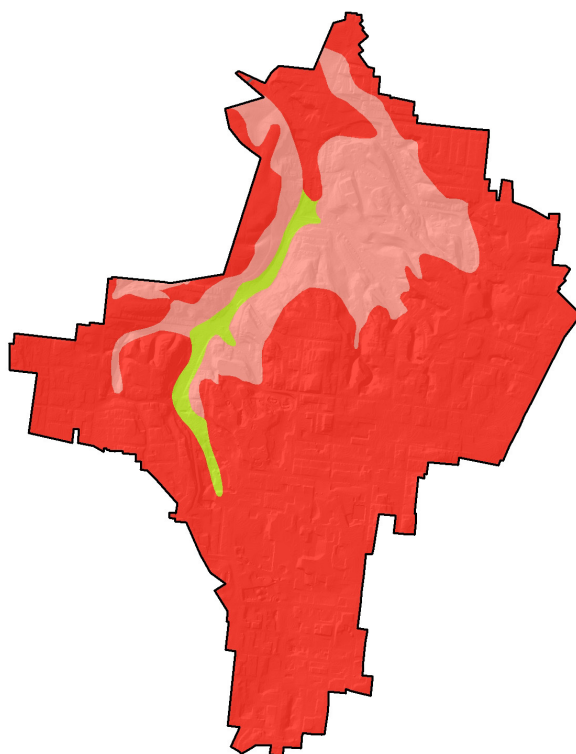


- Sub-basin boundary
- Interstate
- Historical streams
- Existing streams

The pre-development hydrologic network shows an extensive system of creeks and streams within the sub-basin. This network naturally conveyed stormwater runoff to the Mill Creek. Today underground sewer systems have replaced this stream network.

Data source: CAGIS, historical USGS maps








## hydrologic soil groups



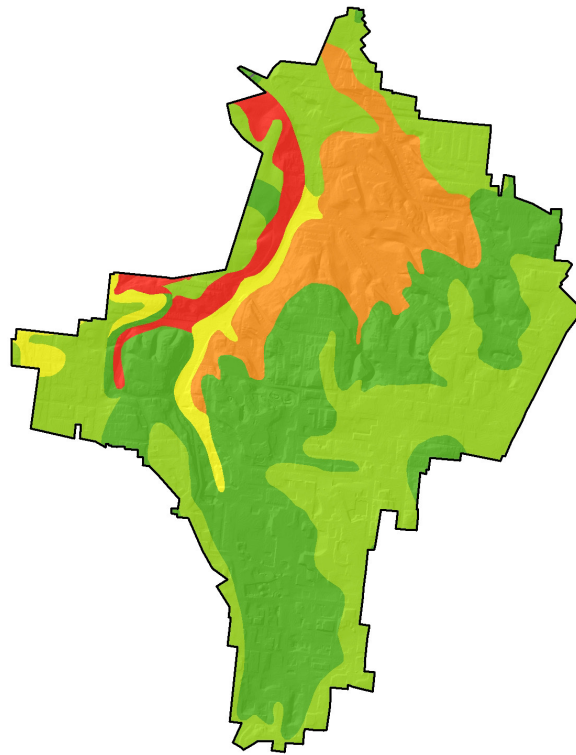
- Sub-basin boundary
- Interstate
- Group A
- Group B
- Group C
- Group D

In the Mitchell sub-basin, the majority of soils are hydrologic group D or group C, having limited potential for infiltration. There may be opportunities for shallow infiltration in Group B soils, which are within the I-75 corridor.

Data source: Hamilton County Soil Survey




-  Sub-basin boundary
-  Interstate
-  0-3 percent
-  3-8 percent
-  8-15 percent
-  15-25 percent
-  25+ percent

slope ranges

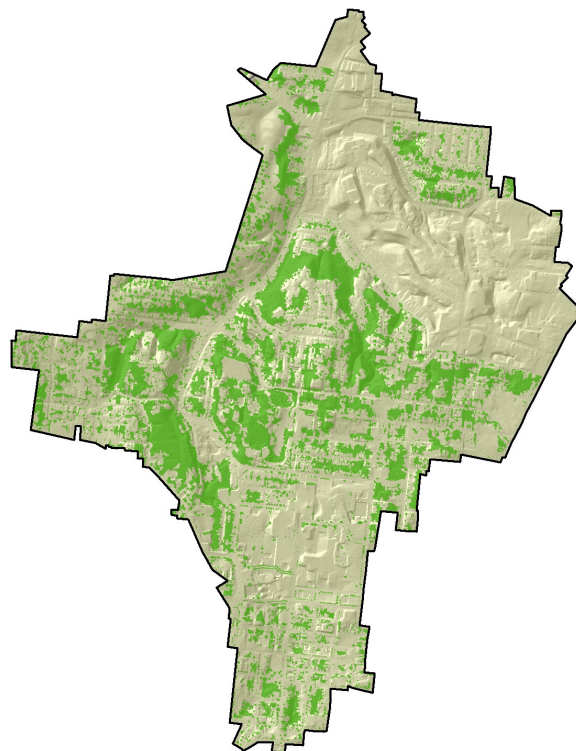


The majority of land in the Mitchell sub-basin has slopes of 8 percent or less.

Data source: Hamilton County Soil Survey

-  Sub-basin boundary
-  Interstate
-  Existing tree canopy

tree canopy cover






There are 398 acres of existing tree canopy in the Mitchell sub-basin, representing 26% of the total land area.

Data source: Cincinnati Park Board, ODNR

## impervious surfaces










-  Sub-basin boundary
-  Interstate
-  Impervious surfaces

There are 626 acres of impervious surfaces in the Mitchell sub-basin, representing 41% of the total land area.

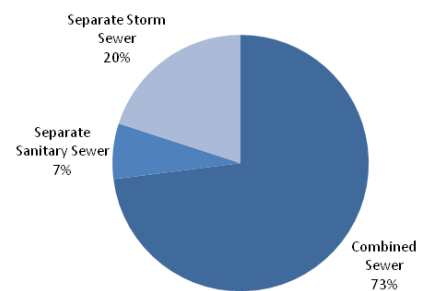
Data source: CAGIS

## combined sewer system









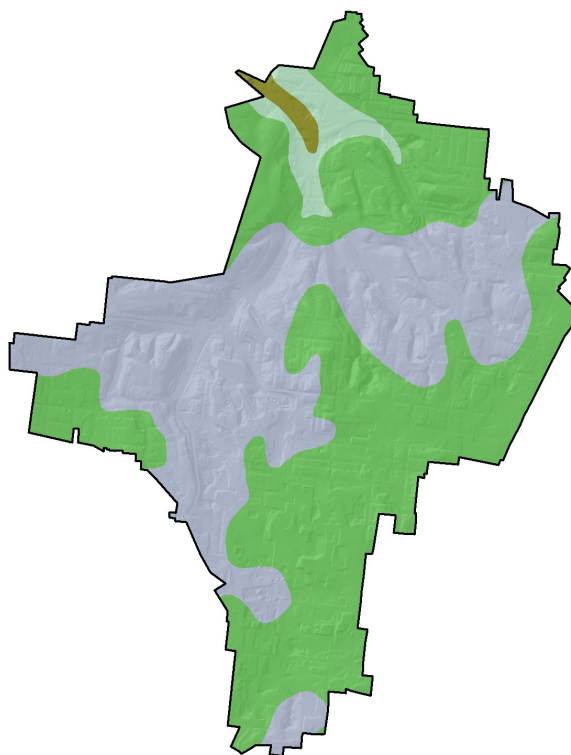
-  Sub-basin boundary
-  Interstate
-  CSO
- Combined sewers (pipe size)
  -  < 12 inches
  -  12-48 inches
  -  48-72 inches
  -  > 72 inches

There are 47 miles of combined sewers in the Mitchell sub-basin.




















Data source: MSD

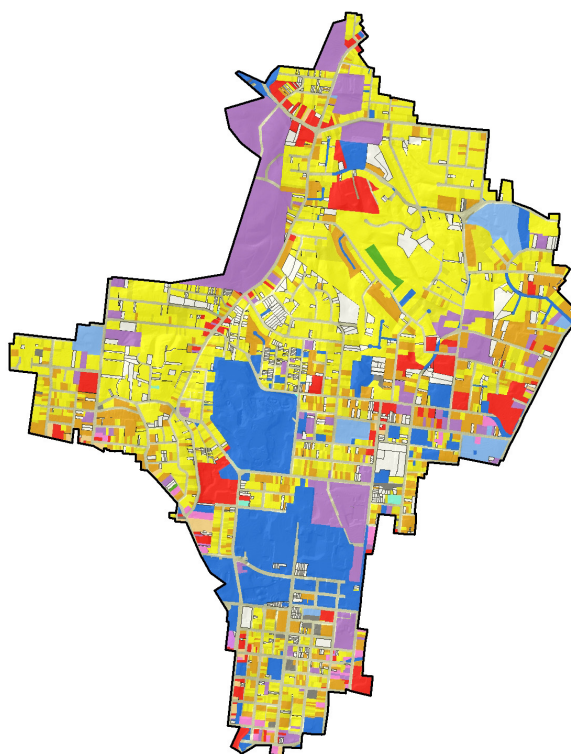
-  Sub-basin boundary
-  Interstate
-  Alluvium
-  Clay
-  Loam till
-  Shale



The majority of the Mitchell sub-basin is underlain by shale and loam till geologic formations.

Data source: Ohio Geological Survey

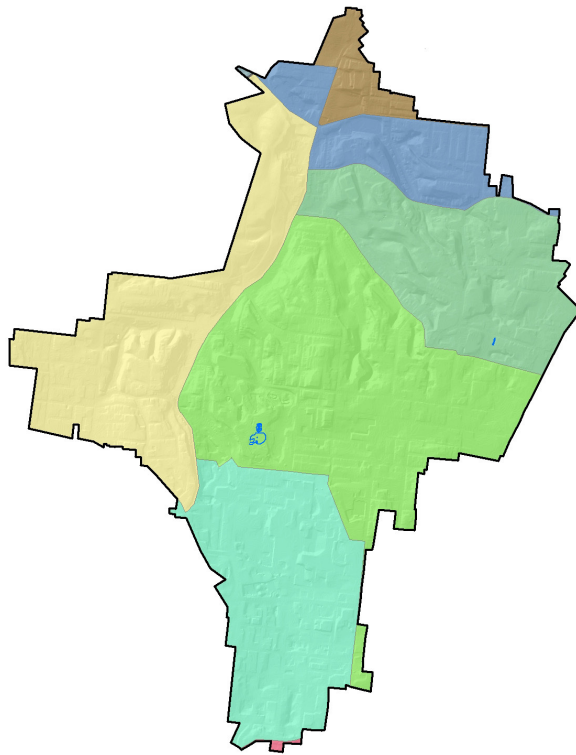
-  Sub-basin boundary
-  Interstate
-  Commercial
-  Educational
-  Industrial
-  Institutional
-  Light industrial
-  Multi-family
-  Mixed-use
-  Office
-  Parks & recreational
-  Public space
-  Public utilities
-  Single-family
-  Two-family
-  Vacant
-  Unknown












The majority of land in the Mitchell sub-basin is single-family (27%), followed by publicly owned (13%).

Data source: Hamilton County Auditor

## neighborhoods

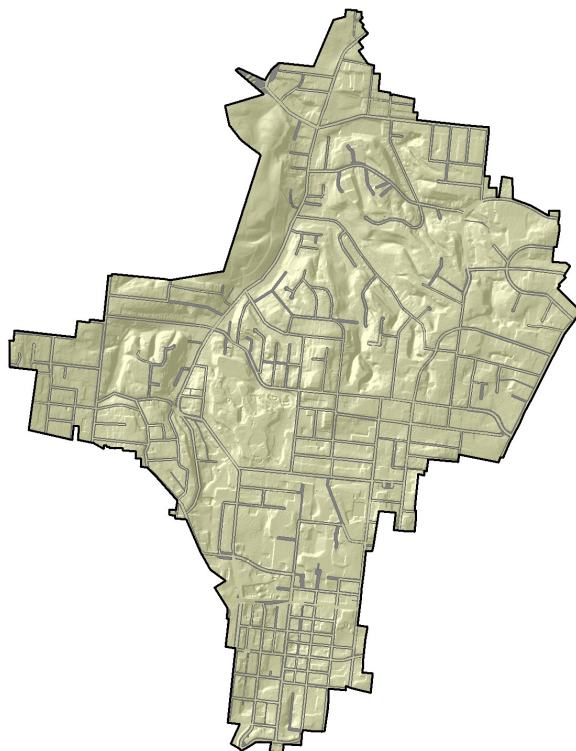





-  Sub-basin boundary
-  Interstate
-  Avondale
-  Clifton
-  Corryville
-  Mt. Auburn
-  North Avondale
-  St. Bernard
-  Contested Area

The Mitchell sub-basin is comprised of 7 different neighborhoods that lie within two jurisdictions (Cincinnati & St. Bernard).

Data source: CAGIS

## right-of-way (ROW)



-  Sub-basin boundary
-  Interstate
-  Impervious surfaces

There are 116 acres of ROW in the Mitchell sub-basin, which is 8% of the total land area.

Data source: CAGIS



## COARSE-LEVEL OPPORTUNITIES

The project team identified several opportunities for reducing the volume of stormwater runoff entering the combined sewer system and the resulting CSO volume. Coarse-level opportunities in the Mitchell sub-basin include Enabled Projects and Inform/Influence Projects. Enabled Projects are wet weather strategies that represent a leveraged infrastructure investment and present opportunities for cost sharing and collaboration among MSD and key watershed stakeholders. Inform/Influence Projects are programmatic elements that engage and educate watershed partners and the broader public in making sustainable decisions that provide water quantity and quality benefits.

The project team identified major direct stormwater entry points and the natural drainage basins that contribute to them (**See Existing Conditions Overview**). These points identify the areas where stormwater directly enters the combined sewer system. Within these drainage areas, the project team identified a few small-scale detention basins; however, due to the lack of and proximity to existing natural systems, priority was given to the enabled and inform and influence opportunities.

### Enabled Projects

#### **Reforestation (Enabled Projects: Reforestation)**

There are currently 398 acres of existing tree canopy in the Mitchell sub-basin, representing 26 percent of the total land area. This canopy network provides valuable benefits in regard to natural stormwater runoff management and air quality improvement. Based on a CITYgreen analysis, the team was able to recommend not only protecting the existing canopy within the sub-basin, but reforesting 60 percent of the canopy-deficient areas along major interstate corridors, road right-of-ways and steep slopes. Reforestation efforts should focus on the 101 acres of canopy-deficient hillsides and 25 acres of right-of-ways present within the Mitchell sub-basin. According to the CITYgreen analysis, such reforestation has the potential to remove approximately 25.2 million gallons (21.3 and 3.9 million gallons respectively) of stormwater runoff from the combined sewer each year.

#### **Interstate 75 Expansion**

An enabled opportunity has been identified with the reconstruction of the Interstate 75 corridor and several of its interchanges within the LMC watershed presents an opportunity to form partnerships (inform and influence) with the Ohio Department of Transportation and the City of Cincinnati (specifically Cincinnati's Department of Transportation and Engineering). As impervious pavement increases, so will the amount of stormwater runoff unless efforts are made to capture the excess water. There are currently 0.5 acres of impervious surface along the I-75 corridor within the Mitchell sub-basin, which generates roughly 0.5 MG of stormwater runoff each year.

### Inform & Influence Projects

#### **Watershed Partners (Inform & Influence Projects: Watershed Partners)**

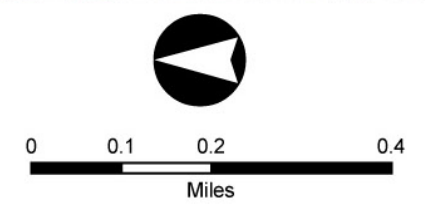
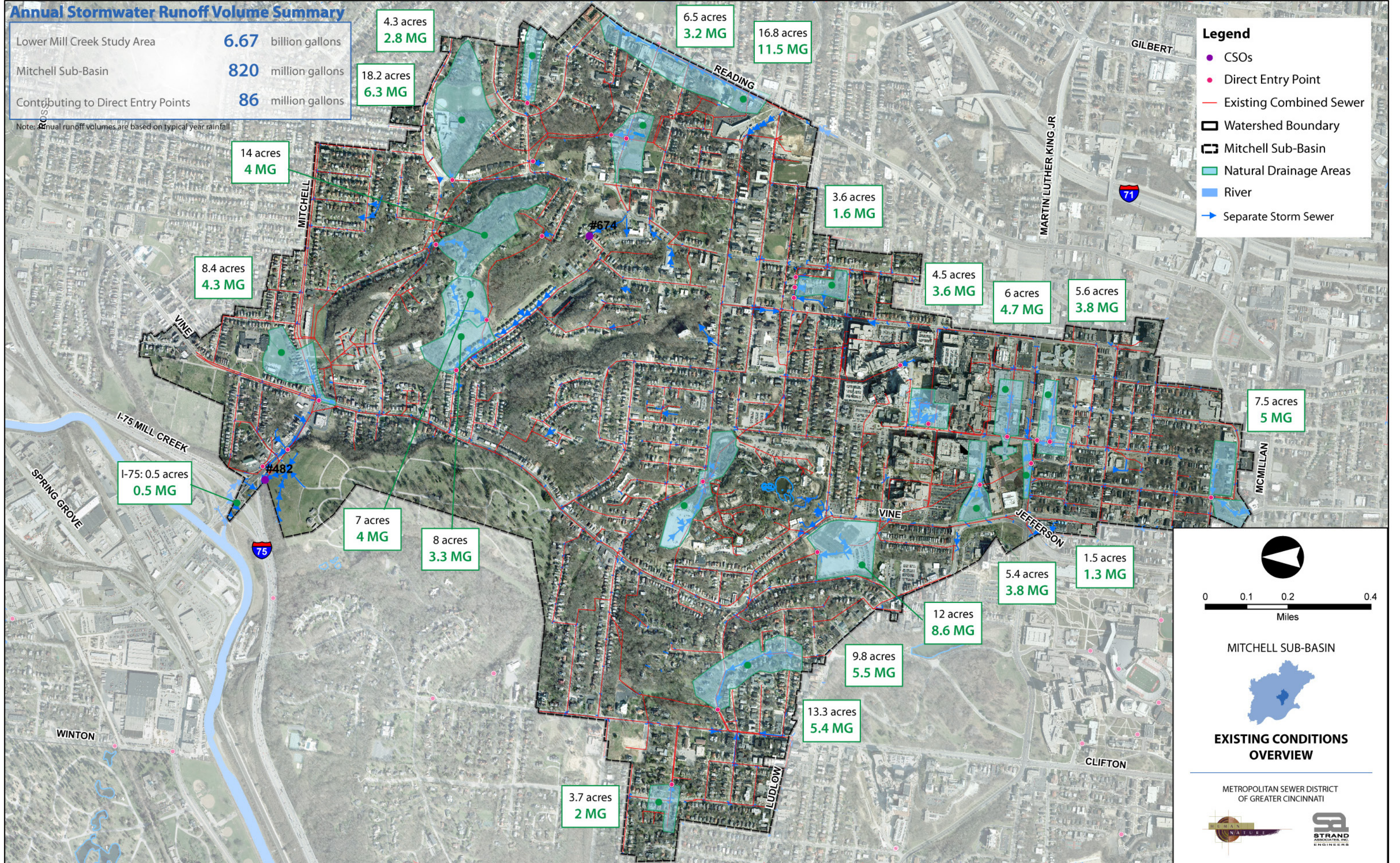
The Mitchell sub-basin offers the greatest opportunity for infrastructure partnerships and collaboration with the major land owners in the sub-basin. Several partners within the sub-basin have been identified as opportunities to inform and influence the implementation of various direct and enabled wet weather strategies or opportunity projects (*i.e.*, detention/retention basins, stormwater separation and reuse, water quality BMPs, and reforestation). The Watershed Partner map depicts the identified partners within the Mitchell sub-basin. Key partners include the Vine Street Hill Cemetery, Cincinnati Zoo & Botanical Gardens, Cincinnati VA Medical Center, the University of Cincinnati, Children's Hospital, University Hospital, Hamilton County Drug & Addiction Services, the U.S. EPA, City of Cincinnati, Cincinnati Board of Education (North Avondale Elementary, South Avondale, and Rockdale Academy), Roger Bacon High School, Shiloh (SDA) Church, Zion Baptist Church, and Cincinnati Municipal Housing Authority (CMHA). These partners may have the ability to work with MSD and integrate stormwater management strategies on their sites.



