PROJECT GROUNDWORK
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SUSTAINABLE WATERSHED EVALUATION PROCESS

ROSS RUN WATERSHED

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

HUMAN NATURE

STRAND ASSOCIATES, INC. ENGINEERS

May
2011

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.

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.

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INTRODUCTION

Human Nature Inc. and Strand Associates Inc. created a series of 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 Ross Run 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.

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:

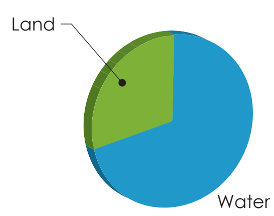
- Reconnect stormwater to natural systems
- Improve and restore terrestrial and aquatic habitats and wildlife corridors
- Restore natural hydrologic patterns and increase natural base flows
- Improve regional water quality
- Build upon community connectivity

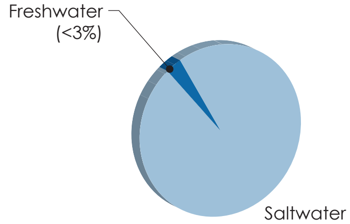
NOTE: The purpose of this document was to identify a comprehensive list of site-specific wet weather strategies in the Ross Run sub-basin. Both Human Nature and Strand Associates developed the recommendations described herein. Not all of the recommended projects have been adopted or endorsed by MSD.

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





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.

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 (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.

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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.

SUSTAINABLE WATERSHED EVALUATION PROCESS

A formal planning process is essential to achieving the goals and objectives of Project Groundwork. This process, known as the 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.

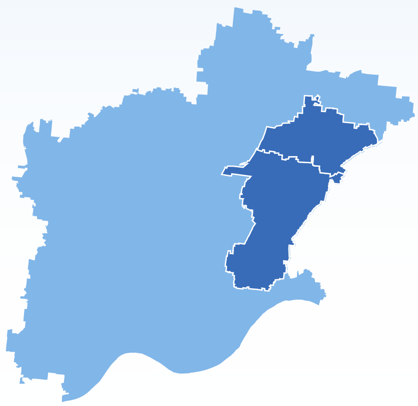
The coarse evaluation for the Ross Run watershed was a first step in the broader SWEP. Specifically, the coarse evaluation focused on Step 1, watershed characterization, and portions of Step 2, potential wet weather strategies.

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.

Communities of the Future

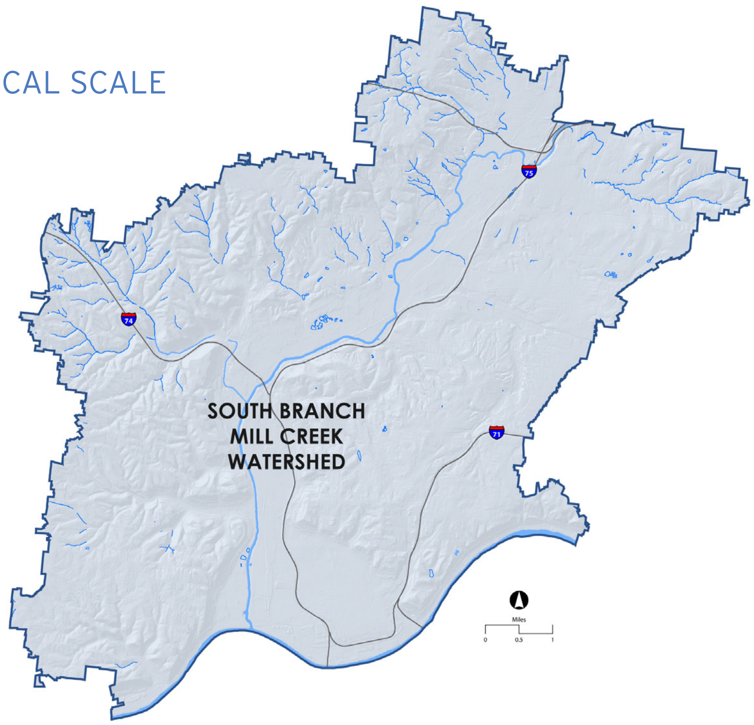


METHOD

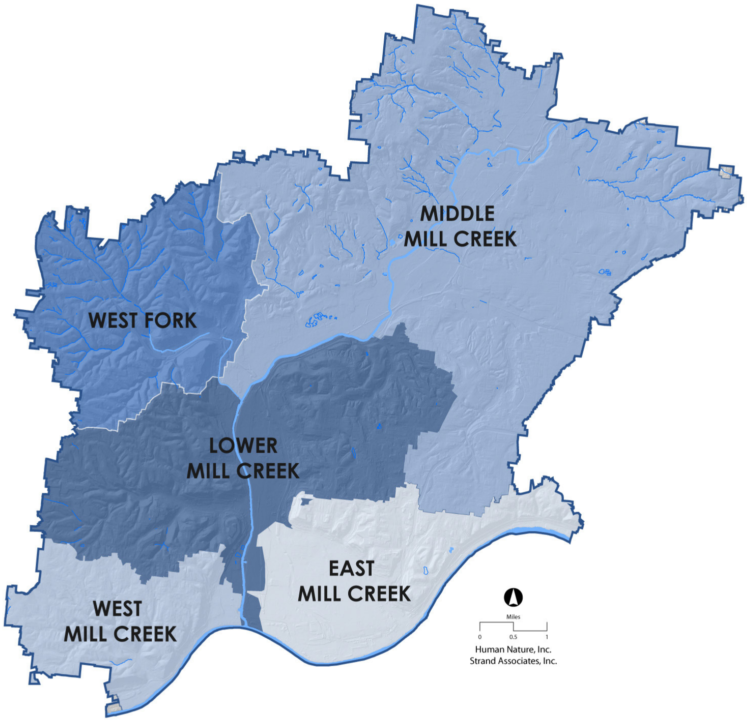
METHOD

As part of the evaluation, the project team critically analyzed the Ross Run 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 MSD's Sustainable Watershed Evaluation Process.

ANALYTICAL SCALE

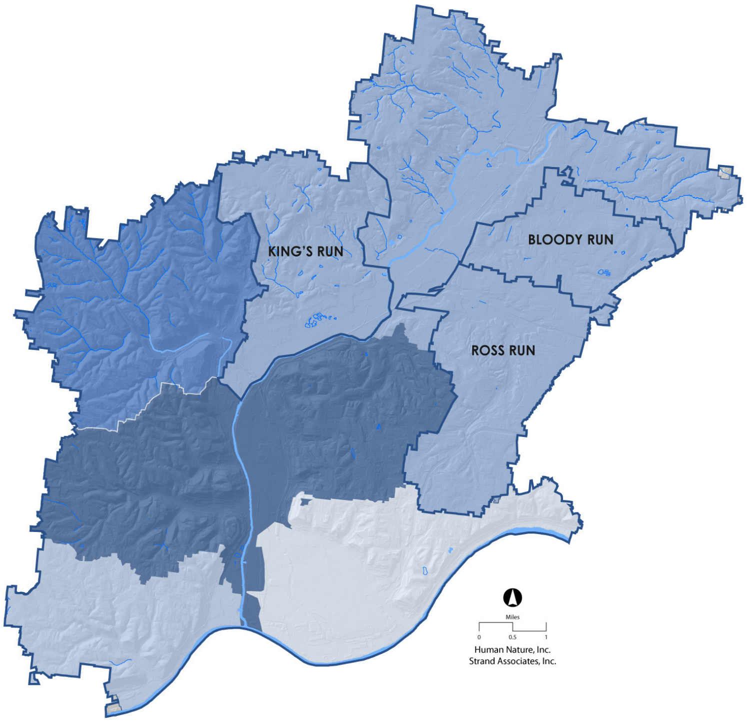


The South Branch Mill Creek watershed covers approximately 40,000 acres (62.5 square miles) within the heart of Hamilton County. The watershed contains the Mill Creek, West Fork Creek and the Ohio River as its major hydrologic features. Interstate 74, Interstate 75, and Interstate 71 comprise the watershed's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



The Middle Mill Creek watershed, part of the South Branch Mill Creek watershed, covers approximately 17,550 acres (27.4 square miles). This watershed contains the middle portion of the Mill Creek and eastern portion of West Fork Creek. This coarse evaluation focuses on the Middle Mill Creek watershed.

SOUTH BRANCH MILL CREEK SUB-WATERSHEDS



The Middle Mill Creek watershed was divided into three different watersheds - King's Run (evaluated as part of the Lower Mill Creek Coarse Evaluation), Ross Run, and Bloody Run - based on natural sub-watershed and sewer catchment boundaries. This evaluation focused solely on the Ross Run watershed.

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 SWEP. 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 Ross Run 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.

Built Systems

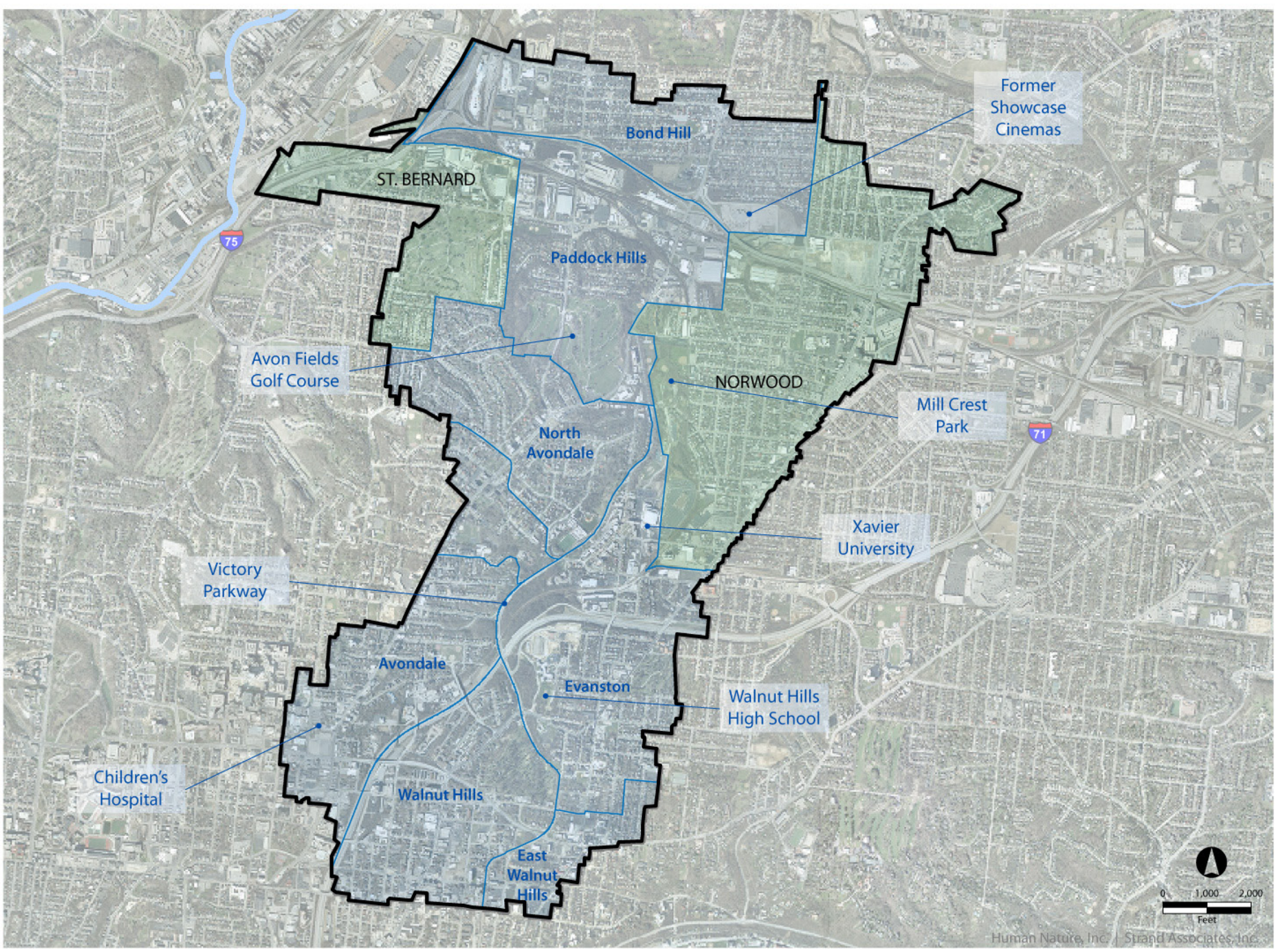
Built systems are the products of urbanization and development. While built systems are essential to the strength of and quality of life in our urban areas, they have undoubtedly influenced the natural conditions of our landscapes and watersheds. In the context of a watershed inventory and analysis,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

INVENTORY & ANALYSIS

INVENTORY

LOCATION

The Ross Run watershed covers approximately 6.1 square miles (3,913 acres and 22.3 percent of the Middle Mill Creek watershed) and overlaps seven neighborhoods within the east side of Cincinnati [*i.e.*, Bond Hill, Paddock Hills, North Avondale, Evanston, Avondale, Walnut Hills, East Walnut Hills] as well as the cities of Saint Bernard and Norwood. The main transportation routes include Interstate 75 to the west, Interstate 71 to the east, Norwood Lateral, Vine Street, Tennessee Avenue, Paddock Road, Reading Road, Montgomery Road, Mitchell Avenue, Victory Parkway, Martin Luther King Jr. Drive, and Gilbert Avenue. There are several key property owners within the Ross Run watershed, including the City of Cincinnati (Avon Fields Golf Course), the Cincinnati Park Board (Victory Park, Hoyles Park), Cincinnati Board of Education (Walnut Hills High School), City of Norwood (Millcrest Park), Children's Hospital, Xavier University, National Amusements Inc (former Showcase Cinema), St. Mary's German Catholic Cemetery, the German Protestant Cemetery, Baltimore Ohio Railroad, Norfolk Western Railway, Pennsylvania Lines LLC and Southwest Ohio Regional Transit Authority.



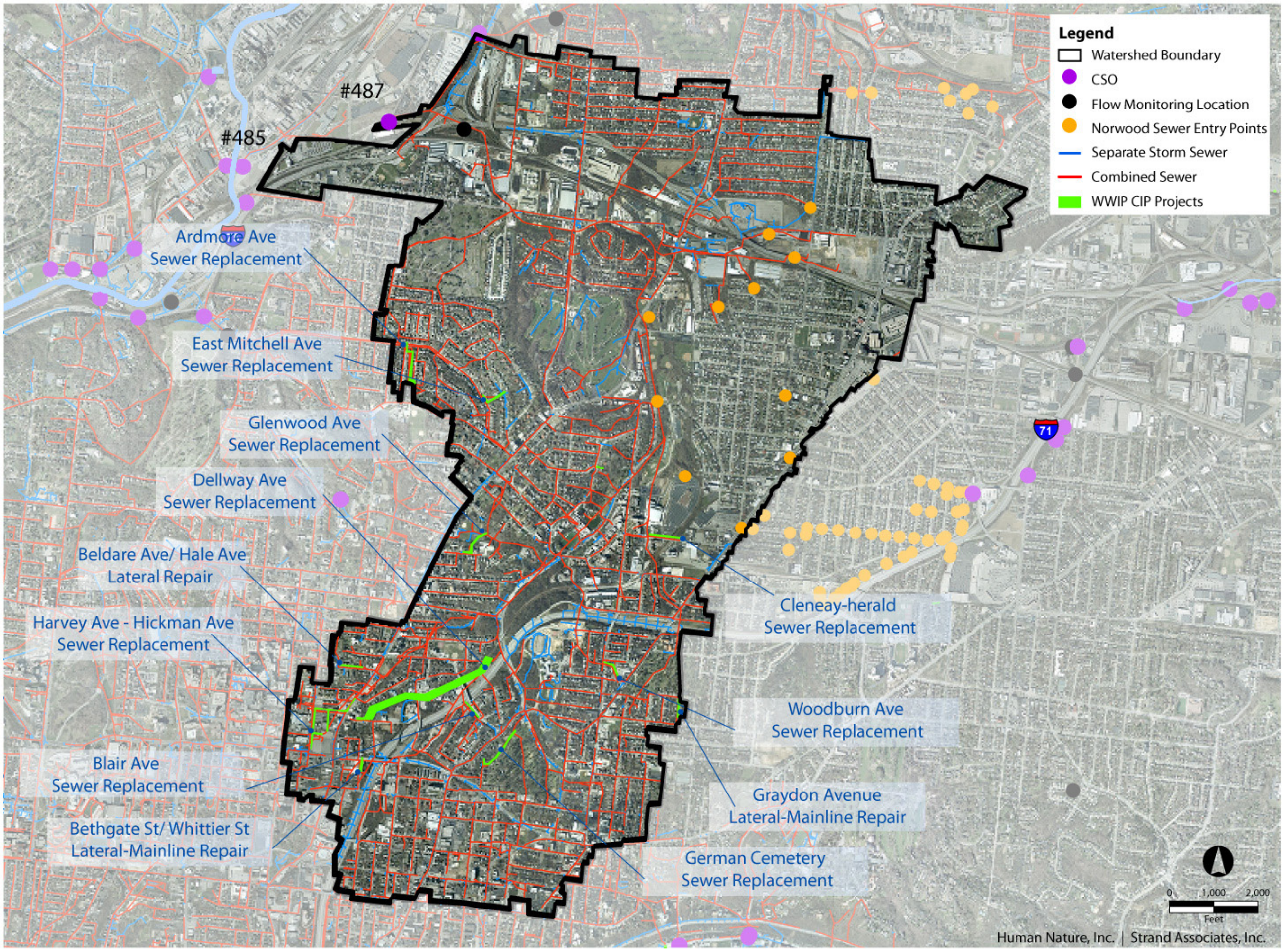
CHARACTERIZATION OF PROBLEM

Based on coarse-level calculations, there are approximately 2.2 billion gallons of stormwater runoff in the Ross Run watershed annually. One of MSD's largest combined sewer overflows is the Ross Run Grating (CSO #487) located in the Ross Run watershed. Each year, about 1.4 billion gallons of combined sewage and storm water overflow through this CSO, which accounts for almost 10 percent of MSD's annual CSO volume.

Total Area (Ac)	**Impervious Area** (Ac)	**Pervious Area** (Ac)	**Annual Runoff** (MG)
3,913	**1,928**	**1,985**	**2,168**

ANNUAL CSO STATISTICS [1]						
CSO NUMBER	NAME	EVENTS	OVERFLOW (MG)	CONTROL (%)	CSO CONTROL STRATEGY [1]	BUNDLE CLUSTER
487	Ross Run Grating	35	1,351	30	Real-Time Control (RTC) Inflatable dam, 250 MG/year	King's Run
TOTAL		35	1,351			

[1] Volume II CSO LTCP Update Report, 2006; 2008 Revised Wet Weather Improvement Program Detailed Conceptual Outline Report, 2008; Final Wet Weather Improvement Program, 2009.



HISTORICAL CONTEXT

The watershed's neighborhoods remained as primarily undeveloped farmland until the late nineteenth century when several villages/neighborhoods were established. These areas experienced population growth with the rise of the Cincinnati, Lebanon & Northern (CL&N) Railroad. The availability of rail transportation into Cincinnati accelerated residential development in the suburbs. The Cincinnati, Hamilton & Dayton Railway, the Dayton Short Line and the Cincinnati Inclined Plane Railway Company's electric streetcar line up the Mill Creek Valley spurred industrial development [*i.e.*, Proctor and Gamble- Ivorydale and Emery Candle Company in St. Bernard and General Motors in Norwood] within the Ross Run watershed. The lakes in St. Bernard that were once used for ice production were drained around 1900 and the land was reclaimed for industrial use. The industrial growth and the rail lines encouraged rapid population growth as many workers in the plants chose to live in the nearby communities (Giglierano and Overmyer 1988).

The presence of thick layers of gravel and sand outwash deposits that fill the bottom of the ancient paths of the Ohio River valley suggest the area's long glacial history. In the city of Norwood, for example, the former path of the Ohio River formed the Norwood Trough, an area spanning the northern portion of the watershed from Fairfax to St. Bernard. Norwood's industrial character can be attributed to this trough as the availability of artesian groundwater, which at the time was cheaper and cleaner than city water, made Norwood an attractive location. These artesian wells supplied Norwood's water needs until the late 1950s when industrial development in the Mill Creek Valley had significantly lowered the watertable and Norwood found it more economical to buy its water from Cincinnati. After a spill of carbon tetrachloride into the Ohio River in 1977, Norwood uncapped one of the artesian wells at Park and Linden avenues to use as an alternative source of drinking water. Today the well is tested for purity three times daily.

Norwood's industrial base gave the city a stable source of tax revenues and the means to remain independent. By the twentieth century, Norwood tripled in size. By the 1950s, the character of Norwood changed as its industry began drawing Appalachian families who had migrated to the cities in search of work and African Americans were discouraged from moving there. At the same time, the neighborhood's large, aging homes were no longer desirable as they once had been and many of the more affluent families moved to newer suburbs. The area therefore became more consistently working-class. Since the recession, Norwood's industrial base declined to about half of what it had been, contributing to a financial crisis in the late 1970s. Since the 1970s, with backing from former resident Carl Lindner, Jr., Norwood has cleared over 80% of its old commercial district, creating new shopping centers, jobs, tax revenues, and retail services for the community and surrounding neighborhoods. In 1987 the General Motors Plant in Norwood closed after 64 years and left 4,300 people unemployed. This closing accelerated the change of Norwood from an industrial-based city to an office and retail center.

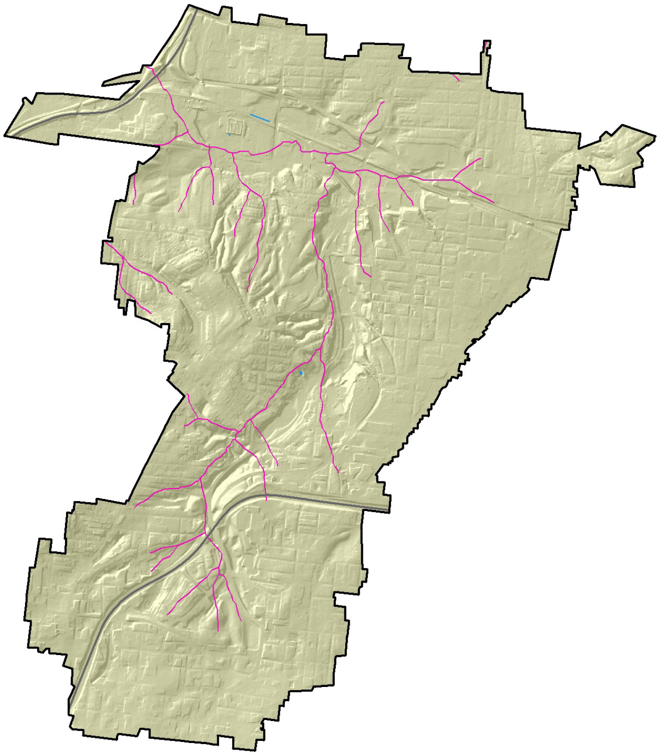
The Miami & Erie Canal ran through St. Bernard which made this area popular for water transportation. Boats not only carried sand, gravel, ice and timber from St. Bernard to Cincinnati, but also Cincinnati residents up to St. Bernard for recreation (*e.g.*, fishing, boating on the lakes, picnicking in the public groves, or watching races at the Buckeye Trotting Park).

The Cincinnati neighborhoods, Paddock Hills and North Avondale, have historically been more affluent neighborhoods ever since the late nineteenth century when wealthy merchants, manufacturers and businessmen such as Stephen Burton, Robert Mitchell, Samuel Pogue, Frank Hershede and Barney Kroger built their large homes in the area. Avondale, Evanston, Walnut Hills and East Walnut Hills were also home to many prosperous citizens. Like many "first-ring" neighborhoods throughout the United States, many of their (wealthy) residents moved to surrounding suburbs after World War II with the dominance of the automobile and availability of inexpensive land.

GIS INVENTORY

The GIS inventory of natural systems investigated the watershed'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

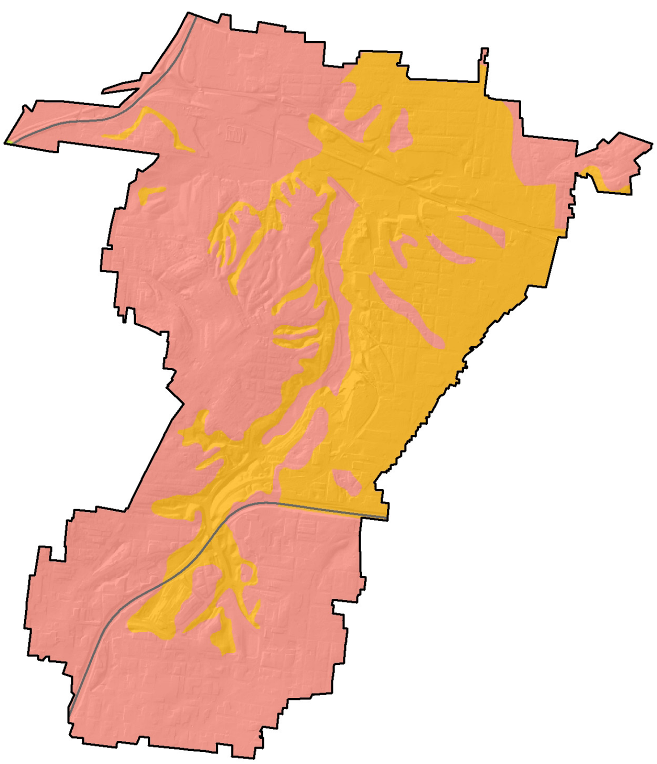


Watershed boundary
Interstate
Historical streams
Existing streams

The pre-development hydrologic network shows 15 miles of an extensive system of creeks and streams within the watershed. This network naturally conveyed stormwater runoff to the Mill Creek. Today underground sewer systems have replaced this entire stream network.

Data source: CAGIS, historical USGS maps

hydrologic soil groups

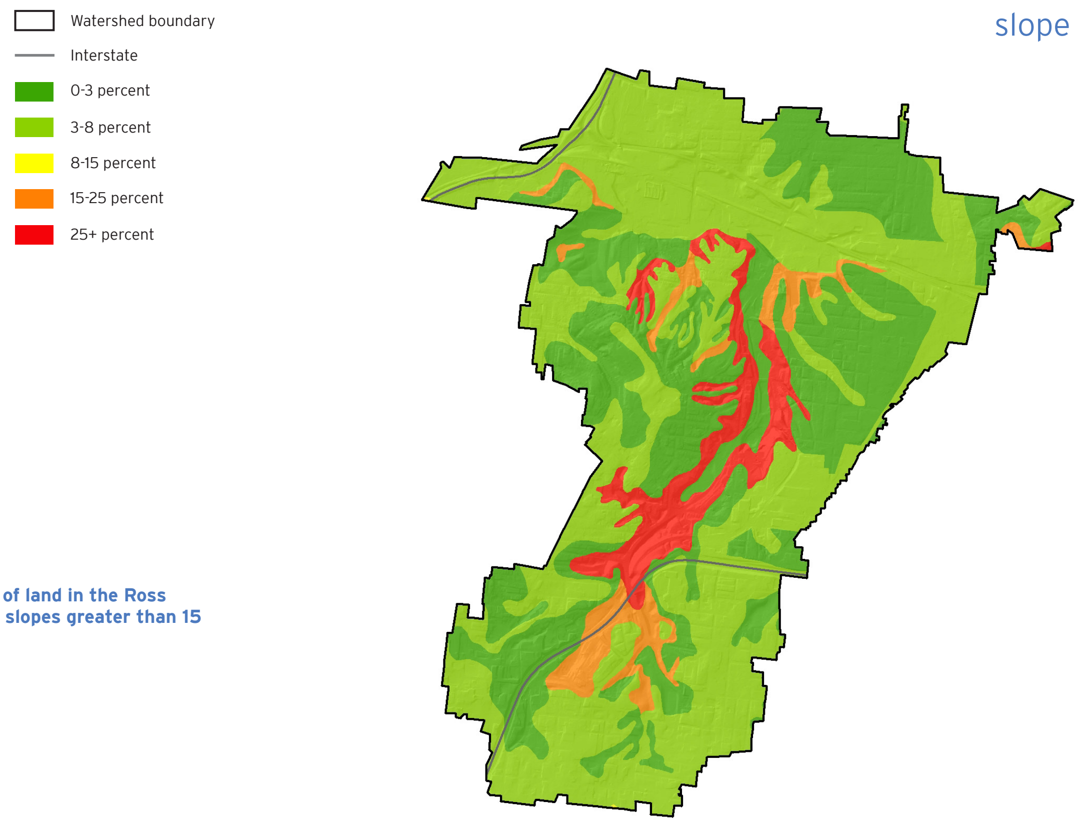


Watershed boundary
Interstate
Group C
Group D

In the Ross Run watershed, 37% of soils are Group C (1,432 acres) and 63% are Group D (2,469 acres).

Data source: Hamilton County Soil Survey

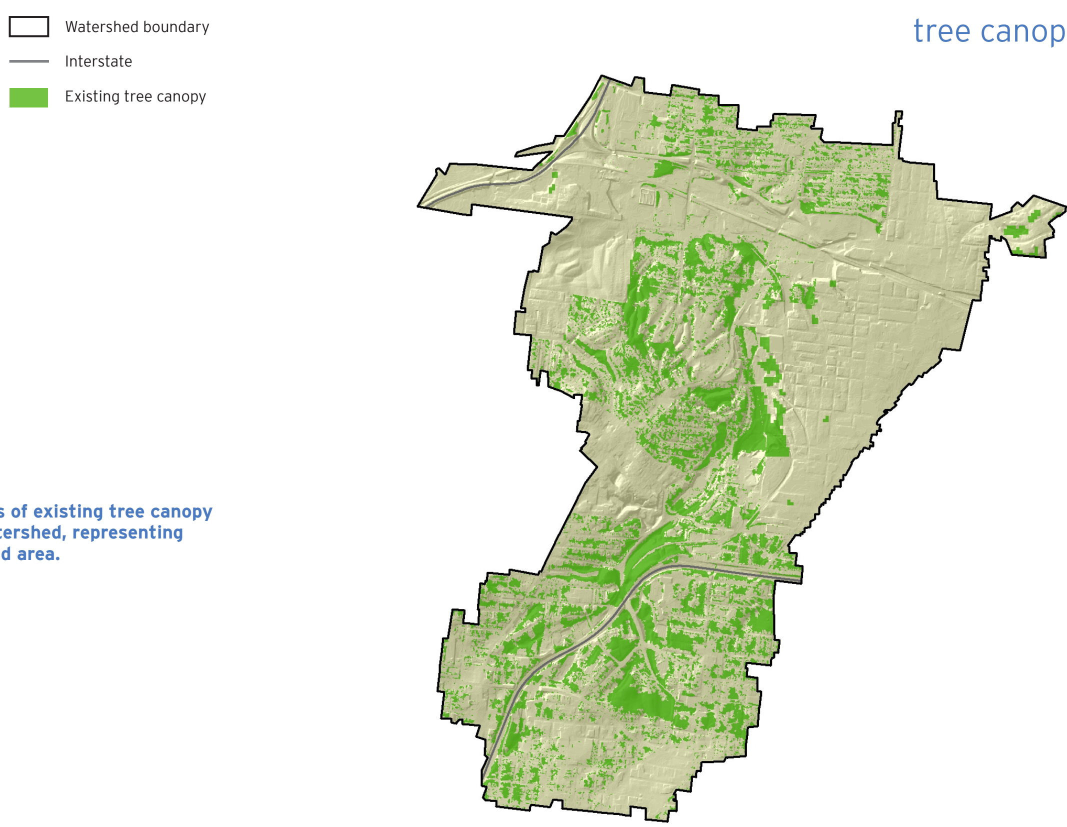
slope ranges



12.3% (483 acres) of land in the Ross Run watershed has slopes greater than 15 percent.

Data source: Hamilton County Soil Survey

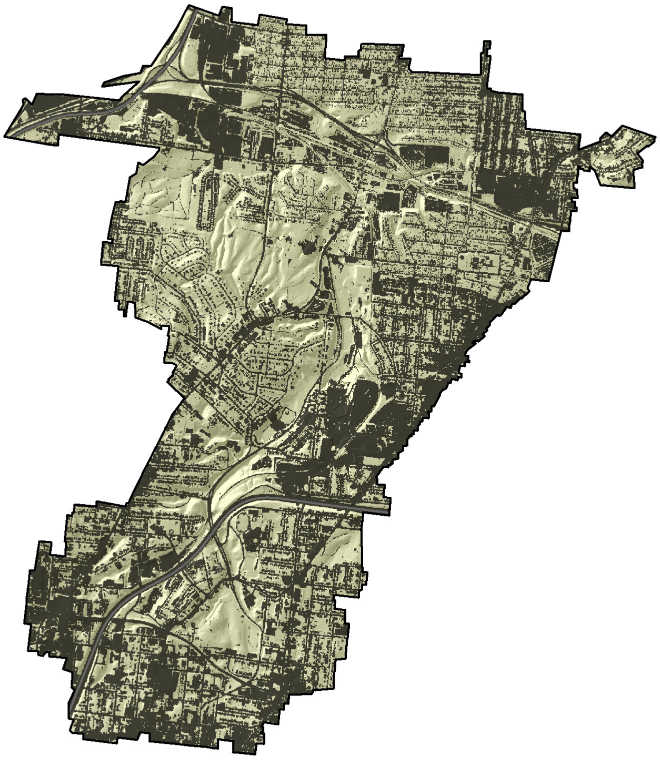
tree canopy cover



There are 827 acres of existing tree canopy in the Ross Run watershed, representing 21% of the total land area.

Data source: Cincinnati Park Board, ODNR

impervious surfaces



Watershed boundary

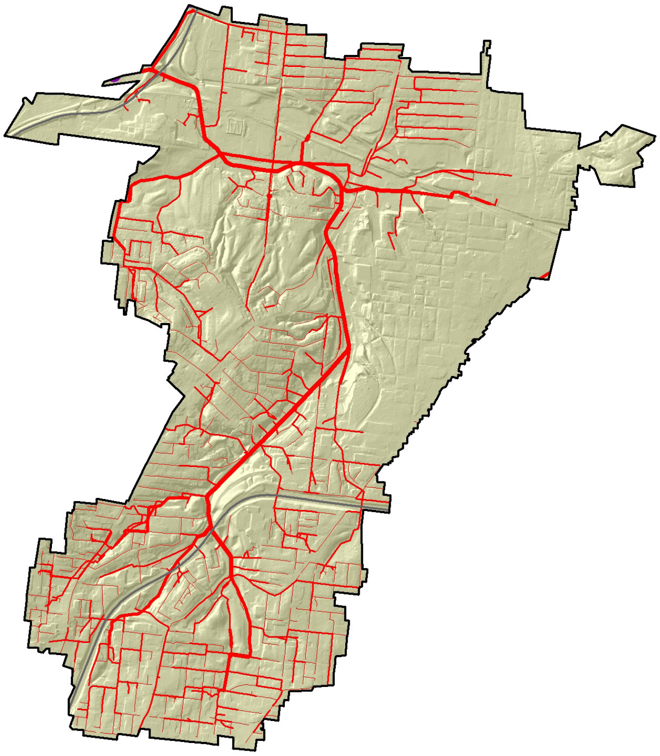
Interstate

Impervious surfaces

There are 1,927 acres of impervious surfaces in the Ross Run watershed, representing 49% of the total land area.

Data source: CAGIS

combined sewer system



Watershed boundary

Interstate

CSO

Combined sewers (pipe size)

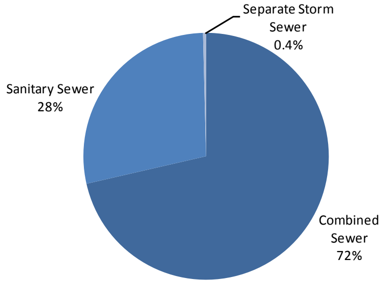
< 12 inches

12-48 inches

48-72 inches

> 72 inches

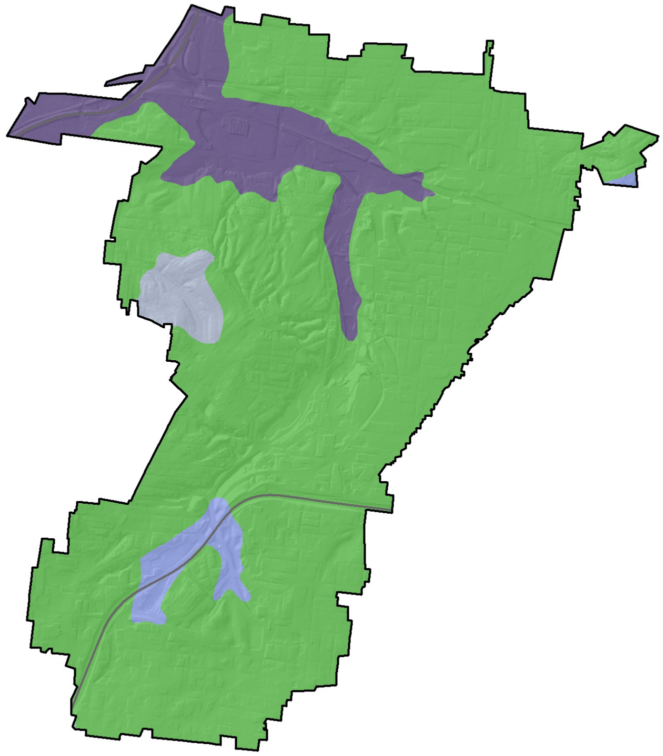
There are 82 miles of combined sewers (71% of sewer infrastructure) in the Ross Run watershed.



Data source: MSD

Watershed boundary
Interstate
Sand
Clay-loam till
Limestone
Loam till
Shale
Silt

geology

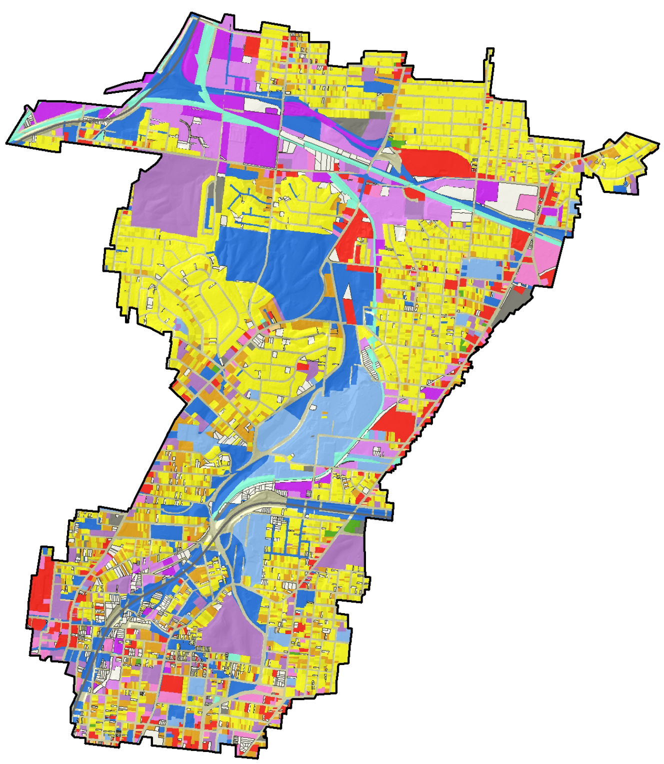


The vast majority of land in the Ross Run watershed is underlain by loam till geology.

Data source: Ohio Geological Survey

Watershed 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

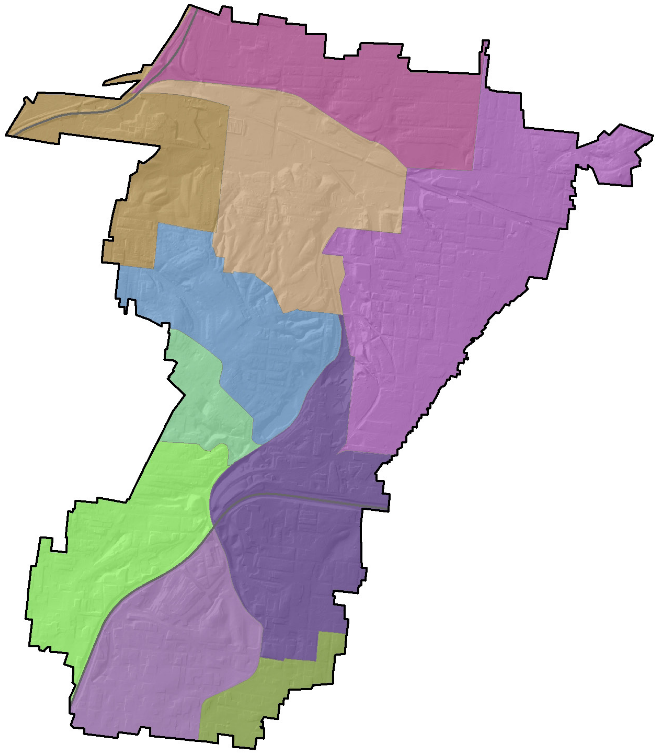
land use



Single family property comprises the greatest percentage (22%) of land within the Ross Run watershed.

