PROJECT GROUNDWORK
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SUSTAINABLE WATERSHED EVALUATION PROCESS

BLOODY RUN WATERSHED

METROPOLITAN SEWER DISTRICT OF GREATER CINCINNATI

HUMAN NATURE

STRAND ASSOCIATES, INC. ENGINEERS

March
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.

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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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CONTENTS

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 Bloody 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.

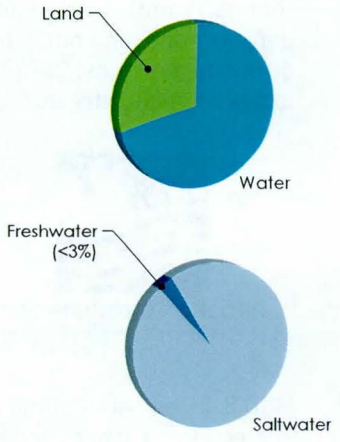
(2) Enabled Projects: Wet weather strategies (*e.g.*, downspout disconnection and reforestation) that represent a leveraged infrastructure investment. Enabled Projects present opportunities for cost sharing and collaboration among MSD and key watershed stakeholders.

(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 Bloody 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.



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.

PROBLEM

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

Human activities of industry, agriculture, development, and consumption pose constant threats to freshwater resources, as these activities produce wastewater and contribute to greater volumes of stormwater runoff. Maintaining and operating

stormwater and wastewater infrastructure is a monumental challenge for local and regional governments. Providing constant and adequate levels of service, while anticipating future changes in demand and financial abilities, places a significant burden on these communities. In the United States, wastewater is transferred to a system of centralized (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.

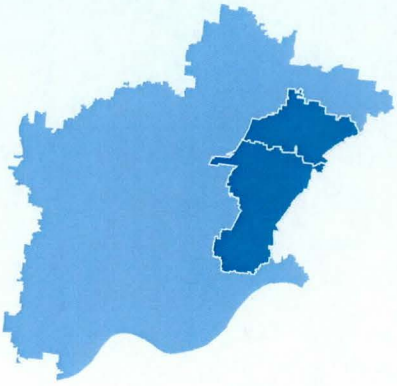
The coarse evaluation for the Bloody Run watershed was a first step in the broader SWEP. Specifically, the coarse evaluation focused on Step 1, watershed characterization, and portions of Step 2, potential wet weather strategies.

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

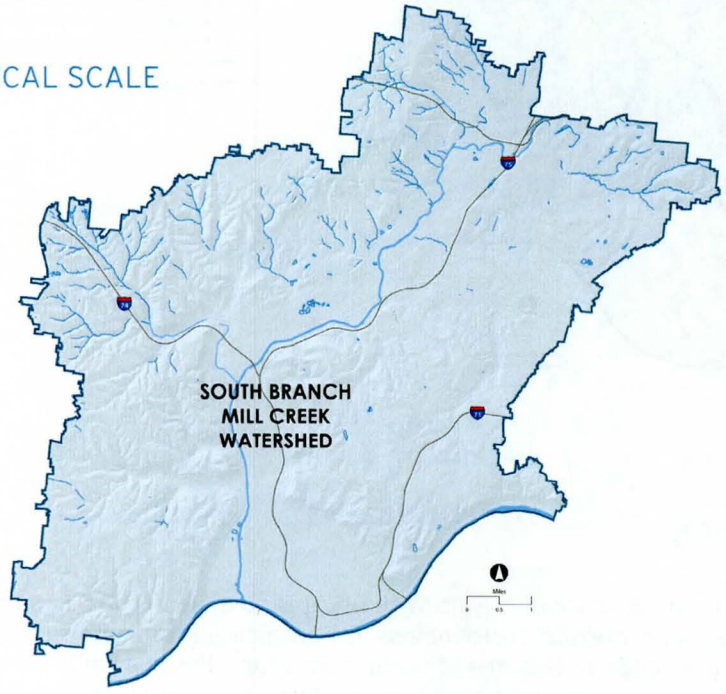


METHOD

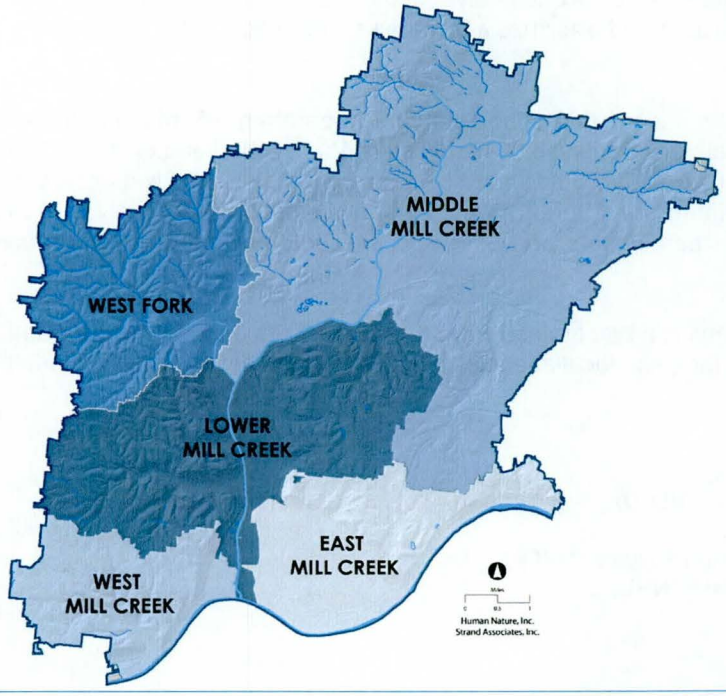
METHOD

As part of the evaluation, the project team critically analyzed the Bloody 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

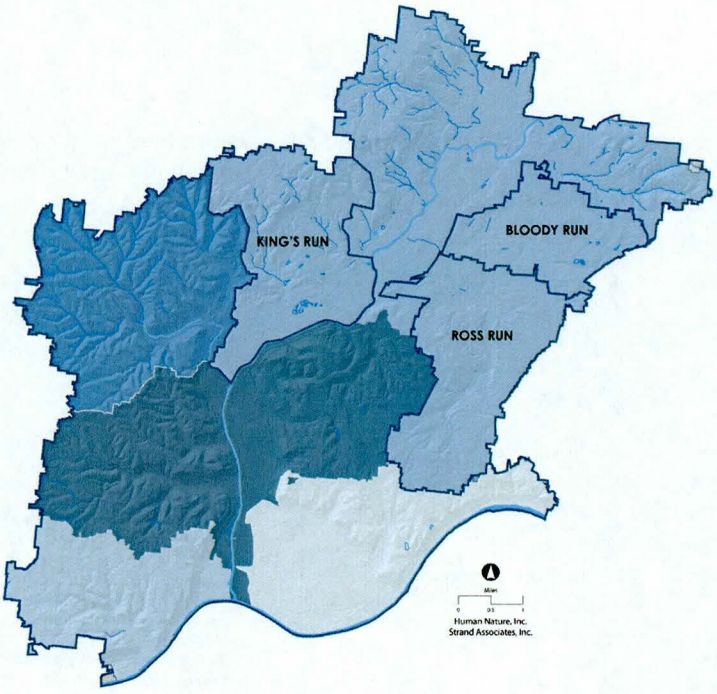


The South Branch Mill Creek watershed covers approximately 40,000 acres (62.5 square miles) within the heart of Hamilton County. The watershed contains the Mill Creek, West Fork Creek and the Ohio River as its major hydrologic features. Interstate 74, Interstate 75, and Interstate 71 comprise the watershed's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

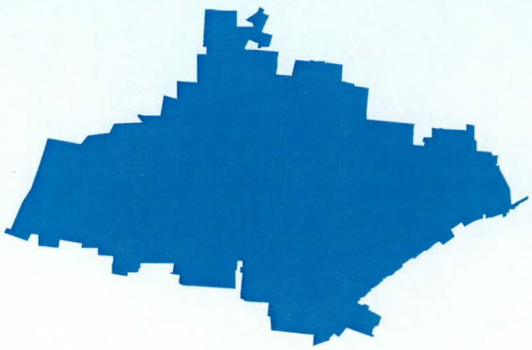
Natural Systems

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.

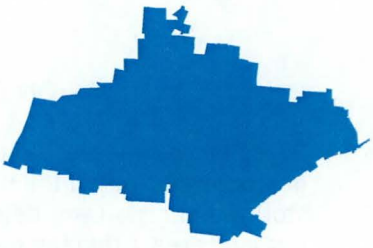
Built Systems

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.



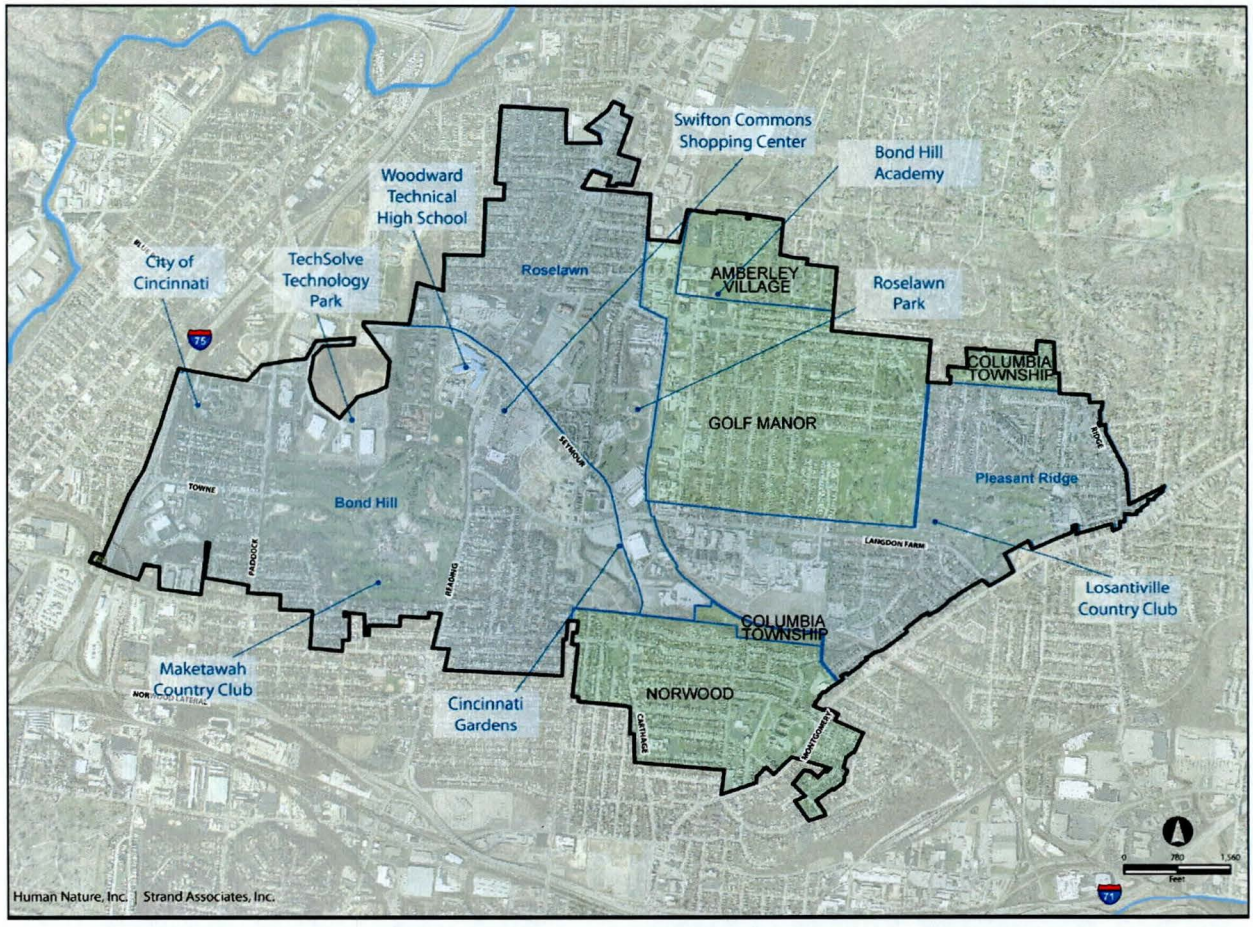
INVENTORY & ANALYSIS

INVENTORY



LOCATION

The Bloody Run watershed covers approximately 3.4 square miles (2,187 acres and 12.4 percent of the Middle Mill Creek watershed) and overlaps five jurisdictions: Cincinnati (Roselawn, Bond Hill, and Pleasant Ridge neighborhoods), Amberley Village, Golf Manor, Columbia Township, and Norwood. The main transportation routes include Interstate 75 defining the Western border, Montgomery Road defining the Eastern border, Seymour Avenue, Carthage Avenue, Reading Road, Langdon Farm Road, Ridge Road, Paddock Road, and Towne Street. There are several key property owners within the Bloody Run watershed, including the City of Cincinnati, Cincinnati Park Board (Roselawn Park), Cincinnati Board of Education (Woodward Technical High School, Pleasant Ridge Montessori and AMIS Elementary), the City of Norwood (Fenwick Park and Linder Park), the Archbishop of Cincinnati, Maketewah Country Club, the Losantiville Country Club (The Ridge Club), Allen Temple Real Estate (Swifton Commons Shopping Center), and property owners within TechSolve Technology Park (Lab Alliance, Inc., Federal Food and Drug Administration and Amantea NonWovens, LLC).



CHARACTERIZATION OF PROBLEM

Based on coarse-level calculations, approximately 1.1 billion gallons of stormwater runoff the Bloody Run watershed each year. Annual stormwater runoff was determined using pervious and impervious land area within the watershed and an annual rainfall of 41.17 inches, based on MSD's typical year rainfall dataset.

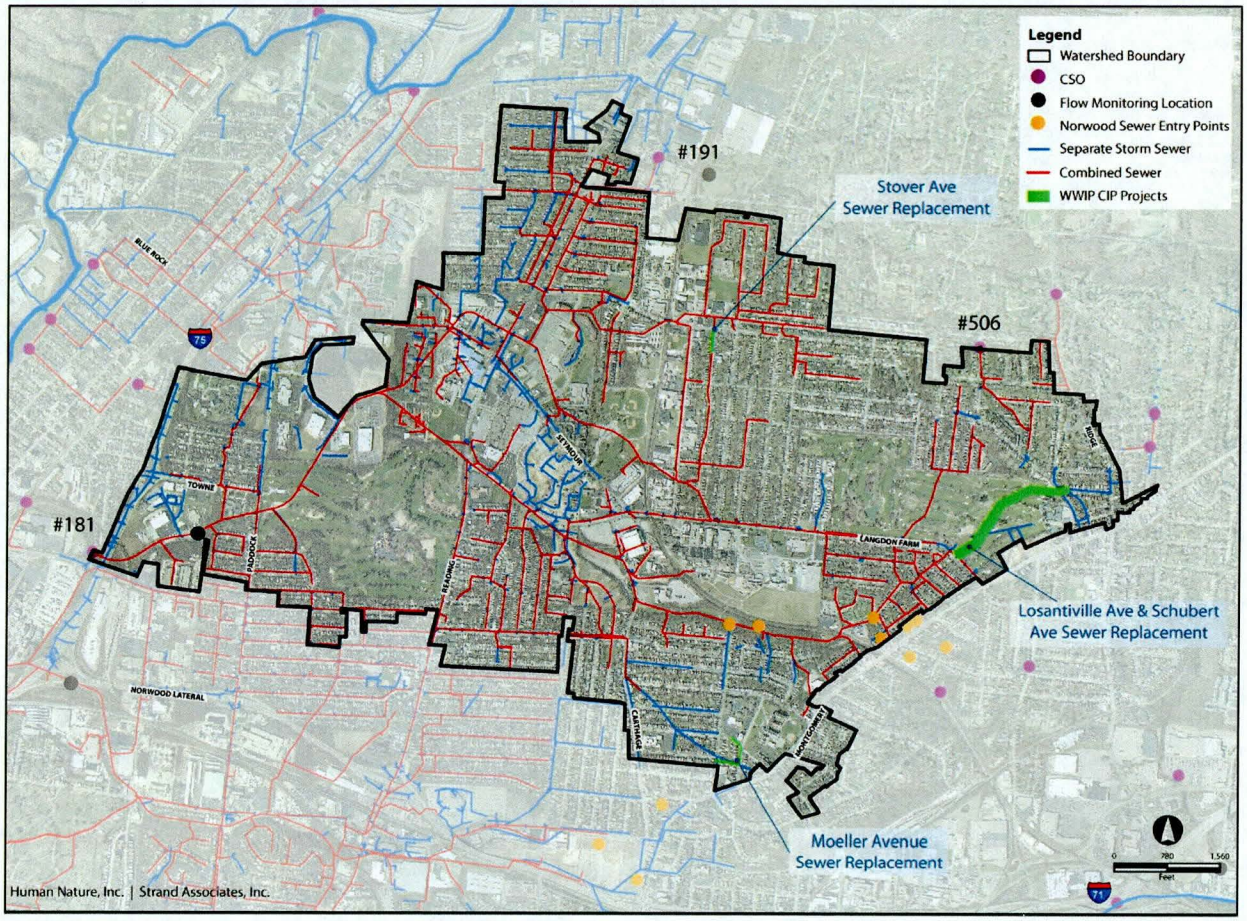
Total Area (Ac)	Impervious Area (Ac)	Pervious Area (Ac)	Total Runoff (MG)
2,187	961	1,226	1,135

One of MSD's largest combined sewer overflows is the Bloody Run Regulater (CSO #181), located in the Bloody Run watershed. Each year, about 916 million gallons of combined sewage and storm water overflow through this CSO, which accounts for about 13 percent of Cincinnati's total combined sewer overflow volume.

ANNUAL CSO STATISTICS [1]

CSO NUMBER	NAME	EVENTS	OVERFLOW (MG)	CONTROL (%)	CSO CONTROL STRATEGY [1]	BUNDLE CLUSTER
181	Bloody Run Regulator	39	916	36	Enhanced High Rate Treatment (EHRT): 230 MGD	Elmwood Place
191	7601 Production Dr. Grating	45	0	88	Regulator Improvement: 0.2 cfs	Amberley Creek
506	6536 Cliff Ridge Grating	41	2	75	Partial Separation	Amberley Creek
TOTAL		**125**	**918**			

[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 Bloody Run watershed was named after the creek that once ran through the middle of this watershed but is now piped underground. The creek was named after a historical event in 1794 where Native Americans ambushed a party of packhorsemen. The area was considered unsafe and there were few permanent settlers in the vicinity until the threat of Native American raids diminished. The area remained as primarily undeveloped farmland until the late nineteenth century when several villages/neighborhoods were established (Norwood, Pleasant Ridge, Bond Hill, Roselawn, Golf Manor and Amberley Village). Most of them (Pleasant Ridge, Bond Hill, Roselawn, Golf Manor and Amberley Village) experienced growth at the same time, evolving as commuter suburbs with the rise of the Cincinnati, Lebanon & Northern (CL&N) Railroad, streetcars, the Interurban Rapid Transit line and the automobile in the late nineteenth and early twentieth centuries. The rise of the automobile, especially, allowed people to move further out into these areas that were "new" and "modern" and hadn't yet experienced crowding, deterioration, crime and race tensions that were affecting the older "inner ring" suburbs and downtown.

The presence of thick layers of gravel and sand outwash deposits that fill the bottom of the LIttle and Great Miami River valleys and the ancient paths of the Ohio River valley suggest the area's long glacial history. The City of Norwood has especially benefitted from its glacial history, represented by the Norwood trough (former path of the Ohio River) that stretches north along Red Bank Road from Fairfax to Madisonville and west along the Norwood Lateral (Ohio Highway 562) to St. Bernard. Norwood's industrial character can be attributed to this trough as the availability of artesian groundwater (which was cheaper and purer than city water) made Norwood an attractive location. This industrial base gave Norwood a solid 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 primarily working-class. In 1987, the General Motors Plant in Norwood closed after 64 years and left forty-three hundred people without jobs. This closing accelerated Norwood's change from an industrial-based city to an office center.

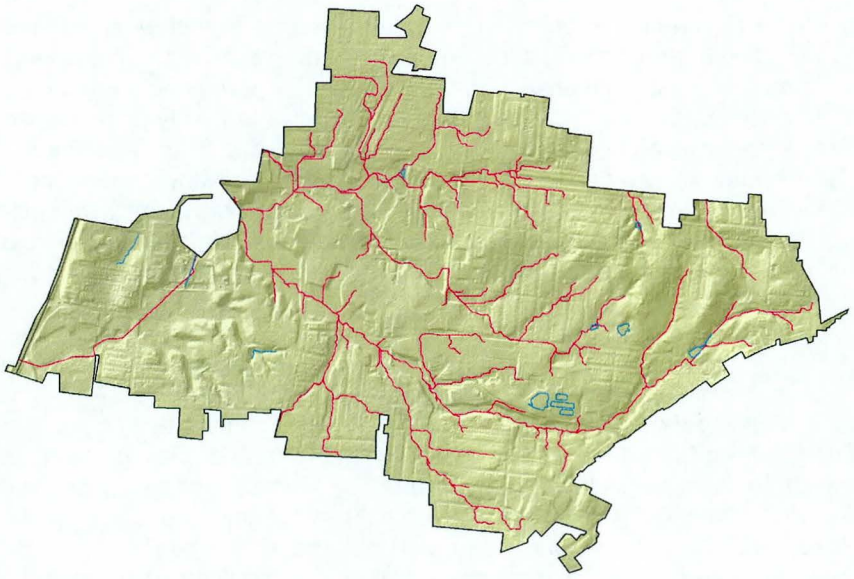
Pleasant Ridge, on the other hand, discouraged industrial development and focused on a smaller business district, believing that manufacturing would reduce the area's appeal. Bond Hill, Roselawn and Golf Manor attracted primarily middle-income residents (blue and white-collar workers) while Amberley Village drew an upper-income population. The residential community in Bond Hill was particularly attractive because of its proximity to the industrial development in Norwood and the Mill Creek Valley.

Eventually these neighborhoods began to decline as they too lost their "newness" and residents moved further out to undeveloped land.

GIS INVENTORY

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

hydrologic network

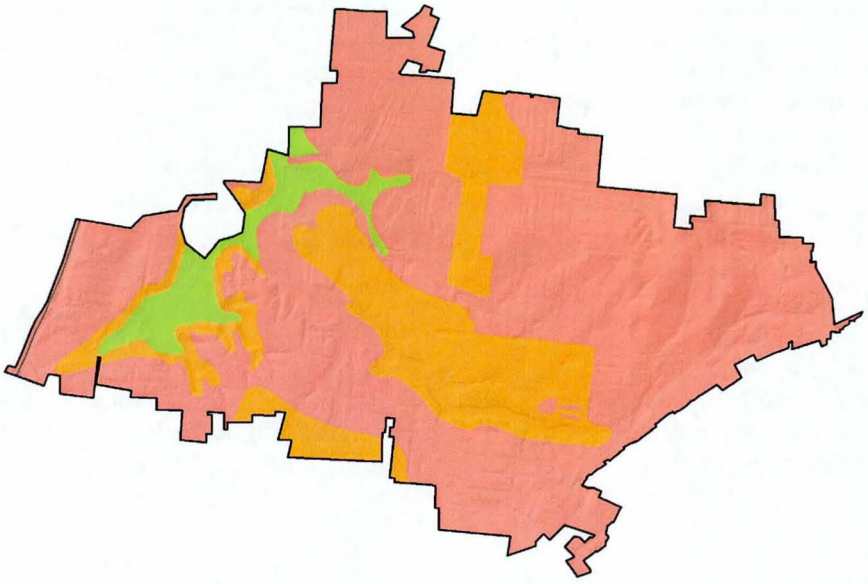


Watershed boundary
Interstate
Historical streams
Existing streams

The pre-development hydrologic network shows 22.7 miles of an extensive system of creeks and streams within the sub-basin. This network naturally conveyed stormwater runoff to the Mill Creek. Today, underground sewer systems have replaced this entire stream network.

Data source: CAGIS, historical USGS maps

hydrologic soil groups



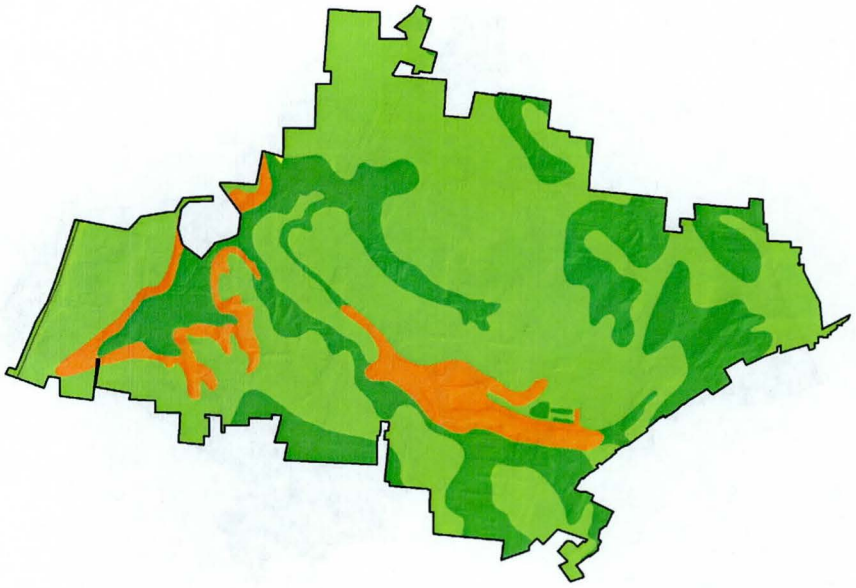
Watershed boundary
Interstate
Group A
Group B
Group C
Group D

In the Bloody Run watershed, 5% of soils are Group B (115 acres), 23% are Group C (496 acres) and 72% are Group D (1,576). There are opportunities for shallow infiltration within Group A and B soils, which are located along the western portion of Bloody Run.

Data source: Hamilton County Soil Survey

slope ranges

Watershed boundary
Interstate
0-3 percent
3-8 percent
8-15 percent
15-25 percent
25+ percent

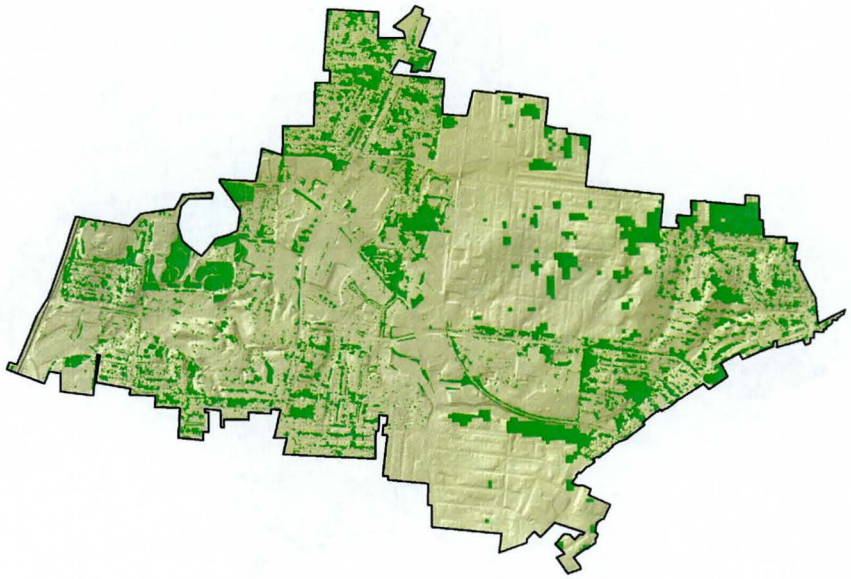


9% (187 acres) of land in the Bloody Run watershed has slopes greater than 15 percent.

Data source: Hamilton County Soil Survey

tree canopy cover

Watershed boundary
Interstate
Existing tree canopy



There are 447 acres of existing tree canopy in the Ross Run sub-basin, representing 20% of the total land area.

Data source: Cincinnati Park Board, ODNR

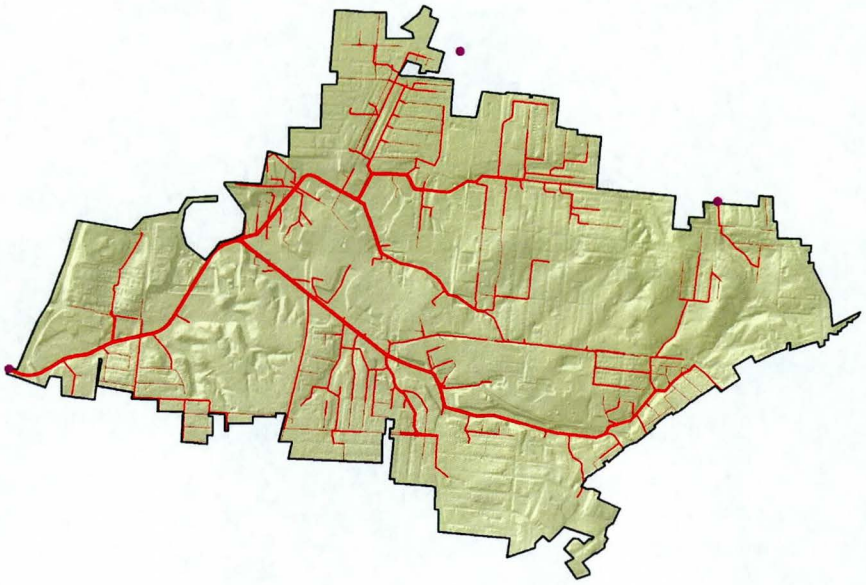
impervious surfaces

Watershed boundary
Interstate
Impervious surfaces

There are 961 acres of impervious surfaces in the Bloody Run watershed, representing 44% of the total land area.

Data source: CAGIS

combined sewer system



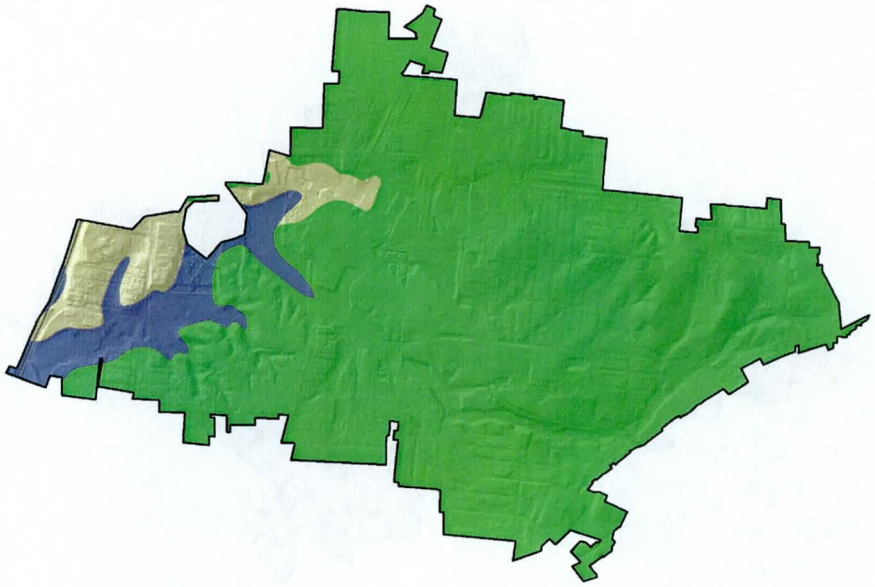
Watershed boundary
Interstate
CSO
Combined sewers (pipe size)
< 12 inches
12-48 inches
48-72 inches
> 72 inches

There are 34 miles of combined sewers (100% of sewer infrastructure) in the Bloody Run watershed.

Data source: MSD

geology

- Watershed boundary
- Interstate
- Grained Materials
- Clay-loam till
- Limestone
- Loam till
- Shale
- Silt

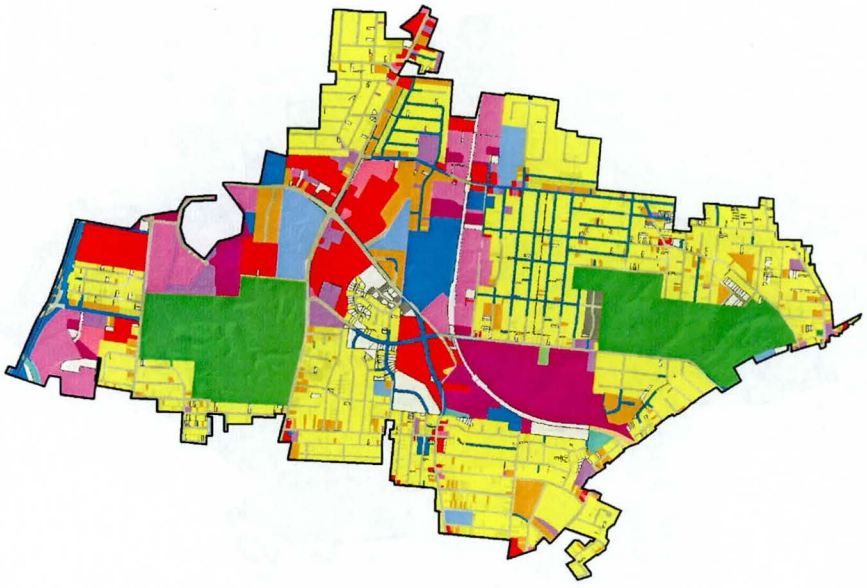


The vast majority of land in the Bloody Run watershed is underlain by loam till geology. Deep infiltration opportunities may exist in grained material deposits, which may be present in the western portion of the sub-basin.

Data source: Ohio Geological Survey

land use

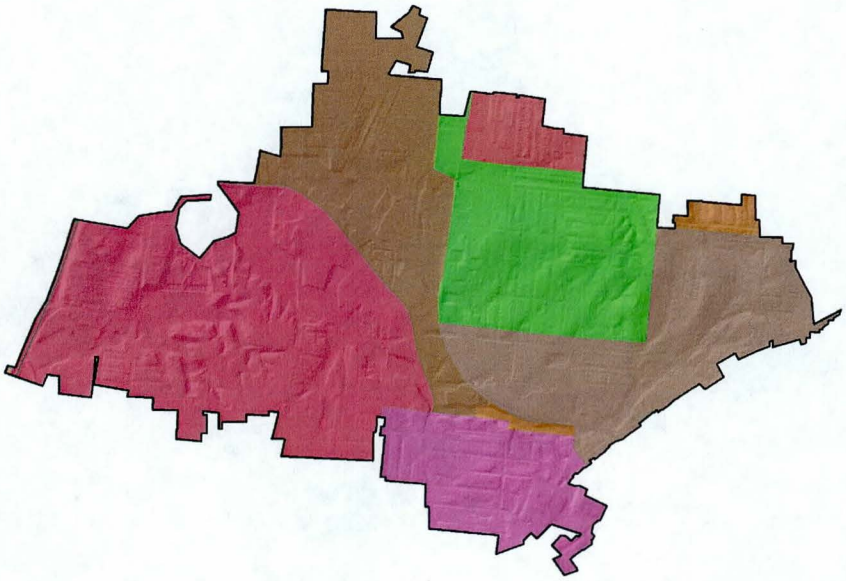
- Watershed boundary
- Interstate
- Agricultural: 1 parcel; 2 acres
- Commercial: 176 parcels; 160 acres
- Educational: 62 parcels; 61 acres
- Industrial: 56 parcels; 149 acres
- Institutional: 99 parcels; 56 acres
- Light industrial: 83 parcels; 164 acres
- Multi-family: 536 parcels; 121 acres
- Mixed-use: 17 parcels; 4 acres
- Office: 40 parcels; 160 acres
- Parks/recreation: 28 parcels; 288 acres
- Public space: 199 parcels; 150 acres
- Public utilities: 9 parcels; 8 acres
- Single-family: 5,276 parcels; 659 acres
- Two-family: 551 parcels; 64 acres
- Vacant: 578 parcels; 64 acres
- Unknown: 15 parcels; 9 acres



Single family property comprises the greatest percentage (30%) of land within the Bloody Run watershed.

Data source: Hamilton County Auditor

neighborhoods



- Watershed boundary
- Interstate
- Roselawn
- Bond Hill
- Pleasant Ridge
- Norwood
- Columbia Township
- Golf Manor
- Amberley Village

The Bloody Run watershed is comprised of 3 different neighborhoods within 5 different jurisdictions.

Data source: CAGIS

right-of-way (ROW)

- Watershed boundary
- Interstate
- Right-of-way

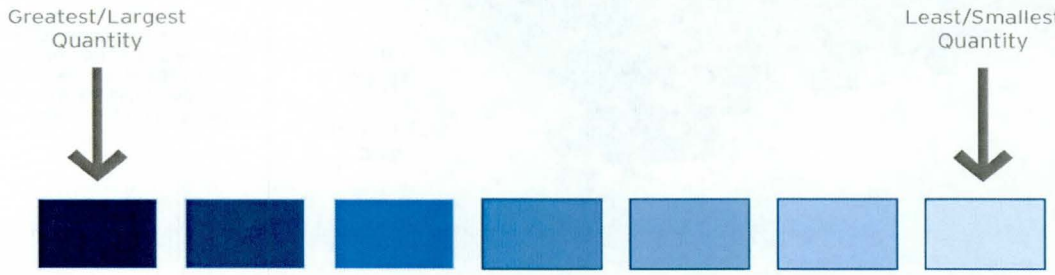
There are 150 acres of ROW in the Bloody Run watershed, which is 7% of the total land area.

Data source: CAGIS

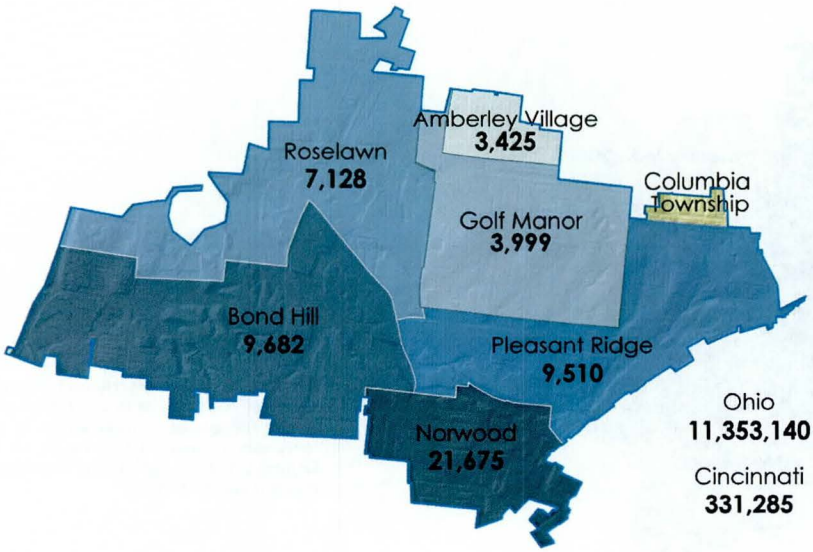
DEMOGRAPHICS

The demographic profile for the Bloody 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 Bloody Run using 2000 Census data.

