Cane Run and Royal Spring Watershed-Based Plan

EPA Project Number: C9994861-06
Dates: 12/01/07-10/31/12

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Executive Summary

The Cane Run and Royal Spring Watershed Based Plan (WBP) is a snapshot of the watershed. This document includes relevant water quality data from the watershed, presents a plan for remediating deficiencies caused by point and nonpoint source pollution, and reports significant efforts that the Cane Run Watershed Project and other stakeholders have completed. This watershed-based plan is designed to be a dynamic document that should be reviewed and updated periodically to reflect watershed improvement, education and outreach efforts, water quality monitoring, and best management practice implementation.

The Cane Run and Royal Spring Watershed (HUC 12: 051002050804) is located within Fayette and Scott Counties in central Kentucky. The upper portion of the watershed, located within Fayette County, drains highly urbanized areas of Lexington, Kentucky, and a portion of the watershed in Scott County drains the southern part of Georgetown, Kentucky. The rest of the watershed is predominantly agricultural. Cane Run contributes to the Kentucky River Watershed, and interstate highways I-64 and I-75 traverse the watershed. Property owners within the Cane Run Watershed include the Lexington-Fayette Urban County Government (LFUCG), University of Kentucky (UK), Lexmark International, Kentucky Horse Park, Marriott Griffin Gate Resort, Barton Brothers Farms, Kentucky River Properties, Vulcan Materials, and Georgetown Water Supply.

The Cane Run has been the focus of water quality sampling and monitoring since the late 1960's. Several different entities including the LFUCG, Georgetown Municipal Water Company, Kentucky Water Resources Research Institute (KWRRI), City of Georgetown, Kentucky Division of Water (KDOW), and Cane Run Watershed Project have monitored water quality in the Cane Run in these years. The basic results of these various studies show that the entire watershed is polluted. Bacteria and nutrients are problem pollutants, while sediment is potentially less of an issue. Aquatic habitat is poor within the stream, and stream bank erosion is a problem throughout the watershed.

Thus far, monitoring has focused on the surface water component; however, the single overriding challenge to water quality enhancement of the Upper Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run Creek). Swallets located throughout the watershed transmit surface water directly to the conduit systems associated with the Royal Spring. As of July 2011, equipment is being installed along a recently discovered conduit, which will be used for future water quality monitoring.

Beginning in 1998, a portion of the Cane Run in Fayette County was classified on the Kentucky Division of Water's 303(d) list of impaired waters. The listed causes for impairment at the time included organic enrichment, low dissolved oxygen, and bacteria coming from urban runoff and storm sewers. By 2010, all 17.4 miles of the Cane Run had been listed on the 303(d) list. In addition, three unnamed tributaries of Cane Run, which total 4.5 miles in Fayette County and 3.5 miles in Scott County, and the Royal Spring itself, which totals 0.7 miles in Scott County have been added to the 303(d) list.

To improve water quality in the Cane Run Watershed, many different financial and technical resources will be needed. Potential programs that could provide financial and technical assistance for implementation of the Cane Run and Royal Spring Watershed Plan include federal and state government programs, such as the KPDES Wastewater Permit program, KPDES Stormwater Permit program, Kentucky Agriculture Water Quality Act, Kentucky 319(h) program, and USDA Conservation programs. Nongovernmental organizations,

including Bluegrass PRIDE, Kentucky River Watershed Watch, and Friends of Cane Run could also provide technical and financial assistance. So far, water quality improvement efforts in the watershed have received assistance from a wide variety of sources including the Kentucky 319(h) program, SB-271, USDA Conservation programs, Kentucky American Water, University of Kentucky, and Lexmark.

Load reduction targets for key pollutants (bacteria and nutrients) in the Cane Run Watershed are in the process of being developed through the creation of total maximum daily loads (TMDLs). Total maximum daily load is a term used to describe the maximum amount of a pollutant a stream can assimilate without violating water quality standards. TMDLs are used to target BMP implementation and other efforts on a sub-catchment scale. KWRRI has developed preliminary bacteria and nutrient TMDLs that quantify the bacteria and nutrient reductions needed to meet water quality standards, which, once implemented, will improve water quality in the Cane Run Watershed.

In order to describe the key problems along the stream and identify potential BMPs, the watershed has been divided into catchments and then stream segments within those catchments. Pollution in these catchments comes from both point and nonpoint sources, including KPDES-permitted facilities, Class V injection wells, sanitary sewer overflows, failing septic systems, straight pipes, wildlife, livestock, domestic pets, lawn and agricultural fertilizers, urban runoff, and illicit discharges. The monitoring data available for each catchment confirms the findings of the watershed-wide monitoring, but also gives a more detailed picture of the origin of the pollution. High priority catchments based on these catchment analyses include several headwater catchments, where the main suspected source of pollution is failing sanitary and storm sewer infrastructure. Lower priority catchments are composed mostly of agricultural land, but are also easier areas in which to affect change, as the more developed headwater catchments are under a Consent Decree. Based on the water quality data, a variety of water quality practices have been recommended, including agricultural water quality plans, rain gardens, floatable controls, swales, nutrient management, filter strips, constructed wetlands, livestock exclusion, and vegetative buffers. Many BMPs have already been implemented in these catchments based on water quality data and stakeholder cooperation, including septic tank owner education, spring development, riparian area enhancement, vegetative buffers, pesticide amnesty, invasive species removal, livestock exclusion, and porous pavement.

The Cane Run and Royal Spring Watershed Plan seeks to improve and protect the overall water quality of the watershed such that the stream meets its designated uses. To accomplish this goal, education and outreach is essential. The education and outreach goals for this project include increasing awareness of: the watershed and potential stream pollutants (non-point source); human interaction and impact on the watershed; best management practices that improve and protect water quality; the importance of source water protection; and healthy streams and methods of restoring impaired streams.

To accomplish these educational and outreach efforts, significant collaboration will be necessary. Potential partners include, but are not limited to the University of Kentucky (UK), UK Cooperative Extension Service, Lexington-Fayette Urban County Government, Kentucky Division of Water, Kentucky River Watershed Watch, Bluegrass PRIDE, Bluegrass Partnership for a Green Community, Fayette and Scott County Public Schools, Cane Run Watershed Council, Friends of Cane Run, Lexmark, Inc., Kentucky Department of Transportation, Bluegrass Rain Garden Alliance, neighborhood associations, and the Kentucky Horse Park.

In the past few years, great strides have been made in the watershed. A change in thinking at the corporate level has occurred as entities in the watershed have taken a more “go green” approach to land management. Projects at the Kentucky Horse Park, Lexmark International, and UK’s Agriculture Experiment Station have led to an awareness that streamside buffers can be aesthetically pleasing; many BMPs have been installed to ease the impact of development and agriculture on this sensitive watershed; and the creation of the Legacy Trail has brought new visitors to the watershed and an opportunity to educate these trail users about the watershed. However, great strides still need to be made with sanitary and storm sewer infrastructure, and there is great potential for the installation of many more BMPs and large-scale stream restoration projects.

Future BMP implementation and other work will continue based on TMDL recommendations and catchment water quality data, as well as stakeholder cooperation, and education and outreach will continue throughout the watershed to increase knowledge and awareness of environmental issues within the watershed. The momentum surrounding this watershed project should be continued with further support and cooperation of state, local, and private entities.

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III. Introduction

Objectives

The objective of the Cane Run and Royal Spring Watershed Based Plan (WBP) is to assemble relevant water quality data from the watershed, present a plan for remediating deficiencies caused by point and nonpoint source pollution, and report significant efforts that the project and other stakeholders have completed. The goal of the remediation methodologies presented is to reduce the effects of point and nonpoint sources of pollution and allow the watershed to meet or exceed the water quality standards of the Commonwealth. Improving water quality in the various agricultural, suburban, and urban landscapes within the watershed requires a broad range of best management practices (BMPs), the implementing of which involves partnerships between stakeholders and landowners within the watershed. The direct link between the Cane Run and Royal Spring also makes monitoring necessary to determine swallet locations and their effect on water quality. Because the Royal Spring is the primary drinking water supply for the city of Georgetown, improvements in the quality and quantity of water within the watershed will not only improve environmental quality, but will also improve human health and safety within the region.

The location of the watershed in the Bluegrass Region and along the I-75 and I-64 corridors makes the watershed highly visible for educational opportunities. The education and outreach goals for the project include: 1) increase awareness of the watershed and potential stream pollutants; 2) increase awareness of human interactions and their impact on the watershed; 3) increase awareness of best management practices to improve and protect water quality, 4) increase awareness of the importance of source water protection; and 5) increase awareness of healthy streams and methods of restoring impaired streams. A key component is the development of a Watershed Council that will bring together major stakeholders to discuss the management and improvement of water quality throughout the watershed. It is important to make restoration efforts as visible as possible, not only to the residents of the watershed, but to those across the region, state, and nation.

Watershed Management Partners

The Cane Run Watershed Project, based in the University Of Kentucky College Of Agriculture, is managed by a watershed team. This team is the author of this plan and the facilitator for many of the implemented and planned water quality improvement projects and education and outreach activities.

The Cane Run Watershed Project originated in late 2006, when discussions at the University Of Kentucky College Of Agriculture regarding ways to leverage the College's SB-271 funds began. These discussions led to the suggestion that the funds should be leveraged with funds from the Section 319(h) Nonpoint Source Pollution Control Program through the KY Division of Water. The Cane Run Watershed emerged as a target of this funding because of two factors: 1) UK's large presence in the watershed through its ownership of the Agricultural Experiment Station, and 2) the priority given to the restoration of impaired and priority watersheds like the Cane Run. Eventually these ideas led to the creation of the Cane Run Watershed Project, a project that would develop and implement a watershed-based plan for the Cane Run Watershed.

The Cane Run Watershed Project partners have worked to plan and implement best management practices and education and outreach activities within the watershed. Project partners are affiliated with many different entities and organizations, including the University of Kentucky College of Agriculture, Kentucky Water Resources Research Institute, Lexington-Fayette Urban County Government, Kentucky Horse Park, Lexmark International, and Fayette County Public Schools.

IV. Watershed Description

The Cane Run and Royal Spring Watershed (HUC 12: 051002050804) is located within Fayette and Scott Counties in central Kentucky (Figure 1 and Figure 2). The upper portion of the watershed, located within Fayette County, drains highly urbanized areas of Lexington, Kentucky, and a portion of the watershed in Scott County drains the southern part of Georgetown, Kentucky. The rest of the watershed is predominantly agricultural. The 7.5 minute quadrangle maps on which Cane Run can be found are Centerville, Georgetown, Lexington East, and Lexington West. Cane Run is part of the larger Kentucky River Watershed (HUC 8: 05100205). Interstate highways I-64 and I-75 traverse the watershed.

The single overriding challenge to water quality enhancement of the Upper Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run Creek). Swallets located throughout the watershed transmit surface water directly to the conduit systems associated with the Royal Spring. The largest historical change in the watershed is the increase in impervious surfaces caused by urban and suburban development. The lack of large pervious areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