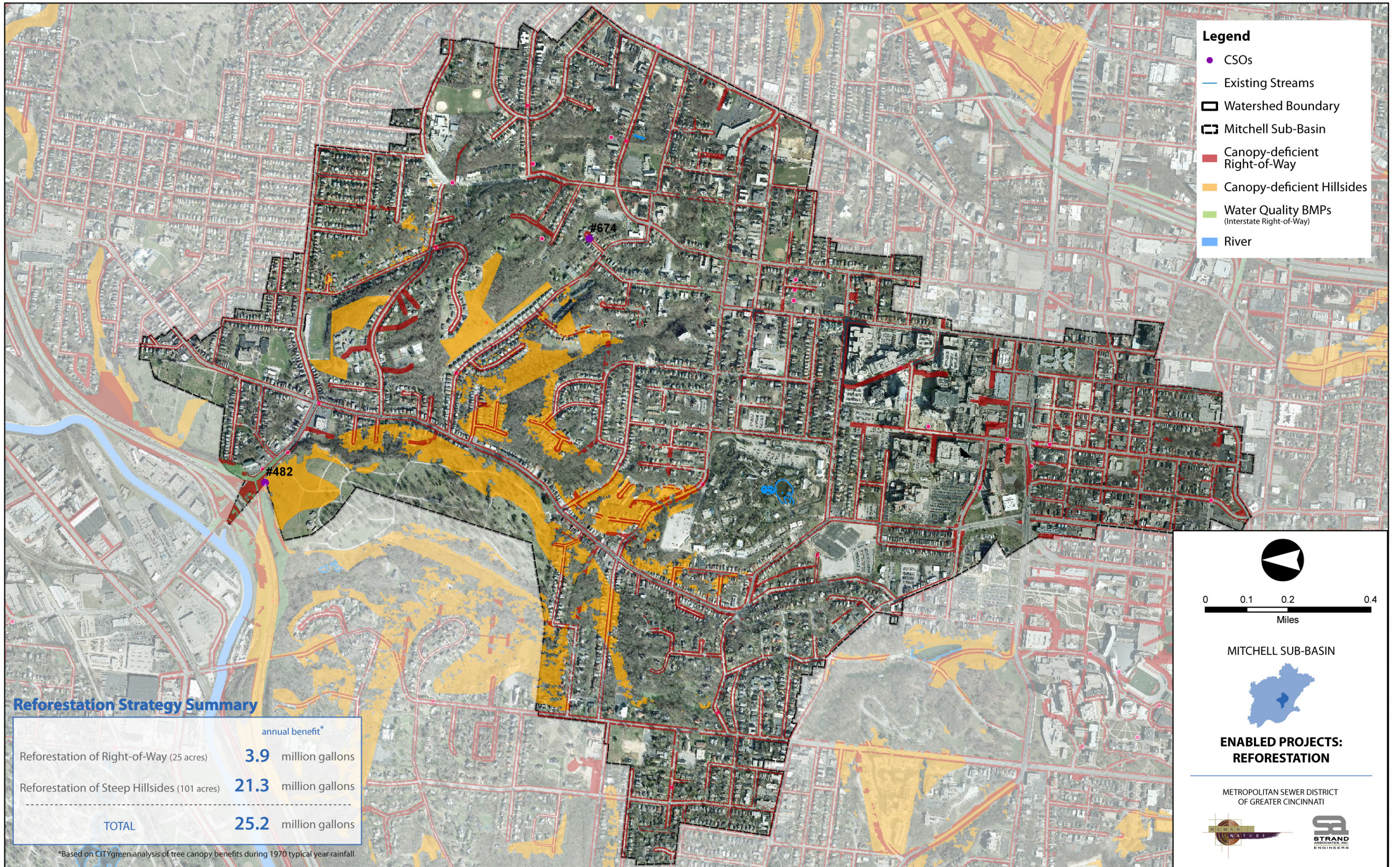
# Annual Stormwater Runoff Volume Summary

Lower Mill Creek Study Area	6.67	billion gallons
Mitchell Sub-Basin	820	million gallons
Contributing to Direct Entry Points	86	million gallons

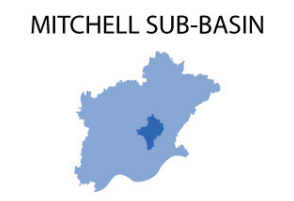
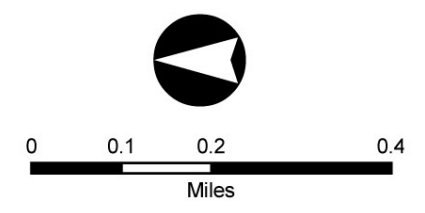
Note: Annual runoff volumes are based on typical year rainfall



METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI



- Legend**
- CSOs
  - Existing Streams
  - ▭ Watershed Boundary
  - ▭ Mitchell Sub-Basin
  - ▭ Canopy-deficient Right-of-Way
  - ▭ Canopy-deficient Hillsides
  - ▭ Water Quality BMPs (Interstate Right-of-Way)
  - ▭ River



**ENABLED PROJECTS:  
REFORESTATION**

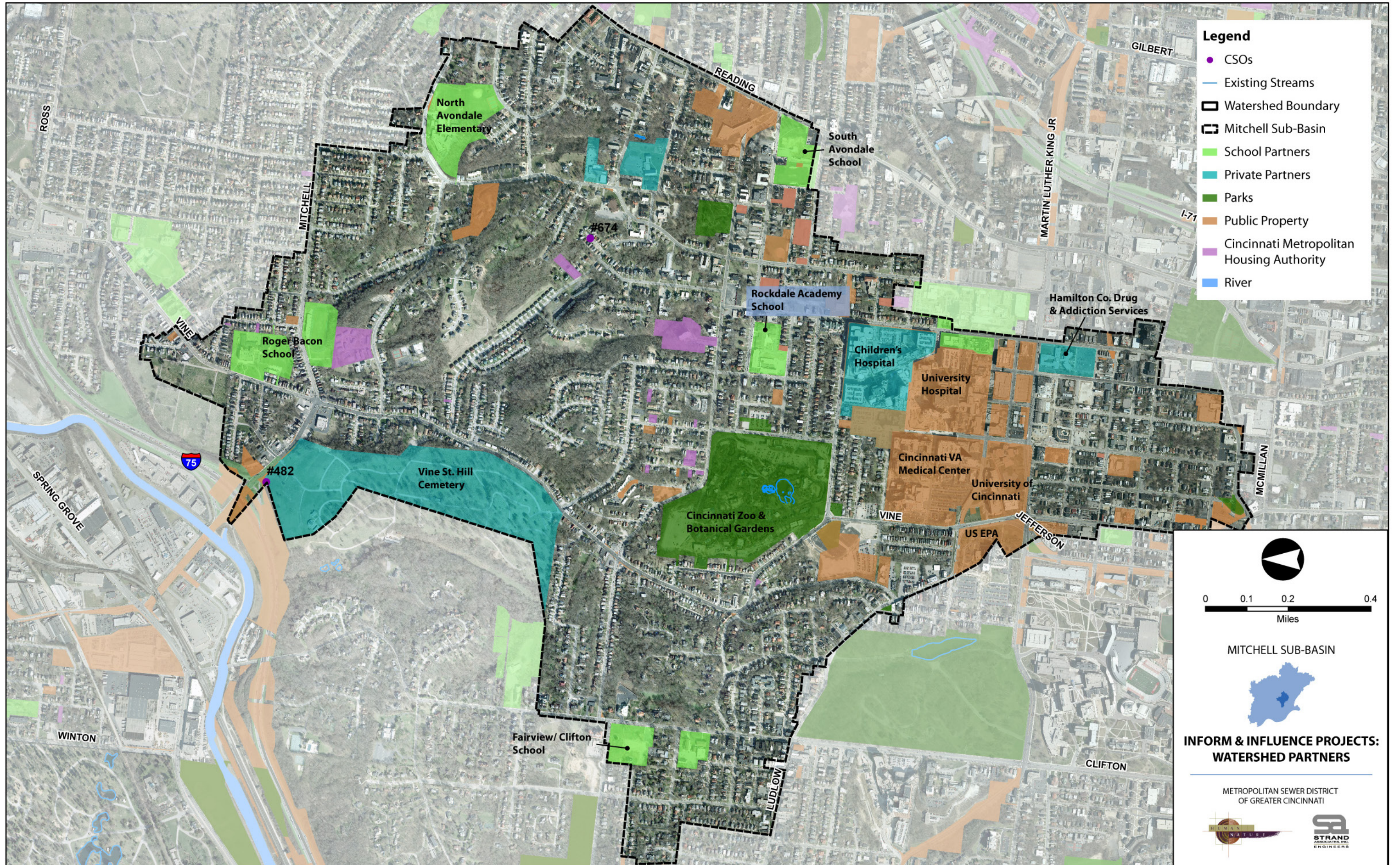
METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI



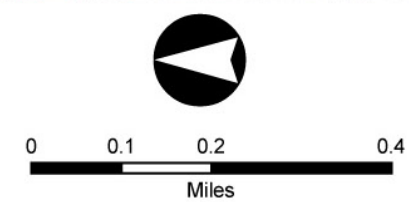
**Reforestation Strategy Summary**

	annual benefit*
Reforestation of Right-of-Way (25 acres)	<b>3.9</b> million gallons
Reforestation of Steep Hillsides (101 acres)	<b>21.3</b> million gallons
<b>TOTAL</b>	<b>25.2</b> million gallons

\*Based on CITYgreen analysis of tree canopy benefits during 1970 typical year rainfall



- Legend**
- CSOs
  - Existing Streams
  - ▭ Watershed Boundary
  - ▭ Mitchell Sub-Basin
  - School Partners
  - Private Partners
  - Parks
  - Public Property
  - Cincinnati Metropolitan Housing Authority
  - River



MITCHELL SUB-BASIN



**INFORM & INFLUENCE PROJECTS:  
WATERSHED PARTNERS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI







**KING'S RUN  
SUB-BASIN**

# KING'S RUN SUB-BASIN



## LOCATION

The King's Run sub-basin covers approximately 6 square miles (9.6 percent of the Lower Mill Creek watershed) and overlaps five neighborhoods within the City of Cincinnati (i.e., College Hill, Winton Hills, Winton Place, Northside, South Cumminsville) and Springfield Township. The main transportation routes include Interstate 74, Winton Road, Mitchell Avenue, Spring Grove Avenue, Hamilton Avenue, Colerain Avenue, and North Bend Road. Key property owners within the Kings Run sub-basin include the City of Cincinnati, the Cincinnati Park Board, the Cincinnati Board of Education (Aiken High School and Clark High School), Spring Grove Cemetery, Wesleyan Cemetery, Greater Cincinnati Water Works, Cincinnati Metropolitan Housing Authority, and the Salvation Army Headquarters.

## CHARACTERIZATION OF PROBLEM

There are 20 CSO locations within the King's Run sub-basin, contributing an annual overflow volume of 688 million gallons. Direct project areas identified during the coarse evaluation contribute approximately 501 MG of stormwater runoff annually.

ANNUAL CSO STATISTICS <sup>1</sup>							
CSO NUMBER	NAME	EVENTS	OVERFLOW (MG)	CONTROL (%)	DIRECT PROJECT <sup>2</sup> (MG)	CSO CONTROL STRATEGY <sup>1</sup>	BUNDLE CLUSTER
529	Liewellen Grating	3	0	97	0	Regulator Improvement (3.9 cfs)	West Fork Creek
528	Beekman North Grating	3	0	96	0	Regulator Improvement (3.0 cfs)	West Fork Creek
17	Dreman Ave. Diversion Dam	27	4	81	0	Tunnel	Northside
18	Colerain Ave. Diversion Dam	62	29	50	0	Tunnel	Northside
22	Ludlow Ave. Diversion Dam	61	43	56	0	Tunnel	Northside
23	Ailbone St. Regulator	42	48	64	0	Tunnel	Northside
24	Ludlow Run Regulator	66	133	45	209	Tunnel	Northside
26	Station Ave. A Diversion Dam	0	0	100	0	Regulator Improvement (7.1 cfs)	King's Run
480	Clifton Ave. West Grating	58	8	56	0	Tunnel	King's Run
25	Winton Rd. A Regulator	66	41	40	31	Tunnel	King's Run
481	Mitchell and Spring Grove	0	0	100	5	Diversion to CSO 029	King's Run
486	Kings Run Regulator	52	20	64	126	Partial separation	King's Run
162	Thompson Heights Grating	63	7	45	126	Collector upgrade CIP 83-10	Spring Grove Cemetery
112	1547 Springlawn Grating	50	3	50	126	Partial separation	Spring Grove Cemetery
111	Springlawn Grating	84	22	25	174	Partial separation	Spring Grove Cemetery
483	Kings Run Regulator	67	157	43	126	Partial separation to new interceptor connection	King's Run
110	4710 Howard Grating	5	0	94	128	Regulator Improvement (2.90 cfs)	Spring Grove Cemetery
217	Wooden Shoe Regulator	58	109	53	126	EHRT: 75 MGD	King's Run
109	Hillcrest North Grating	25	2	73	154	Collector upgrade CIP 83-10	Spring Grove Cemetery
151	Groesbeck Grating	64	62	45	0	Collector upgrade CIP 83-10	Spring Grove Cemetery
<b>TOTAL</b>		<b>856</b>	<b>688</b>		<b>501</b>		

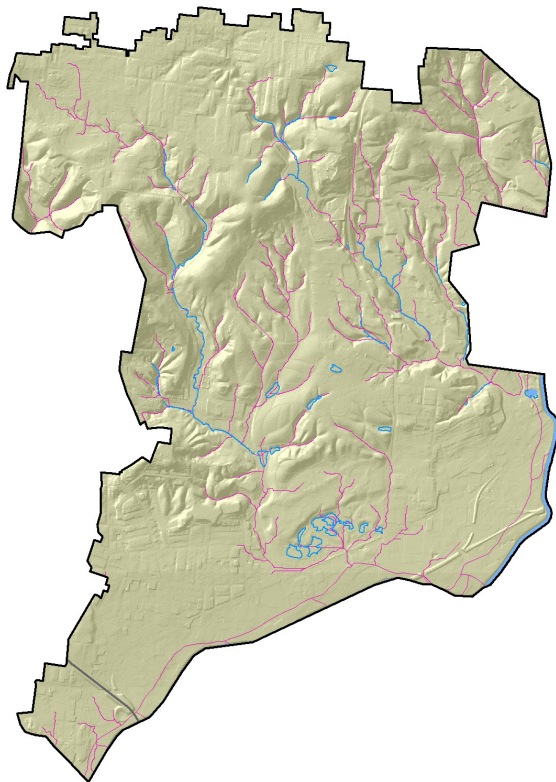
<sup>1</sup> Volume II CSO LTCP Update Report, 2006; 2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report, 2008; Final Wet Weather Improvement Program, 2009.

<sup>2</sup> Represents annual stormwater runoff contributing to direct project areas identified in the Coarse Evaluation; Total number does not consider runoff from drainage areas that are tributary to multiple CSO points

The GIS inventory of natural systems investigated the sub-basin's hydrologic network, soil characteristics, slopes, tree canopy cover, and geology. The GIS inventory of built systems investigated the impervious surfaces, combined sewer system, existing land use, neighborhoods, and road right-of-way. Descriptions of and maps for these systems are included in the following pages.



### hydrologic network

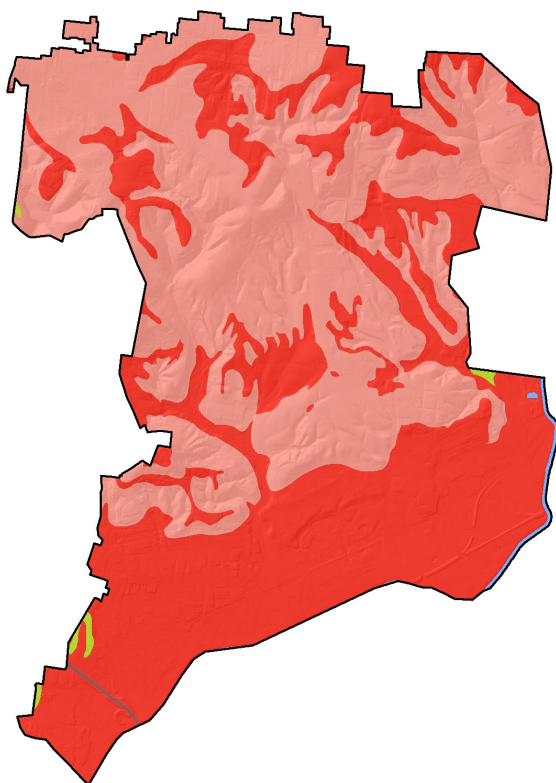


- Sub-basin boundary
- Interstate
- Historical streams
- Existing streams

The pre-development hydrologic network shows an extensive system of creeks and streams within the sub-basin. This network naturally conveyed stormwater runoff to the Mill Creek. Today underground sewer systems have replaced much of this stream network.

Data source: CAGIS, historical USGS maps








### hydrologic soil groups



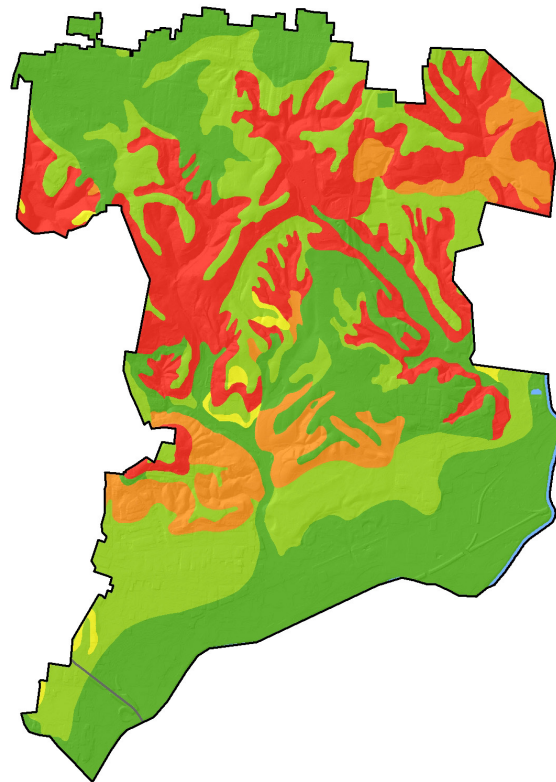
- Sub-basin boundary
- Interstate
- Group A
- Group B
- Group C
- Group D

Nearly all of soils in the King's Run sub-basin are hydrologic group D or C, having limited potential for infiltration.

Data source: Hamilton County Soil Survey




-  Sub-basin boundary
-  Interstate
-  0-3 percent
-  3-8 percent
-  8-15 percent
-  15-25 percent
-  25+ percent

slope ranges

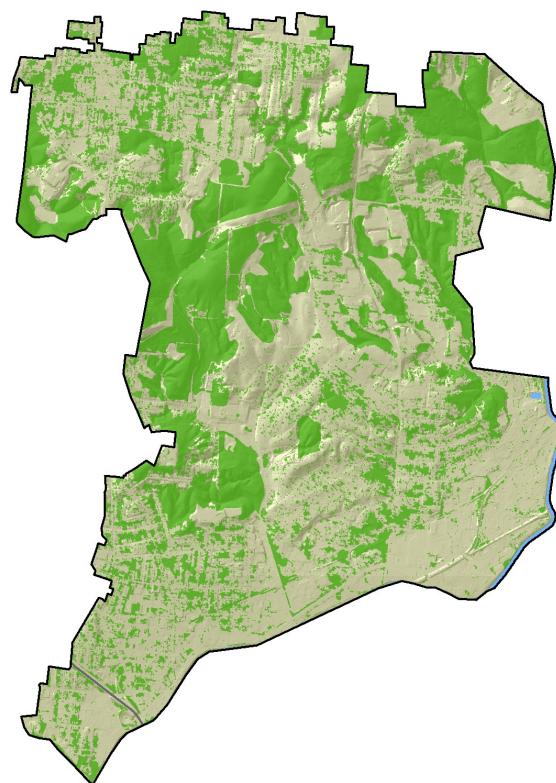


The majority of land in the King's Run sub-basin has slopes of 8 percent or less.