The following sections summarize the 2000 Census demographic data for Cincinnati neighborhoods and Hamilton County jurisdictions within the Bloody Run watershed. Demographic data for Columbia Township was not found. Note that the neighborhoods/jurisdictions are coded by graduated colors as follows:

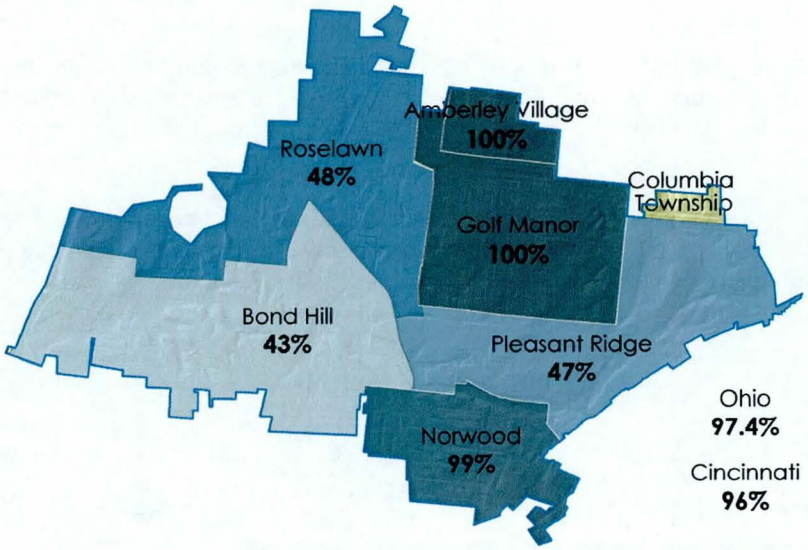


total population



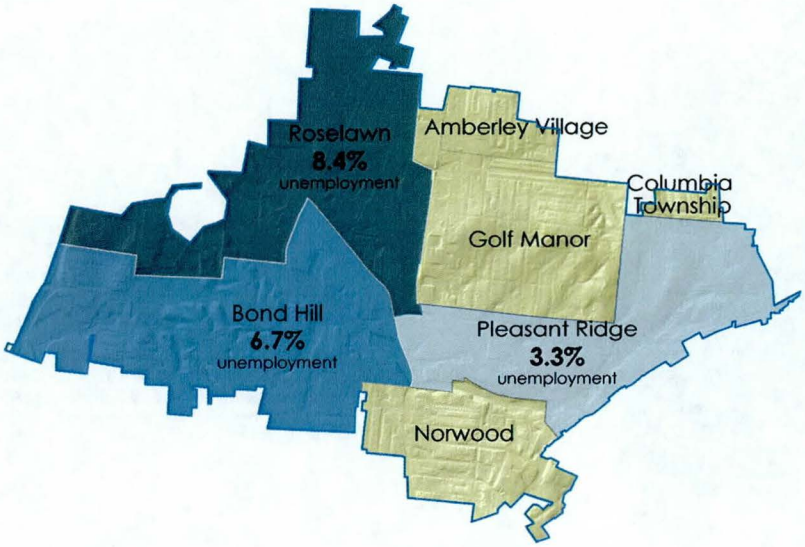
In 2000, The City of Norwood represented the largest population within the Bloody Run watershed with 21,675 individuals. Amberley Village represented the smallest population with 3,425.

household population



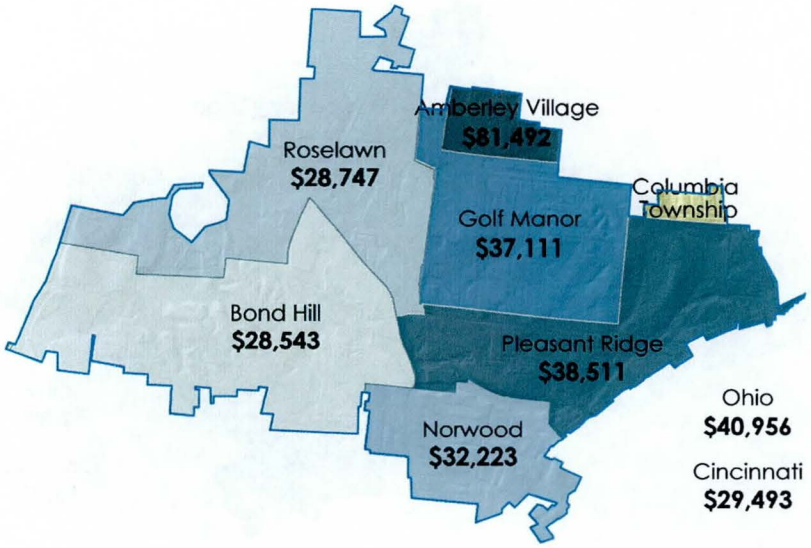
With 100% of individuals living in households in 2000, Amberley Village and Golf Manor had the largest household population. Bond Hill had the smallest household population with 43%.

unemployment



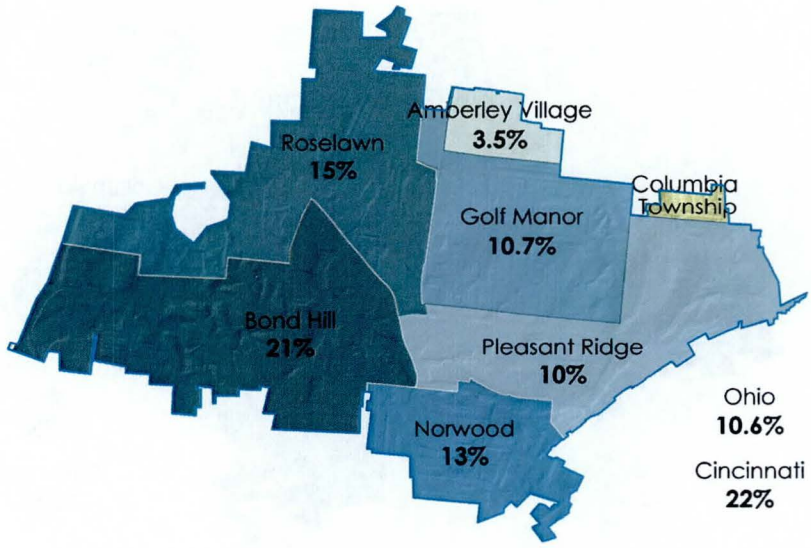
In 2000, Roselawn experienced the highest unemployment rate of 8.4%. Pleasant Ridge experienced the lowest rate of 3.3%. There was no unemployment data for Amberley Village, Golf Manor, Norwood, City of Cincinnati and Ohio.

median household income



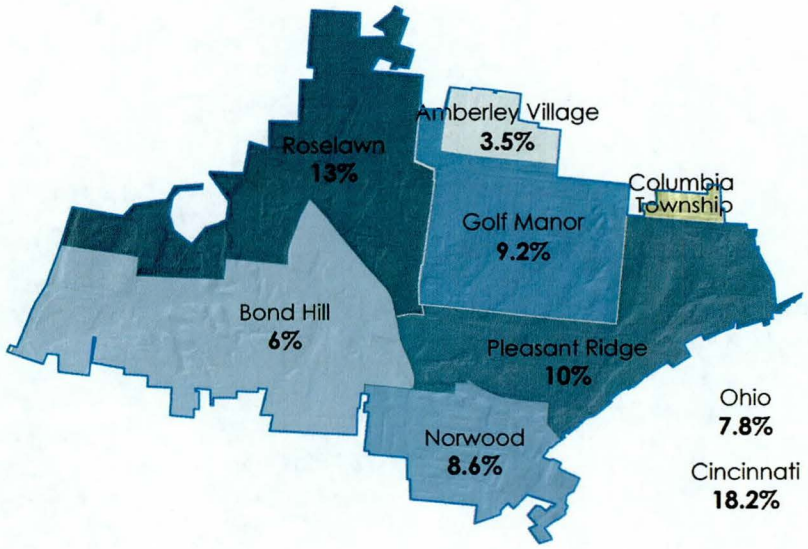
In 2000, Amberley Village is the most affluent, with the highest median household income of $81,492. Bond Hill had the lowest of $28,543. The median household income for the City of Cincinnati was $29,493 and for Ohio was $40,956.

percentage of individuals below poverty line



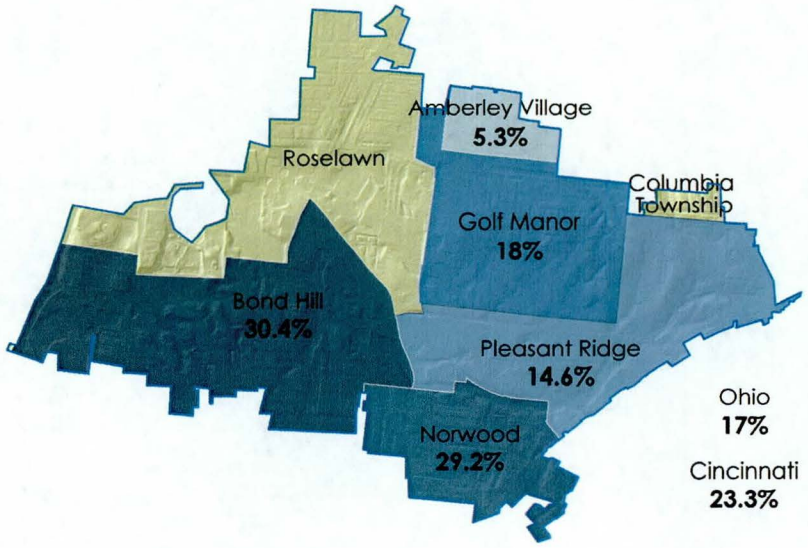
In 2000, Bond Hill had the most individuals below poverty with 21%. Amberley Village had the fewest with 3.5%. The City of Cincinnati had 22% and Ohio had 10.6% of the total population living in poverty.

percentage of families below poverty line



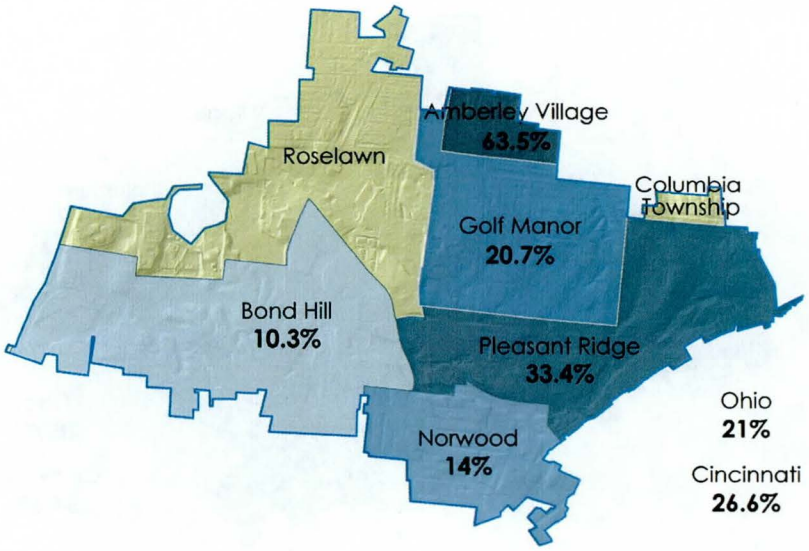
In 2000, Roselawn had the most families living below the poverty line with 13%. Amberley Village had the fewest with 3.5%. The City of Cincinnati had 18.2% and the state of Ohio had 7.8% of their families living in poverty.

percentage of individuals over 25 without a high school degree



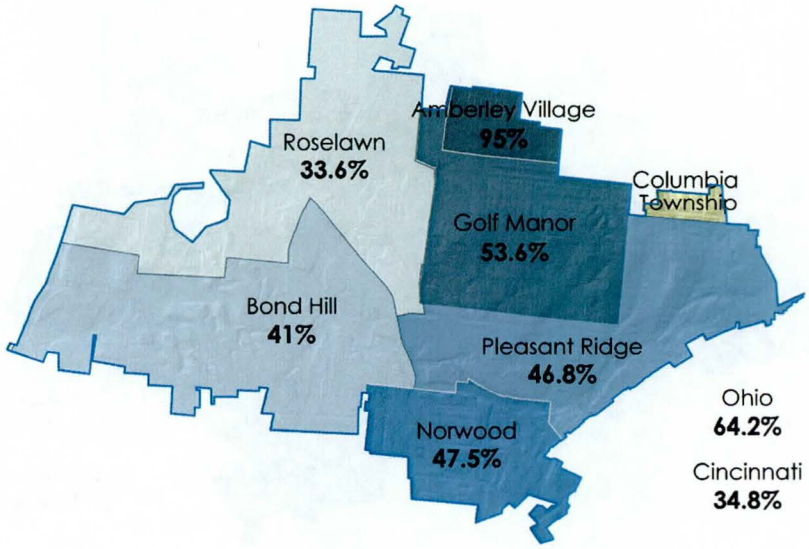
In 2000, Bond Hill had the most individuals over 25 without a high school degree at 30.4%. Amberley Village had the least at 5.3%. The City of Cincinnati had 23.3% and the state of Ohio had 17% of individuals over 25 without a high school degree. There was insufficient data for Roselawn.

percentage of individuals over 25 with a bachelor's degree



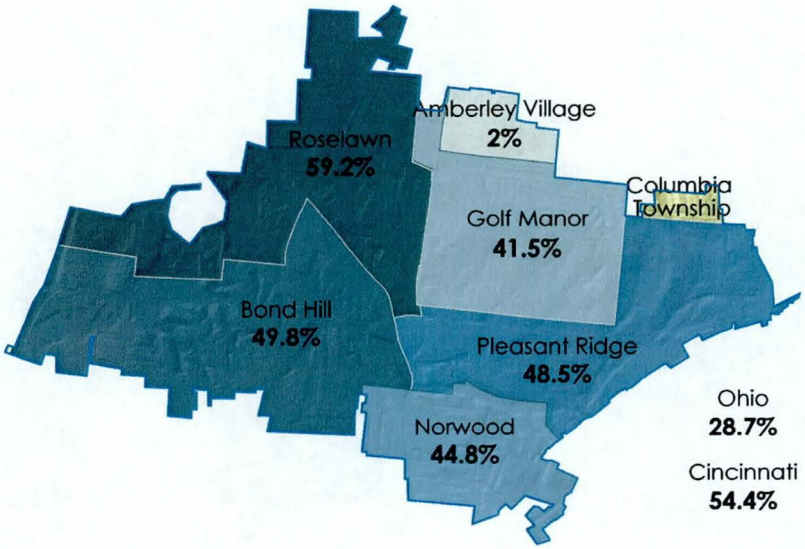
In 2000, Amberley Village had the most individuals over 25 with a bachelor's degree at 63.5%. Bond Hill had the fewest at 10.3%. The City of Cincinnati had 26.6% and Ohio had 21%. There was insufficient data for Roselawn.

housing tenure: percent owner occupancy



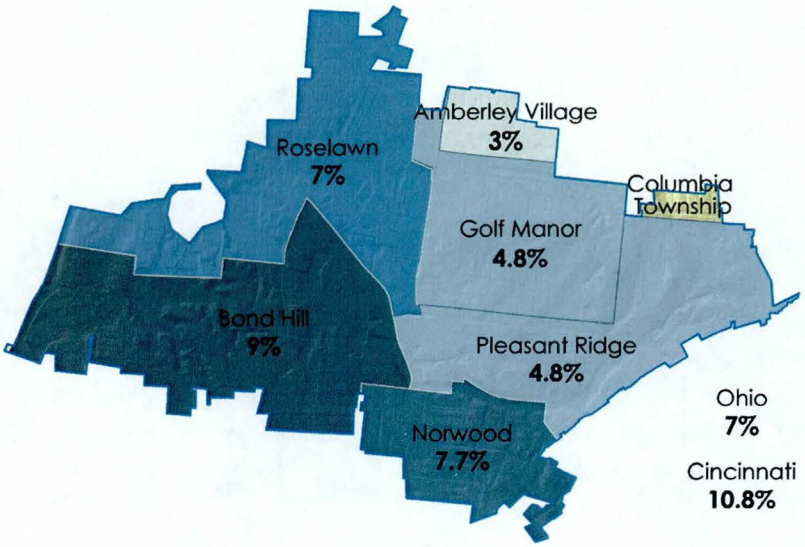
In 2000, Amberley Village had the highest owner-occupancy rate at 95%. Roselawn had the lowest rate at 33.6%. The City of Cincinnati had 34.8% and Ohio had a rate of 64.2%.

housing tenure: percent renter occupied

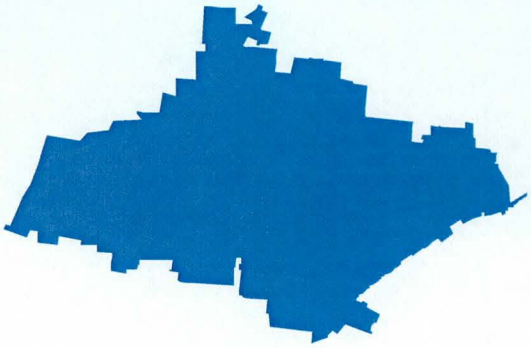


In 2000, Roselawn had the highest renter-occupancy rate at 59.2%. Amberley Village had the lowest at 2%. The City of Cincinnati had a rate of 54.4% and Ohio had 26.7%.

housing tenure: percent vacancy

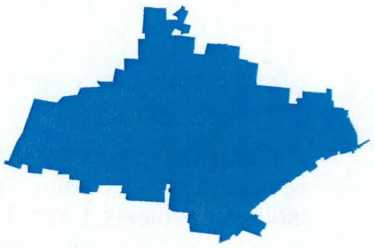


In 2000, Bond Hill had the highest housing vacany rate at 9%. Amberley Village had the lowest at 3%. The City of Cincinnati had a rate of 10.8% and Ohio had 7%.



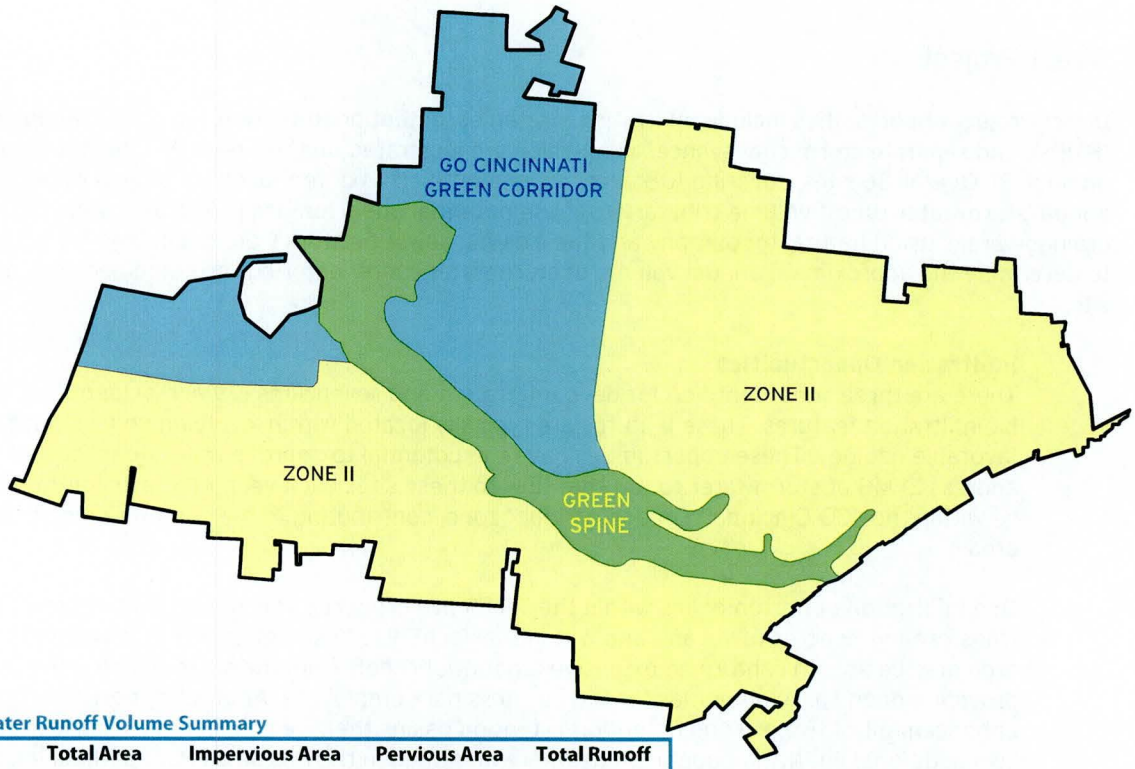
WATERSHED OPPORTUNITIES

WATERSHED OPPORTUNITIES



ZONAL DELINEATION

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



Annual Stormwater Runoff Volume Summary

Zone	Total Area (Ac)	Impervious Area (Ac)	Pervious Area (Ac)	Total Runoff (MG)
Green Spine	228	111	117	126
GO Cincinnati	532	274	257	303
Zone II	1,427	575	852	705
TOTAL	2,187	961	1,226	1,134

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

"Zone II" contains a high percentage of single-family residential properties, as well as large tracts of open space (*e.g.*, Maketewah Country Club and Losantiville Country Club). Slopes are minimal, ranging from zero percent up to eight percent at the interior edges. The northern section drains southward and the southern section drains northward to the "Green Spine".

The "Green Spine" was delineated based on historical streams and steep hillsides that run horizontally across Bloody Run watershed.

The "GO Cincinnati Green Corridor" zone was delineated based on the the Seymour/Reading Road Corridor as identified in the City of Cincinnati's GO Cincinnati Plan (Growth & Opportunities Study). This area was identified as a focal area for a mix of drivable suburban (*i.e.*, R&D, flex-industrial, and back office along Seymour and Paddock) and walkable urban development (mixed-use along Reading Road).

WATERSHED OPPORTUNITIES

The project team identified several opportunities for reducing the volume of stormwater runoff entering the combined sewer system. Opportunities in the Bloody 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 strategies, detention, retention, site best management practices (BMPs), and separate storm conveyance, all of which are illustrated on the Green Wet Weater Strategies graphic on page 31. Overall 36 sites, covering 108 acres, were identified as potential direct project opportunities. The annual stormwater runoff volume tributary to these potential opportunities is approximately 135 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 three sites identified for deep infiltration and seven sites (39 acres) identified for bioinfiltration features. These features are typically located within low-lying undeveloped areas with favorable geology. These opportunities have the potential to improve water quantity and quality and address 21 MG of stormwater runoff that flow to these sites each year. All these infiltration opportunities lie within the "GO Cincinnati Green Corridor" zone, contributing to the "green" image proposed for the area.

One infiltration opportunity lies within the TechSolve property. This opportunity represents transforming 19 acres of vacant land within the TechSolve business park that is currently for sale. This area may be able to capture an extensive amount of runoff from the surrounding watershed area while providing open space amenities for the business park employees. Another opportunity proposes the enhancement of two existing detention/retention basins that are connected to the TechSolve property. Two additional infiltration opportunities were identified in the Roselawn Park parking lot. Since this property is publicly owned, there is an opportunity to expedite this project.

Detention / Underground Storage Opportunities

There are 19 sites (38 acres) identified for potential detention within the Bloody 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 72 MG of stormwater runoff that flow to these sites each year. Several opportunities take advantage of large impervious parking lots (*i.e.*, Swifton Commons Shopping Center) and recommend underground storage. Many of the detention opportunities are found within the "Green Spine" zone as the existing topography allows for natural detention areas.

Bioretention Opportunities

There are seven basins (7 acres) including three existing basins recommended as bioretention opportunities within the Losantiville Country Club. These opportunities work with existing topography and have the potential to improve water quantity and quality and address 13 MG of stormwater runoff that flow to these sites each year. All of the bioretention opportunities lie within "Zone II", taking advantage of the large tract of open space within the Losantiville Country Club and the existing

topography that allows for natural retention.

Site-Specific BMPs / Redevelopment Opportunities

There are two site BMP/multiple strategy opportunities (18 acres) recommended within the Bloody Run watershed. These opportunities have the potential to improve water quantity and quality and address 12 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. See "Eco Redevelopment District" below for redevelopment guidelines. These site BMPs and redevelopment opportunities are located within "Zone II", where urban development is dominant and the need for revitalization is present. Several of these opportunities are proposed at the Cincinnati Gardens southern overflow parking lot, Roselawn Park and the community plan sites listed below. Roselawn Park has been chosen as a MSD Early Success Project, a site-specific stormwater management strategy that provides a water quantity and water quality benefit, builds community support and trust with watershed stakeholders, and results in early benefits for both MSD and the community. This particular project represents an opportunity to build a partnership with the property owner (Cincinnati Park Board) while implementing several stormwater BMPs (detention, infiltration, and reforestation).

Stream Restoration

There is an opportunity for six acres of stream restoration just outside the Bloody Run watershed. Once restored, this stream has the potential to convey not only the 17 MG of stormwater that naturally drains to it each year, but all the stormwater that has been separated through proposed direct projects in the Bloody Run watershed directly to the Mill Creek. Without this restoration, the stream would not be able to hold the water volume or velocity and a separate storm pipe would need to be constructed (**See Stream Restoration detail**). The name of this stream was not provided within the CAGIS dataset.

Separate Stormwater Conveyance System

The proposed separate storm conveyance is approximately 6.5 miles long and links various proposed direct opportunities (detention, infiltration, etc.) to the vacant TechSolve "bowl".

Water Quantity & Quality Benefits

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 provided by the Center for Watershed Protection (2008), the following table was created summarizing the stormwater benefits of the direct project opportunities proposed in the Bloody Run watershed. A 'neutral" benefit was assigned to those projects that have the potential to remove less than 50 percent of stormwater runoff or stormwater pollutants. 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 and Water Quality Benefits graphic**).

Stormwater Benefits Summary

Stormwater BMP	Area (acres)	Drainage Area (acres)	Impervious Drainage Area (acres)	Pervious Drainage Area (acres)	Annual Runnoff (MG)*	Quality: Pollution Removal Potential	Quantity: Volume Removal Potential
Bioretention	7	48	2.73	45.54	13	highly positive	highly positive
Detention	38	137	62.12	74.64	72	highly positive	positive
Infiltration	39	66	9.89	55.71	21	positive	highly positive
Site BMPs	18	22	10.17	11.82	12		
Permeable Pavement						positive	highly positive
Retention						highly positive	highly positive
Infiltration						positive	highly positive
Stream Restoration	6	29	15.21	13.54	17	highly positive	neutral

* Coarse annual runoff volumes based on typical year rainfall

Enabled Projects (Connective Elements)

Enabled Project opportunities include existing community plans, eco-redevelopment districts, complete street corridors, bike trails, reforestation, and I-75 expansion coordination projects.

Community Plans

Existing Community Plans have identified opportunities for several watershed communities.These plans include Pleasant Ridge Vision Plan 1998; Pleasant Ridge NBC Urban Design Plan 2000; and Paddock Hills/Bond Hill NBD Urban Design Plan 2000 outlined in the 2010 Hamilton County Regional Planning document, "Lower Mill Creek Coarse Evaluation Planning Background Report". The projects proposed (7 sites and 44 acres) in these plans include the following:

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

- Reading Road sidewalk repairs, streetscape improvements, street trees
- Paddock Road sidewalk repairs, streetscape improvements, street trees

Lower Mill Creek Coarse Evaluation Planning Background Report (2010)

- CPS Green School - Pleasant Ridge
- CPS Green School - Academy of Multilingual Immersion Studies
- Fire Station 8 applying for LEED-NC Gold
- "The Arbors"- LEED ND
- Messer Headquarters- LEED

Eco-Redevelopment District

These were identified along the Reading Road and Seymour Avenue corridors with nuclei at the Swifton Commons Shopping Center and the Cincinnati Gardens. These districts present opportunities for "green," ecologically conscious redevelopment. Such redevelopment can integrate stormwater management opportunities with future redevelopment and revitalization efforts. The Mayor's *GO Cincinnati: Growth and Opportunities Study* for the City of Cincinnati Final Report, completed in 2008, recommends similar opportunities which highlight the redevelopment of underutilized and brownfield sites and obsolete retail centers as walkable mixed-use sites and green R&D/light industrial developments.

Opportunities were identified that use existing parking lots (*i.e.*, Cincinnati Gardens and Swifton Commons) for alternative uses such as Farmer's Markets during off-peak hours (*i.e.*, after work hours during the week and on weekends) (**See Green Wet Weather Strategies graphic**). One Eco-Redevelopment District opportunity exists at the Swifton Commons Shopping Center site. Redevelopment opportunities at this location can integrate site BMPs to address runoff from the surrounding impervious parking lots (**See Swifton Commons 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

Spuring 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 Bloody Run Watershed that utilizes stormwater quality BMPs (**See Green Wet Weather Strategies graphic**).

Reforestation

There are currently 447 acres of existing tree canopy in the Bloody Run watershed, representing 20 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 49 acres of canopy-deficient hillsides present wihin the Bloody Run watershed. According to the CITYgreen analysis, such reforestation has the potential to intercept approximately 6.2 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	2,310	17,281	20	345,622
0.75	12,482	93,378	13	1,213,912
1.00	23,062	172,527	12	2,070,322
1.50	43,311	324,010	3	972,029
2.00	61,226	458,032	1	458,032
2.50	76,678	573,628	2	1,147,256
TOTAL	219,069	1,638,855		6,207,173

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 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 75 Expansion

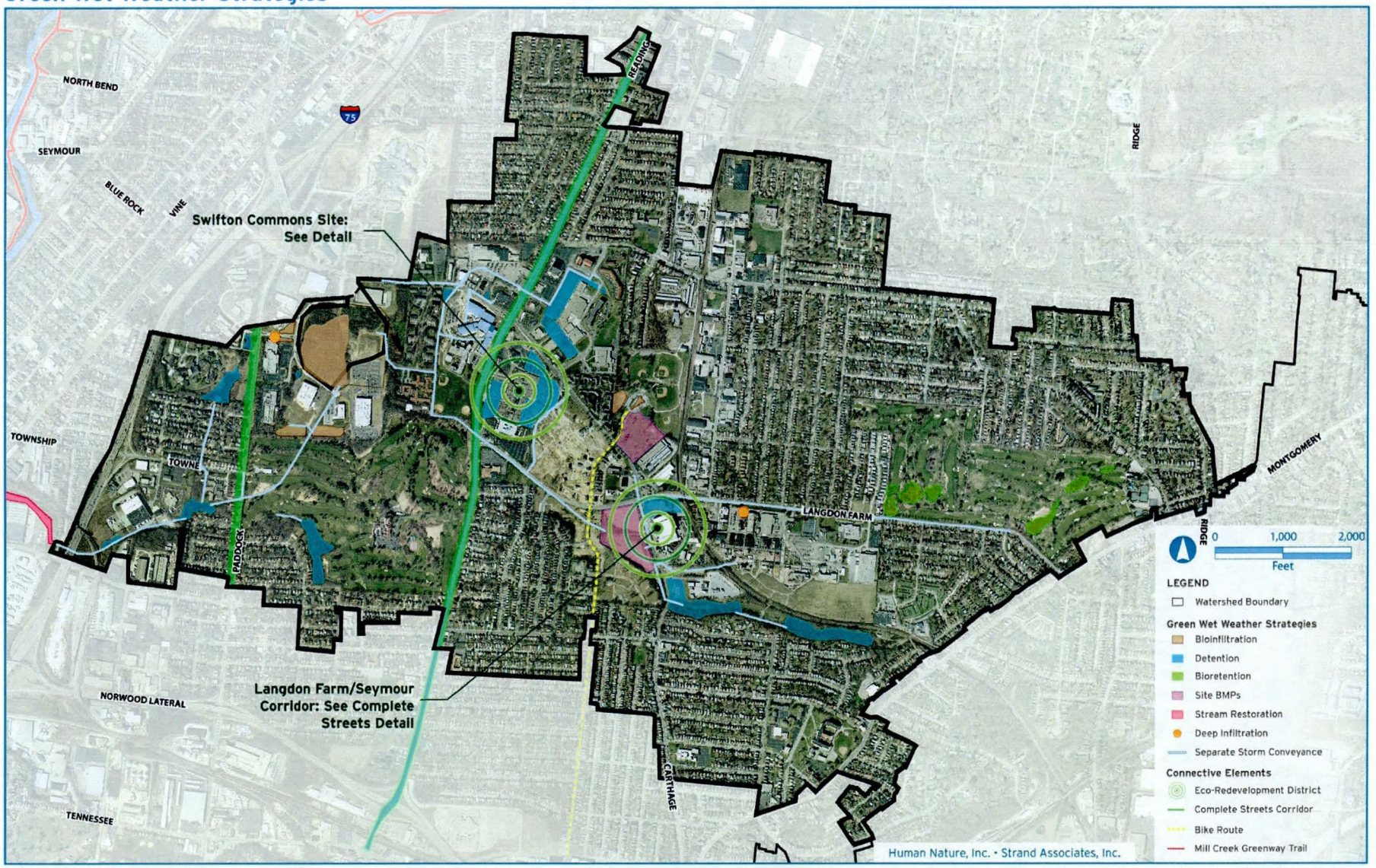
An enabled opportunity has been identified with the reconstruction of the Interstate 75 corridor and several of its interchanges within the Bloody Run watershed which presents an opportunity to form partnerships (inform and influence) with the Ohio Department of Transportation and the City of Cincinnati (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 9 acres of impervious surface along the I-75 corridor within the Bloody Run watershed, which generates roughly 10 MG of stormwater runoff each year.

Inform & Influence Projects

Watershed Partners (Inform & InfluenceOpportunities)

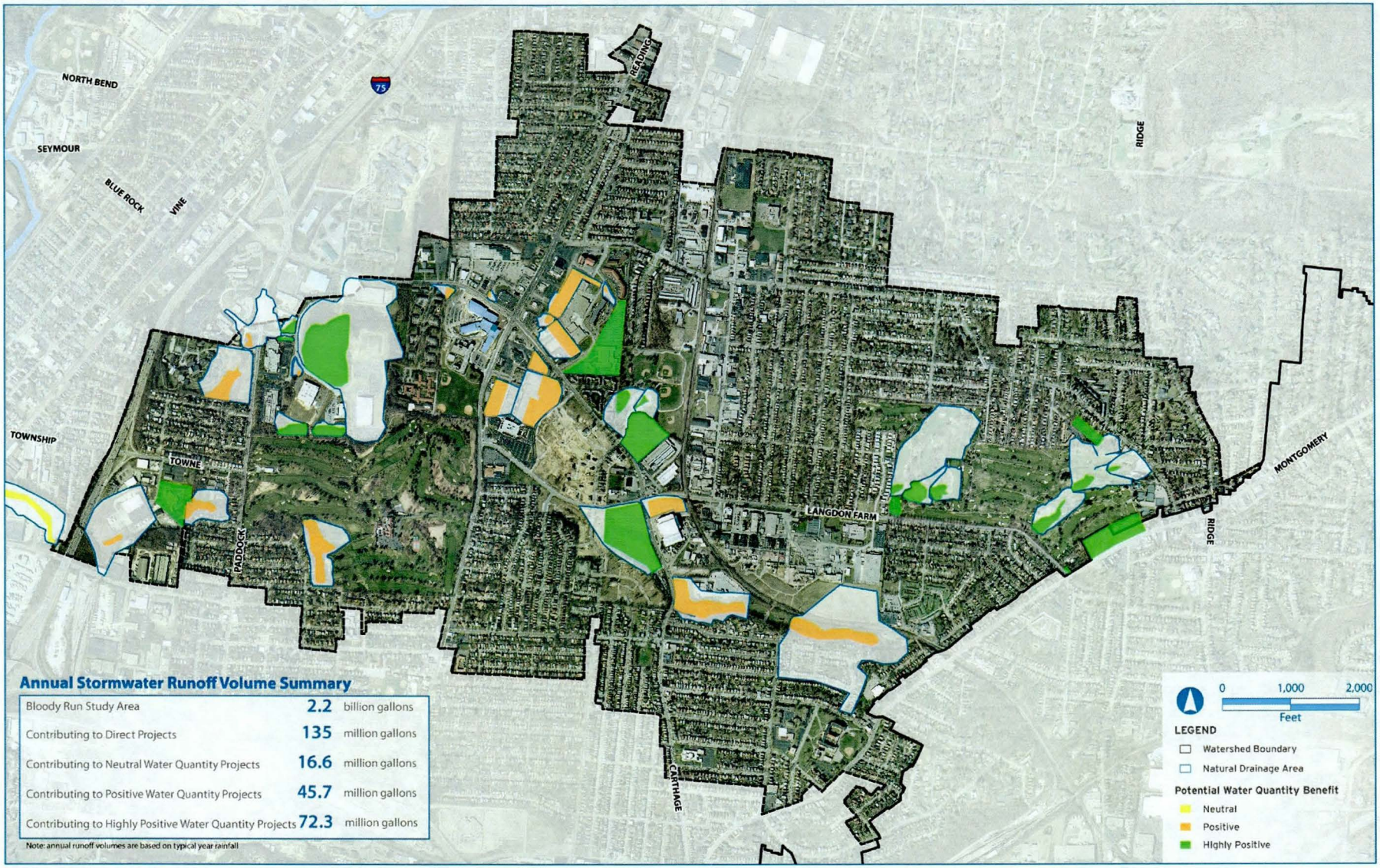
Watershed partners include schools, parks, open spaces, institutional properties, road right-of-way, and vacant, abandoned and foreclosed properties. As potential areas for public-private partnerships, these land uses can integrate multiple stakeholders, thereby increasing public involvement and improving 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 Bloody Run watershed. Watershed Partners within the Ross Run Watershed include the City of Cincinnati, Cincinnati Park Board (*i.e.*, Roselawn Park, Cincinnati Board of Education (*i.e.*, Woodward Technical High School), and the Archbishop of Cincinnati (**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.