Data source: Hamilton County Auditor

neighborhoods

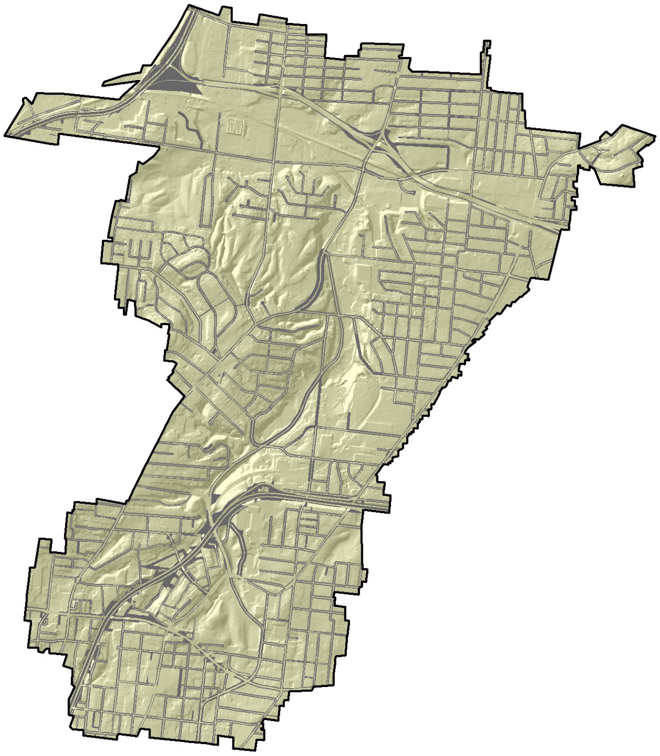


- Watershed boundary
- Interstate
- Avondale
- Bond Hill
- East Walnut Hills
- Evanston
- North Avondale
- Paddock Hills
- Walnut Hills
- Contested Area
- Norwood
- Saint Bernard

The Ross Run watershed is comprised of 7 different neighborhoods within 3 different jurisdictions.

Data source: CAGIS

right-of-way (ROW)



- Watershed boundary
- Interstate
- Impervious surfaces

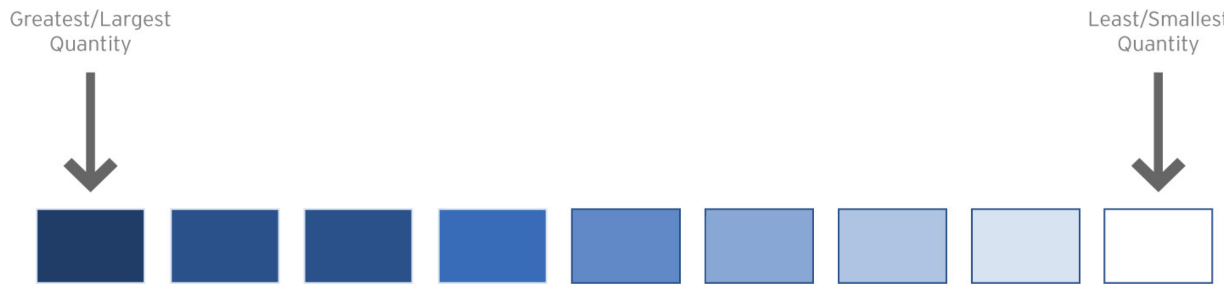
There are 317 acres of ROW in the Ross Run watershed, which is 8% of the total land area.

Data source: CAGIS

DEMOGRAPHICS

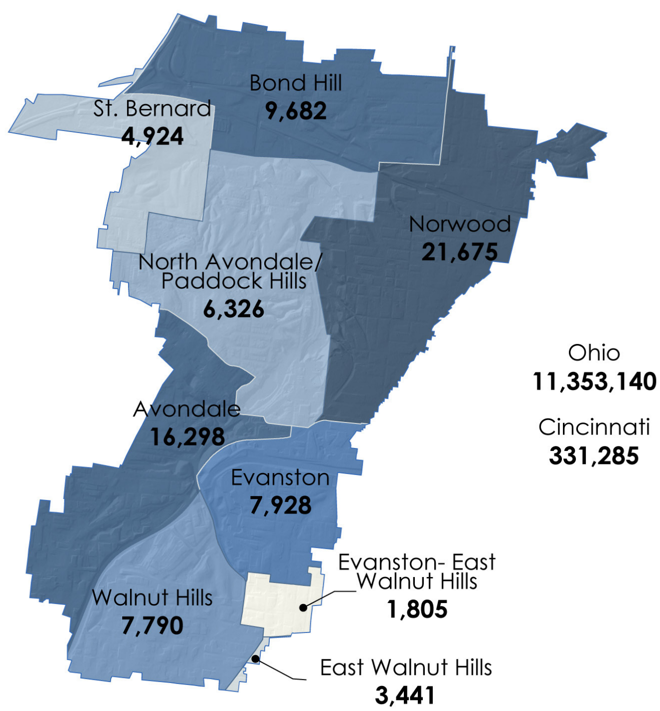
The demographic profile for the Ross Run watershed covers neighborhood and jurisdiction population, income, household structure, housing vacancy, educational attainment and employment concentration information for those Statistical Neighborhood Areas (SNAs) identified by census tract and Hamilton County jurisdictions within Ross Run using 2000 Census data.

The following sections summarize the 2000 Census demographic data for Cincinnati neighborhoods and Hamilton County jurisdictions within the Ross Run watershed. Note that the neighborhoods/jurisdictions are coded by graduated colors as follows:

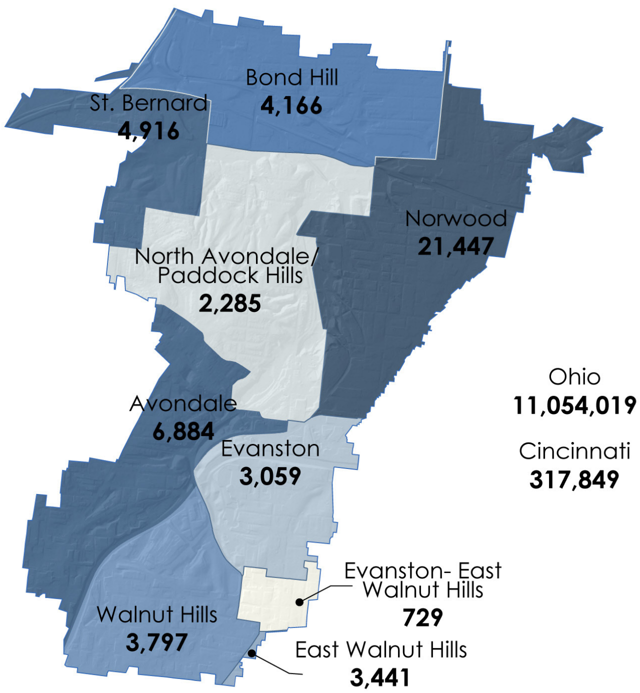


total population

The City of Norwood represented the largest population within the sub-basin with 21,675 people in the year 2000. There were only 1,805 individuals in Evanston-East Walnut Hills in 2000, which represented the smallest population in the sub-basin.

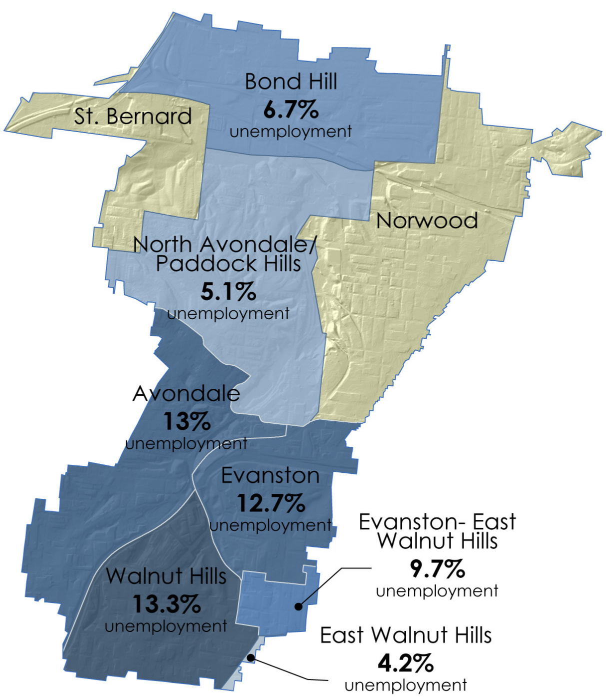


household population



With 21,447 individuals living in households, the City of Norwood had the largest household population in 2000. Evanston-East Walnut Hills represented the smallest household population with 729 individuals.

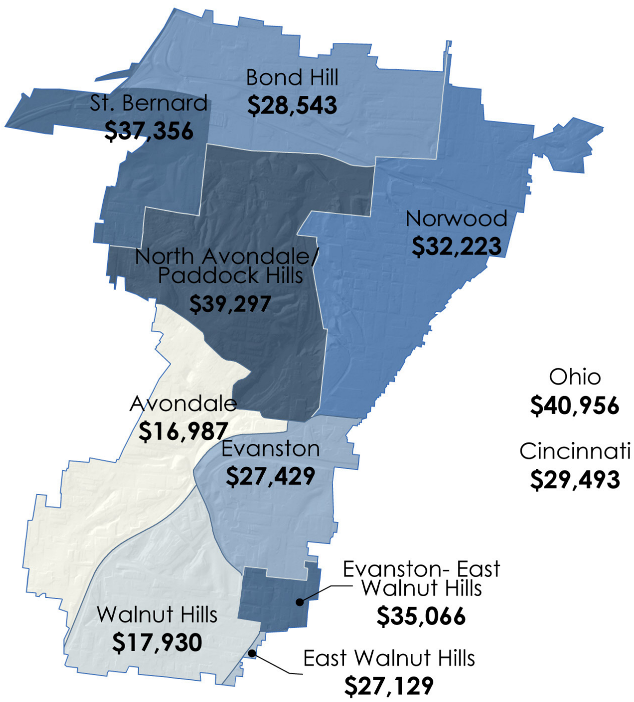
unemployment



In 2000, the Walnut Hills neighborhood experienced the highest unemployment rate in Ross Run watershed as 13.3% of the workforce was unemployed. The East Walnut neighborhood experienced the lowest unemployment rate as only 4.2% of the workforce was unemployed. Unemployment data was not found for the City of Norwood and St. Bernard.

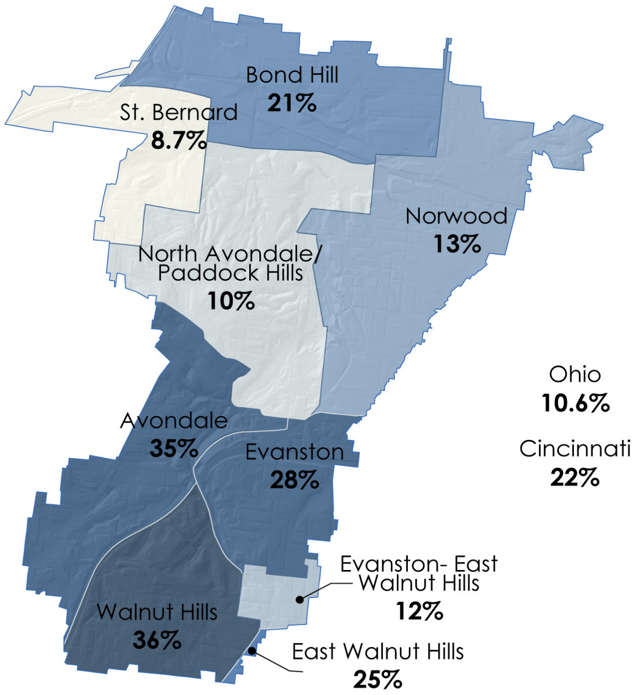
median household income

In 2000, the neighborhood of North Avondale/Paddock Hills had the highest median household income of $39,297 (in 1999 dollars). Avondale had the lowest median household income of $16,987. The City of Cincinnati average is $29,493 and Ohio is $40,956.

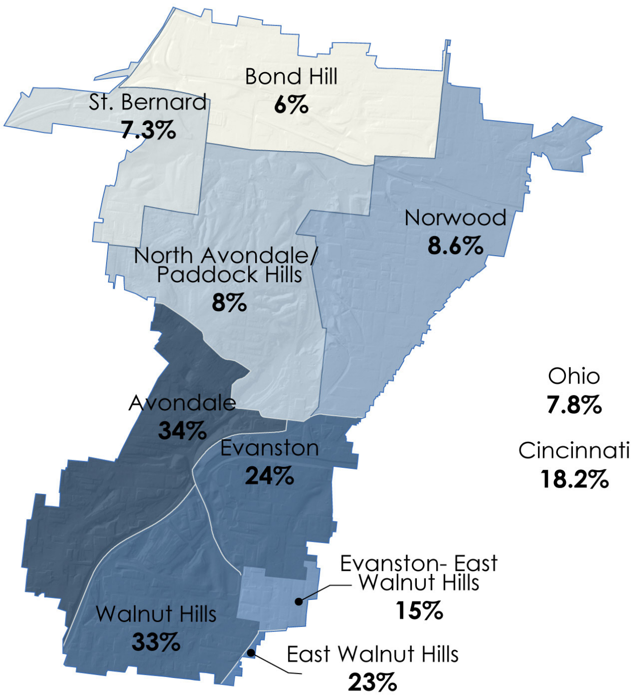


percent of individuals below poverty line

In 2000, Walnut Hills housed the most individuals below the poverty line with 36%. The City of St. Bernard housed the fewest individuals with 8.7%. The City of Cincinnati average is 22% and the Ohio average is 10.6%.

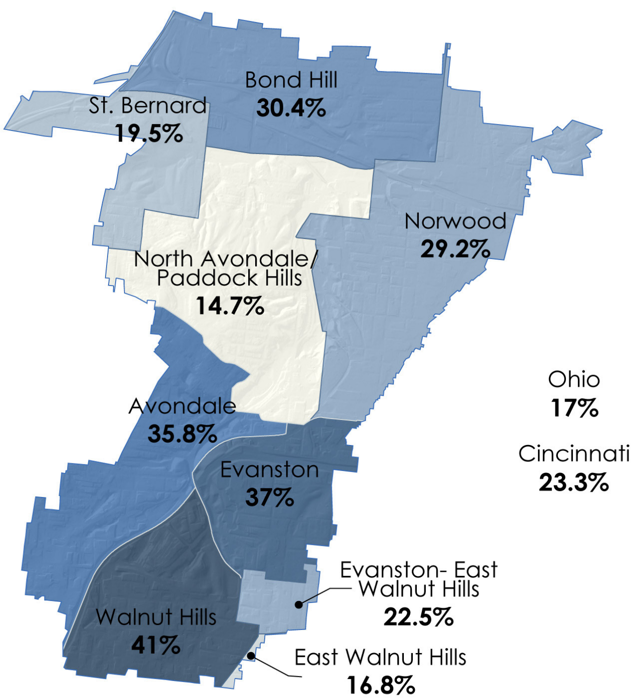


percent of families below poverty line



In 2000, Avondale housed the most families living under the poverty line with 34%. Bond Hill housed the fewest families with 6%. The City of Cincinnati average 18.2% and the Ohio average is 7.8%.

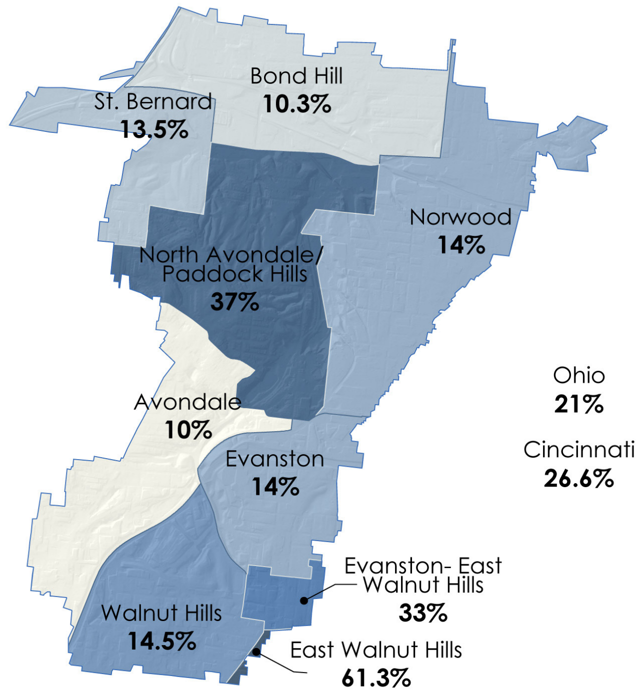
percentage of individuals over 25 without a high school degree



In 2000, the Walnut Hills neighborhood contained the most individuals over the age of 25 without a high school degree with 41%. The North Avondale/Paddock Hills neighborhood contained the fewest individuals with 14.7%. The City of Cincinnati average is 23.3% and the state average is 17%.

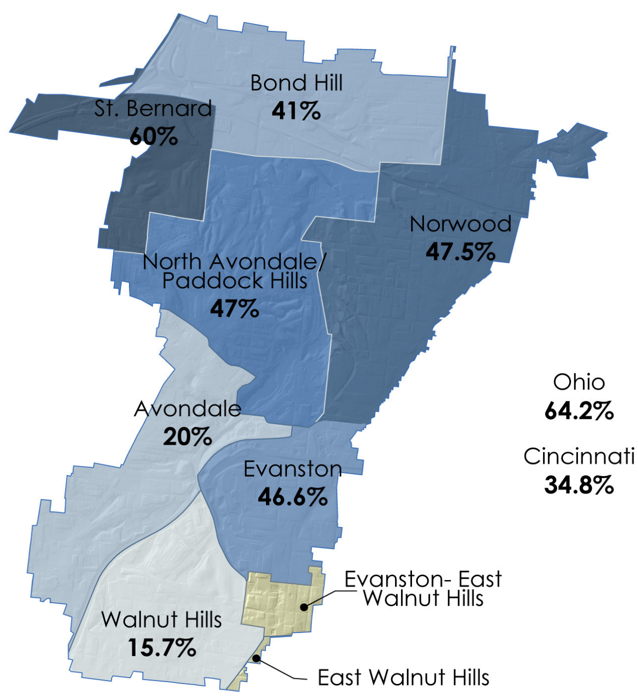
percentage of individuals over 25 with a bachelor's degree

In 2000, North Avondale contained the most individuals of the age of 25 with a bachelor's degree with 37%. Avondale contained the fewest with only 10%. Twenty-seven percent of Cincinnati's population and 21% of Ohio's population over 25 had a bachelor's degree.

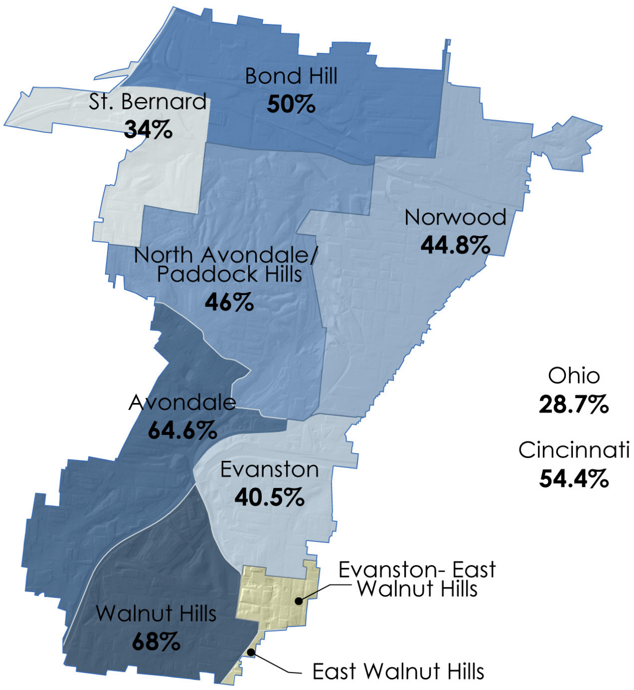


housing tenure: percent owner occupancy

In 2000, St. Bernard had the highest owner-occupancy rate with 60%. Walnut Hills had the lowest with 16.7%. The owner-occupancy rate for Cincinnati was 34.8% and for Ohio was 64.2%. There was insufficient data for Evanston-East Walnut Hills and East Walnut Hills.

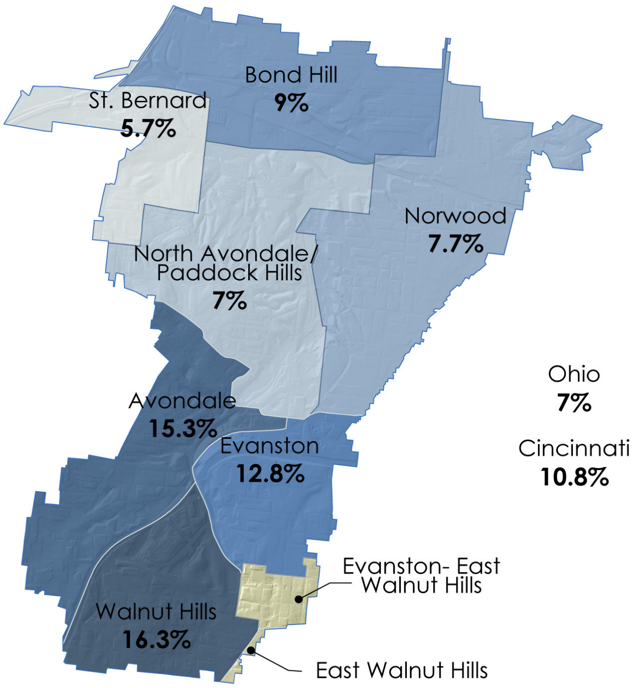


housing tenure: percent renter occupied



In 2000, Walnut Hills had the highest renter-occupancy rate with 68%. St. Bernard had the lowest with 34%. The renter-occupancy rate for Cincinnati was 54.4% and for Ohio was 28.7%. There was insufficient data for Evanston-East Walnut Hills and East Walnut Hills.

housing tenure: percent vacancy



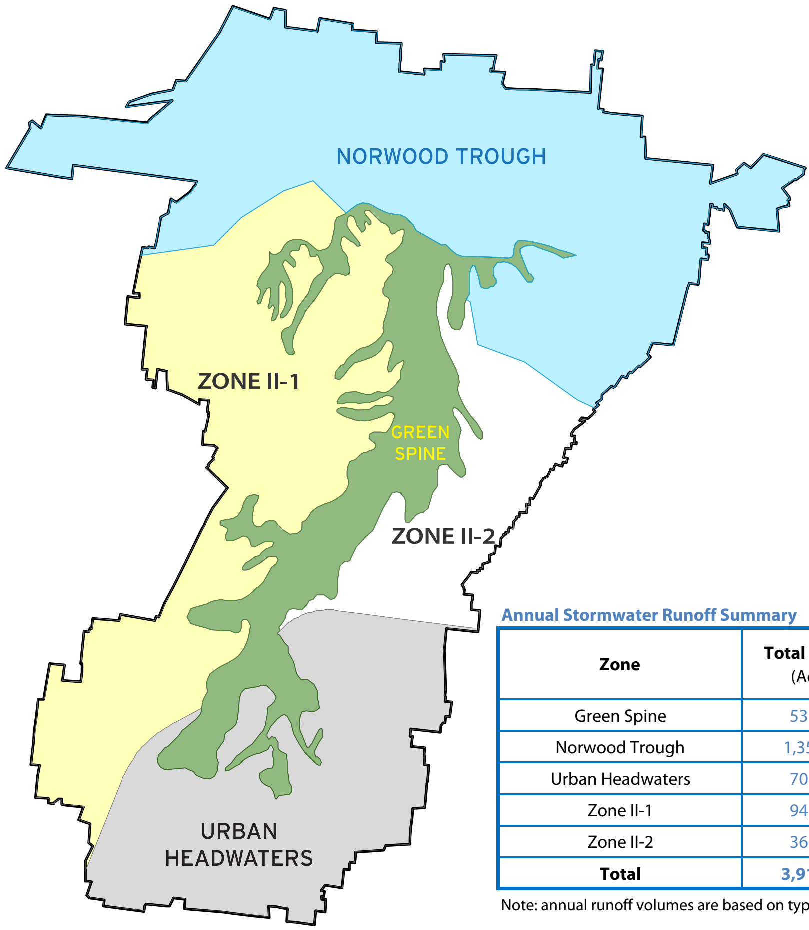
In 2000, Walnut Hills had the highest housing vacancy rate with 16.3%. St. Bernard had the lowest with 5.7%. The housing vacancy rate for Cincinnati was 10.8% and for Ohio was 7%. There was insufficient data for Evanston-East Walnut Hills and East Walnut Hills.

WATERSHED OPPORTUNITIES

WATERSHED OPPORTUNITIES

ZONAL DELINEATION

Based on extensive inventory and analysis of natural and built systems, and investigation of historical development patterns, the watershed was separated into four zones.



Annual Stormwater Runoff Summary

Zone	Total Area (Ac)	Impervious Area (Ac)	Pervious Area (Ac)	Annual Runoff (MG)
Green Spine	539	164	374	230
Norwood Trough	1,354	706	648	775
Urban Headwaters	708	394	314	420
Zone II-1	947	404	542	480
Zone II-2	366	258	107	250
Total	**3,913**	**1,928**	**1,985**	**2,155**

Note: annual runoff volumes are based on typical year rainfall; MG denotes million gallons

The "Urban Headwaters" zone in the southern portion of the watershed is bound by the I-71 corridor to the north. This zone is highly urbanized with significant areas of impervious surfaces.

The "Zone II" area contains a high percentage of single-family residential properties, as well as some institutional properties (*e.g.*, Xavier) and large tracts of open space (e.g., Avon Fields Golf Course). Slopes are minimal, ranging from zero percent up to eight percent at the interior edges. The western section drains eastward and the eastern section drains westward to the "Green Spine".

The "Green Spine" was delineated based on historical streams and the steep hillsides that form the Victory Parkway corridor. This zone follows the path of Martin Luther King Drive, a major arterial road that bisects the Ross Run watershed and has the potential to become a continuous parkway.

The "Norwood Trough" was delineated based on glacial influences on the watershed and the historical alignment of the Ohio River through Norwood. Geologic history portrays thick layers of gravel and sand outwash deposits.

WATERSHED OPPORTUNITIES

The project team identified several opportunities for reducing the volume of stormwater runoff entering the combined sewer system. Opportunities in the Ross Run watershed include Direct, Enabled 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

Direct Project opportunities include infiltration, detention, site best management practices (BMPs)/ redevelopment, and separate storm conveyance, all of which are illustrated on the Green Wet Weather Strategies graphic. Overall 68 sites, covering 195 acres, were identified as potential direct opportunities. The annual stormwater runoff volume tributary to these potential opportunities is approximately 667 MG. Natural drainage areas using natural topography and the existing sewer network were delineated for each direct project to determine the approximate annual volume of stormwater runoff entering the combined system from each site.

Infiltration Opportunities

There are 13 total sites identified for deep infiltration and 13 total sites (78 acres) identified for bioinfiltration features. These features are typically located within low-lying undeveloped areas with favorable geology, have the potential to improve water quantity and quality and address 243 MG of stormwater runoff that flow to these sites each year. Most of these infiltration opportunities lie within the "Norwood Trough" zone, taking advantage of the favorable geology (*i.e.*, permeable sub-layers) present underneath.

There are three sites identified for deep infiltration and seven sites (39 acres) identified for bioinfiltration features. One specific infiltration opportunity lies within the former Showcase Cinema site and adjacent property. This opportunity represents transforming roughly 19 acres of vacant land within the site in order to capture and infiltrate runoff from the city of Norwood and the surrounding area. (**See Former Cinema Site detail**).

NOTE: Recommendations for deep infiltration were based on well log data obtained from the Ohio Department of Natural Resources (ODNR). The feasibility and effectiveness of deep infiltration opportunities is subject to additional site testing and consultation with a geotechnical engineer.

Detention Opportunities

There are 34 sites (35 acres) identified for potential detention within the Ross Run watershed. These sites are typically located in low-lying areas adjacent to large sections of separate storm sewer. These opportunities have the potential to improve water quantity and quality and address 267 MG of stormwater runoff that flow to these sites each year. The majority of the detention opportunities are found within the "Green Spine" zone as the existing topography allows for natural detention areas.

Site-Specific BMPs / Redevelopment Opportunities

There are seven total sites (82 acres) identified for site BMPs/ multiple strategy opportunities and/or redevelopment opportunities within the Ross Run watershed. These opportunities have the potential to improve water quantity and quality and address 157 MG of stormwater runoff that flow to these sites each year. These sites can reconfigure the existing use (i.e. a green parking lot) or be redeveloped into an alternative use. In both cases, a variety of stormwater BMPs can be used. One example is Paddock Hills Park, a site that offers an opportunity for both stormwater management features and recreational improvements. This park can be reconfigured to provide an improved community amenity while addressing local stormwater issues. Further study is needed to determine the appropriate modifications at the park.

Additional site-specific BMPs, not graphically represented, include small-scale practices that individual property owners can initiate (*i.e.*, downspout disconnections and rain gardens). These opportunities will perform best in the "Urban Headwater" zone as they address the 'first flush' rain events by reducing stormwater runoff quantity close to the source as opposed to opportunities further downstream that focus on improving water quality.

Separate Stormwater Conveyance System

The proposed separate storm conveyance is approximately four miles long and links proposed direct project opportunities to the Mill Creek.

Water Quantity & Quality Benefits

To determine the quantity of water contributing to each of the proposed direct opportunities, the project team identified their tributary natural drainage areas and calculated a coarse annual runoff based on annual rainfall for each (**see Water Quantity Benefits graphic**). The Center for Watershed Protection had published the following benefits of stormwater BMPs:

Pollutant Removal (Event Mean Concentration)			
Stormwater BMP	**Runoff Reduction (%)**	**Total Phosphorus (%)**	**Total Nitrogen (%)**
Green Roof	45 - 60	0	0
Rooftop Disconnection	25 - 50	0	0
Raintanks and Cisterns	40	0	0
Permeable Pavement	45 - 75	25	25
Grass Channel	10 - 20	15	20
Bioretention	40 - 80	25 - 50	40 - 60
Dry Swale	40 - 60	20 - 40	25 - 35
Wet Swale	0	20 - 40	25 - 35
Infiltration	50 - 90	25	15
Soil Amendments	50 - 75	0	0
Constructed Wetland	0	50 - 75	25 - 55
Wet Pond	0	50 - 75	30 - 40

Source: Center for Watershed Protection & Chesapeake Stormwater Network, 2008

Based on this data, the following table was created summarizing the stormwater benefits of the direct project opportunities proposed in Ross Run watershed. A "positive" benefit was identified for those projects that have the potential to remove up to 50 percent of stormwater runoff or stormwater pollutants. A "highly positive" benefit was identified for those projects that can potentially remove greater than 50 percent of stormwater runoff or stormwater pollutants (**see Water Quantity Benefits graphic**).

Stormwater BMP	Area (acres)	Drainage Area (acres)	Annual Runoff (MG)*	Quality: Pollution Removal Potential	Quantity: Volume Removal Potential
Infiltration	78	467	243	positive	highly positive
Detention	35	547	267	highly positive	positive
Site BMPs	82	318	157		
Permeable Pavement				positive	highly positive
Retention				highly positive	highly positive
Infiltration				positive	highly positive

*Coarse annual runoff volumes based on typical year rainfall

Enabled Projects (Connective Elements)

Right-of-Way Corridor

This corridor consists of railroad and transportation right-of-way (Norfolk & Western Railway, Baltimore & Ohio Railway, Pennsylvania Lines, and SORTA) that leads to the Mill Creek. These corridors provide opportunities for stormwater conveyance, stormwater management features, multi-modal transit, and/or recreation (*e.g.*, trail networks).

Community Plans

Existing community plans have identified opportunities for several watershed communities. These plans include Paddock Hills/Bond Hill NBD Urban Design Plan 2000; Evanston NBD Urban Renewal Plan 1998; and Evanston Five-Points Urban Renewal Plan 2002, each of which was identified in the 2010 Hamilton County Regional Planning document *Lower Mill Creek Coarse Evaluation Planning Background Report*. Projects (9 sites and 28 acres) proposed in these plans include the following:

Paddock Hills/Bond Hill Neighborhood Business District Urban Design Plan (2000)

- Repair/replace damaged and deteriorated sidewalks along Paddock Road and Tennessee Avenue
- Improve turning conditions at the Reading Road and Tennessee Avenue intersection through corner roundings
- Improve crosswalk conditions at Paddock/Tennessee and Reading/Avon intersections
- Integrate street trees along Tennessee, Reading, and Paddock roads
- Provide gateway plantings and signage at the Norwood Lateral, Paddock Road , and Reading Road intersections

Lower Mill Creek Coarse Evaluation Planning Background Report (2010)

- Emersion Design LLC Office- LEED Platinum Certified

Eco-Redevelopment District

These districts offer an opportunity for "green," ecologically-conscious redevelopment at major points along the Tennessee Avenue corridor. The former Showcase Cinema site is one location that serves as a district nucleus. Such redevelopment can integrate stormwater management opportunities with future redevelopment and revitalization efforts (**see Green Wet Weather Strategies graphic**). One Eco-Redevelopment District opportunity lies within the former Showcase Cinema site and adjacent property. This opportunity represents redeveloping roughly 19 acres of vacant land and integrating infiltration opportunities to capture and infiltrate runoff from the City of Norwood and the surrounding area (**see Former Cinema Site detail**).

Some principles to guide redevelopment include:

- The development should be a model for environmentally-, socially-, and economically-sensitive redevelopment within greater Cincinnati
- The site should be redeveloped in a manner that creates a unique neighborhood, one with strong identity and character
- Businesses should serve both residents and pass-through needs
- Public spaces should serve the recreational, social, and civic needs of the community
- Pedestrian and vehicular circulation systems should be safe, legible, and promote the quality of

life for both residents and visitors

- Bikeways, trails, and other open space systems should connect to existing/proposed systems within the Ross Run and Lower Mill Creek Watershed.
- All redevelopment projects should meet or exceed sustainable principles (*e.g.*, LEED) for green buildings and neighborhoods and incorporate form-based codes (where possible).
- Stormwater management strategies should maximize opportunities for surface infiltration, evaporation, and transpiration.

Complete Streets Corridors

Spurring from Community Plan recommendations to revitalize and improve the condition of several intersections and sidewalks, opportunities to convert several corridors into Compete Streets were identified. Complete Streets are designed and operated to enable safe access for all users- pedestrians, bicyclists, motorists and transit riders of all ages and abilities. Elements such as sidewalks, bike lanes, special bus lanes, pedestrian crosswalks, median islands, curb extensions, street trees, trash receptacles, lighting, and stormwater BMPs are integrated into the existing road network to provide a safe and enjoyable environment. Complete Streets can spur economic development by providing accessible and efficient connections between residences, schools, parks, public transportation, offices, and retail destinations. They also encourage walking and bicycling which improves public health. The added green space and stormwater BMPs will provide aesthetic benefits that instill a sense of pride within the community residents as well as air quality and water quality/quantity benefits (**see Complete Streets details**).

Bike Trails

Connecting to existing trails (*i.e.*, Mill Creek Greenway Trail, City of Cincinnati Bike Trail, and OKI Bike Trail) presents the opportunity for an integrated trail network throughout the Ross Run Watershed that utilizes stormwater quality BMPs (**see Green Wet Weather Strategies graphic**).

Reforestation

There are currently 827 acres of existing tree canopy in the Ross Run watershed, representing 21 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 139 acres of canopy-deficient hillsides present within the Ross Run watershed. According to the CITYgreen analysis, such reforestation has the potential to intercept approximately 6.6 million gallons of stormwater runoff (table below). (**See Enabled Opportunities graphic**). The project team performed this CITYgreen analysis based on the typical year rainfall dataset (**See Appendix A**).

Reforest 60% of Reforestable Tree Deficiency Area of Hillsides

Tree Canopy Benefit

Rain Event (in.)	Cubic Feet	Gallons	Frequency	Annual Benefit (gal)
0.25	0	0	5	0
0.50	0	0	20	0
0.75	12,736	95,278	13	1,238,614
1.00	25,515	190,878	12	2,290,533
1.50	50,569	378,307	3	1,134,920
2.00	73,291	548,290	1	548,290
2.50	93,260	697,678	2	1,395,356
TOTAL	255,371	1,910,430		6,607,713

CITYgreen assesses how land cover, soil type, slope, and precipitation affect stormwater runoff volume, time of runoff concentration, and runoff peak flows. This analysis calculates the volume of runoff that would need to be contained by stormwater retention basins if the vegetation were removed. If this volume is multiplied by local construction costs, the amount saved by onsite tree canopy can be calculated. The CITYgreen report in Appendix A provides these values as well as basic site statistics and values for stormwater control during an average 2-year, 24-hour storm. The stormwater calculations are based on the TR-55 stormwater model developed by the Natural Resource Conservation Service (NRCS). A curve number is similar to a percentage that describes how much of the rainfall falling on the site will run off and how quickly that will happen. The Existing Conditions curve number is based on the site with its present landcover. The Replacement Landcover number is based on the site if the trees were removed and replaced with an impervious surface. Below the curve numbers are several values showing the percent change resulting from changing existing landcover to the replacement landcover. The value for Additional Storage Volume Needed shows the volume of additional water to be managed if the trees were removed from the site. The construction cost per cubic foot is the cost of building a stormwater management facility to control the additional water. This report used the CITYgreen default of $2 per cubic foot of storage. The Total Stormwater Savings number is the additional cost of managing the site's stormwater without trees (volume of water multiplied by the construction cost per cubic foot). The Annual Costs number recognizes that most capital projects are financed over a period of years, rather than paid for in one installment. CITYgreen shows the cost of annual payments on a stormwater facility based on financing the total value at 6% interest over 20 years.

Interstate 71 & Martin Luther King Drive Interchange Redesign

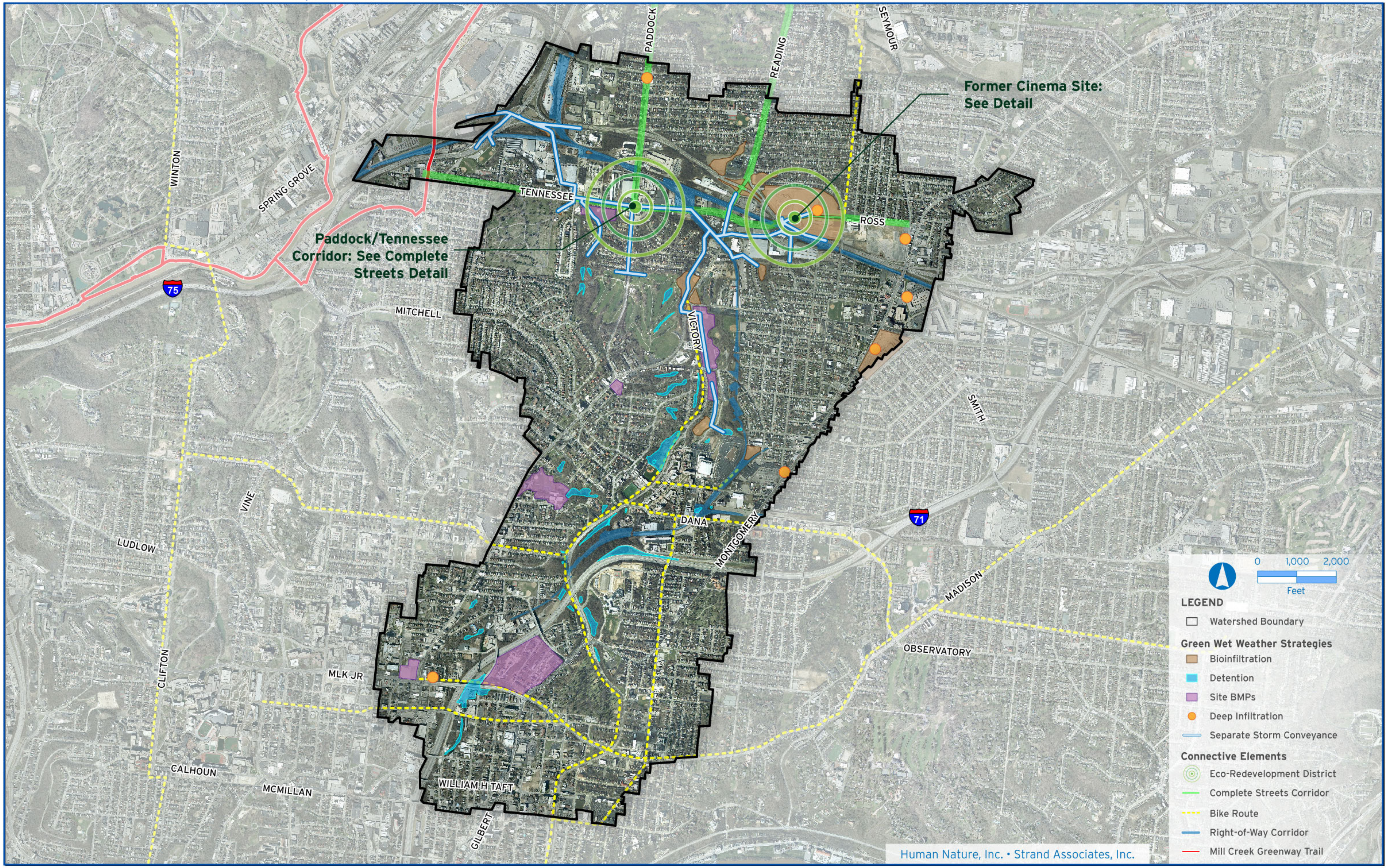
An enabled opportunity has been identified with the future construction of the Interstate 71 interchange at Martin Luther King Drive. This construction presents an opportunity to form partnerships (inform and influence) with the Ohio Department of Transportation and the City of Cincinnati (specifically 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 27 acres of impervious surface along the I-71 corridor and 17 acres along the I-75 corridor within the Ross Run watershed, which generate roughly 28 MG and 18 MG respectively of stormwater runoff each year.