Data source: Hamilton County Soil Survey

-  Sub-basin boundary
-  Interstate
-  Existing tree canopy

tree canopy cover






There are 1,581 acres of existing tree canopy in the King's Run sub-basin, representing 41% of the total land area.

Data source: Cincinnati Park Board, ODNR

### impervious surfaces

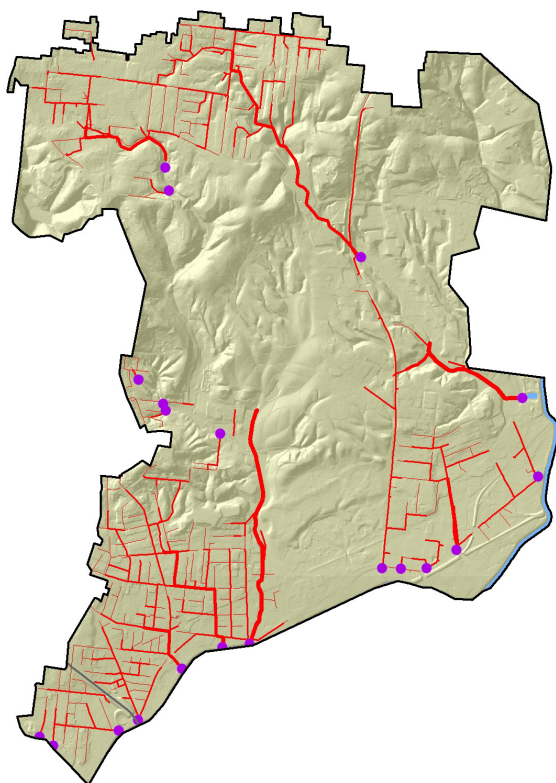









-  Sub-basin boundary
-  Interstate
-  Impervious surfaces

There are 1,236 acres of impervious surfaces in the King's Run sub-basin, representing 32% of the total land area.

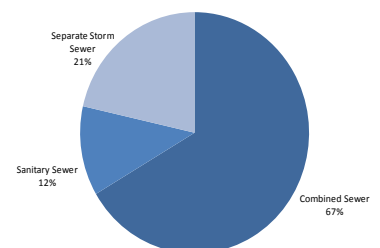
Data source: CAGIS

### combined sewer system



-  Sub-basin boundary
-  Interstate
-  CSO
- Combined sewers (pipe size)
  -  < 12 inches
  -  12-48 inches
  -  48-72 inches
  -  > 72 inches

There are 44 miles of combined sewers in the King's Run sub-basin.

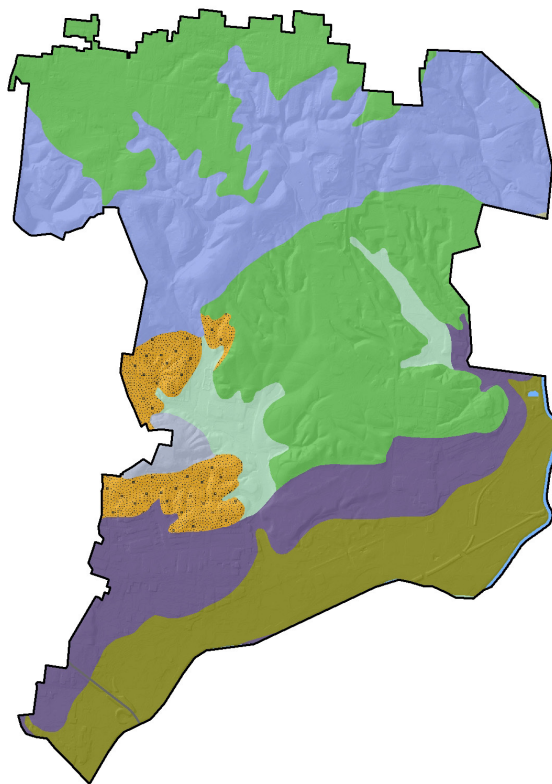


Data source: MSD

geology


















-  Sub-basin boundary
-  Interstate
-  Alluvium
-  Clay
-  Limestone
-  Loam till
-  Sand
-  Shale
-  Silt

Deep infiltration opportunities may exist in alluvium and sand deposits, which may be present along the Mill Creek and in the western section of the sub-basin.

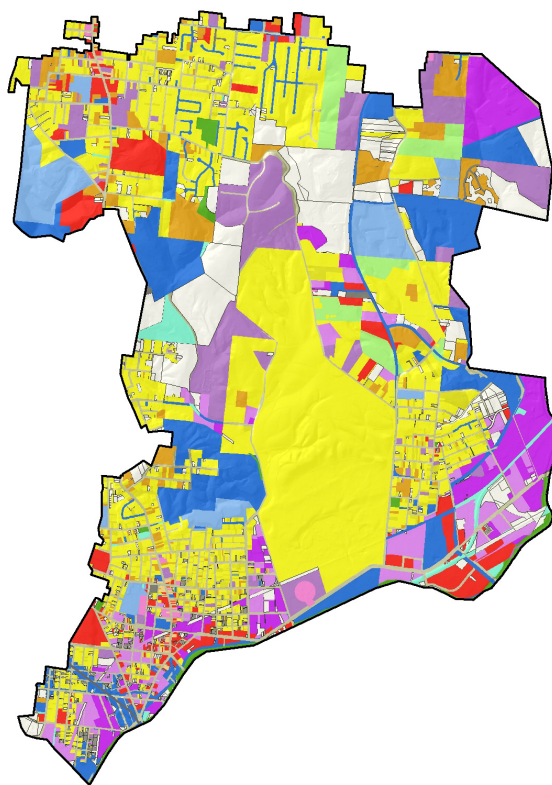


Data source: Ohio Geological Survey

land use

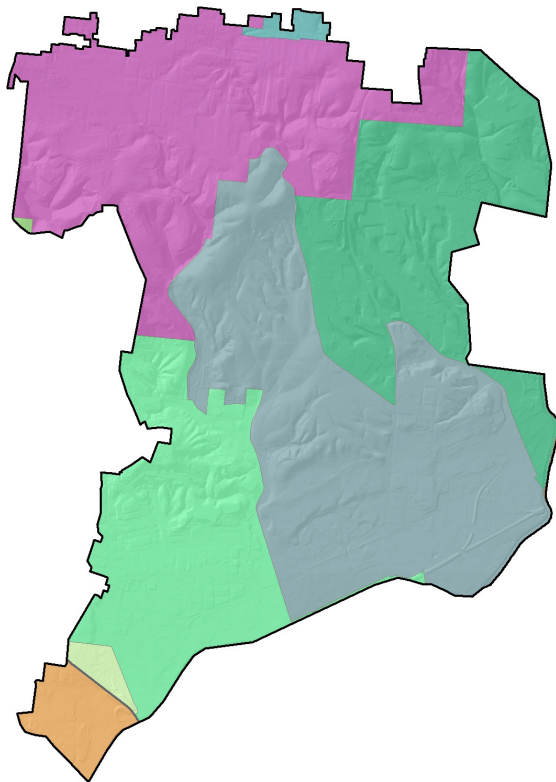
-  Sub-basin boundary
-  Interstate
-  Commercial
-  Educational
-  Industrial
-  Institutional
-  Light industrial
-  Multi-family
-  Mixed-use
-  Office
-  Parks & recreational
-  Public space
-  Public utilities
-  Single-family
-  Two-family
-  Vacant
-  Unknown

The majority of land use in the King's Run sub-basin is single-family (33%), followed by public use (11%).



Data source: Hamilton County Auditor

## neighborhoods

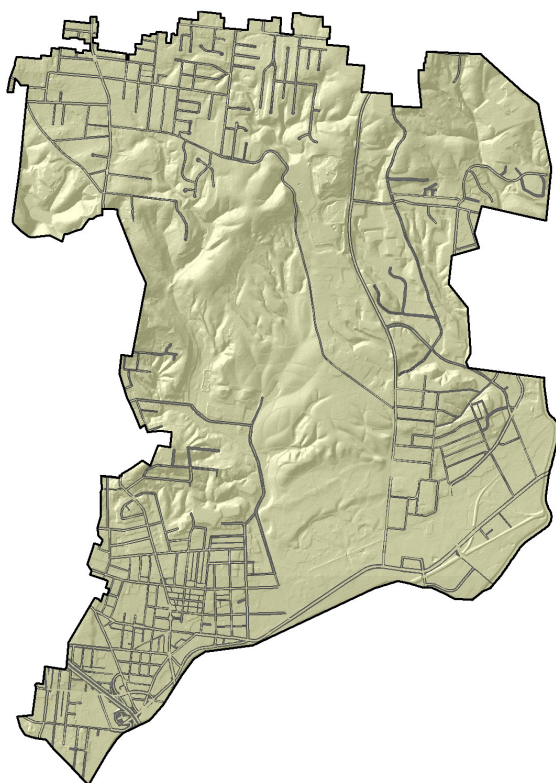


- Sub-basin boundary
- Interstate
- College Hill
- Northside
- Mt. Airy
- South Cumminsville
- Springfield Township
- Winton Hills
- Winton Place
- Contested Area

The King's Run sub-basin is comprised of 5 neighborhoods, Springfield Township and a contested area.

Data source: CAGIS

## right-of-way (ROW)



- Sub-basin boundary
- Interstate
- impervious surfaces

There are 189 acres of ROW in the King's Run sub-basin, which is 5% of the total land area.

Data source: CAGIS

## COARSE-LEVEL OPPORTUNITIES

The project team identified several opportunities for reducing the volume of stormwater runoff entering the combined sewer system and the resulting CSO volume. Coarse-level opportunities in the King's Run sub-basin include Direct Projects, Enabled Projects, and Inform/Influence Projects. Direct projects are wet weather strategies that require direct investment by and provide an immediate benefit to MSD; Enabled Projects are those that provide cost sharing opportunities that benefit MSD's sewer infrastructure, but MSD would not have ownership or direct control of the management strategy; and Inform/Influence Projects are those that inform and educate the broader public to make sustainable decisions through collaboration between MSD and watershed partners.

### Direct Projects

With the objective of reducing combined sewer overflows in the King's Run sub-basin, the project team first identified major direct entry points to the combined sewer system and their tributary natural drainage areas (**See Existing Conditions Overview**). Direct entry points represent areas where stormwater runoff and/or natural stream flows enter the combined sewer system.

Natural drainage basins that contained coarse-level opportunities became "direct project areas" (**See Direct Project Areas Overview**), allowing the team to narrow its focus within the sub-basin. The direct wet weather strategies, or opportunity areas, include retention basins, detention basins, several different stormwater separation opportunities, and water quality BMPs.

#### **Stormwater Separation along Crawford Avenue & Spring Grove Cemetery (Direct Project Area 1)**

The proposed separation will disconnect and offload stormwater from the combined sewer system and direct it to natural systems, separate storm sewers and the Mill Creek. This separation has the potential to reduce the CSO volume from CSO #24 with an average annual overflow volume of 133.5 million gallons, eliminate four CSOs (#110, #111, #112 and #162) with a combined average annual overflow volume of 10.7 million gallons, and improve water quality. The proposed separate storm sewer is approximately 6,150 feet and has the potential to remove approximately 209 million gallons of stormwater runoff from the combined sewer each year.

#### **Stormwater Separation along Winton Road & Spring Grove Cemetery (Direct Project Area 2)**

The proposed separation will disconnect and offload stormwater from the combined sewer system and direct it to separate storm sewers and the Mill Creek. This separation has the potential to reduce the CSO volume from CSO #25 with an average annual overflow volume of 41.1 million gallons, eliminate four CSOs (#110, #111, #112, #162- in conjunction with Project area 1) with a combined average annual overflow volume of 10.7 million gallons, and improve water quality. The proposed separate storm sewer is approximately 885 feet and has the potential to remove approximately 30.6 million gallons of stormwater runoff from the combined sewer each year.

#### **Stormwater Separation along Kings Run & Winton Road (Direct Project Area 3)**

The proposed separation will separate dry weather flow from combined sewer interception. The separation will also offload stormwater from the combined sewer system and direct it to natural drainage features, separate storm sewers and the Mill Creek. This separation has the potential to reduce CSO volume (#217 and #483 with an average annual overflow volume of 108.8 million gallons), build upon the existing separate storm sewer network, and improve water quality. The proposed separate storm sewer is approximately 4,800 feet and has the potential to remove approximately 174 million gallons of stormwater runoff from the combined sewer each year.

#### **Detention: Land Storage along Gray Road (Direct Project Area 4)**

Stormwater runoff will be offloaded and directed to natural drainage features, separate storm sewers and the proposed detention areas. The detention features have the potential to reduce CSO volume of CSO #217 with an average of 108.8 million gallons of overflow each year, reduce peak flows into the combined sewer system, and improve water quality. The three detention basins are approximately 2.5 acres combined and have the potential to remove approximately 57 million gallons of stormwater runoff from the combined sewer each year.

### **Stormwater Separation along Hamilton Avenue & Groesbeck Road (Direct Project Area 5)**

The proposed separation will disconnect and offload stormwater runoff from the combined sewer system and direct it to separate storm sewers and natural drainage features. This separation has the potential to reduce CSO volume from CSO #151, eliminate CSO #109, and improve water quality. The proposed separate storm sewer is approximately 1,755 feet and has the potential to remove approximately 30 million gallons of stormwater runoff from the combined sewer each year.

## Enabled Projects

### **Reforestation (Enabled Projects: Reforestation)**

There are currently 1,581 acres of existing tree canopy in the King's Run sub-basin, representing 41 percent of the total land area. This canopy network provides valuable benefits in regard to natural stormwater runoff management and air quality improvement. Based on a CITYgreen analysis, the team was able to recommend not only protecting the existing canopy within the sub-basin, but reforesting 60 percent of the canopy-deficient areas along major interstate corridors, road right-of-ways and steep slopes. Reforestation efforts should focus on the 219 acres of canopy-deficient hillsides and 36 acres of right-of-ways present within the King's Run sub-basin. According to the CITYgreen analysis, such reforestation has the potential to remove approximately 19.8 million gallons of stormwater runoff from the combined sewer each year.

### **Interstate 75 Expansion**

An enabled opportunity has been identified with the reconstruction of the Interstate 75 and 74 corridor and several of its interchanges within the LMC watershed presents an opportunity to form partnerships (inform and influence) with the Ohio Department of Transportation and the City of Cincinnati (specifically Cincinnati's Department of Transportation and Engineering). As impervious pavement increases, so will the amount of stormwater runoff unless efforts are made to capture the excess water. There are currently 7.5 acres of impervious surface along the I-74 corridor within the King's Run sub-basin, which generate roughly 8 MG of stormwater runoff each year.

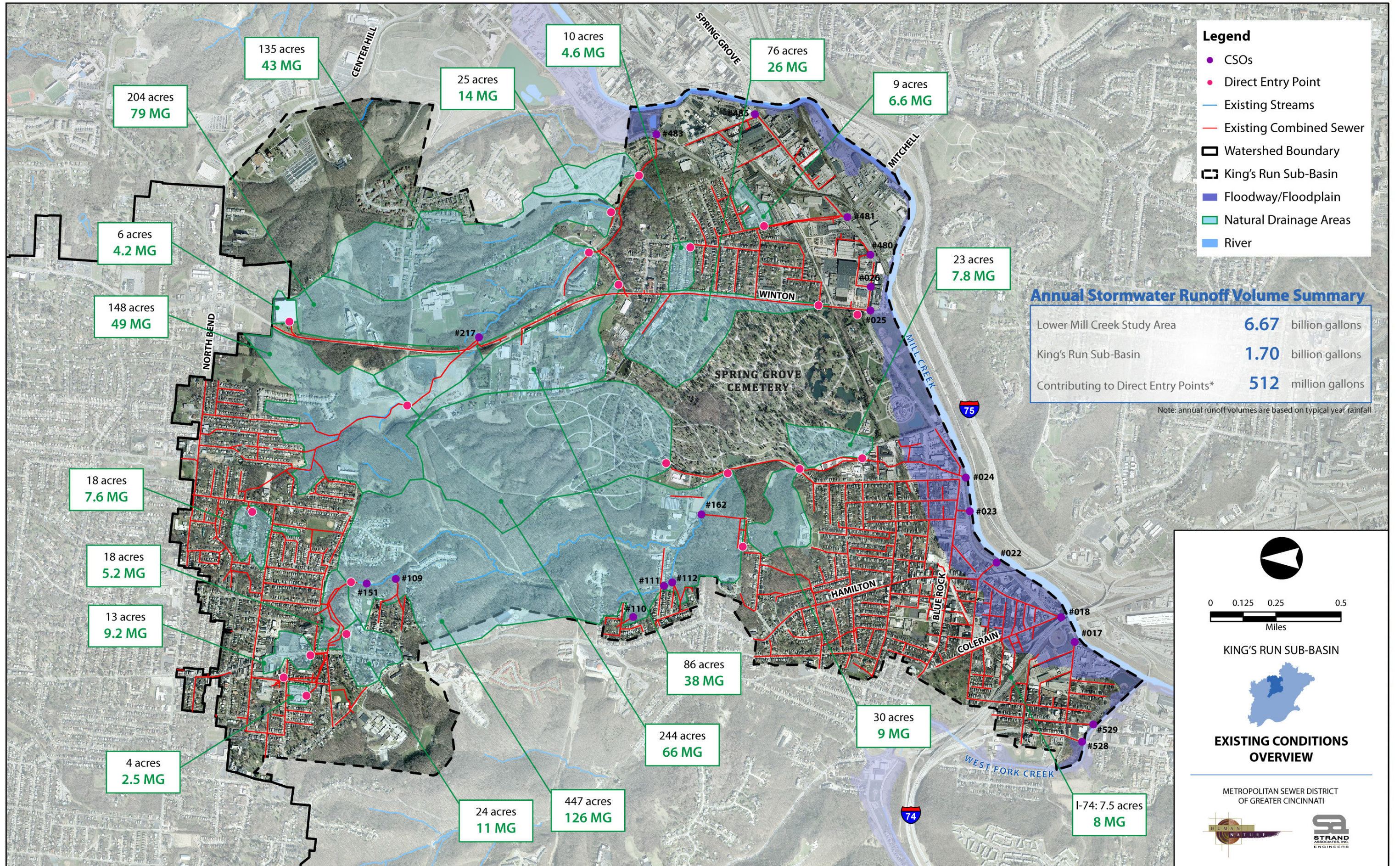
### **Mill Creek Greenway Trail**

The construction of the Mill Creek Greenway trail presents the opportunity to integrate stormwater quality BMPs along the Mill Creek corridor.