Water Quantity Benefits



Annual Stormwater Runoff Volume Summary

Bloody Run Study Area	2.2	billion gallons
Contributing to Direct Projects	135	million gallons
Contributing to Neutral Water Quantity Projects	16.6	million gallons
Contributing to Positive Water Quantity Projects	45.7	million gallons
Contributing to Highly Positive Water Quantity Projects	72.3	million gallons

Note: annual runoff volumes are based on typical year rainfall

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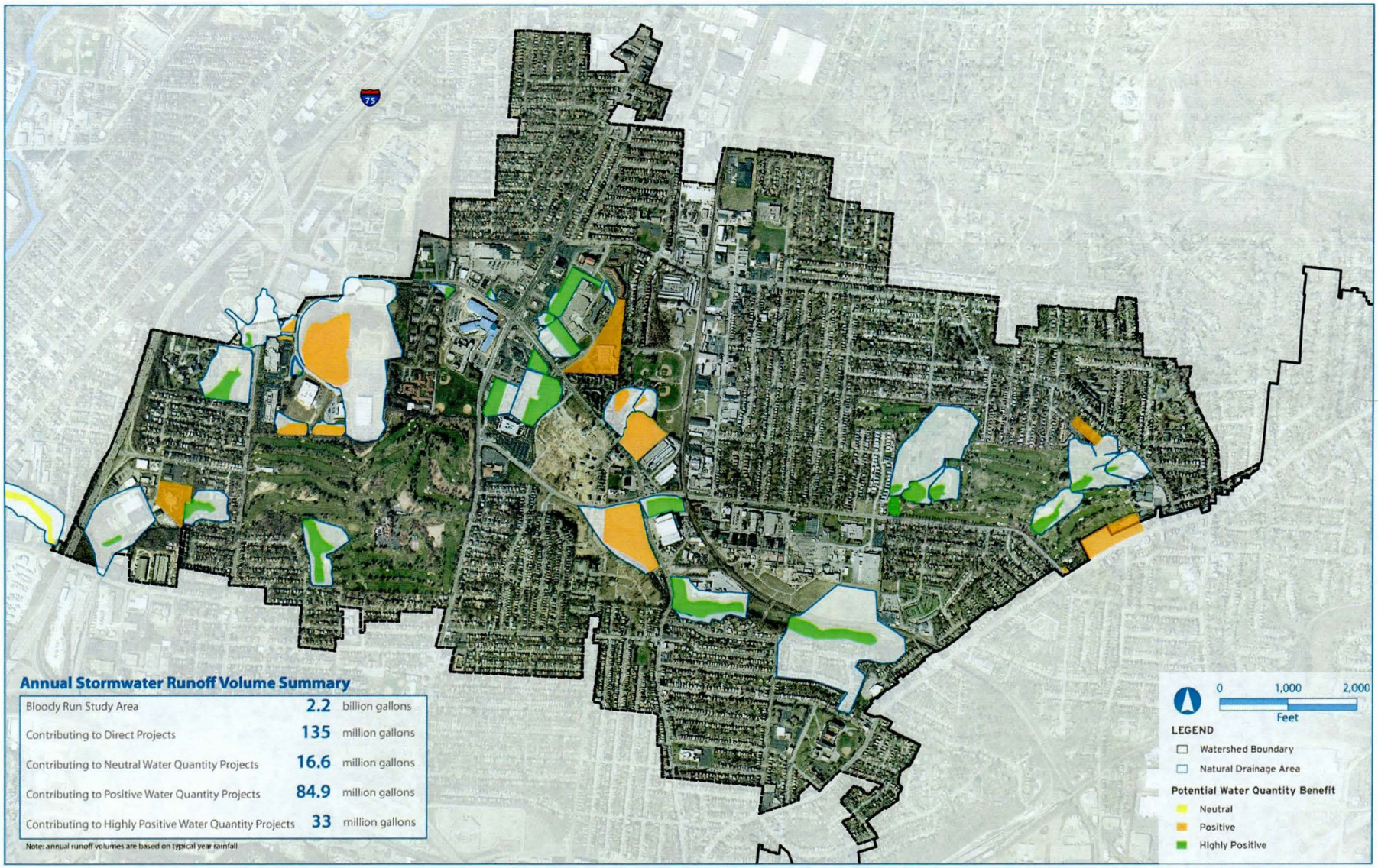
Water Quality Benefits



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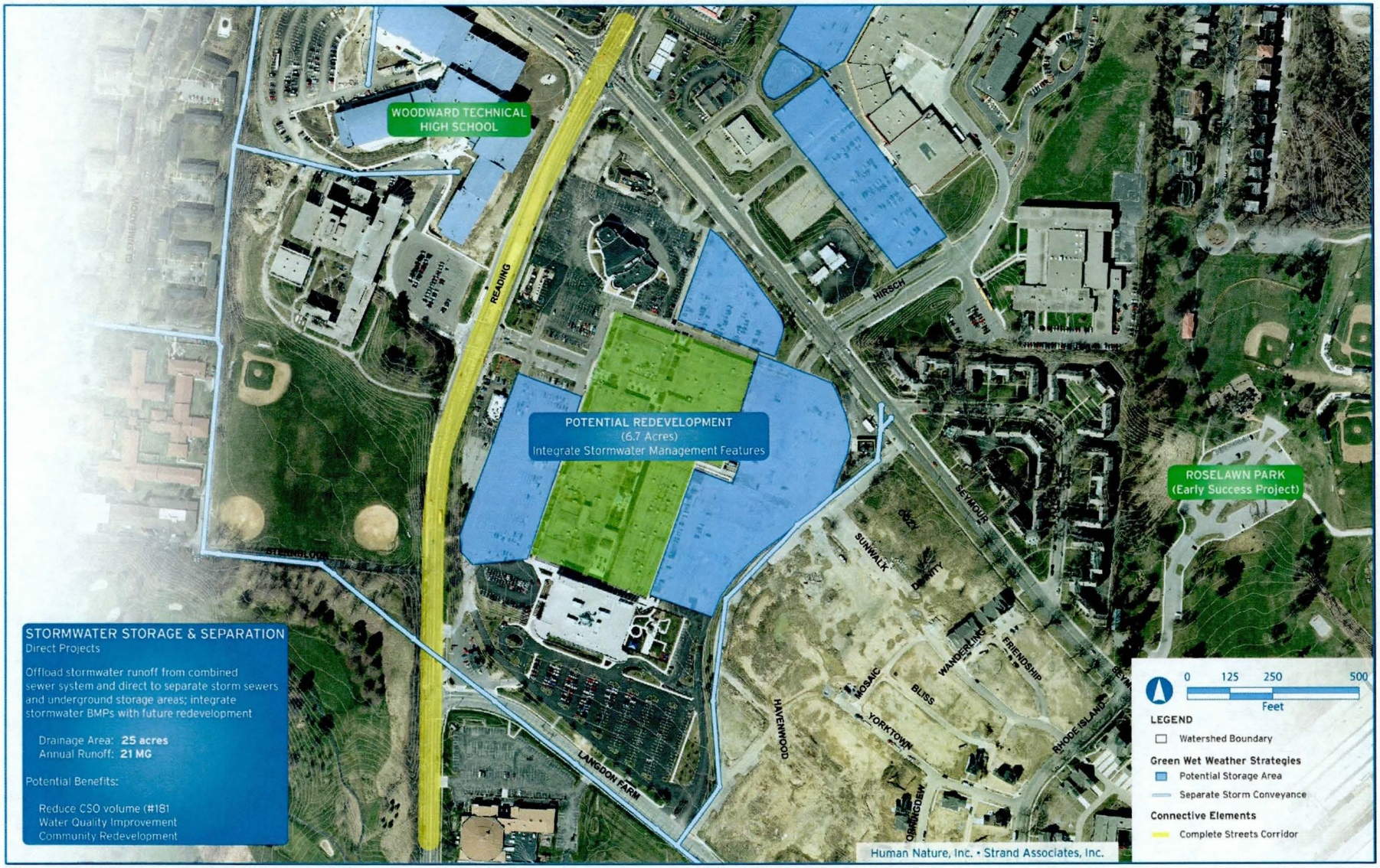
Swifton Commons Site Detail



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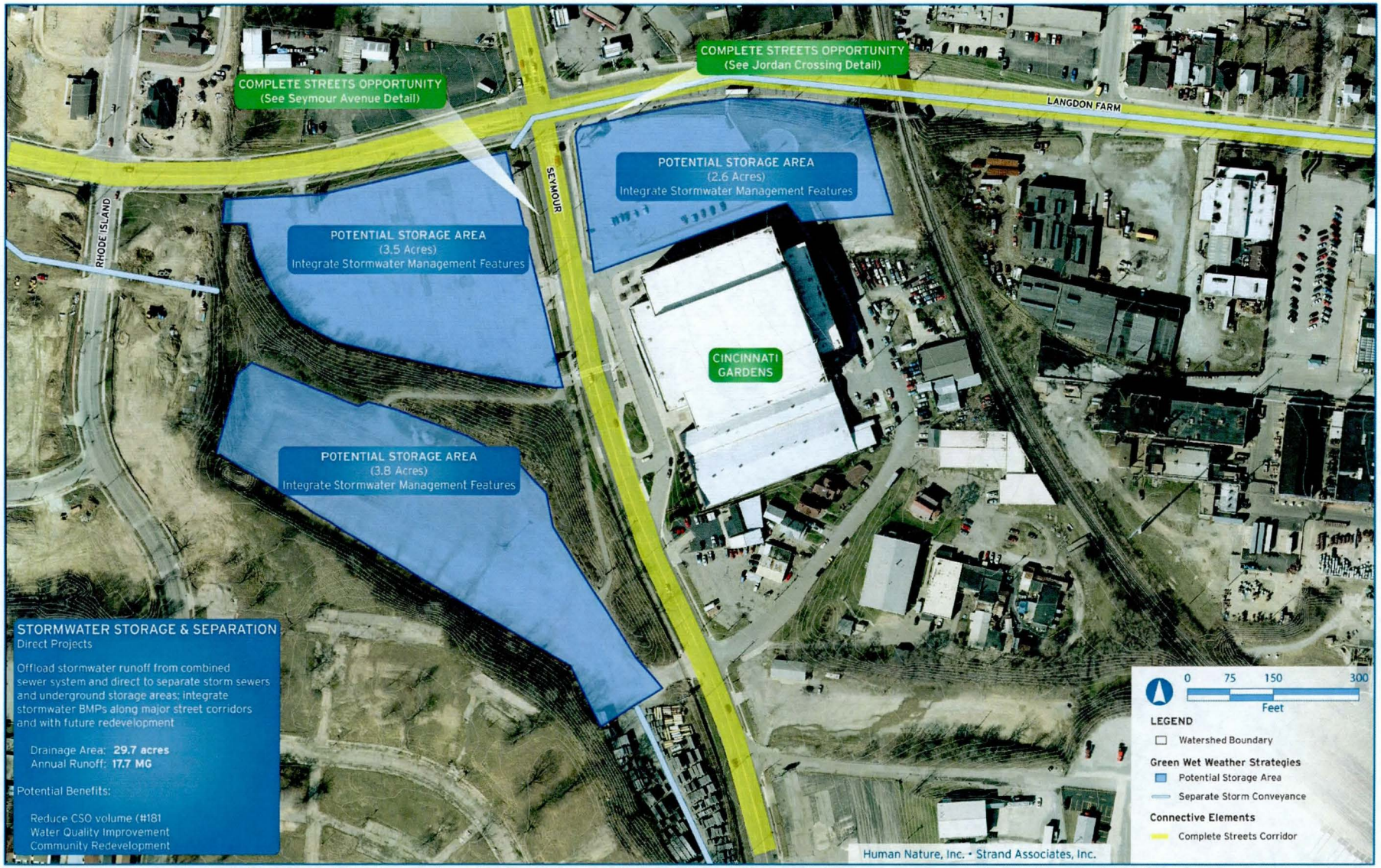
Cincinnati Gardens Site Detail



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Stream Restoration Detail

Complete Streets

Human Nature, Inc.

Existing Conditions

Proposed

SEYMOUR AVENUE

PROPOSED STREETSCAPE ENHANCEMENTS

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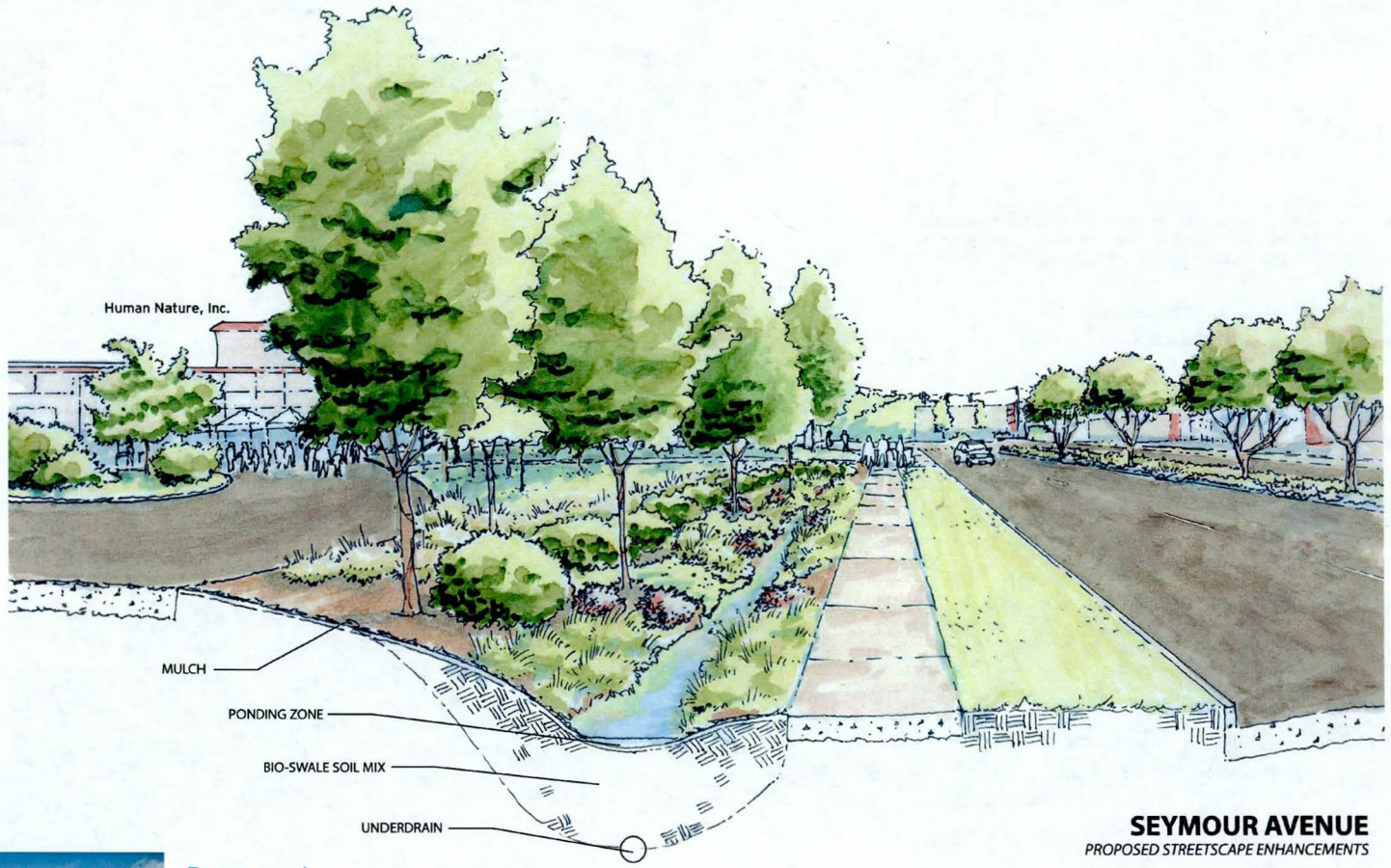
Complete Streets



SEYMOUR AVENUE

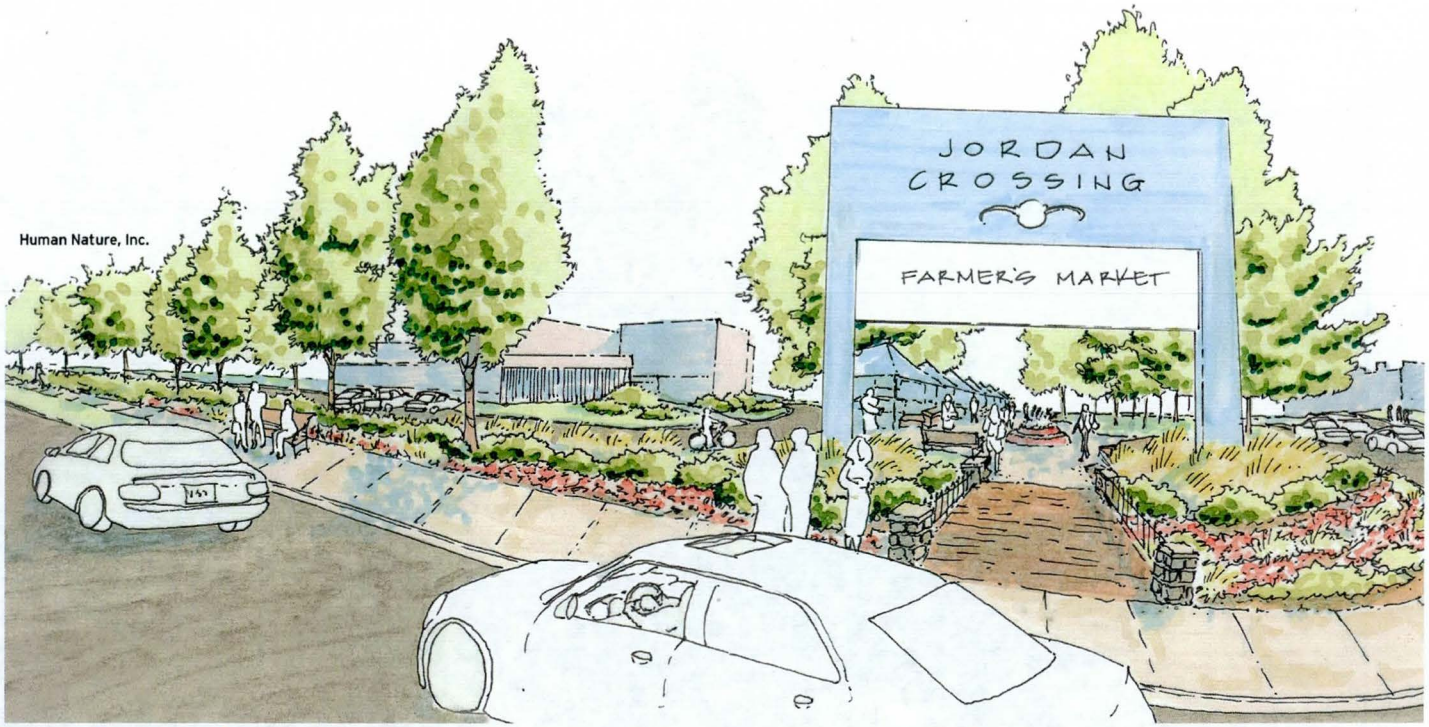
PROPOSED STREETSCAPE ENHANCEMENTS

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.

Existing Conditions

Proposed

Complete Streets



Human Nature, Inc.

Proposed

Existing Conditions

JORDAN CROSSING

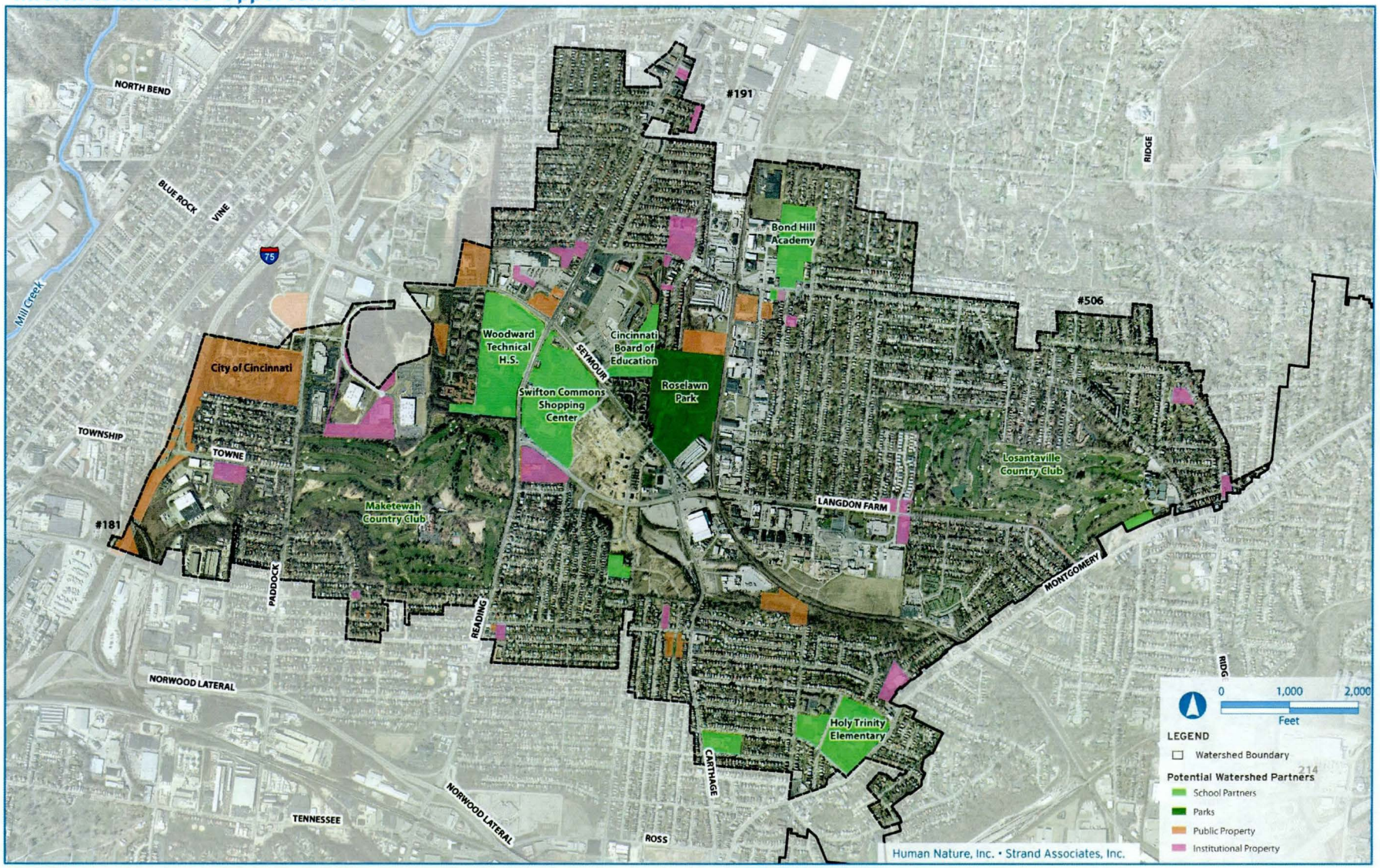
PROPOSED STREETSCAPE ENHANCEMENTS

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.

Enabled Opportunities

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.

Inform & Influence Opportunities



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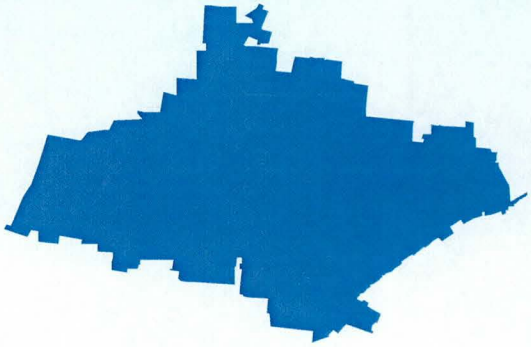
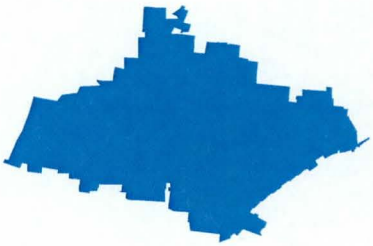


MODELED ALTERNATIVE

MODELED ALTERNATIVE



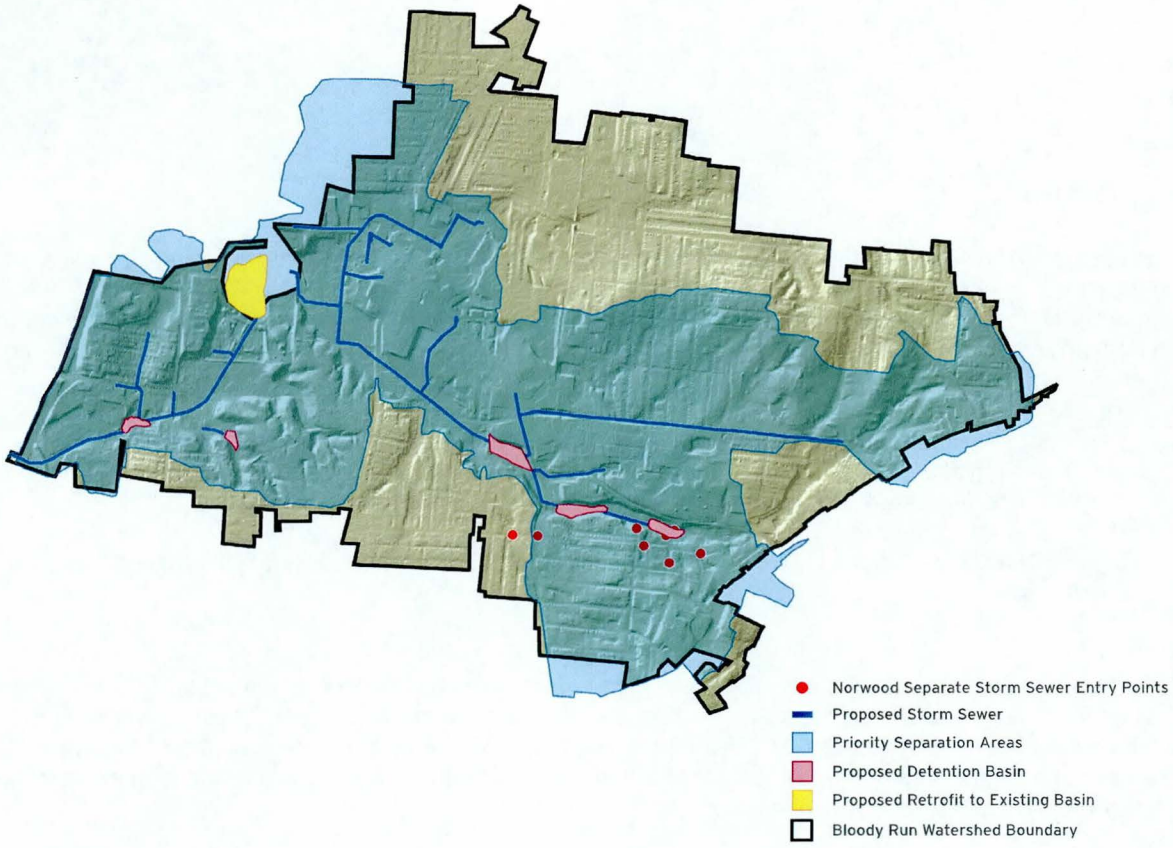
COMPONENTS

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 Bloody Run CSO. In this instance, the selected alternative included:

- Construction of approximately 6 miles of separate storm sewer
- Removal of approximately 201 acres of existing separate sewer areas, primarily within the City of Norwood, that currently discharge into the combined sewer system (CSS)
- Construction of five detention basins
- Retrofitting of one existing basin to function as a regional detention facility (i.e., Tech Solve regional basin)

Currently there are several areas within the Bloody Run watershed with existing separate storm sewer systems. The City of Norwood's separate storm system currently drains approximately 201 acres, within Bloody Run, which discharges directly to MSDGC's combined sewer system in four 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 two golf courses, a park, and a newer residential development between Seymour Avenue and Langdon Farm 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 Bloody 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.



The proposed regional basin is part of a 19 acre vacant parcel owned by Tech Solve and adjacent to the existing Tech Solve commercial site. This parcel is currently for sale. Additionally, there are two other smaller retention basins located on the southern portion of the developed Tech Solve property that provide localized detention for this property. Tech Solve representatives have indicated that they are currently evaluating the feasibility of a facility expansion at this location. For the purposes of this evaluation it was assumed the proposed regional basin could be utilized to collect and store the stormwater from the proposed separation effort throughout Bloody Run. Additionally, the regional basin has been sized to accommodate the flows that are currently directed to the smaller retention basins on the developed Tech Solve site. This would allow for the elimination of these basins thus providing Tech Solve with the opportunity to develop this area and expand the Tech Solve facility. This regional basin would also provide an opportunity for improving the quality of stormwater runoff directed to the basin.

Based on the locations of the proposed storm sewer, City of Norwood entry points, proposed basins, and the Tech Solve basin Bloody Run was divided into 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. 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 916 million gallons of flow discharged from the Bloody Run CSOs annually. Based on this information, Bloody Run was identified as a priority basin accounting for over six 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 Bloody 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 Bloody Run watershed. Based on updates to the model the Bloody Run watershed currently discharges approximately 618 million gallons of combined sewer overflow annually to the Mill Creek.

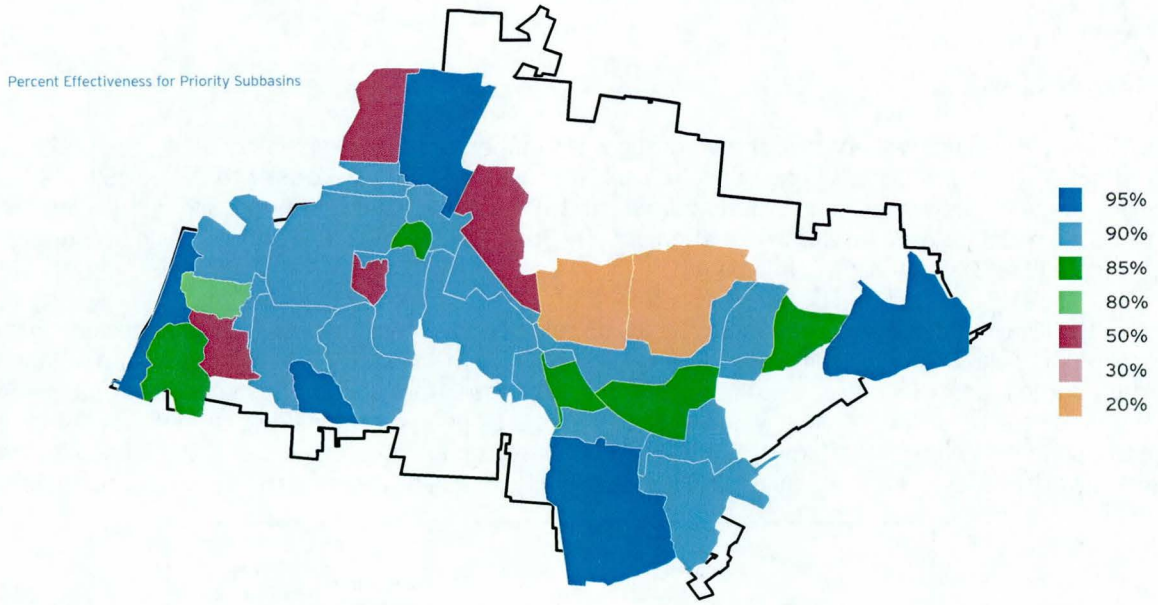
Model	CSO 181	
	Total Overflow Volume (MG)	Percent Control
2006 LTCP Update Report	916	36%
SWM Version 3	618	53%

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 earlier in this report. 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 is 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 graphic on the following page shows the percent effectiveness values assigned to each of the priority basins.

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 Bloody 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 system. A detailed summary of the hydrologic and hydraulic modeling is provided in Appendix B.

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.

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 Bloody Run watershed based on these adjustments in the model. The evaluated alternative reduces the combined sewer overflow volume from the Bloody Run watershed by 421 million gallons annually.

Model	CSO 181	
	Total Overflow Volume (MG)	Percent Control
SWM Version 3	618	53%
SWM Version 3 + Evaluated Alternative	197	85%

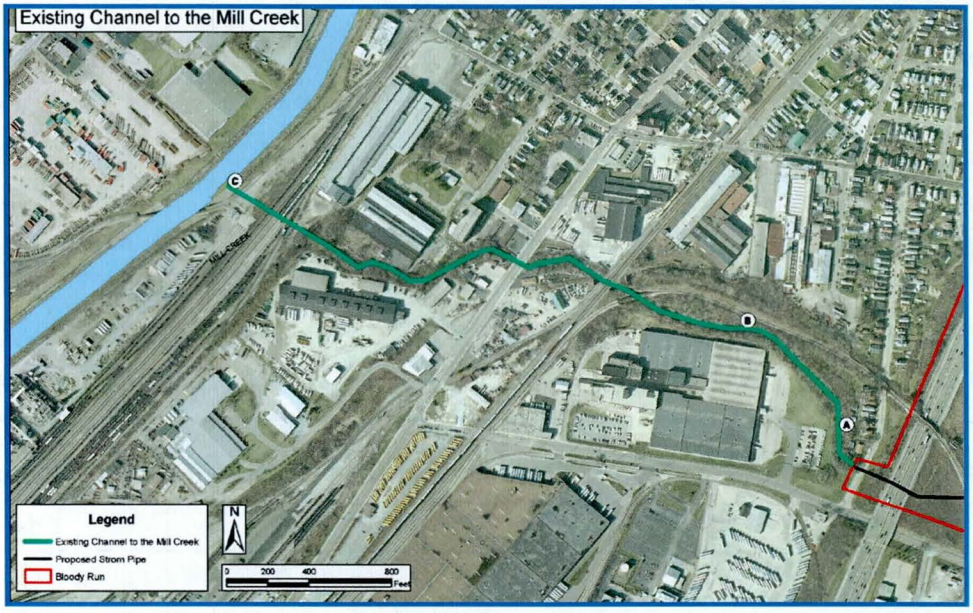
COST BENEFIT ANALYSIS

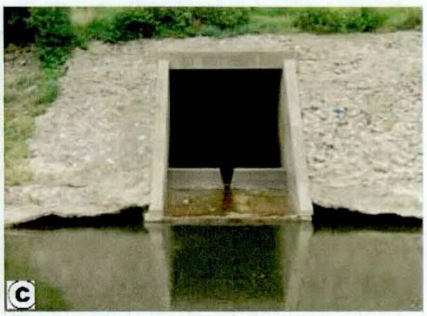
A preliminary opinion of probable construction cost was developed for the selected alternatives modeled within the Bloody Run watershed in order to perform a preliminary a cost/benefit analysis. In order to develop preliminary opinions of construction cost, hydrologic and hydraulic models of the Bloody 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 B. The following items have been included in the preliminary opinion of cost:

- The construction of 32,825 linear feet of proposed storm sewer infrastructure
- Enhancement to one existing detention basin (i.e., TechSolve regional basin) within the priority subbasins
- The construction of five new detention basins within the priority subbasins
- Enhancement to the existing stream network from the Bloody 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. However, implementing the above wet weather strategies will separate significant amounts of stormwater runoff from MSDGC's combined sewer system. It is approximately 3,700 linear feet from the edge of the Bloody Run watershed to the Mill Creek. Currently there is an existing open channel conveyance system running from the edge of the Bloody Run watershed to the Mill Creek. Because this conveyance system is located outside of the

Bloody Run watershed, a detailed analysis on the capacity of the existing channel was not performed as part of this preliminary evaluation. However, a preliminary coarse assessment of the channel utilizing available GIS based contours indicate that there is adequate capacity in this existing channel to convey the additional flow from the proposed separate storm system in Bloody Run. A preliminary cost estimate to provide some clearing and cleanup to this channel section was included in the preliminary opinion of cost; however it does not include fees for any significant grading or stabilization efforts or aesthetic enhancements. In order to more accurately determine the overall feasibility of the Bloody Run opportunities a detailed hydrologic and hydraulic analysis of the existing channel needs to be performed. This would include survey of existing cross-sections to determine the available capacity to convey the additional stormwater runoff collected by the proposed infrastructure. The path of the natural channel and some pictures of the existing conditions are shown below.





Bloody Run Preliminary Opinion of Construction Cost (Alternative 1)

Item	Quantity	Unit	Cost
Storm Sewer Main	33,050	LF	$10,205,725
Precast Storm Sewer Manhole	155	EA	$930,000
Proposed Detention Basins	6	EA	$5,585,000
Apron Endwalls	8	EA	$18,200
Water Main Relocations	1	EA	$2,176,100
Roadway Restoration	1	EA	$16,236,800
Terrace Restoration	1	EA	$1,841,300
Demolition & Connections	1	EA	$1,004,300
Gas, Telephone & Electric Relocations	1	EA	$1,339,100
Rock Excavation	1	EA	$3,515,200
		Sub-Total	$42,851,725
		Miscellaneous Items @ 30%	$12,855,518
		TOTAL	$55,707,243

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

Item	Quantity	Unit	Cost
Rehabilitation of existing natural channel	1	EA	$500,000
		Sub-Total	$500,000
		Miscellaneous Items @ 30%	$150,000
		TOTAL	$650,000

GRAND TOTAL	$56,357,243

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.

The following tables summarize the preliminary opinion of cost for the strategies outlined above, including the use of the Tech Solve property for a regional bioretention facility. The total of this alternative is $56.4 million.

Modeled Annual CSO Reduction	Total Cost	Cost per Gallon
421,000,000	$56,357,243	$0.13

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 and 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 CSO 181 is currently achieving approximately 52.5 percent control. 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 discharge annually from CSO 181 would be reduced by approximately 421 million gallons. Additionally, the level control for the Bloody Run CSO would be increased to 84.8 percent control. Based on a preliminary opinion of construction cost of $56.4 million and a 421 million gallon reduction in annual CSO, the evaluated alternative, results in a cost/benefit of approximately $0.13 per gallon of CSO removed.

As stated above, property acquisition is not included in this preliminary opinion of cost. Since the proposed regional basin on the Tech Solve property is such a large piece of land that could be expensive to acquire and retrofit to serve as a regional basin, an alternative evaluation was performed that assumed there would not be a regional basin on the Tech Solve parcel. The HEC-HMS model was adjusted to remove the proposed basin on the Tech Solve property in order to calculate revised peak flows used to size downstream proposed storm water infrastructure. In addition, the StormCAD model was revised to include additional storm sewer infrastructure necessary to route the separated stormwater to the Bloody Run outfall without utilizing the Tech Solve basin area for detention. By removing the use of the Tech Solve property for storage an additional 1,275 linear feet of proposed storm sewer was required. It should be noted that while two scenarios differ in total project costs, the overall CSO reduction benefit is the same for both alternatives because the priority and non-priority areas have not changed. The following tables summarize the preliminary opinion of cost for the Bloody Run opportunities excluding the use of the Tech Solve property but with the additional storm sewer required for this alternative. The total of this alternative is $56.9 million.