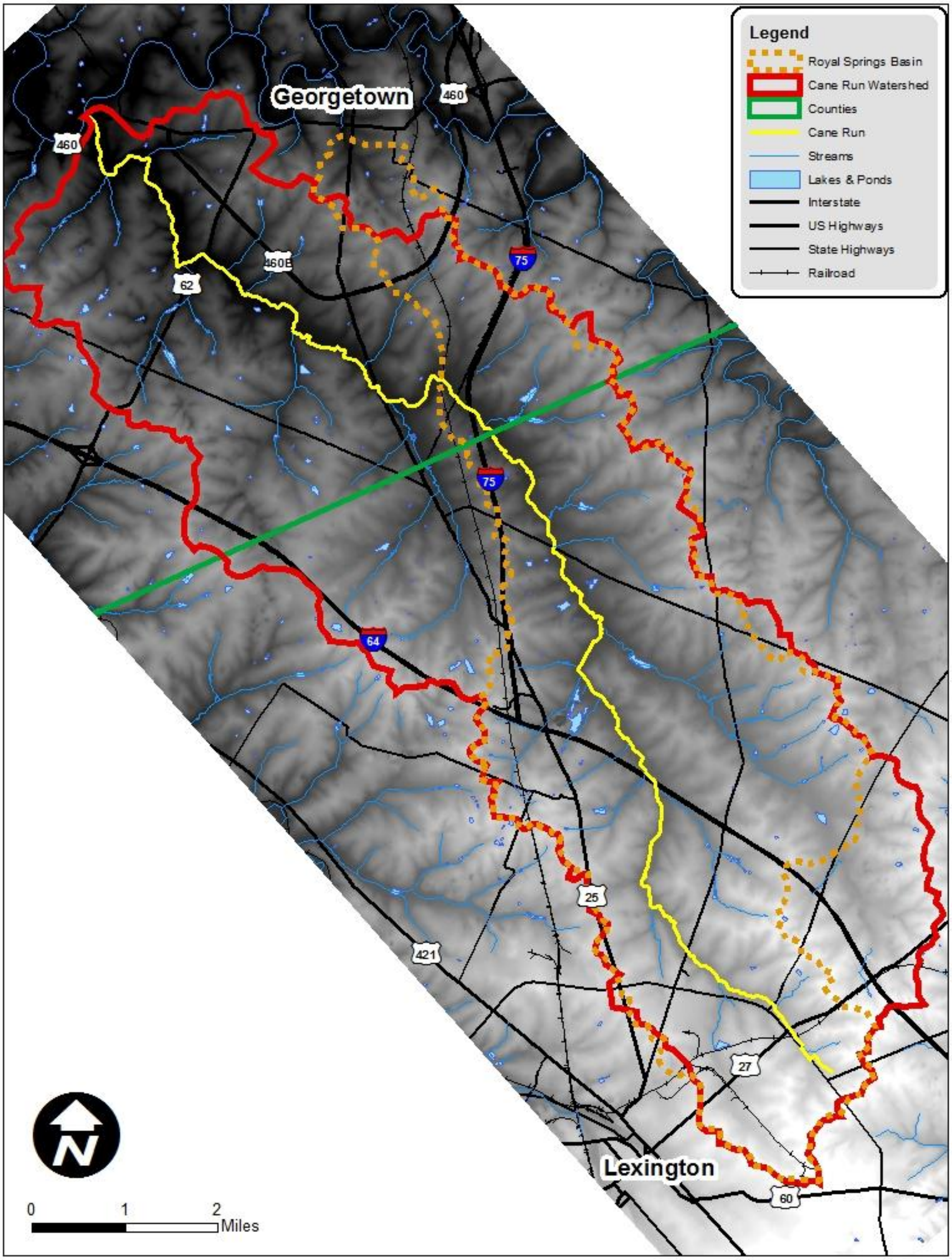

Figure 1. Cane Run Watershed

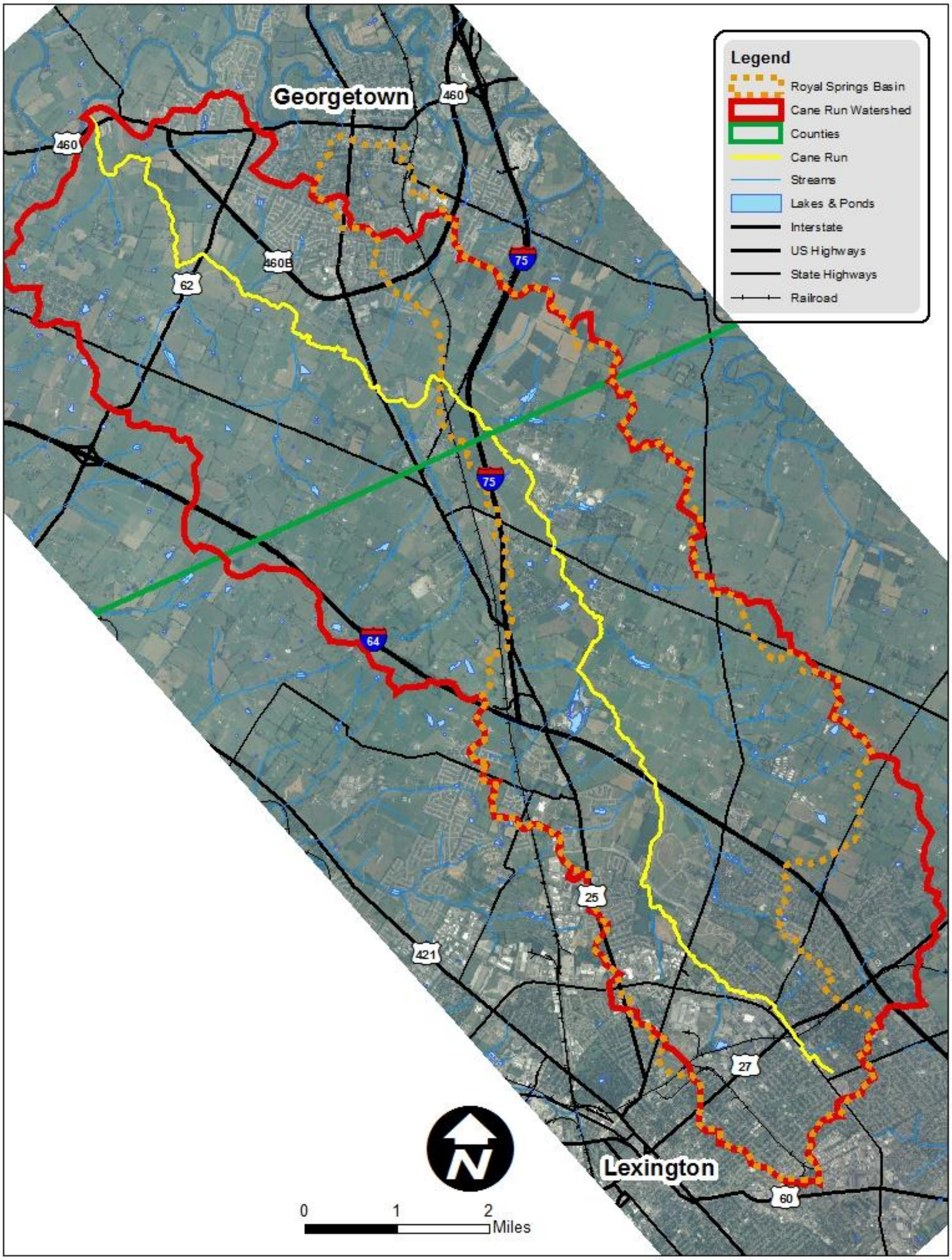

Figure 2. 2010 aerial imagery of the Cane Run Watershed and surrounding areas

Hydrology

Cane Run is a fourth order stream that originates in central Fayette County and flows north to discharge into the North Elkhorn Creek 44.3 km (27.5 miles) upstream of its confluence with the North Elkhorn Creek. North Elkhorn Creek carries the runoff from the county northwest to discharge into the Kentucky River.

The main stem of Cane Run is approximately 28 km (17.4 mi.) long and drains an area of 117.6 km^2 (29,064 acres). The average gradient is 2.34 m/km (12.4 feet/mile). Elevations for Cane Run range from 297 m (975 ft.) above mean sea level (MSL) in the headwaters in Lexington to 232 m (760 ft.) above MSL at the confluence with the North Elkhorn Creek. Like most small watersheds, many of the tributary streams are intermittent.

Catchment Delineation

The Cane Run Watershed can be split into 10 subwatersheds, or catchments as shown in Figure 3. The delineation of catchments within the watershed was accomplished using National Hydrology Data (NHD), which is based on a 10-meter digital elevation map (DEM) characterization of the watershed. This division allows for analysis of both point and nonpoint sources within each subwatershed.

The Cane Run Watershed Project (CRWP) and the Kentucky Water Resources Research Institute (KWRRI) have both divided the Cane Run Watershed into catchments, or subwatersheds, but each organization has used different labeling schemes. The catchments presented in this watershed plan are numbered 1-10. The subwatersheds presented in the bacteria and nutrient TMDLs authored by KWRRI are numbered L1-L6, U1-U8, and K1-K3, with L representing the lower watershed, U representing the upper watershed, and K representing additional karst systems within the watershed (Figure 4). The equivalencies between the labeling schemes can be found in Table 1.

Table 1. CRWP and KWRRI catchment equivalencies

Cane Run Watershed Project Catchment Number	KWRRI TMDL Subwatershed Number(s)
1	K1, K2, U4
2	L6
3	L5, U8
4	L2, L3, L4
5	L1
6	U6
7	U7
8	U3, U5
9	U2
10	U1
--	K3

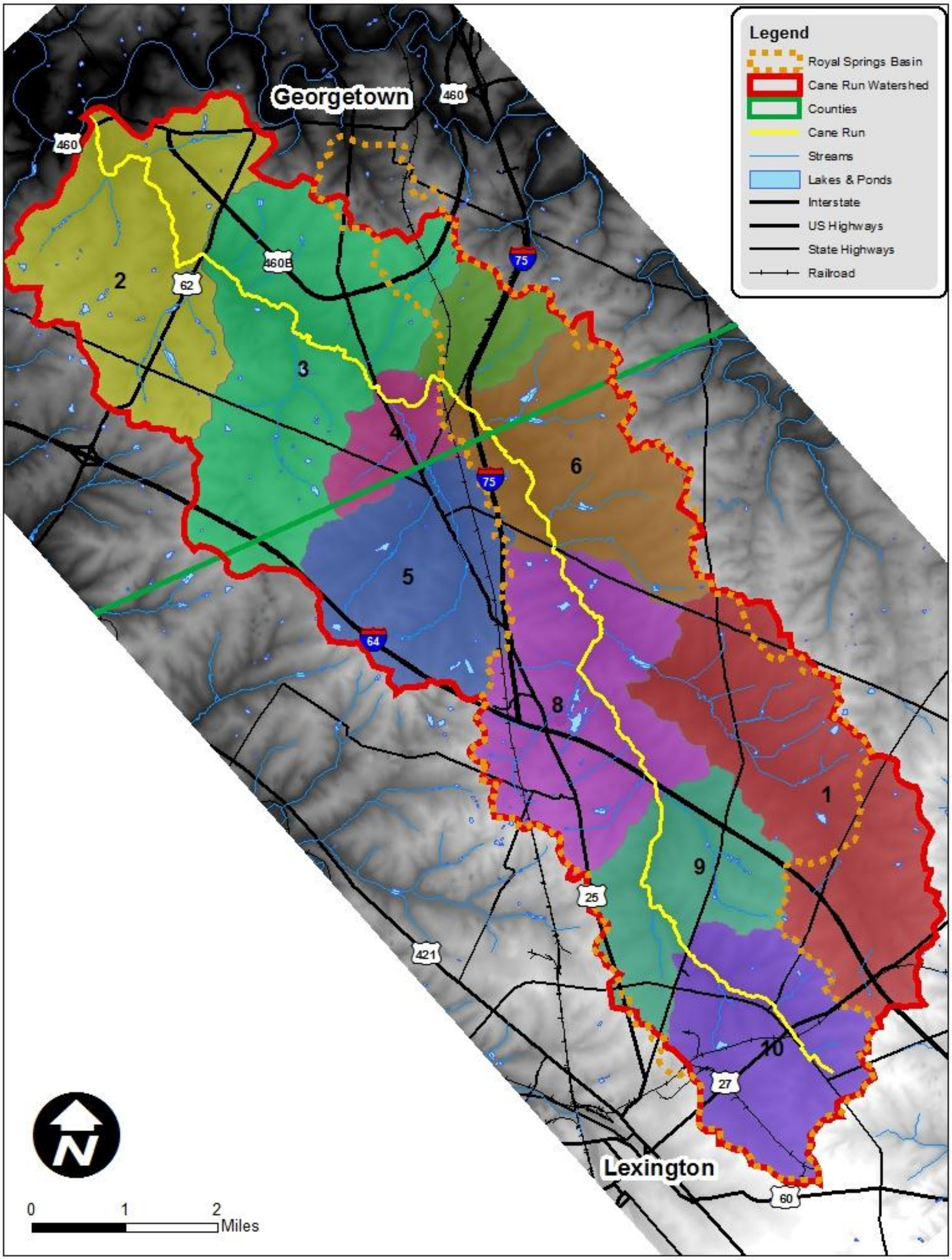

Figure 3. Cane Run Watershed Project catchments

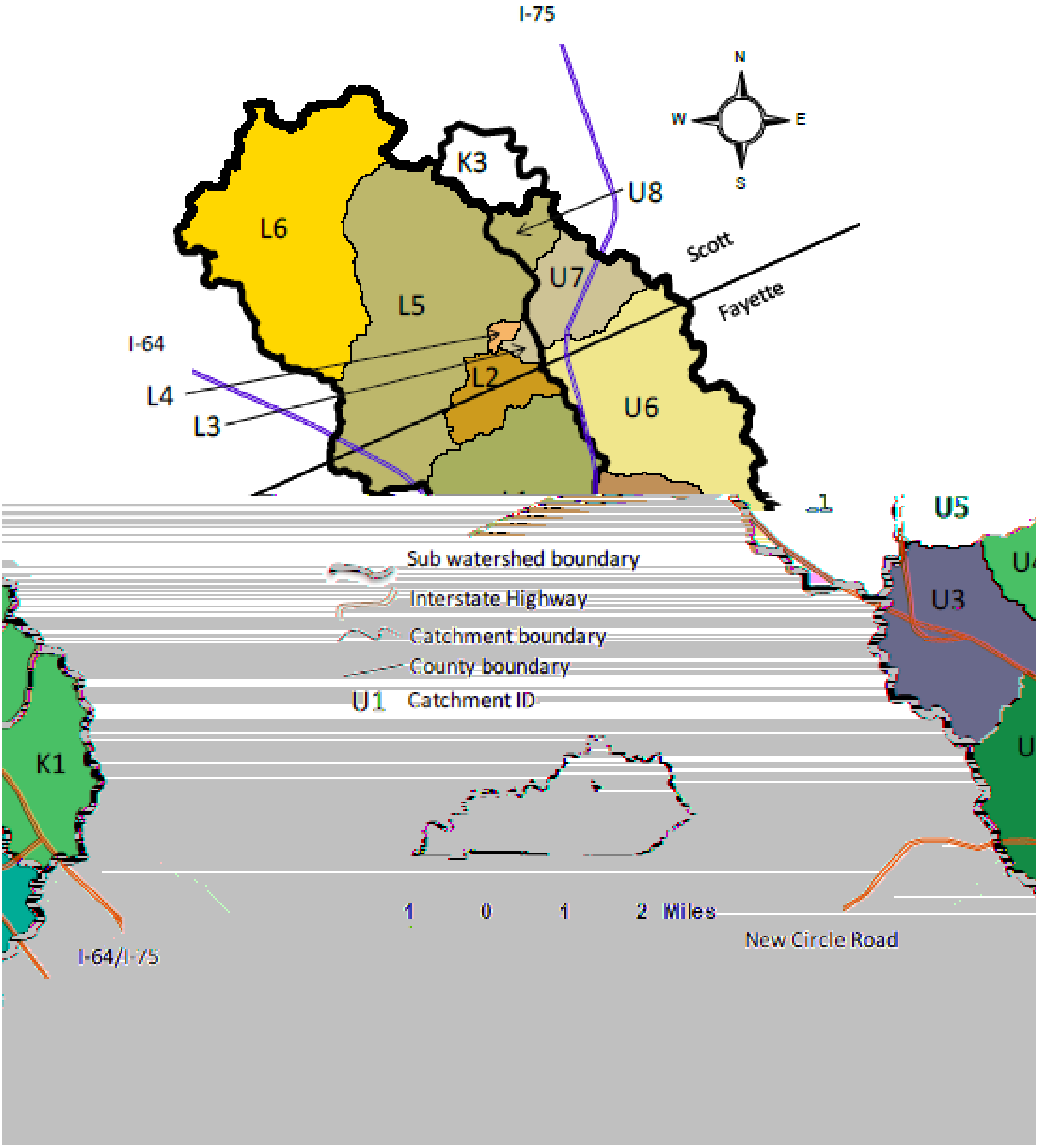

Figure 4. KWRRI catchments

Geology

The Cane Run Watershed is located within the Inner Bluegrass physiographic region. The area is underlain with the Lexington limestone formation of the Ordovician age. The Lexington formation is a thin-bedded shaley phosphatic limestone. The Tanglewood member is exposed in the largest area of the basin and is likely responsible for contributing phosphorus to ground water and surface water. Karst features such as sinkholes and springs dominate the geology. There are moderate amounts of shale and alluvium deposits in the region[1]. The relief of the Cane Run Watershed ranges from nearly level to gently rolling and undulating hills[2].

Figure 5. Typical karst conduits within the Cane Run

Large swallets, like the one shown in Figure 5, are present in portions of the watershed and drain the surface flow to the groundwater system. The Royal Spring groundwater basin (located near Georgetown, KY) and the upper Cane Run surface water basin overlap considerably. At baseflow conditions, a series of swallets within the stream channel of Cane Run divert all water to the Royal Spring. As a result, the gauging station at Cane Run near Bonerail (ID# 03288200) records no flow during these periods. Flow data is only available during high flow periods as surface runoff reaches the Cane Run.