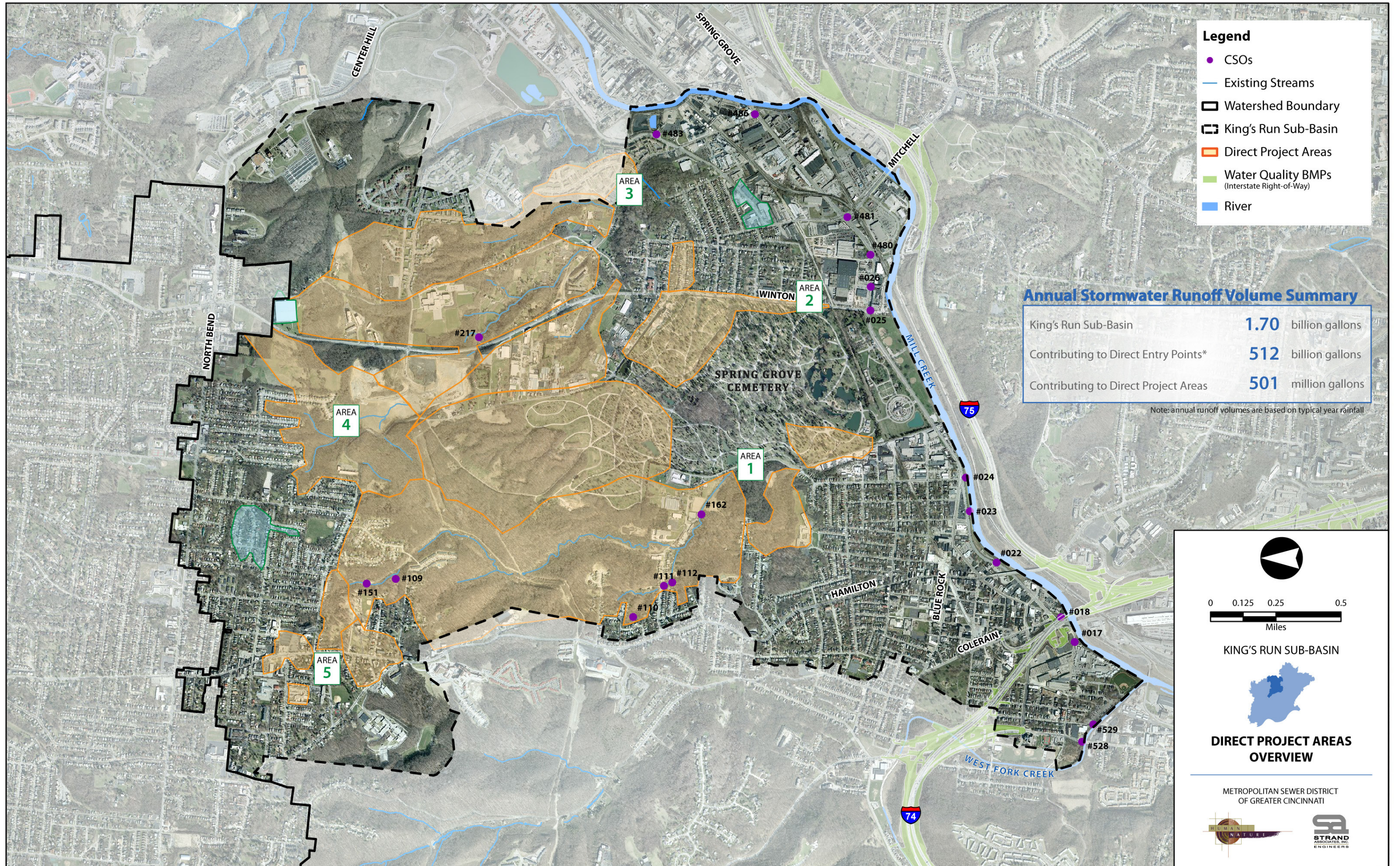
## Inform & Influence Projects

### **Watershed Partners (Inform & Influence Projects: Watershed Partners)**

Watershed Partners within the King's Run sub-basin include the Spring Grove Cemetery Association, Cincinnati Park Board (Laboiteaux Woods, Buttercup Valley, Parkers Woods, McEvoy Park, and Salway park), City of Cincinnati, Cincinnati Board of Education (College Hill Elementary, Chase Elementary, Clark High School, Aiken High School), Gray Road Landfill Redevelopment, and City of Cincinnati SPUR district (The southern portion of this sub-basin contains 420 acres of property that is targeted by the City of Cincinnati SPUR team for brownfield redevelopment).







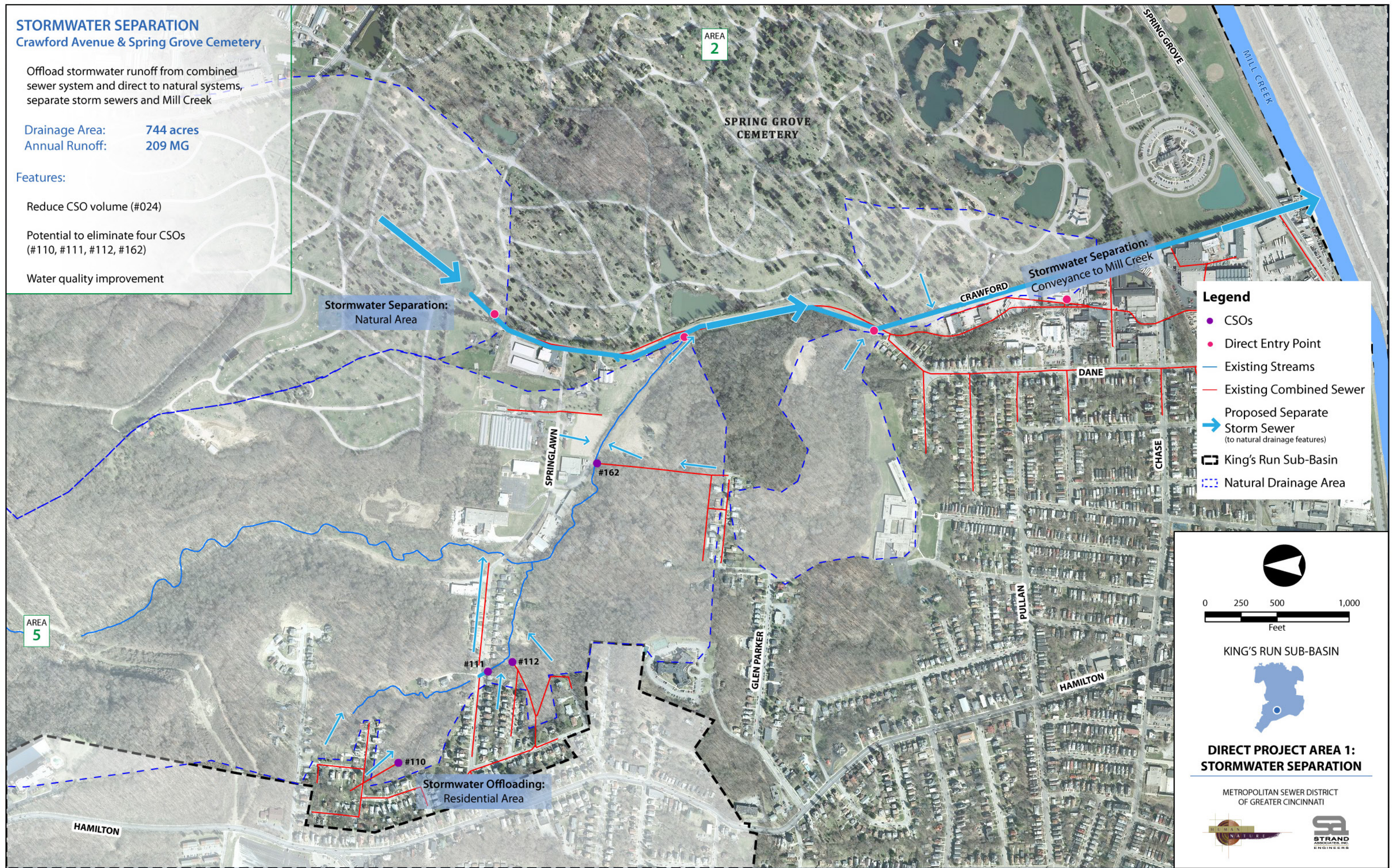
**STORMWATER SEPARATION**  
Crawford Avenue & Spring Grove Cemetery

Offload stormwater runoff from combined sewer system and direct to natural systems, separate storm sewers and Mill Creek

Drainage Area: 744 acres  
Annual Runoff: 209 MG

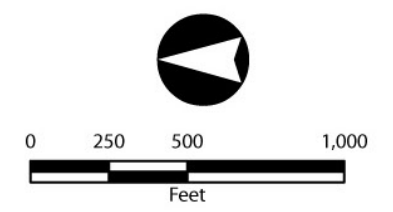
**Features:**

- Reduce CSO volume (#024)
- Potential to eliminate four CSOs (#110, #111, #112, #162)
- Water quality improvement



**Legend**

- CSOs
- Direct Entry Point
- Existing Streams
- Existing Combined Sewer
- ➔ Proposed Separate Storm Sewer (to natural drainage features)
- ▭ King's Run Sub-Basin
- ▭ Natural Drainage Area



KING'S RUN SUB-BASIN

**DIRECT PROJECT AREA 1: STORMWATER SEPARATION**

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

**STORMWATER SEPARATION**  
Winton Road & Spring Grove Cemetery

Offload stormwater runoff from combined sewer system and direct to separate storm sewers and Mill Creek

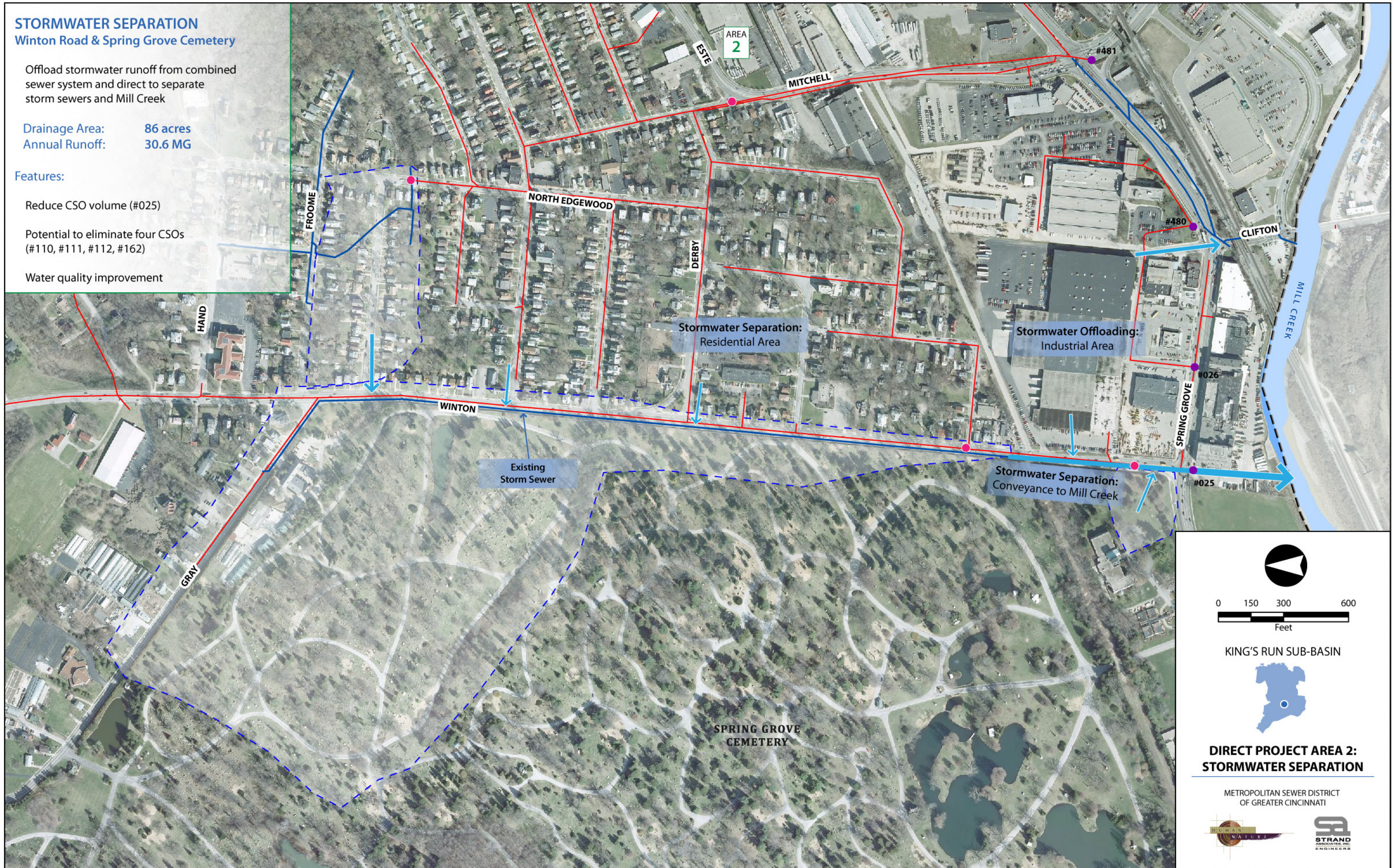
Drainage Area: 86 acres  
Annual Runoff: 30.6 MG

**Features:**

Reduce CSO volume (#025)

Potential to eliminate four CSOs (#110, #111, #112, #162)

Water quality improvement



0 150 300 600  
Feet

KING'S RUN SUB-BASIN

**DIRECT PROJECT AREA 2:  
STORMWATER SEPARATION**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI

**STORMWATER SEPARATION**  
Kings Run & Winton Road

Separate dry weather flow from combined sewer interception

Offload stormwater runoff and direct to natural drainage features, separate storm sewers and Mill Creek

Drainage Area: 450 acres  
Annual Runoff: 174 MG

**Features:**

Reduce CSO volume (#217, #483)

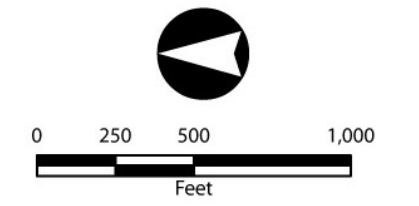
Build upon existing separate storm sewer network

Water quality improvement



**Legend**

- CSOs
- Direct Entry Point
- Existing Combined Sewer
- Existing Storm Sewer
- ➔ Proposed Separate Storm Sewer (to natural drainage features)
- ▭ King's Run Sub-Basin
- ▭ Natural Drainage Area



KING'S RUN SUB-BASIN



**DIRECT PROJECT AREA 3:  
SITE-SPECIFIC SOLUTIONS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI



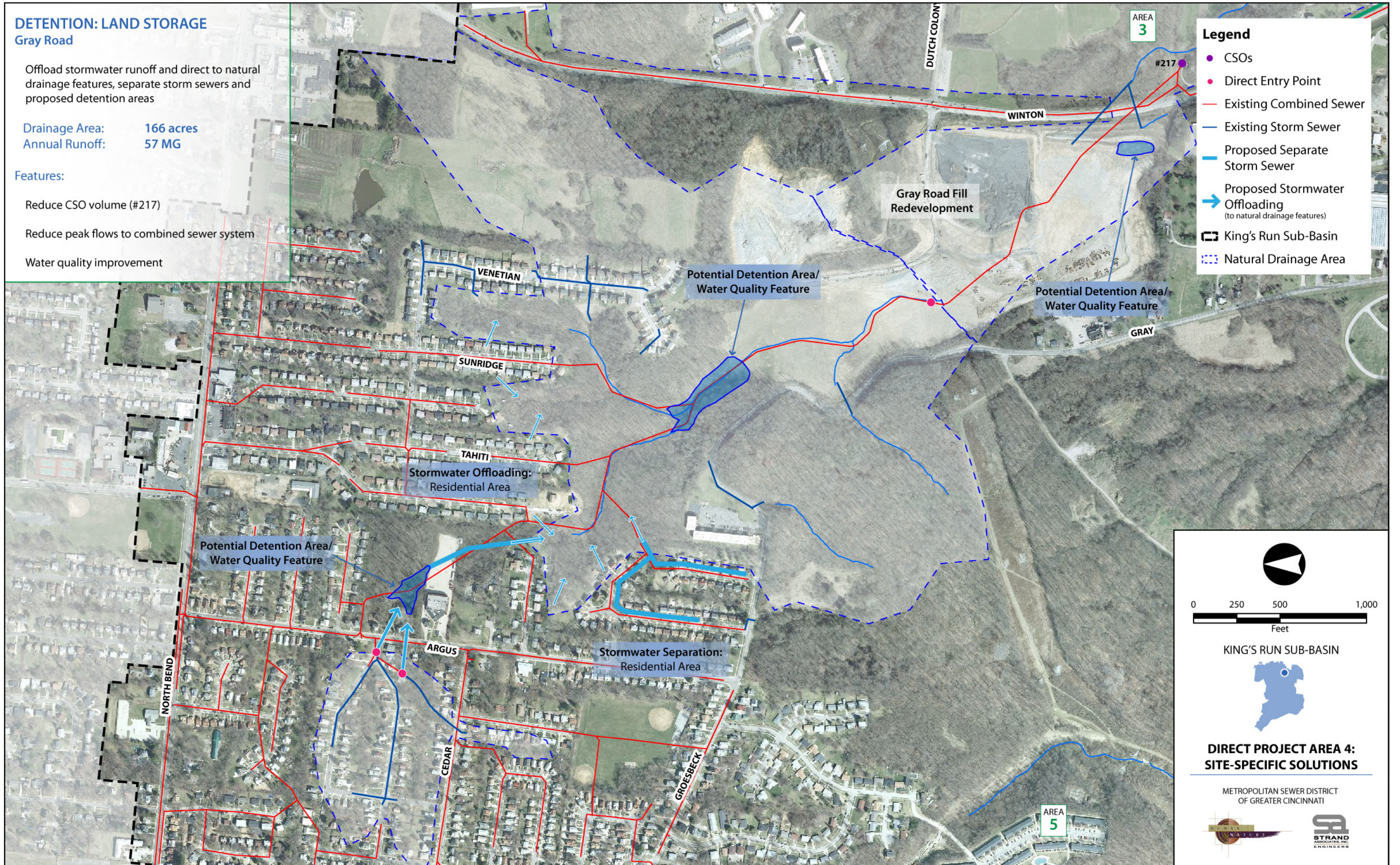
**DETENTION: LAND STORAGE**  
Gray Road

Offload stormwater runoff and direct to natural drainage features, separate storm sewers and proposed detention areas

Drainage Area: **166 acres**  
Annual Runoff: **57 MG**

**Features:**

- Reduce CSO volume (#217)
- Reduce peak flows to combined sewer system
- Water quality improvement



**Legend**

- CSOs
- Direct Entry Point
- Existing Combined Sewer
- Existing Storm Sewer
- Proposed Separate Storm Sewer
- ➔ Proposed Stormwater Offloading (to natural drainage features)
- ▭ King's Run Sub-Basin
- ▭ Natural Drainage Area

0 250 500 1,000  
Feet

KING'S RUN SUB-BASIN

**DIRECT PROJECT AREA 4: SITE-SPECIFIC SOLUTIONS**

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

**STORMWATER SEPARATION**  
Hamilton Avenue & Groesbeck Road

Offload stormwater runoff from combined sewer system and direct to separate storm sewers and natural drainage features

Drainage Area: 60 acres  
Annual Runoff: 30 MG

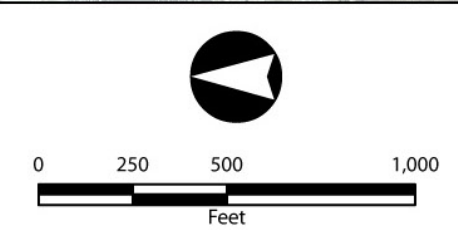
**Features:**

- Reduce CSO volume (#151)
- Potential to eliminate one CSO (#109)
- Water quality improvement



