Wolf Run
Watershed Based Plan

Lexington, KY

Final, March 1, 2013

THIRD ROCK CONSULTANTS

FAYETTE URBAN COUNTY GOVERNMENT LEXINGTON KENTUCKY 1225

Friends of Wolf Run

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This watershed management plan is being developed under a Section 319(h) Nonpoint Source Implementation Program Cooperative Agreement (#C9994861-09) awarded by the Commonwealth of Kentucky, Energy and Environment Cabinet, Department for Environmental Protection, Division of Water (KDOW) to the Lexington-Fayette Urban County Government (LFUCG) based on an approved work plan. These federal funds were awarded to KDOW from the U.S. Environmental Protection Agency (EPA) under Section 319 of the Clean Water Act. Third Rock Consultants, LLC (Third Rock) was selected as the environmental consultant for this grant under a request for proposal issued by LFUCG. Friends of Wolf Run was also issued grant funding through a memorandum of agreement with LFUCG, primarily to engage, educate, and solicit input from the public in the development of this plan.

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CHAPTER I. INTRODUCTION

A. Watershed Background

To tell the history of the Wolf Run Watershed is to tell the history of Lexington. Lexington was first founded in 1775 by William McConnell at what is now known as McConnell Springs in the Wolf Run Watershed. As Lexington has developed, the land use and water quality of the Wolf Run Watershed have changed. While environmental concerns, including water quality, were not a public priority for most of the watershed history, the last 30 years have seen a marked increase in public concern for the impact of land use changes on the streams and groundwater resources of the Wolf Run Watershed.

To highlight some of these changes, we begin with the passage of sinkhole regulation in 1982 to protect karst drainages. In 1993, McConnell Springs Park was established as a public park and significantly restored largely as a result of this ordinance. In 1991, the University of Kentucky created the Arboretum, partly located within the Wolf Run Watershed, showcasing native plants of all regions of the state. In 1999, a weed ordinance was passed allowing native plants next to streams, swales, and karst areas to grow and remain unmowed. In 2001, Lexington adopted its first stormwater manual and floodplain management plan, and in 2002 adopted a greenway master plan. Each of these has been a step of progress towards improving the relationship between urban development and water quality.

Wolf Run was first listed as impaired for swimming use in the 1998 303(d) list of Kentucky impaired waters. This impaired status has remained since then, with additional impairments identified in subsequent years. The impairment of Wolf Run, in addition to other Lexington streams, led the US Environmental Protection Agency (USEPA) and the Kentucky Environmental and Public Protection Cabinet (KY EPPC) to file a lawsuit (United States 2006) against Lexington over violations of the Clean Water Act in 2006. The lawsuit was due to failure of the city to maintain the sanitary and storm sewer systems, causing raw sewer discharges into streams. On March 14, 2008, Lexington lodged a Consent Decree in order to resolve this lawsuit (United States 2008). Within the Consent Decree, Lexington agreed to make extensive improvements to its sewer systems, address sanitary sewer overflows and associated Municipal Separate Storm Sewer System (MS4) permit violations, as well as to reduce the discharge of pollutants via stormwater. With the Consent Decree in place, Lexington is furthering its efforts to improve water quality in Wolf Run.

The citizens of Lexington, especially those in the Wolf Run Watershed, share this interest in water quality improvement. The Friends of Wolf Run, a community based watershed group, became active in the watershed in 1997, prior to the first impaired listing of Wolf Run, educating the community about stream health and making initial steps towards a cleaner watershed. This group continues to be an outspoken proponent of improving the water quality in Wolf Run. The Friends of Wolf Run sponsors the Wolf Run Watershed Council, consisting of groups and individuals working to improve the watershed.

This watershed plan is being developed in order to provide a comprehensive assessment of the health of the watershed, citizen and stakeholder concerns, watershed remediation strategies, and implementation plans for the future. It is being developed under a Section 319(h) Nonpoint Source Implementation Program Cooperative Agreement (#C9994861-09) awarded by the Commonwealth of Kentucky, Energy and Environment Cabinet, Department for Environmental Protection, Division of Water (KDOW) to the Lexington-Fayette Urban County Government (LFUCG) based on an approved work plan. These federal funds were awarded to KDOW from the USEPA under Section 319 of the Clean Water Act. Third Rock Consultants, LLC (Third Rock) was selected as the environmental consultant for this grant under a request for proposal issued by LFUCG. Friends of Wolf Run was also issued grant funding through a memorandum

of agreement with LFUCG, primarily to engage, educate, and solicit input from the public during the development of this plan.

This watershed based plan presents the collaborative culmination of an extensive data collection and analysis effort, recruitment of partners and stakeholders in watershed interests, and remediation strategy development. The Wolf Run Watershed Council has outlined a comprehensive plan to address the watershed issues. This document is intended to address the nine minimum elements required in the USEPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA 2008). These nine elements are as follows:

1. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed based plan (and to achieve any other watershed goals identified in the watershed based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (*e.g.*, X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded stream bank needing remediation).
2. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (*e.g.,* the total load reduction expected for dairy cattle feedlots; row crops; or eroded stream banks).
3. A description of the nonpoint source management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.
4. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, US Department of Agriculture's (USDA) EQIP and Conservation Reserve Program, and other relevant federal, state, local, and private funds that may be available to assist in implementing this plan.
5. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.
6. A schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.
7. A description of interim, measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed based plan needs to be revised or, if a nonpoint source TMDL has been established, whether the nonpoint source TMDL needs to be revised.
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

B. Partners and Stakeholders

The Wolf Run Watershed Council, formed in December 6, 2010 comprises the team of partners and stakeholders who will work together to support the plan sponsor, LFUCG, and accomplish the remediation activities detailed in this plan. The following organizations took an active role in participation of the the Watershed Council and the development of this watershed plan:

- Kentucky Division of Water
- Lexington-Fayette Urban County Government Division of Water Quality
- Lexington-Fayette Urban County Government Division of Environmental Policy
- Lexington-Fayette Urban County Government Parks and Recreation
- 10th District Urban County Council Member Doug Martin
- 11th District Urban County Council Member Peggy Henson
- Friends of Wolf Run
- University of Kentucky College of Agriculture
- University of Kentucky Water Resource Research Institute
- University of Kentucky Environmental Research and Training Laboratory
- Bluegrass Community and Technical College Environmental Science Technology
- Kentucky Geological Survey
- Kentucky River Basin Coordinator
- Fayette County Public Schools
- Red Mile Racetrack
- Calumet Farm
- Three Chimneys Farm
- Good Foods Market and Café
- Southland Association
- Port Royal Neighborhood Association
- Picadome Neighborhood Association
- Harrods Park Townhomes Association
- Cardinal Valley Neighborhood Association
- Gardenside Neighborhood
- Bluegrass PRIDE
- Kentucky Waterways Alliance
- Bluegrass Raingarden Alliance
- Eastway Wetland Committee
- Preston Springs Group
- Third Rock Consultants
- CDP Engineers
- Cedar Creek Engineering
- EcoGro
- Montgomery Plumbing
- National Environmental Compliance
- Leachman Landscape Design

CHAPTER II. WATERSHED INFORMATION

A. Watershed Location

The Wolf Run Watershed, Hydrologic Unit Code (HUC) number 05100205270-070, is a 10.18 square mile (6514 acre) watershed located entirely within Fayette County, Kentucky. Wolf Run Watershed drains into Town Branch, which flows into North Elkhorn Creek and on to the Kentucky River. Wolf Run and Vaughn's Branch are the two main tributaries in the watershed.

The watershed boundary is shown on Exhibit 1, page II-2. The mouth of the watershed is located just east of Alexandria Drive, between Old Frankfort Pike and the railroad. The western watershed boundary extends to the western terminus of Our Native Lane, continues just west of New Circle Road along Versailles Road and Parkers Mill Road, and crosses inside New Circle Road near Georgian Way. It crosses Harrodsburg Road just north of Alexandria Drive and generally follows Pasadena Drive until its intersection with Nicholasville Road. From Nicholasville Road, the eastern watershed boundary continues to the intersection of Alumni Drive and College Way, including much of the University of Kentucky Arboretum. It continues around to the northern terminus of Sports Center Drive and crosses Harrodsburg Road at Bucoto Court and Versailles Road near Woodford Drive. The watershed boundary continues northwestward, crossing Old Frankfort Pike at Duncan Machinery Road before returning to the watershed mouth.

In addition to the watershed's boundary as delineated by surface topography, karst drainage must also be considered. Due to the abundance of limestone near the surface in the Inner Bluegrass, karst formation is common and frequently provides the conduit for subterranean flow. Since karst flows are not simply dictated by topography like surface water flow, their beginning and ending points are more difficult to predict. However, using methods such as dye tracing, geologists have been able to delineate these groundwater flow routes. Several such flow routes have been mapped in the Wolf Run Watershed. As illustrated by Exhibit 2, page II-3, these inputs are located outside the watershed boundary. Preston's Cave Spring/McConnell Springs groundwater basin has inputs located in the Wolf Run Watershed that have been traced to McConnell Springs, which is located in the adjoining Town Branch Watershed. Groundwater flow from McConnell Springs sinks on the western boundary of this karst window before reentering the Wolf Run Watershed where it flows to Preston's Cave Spring and discharges to Wolf Run Creek. The Wolf Run Watershed also receives surface water inputs from the adjoining South Elkhorn Creek Watershed, located southwest of the watershed boundary, via subsurface flow from local sinkholes to Kenton's Blue Hole Spring.

B. Surface Hydrology

Wolf Run lies within the Inner Bluegrass Ecoregion, which contains undulating terrain with moderate rates of both surface runoff and subsurface drainage. Wolf Run flows for approximately 4.75 miles from its headwaters to its confluence with Town Branch. Including Wolf Run, there are approximately 13.5 miles of perennial streams and tributaries within the Wolf Run Watershed. Excluding the headwaters, Wolf Run is predominately a high gradient perennial stream of mixed substrates flowing through a gently rolling topography with relief varying by less than 100 feet. Much of the upper reach of Wolf Run lies in a concrete channel. Vaughn's Branch is the largest of the tributaries feeding Wolf Run and flows approximately 1.6 miles from its headwaters to the confluence with Wolf Run (just north of Cambridge Street). Other tributaries include the Cardinal Run tributary, Gardenside Tributary, McConnell Branch (which flows out of Preston's Spring), and other unnamed tributaries. Big Elm Tributary is a tributary to Vaughn's Branch. Wolf Run is prone to flashy storm flows as rainfall in the stream's urban setting quickly flows off the impervious surfaces (streets, roofs, etc.) and into the stream.

Exhibit 1
Wolf Run Watershed
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

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Exhibit 2
Karst System
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

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A United States Geological Survey gaging station was established on Wolf Run near Old Frankfort Pike in September 1997. Basic statistics on the discharge at this station are provided in Figure 1. These statistics indicate that Wolf Run discharges approximately 0.1 to one cubic foot per second (cfs) under low flows, one to four cfs in dry conditions, four to 10 cfs in mid-range conditions, 10 to 30 cfs under moist conditions, and 30 to 893 cfs in high flows.

FIGURE 1 – WOLF RUN AT OLD FRANKFORT PIKE, MEAN FLOW STATISTICS

C. Climate and Precipitation

Table 1, page II-5, shows the monthly climatological normals for temperature and precipitation based on records from 1981 to 2011 compiled by the National Weather Service (NWS 2011). The temperature in this area ranges from an average monthly minimum of 24.9°F in January to an average monthly maximum of 86.1°F in July. The average total precipitation is 45.17 inches annually with 13.0 inches of snowfall on average.

D. Groundwater-Surface Water Interaction

When limestone bedrock is near the surface, surface water and precipitation often pass through the soil into the limestone, where it is called groundwater. Over time, horizontal and vertical cracks in the rock can become enlarged by the acids in the water to form a landscape characterized by sinkholes, springs, and caves, called karst topography. The groundwater flow pattern in a karst area is not related to the surface drainage flow pattern above it, and the two may in fact flow in different directions.

The Wolf Run Watershed has well developed karst features throughout the watershed area. As shown in Exhibit 2, page II-3, numerous springs and several large karst groundwater basins are located within the watershed.

The Preston's (McConnell) karst basin collects water from throughout the southeastern third of the watershed extending beyond the surface watershed boundary to the southeast and northeast. Known surface water inputs (sinks) into this karst groundwater basin occur at the Lafayette High School sink in the south, the Campbell House sink near Mason Headley Road, and two swallets (open entry points into the

system) near Red Mile. Water from these sinks emerge at McConnell Springs Park. McConnell Springs is a unique geological feature with two successive artesian springs, the Blue Hole and the Boils. Downstream of the Boils, the water enters into another sink before emerging at Preston's Spring and flows downstream to the main stem of Wolf Run.

TABLE 1 – MONTHLY CLIMATOLOGICAL NORMALS 1981 - 2010

Month	Max Temp (°F)	Min Temp (°F)	Avg Temp (°F)	Precip (in)	Snow (in)
January	40.9	24.9	32.9	3.20	3.9
February	45.6	28.1	36.9	3.20	4.6
March	55.4	35.7	45.5	4.07	1.4
April	65.8	44.7	55.3	3.60	0.3
May	74.4	53.9	64.2	5.26	0
June	82.9	62.5	72.7	4.44	0
July	86.1	66.3	76.2	4.65	0
August	85.6	65.0	75.3	3.25	0
September	78.8	57.5	68.1	2.91	0
October	67.5	46.6	57.0	3.13	0
November	55.4	37.3	46.3	3.53	0.3
December	43.9	28.0	36.0	3.93	2.5
Annual	65.3	46.0	55.6	45.17	13.0

National Weather Service, 2011

The Kenton karst groundwater basin also has some marginal influence on the southwestern border of the watershed. The Kenton Blue Hole and Wilhite James springs occur in this area as well as a large sinkhole and an unnamed spring.

In addition to these springs that drain these large karst basins, numerous unnamed springs as well as the Gardenside Spring and Kay Spring are located throughout the watershed area. Some of these springs have perennial flow while others are seasonal. The abundance of springs in the watershed may sustain surface flows during dry conditions. The Wolf Run Trail of Springs was developed through collaboration of the Friends of Wolf Run, Bluegrass Community and Technical College, Kentucky Geological Survey, Kentucky American Water, KDOW, and LFUCG. The Trail of Springs registers known spring locations in the watershed for self-guided exploration. Poster-sized maps have been developed through the project and are available at the McConnell Springs Nature Center or at http://wolfrunwater.org/springs/WolfRunSprings-Map.pdf

In order to evaluate the sensitivity of groundwater resources to water pollution, KDOW developed a hydrologic sensitivity index to quantify the regions of Kentucky (Ray *et al.* 1994). Based on groundwater recharge, flow, and dispersion rates, the index ranges from 1 (low) to 5 (high). With the large amount of karst in the Wolf Run Watershed, the hydrologic sensitivity index is high (5), indicating that the area is highly susceptible to groundwater pollution.

E. Flooding

Floodplains are lands adjacent to streams that flood during intense wet weather events. The ability of a stream to access the floodplain is a critical component of a stream's health. When streams have access to natural floodplains, the number and severity of floods is reduced, nonpoint source pollutants are reduced, water slows down and sediments settle out over the large floodplain area, and groundwater can be recharged. A stream that cannot access its floodplain (*e.g.,* by channelization, channel incision, or construction of a flood wall) will carry more energy, causing bank erosion and channel downcutting. It will also carry a higher pollutant load downstream during storm events and may have reduced baseflow.

Much of the 100-year floodplain along Wolf Run and Vaughn's Branch has been greatly encroached upon by urban development (Exhibit 3, page II-7). LFUCG recently purchased and demolished numerous flood prone homes along Wolf Run (along Roanoke Road and Furlong Drive) in an effort to reclaim a portion of this floodplain. Additionally, LFUCG purchased four properties on Lane Allen Road to prevent development of an area known to have a flooding problem. LFUCG property ownership related to water quality projects is shown in Exhibit 3. These properties are categorized by the reason they came into government ownership and their current purpose.

In addition to floodplain accessibility, the frequency and magnitude of flooding is affected by the percent of impervious surface in a watershed. Under natural conditions, most rainwater is absorbed into the soil or evapotranspired by trees. With increased impervious surfaces such as rooftops or pavement, water cannot infiltrate into the soil and therefore quickly flows into the stream. This can lead to frequent and/or severe flooding events of higher magnitudes.

F. Geology

The Wolf Run Watershed lies in the Lexington West geologic quadrangle (Miller 1967). As shown on Exhibit 4, page II-8, Ordovician Lexington Limestone underlies the watershed in addition to Quaternary Alluvium, which is deposited along the stream channels. Along the watershed boundaries and in the upland areas of the watershed is the Tanglewood Limestone Member which overlays the Brannon Limestone Member. The most dominant layer within the watershed is the Grier Limestone Member.

According to the Lexington West geologic quadrangle, the alluvium formation is clay, silt, and gravel, which locally contains abundant chert and dense argillaceous limestone fragments. Generally, the alluvium is 10 feet thick along larger streams but less than five feet thick along smaller tributaries.

The Tanglewood Limestone Member is described as fine- to medium-grained, crossbedded, and slightly phosphatic with thin shale partings. It is bioclastic. Sometimes the bed is higher than the Brannon Limestone Member; sometimes it is lower.

The Brannon Limestone Member is described as limestone and shale. The limestone is microgranular and argillaceous in part with thin beds of shale locally interbedding with clastic limestone. In thicker areas, such as near the intersection of New Circle Road and Old Frankfort Pike, convolute bedding and flow rolls are common. Chert occurs in thin beds and nodules. Thin beds of swelling bentonite occur near the base of the layer. Springs occur at the top of this layer, but are more common near contact with underlying bioclastic and granular phosphatic limestones.

Grier Limestone Member is described as rubbly and consists of irregular medium and coarse-grained limestone nodules in argillaceous limestone. Shale partings separate some beds.

Exhibit 3
Floodplain
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

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Exhibit 4
Geology
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_4_Geology.mxd) 10/13/2010 -- 10:14:34 AM las

Vulcan Materials currently operates a limestone quarry just outside the watershed area, northeast of McConnell Springs. The operation mines the Tyrone, Oregon, and Camp Nelson geologic formations for limestone to be used in cement, concrete, crushed stone, fertilizer, and acid water treatment, among other applications. Bentonite layers largely separate the groundwater from these lower limestone formations.

G. Ecoregion and Topography

The Wolf Run Watershed is located in the Inner Bluegrass (71l) Level 4 Ecoregion (Woods *et al.* 2002). This region is described as "a weakly dissected agricultural plain containing extensive karst, intermittent streams, and expanding urban-suburban areas that originally developed near major springs." The area is noted for its soil fertility. The land use description of the Inner Bluegrass describes several land use driven pollutant sources typical of the area:

> "Agriculture contributes sediment, nutrients, pesticides, and pathogens to surface water; algal blooms and low concentrations of dissolved oxygen occur especially where the riparian tree canopy has been removed. Wastewater discharge and runoff downstream of urban areas release trace metals into some streams. Package waste treatment plants for small residential subdivisions often discharge into dry valleys, produce effluent-dominated streams, and have a high failure rate." (Woods *et al.* 2002)

The natural vegetation of upland areas is described as oak-hickory forest with dominants of white oak, shumard oak, walnut, chinquapin oak, bur oak, shellbark hickory, and Kentucky coffeetree. Dominant vegetation surrounding sinkholes is described as sycamore, black locust, hackberry, and mulberry while abandoned agricultural land often has broomsedge and sumac dominants. The land uses for the ecoregion are described as follows: "pastureland, cropland, urban-suburban development, ... thoroughbred horse, cattle, burley tobacco, corn, and hay farming. Urban-suburban areas are expanding. Nutrient levels in streams are high. Low dissolved oxygen and high trace metal levels occur in some stream reaches downstream of urban areas." (Woods *et al.* 2002)

Exhibit 5, page II-10, shows that the topography of the Wolf Run Watershed is gently rolling with local relief generally varying by less than 100 feet. Most of the variation is found in the northern third of the watershed towards the mouth. Historic stream data indicates that numerous headwater tributaries along the southeastern portion of the watershed have been removed due to extensive development that has occurred in these areas over time.

H. Soils

According to the soil survey of Fayette County (Sims *et al.* 1987), the most prominent soils within the Wolf Run Watershed are Maury and McAfee silt loams, as shown in Exhibit 6, page II-11. This association of soils is described as "undulating, deep and moderately deep, well drained soils high in phosphate; on uplands." These soils occupy 68 percent of the watershed and are formed mostly from weathered material from phosphatic limestone. Therefore, high phosphorus in the water samples does not necessarily indicate water pollution but could simply indicate background geological conditions. Maury soils are described as "deep, well-drained, and fertile" while McAfee soils are "well drained or somewhat excessively drained and are less than 3 feet deep over bedrock." The soils are noted for their utility in raising thoroughbred racehorses, although hay, silage, beef cattle, and tobacco are also farm uses of the soil. These soils are commonly underlain by sinkholes and karst drain-ways. Maury soils are typically moderately limited for septic tank system field filters while McAfee soils are severely limited due to rock and permeability issues.

Exhibit 5
Topography and Historic Streams
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

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Exhibit 6
Soil Series
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_6_Soils.mxd) 10/13/2010 -- 11:32:29 AM las

Lanton silty clay loam, Melvin silt loam are listed as hydric within Fayette County. Lawrence silt loam, Loudon silt loam, and Newark silt loam are listed as possibly having inclusions of hydric soils. Each of these soils is located within the watershed (Exhibit 6, page II-11) but only form a small percentage of the land area (seven percent). Areas of hydric soil are important since wetland restoration or expansion is more likely to be successful in these areas; particularly in the headwaters in the south and eastern portions of the watershed wetland restoration or creation may be an option.

National Wetland Inventory (NWI) mapping indicates that nine wetlands are located within the Wolf Run Watershed with a total area of 13.46 acres. However all of these wetlands are ponds or retention basins. One spring fed wetland, unmapped by NWI, is located at the Allendale Greenway in the floodplain of Wolf Run near the confluence with Springs Branch. Some scattered wetlands are also located along Cardinal Run. Other wetlands locations in the watershed are unknown.

I. Riparian Ecosystem

Although riparian zones produce many water quality benefits, these benefits are dependent on the width of the riparian area, the size of the stream that it borders, vegetative composition, and density. Stream ordination is a system applied to designate the size and location of stream systems. One method of stream ordination, as shown in Figure 2, assigns all headwater perennial streams with an order of one, and increases the order at the confluence of streams of equal order. Thus, when two third-order streams combine, a fourth-order stream is produced. The water quality functions provided by the riparian zone vary by stream order. Riparian corridors on first and second-order streams provide the maximum nutrient removal, shading, and bank stabilization benefits (Palone *et al.* 1997). Fish habitat and aquatic ecosystem benefits are typically greatest for third and fourth-order streams while flood mitigation benefits of riparian corridors increase as the stream order increases. Sediment control benefits remain relatively constant for all stream orders.

FIGURE 2 – STREAM ORDER DIAGRAM

From FISRWG, 1998

The width of the riparian zone necessary to achieve these benefits varies depending on the function. The US Army Corps of Engineers (Fischer and Fischenich 2000), recommends the following riparian buffer widths for various functions: five to 30 meters (16 to 100 feet) for water quality protection, 30 to over 500

meters (100 to over 1,600 feet) for riparian habitat, 10 to 20 meters (30 to 65 feet) for stream stabilization, 20 to 150 meters (65 to 500 feet) for flood attenuation, and three to 10 meters (10 to 30 feet) for detrital input.

An analysis of the actual riparian widths in the Wolf Run Watershed was compared against the minimum recommended buffer width for each function. Thirty feet was used instead of 16 feet as the minimum width for water quality protection since most filtering occurs within 30 feet for low to moderate slopes found throughout the watershed. The riparian width and edge of water for each bank was delineated from aerial photographs. Areas with forested canopy or overgrown vegetation were included in the riparian buffer zone. Each bank was then divided into segments based on the maximum width of the riparian corridor and stream order. Exhibits 7 and 8, pages II-14 and II-15, show the locations of riparian zones.

The riparian zone analysis, summarized in Table 2, revealed similar trends among all stream orders (though second order streams scored consistently lower than both first and third order in each category). Riparian zones in the watershed were generally abundant within the first 10 feet, but decreased dramatically at each successive threshold.

TABLE 2 – PERCENTAGES OF STREAM BANKS WITH RIPARIAN AREAS PROVIDING FUNCTIONAL BENEFITS IN THE WOLF RUN WATERSHED

Stream Order	Organic Input (>10 ft)	Stream Stabilization & Water Quality (>30 ft)	Flood Attenuation (>65 ft)	Riparian Habitat (>100 ft)
First Order	92.8	61.9	26.8	8.5
Second Order	87.5	52.4	21.1	8.0
Third Order	97.0	64.4	21.7	8.1

Based on the aerial delineations, the majority of the streams and tributaries in the Wolf Run Watershed have some form of riparian cover within 10 feet of the stream bank. While the quality of the riparian zone could not accurately be determined via the aerial image (*i.e.*, mature trees, small shrubs, mowed grass, etc.) the abundance of streams with at least 10 feet of riparian zone is a positive moving forward, as these areas likely have the potential for enhancement. Similarly, over half of the streams in the watershed have at least 30 feet of riparian zone, which plays a crucial role in stream stabilization and water quality. Areas where this 30-foot buffer could be expanded/enhanced and protected will be important to identify for watershed management activities.

Typical of urban streams, the existence of riparian zone substantially declines beyond 65 feet, which is when benefits for flood attenuation and riparian habitat are realized. While there may be some areas at this distance available for expansion and/or enhancement, the highly developed urban setting typically makes it a difficult and expensive task. Fortunately, there are other methods available for aiding in flood attenuation (*e.g.,* rain gardens, green roofs, replacing impervious surfaces, detention/retention basins, etc.). As the possibility for riparian expansion past 100 feet is unlikely in most areas, efforts regarding riparian habitat should be focused on connectivity. Connecting areas that support riparian habitat to areas with less abundant riparian cover that can be enhanced will increase migration corridors and could benefit wildlife by reducing habitat segmentation in the watershed.

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Exhibit 7
Riparian Zone - North
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_8_Riparian.mxd) 1/5/2011 -- 4:27:24 PM sje

Exhibit 8
Riparian Zone - South
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

J. Fauna and Flora

Fauna in the Wolf Run Watershed is primarily domestic (dogs, cats, horses, cows, etc.). Other animals inhabiting the watershed are those that are highly adaptable and/or tolerant of disturbance (*e.g.,* raccoon, opossum, squirrel, northern cardinal, blue jay, robin, house sparrow, starling, etc.) Domestic animals and a select few waterfowl, such as Canada goose and mallard (particularly around Gardenside Park and Wolf Run Park), are likely species that may contribute to fecal inputs in Wolf Run.

The Proposed Draft "Total Maximum Daily Load for Fecal Coliform and *E. coli,* 9 Stream Segments and 2 Springs within the South Elkhorn Creek Watershed, Fayette, Franklin, Jessamine, Scott, and Woodford Counties, Kentucky" developed by UK (Ormsbee *et al.* 2011) took into consideration estimates of wildlife and domestic animal pathogen inputs within the watershed using the USEPA's Bacterial Indicator Tool (BIT) (USEPA 2001). The wildlife in the South Elkhorn Creek watershed was represented by duck, deer, beaver, raccoon, and migratory geese. USEPA's BIT provides a population density for each species of animal for a particular land use (USEPA, 2001). This tool assumes an animal population of five deer, five geese, 10, ducks, one beaver, and two raccoons per square mile of cropland or pastureland land use. For forestland use, the populations are doubled for each animal (except raccoons, for which five per square mile are assumed). Based on these assumptions, there are approximately 46 deer, 46 geese, 50 ducks, five beaver, and 23 raccoon in the Wolf Run Watershed.

According to the Kentucky State Nature Preserve Commission (KSNPC), Fayette County contains several state and federally listed threatened, endangered, or special concern species. Table 3, page II-17, lists these species and communities.

While habitat for these species is present within Fayette County, none lies within the boundaries of Wolf Run Watershed. And though no habitat currently exists in the watershed for these species, management activities that create or enhance habitat for these species, as well as the water quality (both within the watershed and in the water of the receiving streams), are preferable and have greater opportunities for funding.

While consideration of threatened and endangered species is important, consideration of exotic and invasive species in the watershed are also important. Exotic invasive species of plants can wreak havoc with ecological balance, creating trouble for rare and common species alike, and also degrade waterways and interfere with water uses. According to Jim Lempke (Per. Comm. 2010), Curator of Native Plants and Natural Ecosystems for the Arboretum, the following exotic, invasive species have been found in the Arboretum Woods (in order from highest numbers to lowest):

- *Euonymus fortunei* (wintercreeper)
- *Lonicera maackii* (bush honeysuckle)
- *Lonicera japonica* (Japanese honeysuckle)
- *Euonymus alata* (burning bush)
- *Morus alba* (white mulberry)
- *Celastris orbiculatus* (Oriental bittersweet)
- *Rosa multiflora* (multiflora rose)
- *Alliaria petiolata* (garlic mustard)
- *Ligustrum vulgare* (privet)

- *Hedera helix* (English ivy)
- *Acer platanoides* (Norway maple)
- *Hibiscus syriacus* (Rose of Sharon)
- *Viburnum lantana* (Wayfaringtree)
- *Polygonum cuspidatum* (Japanese knotweed)
- *Prunus avium* (bird cherry)
- *Rhamnus davurica* (buckthorn)

TABLE 3 – THREATENED, ENDANGERED, AND SPECIAL CONCERN SPECIES OF FAYETTE COUNTY

Common Name	Scientific Name	US Status*	KY Status*
Amphibians			
Eastern Hellbender	*Cryptobranchus alleganiensis alleganiensis*	-	S
Northern Leopard Frog	*Rana pipiens*	-	S
Birds			
American Coot	*Fulica americana*	-	E
Bank Swallow	*Riparia riparia*	-	S
Barn Owl	*Tyto alba*	-	S
Black-crowned Night-heron	*Nycticorax nycticorax*	-	T
Blue-winged Teal	*Anas discors*	-	T
Bobolink	*Dolichonyx oryzivorus*	-	S
Dark-eyed Junco	*Junco hyemalis*	-	S
Double-crested Cormorant	*Phalacrocorax auritus*	-	E
Henslow's Sparrow	*Ammodramus henslowii*	-	S
Northern Shoveler	*Anas clypeata*	-	E
Lark Sparrow	*Chondestes grammacus*	-	T
Little Blue Heron	*Egretta caerulea*	-	E
Peregrine Falcon	*Falco peregrinus*	PS:LE	E
Savannah Sparrow	*Passerculus sandwichensis*	-	S
Sedge Wren	*Cistothorus platensis*	-	S
Yellow-crowned Night-heron	*Nyctanassa violacea*	-	T
Insects			
Garman's Cave Beetle	*Pseudanophthalmus horni*	-	S
Northern Hairstreak	*Satyrium favonius ontario*	-	S
Sedge Sprite	*Nehalennia irene*	-	E
Mammals			
Gray Myotis	*Myotis grisescens*	LE	T
Indiana Bat	*Myotis sodalis*	LE	E
Least Weasel	*Mustela nivalis*	-	S

**Abbreviations are as follows: LE = Listed Endangered. PS = Partial Status (status only applies to a portion of the species range), E = Endangered, T = Threatened, S = Special Concern*

Ailanthus altissima (tree of heaven) is not currently in the woods but has been found not far from the woodland and has been removed in large numbers from the Arboretum. These exotic invasive species are also expected to be found in the Wolf Run Watershed, particularly along wooded riparian corridors.

K. Land Use and Nonpoint Source Pollutants

1. Land Use

As different types of land use contribute different types of pollution and stresses to the creek, identifying these land uses within the Wolf Run Watershed is important for watershed planning. The *2007 Comprehensive Plan for Lexington-Fayette County, Kentucky* (LFUCG 2007) divided the Lexington-Fayette County area into 20 land use categories described in Table 4. Exhibit 9, page II-20, shows the locations of these land uses within the Wolf Run Watershed.

TABLE 4 – LAND USE DESCRIPTIONS FROM 2007 COMPREHENSIVE PLAN FOR LEXINGTON-FAYETTE COUNTY

Land Use Type	Description
Low Density Residential (LD)	Residential - up to four units per gross acre or up to five units per net acre. Housing types found under this category include single-family detached and may include townhouse and duplex.
Medium Density Residential (MD)	Residential – up to 8 units per gross acre or up to 10 units per net acre. Housing types found under this category include single-family detached, townhouse, duplex, and apartment.
High Density Residential (HD)	Residential – 6-20 units per gross acre or 10-25 units per net acre. Housing types found under this category include townhouse, apartment, dormitories, residential care facilities, and assisted living quarters.
Very High Density Residential (VHD)	Residential – 16-32 units per gross acre or 25-40 units per net acre. Housing types found under this category include apartments, dormitories, residential care facilities, and assisted living quarters.
Highway Commercial (HC)	Establishments for retail sale of goods and services which appeal to the motorist, such as hotels, and establishments which display, rent, sell, and service motor vehicles, boats, and other related equipment. Retail trade, personal services, and professional service activities may also take place in these areas.
Retail, Trade and Personal Services (RT)	Establishments for the retail sale of goods, prepared foods and drinks, or the provision of certain personal services. Establishments that operate in a store or store-like environment including hardware stores, general merchandise and food stores, gasoline service stations, eating and drinking places, beauty or barbershops, shoe repair stores, and professional service activities, such as branch banks.
Professional Service / Office (PS)	Services that are provided within the confines of an office including financial and credit institutions, security and commodity brokers, holding and investment companies, architectural and engineering firms, legal and medical services, insurance, real estate agents, etc.
Commercial Residential Mixed Use (MU)	Mixed-use category that encourages combinations of office and neighborhood retail with residential above, or adjacent to, the retail and office.
Light Industrial (LI)	Establishments that assemble finished or semi-finished materials, food preparation, publishing, communication, construction materials, or any establishment or repair services which may present a moderate nuisance to adjacent properties.

LFUCG 2007

TABLE 4, CONTINUED

Land Use Type	Description
Heavy Industrial (HI)	Establishments that engage in manufacturing involving the transformation of a material from its raw form to a finished or semi-finished product, and establishments with high potential nuisance factors, such as noise, odor, vibrations, etc.
Warehouse and Wholesale (WW)	Establishments that are engaged in bulk storage, wholesale or bulk sale, shipment, and trans-shipment or related activities; some retailers of goods which do not depend on walk-in business; some retailers of goods which are extremely large, noisy, or inappropriate to other business zones.
Office / Warehouse (OW)	Light industrial and warehouse uses that are compatible with offices. Allows businesses to combine their entire operation within one building.
Utilities (U)	This category includes non-office facilities of utility providers such as treatment plants, substations, and towers.
Semi-Public Facilities (SP)	Privately owned facilities that benefit the public and contribute to the general welfare of the entire community. Includes places of worship, cemeteries, private educational institutions, and private recreation.
Other Public Uses (OPU)	Publicly owned facilities that benefit the public and contribute to the general welfare of the entire community. Includes public health and educational institutions, major transportation facilities, libraries, fire stations, and government offices.
Greenspace / Open Space (GS)	Undevelopable open space land including medians, retention basins, excess right-of-way along freeways and expressways, interchange areas, and some common open space areas owned and maintained by homeowners' associations.
Public Education (PE)	All public school facilities, including accessory facilities for public elementary, middle, and high schools.
Public Recreation (PR)	All publicly owned parkland and facilities.
Circulation (CIR)	Lands with predominant automobile and rail circulation facilities and parking uses. Includes the actual pavement dimension for all state maintained minor arterials and higher road classifications, and all locally maintained major arterials.
Agricultural Lands (RL)	Rural land characterized by its predominance of use for agriculture.

LFUCG 2007

Land use in the Wolf Run Watershed is dominated by low density residential, which accounts for over 42 percent of the Wolf Run area (Table 5, page II-21). Light industrial; other public uses; core agriculture and rural lands; public recreation; high density residential; retail, trade and professional services; professional service/office; medium density residential; semi-public facilities; and greenspace/open space combine to account for another 50 percent of land use. With the exception of part of the core agriculture land located at the north end of the watershed, buildings within the watershed are on the Lexington sanitary sewer network.

Exhibit 9
Land Use
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_9_Landuse.mxd) 11/22/2010 -- 6:24:43 PM sje

TABLE 5 – LAND USE

Land Use Type	Total (Acres)	Relative Abundance (%)
Low Density Residential	2,998.06	42.93
Light Industrial	464.28	6.65
Other Public Uses	433.28	6.20
Core Agriculture and Rural Lands	427.60	6.12
Public Recreation	412.30	5.90
High Density Residential	364.38	5.22
Retail, Trade and Personal Services	356.04	5.10
Professional Service / Office	315.28	4.51
Medium Density Residential	296.59	4.25
Semi-Public Facilities	274.18	3.93
Greenspace / Open Space	156.41	2.24
Public Education	129.64	1.86
Circulation	126.83	1.82
Very High Density Residential	74.30	1.06
Warehouse and Wholesale	56.09	0.80
Heavy Industrial	35.83	0.51
Highway Commercial	31.89	0.46
Commercial Residential Mixed Use	30.40	0.44
Utilities	3.51	0.05
Office / Warehouse	2.86	0.04
Total	6,989.74	100.00

As low density residential accounts for such a large proportion of land use in the watershed, nonpoint sources of pollution commonly associated with such land use may play a large role in the health of Wolf Run and its tributaries. Lawn fertilizers (typically high in nitrogen and phosphorus), herbicides and pesticides are commonly applied in these zones to keep grass green. However, fertilizer that is not absorbed into the soil may be carried into streams in runoff resulting in nutrient pollution problems and algal blooms in Wolf Run and its tributaries. Often, household pets are associated with low-density residential areas and can contribute to fecal and nutrient pollution.

In the highly developed Wolf Run Watershed, other threats to stream health and water quality exist, including roadway crossings, streamside businesses, suspected sanitary sewer overflows or losses from the sanitary sewer collection system, and a high level of imperviousness.

Agriculture land, the majority of which is located north of New Circle Road, accounts for approximately six percent of land use in the watershed. Horses, cattle or other livestock operations on these lands are a source of nonpoint source pollution. Through direct inputs of fecal material or via runoff, these animals can raise the pathogen and nutrient levels of streams. Cropland can also contribute nonpoint source pollution due to the addition of fertilizers and pesticides, which may be carried through runoff to streams. In the agricultural areas outside of the sanitary sewer coverage, failing onsite sewage treatment (septic systems) can be a source of nonpoint source (NPS) pollution. Typically, septic system failure can be detected by water falling back into the tanks when the tank is pumped, or by soil flooding due to lack of soil infiltration.

However, in soils with karst or epikarst subsurfaces, such signs of failure may not be detected due to effluent drainage into the groundwater system.

Land use within 100 feet of Wolf Run and its tributaries is still predominately low density residential (35.25 percent), but public recreation (17.9 percent) and light industrial (12.83 percent) account for a higher percentage of land use along the streams (when compared to their overall presence in the watershed), as shown in Table 6. Because opportunities for improving habitat, filtration, and other beneficial water quality functions increase with proximity to the streams, the land use types in this area are important to identify for development and implementation of Best Management Practices (BMPs) to address stormwater runoff NPS pollution.

TABLE 6 – LAND USE WITHIN 100 FEET OF WOLF RUN AND ITS TRIBUTARIES

Land Use Type	Total (Acres)	Relative Abundance (%)
Low Density Residential	101.59	35.25
Public Recreation	51.59	17.90
Light Industrial	36.96	12.83
Residential	26.29	9.12
Core Agriculture and Rural Lands	23.01	7.99
Greenspace / Open Space	19.00	6.59
Retail, Trade and Personal Services	16.34	5.67
Professional Service / Office	16.25	5.64
Medium Density Residential	8.54	2.96
Public Education	3.29	1.14
Circulation	3.10	1.08
Semi-Public Facilities	3.09	1.07
Other Public Uses	1.56	0.54
Utilities	0.30	0.10
Very High Density Residential	0.26	0.09
Total	288.16	100

2. Impervious Surface

Impervious surfaces in Wolf Run account for 40 percent of the watershed area as shown in Table 7, page II-23, and Exhibit 10, page II-24. Impervious surfaces, such as roadways and rooftops, are surfaces which water cannot penetrate. As these surfaces are unable to infiltrate water, they subject streams to extraordinarily high flows during storm events, leading to erosion and further pollution. Impervious surfaces have been found to multiply discharge rates by two to five times for a given event. On impervious roadways, vehicles introduce numerous pollutants including oils, grease, rubber, and heavy metals (lead, zinc, copper). Some of these pollutants also accumulate when the vehicles are idle on parking lots, driveways, and other parking areas. Most heavy metals tend to accumulate and remain within vegetated ditches adjacent to the surface. Other roadway pollutants tend to be more mobile. Research indicates that the amount of pollutants in surface waters is proportional to the amount of average daily traffic. Also, in winter months, deicing salt transported through runoff can be a significant pollutant to surface waters. Roof runoff can also be high in certain metals and solids. In residential areas, lawn fertilization and pesticide applications, carried to streams through the storm sewer system, can also contribute to nonpoint source

pollution. Additionally, runoff from impervious surfaces often has a much higher temperature than receiving streams.

TABLE 7 – SURFACE PERMEABILITY PER LAND USE TYPE

Land Use Type	Total Acreage	% Land Use in Watershed	Impervious Acreage	% Total Impervious Surface in Watershed	% Impervious by Land Use
Low Density Residential	2998.06	42.89	1072.56	38.60	36%
Retail, Trade and Personal Services	356.04	5.09	289.69	10.43	81%
Other Public Uses	433.28	6.20	237.29	8.54	55%
High Density Residential	364.38	5.21	198.26	7.14	54%
Professional Service / Office	315.28	4.51	188.90	6.80	60%
Light Industrial	464.28	6.64	174.52	6.28	38%
Medium Density Residential	296.59	4.24	136.34	4.91	46%
Semi-Public Facilities	274.18	3.92	101.91	3.67	37%
Circulation	126.83	1.81	92.15	3.32	73%
Public Education	129.64	1.85	56.78	2.04	44%
Very High Density Residential	74.30	1.06	42.17	1.52	57%
Public Recreation	412.30	5.90	36.16	1.30	9%
Warehouse and Wholesale	56.09	0.80	36.09	1.30	64%
Greenspace / Open Space	156.41	2.24	26.50	0.95	17%
Heavy Industrial	35.83	0.51	23.33	0.84	65%
Highway Commercial	31.89	0.46	22.31	0.80	70%
Commercial Residential Mixed Use	30.40	0.43	21.32	0.77	70%
Core Agriculture and Rural Lands	427.60	6.12	18.89	0.68	4%
Office / Warehouse	2.86	0.04	2.07	0.07	73%
Utilities	3.51	0.05	1.19	0.04	34%
Total	6989.74	100	2778.45	100	40%

Note: Yellow highlighting indicates land use types contributing a disproportionate amount of impervious surface to the Wolf Run Watershed. Pink highlighting indicates land uses with the highest percentages of impervious surface.

Land uses in the watershed contribute varying proportions of impervious surfaces when compared to their relative abundance in the watershed (Table 7). While low density residential, for example, contributes the most of any other land use at nearly 39 percent, its overall impervious footprint in the watershed is less than its relative abundance in the watershed (42.89 percent). Retail, trade, and personal services, on the other hand, contribute approximately 10 percent of the impervious surface while only accounting for five percent of the land use in the watershed. Retail, trade, personal services, highway commercial, commercial residential mixed use, and office/warehouse land uses have the highest percentage of impervious surface by land use type. BMPs for improving infiltration should be targeted for those land uses that contribute the most to impervious surfaces in the watershed.

Within 100 feet of Wolf Run and its tributaries, impervious surfaces account for only 20 percent of the land surface. This may be a good indicator of the amount of land readily available for riparian zone enhancements and protection.

Exhibit 10
Impervious Surfaces
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_10_Impervious.mxd) 11/24/2010 -- 10:18:04 AM las

3. Zoning

Zoning in Lexington-Fayette County is established and presented in a zoning ordinance document and in Chapter 20 of the Charter and Code of Ordinances (LFUCGa 2010, LFUCGb, 2010). As shown in Exhibit 11, page II-26, the Wolf Run Watershed contains 21 different zoned areas within its boundaries. A summary of the total acreage of each type of zoning and the relative percentage in the watershed is found in Table 8, page II-27.