[1]U.S. Department of Agriculture, 1978, Soil Survey for Fayette and Scott Counties.
[2] U.S. Department of Agriculture, 1978

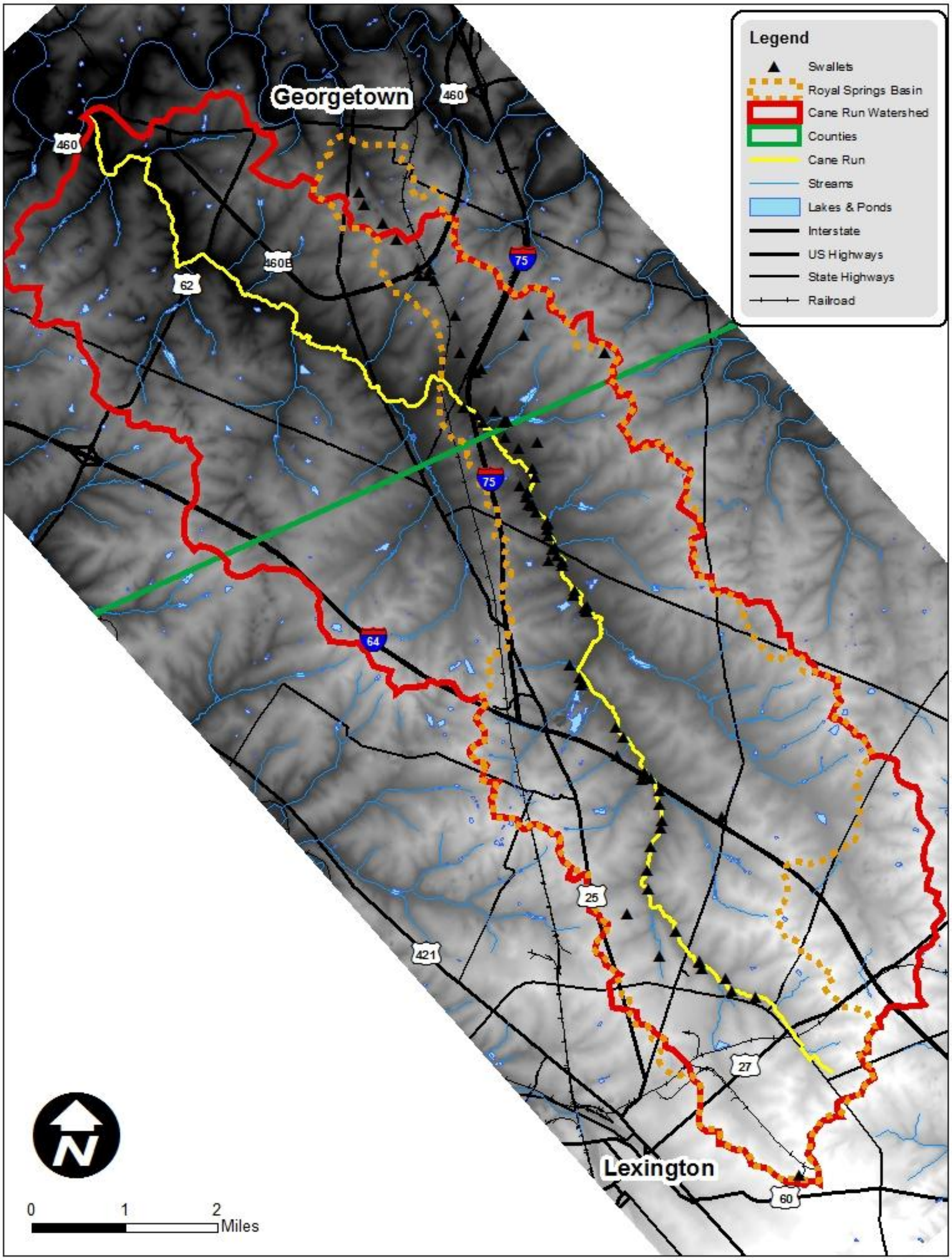

Figure 6. Known swallets within the Cane Run Watershed that divert to the Royal Spring

Geological Monitoring

The Kentucky Geological Survey (KGS) has conducted an extensive geophysical exploration, installed monitoring wells, conducted tracer studies, and delineated the ground water basin for major springs. Figure 6 shows the Cane Run surface water and Royal Springs ground water basins, as well as the swallets located in the Cane Run, as concluded by KGS, and the sections below detail the work completed so far.

Geophysical Exploration (2008-2010)

To help locate a main conduit that feeds Royal Spring, KGS used a variety of geophysical methods in three sites in Cane Run Watershed from the summer of 2008 through April, 2010. The three sites were the Kentucky Horse Park, University of Kentucky properties along Cane Run at Berea Road, and the University's North Farm. The methods employed at the Kentucky Horse Park were electrical resistivity, self-potential, microgravity, and Mise-a-la-masse whereas only electrical resistivity was used at the latter two sites. For more information about the KGS study at the Kentucky Horse Park, see Appendix A.

Monitoring Well Installation (2008-2010)

In so far as there are no known karst windows or other natural access points into the Royal Springs conduit, monitoring wells are essential to make observations of the groundwater in the Cane Run/Royal Spring watershed. The KGS strategy is to monitor the groundwater in the main stem of the Royal Spring karst system at three locations; the Kentucky Horse Park, state property east of and just off of Berea Road south of the surface channel of Cane Run, and the University of Kentucky North Research Farm. Two periods of drilling have taken place. The drilling in 2008 was conducted based on electrical resistivity (ER) surveys by Schnabel Engineering. Most of the holes drilled in 2010 were sited on ER anomalies along profiles conducted by Junfeng Zhu and other KGS staff with ER equipment acquired in 2009 by KGS and the College of Agriculture.

Table 2 summarizes the site location, number of holes drilled, their average depth and the total depth drilled for the three locations and two periods of drilling. A total of 3,316 ft. of hole have been drilled as follows: 1948 ft. at the Kentucky Horse Park, 913 ft. at the Berea Road site, and 455 ft. at the UK North Farm. Also shown below are maps of the three areas of investigation and a plan view of the wells near the conduit at the Kentucky Horse Park (Figure 7, Figure 8, and Figure 9). Wells 20, 23, 24, and 25 are into the conduit. Wells 1, 16, 17, and 19 are in the flanking anastigmatic conduits.

Table 2. Descriptive statistics for bore holes drilled by the KGS in the Cane Run Watershed

Numbers and Group	Date of Drilling	Average Depth, feet	Total Aggregated Depth, feet	Wells Plugged and abandoned	Wells completed	Wells instrumented with stage recorder, etc.
Ky. Horse Park Wells 1 through 7	June, 2008	78	548	6	1	1
Berea Road Wells 1 through 4	June, 2008	77.5	310	2	2	0
UK North Farm Wells 1 through 5	June, 2008	86	430	4	1	0
Ky. Horse Park Wells 8 through 25	June and July, 2010	78	1400	9	9	9
Berea Road Wells 5 through 12	July 2010	150	603	6	4	0
UK North Farm Well 6	July 2010	145	145	1	0	0