Inform & Influence Projects

Watershed Partners (Inform & Influence Opportunities)

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 Ross Run watershed. Watershed Partners within the Ross Run Watershed include the City of Cincinnati, the Cincinnati Park Board, Cincinnati Board of Education (i.e., Walnut Hills High School and North Avondale School), City of Norwood, Xavier University, St. Aloysius Orphanage, St. Mary's German Catholic Cemetery, and the German Protestant Cemetery (**see Inform & Influence Opportunities graphic**).

Green Wet Weather Strategies



This concept is CONCEPTUAL only and subject to further analysis, review and refinement by MSD and other authorities and individuals. MSD's participation in any project based on this concept plan is subject to further discussion with USEPA and other Regulators under the Wet Weather Improvement Plan. Recommendations for deep infiltration were based on well log data obtained from the Ohio Department of Natural Resources (ODNR). The feasibility and effectiveness of deep infiltration opportunities is subject to additional site testing and consultation with a geotechnical engineer.

Former Cinema Site Detail

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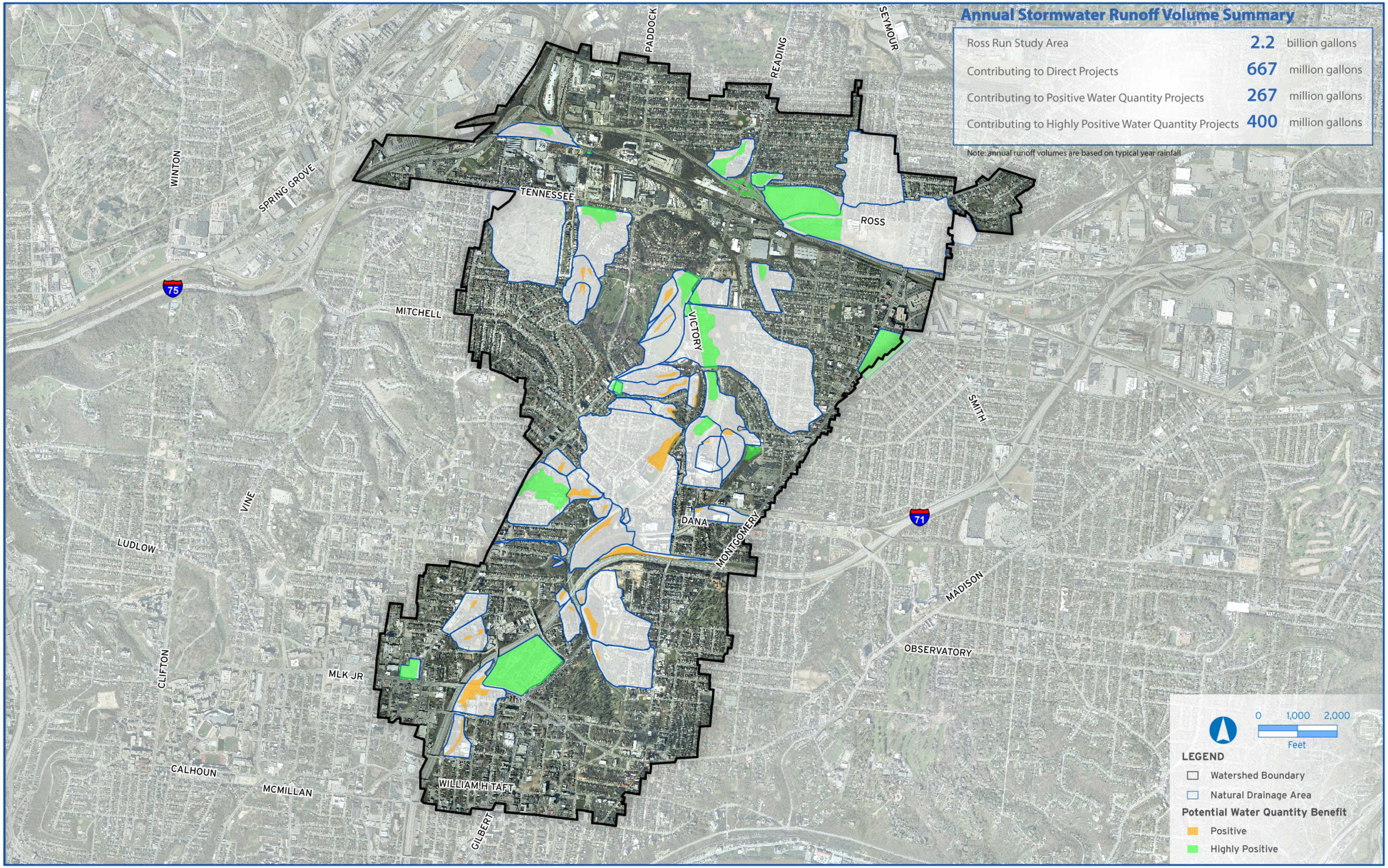
Water Quantity Benefits



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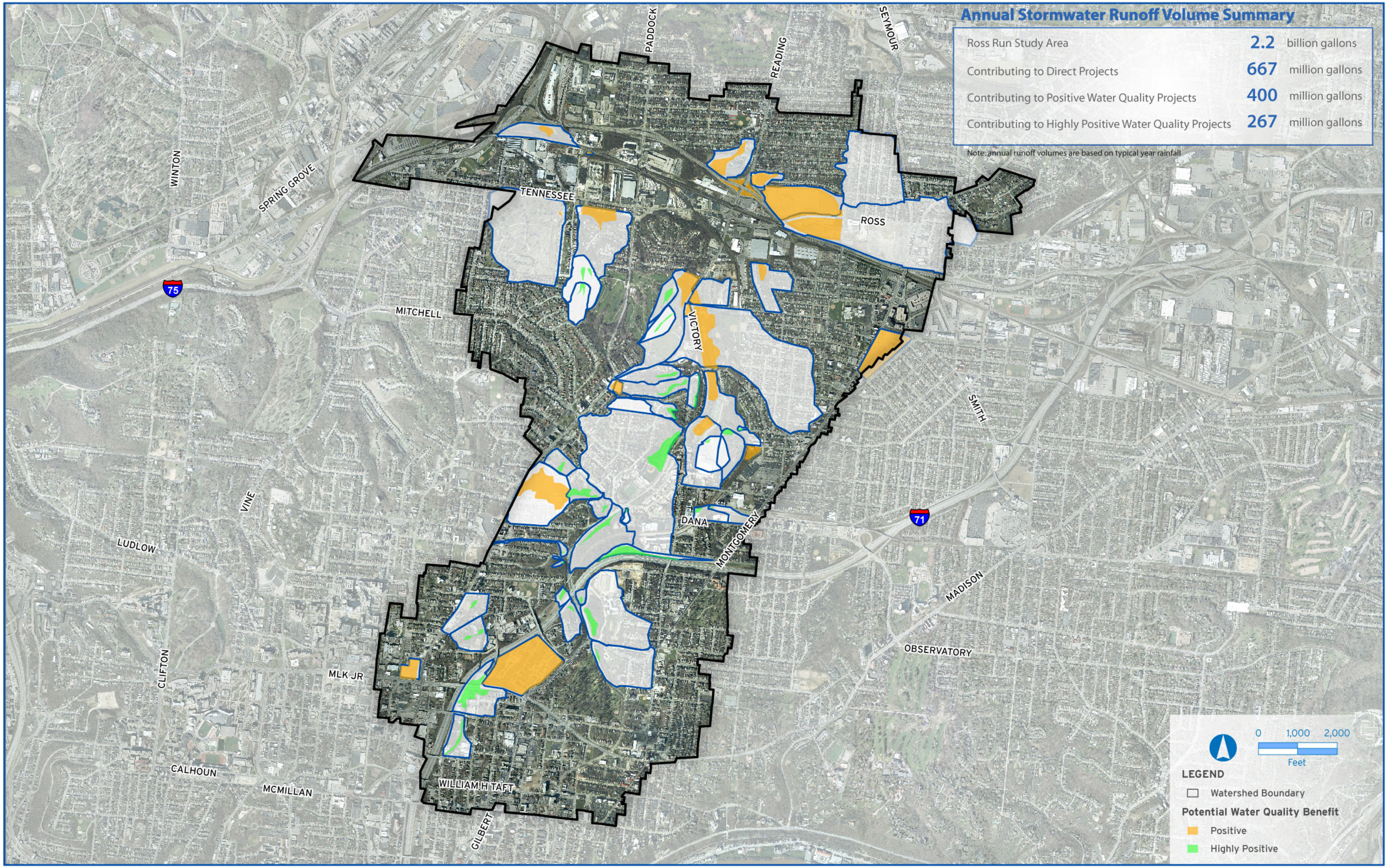
Water Quality Benefits



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Proposed

Existing Conditions

TENNESSEE AVENUE

PROPOSED STREETSCAPE ENHANCEMENTS

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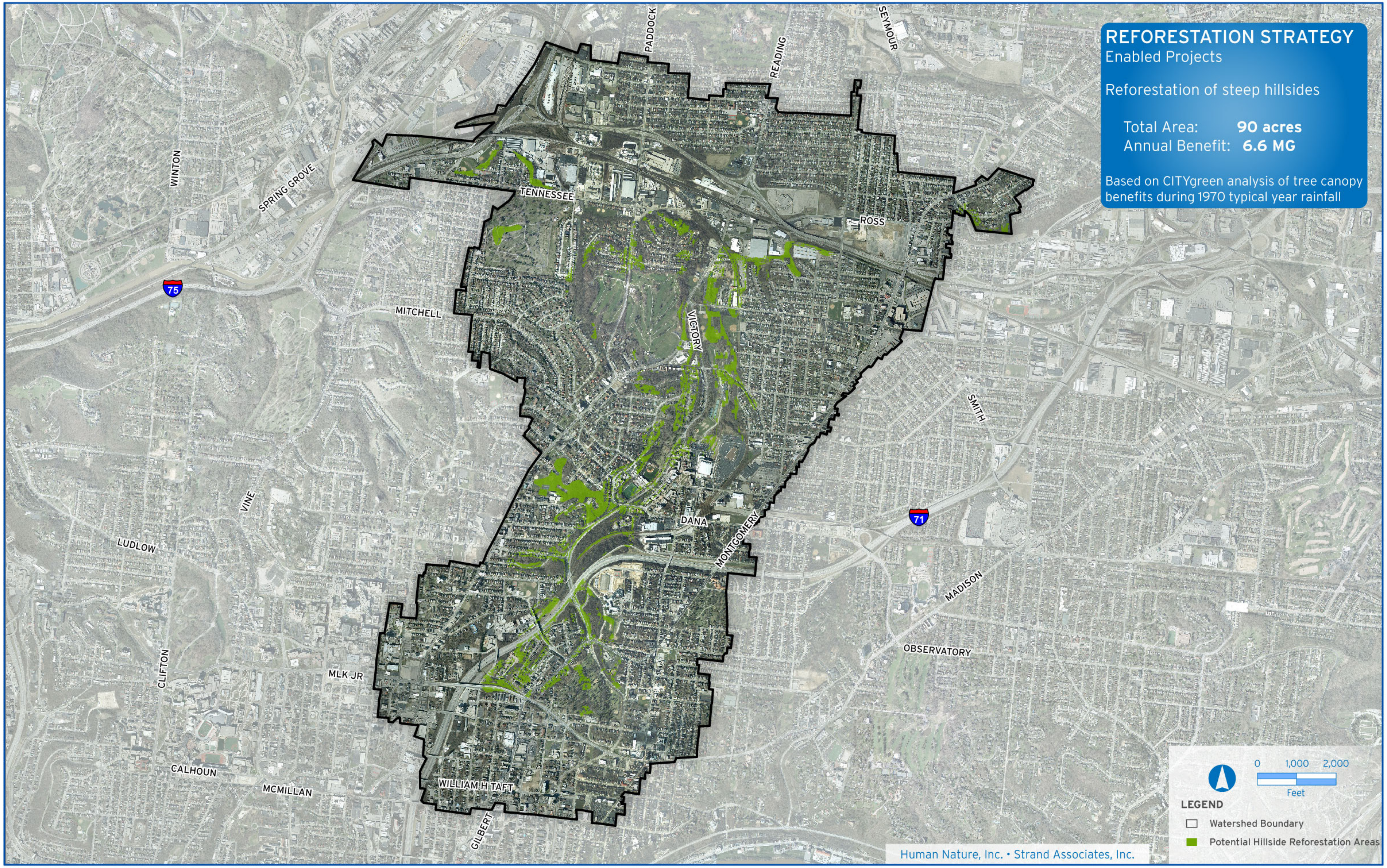
Enabled Opportunities



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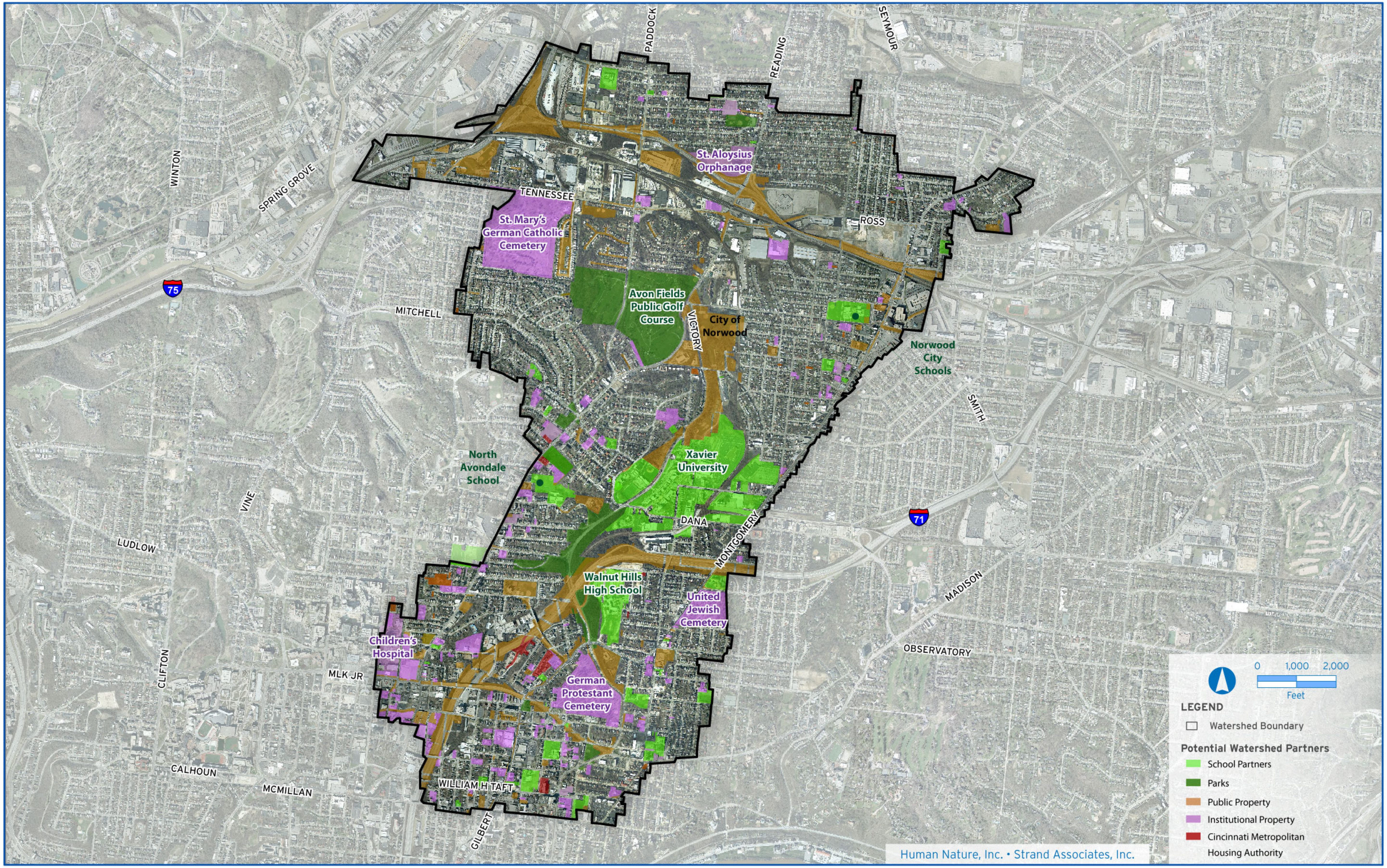
Inform & Influence Opportunities



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MODELED ALTERNATIVE

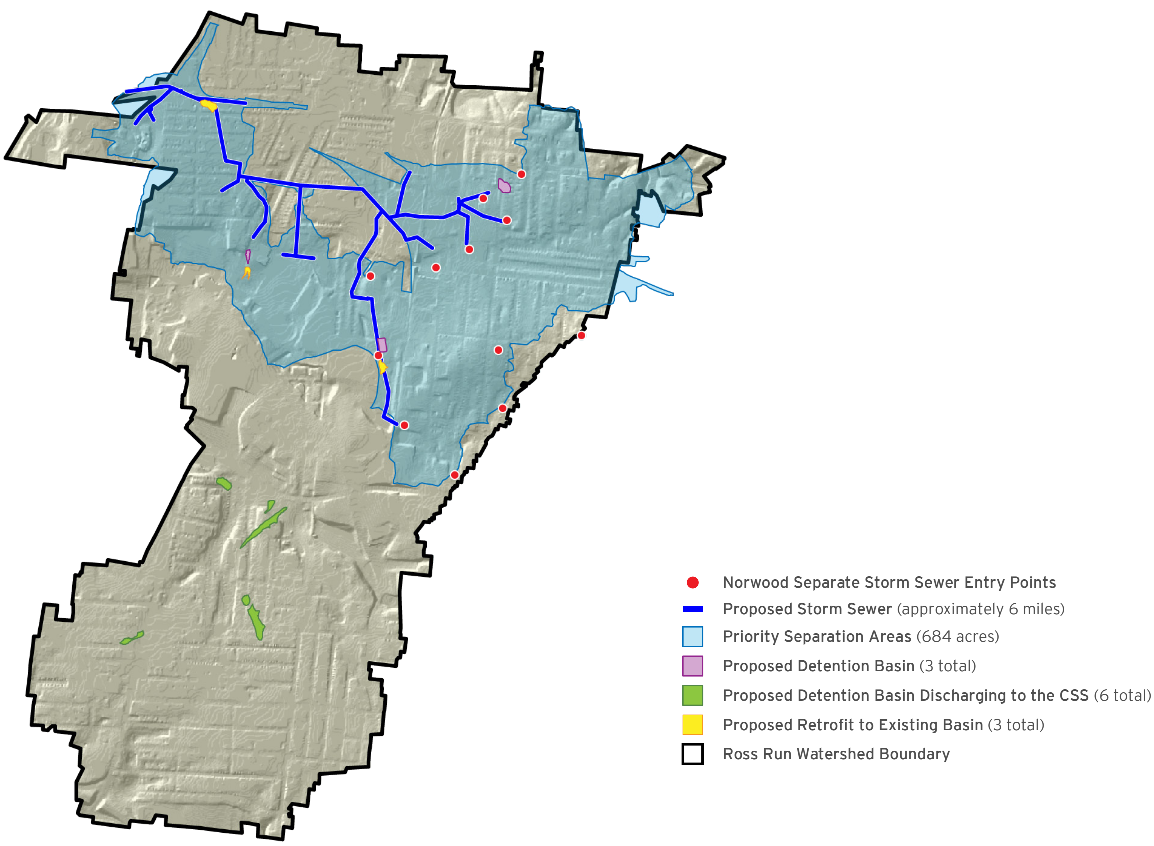
MODELED ALTERNATIVE

COMPONENTS

Starting with the full list of identified Direct opportunities, further evaluations including site visits and coarse modeling were performed to narrow the options down to a selected alternative. This alternative was selected in order to reconnect stormwater to natural systems, improve regional water quality, and create community connectivity. The goal of the selected alternative is to provide a comprehensive plan that provides community benefits while reducing the Ross Run CSO. In this instance, the selected alternative included:

- Construction of approximately 6 miles of separate storm sewer
- Removal of approximately 684 acres of existing separate sewer areas, primarily within the City of Norwood, that currently discharge into the combined sewer system (CSS)
- Construction of three detention basins as part of the proposed separate storm network
- Retrofitting of three existing basins as part of the proposed separate storm network
- Construction of six detention basins that discharge back to the combined system in the upper portions of the watershed

Currently there are several large areas within the Ross Run watershed with existing separate storm sewer systems. Specifically, the city of Norwood's separate storm system currently drains approximately 684 acres within Ross Run, which discharges directly to MSDGC's combined sewer system in six different locations. Separate storm sewer entry points were obtained from City of Norwood record drawings, digital or GIS data with exact infrastructure locations are not currently available.



By connecting these locations to the new proposed storm sewer significant amounts of stormwater runoff could be removed from the combined system. Because additional stormwater is not being added to the Norwood separate storm system the capacity of the existing storm infrastructure was not evaluated as part of this preliminary evaluation. Construction of the proposed storm sewer will also allow stormwater runoff from other separated areas including golf courses, a cemetery, parks, and portions of the Norwood Lateral and Interstate 75 to be removed from the CSS and conveyed directly to the Mill Creek. In addition, to the proposed separate storm system several existing detention basins and numerous proposed detention areas were evaluated for their potential impact on the overall benefit of the preferred alternative. Based on the inventory and analysis of Ross Run locations of existing or potential basin locations were identified based on contours, infrastructure, and land use. As part of the coarse evaluation site visits were conducted to several potential basin areas in order to select the preferred proposed basin locations. Properly located and sized detention facilities reduce peak flow discharges to the storm sewer allowing smaller conveyance systems and therefore reducing the overall project costs. Additionally, these facilities could be designed to provide water quality improvements to stormwater offloaded from the CSS and conveyed to the Mill Creek.

Based on the locations of the proposed storm sewer, City of Norwood entry points, and proposed basins Ross Run was divided into priority, second priority, and non-priority areas. Priority areas are those areas that will be impacted by the selected alternative with the goal of removing stormwater runoff from the combined system. Second priority areas provide the opportunity to delay the amount of stormwater that enters the combined system, reducing peak flows into the system. Non-priority areas will not be directly impacted by the selected alternative and stormwater runoff will continue to enter the combined system.

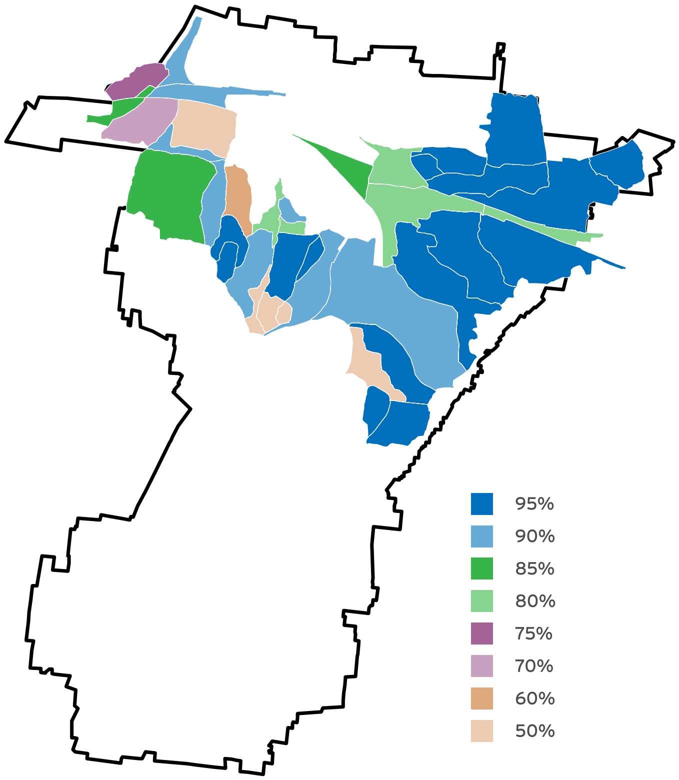
CSO MODELING

In order to determine the impact of the proposed wet weather strategies evaluated above, the project team coordinated with MSDGC's Modeling Consultant (XCG Consultants, Inc). According to the 2006 LTCP Update Report, the original SWM estimated that approximately 1.37 billion gallons of flow discharged from the Ross Run CSOs annually. Based on this information, Ross Run was identified as a priority basin accounting for almost ten percent of MSD's annual CSO volume.

Before the recommended wet weather strategies discussed above could be incorporated into the model, the Modeling Consultant isolated the Ross Run watershed from the existing SWM of the CSS and refined this portion of the model (SWM Version 3) to reflect recent infrastructure changes, updated data and the addition of a real-time control facility. The following table highlights the updated combined sewer overflow information for the two overflow points in the Ross Run watershed. Based on updates to the model including the addition of the existing real time control facility, the Ross Run watershed currently discharges approximately 213 million gallons of combined sewer overflow annually to the Mill Creek.

Model	CSO 485		CSO 487		Total Overflow Volume (MG)
	Total Overflow Volume (MG)	Percent Control	Total Overflow Volume (MG)	Percent Control	
2006 LTCP Update Report	29	95%	1,351	30%	1,370
SWM Version 3	95	88%	471	62%	566
SWM Version 3 + RTC	6	99%	207	83%	213

The Strand/Human Nature project team coordinated with the Modeling Consultant in order to estimate the reduction in CSO volume associated with the evaluated alternative strategy discussed above.   In order to simulate the impact of the proposed separation within the priority basins, each subbasin was assigned a percent effectiveness value that reflected the estimated percentage of the subbasin that would be disconnected from the CSS with the implementation of the proposed projects. While this a subjective process, the percent effectiveness values were based on existing GIS information including impervious area, land use, existing, infrastructure, topography, and soils. A high percent effectiveness value was used in undeveloped areas or areas with existing separate storm infrastructure, while lower values were used in developed areas where downspouts may be connected to the combined system or building roofs may be internally drained. This methodology was utilized for other SWEP evaluations in MSDGC's service area. The following graphic shows the percent effectiveness values assigned to each of the priority basins.



Percent Effectiveness for Priority Subbasins

In order to simulate the CSO reduction associated with the proposed alternative control strategy, the Modeling Consultant added an identically sized, parallel pipe network to the SWM model to intercept and convey the stormwater from the proposed separated areas of each subbasin and directed these flows toward the Ross Run outfall leading to the Mill Creek. The elevations, lengths, and diameters of the stormwater pipes are the same as the combined system with the roughness coefficient adjusted to reflect an assumed concrete piping network for the proposed storm sewer system. The added parallel pipe network is simply a modeling technique that the Modeling Consultant used to provide a routing mechanism for the stormwater runoff removed from the CSS. It was not used as a basis for sizing or costing the proposed storm sewer. A detailed summary of this effort of hydrologic and hydraulic modeling is provided in Appendix A.

In evaluating the stormwater reduction achieved through separation, it was assumed that some stormwater in the separated areas would continue to enter the combined system through various means. To model this condition, the percent effectiveness assigned to each subbasin listed above was utilized. Priority subbasins were divided into two distinct subcatchments. One subcatchment contributed flow to the proposed storm sewer system and the second catchment area represented the percentage of the subbasin that would continue to discharge to the combined system. The drainage area of each catchment was proportional to the percent effectiveness value. For example, a 100 acre subbasin with a 90 percent effectiveness value would be represented in the model by a subcatchment of 90 acres draining to the proposed storm sewer system and a subcatchment area of 10 acres remaining connected to the combined sewer.

In addition to the priority areas, the Modeling Consultant incorporated the six proposed detention basins in the upper portion of the watershed into the collection system model. As previously mentioned, the purpose of these detention basins is to delay stormwater runoff from entering the combined system, thus reducing peak flows in the sewers. However, modeling of proposed stormwater detention facilities indicates no additional reduction in CSO. Therefore, these six locations were not included in the cost benefit analysis discussed in the following section.

The Modeling Consultant modeled the reduction in stormwater runoff to the CSS and the corresponding reduction in CSO volume for the evaluated alternative. The following table summarizes the updated CSO volume for the Ross Run watershed based on these adjustments in the model in the priority areas.

Model	CSO 485		CSO 487		Total Overflow Volume (MG)
	Total Overflow Volume (MG)	Percent Control	Total Overflow Volume (MG)	Percent Control	
SWM Version 3 +RTC	6	99%	207	83%	213
SWM Version 3 + RTC + Evaluated Alternative	4	100%	70	94%	74

Therefore, the evaluated alternative, in conjunction with the existing real time control facility, reduce the combined sewer overflow volume from the Ross Run watershed by 139 million gallons annually.

COST BENEFIT ANALYSIS

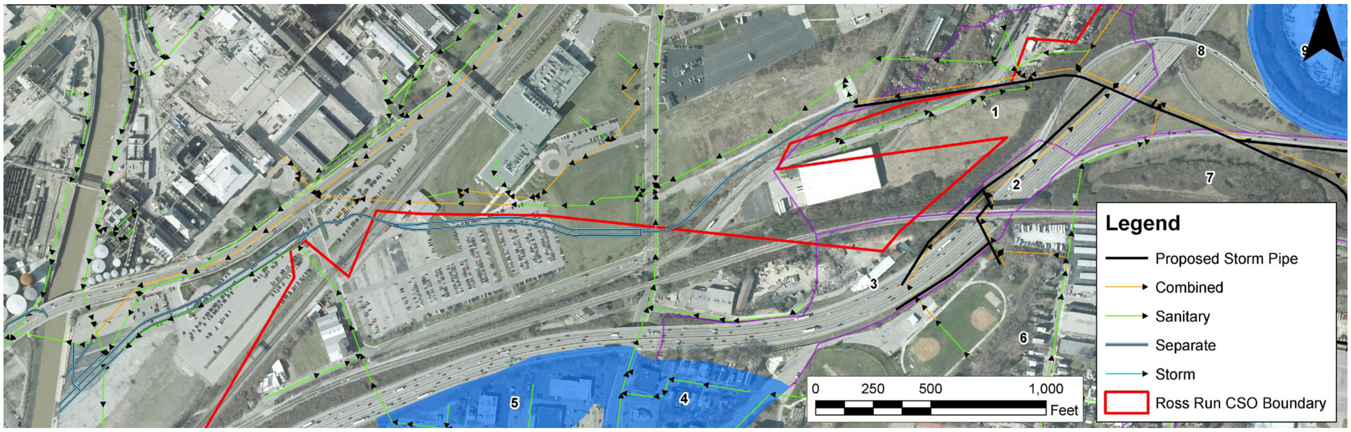
A preliminary opinion of probable construction cost was developed for the selected alternatives modeled within the Ross Run watershed in order to perform a preliminary a cost/benefit analysis. In order to develop preliminary opinions of construction cost, hydrologic and hydraulic models of the Ross Run watershed were used to size the proposed storm sewer system. A detailed summary of this effort of hydrologic and hydraulic modeling is provided in Appendix A. The following items have been included in the preliminary opinion of cost:

- The construction of 31,515 linear feet of proposed storm sewer infrastructure within the Ross Run watershed
- Enhancement to three existing detention basins within the priority subbasins
- The construction of three new detention basins within the priority subbasins
- The construction of a new storm sewer system (3,920 linear feet) to convey separated flow from the Ross Run watershed to the Mill Creek

It is important to note that analysis performed to date is a relatively coarse evaluation. Prior to advancing any of the control alternatives presented in this report, additional evaluation should be conducted. For example, the detention basin opportunities discussed should be further evaluated to optimize the performance of these areas in the context of a selected watershed scale solution. For instance, the proposed basin at the old Showcase Cinema site is located above the geological formation known as the Norwood Trough. As previously mentioned in this report, this area may provide ample opportunity for infiltration of stormwater. Currently a portion of the City of Norwood's separate storm sewer system drains through this property before connecting to the combined system. If it is determined that this property is available for a regional storm water control facility, additional evaluations should be performed to determine the feasibility of deep infiltration at this location.

Preliminary opinions of cost for the proposed enhanced basins and the proposed new detention basins were developed based on the assumption that the basins would be traditional detention basins with limited volume reduction from infiltration.

Currently, CSO 487 which is located in the Ross Run watershed is conveyed approximately 4,000 feet to the Mill Creek through an outfall system comprised of a series of box culverts. The outfall system includes a 14'x20' box conduit leading into twin 11'x14' box conduits, then to an 11'x24' conduit and then back into twin 11'x14' box conduits. This configuration is shown in the figure below.



One of the challenges associated with this proposed approach is the conveyance of large amounts of stormwater from the Ross Run watershed to the Mill Creek. The construction of a completely new storm sewer system to convey this flow would be very expensive and challenging to construct. Therefore, for the purposes of developing an opinion of probable construction cost for a system to connect Ross Run to the Mill Creek, it was assumed that new infrastructure would be required.

The twin box conduits to the west, on the edge of the Mill Creek, house the real time control facility recently constructed by MSDGC. However, additional evaluation for the two segments of existing outfall pipe that currently use twin box structures, may show an opportunity to reduce the length of the proposed conveyance network, providing a cost savings. Potentially, one side of the twin box conduit would continue to convey combined sewage and the other side would convey only stormwater. Further evaluation will be required to determine how the use of the existing structures will impact the combined system capacity and the real time control facility. It should also be noted that for purposes of this preliminary evaluation it was assumed that no additional stormwater would be added to the proposed new storm sewer system between Ross Run and the Mill Creek.

The preliminary opinion of cost quantities are based on planning level deterministic evaluations of the various project elements from the concepts identified in this report. Pricing is based primarily on experience with similar planning projects. The following assumptions and limitations were used in developing this estimate:

- Pricing is based primarily on ODOT's 2009 Bid Summary using the average bid price and supplemented as necessary using MSDGC's Item List or other historical sources. These prices include materials, labor, equipment, overhead, and profit.

- The cost below are for construction only and do not include typical soft costs such as design, financing, inspection and administration.

- A contingency of 30 percent has been applied to the overall estimate to reflect uncertainties associated with existing utility locations, underlying soils, groundwater conditions, and general topographic data.

- Markups for contractor profit and overhead have not been applied separately as these markups are generally included within the unit prices being used
- Life cycle costs have not been analyzed. Such analysis should be completed as part of a future evaluation if it is determined that this project should be advanced.
- Costs for potential property acquisitions are not included.
- Detailed costs associated with possible water quality components, handling disposal of contaminated groundwater and soils, and other elements that would typically be addressed during preliminary and final design phases, have not been fully accounted for in this cost opinion.

Ross Run Preliminary Opinion of Construction Cost

Item	Quantity	Unit	Cost
Box Conduit Structures	6,010	LF	$16,587,000
Storm Sewer Main	25,505	LF	$4,558,675
Precast Storm Sewer Manhole	148	EA	$888,000
Basin Enhancements	3	EA	$600,000
Proposed Basins	3	EA	$1,480,000
Apron Endwalls	6	EA	$12,000
Water Main Relocations	1	EA	$3,136,300
Roadway Restoration	1	EA	$23,401,900
Terrace Restoration	1	EA	$2,653,800
Demolition & Connections	1	EA	$1,447,500
Gas, Telephone & Electric Relocations	1	EA	$1,930,100
Rock Excavation	1	EA	$5,066,400
		Sub-Total	$61,761,675
		Miscellaneous Items @ 30%	$18,528,503
		TOTAL	$80,290,178

Preliminary Opinion of Construction Cost (Outside of Ross Run to connect to the Mill Creek)

Item	Quantity	Unit	Cost
Box Conduit Structures	3,920	LF	$19,600,000
Precast Storm Sewer Manhole	18	EA	$108,000
		Sub-Total	$19,708,000
		Miscellaneous Items @ 30%	$5,912,400
		TOTAL	$25,620,400

GRAND TOTAL	$105,910,578

In addition to the limitations and assumptions that were used in developing the preliminary opinion of construction cost there are other risks and uncertainties to keep in mind as the development of this alternative moves forward. Risks and uncertainties to consider include:

- Land Acquisition–Property acquisition challenges (relocation, loss of business, funding constraints) may result in additional costs and delays.

- Unknowns–The project location is a highly developed area that may be subject to historical, archaeological, environmental, geotechnical, and buried utility issues and conflicts. Any of these issues could lead to delays and cost overruns.

- Agency Alignment–Inability to get alignment/consensus between all affected agencies and organizations around a Community of the Future solution creates the potential for project delays and rescoping.

- Community Support–As with any public utility project, public perception and support are important elements to consider and should be addressed early in the project to minimize the potential for this to become an obstacle in advancing the project.

- Public Safety–Final design of the recommended elements will require specific mitigation strategies regarding the open waterway to the Mill Creek and the large regional basin to address potential safety hazards.

- Regulator Support–Delays in acquiring the necessary federal, state, and local permits or regulator support could delay or suspend project implementation.

The SWM Version 3 indicates that with the existing Real Time Control facilities in place, CSO 485 and 487 are currently achieving relatively high levels of control at, 99.3 and 83 percent respectively. MSD's typical regulatory target for CSO control is approximately 85 percent control. Based on the CSO modeling results for the proposed evaluated alternative, the total volume of CSO discharged annually from CSOs 485 and 487 would be reduced by approximately 139 million gallons. Additionally, the levels of control for each CSO would be increased to 99.6 percent control for CSO 485 and 94.3 percent control for CSO 487.

Utilizing a preliminary opinion of construction cost of $105.9 million and a 139 MG reduction in annual CSO, the evaluated alternative results in a cost/benefit of approximately $0.76 per gallon of CSO removed.

Modeled Annual CSO Reduction	Total Cost	Cost per Gallon
139,000,000	$105,910,578	$0.76

The modeling results provided to the Strand Associates/Human Nature team for the Ross Run watershed indicate that a relatively high level of CSO control is currently being achieved. Based on this information, the modeled alternative does not appear to provide a cost-effective means to enhance the current level of control; however, it should be noted that many opportunities have been identified for direct, enabled, and inform & influence projects (see the Watershed Opportunities section beginning on page 29 and concept diagrams beginning on page 35). As development and redevelopment projects occur in this watershed, these identified opportunities should be evaluated on a project-specific basis to determine if the existing level of control can be cost-effectively increased. An example of this type of opportunity includes the former cinema site located north of the Norwood Lateral in the Norwood Trough zone. As this site is redeveloped, the opportunity to direct separated portions of the city of Norwood to a deep infiltration facility on this site should be explored.

REFERENCES

Center for Watershed Protection & Chesapeake Stormwater Network. Technical Memorandum: The Runoff Reduction Method. April 18, 2008.

City of Cincinnati. *GO Cincinnati: Growth and Opportunities Study for the City of Cincinnati Final Report*. January 2008.

Giglierano, Geoffrey J., Overmyer, Deborah A and Propas, Frederic L. *The Bicentennial Guide to Greater Cincinnati: A Portrait of Two Hundred Years.* Cincinnati, OH: The Cincinnati Historical Society, 1988.

Hamilton County Regional Planning Commission. *Lower Mill Creek Coarse Evaluation Planning Background Report. January 2010.*

Hedeen, Stanley. *The Mill Creek: An Unnatural History of an Urban Stream.* Cincinnati, OH: Blue Heron Press, 1994.

Natural History of the Cincinnati Region. Cincinnati, OH: Cincinnati Museum Center, 2006.