Of the 6,989 acres of land in the Wolf Run Watershed, 4,535 acres (65 percent) are zoned for residential use. Zones R-1A, R-1B, R-1C and R-1D account for the majority of residential land use in the watershed at 2,663 acres. These zones permit for single-family detached residences, in addition to parks and playgrounds operated by government. The remaining residential land use zoning (R-1E, R-2, R-3, R-4, R-5) is for multi-family use or patio homes. In general, zones R-1A through R-1D have more "green" space associated with them and proportionately more pervious surface than higher density, multi-family housing. While land zoned for R-1A through R-1D and R1-T (townhouse residential) accounts for 53 percent of zoned land in the Wolf Run Watershed, it is the location of only 46 percent of impervious surfaces.

Land zoned for agricultural use, both rural (A-R) and urban (A-U), account for the next most abundant zoning type, with 925.2 acres set aside in the Wolf Run Watershed for agricultural uses. The A-R zones are all located within the rural service area and restricted to the north and northwest portions of the watershed. These lands are used solely for agricultural purposes, including small farm wineries, as outlined in KRS 100, and also allow for single family detached dwellings. The A-U zones are scattered throughout the watershed within the urban service area and permit the same uses as those for A-R. The A-U zones are designed to help control and slow the development of agricultural land within the urban service area. Agricultural lands currently make up approximately 13 percent of the watershed but contain only six percent of the impervious surface. Continued use as agricultural lands coupled with proper nutrient management and riparian buffer zones would be beneficial to Wolf Run and its tributaries. Poorly managed development of these lands would almost certainly lead to an increase of impervious surface in the watershed. Should these lands be developed, the Watershed Plan should play a critical role in ensuring the developments do not negatively impact the health of the watershed.

Residential zones R-2, R-3, R-4, and R-5 (higher density residential) account for another 893.4 acres of the watershed, with industrial and business zones accounting for similar portions of the watershed 617.2 acres and 531.5 acres, respectively. Industrial zones are dominated by light industry (456.1 acres), while commercial zones are dominated by neighborhood business (315.6 acres). These high-density residential, industrial, and commercial zones combined comprise 33 percent of the watershed area but are responsible for a disproportionately high ratio of impervious cover at nearly 48 percent of the total. Table 8, page II-27, indicates the zones with disproportionate amounts of impervious land coverage compared to the percentage of that zoning type in the watershed. Particularly high percentages of imperviousness are found in areas zoned for neighborhood business (B-1), planned shopping centers (B-6P), highway service business (B-3), and wholesale warehouse business (B-4). Green roofs, rain gardens, tree wells, and other best management practices that decrease the amount of impervious surface should be targeted towards these zones.

Exhibit 11
Zoning
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_11_Zoning.mxd) 11/24/2010 -- 10:36:40 AM las

TABLE 8 – ZONING TYPES AND IMPERVIOUS SURFACES

Zone Title	Zone Code	Total Acreage	% Zoned of Watershed	Impervious Acreage	% Total Impervious Surface per Zone	% Impervious by Zone
Single Family Residential	R-1C	2663.89	38.15	942.74	33.93	35%
Single Family Residential	R-1D	562.65	8.06	221.35	7.97	39%
Agricultural Urban	A-U	500.46	7.17	149.55	5.38	30%
Light Industrial	I-1	456.13	6.53	176.22	6.34	39%
Agricultural Rural	A-R	424.77	6.08	24.14	0.87	6%
Neighborhood Business	B-1	315.60	4.52	249.16	8.97	79%
High Density Apartment	R-4	309.73	4.44	185.46	6.67	60%
Professional Office	P-1	305.96	4.38	192.50	6.93	63%
Planned Neighborhood Residential	R-3	256.48	3.67	135.90	4.89	53%
Two-Family Residential	R-2	238.50	3.42	92.30	3.32	39%
Single Family Residential	R-1A	226.12	3.24	36.46	1.31	16%
Single Family Residential	R-1B	221.08	3.17	64.99	2.34	29%
Heavy Industrial	I-2	161.02	2.31	84.52	3.04	52%
Planned Shopping Center	B-6P	84.13	1.20	73.27	2.64	87%
Highway Service Business	B-3	82.22	1.18	59.25	2.13	72%
Mixed-use Community Zone	MU-3	66.76	0.96	26.63	0.96	40%
Wholesale and Warehouse Business	B-4	49.58	0.71	34.70	1.25	70%
Single Family Residential	R-1E	29.13	0.42	13.06	0.47	45%
High Rise Apartment	R-5	14.67	0.21	9.10	0.33	62%
Townhouse Residential	R-1T	13.05	0.19	6.35	0.23	49%
Neighborhood Corridor Zone	MU-2	1.22	0.02	0.82	0.03	67%
Total		6983.14	100.00	2778.44	100.00	

Note: Yellow highlighting indicates zoning types contributing a disproportionate amount of impervious surface to the Wolf Run Watershed. Pink highlighting indicates zoning types with the highest percentages of impervious surface.

4. Agricultural Land Use

Agricultural land accounts for approximately six percent (427.6 acres) of land use in the watershed, the majority of which is located north of New Circle Road. The type of agricultural use on these lands will affect the type of pollution produced. In order to evaluate the land use on these lands, countywide estimates of the number of livestock were obtained from the 2007 Census of Agriculture (USDA 2007). A total of 810 farms with 135,969 acres are found in Fayette County with cattle, horses, chickens, and sheep as the top livestock inventory items, with the quantities of each shown in Table 9, page II-28. Based on the acreage of farms in Fayette County and the quantity of livestock, an estimate of the number of each livestock category per acre of agricultural land use was calculated. If the agricultural land use in these areas is typical of Fayette County, then 52 cattle/calves, 46 horses/foals, and three sheep/lambs will be located on these lands.

TABLE 9 – LIVESTOCK QUANTITIES ON FAYETTE COUNTY FARMS, 2007

Livestock	Quantity	Estimated No. / Acre Agricultural Land Use
Cattle and Calves	16,771	0.123
Horses and Ponies	14121	0.108
Chickens	Not Disclosed	N/A
Sheep and Lambs	769	0.006

Although listed as a "Semi-Public Facility" land use, the Red Mile has significant agricultural use with the horse racing conducted at the track. According to the proposed draft pathogen TMDL developed by Kentucky Water Resources Research Institute (KWRRI) for the South Elkhorn watershed (Ormsbee *et* al, 2011), 50 horses are housed at the Red Mile each month on average, except in August and September when 450 horses are housed on average. Muck associated with the racetrack is typically collected in stockpiles that may be held for subsequent transport and disposal.

L. Human Influences on Watershed

Human influences on the Wolf Run Watershed are many and various. In this section, a summary of the different types of human activities in the watershed is given. Demographics of the watershed, point source permitted dischargers, stormwater system, sanitary sewer system, water supply, and watershed management activities are each discussed in their respective sections.

1. Demographics

A summary of the United States Census Bureau's 2000 Census statistics with 2009 amendments (US Census Bureau 2010) for Lexington-Fayette County are shown in Table 10 to provide an overview of the area demographics.

TABLE 10 – COUNTY CENSUS DATA SUMMARY

Census Statistic	Lexington–Fayette County	Kentucky
Population (2009 estimate)	296,545	4,314,113
Percent Growth (April 1, 2000 to July 1, 2009)	13.8%	6.7%
Persons per household, 2000	2.29	2.47
Persons under 18 years old, percent, 2009	21.3%	23.5%
Persons 65 years old and over, percent, 2009	10.8%	13.2%
Education		
% High School Graduate or higher, 2000	85.8%	74.1%
% Bachelor's degree or higher	35.6%	17.1%
Income		
Median Household Income, 2008	$50,267	$41,489
Housing		
Total Housing Units, 2009	133,453	1,935,053
Homeownership rate, 2000	55.3%	70.8%
Median value of specified owner-occupied units, 2000	$110,800	$86,700

Based on U.S. Census Bureau State and County QuickFacts (US Census Bureau 2010)

The human population of the county grew by approximately 13.8 percent from April 2000 to July 2009 for an estimated 2009 total of 296,545. Of these individuals, 21.3 percent were under the age of 18 and 10.8 percent were over the age of 65, both lower than statewide percentages. Lexington-Fayette County residents have a higher median income and home value but lower homeownership rate than the state as a whole. Educationally, Lexington-Fayette County residents have also achieved higher graduation rates.

Within the Wolf Run Watershed, numerous Neighborhood Associations represent the large number of residents in the area. The locations of these Neighborhood Associations are depicted in Exhibit 12, page II-30. The watershed is within Fayette County Public School Board Districts 1, 2, 4, and 5.

For business interests, the Southland Association represents member businesses along Southland Drive while other businesses are grouped by shopping centers such as the Gardenside Shopping Center or Turfland Mall. The University of Kentucky is a large landowner within the watershed as are large farms to the northeast of the watershed.

2. Applicable Laws And Ordinances

The LFUCG Code of Ordinances was reviewed (LFUCGb 2010). While numerous ordinances apply to watershed management and affect water quality in various manners, some ordinances are particularly applicable to watershed management. These ordinances include:

Chapter 12: Housing,
- Article 3: Riparian Areas

Chapter 16: Sewage, Garbage, Refuse and Weeds
- Article 10: Stormwater Discharges
- Article 14: Water Quality Management Fee

Chapter 20: Zoning
- Article 19: Floodplain Conservation and Protection
- Article 26: Tree Protection Standards

A brief summary of each of these ordinances follows. While some areas are addressed with specific ordinances, sinkholes, karst areas, and other special environmental areas are addressed through best management practices and site plans associated with other ordinances. Also, neighborhood specific ordinances, deed restrictions, and design standards not addressed herein may have applicability to watershed management in specific areas.

a. Riparian Areas

This ordinance (Chapter 12, Article 3) allows “any person whose property contains a riparian area… [to] create a buffer area bordering the riparian area upon obtaining a permit from the urban forester or his designee. Such a buffer area shall be exempt from the nuisance provisions of chapter 12 provided that the area is properly maintained as defined herein and acceptable species of vegetation are utilized.” In this way, natural riparian areas may be maintained without being cited for a penalty nuisance provisions. The maximum area for such a riparian zone is “twenty-five (25) feet from the edge of the wetland, river, stream or lake, unless a larger area is approved by the urban forester and so designated on the permit.”

Exhibit 12
Neighborhood Associations
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_12_Neighborhood_Assoc.mxd) 11/22/2010 -- 7:20:11 PM sje

b. Privately-Owned Detention and Retention Basins

The purpose of Division 2 of Article 10, Chapter 16 is to set forth ordinances that will ensure compliance with LFUCG's MS4 permit regulations by clarifying the roles of the private property owner and LFUCG in managing stormwater control devices including detention basins and retention ponds. The ordinance requires that these control structures be properly maintained, both through structural repairs and non-structural maintenance. The ordinance also prohibits structures such as fences, gazebos, swimming pools, and sheds from being located in a detention basin or retention pond.

In an area where a public easement exists, the property owner and LFUCG share responsibility for the basin or pond. The property owner is responsible for non-structural maintenance such as mowing, litter removal, algae removal, tree limb removal, and landscaping. LFUCG is responsible for structural maintenance such as repairing severe erosion, removing excess silt, and removing large debris. LFUCG also repairs any structures that are failing, such as concrete flumes or pipes. In an area without a public easement, the property owner is responsible for all non-structural and structural maintenance of the basin or pond. All structural and non-structural maintenance of stormwater control devices on commercial or industrial property is the responsibility of the property owner and manager.

c. Industrial and High-Risk Commercial Stormwater Runoff

Chapter 16, Article 10, Division 3 specifically allows LFUCG to regulate industrial and high-risk commercial facilities to develop and implement Stormwater Pollution Prevention Plans (SWPPP) and monitoring plans, even if they are not otherwise required to have this information. The purpose of this program is to reduce pollutant loadings and improve the quality of stormwater runoff discharged from these areas into the local waterways.

A SWPPP is more detailed than a BMP Plan, Groundwater Protection Plan (GPP), or Spill Prevention Control and Countermeasure (SPCC) Plan. According to LFUCG's website, the four main objectives of a SWPPP are to identify pollutant sources, control the sources, document the control methods, and integrate pollution prevention.

d. Erosion and Sediment Control

Soil erosion from construction sites contributes to the impairment of the floodplain, increased road maintenance costs, clogging of storm sewers, degradation of land surfaces and streams, flooding, and dusty conditions when eroded material on streets dries. Significant erosion results from rainfall and runoff over unprotected soil. Erosion is increased by intense rainfalls, long slopes, steep slopes, and lack of adequate vegetative cover. These conditions are in part caused by or aggravated by improper construction, grading, or excavation, which results in removal of natural ground cover without taking appropriate steps to control erosion problems. The intent of Chapter 16, Article 10, Division 5 is to reduce soil erosion in Fayette County and to provide procedures for submission, review, and acceptance of erosion and sediment control plans and applications for land disturbance permits prior to soil disturbance.

The ordinance covers control measures such as installation of silt fences, construction entrances, seeding and mulching, proper disposal of trash, curb and surface inlet protection, inspection of controls, street cleaning, drainage alteration, and snow fences for construction sites of various sizes and disturbance limits. The ordinance also includes enforcement measures and penalties for violations.

e. Water Quality Management Fee

Under Chapter 16, Article 14, a water quality management fee is imposed on every parcel of land within the water quality management area except undeveloped parcels, railroad tracks, and federal, state, or urban county streets and roads. Single-family homes and duplexes will pay $4.32 per month, while apartment complexes and non-residential properties will pay the fee based on the total amount of impervious surface on their properties. Impervious surfaces are areas such as roofs, parking lotsb and driveways that do not infiltrate water when it rains. The ordinance establishes a Water Quality Fees Board and a Stormwater Projects Incentive Program.

The Stormwater Quality Projects Incentive Grant Program provides financial assistance for projects in the community that improve water quality, address stormwater runoff, and educate the public about these issues. LFUCG's Division of Water Quality will receive the applications and make recommendations for project selection. Projects will be ranked based upon project impact, project team, and other factors. The Water Quality Fees Board reviews all recommendations and makes the final selection on all grant awards. Because neighborhoods and institutions have different needs, two types of grants are available.

f. Floodplain Conservation and Protection

Under Chapter 20, Article 19, the designation of flood hazard areas and the regulations imposed on these zones are intended to provide for public awareness of the flooding potential, protect human life and health, minimize public and private property damage, protect individuals from buying lands and structures which are unsuited for intended purposes because of flood hazards, and minimize surface and groundwater pollution and erosion of the floodplain soils which will adversely affect human, animal, or plant life.

g. Tree Protection Standards

LFUCG recognizes the importance of trees as a vital component in counterbalancing the effects of an urban setting by providing cooling shade, reducing noise and glare, contributing significantly to urban aesthetics, improving air quality through carbon dioxide reduction and replenishing oxygen to the atmosphere, improving surface drainage and reducing the effects of storm drainage flooding, filtering nonpoint source pollution from area streams, stabilizing soil thereby minimizing erosion, and providing habitat for wildlife. The purpose of Chapter 20, Article 26 is to establish standards and procedures for countywide tree protection and planting in new developments.

3. KPDES Dischargers

Five permitted Kentucky Pollutant Discharge Elimination System (KPDES) facilities are or have been located in the Wolf Run Watershed as shown in Table 11, page II-33. All dischargers to waters of Kentucky are required to obtain a KPDES permit including concentrated animal feeding operations (CAFOs), combined sewer overflows (CSOs), individual residences, Kentucky Inter-Municipal Operating Permits (KIMOPs), mining, municipal, industrial, oil, and gas. These dischargers are shown on Exhibit 13, page II-34.

Detailed reports available through the USEPA Water Discharge Permits (PCS) Web Site (http://www.epa.gov/enviro/html/pcs/pcs_query.html) were reviewed for permit violations and exceedances. Of the sites identified within the Wolf Run Watershed, only the Kentucky Transportation Cabinet Maintenance Lot showed violations, which were due to elevated chloride levels on two occasions from 2003 to 2010. Thus, other than this pollutant, point source discharges from permitted sites do not seem to be large contributors to pollutant loading within the Wolf Run Watershed.

TABLE 11 – KPDES DISCHARGERS IN THE WOLF RUN WATERSHED AND ADJOINING KARST BASINS

KPDES Permit No.	Discharger Name	SIC Code / Type of Discharge
KYG500080	KYTC Fayette Co. Maintenance Lot	4173 / Bus Terminal and Service Facility
KY0022080	Marathon Petroleum Co LP	5171 / Petroleum Bulk Stations and Terminal
KYR10F942	UK Child Development Center	1542 / Nonresidential Construction
KYR10F761	15K Retail at Professional Park	1794 / Excavation Work
KYR000899	GE Lighting LLC Lex Lamp Plt	3641 / Electric Lamps
KYR10F693	Clays Mill Elementary School	-
KYR10F442	CVS #6940	1611 / Highway and Street Construction, except Elevated Highways
KYR10E125	Springs Motel	1611 / Highway and Street Construction, except Elevated Highways
KYR10G577	James Lane Allen Elementary School	-
KYR10G707	Riddell Plaza	1521 / Single-Family Housing Construction
KYR10E703	Homestead Nursing Home	1611 / Highway and Street Construction, except Elevated Highways
KYR10E282	Johnson Baker Development	1611 / Highway and Street Construction, except Elevated Highways
KY0107727	LFUCG Fleet Services	4173 / Terminal and Service Facilities for Motor Vehicle Passenger Transportation
KYR10F776	Frankfort Ct Storage Facility	0241 / Dairy Farms
KYR002134	Cloud Concrete Products Inc	3272 / Concrete Products, except Block and Brick
KYR10G787	Lot 1 Bluegrass Volleyball Center	1623 / Water, Sewer, And Utility Lines
KYR10G784	Wolf Run Pump Station	-
KY0108511	C & R Asphalt LLC	1611 / Highway and Street Construction, except Elevated Highways 3281 / Cut Stone and Stone Products

4. Stormwater System

Stormwater management has grown and developed with the passage of the Clean Water Act by Congress in 1972. The USEPA is the enforcement arm of the federal government for the Clean Water Act. In Kentucky, the enforcement has been delegated to KDOW. The USEPA has categorized MS4s into the three categories of small, medium, and large based on population served. The MS4 is defined as follows:

- A conveyance, or series of conveyances, that include roadways with drainage systems, streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains that are owned and/or operated by the government, state, city, town, county, district or other association or public body or utility having jurisdiction over disposal of stormwater that discharges into the waterways of the Commonwealth of Kentucky
- Is designed or utilized for collecting or conveying stormwater
- Is not a combined sewer and is not part of a publicly owned treatment facility

Lexington is a Phase I MS4 community and is governed under three documents: the Consent Decree, MS4 permit, and the Stormwater Quality Management Plan (SWQMP). In addition to these governing documents, individual institutions may have SWPPPs that govern site-specific practices.

Exhibit 13
KPDES Dischargers
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_13_KPDES_Dischargers.mxd) 11/22/2010 -- 7:23:47 PM sje

Two other MS4 permit holders are located in the Wolf Run Watershed. The University of Kentucky is a small MS4 permittee located in the headwaters of the Wolf Run Watershed. The Kentucky Transportation Cabinet is also an individual stormwater MS4 permit holder with the KDOW.

a. LFUCG Consent Decree

Based on information contained in the Federal Register / Vol. 73, No. 56 / Friday, March 21, 2008 / Notices, on March 14, 2008, a proposed Consent Decree (United States 2008) was lodged with the United States District Court for the Eastern District of Kentucky, Central Division. The sign Consent Decree was filed January 3, 2011 to resolve the lawsuit led by the USEPA and Commonwealth of Kentucky against violations of the Clean Water Act by Lexington. The stated objective of the Consent Decree is:

> "It is the express purpose of the Parties in entering this Consent Decree to further the objectives of the CWA … and to eliminate SSOs, Unpermitted Discharges, Unpermitted Bypasses and Exceedances, to eliminate and prevent CWA permit violations, and, specifically with respect to LFUCG's Stormwater Quality Management Program ("SWQMP"), ensure implementation of a SWQMP that reduces the discharge of pollutants to the maximum extent practicable, and require implementation of measures to ensure compliance with LFUCG's MS4 Permit."

The Consent Decree contains compliance measures that relate to the storm sewer system as well as the sanitary sewer system and additional environmental projects. For the Storm Sewer System, the Consent Decree implements the following compliance measures:

- SWQMP (Section 11) - Implementation of the SWQMP (LFUCG 2008) and enforcement of the "Performance Standards" stated therein
- Legal Authority (Section 12) - Numerous measures that confer legal authority to LFUCG to adopt and/or maintain ordinances that enforce the stormwater program
- Funding (Section 13) - Establishment of a stormwater management fee to fund stormwater management services
- Personnel, Training, and Equipment (Section 14) - Provide annual education on and obtain equipment necessary for Consent Decree compliance.

All Consent Decree related materials may be accessed from the LFUCG Division of Water Quality Web Page (select Community> Live Green Lexington> Division of Water Quality from the main menu on http://www.lexingtonky.gov/) by clicking the "EPA Consent Decree" link on the sidebar menu.

b. MS4 Permit

The Phase I MS4 Permit for LFUCG (KPDES No. KYS00002 AI No. 74551) became effective on September 1, 2009 with a five-year duration period. The permit requires implementation of a program that addresses eight minimum program elements:

- Public Education and Outreach on Stormwater Impacts
- Public Participation and Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control

- Post Construction Stormwater Management in New Development and Redevelopment
- Industrial Monitoring and Control
- Good Housekeeping and Pollution Prevention for Municipal Operations
- Water Quality Monitoring Program

The permit applies to the entire urban-county government area, but the Illicit Discharge Detection and Elimination (IDDE) Program (except for the Industrial Facilities Program), Pollution Prevention in Residential and Commercial Areas, and Pollution Prevention for Municipal Operations only applies inside the Urban Area boundary. The SWQMP developed by LFUCG must meet the minimum requirements specified in the permit for each of these programs. The SWQMP may be modified to add requirements, replace ineffective or infeasible BMPs, or adjust the schedule for maintenance activities during the life of the permit provided the permit specified procedures are followed. The content and provisions of the SWQMP are also not considered permit conditions but a tool to ensure permit compliance.

In the event published TMDLs become available for pollutants of concern within the MS4 area, KDOW may reopen the permit to incorporate TMDL loading allocations.

Lexington's MS4 permit may be viewed on-line at the Stormwater Web Page (http://www.lexingtonky.gov/).

The University of Kentucky (UK) was issued a small MS4 permit (Permit No. KYG200000; AI No. 35050) which became effective on April 1, 2010 with a five-year duration period. The scope and requirements of UK's permit are less than that of LFUCG, addressing only six minimum elements (Industrial Monitoring and Control is excluded) and with lesser individual requirements. Detailed information on this permit may be accessed at http://ehs.uky.edu/env/overview.php. UK and LFUCG are each responsible for their respective drainage areas and are currently actively discussing a memorandum of understanding to guide coordination efforts. A map of the UK MS4 Permit Boundaries is shown in Exhibit 14, page II-37.

c. LFUCG Stormwater Quality Management Plan

The LFUCG SWQMP (LFUCG 2008) is a comprehensive, detailed set of procedures and protocols for implementing the stormwater best management programs in order to manage the quality of stormwater discharged from LFUCG's storm sewer system. The content of the SWQMP is based on the terms and conditions of the MS4 permit and addresses the following specific permit elements:

- Legal Authority
- Public Education and Outreach
- Public Involvement and Participation
- Illicit Discharge Detection and Elimination
- Construction Site Stormwater Runoff Control
- Pollution Prevention in Residential and Commercial Areas
- Pollution Prevention for Municipal Operations
- Industrial Facility and Municipal Waste Facility Pollution Prevention
- Water Quality Monitoring
- Reporting and Recordkeeping

Exhibit 14
Stormsewer Outfalls
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_14_Storm_sewersheds.mxd) 11/22/2010 -- 7:29:44 PM sje

In addition to these elements, a Watershed Management element is included in the SWQMP, but it is not in the permit. This element will serve to document the activities and efforts by major watershed, and the resulting reports will guide stormwater management activities.

The method used to evaluate the program elements of the SWQMP consists of assessing whether the "measurable goals" within each program element have been met. The "measurable goals" consist of clearly defined tasks and schedules. The SWQMP includes a total of 167 measurable goals among eleven program elements as shown in Table 12.

TABLE 12 – LFUCG STORMWATER QUALITY MANAGEMENT PROGRAM MEASURABLE GOALS

Program Element	No. of Measurable Goals
1. Watershed Management	2
2. Legal Authority	8
3. Public Education	10
4. Public Involvement	12
5. Illicit Discharge Detection and Elimination	27
6. Construction Site Runoff	15
7. Pollution Prevention for Residential and Commercial Areas	28
8. Pollution Prevention for Municipal Operations	18
9. Industrial Facility Pollution Prevention	26
10. Water Quality Monitoring	17
11. Recordkeeping	4
Total	167

The success of the SWQMP in minimizing stormwater pollution to the Wolf Run Watershed should result in improvements to water quality and is therefore important in the watershed planning process.

d. Stormwater Pollution Prevention Plans

Under Chapter 16, Article 10, Division 3 of the LFUCG Code of Ordinances (LFUCGb 2010) specifically allows LFUCG to regulate industrial and high-risk commercial facilities to develop and implement SWPPPs and monitoring plans. The purpose of this program is to reduce pollutant loadings and improve the quality of stormwater runoff discharged from these areas into the local waterways.

As shown on Exhibit 15, page II-39, LFUCG identified 11 industrial/high-risk commercial facilities that require a SWPPP within the Wolf Run Watershed and its adjoining karst basins. The pollutants of concern for these facilities are listed in Table 13, page II-40.

For the most part, these SWPPPs indicate that the largest potential stormwater contaminants from these sites are due to vehicle maintenance fluids and parking lot runoff. Chemical parameters that would reflect pollution from these sites in the watershed include oil and grease, biochemical oxygen demand, chemical oxygen demand, benzene, toluene, ethylbenzene, xylenes, MTBE, total dissolved solids, and total suspended solids.

Exhibit 15
Stormwater Controls and Pollution Prevention
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_15_Stormwater_Controls.mxd) 11/24/2010 -- 10:39:04 AM sje

e. Stormwater Controls

Stormwater controls describe a wide variety of best management practices (BMPs) used to treat, store, or otherwise manage the quality or quantity of stormwater. Four types of stormwater controls have been identified within the Wolf Run Watershed: detention basins, retention basins, underground basins, and other BMPs. The locations of these structures are shown in Exhibit 15, page II-39.

A detention basin is a stormwater control basin designed to hold water when it rains and completely drain afterward. During a rainstorm, a detention basin can store a large quantity of water that will be allowed to discharge slowly. As shown in Table 14, page II-41, there are 159 detention basins in the Wolf Run Watershed and its adjoining karst basins. The average basin is 0.2 acre in size with the majority located on commercial lands. The location of these detention basins is shown in Exhibit 15, page II-39.

TABLE 13 – POLLUTANTS OF CONCERN IN INDUSTRIAL AND HIGH-RISK COMMERCIAL FACILITIES IN THE WOLF RUN WATERSHED AND THE ADJOINING KARST BASINS

Facility	Pollutants of Concern
Frito-Lay	Vehicle maintenance materials such as vehicle fluids, motor oils, vehicle wash water, grease, paint, solvents, batteries, and antifreeze
Oldcastle Precast	Vehicle maintenance materials, wash water detergents, oil and grease, suspended soils, biochemical oxygen demand
KYTC Fayette County Maintenance Lot	Vehicle maintenance materials such as vehicle fluids, motor oils, vehicle wash water, grease, paint, solvents, batteries, and antifreeze.
Fayette County Public Schools Miles Point Way Bus Terminal	Vehicle maintenance materials such as vehicle fluids, motor oils, vehicle wash water, grease, paint, solvents, batteries, and antifreeze.
Marathon Pertoleum	Diesel, gasoline, oils, additives, lubricants, vehicle maintenance materials.
Chevron Products	Diesel, gasoline, oils, additives, lubricants, vehicle maintenance materials.
Sherman Dixie Concrete	Sand, fly ash, admixture, aggregate, grease, oil, paint, fluids from vehicles, silicon, dissolved solids, suspended solids, calcium sulfate, tricalcium aluminates, and tetracalcium aluminoferrite.
Harrods Concrete and Stone	Diesel, gasoline, oils, solid waste (paper, cardboard, etc), concrete additive, limestone dust runoff,
Pepsi-Cola	Diesel, gasoline, oils, corn-syrup receiving station and sugar loading station (Biochemical oxygen demand and chemical oxygen demand)
Red Mile / Tatersalls	Not yet developed
GE Lighting – Lexington Lamp	Oil and grease, alcohol, mineral spirits, lacquer, scap metals, debris, residual flammables

Traditional detention basins are designed to reduce peak flows from large storms in developed areas. However, the smaller and more frequent storm events cause streambank erosion and transport pollution to streams. Traditional stormwater basins do little or nothing to filter out pollutants or slow the runoff velocity for these smaller storms. Detention basins can be retrofitted to manage runoff from smaller storms. In this way, stormwater is retained for longer periods than originally designed, and the velocity of the water discharged from small storms is slowed, reducing erosion and filtering pollutants such as sediments, oils, grease, nutrients, and pesticides. Use of native plants can also reduce the maintenance required for the detention basin.

TABLE 14 – SUMMARY OF STORMWATER CONTROLS

Stormwater Control Type	Number of Controls	Total Acreage	Average Acreage
Detention Basin			
Commercial	143	28.66	0.20
Residential	16	2.85	0.18
Total	159	31.5	0.20
Retention Pond			
Commercial	8	10.02	1.25
Residential	5	11.20	2.24
Total	13	21.2	1.63
Other Controls			
Underground Basins	13	N/A	N/A
Other BMPs	23	N/A	N/A

A retention pond maintains a permanent pool of water and can provide greater improvements in water quality when used to capture and treat stormwater runoff. A retention pond slows incoming runoff and facilitates greater settling of sediment and can filter pollution from runoff through natural bio-chemical activity in the pond. Unlike a detention basin, a retention pond permanently holds water instead of draining within a few days of a rainstorm. As shown in Table 14, there are 13 retention ponds in the Wolf Run Watershed and its adjoining karst basins. The average pond is 1.63 acres in size with the ponds on commercial lands averaging larger in size than those on residential lands. The location of these ponds is shown in Exhibit 15, page II-39.

Retention ponds can be retrofitted to add enhanced removal capacities for suspended solids, nutrient, metals, and fecal coliforms. The retrofit typically involves the enhancement of the littoral shelf, or area in which wetland vegetation can grow. The retention ponds in the Wolf Run Watershed should be evaluated for opportunities to increase water quality improvement capacity.

Each retention pond and detention basin larger than 0.4 acre in the Wolf Run Watershed was inspected and evaluated for its retrofit potential to improve water quality. There were 32 ponds and basins in the Wolf Run Watershed that were evaluated for retrofit potential. Two ponds in LFUCG's inventory larger than 0.4 acre in the watershed were not evaluated. One basin is now a football field at Lexington Catholic High School and has no potential for retrofit. The other basin not inspected is located on Frankfort Court and there were private property and safety issues with this location. The opportunities for retrofit, which were evaluated at the other 32 basins, included extending detention to increase settling of pollutants, improving the channel condition to lengthen the travel time through the basin, promoting infiltration through various practices, and other opportunities such as education of residents and businesses in the vicinity of the basin, litter control, and stabilization of eroded areas. Six basins were identified for retrofit potential, as shown in Exhibit 15, page II-39, located at 1592 Hill View Place, Conn Terrace and Transcript Avenue, 2420 Members Way, 2201 Regency Road, 2350 Norman Lane, and 1100 Nicholasville Road. A Basin Retrofit Data Sheet prepared by Tetra Tech, Inc. for each basin evaluated is included in Appendix A.

As most of these stormwater controls are located on commercial areas, the landowners will have full responsibility for their maintenance. On residential areas, the landowners are responsible for mowing;

removal of algae, litter, small dead trees and branches; maintenance of landscaping, and replanting small bare areas. LFUCG will be responsible for severe erosion, excess silt removal, removal of large debris, and maintenance of structural repairs to pipes and spillways.

Underground basins include underground pipe systems and vaults used to store stormwater. Thirteen underground basins are located in the Wolf Run Watershed with locations at Rosemont Garden, Pasadena Drive, Winnie Street, Red Mile Road, South Broadway, Nicholasville Road, Devonshire Drive, Harrodsburd Road, Versailles Road, and Alexandria Drive. For these facilities, the private property owners are required to conduct all necessary maintenance including annual inspections of the facilities.

Twenty-three other stormwater BMPs are located within the Wolf Run Watershed. These BMPs include water quality units, oil-water-debris separators, baffle boxes, catch basin inserts, and basin filters. For these facilities, the private property owners are required to conduct all necessary maintenance, including annual inspections of the facilities. LFUCG also conducts inspection of all above ground devices every five years to ensure the property manager is maintaining the structures.

5. Sanitary Sewer System and Waste Management

As explained in the Stormwater System section of this plan, the Consent Decree (United States 2006) contains compliance measures that relate to the storm sewer system, sanitary sewer system, and additional environmental projects. In regards to the sanitary sewer system, the Consent Decree is divided into two sections (15 and 16).

Section 15 requires:

A: Capital Improvement Projects and Short-Term Measures
B: Sewer System Assessment (SSA)
C: Pumping Station Design, Capacity and Equipment Condition Adequacy Analysis Evaluation
D: Capacity Assessment
E: Hydraulic Model
F: Reporting (SSA Reports)
G: Sanitary Sewer System and WWTP Remedial Measures Plan

Section 16, Capacity, Management, Operation, and Maintenance (CMOM) Program requires the development of a CMOM Self Assessment with the following activities:

A: Sewer Overflow Response Plan
B: System Capacity Assurance Program
C: Fats, Oils, and Grease (FOG) Program
D: Gravity Line Preventative Maintenance Program
E: Pump Station Operation Plan for Power Outages
F: Backup Power for WWTPs

A Sanitary Sewer Assessment Work Plan (LFUCGb 2008), Hydraulic Model Report (LFUCGc 2008), and Capacity Assessment Work Plan (LFUCGd 2008) have been completed to date, and are available at the USEPA Consent Decree Web Site (http://www.lexingtonky.gov/index.aspx?page=2984).

According to the Sanitary Sewer Assessment Work Plan (LFUCGb 2008), the Wolf Run Watershed contains 96,530 linear feet of trunk sewer, 661,780 linear feet of collection sewer, 24,860 linear feet of force main, six pump stations, and 3,660 manholes. A total of 15 SSOs are located in this watershed according to the assessment, of which 14 are manhole SSOs and one is a lift station SSO. The sanitary sewer lines in the Wolf Run Watershed flow to the Town Branch Wastewater Treatment Plant (WWTP), which discharges into the Town Branch watershed. Exhibits 16 and 17, pages II-44 and II-45, show the locations of the sanitary sewer pipes, treatment plant, pump station, and the locations of the SSOs that have been documented in Quarterly Reports from 2009 to 2010. Most of these SSOs are located in close proximity to Wolf Run streams and tributaries and overflow during sustained rain events.

Due to their recurrence interval and the magnitude of the overflows, several SSOs are worthy of additional note. The Wolf Run Pump Station, located at 755 Enterprise Drive, had nine documented by- passes or overflows from 2009 to the 3rd quarter of 2010. Of these overflows, two were noted to exceed one million gallons in volume. Manhole WR5_9, located at 782 Allendale Drive, is a confirmed cross-connection between the sanitary and storm sewer systems with a pipe connecting WR5_9 to the concrete box culvert adjacent to 801 Lane Allen Road. It was noted to have two overflows in 2010, with a January 24 overflow volume estimated at 162,825 gallons and a May 2 overflow volume of over 3.6 million gallons. Other manholes that had more than one overflow include WR1_56A, WR2_488, WR4_10, WR4_25, and WR4_9 with typical overflows estimated at around 40,000 gallons.

In 2011, the Sanitary Sewer Assessment (SSA) Report and Capacity Assessment for Group One (of which Wolf Run is a part) was completed and the Remedial Measures Plan to address problems in the watershed was completed and submitted to the EPA where it currently is pending final approval. The SSA Report entitled "Group 1 Sanitary Sewer Assessment Report" (LFUCG 2011) is available at http://www.lexingtonky.gov/index.aspx?page=2984.

The Sanitary Sewer Assessment report summarizes information collected during various field activities and emphasizes identifying sources of infiltration/inflow, operational conditions, and structural defects that have the potential to contribute or cause SSOs, and identify cross-connections and unauthorized connections to the sanitary sewer. As a result of the monitoring efforts, the revised draft report indicates that 1,939 manhole defects, 1,101 smoke testing defects (one for every 587 feet inspected, 117 of which were major), one stormwater cross-connection, 10,441 defects of sewer pipes (one for every 25.1 feet inspected) identified by closed-circuit television inspections, seven unique SSO locations, and 42 improperly connected sump pumps (based on questionnaire responses) were identified within Wolf Run. The remedial measures plan will address how these problems are to be addressed.

In addition to the defects identified, the report indicates the inflow/infiltration rates from both rainfall and groundwater, both of which have important relationship to watershed planning. When high levels of rainfall enter into the sanitary sewer system, it causes SSOs to occur, which contributes to fecal pollution and nutrient loading in the watershed. Where groundwater inflow/infiltration rates are high, fecal pollution and nutrient loading may pass from the sanitary sewer to the groundwater via diffusion or exfiltrate from the sanitary sewer to the groundwater when groundwater levels are low. Groundwater infiltration would also contribute to SSOs.

Exhibit 16
Sanitary Sewer System and
Rainfall Inflow/Infiltration
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_16_Sewers&Rainfall.mxd) 1/5/2011 -- 4:36:54 PM sje

Exhibit 17
Sanitary Sewer System and
Groundwater Inflow/Infiltration
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_17_Sewers&Groundwater.mxd) 1/5/2011 -- 10:12:17 AM sje

To express the fraction (expressed as a percentage) of rainfall entering the sewer system as rainfall derived inflow/infiltration, the report uses a term called an R-value (Rational value). A total R-value expresses the percentage of rainfall for the entire basin upstream of the flow meter. An incremental R-value uses a formula to divide the R-values to the sewershed between flow meters. A higher R-value indicates a greater the portion of rainfall is entering the sewer. Exhibit 16, page II-44, shows the incremental R-values for the Wolf Run sewershed. As expected, the locations of the highest rainfall infiltration are upstream of SSOs

Sewer flow rates measured during night flow isolation (NFI) provide an approximate indicator of the groundwater infiltration contribution from the collection system. In the Wolf Run sewershed, night flow isolation measurement locations were selected by dividing the entire sewershed into relatively equal smaller subsewersheds, so groundwater infiltration rates could be estimated by subsewersheds and prioritized. Incremental groundwater contributions estimated from night flow isolation measurements are presented in gallons per day upstream sewer length in linear feet (GPD/LF). Exhibit 17, page II-45, shows the NFI incremental GPD/LF for the Wolf Run sewershed, indicating areas of greatest groundwater inflow/infiltration. For the most part, areas of groundwater and rainfall inflow/infiltration are not well correlated to each another.

Numerous improvements and sewer rehabilitation projects have occurred within the watershed to address some impairments identified in the assessment. Exhibit 18, page II-47, shows the locations of the improvements and rehabilitation projects, by type, which have occurred from April 2008 to January 2011. These improvements include abandoned lines, cured-in-place-pipe (CIPP) rehabilitation, root cuts and cleanouts, installation or replacement of cleanouts, jet lines, landscaping and restoration, manhole replacement or improvement, and special projects. Two illicit discharges were identified and repaired in 2010, removing approximately 835 gallons of daily flow from the sanitary sewer into the watershed. These projects have occurred throughout the watershed area with manhole replacements or improvements being the most common.

The Remedial Measures Plan identifies additional improvements planned within the watershed area. As the USEPA has not given final approval, this plan is still preliminary. However, in the Wolf Run Watershed, the remedial measures plan includes over 32.9 million dollars work of repairs over 10 years and would involve an upgrade to the Wolf Run Pump Station, installation of an equalization tank, and replacement of trunk lines along Bob-O-Link Drive to Picadome Golf Course, along Parkers Mill Road from Cross Keys Park to Wolf Run, and along Wolf Run from the railroad crossing at Southland Drive to the confluence with Town Branch.

In addition to the sanitary sewer system, onsite sewage treatment through septic systems is also a potential source of human fecal pollution. Improper maintenance of the septic tank and its drainfield can cause the system to function improperly and reduce the treatment of the sewage effluent. The Fayette County Health Department was contacted in order to identify the locations of these facilities. Their data is currently maintained in two different databases, one for files between 1986 and 2010 and another from 2011 to the present. Due to the manner in which the data is stored, a map of the location for these systems could not be produced. However, based on review of the listed locations, septic systems are primarily located in the unsewered area in the northwestern portion of the watershed, although at least one facility is located in the urban area. Education on the proper care and maintenance of septic systems may reduce any contribution to pollution from these areas.

Exhibit 18
Sanitary Sewer Improvements
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_18_Sewers_Improvements.mxd) 1/12/2011 -- 12:56:48 PM sje

6. Water Supply Planning

The federal *Safe Drinking Water Act Amendments of 1996* require states to analyze existing and potential threats to each of its public drinking water systems. Source Water Protection Plans assess the quantity of water used in a public water system and formulate protection plans for the source waters used by these systems. The drinking water supply for the Wolf Run Watershed is provided by Kentucky American Water and is withdrawn from the Kentucky River at Pool 9, the reservoir near Jacobson Park. An additional withdrawal at Kentucky River Pool 3 with a 30.1-mile pipeline is under construction. According to KDOW, there are no permitted water withdrawal sites within the Wolf Run Watershed.

Wellhead Protection Plans are used to assist communities that rely on groundwater as their public water source. According to the Wellhead Protection Program of KDOW, there are no Wellhead Protection Plans in the Wolf Run Watershed.

Groundwater Protection Plans (GPPs) are required for anyone engaged in activities that have the potential to pollute groundwater. These activities include anything that could leach into the ground, including septic systems and pesticide storage. The law requires that these facilities have a GPP but does not monitor this requirement. GPPs are required to be recertified every three years and must be updated if activities are changed. KDOW retains the plans indefinitely. According to the Groundwater Branch of KDOW, there were three GPPs on file for facilities in the Wolf Run Watershed. These facilities include:

- Picadome Golf Course (AI 1086), 469 Parkway Drive
- Virginia Avenue Shell (AI 66131), 902 South Broadway
- Lexington-Fayette County Public Works Building & Yard (AI 55565), 1555 Old Frankfort Pike

Kentucky Administrative Regulation 401 KAR 5:037 does not require Groundwater Protection Plans (GPPs) to be submitted to the Cabinet for review and approval unless called in by Department for Environmental Protection inspectors, the Groundwater Section of the Watershed Management Branch, or Division of Enforcement. In order to ascertain whether a facility has a GPP, the Groundwater Section highly recommends that a door-to-door survey be conducted within the watershed. Please note that a Stormwater BMP Plan or SPCC Plan is not a substitute for a GPP. Any facilities conducting activities subject to 401 KAR 5:037 that do not have a GPP should contact Patricia Keefe of the Kentucky Division of Water.

7. Watershed Management Activities

a. Kentucky River Basin Management Plan

In 2002, the Kentucky Watershed Management Framework completed the "Kentucky River Basin Management Plan (KWRRI 2002). This plan included summaries of each of the 97 watersheds in the Kentucky River basin. Wolf Run was analyzed as part of the South Elkhorn Creek watershed, one of three priority watersheds for the Kentucky River basin for which action plans were developed. Concerns about impacts to the Wolf Run Watershed included urban runoff via storm sewers, stormwater pollutants, solid waste, fecal coliforms, loss of riparian/streamside buffers, increase in impervious cover, and flooding in agricultural bottlomlands as a result of rapid runoff from impervious surfaces. Actions to respond to these concerns included a stormwater education campaign to draw attention to storm sewers, identification of facilities that need KPDES permits or are routing effluent to sanitary sewers, promotion of riparian revegetation, assistance for McConnell Springs contamination, cleaning up of solid wastes in and near

streams, addressing sedimentation due to poor urban construction practices, identifying sources of nutrient load, addressing sanitary sewer overflows, and investigating treatment options for stormwater runoff.

b. Greenway Master Plan

Greenways are linear corridors that can provide critical linkage and protection of natural and cultural resources. Issues, such as flooding, transportation, water quality, habitat loss, historic preservation, economic stimulation, recreation, and fitness can be addressed and resolved by a multi-objective greenway system. In 2001 as part of the comprehensive plan, LFUCG developed the *Lexington-Fayette County Greenway Master Plan* (LFUCG 2001) in order to communicate the importance and need for greenways, and recommends a county-wide system of interconnected greenways.