**Legend**

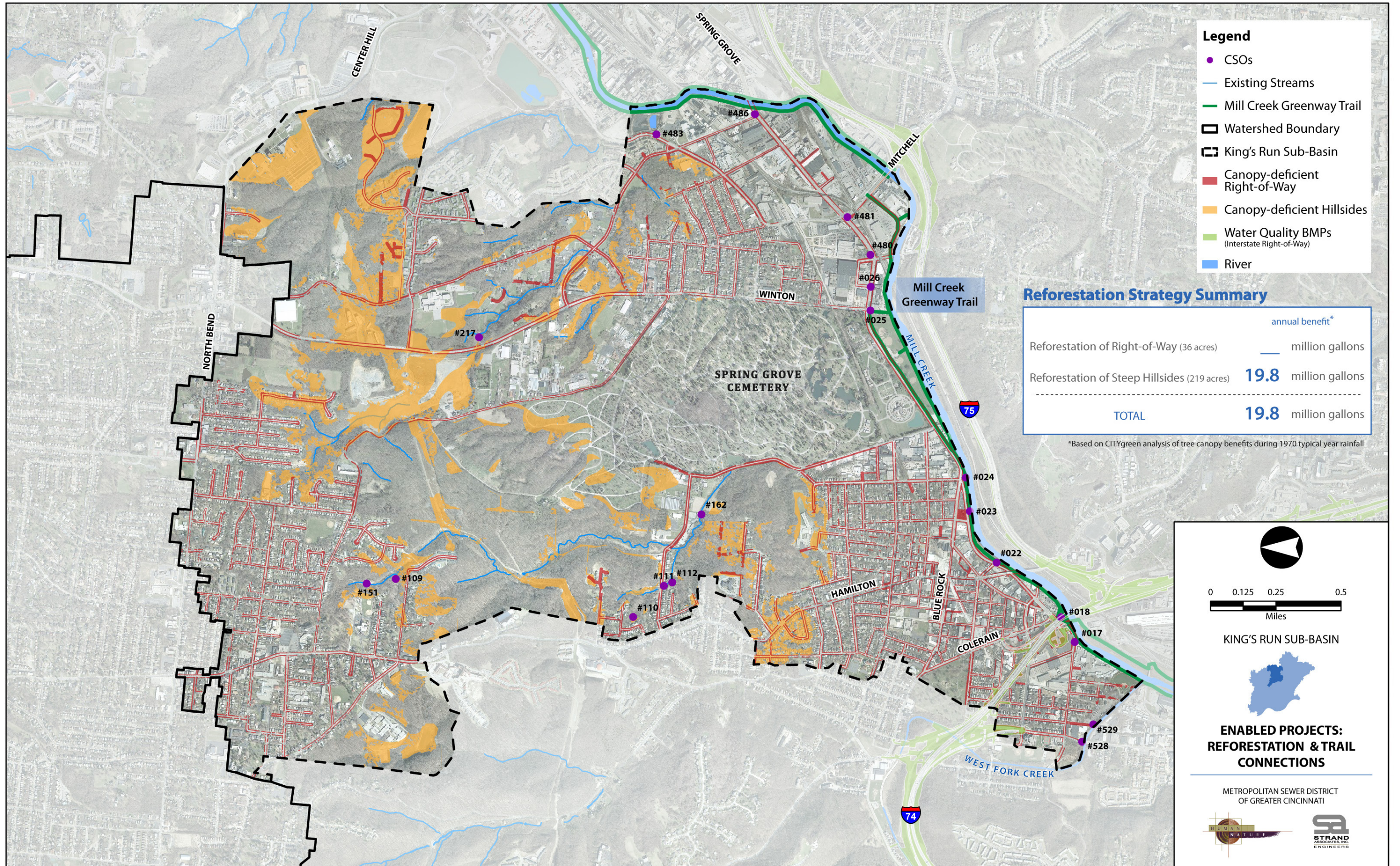
- CSOs
- Direct Entry Point
- Existing Combined Sewer
- Existing Storm Sewer
- Proposed Separate Storm Sewer
- ➔ Proposed Stormwater Offloading (to natural drainage features)
- ▭ King's Run Sub-Basin
- ⋯ Natural Drainage Area

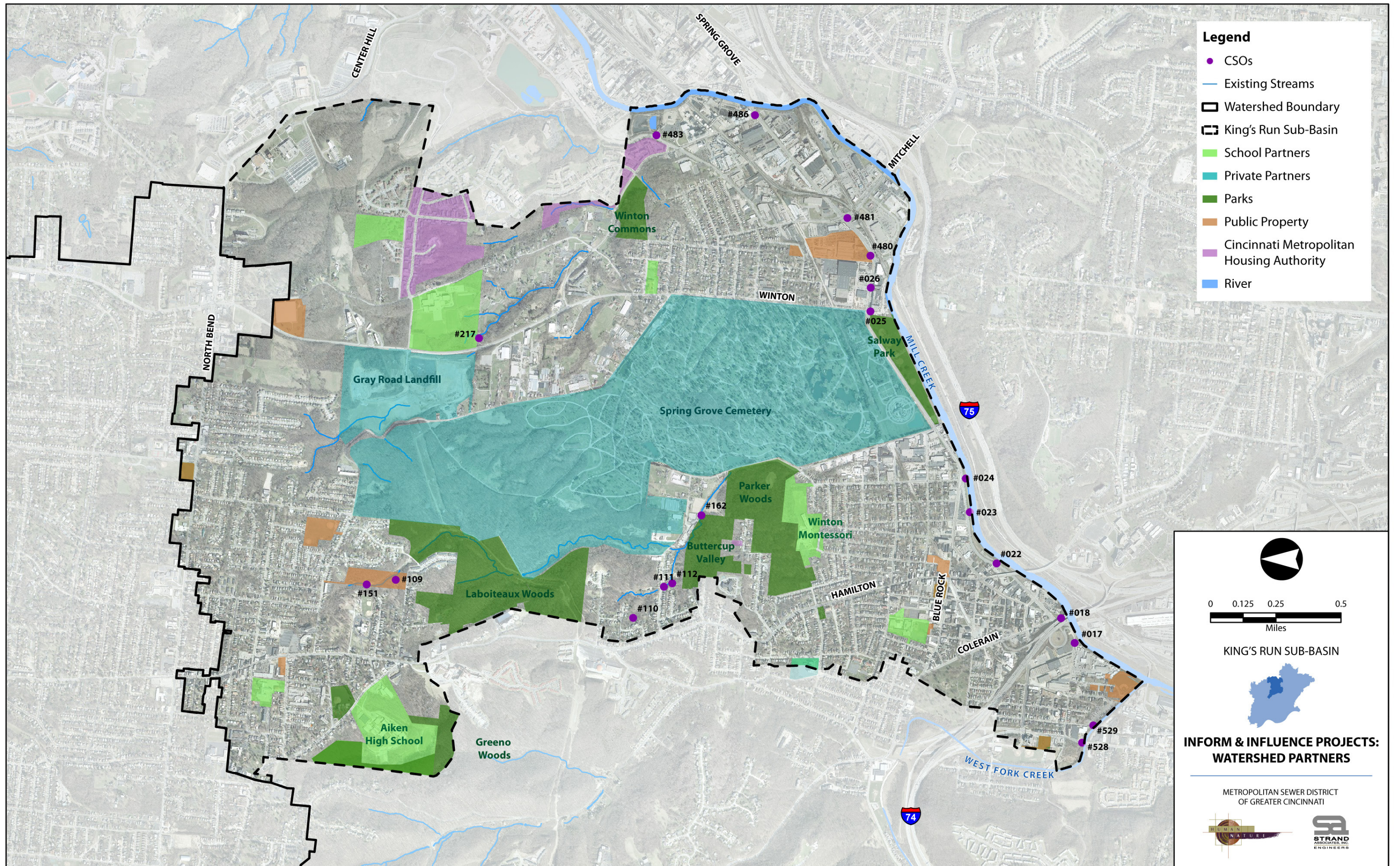


KING'S RUN SUB-BASIN

**DIRECT PROJECT AREA 5:  
SITE-SPECIFIC SOLUTIONS**







**Legend**

- CSOs
- Existing Streams
- ▭ Watershed Boundary
- ▭ King's Run Sub-Basin
- School Partners
- Private Partners
- Parks
- Public Property
- Cincinnati Metropolitan Housing Authority
- River

0 0.125 0.25 0.5  
Miles

KING'S RUN SUB-BASIN

**INFORM & INFLUENCE PROJECTS:  
WATERSHED PARTNERS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI

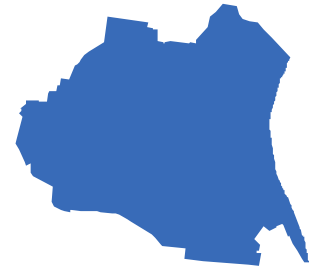




A map showing a large, irregularly shaped area outlined in light blue. Within this larger area, a smaller, more complexly shaped region is filled with a solid dark blue color. The dark blue region is located in the upper right portion of the larger area. The background is a light blue gradient.

**DENHAM  
SUB-BASIN**

# DENHAM SUB-BASIN



## LOCATION

The Denham sub-basin covers approximately 2.1 square miles (3.3 percent of the Lower Mill Creek watershed) and overlaps seven neighborhoods within the City of Cincinnati (Westwood, East Westwood, South Cumminsville, Millvale, English Woods, North Fairmount and South Fairmount). The main transportation routes include Beekman Street, Westwood Northern Boulevard, and Hopple Street. Key property owners include the City of Cincinnati, the Cincinnati Park Board (St Clair Heights Park, North Fairmount Playground and Millvale Park), Cincinnati Metropolitan Housing Authority, Cincinnati Board of Education (Taft High School- temporary location, Millvale Elementary and North Fairmount Education Center), Baltimore Pike Cemetery Association, and Hillside Trust.

## CHARACTERIZATION OF PROBLEM

There are five CSO locations within the Denham sub-basin, contributing an annual overflow volume of 365 million gallons. Direct project areas identified during the coarse evaluation contribute approximately 114 MG of stormwater runoff annually.

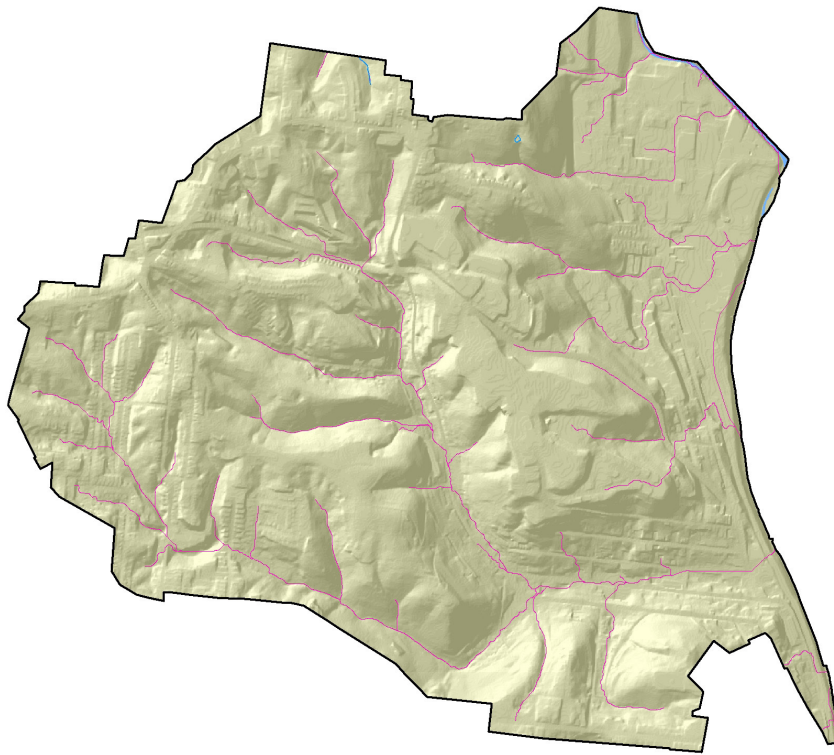
CSO NUMBER	NAME	EVENTS	OVERFLOW (MG)	CONTROL (%)	DIRECT PROJECT <sup>2</sup> (MG)	CSO CONTROL STRATEGY <sup>1</sup>	BUNDLE CLUSTER
8	Vinton St. Regulator	26	1	84	0	Regulator Improvement (1.54 cfs)	Hopple Street Viaduct
10	Denham St. Regulator	61	249	54	77	Tunnel	Hopple Street Viaduct
13	Yonkers St. Regulator	74	56	25	0	Tunnel	Hopple Street Viaduct
14	Station 15 Regulator	64	59	43	38	Tunnel	Hopple Street Viaduct
530	Beekman South Grating	13	0	95	0	Regulator Improvement (8.5 cfs)	West Fork Creek
<b>TOTAL</b>		<b>238</b>	<b>365</b>		<b>114</b>		

<sup>1</sup> Volume II CSO LTCP Update Report, 2006; 2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report, 2008; Final Wet Weather Improvement Program, 2009.

<sup>2</sup> Represents preliminary annual stormwater runoff contributing to direct project areas identified in the Coarse Evaluation; Total number does not consider runoff from drainage areas that are tributary to multiple CSO points

The GIS inventory of natural systems investigated the sub-basin's hydrologic network, soil characteristics, slopes, tree canopy cover, and geology. The GIS inventory of built systems investigated the impervious surfaces, combined sewer system, existing land use, neighborhoods, and road right-of-way. Descriptions of and maps for these systems are included in the following pages.

## hydrologic network

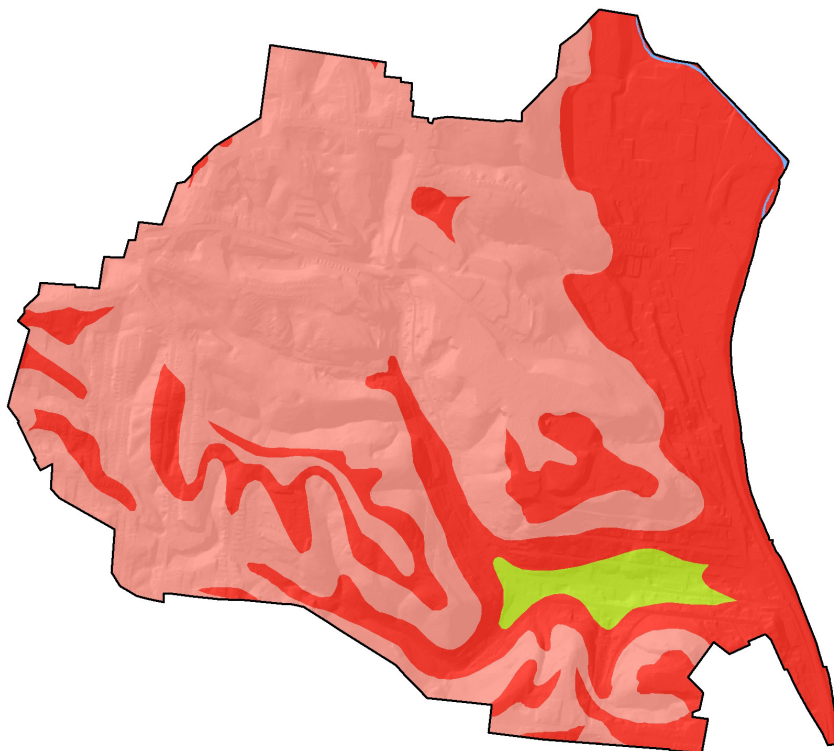


- Sub-basin boundary
- Interstate
- Historical streams
- Existing streams

The pre-development hydrologic network shows an extensive system of creeks and streams within the sub-basin. This network naturally conveyed stormwater runoff to the Mill Creek. Today underground sewer systems have replaced this stream network.

Data source: CAGIS, historical USGS maps








## hydrologic soil groups



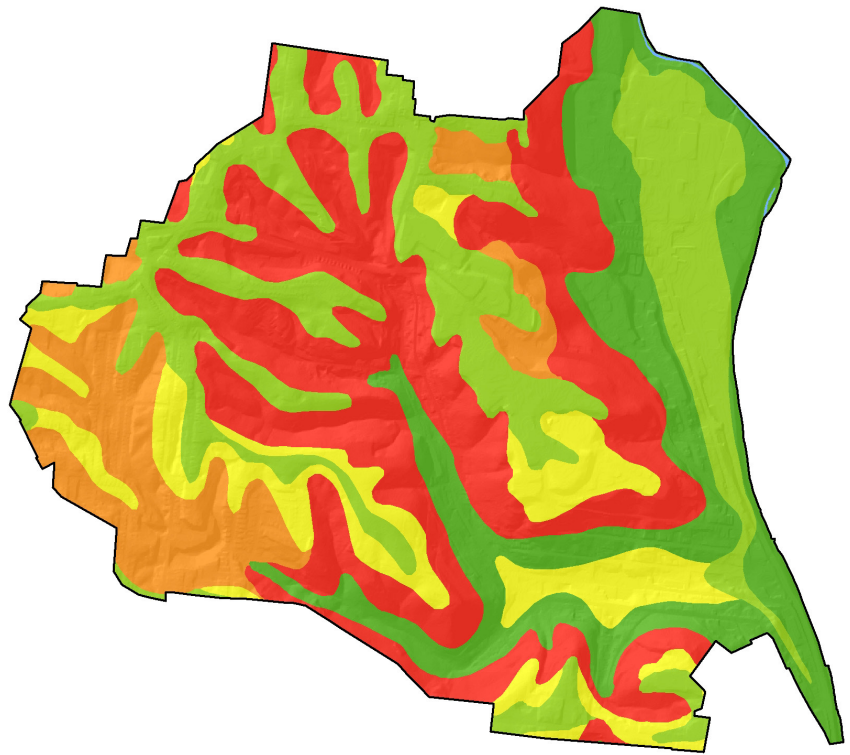
- Sub-basin boundary
- Interstate
- Group A
- Group B
- Group C
- Group D

Nearly all of soils in the Denham sub-basin are hydrologic group D or C, having limited potential for infiltration.

Data source: Hamilton County Soil Survey




-  Sub-basin boundary
-  Interstate
-  0-3 percent
-  3-8 percent
-  8-15 percent
-  15-25 percent
-  25+ percent

slope ranges

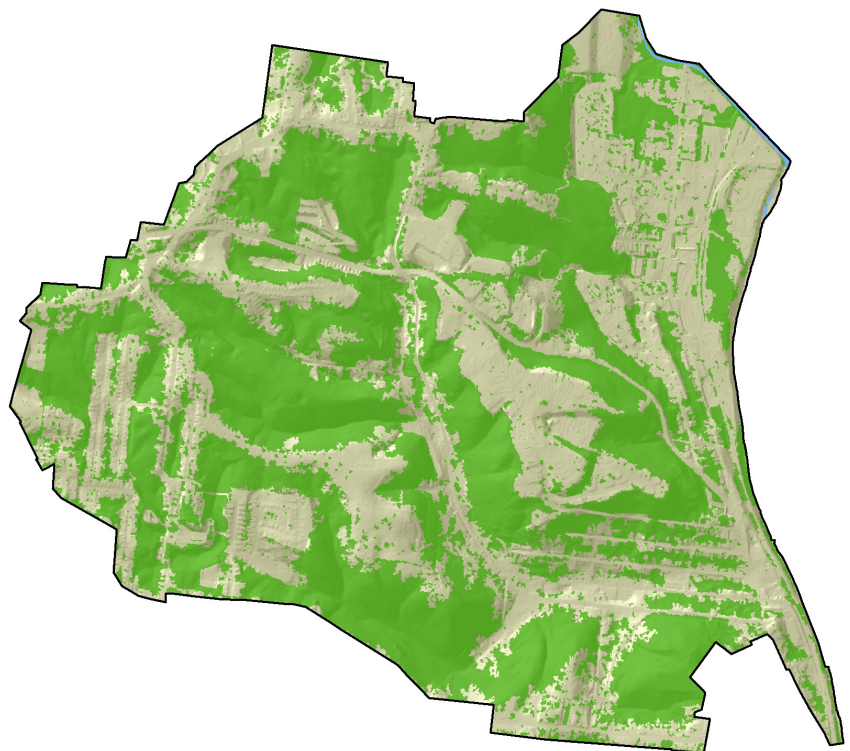


The majority of land in the Denham sub-basin has slopes of 8 percent or greater.

Data source: Hamilton County Soil Survey

-  Sub-basin boundary
-  Interstate
-  Existing tree canopy

tree canopy cover






There are 691 acres of existing tree canopy in the Denham sub-basin, representing 52% of the total land area.

Data source: Cincinnati Park Board, ODNR

## impervious surfaces










-  Sub-basin boundary
-  Interstate
-  Impervious surfaces

There are 350 acres of impervious surfaces in the Denham sub-basin, representing 27% of the total land area.