Bloody Run Preliminary Opinion of Construction Cost (Alternative 2, continued on next page)

Item	Quantity	Unit	Cost
Box Conduit Structures	3,150	LF	$3,432,500
Storm Sewer Main	31,200	LF	$10,444,175
Precast Storm Sewer Manhole	161	EA	$966,000
Proposed Detention Basins	5	EA	$2,065,000
Apron Endwalls	7	EA	$17,200
Water Main Relocations	1	EA	$2,199,900
Roadway Restoration	1	EA	$16,414,300
Terrace Restoration	1	EA	$1,861,400
Demolition & Connections	1	EA	$1,015,300
Gas, Telephone & Electric Relocations	1	EA	$1,353,800
Rock Excavation	1	EA	$3,553,600
		Sub-Total	$43,323,175
		Miscellaneous Items @ 30%	$12,996,953
		TOTAL	$56,320,128

Bloody Run Preliminary Opinion of Construction Cost (Alternative 2, continued from previous page)

Item	Quantity	Unit	Cost
Rehabilitation of existing natural channel	1	EA	$500,000
		Sub-Total	$500,000
		Miscellaneous Items @ 30%	$150,000
		TOTAL	$650,000

GRAND TOTAL	$56,970,128

Based on a preliminary opinion of construction cost of $57 million and a 421 million gallon reduction in annual CSO, this evaluated alternative results in a cost/benefit of approximately $0.14 per gallon of CSO removed; therefore, Alternative 1, which includes the regional basin, is approximately $612,885 less in construction costs (not including property acquisition of the basin property) than Alternative 2. This equates to a difference of approximately $0.01 per gallon of CSO removed. As the SWEP analysis continues on the Bloody Run watershed the selected opportunities and proposed infrastructure will be re-evaluated and enhanced better refining the combined sewer overflow reduction and cost benefit of this alternative.

Modeled Annual CSO Reduction	Total Cost	Cost per Gallon
421,000,000	$56,970,128	$0.14

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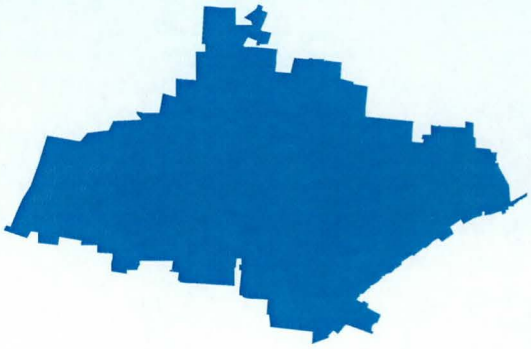
APPENDIX A



CITYGREEN ANALYSIS

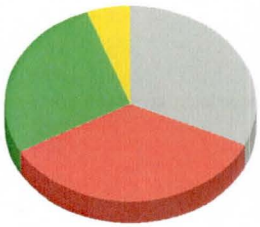
AMERICAN FORESTS americanforests.org CITYgreen

HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides

Land Cover Distribution



Impervious Surfaces	59.3	31.9%
Open Space - Grass/Scattered Trees	65.4	35.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	51.2	27.5%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **51.4 acres (27.6%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	137	$59
Ozone:	1,375	$4,223
Nitrogen Dioxide:	825	$2,534
Particulate Matter:	1,512	$3,102
Sulfur Dioxide:	550	$413
Totals:	**4,399**	**$10,331**

Carbon Storage and Sequestration

Total Tons Stored: **2,212.07**

Total Tons Sequestered (Annually): **17.22**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using default replacement landcover: 91

Additional Storage volume needed: -7,352 cu. ft.

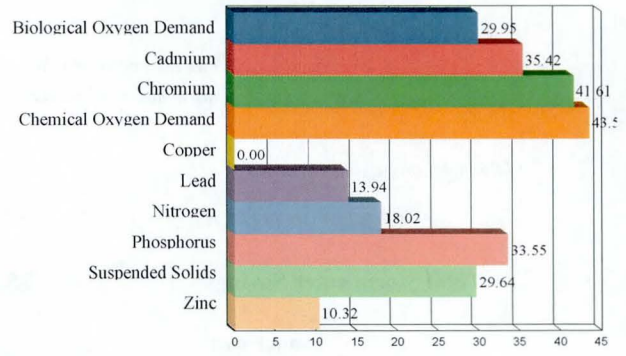
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-14,705**

Annual costs (based on payments over 20 years at 6% interest): **$1,282** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



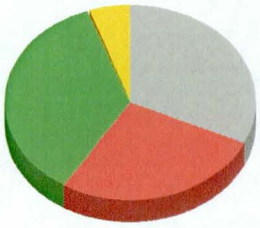
AMERICAN FORESTS CITYgreen

HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 20% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	50.3	27.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	66.3	35.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **66.5 acres (35.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	178	$76
Ozone:	1,778	$5,462
Nitrogen Dioxide:	1,067	$3,277
Particulate Matter:	1,955	$4,011
Sulfur Dioxide:	711	$534
Totals:	**5,689**	**$13,359**

Carbon Storage and Sequestration

Total Tons Stored: **2,860.56**

Total Tons Sequestered (Annually): **22.27**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: 2,918 cu. ft.

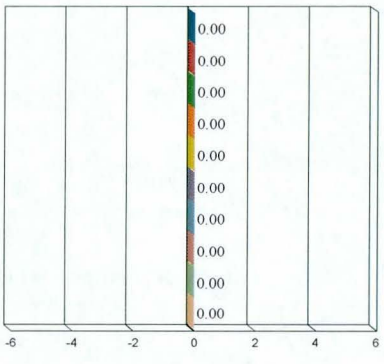
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$5,836**

Annual costs
(based on payments over 20 years at 6% interest): **$509** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



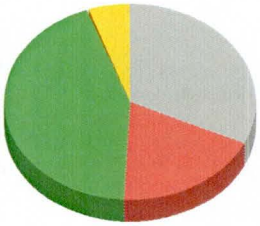
AMERICAN FORESTS americanforests.org CITYgreen

HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 40% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	35.4	19.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	81.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **81.4 acres (43.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	218	$93
Ozone:	2,176	$6,685
Nitrogen Dioxide:	1,306	$4,011
Particulate Matter:	2,394	$4,910
Sulfur Dioxide:	870	$653
Totals:	**6,963**	**$16,353**

Carbon Storage and Sequestration

Total Tons Stored: **3,501.58**

Total Tons Sequestered (Annually): **27.26**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: 2,918 cu. ft.

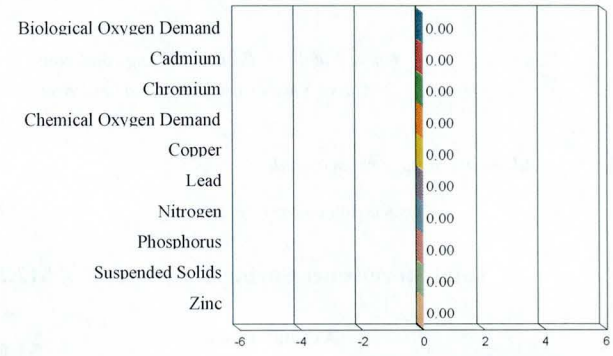
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$5,836**

Annual costs
(based on payments over 20 years at 6% interest): **$509** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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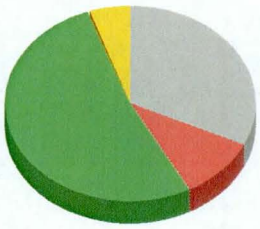
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 60% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	19.4	10.4%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	97.2	52.2%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **97.4 acres (52.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	260	$111
Ozone:	2,604	$8,001
Nitrogen Dioxide:	1,563	$4,801
Particulate Matter:	2,865	$5,876
Sulfur Dioxide:	1,042	$782
Totals:	**8,334**	**$19,571**

Carbon Storage and Sequestration

Total Tons Stored: **4,190.67**

Total Tons Sequestered (Annually): **32.63**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 81

Additional Storage volume needed: 6,142 cu. ft.

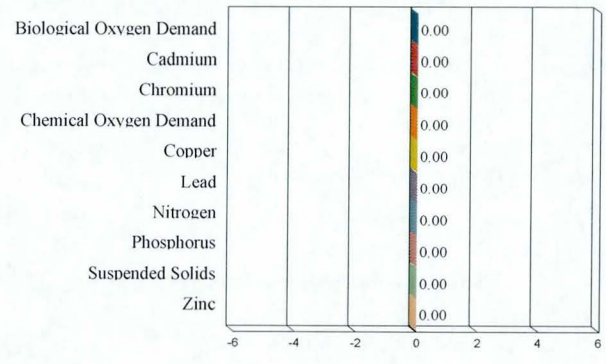
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$12,285**

Annual costs
(based on payments over 20 years at 6% interest): **$1,071** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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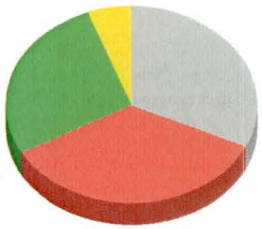
Analysis Report for:

Bloody Run Hillsides

Land Cover Distribution



Impervious Surfaces	59.3	31.9%
Open Space - Grass/Scattered Trees	65.4	35.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	51.2	27.5%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **51.4 acres (27.6%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	137	$59
Ozone:	1,375	$4,223
Nitrogen Dioxide:	825	$2,534
Particulate Matter:	1,512	$3,102
Sulfur Dioxide:	550	$413
Totals:	**4,399**	**$10,331**

Carbon Storage and Sequestration

Total Tons Stored: **2,212.07**

Total Tons Sequestered (Annually): **17.22**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using default replacement landcover: 91

Additional Storage volume needed: 45,226 cu. ft.

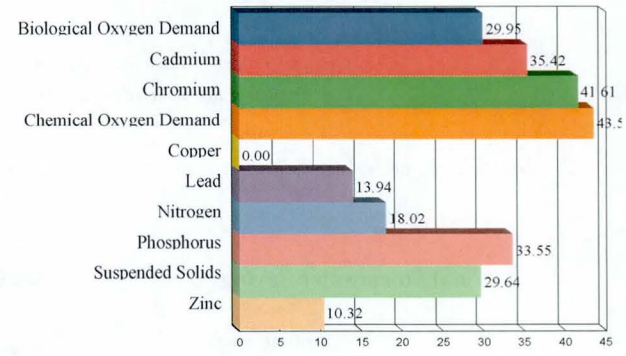
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$90,452**

Annual costs
(based on payments over 20 years at 6% interest): **$7,886** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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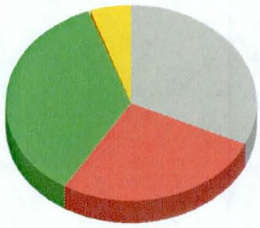
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 20% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	50.3	27.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	66.3	35.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **66.5 acres (35.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	178	$76
Ozone:	1,778	$5,462
Nitrogen Dioxide:	1,067	$3,277
Particulate Matter:	1,955	$4,011
Sulfur Dioxide:	711	$534
Totals:	**5,689**	**$13,359**

Carbon Storage and Sequestration

Total Tons Stored: **2,860.56**

Total Tons Sequestered (Annually): **22.27**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -1,467 cu. ft.

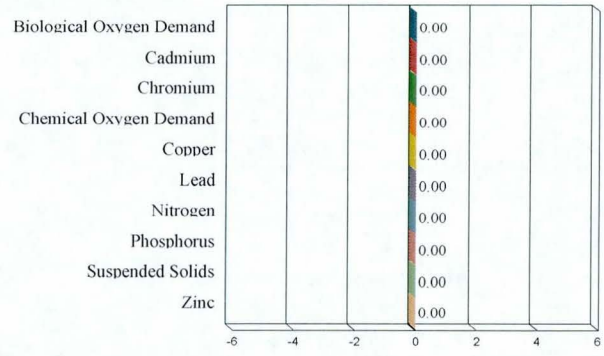
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-2,934**

Annual costs
(based on payments over 20 years at 6% interest): **$256** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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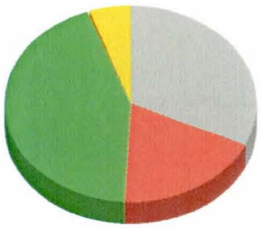
Analysis Report for:

Bloody Run Hillsides: Reforest 40% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	35.4	19.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	81.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **81.4 acres (43.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	218	$93
Ozone:	2,176	$6,685
Nitrogen Dioxide:	1,306	$4,011
Particulate Matter:	2,394	$4,910
Sulfur Dioxide:	870	$653
Totals:	**6,963**	**$16,353**

Carbon Storage and Sequestration

Total Tons Stored: **3,501.58**

Total Tons Sequestered (Annually): **27.26**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -1,467 cu. ft.

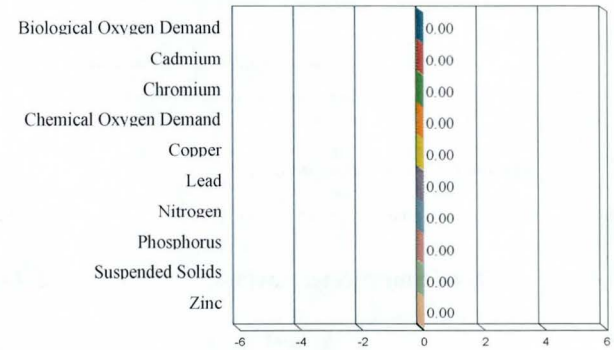
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-2,934**

Annual costs (based on payments over 20 years at 6% interest): **$256** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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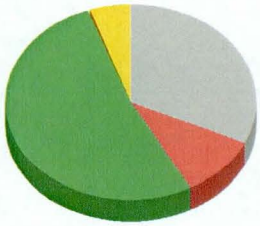
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 60% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	19.4	10.4%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	97.2	52.2%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **97.4 acres (52.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	260	$111
Ozone:	2,604	$8,001
Nitrogen Dioxide:	1,563	$4,801
Particulate Matter:	2,865	$5,876
Sulfur Dioxide:	1,042	$782
Totals:	**8,334**	**$19,571**

Carbon Storage and Sequestration

Total Tons Stored: **4,190.67**

Total Tons Sequestered (Annually): **32.63**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 81

Additional Storage volume needed: -2,310 cu. ft.

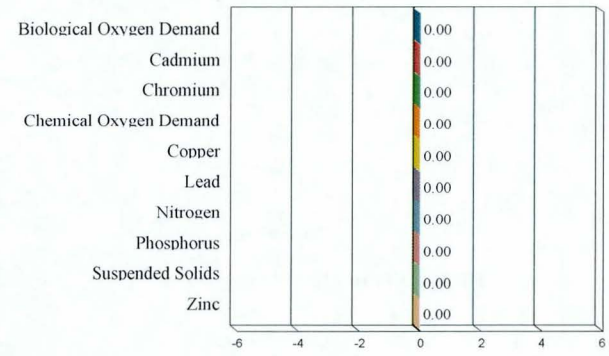
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-4,620**

Annual costs
(based on payments over 20 years at 6% interest): **$403** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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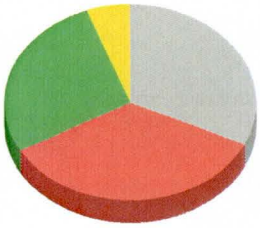
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides

Land Cover Distribution



Impervious Surfaces	59.3	31.9%
Open Space - Grass/Scattered Trees	65.4	35.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	51.2	27.5%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **51.4 acres (27.6%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	137	$59
Ozone:	1,375	$4,223
Nitrogen Dioxide:	825	$2,534
Particulate Matter:	1,512	$3,102
Sulfur Dioxide:	550	$413
Totals:	**4,399**	**$10,331**

Carbon Storage and Sequestration

Total Tons Stored: **2,212.07**

Total Tons Sequestered (Annually): **17.22**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using default replacement landcover: 91

Additional Storage volume needed: 100,948 cu. ft.

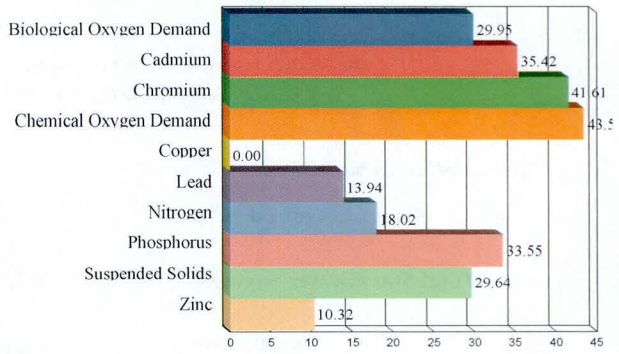
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$201,895**

Annual costs
(based on payments over 20 years at 6% interest): **$17,602** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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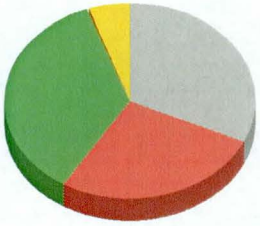
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 20% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	50.3	27.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	66.3	35.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **66.5 acres (35.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	178	$76
Ozone:	1,778	$5,462
Nitrogen Dioxide:	1,067	$3,277
Particulate Matter:	1,955	$4,011
Sulfur Dioxide:	711	$534
Totals:	**5,689**	**$13,359**

Carbon Storage and Sequestration

Total Tons Stored: **2,860.56**

Total Tons Sequestered (Annually): **22.27**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -6,700 cu. ft.

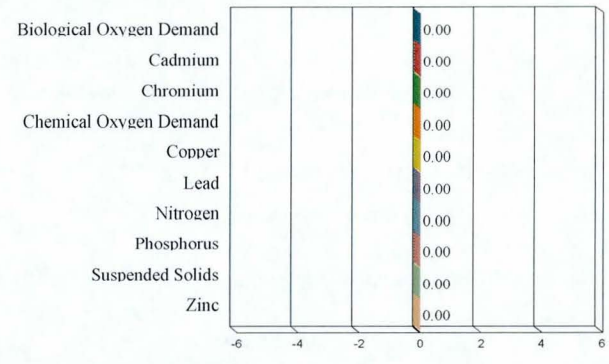
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-13,400**

Annual costs
(based on payments over 20 years at 6% interest): **$1,168** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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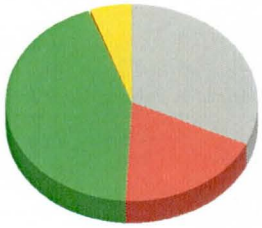
Analysis Report for:

Bloody Run Hillsides: Reforest 40% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	35.4	19.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	81.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **81.4 acres (43.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	218	$93
Ozone:	2,176	$6,685
Nitrogen Dioxide:	1,306	$4,011
Particulate Matter:	2,394	$4,910
Sulfur Dioxide:	870	$653
Totals:	**6,963**	**$16,353**

Carbon Storage and Sequestration

Total Tons Stored: **3,501.58**

Total Tons Sequestered (Annually): **27.26**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -6,700 cu. ft.

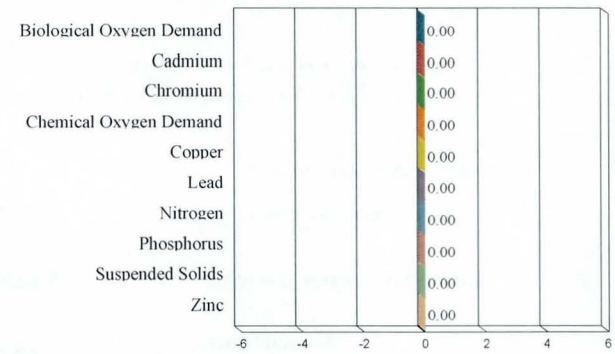
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-13,400**

Annual costs (based on payments over 20 years at 6% interest): **$1,168** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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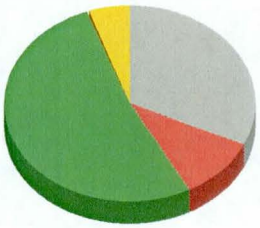
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 60% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	19.4	10.4%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	97.2	52.2%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **97.4 acres (52.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	260	$111
Ozone:	2,604	$8,001
Nitrogen Dioxide:	1,563	$4,801
Particulate Matter:	2,865	$5,876
Sulfur Dioxide:	1,042	$782
Totals:	**8,334**	**$19,571**

Carbon Storage and Sequestration

Total Tons Stored: **4,190.67**

Total Tons Sequestered (Annually): **32.63**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 81

Additional Storage volume needed: -12,482 cu. ft.

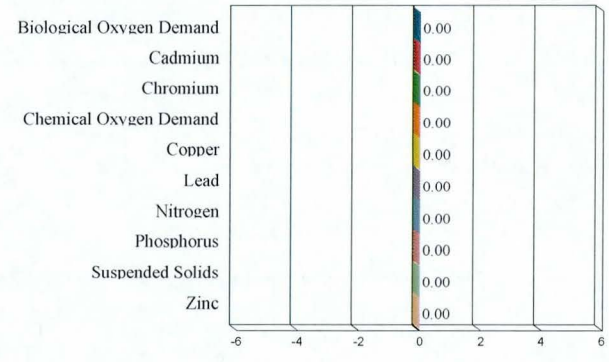
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-24,965**

Annual costs
(based on payments over 20 years at 6% interest): **$2,177** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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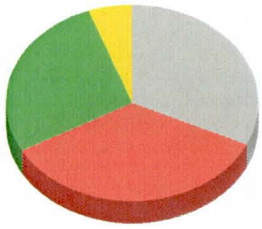
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides

Land Cover Distribution



Impervious Surfaces	59.3	31.9%
Open Space - Grass/Scattered Trees	65.4	35.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	51.2	27.5%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **51.4 acres (27.6%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	137	$59
Ozone:	1,375	$4,223
Nitrogen Dioxide:	825	$2,534
Particulate Matter:	1,512	$3,102
Sulfur Dioxide:	550	$413
Totals:	**4,399**	**$10,331**

Carbon Storage and Sequestration

Total Tons Stored: **2,212.07**

Total Tons Sequestered (Annually): **17.22**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using default replacement landcover: 91

Additional Storage volume needed: 153,556 cu. ft.

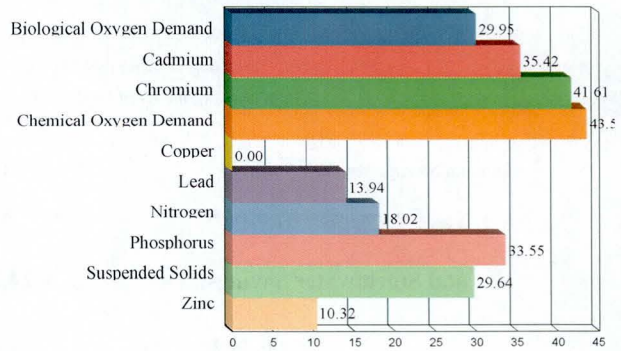
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$307,111**

Annual costs (based on payments over 20 years at 6% interest): **$26,775** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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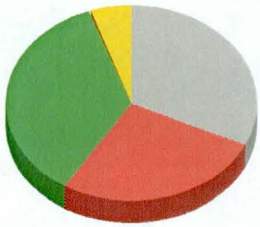
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 20% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	50.3	27.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	66.3	35.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **66.5 acres (35.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	178	$76
Ozone:	1,778	$5,462
Nitrogen Dioxide:	1,067	$3,277
Particulate Matter:	1,955	$4,011
Sulfur Dioxide:	711	$534
Totals:	**5,689**	**$13,359**

Carbon Storage and Sequestration

Total Tons Stored: **2,860.56**

Total Tons Sequestered (Annually): **22.27**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -12,105 cu. ft.

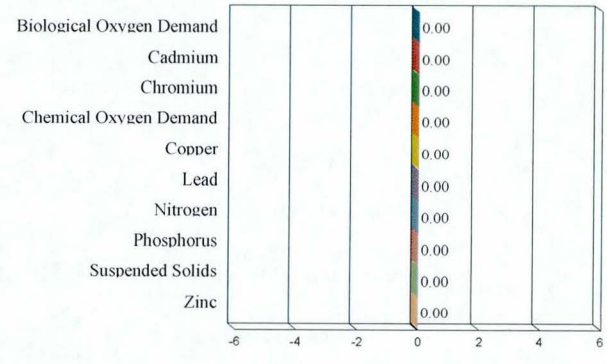
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-24,211**

Annual costs
(based on payments over 20 years at 6% interest): **$2,111** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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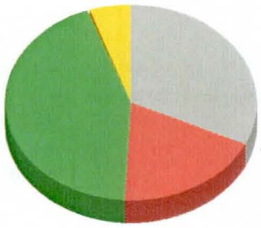
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 40% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	35.4	19.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	81.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **81.4 acres (43.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	218	$93
Ozone:	2,176	$6,685
Nitrogen Dioxide:	1,306	$4,011
Particulate Matter:	2,394	$4,910
Sulfur Dioxide:	870	$653
Totals:	**6,963**	**$16,353**

Carbon Storage and Sequestration

Total Tons Stored: **3,501.58**

Total Tons Sequestered (Annually): **27.26**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -12,105 cu. ft.

Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-24,211**

Annual costs
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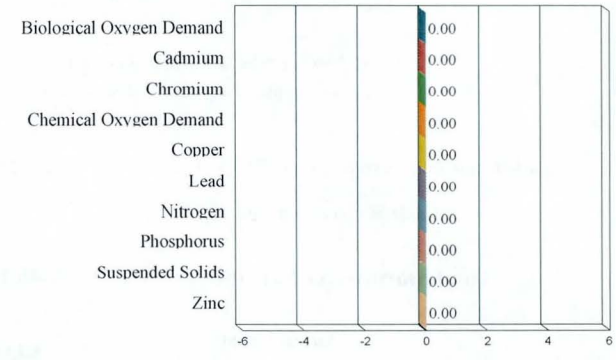
Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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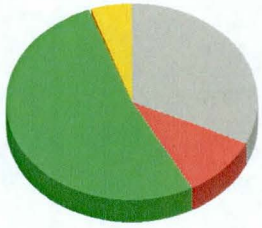
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 60% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	19.4	10.4%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	97.2	52.2%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **97.4 acres (52.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	260	$111
Ozone:	2,604	$8,001
Nitrogen Dioxide:	1,563	$4,801
Particulate Matter:	2,865	$5,876
Sulfur Dioxide:	1,042	$782
Totals:	**8,334**	**$19,571**

Carbon Storage and Sequestration

Total Tons Stored: **4,190.67**

Total Tons Sequestered (Annually): **32.63**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 81

Additional Storage volume needed: -23,062 cu. ft.

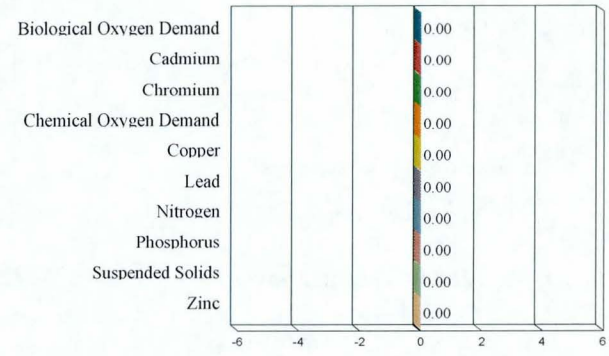
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-46,125**

Annual costs
(based on payments over 20 years at 6% interest): **$4,021** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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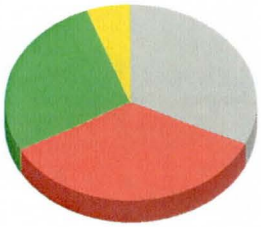
Analysis Report for:

Bloody Run Hillsides

Land Cover Distribution



Impervious Surfaces	59.3	31.9%
Open Space - Grass/Scattered Trees	65.4	35.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	51.2	27.5%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **51.4 acres (27.6%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	137	$59
Ozone:	1,375	$4,223
Nitrogen Dioxide:	825	$2,534
Particulate Matter:	1,512	$3,102
Sulfur Dioxide:	550	$413
Totals:	**4,399**	**$10,331**

Carbon Storage and Sequestration

Total Tons Stored: **2,212.07**

Total Tons Sequestered (Annually): **17.22**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using default replacement landcover: 91

Additional Storage volume needed: 244,212 cu. ft.

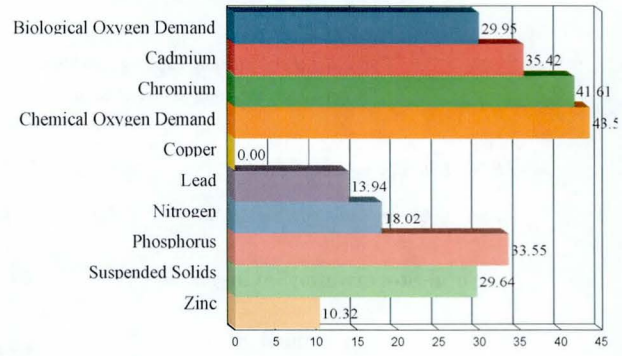
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$488,424**

Annual costs
(based on payments over 20 years at 6% interest): **$42,583** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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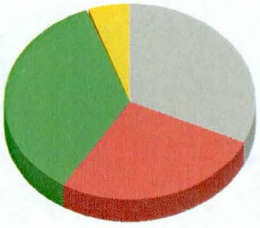
Analysis Report for:

Bloody Run Hillsides: Reforest 20% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	50.3	27.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	66.3	35.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **66.5 acres (35.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	178	$76
Ozone:	1,778	$5,462
Nitrogen Dioxide:	1,067	$3,277
Particulate Matter:	1,955	$4,011
Sulfur Dioxide:	711	$534
Totals:	**5,689**	**$13,359**

Carbon Storage and Sequestration

Total Tons Stored: **2,860.56**

Total Tons Sequestered (Annually): **22.27**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -22,367 cu. ft.

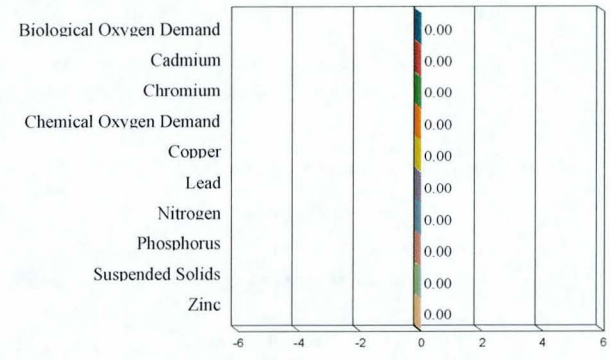
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-44,733**

Annual costs
(based on payments over 20 years at 6% interest): **$3,900** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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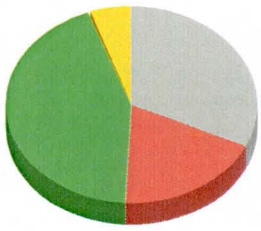
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 40% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	35.4	19.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	81.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **81.4 acres (43.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	218	$93
Ozone:	2,176	$6,685
Nitrogen Dioxide:	1,306	$4,011
Particulate Matter:	2,394	$4,910
Sulfur Dioxide:	870	$653
Totals:	**6,963**	**$16,353**

Carbon Storage and Sequestration

Total Tons Stored: **3,501.58**

Total Tons Sequestered (Annually): **27.26**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -22,367 cu. ft.

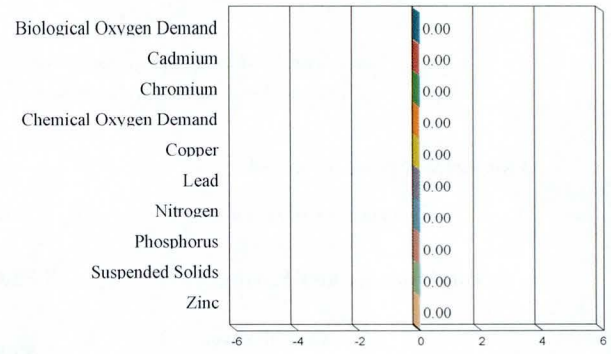
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-44,733**

Annual costs
(based on payments over 20 years at 6% interest): **$3,900** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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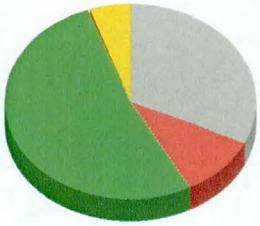
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 60% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	19.4	10.4%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	97.2	52.2%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **97.4 acres (52.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	260	$111
Ozone:	2,604	$8,001
Nitrogen Dioxide:	1,563	$4,801
Particulate Matter:	2,865	$5,876
Sulfur Dioxide:	1,042	$782
Totals:	**8,334**	**$19,571**

Carbon Storage and Sequestration

Total Tons Stored:	**4,190.67**
Total Tons Sequestered (Annually):	**32.63**

Stormwater

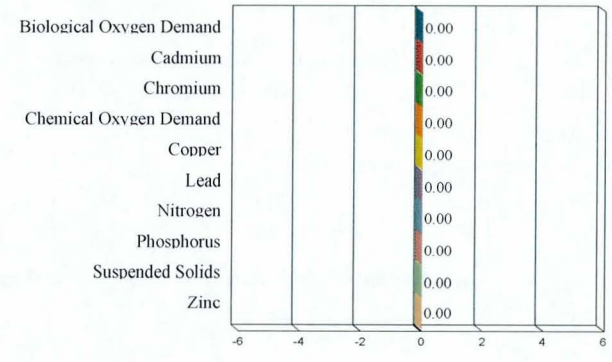
Water Quantity (Runoff)

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

Curve Number reflecting existing conditions:	83
Curve Number using modeled landcover:	81
Additional Storage volume needed:	-43,311 cu. ft.
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$-86,623**
Annual costs (based on payments over 20 years at 6% interest):	**$7,552 per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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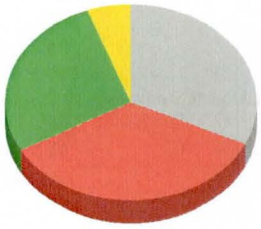
Analysis Report for:

Bloody Run Hillsides

Land Cover Distribution



Impervious Surfaces	59.3	31.9%
Open Space - Grass/Scattered Trees	65.4	35.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	51.2	27.5%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
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Land cover areas are in acres .

Total Tree Canopy: **51.4 acres (27.6%)**

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Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	137	$59
Ozone:	1,375	$4,223
Nitrogen Dioxide:	825	$2,534
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Sulfur Dioxide:	550	$413
Totals:	**4,399**	**$10,331**

Carbon Storage and Sequestration

Total Tons Stored: **2,212.07**

Total Tons Sequestered (Annually): **17.22**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using default replacement landcover: 91

Additional Storage volume needed: 316,673 cu. ft.

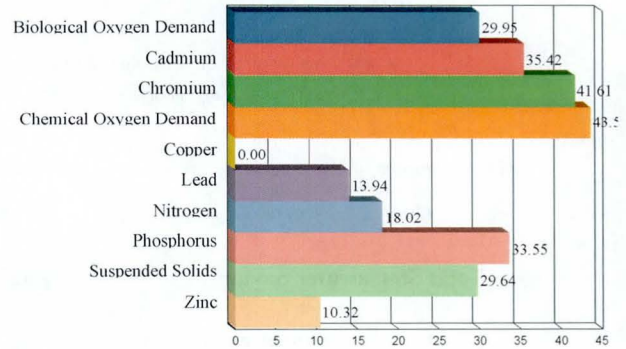
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$633,346**

Annual costs
(based on payments over 20 years at 6% interest): **$55,218** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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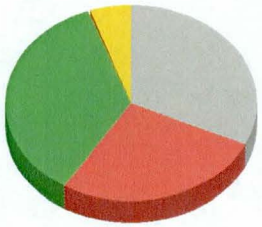
Analysis Report for:

Bloody Run Hillsides: Reforest 20% of Hillsides

Land Cover Distribution



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Totals:	**5,689**	**$13,359**

Carbon Storage and Sequestration

Total Tons Stored: **2,860.56**

Total Tons Sequestered (Annually): **22.27**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -31,368 cu. ft.

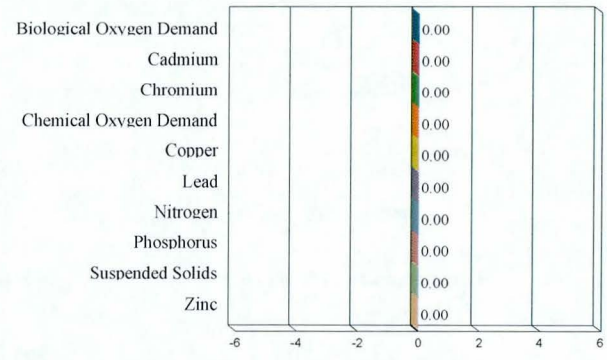
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-62,737**

Annual costs
(based on payments over 20 years at 6% interest): **$5,470** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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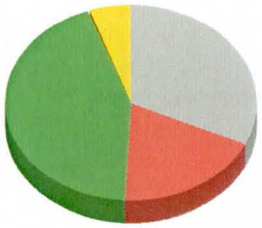
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 40% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	35.4	19.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	81.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
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Particulate Matter:	2,394	$4,910
Sulfur Dioxide:	870	$653
Totals:	**6,963**	**$16,353**

Carbon Storage and Sequestration

Total Tons Stored:	**3,501.58**
Total Tons Sequestered (Annually):	**27.26**

Stormwater

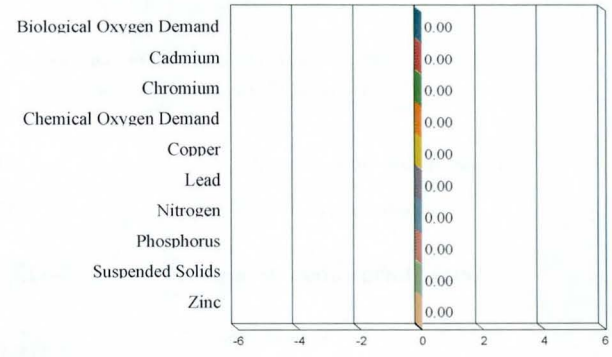
Water Quantity (Runoff)

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

Curve Number reflecting existing conditions:	83
Curve Number using modeled landcover:	82
Additional Storage volume needed:	-31,368 cu. ft.
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$-62,737**
Annual costs (based on payments over 20 years at 6% interest):	**$5,470 per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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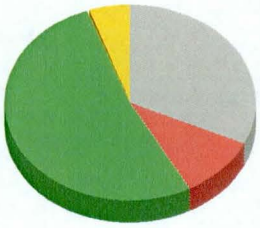
Analysis Report for:

Bloody Run Hillsides: Reforest 60% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	19.4	10.4%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	97.2	52.2%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **97.4 acres (52.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	260	$111
Ozone:	2,604	$8,001
Nitrogen Dioxide:	1,563	$4,801
Particulate Matter:	2,865	$5,876
Sulfur Dioxide:	1,042	$782
Totals:	**8,334**	**$19,571**

Carbon Storage and Sequestration

Total Tons Stored: **4,190.67**

Total Tons Sequestered (Annually): **32.63**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 81

Additional Storage volume needed: -61,226 cu. ft.