Within the plan, numerous trails, greenways, are noted within the Wolf Run Watershed, as shown in Exhibit 19, page II-50. The plan discusses the Wolf Run Conservation Greenway Corridor, Cardinal-Waverly Greenway Trail, Citation Greenway Trail, Lafayette Greenway Trail, Manchester/McConnell Greenway Trail, and the Veterans Greenway Trail.

The Wolf Run Conservation Greenway is described as including Wolf Run and its tributaries, including Vaughn's Branch. The objectives for this greenway include floodplain reclamation, flood reduction, preservation of floodplains and habitat, improving water quality, and providing open space. The 100-year floodplain has been severely encroached upon by development, and homes have been bought out for floodplain reclamation along Roanoke Road and Furlong Drive, along Lane Allen Road, and in the Kilrush and Deauville areas. The Greenway Master Plan recommends that the LFUCG purchase and preserve undeveloped floodplains, particularly along Alexandria Drive, Old Frankfort Pike, and upstream of Versailles Road. Park properties adjacent to the Greenway include Valley Park, Wolf Run, Cross Keys, Pine Meadows, Preston Springs and Picadome Golf Course. James Lane Allen Elementary School is also located on Wolf Run.

With trails that follow the Wolf Run Conservation Greenway, opportunities may exist for stream enhancements in conjunction with trail construction. For instance, water quality enhancement and flood control measures are noted as objectives for the Cardinal-Waverly Greenway Trail.

c. Stream Restoration, Conservation Efforts, and Grants

Stream restoration, conservation efforts, and water quality grants are ongoing in the Wolf Run Watershed. Some of the more prominent projects and programs in the watershed include the McConnell Springs stormwater quality wetland pond construction, Reforest the Bluegrass, LFUCG's Lily Raintainer Program, the Bluegrass Rain Garden Alliance, and grants through LFUCG's Stormwater Quality Projects Incentive Grant Program. The locations of some of these projects are shown in Exhibit 20, page II-51

The Reforest the Bluegrass program was started in March of 1999 as a cooperative effort between the Lexington-Fayette Urban County Government's Water Quality, Urban Forestry, and Parks and Recreation management programs. Its purpose is to recreate pre-settlement, streamside forests that were once native to the Inner Bluegrass Region of Kentucky. Today, through the efforts of thousands of volunteers, Lexington is progressively restoring those long-lost benefits of streamside forests (riparian buffers) for generations to come. This is a crucial step to protecting our valuable water resources and enhancing our living standards. Reforest the Bluegrass uses beneficial qualities of native species of trees to bring natural balance to our ecosystems. To date, Reforest the Bluegrass has not addressed any Wolf Run Watershed streams.

Exhibit 19
Parks, Greenways, and Trails
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_19_Parks&Greenways.mxd) 1/12/2011 -- 1:40:51 PM sje

Exhibit 20
Water Quality Projects
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_20_Water_Quality_Projects.mxd) 1/12/2011 -- 1:37:43 PM sje

Under its Lily Raintainer Program, LFUCG, on a supply-limited basis, provides a program that allows residents to save water, prevent storm-water runoff, and improve water quality. Under the program, residents are responsible for installation of the Lily Raintainer, and they agree to allow an LFUCG Division of Environmental Quality inspector access to the premises in order to verify installation, if selected, for random inspection. The raintainer, or rain barrel, is to remain operational for five years. The Lily Raintainers are available for $75.

The Bluegrass Rain Garden Alliance is an initiative towards building a better Bluegrass by supporting the construction of rain gardens. It is the result of combined effort by LFUCG, Tracy Farmer Center for the Environment, Kentucky Department of Fish and Wildlife, Bluegrass PRIDE, EcoGro, and CDP Engineers. The mission of the Alliance was to build "2010 Rain gardens by 2010." Only 113 have been built to date under the project, but the Alliance continues to offer support for the use of rain gardens as a stormwater management tool.

In 2003, KDOW awarded $314,114 Section 319(h) grant funds to LFUCG to restore the McConnell Springs stormwater quality wetland pond. The McConnell Springs Stormwater Quality Wetlands Pond Project was completed in 2009, satisfying this grant. The stormwater pond controls the impact of stormwater into McConnell Springs, provides education in proper stormwater practices, increased the capacity of the area to address stormwater, and improved habitat for birds, fish, and other animals. This structure was monitored in 2010 to evaluate the water quality benefits of the project. The results of this monitoring are summarized later in this report.

Through funding from the Federal Emergency Management Agency (FEMA) Hazard Mitigation program, the Kentucky Division of Emergency Management and LFUCG, the $2.1 million dollar Sugar Mill/Vaughn's Branch Hazard Mitigation Project was completed in 2009. The project included construction of a 7.2-acre detention basin on Vaughn's Branch upstream from Versailles Road (behind Cardinal Hill Hospital as shown on Exhibit 20, page II-51) with the widening of approximately 1,000 linear feet of channel and installation of box culverts above the detention basin and for the widening of approximately 1,100 linear feet of channel and installation of box culverts below the basin. The project was intended to allow stormwater to drain more quickly under Versailles Road. Sanitary sewer lines were also improved and trees were planted in the detention basin to stabilize the banks as part of the project.

Under the LFUCG's Stormwater Quality Projects Incentive Grant Program, multiple projects within the Wolf Run Watershed have been funded. In 2010, the following projects were funded within the Wolf Run Watershed and are shown in Exhibit 20, page II-51.

- The Friends of Wolf Run, Inc.: $5,000 for water sampling for specific human pathogens and surveying of healthcare practitioners for evidence of waterborne disease in patients. The goal of this project is to analyze surface waters in the Wolf Run Watershed for the presence of specific human pathogens, assess the local population for the presence of waterborne disease caused by these pathogens, analyze the findings, and use the results to educate the local governments, the healthcare community, and the public, and assist with efforts to improve water quality and human health. The target completion date for the effort was May 2011.
- The Friends of Wolf Run, Inc.: $5,000 for stream cleaning and planting native species along eight stream reaches within the Wolf Run Watershed and developing volunteer group leadership for future projects.

- Southern Heights Neighborhood Association, Inc.: $40,630.40 to replace 3,895 square feet of existing asphalt pavement with a permeable paver system; tree planting by volunteers along the edge of the pavers; installation of an educational sign explaining pervious pavement and how it improves water quality and reduces runoff.
- Clays Mill Elementary School: $57,800 for design of a project to restore 800 feet of degraded stream; three constructed wetlands; two rain gardens and a biofiltration swale; installation of pervious pavement.
- Ronald McDonald House Charities of the Bluegrass, Inc.: $201,285 for the design and construction of 15,700 square feet of pervious pavement; rainwater harvest cistern for stormwater reuse; two rain gardens and a biofiltration swale.
- Good Foods Market and Café: $2,600 for the installation of two National Environmental Compliance Stormwater Filter catch basin inserts.
- Rosa Parks Elementary School: $6,700 for an outdoor learning space at the elementary school to include a portable water table with moveable dams used for teaching about surface water flow and water movement; tiered walking paths as part of a larger nature trail.

UK is conducting a Flood Mitigation Project near the intersection of Danzler Drive and Nicholasville Road. The project is intended to provide 100-year storm mitigation to prevent roadway overtopping and improve pedestrian safety. It involves excavation of additional stormwater detention along Shawneetown Drive, upgrading the existing culvert at the upstream side of Nicholasville Road, and replacement of impervious pavement in portions of the Commonwealth Stadium parking lot with pervious pavement. The project cost of over $8 million dollars is funded by a FEMA federal grant. Completion of the final construction is planned for August 19, 2013.

M. Regulatory Status of Waterways

Kentucky assigns designated uses to each of its waterways, such as recreation, aquatic habitat, and drinking water. For each use, certain chemical, biological, or descriptive ("narrative") criteria apply to protect the stream so that its uses can safely continue. The criteria are used to determine whether a stream is listed as "impaired" in the 303(d) list (KDOW 2010a) and therefore needs a watershed based plan or TMDL computations and load allocations. Exhibit 21, page II-54, shows the regulatory status of waterways in the watershed.

1. Designated Uses

The designated uses of Wolf Run and its tributaries include warm water aquatic habitat (WAH), fish consumption, primary contact recreation (PCR), and secondary contact recreation (SCR). The WAH criteria are in place to protect aquatic life that inhabits streams. PCR criteria are in-place to protect people recreating in a way that likely will result in full body immersion in the water body, such as swimming.

Secondary Contact Recreation (SCR) designated use criteria are in place to protect those recreational activities that are likely to result in incidental contact with water, such as boating, fishing, and wading. Fish consumption is not a designated use in Kentucky water quality standards, but the use is implied in 401 KAR 10:031 Section 2 and through human health criteria in Section 6. The fish consumption use is based on waterbody specific monitoring and comparing the fish tissue body burden results for specific pollutants (*e.g.*, mercury, PCB, chlordane) in our water quality standards that apply.

Exhibit 21
Regulatory Status of Waterways
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_21_Regulatory.mxd) 1/12/2011 -- 1:48:30 PM sje

2. Designated Uses Impairment Status

Streams are assessed to determine whether they support their designated uses. Each stream receives one of three classifications to denote relative level of designated use support: fully supporting (good to excellent water quality); partially supporting (fair water quality, does not fully meet designated use); and nonsupporting (poor water quality). Streams which are either partially supporting or nonsupporting their designated uses are listed on the 303(d) list of impaired surface waters of Kentucky.

According to the 2010 303(d) list (KDOW 2010a), Wolf Run is impaired from mile 0.0 to 4.4 for WAH (partially supporting), PCR (nonsupporting), and SCR (nonsupporting). Three pollutants are listed as impairing the waterway: fecal coliform, nutrient/eutrophication biological indicators, and specific conductance. Suspected sources are listed as channelization, loss of riparian habitat, unspecified urban stormwater, and urban runoff/stormsewers.

Although not listed on the 2010 303(d) list, Gardenside Spring and McConnell Springs were found to be impaired by the KDOW during sampling conducted for the pathogen TMDL. The proposed draft TMDL report constitutes the public notice required to list these waterbodies as impaired for PCR (nonsupporting) use due to suspected sources of unspecified urban stormwater and urban runoff/storm sewers. Gardenside Spring (also known locally as Holly Spring) emerges from a spring box that is located within a green space (*i.e.*, a city park) inside Lexington's Gardenside Neighborhood. It is located along the left bank (or south side) of Wolf Run, discharging at RM 3.05.

3. Total Maximum Daily Load

The KWRRI has developed proposed draft pathogen (Ormsbee *et al.* 2011) and nutrient (Ormsbee and Blandford 2010) TMDLs that have been submitted to KDOW. The pathogen TMDL for the South Elkhorn watershed was made available for public comment on December 1, 2011. The nutrient TMDL is still pending.

a. Nutrients (Phosphorus)

A draft nutrient TMDL was initially developed for the Town Branch watershed based on data collected in 2000 (Ormsbee and Blandford 2010). The initial TMDL for Town Branch was set to meet an allowable in-stream total phosphorus concentration target of 0.5 mg/L in South Elkhorn Creek during the summer period of May 1 through October 31 and a concentration of 1.0 mg/l during the winter period of November 1 through April 30. The target was set based on a consideration of stream dynamics and phosphorus levels associated with the natural geology in both the Town Branch and South Elkhorn watersheds. The background geological level was assumed to be 0.25 mg/L.

The current draft TMDL specifies a target concentration of 0.30 mg/L of total phosphorus for the MS4 component of the waste load allocation, which includes the Wolf Run Watershed. However, KDOW has not yet approved the draft TMDL. Therefore, this target concentration is considered a non-regulatory reference point to evaluate phosphorous concentrations in the watershed.

b. Pathogens

A proposed draft pathogen TMDL was developed for the South Elkhorn watershed based on data collected in 2002 (Ormsbee *et al.* 2011). The proposed draft "Total Maximum Daily Load for Fecal Coliform and *E. coli,* 9 Stream Segments and 2 Springs within the South Elkhorn Creek Watershed, Fayette, Franklin,

Jessamine, Scott, and Woodford Counties, Kentucky," as it is entitled, assigns the loads to wasteload allocation (KPDES point sources, MS4 sources from developed lands, and a future growth allocation) and load allocation (MS4 sources from non-developed lands, and non-MS4 sources including both developed and non-developed sources). A margin of safety was enforced through the adoption of conservative modeling assumptions. The difference between the allowable load and the initial conditions is the reduction required. The document specifies TMDLs for Wolf Run for stream miles 0.0 to 4.4 as well as for McConnell Springs and Gardenside Spring, which are in the Wolf Run drainage.

For Wolf Run, the fecal coliform TMDL was established at 8.55E+11 colonies/day with 3.20E+10 colonies/day allocated specifically to developed MS4 loads from Lexington, UK, and the Kentucky Transportation Cabinet, 4.28E+10 colonies/day allocated to future growth and 7.80E+11 colonies/day to other sources. In order to reduce loads to levels below the TMDL, the document assumes load reductions of 50 percent from developed lands, 25 to 50 percent from livestock sources, 100 percent from in-stream cattle sources, and no reduction for wildlife sources.

The TMDL also assumes a 100 percent reduction in illegal loading attributed to point sources including straight pipes, failing septic systems, SSOs, leaking sewers, or cross-connections with existing storm sewers. A significant fecal load was observed in the Vaughn's Branch watershed, hypothesized to be coming from SSOs, leaking sewers, or potentially from runoff from the Red Mile racetrack. This load was estimated at 4.27E+12 colonies/day. A load of 1.25E+09 colonies/day was estimated to be due to failing septic systems, and 6.82E+10 colonies/day was estimated to be due to straight pipes.

For McConnell Springs, the fecal coliform TMDL was established at 5.87E+09 counts/day with 4.35E+09 colonies/day allocated to the MS4 from Lexington and Kentucky Transportation Cabinet, 2.64E+08 colonies/day allocated to future growth and 6.68E+08 colonies/day allocated to other sources. The TMDL endpoint for the watershed is 360 fecal coliform colonies/100ml (400 colonies/100ml minus a 10% Margin of Safety).

For Gardenside Spring, the *E. coli* TMDL was established at 2.94E+08 colonies/day with 2.18E+08 colonies/day allocated to the MS4 from Lexington and Kentucky Transportation Cabinet, 1.32E+07 colonies/day allocated to future growth and 3.34E+07 colonies/day allocated to other sources. The TMDL endpoint for the watershed is 216 *E. coli* colonies/100ml (240 colonies/100ml minus a 10 percent Margin of Safety).

The report indicates the suspected sources of pathogen loading for the springs are 1) urban runoff from developed areas and non-developed areas including domestic pets and urban wildlife, 2) sewage from SSOs and sewer cross-connections, 3) possibly failing onsite wastewater treatment systems (4 predicted in the Wolf Run Watershed) or straight pipes (nine predicted in the Wolf Run Watershed), and 4) the Red Mile Racetrack (for McConnell Springs).

N. Visual Observations

In an effort to improve the problem investigation monitoring, the LFUCG Division of Water Quality Compliance and Monitoring Section conducted "Stream Assessments" of the watersheds within the Urban Service Area in 2010/2011. The streams were visually assessed for five categories of features including: trash and debris, utilities crossings, stormwater outfalls, stream crossings, and severe erosion areas. During the assessment features were documented with photographs, GPS coordinates, and datasheets.

There were 264 outfalls identified along Wolf Run streams, of which 237 were closed pipes, ranging in size from 1.5-inches to 4-foot by 10-foot box outfalls, and 27 were open drainageways including concrete flumes and grassy swales. Fifteen outflows had flow present, of which three were from upstream sources such as blue line/intermittent streams or ponds. Three were tested for ammonia, detergent, and chlorine and it was determined these had groundwater flow while the others were storm flow which ceased when revisited.

Fifty-three utility crossings were documented during the survey; seven were exposed manholes, 45 were exposed sanitary pipes, and one was a sanitary sewer overflow point. Two PVC lateral crossings were noted to have been changed to ductile iron and one area of exposed sanitary sewer in the stream bank was recently stabilized. A concern about woody debris accumulation was also forwarded to the sanitary sewer line maintenance.

There were 18 areas of severe erosion identified in the watershed, as shown in Exhibit 22, page II-58. Some were in areas difficult to access, other areas were encroaching on property fences, and other areas could easily be stabilized, such as the Picadome Golf Course. All of the most severe erosion areas had good accessibility.

A total of 114 stream crossings were found, including three culvert crossings, seven driveways, nine fences, 28 foot bridges, eight manmade dams, four railroads and 54 road crossings. These locations are shown in Exhibit 22, page II-58.

There are 19 significant trash and debris sites noted watershed, as shown in Exhibit 22, page 58. Of these, six are woody debris locations and the rest have varying amounts and types of trash. Volunteer groups could pick up most of the trash although local government would be necessary to remove large trash and debris in some areas. A contractor was hired by LFUCG to remove a large amount of debris from the Picadome sinkhole during 2011.

Debris Accumulation at Picadome Sinkhole Prior to Cleanup

O. Summary and Conclusions

Based on review of the data available on the watershed information available, the Wolf Run Watershed is a highly developed urban watershed with 86 percent developed with commercial, industrial, or residential land use. Associated with the development is a high percentage of impervious surfaces (40 percent), which rainwater cannot penetrate, causing high runoff and flow rates during storm events and associated erosion and pollution. Nearly half of the watershed is comprised of residential land use, which also accounts for approximately half of the impervious surface, indicating that numerous stakeholders will have a role in reducing stormwater impacts in the watershed. Large commercial shopping centers and industrial complexes represent other large contributors to the imperviousness of the watershed. Although 18 KPDES dischargers and 11 industrial or high-risk commercial facilities are located in the Wolf Run Watershed, these facilities appear to be in compliance indicating a greater contribution of nonpoint sources to watershed impairments. However, point sources such as SSOs and failing sewer infrastructure are contributing to impairments in the watershed.

Exhibit 22
Visual Stream Assessment Features
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_22_LFUCG_Stream_Assessments.mxd) 9/12/2012 -- 1:53:57 PM sje

With the developed nature of the watershed, there is also a high degree of encroachment upon the stream riparian zone and floodplain. Many of the headwater streams in the Wolf Run watershed have been straightened, channelized, placed in a culvert, or otherwise paved or armored. Just over half of the streams have a riparian zone wide enough to provide stream stabilization or water quality benefits and even fewer provide flood attenuation or riparian habitat. Many of the streams in the watershed are entrenched and cannot access their floodplain. Other streams have development on both sides of the stream, limiting opportunities for restoration or re-meandering without significant expense in property acquisition.

The Wolf Run Watershed also has unique challenges due to the geology of the watershed. With a heavy karst influence including numerous springs and unique features such as McConnell Springs and Preston's Cave, treatment of stormwater by infiltration may not be a feasible BMP in much of the watershed. Also, tracing of sources may be difficult due to sinking streams and misbehaved karst systems. These geological features also contribute to extended periods where streams go dry and a lack of wetlands throughout the watershed.

With the challenges of the watershed, there are also numerous signs of hope. The watershed has been the subject of multiple scientific research studies and inventoried, providing ample data to trace impacts to their source. Under Consent Decree Requirements, the sanitary sewer has been assessed and remedial measures have been developed and include replacement of most trunk lines in Wolf Run over a 10-year period. These efforts are intended to eliminate the numerous sanitary sewer overflows associated with two-year storm events. The storm sewer system has also been inventoried such that pollutants may be traced upstream to possible sources. Large detention and retention basins have also been assessed for retrofit potential aiding implementation planning. The streams have all been visually surveyed, indicating numerous locations for litter control, potential utility impacts, erosion, and other features. Numerous management activities have also recently been completed, planned, or are in progress, indicating that momentum for improving water quality is already underway. This momentum will be necessary to address the recreational use and warmwater aquatic habitat uses of Wolf Run and its tributaries.

CHAPTER III. MONITORING

A. Existing Monitoring

In order to evaluate the water quality within the Wolf Run Watershed, data was gathered from all available sources including scientific studies, government, and volunteer sources. Table 15 provides an overview of the available data that was gathered as a result of this collection effort.

TABLE 15 – WOLF RUN WATERSHED MONITORING DATA SUMMARY

Sampling Organization	Monitoring Type / Source	Stations Sampled	No. of Sampling Events	Years Sampled	Macroinvertebrates	Fish	Fecal Coliform / *E. coli*	Physicochemical	Nutrients	Total Suspended Solids	Metals	Pesticides / Herbicides	Volatiles / Semi-volatiles
LFUCG	MS4 Stormwater Permit Monitoring	2	68	1999-2011	X	X	X	X	X	X	X		
LFUCG	Golf Course Ponds and Streams	1	2	2010			X	X	X	X			
LFUCG, FOWR	McConnell Springs Stormwater BMP	5	9	2010				X	X	X	X		
UK KWRRI	South Elkhorn Pathogen TMDL	4	10	2002			X						
UK KWRRI	Town Branch Nutrient TMDL	1	2	2000					X				
UK KWRRI	Town Branch Nutrient Sampling	4	13	2009-2010				X	X	X			
UK ERTL	Fecal Source Tracking	24	1 to 10	2007-2008, 2010			X						
KRWW	Volunteer Sampling	7	Varies	1999-2011			X	X	X	X	X	X	
FOWR	Volunteer Conductivity Survey	303	1	2010				X					
KDOW	Groundwater / Spring Sampling	3	6 to 18	2004-2007			X		X	X	X	X	X

NOTE: Organizations abbreviated as follows: LFUCG=Lexington-Fayette Urban County Government, KRWW = Kentucky River Watershed Watch, UK KWRRI = University of Kentucky Water Resources Research Institute, UK = University of Kentucky, UK ERTL, University of Kentucky Environmental Research and Training Laboratory, KDOW= Kentucky Division of Water, FOWR = Friends of Wolf Run

Generators of water quality data for the watershed include LFUCG, Kentucky River Watershed Watch (KRWW), University of Kentucky Water Resources Research Institute (UK KWRRI), University of Kentucky Environmental Research and Training Laboratory (UK ERTL), KDOW, and Friends of Wolf Run. These studies were conducted at differing monitoring locations throughout the watershed over multiple years and for different parameters. Exhibits 23 and 24, pages III-2 and III-3, show the locations of the monitoring sites from which the water quality data was collected. In addition to the monitoring performed at designated sites, the LFUCG Division of Water Quality Compliance and Monitoring team conducted visual stream assessments by walking the streams.

Each of these data sources is described in further detail in the sections following. For studies that are planned or in-progress, the monitoring plan of the study is summarized.

Exhibit 23
Existing Monitoring Sampling Locations
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_23_Sampling_Sites.mxd) 9/25/2012 -- 1:53:57 PM sje

Exhibit 24
Fecal Source Tracking and Volunteer Sites
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_23_Fecal_Source_Tracking_Hot_Spots.mxd) 1/5/2011 -- 4:52:02 PM sie

1. Lexington Fayette Urban County Government Monitoring

The LFUCG conducts monitoring in conformance with its MS4 permit for each of the watersheds within the Urban Service Boundary. The monitoring program was initiated in the spring of 1996 with two stations (WR-S1 and WR-S2) located in the Wolf Run Watershed. Table 16 indicates the types of sampling conducted at these sites from 1999 to 2010. Wet weather chemical sampling was conducted as composite sampling during storm events sporadically in the years from 1999 to 2008. Prior to 1999, the parameters sampled for chemical parameters varied from year to year. However, solids (total dissolved and suspended), fecal coliform, oil and grease, cadmium, copper, lead, zinc, hardness, phenols, phosphorus (dissolved and total), nitrogen (ammonia, total kjeldahl, nitrate, nitrite), biochemical oxygen demand, chemical oxygen demand, specific conductance, dissolved oxygen, temperature, pH, and turbidity were routinely sampled over this period. Discharge and *E. coli* were added to this sampling list in the fall of 2008 when the chemical sampling frequency was increased to quarterly dry weather and wet weather sampling. WR-S1 was also dropped as a routine sampling site at this time.

TABLE 16 – SUMMARY OF MS4 PERMIT SAMPLING EVENTS

Sampling Type	Sampling Events / Year												
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
WR-S1													
Chemical Dry Weather		2	2	2	1	1	1	1	1				11
Chemical Wet Weather		1*						1*	2*				4
Habitat	Monitoring Protocols Changed 2003				1	1	1	1	1	1			6
Macroinvertebrate					2	2	2	1	1	1			9
Fish					1	1	1	1	1	1			6
WR-S2													
Chemical Dry Weather	1	2	2	2	1	1	1	1	1	1	4	4	21
Chemical Wet Weather		1*						1*	1*	1	4	4	12
Habitat	Monitoring Protocols Changed 2003				1		1	1	1	1	1	1	7
Macroinvertebrate					2	1	2	1	1	1	1	1	10
Fish					1	1	1	1	1	1	1	1	8

**Indicates composite sampling during storm events.*

Although biological sampling has occurred since 1996, the monitoring and analysis protocols were updated in 2003 such that data from this period onward is comparable. Current KDOW protocols have been utilized throughout the duration of the sampling. Sampling for habitat, macroinvertebrates, and fish have occurred at these sites with WR-S1 being dropped for monitoring in 2009.

The most recent results are summarized in the *Lexington-Fayette Urban County Government 2011 Monitoring Program Evaluation Report* (Remley 2012). Appendix G of the annual monitoring program evaluation report also contains a detailed analysis of the water quality in Wolf Run. Wolf Run Watershed monitoring data from 1999 through 2011 for the current monitoring site, WR-S2, and from 1999 to 2008 for the historic site, WR-S1, are summarized in Table 17, page III-5. These ratings were developed by comparison to LFUCG benchmarks. Of the parameters measured, the results demonstrated "good" water quality for most parameters at all sites, including water temperature, pH, dissolved oxygen, suspended solids, oil and grease, phenols, phosphorus, cadmium, copper, and lead. Several parameters exceeded benchmarks at both monitoring sites including dissolved solids/conductivity, nitrogen, and *E. coli*/fecal

coliform. Zinc was found to be "poor" at WR-S1. Habitat and macroinvertebrate community rated "poor," and fish community "fair" at WR-S2, which was slightly worse than WR-S1.

TABLE 17 – SUMMARY OF MS4 PERMIT WATER QUALITY MONITORING DATA

Parameter	WR-S1 Water Quality Status	WR-S2 Dry Weather	WR-S2 Wet Weather
Conductivity / Dissolved Solids	Poor	Poor	Poor
Water Temperature	Good	Good	Good
pH	Good	Good	Good
Dissolved Oxygen	Good	Good	Good
Suspended Solids	Good	Good	Good
Oil & Grease	Good	Good	Good
Phenols	Good	Good	Good
Phosphorus	Good	Good	Good
Nitrogen	Poor	Poor	Fair
E. coli / Fecal Coliform	Very Poor	Poor	Very Poor
Cadmium, Copper, Lead	Good	Good	Good
Zinc	Poor	Good	Good
Habitat	Fair	Poor	
Macroinvertebrate	Poor	Poor	
Fish	Good	Fair	

Dissolved solids/conductivity was "poor" at WR-S2 during both dry and wet weather conditions. Total nitrogen was "poor" at WR-S2 during dry conditions and "fair" during wet conditions. Nitrogen levels met benchmark criteria for only 36 percent of the dry weather samples and 69 percent of the wet weather samples. *E. coli* and fecal coliform levels were "poor" during dry events and "very poor" during wet events. Because both dry weather and wet weather samples regularly exceeded the regulatory limit, the source is not solely attributable to runoff related sources. However, the highest loads were primarily observed during wetter conditions, suggesting that the elevated fecal coliform was more associated with nonpoint source runoff events or sewer failures occurring during storm events.

The habitat at WR-S2 was the only site to have a "poor" rating in 2011. Reduced riparian zone vegetation protection and width and unstable banks contributed to the low habitat score for WR-S2. These conditions most likely contributed to the substrate embeddedness and sediment deposition observed at WR-S2, which further impaired the aquatic habitat. The macroinvertebrate community of WR-S2 has consistently rated "poor" throughout its sampling history from 2003 to 2011. High specific conductance levels and substrate embeddedness probably contributed to low taxa richness, EPT richness, and EPT abundance at WR-S2. Low values for these metrics contribute to the "poor" rating for WR-S2 throughout its sampling history from 2003 to 2011. The fish community rating at WR-S2 has been somewhat variable over its sampling history, ranging from "fair" to "excellent." Recently there has been a decline from an "excellent" rating in 2010 to "fair" in 2011. A decline in insectivore abundance and an increase in facultative headwater and tolerant species abundances were primarily responsible for this decline.

In addition to these monitoring stations, according to the MS4 permit, dry weather screening is to be performed at 125 locations per year throughout the permit area as wells as at all major outfalls and

90 percent of industrial outfalls every two years. In 2011, a total of 34 sites (shown in Exhibit 23, page III-2) were screened in the Wolf Run Watershed, with each site being screened twice. Fifteen of the screened sites had dry weather flow. Neither total copper nor total phenols were detected at any of the sites in 2010 or 2011. Of the 15 sites with dry weather flow, total dissolved solids exceeded 325 mg/L at all sites, total residual chlorine was detected at 10 sites, ammonia was detected at eight sites, and detergents did not exceed 0.25 mg/L at any site. These results indicate that the stormsewer system is contributing total dissolved solids as well as ammonia and nitrogen to the overall pollutant load.

In addition to the monitoring required for regulatory purposes, LFUCG has also conducted voluntary monitoring including background water quality sampling and BMP monitoring.

As shown in Exhibit 23, page III-2, nine samples were collected at five background water quality sites during two sampling events in 2011. The purpose of this sampling was to monitor portions of the Urban Services not captured by the MS4 permit sites, to increase geographic resolution in headwater areas, and to provide additional data for use in illicit discharge detection and elimination (IDDE) investigations. Although the samples were generally collected in dry weather conditions, no specific antecedent dry period was utilized to schedule monitoring. The data quality objectives for sensitivity, precision, and accuracy specified in the SWQMP were utilized in the sampling. The results, evaluated against the benchmarks detailed in this report, are shown in Table 18. This additional monitoring indicates that conductivity, *E. coli*, fecal coliform, nitrogen, and zinc are elevated at each of these locations.

TABLE 18 – 2011 LFUCG BACKGROUND WATER QUALITY MONITORING RESULTS IN WOLF RUN

Location	Cond (Field) uS/cm	DO (Field) mg/L	Temp °C	pH (Field) SU	TSS mg/L	*E. Coli* CFU/100mL	Fecal Coliform CFU/100mL	Zn mg/L	Phosphorus, Total mg/L	Ammonia mg/L	Nitrogen, Total mg/L
WR-S20	684	9.20	13.7	7.77	4	4080	2720	0.036	0.269	0.063	1.51
WR-S20	627	6.90	22.3	7.76	29	5040	4960	0.023	0.534	0.039	7.36
WR-S21	954	9.70	15.1	8.35	4	850	1580	0.055	0.232	0.054	1.32
WR-S21	1234	7.33	22.9	7.96	6	1340	1460	0.123	0.321	0.057	4.08
WR-S23	397	14.40	11.9	8.39	4	520	630	0.023	0.287	0.051	1.36
WR-S24	410	12.70	12.6	8.37	9	1340	1600	0.028	0.341	0.049	1.29
WR-S24	547	13.33	24.5	8.28	4	960	2560	0.013	0.313	0.032	5.63
WR-S25	470	9.70	13.5	8.07	6	1200	980	0.018	0.310	0.035	1.54
WR-S25	517	8.98	22.3	7.84	5	6890	5650	0.015	0.000	0.027	6.76

LFUCG also performed two rounds of sampling on the Picadome Golf Course in March and May 2010. Results showed high conductivity and total dissolved solids (greater than 1000 µS/cm, and 500 mg/L, respectively) as well as elevated bacterial levels (*E. coli* and fecal coliform above 700 and 1000 cfu/100mLs, respectively). Phosphorus (0.302 mg/L), ammonia (0,191 mg/L), and nitrate (16.7 mg/L) were high in March, and nitrate (8.27mg/L) was still elevated when sampled again in May. Low flow conditions were noted during both sampling events.

The McConnell Springs Stormwater Quality Wetlands Pond Project was completed in 2009 using combinations of settling basins, nutrient separating baffle box structure, and polishing lagoon. Sampling was conducted by Friends of Wolf Run and McConnell Springs Nature Center staff trained students throughout 2010 and 2011 with emphasis on capturing runoff samples during storm events. Four sampling

sites were initially identified (M1-M4), with an additional site (M5) added later in the year. Bimonthly samples were collected in 2010 and 2011. On-site measurements included: temperature, pH, ortho-phosphorus, dissolved oxygen, conductivity, total dissolved solids, and salinity. Additional analysis included: alkalinity, hardness, carbonaceous biological oxygen demand, total suspended solids, total ammonia, nitrate, nitrite, total phosphorus, orthophosphate, bacterial cultures (*E. coli* and other coliforms), and turbidity. Analyses of metal samples were conducted by the Kentucky Geological Survey (KGS) Laboratory. The sampling results indicate that the BMP is successful in providing reductions in total suspended solids, phosphorus, ammonia, nitrogen, and some metals as water passes through the system.

2. University of Kentucky TMDL Monitoring

a. Pathogen

Data was collected by UK KWRRI from the Wolf Run Watershed in support of a draft pathogen TMDL at four sampling sites during 10 sampling events in 2002 (Ormsbee *et al.* 2010). The data is summarized in Table 19. Of the three sites sampled, W2 on Vaughn's Branch showed the most consistently high fecal coliform counts, but all sites exceeded the instantaneous primary contact recreation limit (400 CFU/100mLs) consistently. The counts for the site on Vaughn's were much higher than would normally be associated with nonpoint sources. The draft TMDL hypothesized that these increased loadings were primarily due to sanitary sewer overflows (SSOs or leaking sewers) or potentially from runoff from the Red Mile racetrack. As shown in Exhibits 23 and 24 (pages III-2 and III-3) multiple SSOs are present upstream of this site as well as areas of high groundwater and rainfall sewer inflow/infiltration. The increased concentrations are most likely due to these sources.

TABLE 19 – FECAL COLIFORM RESULTS (2002) IN SUPPORT OF THE DRAFT PATHOGEN TMDL

Date	W1 (cfu/100ml)	W2 (cfu/100ml)	W3 (cfu/100ml)	W4 (cfu/100ml)
5/31/2002	204	796	946	889
6/17/2002	671	7,801	1,883	1,693
6/26/2002	540	10,173	342	2,527
6/29/2002	883	6,291	21,898	3,562
7/10/2002	3,407	54,480	29,595	8,322
7/16/2002	479	6,662	2,530	1,379
7/30/2002	1,690	27,914	2,935	74,665
8/29/2002	666	5,147	3,208	1,024
9/24/2002	997	2,904	1,235	2,842
10/2/2002	6,649	2,876	1,391	2,027
Instantaneous Limit	400	400	400	400
Median	777	6,477	2,207	2,277
Minimum	204	796	342	889
Maximum	6,649	54,480	29,595	74,665

b. Nutrients

The UK KWRRI has conducted two sampling efforts in support of a TMDL assessment of the Town Branch Watershed, of which Wolf Run is a tributary.

Two samples were collected from one site at the mouth of the Wolf Run Watershed on October 18 and 26, 2000 with total phosphorus results of 0.28 mg/L and 0.30 mg/L respectively (Ormsbee and Blandford 2002). However, because such data was insufficient for TMDL modeling purposes, an additional sampling effort was initiated in March 2009 by UK KWRRI. This effort is described in the report entitled "Town Branch and Wolf Run Data Collection Report" by Rob Doyle (2010). This involved sampling and monitoring 11 sites throughout Town Branch, four of which were located in the Wolf Run Watershed (three on Wolf Run and one on Vaughn's Branch). The samples were analyzed for multiple constituents including total nitrogen and total phosphorus. The data collection was performed monthly for a full year until March 2010. Data analysis was performed using load duration curves and historical flow data.

Town Branch and Wolf Run both show signs of eutrophication due to the growth of algae. Based on the initial analysis, phosphorus was believed to be the limiting nutrient controlling the algal growth (Ormsbee and Blandford 2002). Thus, monthly grab samples were analyzed for total nitrogen and multiple forms of phosphorus. The average concentrations of the nutrients sampled at the Wolf Run stations (W1 through W4) are shown in Table 20. The phosphorus results for Wolf Run are all near the draft TMDL target for phosphorus (0.3 mg/L) for all sites. There are some instances where the concentration is greater than 0.3 mg/L but these are typically during high flows. This suggests that elevated levels may be related to nonpoint sources or wet weather discharges. Nitrogen values were all above 2 mg/L indicating the levels are somewhat elevated compared to non-regulatory reference points.

TABLE 20 – AVERAGE NUTRIENT CONCENTRATIONS FOR 2009 NUTRIENT SAMPLING STUDY

Site Name	Orthophosphate (mg/L as P)	Total Recoverable Phosphorus (mg/L as P)	Total Nitrogen (mg/L as N)
W1	0.289	0.286	2.159
W2	0.329	0.320	2.138
W3	0.309	0.305	2.107
W4	N/A	0.277	N/A

3. University of Kentucky Microbial Source Tracking

In an effort to identify the sources of the high pathogen indicator concentration in the Wolf Run Watershed, UK ERTL has conducted three research projects utilizing microbial source tracking methods. The location of these sampling sites and results are shown in Exhibit 24, page III-3.

In 2007, Tricia Coakley and Dr. Gail Brion of the UK ERTL authored an initial study entitled "Fecal Source Tracking in the Wolf Run Watershed of Lexington, KY using molecular methods for *Bacteroides* bacteria" (Coakley and Brion 2007). Samples were collected at five sampling sites for analysis for *E.coli*, AC/TC ratio, and DNA primers of *Bacteroides* bacteria during five sampling events from July to mid-August of 2007. The AC/TC ratio is used as an indicator of the input freshness with low numbers indicating fresher inputs. The DNA primers of *Bacteroides* bacteria are linked with cattle and human specific source inputs.

No cattle specific inputs were detected in the watershed. AC/TC ratios were the lowest at McConnell Springs (K54), Wolf Run at Gardenside Park (K184), and Cardinal Run at Davenport (K461), indicating the freshest fecal inputs at those locations. Human specific markers were detected most frequently at McConnell Springs and Vaughn's Branch (K470. Wolf Run at Gardenside Park had the highest overall

concentration of *E.coli*. Cardinal Run at Davenport showed no human specific markers. Although the number of sites was limited, the report indicated human source inputs were prevalent in the watershed and further analysis was warranted.

In 2009, a final report was published by Dr. Gail Brion, Dr. Alan Fryar, and Tricia Coakley of UK entitled "Identification of Human and Animal Fecal Sources in Central Kentucky Watersheds by qPCR of 16sDNA Markers from Host Specific Fecal Anaerobes" (Brion *et al.* 2009). This fecal source tracking study examined the results of samples collect at 34 sample locations in Central Kentucky, 19 of which were located in the Wolf Run Watershed. One sampling event was collected in 2008 for *E.coli*, AC/TC, and DNA primers indicating all *Bacteroides* (AllBac), human specific markers (HuBac), and bovine specific markers (BoBac). Of the 19 sites located in Wolf Run, seven were identified as "hot spots" of human fecal contamination (potentially from broken or leaking sewer lines) by human specific marker concentrations of greater than 20 percent of the corresponding general fecal marker concentrations. These sites included Preston's Spring and the downstream McConnell Branch (D04 and D05), multiple sites on Vaughn's Branch (K532/D06, D11, and K470/D13), and two sites on Wolf Run (K466/D14 and K468/D15).

A final study was conducted in 2010 by UK ERTL, which resulted in a final report, published on April 15, 2011 entitled "A Plan for Identifying Hot Spots and Affirming Remediation Impacts on Surface Water Quality: Phase I" (Brion *et al.* 2011). The volunteer group, Friends of Wolf Run, collected grab samples from 18 locations in the Wolf Run watershed during ten sampling events from April 6th to August 5th 2010. Grab samples from these sites, along with inlet domestic sewage and manhole overflows, were analyzed for indicators of fecal load (*E. coli*), fecal age (AC/TC ratio), and fecal source (two human host specific *Bacteroides* DNA markers, HuBac and qHF183) by UK ERTL. A sanitary category value (SCV) was developed by using a simple summation of three indicators (*E. coli*, AC/TC ratio, and the log-transformed ratio of HuBac to the maximum sewage HuBac signal), each assigned values 0 to 1 and summed such that raw sewage had a value of 3.0.

One site (D10) located on Vaughn's Branch at Tazwell Drive was found to have SCVs indistinguishable from sewage during dry conditions. A broken sewage pipe observed in the survey (which has since been repaired) confirmed this finding. D04 at Preston's Cave and D18 on Wolf Run at Roanoke Drive were the least human sewage impacted under dry weather conditions. Under wet conditions, the watershed quality declined. Nine sites (D23, D14, D10, D16, D13, D19, D03, D18, and D09) had SCV values statistically indistinguishable from sewage under rainy conditions. This indicates contributions from sanitary sewer overflows during precipitation. The report indicates Cardinal Run as the least sewage-impacted tributary under wet and dry conditions, Vaughn's Branch the most impacted during dry conditions and also heavily impacted under rain conditions, and Wolf Run impacted primarily with wet weather human sewage, although leaking sewers are suspected to also impact water quality during dry weather.

4. Kentucky Division of Water Groundwater Monitoring

Groundwater quality data for the Lexington West quadrangle (Miller 1967) from KDOW's consolidated groundwater database (KDOW 2010b) are compiled in an online data report summarizing 45 groundwater quality sites sampled between 1953 and 2008. Because the data is not regularly collected, it is of marginal value to the current analysis.

However, KDOW has conducted extensive groundwater monitoring data at three springs (shown in Exhibit 23, page III-2) within the Wolf Run Watershed: Gardenside Spring (GS), Kay-Springhurst Farm Spring

(KSFS), and Kenton Bluehole (KBH). GS and KSFS monitoring included full chemical and *E. coli* (March through July 2004, May through October 2006), while KBH was limited to full chemical (four seasons in 2004, winter and spring 2005). GS and KSFS showed some elevated levels (as compared with regulatory limits) of *E. coli*.

Conductivity, nitrate and phosphorus were high compared to reference values at all monitored springs, ranging from 413 to 682 µmho/c; 2.79 to 4.78 mg/L; and .246 to .318 mg/L, respectively. With the exception of a peak conductivity of 682 µmho/c, values were generally lower at KSFS than either GS or KBH. Values recorded at GS and KBH were similar for these three parameters.

5. Volunteer Monitoring Efforts

KRWW is a non-profit organization composed of the KWRRI, the Kentucky River Authority (KRA), and a network of volunteers. KWRRI and KRA selected six subwatersheds of the Kentucky River Basin to monitor for focused management efforts. The South Elkhorn watershed, one of the six priority basins, contains the Wolf Run Watershed. KRWW has eight monitoring sites located on Wolf Run from near its confluence with Town Branch to its headwaters.

The earliest monitoring at these sites began in 1999 at K034. Monitoring periods per site vary from four to eight years (with the exception of one year at K498). Collection at all sites is primarily limited to mid-summer (July) and early-fall (September). The range of data collected from year to year varies. Physicochemical and fecal data have been collected most regularly, while full chemical data collection varies from every other year at some sites to approximately every four years at others. Fecal coliform, *E. coli* and total phosphorus consistently exceed benchmarks at all sites. One notable factor in the results is the high concentrations of chloride measured in Wolf Run at several sites. Because chloride has a high ionic value, it can contribute to elevated conductivity and dissolved solid levels in the watershed. The most recent sampling conducted in the Wolf Run Watershed are summarized in "Summary of Kentucky River Watershed Watch 2011 Water Sampling Results" (KWRRI and KRA 2012).

In September 2010, the Friends of Wolf Run coordinated a survey of specific conductance in the Wolf Run Watershed. Twelve teams of volunteers were each equipped with Oaktan conductivity meters and sampled 16 kilometers of waterway in Wolf Run. Measurements were taken approximately every 30 meters on segments of 1,000 meters. Because this survey was conducted during a period of low flow, many stream segments were dry during the study, but this helped to identify karst inflow and outflow. The results of this survey are still in draft form.

B. Monitoring Needs and Plan

Subsequent to the review of the existing monitoring conducted in the Wolf Run Watershed, the additional monitoring necessary in order to have sufficient data to complete the watershed based plan were assessed. In order to address these gaps, a quality assurance project plan was developed by the project team and accepted by the KDOW (Evans 2012).