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.

Norwood Historical Society. *Historical Dates for Norwood, Ohio.* Norwood, OH. Available from http://www.rootsweb.ancestry.com/~ohnhs2/. Accessed January 25, 2010.

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. 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.

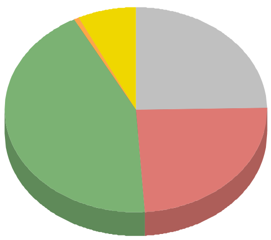
APPENDIX A

CITYGREEN ANALYSIS

Analysis Report for:

Ross Run Hillsides

Land Cover Distribution



Impervious Surfaces	118.7	24.7%
Open Space - Grass/Scattered Trees	115.6	24.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	1.4	0.3%
Urban: Residential: 0.125ac Lots	35.3	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **210.6 acres (43.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	563	$240
Ozone:	5,633	$17,305
Nitrogen Dioxide:	3,380	$10,383
Particulate Matter:	6,196	$12,709
Sulfur Dioxide:	2,253	$1,691
Totals:	**18,024**	**$42,328**

Carbon Storage and Sequestration

Total Tons Stored: **9,063.60**

Total Tons Sequestered (Annually): **70.56**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.25 in.

Curve Number reflecting existing conditions: 81

Curve Number using default replacement landcover: 93

Additional Storage volume needed: -19,126 cu. ft.

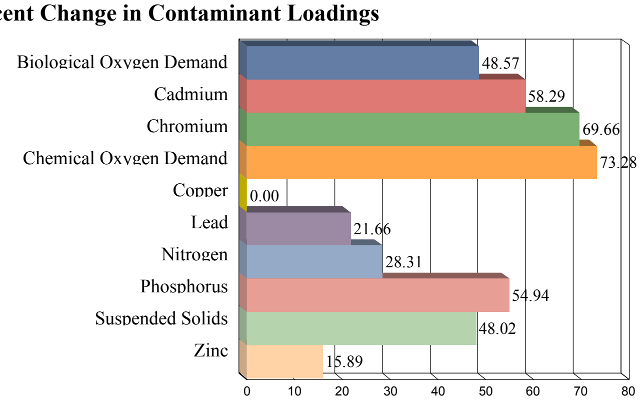
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-38,253**

Annual costs
(based on payments over 20 years at 6% interest): **$3,335** **per year**

Water Quality (Contaminant Loading)

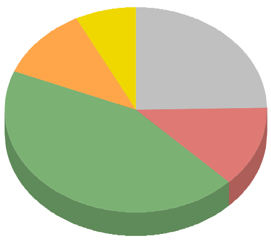
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 20% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	61.0	12.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	55.7	11.6%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **265.1 acres (55.2%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	709	$303
Ozone:	7,089	$21,778
Nitrogen Dioxide:	4,253	$13,067
Particulate Matter:	7,798	$15,994
Sulfur Dioxide:	2,835	$2,128
Totals:	**22,684**	**$53,269**

Carbon Storage and Sequestration

Total Tons Stored: **11,406.54**

Total Tons Sequestered (Annually): **88.80**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.25 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 81

Additional Storage volume needed: 0 cu. ft.

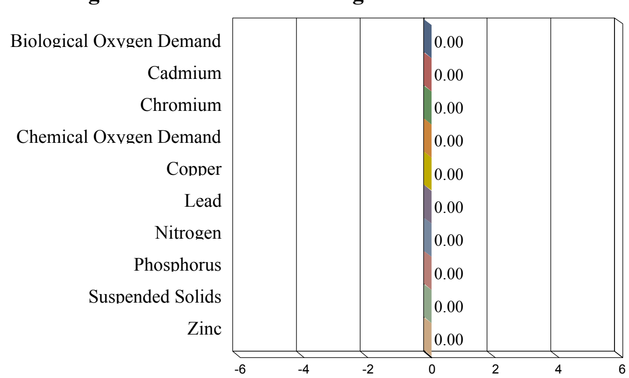
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$0**

Annual costs (based on payments over 20 years at 6% interest): **$0** **per year**

Water Quality (Contaminant Loading)

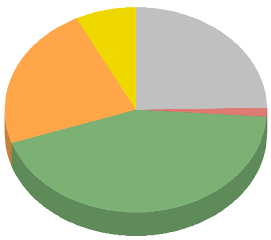
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 40% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	7.2	1.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	109.5	22.8%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **318.9 acres (66.4%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	853	$364
Ozone:	8,527	$26,197
Nitrogen Dioxide:	5,116	$15,718
Particulate Matter:	9,380	$19,239
Sulfur Dioxide:	3,411	$2,560
Totals:	**27,286**	**$64,078**

Carbon Storage and Sequestration

Total Tons Stored: **13,720.91**

Total Tons Sequestered (Annually): **106.82**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.25 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 80

Additional Storage volume needed: 9,058 cu. ft.

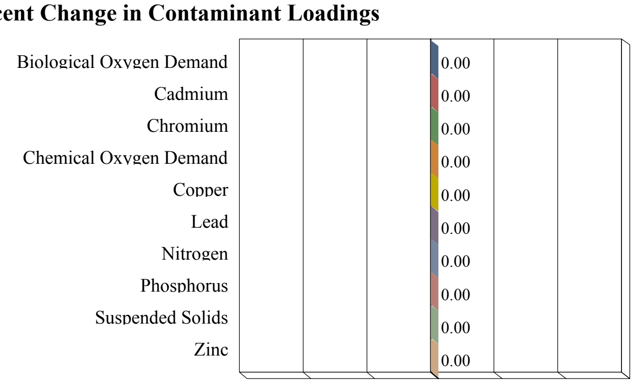
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$18,116**

Annual costs (based on payments over 20 years at 6% interest): **$1,579** **per year**

Water Quality (Contaminant Loading)

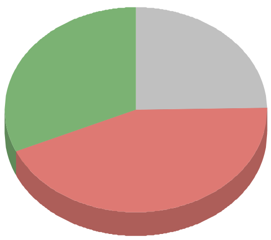
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 60% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	152.2	31.7%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **361.6 acres (75.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	967	$413
Ozone:	9,670	$29,708
Nitrogen Dioxide:	5,802	$17,825
Particulate Matter:	10,637	$21,818
Sulfur Dioxide:	3,868	$2,903
Totals:	**30,944**	**$72,666**

Carbon Storage and Sequestration

Total Tons Stored: **15,560.01**

Total Tons Sequestered (Annually): **121.14**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.25 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 79

Additional Storage volume needed: 18,819 cu. ft.

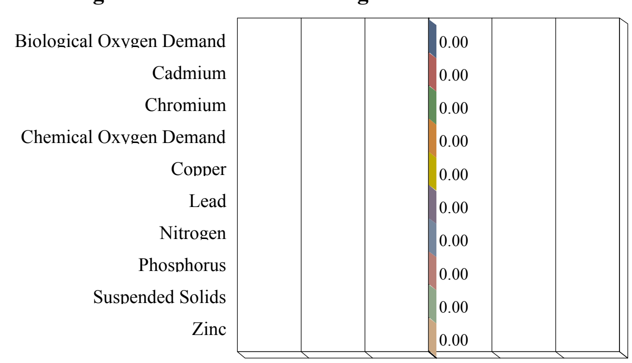
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$37,638**

Annual costs
(based on payments over 20 years at 6% interest): **$3,281** **per year**

Water Quality (Contaminant Loading)

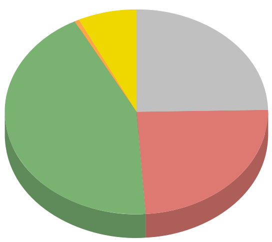
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides

Land Cover Distribution



Impervious Surfaces	118.7	24.7%
Open Space - Grass/Scattered Trees	115.6	24.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	1.4	0.3%
Urban: Residential: 0.125ac Lots	35.3	7.4%
Total:	480.2	100.0%

Land cover areas are in acres.

Total Tree Canopy: **210.6 acres (43.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	563	$240
Ozone:	5,633	$17,305
Nitrogen Dioxide:	3,380	$10,383
Particulate Matter:	6,196	$12,709
Sulfur Dioxide:	2,253	$1,691
Totals:	**18,024**	**$42,328**

Carbon Storage and Sequestration

Total Tons Stored: 9,063.60

Total Tons Sequestered (Annually): 70.56

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using default replacement landcover: 93

Additional Storage volume needed: 192,451 cu. ft.

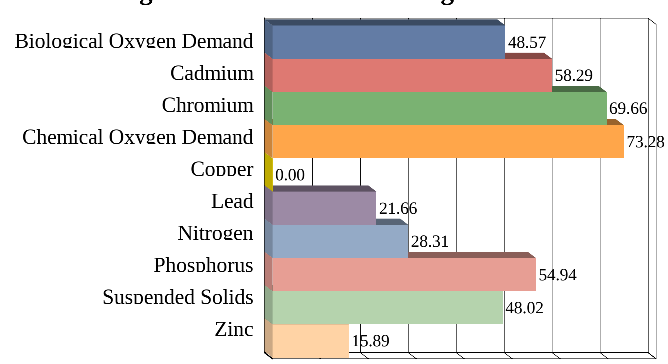
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: $384,903

Annual costs (based on payments over 20 years at 6% interest): **$33,558 per year**

Water Quality (Contaminant Loading)

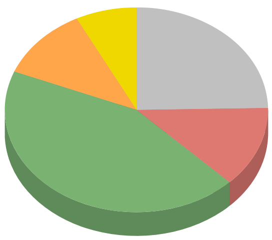
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 20% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	61.0	12.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	55.7	11.6%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres.

Total Tree Canopy: **265.1 acres (55.2%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	709	$303
Ozone:	7,089	$21,778
Nitrogen Dioxide:	4,253	$13,067
Particulate Matter:	7,798	$15,994
Sulfur Dioxide:	2,835	$2,128
Totals:	**22,684**	**$53,269**

Carbon Storage and Sequestration

Total Tons Stored: 11,406.54

Total Tons Sequestered (Annually): 88.80

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.50 in.

Curve Number reflecting existing conditions: 81
Curve Number using modeled landcover: 81

Additional Storage volume needed: 0 cu. ft.

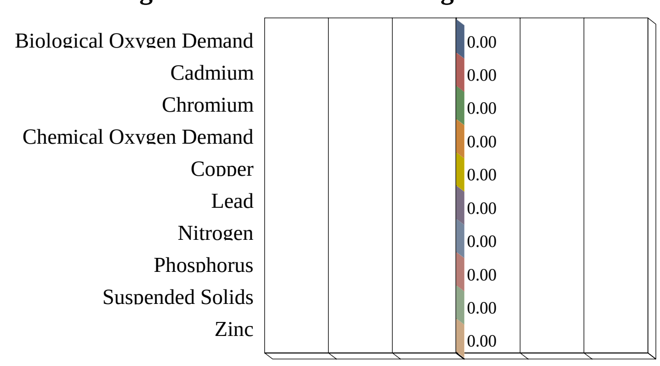
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$0**

Annual costs
(based on payments over 20 years at 6% interest): **$0** **per year**

Water Quality (Contaminant Loading)

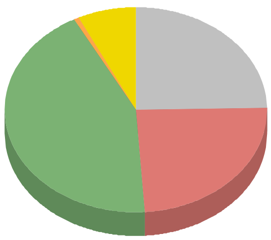
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides

Land Cover Distribution



Impervious Surfaces	118.7	24.7%
Open Space - Grass/Scattered Trees	115.6	24.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	1.4	0.3%
Urban: Residential: 0.125ac Lots	35.3	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **210.6 acres (43.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	563	$240
Ozone:	5,633	$17,305
Nitrogen Dioxide:	3,380	$10,383
Particulate Matter:	6,196	$12,709
Sulfur Dioxide:	2,253	$1,691
Totals:	**18,024**	**$42,328**

Carbon Storage and Sequestration

Total Tons Stored:	**9,063.60**
Total Tons Sequestered (Annually):	**70.56**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.75 in.

Curve Number reflecting existing conditions: 81

Curve Number using default replacement landcover: 93

Additional Storage volume needed: 410,917 cu. ft.

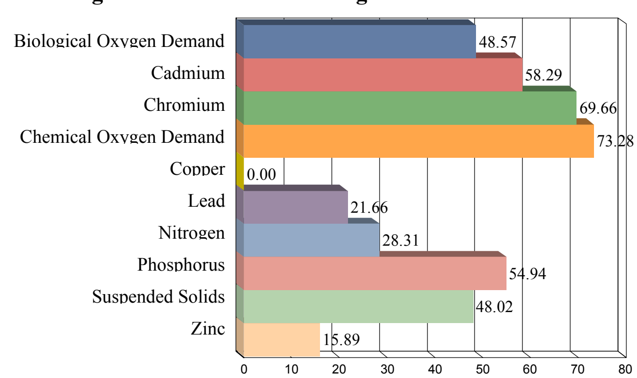
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$821,833**

Annual costs
(based on payments over 20 years at 6% interest): **$71,651** **per year**

Water Quality (Contaminant Loading)

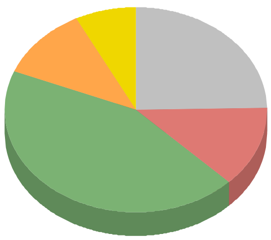
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 20% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	61.0	12.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	55.7	11.6%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **265.1 acres (55.2%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	709	$303
Ozone:	7,089	$21,778
Nitrogen Dioxide:	4,253	$13,067
Particulate Matter:	7,798	$15,994
Sulfur Dioxide:	2,835	$2,128
Totals:	**22,684**	**$53,269**

Carbon Storage and Sequestration

Total Tons Stored: **11,406.54**

Total Tons Sequestered (Annually): **88.80**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.75 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 81

Additional Storage volume needed: 0 cu. ft.

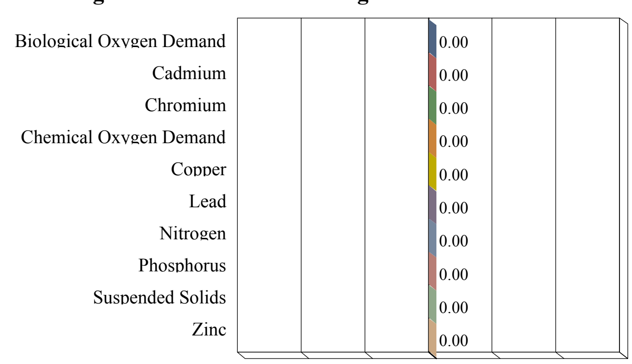
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$0**

Annual costs
(based on payments over 20 years at 6% interest): **$0** **per year**

Water Quality (Contaminant Loading)

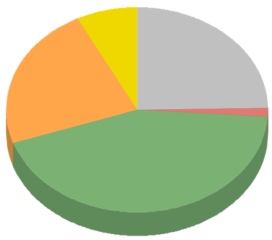
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 40% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	7.2	1.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	109.5	22.8%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **318.9 acres (66.4%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	853	$364
Ozone:	8,527	$26,197
Nitrogen Dioxide:	5,116	$15,718
Particulate Matter:	9,380	$19,239
Sulfur Dioxide:	3,411	$2,560
Totals:	**27,286**	**$64,078**

Carbon Storage and Sequestration

Total Tons Stored: **13,720.91**

Total Tons Sequestered (Annually): **106.82**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.75 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 80

Additional Storage volume needed: -12,736 cu. ft.

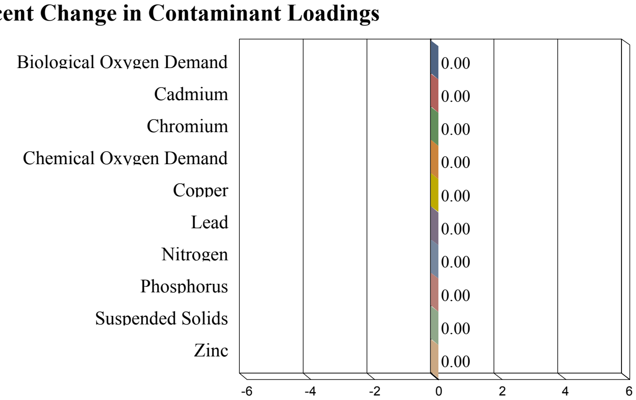
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-25,472**

Annual costs (based on payments over 20 years at 6% interest): **$2,221** **per year**

Water Quality (Contaminant Loading)

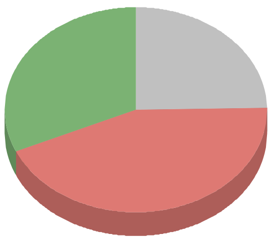
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 60% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	152.2	31.7%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **361.6 acres (75.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	967	$413
Ozone:	9,670	$29,708
Nitrogen Dioxide:	5,802	$17,825
Particulate Matter:	10,637	$21,818
Sulfur Dioxide:	3,868	$2,903
Totals:	**30,944**	**$72,666**

Carbon Storage and Sequestration

Total Tons Stored: **15,560.01**

Total Tons Sequestered (Annually): **121.14**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 0.75 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 79

Additional Storage volume needed: -23,461 cu. ft.

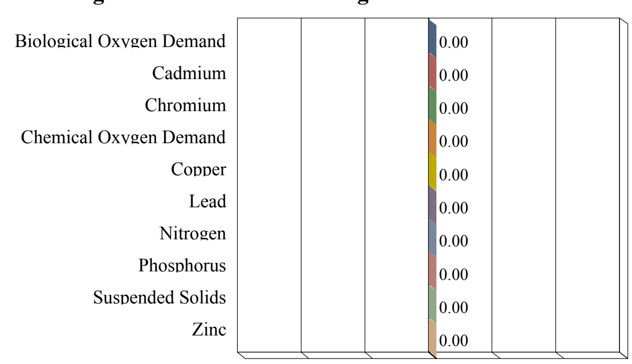
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-46,922**

Annual costs
(based on payments over 20 years at 6% interest): **$4,091** **per year**

Water Quality (Contaminant Loading)

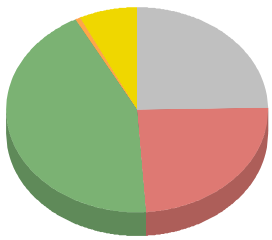
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides

Land Cover Distribution



Impervious Surfaces	118.7	24.7%
Open Space - Grass/Scattered Trees	115.6	24.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	1.4	0.3%
Urban: Residential: 0.125ac Lots	35.3	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **210.6 acres (43.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	563	$240
Ozone:	5,633	$17,305
Nitrogen Dioxide:	3,380	$10,383
Particulate Matter:	6,196	$12,709
Sulfur Dioxide:	2,253	$1,691
Totals:	**18,024**	**$42,328**

Carbon Storage and Sequestration

Total Tons Stored: **9,063.60**

Total Tons Sequestered (Annually): **70.56**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using default replacement landcover: 93

Additional Storage volume needed: 614,313 cu. ft.

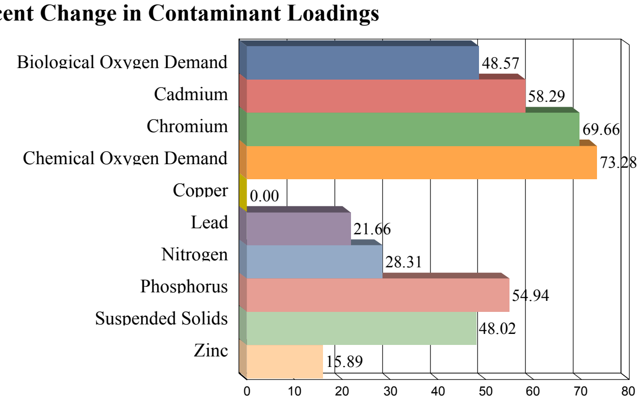
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$1,228,627**

Annual costs
(based on payments over 20 years at 6% interest): **$107,117** **per year**

Water Quality (Contaminant Loading)

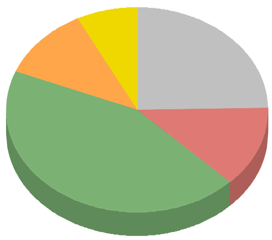
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 20% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	61.0	12.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	55.7	11.6%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **265.1 acres (55.2%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	709	$303
Ozone:	7,089	$21,778
Nitrogen Dioxide:	4,253	$13,067
Particulate Matter:	7,798	$15,994
Sulfur Dioxide:	2,835	$2,128
Totals:	**22,684**	**$53,269**

Carbon Storage and Sequestration

Total Tons Stored: **11,406.54**

Total Tons Sequestered (Annually): **88.80**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 81

Additional Storage volume needed: 0 cu. ft.

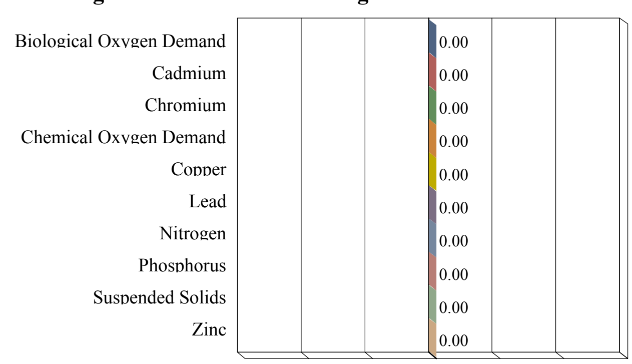
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$0**

Annual costs (based on payments over 20 years at 6% interest): **$0** **per year**

Water Quality (Contaminant Loading)

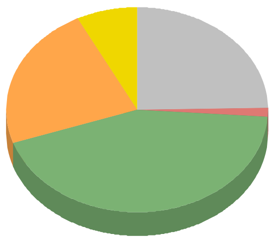
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 40% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	7.2	1.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	109.5	22.8%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **318.9 acres (66.4%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	853	$364
Ozone:	8,527	$26,197
Nitrogen Dioxide:	5,116	$15,718
Particulate Matter:	9,380	$19,239
Sulfur Dioxide:	3,411	$2,560
Totals:	**27,286**	**$64,078**

Carbon Storage and Sequestration

Total Tons Stored: **13,720.91**

Total Tons Sequestered (Annually): **106.82**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 80

Additional Storage volume needed: -25,515 cu. ft.

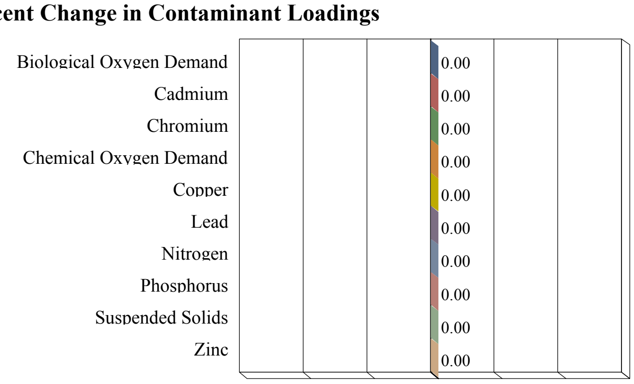
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-51,030**

Annual costs (based on payments over 20 years at 6% interest): **$4,449** **per year**

Water Quality (Contaminant Loading)

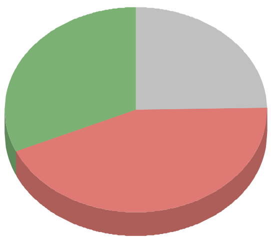
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 60% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	152.2	31.7%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **361.6 acres (75.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	967	$413
Ozone:	9,670	$29,708
Nitrogen Dioxide:	5,802	$17,825
Particulate Matter:	10,637	$21,818
Sulfur Dioxide:	3,868	$2,903
Totals:	**30,944**	**$72,666**

Carbon Storage and Sequestration

Total Tons Stored: **15,560.01**

Total Tons Sequestered (Annually): **121.14**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 79

Additional Storage volume needed: -48,481 cu. ft.

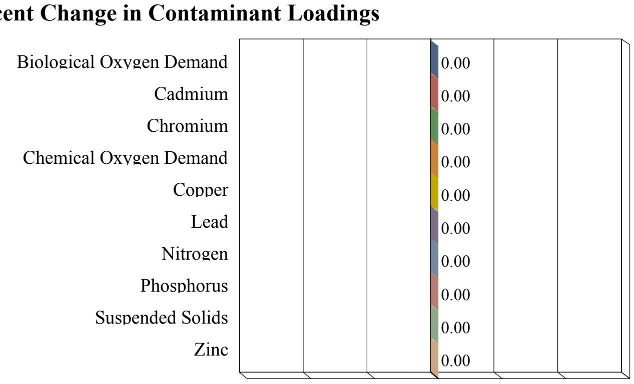
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-96,962**

Annual costs (based on payments over 20 years at 6% interest): **$8,454** **per year**

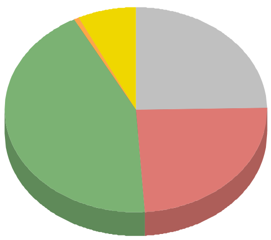
Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides



Land Cover Distribution

Impervious Surfaces	118.7	24.7%
Open Space - Grass/Scattered Trees	115.6	24.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	1.4	0.3%
Urban: Residential: 0.125ac Lots	35.3	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **210.6 acres (43.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	563	$240
Ozone:	5,633	$17,305
Nitrogen Dioxide:	3,380	$10,383
Particulate Matter:	6,196	$12,709
Sulfur Dioxide:	2,253	$1,691
Totals:	**18,024**	**$42,328**

Carbon Storage and Sequestration

Total Tons Stored: **9,063.60**

Total Tons Sequestered (Annually): **70.56**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using default replacement landcover: 93

Additional Storage volume needed: 961,443 cu. ft.

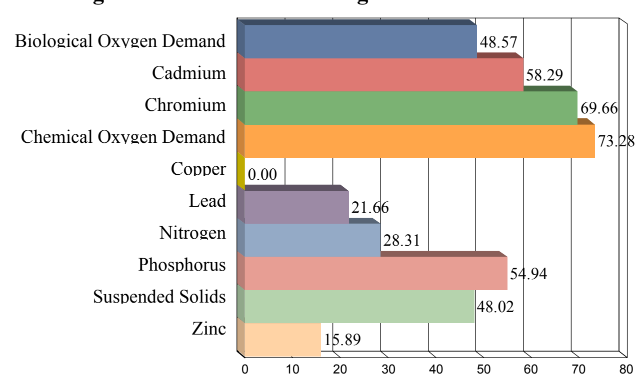
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$1,922,886**

Annual costs
(based on payments over 20 years at 6% interest): **$167,646** **per year**

Water Quality (Contaminant Loading)

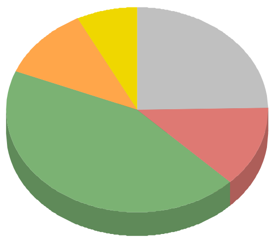
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 20% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	61.0	12.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	55.7	11.6%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **265.1 acres (55.2%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	709	$303
Ozone:	7,089	$21,778
Nitrogen Dioxide:	4,253	$13,067
Particulate Matter:	7,798	$15,994
Sulfur Dioxide:	2,835	$2,128
Totals:	**22,684**	**$53,269**

Carbon Storage and Sequestration

Total Tons Stored: **11,406.54**

Total Tons Sequestered (Annually): **88.80**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 81

Additional Storage volume needed: 0 cu. ft.

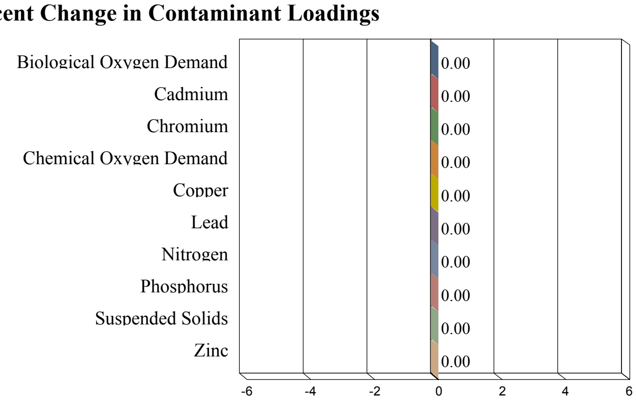
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$0**

Annual costs
(based on payments over 20 years at 6% interest): **$0** **per year**

Water Quality (Contaminant Loading)

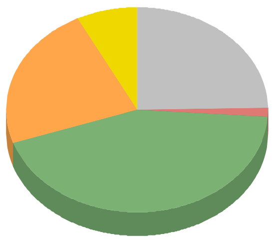
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 40% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	7.2	1.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	109.5	22.8%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **318.9 acres (66.4%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	853	$364
Ozone:	8,527	$26,197
Nitrogen Dioxide:	5,116	$15,718
Particulate Matter:	9,380	$19,239
Sulfur Dioxide:	3,411	$2,560
Totals:	**27,286**	**$64,078**

Carbon Storage and Sequestration

Total Tons Stored: **13,720.91**

Total Tons Sequestered (Annually): **106.82**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 80

Additional Storage volume needed: -50,569 cu. ft.

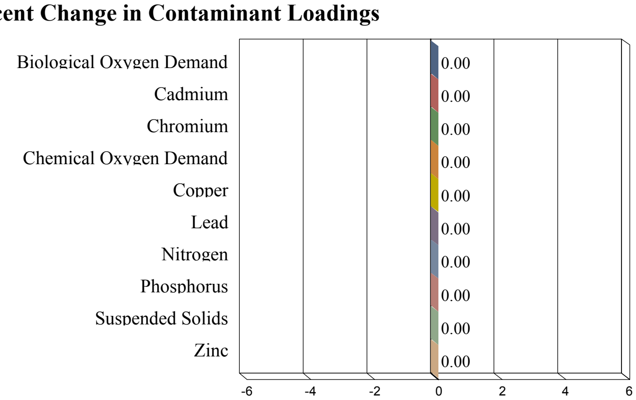
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-101,139**

Annual costs (based on payments over 20 years at 6% interest): **$8,818** **per year**

Water Quality (Contaminant Loading)

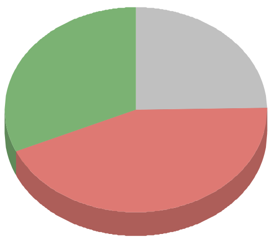
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 60% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	152.2	31.7%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **361.6 acres (75.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	967	$413
Ozone:	9,670	$29,708
Nitrogen Dioxide:	5,802	$17,825
Particulate Matter:	10,637	$21,818
Sulfur Dioxide:	3,868	$2,903
Totals:	**30,944**	**$72,666**

Carbon Storage and Sequestration

Total Tons Stored: **15,560.01**

Total Tons Sequestered (Annually): **121.14**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 1.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 79

Additional Storage volume needed: -97,893 cu. ft.

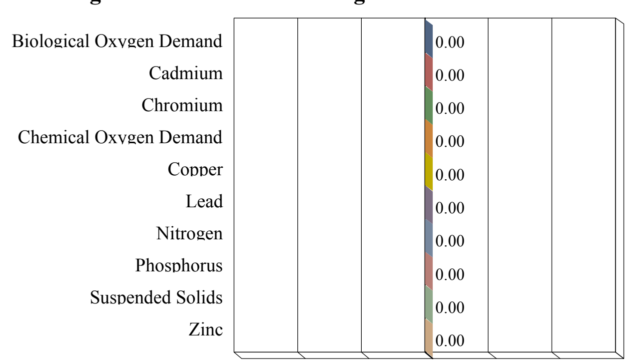
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-195,786**

Annual costs
(based on payments over 20 years at 6% interest): **$17,070** **per year**

Water Quality (Contaminant Loading)

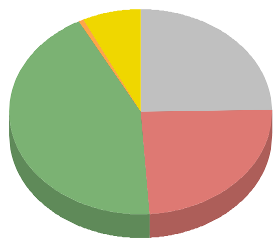
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides

Land Cover Distribution



Impervious Surfaces	118.7	24.7%
Open Space - Grass/Scattered Trees	115.6	24.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	1.4	0.3%
Urban: Residential: 0.125ac Lots	35.3	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **210.6 acres (43.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	563	$240
Ozone:	5,633	$17,305
Nitrogen Dioxide:	3,380	$10,383
Particulate Matter:	6,196	$12,709
Sulfur Dioxide:	2,253	$1,691
Totals:	**18,024**	**$42,328**

Carbon Storage and Sequestration

Total Tons Stored: **9,063.60**

Total Tons Sequestered (Annually): **70.56**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using default replacement landcover: 93

Additional Storage volume needed: 1,237,548 cu. ft.

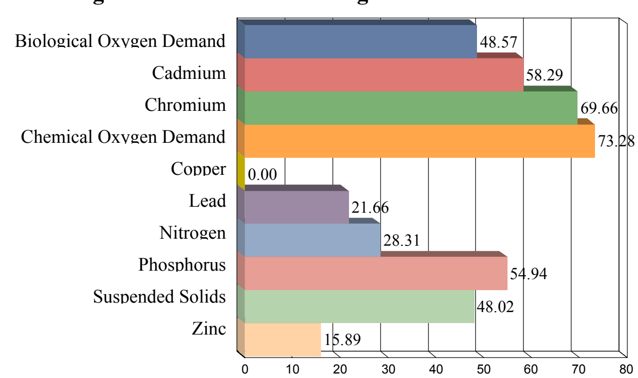
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$2,475,097**

Annual costs
(based on payments over 20 years at 6% interest): **$215,790** **per year**

Water Quality (Contaminant Loading)

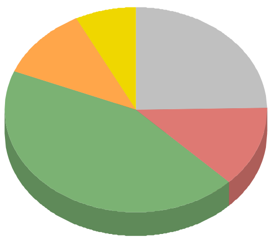
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 20% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	61.0	12.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	55.7	11.6%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **265.1 acres (55.2%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	709	$303
Ozone:	7,089	$21,778
Nitrogen Dioxide:	4,253	$13,067
Particulate Matter:	7,798	$15,994
Sulfur Dioxide:	2,835	$2,128
Totals:	**22,684**	**$53,269**

Carbon Storage and Sequestration

Total Tons Stored: **11,406.54**

Total Tons Sequestered (Annually): **88.80**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 81

Additional Storage volume needed: 0 cu. ft.

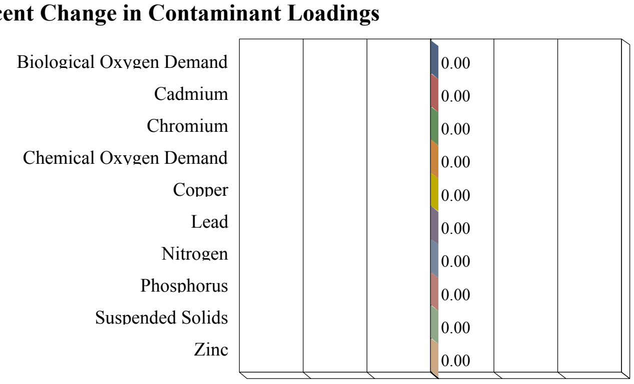
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$0**

Annual costs
(based on payments over 20 years at 6% interest): **$0** **per year**

Water Quality (Contaminant Loading)

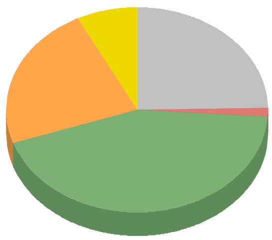
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 40% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	7.2	1.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	109.5	22.8%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **318.9 acres (66.4%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	853	$364
Ozone:	8,527	$26,197
Nitrogen Dioxide:	5,116	$15,718
Particulate Matter:	9,380	$19,239
Sulfur Dioxide:	3,411	$2,560
Totals:	**27,286**	**$64,078**

Carbon Storage and Sequestration

Total Tons Stored: **13,720.91**

Total Tons Sequestered (Annually): **106.82**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 80

Additional Storage volume needed: -73,291 cu. ft.

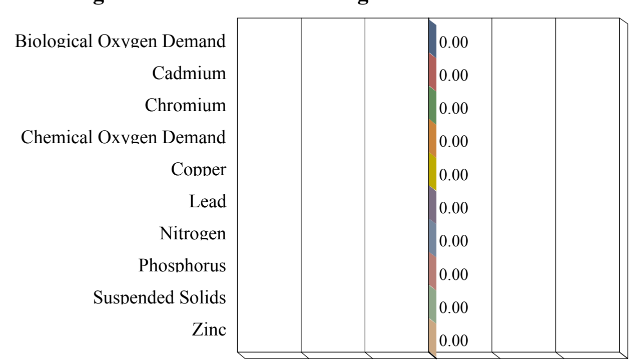
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-146,582**

Annual costs
(based on payments over 20 years at 6% interest): **$12,780** **per year**

Water Quality (Contaminant Loading)

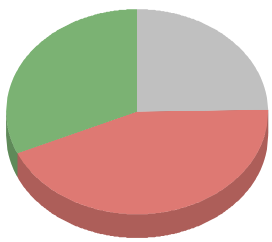
Percent Change in Contaminant Loadings



Analysis Report for:

Ross Run Hillsides: Reforest 60% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	152.2	31.7%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **361.6 acres (75.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	967	$413
Ozone:	9,670	$29,708
Nitrogen Dioxide:	5,802	$17,825
Particulate Matter:	10,637	$21,818
Sulfur Dioxide:	3,868	$2,903
Totals:	**30,944**	**$72,666**

Carbon Storage and Sequestration

Total Tons Stored: **15,560.01**

Total Tons Sequestered (Annually): **121.14**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.00 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 79

Additional Storage volume needed: -143,049 cu. ft.

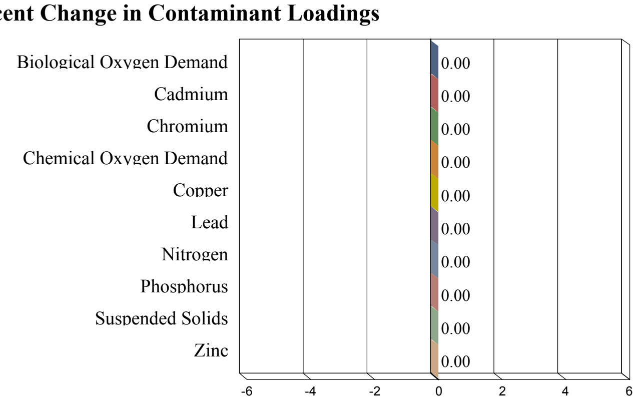
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-286,097**

Annual costs
(based on payments over 20 years at 6% interest): **$24,943** **per year**

Water Quality (Contaminant Loading)

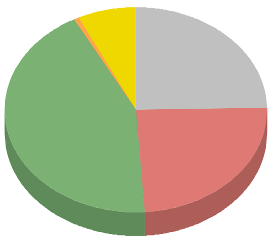
Percent Change in Contaminant Loadings



Analysis Report for:

Hillsides

Land Cover Distribution



Impervious Surfaces	118.7	24.7%
Open Space - Grass/Scattered Trees	115.6	24.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	1.4	0.3%
Urban: Residential: 0.125ac Lots	35.3	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **210.6 acres (43.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	563	$240
Ozone:	5,633	$17,305
Nitrogen Dioxide:	3,380	$10,383
Particulate Matter:	6,196	$12,709
Sulfur Dioxide:	2,253	$1,691
Totals:	**18,024**	**$42,328**

Carbon Storage and Sequestration

Total Tons Stored: **9,063.60**

Total Tons Sequestered (Annually): **70.56**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using default replacement landcover: 93

Additional Storage volume needed: 1,459,039 cu. ft.

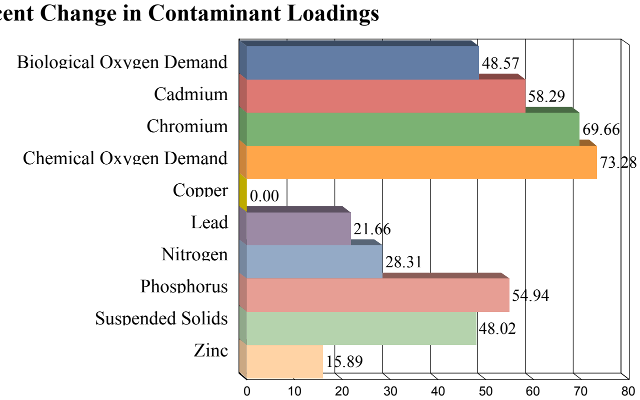
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$2,918,079**

Annual costs
(based on payments over 20 years at 6% interest): **$254,411** **per year**

Water Quality (Contaminant Loading)

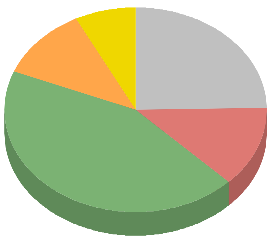
Percent Change in Contaminant Loadings



Analysis Report for:

Hillsides: Reforest 20% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	61.0	12.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover > 75%	55.7	11.6%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **265.1 acres (55.2%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	709	$303
Ozone:	7,089	$21,778
Nitrogen Dioxide:	4,253	$13,067
Particulate Matter:	7,798	$15,994
Sulfur Dioxide:	2,835	$2,128
Totals:	**22,684**	**$53,269**

Carbon Storage and Sequestration

Total Tons Stored: **11,406.54**

Total Tons Sequestered (Annually): **88.80**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 80

Additional Storage volume needed: -93,260 cu. ft.