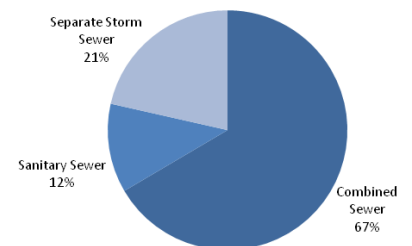
Data source: CAGIS

## combined sewer system








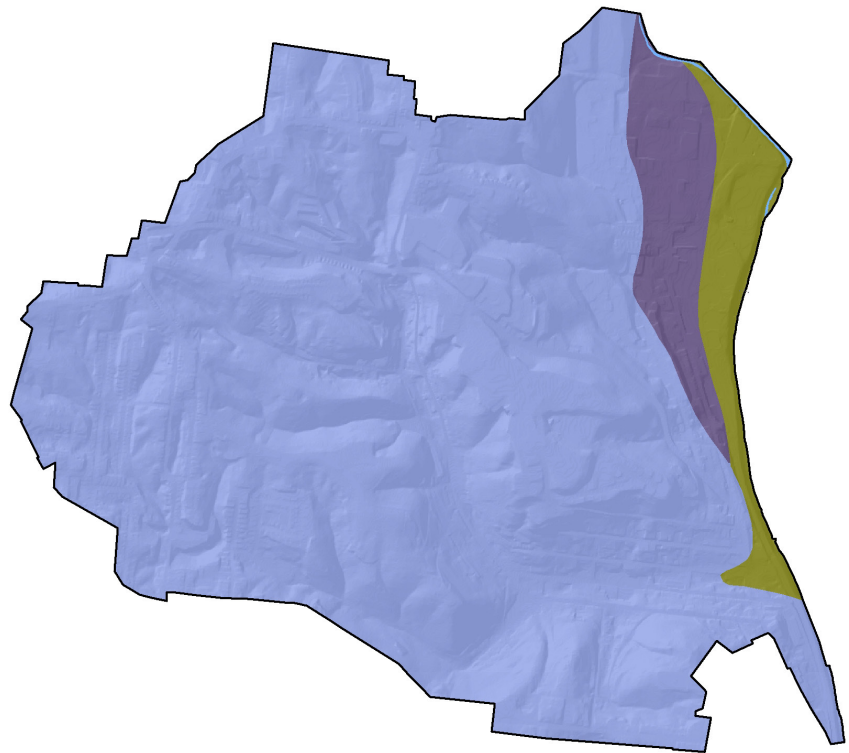
-  Sub-basin boundary
  -  Interstate
  -  CSO
- Combined sewers (pipe size)
-  < 12 inches
  -  12-48 inches
  -  48-72 inches
  -  > 72 inches

There are 25 miles of combined sewers in the Denham sub-basin.




Data source: MSDGC

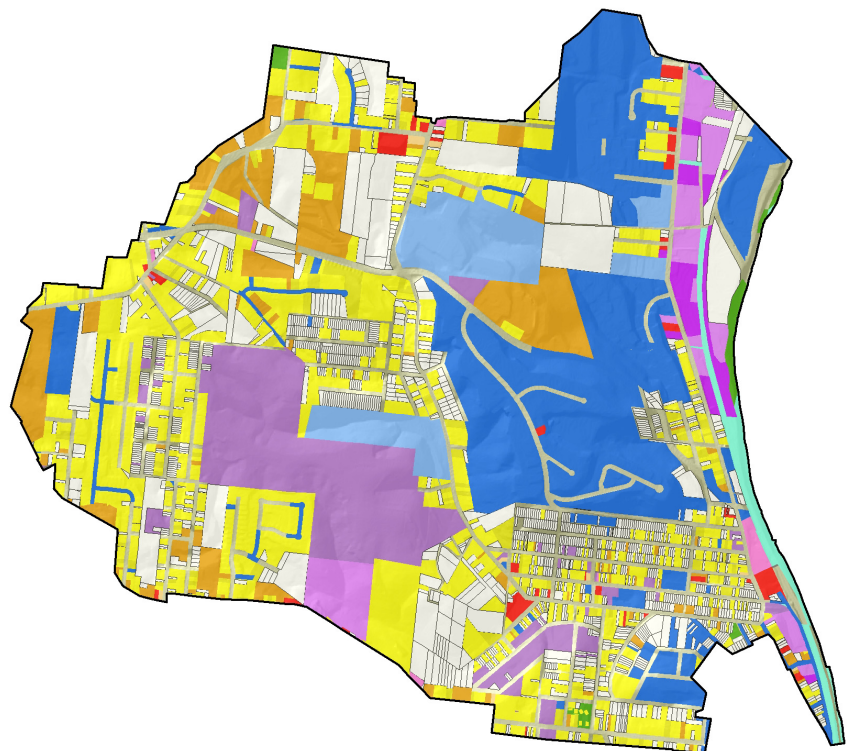
-  Sub-basin boundary
-  Interstate
-  Alluvium
-  Limestone
-  Silt



The vast majority of land in the Denham sub-basin is underlain by limestone geologic formations; however, deep infiltration opportunities may be possible in alluvium deposits, which may be present along the Mill Creek.

Data source: Ohio Geological Survey

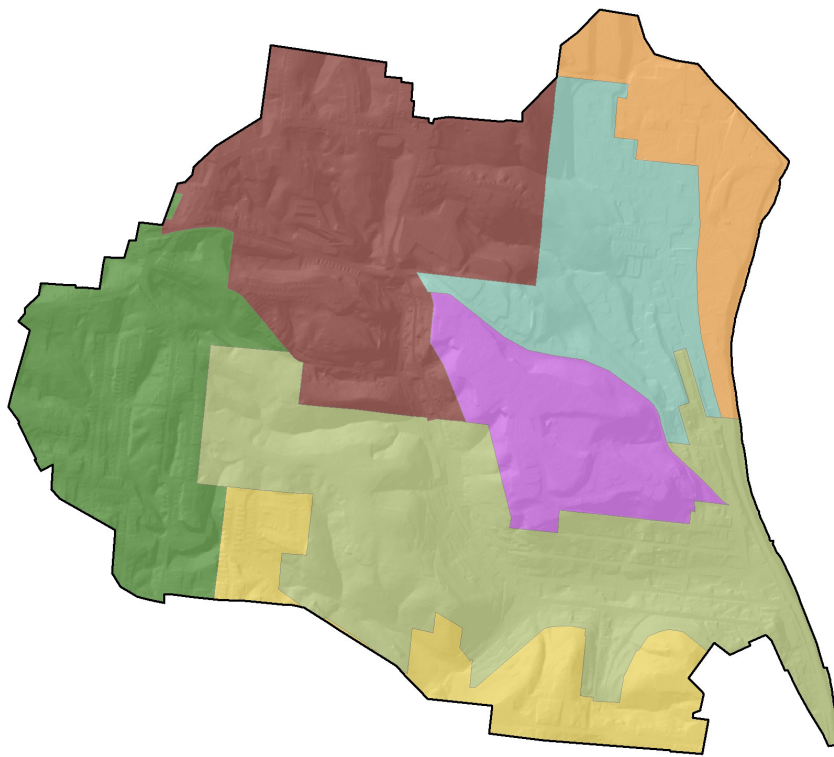
-  Sub-basin boundary
-  Interstate
-  Commercial
-  Educational
-  Industrial
-  Institutional
-  Light industrial
-  Multi-family
-  Mixed-use
-  Office
-  Parks & recreational
-  Public space
-  Public utilities
-  Single-family
-  Two-family
-  Vacant
-  Unknown



The majority of land use in the Denham sub-basin is single-family (20%) or vacant (20%).

Data source: Hamilton County Auditor

## neighborhoods



- Sub-basin boundary
- Interstate
- East Westwood
- English Woods
- North Fairmount
- Millvale
- South Cumminsville
- South Fairmount
- Westwood

The Denham sub-basin is comprised of 7 neighborhoods.

Data source: CAGIS

## right-of-way (ROW)



- Sub-basin boundary
- Interstate
- Impervious surfaces

There are 98 acres of ROW in the Denham sub-basin, which is 7% of the total land area.

Data source: CAGIS



## COARSE-LEVEL OPPORTUNITIES

The project team identified several opportunities for reducing the volume of stormwater runoff entering the combined sewer system and the resulting CSO volume. Coarse-level opportunities in the Denham sub-basin include Direct Projects, Enabled Projects, and Inform/Influence Projects. Direct projects are wet weather strategies that require direct investment by MSD for planning and long-term maintenance; Enabled Projects are wet weather strategies that represent a leveraged infrastructure investment and present opportunities for cost sharing and collaboration among MSD and key watershed stakeholders; and Inform/Influence Projects are programmatic elements that engage and educate watershed partners and the broader public in making sustainable decisions that provide water quantity and quality benefits.

### Direct Projects

With the objective of reducing combined sewer overflows in the Denham sub-basin, the project team first identified major direct entry points to the combined sewer system and their tributary natural drainage areas (**See Existing Conditions Overview**). Direct entry points represent areas where stormwater runoff and/or natural stream flows enter the combined sewer system.

Natural drainage basins that contained coarse-level opportunities became “direct project areas” (**See Direct Project Areas Overview**), allowing the team to narrow its focus within the sub-basin. The direct wet weather strategies, or opportunity areas, include detention basins, several different stormwater separation opportunities, water quality BMPs, and stream daylighting.

#### **Detention: Land Storage, Stormwater Separation & Water Quality BMP (Direct Project Area 1)**

Stormwater runoff will be offloaded and directed to natural drainage features, separate storm sewers and the proposed detention areas and water quality features. The detention features have the potential to reduce CSO volume of CSO #14 with an average of 58.5 million gallons of overflow each year, reduce peak flows into the combined sewer system, and improve water quality. The five detention basins (approximately 2.75 acres combined), the water quality BMP (0.36 acres), and the separate storm sewer (430 feet) will contribute to the removal of approximately 37.5 million gallons of stormwater runoff from the combined sewer each year.

#### **Detention: Land Storage (Direct Project Area 2)**

Stormwater runoff will be offloaded and directed to natural drainage features, separate storm sewers and the proposed detention areas. The detention features have the potential to reduce CSO volume of CSO #10 with an average of 249.2 million gallons of overflow each year, reduce peak flows into the combined sewer system, and improve water quality. The three detention basins are approximately 2.73 acres combined and have will contribute to the removal of approximately 12.7 million gallons of stormwater runoff from the combined sewer each year.

#### **Stream Daylighting (Direct Project Area 3)**

The proposed stream daylighting will disconnect and offload stormwater from the combined sewer system to natural drainage areas and a daylighted stream. The stream has the potential to reduce CSO volume of CSO #10 with an average of 249.2 million gallons of overflow each year, reduce peak flows into the combined sewer system, improve water quality and provide an amenity to the community. The natural drainage basin is approximately 116.45 acres and have will contribute to the removal of approximately 63.5 million gallons of stormwater runoff from the combined sewer each year.

### Enabled Projects

#### **Reforestation (Enabled Projects: Reforestation)**

There are currently 691 acres of existing tree canopy in the Denham sub-basin, representing 52 percent of the total land area. This canopy network provides valuable benefits in regard to natural stormwater runoff management and air quality improvement. Based on a CITYgreen analysis, the team was able to recommend not only protecting the existing canopy within the sub-basin, but reforesting 60 percent of the canopy-deficient areas along major interstate corridors, road right-of-ways and steep slopes. Reforestation efforts should focus on the 61 acres of canopy-deficient hillsides and 15 acres of right-of-ways present within the King's Run sub-basin. According to the CITYgreen analysis, such reforestation has the potential to remove approximately 9.7 million gallons (7.9 and 1.8 million gallons respectively) of stormwater runoff from the combined sewer each year.

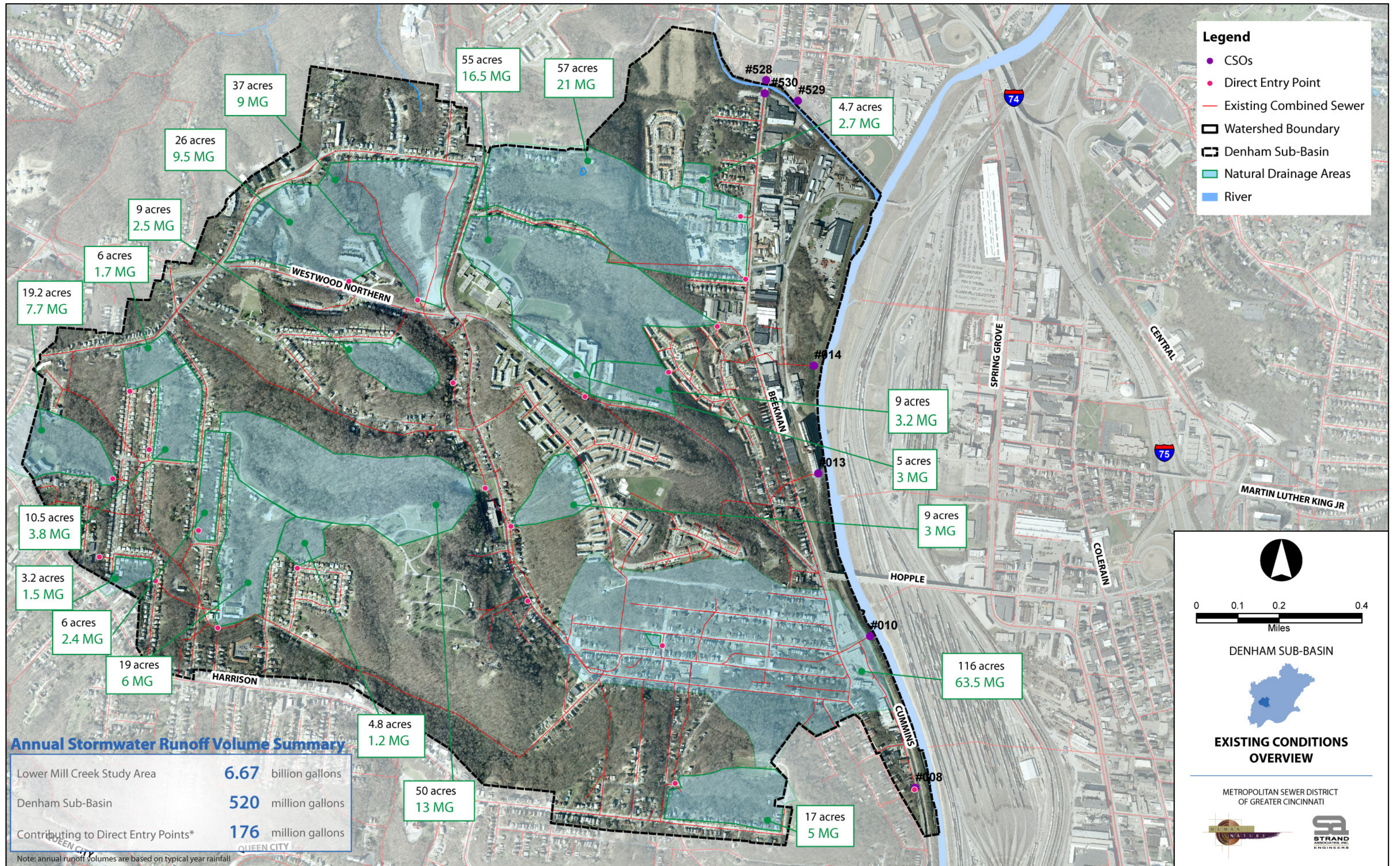
### **Mill Creek Greenway Trail**

The construction of the Mill Creek Greenway trail presents the opportunity to integrate stormwater quality BMPs along the Mill Creek corridor.

## Inform & Influence Projects

### **Watershed Partners (Inform & Influence Projects: Watershed Partners)**

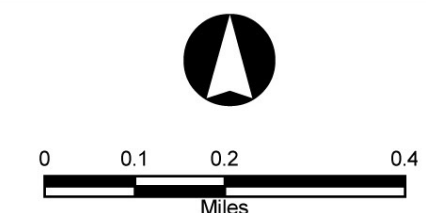
Watershed partners include schools, parks, open spaces, institutional properties, road right-of-way, and vacant, abandoned and foreclosed properties. As potential areas for public-private partnerships, these land uses can integrate multiple stakeholders, thereby increasing public involvement and improving public perception of infrastructure projects. For example, forging partnerships with institutional and educational properties can create highly-visible projects within the community, and foster long-lasting, inter-agency relationships. The Watershed Partners map depicts the identified partners within the Denham sub-basin. Watershed partners in the Denham sub-basin include the the Cincinnati Metropolitan Housing Authority, the City of Cincinnati, the Cincinnati Board of Education (Taft High School- temporary location, Millvale Elementary, and North Fairmount Education Center), Baltimore Pike Cemetery Association, and Hillside Trust. The eastern portion of this sub-basin contains 44.4 acres of property that is targeted by the City of Cincinnati SPUR team for brownfield redevelopment (SPUR district #3- Beekman).





**Legend**

- CSOs
- Direct Entry Point
- Existing Streams
- Existing Combined Sewer
- ▭ Denham Sub-Basin
- ▭ Direct Project Areas
- River



DENHAM SUB-BASIN



**DIRECT PROJECT AREAS**

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI



**Annual Stormwater Runoff Volume Summary**

Denham Sub-Basin	<b>520</b> million gallons
Contributing to Direct Entry Points*	<b>176</b> million gallons
Contributing to Direct Project Areas	<b>114</b> million gallons

Note: annual runoff volumes are based on typical year rainfall



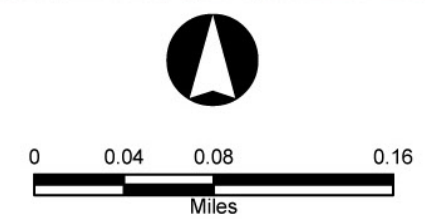
- Legend**
- CSOs
  - Direct Entry Point
  - Proposed Storm Sewer
  - Existing Combined Sewer
  - ▭ Denham Sub-Basin
  - ▭ Natural Drainage Basin
  - ▭ Downspout Disconnection
  - ▭ Detention Basin
  - ▭ Stormwater BMP
  - ▭ River
  - ➔ Stormwater Flow

**DETENTION: LAND STORAGE, STORMWATER SEPARATION & WATER QUALITY BMPs**

Offload stormwater runoff and direct to natural drainage features, separate storm sewers and proposed detention areas and water quality features

- Detention Area 1: 0.38 acres
- Detention Area 2: 0.17 acres
- Detention Area 3: 0.4 acres
- Detention Area 4: 0.3 acres
- Detention Area 5: 1.5 acres
- Stormwater BMP 6: 0.36 acres