Six different monitoring activities were conducted under this project plan including:

1. Karst hydrograph characterization
2. Conductivity survey
3. Benthic macroinvertebrate collection

4. Watershed habitat assessment
5. Hydrogeomorphic assessment
6. Water quality monitoring

Each of these monitoring activities, conducted by Third Rock and the Friends of Wolf Run, are summarized in Table 21. Monitoring was planned to start in May 2011 and end in February 2012. Sites were selected by review of aerial mapping, previous sampling locations, and field review. Numerous factors including previously collected data, accessibility, land use, upstream disturbances and suspected sources, and projected cost were considered in determining the number of sampling sites and their locations. Summaries of the planned monitoring activities are included below. For details on the monitoring plan, see the Quality Assurance Project Plan (QAPP) (Evans 2012). The QAPP specified locations in which these sampling activities were to occur are shown in Exhibit 25, page III-12. A summary of the sampling site locations and the sampling dates are shown in Table 22 and Figure 3; both are located on page III-13.

TABLE 21 – SUMMARY OF PROJECT MONITORING ACTIVITIES AND SAMPLING DATES

Monitoring Activity	Collected by	No. of Sites	Monitoring Period / Dates
Karst hydrograph characterization	Third Rock	6	Loggers deployed from 6/13/2011 to 12/2/2011
Conductivity survey	Friends of Wolf Run	373	8 days from 9/17/2011 to 10/11/2011
Macroinvertebrate Collection	Third Rock	6	May 12, 17 and 18, 2011
Habitat Assessment	Third Rock and Friends of Wolf Run	33	16 days from 5/23/2011 to 10/10/2011
Hydrogeomorphic Assessment	Third Rock	9	Initial Survey – 5/23/2011 to 6/22/2011 Final Survey – 3/13/2012 to 5/17/2012
Water Quality Monitoring	Third Rock and Friends of Wolf Run	12	15 Days – 5/25/2011 to 2/17/2012

Exhibit 25
Project Plan Monitoring Locations
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_25_Project_Plan_Monitoring.mxd) 9/26/2012 -- 11:00:05 AM sje

TABLE 22 – DESCRIPTION OF PROJECT MONITORING LOCATIONS

Site Name	Stream	Location	Latitude	Longitude	Upstream Area (Acres)	Upstream Sites
W01	Wolf Run	Old Frankfort Pike	38.067303	-84.554182	6614* **	All
W02	McConnell Branch	Preston's Cave	38.057333	-84.542169	418*	-
W03	Wolf Run	Valley Park	38.053742	-84.550782	3532**	W05, W06, W09, W10, W12
W04	Vaughn's Branch	Valley Park	38.054904	-84.549624	1966	W07, W08, W11, W11A***
W05	Cardinal Run	Devonport Dr	38.048594	-84.553867	1033**	-
W05A	Cardinal Run	Parkers Mill Rd	38.043212	-84.557131	810**	W05
W06	Wolf Run	Wolf Run Park	38.045274	-84.550661	2234	W09, W10, W12
W07	Vaughn's Branch	Pine Meadow Park	38.044927	-84.536148	1630	W08, W11, W11A***
W08	Vaughn's Branch	Picadome Golf Course	38.037453	-84.525057	575	-
W09	Wolf Run	Faircrest Drive	38.029954	-84.537091	1024	W12
W10	Springs Branch	Faircrest Drive	38.029855	-84.537196	428	-
W11	Big Elm Tributary	Harrodsburg Road	38.031245	-84.526027	581	-
W11A	Big Elm Tributary	Picadome Golf Course	38.037494	-84.527095	678	W11
W12	Wolf Run	Lafayette Parkway	38.022932	-84.528581	749	-

* Includes 402 acres of misbehaved karst in the Town Branch watershed that flow to McConnell Springs.
** Includes 121 acres of misbehaved karst in the South Elkhorn watershed that flow to the Kenton Blue Hole.
*** The Big Elm Tributary only flows into Vaughn's Branch under conditions of excessive rainfall when the Picadome sinkhole is overwhelmed.

FIGURE 3 – PROJECT SAMPLING EVENT SUMMARY

1. Karst Hydrograph Characterization

The Wolf Run Watershed has a karst influence which should be considered during the loading calculations and can influence the decision making process in development of the action plan. Based on dye traces, a substantial fraction of both the Vaughn's Branch and main stem of Wolf Run sub-watersheds are captured by the Preston's (McConnell) Spring basin. During base flow and dryer conditions most of the surface water in the karst-influenced fractions of these subwatersheds are directed to Preston's Spring. During high flow conditions the surface component of the discharge becomes greater as the karst system conduit limits are approached. In order to determine the influence of the karst system, storm event gauging of Preston's Spring was to be conducted to determine the discharge and the nature of the hydrograph.

Simultaneous gaging of the three affected tributaries and a major sinkhole were planned to be conducted during base flow conditions and during a wet weather event. Temporary water level gages (pressure transducers with data loggers) were installed at each of the five gaging stations. Surface flow was measured at each of these locations to evaluate the flow into and out of the karst system.

Flow measurements was to be conducted according to KDOW's *Measuring Stream Discharge Standard Operating Procedure* (KDOW 2010c). The base flow event was to be a single flow measurement at each of six gaging stations as shown on Exhibit 25, page III-12. It was anticipated that the base flow period would occur in late August to October 2011. The wet weather event was to target a storm event that is expected to have uniform rainfall across the watershed with expected accumulation of over one inch. The gaging was to be performed by two teams of surveyors circulating to each of the five gaging points a minimum of every 30 minutes during the storm event. Monitoring was to continue until past the hydrograph peak.

2. Conductivity Survey

Specific conductance was recently listed as a cause of impairment in the Wolf Run Watershed. Although specific conductance or conductivity has been analyzed during several studies and the Friends of Wolf Run conducted a broad study of conductivity levels in the watershed, a study under base flow conditions was necessary to aid in identifying inputs and problem areas.

During medium to low-flow conditions (0.5 to 5 cfs at the USGS gage), a survey was planned to use *in situ* field temperature and specific conductance measurements to identify locations of "jumps" in the specific conductance levels as possible locations of pollution. Using GPS data loggers, field meters, data sheets, and photographs, all streams and tributaries (approximately 13.5 miles) were to be measured at approximately 100-foot intervals (approximately 700 locations). Volunteer samplers were trained to perform the survey. The survey was targeted for completion within a one-week period, but in the event of a precipitation event was to be delayed until conditions returned to the initial survey conditions.

3. Benthic Macroinvertebrate Collection

Macroinvertebrate samples had been collected at two sites in the watershed, both located near the mouth of Wolf Run. The nutrient/eutrophication biological indicators impairment of Wolf Run was based on the macroinvertebrate data collected at these sites. However, the health of the macroinvertebrate community in the headwaters of the watershed had not been assessed.

To address this need, macroinvertebrate samples were to be collected at six sites within the Wolf Run Watershed. The six sites are located on Vaughn's Branch, Big Elm Tributary, Cardinal Run, McConnell Branch, and two sites on Wolf Run (one upstream of Harrodsburg Road, one upstream of Versailles Road).

These sites are identified on Exhibit 25, page III-12. A seventh site is also identified at Old Frankfort Pike and Wolf Run, which is be sampled annually under LFUCG's MS4 permit.

The macroinvertebrate community at each site was to be sampled using the recommended methods developed by KDOW (2009b, 2009c), which involve the collection of a riffle and multihabitat sample at each location. The riffle sample consisted of four 0.25 meters^2 (m^2) samples collected from two separate riffles at each station using a 0.25 m^2 grid and a kicknet (600µm mesh). Riffle collections at each station were composited to form one semi-quantitative sample. The qualitative, multihabitat sample includes, where habitat is available, samples from leaf packs; sticks/wood; bedrock/slabrock; undercut banks/submerged roots; aquatic macrophyte beds; soft sediment; hand-picking of rocks from riffles, runs, and pools; *aufwuchs* material off rocks, sticks, leaves, and filamentous algae; and visual searches of large woody debris. All samples collected with the dip net and the rock and wood samples were processed through a wash bucket and composited to form one sample for each station. Samples will be preserved and returned to the laboratory for processing and identification. All organisms were identified to the lowest possible taxonomic level and recorded on laboratory data sheets using methods described by KDOW (2009b).

Habitat assessments were performed by Third Rock personnel at each of these sites according to the procedures outlined in *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (Barbour *et al.* 1999).

4. Watershed Habitat Assessments

In addition to the habitat assessments conducted at the macroinvertebrate sites, habitat assessments were performed by trained volunteers throughout the watershed on parcel-sized or 100-meter stream reaches. Using the visual-based habitat assessment procedures in Barbour *et al.* 1999, volunteers surveyed as many segments as time permitted within 24 selected stream segments into which the watershed has been subdivided. At least one assessment was to be performed in each segment

5. Hydrogeomorphic Assessment

No assessments for the hydrogeomorphic condition of the watershed were identified in the existing data. To address this need, nine hydrogeomorphic monitoring sites, as shown in Exhibit 25, page III-12, were designated to measure channel changes in representative reaches. Assessments at these sites were to include cross-section and longitudinal profile surveys and streambed substrate evaluation to determine the extent of the effects of hydromodification. The relative potential for improvement was also to be qualitatively assessed based on the lack of obvious physical constraints in a reach, position in the landscape, or position in the watershed.

The baseline cross-section, profile, and bed substrate were to be compared to a subsequent survey to determine the degree and type of changes in physical structure and stream function that has occurred. The hydrogeomorphic assessments were to supplement biological, physicochemical, and habitat data in determining the overall health of the stream reach and stream-use designation. The sampling was to quantify physical stream changes that occurred over time, help identify potential BMPs/implementation solutions, and prioritize reaches for implementation of those solutions.

6. Water Quality Monitoring

Although sampling data is available at multiple sites throughout the watershed, most of the available data was limited spatially or temporally. According to KDOW's "Watershed Planning Guidebook for Kentucky

Communities" (2010d), monitoring data needs to meet the sampling protocol for new data in order to satisfy the requirements of KY 319-funded plans. This includes monthly sampling for one year during dry and wet conditions for discharge, total suspended solids, total phosphorus ortho-phosphorus, ammonia, total kjeldahl nitrogen, nitrate+nitrite, total dissolved soilds, turbidity, dissolved oxygen, specific conductance, temperature, and pH.

Water quality monitoring was conducted during 10 monthly sampling events at 12 sampling stations in the watershed, shown in Exhibit 25, page III-12, during dry and wet conditions. The sampling date within each month was to be flexible such that at least two of the events were considered "wet weather" and two of the events were considered "dry weather." Sampling parameters included discharge, *E. coli*, fecal coliform, total suspended solids, total phosphorus, ortho-phosphorus, ammonia, total kjeldahl nitrogen, nitrate, nitrite, total dissolved solids, carbonaceous biochemical oxygen demand, turbidity, dissolved oxygen, specific conductance, temperature, and pH. The LFUCG Town Branch laboratory analyzed samples for *E. coli*, fecal coliform, total suspended solids, ammonia, nitrite, total dissolved solids, alkalinity, and hardness. KGS analyzed samples for total phosphorus, ortho-phosphorus, total kjeldahl nitrogen, and nitrate. Friends of Wolf Run volunteer samplers performed field measurements of turbidity, dissolved oxygen, specific conductance, temperature, and pH. Third Rock staff accompanied the volunteers and conducted discharge monitoring and field filtered ortho-phosphorus samples. Additionally, two wet weather sampling events were to be collected on the hydrographic rise by Third Rock staff.

In addition to the monthly sampling, volunteers were collect an additional four events within a 30-day period during the Primary Contact Recreation period (May 1 to October 31) for *E. coli* and fecal coliform to evaluate the geometric mean for the primary contact period. A Third Rock staff member was to accompany the volunteers during each event to conduct discharge monitoring. Only flow, *E. coli* and fecal coliform were collected during these events. The LFUCG Town Branch laboratory analyzed the samples.

C. Monitoring Implementation Overview

Technical reports detailing the results of each of the monitoring activities are provided in the following reports:

- Karst Hydrograph Characterization Report (Appendix B)
- Conductivity Survey (Appendix C)
- Habitat and Macroinvertebrate Assessment Report (Appendix D)
- Hydrogeomorphic Assessment Report (Appendix E)
- Watershed Monitoring Report (Appendix F)

The monitoring plan was primarily executed as planned. However, some changes were made to account for irregular circumstances that arose during the project.

The monitoring effort was conducted during the wettest year on record for Fayette County. Because of this, antecedent dry conditions were difficult to achieve during the study. Only 14 percent of days within the entire monitoring period had an antecedent dry period of seven days, which was originally specified in the QAPP per KDOW's recommendation. With these specifications, sampling could only be conducted four days a month, making coordination difficult, particularly for wet weather conditions that can occur in evenings or on weekends. A three-day (72-hour) antecedent dry period was used to define wet and dry weather events due to these conditions.

Some water quality results had to be rejected due to the precision or accuracy of the results or the conditions under which they were collected, but sufficient data was collected to fulfill the project goals. Unusable data was qualified for screening use only or rejected from loading calculation and analysis. The LFUCG Town Branch Laboratory utilized this project to improve its quality control testing and reporting criteria, so some of the initial sampling events were deficient in the quality control testing. However, the data quality improved with the project and the laboratory has improved and expanded its capabilities as a result.

This project was unique in that the sampling efforts were coordinated between consultant staff and volunteer samplers. It is believed that the collaboration between the volunteers and consultants enhanced the experience of the volunteers and provided additional insight into their understanding of stream water quality and sampling methodology. The volunteers were competent in their responsibilities and quality control issues were identified and addressed early in the project so as to not be an obstacle in analysis. As a result of the collaborative experience, the need for improved field equipment was identified and now is available for future volunteer efforts. However, the scheduling of sampling activities with volunteers and consultants proved challenging due to conflicts in time availability. In future monitoring efforts, use of trained staff or volunteer monitoring with periodic quality control checks may improve efficiency and mobilization.

For the karst hydrograph characterization, loggers recorded data from June 13 until December 2, 2011. Because the caps were cemented in place to prevent theft, loggers could not be downloaded until after the wet event was monitored, which was delayed due to the infrequency of such a heavy rain event. One wet event was captured, but only two or three measurements were recorded at each site due to the time required to make each measurement. Although fewer measurements were made during a single wet weather event than expected, more events were measured than initially planned due to the long installation period. In total, flow was measured during 11 monitoring events conducted during the period of data logger recording. The cross-sectional areas, longitudinal profiles, and pebble counts measured at the karst sites were also utilized to predict flows and improve the stage-discharge curves generated for each site.

The conductivity survey was conducted at 373 sites on eight days from September 17, 2011 to October 11, 2011. A rain event delayed the surveys from being collected within one week of initiation, but all sites were collected under medium to low flows meeting the objective for the study. Each stream segment was surveyed within a single day, such that changes along a reach could be assessed. Some reaches could not be sampled because they were either dry or could not be accessed.

CHAPTER IV. ANALYSIS

A. Aquatic Community and Habitat

1. Fish

Although not collected under this project, fish have been sampled using KDOW methods from 2003 to 2011 at the mouth of the watershed under annual LFUCG MS4 permit monitoring. Over that time period, 22 species of fish have been collected from Wolf Run but only 12 to 15 species are typically collected in an individual year. Species collected in multiple sampling years include stoneroller *(Campostoma anomalum*), scarletfin shiner *(Lythrurus fasciolaris*), bluntnose minnow *(Pimephales notatus*), fathead minnow *(P. promelas*), blacknose dace *(Rhinichthys atratulus*), creek chub *(Semotilus atromaculatus*), white sucker *(Catostomus commersoni*), northern hogsucker *(Hypentelium nigricans*), yellow bullhead*(Ameiurus natalis*), mosquitofish *(Gambusia affinis*), banded sculpin*(Cottus carolinae*), green sunfish *(Lepomis cyanellus*), bluegill *(L. macrochirus*), longear sunfish *(L. megalotis*), greenside darter *(Etheostoma blennoides*), fantail darter *(E. flabellare*), and orangethroat darter *(E. spectabile*). Species that have only been collected during one or two sampling years include: carp *(Cyprinus carpio*), rosyface shiner *(Notropis rubellus*), black bullhead *(Ameiurus melas*), warmouth *(L. gulosus*), and spotted bass *(M. punctulatus*). Index of Biotic Integrity (IBI) ratings have ranged from “excellent” to “fair,” although most years have been excellent.

2. Macroinvertebrates

Results of the macroinvertebrate sampling for the project are shown in Exhibit 26, page IV-2. Macroinvertebrate Bioassessment Index (MBI) scores calculated for the seven sampling stations in the Wolf Run Watershed resulted in classifications of “poor” at six sites. The other site, W12, was “very poor,” scoring just below the threshold of 19 for a “poor” rating. The minimum MBI score for a “fair” rating is 41 for wadeable streams, such as W1, and 39 for headwater locations in the Bluegrass Bioregion. This indicates that considerable improvement will be necessary to achieve a “fair” rating.

The low MBI scores observed in the Wolf Run watershed are the result of several conditions, most of which are re-occurring at each of the seven sampling stations. All stations were extremely low in the number of pollution intolerant EPT (ephemeroptera, plecoptera, and trichoptera commonly known as mayflies, stoneflies, and caddisflies) taxa. No station had more than two genera of EPT (W11 and W12 had zero genera) and % EPT ranged from 0 to 0.9 percent. With the exception of W5A, all stations were also relatively low in overall genus taxa richness, which ranged from eight to 14 taxa. The exception, W5A, had 30 total taxa. However, the higher taxa richness observed at this station was primarily the result of an increase in diversity of pollution tolerant taxa such as Chironomidae and annelida (midges and worms), as well as several tolerant members of mollusca. The abundance of clingers (taxa requiring stable substrates to cling to, such as gravel, boulders, root wads, etc.) was very low, which is frequently an indicator of unstable substrate or high levels of siltation or embeddedness. The pollution tolerant isopod, *Lirceus fontinalis*, and the tolerant *Cricotopus/Orthocladius* members of Chironomidae were the most abundant organisms. The Habitat and Macroinvertebrate Report in Appendix D contains additional information.

Exhibit 26
Habitat and Macroinvertebrate Scores
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_26_Habitat_and_Macroinvertebrate_Scores.mxd) 9/13/2012 -- 9:51:21 PM sje

3. Habitat

Results of the habitat assessments for the project are shown in Exhibit 26, page IV-2. Total habitat scores ranged from 50 to 153. Out of the 33 reaches assessed, only two were "fair" with all others "poor." The "fair" scores were assessed within McConnell Springs Park (2A) and at the mouth of Wolf Run (1A1). Downstream of Preston's Cave (2B), scores were at the threshold between "fair" and "poor" with marginal sediment deposition and embeddedness scores causing the poor rating at that location. Wolf Run at the Furlong Drive Greenway (1F), where the riparian width is wider, also approaches a "fair" rating.

The lowest scores (50) were assessed at Vaughn's Branch at Pine Meadow Park (3C1) and at Big Elm Tributary on the Picadome Golf Course flowing into the sinkhole (4A). Each of these streams has poor scores across all parameters. Other extremely low sites are located in the headwaters of Wolf Run (1G1, 1H, 1J) and Vaughn's Branch (3E, 3F).

Figure 4 shows the range of scores for each habitat parameter measured under this project. As shown, several factors contributed to the poor habitat scores in the watershed. The riparian zone width was routinely the lowest overall parameter, indicating that remediation activities focusing on expanding the width of the vegetated area beside the stream will provide the greatest benefit throughout the watershed. Low scores for epifaunal substrate/available cover, embeddedness, and velocity depth regime together suggest that little habitat is available for macroinvertebrates due to a lack of pools and available cobble habitat in the stream. Restoration activities focused on creating pools, increasing base flows, and increasing the in-stream habitat will aid in improving the macroinvertebrate community within the watershed. See Appendix D for additional information.

FIGURE 4 – WOLF RUN WATERSHED HABITAT SUMMARY

4. Hydrogeomorphic Assessment

Nine hydrogeomorphic stream reaches were surveyed twice. Surveying was initially conducted from May 23 to June 22, 2011 and again from March 13 to May 17, 2012 after numerous erosive flow events had

occurred. Appendix E contains the full *Hydrogeomorphic Assessment Report*. At each site, the stream permanent cross-section, longitudinal profile, and substrate (through pebble counts) were surveyed. Each reach location was chosen such that typical conditions of Wolf Run and its tributaries were evaluated, rather than the worst conditions within the stream. As the most upstream segment of Wolf Run, upstream from approximately Clays Mill Road, is heavily modified, it was excluded from the assessment. This segment of Wolf Run is either paved/armored or confined by bedrock and therefore the physical channel character was not expected to change during the monitoring period.

In general, the streams assessed are over-widened and entrenched such that the channel width and area are larger than expected for streams in the Bluegrass physiographic region (Parola 2007). Entrenchment indicates that flood flows are contained within the stream banks and do not release onto the floodplain where their energy may be dissipated. When streams are entrenched, the velocity of flow is increased during flood events, causing further erosion, and the water table is lowered, resulting in more intermittent stream flows. Over-widened stream channels typically have a lack of pool/riffle habitat and a flat bottom. Together, over-widening and entrenchment impact the macroinvertebrate community negatively because in-stream habitat is reduced, streams go dry more frequently, and macroinvertebrates are swept downstream during flood flows.

Disturbances were observed to some degree at all reaches surveyed. The degree of alteration within the stream depends on the magnitude of the disturbances, the erosion resistance of the channel banks (cohesiveness) and substrates, the type and density of riparian vegetation, and the presence of grade controls. There are several exposures of bedrock within the study area. Though the monitored reaches exhibit channel incision and over widening throughout and absence of pools and reduced access to the floodplain in some locations, the relatively cohesive nature of the clay and silt material in the channel banks and the presence of bedrock in the stream beds have resulted in the relatively stable condition (little observed active vertical and lateral stream adjustment) of these reaches over the monitoring period. Though rates of channel change may not currently be rapid, these reaches do not provide sufficient habitat for aquatic life.

Although surveying indicated that many of the sites were relatively stable over the monitoring period, the assessment does indicate that hydromodification is causing bed and bank erosion, sedimentation, and habitat loss (poor in-stream and riparian habitat). The condition of each reach will help define sustainability of various restoration or management projects and the compatibility of such projects with land use and channel management activities.

Significant stream disturbances noted through the field investigation of Wolf Run and its tributaries included:

- Minimal or absent riparian zone
- Active bank erosion/absent bank vegetative protection
- Floodplain encroachment and/or channel incision such that floodplain connection is reduced
- Channel armoring
- Unmitigated stormwater runoff from roads and other paved surfaces
- Channelization

Opportunities for improvement were observed at each reach surveyed and these opportunities are indicated in the reach summaries that follow. Based on the lack of obvious physical constraints in a reach, position in the landscape, etc., reaches W5A, W6, W7, W8, and W9 are considered the highest priority for restoration or enhancement, as shown in Exhibit 27, page IV-6. Locations of manmade dams and severe erosion areas identified by LFUCG during their visual stream assessments are also shown on Exhibit 27 as well as areas of bank armoring or channelization.

a. Wolf Run at Old Frankfort Pike

As the most-downstream reach, this is the largest stream channel surveyed in this assessment. Trash/debris (*i.e.,* shopping carts) were abundant in this reach. Areas of raw, nearly vertical, eroding stream banks were observed in this assessment (Exhibit 27, page IV-6). The stream has riparian cover on both sides for much of this reach, but there are still segments where riparian cover is absent. Additional area is available to expand the riparian width and/or enhance the composition of the existing riparian buffer. For this site, the particle size measured in the active riffle is larger than for other sites, and is not expected to be mobile at the top of low bank flow depth. The median particle size in active riffles was coarse to very coarse gravel. This indicates that these substrates provide stable aquatic habitat. However, this reach does have some bedrock-dominated pools and a rather monotonous bed comprised of run/shallow pool based on the longitudinal profile survey. Due to the existing undeveloped area adjacent to this reach, there is potential to improve the stream cross-section and profile (possibly through the installation of in-stream structures) to increase sediment transport, reduce bank erosion, and improve the physical aquatic habitat.

b. McConnell Branch at Preston's Cave

McConnell Branch (W2), which receives most of its flow from Preston's Cave and the upstream McConnell Springs groundwater sources, exhibits modulated hydrology due to the karst drainage. Banks within this reach are relatively stable and not actively eroding. In fact, in-stream deposition and aggradation seems to be more negatively impacting aquatic habitat than erosion. The stream is likely over-widened and thus does not have the capacity to transport the current sediment load. Though this reach is shaded by riparian vegetation, algal growth was observed throughout the reach during 2012 monitoring. Additionally, the riparian vegetation contains non-desirable invasive species and the riparian zone would benefit from invasive species removal/management and establishment of site-specific, native vegetation. Stakeholders indicate that the observed sedimentation at this site may be a result of prior disturbance and fill rather than ongoing sediment transport to the reach. The median particle size in active riffles is medium to coarse gravel. Additional study and design calculations could be used to evaluate what the current sediment load to this stream is (though complicated by the karst drainage) and whether modifications to the channel dimensions and profile could increase sediment transport capacity of the stream in order to alleviate the embedded substrate and sedimentation observed here. This reach has more pattern and more desirable vertical diversity of the streambed, with rather deep pools being measured by the longitudinal profile survey. This reach is an attractive recreational segment accessed by the public on an adjacent trail. Improving the riparian vegetation and sediment transport/aquatic habitat

Preston's Cave, a Unique Geological Feature

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Exhibit 27
Hydrogeomorphic Assessment Results
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

would improve this stream as a recreational resource as well as improve stream function/aquatic habitat. Several tributaries enter McConnell Branch within the reach represented by this station. Their condition needs to be further evaluated if this reach is prioritized for remediation activities. There is stakeholder concern about headcutting within a tributary that enters McConnell Branch downstream of the surveyed reach. Unstable tributaries could be contributing high sediment load to McConnell Branch.

c. Vaughn's Branch at Valley Park

The reach represented by this site is the most downstream portion of Vaughn's Branch, just upstream of its confluence with Wolf Run. As observed during the longitudinal profile survey and as indicated by the habitat assessment data, there is a relatively frequent occurrence of riffles in this section of stream, which provides aquatic habitat, but visible bank erosion, lack of bank cover, and low riparian width reduce the stability and quality of this reach. A severe erosion area is located in this reach near the confluence with Wolf Run and has impacted infrastructure (utility pole, stormwater outfall). The longitudinal profile indicated a deep pool on bedrock and the remainder of the reach was predominately riffle and run habitat. The median particle size in active riffles is coarse gravel. The vertical diversity could be enhanced to create more niche habitats for aquatic life. Improvement to this section of Vaughn's Branch could focus more on creating a stable stream cross-section, which would stabilize the stream banks, and increasing riparian width and quality. The public frequently crosses Vaughn's Branch in the downstream portion of this surveyed reach. This contributes to frequent trash dumping within this reach. If the water quality and physical stream condition were improved, it would be a good location to re-connect the public with their water resources.

Erosion and Infrastructure Damage at Vaughn's Branch Mouth

d. Cardinal Run at Parkers Mill Road

This reach, on private property, has tremendous potential for restoration and achieving substantial ecological lift. As such, it is identified as a priority restoration area in the watershed. The in-stream habitat is very low, due to low availability of stable substrate, embeddedness of substrate, and some in-stream deposition. The substrate data collected during this assessment indicate the presence of much finer bed material (silt/clay conglomerate) in this reach of Cardinal Run compared to every other site where the beds are dominated by gravel and small cobble. The bed substrate at this site does not provide adequate aquatic habitat (*i.e.* lack of gravel and cobble for macroinvertebrate colonization) and could be enhanced through restoration activities. The profile observed for Cardinal Run Tributary, shown in Figure 5, page IV-8, indicates that the pool is filled in roughly three inches due to deposition, likely from material supplied by the deepening of an upstream pool. The biggest and most obvious need for this reach is bank stabilization/ vegetation and riparian planting. The riparian zone is highly modified by mowing activities and removal of all streamside, rootwad-producing vegetation. Bare and vertical banks, susceptible to erosion, were observed in this reach. There is a wetland area adjacent to the stream reach, as well as a wetland area downstream of the assessment reach. Several mallard ducks were observed in the wetland zones during 2011 data collection. These wetland features could be incorporated into the overall restoration of the site, providing additional water quality and aquatic habitat improvements.

FIGURE 5 – CARDINAL RUN AT PARKERS MILL ROAD, CHANNEL PROFILE AND CROSS-SECTIONAL AREA

e. Wolf Run at Wolf Run Park

Habitat assessment data indicates that available epifaunal substrate and cover are diminished in this reach, but like most of the sites, the lack of bank protection, stability and riparian vegetation is primarily contributing to this stream's poor aquatic quality. Due to its location adjacent to Wolf Run Park, restoration of stream dimension, pattern, profile, and riparian zone is feasible in this reach. The longitudinal profile surveyed in this assessment indicates long stretches of run/shallow pool habitat, and this reduced diversity in the stream profile indicates reduced habitat to support aquatic species. The assessment observed exposed bedrock within this reach, which also contributes to the lack of vertical profile diversity. This watershed is highly karst; thus, prior to any stream restoration, especially bedrock excavation, additional analyses need to be completed to ensure that excavation would not result in a sinking stream. The presence of bedrock can be problematic from a restoration potential, but deep pools can be excavated within bedrock if necessary and stream structures can be utilized with caution. If the stream can be partially relocated to the area within Wolf Run Park, extensive bedrock could possibly be avoided. If the water quality and physical stream condition were improved, this reach would be a good location to re-connect the public with their water resources.

f. Vaughn's Branch at Pine Meadow Park

This reach has a strikingly low habitat assessment score, with very low availability of stable substrate, high indication of substrate embeddedness and in-stream deposition, evidence of eroding banks and little bank protection, and diminished riparian zone. Changes in the longitudinal profile observed in the second monitoring event indicate the mobility of substrates within this reach. There has been some bank stabilization by LFUCG within small portions of the surveyed reach. The downstream extent of this surveyed reach contains a sanitary sewer crossing; the pipe was exposed during 2011 monitoring and was subsequently replaced and protected by armoring. The larger section of Vaughn's Branch, of which this site is representative, contains numerous stormwater sewer outfalls, as well as sanitary sewer crossings. This complicates restoration, but stream improvements can be made while considering these constraints.

Opportunities may exist to incorporate BMPs for mitigating stormwater adjacent to this reach. Due to its location adjacent to Pine Meadow Park, restoration of stream dimension, profile, and riparian zone is feasible in this reach. To a lesser degree, stream pattern could be improved within this reach. If the water quality and physical stream condition were improved, it would be a good location to re-connect the public with their water resources. As such, this reach has been identified as a priority restoration area.

Erosion on Vaughn's Branch on Picadome Golf Course

g. Vaughn's Branch at Picadome Golf Course

This reach, within Picadome Golf Course, also has a strikingly low habitat assessment score, with very low availability of stable substrate, high indication of substrate embeddedness and in-stream deposition, evidence of eroding banks and little bank protection, and a riparian corridor highly modified by landscape maintenance activities and removal of all streamside, rootwad-producing vegetation. This reach shows numerous areas of severe erosion. Due to its location within LFUCG park property, restoration of stream dimension, pattern, profile, and riparian zone is feasible in this reach if changes to the golf course are acceptable. This is a very public location to showcase a successful stream restoration project and re-connect the public with their water resources. For this reason, this reach has been identified as a priority restoration area.

Stream Flow and Erosion across Fairways from Big Elm Tributary to Vaughn's Branch

Big Elm tributary contributes flow to Vaughn's Branch within the golf course. However, there is not a stream connecting the two reaches. Under base flow conditions, all of the flow from the Big Elm tributary flows into a large sinkhole. Under flood conditions, the stream flow exceeds the capacity of the sinkhole and floodwater flows across the fairways to Vaughn's Branch. The absence of a channel connection from Big Elm tributary to Vaughn's Branch causes erosion as well as deposition of large debris subsequent to storms. This could be remedied by restoration of the channel, though it will impact play at the golf course and require careful planning.

Severe Erosion on Big Elm Tributary near Picadome Sinkhole

h. Wolf Run at Faircrest Drive

This reach was characterized as having an acceptable frequency of riffles, and three riffles surveyed in this assessment have relatively un-embedded substrate providing some potential habitat. However, the presence of rather long stretches of monotonous, shallow run/shallow pool habitat was also observed. This is likely indicative of the channel alteration/channelization at this site. This stream is rather wide and shallow, which diminishes flow depth during dry periods and can stress aquatic species. Substrate data indicates the bed is comprised of gravel and small cobble, with the pools containing smaller sized material. Channelization of this reach is obvious and the stream would benefit from re-establishment of a meandering pattern. Due to its location adjacent to the Allendale Greenway, restoration of stream dimension, pattern, profile, and riparian zone is feasible in this reach. As such this reach has been designated a priority restoration area.

i. Big Elm Tributary at Harrodsburg Road

As observed during the longitudinal profile survey, there is a relatively frequent occurrence of riffles in this section of tributary, which provides aquatic habitat. There are areas where concrete armors the bank and areas of severe erosion. Sediment deposition and embeddedness are suboptimal in this reach, but still indicate better habitat than many other reaches evaluated. Improvement to Big Elm tributary could focus more on stabilizing the stream banks, removing concrete bank armor, and increasing riparian width and quality. Additionally, finding ways to increase and sustain base flow in this karst subwatershed would improve habitat for aquatic life in this reach.

j. Restoration Measures

Recommended measures include restoring floodplain access; restoring channel dimensions, pattern, and profile in previously channelized segments; providing bank stabilization where opportunity for restoring channel dimensions is limited; and increasing riparian width and vegetation quality throughout the watershed. Additional remediation measures to consider, though specific locations for application were not identified in the assessment, include replacing crossing structures with less constricting bridges and culverts and mitigating stormwater runoff. The Wolf Run Watershed is highly developed with a high percentage of impervious surfaces. Reducing and treating stormwater runoff throughout the entire watershed can mitigate erosive flows, reduce pollutants, and promote conditions for improved aquatic habitat in Wolf Run and its tributaries. Specific analysis of the impacts of flow alterations at each site should be performed to determine which remediation measures are best suited to reduce and treat stormwater for a particular site. Additionally, eliminating future channel and riparian manipulations should be a goal across the entire watershed.

Based on review of the habitat assessment data in conjunction with the hydrogeomorphic data, the narrow riparian zone width was routinely the lowest overall habitat score parameter, indicating that remediation activities focusing on expanding the width of the vegetated area beside the stream will provide the greatest benefit throughout the watershed. Low habitat scores for epifaunal substrate/available cover, embeddedness, and velocity depth regime together suggest that little habitat is available for macroinvertebrates due to a lack of pools and available cobble habitat in the stream. Restoration activities focused on creating pools, increasing base flows, and increasing the in stream habitat will aid in improving the macroinvertebrate community within the watershed.

B. Volume and Velocity Impacts

In addition to lack of habitat within the watershed, the volume and velocity of stream flows can impact aquatic ecosystems. The high percentage of impervious surface in the watershed causes increased runoff volume and velocities in the watershed. These surfaces, as well as the karst geology of the watershed, also contribute to frequent dry or low flow conditions in the watershed, particularly in the headwaters. The karst hydrograph characterization study was aimed at providing a more comprehensive assessment of these impacts.

Under the study, flow was measured during 11 monitoring events conducted during the period of data logger recording which extended from June 13, 2011 to December 2, 2011. In-stream water levels were recorded every five minutes over that period. Six monitoring events were conducted during base flow while five events measured stream flow during precipitation. Two events were conducted during storms where more than one inch of daily rainfall was recorded at the Bluegrass airport. Precipitation was recorded on 62 of the 185 days in which the data loggers were deployed, or 34 percent of the days in the monitoring period.

In-stream flow measurements and stream geomorphic surveys were utilized to generate stage-discharge curves for each monitoring site. These stream-discharge curves were sufficient to analyze the full range of flows at the mouth of the watershed and the hydrographic rise and fall associated with storm events at other locations.

The study showed that the streams were extremely flashy during storm events, but also sustain frequent and prolonged periods of dry or low flows. The median time to peak of 3.1 hours at the USGS gage at the mouth of the watershed indicates the extent of the flashiness, which is also associated with dramatic flushing events, such as a jump from 1.9 cfs to 1,150 cfs in just 2.6 hours on August 3, during which over 1.8 inches of precipitation were recorded at the Bluegrass airport.

As measured by the USGS gage, stream flows at the mouth of the Wolf Run watershed ranged from 0.46 cfs to 1,150 cfs. The median flow at the site was 7.3 cfs, but only 3.8 percent of the flows exceeded 100 cfs. This indicates an extremely flashy stream system with a quick rise and fall during storm events due to numerous upstream factors including a high percentage of impervious surface and geological factors.

McConnell Branch (W02), which receives most of its flow from Preston's Cave and the upstream McConnell Springs groundwater sources, exhibited the most gradual rise and fall of all the monitoring locations. The low maximum calculated flow of 51 cfs is due to the flow restriction created by the size of the cave opening. Based on field measurements, McConnell Branch comprises an increasingly greater portion of the total flow at the mouth of the watershed as the time since the last precipitation event increases. During field measurements on August 29 when the flow at the mouth of the watershed was measured at 1.1 cfs, which is near the lowest observed over the monitoring period, the flow at McConnell Branch was 0.8 cfs.

At Roanoke Drive (W06), Wolf Run flows exceeding 100 cfs only occurred during 1.1 percent of the monitoring period. The flow is also much lower during median flows, at only 0.58 cfs as compared to 7.3 cfs the mouth of the watershed. Although peak flows at Roanoke Drive were found to approach or exceed the peak flows at the mouth of the watershed during several events, this result is most likely due the margin of error of the calculated flows. This was one of only two locations where the water depth exceeded the top of

bank, doing so on three dates, July 7, August 3, and September 4, for a total of 3 hours 25 minutes during the monitoring period. As mentioned previously, flows at water depths that exceeded the top of bank (near 500 cfs) are considered estimates at this site and may be over-predicted. Regardless, the site shows impacts from high velocities and the channel was observed to go dry on occasion.

Further upstream at Faircrest Drive (W09), just upstream of the confluence with Spring Branch, the flows at Wolf Run are much lower, reaching a maximum of 170 cfs, but only 15 percent of flows exceed 1.9 cfs. The site was pooled during field measurements on July 29, indicating that no flow is present during extended dry weather conditions. A known karst window is located upstream at Southbend Drive. On August 29, a measured flow of 0.03 cfs was observed entering this window, with no flow downstream. The measured flow at W09 at this time was 0.01 cfs. Thus, the base flow of Wolf Run at Roanoke Drive is reduced due to the karst re-direction in the upstream area. It is suspected that peak flows are also reduced in this watershed area due to the karst system, but this study was not able to determine the degree of reduction. The wide, bedrock structure of many of the streams upstream of this location may also contribute to increased evaporation during dry weather conditions.

Although Vaughn's Branch (W04) reached a maximum flow of 668 cfs, only 20 percent of the flows were greater than 1.0 cfs. Of the sites assessed in the watershed, Vaughn's Branch had the most measurements below 1.0 cfs. Vaughn's Branch was pooled on July 29, indicating that no flow is present during periods of extended dry weather. The flashiness and frequent dry or low flow conditions are due to numerous factors, including redirection of the flow of the Big Elm tributary into the Picadome sinkhole during base flow conditions, high percentage of impervious surface in the headwaters, and the possibility of other karst features within the subwatershed area.

Big Elm Tributary (W11), in the headwaters of the watershed, was routinely the first site to reach peak flow, as might be expected due to its small watershed area. However, flow levels between one and 10 cfs were sustained longer than other sites with larger watershed areas (Vaughn's Branch, Wolf Run at Faircrest Drive) and the peak flows appear suppressed, most likely due to the restriction of flows at the Picadome sinkhole. This was one of only two sites in which water depth exceeded top of bank, doing so for 10 minutes on August 3. The site does go dry during prolonged dry periods, as shown by the August 29 sampling in which no water was present in the stream.

In addition to quantifying the degree of flashiness in the watershed and the range of flows measured on the tributaries to Wolf Run, the study helped to clarify the relationship between surface and karst groundwater flows, particularly under storm conditions at the confluence of the Big Elm Tributary and Vaughn's Branch. The study found that as the karst conduit's flow capacity is maximized, through upstream inputs such as Wolf Run at Southbend Drive or through the maximized capacity at the spring outlets (McConnel Springs), water begins to back up at the Picadome sinkhole until flood levels are sufficient to allow for the bypass across to Vaughn's Branch. Under these conditions, almost the entire flow from the Big Elm Tributary enters Vaughn's Branch. Once the groundwater system has additional capacity to accept additional flow input, floodwaters begin to decline at the Picadome sinkhole. These multiple inputs into the karst system cause higher flow levels at McConnell Branch to be sustained for longer periods of time while also suppressing the peak flows and lengthening both the rising and falling limbs of the hydrographs in the headwater areas of Wolf Run and the Big Elm Tributary.

Panorama of Flood Waters at Confluence of Big Elm Tributary and Vaughn's Branch

Results also indicate that Best Management Practices to improve the warmwater aquatic habitat in the Wolf Run Watershed should target improving the flow regime. Frequent dry periods impair the ability of a stream to support aquatic life, as do increased occurrence of scouring events in the watershed. Best Management Practices to increase base flow, as well as measures to increase infiltration, storage, or re-direction of stormwater runoff should aid the survival of aquatic life. However, because of the difficulty in restoring base flow in heavily karst areas, efforts to improve the health of the aquatic ecosystem may best be focused in areas with lesser karst influences since these areas have one less potential source of impairment. Areas with reduced karst influence include McConnell's Branch, Cardinal Run, Gardenside Tributary, and the lower portions of Wolf Run and Vaughn's Branch. All areas in the watershed would benefit from efforts to capture or infiltrate stormwater.

C. Water Quality

Monitoring was conducted on 15 days from May 25, 2011 to February 17, 2012 at the locations shown in Exhibit 25, page III-12. "Wet" events, which occurred on 12 percent of the days in the monitoring period, were defined as over 0.1 inch of precipitation occurring after a three-day (72-hour) antecedent dry period. "Dry" events, which occurred on 46 percent of the days in the monitoring period, were defined by no rainfall and at least a three-day (72-hour) antecedent dry period. Events conducted less than 72 hours after precipitation of more than 0.1 inch, which occurred during 42 percent of the period, were categorized as "intermediate" events.

Monthly sampling included four "dry" events, two "wet" events, and four "intermediate" events, one of which was conducted during rainfall. The *E. coli* geomean sampling events are categorized as five intermediate events (one conducted during rainfall) and one dry event. Due to a laboratory error on six of the samples collected on the intermediate July 29 event, re-collection event was performed on August 2 at the six sites to allow for the geomean calculations.

Appendix F contains the full *Watershed Monitoring Report*.

1. Benchmarks

In order to evaluate the nature and extent of impairments in the Wolf Run Watershed, results were compared to applicable water quality benchmarks. Both regulatory and non-regulatory benchmarks are applicable for this analysis. Regulatory criteria are specified for parameters in which a given concentration of the pollutant is directly linked with impairment in the designated use. For other parameters, such as nutrients, specific conductance, suspended solids, or dissolved solids, no regulatory numeric standard has been established due to the variable relationship between biological integrity and concentration levels in

different streams. Only narrative criteria have been established due to the difficulty in determining impairment thresholds for these parameters as well as the natural geographic variation of these parameters. The benchmarks used for this analysis are summarized in Table 23.