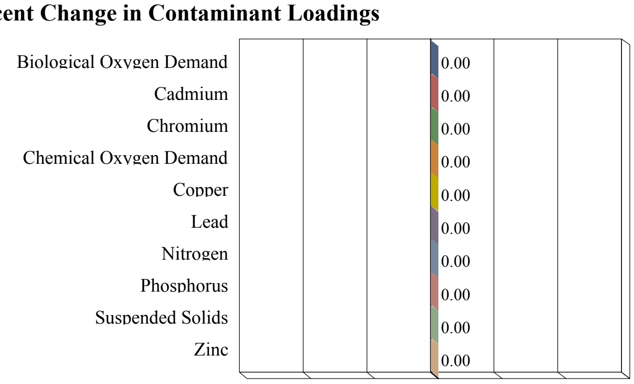
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-186,520**

Annual costs (based on payments over 20 years at 6% interest): **$16,262** **per year**

Water Quality (Contaminant Loading)

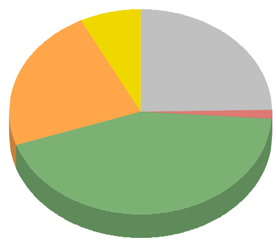
Percent Change in Contaminant Loadings



Analysis Report for:

Hillsides: Reforest 40% Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	7.2	1.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	109.5	22.8%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **318.9 acres (66.4%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	853	$364
Ozone:	8,527	$26,197
Nitrogen Dioxide:	5,116	$15,718
Particulate Matter:	9,380	$19,239
Sulfur Dioxide:	3,411	$2,560
Totals:	**27,286**	**$64,078**

Carbon Storage and Sequestration

Total Tons Stored: **13,720.91**

Total Tons Sequestered (Annually): **106.82**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 80

Additional Storage volume needed: -93,260 cu. ft.

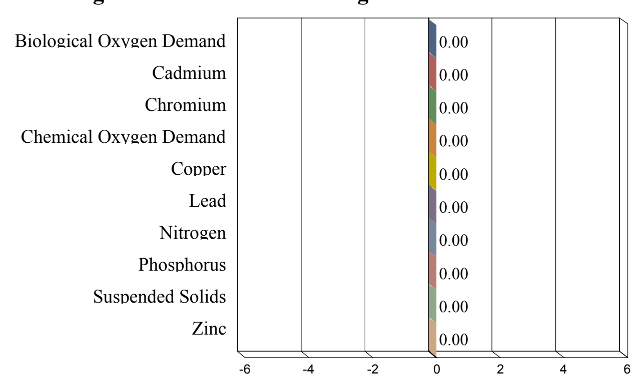
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-186,520**

Annual costs
(based on payments over 20 years at 6% interest): **$16,262** **per year**

Water Quality (Contaminant Loading)

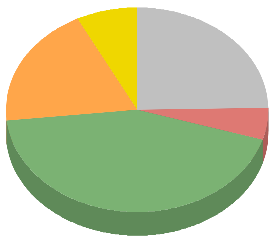
Percent Change in Contaminant Loadings



Analysis Report for:

Hillsides: Reforest 60% Reforestable Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Open Space - Grass/Scattered Trees	24.0	5.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	92.7	19.3%
Urban: Residential: 0.125ac Lots	35.5	7.4%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **302.1 acres (62.9%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	808	$345
Ozone:	8,078	$24,816
Nitrogen Dioxide:	4,847	$14,890
Particulate Matter:	8,885	$18,225
Sulfur Dioxide:	3,231	$2,425
Totals:	**25,848**	**$60,700**

Carbon Storage and Sequestration

Total Tons Stored: **12,997.67**

Total Tons Sequestered (Annually): **101.19**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 81

Additional Storage volume needed: 0 cu. ft.

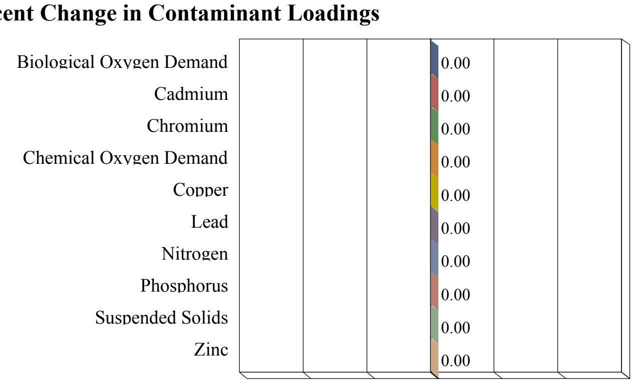
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$0**

Annual costs
(based on payments over 20 years at 6% interest): **$0 per year**

Water Quality (Contaminant Loading)

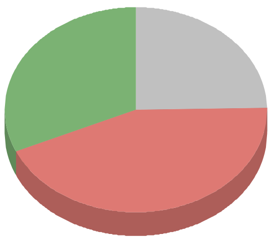
Percent Change in Contaminant Loadings



Analysis Report for:

Hillsides: Reforest All Reforestable Tree Deficient Area

Land Cover Distribution



Impervious Surfaces	118.6	24.7%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	209.4	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	152.2	31.7%
Total:	480.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **361.6 acres (75.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	967	$413
Ozone:	9,670	$29,708
Nitrogen Dioxide:	5,802	$17,825
Particulate Matter:	10,637	$21,818
Sulfur Dioxide:	3,868	$2,903
Totals:	**30,944**	**$72,666**

Carbon Storage and Sequestration

Total Tons Stored: **15,560.01**

Total Tons Sequestered (Annually): **121.14**

Stormwater

Water Quantity (Runoff)

2-yr, 24-hr Rainfall: 2.50 in.

Curve Number reflecting existing conditions: 81

Curve Number using modeled landcover: 79

Additional Storage volume needed: -182,968 cu. ft.

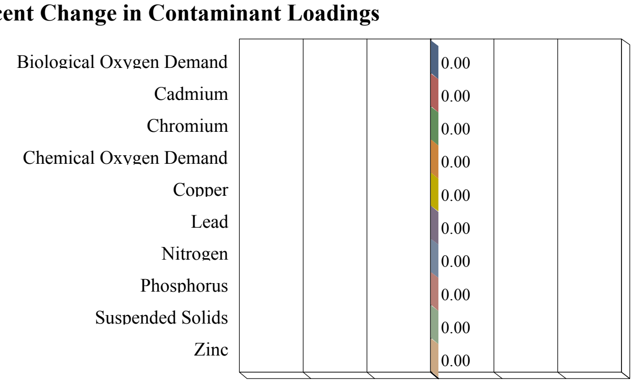
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-365,936**

Annual costs (based on payments over 20 years at 6% interest): **$31,904** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



APPENDIX B

HYDRAULIC & HYDROLOGIC MODELING

STORMWATER MODELING

As part of the opportunities analysis, preliminary drainage areas were delineated for each proposed opportunity utilizing GIS based contours and existing sewer infrastructure. Based on the review of the estimated stormwater reduction estimates for each opportunity and with input from MSD staff, a subset of the opportunities was identified as the modeled alternative. Drainage areas to each of the elements in the modeled alternative were refined for the purpose of performing more detailed hydrologic and hydraulic modeling. The watershed was divided into three distinct categories - Priority, 2nd Priority, and Non-priority areas. Area contributing flow to a recommended element with the modeled alternative were categorized as Priority Areas. Portions of the Ross Run watershed not impacted by the modeled alternative are identified as 2nd priority and non-priority areas because stormwater runoff will continue to enter the combined system and not impact the sizing of the proposed stormwater infrastructure.

It should be noted that the drainage area for the Ross Run based used in this evaluation does not match the drainage area used in MSD's System Wide Model (SWM) of the combined sewer system. This is attributable to the fact that the SWEP analysis uses ground contours to delineate drainage areas while the SWM appears to be based more on collection system configurations. The result of this discrepancy is that the Ross Run watershed as delineated in the SWM is approximately 3,913 acres while the Ross Run watershed as defined by the SWEP is approximately 3,811 acres. The information and data developed as part of the stormwater modeling, presented in this Appendix, is based on the 3,811 acre drainage area.

The volume of stormwater runoff produced by a storm event is impacted by the types of soil underlying the watershed. Soils having a high percentage of sand and gravel will absorb a greater amount of stormwater runoff than will soils having high clay content. This means that sandy soil generally produces less runoff than clay soil. The Natural Resource Conservation Service (NRCS) classifies soil types into categories known as Hydrologic Soil Groups (HSG). Group A soils consist of sandy soils having high infiltration rates and low runoff potential. Group B soils have moderately fine to moderately coarse textures and moderate runoff potential. Group C soils are typically sandy clay loam soils having moderately fine to fine textures and a low infiltration capacity. Examples of Group D soils include high content clay soils, soils with a permanent high water table, and shallow soils over nearly impervious material. Group D soils have a very low infiltration capacity and have high runoff potential.

The characteristics of the soils in the Ross Run watershed by hydrologic soil group are shown in the table below. Review of this data indicates that 86 percent of the watershed consists of HSG C soils and the remaining 14 percent consisting of HSG B soils.

Ross Run Hydrologic Soil Groups Table

HSG	Area (Acres)	Percent of Watershed
A	0	0%
B	501	13%
C	3310	87%
D	0	0%
Unnamed	0	0%
Total	3,811	100%

Land use is another factor that affects the amount of stormwater runoff that will be produced by a rainstorm. Urbanization and development that replaces natural vegetation with impervious surfaces reduce the ability of the ground to absorb stormwater, typically causing peak discharges and runoff volumes to increase. The time from the beginning of the storm event to the occurrence of the peak runoff may also be significantly shortened. The following table summarizes the areas and relative magnitude of various land use types within the watershed.

Ross Run Land Use Summary Table

Land Use	Area (acres)	Percent of Watershed
Cemetery	147	4%
Commercial/Industrial	616	16%
Multi-Residential	452	12%
Public Building	111	3%
Public Open Space	634	17%
Residential	833	22%
Road	754	20%
Undeveloped	264	7%
Total	3,811	100%

The Ross Run hydrologic model was developed using the computer program HEC-HMS (Version 4.0). HEC-HMS is a computer program developed by the USACE that simulates the precipitation-runoff process. HEC-HMS estimates peak stormwater discharges and volumes based on mathematical input parameters representing precipitation depth and time distribution, drainage area, land use, and time of concentration for each subbasin. Primary input parameters include the drainage area, runoff curve number (CN), and time of concentration (Tc). The CN considers land use, soil types, and saturation conditions and impacts the volume of stormwater runoff for a given rainfall depth. The Tc is the time it takes for stormwater to travel from the most hydrologically remote point in the watershed to the outfall. Parameters representing rainfall depth and distribution and watershed storage are also included in the model. Based upon user input coding, HEC-HMS generates hydrographs for each subbasin, routes them through storage areas, and combines them at appropriate locations. The result is a rainfall-runoff model of the storm event of interest. The following table summarizes the primary input parameters for each of the subbasins.

Ross Run Subbasin Characteristics Table

Subbasin ID	Subbasin Name	Subbasin Area (Ac)	Curve Number	Time of Concentration (min)
1	I-75 and Railroad Ave	20.06	91	13.86
2	I-75 and Norwood Lateral 2	1.76	78	10.00
3	I-75 and Norwood Lateral 3	9.96	83	24.00
6	Broermann Ave and Moeller Ave	35.55	83	20.22
7	Norwood Lateral and Paddock Rd	23.39	88	10.00
8	I-75 and Norwood Lateral 1	15.81	98	20.04
15	Kieley Place and Ross Ave	43.66	89	14.40

Subbasin ID	Subbasin Name	Subbasin Area (Ac)	Curve Number	Time of Concentration (min)
17	Ross Ave and Imwalle Ave	11.69	90	14.10
18	St. Mary's Cemetery	90.92	80	23.22
19	Chaley Dr and Heger Dr	22.68	84	14.22
21	Paddock Rd and Egan Hills Dr	10.91	88	10.00
22A	Paddock Hills Ave and Paddock Rd	6.08	82	22.80
22B	Paddock Hills Ave and Paddock Ln	4.96	84	14.05
24	Tennessee Ave and Reading Rd	19.15	86	13.80
24A	Tennessee Ave and Paddock Rd	7.42	92	18.90
29	Norwood Lateral and Reading Rd	27.43	92	13.32
30A	Former Showcase Cinema 2	20.61	93	15.36
30B	Ross Ave and Rhode Island Ave	41.28	91	16.80
30C	Former Showcase Cinema 1	8.43	93	37.80
32A	Rhode Island Ave and Lawn Ave	59.74	92	18.90
33	Indian Mound Ave and Montgomery Rd	26.75	85	14.34
34	Montgomery Rd and Norwood Ave	84.85	89	20.58
35	Norwood Lateral and Montgomery Rd	16.59	93	28.20
36	Montgomery Rd and Maple Ave	75.84	90	28.02
37	Elm Ave and Section Ave	70.16	89	25.50
38	Transpark Dr and Tennessee Ave	54.74	92	21.84
41	Mill Crest Park	153.99	86	32.94
42	Avon Field Golf Course 4	38.66	80	14.76
43	Avon Field Golf Course 3	7.45	79	16.80
44A	Avon Field Golf Course 2	30.71	79	11.04
45	Avon Field Golf Course 1	32.51	80	17.40
46	Avon Woods Nature Center 1	15.26	80	17.82
46A	Springmeadow Dr and Clearbrook Dr	21.25	82	12.97
47	Avon Woods Nature Center 2	9.81	80	19.50
50	Paddock Rd and Stratford Pl	9.13	86	14.04
51A	Debbie Ln and Stratford Pl	10.49	83	10.00
51B	Debbie Ln and Reading Rd	4.00	83	10.00
53	Houston Ave and Hopkins Ave	37.85	89	21.72
54	Sherman Ave and Carter Ave	76.70	89	31.68
55	Webster Ave and Hopkins Ave	24.51	80	18.42
56A	Cintas Center	13.89	79	24.66
56B	Wayland Ave and Ivanhoe Ave	30.02	90	10.98

Refer to the end of this Appendix for a full-size map showing the location of each of Ross Run subbasins.

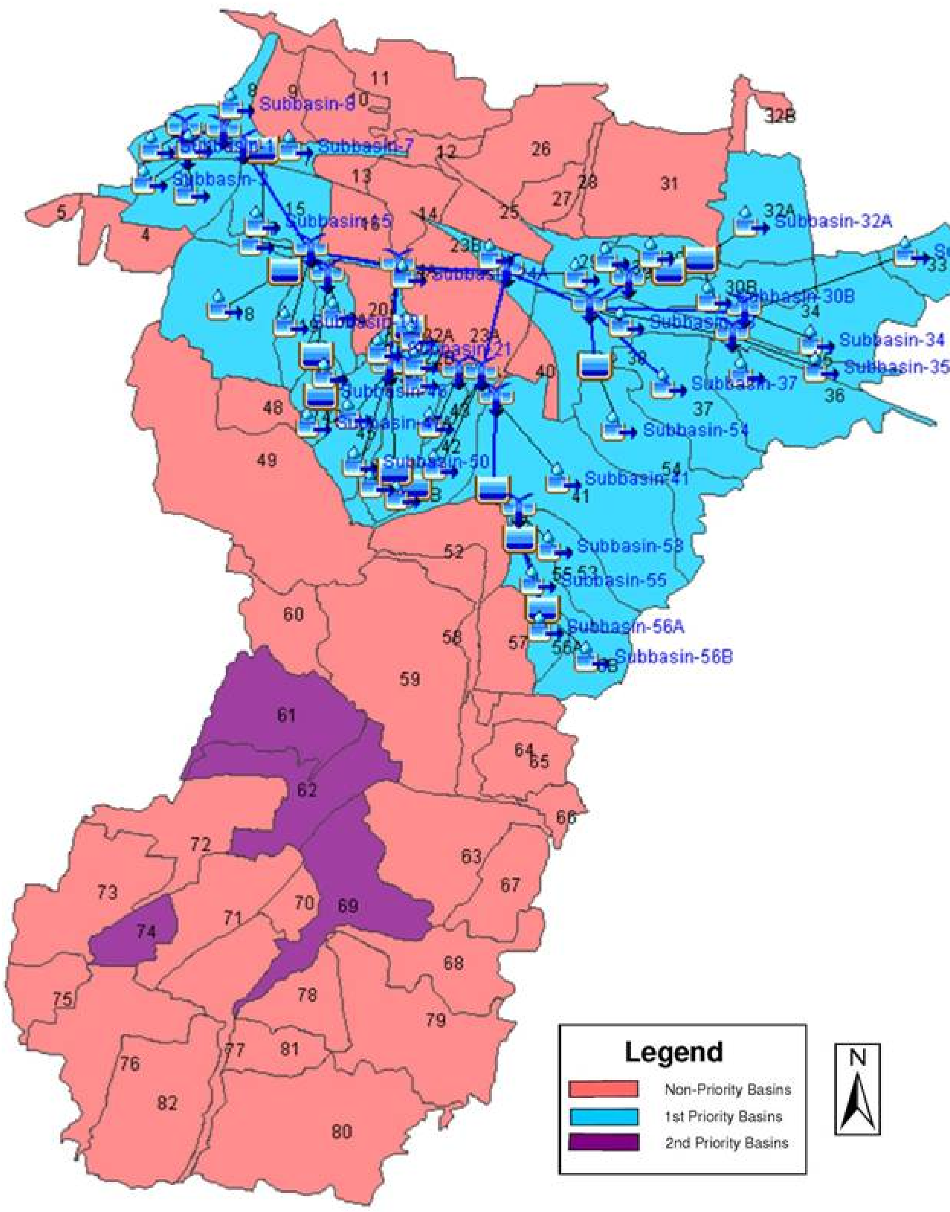
To model the Ross Run watershed, data for the input parameters was collected using MSDGC's GIS, CAGIS data, and data collected during field reconnaissance. Forty-three sub-watersheds were delineated within the Ross Run watershed. Based on the opportunities analysis the sub-watersheds were divided into 1st priority, 2nd priority and non-priority basins based on the ability to effectively remove stormwater from the basin area. Basins listed as 1st priority provide the opportunity to remove stormwater runoff from entering the combined system, basins listed as 2nd priority provide the opportunity to delay the amount of stormwater that enters the combined system, and non-priority basins will continue to discharge stormwater runoff directly to the CSS. Approximately 1,327 acres, nearly 35 percent, of the Ross Run watershed, were delineated as priority areas, and 255 acres, nearly 7 percent, were delineated as 2nd priority areas.

Within the priority areas the HEC-HMS model was used to generate runoff hydrographs for each of the priority subbasins which are then used to size proposed infrastructure. The scenario that was modeled included the installation of approximately 31,515 linear feet of proposed storm sewer, enhancement of ten existing basins, and the construction of three new detention basins.

The 2nd priority basins, which included 6 existing detention basins, were not included in the HECHMS evaluation since the flow from these basins will continue to discharge to the CSS and therefore is not factored into the sizing of the proposed storm sewer system. However, the potential impacts of the proposed detention facilities were incorporated in the CSO reduction modeling to be discussed later in this section. The following table summarizes the land and area and stormwater runoff generated by each basin category.

Basin Category	Area (Ac)	Percent of Area	Annual Stormwater Runoff (MG)	Percent of Stormwater Runoff
1st Priority	1,327	35%	708	34%
2nd Priority	255	7%	123	6%
Non-Priority	2,229	58%	1262	60%

The watershed schematic for the HEC-HMS model is shown below.



Ross Run HEC-HMS Watershed Schematic

Refer to the end of this Appendix for a full-size map showing the Ross Run HEC-HMS watershed schematic.

Storm Duration	10-year Rainfall Depth (inches)	Rainfall Distribution
0.5-hour	1.48	Huff 1st Quartile
1.0-hour	1.88	Huff 1st Quartile
2.0-hour	2.31	Huff 1st Quartile
3.0-hour	2.55	Huff 1st Quartile
6.0-hour	2.99	Huff 1st Quartile
24.0-hour	3.99	Huff 1st Quartile

Rainfall Depths and Distributions

Rainfall depths used for the hydrologic analysis were taken from Bulletin 71, Rainfall Frequency Atlas of the Midwest, Floyd A. Huff and James R. Angel, 1992. Appropriate Huff rainfall time distributions taken from Circular 173, Time Distribution of Heavy Rainstorms in Illinois, Floyd A. Huff, 1990, were applied for the analysis. 10-year frequency storm event rainfall depths for 0.5-, 1-, 2-, 3-, and 6-hour duration storms are presented in Table 3.01-3. Note that a Huff 1st Quartile rainfall distribution, which is typical of short duration storm events in the region, was applied for each of these storm durations.

The Ross Run HEC-HMS model was run for each of the above storm events and the peak discharge for each priority subbasin was recorded for each of the six events. A sensitivity analysis was performed to identify the storm duration generating the highest peak discharges for each of the priority subbasins. This analysis identified the critical 10-year storm duration for each of the priority subbasins. The following table summarizes the critical duration analysis.

Critical Duration Analysis Table

HEC-HMS Node	10YR-0.5Hr (cfs)	10YR-1Hr (cfs)	10YR-24Hr (cfs)	10YR-2Hr (cfs)	10YR-3Hr (cfs)	10YR-6Hr (cfs)
Junction-1	595.00	719.80	411.40	**779.80**	739.90	630.30
Junction-17	595.10	690.80	360.70	**727.00**	676.90	552.60
Junction-2	34.70	**39.70**	14.90	37.00	32.00	22.50
Junction-22B	20.60	**23.00**	9.10	21.30	18.30	12.80
Junction-24A	570.40	652.30	309.70	**664.60**	609.30	481.00
Junction-24B	600.00	**675.50**	276.40	652.60	582.10	432.60
Junction-30C	59.40	65.40	43.50	**67.10**	64.40	58.70
Junction-34	143.10	**151.10**	42.10	132.90	112.20	78.40
Junction-35	122.20	**131.20**	36.60	118.10	101.70	72.80
Junction-38	458.00	**503.10**	173.30	463.90	405.50	292.30
Junction-41	129.80	**148.90**	71.00	144.30	128.10	99.10
Junction-42	150.80	**174.40**	85.70	172.30	153.60	119.80
Junction-43	4.30	**5.10**	2.20	4.80	4.20	3.10
Junction-45	51.80	**59.00**	24.60	55.10	47.80	34.50
Junction-46A	21.00	**23.80**	13.10	22.60	20.20	17.00
Junction-53	50.60	**53.80**	21.80	48.40	41.90	30.40
Junction-7	580.10	691.40	383.90	**743.70**	701.20	588.20
Junction-8	599.90	707.50	390.70	**760.80**	717.10	601.00
Reach-15	66.80	**68.00**	16.80	57.30	47.10	33.60
Reach-18	42.30	**49.60**	27.30	51.30	47.00	38.30
Reach-19	531.50	642.60	358.70	**689.10**	650.30	546.00
Reach-2	34.40	**39.40**	14.90	36.90	31.90	22.50
Reach-22	3.70	**4.50**	1.90	4.40	3.90	2.90
Reach-24A	519.00	601.70	308.50	**631.40**	588.10	478.20
Reach-24B	510.80	581.40	274.90	**592.20**	544.10	429.20
Reach-30C	59.10	65.30	43.50	**67.10**	64.30	58.70
Reach-34	132.30	**143.30**	42.00	129.70	110.90	77.70
Reach-37	83.20	**90.40**	26.90	82.30	71.00	50.20
Reach-38	412.90	**457.70**	173.00	437.10	390.30	288.10
Reach-41	128.20	**147.30**	71.00	143.60	127.70	99.00
Reach-42	150.60	**174.20**	85.70	172.20	153.50	119.80
Reach-45	56.00	**65.40**	28.20	62.10	54.20	39.90
Reach-46A	20.80	**23.70**	13.10	22.60	20.20	17.00
Reach-53	8.60	14.00	**18.30**	17.00	17.30	17.60

HEC-HMS Node	10YR-0.5Hr (cfs)	10YR-1Hr (cfs)	10YR-24Hr (cfs)	10YR-2Hr (cfs)	10YR-3Hr (cfs)	10YR-6Hr (cfs)
Reach-54	1.80	2.20	**3.20**	2.50	2.70	2.90
Reach-56A	12.70	13.70	11.70	**14.00**	**14.00**	13.60
Reach-7	21.00	**22.70**	8.80	21.70	19.70	14.90
Reach-8	558.30	682.00	389.00	**735.20**	698.50	594.80
Reservoir-18	42.40	49.70	27.30	**51.30**	47.00	38.30
Reservoir-22	3.70	**4.50**	1.90	4.40	3.90	2.90
Reservoir-30A	48.60	55.20	40.00	**57.60**	56.70	52.50
Reservoir-32A	38.10	42.60	32.90	**43.50**	43.50	41.60
Reservoir-41	8.60	14.10	**18.30**	17.00	17.30	17.60
Reservoir-46	6.30	7.80	6.60	8.20	**8.30**	7.60
Reservoir-47	4.40	5.30	2.90	**5.50**	5.10	4.20
Reservoir-51A	2.20	2.70	2.60	**2.90**	**2.90**	2.80
Reservoir-51B	1.20	1.40	1.10	**1.50**	**1.50**	1.40
Reservoir-54	1.80	2.20	**3.20**	2.50	2.70	2.90
Reservoir-55	5.80	6.70	**9.40**	7.70	8.20	9.00
Reservoir-56A	12.70	13.70	11.70	**14.00**	**14.00**	13.60
Reservoir-7	21.00	**22.70**	8.80	21.80	19.70	14.90
Subbasin-1	**38.80**	37.70	8.10	30.20	25.20	17.70
Subbasin-15	**69.80**	69.70	16.90	57.60	47.20	33.80
Subbasin-17	**20.60**	20.20	4.60	16.50	13.50	9.70
Subbasin-18	51.20	**61.50**	27.40	59.50	52.00	39.10
Subbasin-19	23.10	**24.50**	7.80	21.70	18.30	12.20
Subbasin-2	1.10	**1.20**	0.50	1.10	1.00	0.70
Subbasin-21	**18.10**	17.60	4.10	13.90	11.30	8.10
Subbasin-22	4.20	**4.90**	2.00	4.60	4.00	2.90
Subbasin-22B	5.00	**5.40**	1.70	4.70	4.00	2.70
Subbasin-24A	13.70	**13.70**	3.00	11.40	9.50	6.80
Subbasin-24B	23.80	**24.50**	6.90	21.00	17.50	12.00
Subbasin-29	**59.10**	56.30	11.20	44.60	37.80	25.90
Subbasin-3	7.40	**8.50**	3.30	8.00	7.00	5.00
Subbasin-30A	**45.70**	43.80	8.60	35.20	29.90	20.70
Subbasin-30B	**73.70**	73.20	16.60	60.70	50.10	36.00
Subbasin-30C	11.40	**12.30**	3.50	11.40	10.00	7.40
Subbasin-32A	**110.00**	109.90	24.40	92.10	76.70	55.10
Subbasin-33	29.80	**31.30**	9.40	27.30	22.90	15.50
Subbasin-34	115.30	**120.70**	32.70	105.80	89.30	63.00
Subbasin-35	26.70	**28.10**	6.90	24.80	21.30	15.50
Subbasin-36	95.60	**103.20**	29.70	93.40	80.60	57.40
Subbasin-37	85.50	**92.20**	26.90	83.10	71.40	50.30
Subbasin-38	93.50	**95.50**	22.30	81.90	68.70	49.60
Subbasin-41	127.40	**145.20**	54.70	138.70	122.20	88.80
Subbasin-42	25.90	**29.70**	11.80	27.70	23.80	16.80
Subbasin-43	4.30	**5.10**	2.20	4.80	4.20	3.10
Subbasin-44A	20.60	**23.00**	9.10	21.30	18.30	12.80
Subbasin-45	20.50	**24.00**	9.90	22.60	19.60	14.10
Subbasin-46	9.50	**11.20**	4.60	10.60	9.10	6.60

HEC-HMS Node	10YR-0.5Hr (cfs)	10YR-1Hr (cfs)	10YR-24Hr (cfs)	10YR-2Hr (cfs)	10YR-3Hr (cfs)	10YR-6Hr (cfs)
Subbasin-46A	18.40	**19.90**	6.90	17.90	15.20	10.20
Subbasin-47	5.90	**7.00**	3.00	6.70	5.80	4.20
Subbasin-50	11.30	**11.60**	3.30	10.00	8.30	5.70
Subbasin-51A	10.90	**11.30**	3.50	9.70	8.20	5.40
Subbasin-51B	4.20	**4.30**	1.30	3.70	3.10	2.10
Subbasin-53	50.10	**52.80**	14.60	46.60	39.50	27.90
Subbasin-54	83.20	**91.80**	29.30	85.20	74.40	53.10
Subbasin-55	15.10	**17.80**	7.40	16.90	14.60	10.60
Subbasin-56A	6.90	**8.50**	4.10	8.30	7.30	5.70
Subbasin-56B	**58.10**	55.40	11.80	43.10	36.40	25.20
Subbasin-6	26.70	**30.30**	11.10	28.10	24.20	16.90
Subbasin-7	**38.90**	37.80	8.90	29.80	24.20	17.30
Subbasin-8	**47.80**	45.50	7.00	37.30	31.90	22.60

Use of the HEC-HMS hydrologic model for developing peak discharges was selected primarily to evaluate the potential effects of both existing and future stormwater detention facilities in the priority basins. Based on site visits to all of the facility locations and review of pertinent GIS data it was decided that seven of the ten basins were not good candidates for retrofits due to the limited potential to significantly increase storage capacity and therefore these facilities were not included in the modeled alternative. However, the three basins suitable for retrofitting to reduce peak outflow rates are located in Priority Subbasin 7 along the Norwood Lateral, Priority Subbasin 47 in Avon Fields park, and Priority Subbasin 55 near Victory Parkway and Asmann Avenue.

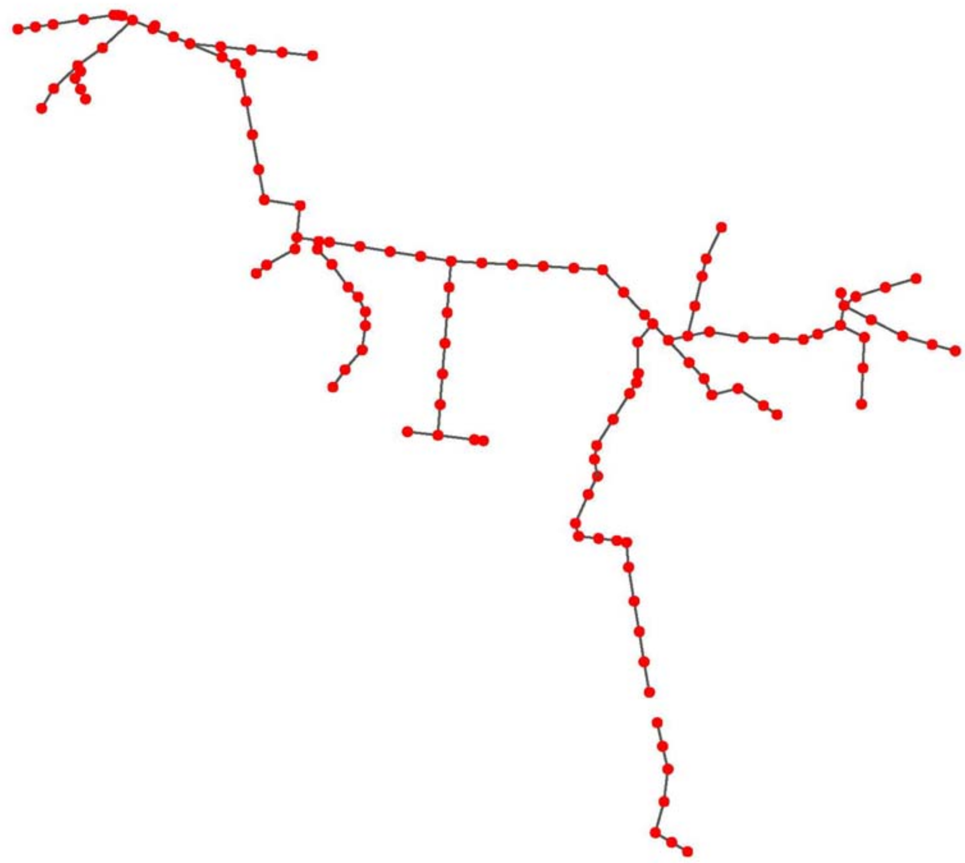
The HEC-HMS model was utilized to generate peak flows for specific node locations based on the proposed separate storm network, existing detention basins and proposed detention basins. The following table provides summaries of the estimated peak 10-year return frequency discharges that were used to size the proposed storm sewer improvements.

Peak Discharge Summary Table

HEC-HMS Node ID	Location Description	Drainage Area (acres)	Peak 10-Year Discharge (cfs)
Reservoir 56A	Cintas Center Existing Basin	43.90	14.00
Reservoir 55	Webster Ave and Houston Ave	68.41	9.40
Reach 41	Reading Rd and Victory Pkwy	42.66	30.80
Subbasin 43	Avon Field Golf Course 3	7.45	5.10
Junction 45	Paddock Rd and Egan Hills Dr	93.74	81.60
Junction 24A	Ross Ave and Paddock Rd	814.14	664.60
Junction 17	Ross Ave and Fischer Pl	1201.47	727.00
Junction 1	I-75 at Norwood Lateral	1331.60	779.80
Reservoir 30A	Showcase Cinema Existing Basin	121.62	57.60
Subbasin 37	Elm Ave and Section Ave	70.16	92.20
Junction 34 + Junction 35	Norwood Lateral and Section Ave	204.03	282.30
Subbasin 30C	Former Showcase Cinema West	8.43	12.30
Junction 38	Transpark Dr and Tennessee Ave	334.08	503.10

HEC-HMS Node ID	Location Description	Drainage Area (acres)	Peak 10-Year Discharge (cfs)
Reservoir 54	Maple Ave and McNeil Ave	76.70	3.20
Junction 24B	Reading Rd and Tennessee Ave	691.03	675.50
Subbasin 45	Avon Field Golf Course 1	32.51	24.00
Subbasin 50	Paddock Rd and Stratford Pl	9.13	11.60
Reservoir 22A	Paddock Hills and Paddock Rd	6.08	4.50
Reservoir 18	St. Mary's Cemetery	90.92	51.30
Subbasin 7	Norwood Lateral and Paddock Rd	23.39	38.90
Junction 7	I-75 and Norwood Lateral East	1268.52	743.70
Subbasin 8	I-75 and Norwood Lateral North	15.81	47.80
Subbasin 3	I-75 and Norwood Lateral South	9.96	8.50
Junction 2	Ross Park and I-75	47.27	39.70
Subbasin 6	Broermann Ave and Moeller Ave	35.55	30.30
Subbasin 29	Norwood Lateral and Reading Rd	27.43	59.10
Reservoir 46	Avon Woods Nature Center North	93	8.30
Junction 46A	Baseball Fields along Tennesssee Ave	46.32	23.80
Reservoir 41	Mill Crest Park	106.27	18.30
Junction 53	Asmann Ave and Victory Pkwy	106.27	53.80
Junction 41	Sherman ave and Victory Pkway	260.26	148.90
Reservoir 32A	Former Showcase Cinema East	101.02	43.50
Subbasin 19 + Reservoir 18	Chalet Dr and St. Mary's Cemetery	113.61	75.80
Subbasin 15	Kieley Place and Ross Ave	43.66	69.80

In order to determine the feasibility and size the proposed storm sewer systems, a hydraulic model using Bentley StormCAD V8 XM Edition (StormCAD) was developed. Based on the preliminary storm sewer layout, pipe network data was input into the model including the storm sewer alignments, approximate pipe slopes, manhole locations, rim and invert elevations, and 10-year peak discharge data. A system schematic of the proposed storm sewer system is shown below.



Ross Run StormCAD System Schematic

Refer to the end of this Appendix for a more detailed full-size map showing the Ross Run StormCAD system schematic.

In an effort to generate reasonable cost estimates for the proposed storm sewer infrastructure, it was necessary to perform coarse level modeling of the proposed system to develop planning level quantities for storm sewer construction. The quantities represented in this analysis are based on conceptual plan view alignments with assumed average depths. Additional field work and utility location will be required to develop more refined plan and profile information.

As stated in the SMU design standards for Storm Sewers, Section 9.2.2 Design Frequency states: "Storm sewer sizing shall be based on the just full capacity for a 10-year frequency rainfall. After initial sizing, a hydraulic grade line (HGL) check shall be made for a 25-year frequency rainfall. If the check shows water flowing out of the system, then the system need to be revised to contain the rainfall."

However, based on the preliminary nature of the study at this stage of the project, the modeling used to size the piping network assumed a minimum cover of four feet and the hydraulic grade line for the 10-year design storm would remain below the existing ground elevation. This modeling approach is consistent with previous preliminary sizing exercises performed on the Lick Run Watershed as part of the SWEP process. If the Ross Run is advanced to a higher level of design additional and more detailed information on existing utilities, ground surface, etc. will be required to update the preliminary model to demonstrate compliance with the SMU requirements (i.e. the hydraulic grade line for the 10-year storm is contained within the pipe). Inlet capacity calculations were not performed as part of this hydraulic analysis. As preliminary design of the storm sewer system proceeds, proposed inlet structures should be designed and analyzed to confirm adequate inlet capacity is available to intercept a 10-year return frequency event and that the proposed storm sewer system has adequate capacity to store and convey the runoff from a 25-year design storm event without surcharging to the ground surface.

The following table summarizes the results of the StormCAD storm sewer hydraulic analysis providing physical pipe data for each proposed storm sewer segment including pipe lengths, sizes, slopes, design 10-year flows, and estimated pipe flowing full capacities. **It should be noted that the hydraulic evaluation of the proposed storm sewer system indicates that the elevation of the HGL for the 25-year storm exceeds the ground surface elevation at a number of structures. If it is determined that the construction of the storm sewer system is a viable option to pursue, future design efforts should ensure that the HGL for the 25-year design storm remains below the ground surface elevation at all locations in the proposed storm sewer system. Refinement to pipe sizes, slopes, and depths during the advancement of sewer design are mechanism to achieve the desired performance of the system.** Refer to the end of this Appendix for the 10-year storm hydraulic grade line profiles.