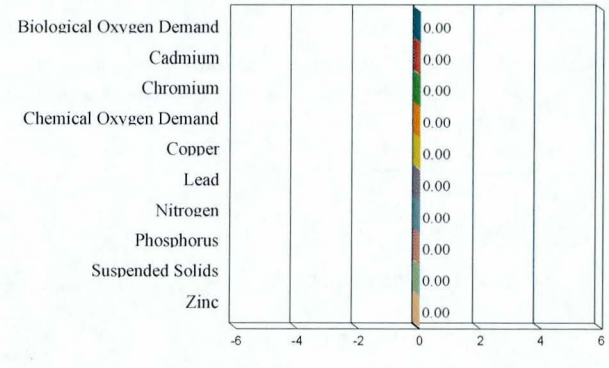
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-122,451**

Annual costs
(based on payments over 20 years at 6% interest): **$10,676** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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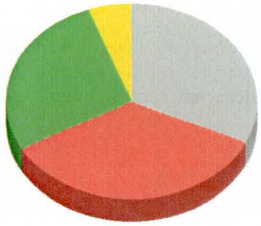
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides

Land Cover Distribution



Impervious Surfaces	59.3	31.9%
Open Space - Grass/Scattered Trees	65.4	35.1%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	51.2	27.5%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **51.4 acres (27.6%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	137	$59
Ozone:	1,375	$4,223
Nitrogen Dioxide:	825	$2,534
Particulate Matter:	1,512	$3,102
Sulfur Dioxide:	550	$413
Totals:	**4,399**	**$10,331**

Carbon Storage and Sequestration

Total Tons Stored: **2,212.07**

Total Tons Sequestered (Annually): **17.22**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using default replacement landcover: 91

Additional Storage volume needed: 374,841 cu. ft.

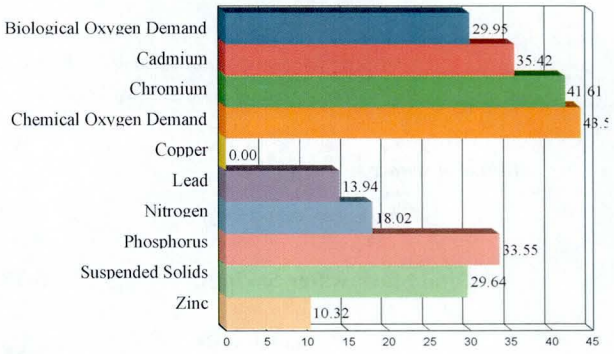
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$749,682**

Annual costs
(based on payments over 20 years at 6% interest): **$65,361** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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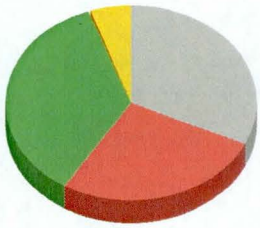
Analysis Report for:

HUMAN NATURE

Bloody Run Hillsides: Reforest 20% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	50.3	27.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	66.3	35.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **66.5 acres (35.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	178	$76
Ozone:	1,778	$5,462
Nitrogen Dioxide:	1,067	$3,277
Particulate Matter:	1,955	$4,011
Sulfur Dioxide:	711	$534
Totals:	**5,689**	**$13,359**

Carbon Storage and Sequestration

Total Tons Stored: **2,860.56**

Total Tons Sequestered (Annually): **22.27**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -39,084 cu. ft.

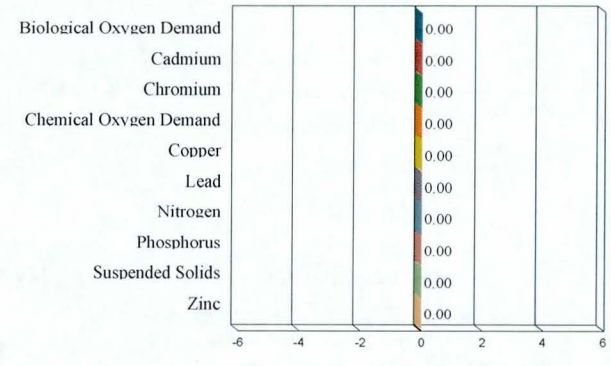
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-78,167**

Annual costs
(based on payments over 20 years at 6% interest): **$6,815** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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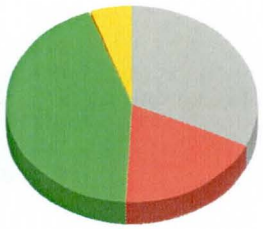
HUMAN NATURE

Analysis Report for:

Bloody Run Hillsides: Reforest 40% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	35.4	19.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	81.2	43.6%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **81.4 acres (43.7%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	218	$93
Ozone:	2,176	$6,685
Nitrogen Dioxide:	1,306	$4,011
Particulate Matter:	2,394	$4,910
Sulfur Dioxide:	870	$653
Totals:	**6,963**	**$16,353**

Carbon Storage and Sequestration

Total Tons Stored: **3,501.58**

Total Tons Sequestered (Annually): **27.26**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 82

Additional Storage volume needed: -39,084 cu. ft.

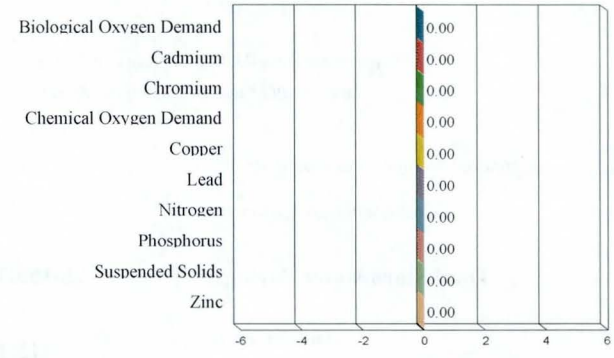
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-78,167**

Annual costs
(based on payments over 20 years at 6% interest): **$6,815** **per year**

Water Quality (Contaminant Loading)

Percent Change in Contaminant Loadings



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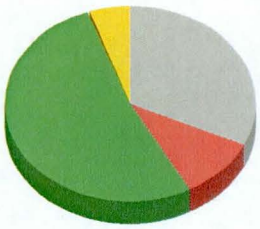
Analysis Report for:

Bloody Run Hillsides: Reforest 60% of Hillsides

Land Cover Distribution



Impervious Surfaces	59.4	31.9%
Open Space - Grass/Scattered Trees	19.4	10.4%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	97.2	52.2%
Trees: Grass/turf understory: Ground cover 50% - 75%	0.2	0.1%
Urban: Residential: 0.125ac Lots	10.1	5.4%
Total:	186.2	100.0%

Land cover areas are in acres .

Total Tree Canopy: **97.4 acres (52.3%)**

Air Pollution Removal

Nearest Air Quality Reference City: **Cincinnati**

	Lbs. Removed/yr	Dollar Value
Carbon Monoxide:	260	$111
Ozone:	2,604	$8,001
Nitrogen Dioxide:	1,563	$4,801
Particulate Matter:	2,865	$5,876
Sulfur Dioxide:	1,042	$782
Totals:	**8,334**	**$19,571**

Carbon Storage and Sequestration

Total Tons Stored: **4,190.67**

Total Tons Sequestered (Annually): **32.63**

Stormwater

Water Quantity (Runoff)

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

Curve Number reflecting existing conditions: 83

Curve Number using modeled landcover: 81

Additional Storage volume needed: -76,678 cu. ft.

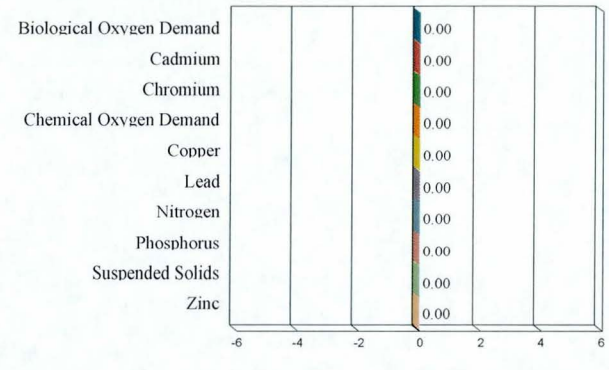
Construction cost per cu. ft.: $2.00

Total Stormwater Savings: **$-153,356**

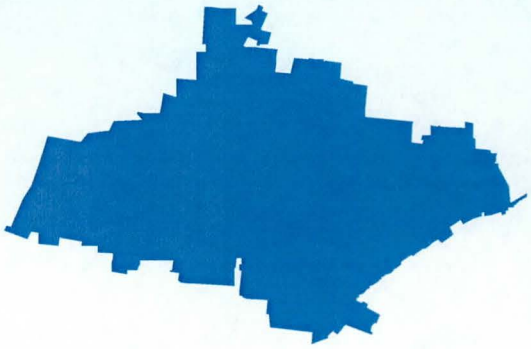
Annual costs
(based on payments over 20 years at 6% interest): **$13,370** **per year**

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 a review of the estimated storm water reduction estimates for each opportunity and with input from MSD staff, a subset of the opportunities was identified as the preferred 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 two distinct categories - Priority and Non-priority areas. Areas contributing flow to a recommended element within the modeled alternative were categorized as Priority Areas. Portions of the Bloody Run watershed not impacted by the preferred alternative are identified as non-priority areas because stormwater runoff from these areas will continue to enter the combined system.

It should be noted that the drainage area for the Bloody Run basin used is 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 Bloody Run watershed as delineated in the SWM is approximately 2,187 acres while the Bloody Run watershed as defined by the SWEP is approximately 2,262 acres. The information and data developed as part of the stormwater modeling, presented in this Appendix, is based on the 2,262 acre drainage area.

The amount 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 in 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 Bloody 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. Note that the percentage of the soils within the watershed that were unnamed was assumed to be HSG D soils to be conservative.

Bloody Run Hydrologic Soil Groups

HSG	Area (Acres)	Percent of Watershed
A	0	0%
B	247	11%
C	1,574	70%
D	121	5%
Unnamed	320	14%
Total	2,262	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 relative magnitude of various land use types within the watershed.

Bloody Run Land Use Summary

Land Use	Area (acres)	Percent of Watershed
Cemetery	0	0%
Commercial/Industrial	451	20%
Multi-Residential	197	9%
Public Building	56	2%
Public Open Space	526	23%
Residential	627	28%
Road	305	14%
Undeveloped	100	4%
Total	**2,262**	**100%**

The Bloody 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.

Bloody Run Subbasin Characteristics

Subbasin ID	Subbasin Name	Subbasin Area (Ac)	Curve Number	Time of Concentration (min)
1	Losantiville Country Club 1	101.62	82	18.36
2	Langdon Farm and Montgomery Rd	23.58	83	12.84
3	Losantiville Country Club 2	31.34	76	22.14
4	Losantiville Country Club 3	32.80	75	21.96
5	Langdon Farm and Ferriview Ave	8.13	85	10.02
6	Langdon Farm and Seymour Ave	54.98	91	18.96
7	Gulf Manor	92.91	86	18.48
8	Langdon Farm and Ridgeacres Dr	47.68	92	10.00
9	Fusite Corporation	33.46	88	16.92
10	Norwood and Quatman Ave	70.90	88	13.38

Subbasin ID	Subbasin Name	Subbasin Area (Ac)	Curve Number	Time of Concentration (min)
11	Wiehe and Rosedale Ave	68.41	87	22.74
12	Carthage Ct	4.03	93	10.00
13	Cincinnati Gardens	18.30	94	10.00
14	Fenwick Park	22.91	86	10.00
15	Norwood and Fenwick Ave	130.23	88	14.16
16	Hirsch Dr	61.44	86	16.20
17	Seymour and Mosiac Ln	22.09	92	11.82
18	Langdon Farm and Rhode Island Ave	74.87	90	14.94
19	Langdon Farm and Cathage Ct	17.35	92	12.36
20	Elm Shade and Lakeland Ave	83.12	87	23.34
21	Seymour and Reading Ave	21.95	89	14.46
22	Woodland High School	8.98	75	10.00
23	Stemblock Lane and Reading Ave	44.67	78	27.90
24	Lewis Dr	43.71	63	36.54
25	Steger and Lewis Dr	10.56	65	19.08
26	Seymour and Steger Dr	9.11	78	10.00
27	Tech Solve	104.79	85	21.90
28	Glenmeadow Lane	11.89	89	21.54
29	Maketewah Country Club 1	64.08	71	26.04
30	Maketewah Country Club 2	56.38	68	22.08
31	Maketewah Country Club 3	23.22	70	22.32
32	Paddock and E 66th St	48.04	77	15.06
33	Elm View Pl and Cheyenne Dr	20.49	83	10.00
34	Paddock and Elm Park Dr	7.91	90	17.16
35	Towne and Paddock Rd	26.95	86	21.12
36	Fishwick Dr	42.55	90	18.90
37	I-75 and Towne St	32.19	89	14.22

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

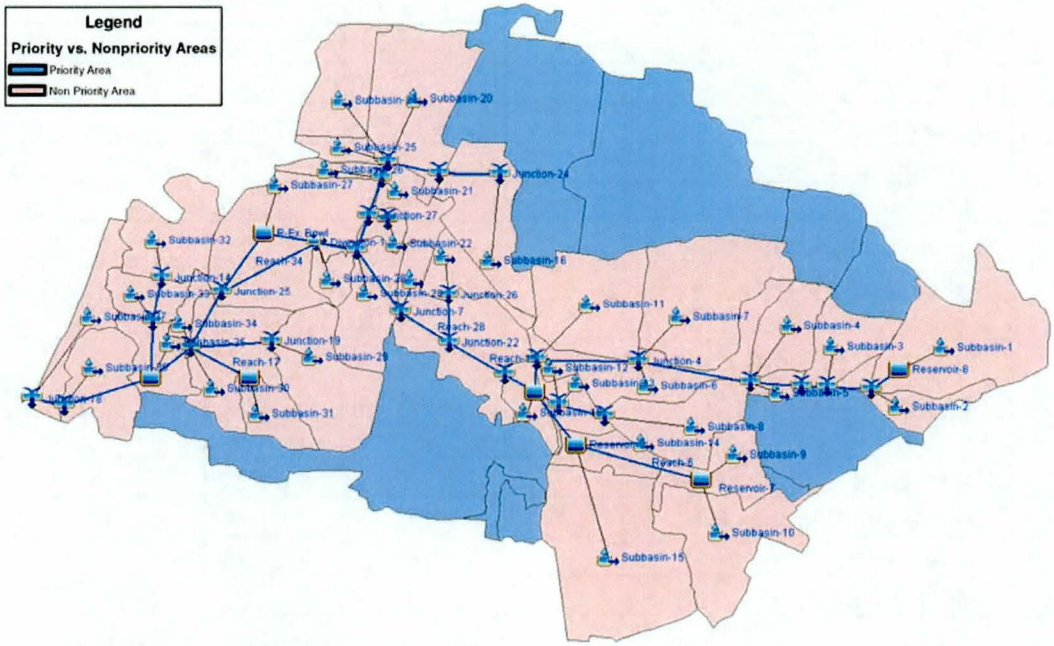
To model the Bloody Run watershed, data for the input parameters was collected using MSDGC's GIS, CAGIS data, and data collected during field reconnaissance. Thirty-seven sub-watersheds were delineated within the Bloody Run watershed. Based on the opportunities analysis the sub-watersheds were divided into priority and non-priority basins based on the ability to effectively remove stormwater from the basin area. Basins listed as priority provide the opportunity to remove stormwater runoff from entering the combined system while basins listed as non-priority will continue to discharge stormwater runoff directly to the CSS. Approximately 1,577 acres, nearly 70 percent, of the Bloody Run watershed, were delineated as 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 32,825 linear feet of proposed storm sewer, enhancement of two existing basins, and the construction of five new detention basins.

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
Priority	1,577	70%	795.59	68%
Non-Priority	685	30%	377.63	32%

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



Bloody Run HEC-HMS Watershed Schematic

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

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

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

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 Bloody 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 discharge 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

HEC-HMS Node	10YR-0.5Hr (cfs)	10YR-1Hr (cfs)	10YR-24Hr (cfs)	10YR-2Hr (cfs)	10YR-3Hr (cfs)	10YR-6Hr (cfs)
Junction-1	77.40	**99.40**	40.60	96.60	84.20	60.40
Junction-2	105.50	**134.80**	59.90	132.40	115.60	86.10
Junction-3	331.20	**389.80**	140.30	366.50	317.00	219.60
Junction-4	260.80	**312.40**	115.20	295.30	255.50	178.00
Junction-5	**175.70**	160.00	28.90	124.80	107.90	71.90
Junction-6	29.80	37.00	**252.50**	185.80	224.00	227.60
Junction-7	196.20	187.60	**286.40**	225.00	256.70	257.40
Junction-8	70.90	**74.80**	22.10	65.70	55.30	37.90
Junction-9	187.20	**205.70**	71.20	185.50	158.40	108.40
Junction-10	159.50	**172.70**	60.30	155.40	132.70	90.40
Junction-11	359.90	**396.90**	375.40	367.50	362.10	334.00
Junction-12	345.30	**380.90**	371.10	353.50	359.50	330.50
Junction-13	29.20	43.50	**227.90**	115.40	152.90	176.40
Junction-14	23.00	**28.20**	13.20	27.20	23.60	17.90
Junction-15	39.40	**46.70**	20.00	44.30	38.40	28.00
Junction-16	67.50	106.20	**248.10**	119.70	159.60	189.70
Junction-17	**114.00**	104.50	19.50	81.10	70.30	46.70
Junction-18	112.80	124.10	**253.90**	139.50	164.90	194.80
Junction-19	12.50	17.50	13.80	**19.90**	18.30	15.70
Junction-20	89.00	**113.90**	48.80	111.20	97.10	71.10
Junction-21	89.20	**114.10**	48.80	111.40	97.10	71.10
Junction-22	50.70	52.00	**260.70**	195.10	232.50	234.80
Junction-23	3.80	**4.70**	2.30	4.50	4.00	3.00
Junction-24	71.40	**75.10**	22.10	65.80	55.40	37.90
Junction-25	14.10	30.10	**210.70**	107.70	142.20	164.20
Junction-26	**49.80**	46.70	9.00	36.60	31.30	21.10
Junction-27	189.10	**209.10**	73.50	189.40	162.00	110.60
Reach-1	77.30	**99.10**	40.50	96.50	84.10	60.30
Reach-2	105.40	**134.50**	59.90	132.30	115.50	86.10
Reach-3	260.00	**311.30**	115.20	294.60	255.00	178.00
Reach-4	5.80	7.20	**82.40**	56.70	68.60	78.60
Reach-5	331.00	**389.40**	140.20	366.30	316.80	219.60
Reach-6	6.50	7.50	**33.70**	31.10	32.40	33.70

HEC-HMS Node	10YR-0.5Hr (cfs)	10YR-1Hr (cfs)	10YR-24Hr (cfs)	10YR-2Hr (cfs)	10YR-3Hr (cfs)	10YR-6Hr (cfs)
Reach-7	**175.60**	159.90	28.90	124.80	107.90	71.90
Reach-8	70.40	**74.60**	22.10	65.60	55.20	37.80
Reach-9	159.20	**172.60**	60.30	155.30	132.60	90.40
Reach-10	185.70	**204.50**	71.20	185.00	158.20	108.30
Reach-11	344.10	**380.20**	370.90	352.90	356.80	330.20
Reach-12	358.90	**396.30**	375.30	367.20	360.00	333.80
Reach-13	194.70	186.90	**286.30**	224.90	255.50	257.20
Reach-14	**49.60**	46.60	9.00	36.50	31.30	21.10
Reach-15	29.80	37.00	**252.50**	185.80	223.50	227.50
Reach-16	14.10	30.10	**210.70**	107.70	142.20	164.20
Reach-17	0.10	0.50	**1.00**	0.80	0.80	0.90
Reach-18	29.20	43.50	**227.90**	115.40	152.90	176.40
Reach-19	22.90	**28.10**	13.20	27.20	23.60	17.80
Reach-20	39.30	**46.60**	20.00	44.30	38.40	28.00
Reach-21	36.40	80.40	**240.50**	116.40	155.00	184.30
Reach-22	**113.80**	104.30	19.50	81.00	70.10	46.60
Reach-23	66.80	105.90	**248.00**	119.50	159.30	189.60
Reach-24	12.30	17.40	13.70	**19.80**	18.30	15.60
Reach-25	89.00	**113.70**	48.80	111.20	97.00	71.10
Reach-26	89.00	**113.90**	48.80	111.20	97.10	71.10
Reach-27	29.80	37.00	**252.50**	185.80	224.00	227.60
Reach-28	50.50	52.00	**260.60**	195.00	231.50	234.70
Reach-29	3.80	**4.70**	2.30	4.50	4.00	3.00
Reach-30	70.90	**74.80**	22.10	65.70	55.30	37.90
Reach-31	14.10	30.10	**210.70**	107.70	142.20	164.10
Reach-32	61.90	**79.50**	32.70	77.50	67.50	48.60
Reach-33	187.90	**208.20**	73.50	189.10	161.80	110.60
Reservoir-1	29.80	37.00	**253.60**	190.60	231.60	228.70
Reservoir-2	5.80	7.20	**82.60**	58.20	68.80	79.30
Reservoir-3	14.10	30.10	**210.70**	107.80	142.20	164.20
Reservoir-5	0.10	0.50	**1.00**	0.80	0.80	0.90
Reservoir-6	37.20	80.60	**240.50**	116.50	155.20	184.30
Reservoir-7	6.50	7.50	**33.70**	31.10	32.40	33.70
Reservoir-8	61.90	**79.60**	32.70	77.50	67.50	48.60
Subbasin-1	89.50	**96.40**	32.90	86.30	73.20	49.00
Subbasin-2	22.90	**24.30**	7.90	21.40	18.10	12.00
Subbasin-3	11.90	**15.20**	8.30	15.20	13.40	10.80
Subbasin-4	11.20	14.40	8.30	**14.70**	13.00	10.60
Subbasin-5	10.20	**10.30**	2.90	8.60	7.10	4.90
Subbasin-6	92.50	**93.60**	22.10	79.30	65.80	47.40
Subbasin-7	101.70	**109.00**	33.40	97.20	82.50	56.30
Subbasin-8	**114.00**	104.50	19.50	81.10	70.30	46.70
Subbasin-9	45.70	**47.10**	12.60	40.50	33.90	23.70

HEC-HMS Node	10YR-0.5Hr (cfs)	10YR-1Hr (cfs)	10YR-24Hr (cfs)	10YR-2Hr (cfs)	10YR-3Hr (cfs)	10YR-6Hr (cfs)
Subbasin-10	**117.80**	114.50	26.80	90.20	73.40	52.60
Subbasin-11	74.30	**80.90**	25.10	73.10	62.70	43.30
Subbasin-12	**10.60**	9.50	1.70	7.50	6.50	4.30
Subbasin-13	**52.50**	46.80	7.70	37.00	31.90	21.20
Subbasin-14	**31.70**	31.60	8.30	25.80	21.30	14.80
Subbasin-15	**216.40**	210.30	49.30	165.70	134.80	96.50
Subbasin-16	71.40	**75.10**	22.10	65.80	55.40	37.90
Subbasin-17	**49.80**	46.70	9.00	36.60	31.30	21.10
Subbasin-18	**149.50**	140.90	29.60	108.40	92.60	63.20
Subbasin-19	**37.90**	35.90	7.10	28.30	24.10	16.40
Subbasin-20	89.10	**97.30**	30.50	88.30	75.90	52.40
Subbasin-21	**40.00**	38.30	8.50	29.70	24.80	17.40
Subbasin-22	3.80	**4.70**	2.30	4.50	4.00	3.00
Subbasin-23	19.20	23.80	12.50	**24.10**	21.40	17.10
Subbasin-24	1.30	4.30	**6.10**	5.50	6.10	5.20
Subbasin-25	0.80	1.50	1.70	1.90	**2.00**	1.60
Subbasin-26	5.60	**6.30**	2.60	5.90	5.10	3.60
Subbasin-27	96.90	**107.70**	36.60	98.80	85.10	58.10
Subbasin-28	15.80	**16.70**	4.60	14.70	12.50	8.80
Subbasin-29	12.50	17.50	13.80	**19.90**	18.30	15.70
Subbasin-30	7.50	11.30	10.60	**13.70**	13.20	11.10
Subbasin-31	4.20	6.00	4.80	**6.70**	6.20	5.40
Subbasin-32	23.00	**28.20**	13.20	27.20	23.60	17.90
Subbasin-33	21.30	**22.20**	6.80	19.00	16.00	10.60
Subbasin-34	12.80	**13.00**	3.10	10.90	9.00	6.50
Subbasin-35	27.70	**30.30**	9.70	27.40	23.50	16.00
Subbasin-36	65.80	**67.30**	16.70	57.60	48.00	34.30
Subbasin-37	**51.70**	51.50	12.40	42.50	34.80	24.90

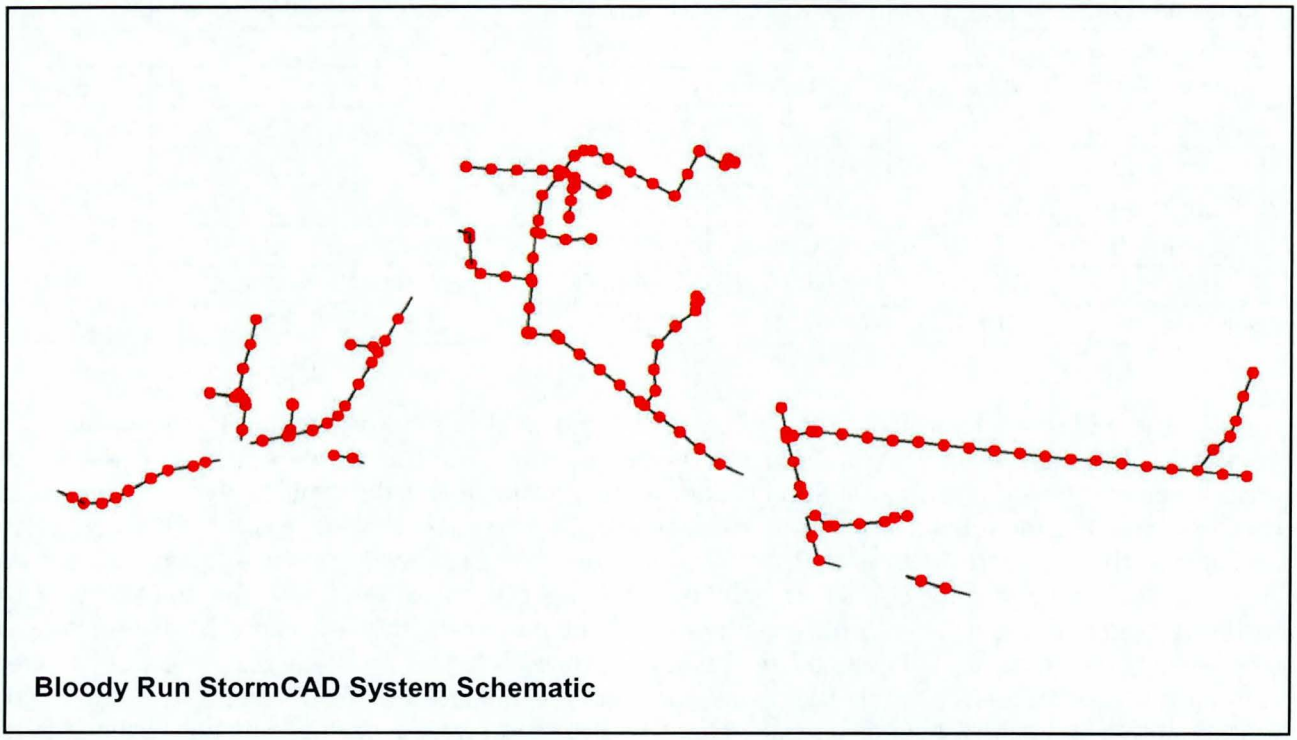
Use of the HEC-HMS hydrologic model for developing peak discharges was selected primarily to evaluate the potential effects of both existing and future stormwater detention facilities in the priority basins. Based on the evaluation of the existing basins it was determined that only one of the two was suitable for retrofitting to reduce peak outflow rates. Several site visits and review of the document titled *Isolated Wetland Permit for the 19 Acre TechSolve Site in Cincinnati, Hamilton County, Ohio*, prepared by EHM&T in October 2008 were used to determine the suitability of the proposed regional basin for retrofit. The other proposed basin retrofit was to an existing wet pond on the Losantiville Country Club golf course. Based on site visits to this facility and a review of pertinent GIS data it was decided that this basin was not a good candidate for retrofitting due to the limited potential to significantly increase storage capacity and therefore this facility was not included in the modeled alternative. 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

HEC-HMS Node ID	Location Description	Drainage Area (acres)	Peak 10-Year Discharge (cfs)
Junction-2	Ridge Acres Dr and Langdon Farm Rd	166.08	134.80
Junction-3	Seymour Ave and Langdon Farm Rd	382.40	389.80
Junction-5	Seymour Ave and Carthage Ct	70.02	160.00
Junction-9	Seymour Ave and Shona Dr	229.89	205.70
Junction-12	TechSolve Property	1107.78	380.90
Junction-13	Paddock Rd and Towne St	1376.06	43.50
Junction-18	Bloody Run Outfall	1577.66	124.10
Junction-21	Fairway Dr and Langdon Farm Rd	156.54	114.10
Junction-22	Grafton Ave and Langdon Farm Rd	692.93	52.00
Reach-20	Towne St and Fenwick Dr	68.54	46.60

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.

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



Bloody 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 needs 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 4 feet and the hydraulic grade line for the 10 year design storm would remain below 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 Bloody 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 systems 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. 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)
I-219	MH-346	47.5	12 inch	9.50%	3.8	10.97
I-226	MH-363	134	12 inch	5.00%	0.5	8
I-227	MH-365	265.5	12 inch	1.20%	2.29	3.85
MH-363	MH-364	224.5	12 inch	1.60%	0.5	4.45
MH-365	I-223	94.5	12 inch	0.40%	2.29	2.32
I-203	MH-298	258.5	15 inch	1.40%	7.2	7.52
I-213	MH-342	300	15 inch	0.80%	4.70	5.90
I-220	MH-350	300.5	15 inch	1.20%	6.3	6.97
I-228	MH-366	300.5	15 inch	4.20%	7.58	13.17
I-246	MH-352	300	15 inch	5.50%	6.3	15.15
MH-298	MH-299	300.5	15 inch	1.80%	7.2	8.74
MH-341	I-212	62.5	15 inch	19.40%	4.7	28.42
MH-342	MH-341	300	15 inch	4.80%	4.7	14.2

Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-346	I-216	44	15 inch	0.50%	3.8	4.57
MH-350	I-246	300	15 inch	3.70%	6.3	12.37
MH-352	MH-353	191	15 inch	2.50%	6.3	10.19
MH-353	I-211	44	15 inch	9.20%	6.3	19.6
MH-366	I-238	90	15 inch	2.30%	7.58	9.86
I-208	I-207	45.5	18 inch	0.80%	4.67	9.28
I-217	MH-347	55	18 inch	4.50%	15.30	22.39
MH-364	I-224	384	18 inch	0.70%	0.5	8.89
I-198	MH-283	300	24 inch	1.00%	14.04	22.62
I-200	MH-286	300	24 inch	2.80%	515	37.51
I-201	MH-288	300.5	24 inch	1.30%	15.2	26.1
I-204	MH-300	300.5	24 inch	3.50%	37	42.29
I-215	MH-343	198	24 inch	0.50%	12.80	16.00
I-230	MH-380	18	24 inch	1.40%	13.00	26.66
MH-283	I-197	55	24 inch	29.60%	14.04	123.16
MH-288	MH-289	300	24 inch	1.50%	15.2	27.71
MH-289	MH-290	197.5	24 inch	2.50%	15.2	35.99
MH-290	MH-291	246	24 inch	1.80%	15.2	30.6
MH-291	I-195	318	24 inch	0.50%	15.2	16
MH-299	OF-38	237.5	24 inch	0.10%	7.2	7.34
MH-343	MH-344	141.5	24 inch	0.50%	12.80	16.00
MH-344	I-216	127	24 inch	4.70%	12.80	49.26
MH-345	I-216	16	24 inch	1.40%	15.30	26.53
MH-347	MH-345	377.5	24 inch	1.60%	15.30	28.52
MH-380	MH-381	300	24 inch	0.50%	13	16
MH-381	I-225	61.5	24 inch	12.80%	13	80.82
I-193	I-239	142.5	30 inch	5.30%	79.6	94.09
I-206	I-207	71	30 inch	0.70%	4.67	34.42
I-237	MH-383	300	30 inch	0.70%	28.2	33.49
MH-286	MH-287	300	30 inch	0.60%	515	31.33
MH-287	OF-37	177.5	30 inch	0.50%	515	29
MH-383	I-251	300	30 inch	0.50%	28.2	29
I-207	MH-321	90	36 inch	0.50%	46.7	47.16
I-209	MH-305	76.5	36 inch	0.70%	52	53.92
I-216	MH-349	126.5	36 inch	0.50%	38.3	47.16
I-243	MH-324	300	36 inch	0.50%	46.7	47.16
I-251	MH-385	300	36 inch	0.50%	46.7	47.16
MH-300	MH-301	300.5	36 inch	0.50%	37	47.16
MH-301	MH-302	299.5	36 inch	1.30%	37	77.05
MH-302	MH-303	300	36 inch	0.70%	37	54.46
MH-303	I-209	223.5	36 inch	0.70%	37	54.64
MH-321	MH-322	300	36 inch	0.50%	46.7	47.16

Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-322	I-243	300	36 inch	0.50%	46.7	47.16
MH-324	MH-325	249	36 inch	1.00%	46.7	66.83
MH-325	I-209	212.5	36 inch	3.80%	46.7	129.41
MH-349	I-211	30.5	36 inch	5.40%	38.3	155.01
MH-385	I-238	69	36 inch	0.50%	46.7	47.16
I-202	MH-292	148.5	42 inch	1.20%	104.5	109.21
I-210	MH-326	86.5	42 inch	1.20%	75.1	108.17
I-238	MH-368	48.5	42 inch	0.50%	57.8	71.14
MH-292	MH-293	122.5	42 inch	2.20%	104.50	150.74
MH-293	MH-294	300	42 inch	1.00%	104.5	100.6
MH-294	MH-295	300	42 inch	2.70%	104.5	164.29
MH-295	MH-296	65	42 inch	1.90%	104.5	139.51
MH-305	MH-306	300	42 inch	0.50%	52	71.14
MH-306	I-244	300	42 inch	0.60%	52	76.84
MH-326	MH-327	82	42 inch	1.80%	75.1	136.07
MH-368	MH-369	46.5	42 inch	0.50%	57.8	70.75
MH-369	MH-370	300	42 inch	0.90%	57.8	95.09
MH-370	OF-42	112	42 inch	0.50%	57.8	71.14
I-239	MH-262	131.5	48 inch	0.50%	99.4	100.98
I-248	MH-332	300	48 inch	0.50%	74.8	101.57
MH-262	MH-263	96	48 inch	0.50%	99.4	103.66
MH-263	MH-264	33.5	48 inch	0.40%	99.4	96.11
MH-264	MH-265	286.5	48 inch	0.40%	99.4	91
MH-265	I-195	299.5	48 inch	1.90%	99.4	197.98
MH-327	MH-328	340	48 inch	0.40%	75.1	85.33
MH-328	MH-329	300	48 inch	0.30%	75.1	82.93
MH-329	MH-330	300	48 inch	0.50%	75.1	101.57
MH-330	I-248	300	48 inch	0.50%	75.1	101.57
MH-332	MH-333	300	48 inch	0.50%	74.8	101.57
MH-333	MH-334	207	48 inch	0.50%	74.8	101.57
MH-334	MH-335	100.5	48 inch	0.50%	74.8	101.57
MH-335	I-247	122.5	48 inch	0.50%	74.80	101.57
I-195	MH-266	300	54 inch	0.50%	114.1	139.04
I-196	MH-269	300	54 inch	1.70%	134.8	257.64
MH-266	MH-267	300	54 inch	0.50%	114.10	139.04
MH-267	MH-268	300	54 inch	1.40%	114.1	231.56
MH-268	I-196	300.5	54 inch	2.30%	114.1	300.12
MH-269	MH-270	300	54 inch	0.70%	134.8	164.52
MH-270	MH-271	300	54 inch	1.80%	134.8	266.25
MH-271	MH-272	300	54 inch	3.60%	134.8	372.23
MH-272	MH-273	300	54 inch	3.80%	134.8	380.79
MH-273	I-240	300	54 inch	1.80%	134.8	266.25

Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-296	I-245	201	54 inch	0.50%	104.5	139.04
I-221	MH-354	300	60 inch	0.80%	216.1	237.74
I-223	MH-356	139	60 inch	0.80%	218.39	228.49
I-244	MH-308	300	60 inch	1.60%	187.6	327.7
I-245	OF-38	103.5	60 inch	1.40%	160	313
MH-354	MH-355	300	60 inch	0.50%	216.1	184.15
MH-355	I-223	161	60 inch	1.30%	216.1	297.43
MH-356	MH-357	300	66 inch	0.50%	218.39	237.24
I-211	MH-337	56	72 inch	0.10%	205.70	126.54
I-224	I-225	272.5	72 inch	0.30%	256.5	222.17
I-225	MH-361	27.5	72 inch	0.70%	251.9	361.15
I-229	MH-371	165	72 inch	0.30%	243.1	233.12
I-247	I-211	243.5	72 inch	0.20%	172.70	182.05
I-250	MH-359	146	72 inch	0.30%	229.8	229.82
I-252	MH-377	172.5	72 inch	0.10%	284.50	144.20
MH-308	MH-309	300	72 inch	0.80%	187.6	386.59
MH-309	MH-310	46	72 inch	1.10%	187.6	441.51
MH-310	MH-311	300	72 inch	0.50%	187.6	299.45
MH-311	MH-312	46.5	72 inch	0.50%	187.6	297.84
MH-312	MH-313	300	72 inch	0.50%	187.60	299.45
MH-313	MH-314	300	72 inch	0.50%	187.6	299.45
MH-357	I-250	300	72 inch	0.30%	218.39	222.75
MH-359	MH-360	154.5	72 inch	0.40%	229.8	263.91
MH-360	I-224	191	72 inch	0.20%	229.8	188.89
MH-361	MH-362	300	72 inch	0.10%	251.9	133.92
MH-371	MH-372	147	72 inch	0.30%	243.10	246.98
MH-372	MH-373	299.5	72 inch	0.30%	243.10	220.23
MH-373	MH-374	223.5	72 inch	0.50%	243.1	298.44
MH-374	MH-375	300	72 inch	0.20%	243.1	172.89
MH-375	I-252	169	72 inch	0.20%	243.10	172.37
I-240	MH-275	300	78 inch	0.50%	312.4	370.7
MH-275	MH-276	300	78 inch	0.50%	312.4	370.7
MH-276	MH-277	300	78 inch	1.10%	312.4	545.66
	MH-278	300	78 inch	5.60%	312.4	1238.75
I-197	MH-386	301	84 inch	0.50%	389.8	451.7
MH-278	MH-279	300	84 inch	0.50%	312.4	451.7
MH-279	MH-280	60.5	84 inch	0.50%	312.40	449.83
MH-280	MH-281	225	84 inch	0.50%	312.4	452.7
MH-281	I-197	75	84 inch	0.50%	312.4	450.19
MH-284	MH-285	95.5	84 inch	0.50%	389.8	451.7
MH-285	OF-36	94.5	84 inch	1.60%	389.8	804.81
MH-314	I-205	25	84 inch	1.90%	187.6	875.87

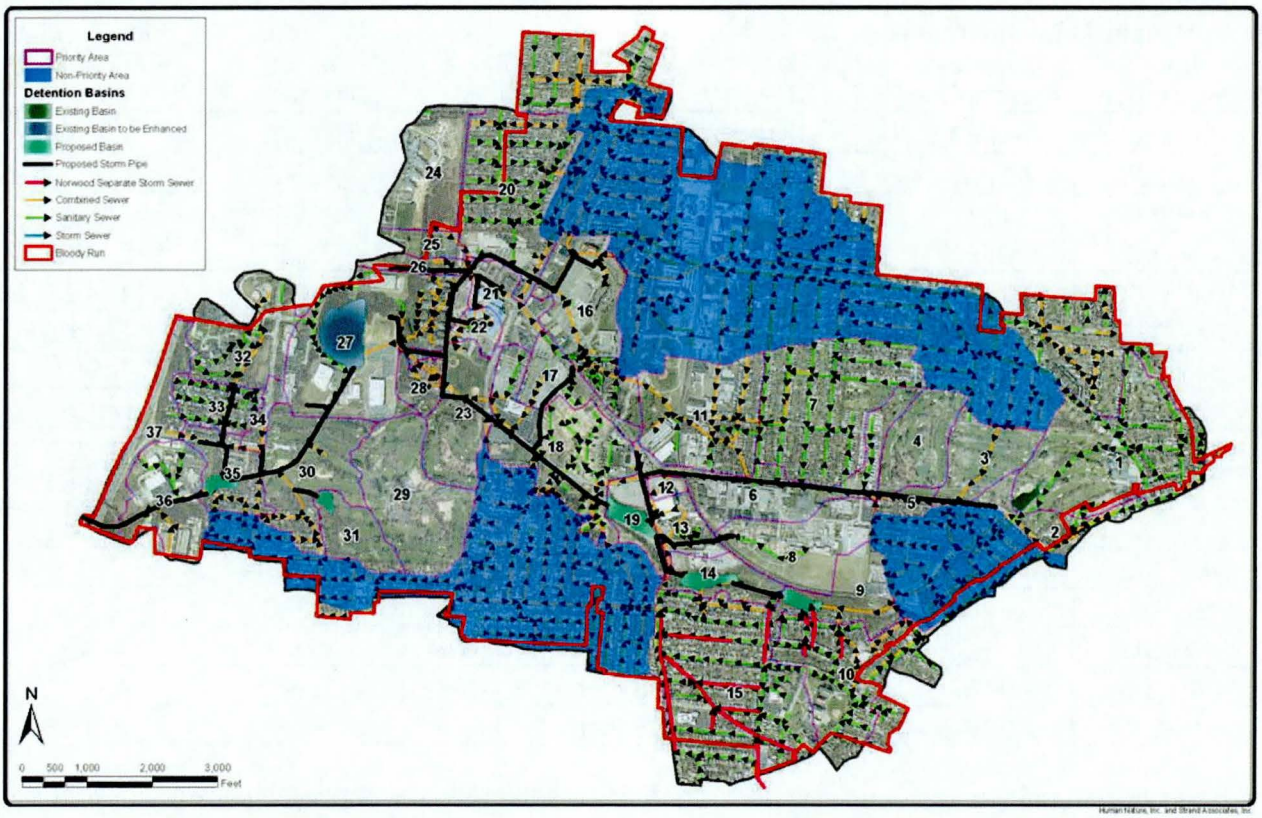
Upstream Node Description	Downstream Node Description	Pipe Length (ft)	Pipe Size	Slope (%)	10-Year Design Discharge	Pipe Flowing Full Capacity (cfs)
MH-337	MH-338	300	84 inch	0.10%	205.7	233.26
MH-338	MH-339	300	84 inch	0.10%	205.7	142.84
MH-339	I-212	145.5	84 inch	0.10%	205.7	205.11
MH-362	OF-41	136	84 inch	0.10%	251.9	244.97
MH-377	MH-378	218.5	84 inch	0.10%	284.50	193.26
MH-378	MH-387	148	84 inch	0.10%	284.50	234.83
MH-386	MH-284	299.5	84 inch	0.50%	389.8	451.7
MH-387	OF-43	182	84 inch	0.10%	284.50	211.76
I-205	MH-316	300	96 inch	0.10%	396.9	311.52
I-212	MH-340	300	96 inch	0.10%	209.10	263.28
I-249	MH-318	161	96 inch	0.10%	396.9	321.45
MH-316	I-249	299.5	96 inch	0.10%	396.9	263.5
MH-340	I-205	267	96 inch	0.10%	209.10	216.17
MH-318	MH-319	300	108 inch	0.10%	396.9	444.37
MH-319	MH-320	65.5	108 inch	0.10%	396.9	462.82
MH-320	OF-45	126	108 inch	0.10%	396.9	401.05

Based on the opportunities analysis performed, the evaluated alternative as shown below includes: approximately 32,825 linear feet of storm sewer, conversion of an existing detention basin into a large, regional detention facility and the addition of five new stormwater detention basins. Site visits were conducted at each of the proposed stormwater detention basins locations. The new basins are proposed for the following locations:

- Two on undeveloped and industrial property south of the railroad, in Subbasin 14;
- One on undeveloped commercial property south of Langdon Farm, in Subbasin 19;
- One west of the Maketewah Country Club golf course in Subbasin 31; and
- One on undeveloped commercial property south of Towne Street in Subbasin 35.