TABLE 23 – WARMWATER AQUATIC HABITAT STANDARDS

Parameter	Warmwater Aquatic Habitat Standard	Type
pH	6.0 and 9.0 SU, and not to fluctuate more than 1.0 SU over 24 hours	Regulatory WAH
Temperature	< 31.7°C (89°F)	Regulatory WAH
Dissolved oxygen	> 5.0 mg/L as a 24-hour average; or > 4.0 mg/L for instantaneous	Regulatory WAH
Un-ionized Ammonia*	< 0.05 mg/L*	Regulatory WAH
Fecal Coliform**	200 CFU/100mLs as 30-day geometric mean, or 400 CFU/100mLs as an instantaneous measurement	Regulatory PCR
Fecal Coliform**	1000 CFU/100mLs as 30-day geometric mean, or 2000 CFU/100mLs as an instantaneous measurement	Regulatory SCR
*E. coli***	130 CFU/100mLs as 30-day geometric mean, or 240 CFU/100mLs as an instantaneous measurement	Regulatory PCR
Total Phosphorus as P	0.35 mg/L	Non-regulatory WAH
Total Nitrogen as N	3.0 mg/L	Non-regulatory WAH
Ammonia (as N)	0.1 mg/L	Non-regulatory WAH
Specific Conductance	650 µS/cm	Non-regulatory WAH
Total Dissolved Solids	373 mg/L	Non-regulatory WAH
Total Suspended Solids	80 mg/L	Non-regulatory WAH

NOTE: The following abbreviations are utilized for the designated uses: warmwater aquatic habitat (WAH), primary contact recreation (PCR), secondary contact recreation (SCR).
**Un-ionized ammonia shall be determined from values for total ammonia as N, in mg/l, pH and temperature, by means of the equation: un-ionized ammonia (mg/L) = 1.2[Total ammonia as N / (1 + 10^{pKa-pH})], where pKa = 0.0902 +[2730/(273.2 +T_c)] and T_c = temperature, °C.*
***Geometric mean based on not less than five samples taken during a 30-day period. Instantaneous standard is not to be exceeded in 20% or more of all samples taken during a 30-day period. If less than five samples are taken in a month, this standard applies.*

The regulatory statute for surface waters in Kentucky is found in 401 KAR 10:031. The statute provides minimum water quality standards for all surface waters as well as specific standards that apply to particular designated uses. All streams monitored have designated uses of warmwater aquatic habitat (WAH), primary contact recreation (PCR), secondary contact recreation (SCR), and fish consumption (FC). Warmwater aquatic habitat standards apply for the protection of productive warm water aquatic communities, fowl, animal wildlife, arboreous growth, agricultural, and industrial uses. Standards for primary contact recreation (PCR) are applicable to full body contact during the recreation season of May 1 through October 31. Secondary contact recreation (SCR) standards are applicable to partial body contact, with minimal threat to public health due to water quality, and these standards apply for the entire year.

For other parameters, no regulatory numeric standard has been established due to the variable relationship between biological integrity and concentration levels in different streams. Multiple factors are impacting warmwater aquatic habitat use of the Wolf Run Watershed, including poor riparian and in-stream habitat and poor hydrology/flow regime as well as elevated water quality parameters. Because of the uncertainty in assigning definitive thresholds for these parameters as well as the feasibility and cost-effectiveness of

reducing concentrations, a phased approach was utilized in the development of benchmarks for non-regulatory water quality parameters.

Under this phased approach, non-regulatory reference points are initially established higher than reference conditions since the reference levels may be well below the level necessary to restore support of the use. These target levels are established based the extent and magnitude of the problem as well as technological feasibility, cost, and achievability. These goals would be re-assessed through the watershed planning process on regular time intervals and lowered if the designated use does not become fully supported through the implementation plan efforts when target levels are achieved. Table 23, page IV-14, lists the non-regulatory reference points for the Wolf Run Watershed. These levels were developed in consideration of the recommendations made by KDOW, are applicable only for the Wolf Run Watershed, and are not intended to have any regulatory use.

The rationale behind the selection of these non-regulatory reference points is as follows. The nutrient levels (total phosphorus at 0.35 mg/L and total nitrogen at 3.0 mg/L) were each established between the 75th and 90th percentile concentrations for reference reaches in the Inner Bluegrass. The ammonia benchmark of 0.1 mg/L was near the 75th percentile for the Wolf Run data collected. These higher concentrations were utilized based on published literature (Pond *et al.* 2003), which indicates that nutrient concentrations are not well correlated with macroinvertebrate metrics in the Bluegrass Bioregion. The main stem of the Ohio River has a specific conductance limit of 800 µS/cm, which was considered too high for this region. The benchmark of 650 µS/cm was established near the average of the Wolf Run sampling site medians. The total dissolved solids benchmark was derived based on the ratio to conductivity as measured in the study. The total suspended solids benchmark was established at 80 mg/L based on a number of studies that indicate that concentrations above this level impact fisheries (as listed in Rowe *et al.* 2003).

2. Watershed Concentrations

Based on the analysis of all monitoring results, multiple factors are impacting the water quality in the Wolf Run watershed. Concentrations of nitrogen, phosphorus, dissolved oxygen, ammonia, specific conductance, suspended solids, and *E. coli* each exceeded benchmarks for one or more events. Exhibit 28, page IV-16, and Table 24, page IV-17, identify the relative priority of remediation of each site by parameter. Locations of abundant algal growth and low dissolved oxygen levels are also indicated on Exhibit 28. All sites with high priority require reductions in order to achieve regulatory or target loading levels. Low and medium priority levels were determined by the relative frequency by which reference points were exceeded. Overall, Spring Branch (W10) and the Big Elm Tributary (W11) are the worst areas in the watershed for water quality. The average results for the monthly sampling events that included four “dry” events, two “wet” events, and four “intermediate” events are shown in Tables 25 through 27, pages IV-17 through IV-19.

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_28_Water_Quality_Results.mxd) 7/24/2012 -- 11:27:46 AM sje

Exhibit 28
Water Quality Results
Wolf Run Watershed
Lexington, Fayette County, Kentucky

TABLE 24 – PRIORITY OF SITES FOR POLLUTANT REDUCTION BY PARAMETER

Parameter	W01	W02	W03	W04	W05	W06	W07	W08	W09	W10	W11	W12
E. coli	High	High	High	High	High	High	High	High	High	High	High	High
Total Nitrogen	Medium	High	Low	Low	Low	Medium	Low	Medium	Low	Medium	Medium	Low
Total Phosphorus	Low	Medium	Low	High	Low	Low	High	Low	Low	High	High	Low
Total Suspended Solids	Medium	Low	Medium	High	Medium	Low	Low	Low	High	High	Medium	Low
Specific Conductance	High	High	Low	Medium	Low	Low	Low	High	Medium	Medium	High	High

NOTE: High priority sites require a loading reduction or the concentration exceeded the benchmark in more than 50% of the measurements. Low priority sites had concentrations that exceeded the non-regulatory indicator level for less than 40% of samples for nitrogen, less than 30% for phosphorus, 0% for suspended solids, and less than 20% for specific conductance.

TABLE 25 – DRY WEATHER EVENT AVERAGES FOR WOLF RUN WATERSHED

Parameter	Unit	Benchmark	W01, WR at Old Frankfort	W02, Preston's Cave	W03, WR at Valley Park	W04, Vaughn's at Valley Park	W05, Cardinal at Devonport	W06, WR at Wolf Run Park	W07, Vaughn's at Pine Meadow	W08, Vaughn's at Picadome	W09, WR at Faircrest Dr	W10, Springs Branch	W11, Big Elm at Harrodsburg	W12, WR at Lafayette Pkwy
Dissolved Oxygen	mg/L	> 4.0	8.6	7.7	14.1	8.9	8.1	11.1	6.9	12.8	12.1	10.2	9.1	10.0
pH	SU	6.0 to 9.0	7.9	7.1	8.1	8.1	7.7	8.1	6.8	8.2	7.9	7.7	7.7	7.8
Specific Conductivity	µS/cm	650	708	779	627	629	616	588	545	1174	856	630	956	672
E. coli	CFU/100mLs	130 / 240	617	1691	537	3087	511	1404	2147	1220	2069	590	1095	801
Fecal coliform	CFU/100mLs	200 / 400	972	2202	767	1796	529	1679	1650	1191	2418	794	1702	728
Suspended Solids, Total	mg/L as P	80	4.7	5.3	5.0	1.7	5.3	7.3	3.0	5.0	26.7	8.7	11.0	10.0
Dissolved Solids, Total*	mg/L as P	373	372	429	345	349	343	327	310	624	486	363	554	419
Alkalinity, Total	mg/L as CaCO3	-	214	200	197	222	214	189	223	191	224	196	199	170
Hardness, Total	mg/L as CaCO3	-	268	282	259	270	267	258	259	348	296	260	324	266
Ammonia	mg/L as N	0.1	0.022	0.011	0.015	0.015	0.016	0.013	0.019	0.018	0.012	0.010	0.019	0.011
Nitrite	mg/L as N	-	0.019	0.008	0.018	0.008	0.015	0.021	0.023	0.019	0.021	0.017	0.013	0.011
Total Kjeldahl Nitrogen	mg/L as N	-	0.08	0.43	0.04	0.04	0.07	0.07	0.04	0.34	0.28	0.70	0.55	0.04
Nitrate	mg/L as N	-	2.60	3.35	2.30	1.77	2.48	2.98	2.65	3.50	2.78	3.58	3.80	1.85
Total Nitrogen	mg/L as N	3.0	2.70	3.79	2.36	1.82	2.55	3.07	2.71	3.86	3.08	4.29	4.36	1.90
Ortho-phosphorus	mg/L as P	-	0.283	0.297	0.290	0.323	0.307	0.315	0.418	0.192	0.261	0.270	0.277	0.123
Phosphorus, Total	mg/L as P	0.35	0.30	0.30	0.29	0.33	0.31	0.33	0.41	0.26	0.30	0.35	0.33	0.14

**Dissolved solid results should be utilized for screening purposes only due to the data quality.*

TABLE 26 – INTERMEDIATE EVENT AVERAGES FOR WOLF RUN WATERSHED

Parameter	Unit	Benchmark	W01, WR at Old Frankfort	W02, Preston's Cave	W03, WR at Valley Park	W04, Vaughn's at Valley Park	W05, Cardinal at Devonport	W06, WR at Wolf Run Park	W07, Vaughn's at Pine Meadow	W08, Vaughn's at Picadome	W09, WR at Faircrest Dr	W10, Springs Branch	W11, Big Elm at Harrodsburg	W12, WR at Lafayette Pkwy
Dissolved Oxygen	mg/L	> 4.0	8.9	7.3	10.6	10.0	7.9	9.3	9.0	10.2	10.0	9.1	8.5	9.9
pH	SU	6.0 to 9.0	7.4	7.0	7.6	7.5	7.5	7.7	7.3	7.9	7.8	7.7	7.8	7.8
Specific Conductivity	µS/cm	650	587	739	525	577	586	504	524	763	589	544	703	667
E. coli	CFU/100mLs	130 / 240	7063	5534	6730	3332	3278	2665	4896	4278	4958	1716	4744	2017
Fecal coliform	CFU/100mLs	200 / 400	5118	4405	6286	7803	3759	8437	6947	3524	5281	3428	5732	3329
Suspended Solids, Total	mg/L as P	80	11.8	14.0	7.3	6.5	8.5	6.0	27.0	7.5	5.0	4.8	11.0	8.2
Dissolved Solids, Total*	mg/L as P	373	429	405	280	300	310	259	298	633	276	303	457	387
Alkalinity, Total	mg/L as CaCO3	-	160	152	148	170	161	150	151	144	149	162	161	153
Hardness, Total	mg/L as CaCO3	-	207	236	208	216	230	210	207	255	228	222	261	221
Ammonia	mg/L as N	0.1	0.027	0.020	0.019	0.019	0.049	0.021	0.038	0.033	0.013	0.016	0.022	0.017
Nitrite	mg/L as N	-	0.019	0.012	0.022	0.021	0.032	0.010	0.034	0.041	0.008	0.017	0.014	0.021
Total Kjeldahl Nitrogen	mg/L as N	-	0.40	0.30	0.27	0.40	0.36	0.29	0.37	0.37	0.39	0.28	0.55	0.37
Nitrate	mg/L as N	-	2.19	2.60	2.35	2.09	2.18	2.55	2.03	2.57	2.33	3.03	2.80	2.10
Total Nitrogen	mg/L as N	3.0	2.61	2.91	2.64	2.50	2.56	2.85	2.44	2.98	2.72	3.32	3.36	2.49
Ortho-phosphorus	mg/L as P	-	0.185	0.273	0.268	0.278	0.287	0.271	0.323	0.152	0.227	0.248	0.324	0.132
Phosphorus, Total	mg/L as P	0.35	0.29	0.33	0.29	0.28	0.31	0.26	0.40	0.16	0.24	0.26	0.37	0.15

**Dissolved solid results should be utilized for screening purposes only due to the data quality.*

TABLE 27 – WET WEATHER EVENT AVERAGES FOR WOLF RUN WATERSHED

Parameter	Unit	Benchmark	W01, WR at Old Frankfort	W02, Preston's Cave	W03, WR at Valley Park	W04, Vaughn's at Valley Park	W05, Cardinal at Devonport	W06, WR at Wolf Run Park	W07, Vaughn's at Pine Meadow	W08, Vaughn's at Picadome	W09, WR at Faircrest Dr	W10, Springs Branch	W11, Big Elm at Harrodsburg	W12, WR at Lafayette Pkwy
Dissolved Oxygen	mg/L	> 4.0	22.0	17.4	19.4	16.5	20.2	19.5	19.3	20.2	20.3	20.8	18.3	19.2
pH	SU	6.0 to 9.0	7.6	7.2	7.6	7.7	7.5	7.7	8.0	7.9	7.9	7.9	7.9	7.8
Specific Conductivity	µS/cm	650	228	725	184	239	200	427	96	98	117	74	622	376
E. coli	CFU/100mLs	130 / 240	58244	232	105493	48788	1600	5024	21464	12535	88667	66248	57048	4012
Fecal coliform	CFU/100mLs	200 / 400	22704	467	34347	29759	1620	4514	9929	5946	39620	33532	31811	3253
Suspended Solids, Total	mg/L as P	80	108.0	33.5	117.0	141.5	66.5	30.5	44.5	41.5	131.5	180.0	65.5	19.0
Dissolved Solids, Total*	mg/L as P	373	174	398	84	138	118	110	73	86	52	209	385	177
Alkalinity, Total	mg/L as CaCO3	-	115	221	86	82	72	151	50	55	44	44	131	118
Hardness, Total	mg/L as CaCO3	-	118	225	123	126	100	202	98	94	99	90	240	188
Ammonia	mg/L as N	0.1	0.127	0.023	0.141	0.118	0.195	0.085	0.184	0.144	0.228	0.111	0.079	0.086
Nitrite	mg/L as N	-	0.019	0.009	0.024	0.020	0.010	0.022	0.015	0.021	0.025	0.017	0.018	0.011
Total Kjeldahl Nitrogen	mg/L as N	-	0.04	0.04	0.04	0.04	0.04	0.04	0.26	0.23	0.33	0.04	0.04	0.04
Nitrate	mg/L as N	-	0.61	3.15	0.66	0.27	1.17	1.03	0.28	0.27	0.35	0.29	1.01	1.04
Total Nitrogen	mg/L as N	3.0	0.67	3.20	0.72	0.33	1.22	1.09	0.56	0.52	0.70	0.34	1.06	1.09
Ortho-phosphorus	mg/L as P	-	0.251	0.274	0.206	0.240	0.166	0.310	0.214	0.174	0.295	0.222	0.351	0.120
Phosphorus, Total	mg/L as P	0.35	0.35	0.47	0.34	0.79	0.27	0.37	0.44	0.30	0.35	0.82	0.47	0.20

**Dissolved solid results should be utilized for screening purposes only due to the data quality.*

In-stream flow was measured concurrent with grab sample collections for each event. The results of these measurements are shown in Table 28, page IV-20. Wet weather conditions are typically one to two orders of magnitude higher than dry weather conditions. Also, during dry weather conditions, the groundwater flow from Preston's Cave (W02) represents a much greater percentage of the flow contribution at the mouth of the watershed due to the karst re-direction of surface flow from the headwaters of Vaughn's Branch and Wolf Run into the groundwater system. Because flow at W02 is primarily due to groundwater sources, the difference between wet and dry weather flows is much less than at other locations in the watershed.

TABLE 28 – FLOW MEASUREMENTS FOR ALL EVENTS

Date	Event	Flow (cfs)											
		W01	W02	W03	W04	W05	W06	W07	W08	W09	W10	W11	W12
5/25/11	Intermediate	30.6	10.3	11.5	1.6	5.0	7.0	0.5	0.7	1.0	1.5	2.3	1.4
6/13/11	Dry	2.7	1.3	0.5	0.02	0.4	0.4	Pooled	Pooled	0.3	0.01	Dry	Pooled
7/8/11	Intermediate while Raining – *E. coli*	36.2	15.6	Too Fast	Too Fast	Too Fast	Too Fast	9.7	173.0	Too Fast	20.6	Too Fast	21.5
7/11/11	Intermediate	7.8	4.2	3.0	0.4	1.4	1.6	0.2	0.3	0.4	0.6	0.6	0.02
7/15/11	Dry – *E. coli*	6.3	3.9	0.2	1.7	0.5	1.1	Pooled	0.04	0.1	0.4	0.2	0.05
7/25/11	Intermediate – *E. coli*	6.3	4.0	8.7	2.8	0.1	3.1	3.9	3.0	2.0	0.9	1.6	1.5
7/29/11	Intermediate – *E. coli*	1.9	1.4	0.3	<0.01	0.2	0.3	0.02	0.2	<0.01	0.5	0.05	0.04
8/2/11	Intermediate – *E. coli* Recollection	---	---	---	---	---	0.3	<0.01	0.5	0.01	0.4	<0.01	---
8/29/11	Dry	1.1	0.8	0.04	0.03	0.10	0.15	<0.01	0.01	0.01	0.11	Dry	0.03
9/30/11	Dry	10.9	2.4	2.6	0.4	1.6	1.1	0.04	0.14	0.12	0.5	0.14	0.04
10/13/11	Wet	69.9	8.6	20.7	13.3	1.0	0.04	9.1	5.8	39.6	20.1	1.9	0.2
11/16/11	Intermediate while Raining	47.9	16.8	16.0	5.0	6.7	12.1	3.9	3.8	6.2	1.7	4.8	11.8
12/12/11	Dry	12.8	3.9	4.2	0.7	2.4	1.8	0.14	0.08	0.6	0.8	0.3	0.4
1/11/12	Wet	148.9	14.4	96.7	55.9	11.7	47.8	28.8	20.0	55.1	18.8	19.0	23.8
2/17/12	Intermediate	11.7	5.1	3.1	0.52	1.8	2.4	0.02	0.16	0.26	0.84	0.6	0.41
Wet Average		109.4	11.5	58.7	34.6	6.4	23.9	19.0	12.9	47.4	19.5	10.5	12.0
Intermediate Average		17.7	7.0	7.1	1.7	2.5	4.4	1.4	1.4	1.6	1.0	1.7	2.5
Dry Average		6.8	2.5	1.5	0.6	1.0	0.9	0.1	0.1	0.2	0.4	0.2	0.1

NOTE: Intermediate average excludes the event on 7/8/2011 in which most sites could not be measured due to high velocities. Pooled and dry sites were excluded from calculations. For streams with flow levels less than 0.01 cfs, 0.005 cfs was utilized for calculation purposes.

Overall, the most severe problem throughout the watershed is the pathogen indicator parameters, *E. coli* and fecal coliform, for which averages were above the instantaneous benchmark levels at all sites for all event types. Only 17 percent of the fecal coliform results were below the instantaneous PCR limit of 400 MPN/100mLs while 38 percent were below the SCR limit of 1,000 MPN/100mLs. *E. coli* concentrations only met the instantaneous PCR limit of 240 MPN/100mLs in 14 percent of the results. Even lower percentages met the criteria for the geometric mean over a 30-day period for fecal coliform (10 percent below 200 CFU/100mLs) or *E. coli* (seven percent below 130 CFU/100mLs). The geometric mean concentrations are shown in Table 29.

TABLE 29 – GEOMETRIC MEAN CONCENTRATIONS OF FECAL INDICATORS COMPARED TO WATER QUALITY CRITERIA

Site	W01	W02	W03	W04	W05	W06	W07*	W08	W09	W10	W11	W12	WQS
Geomean *E. coli* (MPN/100mLs)	3009	1366	3031	2237	1482	2267	9071	2946	6395	1353	4795	770	130
Geomean Fecal Coliform (MPN / 100mLs)	3074	1188	4354	5528	1559	5294	8477	1974	5861	3274	6221	2266	200

**Geometric mean of only four samples due to pooled water during 7/15/11 event.*

With a human source likely for much of this load (Brion 2011), these levels pose a risk for recreational users of waters within the Wolf Run Watershed and reductions will be necessary throughout the watershed. Average concentrations varied considerably by event type, but generally wet weather events had much higher concentrations than dry weather events. W08 and W02 were each exceptions with W08 being high during dry weather and W02 being low during wet weather. Despite the high concentrations of fecal coliform and *E. coli*, no sanitary sewer overflows were documented by LFUCG for the dates in which the wet weather sampling was conducted. This may indicate sanitary sewer exfiltration from sources other than known overflowing manhole locations or additional sources of input including urban wildlife, pet waste, or other sources.

Abundant algal growth was observed at multiple areas across the Wolf Run Watershed as identified in Exhibit 28, page IV-16. This algal growth is cause by excessive nutrient loading and lack of stream shading and causes low dissolved oxygen levels and high pH. Aquatic plants and algae, which produce oxygen during the day through photosynthesis, consume dissolved oxygen after sunset, when no photosynthesis occurs. If a large volume of aquatic plant material is present in the stream, the plants may use so much dissolved oxygen that conditions toxic to aquatic life are produced at night. Additionally, abundant decaying plant matter leads to excessive oxygen use during bacterial decomposition. Fish require at least 5 to 6 mg/L of dissolved oxygen for normal activity. Levels below 4 mg/L are stressful, and levels below 2 mg/L are lethal. No fish kills were known to occur during the monitoring period.

Significant Algal Growth on McConnell Branch

Dissolved oxygen levels were detected below the instantaneous water quality limit (4.0 mg/L) once on August 29, 2011 at W07 and were once found below the chronic water quality limit (5.0 mg/L) at W04. All other measurements meet the minimum water quality standard. The highest dissolved oxygen levels recorded, 22.0 mg/L at W12, occurred along with the highest pH levels measured. Algal growth was extremely abundant at the site during the measurements and bubbles from the algae could be observed in the near-stagnant water.

The pH values ranged from a maximum of 8.6 SU to a low of 6.5 SU, each measured under dry conditions. All values were within the warmwater aquatic habitat standards of 6.0 to 9.0 SU. The limestone bedrock geology and heavy algal growth in some areas are suspected as contributing to the higher pH levels observed in the watershed.

The nutrient levels in the watershed were found to be high, contributing to abundant algal growth, but also contributing to other short and long term effects on stream ecosystems, including hypoxia in the Gulf of Mexico.

The total nitrogen concentrations were lowest during wet weather and highest during dry weather. Total nitrogen results ranged from below the reporting limit to 5.6 mg/L (at W11). W02 had concentrations above the non-regulatory reference point of 3.0 mg/L the most frequently, in seven of 10 events. W10, W08, and

W11 also exceeded the non-regulatory reference point during at least half of the measurements. The total nitrogen was comprised primarily of nitrate in all events, with total kjeldahl nitrogen and nitrite commonly below detection limits. At most, nitrite was only five percent of the total nitrogen. Total kjeldahl nitrogen was typically less than 20 percent of the total nitrogen, but comprised 44 to 47 percent during wet events at sites W07, W08, and W09. Thus, nitrate is the most common form of nitrogen in the watershed.

Ammonia, a type of nitrogen, results ranged from less than 0.015 mg/L to 0.306 mg/L. Unlike the total nitrogen, wet weather averages for ammonia were much higher at all sites (except W2) than dry or intermediate averages. All sites except W02 had one measurement above the non-regulatory reference point of 0.1 mg/L; five sites had two measurements above that concentration. All unionized ammonia concentrations were well below the warmwater aquatic habitat regulatory limit of 0.05 mg/L.

Phosphorus was measured in two forms: orthophosphorus and total phosphorus. Orthophosphorus is the available form of phosphorus that can be utilized by plants and algae while total phosphorus includes orthophosphorus and other forms. Orthophosphorus is a dissolved form of phosphorus while total phosphorus includes both dissolved and particle-bound phosphorus. Background concentrations of phosphorus approached the non-regulatory reference point of 0.35 mg/L throughout the watershed, with orthophosphorus averaging approximately 0.25 mg/L for all conditions and total phosphorus averaging approximately 0.29 mg/L for dry and intermediate events. Orthophosphorus ranged from below the reporting limit to a maximum of 0.604 mg/L, but was fairly consistent across event types. Sites W12 and W08 were consistently lower than other sites while sites W11 and W07 were consistently higher. Total phosphorus concentrations were much higher for wet weather than dry or intermediate averages. Wet weather events averaged 0.428 mg/L., due in part to increased suspended sediment levels measured during these events. The highest measured total phosphorus was 1.12 mg/L. All sites except W12 had at least one measurement above the non-regulatory reference point of 0.35 mg/L. Site W07 had concentrations above that level most frequently, exceeding it during six of the 10 measurements.

Total suspended solids were, as expected, higher in wet weather events than during dry and intermediate events. Sites W01, W03, W04, W09, and W10 each had suspended solid levels exceeding 80 mg/L with a high of 200 mg/L measured at W10 on October 13. All of these elevated events occurred during wet events. During wet weather events with high concentrations of suspended sediment, the color of the water is typically black or gray rather than brown like the soil color. Although erosion is a contributor to the suspended sediment load, the color of the turbidity indicates that stormwater runoff is a greater contributor to suspended sediments in Wolf Run.

Grey Colored Stormwater on Vaughn's Branch Upstream of Picadome Golf Course

Water temperature ranged from 5.3˚C (41.5˚F) to 26.0˚C (78.8˚F). All values are below the warmwater aquatic habitat maximum of 31.7°C (89°F). For the period sampled, the greatest variability in temperature was shown at W08 and W12 due to the shallow bedrock nature of these streams. These sites, as well as W03 and W06, were also slightly warmer than other sites on average. Sparse canopy coverage of the wide, shallow streams contribute to these higher averages. W02, located at Preston's Cave, had the least

variability in temperature measurements due to the groundwater flow source regulating temperature fluctuations.

Specific conductance levels are frequently elevated at several locations in the watershed. Sites W02, W11, W08, W12, and W01 all exceeded 650 µS/cm in more than half of the measurements at those sites, particularly under dry and intermediate conditions. Sites W03, W05, W06, and W07 had the lowest conductivity levels with only one measurement exceeding 650 µS/cm during the monthly monitoring. For the Wolf Run Watershed, total dissolved solids and specific conductance were related such that the dissolved solids concentration is typically approximately 57 percent of the specific conductance value. High conductivity or total dissolved solids may be due to nutrients, metals, or other compounds from sources such as natural geology or pollutants. While background levels due to geology are approximately 375 µS/cm (based on calculations using the total alkalinity and hardness concentrations), additional dissolved ion contributions can elevate these levels to above 650 µS/cm. Additional studies should examine the prevalence of chloride as volunteer data indicates it may be a large contributor to the conductivity in Wolf Run.

In addition to the monthly conductivity measurements, a conductivity survey was conducted throughout the Wolf Run watershed, the results of which are presented in a *Conductivity Survey Report* (Appendix C). The study provided a "snapshot" of low flow, dry weather conductivity in the Wolf Run Watershed, shown in Exhibit 29, page IV-24. In agreement with the monthly sampling results, high conductivity levels were measured on the Big Elm Tributary upstream of Nicholasville Road, Vaughn's Branch headwaters, and Wolf Run headwaters along Southland Drive. Additionally, an oily sheen and increase in conductivity in Wolf Run downstream of Harrodsburg Road, an increase from McConnell Springs to Preston's Cave, and a drop in conductivity on Picadome Golf Course were findings that should be investigated further. Additional monitoring should be conducted at these locations to indicate whether these problems are temporal or long-term in nature. Investigations into the root causes should be initiated in order to provide the most effective remediation.

In an effort independent of this study, the University of Kentucky has conducted extensive investigations to determine the source of the high conductivity levels from sources within their MS4 area. In a *Water Quality Investigation Report* dated November 3, 2011, the University explains their findings to date related to high conductivity levels noted in Vaughn's Branch and Big Elm Tributary.

For the headwaters of Vaughn's Branch, investigations indicated that a potential source for the high conductivity levels include runoff from South Limestone and commercial gas stations, natural sources including a suspected historic stream flowing under Seaton Center, groundwater infiltration into the stormsewer system, and several springs with high conductivity levels. The investigations identified a leaking cooling tower and greenhouse cooling equipment as contributing sources as well. The leaking cooling tower water was redirected into the sanitary sewer system in mid-October 2011 and the University is preparing short and long-term retrofitting plans to prohibit the discharge of non-contact cooling water originating from the greenhouses. Thus, one source of conductivity has been removed from the watershed and further work is ongoing by the University to determine other sources.

Exhibit 29
Conductivity Survey Results
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Conductivity readings were measured by the Friends of Wolf Run using calibrated meters during low flow conditions between September 17 and October 11, 2011.

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_29_Conductivity.mxd) 9/14/2012 -- 11:21:49 AM sje

For the Big Elm Tributary headwaters, the dominant source of the high conductivity levels was traced to two natural springs (called "Parking Lot Spring" and "Detention Basin Spring") that are located in the detention basin upstream of the pipe outfall near Alumni Drive. The University also noted a pipe near Nicholasville Road that was discharging high levels of conductivity and a small dry-weather discharge from Shawneetown Apartments with high *E. coli* levels (potentially indicating a sanitary waste source). The University plans to continue investigations of these sources.

3. Pollutant Loads and Reduction Targets

In order to calculate the annual loads at each site, concentrations for each parameter were first averaged for each event type (dry, wet, intermediate). Second, a flow was determined for each event type. For intermediate and dry events, the average of the measured flow was utilized. For wet weather, average measured flow at the mouth of the watershed (W01) was multiplied by the percentage of the total watershed area located upstream of each site to produce an "engineered" wet weather flow for each site (flow at mouth scaled for each site based on subwatershed drainage area). Third, for each event type the average concentration and engineered flow were multiplied by the concentration and a conversion factor to develop a daily load value for each site. Lastly, an annual load was calculated by weighting the daily load for each event type by the percentage of days in the period in which that type of condition was present (0.46 for dry, 0.42 for intermediate, and 0.12 for wet) and multiplying by 365.

To calculate the target load for each site, this same process was utilized, substituting the benchmark concentrations for the measured concentrations. Although the wet weather events occurred at a lower frequency than intermediate or dry events, the target load contribution during these events composed over 50 percent of the total load for all sites, except W02, due to the higher flows associated with these events. This target load was then subtracted from the actual annual load to determine the load reduction needed to reach the target load.

The load reductions required for the Wolf Run Watershed are summarized in Table 30, page IV-26, by subwatershed area. Over 90 percent load reductions are required for *E. coli* at all sites, with the most significant loading coming during wet weather. Remediation of the sanitary sewer system, including private laterals as well as public lines, will be critical to reducing the load in the watershed. For nitrogen, load reductions are necessary at Preston's Cave Spring (W02) but due to the karst influence, remediation for these levels should be targeted to the area of the Town Branch Watershed captured by the McConnell Springs drainage as well as in the Big Elm Tributary subwatershed area (W11). Ammonia levels were high at many locations in the watershed during wet weather events, but should be addressed through efforts to reduce the fecal load. For total phosphorus, load reductions are necessary on Vaughn's Branch downstream of Picadome Golf Course (W04 and W07), Spring Branch (W10), and Big Elm Tributary (W11) due in part to increased loading of wet particulate-bound phosphorus. Reduction of stream erosion and increased filtration of storm flows will aid in reducing the phosphorus levels in priority areas. Reductions of suspended sediments on Vaughn's Branch near the mouth (W04), Spring Branch (W10), and Wolf Run between Faircrest Drive and Lafayette Drive (W09) require reductions in storm loadings. Reduction of the erosive flow levels, restoration of eroded banks, and filtration of stormwater runoff will aid in achieving these target loads.

TABLE 30 – PERCENTAGE ANNUAL LOADING REDUCTION BY SITE

Parameter	% Reduction											
	W01	W02	W03	W04	W05	W06	W07	W08	W09	W10	W11	W12
E. coli – 130 CFU/100mLs	99.6	96.5	99.8	99.7	93.4	96.8	99.3	98.7	99.8	99.7	99.6	95.8
E. coli – 240 CFU/100mLs	99.3	93.6	99.7	99.4	87.9	94.2	98.7	97.5	99.6	99.4	99.3	92.2
Total Nitrogen	-	5	-	-	-	-	-	-	-	-	-	-
Total Phosphorus	-	-	-	49	-	-	18	-	-	42	18	-
Total Suspended Solids	-	-	-	30	-	-	-	-	16	26	-	-

a. E. coli Loading

Daily *E. coli* loadings for each event type and site are shown in Figure 6. The average daily load values range from a minimum of 1.49 billion MPN for dry weather at W08 to a maximum of 156 trillion MPN for wet weather at W01. For all sites except W02, the daily load is highest for the wet events, typically near 100 times greater, indicating significant loading is added from sanitary sewer exfiltration as well as runoff sources. Fecal coliform shows a similar pattern of loading as *E. coli* for each site.

FIGURE 6 – DAILY *E. COLI* LOADING BY EVENT TYPE

Table 31, page IV-27, indicates the load reductions necessary to achieve the PCR standards of 130 and 240 MPN/100 mLs during all weather conditions. A reduction of over 90 percent is required at all sites in the watershed in order to achieve these results (87.9 percent at W05 is the lowest reduction to achieve the instantaneous standard). For most sites, over 70 percent of the loading comes in wet weather conditions and at some sites (W04, W09, W10), 98 percent of the loading is due to wet weather. The loading for W02 is more evenly distributed across dry and intermediate conditions while W05 has nearly equal loading due

to wet and intermediate conditions. Dry weather loading was a very small percentage (less than four percent) of the annual loading at all sites except W02. The large reductions needed to meet targets indicate that supporting recreational use in the Wolf Run Watershed will require significant remediation efforts.

TABLE 31 – *E. COLI* ANNUAL LOAD REDUCTION

Site	Annual Load (trillion CFU/year)	30-day Geometric Mean Target Load* (trillion CFU/year)	Required Reduction (trillion CFU/year)	% Reduction	Instantaneous Standard Target Load* (trillion CFU/year)	Required Reduction (trillion CFU/year)	% Reduction
W01	7317	27.49	7290	99.6%	50.75	7267	99.3%
W02	164	5.69	158	96.5%	10.51	153	93.6%
W03	6840	12.46	6828	99.8%	23.00	6817	99.7%
W04	1750	5.72	1744	99.7%	10.55	1739	99.4%
W05	63.1	4.16	58.9	93.4%	7.68	55.4	87.9%
W06	248	7.77	240	96.8%	14.34	234	94.2%
W07	644	4.45	639	99.3%	8.22	635	98.7%
W08	157	2.10	155	98.7%	3.87	153	97.5%
W09	1645	3.31	1642	99.8%	6.11	1639	99.6%
W10	502	1.65	501	99.7%	3.05	499	99.4%
W11	640	2.29	637	99.6%	4.22	635	99.3%
W12	70.4	2.94	67.5	95.8%	5.42	65.0	92.2%

*Targets load based on 130 and 240 CFU/100mLs primary contact recreation standards for *E. coli*, respectively.

b. Nitrogen Loading

Figure 7, page IV-28, indicates the relative contribution to the annual load for each event type at each site. At all sites except W02, the actual annual load is below benchmark load levels. Although concentrations exceeded 3.0 mg/L at dry and intermediate weather conditions for all sites, most sites had very low concentrations (below 1.25 mg/L) during wet weather conditions due to dilution. Wet weather loading was near or slightly above intermediate load amounts at all sites, indicating little additional contribution due to runoff. Intermediate conditions had the greatest load contribution annually for most sites due to the higher flows in conjunction with high concentrations.

As shown in Table 32, page page IV-28, the only site that requires a reduction to reach the target annual loading is W02, which averaged 3.2 mg/L during wet weather events. Removal of 1,600 lbs of nitrogen/year will achieve the target reduction. As W02 is located at Preston's Cave, these load reductions will need to be targeted in the upstream karst basin.

FIGURE 7 – ANNUAL TOTAL NITROGEN LOADING CONTRIBUTIONS BY EVENT TYPE

*Target load based on 3.0 mg/L non-regulatory reference point.

TABLE 32 – TOTAL NITROGEN ANNUAL LOAD REDUCTION

Site	Annual Load	Target Load*	Load Reduction	% Reduction
	(lbs nitrogen as N/year)			
W01	72,100	140,000	-	-
W02	30,600	29,000	1,610	5%
W03	28,700	63,500	-	-
W04	7,020	29,100	-	-
W05	12,700	21,200	-	-
W06	22,400	39,600	-	-
W07	6,460	22,700	-	-
W08	4,850	10,700	-	-
W09	7,290	16,900	-	-
W10	4,710	8,410	-	-
W11	7,750	11,600	-	-
W12	8,380	15,000	-	-

**Target load based on 3.0 mg/L non-regulatory reference point.*

c. Phosphorus Loading

The relative contribution of total phosphorus annual loading for each event type and site are shown in Figure 8. As previously indicated, the total phosphorus concentrations under wet and dry conditions typically average near 0.3 mg/L; wet weather concentrations are higher, particularly for sites W04 and W10, which averaged near 0.8 mg/L. Together with high flow levels, the annual wet weather load contribution was disproportionate to the occurrence frequency, averaging 68 percent of the total load while only occurring on 12 percent of the days.

FIGURE 8 – ANNUAL TOTAL PHOSPHORUS LOADING CONTRIBUTIONS BY EVENT TYPE

*Target load based on 0.35 mg/L non-regulatory reference point.

In order to reach the target loading, load reductions are required at four sites in the watershed, as shown in Table 33, page IV-30. The greatest annual reduction is necessary on Vaughn's Branch, with 3,300 lbs near the mouth (W04); 590 of which are needed upstream of the Pine Meadows Park (W07) primarily from the Picadome Golf Course area. Sizeable annual reductions of 698 lbs in the Spring Branch subwatershed (W10) and 290 lbs from the Big Elm Tributary subwatershed are also required. These reductions should be achieved by erosion reduction and storm event filtration methods.

TABLE 33 – TOTAL PHOSPHORUS ANNUAL LOAD REDUCTION

Site	Annual Load	Target Load*	Load Reduction	% Reduction
	(lbs phosphorus as P/year)			
W01	15,100	16,300	-	-
W02	3,350	3,390	-	-
W03	6,830	7,410	-	-
W04	6,700	3,400	3,300	49%
W05	2,030	2,470	-	-
W06	4,450	4,620	-	-
W07	3,240	2,650	590	18%
W08	894	1,250	-	-
W09	1,810	1,970	-	-
W10	1,680	982	698	42%
W11	1,650	1,360	290	18%
W12	874	1,750	-	-

*Target load based on 0.35 mg/L non-regulatory reference point.

d. Suspended Solids

The total suspended solids annual loading and reductions are shown in Figure 9 and Table 34, both of which are located on page IV-31. Dry weather events comprised less than three percent of the total annual load at all sites except W02, which is below Preston's Cave Spring. Wet weather loading averaged 88 percent of the total annual load for all sites as expected due to the higher flows and higher concentrations. Three sites require load reductions to meet target levels. Vaughn's Branch near the mouth (W04) requires a 30 percent reduction of over 300,000 lbs/year. Springs Branch (W10) and Wolf Run between Faircrest Drive and Lafayette Drive (W09) also require annual reductions near 80,000 lbs, which are 26 percent and 16 percent of the total loads, respectively. Reduction of the erosive flow levels, restoration of eroded banks, and filtration of stormwater runoff will aid in achieving these target loads.

According to Kevin Lyne of LFUCG DWQ Compliance and Monitoring Section (Personal Communication October 2012), there are several locations where construction runoff contributed to sediment loading based on notices of violation issued and verbal warnings. Cardinal Valley School (located in W4) and CVS Pharmacy in Spring Branch (W10) were each given several verbal warnings and notices of violation over the monitoring period for issues that contributed to sediment loading in the time between issuance and resolution. The amount of load contribution is unknown, as is other construction site runoff contributions that may have occurred during the monitoring period.

FIGURE 9 – ANNUAL TOTAL SUSPENDED SOLIDS LOADING CONTRIBUTIONS BY EVENT TYPE

**Target load based on 80 mg/L non-regulatory reference point.*

TABLE 34 – TOTAL SUSPENDED SOLIDS ANNUAL LOAD REDUCTION

Site	Annual Load	Target Load*	Load Reduction	% Reduction
	(lbs/year)			
W01	3,000,000	3,740,000	-	-
W02	148,000	774,000	-	-
W03	1,680,000	1,690,000	-	-
W04	1,110,000	777,000	330,000	30%
W05	290,000	565,000	-	-
W06	294,000	1,060,000	-	-
W07	315,000	605,000	-	-
W08	107,000	285,000	-	-
W09	538,000	450,000	88,000	16%
W10	304,000	224,000	80,000	26%
W11	171,000	311,000	-	-
W12	71,800	399,000	-	-

**Target load based on 80 mg/L non-regulatory reference point.*

4. Achieving Pollutant Load Reduction Targets

In order to achieve the over 90 percent load reductions required to meet *E. coli* water quality goals, significant remediation of the sanitary sewer system, including private laterals as well as public lines, will be necessary. However, the load reduction achieved by any particular project or line replacement is difficult to project as the bacteria load is dependent upon numerous factors, including the degree of exfiltration, the

amount of flow in a particular line, and the concentration of *E. coli*. Because of these factors, an iterative approach of project construction followed with post-construction monitoring will be utilized to determine the reductions achieved for a given project and the need for additional source identification and treatment in the upstream watershed.

For suspended solids, phosphorus, and nitrogen loading, a simple stormwater model (Schueler 1987 as detailed NY DEC 2012) was used to estimate how much individual sources would need to be reduced in order to achieve the calculated pollutant load reductions. Although this method only estimates pollutant loads generated during storm events in urban areas, this is appropriate for the Wolf Run Watershed because it is almost entirely urban and the majority of the loading is attributed to stormwater sources, with the exception of phosphorus for which stormwater sources are a lesser contributor. It is important to consider that these values are estimates intended only to provide a general sense of the magnitude of reductions by source type necessary to achieve the reduction goals.

Under the simple method, the annual load is calculated for each source type based on multiplying the annual runoff by the area and then by the pollutant concentration, converting for unit differences.

The annual runoff volume of the impervious and pervious surfaces was calculated by multiplying the annual rainfall by the fraction of annual events that produce runoff (assumed to be 0.9 as typical) by the runoff coefficient. The annual rainfall value, 45.81 inches was derived by converting the rainfall measured at the KLEX station over the monitoring period (33.76 inches) to an annual basis. The runoff coefficient for pervious surfaces was assumed to be 0.95 and 0.05 for impervious surfaces. Thus, the annual runoff was calculated as 39.2 inches for impervious surfaces and 2.1 inches for pervious surfaces.

Table 35 indicates values that were used for pollutant concentrations for each respective source area. These values are modified from the national values provided in NY DEC 2012, based on KDOW recommendations, to better correlate with loadings observed in the Wolf Run Watershed.

TABLE 35 – POLLUTANT CONCENTRATIONS FROM SOURCE AREAS

Source Area	TSS (mg/L)	TP (mg/L)	TN (mg/L)
Commercial Roof	9	0.20	2.1
Industrial Roof	17	0.20	2.1
Residential Roof	19	0.15	1.5
Driveway	173	0.78	2.1
Parking Lot	228	0.78	1.9
Urban Highway	142	0.45	3.0
Commercial Street	468	0.80	1.4
Residential Street	172	0.80	1.4
Lawns	602	3.00	9.1

A GIS analysis was conducted to determine the amount of area in each subwatershed that was composed of roof (commercial, industrial, or residential), paved driveway, parking (industrial, commercial, and residential), urban highways, commercial streets, residential streets, and lawns (residential, public recreation, and other public facilities). The 2007 comprehensive plan (LFUCG 2007) land use GIS layer was intersected with the impervious surface GIS layer, and then areas within each of these categories were

summed to determine the total area of each type within each subwatershed. The acreages are shown in Table 36 and the estimated annual pollutant loadings from stormwater sources summarized in Table 37.