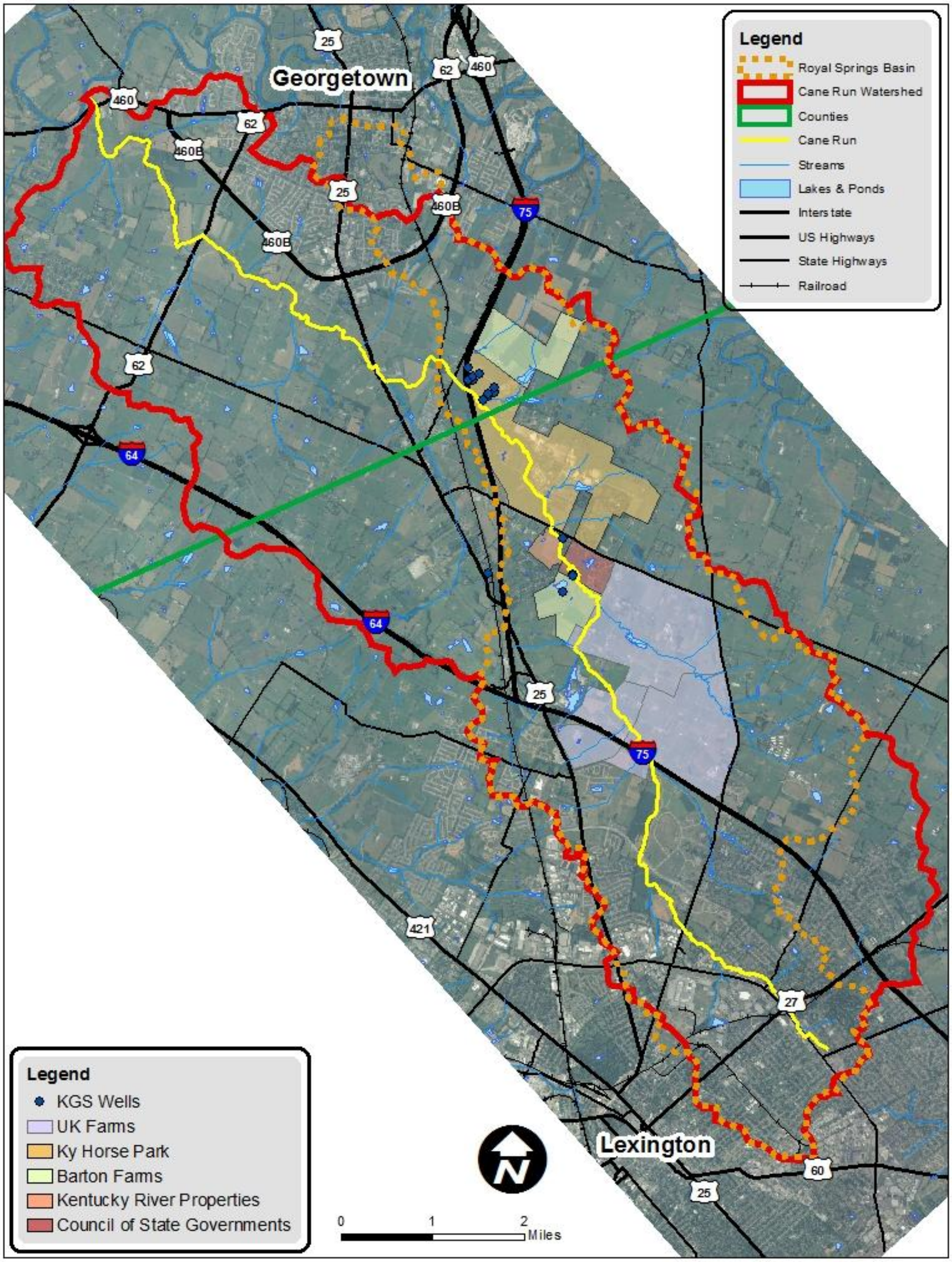

Figure 7. KGS investigative well locations

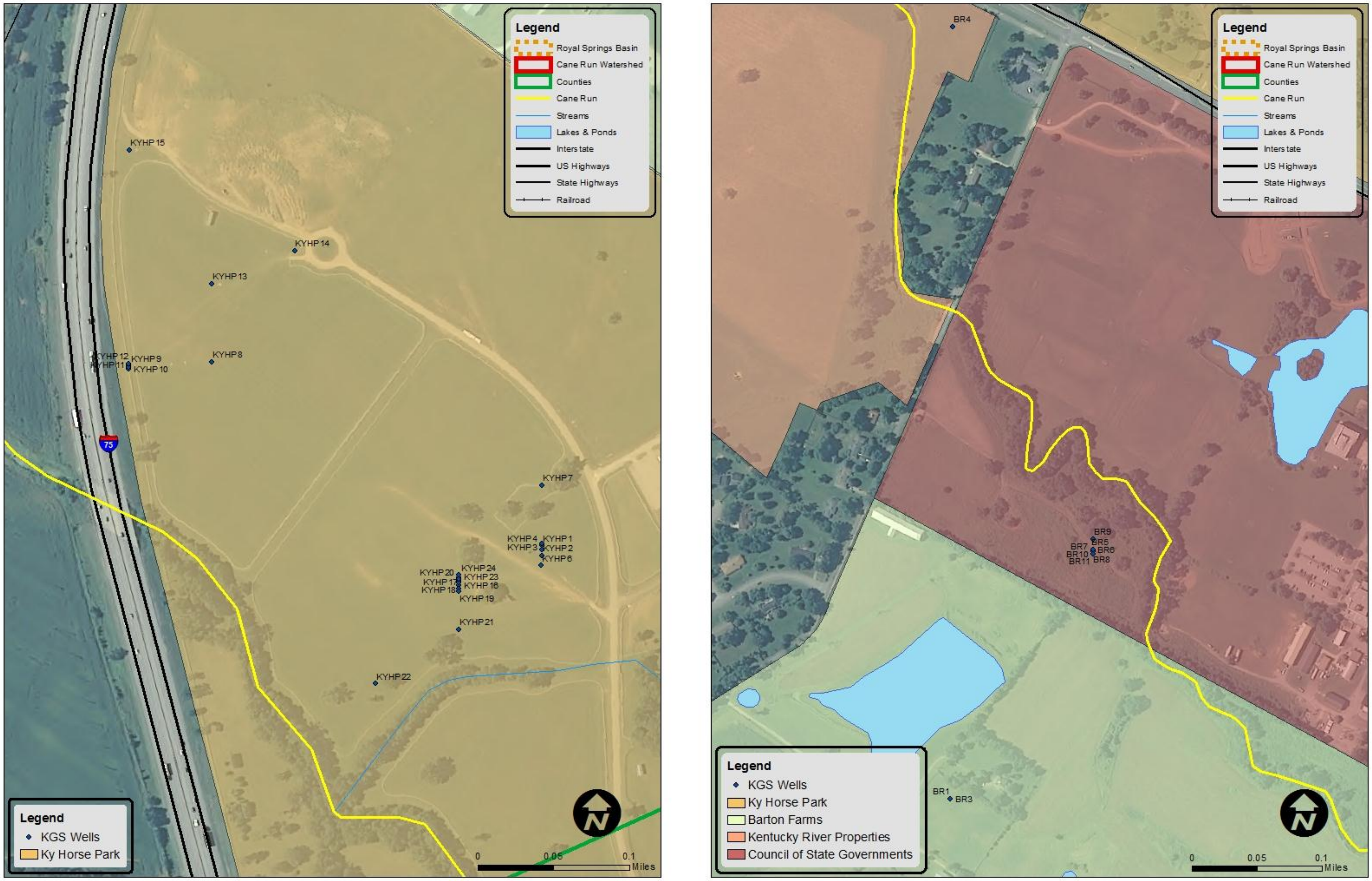

Figure 8. KGS wells at the Kentucky Horse Park and near Berea Road

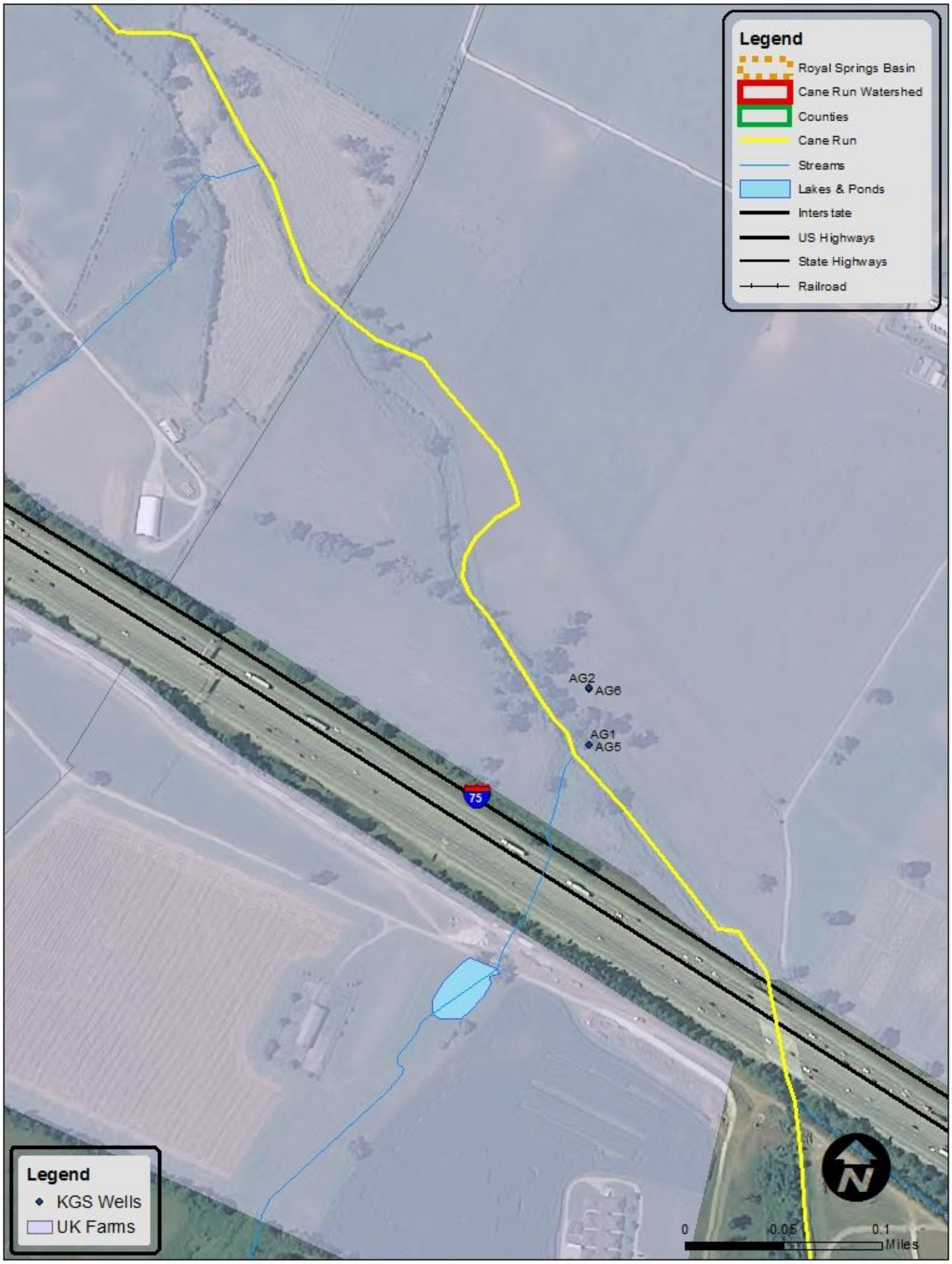

Figure 9. KGS wells at the University of Kentucky North Farm

The geophysical exploration that occurred over the two year period resulted in locating the conduit at the Kentucky Horse Park. Important observations that resulted in drilling the first monitoring well into the conduit included the ER analyses, groundwater elevations or lack of groundwater in numerous drilled exploration wells, groundwater stage fluctuation in monitoring Well 1 (drilled in 2008) as compared to other exploration wells, and dye tracing results. A karst conceptual model showing anastigmatic conduits flanking the main stem conduit in high-head circumstances was applied to these data to site the well that was completed in the open conduit.

In the summer of 2011, wells at the Kentucky Horse Park were extensively instrumented. Wells 1, 24, 17, 19, 22, and 21 contain stage or water level recorders which record the depth to the water every 10 minutes. Well number 23 was lined with a 4-inch diameter, schedule 80 PVC casing with the lower end perforated with ½-inch holes drilled on one inch centers around the circumference. This "basket" structure is to protect the delicate probes of the YSI Water Quality Sonde from debris moving through the cave with the flow. The casing was precisely positioned so that the perforated section is vertically spanning the cave opening. Well number 20 has a 12-volt submersible pump for water sampling. The pump is controlled by a timer that turns it on at 0700 and 1900 hours for ten minutes. The pump discharges into a ten gallon carboy from which an ISCO automatic sampler withdraws a water sample on the same schedule. Well number 25 was instrumented with a Marsch-McBirney flow velocity meter. This instrumenting will allow future monitoring of groundwater within the Cane Run Watershed.

Groundwater Tracing (2008-2010)

Groundwater tracing was used extensively to delineate the springshed of Royal Spring by researchers in the 1970's through 2005. Therefore, the more recent tracing conducted by KGS was directed toward specific details of the hydrogeology. For example, dye receptors were placed in several of the wells at the Horse Park to demonstrate that the main stem had been intersected. Twelve 12 traces have been conducted, including two that were designed to be detected by the ER equipment.

Soils

Level to strongly sloping silt loam and silty clay loam soils dominate the Cane Run Watershed. The area is comprised mostly of the Maury, McAfee, and Lowell soil series (Figure 10). The Maury series are deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately rapid. The McAfee soil series are moderately deep to deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately low. The Lowell series are deep, well drained to moderately drained soils formed from weathered interbedded limestone and calcareous shale. Permeability for this series is moderate to moderately low[3].

[3] U.S. Department of Agriculture, 1978.

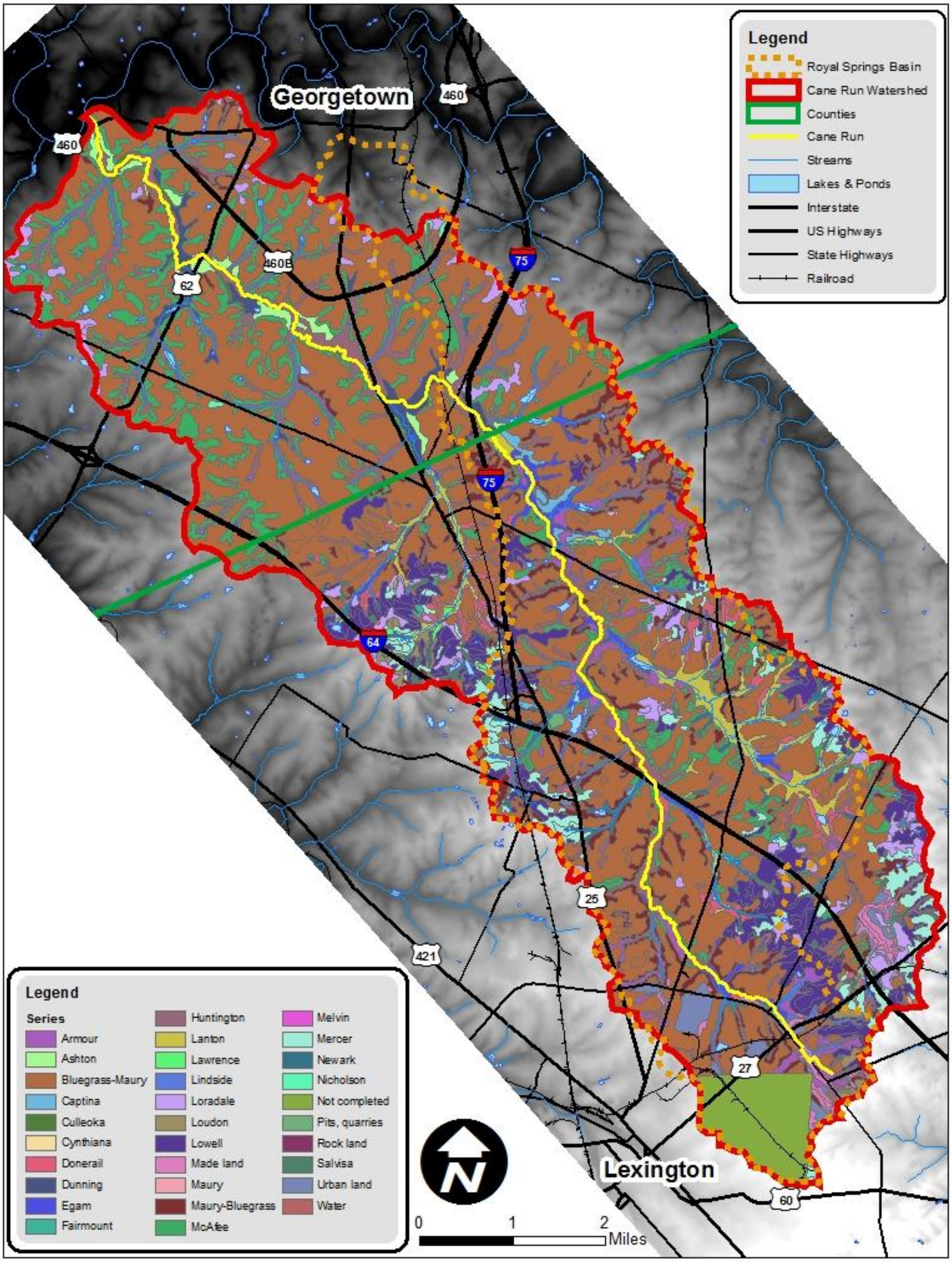

Figure 10. Cane Run soil series

Land Use

The land in the Cane Run Watershed, with its phosphorus rich soils, is conducive to agricultural use. Approximately 67% of the watershed consists of land in agricultural production, and about 29% of the watershed is developed (Figure 11). The developed area ranges from residential to commercial and industrial tracts, and much of this developed land is impervious, which leads to the entire watershed having approximately 10% impervious area (Figure 12). A detailed breakdown of the land use distribution for each catchment is provided in Table 3 and Table 4. These values were derived using the National Land Cover Data (NLCD) from 2001[4].

[4] U.S. Geological Survey. 2007. NLCD 2001 Land Cover. Sioux Falls, SD.