Proposed Storm Sewer Data

Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-400	I-285	300.5	10 x 6 ft	0.5%	675.5	737.38
I-285	MH-443	299.5	10 x 6 ft	0.5%	664.6	737.38
MH-443	MH-444	300	10 x 6 ft	0.5%	664.6	737.38
MH-444	MH-445	300	10 x 6 ft	0.5%	664.6	737.38
MH-445	MH-446	300	10 x 6 ft	0.5%	664.6	737.38
I-290	MH-450	313.5	10 x 6 ft	0.5%	727.0	737.38
MH-450	MH-451	353.5	10 x 6 ft	0.5%	727.0	737.38
MH-446	MH-486	104.5	10 x 6 ft	0.5%	664.6	737.38
MH-486	I-290	215.5	10 x 6 ft	0.5%	688.4	737.38
MH-466	I-307	300	10 x 8 ft	0.5%	831.2	1101.08
I-307	MH-467	174	10 x 8 ft	0.5%	779.8	1101.08
MH-467	OF-48	173	10 x 8 ft	0.5%	779.8	1104.26
MH-451	MH-452	301	10 x 8 ft	0.5%	727.0	1101.08
MH-452	MH-496	345	10 x 8 ft	0.5%	727.0	1101.08
MH-496	MH-453	331.5	10 x 8 ft	0.5%	727.0	1101.08
I-337	MH-457	167	10 x 8 ft	1.1%	743.7	1630.05
MH-457	MH-458	175.5	10 x 8 ft	0.5%	743.7	1102.65
MH-458	MH-459	216.5	10 x 8 ft	0.5%	743.7	1101.08
MH-459	MH-462	218	10 x 8 ft	0.5%	791.5	1101.08
MH-462	MH-463	105	10 x 8 ft	0.5%	831.2	1101.08
MH-463	MH-464	36	10 x 8 ft	0.5%	831.2	1101.08

Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-464	MH-465	46	10 x 8 ft	0.5%	831.2	1101.08
MH-465	MH-466	299.5	10 x 8 ft	0.5%	831.2	1101.08
MH-453	I-337	632	10 x 8 ft	0.5%	727.0	1101.08
MH-397	MH-398	300	102 inch	0.5%	675.5	758.06
MH-398	MH-399	300	102 inch	0.5%	675.5	758.06
MH-399	MH-400	300	102 inch	0.5%	675.5	758.06
I-327	MH-397	280.5	102 inch	0.5%	675.5	758.06
MH-394	MH-395	300	96 inch	0.5%	601.3	644.90
MH-411	MH-417	195	96 inch	0.5%	562.2	644.90
MH-395	I-327	300	96 inch	0.5%	601.3	644.90
MH-417	MH-494	221.5	96 inch	4.9%	565.4	2014.34
MH-494	MH-394	117.5	96 inch	0.5%	601.3	644.90
MH-390	MH-391	286	84 inch	0.5%	444.4	451.70
MH-391	I-324	300	84 inch	1.1%	444.4	660.78
I-324	MH-393	334	84 inch	1.8%	503.1	855.47
MH-393	MH-411	215.5	84 inch	1.2%	503.1	712.04
MH-389	MH-390	150	78 inch	1.1%	444.4	556.46
MH-407	MH-389	236.5	78 inch	0.8%	444.4	474.81
MH-406	MH-407	197	72 inch	1.3%	352.2	482.75
MH-493	MH-494	233.5	72 inch	0.9%	35.9	408.25
MH-404	MH-405	299.5	66 inch	0.9%	282.3	325.25
MH-405	MH-403	345	66 inch	2.8%	282.3	565.94
MH-403	MH-406	301	66 inch	5.4%	282.3	779.73
I-318	MH-404	234.5	60 inch	1.6%	282.3	326.69
I-348	MH-423	96.5	60 inch	0.5%	148.9	184.15
MH-423	MH-424	180	60 inch	0.5%	148.9	184.15
MH-424	I-270	195	60 inch	0.5%	148.9	184.15
I-270	MH-425	129.5	60 inch	0.5%	30.8	184.15
MH-425	MH-426	308	60 inch	0.5%	30.8	186.97
MH-426	MH-427	200.5	60 inch	0.5%	30.8	184.15
MH-427	MH-487	168	60 inch	0.5%	35.9	184.15
MH-487	MH-488	130	60 inch	0.5%	35.9	184.15
MH-488	MH-489	300.5	60 inch	0.5%	35.9	184.15
MH-489	MH-490	300	60 inch	0.5%	35.9	184.15
MH-490	MH-491	125	60 inch	0.5%	35.9	184.15
MH-491	MH-492	93.5	60 inch	0.5%	35.9	184.15
MH-492	MH-493	304.5	60 inch	1.2%	35.9	280.10
I-317	MH-401	353	48 inch	0.5%	92.2	101.57
MH-401	MH-402	300	48 inch	0.5%	92.2	101.57
MH-410	MH-411	299.5	48 inch	0.7%	59.1	117.38
MH-439	MH-440	134.5	48 inch	0.5%	86.1	101.57

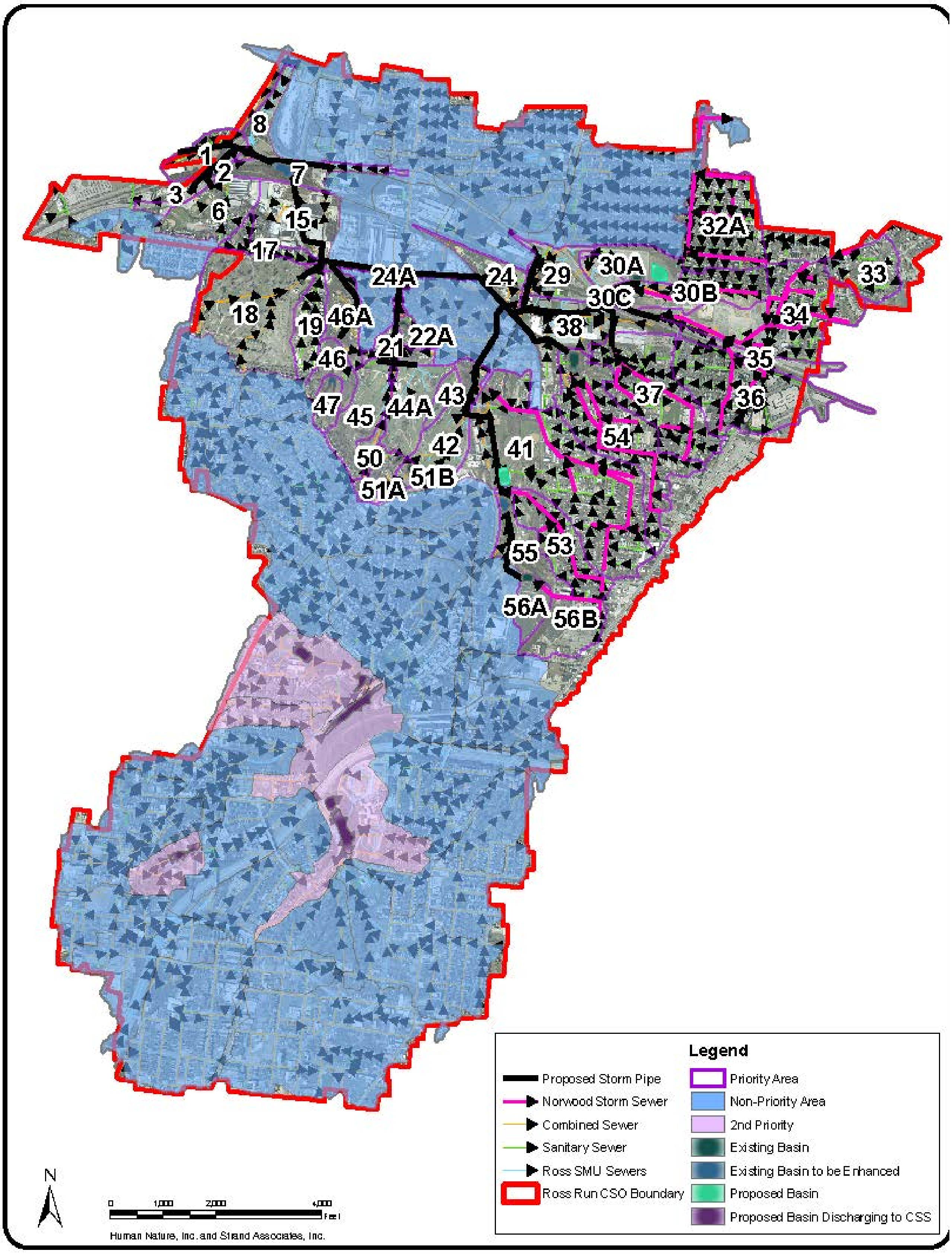
Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-440	MH-441	301	48 inch	0.5%	86.1	101.57
MH-441	MH-442	249	48 inch	2.6%	86.1	229.47
MH-442	I-285	257	48 inch	6.5%	86.1	366.58
I-351	I-290	113.5	48 inch	18.2%	75.8	612.18
MH-402	MH-499	131	48 inch	1.1%	92.2	150.65
MH-499	MH-407	130.5	48 inch	4.4%	92.2	302.91
MH-500	MH-388	300	42 inch	0.5%	57.6	71.14
MH-388	MH-406	146	42 inch	12.2%	57.6	350.88
MH-478	MH-410	300	42 inch	1.8%	59.1	136.22
MH-438	I-281	300	42 inch	0.5%	60.3	71.14
I-281	MH-439	165	42 inch	18.5%	81.6	432.31
MH-447	MH-448	129	42 inch	0.5%	51.3	71.14
MH-448	I-351	319	42 inch	0.5%	51.3	71.14
I-338	MH-459	37	42 inch	0.5%	47.8	71.14
I-353	MH-497	336.5	42 inch	0.5%	69.8	71.14
MH-497	MH-498	352.5	42 inch	1.5%	69.8	123.56
MH-498	OF-47	184.5	42 inch	1.4%	69.8	117.34
MH-437	MH-438	299.5	36 inch	1.9%	60.3	92.93
I-334	MH-447	27.5	36 inch	0.7%	51.3	56.88
MH-455	MH-456	299.5	36 inch	0.8%	38.9	61.18
I-340	MH-461	296.5	36 inch	0.5%	39.7	47.16
MH-461	MH-462	399.5	36 inch	7.9%	39.7	187.71
I-341	MH-469	108	36 inch	0.5%	30.3	47.16
MH-469	MH-470	119	36 inch	3.2%	30.3	119.96
MH-470	MH-471	87	36 inch	1.5%	30.3	81.53
MH-471	I-340	63.5	36 inch	0.5%	30.3	47.16
MH-456	OF-51	68	36 inch	2.1%	38.9	97.73
I-312	MH-500	311	30 inch	4.1%	57.6	83.01
I-342	MH-409	341	30 inch	5.3%	59.1	94.36
MH-409	MH-478	175	30 inch	3.6%	59.1	78.07
I-346	MH-420	300	30 inch	0.5%	18.3	29.00
MH-420	MH-421	336	30 inch	0.5%	18.3	29.00
MH-421	I-348	245.5	30 inch	0.5%	18.3	29.00
I-330	MH-437	300	30 inch	3.7%	24.0	79.30
I-328	MH-437	357	30 inch	0.5%	24.7	29.00
MH-454	MH-455	300	30 inch	1.3%	38.9	47.48
I-344	MH-485	204	30 inch	0.5%	23.8	29.00
MH-485	MH-486	84.5	30 inch	11.5%	23.8	139.14
I-347	OF-49	179.5	30 inch	2.7%	53.8	67.53
MH-474	MH-475	315.5	24 inch	0.7%	14.0	19.44
MH-475	MH-476	317.5	24 inch	0.7%	14.0	18.48

Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-476	MH-477	230.5	24 inch	3.0%	14.0	38.97
MH-477	OF-45	236	24 inch	0.5%	14.0	16.00
I-321	MH-406	126	24 inch	18.4%	12.3	96.96
I-331	MH-432	320	24 inch	0.5%	11.6	16.00
MH-432	MH-433	346.5	24 inch	5.6%	11.6	53.46
MH-433	MH-434	338	24 inch	6.6%	11.6	57.93
MH-434	MH-435	311.5	24 inch	4.5%	11.6	48.18
I-336	MH-454	299.5	24 inch	3.6%	38.9	43.21
I-339	MH-460	226	24 inch	0.5%	8.5	16.00
MH-460	I-340	323.5	24 inch	0.9%	8.5	21.26
MH-435	MH-437	289	24 inch	8.0%	11.6	64.16
MH-480	MH-481	237.5	24 inch	0.5%	8.3	16.00
MH-481	MH-482	138	24 inch	2.9%	8.3	38.76
MH-482	MH-483	161	24 inch	9.2%	8.3	68.49
MH-483	MH-484	137	24 inch	0.5%	8.3	16.00
MH-484	I-344	272	24 inch	0.5%	8.3	16.00
I-350	OF-50	148.5	24 inch	6.2%	43.5	56.37
I-326	MH-412	158.5	15 inch	0.5%	3.2	4.57
MH-412	MH-413	300	15 inch	6.7%	3.2	16.69
MH-413	MH-414	263	15 inch	0.5%	3.2	4.57
MH-414	MH-415	176	15 inch	0.5%	3.2	4.57
MH-415	MH-416	213	15 inch	0.5%	3.2	4.57
MH-416	MH-417	300.5	15 inch	7.3%	3.2	17.47
I-333	MH-439	57.5	15 inch	0.5%	4.5	4.57
MH-479	MH-480	255	15 inch	5.1%	8.3	14.53
I-262	I-347	120.5	15 inch	2.9%	9.4	10.90
I-254	MH-473	179.5	12 inch	33.3%	14.0	20.57
MH-473	MH-474	185	12 inch	17.9%	14.0	15.08
MH-427	MH-428	194.5	12 inch	9.8%	5.1	11.13
MH-428	I-275	278	12 inch	13.0%	5.1	12.86
I-343	MH-479	313.5	12 inch	11.2%	8.3	11.92

Based on the opportunities analysis performed, the evaluated alternative as shown below includes: approximately 31,515 linear feet of storm sewer, enhancement of three detention basins and the addition of three new storm water detention basins. Site visits were conducted at each of the proposed stormwater detention basins locations. The new basins are proposed for the following locations:

- Avon Fields Park in Priority Subbasin 46;
- Mill Crest Park in Priority Subbasin 41; and
- Showcase Cinema property along the Norwood Lateral in Priority Subbasin 32A.

The below figure highlights the locations of the proposed strategies that were represented in the stormwater model. Refer to the end of this Appendix for a full-size map showing the proposed strategies for the Ross Run watershed.



Ross Run Proposed Opportunities

COST ESTIMATE SUMMARY

The preliminary opinion of cost quantities are based on planning level deterministic evaluations of the various project elements from the concepts identified in this report. Pricing is based primarily on experience with similar planning projects. The following assumptions and limitation were used in developing these numbers:

- Pricing is based primarily on ODOT's 2009 Bid Summary using the average bid price and supplemented as necessary using MSDGC's Item List or other historical sources. These prices include materials, labor, equipment, overhead, and profit.

- The cost below are for construction only and do not include typical soft costs such as design, financing, inspection and administration.

- A contingency of 30 percent has been applied to the overall estimate to reflect uncertainties associated with existing utility locations, underlying soils, groundwater conditions, and general topographic data.

- Markups for contractor profit and overhead have not been applied separately as these markups are generally included within the unit prices being used

- Life cycle costs have not been analyzed. Such analysis should be completed as part of a future evaluation if it is determined that this project should be advanced.

- Costs for potential property acquisitions are not included.

- Detailed costs associated with possible water quality components, handling disposal of contaminated groundwater and soils, and other elements that would typically be addressed during preliminary and final design phases, have not been fully accounted for in this cost opinion.

The following table summarizes the preliminary opinion of construction cost for the evaluated alternative outlined above and totals $105.9 million.

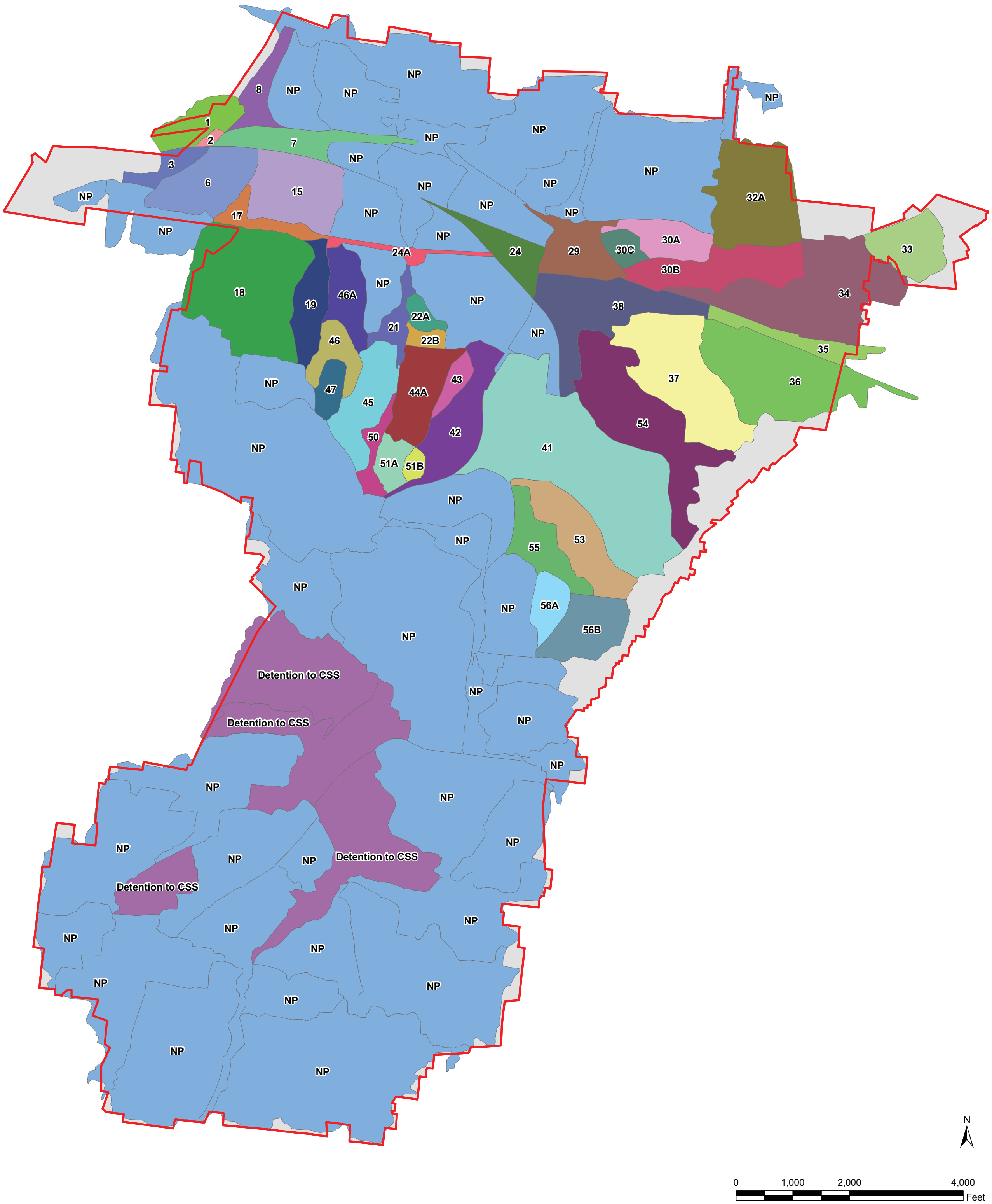
Ross Run Preliminary Opinion of Construction Cost

Inside of Ross Run Basin Does Not Connect to the Mill Creek

Item	Quantity	Unit	Unit Cost	Cost
10x8 FT RCP Box Conduit	2470	LF	$1,100	$2,717,000
10x8 FT box RCP conduit - Tunneling under interstate	870	LF	$10,000	$8,700,000
10x8 FT box RCP conduit - Tunneling under railroad	180	LF	$5,000	$900,000
10x6 FT RCP Box Conduit	2045	LF	$1,000	$2,045,000
10x6 FT box RCP conduit - Tunneling under major artery	445	LF	$5,000	$2,225,000
102 IN RCP-Storm Sewer Main	1180	LF	$525	$619,500
96 IN RCP-Storm Sewer Main	1135	LF	$500	$567,500
84 IN RCP-Storm Sewer Main	1135	LF	$385	$436,975
78 IN RCP-Storm Sewer Main	390	LF	$305	$118,950
72 IN RCP-Storm Sewer Main	430	LF	$235	$101,050
66 IN RCP-Storm Sewer Main	945	LF	$245	$231,525
60 IN RCP-Storm Sewer Main	2770	LF	$250	$692,500
48 IN RCP-Storm Sewer Main	1970	LF	$135	$265,950
42 IN RCP-Storm Sewer Main	2570	LF	$125	$321,250
36 IN RCP-Storm Sewer Main	2070	LF	$140	$289,800
30 IN RCP-Storm Sewer Main	3135	LF	$120	$376,200
24 IN RCP-Storm Sewer Main	4650	LF	$80	$372,000
15 IN RCP-Storm Sewer Main	1845	LF	$55	$101,475
12 IN RCP-Storm Sewer Main	1280	LF	$50	$64,000
Precast Storm Sewer Manhole	148	EA	$6,000	$888,000
Basin Enhancement - Subbasin 7	1	EA	$200,000	$200,000
Basin Enhancement - Subbasin 47	1	EA	$200,000	$200,000
Basin Enhancement - Subbasin 55	1	EA	$200,000	$200,000
Proposed Basin - Subbasin 32A	1	EA	$570,000	$570,000
Proposed Basin - Subbasin 41	1	EA	$425,000	$425,000
Proposed Basin - Subbasin 46	1	EA	$485,000	$485,000
Apron Endwall for 10x8 FT RCP	1	EA	$8,000	$8,000
Apron Endwall for 42 IN RCP	1	EA	$1,100	$1,100
Apron Endwall for 36 IN RCP	1	EA	$900	$900
Apron Endwall for 30 IN RCP	1	EA	$700	$700
Apron Endwall for 24 IN RCP	2	EA	$650	$1,300
Water Main Relocations	1	EA	$3,136,300	$3,136,300
Roadway Restoration	1	EA	$23,401,900	$23,401,900
Terrace Restoration	1	EA	$2,653,800	$2,653,800
Demolition & Connections	1	EA	$1,447,500	$1,447,500
Gas, Telephone, & Electric Relocations	1	EA	$1,930,100	$1,930,100
Rock Excavation	1	EA	$5,066,400	$5,066,400
			Sub Total =	$61,761,675
			Miscellaneous Items @ 30% =	$18,528,503
			Sub Total =	$80,290,178

Outside of Ross Run Basin to Connect to the Mill Creek

10x8 FT box RCP conduit - Tunneling under railroad	250	LF	$5,000	$1,250,000
10x8 FT box RCP conduit - Tunneling under paved area	2680	LF	$5,000	$13,400,000
10x8 FT box RCP conduit - Tunneling under pervious area	990	LF	$5,000	$4,950,000
Precast Storm Sewer Manhole	18	EA	$6,000	$108,000
			Sub Total =	$81,469,675
			Miscellaneous Items @ 30% =	$24,440,903
			Grand Total =	$105,910,578
			Gallons Removed: 139,000,000	**$0.76**

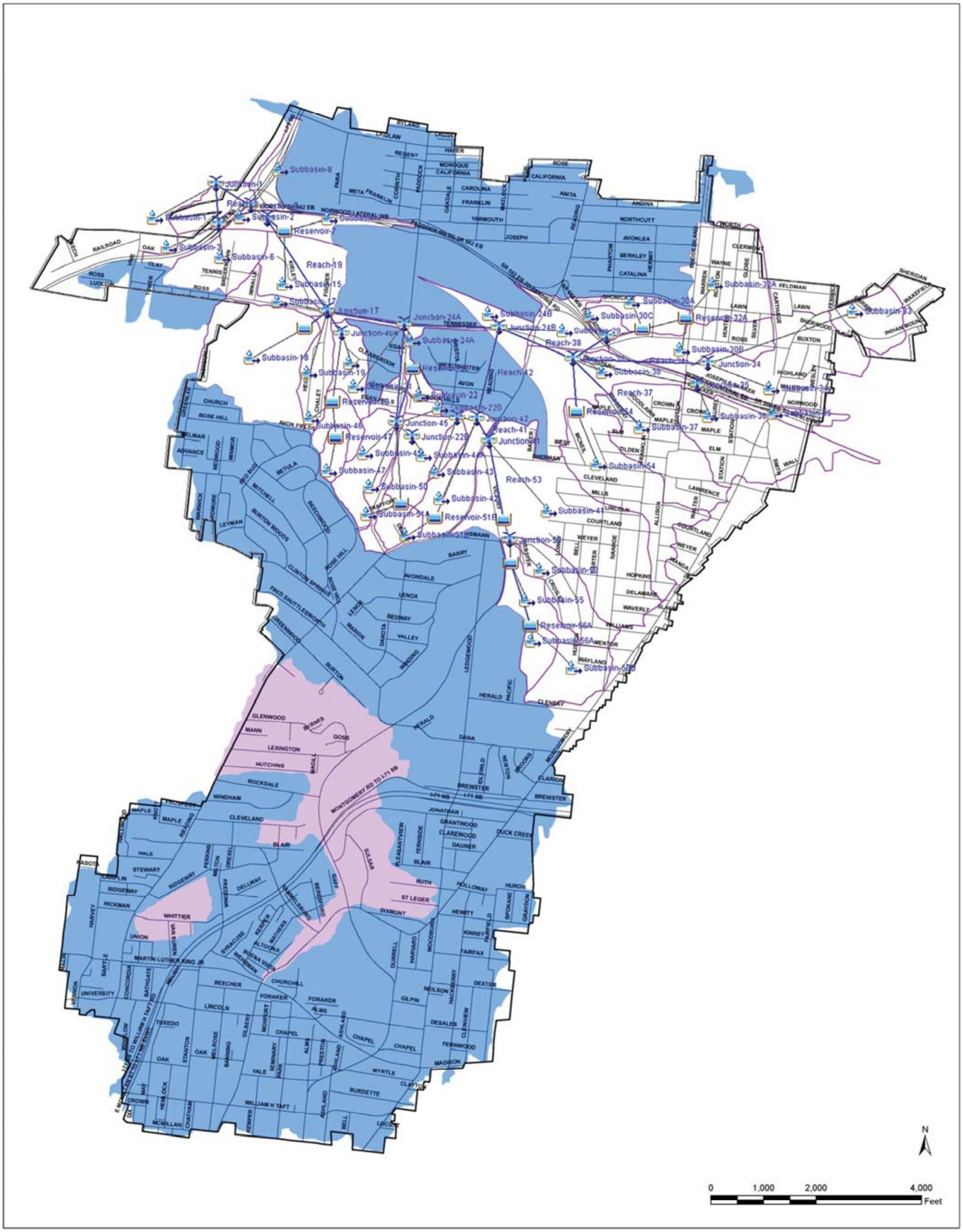


Ross Run Watershed
HEC-HMS Sub-Basins

Legend

- Ross Run CSO Boundary
- NP - Non-Priority Area
- 1 - I-75 and Railroad Ave
- 2 - I-75 and Norwood Lateral 2
- 3 - I-75 and Norwood Lateral 3
- 6 - Broermann Ave and Moeller Ave
- 7 - Norwood Lateral and Paddock Rd
- 8 - I-75 and Norwood Lateral 1
- 15 - Kieley Place and Ross Ave
- 17 - Ross Ave and Imwalle Ave
- 18 - St. Mary's Cemetery
- 19 - Chaley Dr and Heger Dr
- 21 - Paddock Rd and Egan Hills Dr
- 22A - Paddock Hills Ave and Paddock Rd
- 22B - Paddock Hills Ave and Paddock Ln
- 24 - Tennessee Ave and Reading Rd
- 24A - Tennessee Ave and Paddock Rd
- 29 - Norwood Lateral and Reading Rd
- 30A - Former Showcase Cinema 2
- 30B - Ross Ave and Rhode Island Ave
- 30C - Former Showcase Cinema 1
- 32A - Rhode Island Ave and Lawn Ave
- 33 - Indian Mound Ave and Montgomery Rd
- 34 - Montgomery Rd and Norwood Ave
- 35 - Norwood Lateral and Montgomery Rd
- 36 - Montgomery Rd and Maple Ave
- 37 - Elm Ave and Section Ave
- 38 - Transpark Dr and Tennessee Ave
- 41 - Mill Crest Park
- 42 - Avon Field Golf Course 4
- 43 - Avon Field Golf Course 3
- 44A - Avon Field Golf Course 2
- 45 - Avon Field Golf Course 1
- 46 - Avon Woods Nature Center 1
- 46A - Springmeadow Dr and Clearbrook Dr
- 47 - Avon Woods Nature Center 2
- 50 - Paddock Rd and Stratford Pl
- 51A - Debbie Ln and Stratford Pl
- 51B - Debbie Ln and Reading Rd
- 53 - Houston Ave and Hopkins Ave
- 54 - Sherman Ave and Carter Ave
- 55 - Webster Ave and Hopkins Ave
- 56A - Cintas Center
- 56B - Wayland Ave and Ivanhoe Ave
- Proposed Detention to CSS

Human Nature, Inc. and Strand Associates, Inc.

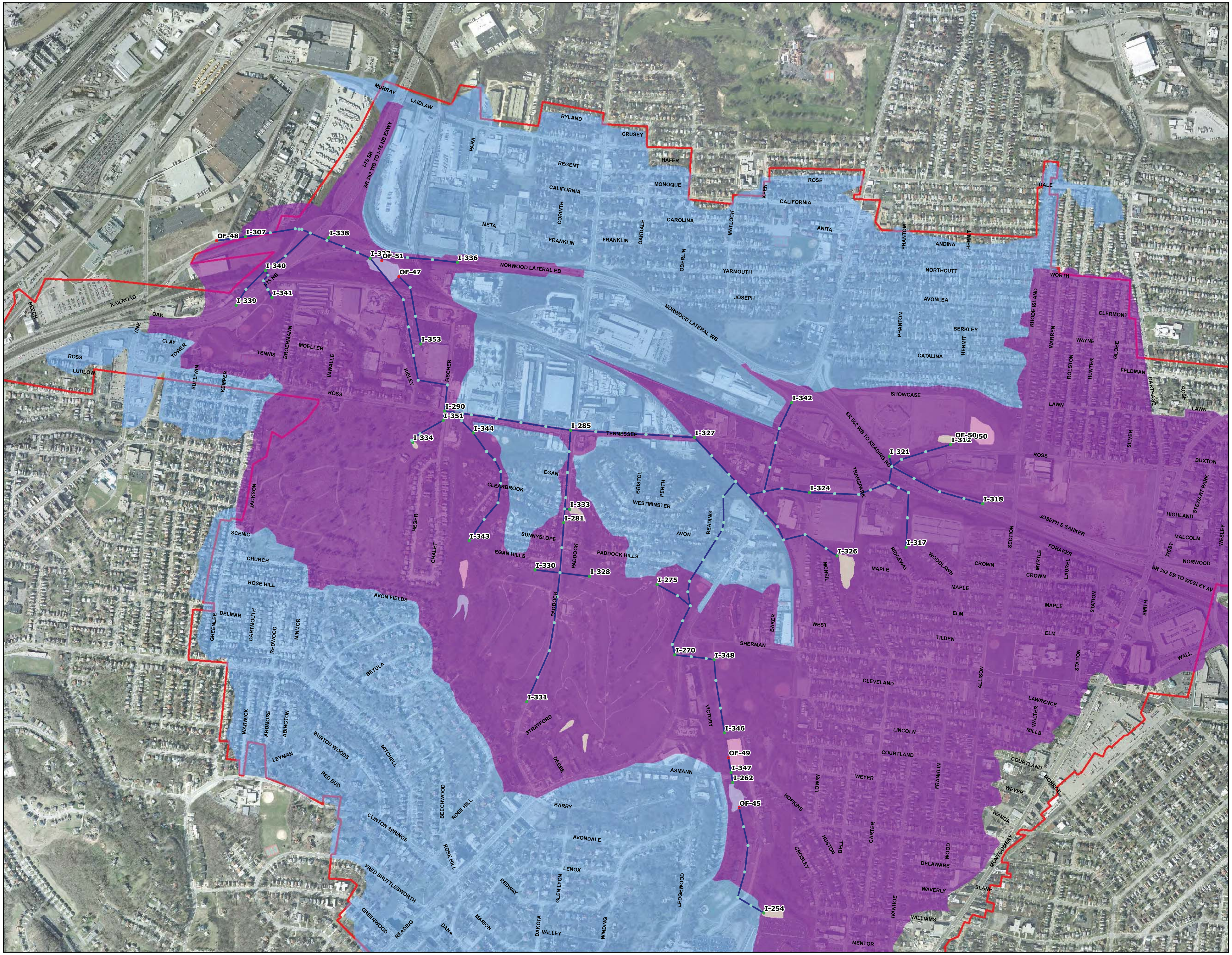


Ross Run Watershed
HEC-HMS Schematic

Legend

- Street
- Ross Run CSO Boundary
- Priority Area
- Non-Priority Area
- Proposed Detention to CSS

Human Nature, Inc. and Strand Associates, Inc.



Ross Run Watershed StormCAD Schematic

Legend

- StormCAD Proposed Sewer
- StormCAD Inlet
- StormCAD Outfall
- StormCAD Manhole
- Existing Basin
- Existing Basin to be Enhanced
- Proposed Basin
- Priority Area
- Non-Priority Area
- Ross Run CSO Boundary

0 500 1,000 2,000 Feet

N

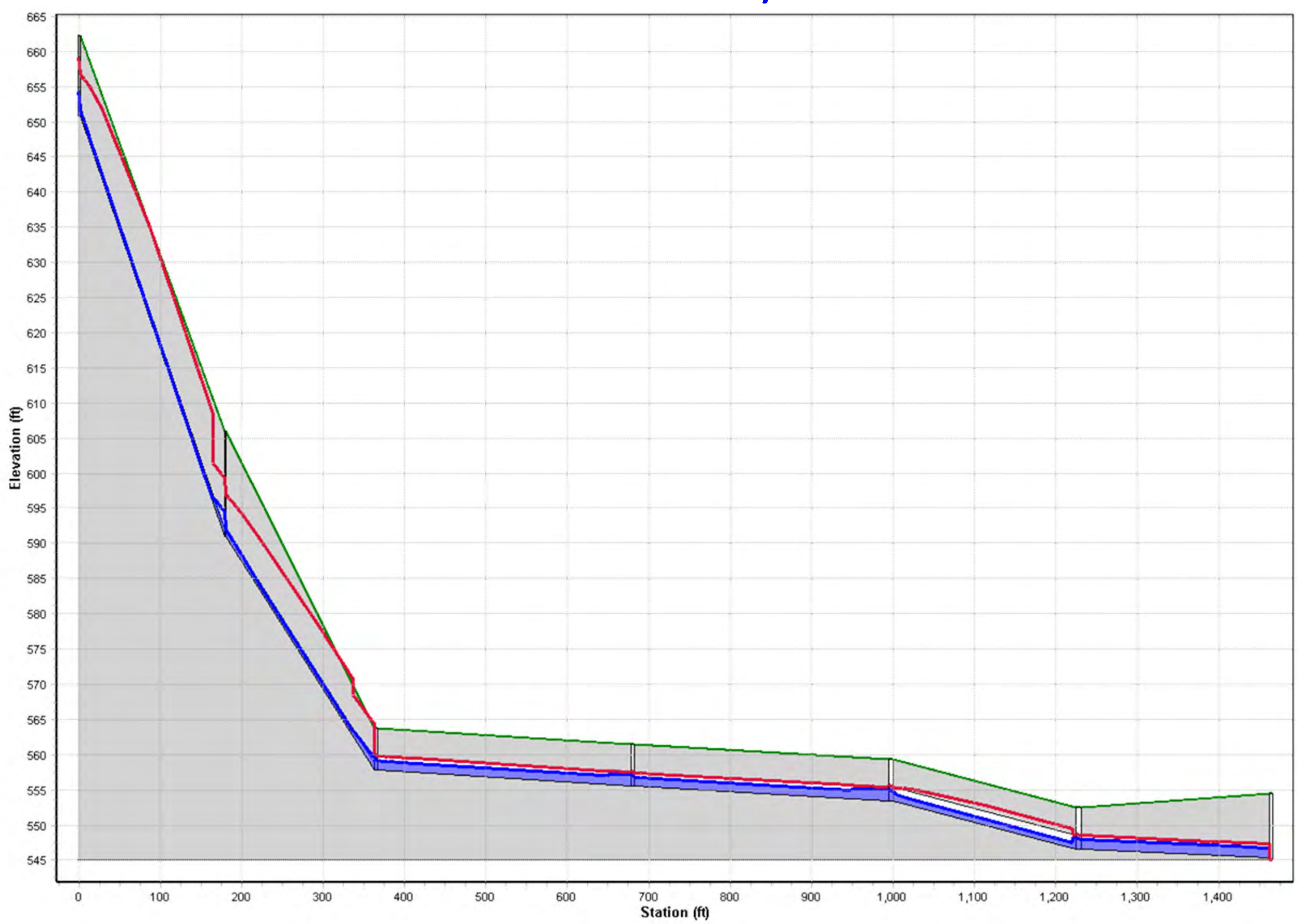
Human Nature, Inc. and Strand Associates, Inc.