TABLE 36 – ACERAGE OF SOURCE AREAS BY SUBWATERSHED

Land Use	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
Commercial Roof	6.0	15.0	4.5	7.2	12.9	11.9	14.8	68.0	7.8	28.6	33.0	43.1
Industrial Roof	28.5	21.7	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.0	2.3
Residential Roof	14.1	21.2	26.5	34.8	85.9	99.2	42.5	40.3	36.9	37.9	44.8	78.3
Paved Driveway	11.0	14.3	18.1	25.2	49.4	54.0	12.9	14.4	18.6	29.6	21.0	43.9
Industrial Parking	47.4	11.2	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	3.8	3.7
C/R Parking	12.4	29.5	17.4	18.9	28.3	36.2	37.8	114.2	12.7	51.3	87.0	89.9
Urban Highway	8.9	5.0	5.3	5.7	19.2	1.2	3.7	10.1	3.0	7.8	6.1	8.4
Commercial Street	16.7	3.3	2.8	2.1	4.4	6.0	3.9	27.5	2.3	2.8	9.7	19.2
Residential Street	17.3	10.9	16.3	20.4	63.1	68.0	27.5	22.3	21.3	25.1	24.4	44.0
Residential Lawns	64.8	82.1	93.9	166.8	460.1	386.1	145.2	103.4	129.4	163.9	184.2	292.4
Public Recreational Lawns	34.46	26.16	3.14	1.75	127.15	26.20	102.16	5.04	0.00	11.06	35.49	3.45
Other Public Facility Lawns	31.60	73.75	17.62	16.92	37.74	27.03	34.05	83.17	11.79	25.46	74.58	6.52

TABLE 37 – ESTIMATED ANNUAL POLLUTANT LOADING FROM STORMWATER SOURCES

Source Area	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
Estimated Annual Total Suspended Solids Load (lbs)												
Industrial and Commercial Roof	4,800	4,500	350	570	1,000	950	1,200	5,400	1,000	2,300	2,900	3,800
Residential Roof and Lawn	21,000	27,000	31,000	53,000	140,000	120,000	48,000	36,000	43,000	52,000	59,000	95,000
Streets and Highways	110,000	37,000	43,000	47,000	140,000	130,000	63,000	160,000	46,000	60,000	85,000	160,000
Parking Lot	120,000	82,000	35,000	38,000	57,000	73,000	76,000	230,000	32,000	100,000	180,000	190,000
Driveway	17,000	22,000	28,000	39,000	76,000	83,000	20,000	22,000	29,000	45,000	32,000	67,000
Other Lawns	19,000	28,000	5,800	5,200	46,000	15,000	38,000	25,000	3,300	10,000	31,000	2,800
Total Load	291,800	200,500	143,150	182,770	460,000	421,950	246,200	478,400	154,300	269,300	389,900	518,600
Sum of Upstream	3,756,870	590,400	1,967,300	907,370	460,000	1,364,150	724,600	478,400	672,900	269,300	389,900	518,600

TABLE 37 - ESTIMATED ANNUAL POLLUTANT LOADING FROM STORMWATER SOURCES, CONTINUED

Source Area	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
Estimated Annual Total Phosphorus Load (lbs)												
Industrial and Commercial Roof	61	65	8	13	23	21	26	120	18	51	62	80
Residential Roof and Lawn	109	143	166	279	757	671	259	198	230	279	317	513
Streets and Highways	277	121	156	182	554	529	237	393	179	229	266	481
Parking Lot	413	281	120	131	196	250	261	789	109	354	627	647
Driveway	76	99	125	174	341	373	89	100	129	205	145	303
Other Lawns	92	140	29	26	230	74	190	123	16	51	154	14
Total Load	1,029	848	604	805	2,101	1,918	1,063	1,723	682	1,169	1,570	2,038
Sum of Upstream	15,550	2,419	8,512	3,591	2,101	5,807	2,786	1,723	2,720	1,169	1,570	2,038
Estimated Annual Total Nitrogen Load (lbs)												
Industrial and Commercial Roof	642	682	83	133	241	221	275	1,264	192	532	651	843
Residential Roof and Lawn	462	630	749	1,170	3,092	2,953	1,179	974	1,039	1,198	1,376	2,279
Streets and Highways	659	308	377	430	1,345	949	486	885	373	553	585	1,006
Parking Lot	1,007	685	292	319	477	609	637	1,921	267	863	1,527	1,575
Driveway	205	266	336	468	918	1,004	240	268	346	551	390	816
Other Lawns	280	424	88	79	699	226	577	374	50	155	467	42
Total Load	3,254	2,995	1,926	2,598	6,772	5,963	3,395	5,687	2,267	3,852	4,995	6,562
Sum of Upstream	50,265	7,990	27,340	11,680	6,772	18,643	9,082	5,687	8,829	3,852	4,995	6,562

Based on these estimates, the restoration activities should be targeted towards capturing and reducing the pollutant load from residential roof and lawns, parking lots, and streets and highways since these represent the largest stormwater sources of total suspended solids, phosphorus, and nitrogen. In order to achieve the reduction goals summarized in Tables 32 through 34, one reduction scenario is proposed in Table 38, page IV-35. Although these reductions would not meet the phosphorus reduction targets according to the model, stormwater comprised a lesser portion of the overall phosphorus loading and the model predicts only loading due to stormwater, so the actual reductions may be greater. The nitrogen load reduction required for the Preston's Cave/McConnell Springs karst basin drainage is addressed through reductions in Vaughn's Branch, Big Elm Tributary, and Upper Wolf Run.

TABLE 38 – REDUCTION OF STORMWATER SOURCE LOADS TO ACHIEVE POLLUTANT REDUCTION TARGETS

Source Area	Lower Wolf Run (W1,W3)	Preston's Cave / McConnell Springs (W2)	Cardinal Run / Garden-side Trib (W5)	Middle Wolf Run (W6)	Vaughn's Branch (W4, W7, W8)	Spring Branch (W10)	Big Elm Tributary (W11)	Upper Wolf Run (W9,W12)
Residential Roofs and Lawns	0%	0%	0%	0%	30% TSS, TP, TN	35% TSS, TP	25% TP, TN	25% TSS, TN
Streets	0%	0%	0%	0%	30% TSS, TP, TN	35% TSS, TP	25% TP, TN	15% TSS, TN
Parking Lots	0%	0%	0%	0%	20% TSS, TP, TN	50% TSS, TP	25% TP, TN	25% TSS, TN

CHAPTER V. BMP SELECTION PROCESS AND FEASIBILITY CONCERNS

In order to develop a strategy to restore the watershed and meet the watershed goals, the Wolf Run Watershed Council held a series of meetings and activities to select the BMPs best suited to accomplish the watershed goals.

The Wolf Run Watershed Council met quarterly beginning in December 2010 and technical presentations and discussion of watershed activities and plan development were discussed during each meeting. These quarterly meetings were utilized as a platform to educate stakeholders on the impairments in the watershed and maximize the public involvement in the selection of BMPs to address these impacts. The following is an overview of the agendas of each meeting:

- December 2010: Overview of watershed planning and invitation to join council
- April 2011: Group discussions of current and proposed watershed projects and objectives
- June 2011: Presentation of microbial source tracking results by Dr. Gail Brion
- September 2011: Update on monitoring results and formation of Outreach Campaign Committee
- December 2011: Finalization of public outreach strategy
- March 2012: Water quality resource fair and BMP identification exercise
- June 2012: Watershed monitoring results and draft watershed goal development
- September 2012: Watershed goal finalization, draft water quality BMP plan, and formation of Water Quality BMP Technical Committee
- December 2012: Finalization of water quality BMP plan and development of implementation team

Two technical committees were launched in order to provide detailed discussion and analysis of BMP strategies. The Outreach Campaign Committee and the Water Quality BMP Technical Committee each took input from the Watershed Council, developed a more comprehensive strategy, and then presented the results to the Council for prioritization and finalization.

A. Public Education and Outreach Strategy

The Outreach Campaign Committee was formed on September 19, 2011 and met twice during October and November 2011. During these meetings, the group discussed goals, strategies, target audience, and messaging. Four goals were developed for public education and outreach with an ultimate goal of improving water quality:

- Increase the public's awareness that they live/work in the Wolf Run Watershed and the impacts (both positive and negative) their lifestyle choices and behavior have on water quality within the watershed.
- Educate property owners of the importance and benefits of restoration of the riparian buffer zone along Wolf Run.
- Educate residents on the fiscal and environmental impacts sump pumps and downspout connections have on the sanitary sewer system and water quality.
- Provide citizens with information and training to empower them to take action to reduce stormwater runoff within the watershed. Currently, 40 percent of the watershed is covered with impervious surfaces, resulting in significant stormwater runoff.

The technical committee identified specific groups within the watershed to receive targeted messaging to support the developed goals and strategies. The audience includes:

- Streamside landowners including governmental, residential, commercial and institutional
- Property management companies of apartment complexes
- Neighborhoods identified by sanitary sewer assessment surveys to be in high-flow areas
- Key commercial districts such as Southland Drive
- Institutions with significant footprint in the watershed, such as the University of Kentucky, Fayette County Public Schools, hospital campuses, and parks

The committee found that messages must engage and resonate with that specific audience and spur them to take a specific action. To do so, messages should:

- Be clear and direct
- Be relevant for the audience
- Be positive, providing examples of "what to do" as opposed of "what not to do"
- Instill a sense that individual actions matter

The Watershed Council prioritized the specific strategies developed by the technical committee at a subsequent meeting. Each Council member was given 10 markers in order to indicate the strategies they thought were of the highest priority. The amount of support for each education and public outreach strategy was utilized to prioritize them as high, medium, and low priority. These results have been incorporated into the comprehensive strategy for success presented in the following chapter.

B. BMP Selection Process

1. Water Quality Resource Fair

In order to familiarize stakeholders with BMPs and generate discussion about what type of BMPs should be installed to address water quality improvement, a water quality resource fair was held on March 19, 2011. The resource fair was also intended to introduce stakeholders in the area to technical experts capable of installing, operating, and maintaining BMPs in the watershed. Four categories of experts were present to answer questions of stakeholders, who were submitting a list of BMPs they believed would be the most effective in addressing the watershed impairments:

- Funding: Representatives of funding agencies, including KDOW and LFUCG, were available to address whether the practice would be eligible for funding
- Social Acceptance: A panel of neighborhood association presidents and city council members were present to provide feedback on political acceptance of practices in the watershed
- Appropriate: Technical representatives were available to indicate whether the BMP would address impairment in the watershed
- Technical Feasibility: Local consultants, engineers, non-profits, and other parties experienced in installing, operating, and maintaining BMPs were available to discuss their capabilities and recommendations. Participants included:
    - Bluegrass Rain Garden Alliance
    - Bluegrass PRIDE Environmental Program
    - CDP Engineers

- Cedar Creek Engineering
- EcoGro
- LFUCG Division of Water Quality
- Montgomery Plumbing
- National Environmental Compliance
- Third Rock Consultants

Stakeholders completed "BMP Bingo" cards indicating if the practices they recommended were fundable, acceptable, appropriate, and technically feasible. Table 39 summarizes the practices most recommended. To determine the priority of projects, these BMP recommendations were considered along with land owner willingness to participate, impairments addressed, amount of pollutants removed, and the cost effectiveness.

TABLE 39 – WATER QUALITY RESOURCE FAIR BMP RECOMMENDATION SUMMARY

Rank	Type of BMP
High	Bio-swales / Rain Gardens
High	Riparian Buffers
Medium	Parking Lot Retrofits
Medium	Streetscape Improvements
Low	Erosion and Sediment Control
Low	Educational Activity
Low	Green Roofs
Low	Rainwater Harvesting
Low	Enforcement of Ordinances
Low	Sanitary Sewer Repairs

2. Water Quality BMP Locations

During the September 17, 2012 Wolf Run Watershed Council Meeting, the council was asked to provide recommendations for locations for BMP implementation, including the rationale behind these selections and the feasibility concerns for the area.

In order to development these initial plan BMP recommendations, the Council was provided with various decision-making tools including:

- Results of the water quality resource fair to evaluate the practices deemed most appropriate by their peers
- Cost and effectiveness summary of structural BMPs
- Maps summarizing the impairments in the Wolf Run Watershed, as presented in Chapters III and IV
- A large aerial map indicating the location of various water infrastructure

The Council was divided into five groups based on geographic area. The groups specified locations and types of BMPs best suited to address the impairments in these respective areas. The groups were asked to consider structural, source control, and educational BMPs to address the impairments to the warmwater aquatic habitat use.

The results of this effort were compiled and submitted to the Water Quality BMP Technical Committee for further development. The Technical Committee considered the recommendations of the council, adding the requisite details to form the implementation strategy presented in the following chapter. Each of the watershed implementation tasks were then prioritized into a high, medium, or low priority by the Watershed Council.

C. Feasibility Considerations

The Wolf Run Watershed contains unique challenges and feasibility constraints due to the land use, geology, and regulatory mechanisms in the watershed. These factors were considered during the implementation plan development and influenced the type of BMPs considered within various geographic areas.

1. Development into the Floodplain

The encroachment of development into the floodplain and riparian zone of some streams within the Wolf Run Watershed have rendered restoration of certain reaches unfeasible due to the high cost involved with the acquisition of property and stream and floodplain restoration. Specifically, over 4,300 feet of Wolf Run upstream of Clays Mill Road is either located within a concrete channel or has stone armored banks. Much of this reach is also located between roadways or shopping centers. These urban constrains limit the restoration options for these reaches and make restoration very difficult; thus, stream restoration is considered unfeasible for these reaches. Green infrastructure to contain stormwater onsite and reduce runoff volumes is considered a more feasible BMP in this area.

Armored Banks on Wolf Run at Lafayette Parkway

2. Private Versus Public Ownership

The ownership of property was considered when determining the feasibility of BMPs. Publicly-owned lands were given priority for BMP installation, particularly for stream restoration, due to the ease in procuring funding and coordination and avoidance of some of the challenges of obtaining landowner permission and participation. When projects are located on properties owned by multiple landowners, the coordination process is often slow and can fail after considerable expense has gone towards conceptual development and planning. Therefore, projects with public ownership or single property ownership were preferred.

Wolf Run, Concrete Channel Beside Southland Drive

3. Infiltration and Karst

As the Wolf Run Watershed has karst features in many areas, infiltration BMPs may not be suitable in some areas. These activities may have a negative impact on surrounding areas, such as raising the groundwater table or discharging pollutants into the groundwater. Particularly in the McConnell Springs/ Preston's Cave karst basin, infiltration practices are not always feasible for pollutant reduction. Additionally in these areas, geotechnical studies should be conducted prior to stream restoration projects, lest a surface water stream be converted to a sinking stream.

4. Consent Decree Requirements

The Consent Decree (United States 2006) contains compliance measures that relate to the storm sewer system, sanitary sewer system, and additional environmental projects. In regards to the sanitary sewer system, the Consent Decree mandates the implementation of the remedial measures plan developed for Wolf Run Watershed and the other Lexington area watersheds. As the Consent Decree schedules take precedence over watershed planning goals and objectives, the timelines for Consent Decree projects and objectives were assumed in this watershed plan. No attempts to modify project timelines or schedules were made in this watershed plan. Therefore, reduction goals are made to correspond with expected achievements under the remedial measures plan with additional efforts added to these fixed goals.

CHAPTER VI. STRATEGY FOR SUCCESS

A. Goals and Objectives

On September 17, 2012, the Wolf Run Watershed Council approved a list of goals to indicate the major concerns and desires of the community for the watershed. These goals were also prioritized from greatest to least concern, as follows:

1. Decrease bacteria levels to allow for safe recreational use
2. Decrease the velocity and volume of stormwater runoff into Wolf Run streams
3. Improve the stream habitat to support a healthy aquatic ecosystem
4. Reduce the algal growth in the watershed
5. Reduce other pollutants contributing to aquatic life impairment
6. Preserve and enhance the unique natural resources at Preston's Cave Spring

For each goal, the pollutant source or cause is indicated as well as the measurable indicator of success and the objectives to be addressed in order to accomplish the goal. These objectives are summarized in Table 40.

TABLE 40 – WOLF RUN WATERSHED PLAN GOALS AND OBJECTIVES

Goal	Source, Cause, Pollutant, or Threat	Measurable Indicator	Objective
Decrease bacteria levels to allow for safe recreational use	• Sanitary sewer system: exfiltration from private lateral lines and public sewer including sewer overflows • Septic systems • Domestic pets, wildlife, and other sources	• *E. coli* • Fecal coliform	• Repair, replace, and rehabilitate the public sanitary sewer system to prevent exflow and exfiltration • Reduce the private sanitary sewer contributions from sump pumps, downspouts, and broken lateral lines • Encourage proper care and maintenance of septic systems • Investigate Red Mile Racetrack runoff as a source • Encourage pet waste management
Decrease the velocity and volume of stormwater runoff into Wolf Run streams	• High percentage of impervious surface leading to elevated runoff volumes and velocities • Channel alteration including straightening, channelization, and channel lining.	• Impervious acreage • Runoff volume	• Reduce the amount of impervious surface in the watershed • Restore channel dimensions, pattern, and profile • Reduce stormwater runoff through infiltration or storage including retrofits of parking lots and other impervious areas
Improve the stream habitat to support a healthy aquatic ecosystem	• Narrow riparian width • Wide, shallow, bedrock streams • Channelization and entrenchment • Erosion • High frequency of dry channels	• Macroinvertebrate score • Habitat score • Bank measurements • Visual observations	• Improve the quality and width of riparian zones by native plantings and exotic invasive removal • Stabilize eroding stream banks • Restore habitat to the streams including riffles/pools, leaf packs, and epifaunal substrate • Restore stream attachment with the floodplain and reduce channelization • Utilize regulatory or administrative measures to protect and expand riparian buffer areas

TABLE 40 – WOLF RUN WATERSHED PLAN GOALS AND OBJECTIVES, CONTINUED

Goal	Source, Cause, Pollutant, or Threat	Measurable Indicator	Objective
Reduce the algal growth in the watershed	• High nutrient levels from nonpoint sources and sanitary sewer exfiltration • Poor shading of stream	• Nitrogen • Phosphorus • Dissolved oxygen • Visual observations	• Removal of fecal sources through priorities listed to address bacteria levels • Increase stream shading through riparian planting / restoration • Reduce the amount of nutrients entering the watershed • Improve in-stream habitat and channel dimensions • Education and outreach to reduce nonpoint sources of nutrients
Reduce other pollutants contributing to aquatic life impairment	• Siltation and deposition from urban runoff sources • Elevated dissolved solid and conductivity levels due to urban sources • Trash and debris decreasing aesthetic beauty of watershed	• Suspended solids • Conductivity • Dissolved solids • Chloride • Alkalinity / Hardness	• Organize efforts to remove trash and debris from watershed on a routine basis • Reduce pollutant levels through stormwater treatment, storage or redirection • Decrease sediment loading from construction site runoff • Stabilize or restore eroding stream banks • Investigate, identify and remediate sources of high conductivity or dissolved solids
Preserve and enhance the unique natural resources at Preston's Cave Spring	• Heavy siltation and debris in stream and floodplain • Invasive species are dominant throughout the area	• Habitat score • Pebble counts • Visual observations	• Remove siltation / large debris from stream • Remove exotic, invasive species and restore native flora • Investigate and remediate, if necessary, head cut on McConnell Branch tributary • Perform in-stream habitat restoration and channel design

Most of the goals and objectives address impairments and pollutants identified in the watershed. The reduction of bacteria levels in the watershed was considered the greatest priority due to the risk of human illness during recreational use. Decreasing the velocity and volume of stormwater runoff, improving the habitat, reducing the algal growth, and reducing other pollutants are all goals aimed at restoring a healthy aquatic ecosystem. While other goals are watershed-wide, one goal is unique in its localization. Preston's Cave Spring is a unique natural resource which the community has interest in preserving and enhancing through restoration.

Measurable indicators of success were selected due to regulatory standards for comparison (such as *E. coli* and fecal coliform) or impairments indicated in the watershed monitoring. Other parameters may be utilized, as appropriate, to gage overall success in reducing pollutant loading or linking a loading to a particular source. However, to evaluate overall progress in water quality improvement, the measurable indicators specified should be utilized.

B. BMP Implementation Plan

The watershed goals and objectives were used as a framework to develop a comprehensive list of BMP projects and opportunities necessary to restore the designated uses to the watershed and achieve the community goals. The list of BMPs includes projects in various stages of development and execution.

Some BMPs are existing programs or projects completed during or subsequent to the watershed plan monitoring completion. Others are projects currently funded or planned, but not yet implemented. Many BMPs are opportunities at the conceptual stage, requiring landowner support, further evaluation, and funding prior to initiation.

The BMP Implementation plan is intended to guide BMP implementation efforts and represent the scope and types of efforts that will be required to meet the watershed goals. For these BMPs, the identification of the responsible parties includes possible stakeholders to be contacted in order to initiate such a project. Likewise, the action items listed indicate possible approaches to achieving the watershed objectives. If an alternative approach can be used to achieve the same objective, that approach may also be acceptable. For instance, the University of Kentucky's stormwater planning efforts, as described in Appendix G, concurs with this plan, but may be implemented in a slightly different approach.

For each BMP, information necessary for project implementation is summarized, as best as currently possible, including:

- Type of BMP
- Target audience or area
- Project priority
- Description of the project including action items
- Impairment/pollutant addressed
- Responsible parties
- Estimated cost
- Estimated load reduction
- Funding source(s) or program(s)
- Technical assistance required
- Short, mid, and long term milestones

The BMP Implementation Plan for the Wolf Run Watershed is provided in Table 43, pages VI-14 through VI-34, with the location of each project provided, where appropriate, in Exhibit 30, page VI-4. One hundred and thirty eight BMPs are proposed in order to achieve the watershed goals and objectives.

Sixty-two BMPs are identified as high priority, 32 as medium priority, and 44 as low priority. High priority BMPs include areas or audiences which are necessary to achieve watershed goals, are believed to provide the greatest benefit to the watershed, and which have stakeholder cooperation and support. High priority BMPs also include projects or phases of projects in the watershed that have recently been completed or where initial funding has been awarded. Medium priority BMPs typically target areas or audiences where BMPs are necessary, but it is unknown if all stakeholders would be willing to pursue implementation. BMPs may also be of medium priority if implementation is evaluated to be less effective. Low priority BMPs would be beneficial in improving the watershed, but are located in an area in which pollutant loading reductions are not required or the implementation is evaluated to be less feasible or effective.

Although the project objectives specify reduction of elevated dissolved solid and conductivity levels, the BMP implementation plan does not specifically mention this pollutant. It is believed that many of the green infrastructure practices in the plan will reduce the dissolved solid and conductivity levels; however, the amount of reduction is difficult to calculate. Ongoing monitoring to identify sources of elevated conductivity levels for investigation and remediation will be the best means of reductions targeted to these parameters.

Exhibit 30
BMP Implementation Plan
Wolf Run Watershed
Lexington, Fayette County, Kentucky

BMPs for Implementation

- Bank Stabilization
- Bioswale
- Green Infrastructure
- Infill/Redevelopment
- Trash and Debris
- Neighborhood Assc
- Pervious Pavement
- Basin Retrofit
- Riparian Buffer
- Spring Enhancement
- Stream Restoration
- Streetscaping
- Wetland
- Water Quality Sites
- Existing BMPs
- Industr./High-Risk Comm. Fac.
- Underground Basin
- Stormwater Structures
- Spring
- Karst Inflow / Outflow
- Karst Flow
- Intermittent Stream
- Stream
- Railroad
- Street
- Channelized / Armored Reach
- Stormwater Pipes
- Proposed Remedial Measures
- Detention Basin
- Retention Pond
- Subwatershed Boundary
- Park
- Greenway
- Green Infrastructure Area
- Neighborhood Assc
- Wolf Run Watershed
- Adjoining Karst Basin

Feet
500 0 500 1,000 1,500

C. Summary of BMPs

Eight general types or categories of BMPs have been identified in the implementation plan. The following summaries are intended to provide an overview of the more detailed listed in the plan.

1. Bacterial and Sanitary Sewer BMPs

Eighteen BMPs are targeted to address the reduction of the bacterial levels in the watershed in an effort to achieve safe recreational use. These BMPs include proposed sanitary sewer remedial measurement plans and other sanitary sewer related programs which are intended to reduce the *E. coli* and fecal coliform loading in the watershed. It also includes reduction of bacterial inputs from other sources such as septic systems, pets, or livestock. These types are categorized as "Sanitary Sewer" and "Bacterial," respectively.

For the 11 proposed remedial measures plan projects, the listed milestones indicate the proposed schedule as submitted to the US EPA. As this schedule has not yet been approved by the US EPA, the projects and schedule may vary in the future based on the US EPA response. The milestones for remedial measures projects are dictated by the agreement between the US EPA, KDOW, and LFUCG, and not this watershed plan. Therefore, when other BMPs, such as stream restoration or riparian buffer restoration, are to be conducted in area, they should be coordinated with the proposed remedial measures plans such that the projects are complementary and that construction disturbances are minimized.

All 15 BMPs addressing the sanitary sewer system are high priority while one BMP evaluating Red Mile as a source is medium priority and two BMPs addressing septic system and pet sources are low priority.

2. Education & Outreach BMPs

Fourteen BMPs are indicated as "Education & Outreach BMPs:" seven of high priority, three of medium priority, and four of low priority. These BMPs were developed by the Wolf Run Outreach Campaign Committee, and subsequently grouped according to the target audience or type of outreach. These BMPs are intended to educate businesses, homeowners, and other stakeholders in the watershed to understand how the aquatic ecosystem works, how they might be contributing to the impairment of the waterways, and what they can do to help improve the watershed.

Several education and outreach BMPs are part of a larger program in which the outreach and education is the first step towards implementation or construction of structural BMPs. As such, the education and outreach campaigns are beneficial to audiences throughout the watershed, but subsequent implementation activities are critical for particular locations within the watershed. For instance, one education and outreach activity targets all landowners in neighborhood associations throughout Wolf Run for education on green infrastructure solutions for homeowners, but the installation of green infrastructure such as rain barrels and rain gardens is critical for the neighborhood associations located within Vaughn's Branch, Upper Wolf Run, Spring Branch, and Big Elm Tributary subwatersheds. As such, outreach and education activities which are part of a larger program should be targeted to areas in which structural BMP opportunities are listed, if possible.

3. General BMPs

Four general BMPs are identified in the plan. BMPs in this category include regulatory measures to protect riparian buffers (low priority), supporting regulatory measures/ordinances or city manual revisions (medium

priority), as well as general habitat improvement projects such as tree canopy surveys (high priority) and "Reforest the Bluegrass" planting (low priority) within the watershed.

4. Green Infrastructure BMPs

The Green Infrastructure BMPs are intended to address the pollutant load reductions from runoff from parking lots and other impervious surfaces on business, schools, churches, and other non-residential institutions property. According to the stormwater model, a reduction of approximately 20 percent of the pollutant load in Vaughn's Branch (suspended solids, phosphorus, and nitrogen), 25 percent in Big Elm Tributary (phosphorus and nitrogen) and Upper Wolf Run (suspended solids and nitrogen), and 50 percent in Spring Branch (suspended solids and phosphorus) subwatersheds are necessary to achieve the water quality goals. Green infrastructure will help reduce the volume and velocity of stormwater in other subwatersheds, but these were considered of lesser priority in the targeting of BMPs in this plan.

Thirty-nine businesses, schools, churches, and other non-residential institutions were identified for projects with a green infrastructure implementation component. Many of these locations are larger landowners in the watershed where multiple options may be available to reduce, redirect, or infiltrate stormwater runoff; a study of the most feasible and effective green infrastructure BMPs should be conducted prior to implementation. Twenty-one locations are identified for feasibility analysis and then implementation, while other locations were identified for specific BMPs, including five locations for "bioswale" construction, eleven locations for a retrofit of stormwater detention or retention basins, and two locations for infill/redevelopment BMPs. Of the 39 projects identified, nine are of high priority, 16 are of medium priority, and 14 are low priority.

Construction was recently completed for four high priority projects including Clays Mill Elementary School, Beaumont Middle School, Red Mile Racetrack, and the Ronald McDonald House. Five other high priority projects with green infrastructure components are located in the watershed. The Southland Association has begun a feasibility study for BMPs to address flooding. James Lane Allen Elementary has completed a feasibility study, which could be implemented. The University of Kentucky FEMA project is funded and scheduled to be designed and constructed within three years of selection of contractor, which is currently in progress. The Cross Keys Park Retention Basin is located on public property and is in need of construction to retain or enhance the valuable water quality benefits the site currently provides. The Lafayette School Property is located an area in need of pollutant load reductions and Fayette County Public Schools has been a willing and successful partner in implementing BMPs in the watershed.

For many medium and low priority projects, outreach and education will be a crucial step in successful implementation. Several education and outreach BMPs are geared towards meeting this need.

Bioswales were proposed at five locations in the watershed, three of medium priority and two of low priority. Some sites would require removal of the current concrete stormwater channel. Each of these projects is conceptual and would begin by contacting landowners to evaluate interest in pursuing construction.

"Retrofit" projects address both detention and retention basins. For example, the addition of floating biohabitat, or a floating synthetic mesh planted with native plants (or even landscaping species) which sequesters nutrients and provides fish and animal habitat, is recommended for four retention basin locations.

Two locations identified for "Infill/Redevelopment" are currently low priority, but could become high priority if other actions are taken. The Turfland Mall Redevelopment includes approximately 46 acres of impervious surface in the Spring Branch subwatershed, where large reductions of stormwater runoff and pollutant loading are required. However, the current owner has been stalled by lack of funding, so action is unfeasible at this time. The Nicholasville Road Corridor also represents a larger area of impervious surface, but the *Nicholasville Road Corridor Landscape Master Plan Review* (M2D Design Group 2010) indicates difficulty in implementation of that plan due to lack of enforcement, poor coordination, cost concerns, and lack of public right of way. 7Therefore, additional actions along this corridor are also pending.

5. Neighborhood Association BMP Program

The Neighborhood Association BMP Program is intended to address the pollutant load reductions from runoff from residential properties and habitat improvement for streamside homeowners. According to the stormwater model, a reduction of approximately 25 percent of the pollutant load from residential roofs and lawns in Big Elm Tributary (phosphorus and nitrogen) and Upper Wolf Run (suspended solids and nitrogen), 30 percent in Vaughn's Branch (suspended solids, phosphorus, and nitrogen), and 35 percent in Spring Branch (suspended solids and phosphorus) subwatersheds are necessary to achieve the water quality goals. In these areas, BMPs such as rain gardens and rain barrels will aid in reducing the pollutant load as well as the stormwater runoff volume. For homeowners adjacent to streams or other water conveyances, riparian buffer zone stewardship and implementation of green stormwater conveyances will further aid in reductions as well as improve habitat.

A key initial aspect of the Neighborhood Association BMP Program is education of residential property owners on their effect on the water quality in the Wolf Run Watershed and the actions they can take to improve the water quality. The program will be led by the Fayette County Neighborhood Council and the Wolf Run Watershed Council and should garner technical resources from the University of Kentucky Extension Office, Bluegrass PRIDE, LFUCG Division of Water Quality, LFUCG Division of Environmental Policy, Bluegrass Community and Technical College, Friends of Wolf Run, and other willing participants.

The education and outreach program is intended to address all residents in the Wolf Run Watershed, but the implementation is critical in the subwatersheds and neighborhood associations listed in Table 41, page VI-8. In order to improve the success of the program, pilot programs should be initiated in the strongest of these neighborhood associations with the program expanded to other areas and neighborhood associations.

TABLE 41 – KEY NEIGHBORHOOD ASSOCIATIONS FOR BMP IMPLEMENTATION BY SUBWATERSHED

Subwatershed	Neighborhood Associations
Upper Wolf Run (W9, W12)	Penmoken Park, WGPL, Hill-N-Dale, Rosemill, Picadome, Harrods Park Townhomes, Skycrest, Deerfield, Southern Heights
Spring Branch (W10)	Twin Oaks, Southland Park, Pasadena
Upper Vaughn's Branch (W8)	North Elizabeth Street, Golf View Estates
Big Elm Tributary (W11)	Southern Heights, Elizabeth Street, Seven Parks, Cherokee Park, Picadome
Middle and Lower Vaughn's Branch (W4, W7)	Cardinal Valley, Pine Meadow, Golf View Estates, Headley Green, Mason Headley

The education component should target these neighborhood associations as well as garden clubs, such as Wild Ones, and other relevant associations. Educational material is to provide leaders of associations with all of the tools needed to educate the residents in the area on what to do to improve water quality. Specifically, they should be focused to address two residential groups: 1) general landowners and 2) property owners adjacent to streams or other water conveyances.

In order to document the success of such programs, neighborhood leaders or the Wolf Run Watershed Council should track the implementation of BMPs within each area. The number of BMPs installed as well as the area treated will help to gage progress towards success.

6. Stream and Habitat Improvement BMPs

In order to improve the aquatic habitat in the Wolf Run Watershed, 41 projects including stream restoration, bank stabilization, riparian buffer restoration, wetland creation or expansion, and spring enhancement BMPs are proposed in the implementation plan. Improvements are proposed for over 7.6 miles of stream including 3.5 miles of stream restoration, 5.6 miles of riparian buffer restoration, and approximately 850 feet of bank stabilization. Wetland creation or expansion is proposed for approximately 20 acres and enhancements are proposed at two springs. The stream and wetland improvements are summarized in Table 42, page VI-9.

Stream restoration in the Wolf Run Watershed is essential in order to provide additional instream habitat for macroinvertebrates and fish. According to the hydrogeomorphic assessment, stream reaches in the Cardinal Run/Gardenside Tributary (W5), Middle Wolf Run (W6), Middle and Upper Vaughn's Branch (W7 and W8), and Upper Wolf Run, below Clays Mill Road (W9) subwatersheds are considered the highest priority for restoration or enhancement. Of the 3.5 miles on which stream restoration is proposed, over 2.5 miles are high priority projects, with the remainder as low priority projects. Two high priority projects, Clays Mill Elementary and the University of Kentucky FEMA project located upstream of Nicholasville Road near Alumni Drive, are located outside of these priority areas but are completed or in progress, addressing 1,800 feet of stream.

TABLE 42 – STREAM AND HABITAT IMPROVEMENT BMP SUMMARY

BMP No.	Target Area	Best Management Practice	Priority	Stream Restoration (ft)	Riparian Buffer (ft)	Bank Stabilization (ft)	Wetland (Acres)
43	Upper Wolf Run (W9, W12)	Hill-N-Dale Park	Low	275			
44		Above Nicholasville Road	Low	400			
55	Spring Branch (W10)	Below Clays Mill Elementary	High		600		
57		Clays Mill Elementary School	High	900			
63		Cardinal Lane Stormwater Project	High	Dependent			
76	Big Elm Tributary (W11)	Big Elm along Bob-O-Link	High		3,800	340	
79		University of Kentucky FEMA Project	High	900			
84		Commonwealth Stadium Detention Basin Wetland	Low				1.5
87-89	Middle Wolf Run (W6)	Allendale Greenway	High	1,800	1,800		10
90-91		Wolf Run Park	Med		1,600		0.75
92		Roanoke Greenway	High		1,400		
94		James Lane Allen Elementary	High		600		
99	Gardenside Tributary / Cardinal Run (W5)	The Lexington School	Med		1,200	15	
100		Gardenside Tributary above Cross Keys	Med		1,800	160	
101		Gardenside Tributary below Cross Keys	Low			40	
102		Cardinal Run Headwaters	Med		1,500	100	
103		Cardinal Run along Parkers Mill Road	Med		1,000		
104		Cardinal Run from Parkers Mill to Versailles Rd	High	1,400			1
105		Cardinal Run Mouth	High		1,000		
106		Cross Keys Park	High	1,700			4
113	Middle and Lower Vaughn's Branch (W4, W7)	Picadome Golf Course	High	4,200			
114		Pine Meadows Park	High		800		
116		Vaughn's Branch below Versailles Rd	Low	800			
117		Vaughn's Branch below Oxford Circle	Low			100	
118		Vaughn's Branch below Oxford Circle	High		1,300		
119		Deauville Greenway	Low	1,200	1,200		0.25
128	Preston's Cave/McConnell Springs (W2)	McConnell Springs Park	High		800		
131	Lower Wolf Run (W1, W3)	Valley Park	Low	2,400	2,400		0.25
132-133		Preston's Spring Park	High	2,600	2,600		1
134		Wolf Run above Old Frankfort Pike	Low		1,100		
135		Wolf Run below Old Frankfort Pike	Low		3,000	100	1
			TOTAL	18,575	29,500	855	19.75

The highest priority stream restoration project for this watershed plan is in Picadome Golf Course. Over 4,200 feet of stream on Vaughn's Branch and the Big Elm Tributary are located on this site, much of which

has severe erosion problems and no riparian area. Additionally, a flow path from the Big Elm Tributary to Vaughn's Branch needs to be created in order to reduce the erosion occurring when the sinkhole is overwhelmed during storm events. The golf course is willing to pursue restoration, but the project design needs to be coordinated with the course design.

Preston's Spring Park is another large, high priority reach, at approximately 2,600 feet. Restoring the reach within the park by removing large debris and siltation from the area and improving the aquatic habitat would enhance this unique area. The wide riparian zone could also be enhanced by removal of the invasive species and replacement with native species. Creation of wetlands in this area would further improve the habitat. As improvement of this reach is identified as a project goal, funding for such measures should be pursued.

Riparian buffer restoration is proposed for approximately 29,500 feet of stream, including 14,700 feet of high priority, 7,100 feet of medium priority, and 7,700 feet of low priority. Three reaches and one wetland previously planted and maintained by FOWR are not included in this total. Approximately 8,000 feet could be addressed as a part of proposed stream restoration at the Allendale Greenway, Deauville Greenway, Valley Park, and Preston's Spring Park, but if these projects are deemed unfeasible by stakeholders, riparian buffer restoration should still be pursued. FOWR currently has a riparian buffer stewardship program that has conducted restoration at 11 reaches within the watershed to date. According to their technical representatives, they expect to remove invasive species and plant native species on approximately 1,000 feet per year under this program. Other volunteer efforts could be organized or contactors hired in order to increase the rate of restoration. Individual homeowner support under the Neighborhood Association BMP Program could also increase this rate.

Bank stabilization is proposed for approximately 340 feet of stream in the watershed where erosion was identified by LFUCG during the stream assessment surveys. The stabilization method needs to be evaluated on a site specific basis by stream restoration design engineers.

Of the 19.75 acres of wetland to be created in the project area, 10 acres are located at the Allendale Greenway. Some wetland currently exists in this area and efforts are underway to establish a "riparian arboretum" in the area. However, a drainage ditch could be plugged to expand the wetland area and the habitat it provides.

7. Streets and Roads BMPs

Streets and roads BMPs, or "streetscaping" BMPs include a variety of green infrastructure measures intended to reduce the stormwater runoff quantity and pollutant load from highways, commercial streets, and residential roads, as well as improving the roadway aesthetics. Because of the large loads of suspended solids, phosphorus, and nitrogen due to roadway sources, addressing these areas is a key part of achieving the pollutant reduction targets in the watershed. According to the stormwater model, a reduction of approximately 35 percent of the pollutant load from streets and roads in Spring Branch (suspended solids and phosphorus), 30 percent in Vaughn's Branch (suspended solids, phosphorus, and nitrogen), 25 percent in Big Elm Tributary (phosphorus and nitrogen), and 15 percent in Upper Wolf Run (suspended solids and nitrogen) subwatersheds are necessary to achieve the water quality goals.

Streets and roads BMPs may include planter boxes, tree trenches, and stormwater bump-outs. These are all methods of increasing aesthetic beauty as well as providing storage, infiltration, and evapotranspiration

of runoff. Planter boxes are specialized planters where the top of the soil in the planter is lower in elevation than the sidewalk, allowing for runoff to flow into the planter through an inlet at street level. Tree trenches look to be a series of tree pits on the surface, but an underground infiltration system connects the trees. A stormwater bump-out is a vegetated curb extension that protrudes into the street either mid-block or at an intersection into which stormwater runoff is directed. These bump-outs also help with traffic-calming and can increase pedestrian safety. These features can also be combined with bioretention features, pervious pavement, or stormwater quality devices to provide additional benefits. The amount of benefits provided depends on the individual BMPs selected.

The Wolf Run Technical Committee identified several roadways which represent good targets for streetscaping improvements. These areas include Mitchell Avenue, Pin Oak Drive, Koster Drive, Phoenix Drive, the block from Ridge Road to Southbend Drive and Clays Mill Road to Lafayette Parkway, the block from Burley Avenue to Waller Avenue and Broadway Road to the railroad, the block from Devonshire Avenue to Broadway Road, the block from Waller Avenue to Conn Terrace and Nicholasville to the railroad, and the block of Waller Avenue to Bob-O-Link Drive and St. Joseph's Drive to the railroad. These represent some potential target areas, but if other locations with willing stakeholders are identified, BMPs should be pursued in these areas. Three streets and roads BMPs areas are medium priority due to a high need for project implementation to reach reduction goals, but unknown stakeholder support and funding. Due to expressed support for streetscaping from the Mitchell Avenue Group, BMP No. 52 is of high priority.

8. Trash and Debris BMPs

Sixteen BMPs are proposed to address trash and debris, seven of high priority, six of medium priority, and three of low priority. These BMPs are intended to address the trash and debris accumulation identified during LFUCG stream assessments, as well as other locations of frequent littering or dumping.

Currently LFUCG has several programs on a countywide basis to help address litter. Two high priority programs, the street sweeping program conducted by Streets and Roads and the critical culvert inspection and maintenance program conducted by the Division of Water Quality, reduce much litter entering the streams. A new program to identify dumpster locations that frequently contribute litter in close proximity to streams and evaluate whether better screening and control may be provided has been recommended as a way to reduce litter reaching the streams.

The Keep Lexington Beautiful Commission is a countywide program that focuses on litter prevention and beautification, community improvement, and waste reduction efforts. The commission promotes annual Great American Cleanup™ events throughout the city with signups typically occurring from March 1st to May 31st. Great American Cleanup events have been held at ten locations in the Wolf Run Watershed in 2011 and 2012, with events occurring both years at four sites (Port Royal Neighborhood Association, Southland Association, Valley Park, and Preston's Spring) identified as high priority areas. Nearly 6,500 lbs of litter and debris were removed in 2011 and almost 2,500 lbs in 2012, so such efforts should continue. If volunteer support exists, additional events could be organized in areas where trash accumulation has been observed including Big Elm Tributary along Bob-O-Link Drive, Wolf Run at Allendale Greenway and Wolf Run Park, Cardinal Run from Versailles Road to the confluence with Wolf Run, on the intermittent stream downstream of Red Mile Road, Vaughn's Branch upstream of Cardinal Hill Hospital, Wolf Run above Old Frankfort Pike, and the detention basins in the Upper Vaughn's Branch subwatershed. On Wolf Run from Harrodsburg Road to Faircrest Drive, heavy equipment will be necessary to remove some large debris.

The Picadome Sinkhole has also been observed as a site where large amounts of debris accumulate. A contractor was hired by LFUCG to remove debris from the sinkhole in 2011. However, a more permanent structure, such as a trash rake, should be installed to prevent debris accumulation through regular maintenance.

D. Funding Sources

Funding for projects listed in the BMP implementation plan may come from a variety of sources to help the property owners or responsible parties to implement the BMPs. Several known funding sources for individual project types are listed in the implementation plan including designated state or city budgets or designated funding, sanitary sewer user fees, and various grant programs. The grant opportunities are described in more detail in the following sections in order to aid interested applicants.

1. US EPA 319(h) Grants

The US EPA provides funding through Section 319(h) of the Clean Water Act to the Kentucky Nonpoint Source (NPS) Pollution Control Program. These funds can be used to pay for 60 percent of the total cost for qualifying projects, but require a 40 percent nonfederal match. Grants are available for watershed based implementation, and priority consideration will be given to projects for which implement a watershed based plan, such as this one. Project proposal forms may be submitted to the Kentucky NPS Pollution Control Program at any time; however, deadlines apply to specific federal funding cycles. For more information on this grant program, see Kentucky Division of Water website: http://water.ky.gov.

2. LFUCG Stormwater Quality Projects Incentive Grant Program

The LFUCG Stormwater Quality Projects Incentive Grant Program provides financial assistance for projects in Lexington that improve water quality, address stormwater runoff, and educate the public about these issues. The annual program typically provides over $1 million in funding. The LFUCG Division of Water Quality receives applications and makes recommendations for project selection to the Water Quality Fees Board, who makes the final selection on all grant awards. The grants are divided into three classes: Class A neighborhood grants, Class B infrastructure grants, and Class B education grants.

Class A neighborhood grants are open to neighborhood, community, and homeowner associations incorporated with the Commonwealth of Kentucky that represent single family homeowners or farms. In previous years, projects could be funded up to $100,000 with a required 20 percent cost share of total project cost in cash or in-kind donation.

Class B infrastructure grants are open to owners and tenants of non-farm, non-single family residential facilities including businesses, schools, churches, and non-profits located in Fayette County that pay the Water Quality Management Fee. In previous years, projects could be funded for the full project amount up to $350,000, but a 10 percent cost share was required for feasibility and design phase costs.