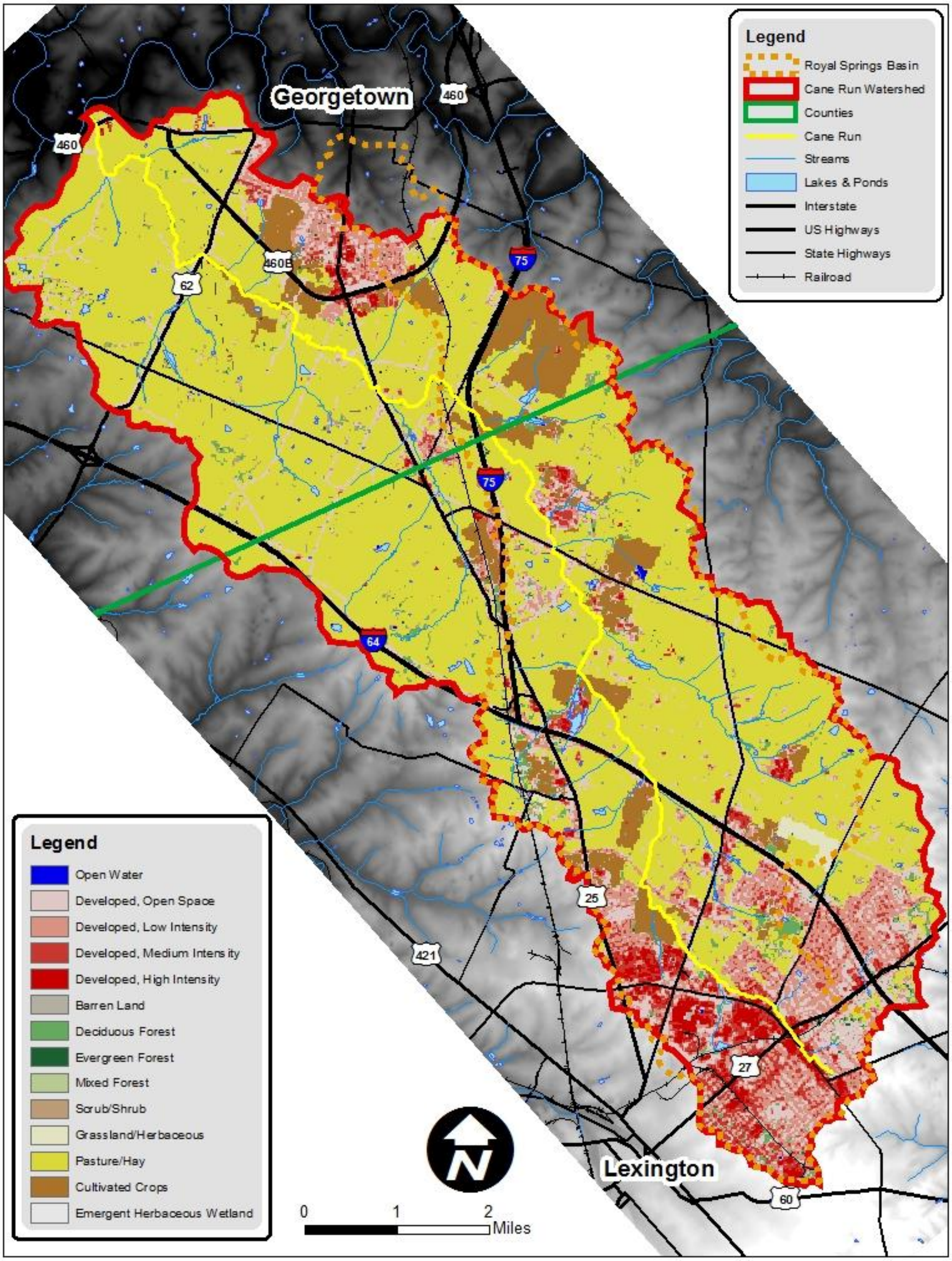

Figure 11. Land cover in the Cane Run Watershed

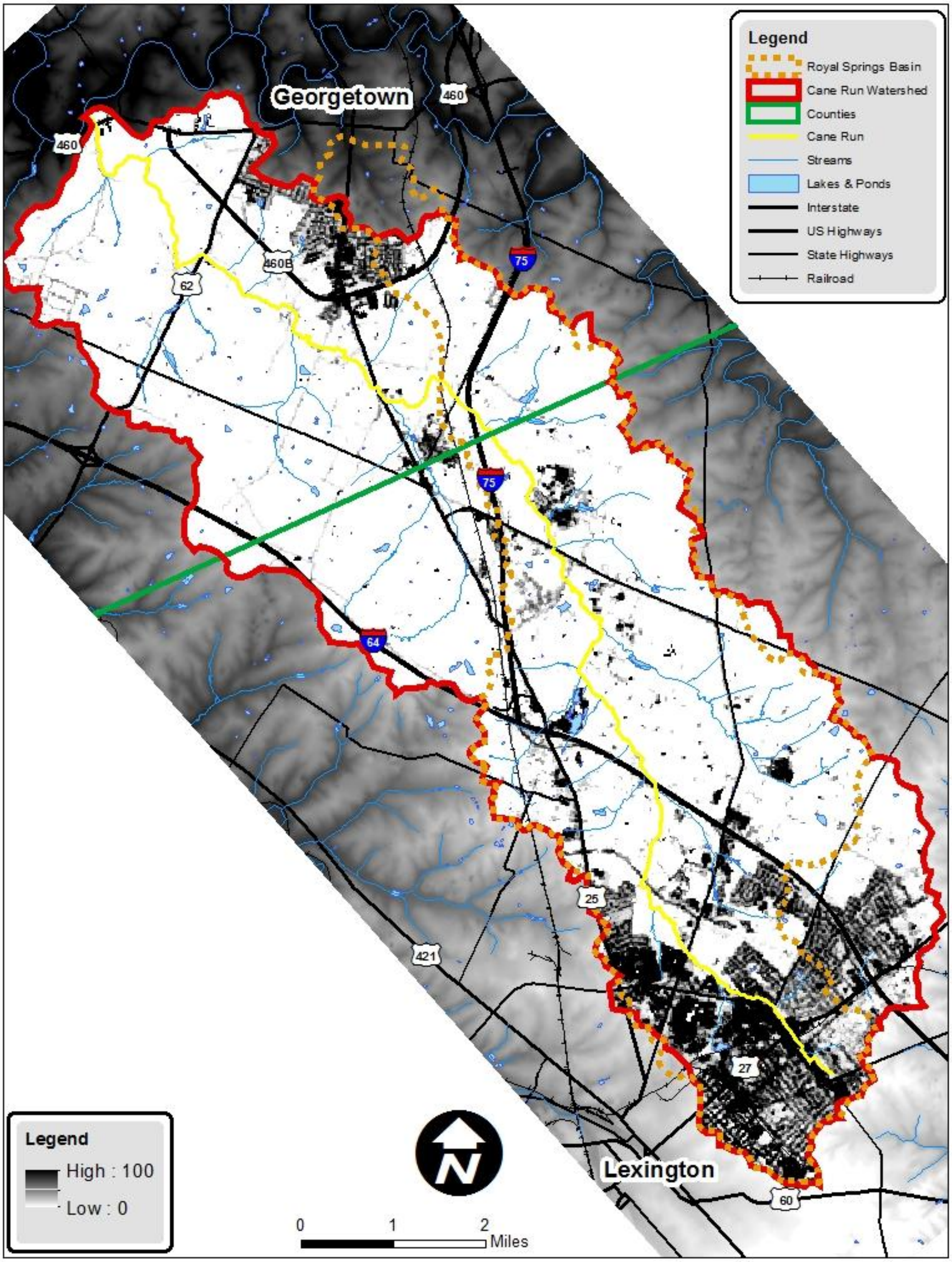

Figure 12. Percent impervious surface in the Cane Run Watershed and surrounding area

Table 3. Land cover in the Cane Run Watershed (acres)[5]

Catchment Number	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture/ Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
1	8.45	1260.75	0.22	116.53	42.25	94.52	2898.24	57.38	0.00	**4478**
2	11.34	483.04	1.11	60.05	28.91	0.00	3330.57	2.67	1.11	**3919**
3	5.12	1176.46	0.89	66.72	33.36	0.00	3133.75	400.98	0.89	**4818**
4	0.00	208.16	1.56	9.34	4.89	0.00	597.57	0.00	0.00	**822**
5	12.23	373.40	0.22	57.16	19.13	0.00	2065.37	94.52	0.44	**2622**
6	23.80	372.73	0.44	72.06	34.92	1.33	1925.93	541.97	1.78	**2975**
7	0.00	119.20	0.00	7.56	2.22	0.00	524.85	270.65	0.00	**924**
8	16.46	864.22	1.78	85.62	19.79	12.01	2213.71	442.79	0.44	**3657**
9	2.22	1191.36	1.11	41.14	11.79	1.33	741.91	212.61	0.22	**2204**
10	1.56	2342.70	5.34	94.30	15.57	1.33	203.49	10.45	1.33	**2676**
Total	**81**	**8392**	**13**	**610**	**213**	**111**	**17635**	**2034**	**6**	**29095**

[5] U.S. Geological Survey, 2007

Table 4. Land cover in the Cane Run Watershed (percent)[6]

Catchment Number	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture/ Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
1	0.19	28.15	0.00	2.60	0.94	2.11	64.72	1.28	0.00	**100**
2	0.29	12.33	0.03	1.53	0.74	84.99	84.99	0.07	0.03	**100**
3	0.11	24.42	0.02	1.38	0.69	0.00	65.04	8.32	0.02	**100**
4	0	25.34	0.19	1.14	0.60	0.00	72.74	0.00	0.00	**100**
5	0.47	14.24	0.01	2.18	0.73	0.00	78.76	3.60	0.02	**100**
6	0.80	12.53	0.01	2.42	1.17	0.04	64.74	18.22	0.06	**100**
7	0.00	12.89	0.00	0.82	0.24	0.00	56.77	29.28	0.00	**100**
8	0.45	23.63	0.05	2.34	0.54	0.33	60.54	12.11	0.01	**100**
9	0.10	54.06	0.05	1.87	0.53	0.06	33.67	9.65	0.01	**100**
10	0.06	87.54	0.20	3.52	0.58	0.05	7.60	0.39	0.05	**100**
Total	**0.27**	**29.38**	**0.04**	**2.18**	**0.74**	**0.35**	**60.33**	**6.69**	**0.03**	**100**

[6] U.S. Geological Survey, 2007

Stakeholders

The Cane Run Watershed has a unique group of stakeholders (Figure 13). The upper reaches of the watershed begin on the northern edge of Lexington, which makes the Lexington-Fayette Urban County Government (LFUCG) a key stakeholder in the improvement of water quality within the watershed. The United States Environmental Protection Agency (USEPA), Kentucky Division of Water (KDOW), and LFUCG have finalized a Consent Decree that will require LFUCG to remediate existing stormwater and sanitary sewer deficiencies and enhance the quality of the surface and ground water that exits the city. LFUCG also controls a portion of the UK Coldstream Research Park where streamside management can be incorporated (the University of Kentucky (UK) farms and maintains the rest of the research park). Former LFUCG mayoral administrations have shown support for these initiatives, and the timeliness and effectiveness of the newly elected LFUCG mayoral administration's response to this Consent Decree will be a key to the success of this WBP. The finalized Consent Decree can be found in Appendix B.

Another key stakeholder in the Cane Run Watershed is Lexmark International, which owns a significant portion of land on the northern urban fringe of Lexington at the junction of a large tributary to the Cane Run. Lexmark is an active participant on the Cane Run Watershed Project team and continues to work to improve the quality of water that flows out of their property.

The Cane Run also flows through the University of Kentucky's Agricultural Experiment Station, which is the largest single landowner in the watershed. This makes the University of Kentucky another major stakeholder in the success of this project. University administrators have agreed to make the Experiment Station a working model of BMPs for streams, which will directly improve water quality and serve as an example for nearby producers, which could encourage a more broad application of water quality BMPs.

The second largest landowner in the Cane Run Watershed is the Kentucky Horse Park, whose managers worked with the Cane Run Watershed Project to protect water quality in preparation for the FEI World Equestrian Games and continue to work to protect water quality on their property after the WEG.

Other large landowners in the watershed include Marriott Griffin Gate Resort, Barton Brothers Farms, Kentucky River Properties, and Vulcan Materials. Georgetown Water Supply has also been very vocal in their support for the restoration efforts.

Because of the differences between and within the urban and rural landscapes, the karstic linkage between surface water and groundwater, and the diversity of landowners within the watershed, a significant level of coordination between stakeholders and watershed managers and planners will be necessary to identify and implement BMPs on a watershed scale.

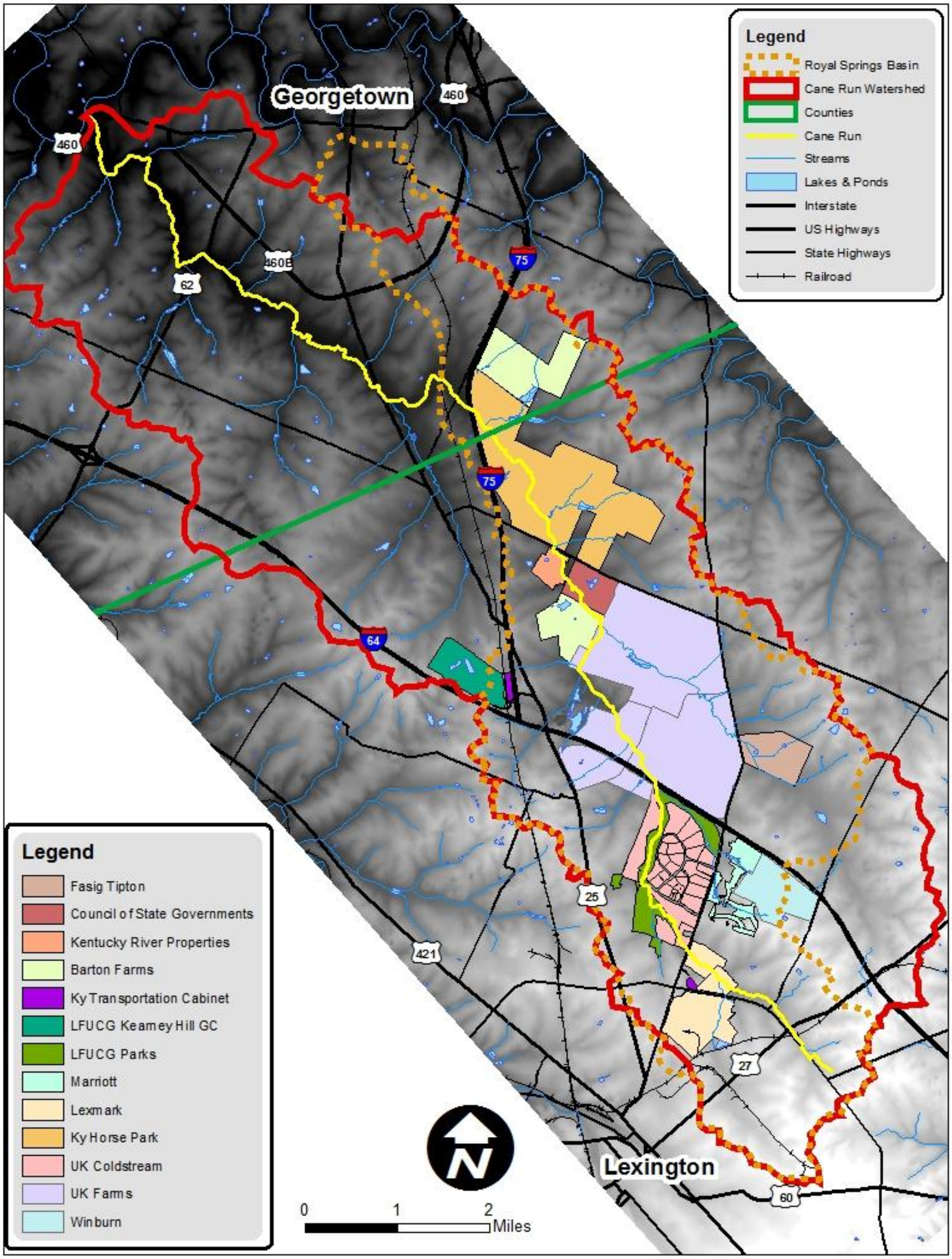

Figure 13. Cane Run cooperators

V. Watershed Condition

KDOW 303(d) Listing

Beginning in 1998, a portion of the Cane Run in Fayette County was classified on the Kentucky Division of Water's 303(d) list of impaired waters. The listed causes for impairment at the time included organic enrichment, low dissolved oxygen, and bacteria coming from urban runoff and storm sewers[7]. By 2010, all 17.4 miles of the Cane Run had been listed on the 303(d) list. In addition, three unnamed tributaries of Cane Run, which total 4.5 miles in Fayette County and 3.5 miles in Scott County, and the Royal Spring itself, which totals 0.7 miles in Scott County have been added to the 303(d) list[8]. Table 5 details the pollutants and their suspected sources for all impaired stream sections within the Cane Run Watershed, and Figure 14 maps these stream sections.

[7] Kentucky Division of Water. 1998 Kentucky Report to Congress on Water Quality: Rivers and Streams.
[8] Kentucky Division of Water. 2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky.