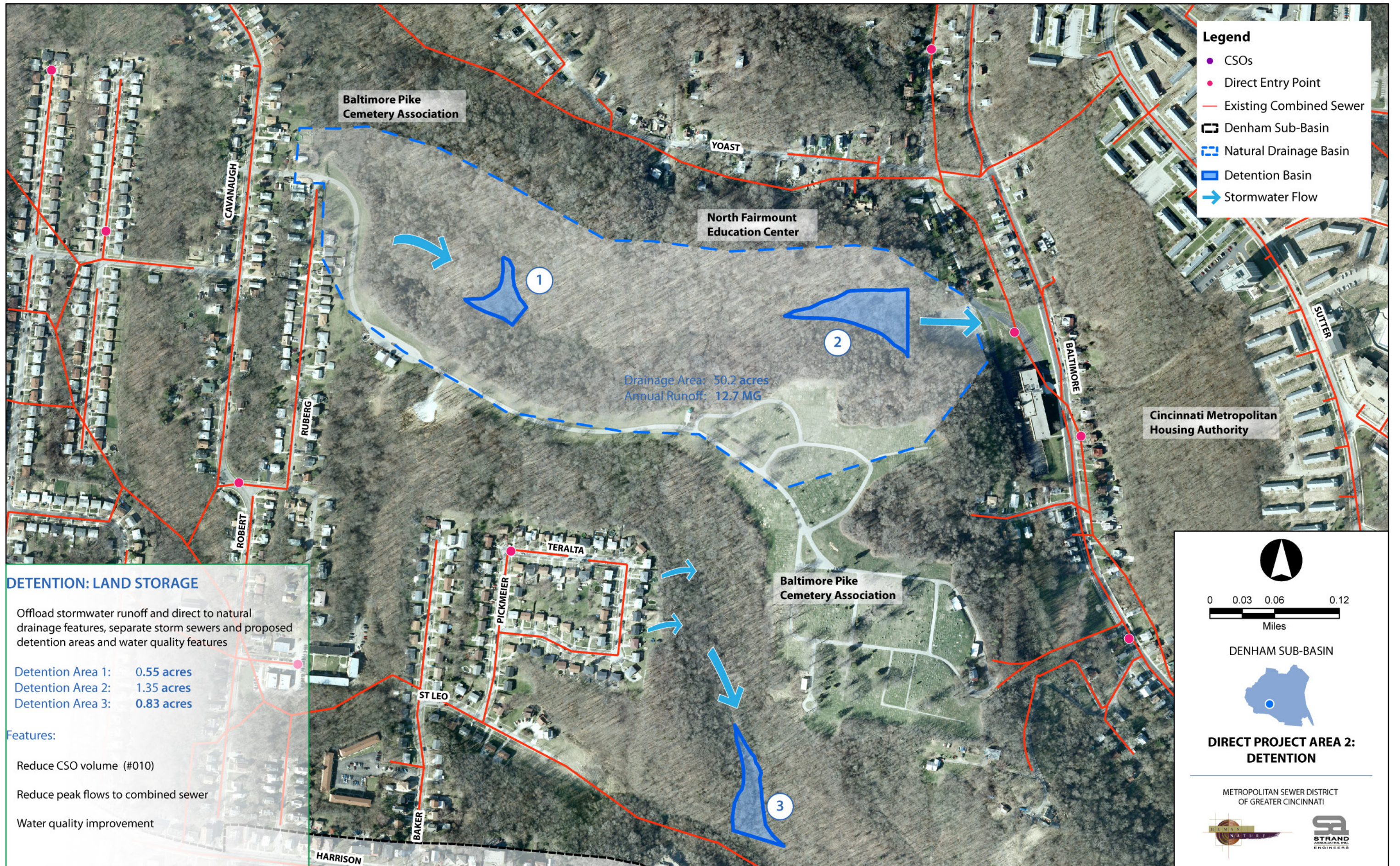
- Features:**
- Reduce CSO volume (#014)
  - Reduce peak flows to combined sewer
  - Water quality improvement



DENHAM SUB-BASIN

**DIRECT PROJECT AREA 1: DETENTION**





**Legend**

- CSOs
- Direct Entry Point
- Existing Combined Sewer
- ▭ Denham Sub-Basin
- ▭ Natural Drainage Basin
- ▭ Detention Basin
- ➔ Stormwater Flow

0 0.03 0.06 0.12  
Miles

DENHAM SUB-BASIN

**DIRECT PROJECT AREA 2: DETENTION**

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

**DETENTION: LAND STORAGE**

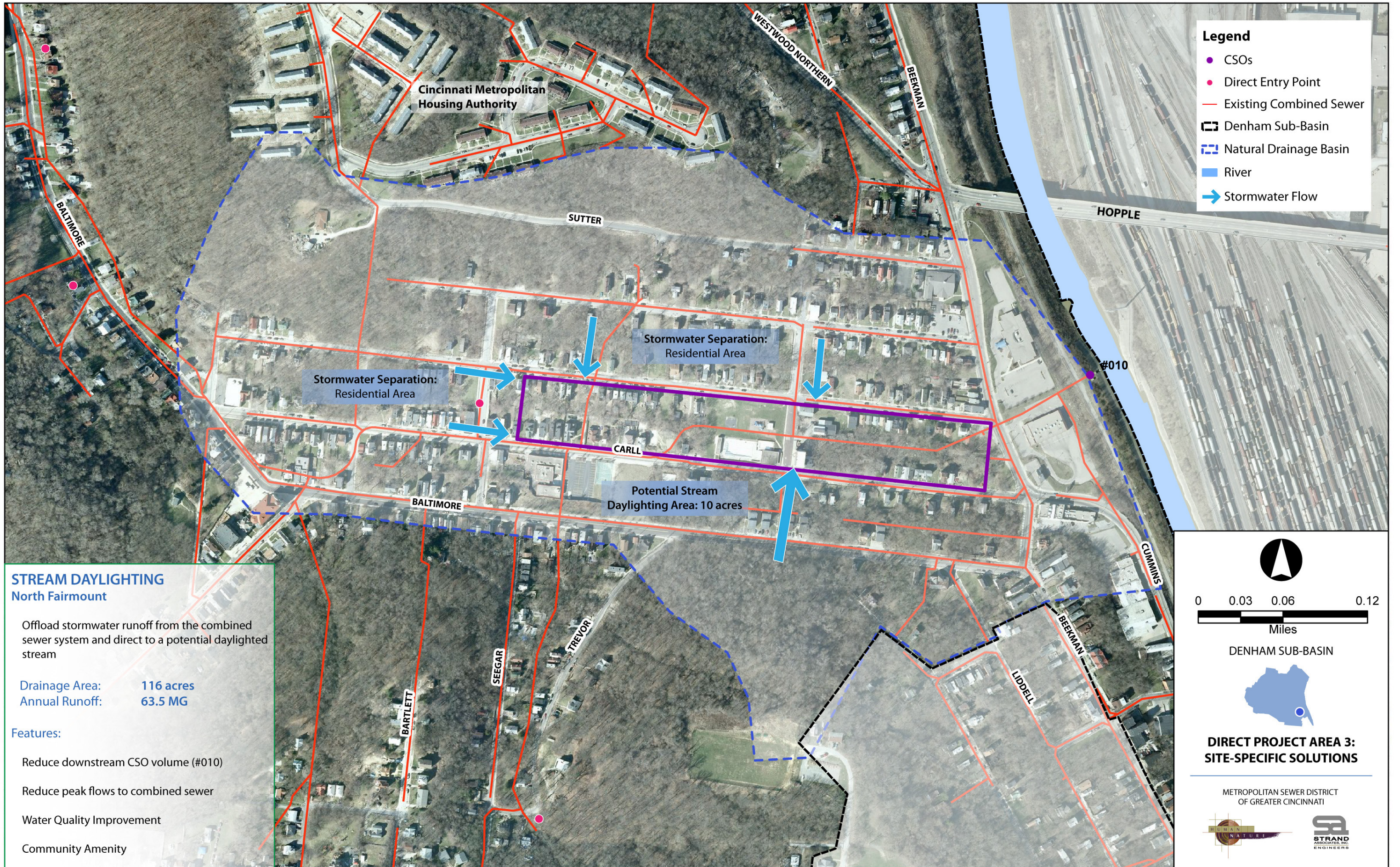
Offload stormwater runoff and direct to natural drainage features, separate storm sewers and proposed detention areas and water quality features

Detention Area 1: 0.55 acres  
 Detention Area 2: 1.35 acres  
 Detention Area 3: 0.83 acres

Features:

- Reduce CSO volume (#010)
- Reduce peak flows to combined sewer
- Water quality improvement

Drainage Area: 50.2 acres  
 Annual Runoff: 12.7 MG



**Legend**

- CSOs
- Direct Entry Point
- Existing Combined Sewer
- ▭ Denham Sub-Basin
- - - Natural Drainage Basin
- ▭ River
- ➔ Stormwater Flow

**STREAM DAYLIGHTING**  
North Fairmount

Offload stormwater runoff from the combined sewer system and direct to a potential daylighted stream

Drainage Area: 116 acres  
Annual Runoff: 63.5 MG

**Features:**

- Reduce downstream CSO volume (#010)
- Reduce peak flows to combined sewer
- Water Quality Improvement
- Community Amenity

0 0.03 0.06 0.12  
Miles

DENHAM SUB-BASIN

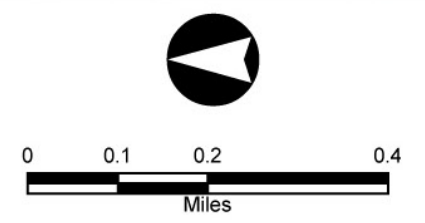
**DIRECT PROJECT AREA 3:  
SITE-SPECIFIC SOLUTIONS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI



**Legend**

- CSOs
- Existing Streams
- Mill Creek Greenway Trail
- ▭ Denham Sub-Basin
- ▭ Canopy-deficient Right-of-Way
- ▭ Canopy-deficient Hillsides
- ▭ River



DENHAM SUB-BASIN



**ENABLED PROJECTS:  
REFORESTATION & TRAIL  
CONNECTIONS**

METROPOLITAN SEWER DISTRICT  
OF GREATER CINCINNATI

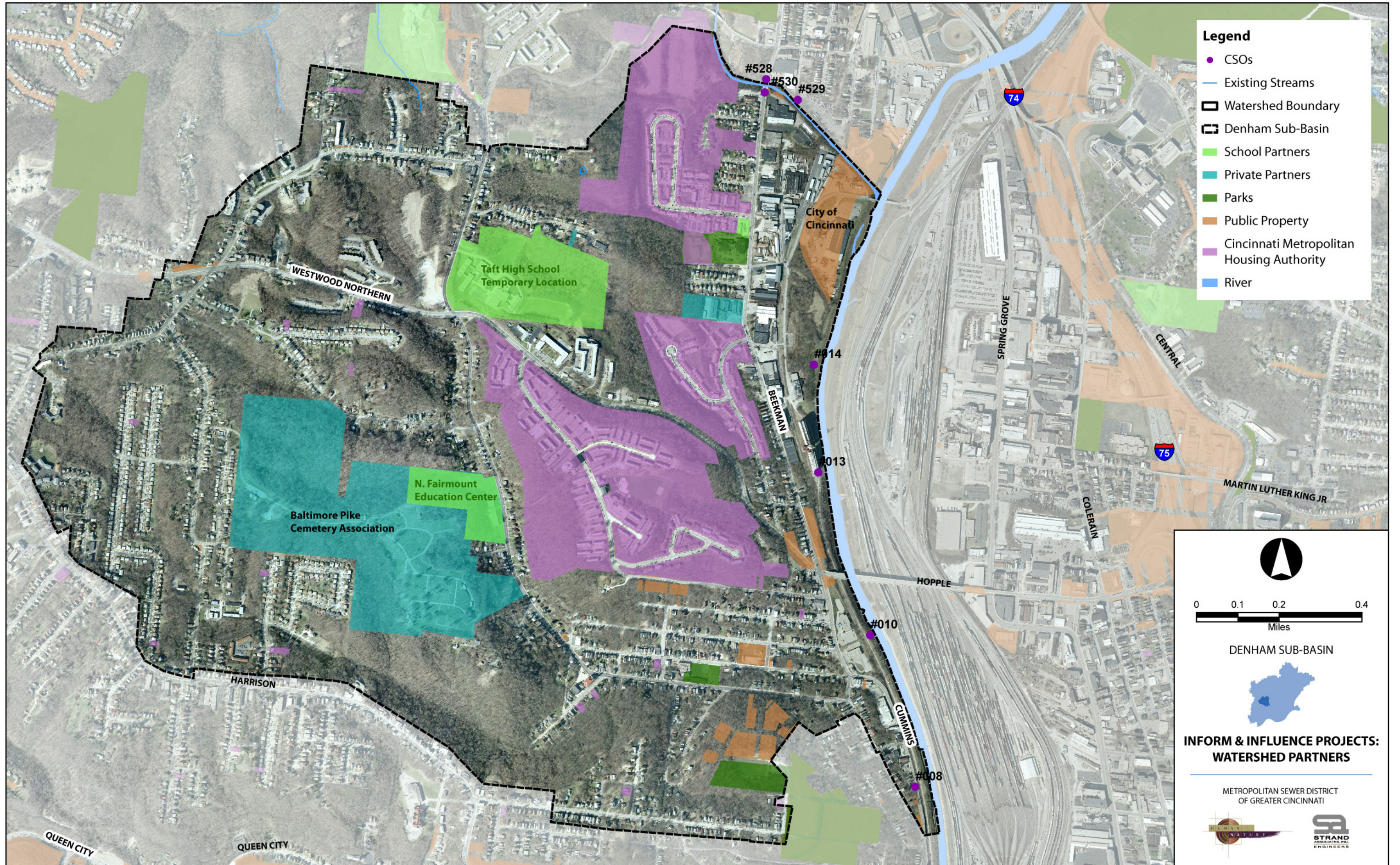


**Reforestation Strategy Summary**

	annual benefit*
Reforestation of Right-of-Way (15 acres)	1.8 million gallons
Reforestation of Steep Hillsides (61 acres)	7.9 million gallons
<b>TOTAL</b>	<b>9.7 million gallons</b>

\*Based on CITYgreen analysis of tree canopy benefits during 1970 typical year rainfall









**GEST  
SUB-BASIN**

# GEST SUB-BASIN



## LOCATION

The Gest sub-basin covers approximately 0.7 square miles (1 percent of the Lower Mill Creek watershed) and overlaps four neighborhoods within the City of Cincinnati (South Fairmount, East Price Hill, Lower Price Hill and Queensgate). The main transportation routes include Harrison Avenue, State Avenue, West 8th Street, and 6th Street. There are several key property owners within the Gest sub-basin, which include MSD, Baltimore & Ohio Railroad, Chesapeake & Ohio Railway, Cincinnati Southern Rail, and Cincinnati-New Orleans Railway.

## CHARACTERIZATION OF PROBLEM

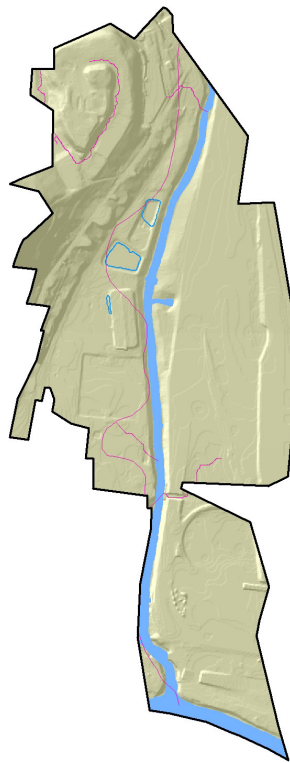
There are five CSO locations within the Gest sub-basin, contributing an annual overflow volume of 40 million gallons.





CSO NUMBER	NAME	EVENTS	OVERFLOW (MG)	CONTROL (%)	CSO CONTROL STRATEGY <sup>1</sup>	BUNDLE CLUSTER
489	7th and McLean Diversion Dam	63	3	41	Partial separation	East Ohio River-1
429	Gest St. East Diversion Dam	5	0	95	Regulator Improvement (2.15 cfs)	East Ohio River-1
152	Fitzpatrick St. Regulator	66	10	38	Partial separation	Western Hills Viaduct
2	Liberty St. Regulator	49	18	63	Full separation	Western Hills Viaduct
3	Harrison and State West Regulator	52	9	60	HW/DW protection	Western Hills Viaduct
<b>TOTAL</b>		<b>235</b>	<b>40</b>			

<sup>1</sup> Volume II CSO LTCP Update Report, 2006; 2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report, 2008; Final Wet Weather Improvement Program, 2009.

The GIS inventory of natural systems investigated the sub-basin's hydrologic network, soil characteristics, slopes, tree canopy cover, and geology. The GIS inventory of built systems investigated the impervious surfaces, combined sewer system, existing land use, neighborhoods, and road right-of-way. Descriptions of and maps for these systems are included in the following pages.

### hydrologic network

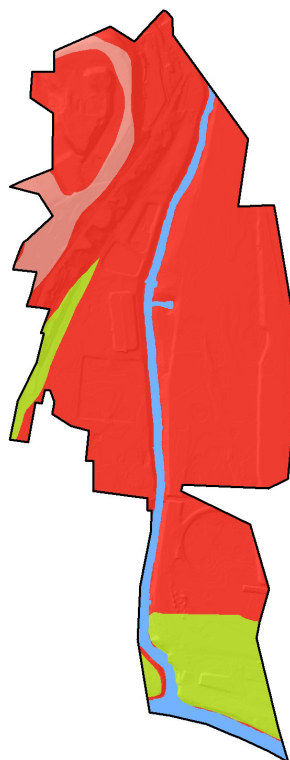








-  Sub-basin boundary
-  Interstate
-  Historical streams
-  Existing streams

The pre-development hydrologic network shows an extensive system of creeks and streams within the sub-basin. This network naturally conveyed stormwater runoff to the Mill Creek. Today underground sewer systems have replaced this stream network.

Data source: CAGIS, historical USGS maps








### hydrologic soil groups



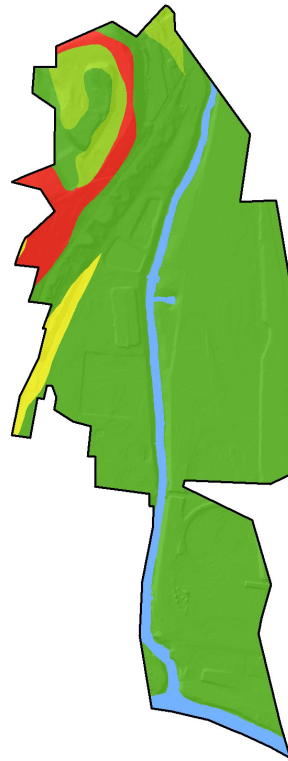
-  Sub-basin boundary
-  Interstate
-  Group A
-  Group B
-  Group C
-  Group D

The majority of soils in the Gest sub-basin are hydrologic group D or C, having limited potential for infiltration.

Data source: Hamilton County Soil Survey




-  Sub-basin boundary
-  Interstate
-  0-3 percent
-  3-8 percent
-  8-15 percent
-  15-25 percent
-  25+ percent

slope ranges

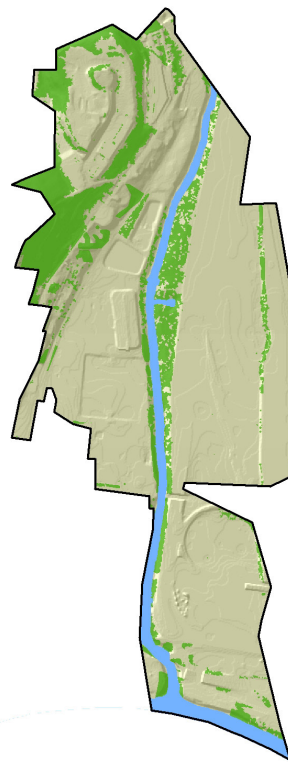


The majority of land in the Gest sub-basin has slopes of 3 percent or less.

Data source: Hamilton County Soil Survey

-  Sub-basin boundary
-  Interstate
-  Existing tree canopy

tree canopy cover






There are 80 acres of existing tree canopy in the Gest sub-basin, representing 17% of the total land area.

Data source: Cincinnati Park Board, ODNR

## impervious surfaces

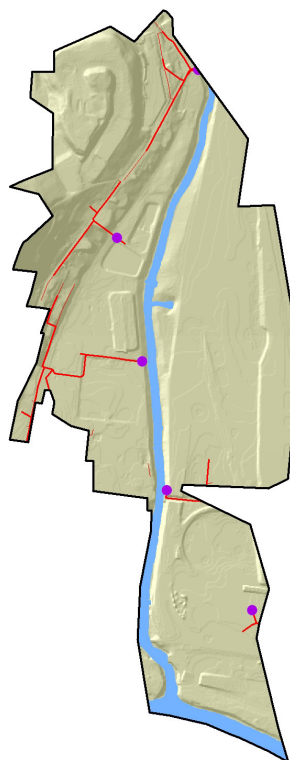









-  Sub-basin boundary
-  Interstate
-  Impervious surfaces

There are 323 acres of impervious surfaces in the Gest sub-basin, representing 69% of the total land area.