The proposed regional basin, located in subbasin 27, is part of a 19 acre vacant parcel owned by Tech Solve and adjacent to the existing Tech Solve commercial site. This parcel is currently for sale. Additionally, there are two other smaller retention basins located on the southern portion of the developed Tech Solve property that provide localized detention for this property.Tech Solve representatives have indicated that they are currently evaluating the feasibility of a facility expansion at this location. For the purposes of this evaluation it was assumed the proposed regional basin could be utilized to collect and store the stormwater from the proposed separation effort throughout Bloody Run. Additionally, the regional basin has been sized to accommodate the flows that are currently directed to the smaller retention basins on the developed Tech Solve site. This would allow for the elimination of these basins thus providing Tech Solve with the opportunity to develop this area and expand the Tech Solve facility.

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 Bloody Run watershed.



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 tables summarize the preliminary opinion of cost for the strategies outlined above, including the use of the Tech Solve property for a regional bioretention facility. The total of this alternative is $56.4 million.

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

Item	Quantity	Unit	Unit Cost	Cost
108 IN RCP-Storm Sewer Main	500	LF	$550	$275,000
96 IN RCP-Storm Sewer Main	1350	LF	$500	$675,000
84 IN RCP-Storm Sewer Main	3770	LF	$385	$1,451,450
72 IN RCP-Storm Sewer Main	4800	LF	$233	$1,118,400
60 IN RCP-Storm Sewer Main	1300	LF	$248	$322,400
54 IN RCP-Storm Sewer Main	3200	LF	$195	$624,000
48 IN RCP-Storm Sewer Main	3150	LF	$135	$425,250
42 IN RCP-Storm Sewer Main	2125	LF	$121	$257,125
36 IN RCP-Storm Sewer Main	3200	LF	$139	$444,800
30 IN RCP-Storm Sewer Main	1300	LF	$119	$154,700
24 IN RCP-Storm Sewer Main	3800	LF	$79	$300,200
18 IN RCP-Storm Sewer Main	500	LF	$68	$34,000
15 IN RCP-Storm Sewer Main	2800	LF	$56	$156,800
12 IN RCP-Storm Sewer Main	800	LF	$52	$41,600
84 IN RCP-Storm Sewer Main - Tunneling under interstate	330	LF	$10,000	$3,300,000
42 IN RCP-Storm Sewer Main - Tunneling under railroad	125	LF	$5,000	$625,000
Precast Storm Sewer Manhole	155	EA	$6,000	$930,000
Detention Basin 1	1	EA	$470,000	$470,000
Detention Basin 2	1	EA	$490,000	$490,000
Detention Basin 3 (Tech Solve)	1	EA	$3,520,000	$3,520,000
Detention Basin 6	1	EA	$595,000	$595,000
Detention Basin 7	1	EA	$360,000	$360,000
Detention Basin 5	1	EA	$150,000	$150,000
Apron Endwall for 108 IN RCP	1	EA	$5,000	$5,000
Apron Endwall for 84 IN RCP	2	EA	$4,000	$8,000
Apron Endwall for 60 IN RCP	1	EA	$2,300	$2,300
Apron Endwall for 42 IN RCP	1	EA	$1,100	$1,100
Apron Endwall for 30 IN RCP	1	EA	$700	$700
Apron Endwall for 18 IN RCP	2	EA	$550	$1,100
Water Main Relocations	1	EA	$2,176,100	$2,176,100
Roadway Restoration	1	EA	$16,236,800	$16,236,800
Terrace Restoration	1	EA	$1,841,300	$1,841,300
Demolition & Connections	1	EA	$1,004,300	$1,004,300
Gas, Telephone, & Electric Relocations	1	EA	$1,339,100	$1,339,100
Rock Excavation	1	EA	$3,515,200	$3,515,200

Sub Total =	$42,851,725
Miscellaneous Items @ 30% =	$12,855,518
Sub Total =	$55,707,243

Outside of Bloody Run Basin to Connect to the Mill Creek

Rehabilitation to the existing natural channel	1	Each	$500,000	$500,000

Sub Total =	$43,351,725
Miscellaneous Items @ 30% =	$13,005,518
Grand Total =	$56,357,243

Gallons Removed: 421,000,000 **$0.13**

The following table summarizes the preliminary opinion of cost for the alternative control strategy described above (e.g. no regional basin).

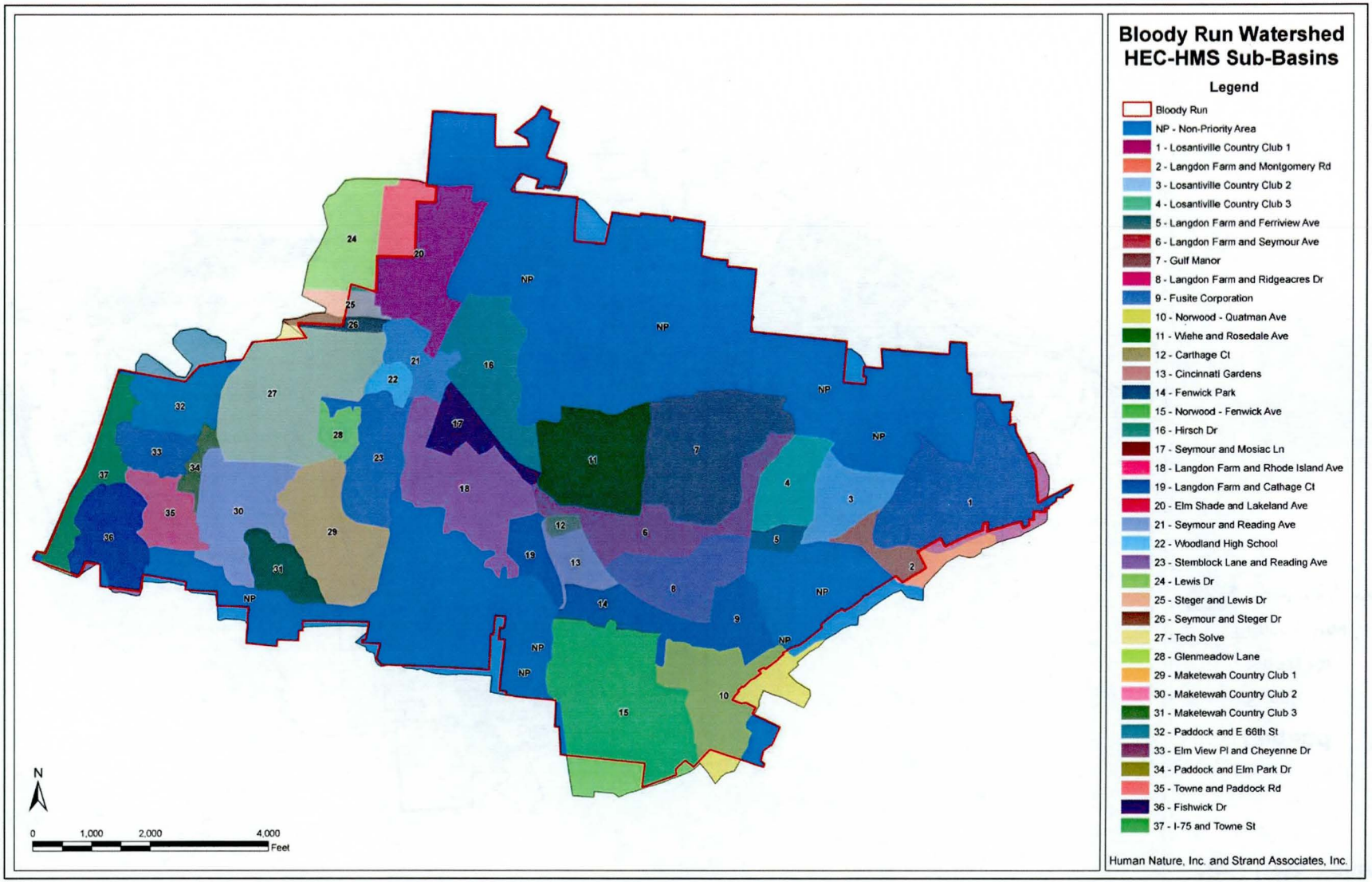
Inside of Bloody Run Basin Does Not Connect to the Mill Creek

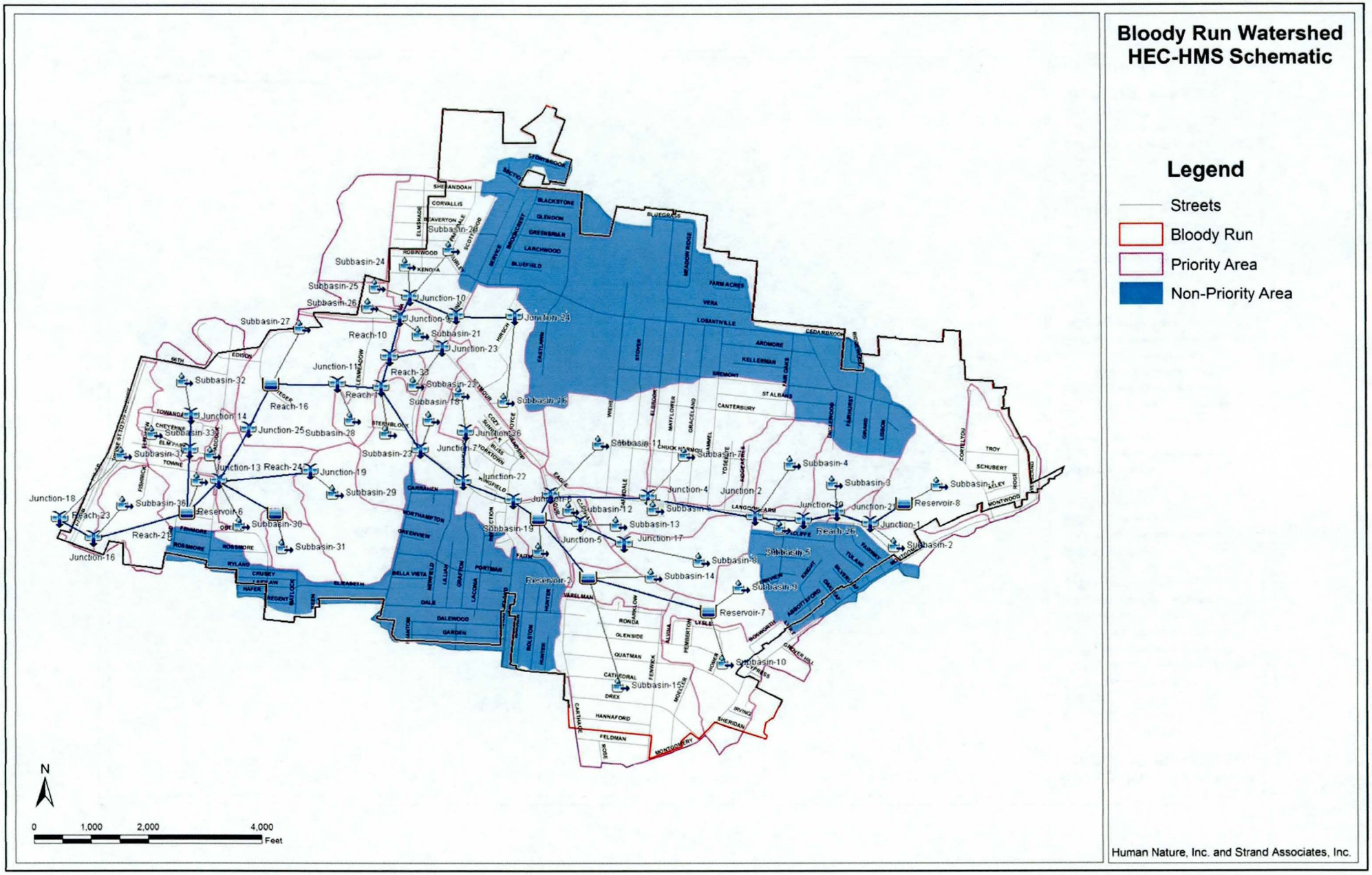
Item	Quantity	Unit	Unit Cost	Cost
10x10 FT RCP Box Conduit	750	LF	$1,680	$1,260,000
10x8 FT RCP Box Conduit	350	LF	$1,100	$385,000
10x6 FT RCP Box Conduit	550	LF	$1,000	$550,000
8x6 FT RCP Box Conduit	1500	LF	$825	$1,237,500
108 IN RCP-Storm Sewer Main	650	LF	$550	$357,500
96 IN RCP-Storm Sewer Main	4100	LF	$500	$2,050,000
84 IN RCP-Storm Sewer Main	3120	LF	$385	$1,201,200
72 IN RCP-Storm Sewer Main	1600	LF	$233	$372,800
60 IN RCP-Storm Sewer Main	400	LF	$248	$99,200
54 IN RCP-Storm Sewer Main	3200	LF	$195	$624,000
48 IN RCP-Storm Sewer Main	3150	LF	$135	$425,250
42 IN RCP-Storm Sewer Main	2125	LF	$121	$257,125
36 IN RCP-Storm Sewer Main	3200	LF	$139	$444,800
30 IN RCP-Storm Sewer Main	1300	LF	$119	$154,700
24 IN RCP-Storm Sewer Main	3800	LF	$79	$300,200
18 IN RCP-Storm Sewer Main	500	LF	$68	$34,000
15 IN RCP-Storm Sewer Main	2800	LF	$56	$156,800
12 IN RCP-Storm Sewer Main	800	LF	$52	$41,600
84 IN RCP-Storm Sewer Main - Tunneling under interstate	330	LF	$10,000	$3,300,000
42 IN RCP-Storm Sewer Main - Tunneling under railroad	125	LF	$5,000	$625,000
Precast Storm Sewer Manhole	161	EA	$6,000	$966,000
Detention Basin 1	1	EA	$470,000	$470,000
Detention Basin 2	1	EA	$490,000	$490,000
Detention Basin 6	1	EA	$595,000	$595,000
Detention Basin 7	1	EA	$360,000	$360,000
Detention Basin 5	1	EA	$150,000	$150,000
Apron Endwall for 10x10 FT RCP	1	EA	$8,000	$8,000
Apron Endwall for 84 IN RCP	1	EA	$4,000	$4,000
Apron Endwall for 60 IN RCP	1	EA	$2,300	$2,300
Apron Endwall for 42 IN RCP	1	EA	$1,100	$1,100
Apron Endwall for 30 IN RCP	1	EA	$700	$700
Apron Endwall for 18 IN RCP	2	EA	$550	$1,100
Water Main Relocations	1	EA	$2,199,900	$2,199,900
Roadway Restoration	1	EA	$16,414,300	$16,414,300
Terrace Restoration	1	EA	$1,861,400	$1,861,400
Demolition & Connections	1	EA	$1,015,300	$1,015,300
Gas, Telephone, & Electric Relocations	1	EA	$1,353,800	$1,353,800
Rock Excavation	1	EA	$3,553,600	$3,553,600

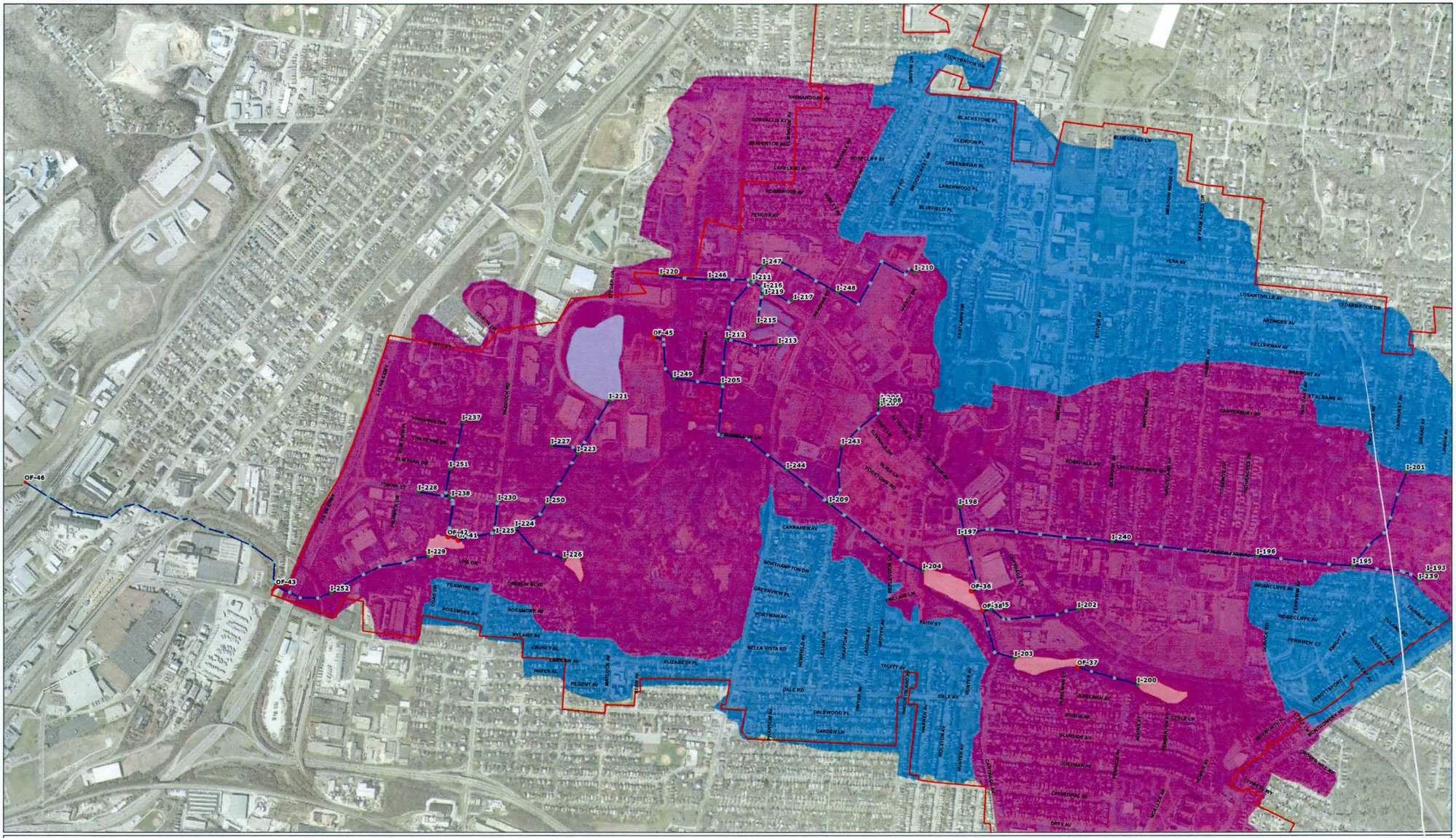
			Sub Total =	$43,323,175
			Miscellaneous Items @ 30% =	$12,996,953
			Sub Total =	$56,320,128

Outside of Bloody Run Basin to Connect to the Mill Creek

Rehabilitation to the existing natural channel	1	Each	$500,000	$500,000
			Sub Total =	$43,823,175
			Miscellaneous Items @ 30% =	$13,146,953
			Grand Total =	$56,970,128
			Gallons Removed: 421,000,000	**$0.14**


Bloody Run Watershed
HEC-HMS Sub-Basins
Legend
Bloody Run
NP - Non-Priority Area
1 - Losantiville Country Club 1
2 - Langdon Farm and Montgomery Rd
3 - Losantiville Country Club 2
4 - Losantiville Country Club 3
5 - Langdon Farm and Ferriview Ave
6 - Langdon Farm and Seymour Ave
7 - Gulf Manor
8 - Langdon Farm and Ridgeacres Dr
9 - Fusite Corporation
10 - Norwood - Quatman Ave
11 - Wiehe and Rosedale Ave
12 - Carthage Ct
13 - Cincinnati Gardens
14 - Fenwick Park
15 - Norwood - Fenwick Ave
16 - Hirsch Dr
17 - Seymour and Mosiac Ln
18 - Langdon Farm and Rhode Island Ave
19 - Langdon Farm and Cathage Ct
20 - Elm Shade and Lakeland Ave
21 - Seymour and Reading Ave
22 - Woodland High School
23 - Stemblock Lane and Reading Ave
24 - Lewis Dr
25 - Steger and Lewis Dr
26 - Seymour and Steger Dr
27 - Tech Solve
28 - Glenmeadow Lane
29 - Maketewah Country Club 1
30 - Maketewah Country Club 2
31 - Maketewah Country Club 3
32 - Paddock and E 66th St
33 - Elm View Pl and Cheyenne Dr
34 - Paddock and Elm Park Dr
35 - Towne and Paddock Rd
36 - Fishwick Dr
37 - I-75 and Towne St
Human Nature, Inc. and Strand Associates, Inc.
N
0
1,000
2,000
4,000
Feet

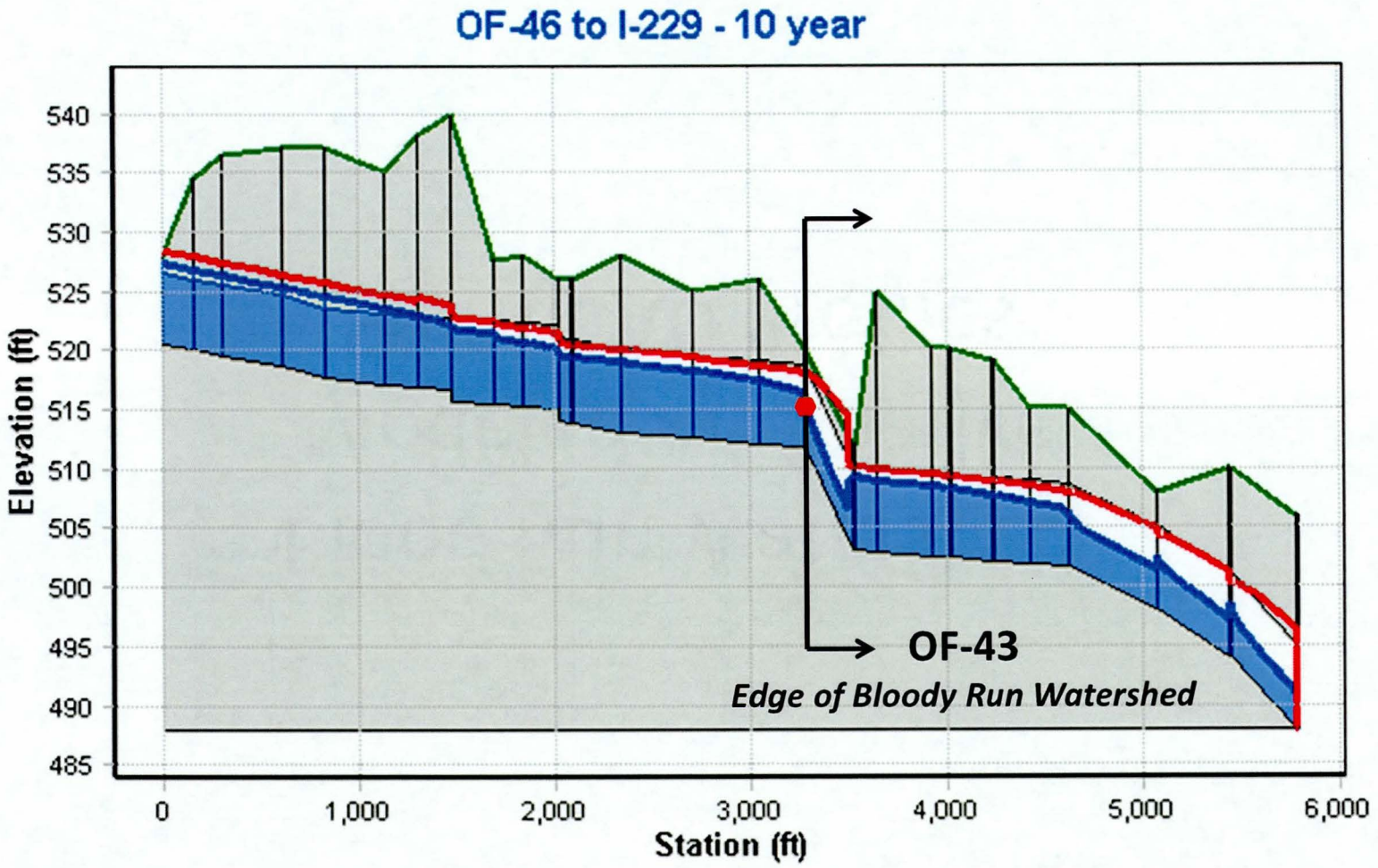

Bloody Run Watershed
HEC-HMS Schematic
Legend
Streets
Bloody Run
Priority Area
Non-Priority Area
Human Nature, Inc. and Strand Associates, Inc.
N
0
1,000
2,000
4,000
Feet


Legend
StormCAD Proposed Sewer
StormCAD Inlet
StormCAD Outfall
StormCAD Manhole
Existing Basin to be Enhanced
Proposed Basin
Priority Area
Non-Priority Area
Bloody Run
Bloody Run StormCAD Schematic
0
1,000
2,000
4,000
Feet
N
Strand Associates, Inc
September 2010

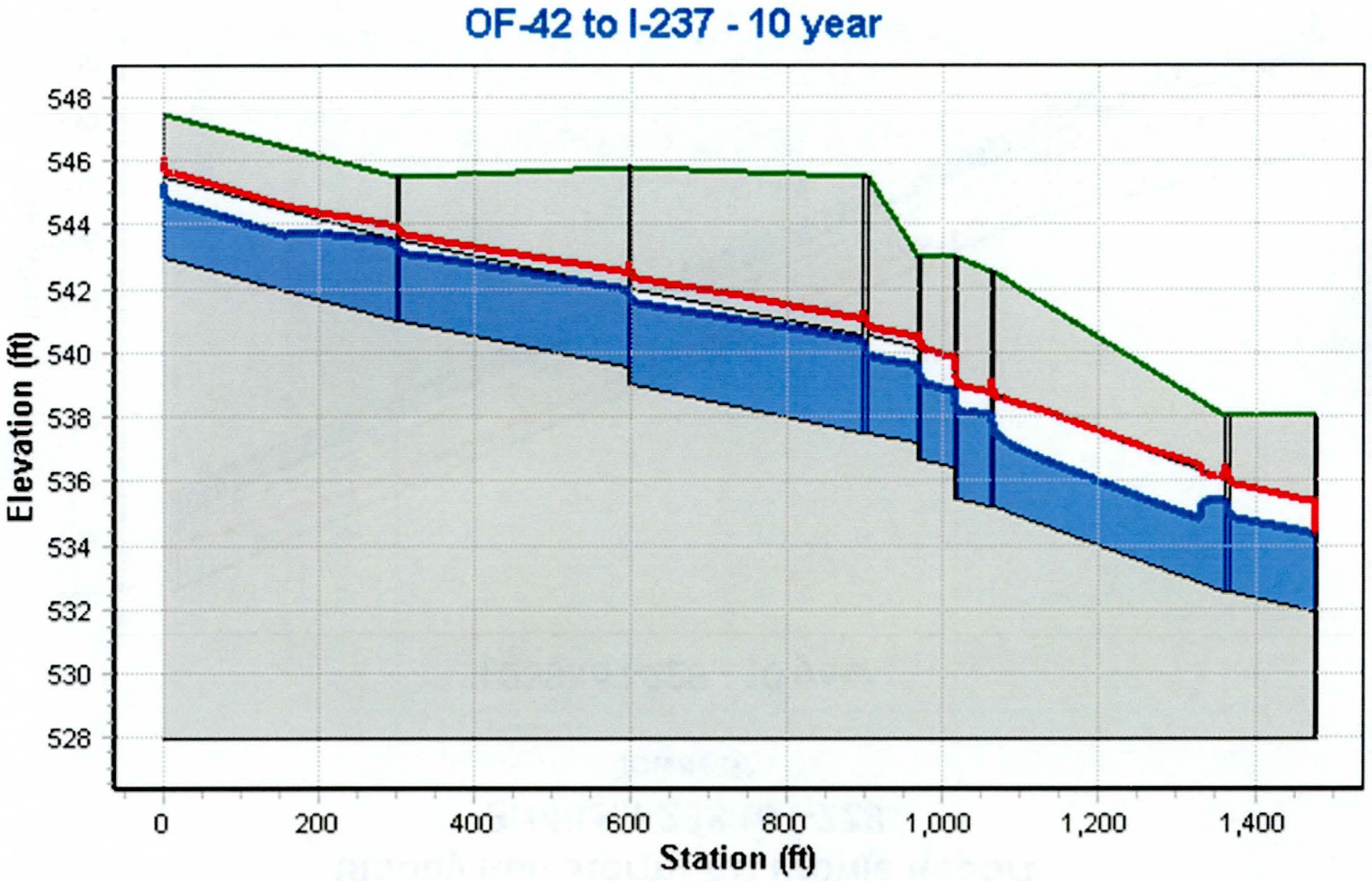
Blood Run Watershed Modeled Alternative StormCAD Profiles

Strand Associates, Inc.
September 2010

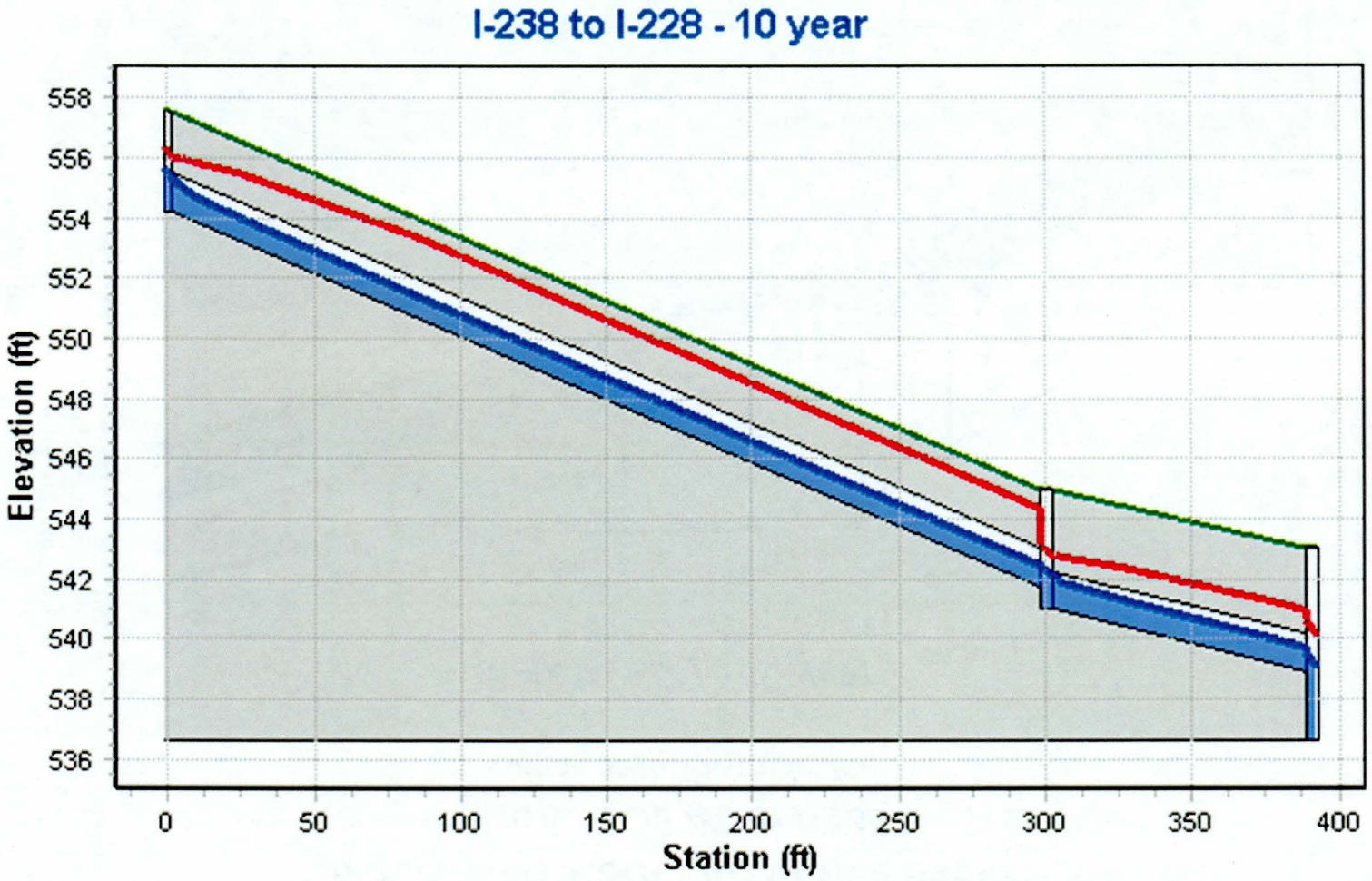
Bloody Run StormCAD Profile Report
Profile: OF-46 to I-229
Mill Creek to Lois Dr