Table 5. Cane Run sections and tributaries listed on the KDOW 303(d) impaired list[9]

Stream Name	County	River Miles	Impaired Uses	Pollutant	Suspected Sources
Cane Run 0.0 to 3.0	Scott	3.0	Warm Water Aquatic Habitat (Nonsupport); Primary Contact Recreation Water (Nonsupport); Secondary Contact Recreation Water (Partial Support)	Fecal Coliform; Nutrient/ Eutrophication Biological Indicators; Sedimentation/Siltation	Livestock (Grazing or Feeding Operations); Managed Pasture Grazing; Non-irrigated Crop Production; Package Plant or Other Permitted Small Flows Discharges; Unspecified Urban Stormwater
Cane Run 3.0 to 9.6	Scott	6.6	Warm Water Aquatic Habitat (Nonsupport); Primary Contact Recreation Water (Nonsupport)	Fecal Coliform; Nutrient/ Eutrophication Biological Indicators; Specific Conductance	Highways, Roads, Bridges, Infrastructure (New Construction); Landfills, Livestock (Grazing or Feeding Operations); Package Plant or Other Permitted Small Flows Discharges
Cane Run 9.6 to 17.4	Fayette	7.8	Warm Water Aquatic Habitat (Nonsupport); Primary Contact Recreation Water (Nonsupport); Secondary Contact Recreation Water (Nonsupport)	Fecal Coliform; Nutrient/ Eutrophication Biological Indicators; Organic Enrichment (Sewage) Biological Indicators	Livestock (Grazing or Feeding Operations); Unspecified Urban Stormwater

[9] Kentucky Division of Water. 2010

Stream Name	County	River Miles	Impaired Uses	Pollutant	Suspected Sources
Unnamed Tributary of Cane Run at mile 6.13	Scott	3.5	Warm Water Aquatic Habitat (Nonsupport); Primary Contact Recreation Water (Nonsupport)	Fecal Coliform; Nitrogen (Total); Phosphorus (Total)	Livestock (Grazing or Feeding Operations); Managed Pasture Grazing; Non-irrigated Crop Production; Package Plant or Other Permitted Small Flows Discharges
Unnamed Tributary of Cane Run at mile 10.8	Fayette	2.4	Warm Water Aquatic Habitat (Nonsupport)	Nitrogen (Total); Phosphorus (Total)	Managed Pasture Grazing; Non-irrigated Crop Production
Unnamed Tributary of Cane Run at mile 12.9	Fayette	2.1	Warm Water Aquatic Habitat (Nonsupport)	Phosphorus (Total)	Managed Pasture Grazing; Non-irrigated Crop Production; Unspecified Urban Stormwater
Royal Spring into North Elkhorn Cr.	Scott	0.7	Warm Water Aquatic Habitat (Nonsupport)	Nitrogen (Total); Phosphorus (Total)	Managed Pasture Grazing; Non-irrigated Crop Production; Unspecified Urban Stormwater

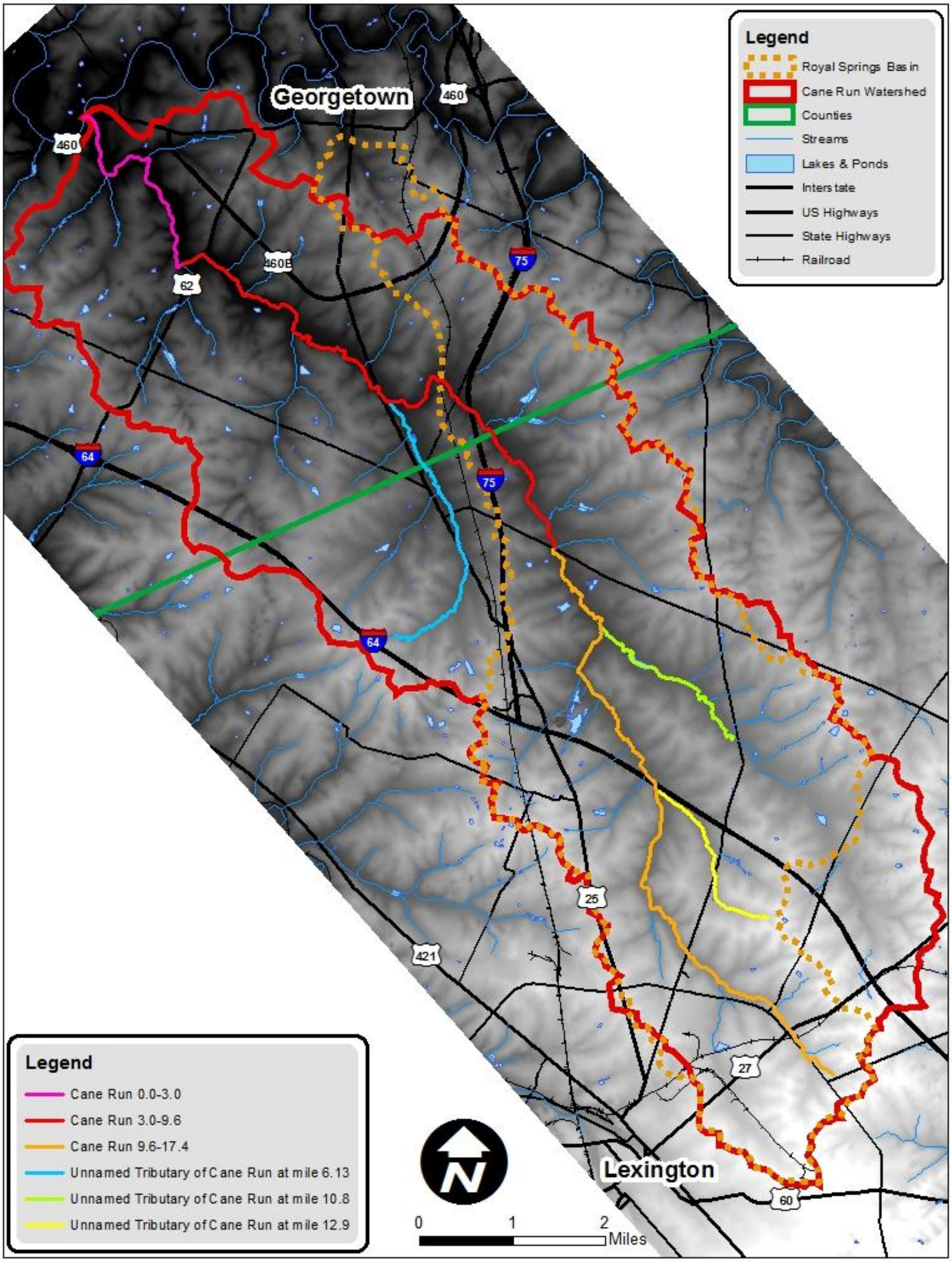

Figure 14. Stream segments within the Cane Run Watershed listed by KDOW as impaired

Water Quality Monitoring

Geomorphic and water quality data acquisition in the watershed can be used to quantify the sources of pollutants entering the stream and document the improvements in stream quality as BMPs are implemented. The Cane Run has been the focus of sampling and monitoring since the late 1960's. Several different entities have monitored water quality in the Cane Run in these years, and the basic results of these various studies as they apply to the entire watershed are included in this section. Figure 15 illustrates the locations of these monitoring points throughout the watershed. A catchment-by-catchment analysis of select monitoring data can be found in Chapter VIII.

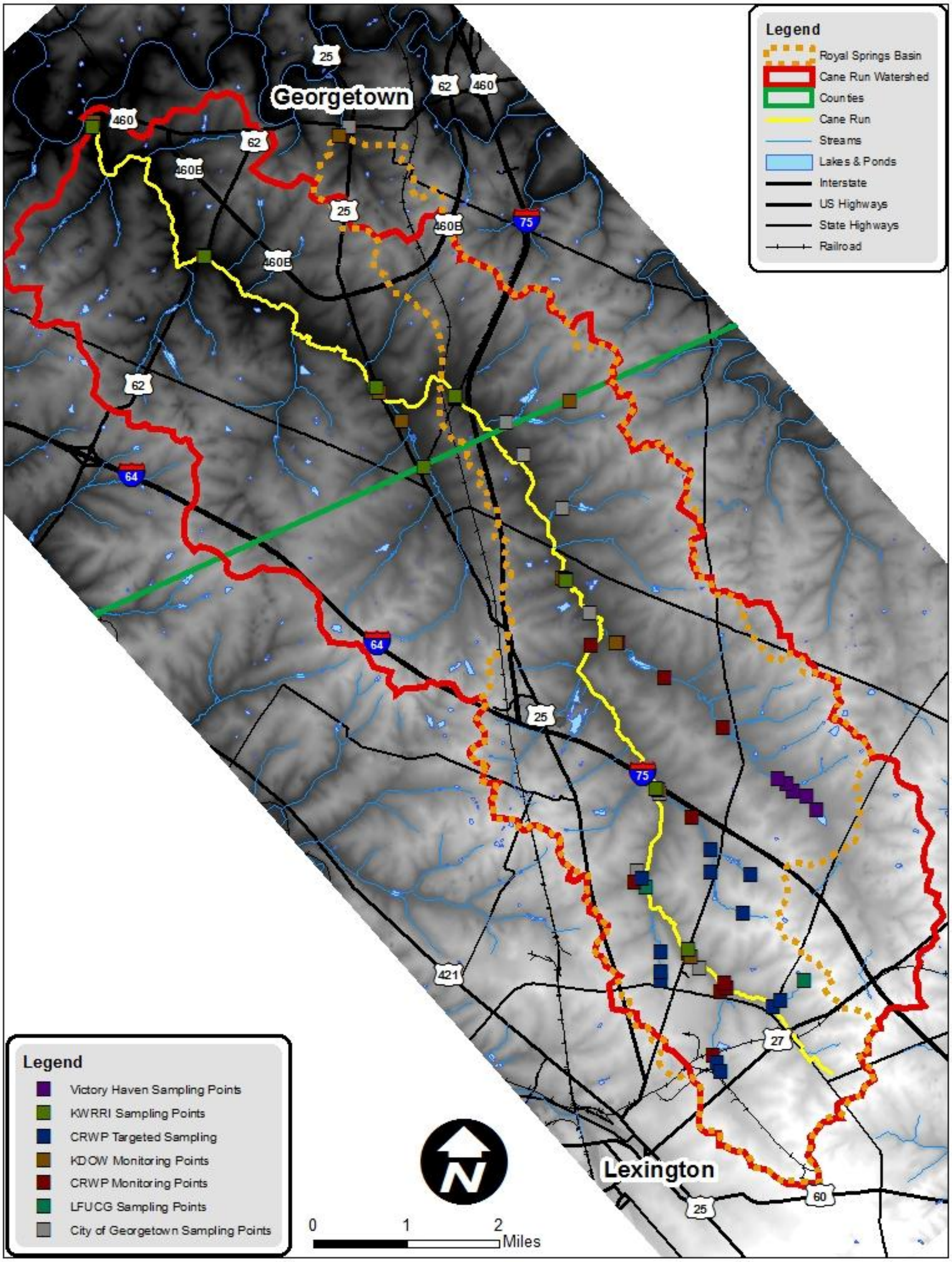

Figure 15. Cane Run monitoring points

LFUCG

Lexington-Fayette Urban County Government has been performing bacteria sampling in Cane Run in support of its KPDES Stormwater Permit since 1993. LFUCG's sampling network includes 5 monitoring stations that are located within the Cane Run Watershed (Table 6 and Figure 16). As demonstrated in Table 6, significant fecal coliform contamination exists throughout the watershed. A comprehensive set of data collected by LFUCG can be found in Appendix C.

Table 6. LFUCG monitoring stations and fecal coliform data

Station ID	Station Description	Sampling Dates	Fecal Geometric Mean Cfu/100 ml
CR-L1	Nandino Blvd	Dec-01 to Apr 02	4,240
CR-L2	Silver Lane	Nov-01 to Dec-01	2,711
CR-S1	Lexmark	May-96 to Jun-02	5,755
CR-S2	Cold Stream Farm	May-96 to Oct-96	36,037
CR-S3	US-25	May-98 to Nov-03	629

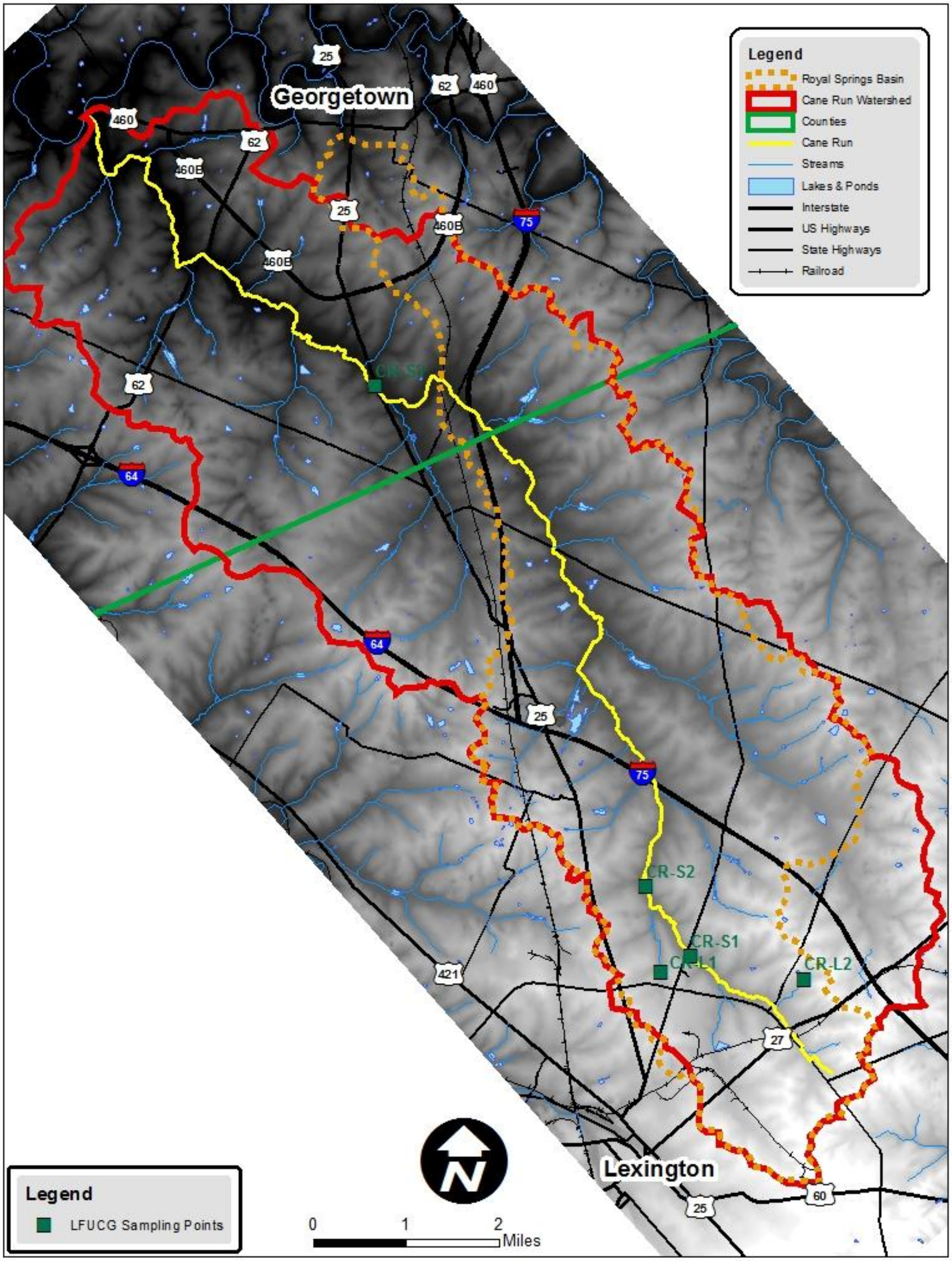

Figure 16. LFUCG sampling points

Georgetown Municipal Water Company

Georgetown Municipal Water Company has also collected fecal coliform data at Royal Spring, which shows levels that exceed Kentucky's water quality standard of 200 cfu/mL (Table 7). A comprehensive set of data collected by Georgetown Municipal Water Company can be found in Appendix D.

Table 7. Georgetown Municipal Water Company sampling data

Year	Annual Fecal Coliform Geomean (cfu/100mL)
2002	237
2003	468
2004	No data
2005	75

KWRRI

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources (Table 8 and Figure 17). Consistent with the 303(d) listing, this monitoring found that Cane Run fails to meet the designated use criteria for primary recreational contact because geometric means of fecal coliform must be less than 200 cfu/ml (Figure 18). A Quality Assurance Plan for this sampling can be found in Appendix E, and the comprehensive set of data collected by KWRRI can be found in Appendix F.