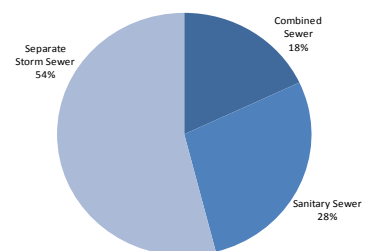
Data source: CAGIS

## combined sewer system







-  Sub-basin boundary
  -  Interstate
  -  CSO
- Combined sewers (pipe size)
-  < 12 inches
  -  12-48 inches
  -  48-72 inches
  -  > 72 inches

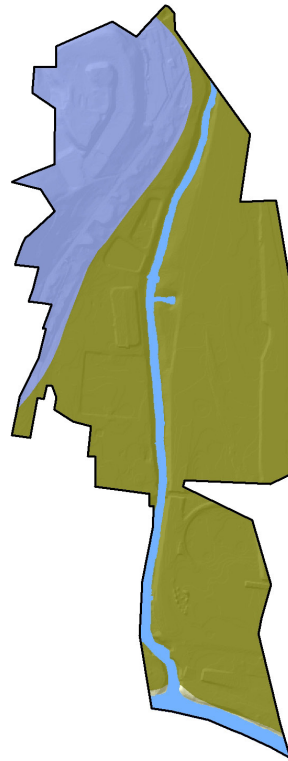
There are 3 miles of combined sewers in the Gest sub-basin.



Data source: MSDGC


















-  Sub-basin boundary
-  Interstate
-  Alluvium
-  Limestone

geology



The majority of land in the Gest sub-basin is underlain by alluvium, which may present opportunities for deep infiltration.

Data source: Ohio Geological Survey

-  Sub-basin boundary
-  Interstate
-  Commercial
-  Educational
-  Industrial
-  Institutional
-  Light industrial
-  Multi-family
-  Mixed-use
-  Office
-  Parks & recreational
-  Public space
-  Public utilities
-  Single-family
-  Two-family
-  Vacant
-  Unknown

land use

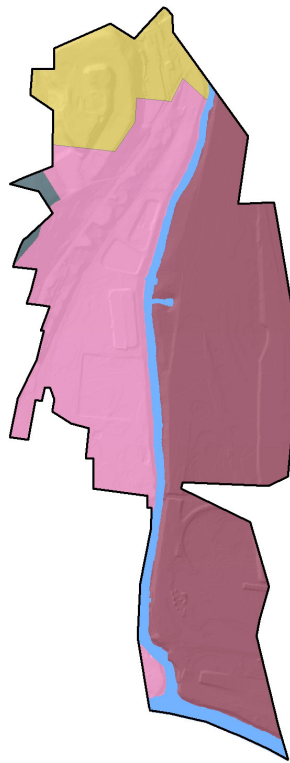


The majority of land use in the Gest sub-basin is public utilities (42.5%).

Data source: Hamilton County Auditor



## neighborhoods

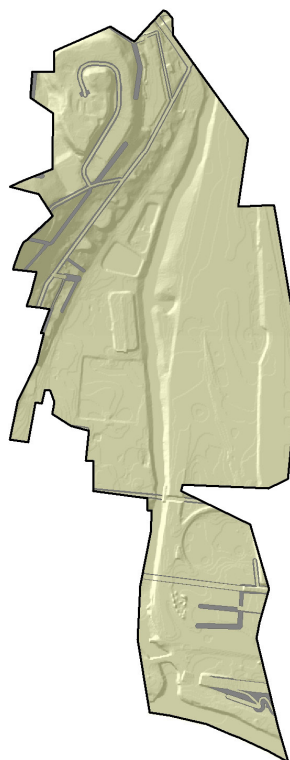


- Sub-basin boundary
- Interstate
- East Price Hill
- Lower Price Hill
- Queensgate
- South Fairmount

The Gest sub-basin is comprised of 4 neighborhoods.

Data source: CAGIS

## right-of-way (ROW)



- Sub-basin boundary
- Interstate
- Impervious surfaces

There are 14.8 acres of ROW in the Gest sub-basin, which is 3% of the total land area.

Data source: CAGIS

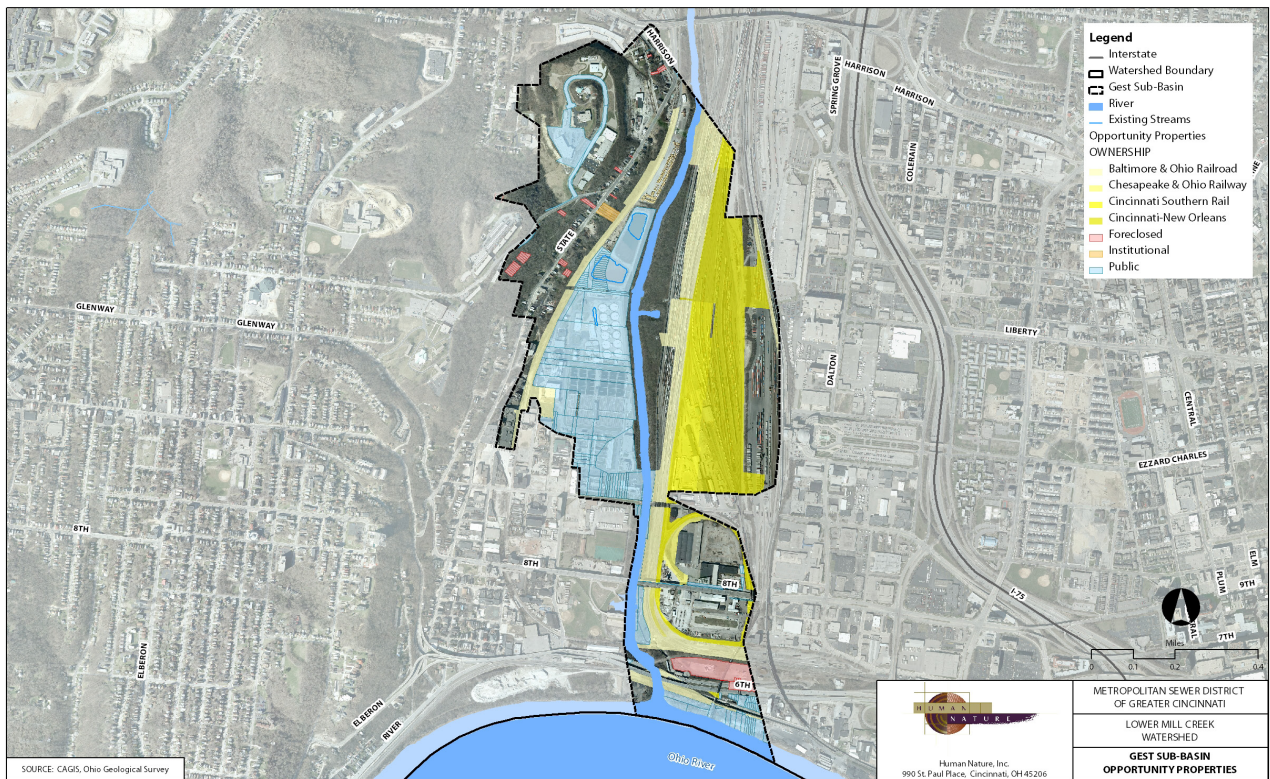
## COARSE-LEVEL OPPORTUNITIES

The Gest sub-basin contains MSD's Mill Creek wastewater treatment plant and the railroads directly east of the Mill Creek. Because of the constrained land area and the lack of natural features, the project team did not identify any direct or enabled projects within this sub-basin. There may be opportunities for Inform/Influence projects, which inform and educate the broader public to make sustainable decisions through collaboration between MSD and watershed partners.

### Inform & Influence Projects

#### Watershed Partners

Watershed partners include schools, parks, open spaces, institutional properties, road right-of-way, and vacant, abandoned and foreclosed properties. As potential areas for public-private partnerships, these land uses can integrate multiple stakeholders, thereby increasing public involvement and improving public perception of infrastructure projects. For example, forging partnerships with institutional and educational properties can create highly-visible projects within the community, and foster long-lasting, inter-agency relationships. The Watershed Partner map depicts the identified partners within the Gest sub-basin. As mentioned earlier, partners within the sub-basin include the City of Cincinnati Emergency Management Agency, Baltimore & Ohio Railroad, Chesapeake & Ohio Railway, Cincinnati Southern Rail, and Cincinnati-New Orleans. The western and southern portion of this sub-basin contains 42.7 acres of property that is targeted by the City of Cincinnati SPUR team for brownfield redevelopment (SPUR district #2- Western Riverfront/ Queensgate South and #5- South Lower Price Hill).







# **OPPORTUNITY SUMMARY**

# SUMMARY OF COARSE OPPORTUNITIES

## WEST FORK



1,830 MG  
stormwater runoff

Projects	Runoff Volume	Category
<b>Retention: Land Storage</b>	307 MG	Direct
<b>Detention 1: Land Storage</b>	117 MG	Direct
<b>Detention 2: Land Storage</b>	76 MG	Direct
<b>Stormwater Separation</b>	84 MG	Direct
<b>Flooding Mitigation &amp; Stream Restoration</b>	55 MG	Direct
<b>Stormwater Offloading/Separation</b>	246 MG	Direct/ Enabled
<b>Reforestation</b>	59.5 MG	Enabled
<b>Interstate 74</b>	50.7 MG	Enabled
<b>Watershed Partners</b>	224 MG	Inform & Influence
<b>TOTAL</b>	<b>1,218 MG</b>	

Watershed partners in the West Fork Sub-basin include: Cincinnati Park Board (Mt. Airy Forest and Bradford-Felters Tanglewood Park) and Cincinnati Metropolitan Housing Authority (CMHA)

## TRIPLE BOTTOM LINE

### Environmental Sustainability

Proposed projects within the West Fork sub-basin may help restore the natural water balance and improve water quality (by reducing the volume and frequency of CSOs), thereby improving terrestrial and aquatic biological resources along existing streams, the West Fork Creek, and the Mill Creek.

### Social Sustainability

Proposed projects within the West Fork sub-basin may address social sustainability by improving community services and infrastructure, and addressing potential environmental justice concerns. Proposed projects, specifically flooding mitigation along West Fork Creek, may help improve visual and aesthetic resources.

### Economic Sustainability

Proposed projects within the sub-basin may address the local economy by helping lessen the economic impacts from flooding and to improve property values. Reforestation projects within the sub-basin may provide a cost-effective means of stormwater management. Removing natural stormwater runoff from the combined system may help to reduce long-term wastewater treatment costs.

## CLIFTON



1,484 MG  
stormwater runoff

<u>Projects</u>	<u>Runoff Volume</u>	<u>Category</u>
<b>Stormwater Separation</b>	93 MG	Direct
<b>Stormwater Separation &amp; Underground Storage</b>	10 MG	Direct
<b>Retention, Daylighting &amp; Detention</b>	136 MG	Direct
<b>Mill Creek Greenway Trail</b>		Enabled
<b>Reforestation</b>	16.1 MG	Enabled
<b>Interstate 75</b>	63 MG	Enabled
<b>Interstate 74</b>	5.25 MG	Enabled
<b>Watershed Partners</b>	328.6 MG	Inform & Influence
<b>TOTAL</b>	<b>652 MG</b>	

Watershed partners in the Clifton Sub-basin include: Cincinnati Park Board (Mt. Storm Park, Burnet Woods, and Central Parkway), University of Cincinnati, Cincinnati State University, US Environmental Protection Agency (U.S. EPA), CSX Railroad, Good Samaritan Hospital, Hebrew Union College, the Mill Creek Restoration Project (Mill Creek Greenway Trail) and City of Cincinnati's SPUR redevelopment.

The CSX Railroad directly adjacent to the Mill Creek has served as a physical barrier and obstacle for conveying stormwater runoff to the Mill Creek; however, because of its proximity to this natural water feature, this area offers a wealth of wet weather strategies and comprehensive opportunities. These opportunities can range from storm separation to complete reconfiguration of the railyards and integration of green space and stormwater management BMPs.

### TRIPLE BOTTOM LINE

#### Environmental Sustainability

Proposed projects within the Clifton sub-basin may help restore the natural water balance and improve water quality (by reducing the volume and frequency of CSOs), thereby improving terrestrial and aquatic resources along the Mill Creek corridor.

#### Social Sustainability

Proposed projects within the Clifton sub-basin help raise public awareness about infrastructure-related challenges, improve community services and infrastructure, and integrate opportunities for recreation and education.

#### Economic Sustainability

In addition to supporting economic development needs in the community, the proposed projects within the Clifton sub-basin may help create cost-sharing opportunities and integrate unique funding source. Reforestation projects may provide a cost-effective means of stormwater management. Removing natural stormwater runoff from the combined system may help to reduce long-term wastewater treatment costs.

## MITCHELL



820 MG  
stormwater runoff

<u>Projects</u>	<u>Runoff Volume</u>	<u>Category</u>
<b>Reforestation</b>	25.2 MG	Enabled
<b>Interstate 75</b>	0.5 MG	Enabled
<b>Watershed Partners</b>	221.6 MG	Inform & Influence
<b>TOTAL</b>	<b>247 MG</b>	

Watershed partners in the Mitchell Sub-basin include: Vine Street Hill Cemetery, Cincinnati Zoo & Botanical Gardens, Cincinnati VA Medical Center, University of Cincinnati, Children's Hospital, University Hospital, Hamilton County Drug & Addiction Services, US EPA, City of Cincinnati, Cincinnati Board of Education (North Avondale Elementary, South Avondale, and Rockdale Academy), Roger Bacon High School, Shiloh (SDA) Church, Zion Baptist Church, and CMHA.

## TRIPLE BOTTOM LINE

### **Environmental Sustainability**

Proposed projects within the Mitchell sub-basin may help improve water quality (by reducing the volume and frequency of CSOs) and reconnect natural systems through reforestation efforts.

### **Social Sustainability**

Proposed projects within the Mitchell sub-basin may help raise public awareness about infrastructure-related challenges, improve infrastructure services, and integrate educational opportunities.

### **Economic Sustainability**

Reforestation projects within the sub-basin may provide a cost-effective means of stormwater management. Removing natural stormwater runoff from the combined system may help to reduce long-term wastewater treatment costs.

## KING'S RUN



1,696 MG  
stormwater runoff

<u>Projects</u>	<u>Runoff Volume</u>	<u>Category</u>
<b>Stormwater Separation 1</b>	209 MG	Direct
<b>Stormwater Separation 2</b>	31 MG	Direct
<b>Stormwater Separation 3</b>	174 MG	Direct
<b>Detention: Land Storage</b>	57 MG	Direct
<b>Stormwater Separation 4</b>	30 MG	Direct
<b>Mill Creek Greenway Trail</b>		Enabled
<b>Reforestation</b>	19.8 MG	Enabled
<b>Interstate 74</b>	8 MG	Enabled
<b>Watershed Partners</b>	190 MG	Inform & Influence
<b>TOTAL</b>	<b>719 MG</b>	

Watershed partners in the King's Run Sub-basin include Spring Grove Cemetery, Cincinnati Park Board (Laboiteaux Woods, Buttercup Valley, Parkers Woods, McEvoy Park, and Salway park), City of Cincinnati, Cincinnati Board of Education (College Hill Elementary, Chase Elementary, Clark High School, Aiken High School), Gray Road Fill Redevelopment, Mill Creek Restoration Project (Mill Creek Greenway Trail), and City of Cincinnati SPUR redevelopment district.

## TRIPLE BOTTOM LINE

### Environmental Sustainability

Proposed projects within the King's Run sub-basin may help restore the natural water balance and improve water quality (by reducing the volume and frequency of CSOs), thereby improving terrestrial and aquatic resources along existing streams and the Mill Creek corridor.

### Social Sustainability

Proposed projects within the King's Run sub-basin help raise public awareness about infrastructure-related challenges, improve overall infrastructure efficiency, and integrate opportunities for recreation and education.

### Economic Sustainability

In addition to supporting economic development needs in the community, the proposed projects within the King's Run sub-basin may help create cost-sharing opportunities and integrate unique funding sources. Reforestation projects may provide a cost-effective means of stormwater management. Removing natural stormwater runoff from the combined system may help to reduce long-term wastewater treatment costs.



## DENHAM



520 MG  
stormwater runoff

<u>Projects</u>	<u>Runoff Volume</u>	<u>Category</u>
<b>Detention: Land storage 1 Stormwater Separation &amp; Water Quality BMP</b>	37.5 MG	Direct
<b>Detention: Land Storage 2</b>	12.7 MG	Direct
<b>Stream Daylighting</b>	63.4 MG	Direct
<b>Mill Creek Greenway Trail</b>		Enabled
<b>Reforestation</b>	9.7 MG	Enabled
<b>Watershed Partners</b>	230.5 MG	Inform & Influence
<b>TOTAL</b>	<b>354 MG</b>	

Watershed partners in the Denham Sub-basin include: CMHA, Cincinnati Board of Education (Taft High School- temporary location), City of Cincinnati, North Fairmount Education Center, Baltimore Pike Cemetery Association, Mill Creek Restoration Project (Mill Creek Greenway Trail), City of Cincinnati SPUR redevelopment district, and a TIF District.

## TRIPLE BOTTOM LINE

### Environmental Sustainability

Proposed projects within the Denham sub-basin may help restore the natural water balance and improve water quality (by reducing the volume and frequency of CSOs), thereby improving terrestrial and aquatic resources along the Mill Creek corridor.

### Social Sustainability

Proposed projects within the Denham sub-basin help raise public awareness about infrastructure-related challenges, improve overall infrastructure efficiency, and integrate opportunities for recreation and education.

### Economic Sustainability

Proposed projects within the Denham sub-basin may help create cost-sharing opportunities and integrate unique funding sources. Reforestation projects may provide a cost-effective means of stormwater management. Removing natural stormwater runoff from the combined system may help to reduce long-term wastewater treatment costs.

## GEST



The Gest sub-basin contains MSD's Mill Creek wastewater treatment plant and the railroads directly east of the Mill Creek. Because of the constrained land area and the lack of natural features, the project team did not identify any projects within this sub-basin.

319 MG  
stormwater runoff

## RELATED PROJECTS

Watershed strategies in the Lower Mill Creek are not limited to the Direct, Enabled, and Inform & Influence projects identified during the coarse evaluation. In fact, there are existing plans and ongoing planning efforts throughout the watershed that are related to MSD's water quantity and quality goals.

Several notable examples include:

# PLAN CINCINNATI

a comprehensive plan for the future

City of Cincinnati  
Comprehensive Plan

Interstate 75:  
Corridor reconstruction  
&  
*Revive I-75, Cincinnati Focus Area Plans*



Cincinnati Park Board  
*Centennial Master Plan*

Mill Creek Restoration Project:  
Mill Creek Greenway Plan



While not a complete list, these related projects invite collaboration for comprehensive and holistic watershed planning.



# REFERENCES

- Metropolitan Sewer District of Greater Cincinnati. *2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report*. Prepared for the Board of County Commissioners of Hamilton County, Ohio and the City of Cincinnati. Cincinnati, OH. September 16, 2008.
- June 2006. CSO LTCP Update Report. *Baseline Collection System and Treatment Facility Evaluation, Volume II: Section 5*. Cincinnati, OH.
- June 2009. *Final Wet Weather Improvement Program*. Cincinnati, OH.
- Nadakavukaren, Anne. *Our Global Environment, a Health Perspective*. 6th ed. Long Grove, IL: Waveland Press Inc, 2006.
- National Small Flows Clearinghouse (NSFC). 1995. *Summary of Onsite Systems in the U.S., 1993*. John Mori, Peter Casey and Tricia Angoli, eds. Morgantown, WV: NSFC.
- Sanitation District No. 1 of Northern Kentucky (SD1). 2006. "SD1 Facts." Available from <http://www.sd1.org/about/facts.asp>. Accessed March 30, 2009.
- U.S. Environmental Protection Agency (U.S. EPA). "EPA Sanitary Sewer Overflows." Available from [http://cfpub.epa.gov/npdes/home.cfm?program\\_id=4](http://cfpub.epa.gov/npdes/home.cfm?program_id=4). Accessed March 30, 2009.
- U.S. Environmental Protection Agency (U.S. EPA). 2001. *Guidance: Coordinating CSO Long-Term Planning with Water Quality Standards Reviews*. Washington D.C.: Office of Water, EPA/833/R-01/002.