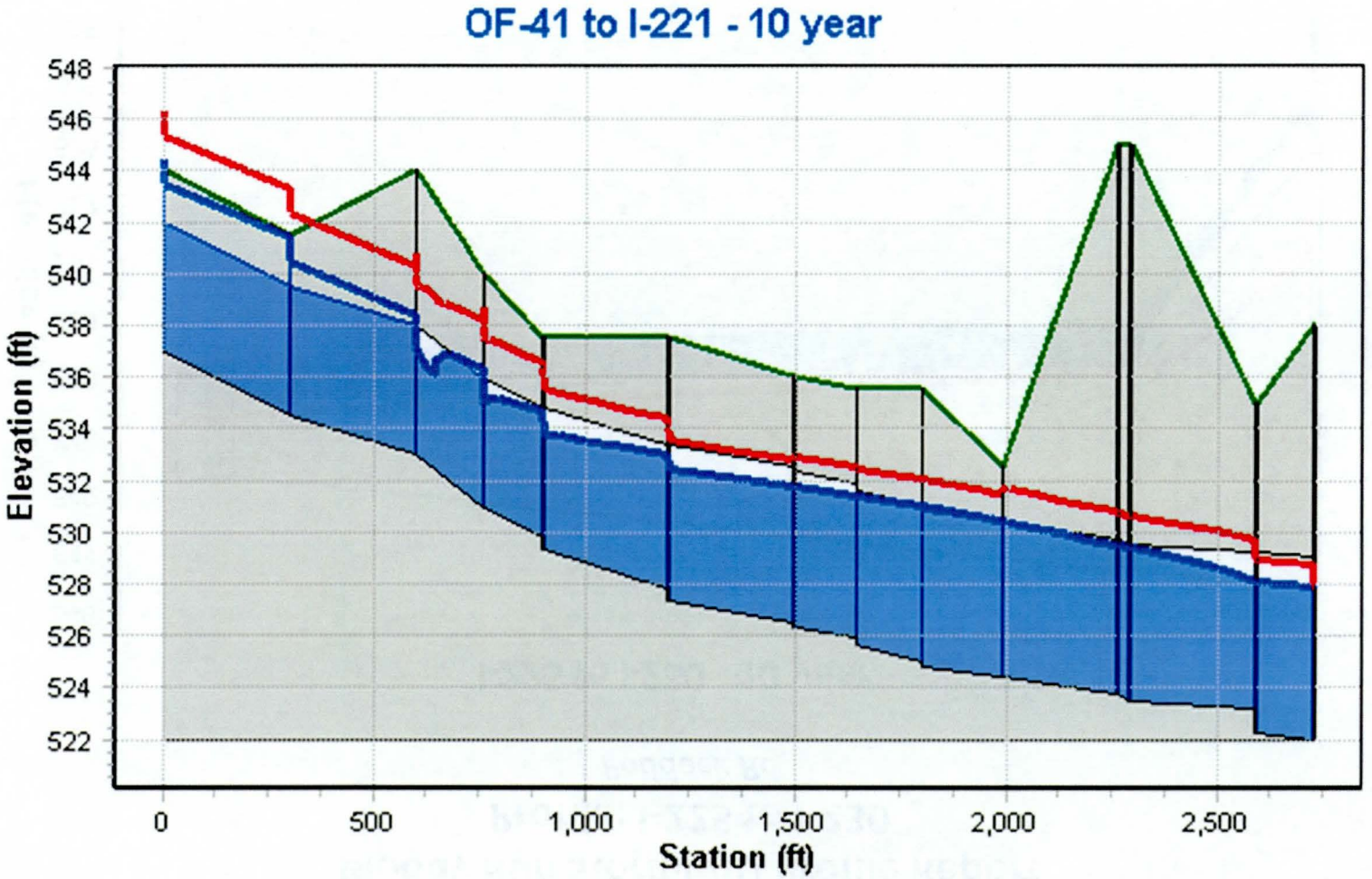
Bloody Run StormCAD Profile Report
Profile: OF-42 to I-237
Towne St to Towanda Ter



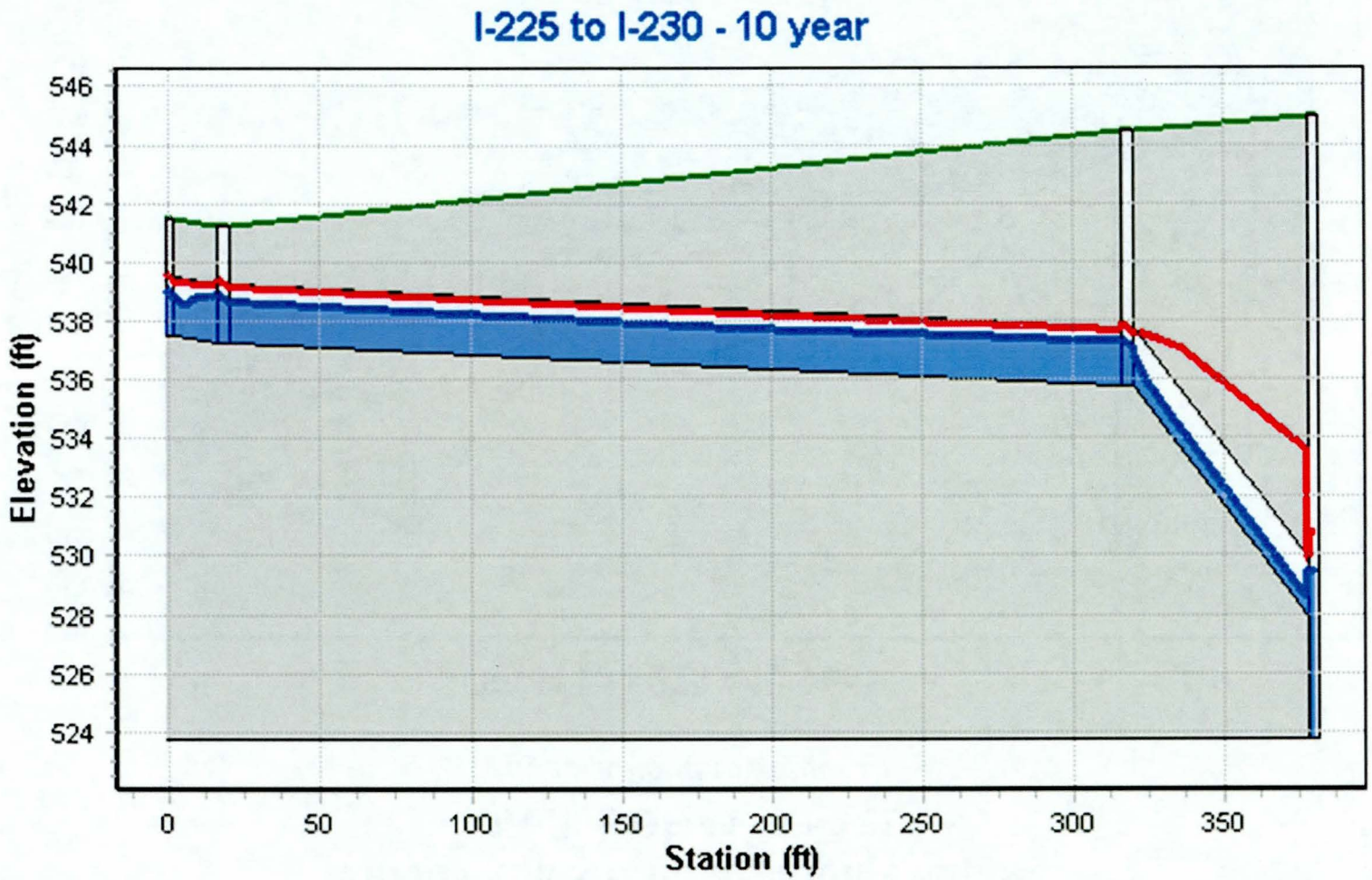
Bloody Run StormCAD Profile Report
Profile: I-238 to I-228
Towne St



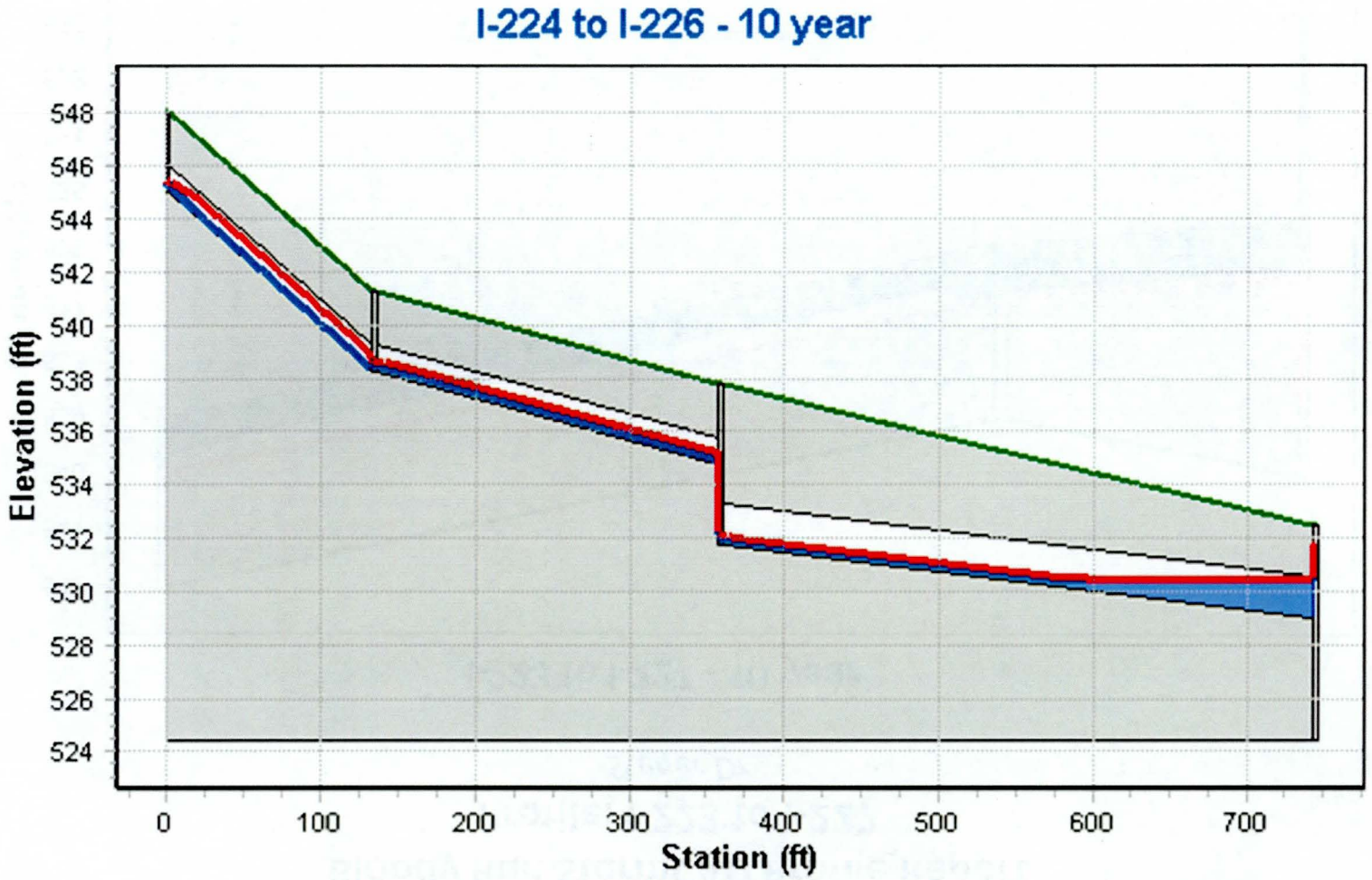
Bloody Run StormCAD Profile Report
Profile: OF-41 to I-221
Paddock Road to Steger Dr



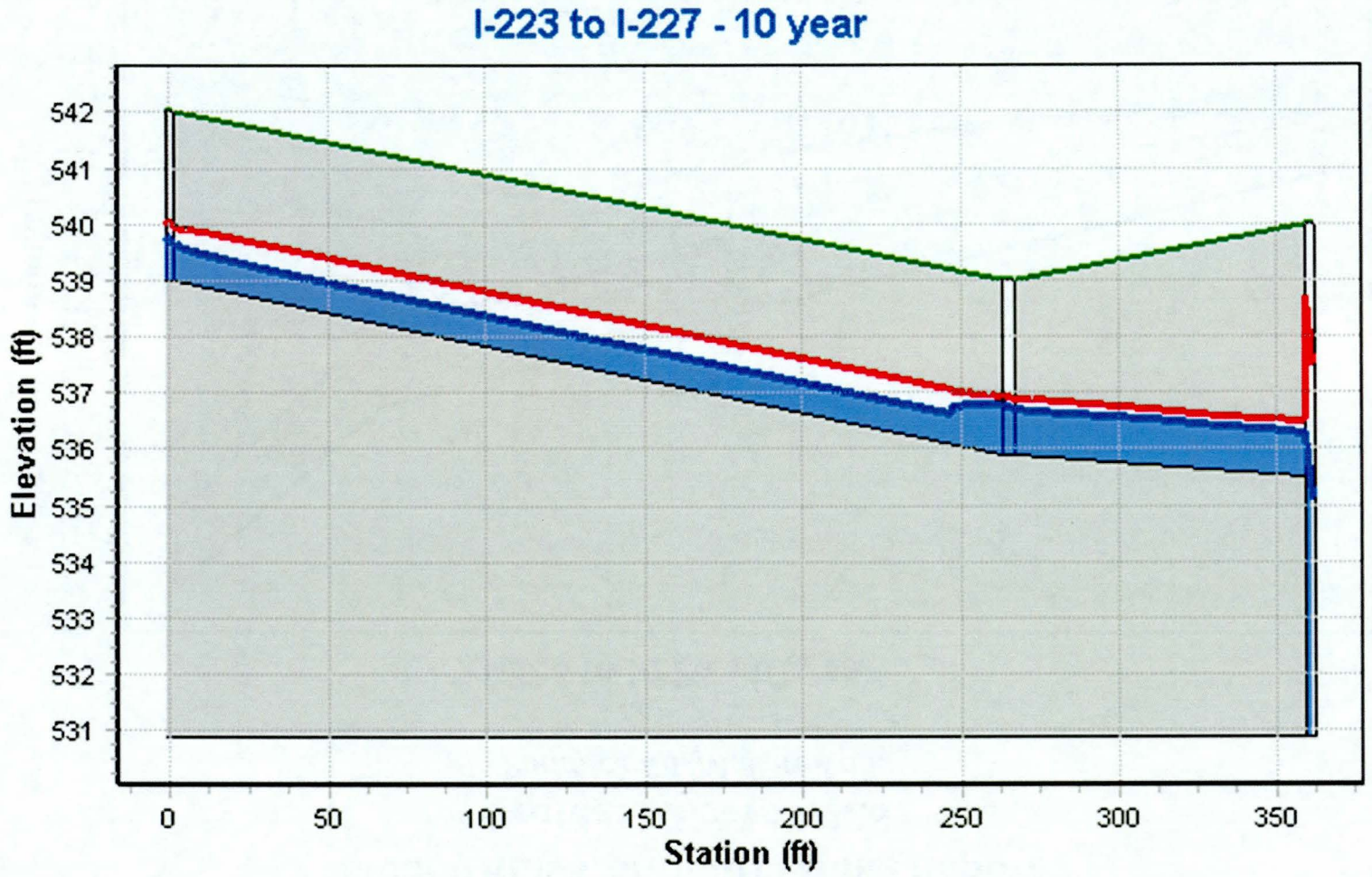
Bloody Run StormCAD Profile Report
Profile: I-225 to I-230
Paddock Rd



Bloody Run StormCAD Profile Report
Profile: I-224 to I-226
Paddock Rd/Maketewah

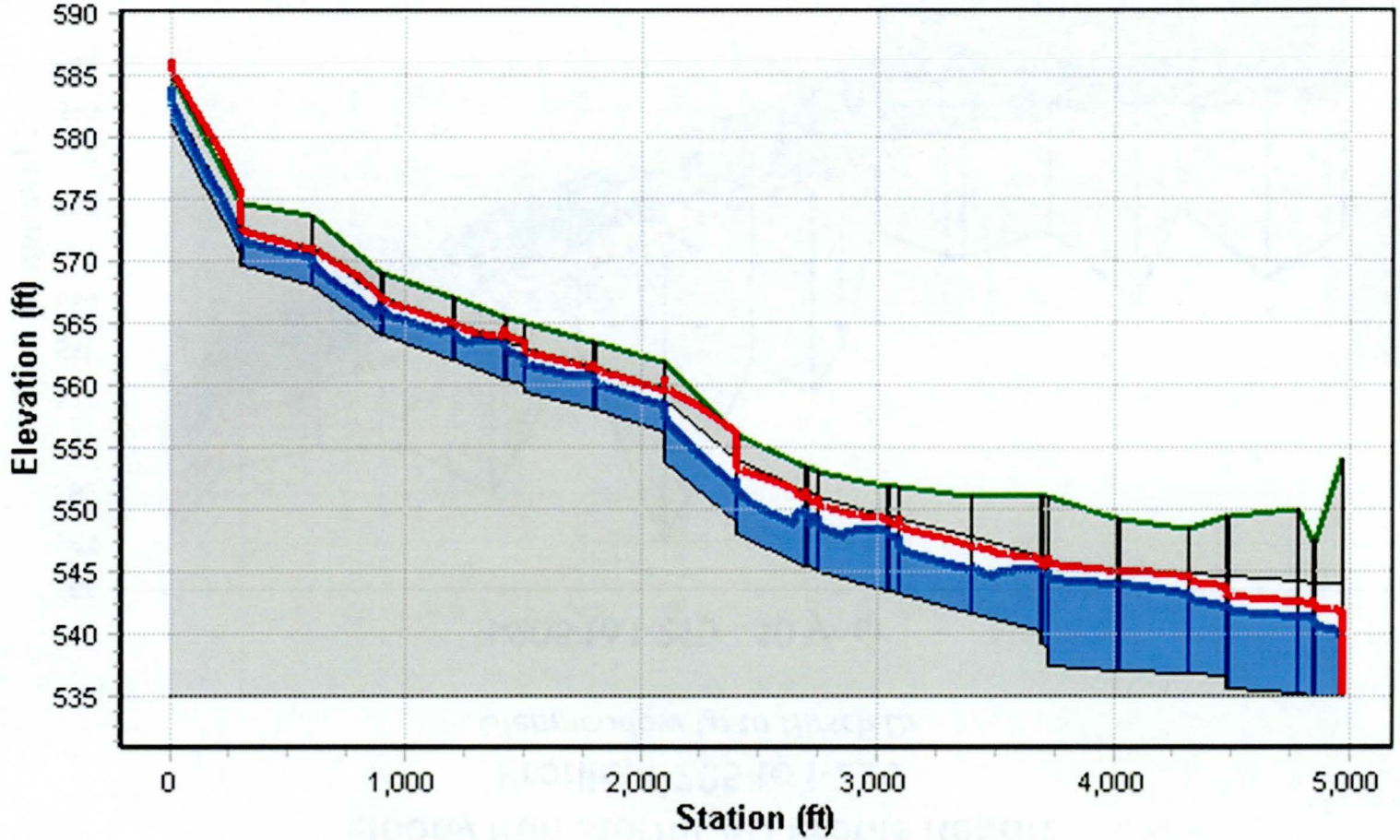


Bloody Run StormCAD Profile Report
Profile: I-223 to I-227
Steger Dr

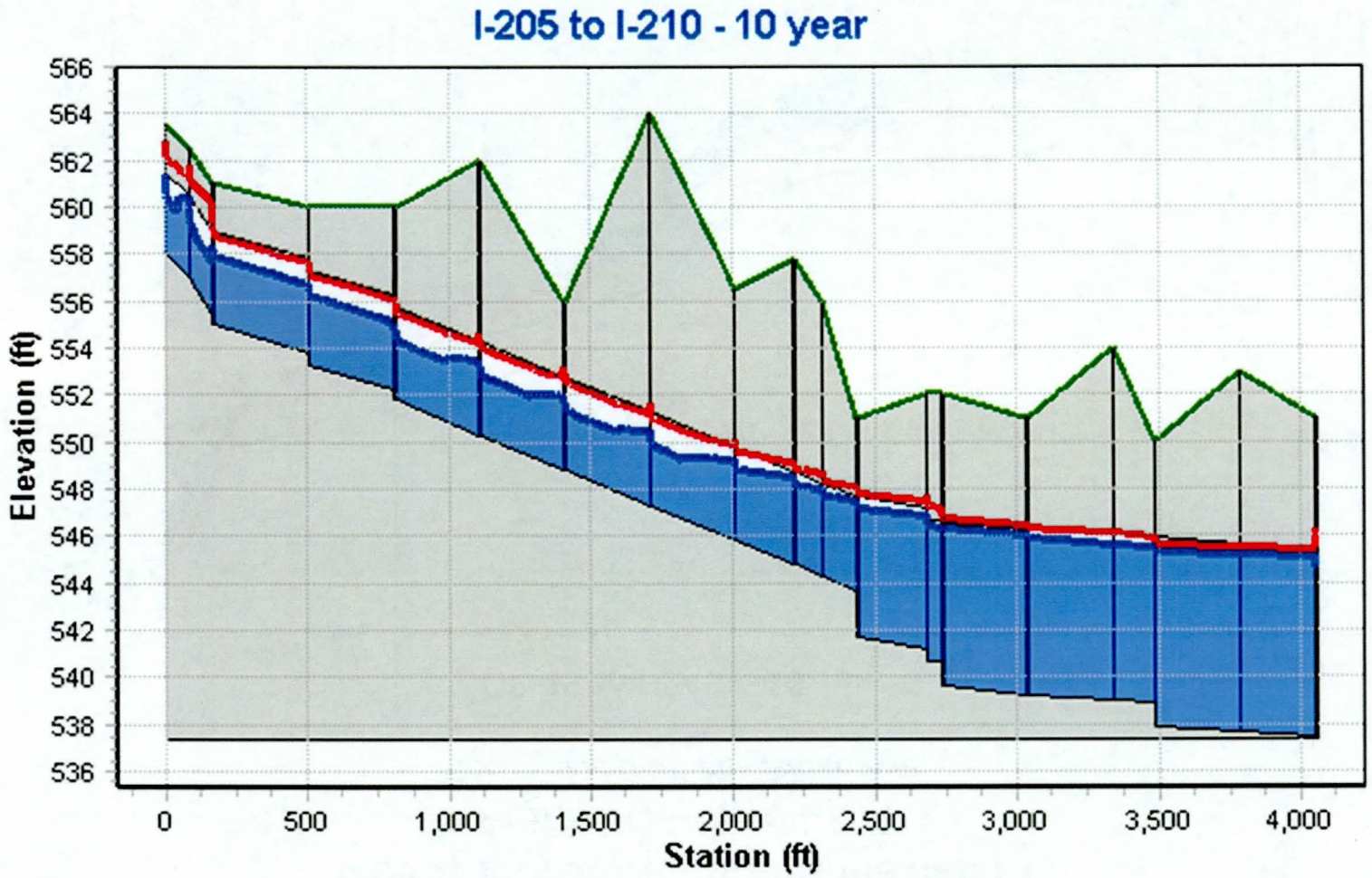


Bloody Run StormCAD Profile Report
Profile: OF-45 to I-204
Tech Solve to Rhode Island Ave

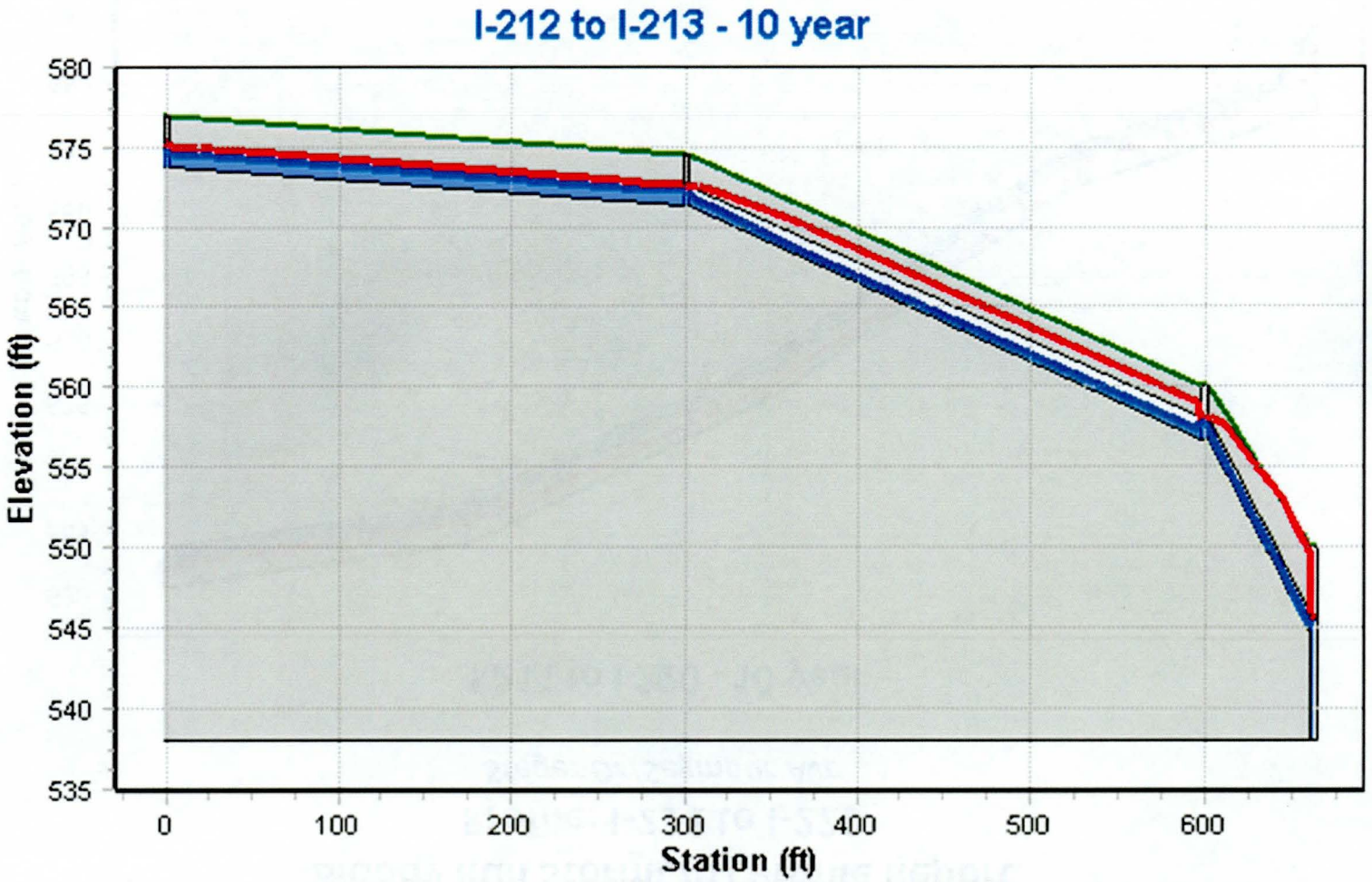
OF-45 to I-240 – 10 Year



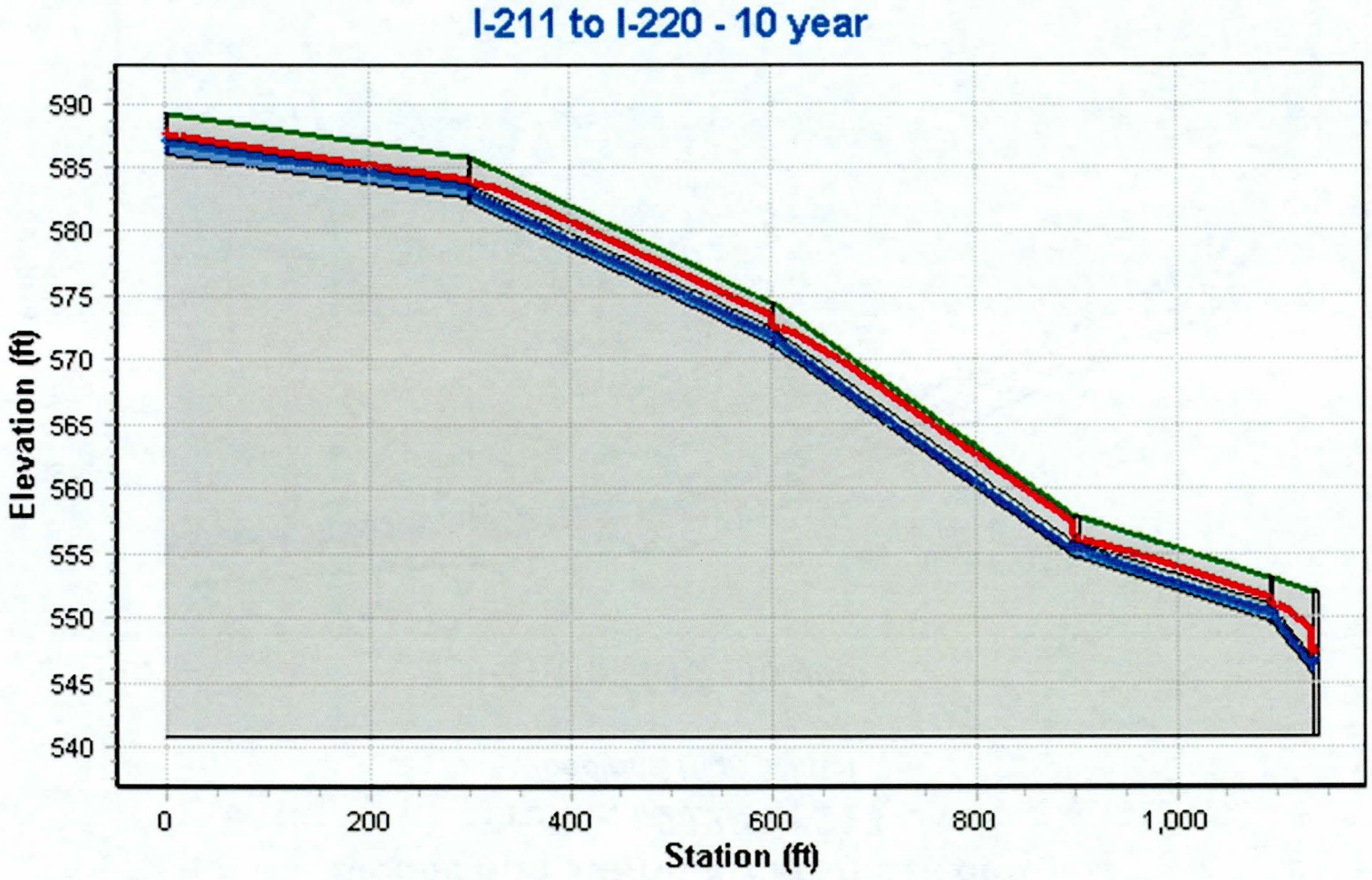
Bloody Run StormCAD Profile Report
Profile: I-205 to I-210
Glenmeadow Ln to Hirsch Dr



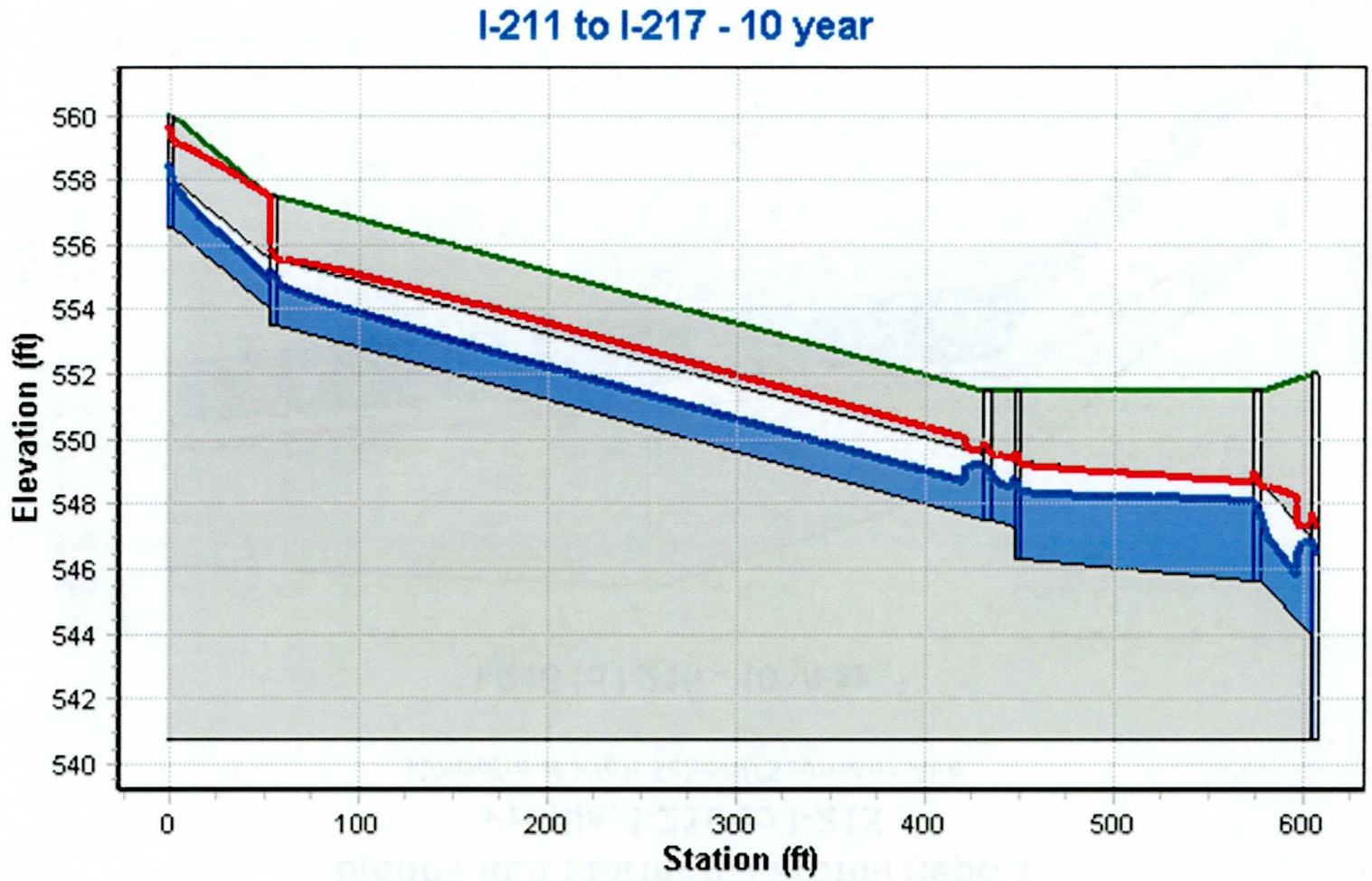
Bloody Run StormCAD Profile Report
Profile: I-212 to I-213
Woodland High School



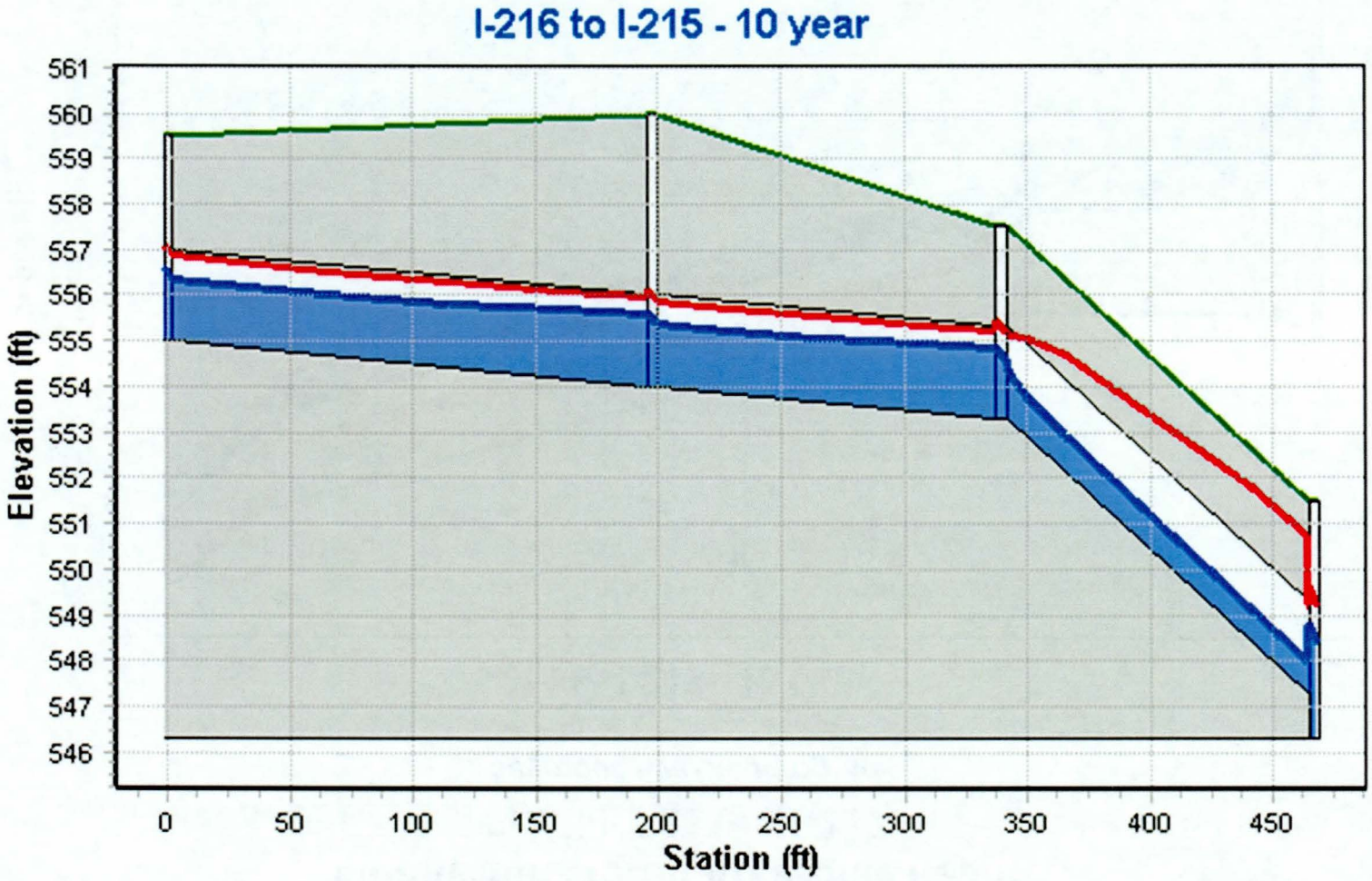
Bloody Run StormCAD Profile Report
Profile: I-211 to I-220
Steger Dr/Seymour Ave