Table 8. UK-KWRRI water quality monitoring stations

Station ID	Creek	Stream Mile	Description
C6	Cane Run	0.0	Paynes Depot Road
C7	Cane Run	2.9	Frankfort Road
C5	Cane Run	5.8	Lexington Road
C4	Cane Run	6.9	Lisle Road
C3	Cane Run	7.2	Lisle Road at Cane Run Bridge
C2	Cane Run	9.5	Berea Road
C1	Cane Run	12.9	I-75 bridge across Cane Run
C0	Cane Run	14.9	Newtown Pike Road

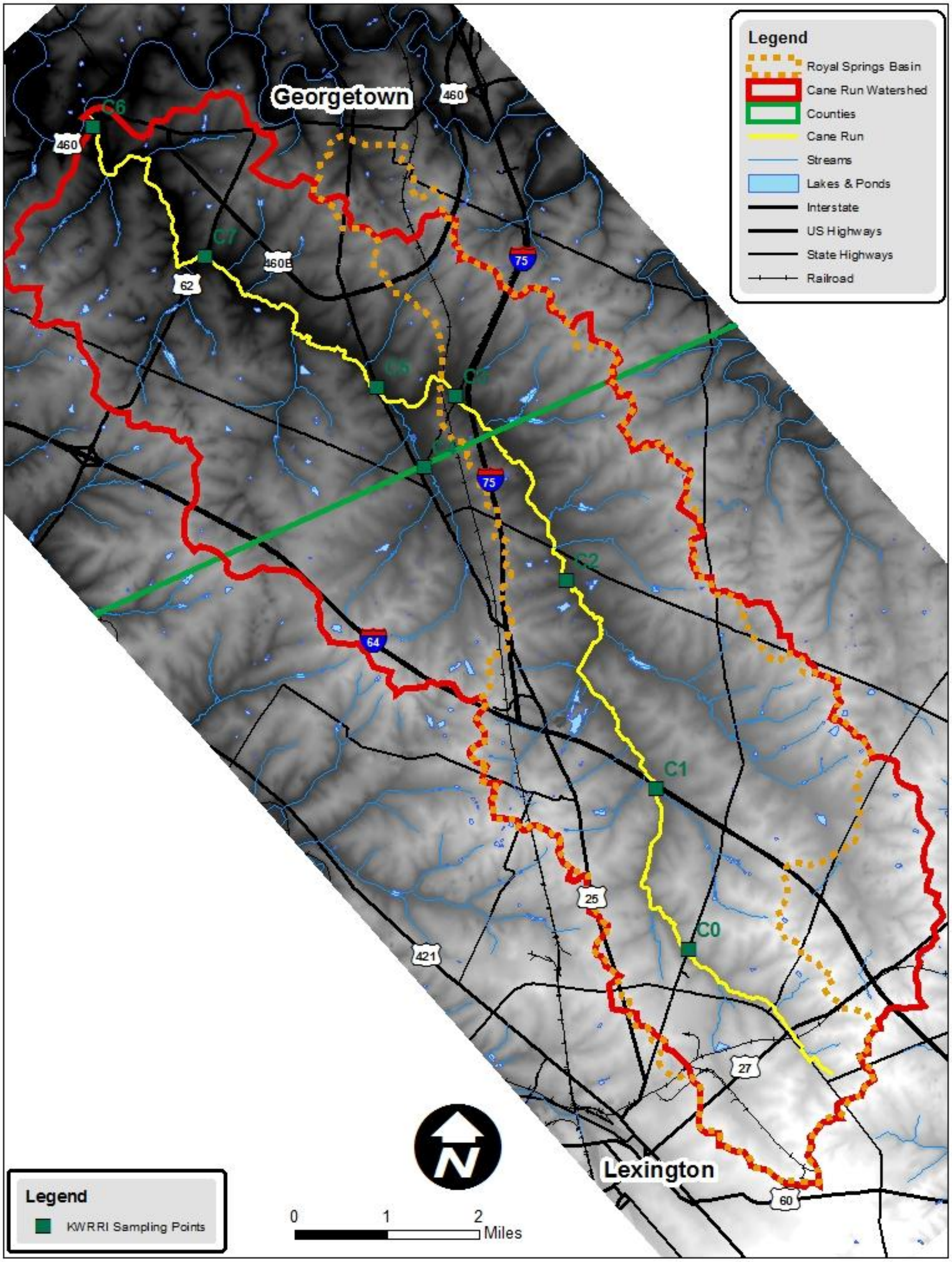

Figure 17. KWRRI Cane Run sampling sites

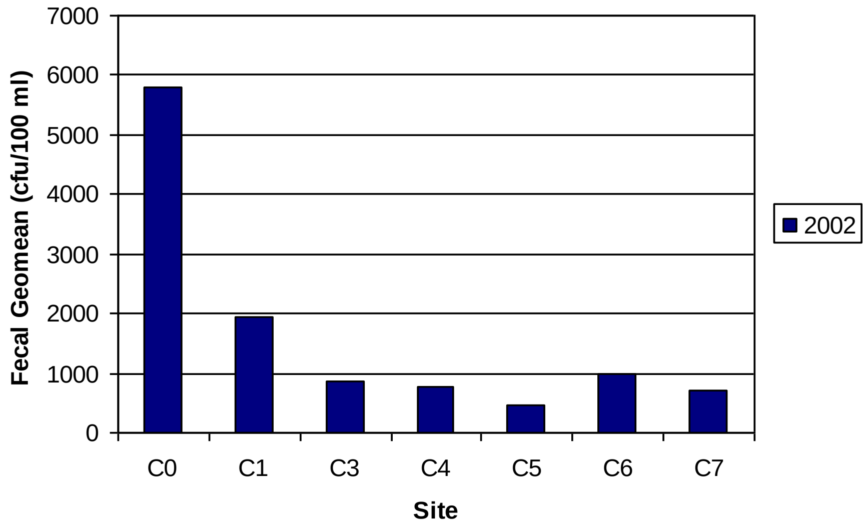

Figure 18. Fecal coliform levels for the Cane Run; collected by KWRRI in 2002

City of Georgetown

The spring system that serves as the water source for the city of Georgetown is under the influence of multiple sources of fecal pollution. Of these sources, inputs of domestic sewage containing human fecal material can introduce large numbers of potential human bacteria, particularly enteric viruses. To protect the people served by the Georgetown water system, it is imperative that sources of human fecal material be identified, and their impact upon the spring quantified, so that remediation and watershed management plans can be created.

In 2005, the city of Georgetown contracted with Dr. Gail Brion at the University of Kentucky to conduct a study within the Cane Run Watershed in an attempt to identify and rank potential sources of sewage contamination into the Royal Springs water supply. This study involved weekly testing of surface water quality near known swallets for indicators of fecal load (*E. coli*), fecal source (F+ phage), and fecal age (AC/TC ratio) and provided valuable information that can be used to identify potential hot-spots of contamination within the watershed.

Eight sampling sites feeding into the spring were selected for weekly sampling during the period of March 2, 2005 to May 11, 2005. Sites were selected in consultation with Georgetown Water officials and Jim Currens and Randy Paylor of the Kentucky Geological Survey. These sites were selected for their accessibility and to enumerate the microbiological impacts of agricultural practices and suburban development on water quality in the spring system. Table 9 and Figure 19 give more information about these sample sites.

Based on an analysis of the results, the study concluded that: 1) Of the sites sampled, Highland Springs and IBM are strongly suspected of inputting untreated human sewage into the water supply for Georgetown, and 2) There is as of yet a large, undiscovered source of human sewage in the spring system. This sewage is important because sewage can be a significant source of phosphorus loading. Further study is required to identify this source, or these sources, so that a remediation plan can be developed. For more information about the methods and results, as well as the complete set of data, see the Report to the City of Georgetown: Water Quality Analysis Project 2005 in Appendix G.

Table 9. City of Georgetown sampling point descriptions

Site Name	Description
Highland Springs	A small creek that flows past an older subdivision north of the city of Lexington and into a swallet
IBM	A medium-sized creek that has signs posted warning of potential human sewage contamination in urban Lexington
Barton Springs	An agriculturally-impacted stream that disappears into a large swallet found on the property of the Horse Park near a large manure pile
Newtown Exchange	A confluence of two streams influenced by urban runoff that flows under a bridge and disappears into a swallet
Spindletop	A stream with swallets in the creek bottom located behind the UK asphalt research facility and beside a pressurized sewer main impacted by a variety of land uses
Pristine Spring	A very small spring-swallet combination on the Horse Park property that collects drainage from a flat agricultural pasture that quickly disappears into a swallet a few feet away
Georgetown WTP	Inlet water from the spring coming into the water treatment plant
Retention Pond	A water feature at the entrance to the Horse Park

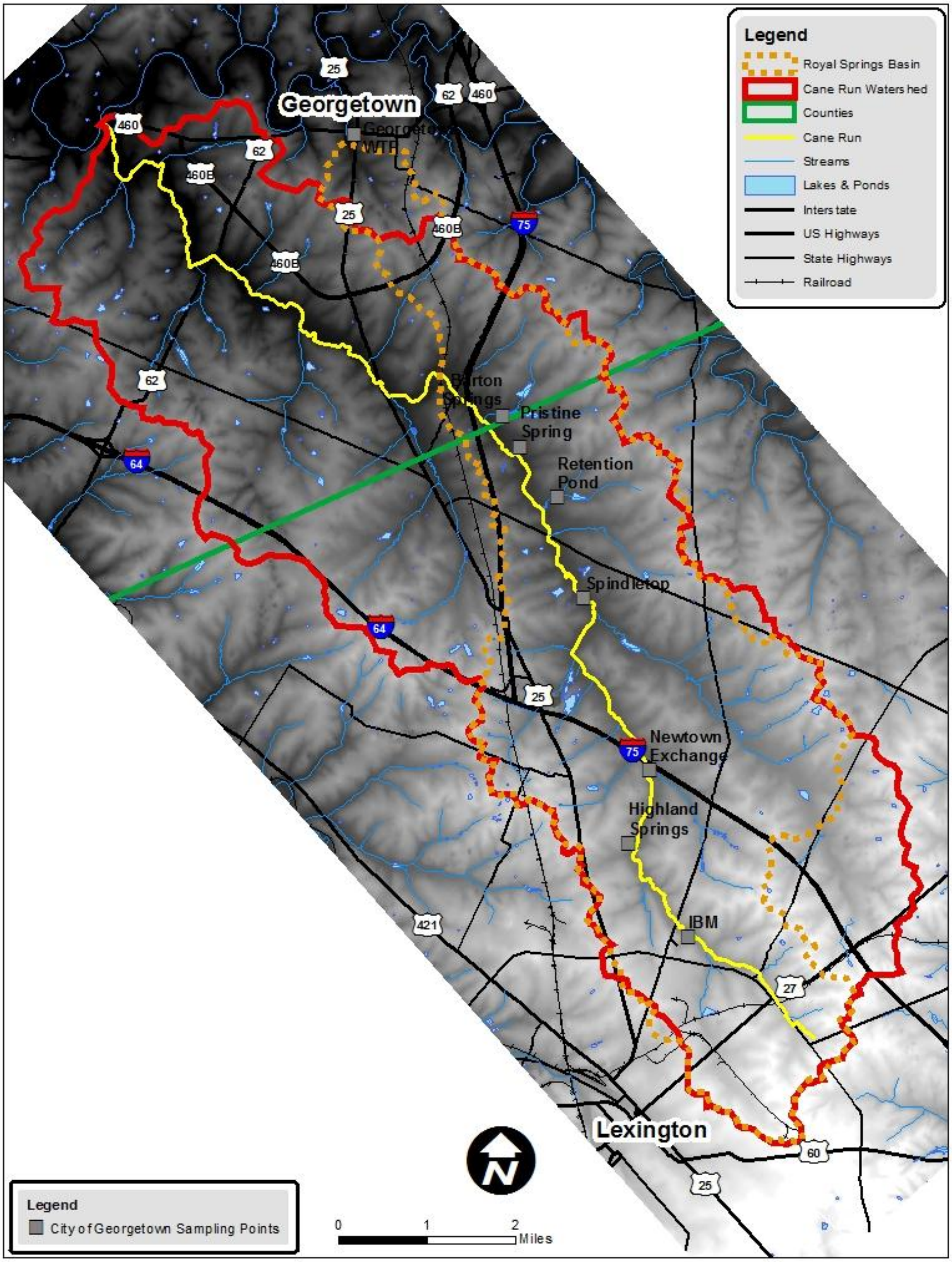

Figure 19. City of Georgetown sampling points

KDOW

Water samples were taken at stations along the Cane Run and Royal Spring from November 8, 2006 to October 4, 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development. Aquatic habitat and benthic sampling was also conducted. The QAPP for this sampling can be found in Appendix H and the monitoring plan in Appendix I. Sampling locations were selected for the impaired streams based on KWRRI's 2002 bacteria monitoring locations. Additional sites were determined by assessing the watershed's accessibility, drainage area, hydrologic changes, and land use. All of the sites and corresponding descriptions can be found in Table 10 and are mapped in Figure 20. The comprehensive set of data collected by KDOW can be found in Appendices J, K, L, and M.

The Cane Run Nutrient TMDL focuses on phosphorus as the limiting nutrient, and the data shows that for 46% of all samples at all sites, phosphorus values in Cane Run and its tributaries exceed the target of 0.3 mg/L set forth by the Kentucky Division of Water (Table 11 and Figure 21).

KDOW also took basic water chemistry measurements in the Cane Run and found that the dissolved oxygen (DO) throughout the watershed was well above the 5.0 minimum set by the Kentucky Division of Water for warm water aquatic habitat (Table 12). KDOW also found that the pH of the streams throughout the watershed was consistently between 6.0 and 9.0, the range set by KDOW for warm water aquatic habitat (Table 12); however, the KDOW sampling found that aquatic habitat across the watershed is generally poor, and the Macroinvertebrate Bioassessment Index (MBI), an index of biotic integrity, also ranked fair or poor throughout the watershed (Table 13 and Table 14).