Ross Run Watershed
Modeled Alternative
Preliminary StormCAD Profiles

Strand Associates, Inc.
September 2010

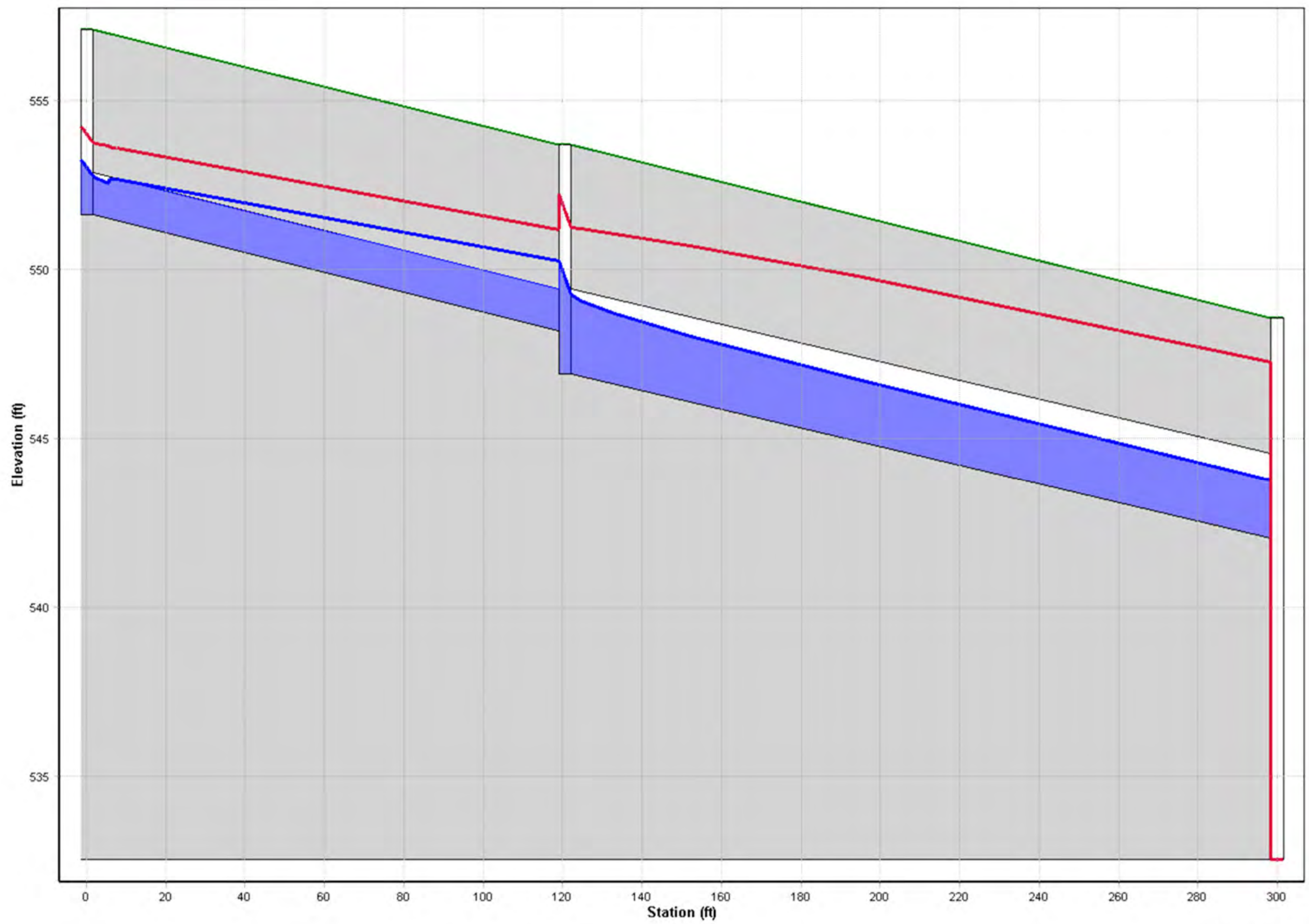
Ross Run StormCAD Profile Report
Profile: OF-45 to I-254
Hopkins Ave to Cintas Center

OF-45 to I-254 – 10 year



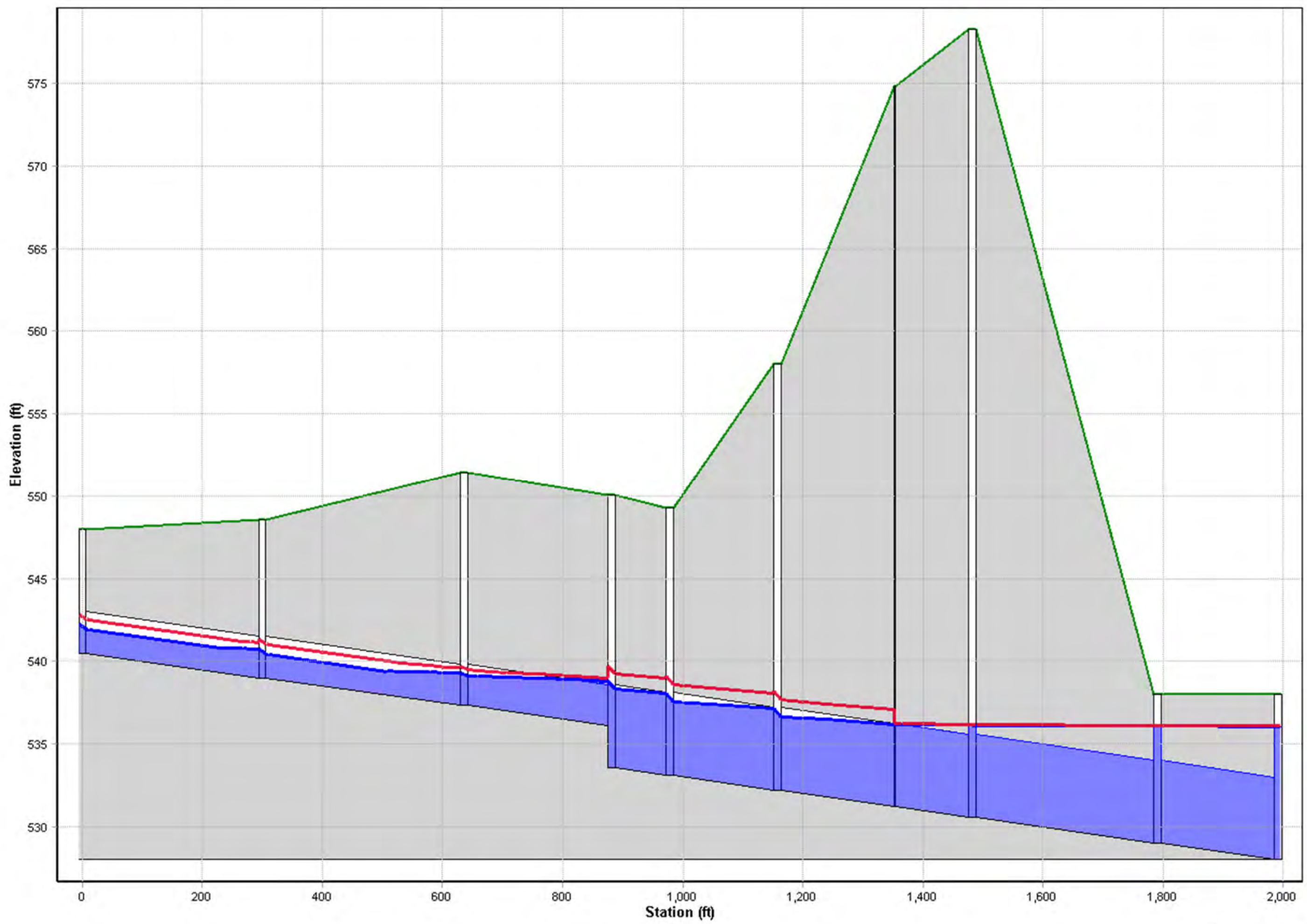
Ross Run StormCAD Profile Report
Profile: OF-49 to I-262
Mill Crest Park to Hopkins Ave

OF-49 to I-262 – 10 year



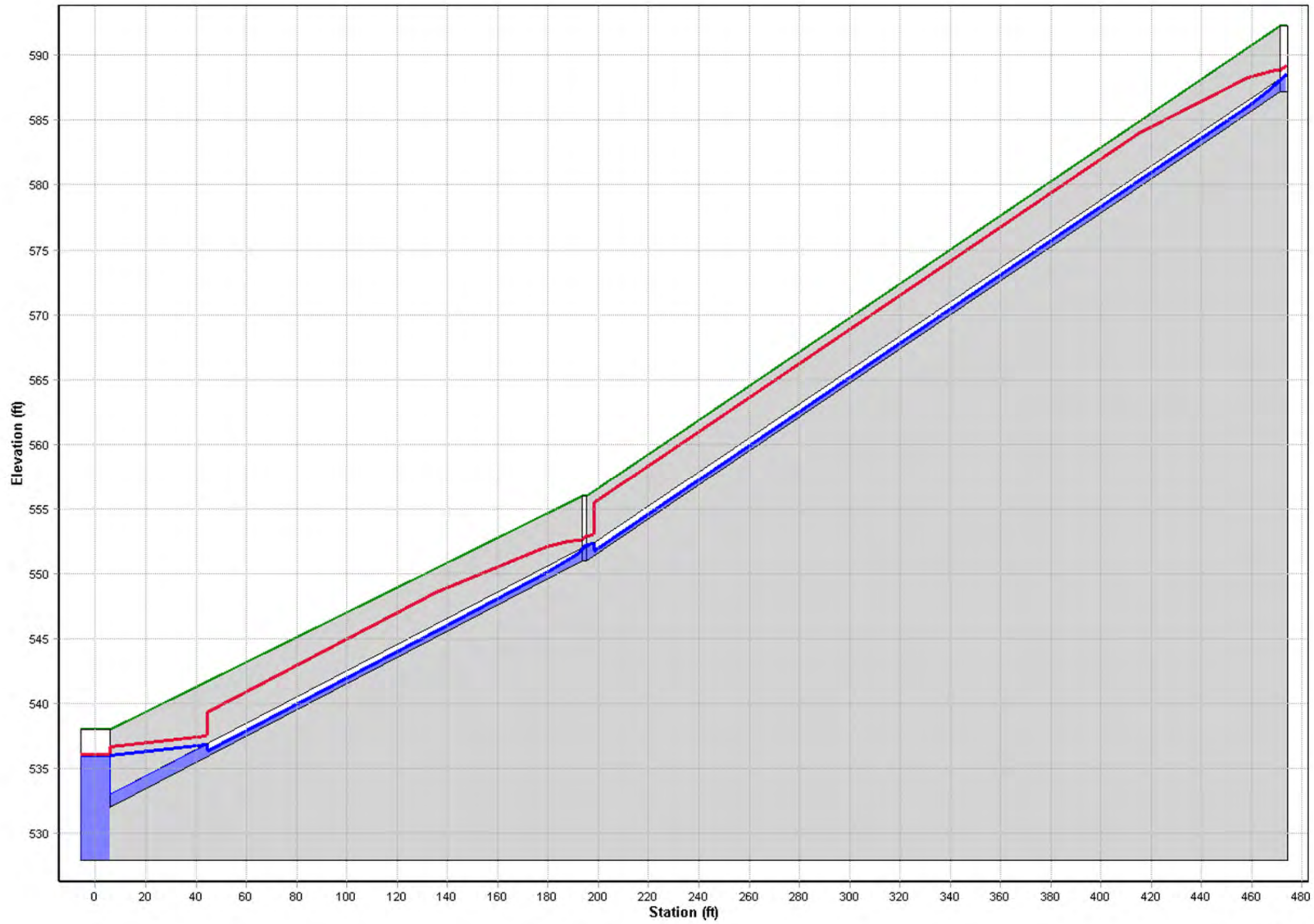
Ross Run StormCAD Profile Report
Profile: MH-427 to I-346
Reading Rd to Mill Crest Park

MH-427 to I-346 – 10 year



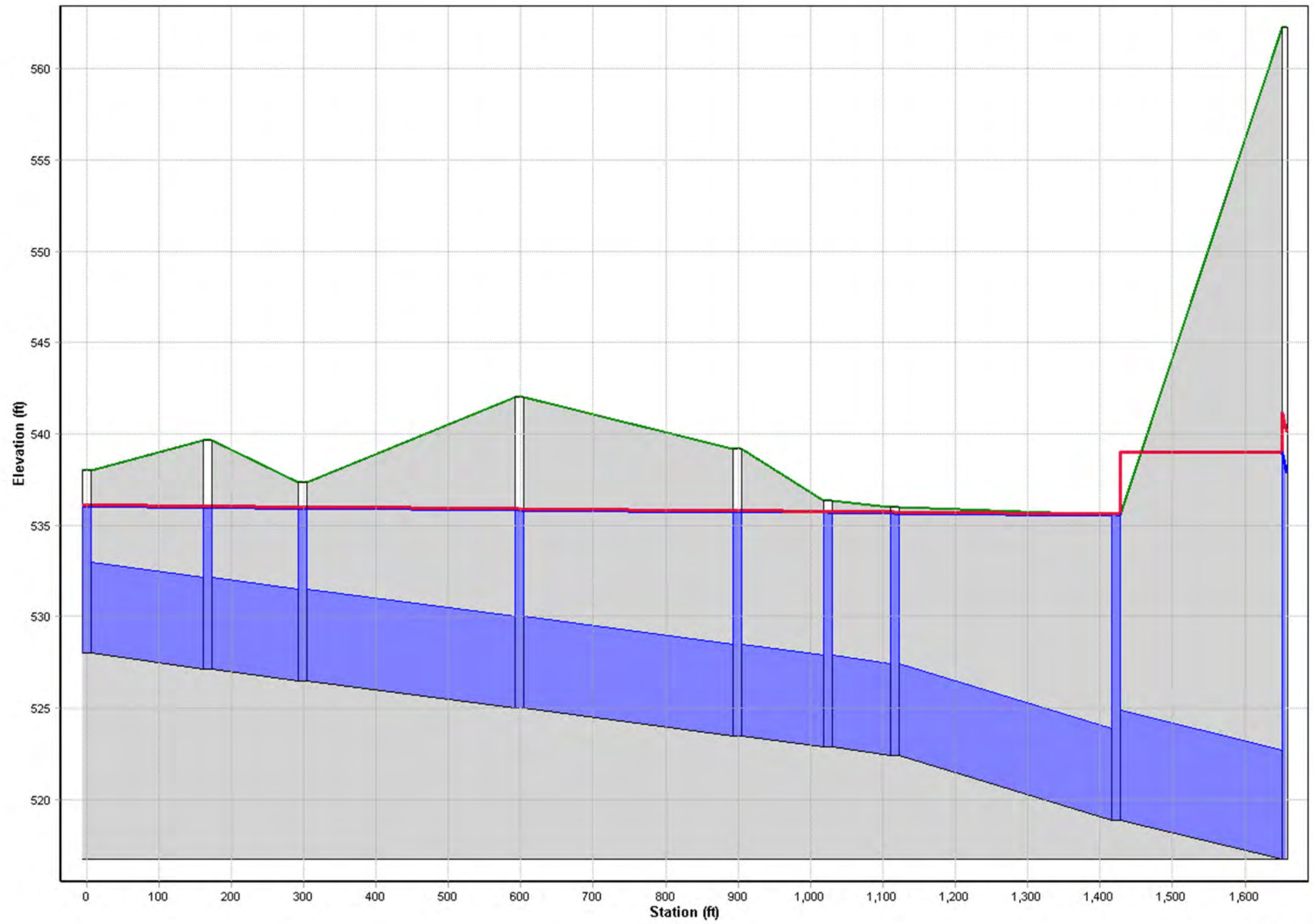
Ross Run StormCAD Profile Report
Profile: MH-427 to I-275
Reading Rd to Avon Field Golf Course

MH-427 to I-275 – 10 year



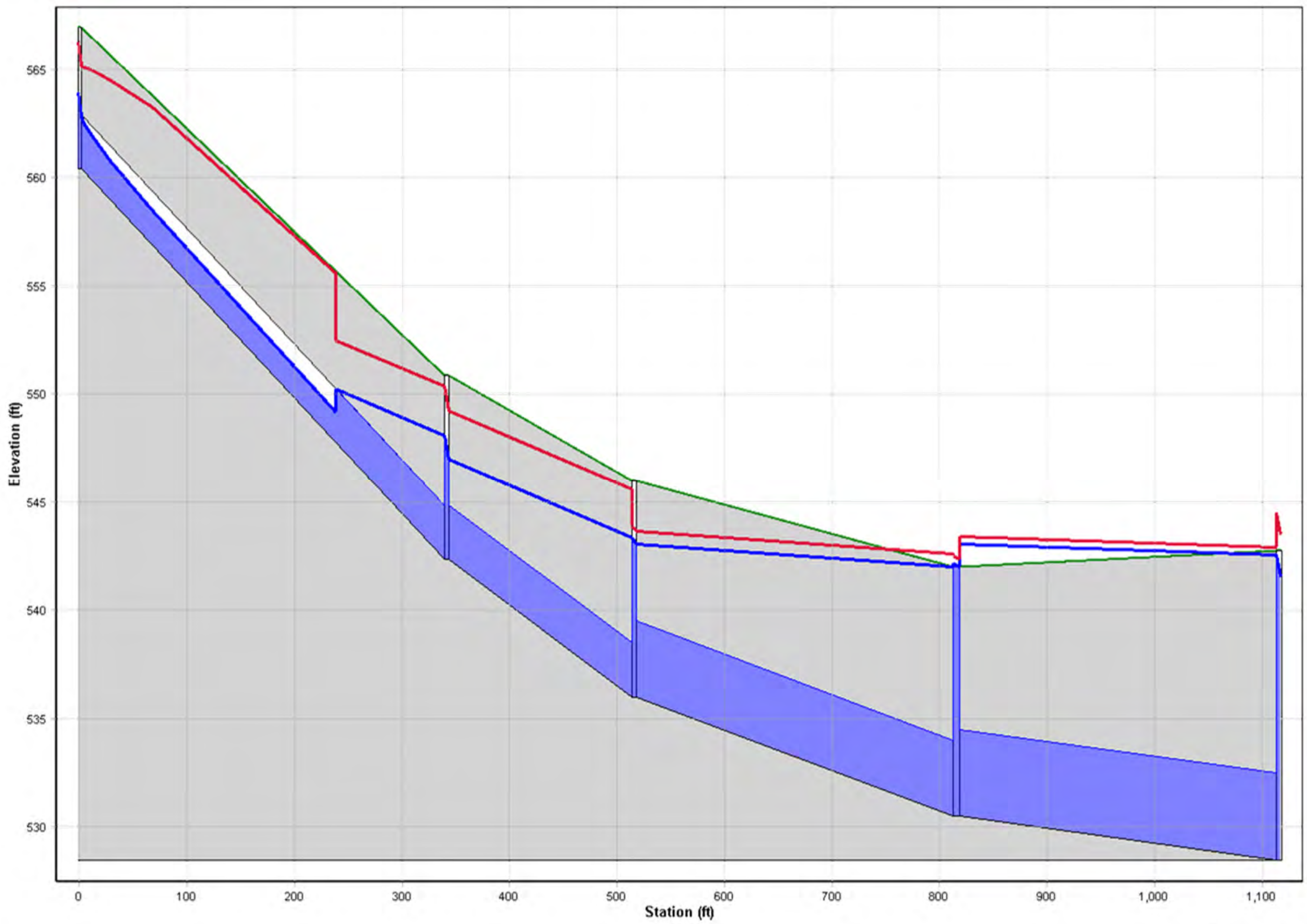
Ross Run StormCAD Profile Report
Profile: MH-494 to MH-427
Tennessee Ave to Sherman Ave

MH-494 to MH-427 – 10 year



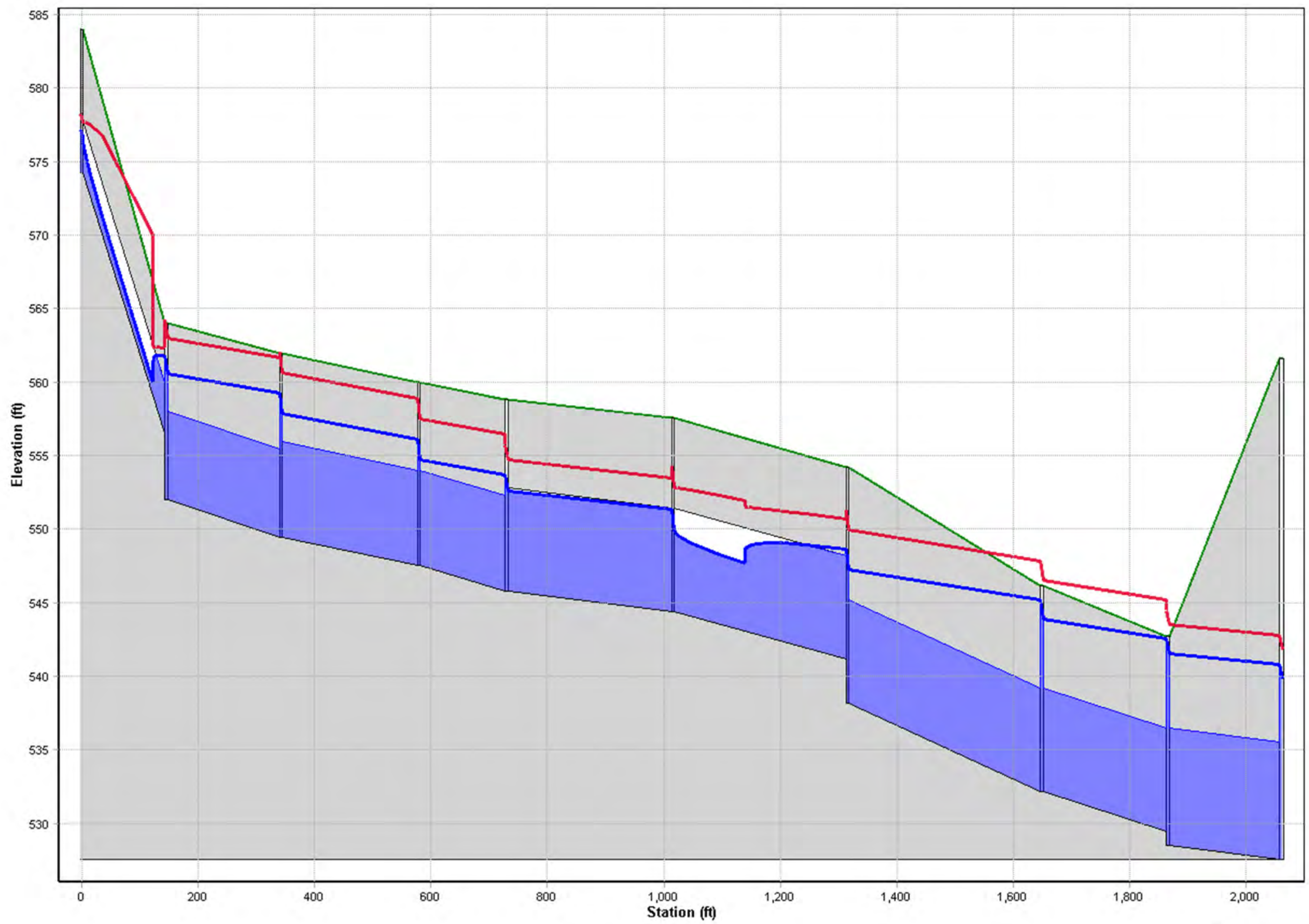
Ross Run StormCAD Profile Report
Profile: MH-411 to I-342
Reading Rd at Norwood Lateral

MH-411 to I-342 – 10 year



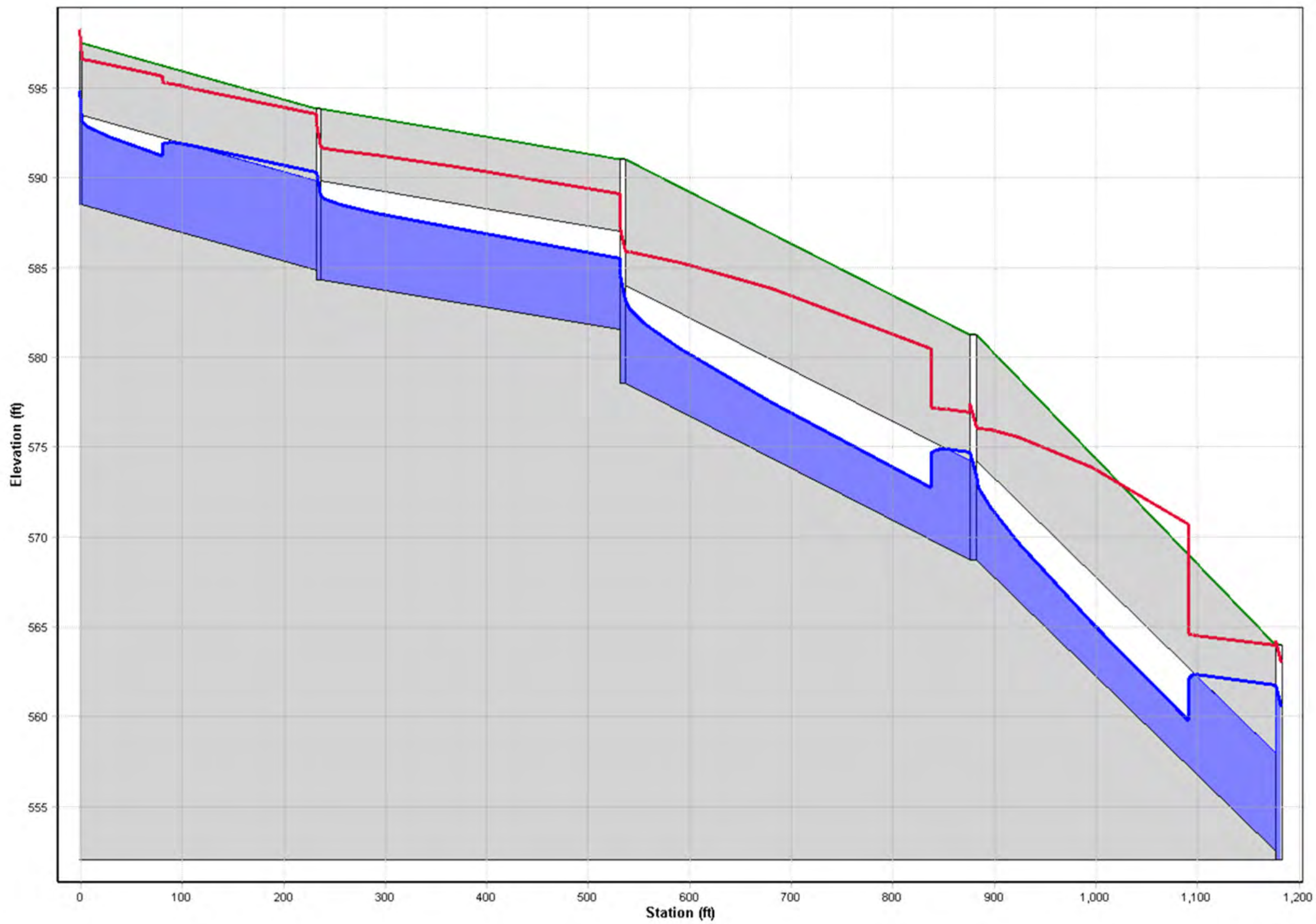
Ross Run StormCAD Profile Report
Profile: MH-417 to MH-388
Reading Rd to Showcase Dr

MH-417 to MH-388 – 10 year



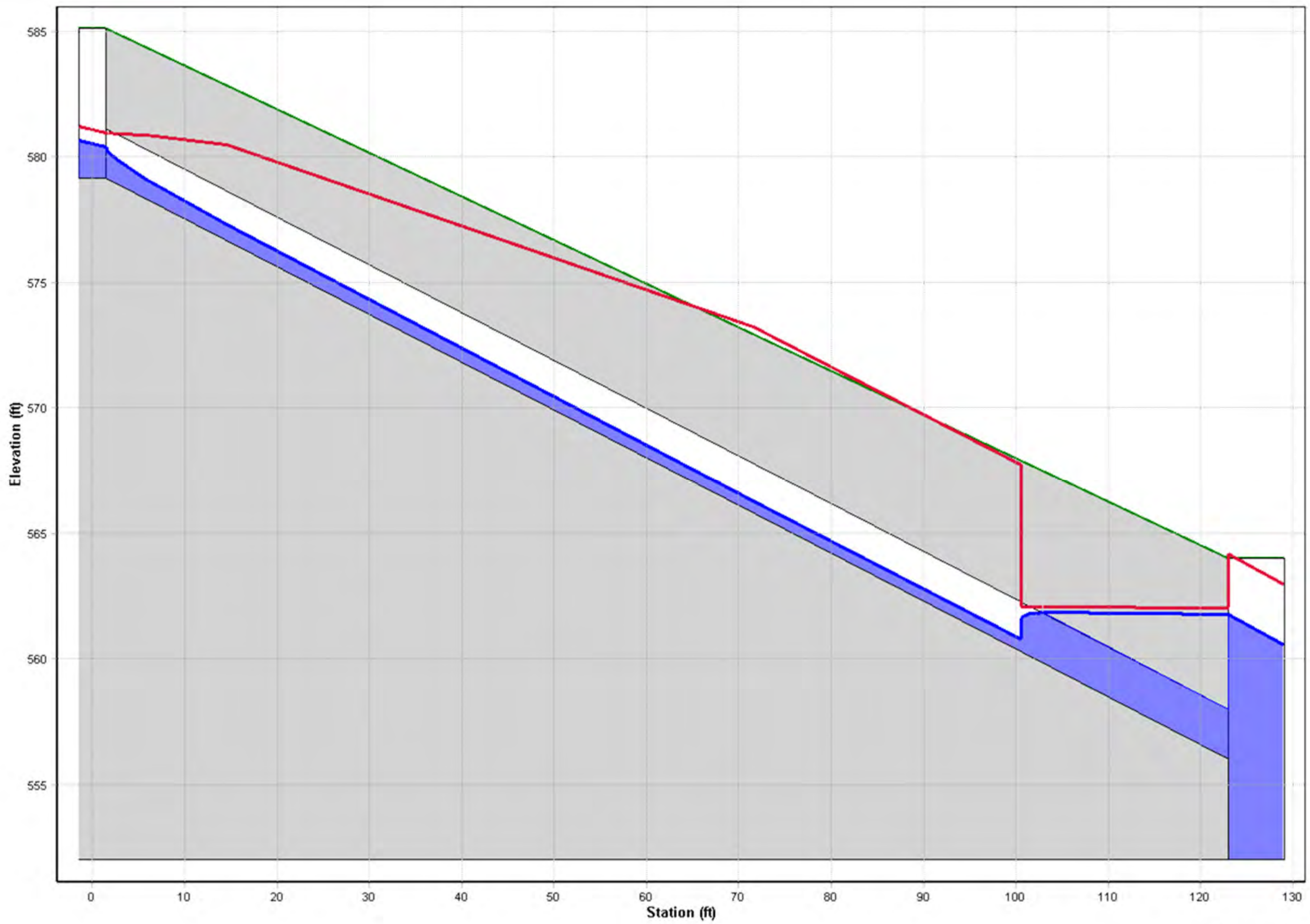
Ross Run StormCAD Profile Report
Profile: MH-406 to I-318
Norwood Lateral to Section Ave

MH-406 to I-318 – 10 year



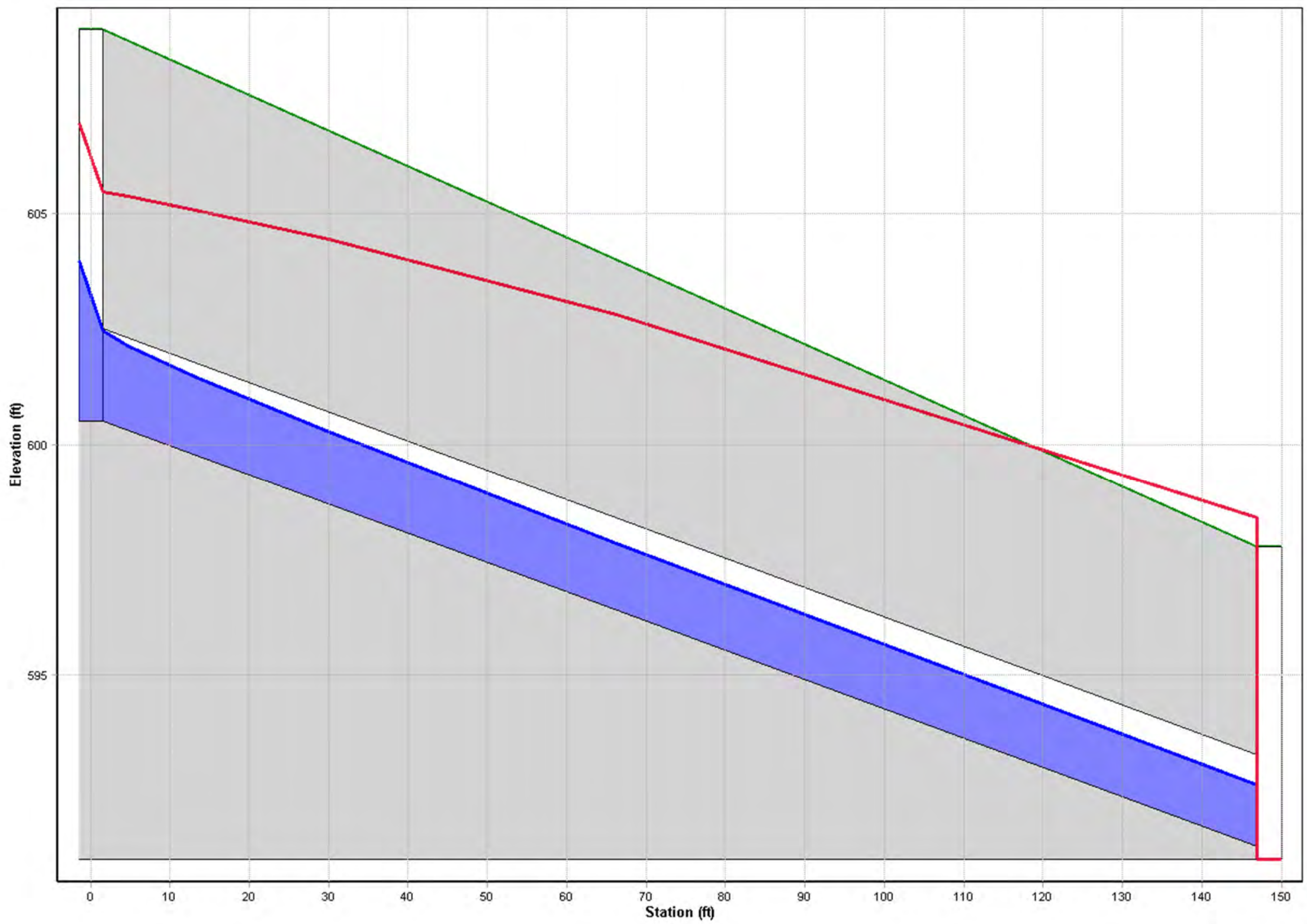
Ross Run StormCAD Profile Report
Profile: MH-406 to I-321
Ross Ave to Showcase Dr

MH-406 to I-321 – 10 year



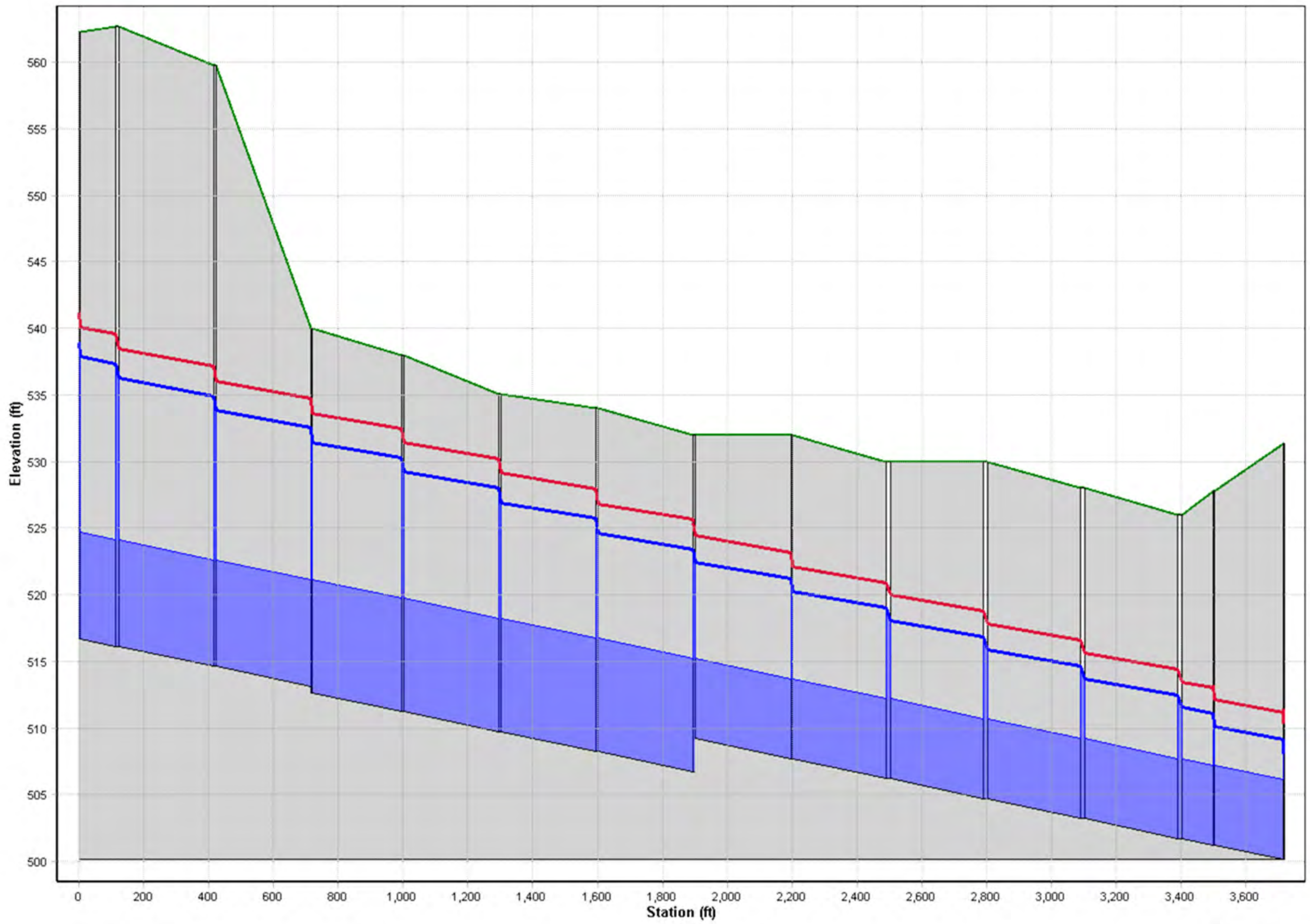
Ross Run StormCAD Profile Report
Profile: OF-50 to I-350
Former Showcase Cinema Property

OF-50 to I-350 – 10 year



Ross Run StormCAD Profile Report
Profile: I-290 to MH-494
Fischer Pl to Reading Rd

I-290 to MH-494 – 10 year



Ross Run StormCAD Profile Report

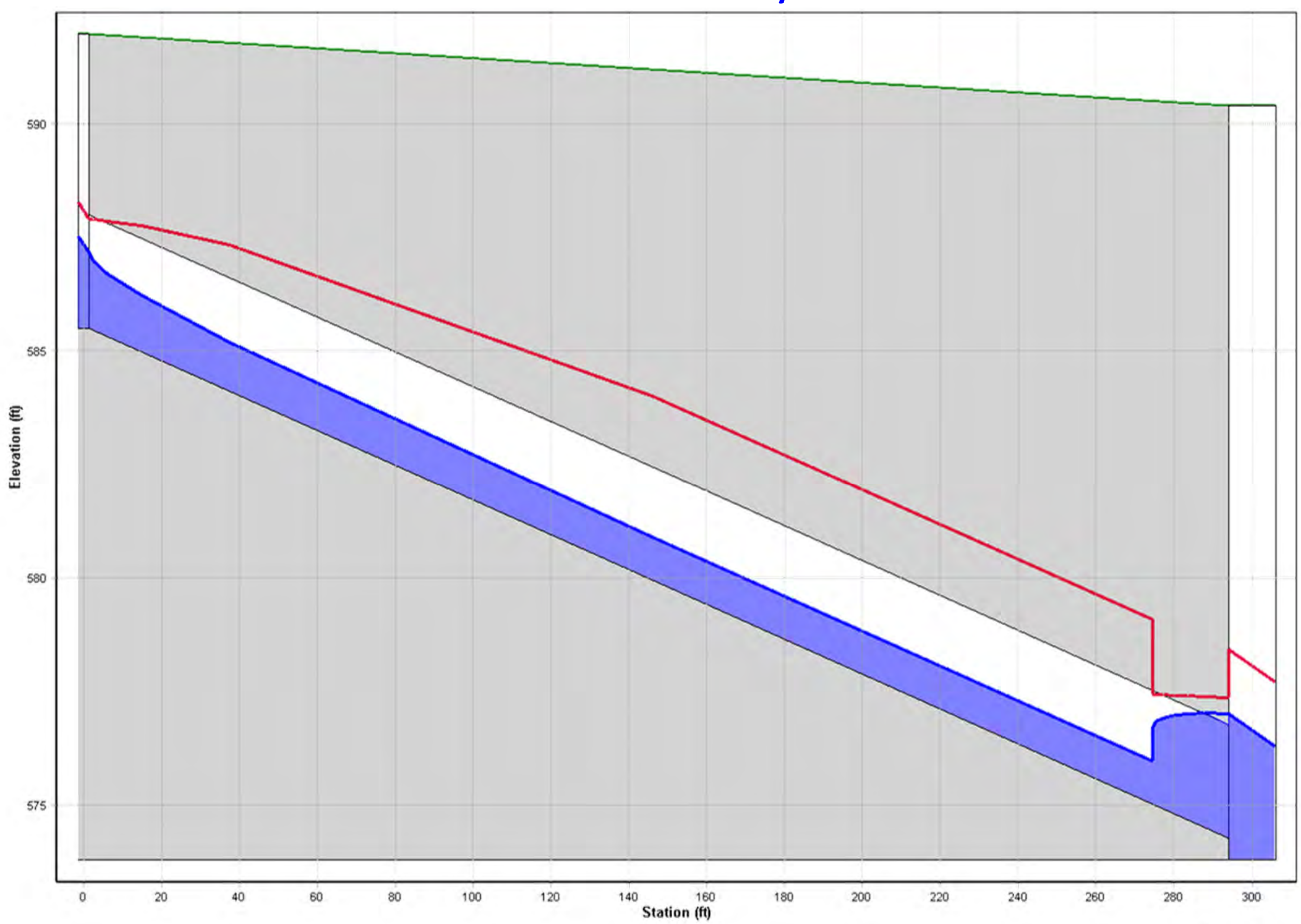
Profile: I-285 to I-331

Tennessee Ave to Stratford Pl

I-285 to I-331 – 10 year

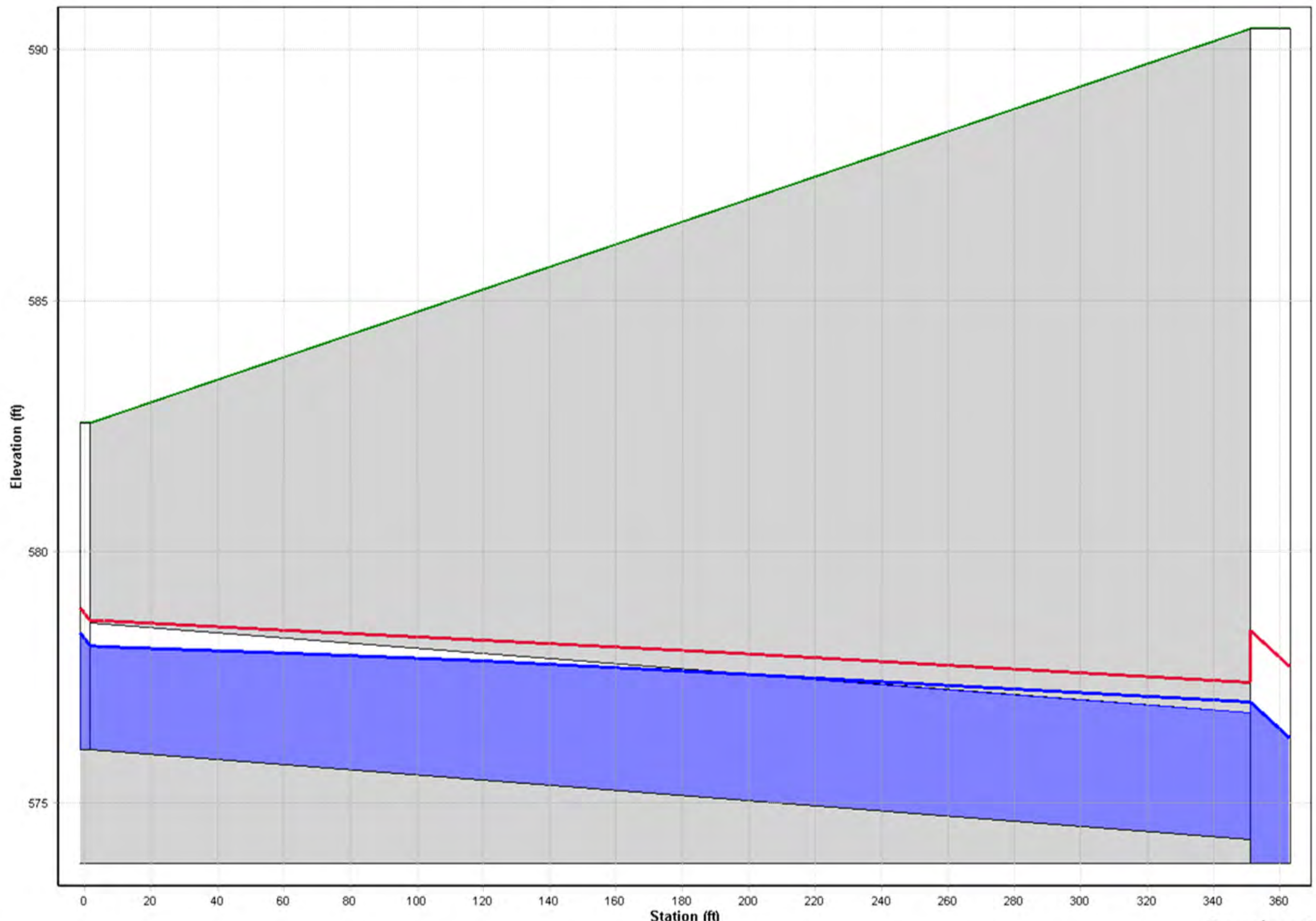
Ross Run StormCAD Profile Report
Profile: MH-437 to I-330
Paddock Rd to Avon Hills Golf Course West