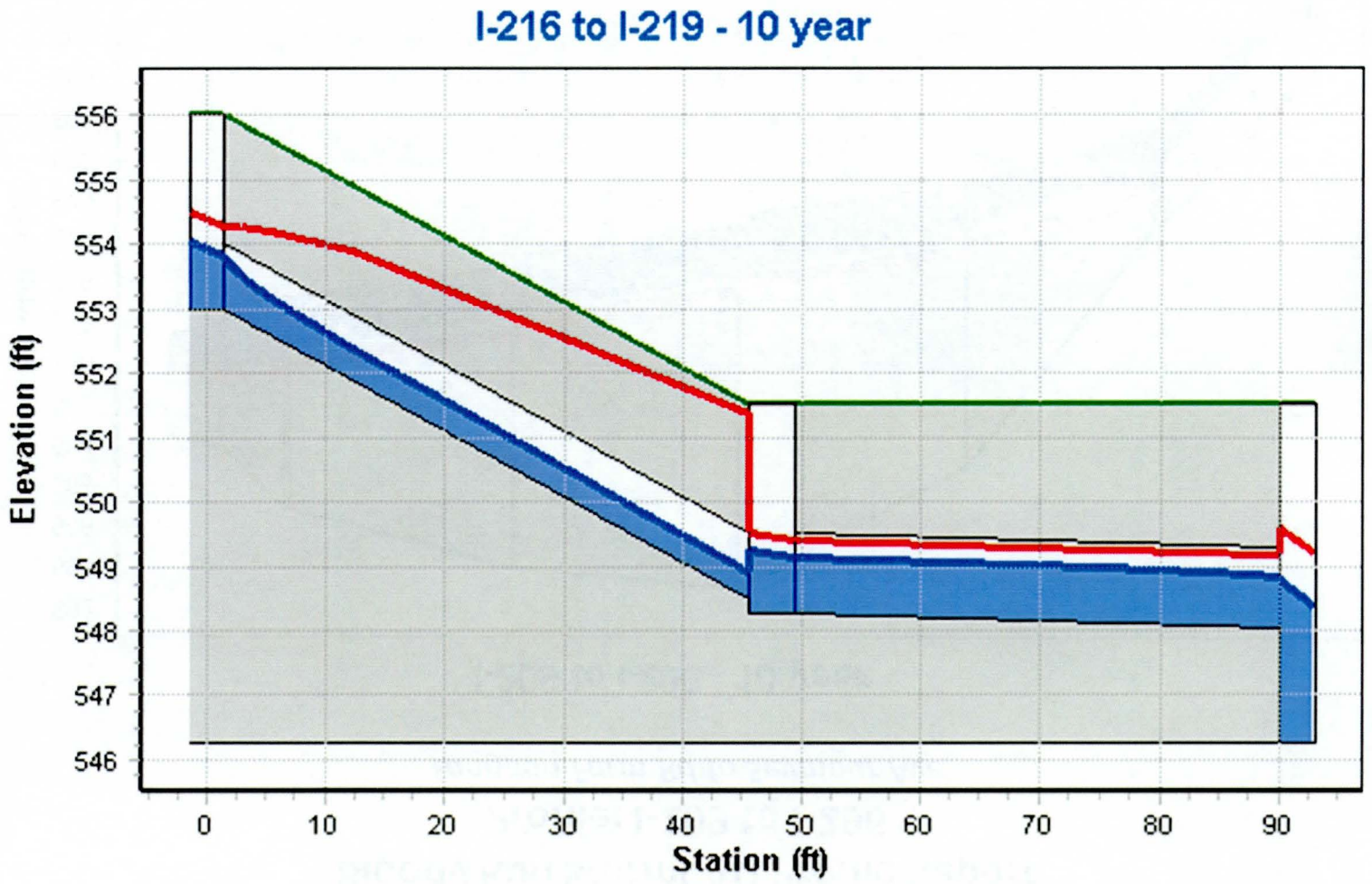
Bloody Run StormCAD Profile Report
Profile: I-211 to I-217
Seymour Ave/Reading Rd



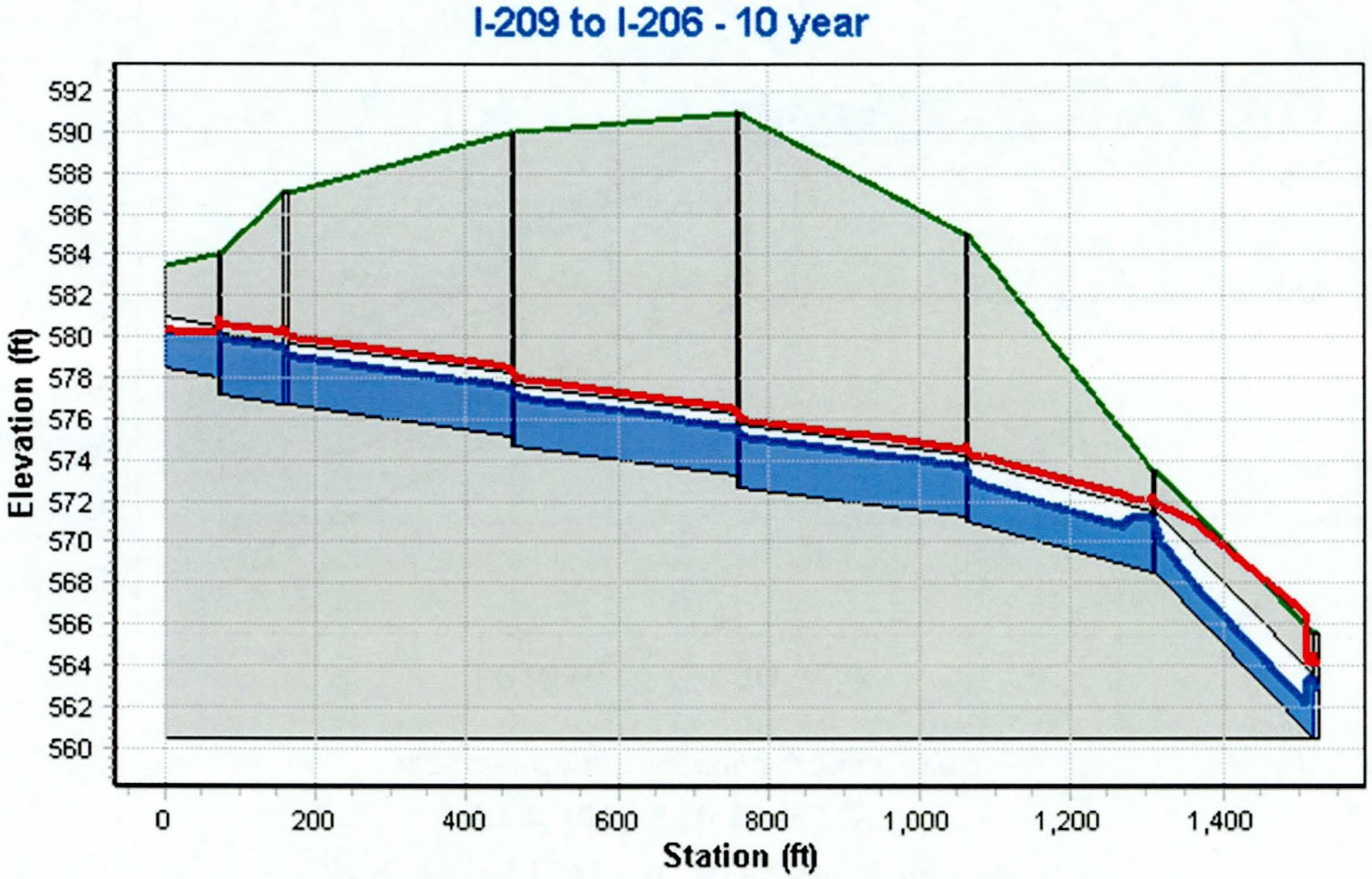
Bloody Run StormCAD Profile Report
Profile: I-216 to I-215
Woodland High School/Seymour Ave



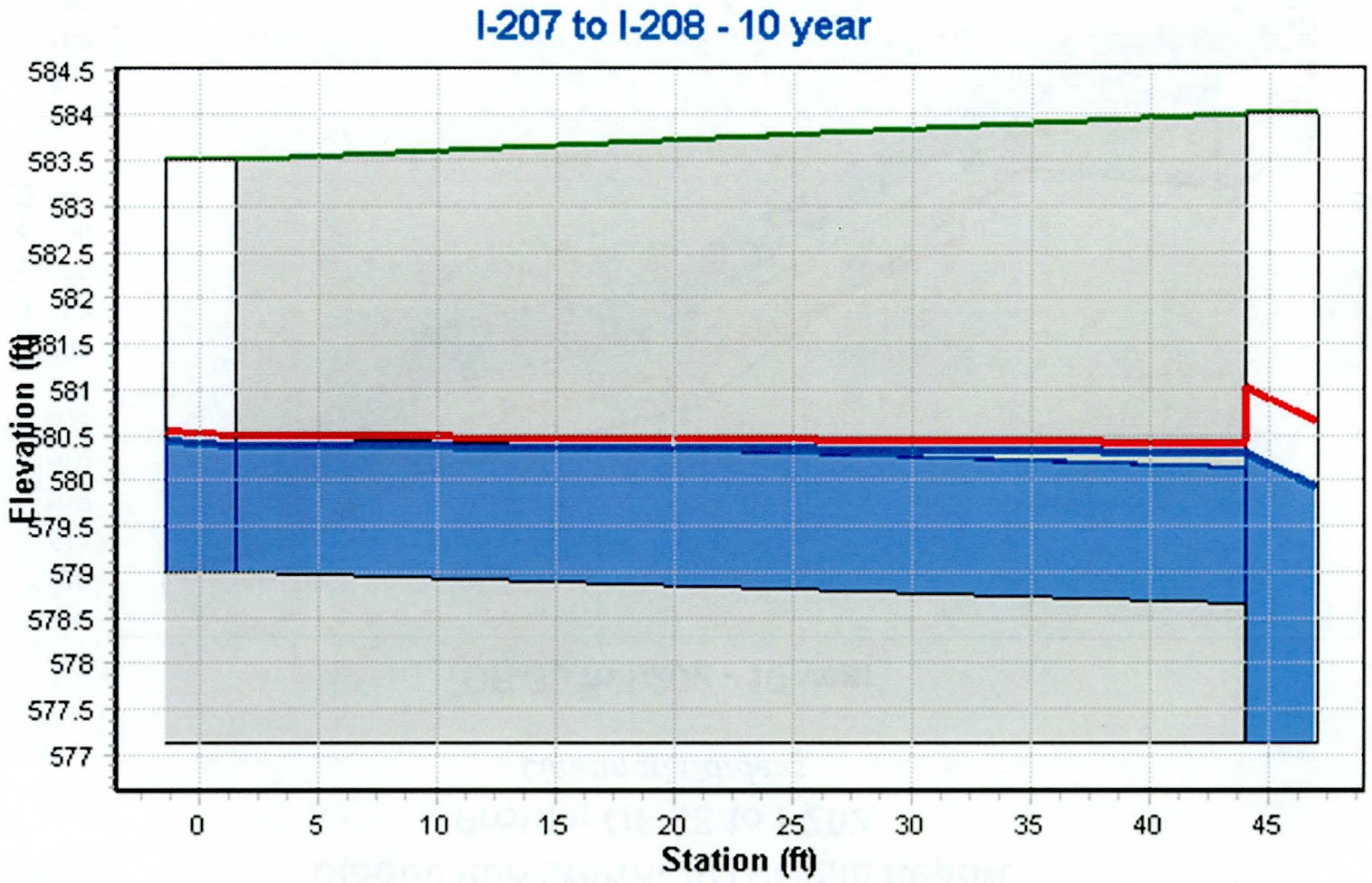
Bloody Run StormCAD Profile Report
Profile: I-216 to I-219
Woodland High School/Seymour Ave



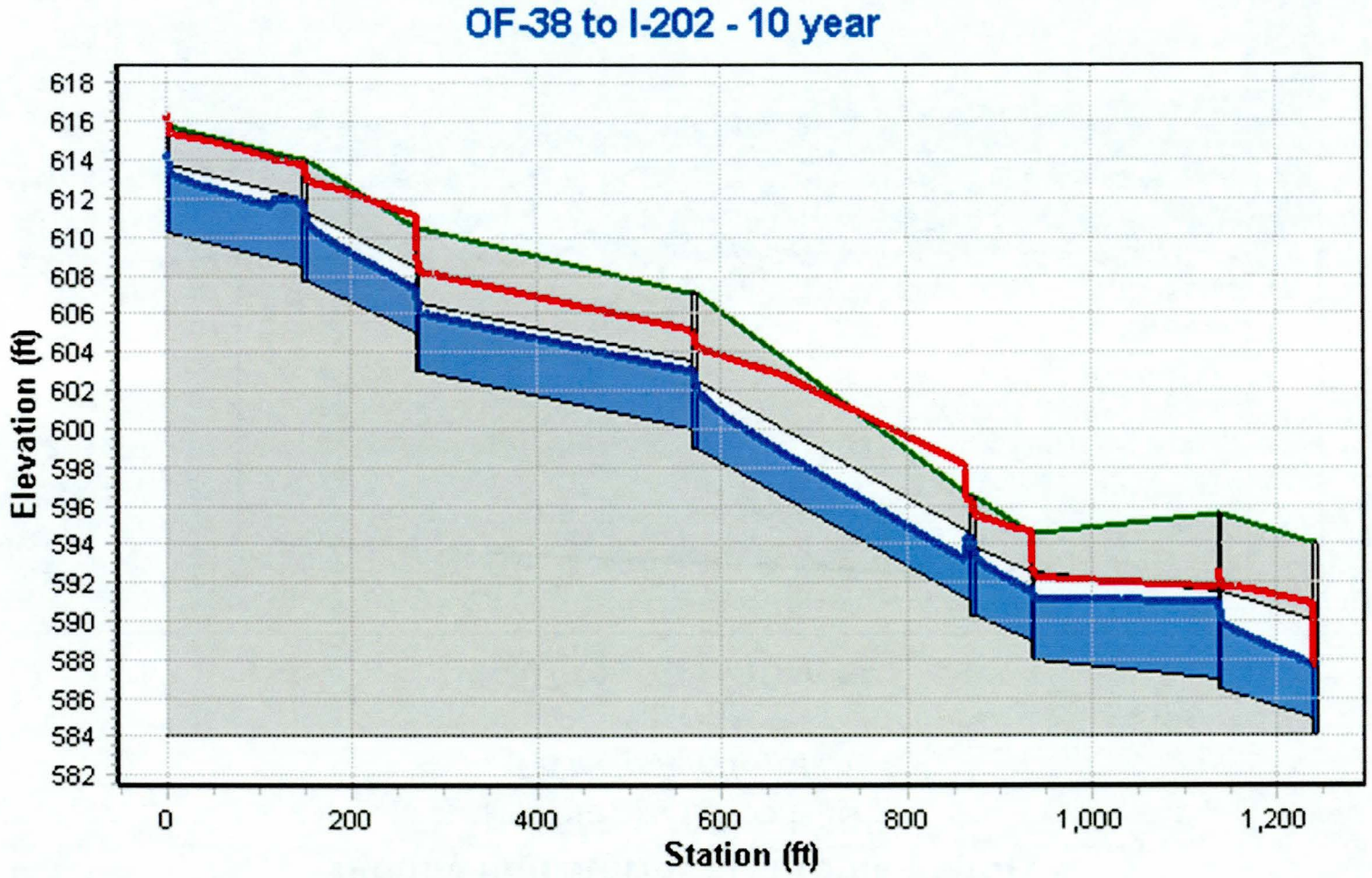
Bloody Run StormCAD Profile Report
Profile: I-209 to I-206
Langdon Farm Rd to Seymour Ave



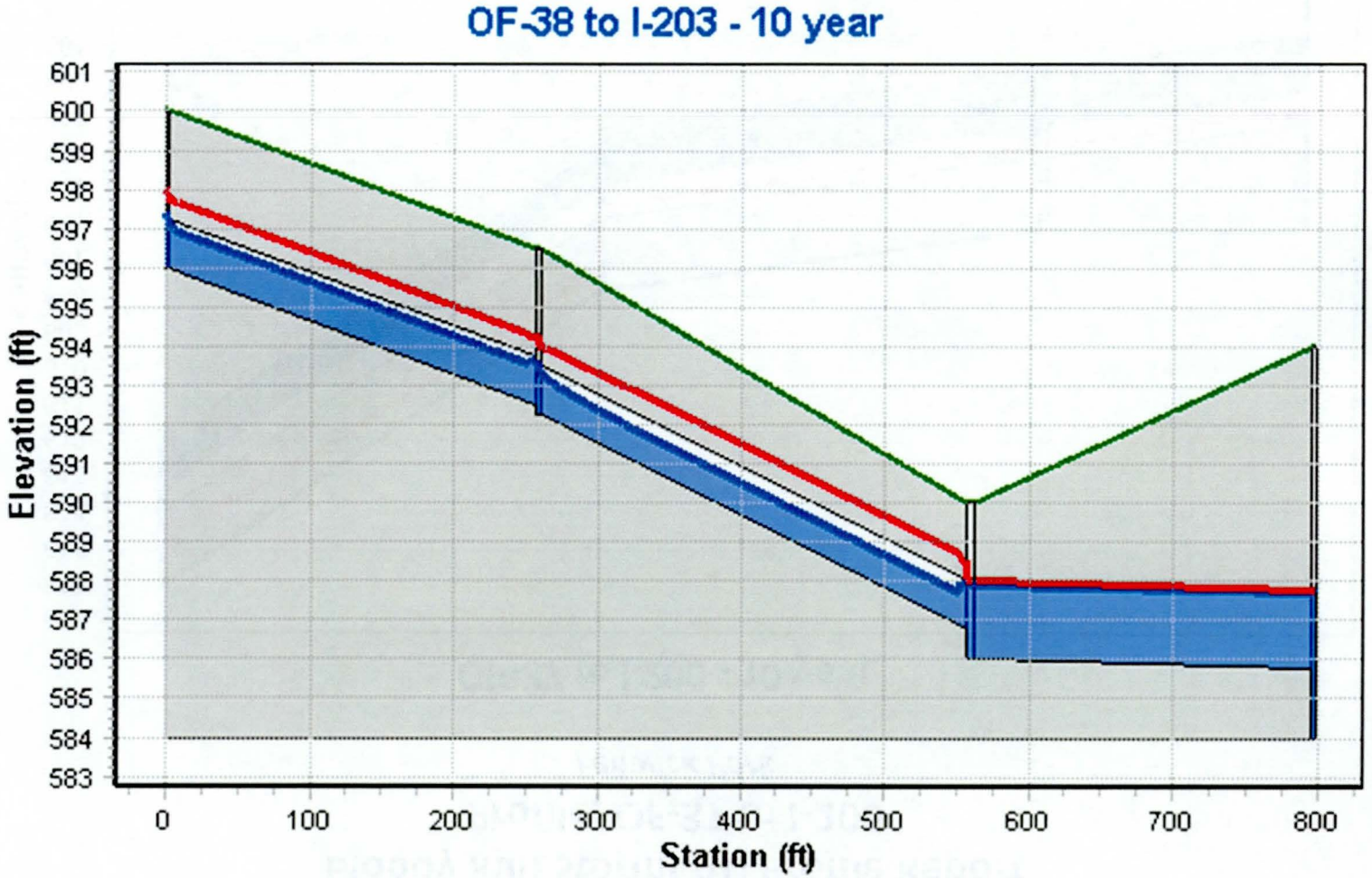
Bloody Run StormCAD Profile Report
Profile: I-207 to I-208
Seymour Ave/Joyce Ln



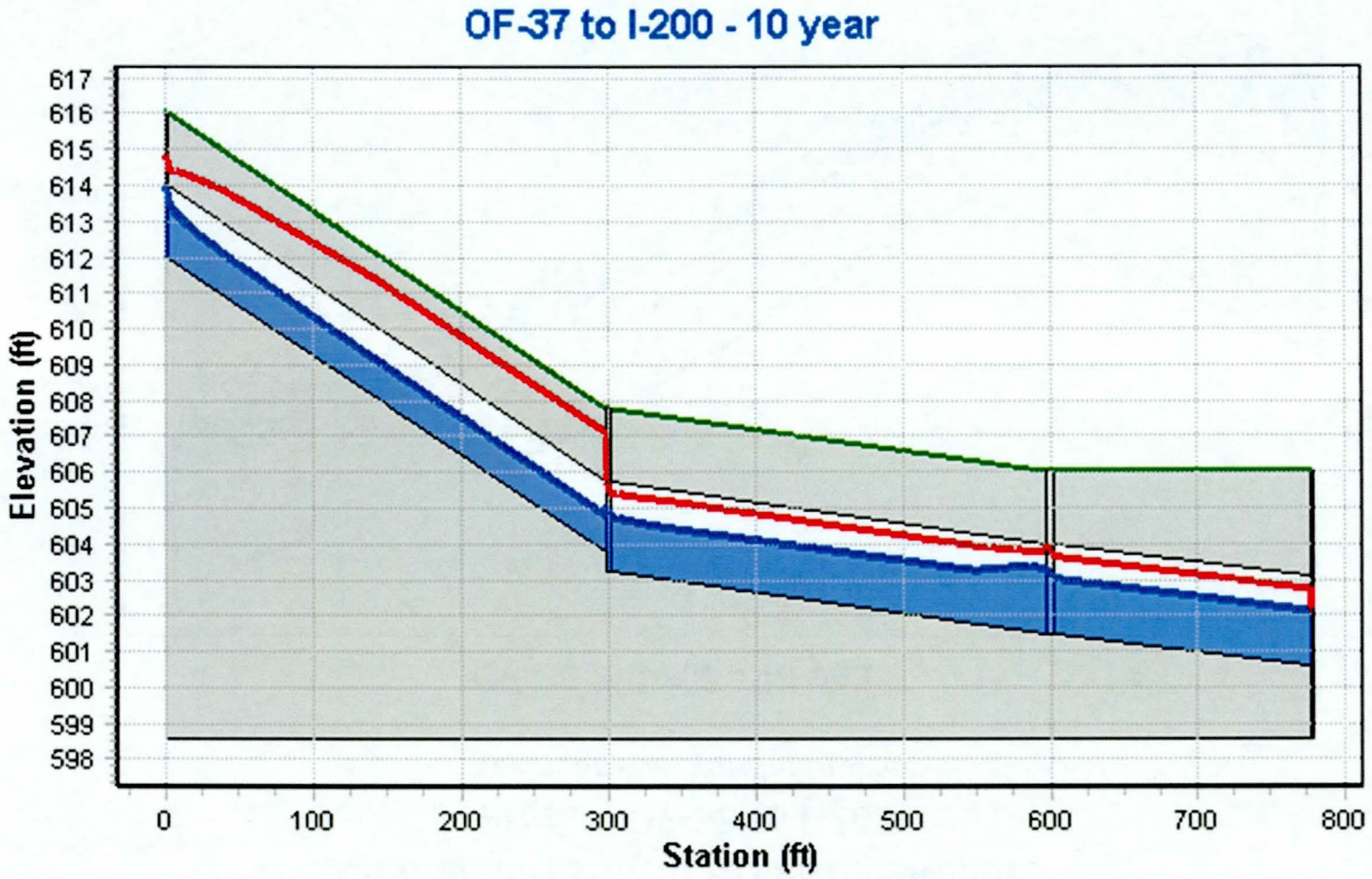
Bloody Run StormCAD Profile Report
Profile: OF-38 to I-202
Cincinnati Gardens



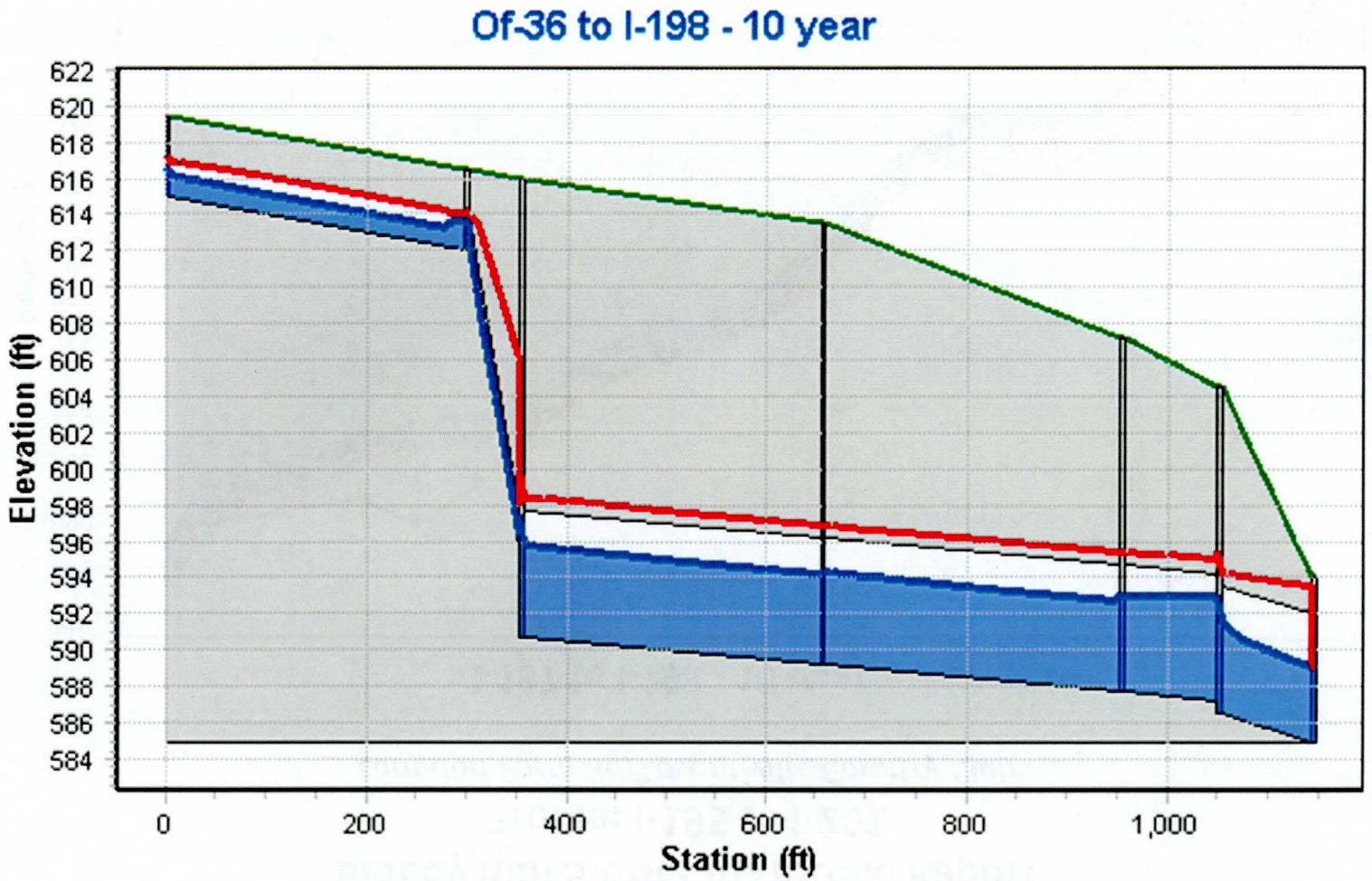
Bloody Run StormCAD Profile Report
Profile: OF-38 to I-203
Seymour Ave/Varelman Ave



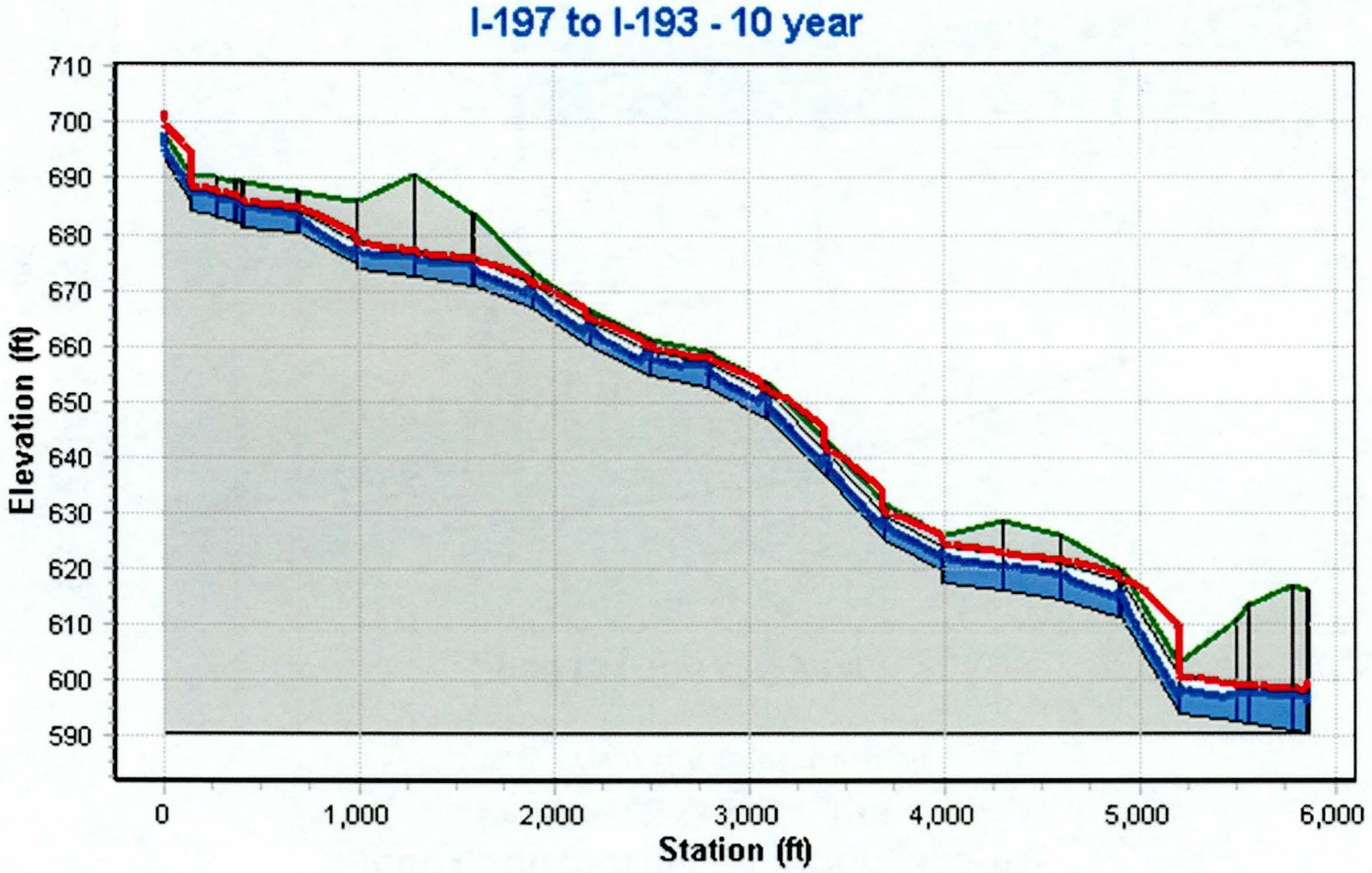
Bloody Run StormCAD Profile Report
Profile: OF-37 to I-200
Fenwick Park



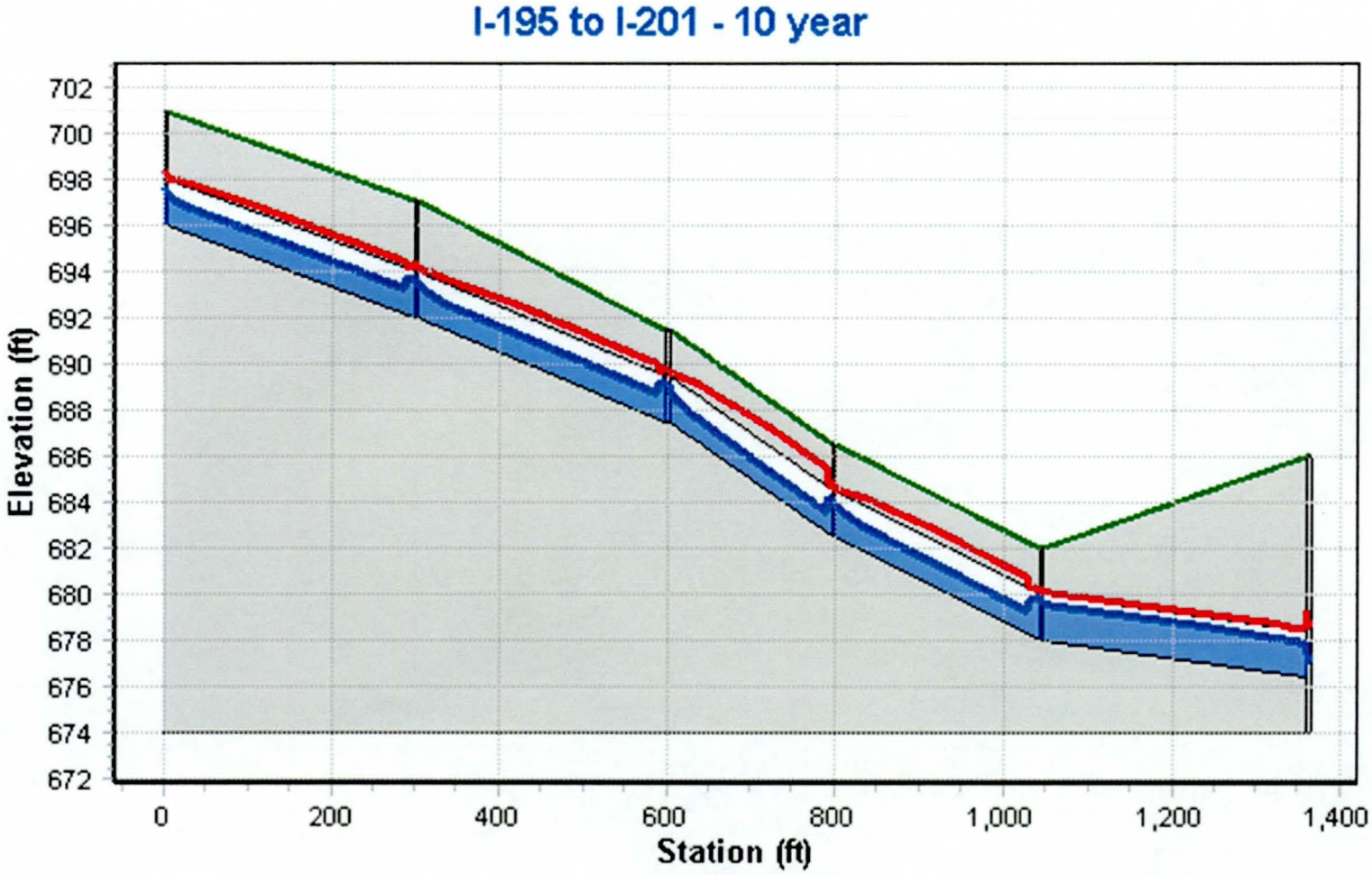
Bloody Run StormCAD Profile Report
Profile: OF-36 to I-198
Seymour Ave/Cincinnati Gardens

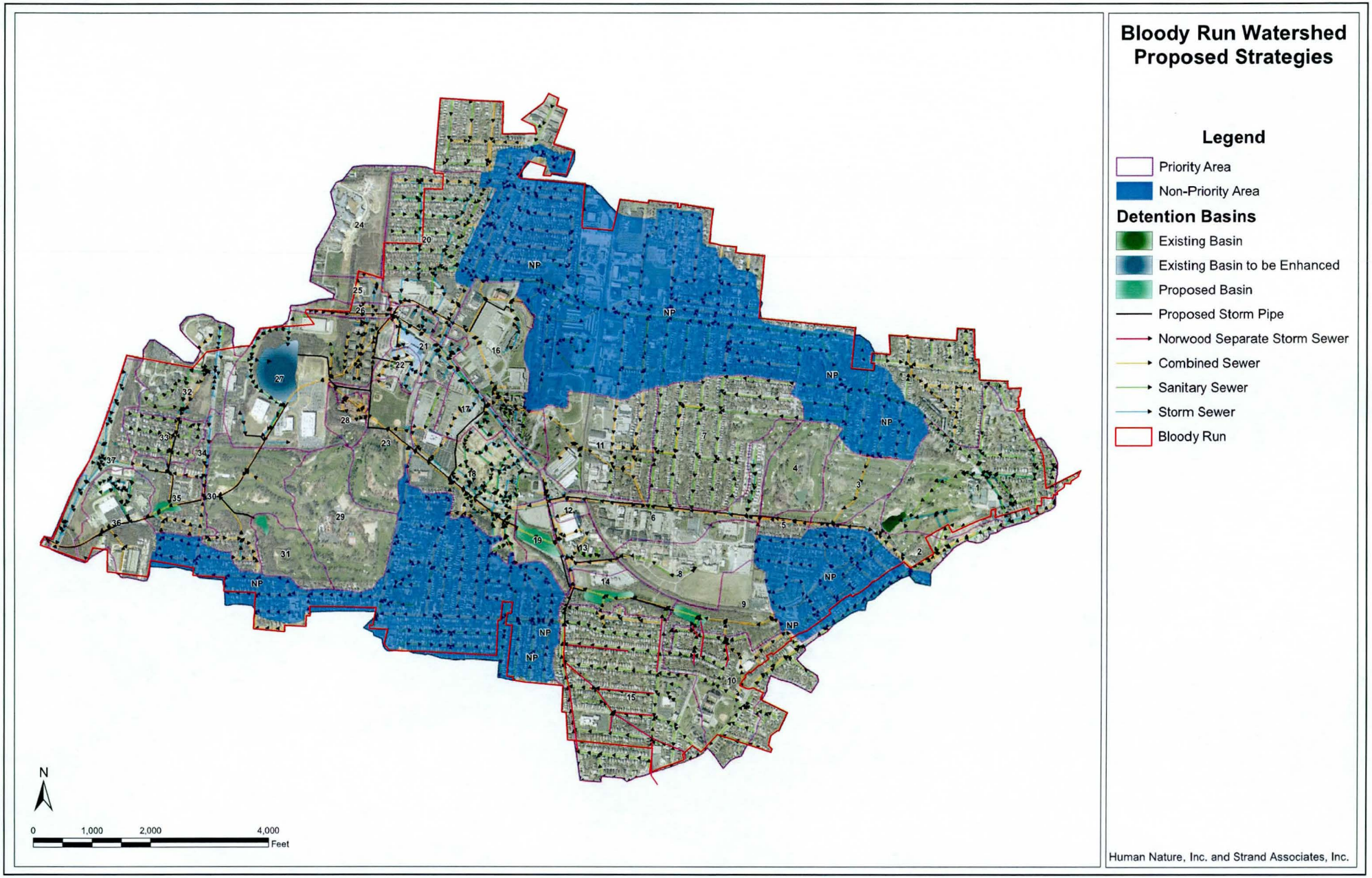


Bloody Run StormCAD Profile Report
Profile: I-195 to I-201
Langdon Farm Rd/Losantiville Country Club



Bloody Run StormCAD Profile Report
Profile: I-195 to I-201
Losantiville Country Club




Bloody Run Watershed
Proposed Strategies
Legend
Priority Area
Non-Priority Area
Detention Basins
Existing Basin
Existing Basin to be Enhanced
Proposed Basin
Proposed Storm Pipe
Norwood Separate Storm Sewer
Combined Sewer
Sanitary Sewer
Storm Sewer
Bloody Run
NP
N
0
1,000
2,000
4,000
Feet
Human Nature, Inc. and Strand Associates, Inc.