Class B Education Grants are open to owners and tenants of non-farm, non-single family residential facilities including businesses, schools, churches, and non-profits located in Fayette County that pay the Water Quality Management Fee. In previous years, no cost share was required for up to $2,500, but 50 percent cost share was required above that to a maximum grant award of $35,000.

Additional information can be found online on the LFUCG website: http://www.lexingtonky.gov.

3. LFUCG Neighborhood Community and Sustainability Grants

Neighborhood Community and Sustainability Grants offer funding to community gardens, streamside restoration, recycling programs, cleanups, and other projects that promote sustainability in Lexington communities. Eligible projects can receive up to $2,500, but must have 100 percent matching through materials, in-kind services, or a combination of both. Eligible projects must enhance the environmental quality of some aspect of the neighborhood or community, relate to sustainability principles, comply with applicable laws and regulations, be nonprofit, and have lasting and/or direct benefit to the community.

4. Kentucky American Water Environmental Grant Program

Kentucky American Water supports an annual environmental grant program to offer funds for innovative, community-based environmental projects that improve, restore, or protect the watersheds, surface water and/or groundwater supplies in our local communities. Since launching the program in 2006, Kentucky American Water has awarded more than $96,710 for environmental projects. To qualify, a proposed project in the Wolf Run Watershed must address a source water or watershed protection need, be completed between May and November of the grant funding year, establish a new or innovative program or a significant expansion to an existing program, be carried out by a formal or informal partnership of at least two organizations, and provide evidence of sustainability. Additional details may be found at KAWC's website: http://www.amwater.com/.

5. FEMA Hazard Mitigation Grant

FEMA's Hazard Mitigation Assistance grant programs provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damages including the Hazard Mitigation Grant Program, Pre-Disaster Mitigation, Flood Mitigation Assistance, Repetitive Flood Claims, and Severe Repetitive Loss. If a project will reduce or eliminate the risk of flood damage to the population or structures insured under the National Flood Insurance Program, it may be eligible for funding under one of these programs. For additional details on eligibility requirements and grant details, visit the FEMA website: http://www.fema.gov.

6. Lily Raintainer Program

LFUCG's Division of Environmental Policy offers Lily raintainers, a type of rain barrel, at a discounted cost of $75 for eligible applicants. To be eligible, applicants must live in Lexington-Fayette County, own the property on which the Lily will be installed, install the Lily on their own, and agree to allow an LFUCG DEQ inspector access to the premises in order to verify installation, if selected for random inspection. More information on the program can be found on the LFUCG website.

7. Keep Lexington Beautiful's Great American Cleanup

The Keep Lexington Beautiful's Great American Cleanup™ events are sponsored by local, state, and national sponsors. They provide supplies for litter removal, graffiti removal, recycling, clothing collection, stream cleanups, beautification, or community improvement events. Those who are interested in participating can sign up through registration forms available through the Keep Lexington Beautiful Commission, typically posted annually to LFUCG's website.

TABLE 43 – WOLF RUN WATERSHED BMP IMPLEMENTATION PLAN

BMP No.	Type	Target Audience or Area	Best Management Practice Description and Action Items	Priority	Impairment / Pollutant Addressed	Responsible Parties	Estimated Cost	Estimated Load Reduction	Funding Source(s) / Program(s)	Technical Assistance Needed	Short Term Milestones (0-5 Years)	Mid-Term Milestones (5-10 Years)	Long-Term Milestones (10-25 Years)
1	Sanitary Sewer	Lower Wolf Run (W1, W3)	Replace Wolf Run Main Trunk A - New Circle to past Enterprise Drive - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$210,000 Design; $3,800,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	Planned for Year 1 Design, Year 2-3 Construction	None	None
2	Sanitary Sewer	Lower Wolf Run (W1, W3)	Replace Wolf Run Main Trunk B - New Circle to Cambridge Dr -Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$230,000 Design; $2,180,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	Planned for Year 4 Design, Year 5 Construction	None	None
3	Sanitary Sewer	Lower Wolf Run (W1, W3)	Replace Wolf Run Main Trunk C - Cambridge Dr to Roanoke Dr - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$420,000 Design; $4,140,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	Planned for Year 5 Design	Planned for Year 6-7 Construction	None
4	Sanitary Sewer	Middle Wolf Run (W6)	Replace Wolf Run Main Trunk D - Roanoke to Appomattox - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$190,000 Design; $1,730,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	None	Planned for Year 7 Design, Year 8 Construction	None
5	Sanitary Sewer	Middle Wolf Run (W6)	Replace Wolf Run Main Trunk E - Appomattox to Faircrest Dr - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$230,000 Design; $2,140,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	None	Planned for Year 8 Design, Year 9 Construction	None
6	Sanitary Sewer	Middle / Upper Wolf Run (W6, W9)	Replace Wolf Run Main Trunk F - Faircrest Dr to Rosemont Garden- Remedial Measures Plan	High	PCR, SCR / *E. coli,* Fecal coliform	LFUCG DWQ	$260,000 Design; $2,460,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	None	Planned for Year 9 Design, Year 10 Construction	None
7	Sanitary Sewer	Upper Wolf Run (W9, W12)	Replace Wolf Run Main Trunk G - Rosemont Garden to Goodrich Ave - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$220,000 Design; $1,990,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	None	Planned for Year 10 Design	Planned for Year 11 Construction
8	Sanitary Sewer	Lower Wolf Run (W1, W3)	Install Wolf Run Equalization Tank - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$740,000 Design; $7,940,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	Planned for Year 1 Design, Year 2-3 Construction	None	None
9	Sanitary Sewer	Gardenside Tributary / Cardinal Run (W5)	Replace Parkers Mill Trunk - Devonport Dr to Darien Dr - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$190,000 Design; $1,770,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	None	None	Planned for Year 11 Design, Year 12 Construction
10	Sanitary Sewer	Middle Vaughns Br and Big Elm Tributary (W7, W11)	Replace Bob-O-Link Trunk - Vaughns Branch at Picadome to terminus of Bob-O-Link Dr - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$190,000 Design; $1,650,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	Planned for Year 1 Design, Year 2-3 Construction	None	None
11	Sanitary Sewer	Lower Wolf Run (W1, W3)	Install Wolf Run Pump Station and sewer line from Enterprise Drive to near Wolf Run mouth - Remedial Measures Plan	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ	$9,500,000 Construction	Unknown	Sanitary Sewer Fees	Design Engineers, Construction Contractors	Planned for Year 1-2 Construction	None	None
12	Sanitary Sewer	Countywide	Eliminate improper or unauthorized discharges to the sanitary sewer system through the Private Infiltration and Inflow Elimination Program (PIIEP). This program allows for the inspection and enforced removal of discharges sump pumps, downspouts, foundation drains, outside stairwells, and driveway drains to the sanitary sewer system under the new ordinance (Ch 16, Art XI, 16-111-115)	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ, Property Owners	Dependent upon requests	Unknown	A supplemental fee and other fines will be charged upon refusal of inspection or compliance. LFUCG has a cost sharing reimbursement program up to $3,000 for work completed by a licensed plumber and issued a Notice of Compliance.	Inspectors, Licensed Plumbers	Ongoing inspection, compliance, and enforcement		

BMP No.	Type	Target Audience or Area	Best Management Practice Description and Action Items	Priority	Impairment / Pollutant Addressed	Responsible Parties	Estimated Cost	Estimated Load Reduction	Funding Source(s) / Program(s)	Technical Assistance Needed	Short Term Milestones (0-5 Years)	Mid-Term Milestones (5-10 Years)	Long-Term Milestones (10-25 Years)
13	Sanitary Sewer	Countywide	Implement the Fats, Oil, and Grease (FOG) Program to reduce the sanitary sewer overflows. The program requires all food service facilities to have a permit or waiver, sets requirements for grease and oil interceptors and maintenance, inspects these facilities and enforces the existing ordinance.	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ, CMOM Program Managers	LFUCG City Program	Unknown	LFUCG Budget	Education, Inspection, Maintenance, Enforcement	Ongoing education, inspection, and enforcement		
14	Sanitary Sewer	Countywide	Utilize the Gravity Line Preventative Maintenance Program (GLPMP) to help maintain the capacity of the sanitary sewer system by hydraulic cleaning, mechanical cleaning, and root control. The program identifies areas needing increased frequency of cleaning, provides consistent maintenance, and identifies repair / rehabilitation locations.	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ, CMOM Program Managers	LFUCG City Program	Unknown	LFUCG Budget	Maintenance, Repair and Rehabilitation	Ongoing cleaning, maintenance, and repair / rehabilitation		
15	Sanitary Sewer	Countywide	Use the Sanitary Sewer Survey and Rehabilitation (General, Find and Fix Program) to reduce Infiltration / Inflow (I/I), identify exfiltration sources, and correct problems. If stormwater outfalls or illicit discharges are detected and testing indicates the potential sewage sources, Sewer Line Maintenance will evaluate the issue. If Sewer Line Maintenance does not take action, then the issue will be forwarded to I/I Program for repair. Sewer Line Maintenance or I/I will update Stormwater on actions taken to allow for follow up monitoring to confirm the problem was addressed.	High	PCR, SCR / *E. coli*, Fecal coliform	LFUCG DWQ, Compliance and Monitoring, Sewer Line Maintenance, I/I Program, CMOM Program Managers	$5,000,000 Annually for Repairs Countywide	Unknown	Sanitary Sewer Fees	Monitoring and Repair	Ongoing monitoring, evaluation, and repair		
16	Bacterial	Prestons Cave / McConnell Springs (W2)	Investigate Red Mile Racetrack runoff as a wet weather fecal source. This location was mentioned in the proposed TMDL as a source but focused sampling to determine whether the site is a load contributor has not been conducted. Under a Notice of Violation (NOV) issued by LFUCG, Red Mile is required to develop a Stormwater Pollution Prevention Plan (SWPPP) and conduct semi-annual monitoring for TSS, E. coli, ammonia, and pH. Sampling would evaluate the performance of onsite BMPs. LFUCG inspections will also confirm these inspections.	Med	PCR, SCR / *E. coli*, Fecal coliform	Red Mile Racetrack, LFUCG DWQ	Monitoring costs	None	Red Mile Racetrack, Stormwater Program Funding	Laboratory Analysis, Field Samplers	Conduct Monitoring and Evaluate Results.	None	None
17	Bacterial	Watershed	Reduce septic system contributions to the fecal load. Work with the local health department to evaluate the number landowners on septic systems within the watershed. Depending on the number, outreach to businesses for the potential to provide group rates for septic system pump outs in the area.	Low	PCR, SCR / *E. coli*, Fecal coliform	WRWC, Fayette County Health Department	Dependent on number of systems	Unknown	Discounted rates, landowner system maintenance cost	GIS Processing of Septic Locations, Proper Septic System Care Information	Evaluate in Short Term With Ongoing Maintenance		
18	Bacterial	Parks	Evaluate reduction pet sources of pathogens by installation of pet waste cleanup stations in parks.	Low	PCR, SCR / *E. coli*, Fecal coliform	LFUCG Parks	$200 - $400 / station	Unknown	Unknown	None	Evaluation, installation, and maintenance		

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19	Education & Outreach	General	Develop appropriate watershed signage and place at key locations to increase public awareness. Signs could mark buffer zone areas, watershed boundaries, no-mow areas, and key stream crossings. Currently some boundary signs, educational signs, and buffer restoration signs are present in small numbers. Over 200 no-mow signs have been produced and placed in the watershed along riparian buffers.	High	Education & Outreach	FOWR, LFUCG	$3 - $300 / sign Dependent upon size and quantity.	None	Grants	Sign Development and Installation	2006 -2013 and ongoing placement of signs as restoration projects are conducted or along key travel paths		
20	Education & Outreach	Neighborhood Associations	Rate the relative strength of neighborhood associations and prioritize the educational presentation and implementation plans in these respective areas.	High	Education & Outreach	FCNC	None	N/A	N/A	Map of watershed	Rank and prioritize in 2013	None	None
21	Education & Outreach	Neighborhood Associations	Provide "content" (articles / tips / factoids / event information) for Neighborhood and Council newsletters.	High	Education & Outreach	LFUCG DEP, FCNC, NA	None	N/A	N/A	LFUCG DEP to provide the content to be distributed by the neighborhood associations	Ongoing: LFUCG DEP to develop content and make available to the FCNC for distribution		
22	Education & Outreach	Neighborhood Associations	General Landowner Educational Package for Neighborhood Association BMP Program: 1. Compile or develop educational materials on what residents can do to reduce water pollution on their property including: the impacts of private contributions to sanitary sewer overflows, nonpoint sources of pollution, proper lawn care practices, pet waste clean-up, litter, stormwater runoff and impervious surfaces. 2. Compile or develop educational material on installation and benefits of street trees, rain barrels, rain gardens and green infrastructure such as permeable pavers and bioswales. 3. Develop educational material that summarizes the relevant information in the watershed plan for local landowners. 4. Publicize grant programs available to install "green infrastructure" such as the Neighborhood Sustainability Grant and Stormwater Quality Incentive Grant programs. 5. Distribute information through workshops, social media, webpages, and other means to garden clubs and neighborhood associations. 6. Identify or develop a demonstration project and workshop illustrating rain barrel and rain garden installation in each neighborhood area.	High	Education & Outreach	WRWC, LFUCG DEP, LFUCG DWQ, Bluegrass PRIDE, FCNC, UK Extension, BCTC, NA, FOWR	Dependent on type of presentation / materials presented and number of workshops and demonstration projects implemented	Not calculable	LFUCG DEP Budget, 319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant	Development of technical material for problems and BMPs, Technical Presenters, implementation of BMPs	Educational Package Development and initial implementation	Ongoing Implementation	

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23	Education & Outreach	Streamside Landowners	Streamside Landowner Educational Package for Neighborhood Association BMP Program: 1. Compile or develop educational material on backyard erosion problems, stream stewardship and values / functions of riparian areas. 2. Compile or develop educational material on solutions for streamside owners including riparian buffer zones, green engineering for ephemeral streams and stormwater conveyances, and opportunities to fund such projects. The material should cover technical information such as the types, sources, costs, and planting techniques for riparian restoration to train participants for implementation. 3. Distribute information through workshops, social media, webpages, and other means to garden clubs and neighborhood associations. 4. Identify or develop a demonstration project and workshop illustrating buffer zone restoration or other green engineering in each neighborhood area.	High	Education & Outreach	WRWC, LFUCG DEP, LFUCG DWQ, Bluegrass PRIDE, FCNC, UK Extension, BCTC, NA, FOWR	Dependent on type of presentation / materials presented and number of workshops and demonstration projects implemented	Not calculable	LFUCG DEP Budget, 319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant	Development of technical material for problems and BMPs, Technical Presenters, implementation of BMPs	Educational Package Development and initial implementation	Ongoing Implementation	
24	Education & Outreach	Businesses, Neighborhood Association	Commercial and Institutional Green Infrastructure Implementation and Outreach Program: 1. Conduct outreach to businesses/residents to increase awareness of the problem associated with increased stormwater runoff and what can be done to reduce it. 2. Publicize grant programs available to neighborhoods / businesses to install “green infrastructure” such as the Neighborhood Sustainability Grant and Stormwater Quality Incentive Grant programs. 3. Develop a demonstration project / workshop for stormwater runoff reduction. 4. Approach businesses and other non-residential organizations identified in the watershed based plan about conducting a green infrastructure feasibility study on their property. 5. Conduct a feasibility study to determine the best locations and types of green infrastructure to install in a given area. 6. Apply for financial assistance to implement these practices.	High	Education & Outreach	WRWC, LFUCG DEP Green Partners Program, Bluegrass PRIDE, FOWR	Dependent on type of presentation / materials presented and number of workshops and demonstration projects implemented	Not calculable	LFUCG DEP Budget, 319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant	Development of technical material for problems and BMPs, Technical Presenters, implementation of BMPs	Educational Package Development and initial implementation	Ongoing Implementation	
25	Education & Outreach	Middle Wolf Run (W6)	Provide professional development sessions and educational units for teachers and students at James Lane Allen Elementary School on stormwater and water quality topics. Teachers will attend workshops then implement lessons learned within their classrooms, allowing students to then present lessons learned to environmental professionals on an education day.	High	Education & Outreach	University of Kentucky Research Foundation; James Lane Allen Elementary	$17,514 awarded in FY2012	N/A	LFUCG Water Quality Incentive Grant	Workshop on educational units, teachers / educators	The grant will be completed by 2013.	None	None

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26	Education & Outreach	General	Develop a speaker's bureau for water quality related topics and make available to groups within the watershed.	Med	Education & Outreach	LFUCG DWQ	None	N/A	N/A	None	Ongoing LFUCG DWQ to develop a list and post to their website with ongoing maintenance.		
27	Education & Outreach	General	Add watershed maps and watershed plan documents to the Friends of Wolf Run and LFUCG Environmental web sites.	Med	Education & Outreach	LFUCG,FOWR	None	None	N/A	Webmaster	Post after plan finalization and approval by KDOW	None	None
28	Education & Outreach	General	Establish stream access points within restored buffer zone areas.	Med	Education & Outreach	Riparian buffer restoration teams	None	N/A	N/A	None	Ongoing effort associated with riparian restoration activities and sign installation		
29	Education & Outreach	Businesses	Reach out to area realtors such as LBAR with educational materials emphasizing increased home value associated with green practices.	Low	Education & Outreach	FOWR, Volunteers	Dependent upon action taken	N/A	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant	Development of technical material, Outreach	Ongoing		
30	Education & Outreach	Septic system homeowners	Educate homeowners on septic system maintenance. Identify septic system owners and distribute "A Kentucky Homeowner's Guide to Septic Systems" available from the Kentucky Onsite Wastewater Association, Inc.	Low	Education & Outreach	Fayette County Health Dept., WRWC, Volunteers	None	N/A	None	Homeowner's Guide	Identify owners and distribute information	None	None
31	Education & Outreach	General	Develop "brand recognition" for the watershed with logo / mascot. Key features / concepts should be discussed and design options considered and approved by the community	Low	Education & Outreach	WRWC	$100 - $200	None	N/A	Graphic Designer; Citizen Review and Approval	WRWC to discuss key features. Options presented. Vote of selection.	None	None
32	Education & Outreach	General	Organize Wolf Run "Stream Teams" as a service/education program. Under this program, volunteer labor services in designing, building and/or maintaining BMPs would be matched with an educational component to learn about watershed / water quality issues and associated sciences.	Low	Education & Outreach	WRWC, FOWR, UK, BCTC, FCPS, Consultant(s)	Dependent on action taken	N/A	Local organization and coordination with other projects	Water Quality Professionals and Educators	Ongoing development of teams and organization of events		
33	General	General	Evaluate revising the LFUCG Stormwater Manual or the implementation thereof such that all new development and redevelopment projects where the total impervious surface area is greater than 1 acre are required to construct water quality BMPs or pay a fee in lieu. The Wolf Run Watershed Council and other entities should provide input into the process.	Med	Policy	LFUCG DWQ	N/A	Reduced runoff quantity unknown	None	LFUCG DWQ, Division of Engineering, Consultants, WRWC	Stormwater Manual review is scheduled to begin 2013.	None	None
34	General	General	Support a "Reforest the Bluegrass" event in the Wolf Run Watershed to increase the riparian zone width in areas identified in the plan.	Low	WAH / Habitat Improvement	LFUCG DEP Urban Forestry, Reforest the Bluegrass	Dependent on area planted	Dependent on area planted	Local government funding and private sponsors	Planting supplies, organization	Conduct an event along one of the riparian areas identified for improvement		
35	General	General	Support a tree canopy survey of Lexington in order to improve Urban Forestry and identify opportunities for additional planting.	High	WAH / Habitat Improvement	LFUCG DEP Urban Forestry, WRWC	Unknown	Not calculable	LFUCG Designated Funding	Botanists, GIS Modeling	Conduct a tree canopy survey	None	None
36	General	General	Support the regulatory measures to protect riparian buffers including creation of an ordinance to enhance protection and management of riparian buffers and expansion of conservation easements.	Low	WAH / Habitat Improvement	WRWC	None	Not calculable	None	Ordinance drafting, regulatory review	Ongoing review and support of protection / management measures		
37	Trash and Debris	Countywide	Continue street sweeping program to reduce litter from entering the waterways.	High	WAH / Trash and Debris	LFUCG Streets and Roads	Dependent upon frequency and length swept	Not calculable	LFUCG Budget	Equipment, Organization	Ongoing		

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38	Trash and Debris	Countywide	Continue critical culvert inspections and maintenance on monthly basis and following 1 inch rain events per LFUCG SWQMP requirements.	High	WAH / Trash and Debris	LFUCG DWQ	Dependent upon number of culverts and frequency	Not calculable	LFUCG Budget	Evaluation of critical needs and maintenance	Ongoing		
39	Trash and Debris	Watershed	Identify dumpster locations in close proximity to streams that are frequent contributors to litter. Evaluate whether better screening and control may be provided.	Low	WAH / Trash and Debris	LFUCG DEP, Code Enforcement, Volunteers	Unknown	Not calculable	LFUCG Budget	Survey of dumpster locations, code enforcement	Ongoing		
40	Riparian Buffer	Upper Wolf Run (W9, W12)	Goodrich Ave Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along Goodrich Ave. Plantings occurred in 2012. Provide maintenance to plantings.	Low	WAH / Habitat Improvement	Michael Peabody, Ann Bowe, WGPL NA, FOWR	$7,700 was awarded in FY2011, Annual maintenance	Improved habitat, stream shading	LFUCG Water Quality Incentive Grant, FOWR Stream Buffer Stewardship	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Ongoing maintenance		
41	Riparian Buffer	Upper Wolf Run (W9, W12)	Clays Mill Greenway Stream Buffer Stewardship: riparian planting and invasive species removal on about 230 ft of stream. Plantings have been conducted, but ongoing maintenance is necessary.	Low	WAH / Habitat Improvement	Sandy Scafer, Julian Campbell, Picadome NA, FOWR	Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Ongoing maintenance		
42	Wetland	Upper Wolf Run (W9, W12)	Eastway and Sunseeker Drives Wetland Stewardship: wetland vegetation maintenance and invasive species removal. Plantings have been conducted, but ongoing maintenance is necessary.	Low	WAH / Habitat Improvement	Janet Cabanis, Thomas Martin, Hill-N-Dale NA, Southland NA, FOWR	Annual maintenance	Improved habitat, stream shading	FOWR Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Ongoing maintenance		
43	Stream Restoration	Upper Wolf Run (W9, W12)	Hill-N-Dale Park Stream Restoration: only about 275 feet of this tributary to Wolf Run (confluence near Southport Drive) are out of pipe. BMPs to create aquatic habitat and to stabilize banks should be evaluated in this area.	Low	WAH / Habitat Improvement	LFUCG Parks, WRWC, Consultant(s)	Dependent on action taken	Dependent on action taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Meet with Parks staff to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Secure funding, 2) Conduct pre- and post-construction monitoring, 3) Implement BMPs.	Ongoing monitoring and maintenance
44	Stream Restoration	Upper Wolf Run (W9, W12)	Stream Restoration: Small Wolf Run stream segment (about 400 feet) between Greenbriar Rd, Nicholasville Road, Zandale Drive, and Jesselin Dr (Behind Medical Plaza): One of few segments in the watershed which may have restoration potential. Evaluate feasibility of stream restoration or other green infrastructure BMPs.	Low	WAH / Habitat Improvement	Landowners, Consultants(s), WRWC	Dependent on action taken	Dependent on action taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact landowners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Secure funding, 2) Conduct pre- and post construction monitoring, 3) Implement BMPs.	Ongoing monitoring and maintenance
45	Infill / Redevelop	Upper Wolf Run (W9, W12)	Nicholasville Road Corridor: Corridor Landscape Master Plan Review (February 2010) indicates difficulty in implementation of that plan due to lack of enforcement, poor coordination, cost concerns, and lack of public right of way. Such problems would also stymie water quality projects. Therefore projects are less feasible in this area currently. Additional action pending.	Low	WAH / Water Quantity, TSS, P, N	WRWC	Unknown	None	None	Review of Planning for Nicholasville Road Corridor	None	Pending BMPs in this area should be considered if a corridor overlay ordinance is developed, during a comprehensive study, or subsequent to construction of Southland Association BMPs.	

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46	Retrofit	Upper Wolf Run (W9, W12)	Regency Center Detention Basin Retrofit: Removal of concrete channels, tree planting, wetland retrofit and micro-pool construction on detention center in front of Regency Center on Nicholasville Road.	Med	WAH / Water Quantity, TSS, P, N	Landowner, Consultant, Contractor	Dependent on action taken	Depends on action taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact landowners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Secure funding, 2) Conduct pre- and post construction monitoring, 3) Implement BMPs.	Ongoing monitoring and maintenance
47	Retrofit	Upper Wolf Run (W9, W12)	Pasadena Drive Retention Basin Retrofit: Installation of floating biohabitat to increase habitat, reduce algae abundance, and improve water quality at retention basin along Pasadena Drive.	Med	WAH / Habitat Improvement, TSS, P, N	Landowners Consultants, WRWC	$3 - $15 / sq. ft - Total cost dependent on size of floating biohabitats	Biohabitat: 50-80% TSS, 50-80% P, 40-80% N	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, private funding	Plant Selection, Location, Anchoring	1) Contact retention basin owners to evaluate support, 2) Secure funding, 3) Conduct pre- and post-implementation monitoring, 4) Install BMP	Ongoing monitoring and maintenance	
48	Retrofit	Upper Wolf Run (W9, W12)	Regency Road Detention Basin Retrofit: Removal of concrete channels, wetland micropools, and tree planting at the retention basin on Regency Road between Derby Drive and Lowry Ln.	Med	WAH / Water Quantity, TSS, P, N	Landowner, Consultant, Contractor	Dependent on action taken	Depends on action taken	320 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact landowners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Secure funding, 2) Conduct pre- and post construction monitoring, 3) Implement BMPs.	Ongoing monitoring and maintenance
49	Green Infrastructure	Upper Wolf Run (W9, W12)	Southland Association Green Infrastructure Feasibility Study: A grant has been awarded to examine the portion of Wolf Run watershed along Southland Drive from Rosemont Garden to Nicholasville Road. The are will be evaluated for feasible locations to install BMPs that would address flooding and increase runoff infiltration or redirection. Once the area has been evaluated action should be taken to implement the identified options.	High	WAH / Water Quantity, TSS, P, N	Southland Assc, CDP Engineering, Designer(s), Contractor(s)	Awarded FY2013 grant for a feasibility study; Implementation cost dependent on action taken	Depends on action taken	Funded by LFUCG Stormwater Quality Incentive Grant; Additional funding to be sought for implementation	Consultants, Designers, Contractors, Monitoring	1) Conduct Study, 2) Select BMPs for implementation, 3) Secure implementation funding, 4) Conduct pre- and post construction monitoring, 5) Implement BMPs.	Ongoing monitoring and maintenance	
50	Neighborhood Association BMP Program	Upper Wolf Run (W9, W12)	Neighborhood Association BMP Program: Penmoken Park, WGPL, Hill N Dale, Rosemill, Picadome, Harrods Park Townhomes, Skycrest, Deerfield, Southern Heights Neighborhood Associations. Provide education and funding for implementation of residential BMPs as described in the text.	High	WAH / Water Quantity, TSS, P, N	LFUCG DEP, LFUCG DWQ, Bluegrass PRIDE, FCNC, UK Extension, BCTC, NA	$50 - $150 / rain barrel, $500 - $2,000 / rain garden, $15 - $20 / lin ft riparian	Rain Barrel: 40% Vol Rain Garden: 15-74% TSS, 40-55% N, 60% Vol Riparian: 60-90% TSS, 25-75% P, 20-100% N, Some Vol	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Lily Raintainer Program	BMP Design and Installation Assistance, Planting Supplies, Education	Educational Package Development and initial implementation	Ongoing Implementation	
51	Retrofit	Upper Wolf Run (W9, W12)	Goodrich Ave Detention Basin Retrofit: Evaluate for regional treatment by expansion and retrofitting basin for a wet pond.	Low	WAH / Habitat Improvement, TSS, P, N, E. coli	LFUCG DWQ, Landowners	$0.80 - $1.60 / cubic ft for retention basin:	Retention Pond: 60-90% TSS, 40-70% P, 15-40 % N, 50-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	1) Evaluate feasible options, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance	

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52	Streets and Roads BMP	Upper Wolf Run (W9, W12)	Streets and Roads BMPs: Evaluate streetscaping BMPs in this watershed. Mitchell Ave, Pin Oak Dr, Koster Dr, and the block from Ridge Rd to Southbend Dr and Clays Mill Rd to Lafayette Pkwy have been identified as particular roadways of interest. See the streets and roads BMP plan in text.	High	WAH / TSS, P, N	Rose Mill NA, Picadome NA, Mitchell Avenue Group, LFUCG Streets & Roads, Consultants	Dependent on action taken	Depends on action taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Design Engineers, Consultants, Construction Contractors	Contact Neighborhood Assc to evaluate support	1) Secure funding, 2) Design BMPs, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
53	Trash and Debris	Upper Wolf Run (W9, W12)	Trash and Debris Downstream of Harrodsburg Road: Trash and debris were found to accumulate just downstream of Harrodsburg Road to Faircrest Drive. Some debris is large will require heavy equipment for removal.	Low	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, LFUCG DWQ	Varies by event, additional cost for equipment	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies, Contractor	Initial cleanup with heavy equipment, then annual volunteer clean up efforts		
54	Trash and Debris	Upper Wolf Run (W9, W12)	Trash and Debris in Southland Association Area: Continue the Keep America Beautiful's Great American Cleanup annual event in the Southland Association Area. 560 lbs of trash were collected in 2011 and 420 lbs in 2012.	High	WAH / Trash and Debris	Good Foods Market, Southland Assc, LFUCG DEP, Keep Lexington Beautiful Commission	Varies by event	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies	Continue annual event		
55	Riparian Buffer	Spring Branch (W10)	Spring Branch Stream Buffer Stewardship: riparian planting and invasive species removal from Clays Mill Elementary property downstream to Sheridan Drive (about 600 ft).	High	WAH / Habitat Improvement	Christy Cartner, Twin Oaks NA, FOWR	$9,000 - $12,000 Total for Native Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
56	Spring Enhancement	Spring Branch (W10)	Kay Spring Enhancement and Water Quality Improvements: Kay Spring is located between Springhurst Drive, Mitchell Ave, and Spring Grove Ave. Enhancement of the stream feature including a pool or other feature and water quality treatment through a bioswale along the edge of the commercial property to Harrodsburg Road.	Low	WAH / Habitat Improvement, TSS, N, Water Quantity	Landowners, Consultants, WRWC	$3 - $30/ sq. ft of bioswale Unknown cost for spring enhancement	70-80% TSS, 40 -75% N, 40-50% Volume	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Designers, Sign Development, Contractors	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Bioswale Design	Phase II: 1) Secure funding, 2) Conduct pre- and post construction monitoring, 3) Implement BMPs.	Ongoing monitoring and maintenance
57	Stream Restoration, Green infrastructure	Spring Branch (W10)	Clays Mill Elementary School: A grant has been provided for 900 linear feet of stream restoration with riparian buffer, a 600 square foot constructed wetland, a 450 square foot bio-infiltration swale, retrofit of existing 3,000 square foot detention basin to include bioretention for water quality, a new 500 square foot rain garden, and a new culvert and stream crossing with permeable pavement. These site features will provide an added educational benefit by being directly incorporated into the science curriculum at the school.	High	WAH / Habitat Improvement, Water Quantity, TSS, P, N	Clays Mill Elementary School	$57,800 awarded for design in FY2011 $320,400 awarded for construction in FY 2012	Expected Reductions in Volume, TSS, P, N and increase in habitat but values reductions unknown	Funded by LFUCG Stormwater Quality Incentive Grant	Design developed under previous FY 2011 grant. Construction underway.	Construction in 2012	Post - construction monitoring for success	None
58	Infill / Redevelop	Spring Branch (W10)	Turfland Mall Redevelopment: Approximately 46 acres (800 ERUs) of impervious surface are located on this property with adjoining businesses. Currently Turfland Mall is in the process of redevelopment, but the current owner has been stalled by lack of funding / grants. Watershed stakeholders should advocate	Low	WAH	WRWC, Landowners, Developers	Unknown	Depends on action taken	N/A	Pending	Pending Redevelopment: WRWC should monitor redevelopment process and advocate for BMP installation.		

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			for water quality BMP installation and impervious surface reduction during redevelopment / infill process.										
59	Neighborhood Association BMP Program	Spring Branch (W10)	Neighborhood Association BMP Program: Twin Oaks, Southland Park, Pasadena Neighborhood Associations. Provide education and funding for implementation of residential BMPs as described in the text.	High	WAH / Water Quantity, TSS, P, N	LFUCG DEP, LFUCG DWQ, Bluegrass PRIDE, FCNC, UK Extension, BCTC, NA	$50 - $150 / rain barrel, $500 - $2,000 / rain garden, $15 - $20 / lin ft riparian	Rain Barrel: 40% Vol Rain Garden: 15-74% TSS, 40-55% N, 60% Vol Riparian: 60-90% TSS, 25-75% P, 20-100% N, Some Vol	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Lily Raintainer Program	BMP Design and Installation Assistance, Planting Supplies, Education	Educational Package Development and initial implementation	Ongoing Implementation	
60	Streets and Roads BMP	Spring Branch (W10)	Streets and Roads BMPs: Evaluate streetscaping BMPs in this watershed. Phoenix Drive has been identified as a particular roadway of interest. See the streets and roads BMP action plan.	Med	WAH / TSS, P, N	Pasadena NA, LFUCG Streets & Roads, Consultants	Dependent on action taken	Depends on action taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Design Engineers, Consultants, Construction Contractors	Contact Neighborhood Assc to evaluate support	1) Secure funding, 2) Design BMPs, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
61	Green Infrastructure	Spring Branch (W10)	Sullivan College Campus Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding. Several detention basins may be retrofitted, rainwater harvesting could be installed, as well as other feasible solutions.	Med	WAH / Water Quantity, TSS, P, N	Landowners Consultants, WRWC	feasibility study and design: $7,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
62	Retrofit	Spring Branch (W10)	South Creek Properties Retention Basin Biohabitat: Installation of floating biohabitat to increase habitat and improve water quality at retention basin along Harrodsburg Road.	Med	WAH / Habitat Improvement, TSS, P, N	Landowners Consultants, WRWC	$3 - $15 / Sq. ft - Total cost dependent on size of floating biohabitats	Biohabitat: 50-80% TSS, 50-80% P, 40-80% N	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, private funding	Plant Selection, Location, Anchoring	1) Contact retention basin owners to evaluate support, 2) Secure funding, 3) Conduct pre- and post-implementation monitoring, 4) Install BMP	Ongoing monitoring and maintenance	
63	Stream Restoration	Spring Branch (W10)	Cardinal Lane Stormwater Project: Feasibility study was completed to investigate options to reduce flooding in the area. Construction to begin early 2013 with alternatives including replacement of the box culvert at 633 Cardinal Lane and potentially an inline water quality unit for the stormwater from Stratford Drive as well as other options.	High	WAH / TSS, P, N	LFUCG DWQ, Construction Contractor	$200,000 Available for Implementation	Depends on alternatives selected	LFUCG Council Budget Allocation	NA, Stormwater Study conducted by Vision Engineering prior to construction.	Construction scheduled for 2013	None	None

BMP No.	Type	Target Audience or Area	Best Management Practice Description and Action Items	Priority	Impairment / Pollutant Addressed	Responsible Parties	Estimated Cost	Estimated Load Reduction	Funding Source(s) / Program(s)	Technical Assistance Needed	Short Term Milestones (0-5 Years)	Mid-Term Milestones (5-10 Years)	Long-Term Milestones (10-25 Years)
64	Bioswale	Spring Branch (W10)	Southland Park Bioswale: Construction of bioswale in Southland Park leading to Clays Mill Elementary Stream Restoration	Med	WAH / Water Quantity, TSS, N	LFUCG Parks, Consultants, WRWC	$3 - $30/ sq. ft of bioswale	Bioswale: 70-80% TSS, 40 -75% N, 40-50% Volume	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Bioswale design and construction, 4) Conduct pre- and post- construction monitoring.		Ongoing monitoring and maintenance
65	Bioswale	Spring Branch (W10)	Claymont Drive Bioswale: remove concrete channel and construction of bioswale and tree planting behind new construction between Alexandria Dr and Claymont Dr	Med	WAH / Water Quantity, TSS, N	Landowners, Consultants, WRWC	$80 / sq. ft concrete removal; $3 - 30 / linear ft for bioswale	Bioswale: 70-80% TSS, 40 -75% N, 40-50% Volume	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Bioswale design and construction, 4) Conduct pre- and post- construction monitoring.		Ongoing monitoring and maintenance
66	Green Infrastructure	Upper Vaughns Branch (W8)	Lexington Clinic Parking Lot Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding. Installation of tree box units or other water quality devices are feasible for this parking area.	Med	WAH / Water Quantity, TSS, P, N	Landowners Consultants, WRWC	feasibility study and design: $5,000 - $10,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
67	Retrofit	Upper Vaughns Branch (W8)	Retrofit of Detention Basin along Conn Terrace and Transcript Ave as well as near the railroad tracks to remove concrete channels and provide increased infiltration and treatment of runoff.	Med	WAH / Water Quantity, TSS, P, N	Landowners, Consultants	$80 / sq. ft concrete removal; $3 - 30 / linear ft for bioswale	Bioswale: 70-80% TSS, 40 -75% N, 40-50% Volume	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Design and Construction	Ongoing monitoring and maintenance	
68	Bioswale	Upper Vaughns Branch (W8)	Elaine Dr Bioswale: construction of bioswale along Elaine Dr besides Saint Joseph Hospital Child Care Center.	Med	WAH / Water Quantity, TSS, N	Saint Joseph Hospital, Consultants, WRWC	$3 - $30 / sq. ft of bioswale	Bioswale: 70-80% TSS, 40 -75% N, 40-50% Volume	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Bioswale design and construction, 4) Conduct pre- and post- construction monitoring.		Ongoing monitoring and maintenance
69	Green Infrastructure	Upper Vaughns Branch (W8)	University of Kentucky Campus Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding. A green roof was recently installed as part of the new hospital construction. Since the Master Plan is currently under review, green infrastructure could be incorporated into construction at this time.	High	WAH / Water Quantity, TSS, P, N	UK, Consultants, WRWC	Feasibility Study : $10,000 - $20,000, Design and Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct Feasibility Study	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4)Design and Implement BMPs.	Ongoing monitoring and maintenance
70	Green Infrastructure	Upper Vaughns Branch (W8)	Business Area Green Infrastructure Study: evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding in commercial area between Harrodburg Road and the railroad and between Virginia Ave and Simpson Ave.	Low	WAH / Water Quantity, TSS, P, N	Landowners Consultants, WRWC	feasibility study and design: $5,000 - $15,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance

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71	Neighborhood Association BMP Program	Upper Vaughns Branch (W8)	Neighborhood Association BMP Program: North Elizabeth Street, Golf View Estates Neighborhood Associations. Provide education and funding for implementation of residential BMPs as described in the text.	High	WAH / Water Quantity, TSS, P, N	LFUCG DEP, LFUCG DWQ, Bluegrass PRIDE, FCNC, UK Extension, BCTC, NA	$50 - $150 / rain barrel, $500 - $2,000 / rain garden, $15 - $20 / lin ft riparian	Rain Barrel: 40% Volume Rain Garden: 15-74% TSS, 40-55% N, 60% Volume Riparian: 60-90% TSS, 25-75% P, 20-100% N, Some Volume	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Lily Raintainer Program	BMP Design and Installation Assistance, Planting Supplies, Education	Educational Package Development and initial implementation	Ongoing Implementation	
72	Streets and Roads BMP	Upper Vaughns Branch (W8)	Streets and Roads BMPs: Evaluate streetscaping BMPs in this watershed. Several neighborhoods have good potential for bump-outs including the block from Burley Ave to Waller Ave and Broadway Road to railroad, the block from Devonshire Ave to Broadway Road, and the block from Waller Ave to Conn Terrace and Nicholasville to railroad. See the streets and roads BMP action plan.	Med	WAH / TSS, P, N	Golf View Estates NA, North Elizabeth Str NA, WRWC, LFUCG Streets & Roads, Consultants	Dependent on action taken	Depends on action taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Design Engineers, Consultants, Construction Contractors	Contact Neighborhood Assc to evaluate support	1) Secure funding, 2) Design BMPs, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
73	Green Infrastructure	Upper Vaughns Branch (W8)	Ronald McDonald House Project: Completed in 2012 this project included installation of 15,700 sq. ft pervious pavement, a rainwater cistern, two rain gardens, and a bioswale	High	WAH / Water Quantity, TSS, P, N	Ronald McDonald House, CDP Engineering	$201,285 was awarded in FY2011 plus donated design, paver and supply costs	Unknown	LFUCG Water Quality Incentive Grant and Match	None	Completed 2012	None	None
74	Trash and Debris	Upper Vaughns Branch (W8)	Trash and Debris in Upper Vaughns Branch Detention Basins: Stream is piped over much of this watershed area with trash accumulating in detention basins. Organize annual volunteer clean-up efforts to pick up litter in these areas.	Low	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, Lexington Clinic,	Varies by event	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Event Coordination, Supplies	Organize a cleanup event for this reach. If successful, hold event annually.		
75	Green Infrastructure	Big Elm Tributary (W11)	Central Baptist Hospital Green Infrastructure Study: the property has approximately 21 acres (over 350 ERUs) of impervious surface. BMPs to treat, reduce, or infiltration runoff from this areas should be evaluated.	Med	WAH / Water Quantity, TSS, P, N	Central Baptist Hospital, Consultants, Contractors	feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
76	Bank Stabilization, Riparian Buffer	Big Elm Tributary (W11)	Big Elm Tributary along Bob-O-Link Stream Buffer Stewardship: riparian planting and invasive species removal on approximately 3,800 ft of stream. Current stewardship includes only a small reach. Bank stabilization is necessary on about 340 feet along this reach.	High	WAH / Habitat Improvement	Jennifer Arena, Picadome NA, Consultants	$62,000 - $83,000 for Native Planting / Invasive Removal, Bank Stabilization	Improved habitat, stream shading, TSS reduction	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate. Bank stabilization will require consultants design and installation.		