MH-437 to I-330 – 10 year



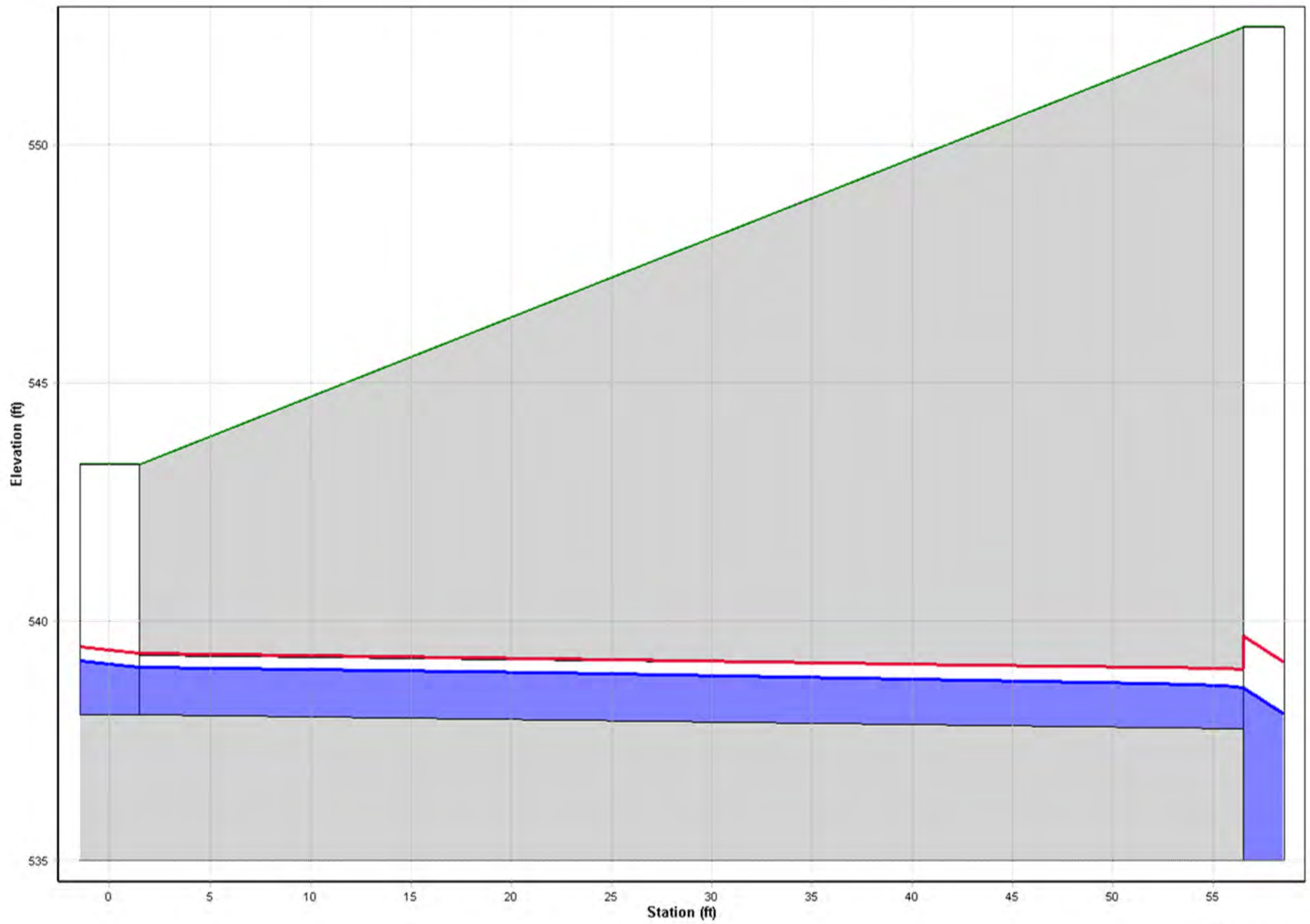
Ross Run StormCAD Profile Report
Profile: MH-437 to I-328
Paddock Rd to Avon Hills Golf Course East

MH-437 to I-328 – 10 year



Ross Run StormCAD Profile Report
Profile: MH-439 to I-333
Paddock Rd to Paddock Hills Ave

MH-439 to I-333 – 10 year

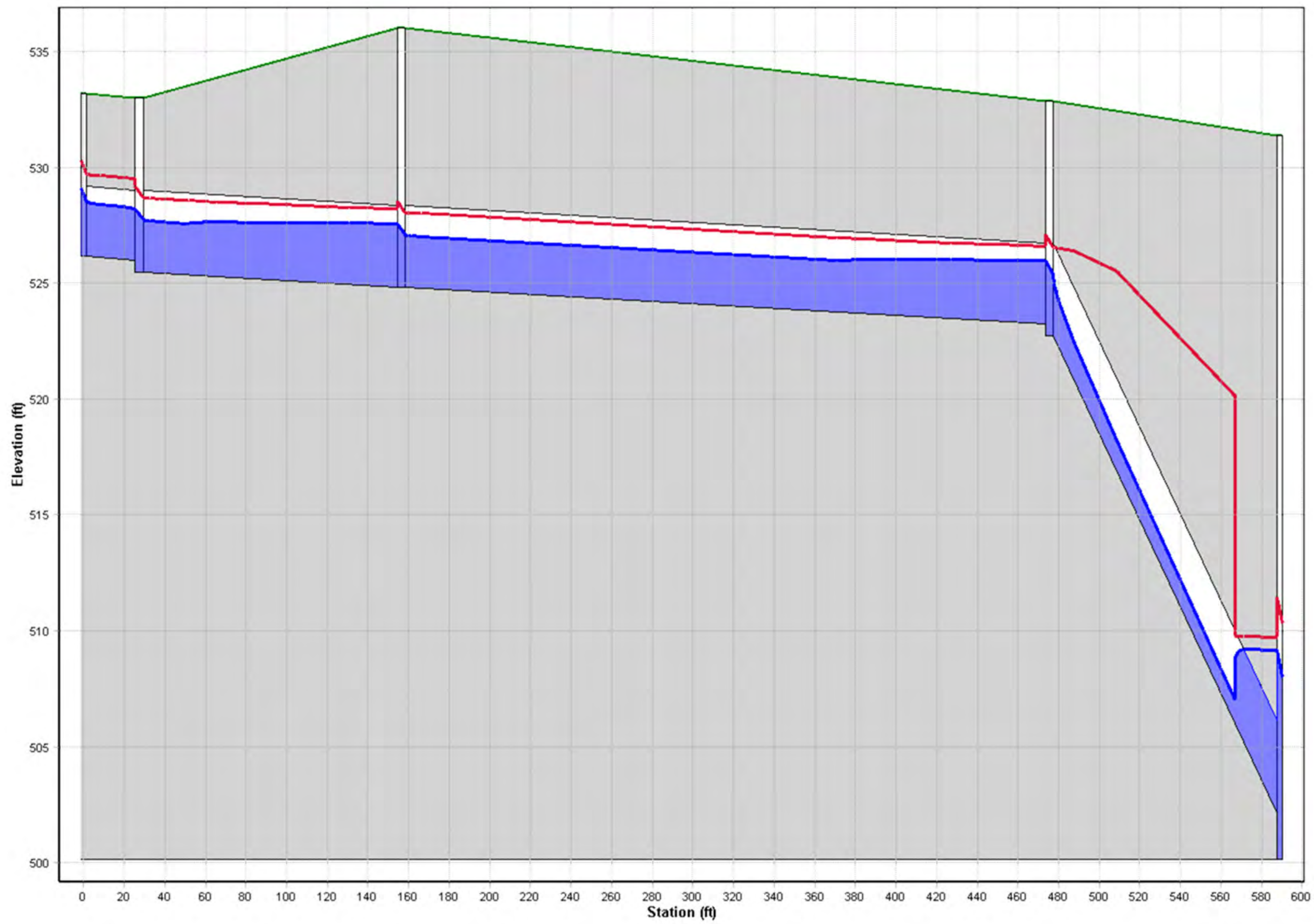


Ross Run StormCAD Profile Report
Profile: MH-486 to I-343
Ross Ave to Avon Woods Nature Center

MH-486 to I-343 – 10 year

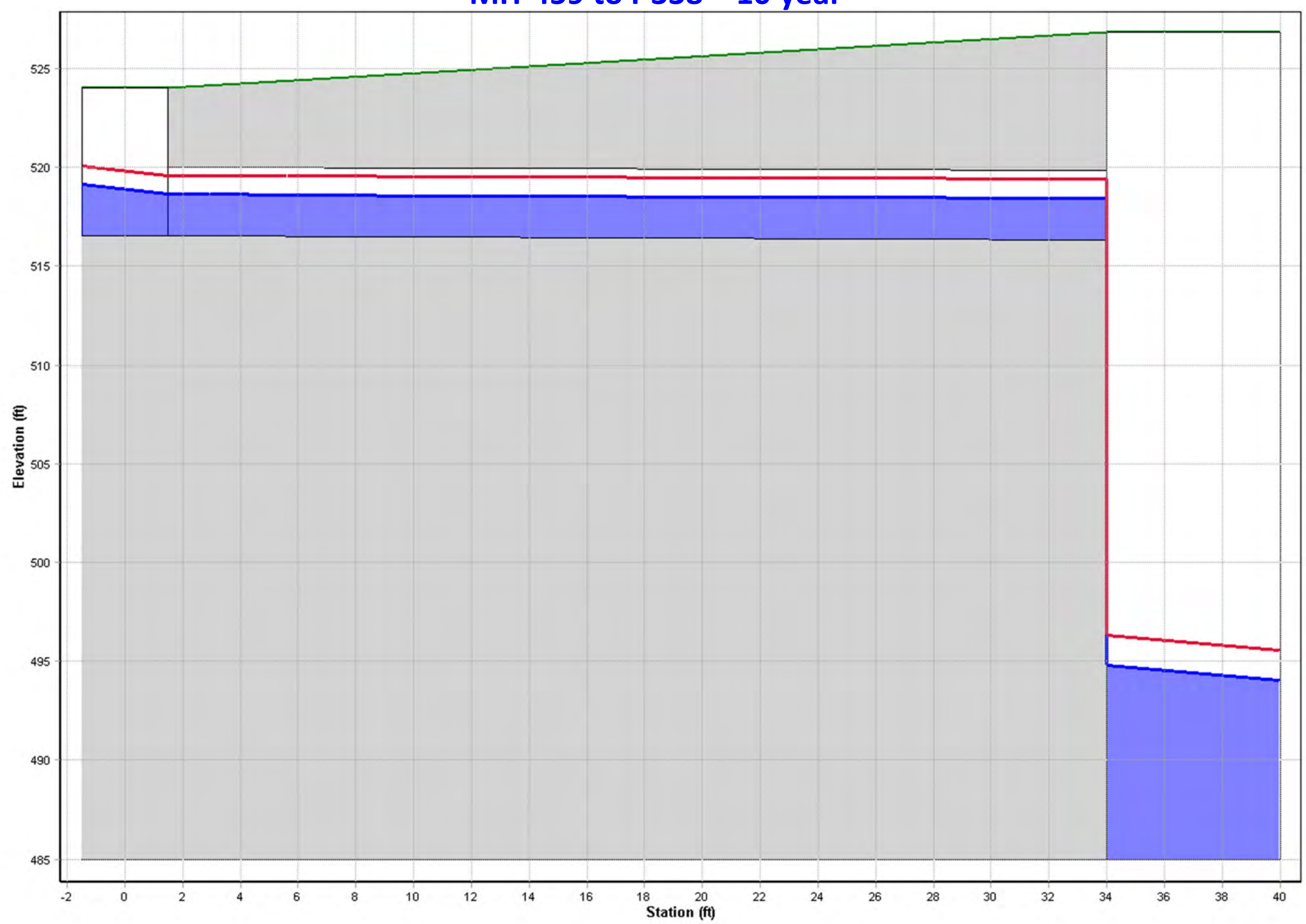
Ross Run StormCAD Profile Report
Profile: I-290 to I-334
Ross Ave to St. Mary's Cemetery

I-290 to I-334 – 10 year



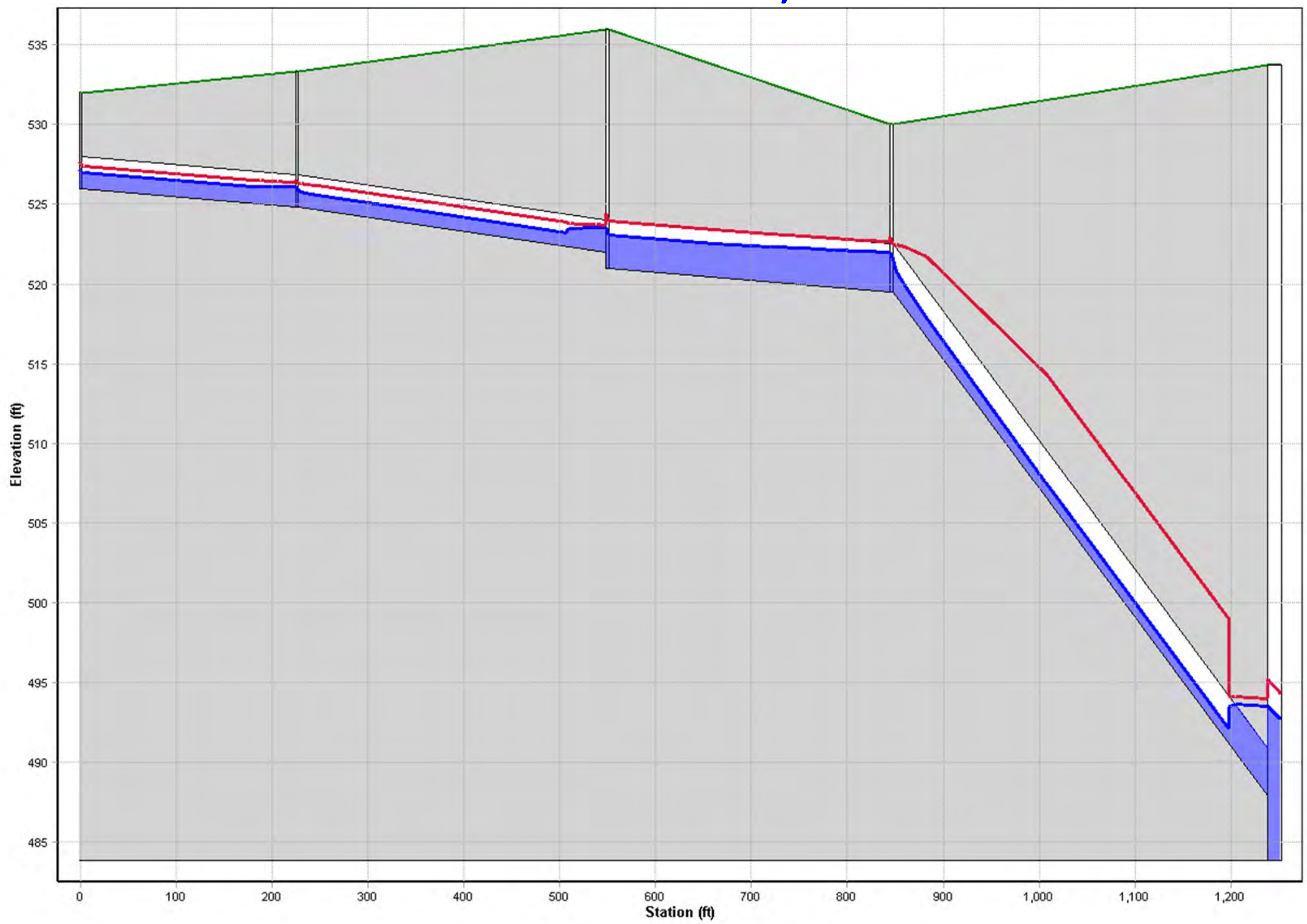
Ross Run StormCAD Profile Report
Profile: MH-459 to I-338
Norwood Lateral to I-75

MH-459 to I-338 – 10 year



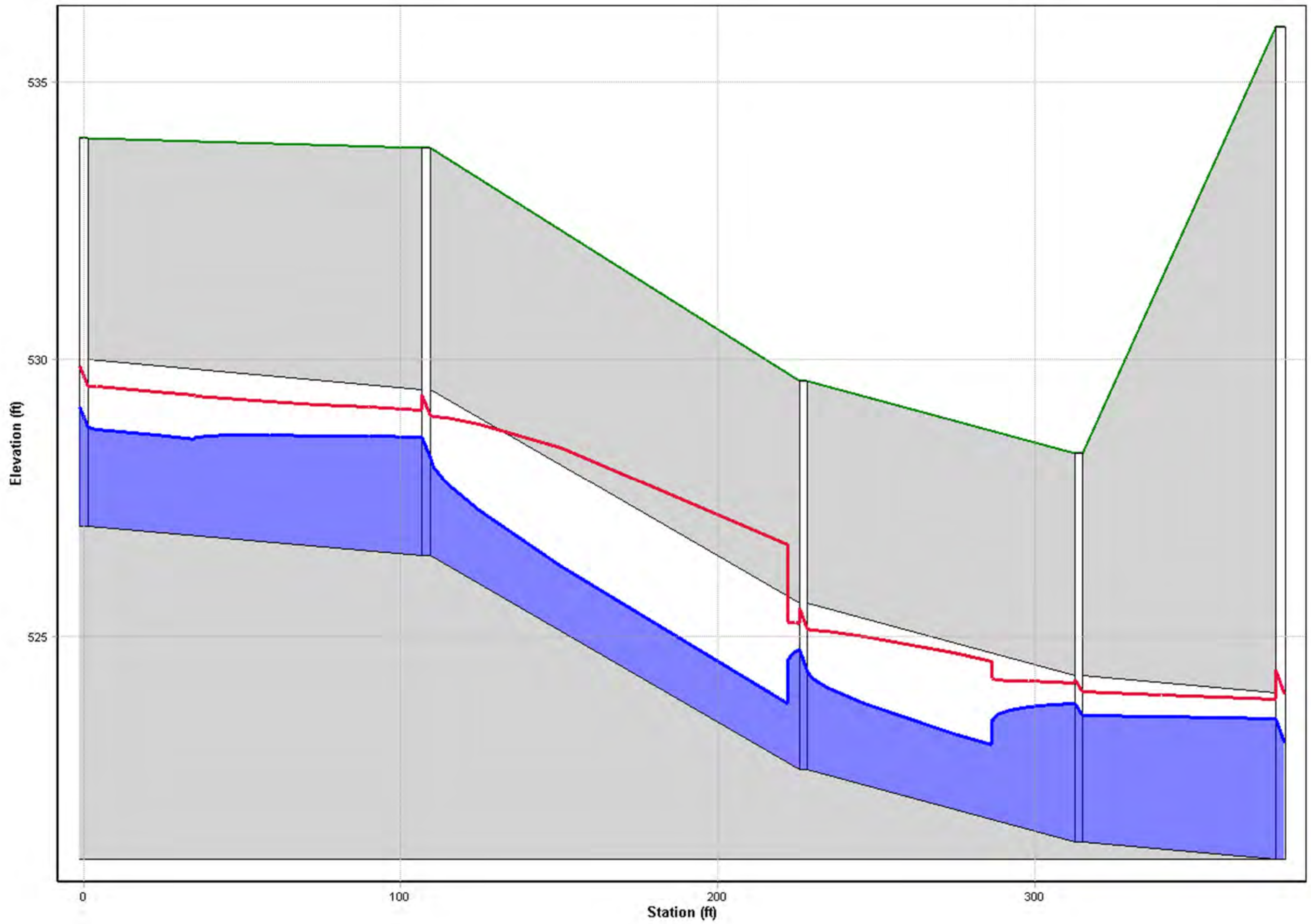
Ross Run StormCAD Profile Report
Profile: MH-462 to I-339
I-75 to Ross Park

MH-462 to I-339– 10 year



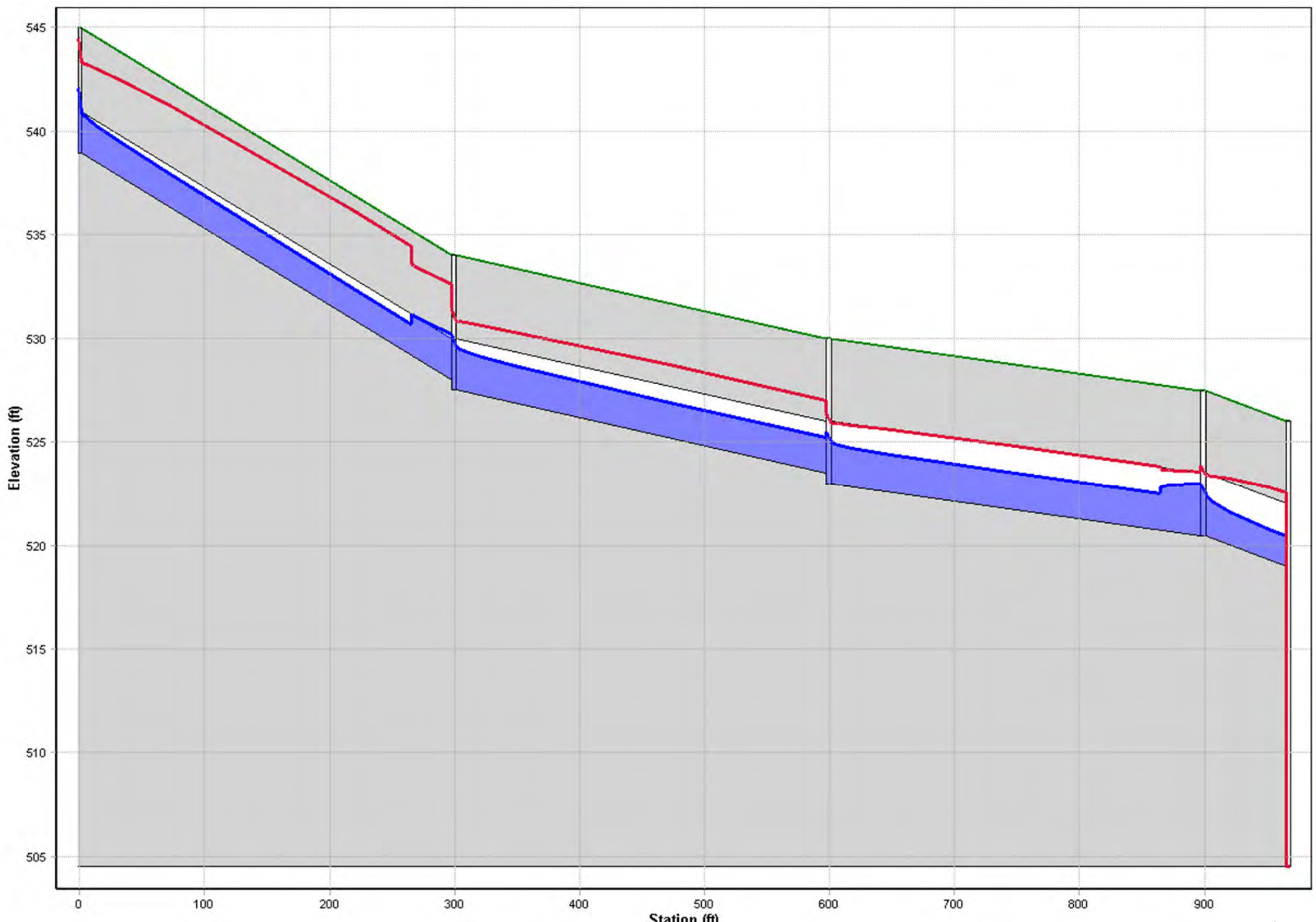
Ross Run StormCAD Profile Report
Profile: I-340 to I-341
Ross Park

I-340 to I-341 – 10 year



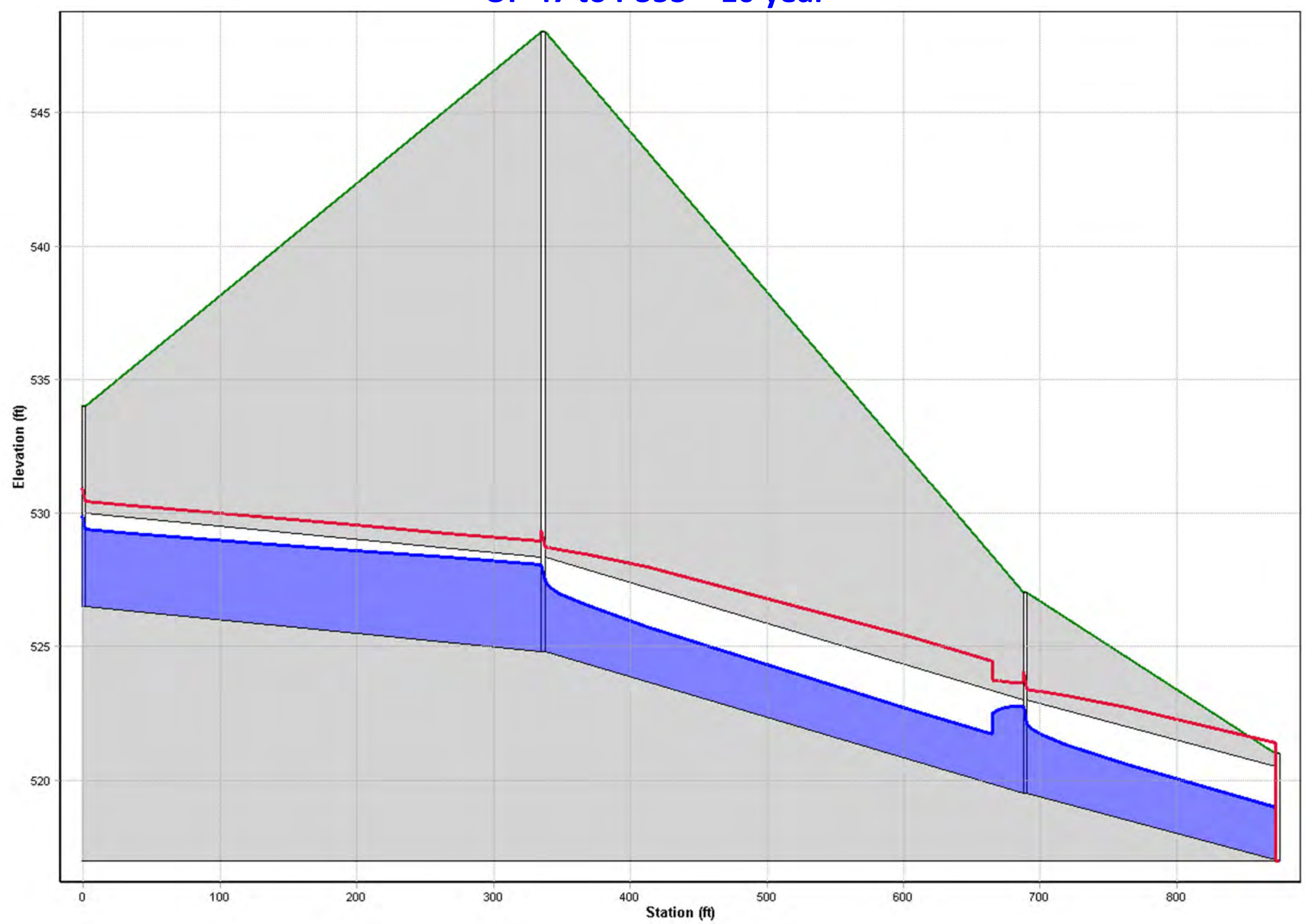
Ross Run StormCAD Profile Report
Profile: OF-51 to I-336
I-75 to Paddock Rd

OF-51 to I-336 – 10 year



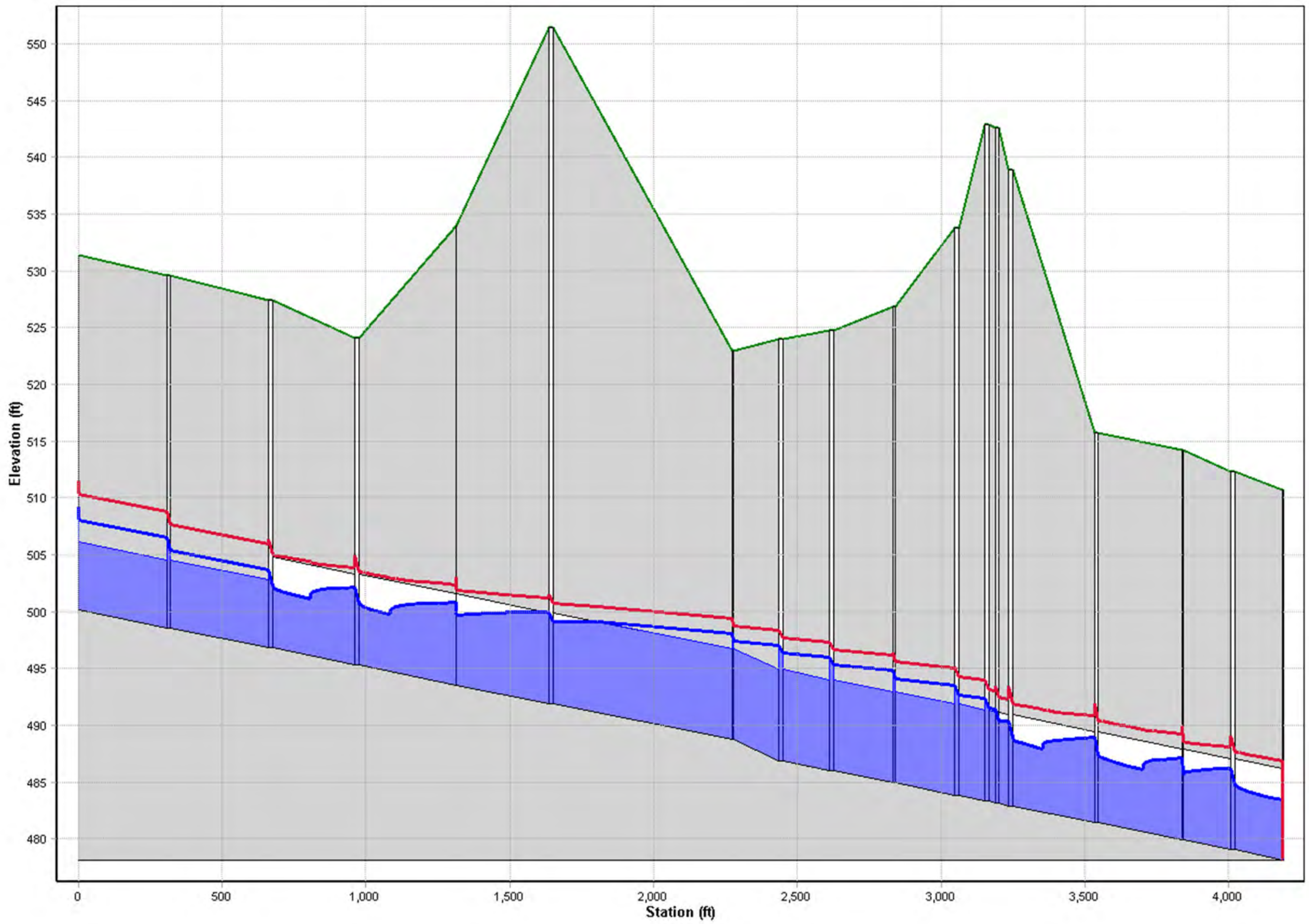
Ross Run StormCAD Profile Report
Profile: OF-47 to I-353
Norwood Lateral to Fischer Pl

OF-47 to I-353 – 10 year



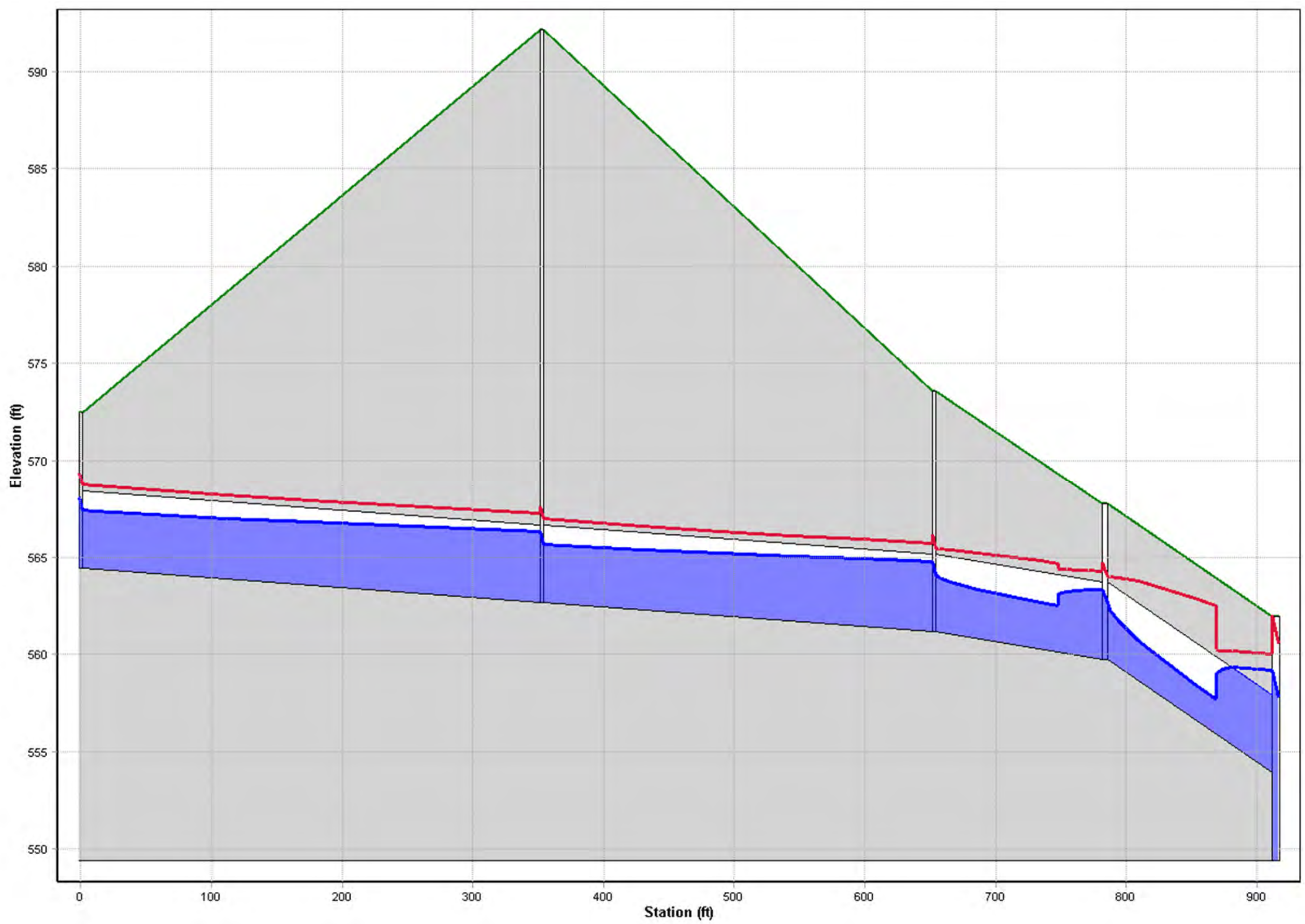
Ross Run StormCAD Profile Report
Profile: OF-48 to I-290
Ross Run Outfall to Tennessee Ave

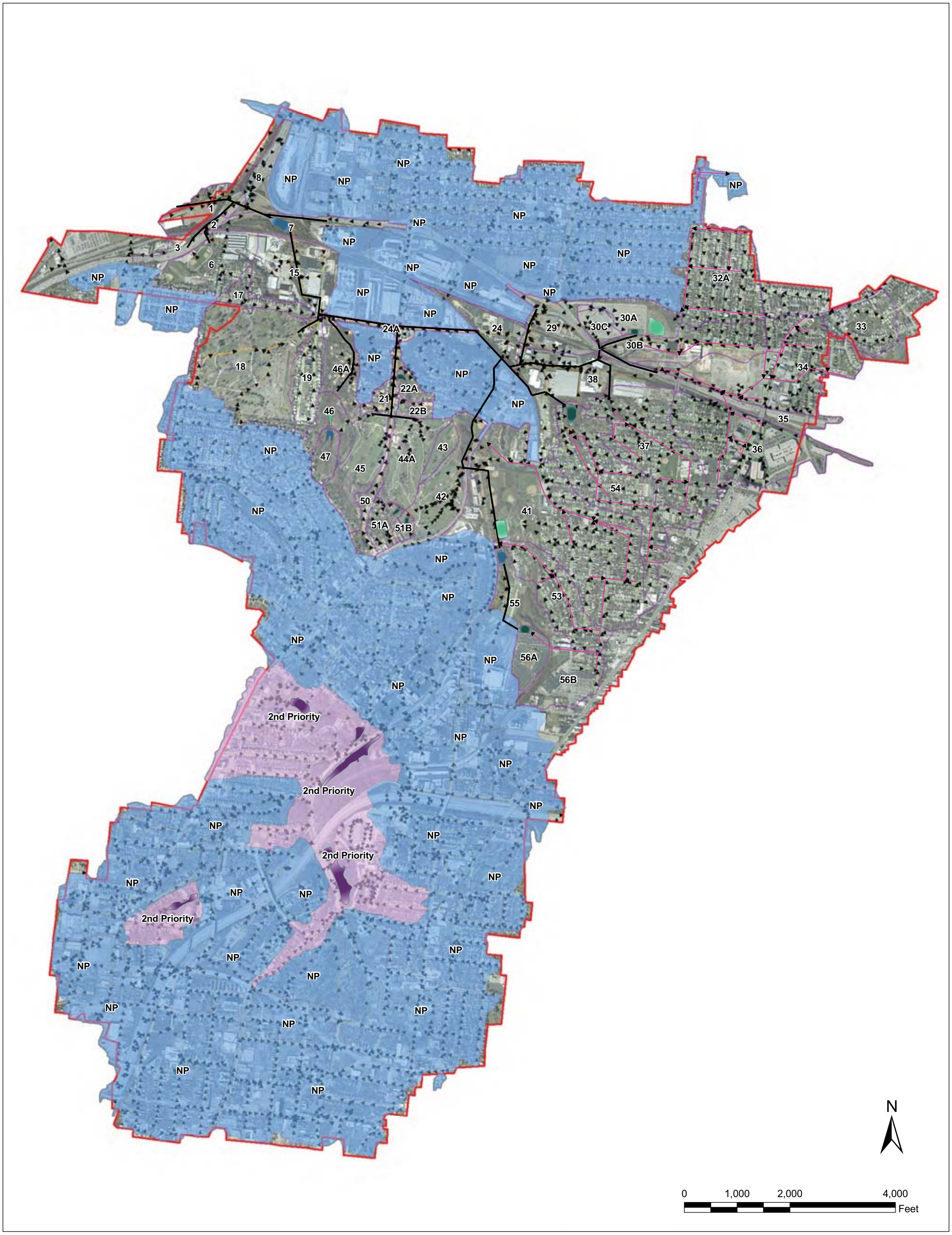
OF-48 to I-290 – 10 year



Ross Run StormCAD Profile Report
Profile: MH-07 to I-317
Ross Ave to Maple Ave

MH-07 to I-317 – 10 year





Ross Run Watershed
Proposed Strategies

Legend

Proposed Storm Pipe	Ross Run CSO Boundary	Existing Basin
Norwood Storm Sewer	Priority Area	Existing Basin to be Enhanced
Combined Sewer	Non-Priority Area	Proposed Basin
Sanitary Sewer	2nd Priority	Proposed Basin Discharging to CSS
Ross SMU Sewers		

Human Nature, Inc. and Strand Associates, Inc.