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77	Retrofit	Big Elm Tributary (W11)	University of Kentucky Gluck Bio-System and Agricultural Engineering Building Biohabitat: Addition of floating biohabitat to improve water quality downstream of this retention basin.	Med	WAH / Habitat Improvement, TSS, P, N	UK, Consultants, WRWC	$3 - $15 / sq. ft - Total cost dependent on size of floating biohabitats	Biohabitat: 50-80% TSS, 50-80% P, 40-80% N	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Plant Selection, Location, Anchoring	1) Contact university to evaluate support, 2) Secure funding, 3) Conduct pre- and post-implementation monitoring, 4) Install BMP	Ongoing monitoring and maintenance	
78	Retrofit	Big Elm Tributary (W11)	Evaluate the Elizabeth Street Park as an area to provide regional stormwater treatment via a retention pond or other water quality BMP.	Low	WAH / Habitat Improvement, TSS, P, N, E. coli	LFUCG Parks, WRWC, Consultants	$0.80 - $1.60 / cubic ft for retention basin:	Retention Pond: 60-90% TSS, 40-70% P, 15-40 % N, 50-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Design and Construction	Ongoing monitoring and maintenance	
79	Stream Restoration, Retrofit	Big Elm Tributary (W11)	University of Kentucky FEMA Project: The project involves culvert improvement, excavation for additional detention, underground retention, removal of Shawneetown Road, and relocation / replacement of utilities. The length of stream addressed is about 900 feet.	High	WAH / Water Quantity, TSS, P, N, E. coli	University of Kentucky Research Foundation	$11,880,030 available for design and construction	Unknown	FEMA Hazard Mitigation Grant and Local Funding	Design and Construction	Engineering Design and Construction Completion within 3 years	Post construction monitoring	None
80	Green Infrastructure	Big Elm Tributary (W11)	Lafayette Schools Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding.	High	WAH / Water Quantity, TSS, P, N	Landowners Consultants, WRWC	Feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
81	Neighborhood Association BMP Program	Big Elm Tributary (W11)	Neighborhood Association BMP Program: Southern Heights, Elizabeth Street, Seven Parks, Cherokee Park, Picadome Neighborhood Associations. Provide education and funding for implementation of residential BMPs as described in the text.	High	WAH / Water Quantity, TSS, P, N	LFUCG DEP, LFUCG DWQ, Bluegrass PRIDE, FCNC, UK Extension, BCTC, NA	$50 - $150 / rain barrel, $500 - $2,000 / rain garden, $15 - $20 / lin ft riparian	Rain Barrel: 40% Vol Rain Garden: 15-74% TSS, 40-55% N, 60% Vol Riparian: 60-90% TSS, 25-75% P, 20-100% N, Some Vol	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Lily Raintainer Program	BMP Design and Installation Assistance, Planting Supplies, Education	Educational Package Development and initial implementation	Ongoing Implementation	
82	Streets and Roads BMP	Big Elm Tributary (W11)	Streets and Roads BMPs: Evaluate streetscaping BMPs in this watershed. Block of Waller Ave to Bob-O-Link Dr and St Joseph's Dr to the railroad have been identified as particular roadways of interest. See the streets and roads BMP action plan.	Med	WAH / TSS, P, N	North Elizabeth Street NA, Picadome NA, LFUCG Streets & Roads, Consultants	Dependent on action taken	Depends on action taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Design Engineers, Consultants, Construction Contractors	Contact Neighborhood Assc to evaluate support	1) Secure funding, 2) Design BMPs, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
83	Neighborhood Association BMP Program	Big Elm Tributary (W11)	Southern Heights NA Project: 3,895 sq. ft of existing asphalt removed and replaced with permeable pavement at access road from Nicholasville Road (1820-1828). Also tree planting and educational signage were a part of the grant.	High	WAH / TSS, P, N, E. coli, Water Quantity	Southern Heights NA	$40,630.40 awarded in FY2011	Pervious Pavement: 65-100% TSS, 25% P, 25% N, 65-	LFUCG Water Quality Incentive Grant	Contractors	Completed in 2011	None	None

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								100% E. coli, 45-75% Vol					
84	Wetland	Big Elm Tributary (W11)	Commonwealth Stadium Detention Basin Wetland: the detention basin southwest of Commonwealth Stadium could be retrofitted to retain water or for treatment via constructed wetlands.	Low	WAH / TSS, P, N, E. coli	UK, Consultants	Wetland: $30,000 - $40,000 / acre	Wetlands: 45-85% TSS, 20-75% P, 0-50% N, 70-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Design and Construction	Ongoing monitoring and maintenance	
85	Green Infrastructure	Big Elm Tributary (W11)	Commonwealth Stadium Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality. Parking covers over 47 acres and 800 ERUs of impervious surface. Methods such as green parking or green infrastructure to reduce the impervious surface and runoff from the area should be evaluated.	Low	WAH / Water Quantity, TSS, P, N	Landowners Consultants, WRWC	feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	320 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
86	Trash and Debris	Big Elm Tributary (W11)	Trash and Debris on Big Elm along Bob-O-Link Drive: Trash and debris was scattered over this entire reach. Volunteer stream cleanup efforts should be focused along this reach. Cleaning of honeysuckle may reduce the amount of trash accumulated in the area.	Med	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, Picadome NA	Varies by event	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Event Coordination, Supplies	Organize a cleanup event for this reach. If successful, hold event annually.		
87	Stream Restoration, Wetland	Middle Wolf Run (W6)	Allendale Greenway Stream Improvements: The confluence of Spring Branch and Wolf Run is a well trafficked and has a potentially large riparian area although currently mowed. Approximately 1,800 feet of stream are within this reach and along Furlong Drive. The Moberly spring on the hillside has caused wetland features to develop which could be increased by plugging the drainage ditch. Springs Branch could be re-meandered into the available floodplain to increase instream habitat / wetland and floodplain functions. A bridge / trail from Faircrest to Allendale with water quality education would be beneficial.	High	WAH / Habitat Improvement, TSS, P, N	LFUCG DWQ, Landowners, Consultants	Stream Restoration: $700,000 - $1,000,000 for design and construction Additional for bridge / trail	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually, Wetlands: 45-85% TSS, 20-75% P, 0-50% N, 70-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Meet with Parks staff and landowners to evaluate support, 2) Secure funding, 3) Project Design	Phase II: 1) Conduct pre- and post construction monitoring, 2) Construction	Ongoing monitoring and maintenance
88	Wetland, Riparian Buffer	Middle Wolf Run (W6)	Allendale-Moberly Spring Greenway "Riparian Arboretum" Project: About 10 acres of the site will be devoted to restoring patches and strips of native vegetation that will include a diverse living collection of species with local provenance. This collection will become available for local propagation, education and research. This project will include removal of bush honeysuckle and trash removal. A web brochure will also be produced.	High	WAH / Habitat Improvement	Bluegrass Woodland Restoration Center, FOWR, Skybax Ecological Services, NA	$13,850 awarded for project in FY2012	Improved habitat, stream shading	LFUCG Water Quality Incentive Grant	Plant Materials (Local genotypes), Maintenance Supplies, Volunteer Support	2012-2013: Project start to completion	Replanting of other riparian areas utilizing the propagated seed source at this site.	

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89	Riparian Buffer	Middle Wolf Run (W6)	Allendale Greenway Riparian Stream Buffer Stewardship: riparian planting and invasive species removal. Site has been planted in areas, but needs expansion and maintenance.	High	WAH / Habitat Improvement	Sarah Barbee, BCTC ESTP	Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
90	Riparian Buffer	Middle Wolf Run (W6)	Wolf Run Park Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 1,600 ft of stream.	Med	WAH / Habitat Improvement	FOWR and Volunteers	$24,000 - $32,000 Total for Native Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
91	Wetland	Middle Wolf Run (W6)	Wolf Run Park Constructed Wetland: Wolf Run Park has open space that could be used to construct wetlands to improve habitat and water quality. Two potential sites including a section of braided stream and a streamside wetland, both on the left bank. This project should be coordinated with the proposed remedial measures plan for the Wolf Run Main Trunk D from Roanoke to Appomattox Dr (BMP No. 4)	Med	WAH / Habitat Improvement, TSS, P, N, E. coli	LFUCG Parks, LFUCG DWQ, Consultants	Wetland: $30,000 - $40,000 / acre	Wetlands: 45-85% TSS, 20-75% P, 0-50% N, 70-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Meet with Parks staff to evaluate support, 2) Secure funding, 3) Project Design	Phase II: 1) Conduct pre- and post construction monitoring, 2) Construction	Ongoing monitoring and maintenance
92	Riparian Buffer	Middle Wolf Run (W6)	Roanoke Greenway Riparian Stream Buffer Stewardship: riparian planting and invasive species removal on about 1,400 ft of stream. Site has been planted in areas, but a much larger reach needs to be addressed	High	WAH / Habitat Improvement	Wendy Havens, Port Royal NA	$21,000 - $28,000 Total for Native Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
93	Green Infrastructure	Middle Wolf Run (W6)	Gardenside Christian Church Green Infrastructure: This landowner has been identified as a potential participant to install a rain garden or other BMP on their property.	Low	WAH / TSS, N, Water Quantity	Beaumont Presbyterian Church, FOWR	$500 - $2,000 / rain garden	Rain Garden: 15-74% TSS, 40-55% N, 60% Vol	320 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	BMP Design and Installation Assistance, Planting Supplies, Education	1) Contact church to evaluate support, 2) Secure funding, 3) Install BMP	Ongoing monitoring and maintenance	
94	Green Infrastructure, Riparian Buffer	Middle Wolf Run (W6)	James Lane Allen Elementary: Grant to perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding. Students and teachers at the school will have input into the feasibility study. Riparian planting should also be conducted approximately 600 feet of stream bank on the site, but should be coordinated with the proposed remedial measures plan for the Wolf Run Main Trunk D from Roanoke to Appomattox (BMP No. 4).	High	WAH / Water Quantity, TSS, P, N	FCPS, James Lane Allen Elementary, EcoGro	$12,000 awarded for feasibility study in FY2012, Additional for implementation	Dependent on action taken	LFUCG Stormwater Quality Incentive Grant	Consultants, Designers, Contractors, Monitoring	1) 2013 Conduct Study, 2) Select BMPs for implementation, 3) Secure implementation funding, 4) Conduct pre- and post construction monitoring, 5) Implement BMPs.	Ongoing monitoring and maintenance	
95	Bioswale	Middle Wolf Run (W6)	Parkside Development Property: Replace concrete channel with bioswale on property.	Low	WAH / Water Quantity, TSS, N,	Parkside Development Landowners, Consultants, WRWC	$80 / sq. ft concrete removal; $3 - $30 / linear ft for bioswale	Bioswale: 70-80% TSS, 40 -75% N, 40-50% Volume	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Bioswale design and construction, 4) Conduct pre- and post- construction monitoring.		Ongoing monitoring and maintenance

BMP No.	Type	Target Audience or Area	Best Management Practice Description and Action Items	Priority	Impairment / Pollutant Addressed	Responsible Parties	Estimated Cost	Estimated Load Reduction	Funding Source(s) / Program(s)	Technical Assistance Needed	Short Term Milestones (0-5 Years)	Mid-Term Milestones (5-10 Years)	Long-Term Milestones (10-25 Years)
96	Trash and Debris	Middle Wolf Run (W6)	Trash and Debris along Middle Wolf Run: Some trash accumulation in park areas and greenways along this reach including the Allendale Greenway and Wolf Run Park. Organize volunteer trash cleanup efforts in these areas.	Med	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, FOWR	Varies by event; Some cleanup provided under Allendale-Moberly Spring Greenway Project	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies	Organize a cleanup event for this reach. If successful, hold event annually.		
97	Trash and Debris	Middle Wolf Run (W6)	Trash and Debris Port Royal NA: Continue the Keep America Beautiful's Great American Cleanup annual event in the Port Royal NA. 200 lbs of trash were collected in 2011 and 420 lbs in 2012 over 0.5 miles of stream.	High	WAH / Trash and Debris	Wendy Haven, Port Royal NA, LFUCG DEP, Keep Lexington Beautiful Commission	Varies by event	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies	Continue annual cleanup event		
98	Green Infrastructure	Middle Wolf Run (W6), Gardenside Tributary / Cardinal Run (W5)	Gardenside Shopping Center Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding. Gardenside is a large impervious surface draining to Wolf Run and the Gardenside Tributary.	Low	WAH / Water Quantity, TSS, P, N	Landowners Consultants, WRWC	feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on action taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
99	Riparian Buffer	Gardenside Tributary / Cardinal Run (W5)	The Lexington School Riparian Stream Buffer Stewardship: riparian planting and invasive species removal needed on about 1,200 ft of stream located in the vicinity of the Lexington School. Bank stabilization is necessary on about 15 feet on this reach.	Med	WAH / Habitat Improvement	FOWR and Volunteers	$18,000 - $24,000 Total for Native Planting / Invasive Removal / Bank stabilization, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate. Bank stabilization will require consultants design and installation.		
100	Bank Stabilization, Riparian Buffer	Gardenside Tributary / Cardinal Run (W5)	Gardenside Tributary Above Cross Keys Riparian Stream Buffer Stewardship: riparian planting and invasive species removal needed on about 1,800 ft of stream. Bank stabilization is necessary on about 160 feet on this reach.	Med	WAH / Habitat Improvement	FOWR and Volunteers	$29,400 - $39,200 Total for Native Planting / Invasive Removal / Bank stabilization, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate. Bank stabilization will require consultants design and installation.		
101	Bank Stabilization	Gardenside Tributary / Cardinal Run (W5)	Gardenside Tributary Below Cross Keys: Bank stabilization is necessary on about 40 feet of bank in this reach.	Low	WAH / Habitat Improvement	Private landowners, Consultants, Contractors	$600 - $800 for bank stabilization	Dependent on area exposed and method utilized	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors	Bank stabilization will require consultants design and installation. Evaluate landowner support. Engineers to evaluate appropriate grading, vegetation, and stabilization techniques and exact lengths to be addressed. Secure funding, and conduct design and construction.		
102	Bank Stabilization, Riparian Buffer	Gardenside Tributary / Cardinal Run (W5)	Cardinal Run Headwaters Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 1,500 ft of stream. Bank stabilization is necessary on about 100 feet on this reach.	Med	WAH / Habitat Improvement	FOWR and Volunteers	$24,000 - $32,000 Total for Native Planting / Invasive Removal / Bank stabilization, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate. Bank stabilization will require consultants design and installation.		
103	Riparian Buffer	Gardenside Tributary / Cardinal Run (W5)	Cardinal Run Along Parkers Mill Road Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 1,000 ft of stream.	Med	WAH / Habitat Improvement	FOWR and Volunteers	$15,000 - $20,000 Total for Native Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		

BMP No.	Type	Target Audience or Area	Best Management Practice Description and Action Items	Priority	Impairment / Pollutant Addressed	Responsible Parties	Estimated Cost	Estimated Load Reduction	Funding Source(s) / Program(s)	Technical Assistance Needed	Short Term Milestones (0-5 Years)	Mid-Term Milestones (5-10 Years)	Long-Term Milestones (10-25 Years)
104	Stream Restoration, Wetland	Gardenside Tributary / Cardinal Run (W5)	Cardinal Run Stream Restoration from Parkers Mill to Versailles Rd: about 1,400 ft of stream in this area has been identified as a priority area for restoration. An existing wetland in this area which could be enhanced and expanded. This project should be coordinated with the proposed remedial measures plan for the Parkers Mill Trunk line from Devonport Dr to Darien Dr (BMP No. 9).	High	WAH / Habitat Improvement, TSS, P, N	Private landowners, Consultants, Contractors	Stream Restoration: $560,000 - $840,000 for design and construction	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Meet with landowners to evaluate support, 2) Secure funding, 3) Project Design	Phase II: 1) Conduct pre- and post construction monitoring, 2) Construction	Ongoing monitoring and maintenance
105	Riparian Buffer	Gardenside Tributary / Cardinal Run (W5)	Cardinal Run Mouth Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 1,000 ft of stream near the mouth of Cardinal Run. This project should be coordinated with the proposed remedial measures plan for the Parkers Mill Trunk line from Devonport Dr to Darien Dr (BMP No. 9).	High	WAH / Habitat Improvement	Peggy Henson, Urban County Council	$15,000 - $20,000 Total for Native Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
106	Stream Restoration, Retrofit	Gardenside Tributary / Cardinal Run (W5)	Cross Keys Park Retention Basin Retrofit: The retention pond with its embankment is over 40 years old and has become degraded due to siltation, and the condition of the embankment is in need of assessment. This LFUCG-owned pond is performing key water quality improvement functions, which should be retained. Options for retrofitting the 4 acre pond to treat stormwater runoff and remove nonpoint source pollutants will be evaluated and implementation should include bank stabilization below and above the pond. Various alternatives include pond dredging, addition of an aquatic shelf, addition or retrofit to constructed wetlands in series, floating bio-habitat, trash and debris capture, etc.	High	WAH / Habitat Improvement, TSS, P, N	LFUCG Parks, LFUCG DWQ, Urban County Council, Consultants	Stream Restoration: $400 - 600 / foot for design and construction Wetland: $30,000 - $40,000 / acre Excavation: $12-15 / cubic foot	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually Wetlands: 45-85% TSS, 20-75% P, 0-50% N, 70-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Secure funding, 2) Bid Project and Select Consultant, 3) Design stream in conjunction with golf course needs, 4) Conduct pre- and post construction monitoring, 5) Conduct restoration		Ongoing monitoring and maintenance
107	Retrofit	Gardenside Tributary / Cardinal Run (W5)	Retention Ponds Floating Biohabitat: Install floating biohabitat in four ponds in John Alden Estates, Colony, and Saddle Club Neighborhoods in order to improve water quality and create additional habitat. Three of these ponds were previously enhanced with aeration and algal control under a FY 2011 Water Quality Incentive Grant	Low	WAH / Habitat Improvement, TSS, P, N	Neighborhood Assc, WRWC	$3 - $15 / Sq. ft - Total cost dependent on size of floating biohabitats	Biohabitat: 50-80% TSS, 50-80% P, 40-80% N	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Plant Selection, Location, Anchoring	1) Contact retention basin owners to evaluate support, 2) Secure funding, 3) Conduct pre- and post-implementation monitoring, 4) Install BMP	Ongoing monitoring and maintenance	
108	Green Infrastructure	Gardenside Tributary / Cardinal Run (W5)	Beaumont Presbyterian Church: This landowner has been identified as a potential participant to install a rain garden or other BMP on their property.	Low	WAH / TSS, N, Water Quantity	Beaumont Presbyterian Church, FOWR	$500 - $2,000 / rain garden	Rain Garden: 15-74% TSS, 40-55% N, 60% Vol	320 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	BMP Design and Installation Assistance, Planting Supplies, Education	1) Contact church to evaluate support, 2) Secure funding, 3) Install BMP	Ongoing monitoring and maintenance	
109	Green Infrastructure	Gardenside Tributary / Cardinal Run (W5)	Beaumont Middle School - Construct a rain garden that will be used as an environmental educational tool for approximately 1,200 middle school students. Educational material will developed and distributed to parents of students and selected local residents. Local organizations will also be able to utilize the rain garden for educational purposes.	High	WAH / TSS, N, Water Quantity	FCPS, Beaumont Middle School, Consultants	$2,500 awarded in FY2012	Rain Garden: 15-74% TSS, 40-55% N, 60% Vol	LFUCG Water Quality Incentive Grant	Educational materials, construction design and implementation	Construction and education in 2012	Ongoing education	

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110	Spring Enhancement	Gardenside Tributary / Cardinal Run (W5)	Kenton Blue Hole Spring Enhancement: improve the spring features by aesthetic improvements to landscaping, fencing, signage, flow path and spring pool to highlight this unique water feature and provide education.	Low	WAH / Habitat Improvement	Landowner, Consultants, Landscape Architect	Dependent on action taken	Dependent on action taken	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding, private funding	Landscape Architect, Designer	1) Contact landowners to evaluate support, 2) Secure funding, 3) Design and Construct Improvements	None	None
111	Trash and Debris	Gardenside Tributary / Cardinal Run (W5)	Trash and Debris Versailles Road to Devonport Drive: Trash accumulates along reach of Cardinal Run from Versailles Road to the confluence with Wolf Run. Organize volunteer cleanup efforts in this area.	Med	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, FOWR, Friends of Versailles Road, West Gardenside NA, Calumet NA, Holiday Hills NA	Varies by event	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies	Organize a cleanup event for this reach. If successful, hold event annually.		
112	Green Infrastructure	Gardenside Tributary / Cardinal Run (W5), Lower Wolf Run (W1, W3)	Versailles Rd / Alexandria Dr Businesses Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff and flooding. Several BMPs have already been installed in the area. Additional BMPs at the library or other areas should be evaluated.	Low	WAH / Water Quantity, TSS, P, N	Businesses and Landowners, Consultants, WRWC	Feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
113	Stream Restoration	Middle and Lower Vaughns Branch (W4, W7)	Picadome Golf Course: About 4,200 ft of stream are located on this property. The site has poor habitat, some of the worst erosion in the watershed, and is located in a priority restoration area. A new channel from Big Elm tributary to the Vaughns Branch, crossing three fairways, is necessary to prevent erosion due to flooding backup from the sinkhole. Additionally the Vaughns Branch reach throughout the site is in need of restoration. Pockets of bioretention and wetland could be utilized to treat nutrients and conductivity sources. Capturing and storing stormwater runoff for irrigation should also be evaluated. Coordination with the golf staff is critical. The effort should also be coordinated with Remedial Measures on the Bob-O-Link Trunk.	High	WAH / Habitat Improvement, TSS, P, N	LFUCG Parks, LFUCG DWQ, Urban County Council, Consultants	Stream Restoration: $1,500,000 - $2,500,000 for design and construction	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Secure funding, 2) Bid Project and Select Consultant, 3) Design stream in conjunction with golf course needs, 4) Conduct pre- and post construction monitoring, 5) Conduct restoration	Ongoing monitoring and maintenance	
114	Riparian Buffer	Middle and Lower Vaughns Branch (W4, W7)	Pine Meadows Park Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 800 feet	High	WAH / Habitat Improvement	Will Overbeck, LFUCG Parks, Pine Meadows NA	$12,000 - $16,000 Total for Native Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		

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115	Riparian Buffer	Middle and Lower Vaughns Branch (W4, W7)	Sugar Mill FEMA Project Riparian Plantings: about 1,300 ft of riparian plantings were completed in 2009. Ongoing maintenance of these plantings.	Low	WAH / Habitat Improvement	Paula Singer, Friends of Versailles Rd	Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Ongoing maintenance		
116	Stream Restoration	Middle and Lower Vaughns Branch (W4, W7)	Stream Restoration on Vaughns Branch Below Versailles Rd: about 800 ft of stream in need of restoration due to erosion. The banks are steep in this reach upstream of Oxford Circle, so restoration may be difficult or unfeasible.	Low	WAH / Habitat Improvement, TSS, P, N	Private landowners, Consultants, Contractors	Stream Restoration: $320,000 - $480,000 for design and construction	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Meet with landowners to evaluate support, 2) Secure funding, 3) Project Design	Phase II: 1) Conduct pre- and post construction monitoring, 2) Construction	Ongoing monitoring and maintenance
117	Bank Stabilization	Middle and Lower Vaughns Branch (W4, W7)	Vaughns Branch Below Oxford Circle Bank Stabilization: needed intermittently on eroding areas on about 100 ft of stream.	Low	WAH / Habitat Improvement	Private landowners, Consultants, Contractors	$1,500 - $2,000 for bank stabilization	Dependent on area exposed and method utilized	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors	Bank stabilization will require consultants design and installation. Evaluate landowner support. Engineers to evaluate appropriate grading, vegetation, and stabilization techniques and exact lengths to be addressed. Secure funding, and conduct design and construction.		
118	Riparian Buffer	Middle and Lower Vaughns Branch (W4, W7)	Vaughns Branch Below Oxford Circle Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 1,300 ft of stream	High	WAH / Habitat Improvement	Paula Singer, Friends of Versailles Rd	$19,500 - $26,000 Total for Native Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
119	Stream Restoration, Wetland, Riparian Buffer	Middle and Lower Vaughns Branch (W4, W7)	Deauville Greenway Stream Restoration: about 1,200 ft of stream in need of restoration. The site reach is straightened and has housing on both sides of the stream, but some area is available for remeandering. Erosion is occurring in this area. A constructed wetland in the greenway area would aid in reducing nutrient loads and provide habitat. If stream restoration is unfeasible, riparian buffer restoration would be beneficial.	Low	WAH / Habitat Improvement, TSS, P, N	Private landowners, Consultants, Contractors	Stream Restoration: $480,000 - $720,000 for design and construction Wetland: $30,000 - $40,000 / acre dependent on depth	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually Wetlands: 45-85% TSS, 20-75% P, 0-50% N, 70-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Meet with landowners to evaluate support, 2) Secure funding, 3) Project Design	Phase II: 1) Conduct pre- and post construction monitoring, 2) Construction	Ongoing monitoring and maintenance
120	Neighborhood Association BMP Program	Middle and Lower Vaughns Branch (W4, W7)	Neighborhood Association BMP Program: Cardinal Valley, Pine Meadow, Golf View Estates, Headley Green, Mason Headley Neighborhood Associations. Provide education and funding for implementation of residential BMPs as described in the text.	High	WAH / Water Quantity, TSS, P, N	LFUCG DEP, LFUCG DWQ, Bluegrass PRIDE, FCNC, UK Extension, BCTC, NA	$50 - $150 / rain barrel, $500 - $2,000 / rain garden, $15 - $20 / lin ft riparian	Rain Barrel: 40% Vol Rain Garden: 15-74% TSS, 40-55% N, 60% Vol Riparian: 60-90% TSS, 25-75% P, 20-100% N, Some Vol	319 Grant, LFUCG Water Quality Incentive Grant, Neighborhood Sustainability Grant, KAWC Grant, Lily Raintainer Program, Designated city or state funding, private funding	BMP Design and Installation Assistance, Planting Supplies, Education	Educational Package Development and initial implementation	Ongoing Implementation	

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121	Green Infrastructure	Middle and Lower Vaughns Branch (W4, W7)	Cardinal Hill Hospital Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff. Several BMPs are already present on the Cardinal Hill property, but treatment to the parking lot should be evaluated.	Med	WAH / Water Quantity, TSS, P, N	Cardinal Hill Hospital, Consultants, WRWC	feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	317 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
122	Green Infrastructure	Middle and Lower Vaughns Branch (W4, W7)	Oxford Circle Businesses Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff. Currently no stormwater BMPs are present in this area of large impervious surface.	Med	WAH / Water Quantity, TSS, P, N	Businesses and Landowners, Consultants, WRWC	Feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	318 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
123	Green Infrastructure	Middle and Lower Vaughns Branch (W4, W7)	Cardinal Valley Elementary School Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff. Construction to improve the school facilities are in progress.	Med	WAH / Water Quantity, TSS, P, N	FCPS, Consultants, WRWC	Feasibility study and design: $10,000 - $20,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct feasibility study and design	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
124	Trash and Debris	Middle and Lower Vaughns Branch (W4, W7)	Trash and Debris at Confluence of Vaughns Branch and Wolf Run: Dumping of trash in this area is frequent addition to trash and debris transported during storm events. Address dumping in the area through enforcement. Continue the Keep America Beautiful's Great American Cleanup annual event in Valley Park. 4000 lbs of trash were collected in 2011 and 400 lbs in 2012 on over 1.25 miles of stream.	High	WAH / Trash and Debris	Cardinal Valley Clean Stream Committee, LFUCG DEP, Keep Lexington Beautiful Commission, FOWR	Varies by event	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup; Code Enforcement	Cleanup Event Coordination, Supplies	Continue annual cleanup event. Monitor and enforce dumping		
125	Trash and Debris	Middle and Lower Vaughns Branch (W4, W7)	Trash and Debris at Picadome Sinkhole: Significant debris accumulates in the sinkhole. Recently a contractor was hired to remove this debris, but additional measures are necessary. Evaluate the installation of a trash rake to capture litter and annual cleanup efforts in this area.	High	WAH / Trash and Debris	LFUCG Parks	Unknown - Dependent upon drainage	Amount of trash removed varies	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Design and Construction, Ongoing Maintenance	Evaluate feasibility and project acceptance, obtain funding, construction	Ongoing maintenance	
126	Trash and Debris	Middle and Lower Vaughns Branch (W4, W7)	Trash and Debris Downstream of Red Mile Road: Trash accumulates along this intermittent reach downstream of Red Mile Road. Organize volunteer cleanup efforts in this area.	Low	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, FOWR	Varies by event; Some cleanup provided under Allendale-Moberly Spring Greenway Project	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies	Organize a cleanup event for this reach. If successful, hold event annually.		
127	Trash and Debris	Middle and Lower Vaughns Branch (W4, W7)	Trash and Debris Hope VI Greenway: Trash accumulates along Hope VI Greenway located upstream of Cardinal Hill Hospital on Vaughns Branch. Organize volunteer cleanup efforts in this area.	Low	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, FOWR	Varies by event; Some cleanup provided under Allendale-Moberly Spring Greenway Project	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies	Organize a cleanup event for this reach. If successful, hold event annually.		

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128	Riparian Buffer	Prestons Cave / McConnell Springs (W2)	McConnell Springs Park Riparian Stream Buffer Stewardship: riparian planting and invasive species removal within park.	High	WAH / Habitat Improvement	Laurie Thomas, LFUCG Parks	Unknown - Ongoing Maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
129	Bioswale	Prestons Cave / McConnell Springs (W2)	Chevron / Marathon Bioswale: Construction of a bioswale in rear of property for runoff flowing into McConnell Branch	Low	WAH / Water Quantity, TSS, N	Chevron / Marathon, Consultants, WRWC	$3 - $30/ sq. ft of bioswale	Bioswale: 70-80% TSS, 40 -75% N, 40-50% Volume	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant	Designers, Contractors	1) Contact property owners to evaluate support, 2) Secure funding, 3) Bioswale design and construction, 4) Conduct pre- and post- construction monitoring.		Ongoing monitoring and maintenance
130	Green Infrastructure	Prestons Cave / McConnell Springs (W2)	Red Mile Racetrack Stormwater BMPs: The property owners have recently installed a berm in the front of drainage to the spring / sinkhole to help slow down the water and settle out solids. They have also installed underdrains around the track area to filter out sediment. Ongoing monitoring to be conducted to indicate performance.	High	WAH / TSS, P, N, E. coli	Red Mile Racetrack, LFUCG DWQ	Unknown	Unknown amounts of TSS, P, N, E. coli	Property Owner	None	Constructed 2012; Ongoing monitoring		
131	Stream Restoration, Wetland, Riparian Buffer	Lower Wolf Run (W1, W3)	Stream Restoration in Valley Park: this reach of about 2,400 ft would benefit from stream restoration including constructed wetlands as the reach is straight, disconnected from the floodplain and has some bank erosion. Design plans have been developed in the past but should be evaluated in conjunction with heavy use of Valley Park. Currently some riparian restoration is occurring in this area and should continue if stream restoration is unfeasible. This project should be coordinated with the proposed remedial measures plan for the Wolf Run Main Trunk B from New Circle to Cambridge Dr (BMP No. 2)	Low	WAH / Habitat Improvement, TSS, P, N	LFUCG Parks, LFUCG DWQ, Consultants, Peggy Henson, Urban County Council, Modern Property Management	Stream Restoration: $1,000,000 - $1,500,000 for design and construction Wetland: $30,000 - $40,000 / acre	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually Wetlands: 45-85% TSS, 20-75% P, 0-50% N, 70-90% E. coli	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, Riparian through FOWR Stream Buffer Stewardship	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Meet with Parks staff to evaluate support, 2) Secure funding, 3) Project Design	Phase II: 1) Conduct pre- and post construction monitoring, 2) Construction	Ongoing monitoring and maintenance
132	Stream Restoration, Wetland	Lower Wolf Run (W1, W3)	Prestons Spring Park Stream Restoration: Approximately 2,600 ft of stream in the park with the widest riparian area in the watershed although it is primarily invasives species. Siltation is a problem as well as some upcutting and erosion due to a tributary. Channel restoration and wetlands or other bioretention features could further improve water quality and habitat. Widespread public support exists for such a project.	High	WAH / Habitat Improvement, TSS, P, N	LFUCG Parks, LFUCG DWQ, Consultants, FOWR	Stream Restoration: $1,000,000 - $1,500,000 for design and construction	Stream Restoration: 2.55 lbs /ft TSS, 0.0035 lbs /ft P, 0.02 lbs /ft N annually	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Secure funding, 2) Bid Project and Select Consultant, 3) Design stream in conjunction with golf course needs, 4) Conduct pre- and post construction monitoring, 5) Conduct restoration		Ongoing monitoring and maintenance
133	Riparian Buffer	Lower Wolf Run (W1, W3)	Prestons Spring Park Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 2,600 ft of stream. Current efforts are also seeking to create glade habitat just above the spring as well as addressing the riparian buffer. If stream restoration occurs, such efforts should be included in the restoration project.	High	WAH / Habitat Improvement	Billie Offutt, Cardinal Valley NA, MMSK, Jim Rebmann, LFUCG Environmental Council	$39,000 - $52,000 Initial Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		
134	Riparian Buffer	Lower Wolf Run (W1, W3)	Wolf Run above Old Frankfort Pike Riparian Stream Buffer Stewardship: riparian planting and invasive species removal along about 1,100 ft of stream.	Low	WAH / Habitat Improvement	FOWR and Volunteers	$16,500 - $22,000 Planting / Invasive Removal, Annual maintenance	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate.		

BMP No.	Type	Target Audience or Area	Best Management Practice Description and Action Items	Priority	Impairment / Pollutant Addressed	Responsible Parties	Estimated Cost	Estimated Load Reduction	Funding Source(s) / Program(s)	Technical Assistance Needed	Short Term Milestones (0-5 Years)	Mid-Term Milestones (5-10 Years)	Long-Term Milestones (10-25 Years)
135	Wetland, Bank Stabilization, Riparian Buffer	Lower Wolf Run (W1, W3)	Wolf Run Below Old Frankfort Pike Stream Improvements: Reach is about 3,000 ft in needs riparian planting, intermittent bank stabilization (about $100 ft), and constructed wetlands.	Low	WAH / Habitat Improvement	FOWR and Volunteers; Consultants, Landowners	$16,500 - $22,000 Planting / Invasive Removal / Bank Stabilization; $30,000 - $40,000 / acre for wetland	Improved habitat, stream shading	FOWR Stream Buffer Stewardship funded by composite of multiple grants, discretionary funds, in-kind match Will need additional funding for wetland construction	Plant Materials, Maintenance Supplies, Botanist / Biologist, Volunteer Support; Design of wetlands, construction	Average of 1,000 linear feet / year through volunteer efforts throughout the watershed. Use of contractors for clearing will increase this rate. Contact landowner to evaluate support for wetland construction; design and construct wetlands		
136	Green Infrastructure	Lower Wolf Run (W1, W3)	Old Frankfort Pike Industrial Area Green Infrastructure Study: Perform a study of the property to evaluate the feasibility of installing stormwater BMPs to improve water quality and reduce stormwater runoff. This district has a large amount of impervious surface which may be treated or captured for use.	Low	WAH / Water Quantity, TSS, P, N	Industrial Landowners, Consultants, WRWC	Feasibility Study: $10,000 - $50,000, Construction Cost Dependent on Actions Taken	Dependent on Actions Taken	319 Grant, LFUCG Water Quality Incentive Grant, KAWC Grant, Designated city or state funding, private funding	Consultants, Designers, Contractors, Monitoring	Phase I: 1) Contact property owners to evaluate support, 2) Secure funding, 3) Conduct Feasibility Study	Phase II: 1) Choose feasible BMPs to pursue, 2) Secure funding, 3) Design BMPs, 4) Conduct pre- and post construction monitoring, 4) Implement BMPs.	Ongoing monitoring and maintenance
137	Trash and Debris	Lower Wolf Run (W1, W3)	Trash and Debris in Prestons Cave Park: Large millstones and other large debris remains at Prestons Cave Park which should be removed. Residents have complaints of trash collecting at near confluence with Wolf Run and along stormsewers approaching McConnell Branch. Continue the Keep America Beautiful's Great American Cleanup annual event in Prestons Cave Spring Park. 350 lbs of trash were collected in 2011 and 120 lbs in 2012.	High	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, FOWR	Varies by event, additional expense for contractor / equipment	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies, Heavy Equipment	Hire contractor to remove large debris, continue annual cleanup event		
138	Trash and Debris	Lower Wolf Run (W1, W3)	Trash and Debris above Old Frankfort Pike: Some trash accumulation was noted upstream of Old Frankfort Pike and downstream of the industrial area. Cleanup efforts should be directed towards these areas. No cleanup events have been held in recent years	Low	WAH / Trash and Debris	LFUCG DEP, Keep Lexington Beautiful Commission, FOWR, Industrial Landowners	Varies by event	Amount of trash removed varies	Keep Lexington Beautiful's Great American Cleanup	Cleanup Event Coordination, Supplies	Organize a cleanup event for this reach. If successful, hold event annually.		

FCNC: Fayette County Neighborhood Council
NA: Neighborhood Association
WRWC: Wolf Run Watershed Council
BCTC: Bluegrass Community and Technical College

CHAPTER VII. IMPLEMENTATION OVERSIGHT AND SUCCESS MONITORING

The implementation plan for the Wolf Run Watershed has numerous best management practices, responsible parties, timelines, objectives, and goals. Key to ensuring that the watershed goals are achieved is monitoring of the implementation activities and their success. This section describes how the plan implementation will be evaluated.

A. Organization

With the completion of this watershed based plan, the focus transitions from planning to implementation. Progress on the plan goals, objectives, and action items will need to be coordinated and monitored in order to ensure that the implementation moves according to schedule and achieves the expected level of success. The transition in focus must also be accompanied by a transition in organization.

The Wolf Run Watershed Council was formed for the purpose of providing input into the development of the Wolf Run Watershed Based Plan. Participation in the Council has been open to all interested stakeholders with input provided at quarterly meetings and technical committees. As the central organization involved in the development of the plan, the Wolf Run Watershed Council is the organization best suited to coordinate and monitor the implementation of the watershed based plan. However, to do so, the structure of the organization must change.

It is recommended that the Wolf Run Watershed Council establish a set of bylaws or organizational rules to determine how to proceed with decision making in the organization. It is also recommended that the Council secure commitments for key roles in the organization, including a Watershed Coordinator, Executive Team, Implementation Team, and Technical Team. Commitment to serve in these roles would be for a defined period, to allow for stakeholders to change with circumstances.

The Watershed Coordinator would provide a central contact for the watershed implementation. The responsibilities of this position would include coordination amongst various responsible parties, funding sources, stakeholders, partners, and technical resources, as well as tracking progress of implementation projects and scheduling Council meetings. It is recommended that this position be funded, at least in part, through program grants. The Watershed Coordinator would follow the proposals in the watershed based plan to ensure the Council remains on course in its implementation while also considering adaptive management as the watershed and desires of the stakeholders change.

The Executive Team would be responsible for making decisions between Council meetings and could increase the progress of the Council on watershed activities and documentation between meetings. This group would record Council meeting minutes, set agendas, and be responsible for coordinating watershed events. This team would replace the role fulfilled by the Wolf Run Project Team in development of the watershed based plan.

The Implementation Team would be responsible for reviewing progress of project implementation, including progress on funded projects or events, tracking outreach and support of stakeholders for BMP implementation, watching for new opportunities or strategy as they arise, and summarizing the progress and volunteer opportunities for the larger Council audience. This team would also be responsible for adjusting the milestones for individual BMPs and projects according to stakeholder support or opportunities. Members of this team should include representatives of key projects or landowners in the watershed, if possible.

The Technical Team would be responsible for evaluating the technical aspects of implementation as well as water quality monitoring data from pre- and post-construction. This team would include technical consultants as well as partnering organizations. The Technical Team would advise the Council on progress towards load reductions and on feasible implementation options for willing stakeholders. They would also report technically on BMP accomplishments or failures, such as meeting/not meeting pollutant reduction milestones, and recommend adapting implementation strategies based on the findings of the Implementation Team.

Together, through these roles and responsibilities the Wolf Run Watershed Council will ensure that the plan is a living document, responding to challenges and opportunities that may arise over time. Responsible parties listed in the implementation plan may form the base of many of these teams, but outreach to additional stakeholders may be necessary to achieve the project goals.

B. Presentation and Outreach

The Wolf Run Watershed Council will work to present the objectives and recommendations of the Wolf Run Watershed Based Plan to the general public as well as key stakeholders within the watershed. The Watershed Based Plan will be published on the LFUCG and FOWR websites in order to increase its accessibility to the public. FOWR also has obtained funding, through the FY 2012 LFUCG Stormwater Quality Projects Incentive Grant Program, to recruit property owners in the Wolf Run Watershed to install BMPs or apply for grants to do so in the future. Such outreach efforts, as well as those listed in the implementation plan, will be necessary to ensure that BMPs are implemented.

Marketing of the Watershed Based Plan will remain a critical role of the Watershed Coordinator as well as the Implementation Team. For many of the BMPs, milestones were less concrete because landowner support for implementation had not been evaluated. One of the initial goals of the Wolf Run Watershed Council should be to outreach to the stakeholders identified in the Watershed Plan, evaluate the support for implementation, and then establish renewed milestones and priorities based upon the response.

Development of a brief summary of the Watershed Plan will also aid in the education and outreach efforts by condensing the findings of the plan for consumption by local leaders and important audiences. Additionally slideshow presentations of the plan findings will allow for outreach to local groups and meetings.

C. Monitoring Success

Success of the Watershed Plan should be monitored in terms of implementation progress, education and behavior change, as well as water quality sampling results. Review of these success indicators will allow the Council to evaluate whether changes in the implementation strategy or planning are necessary.

1. Implementation Tracking

One measures of success is the evaluation of whether the implementation plan is actually being carried out. As such, the Council, and the Implementation Team in particular, should document progress on each of the 138 listed BMPs over time. Such tracking should include responses from responsible parties, funding updates, design and construction updates, impediments, and pending responses. In addition to tracking the status of the individual BMPs, specific measurable indicators of success should be tracked for each BMP. For instance, for the Neighborhood Association BMP Program, the number of outreach events should be recorded as well as the number of rain gardens and rain barrels installed and the length of riparian buffer

improved. For Trash and Debris BMPs, the pounds of trash collected and number of participating volunteers should be recorded. For numerous BMPs in which evaluation of the landowner support is the first step, such contacts should be documented. The latitude and longitude of each of the implemented BMPs should also be documented in order to aid future success monitoring.

2. Education and Outreach Tracking

For education and outreach activities, pre- and post-educational surveys should be utilized to document changes in perceptions and behaviors as a result of educational activities. These surveys may be used to refine and improve training workshops and outreach events based on the aspects of the programs view as most valuable. These activities should also be evaluated as to whether they are utilizing the most appropriate venues and addressing the desired audiences to accomplish the plan goals.

3. Water Quality Monitoring

The water quality monitoring should be performed, using the parameters listed in Table 40, page VI-1 through VI-2, in order to measure the progress made towards the watershed plan goals. A number of monitoring data sources should be used to evaluate the progress on water quality goals.

A number of agencies will continue to perform water quality monitoring for baseline conditions in the watershed areas. This includes MS4 permit compliance monitoring by LFUCG and University of Kentucky, volunteer monitoring by FOWR and Kentucky Watershed Watch, periodic surface water monitoring by KDOW, and quarterly monitoring of McConnell Springs by KDOW under the ambient groundwater monitoring network. These sources should be evaluated to determine how the water quality may be improving with BMP implementation.

Pre- and post-construction sampling should be utilized for projects which incorporate stream improvements or green infrastructure. The Technical Team should develop monitoring standards for each implementation activity type. The data should allow for statistical analysis and be sufficient to demonstrate improvement due to the project construction. If the project is funded under a 319 grant, then a quality assurance project plan will need to be developed.

Some monitoring will need to be implemented to further trace sources of bacteria and conductivity within the watershed. Volunteer monitoring as well as monitoring under the LFUCG or University of Kentucky MS4 illicit discharge detection and elimination programs will be utilized to trace the source of pollutants and propose remediation efforts to reduce these levels. These monitoring activities will be ongoing, but updates should be provided to the Council.

Because Wolf Run is an urban environment, future monitoring should be performed for benzene, toluene, ethylbenzene, and xylene volatile organic compounds (BTEX) as well as polycyclic aromatic hydrocarbons (PAHs). BTEX are typically found in petroleum products including gasoline and diesel fuel, and therefore roadway runoff and underground storage tank leachate. Commons sources of PAHs include ignition of petroleum products and wood, road asphalt surfaces, and parking lot sealants. Sampling has not been conducted for these pollutants, so monitoring in the watershed should evaluate whether these chemical are pollutants of concern in the watershed. Finally, a comprehensive watershed monitoring effort should be conducted after five years of implementation. This comprehensive monitoring should be similar in scope and effort as the monitoring plan developed for this watershed plan. The purpose of this sampling would be

to compare progress towards to the project goals over five years and evaluate how the plan may need to be adjusted to account for these changes.

D. Evaluating and Updating the Plan

The goals, objectives, and recommended BMPs were based upon the best available information and projected needs of the community at the time of this plan development. With time, the watershed changes as well as the people within it and their desires. The impacts to the watershed can also change with time and as new monitoring data is collected. Therefore, the Watershed Plan must have the flexibility to change with time.

As mentioned previously, some readjustment of project priorities may needed after the first year of implementation due to the large number of areas in which landowner support for BMP implementation was unknown. Once these landowners have been contacted to determine their support, the milestones and implementation schedules for individual BMPs should be clarified by the Watershed Council.

It is recommended that the Wolf Run Watershed Council update the plan on a five year basis, and consider significant changes in approaches on an annual basis. The five year evaluation corresponds with milestone time frames and allows sufficient time for improvements to occur between evaluation periods. It also corresponds with a comprehensive monitoring effort which should indicate the water quality progress achieved by the plan. Annual evaluations of changes in approach allow for sufficient flexibility to adjust to changes as they occur.

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APPENDICES

APPENDIX A – BASIN RETROFIT DATA SHEETS

APPENDIX B – KARST HYDROGRAPH CHARACTERIZATION REPORT

APPENDIX C – CONDUCTIVITY SURVEY

APPENDIX D – HABITAT AND MACROINVERTEBRATE ASSESSMENT REPORT

APPENDIX E – HYDROGEOMORPHIC ASSESSMENT REPORT

APPENDIX F – WATERSHED MONITORING REPORT

APPENDIX G – UNIVERSITY OF KENTUCKY STORMWATER PLANNING