Table 10. KDOW monitoring points

Station ID	Stream Name	Location	River Mile	Stream Order	Catchment Area	County	Parameters
DOW04018001	CANE RUN	OFF SR 62	3	3	39.44	SCOTT	Nutrients, Benthics, Habitat, Chemistry
DOW04018002	CANE RUN	At US460 bridge	0.17	3	45.36	SCOTT	Nutrients, Benthics, Habitat, Chemistry
DOW04018003	CANE RUN	At Landscape Alternatives nursery bridge off US25; above US25 bridge	5.8	3	31.78	SCOTT	Chemistry
DOW04018004	CANE RUN UT	Off field off of US25	0.1	2	5.1	SCOTT	Nutrients, Benthics, Habitat, Chemistry, Diatoms
DOW04018005	CANE RUN	At Lisle Rd. (SR1963) bridge	6.9	3	24.93	SCOTT	Chemistry
DOW04018006	CANE RUN	At Berea Rd. bridge	9.5	3	19.84	FAYETTE	Chemistry
DOW04018007	CANE RUN UT	At UK Ag Research Farm road bridge	0.2	2	7.35	FAYETTE	Nutrients, Benthics, Habitat, Chemistry
DOW04018009	CANE RUN	Below Newtown Pike bridge; off Lexmark road	14.9	3	4.09	FAYETTE	Nutrients, Habitat, Chemistry, Diatoms
DOW04018010	CANE RUN UT	Below bridge at UK ag research farm; 0.05 mi. above mouth	0.05	2	1.48	FAYETTE	Nutrients, Benthics, Habitat, Chemistry
DOW04018011	CANE RUN UT	Below Berea Rd. bridge; ~0.05 mi. above confluence with Cane Run	0.05	1	0.2	FAYETTE	Chemistry
DOW04018012	CANE RUN	~0.05 mi above UT Cane Run; behind church building	6.2	3	26.6	FAYETTE	Nutrients, Habitat, Chemistry
DOW04018013	CANE RUN	Royal Springs at Georgetown Water Plant; Spring actually flows into N. Elkhorn, but its catchment is entirely from Cane Run	0.6	1	23.4	SCOTT	Nutrients, Chemistry

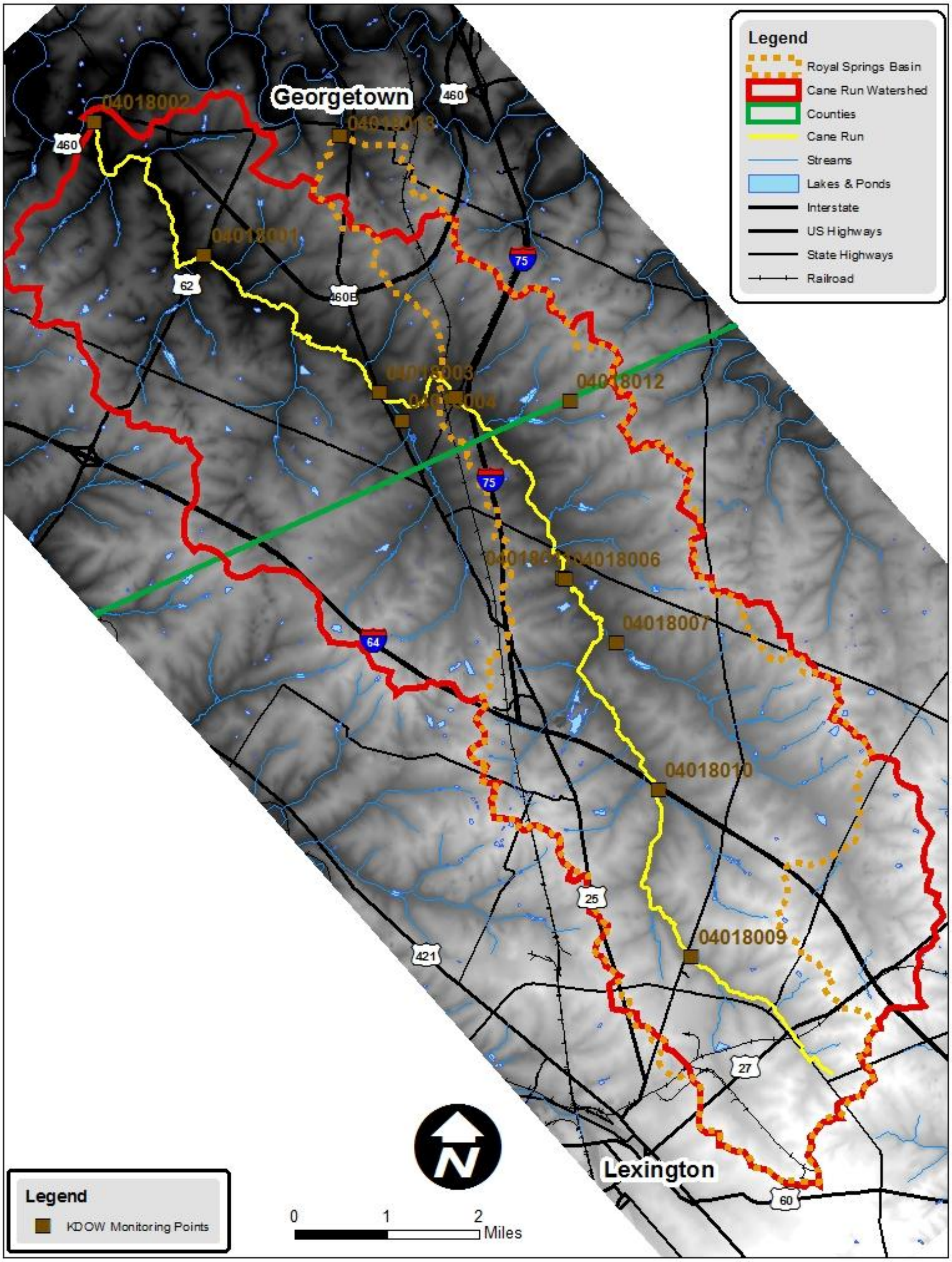

Figure 20. KDOW monitoring points

Table 11. Geometric means for 2006-2007 KDOW nutrient sampling parameters

Station ID	Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
DOW04018001	0.107	Not detected	1.84	1.99	0.118	0.263	4.2	0.528
DOW04018002	0.059	Not detected	1.35	2.38	0.197	0.326	4.8	0.558
DOW04018004	0.246	2.96	2.60	2.55	0.361	0.575	6.0	0.713
DOW04018007	0.049	Not detected	0.867	1.80	0.144	0.279	4.0	0.303
DOW04018009	0.070	4.46	2.04	2.91	0.209	0.381	5.3	0.458
DOW04018010	Not detected	Not detected	0.927	1.94	0.106	0.221	4.1	0.364
DOW04018012	0.070	2.21	0.869	1.46	0.149	0.292	6.1	0.467
DOW04018013	0.034	Not detected	3.05	1.11	0.152	0.253	5.1	0.407

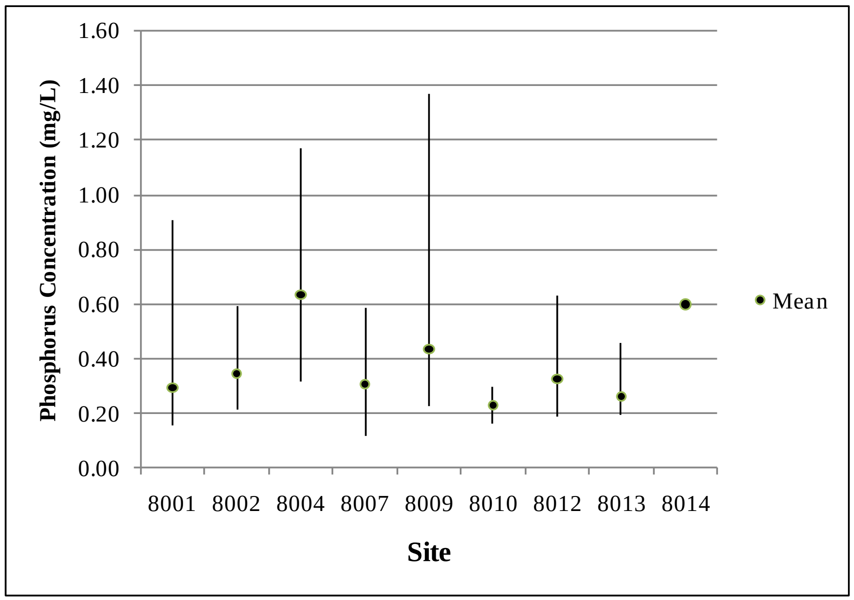

Figure 21. Range of phosphorus values for sites sampled in the Cane Run

Table 12. Average values for 2006-2007 KDOW water chemistry sampling parameters

Station ID	DO	pH
DOW04018001	7.29	7.49
DOW04018002	7.99	7.71
DOW04018003	8.38	7.60
DOW04018004	9.08	7.62
DOW04018005	6.51	7.43
DOW04018006	9.72	7.90
DOW04018007	9.04	7.64
DOW04018009	8.16	7.64
DOW04018010	9.66	7.79
DOW04018011	8.36	7.78
DOW04018012	10.18	7.24
DOW04018013	No data	7.45

Table 13. KDOW narrative habitat scores

Station ID	Collection Date	Narrative Habitat Score
DOW04018001	7/7/1998	Fair
	9/3/2009	Poor
DOW04018002	6/10/2009	Fair
DOW04018004	3/27/2007	Poor
DOW04018007	2/9/2000	Poor
DOW04018009	3/27/2007	Poor
DOW04018010	9/2/2009	Poor
DOW04018012	9/3/2009	Poor

Table 14. KDOW MBI narrative scores

Station ID	Collection Date	Macroinvertebrate Bioassessment Index (MBI) Narrative Score
DOW04018001	7/7/1998	N/A[1]
	9/3/2009	Fair
DOW04018002	6/10/2009	Fair
DOW04018004	3/27/2007	Poor
DOW04018007	9/2/2009	Poor
DOW04018010	9/2/2009	Fair

[1]Cannot calculate MBI due to the collection method used. However, individual metric calculations can be used to glean information about the macroinvertebrate community. See *The Kentucky Macroinvertebrate Bioassessment Index (MBI)* (Pond, et. Al. 2003) in Appendix N.

Cane Run Watershed Project

The monitoring data that was collected as part of the Cane Run Watershed Project differs from previously collected data because this project gained access to sites previously unavailable for sampling. Previous sampling conducted by KDOW occured near bridges of public roads, and in many cases, water could not be collected, because the water was not flowing above ground, having reached a swallet before making it to the bridge. The cooperation achieved with this project allowed samplers to be placed throughout the watershed on cooperator properties. A QAPP for this monitoring was approved in 2007 and can be found in Appendix O.

In June of 2008, the Cane Run monitoring network was successfully installed and began to operate. Monitoring station locations are shown in Figure 22. A summary of the parameters monitored at each site is given in Table 15. Bacteria and sediment samples were collected biweekly by hand at all 14 sites. Storm sediment samples were collected via automated samplers at seven sites (CR01, CR02, CR03, CR05, CR06, CR08, and CR12). A summary of the number of samples collected in 2008, 2009, and 2010 at each site is given in Table 16. Sampling was suspended in March, 2010 due to financial constraints. From June of 2008 through March of 2010, 460 bacteria samples and 2992 sediment samples were collected. Details of the sampling regimen and sample analyses can be found in the project QAPP (Appendix O). A discussion of the bacteria, sediment, and turbidity data follows, and the complete data for each of these categories can be found in Appendices P and Q.

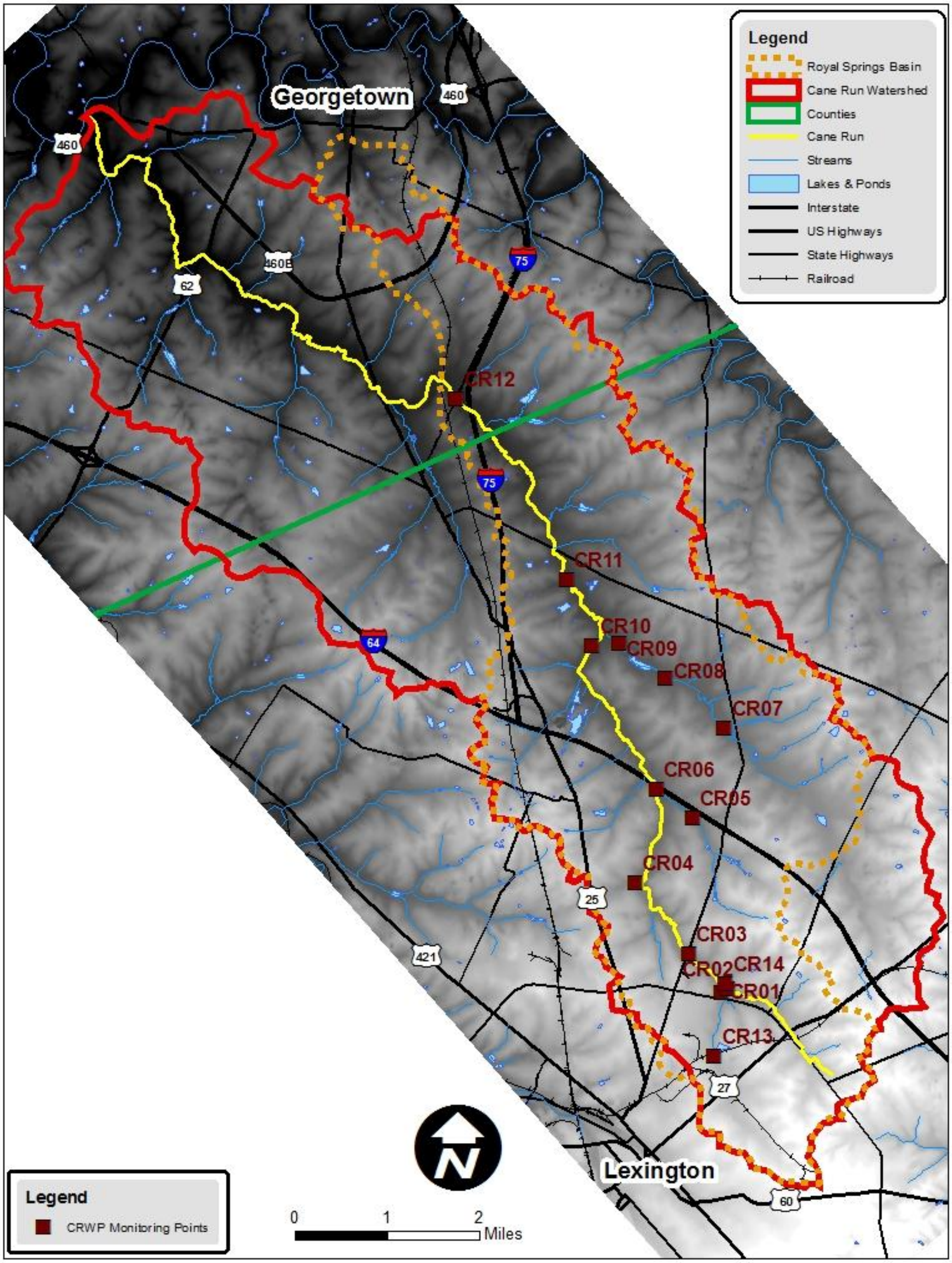

Figure 22. Cane Run Watershed Project monitoring sites

Table 15. Cane Run Watershed Project monitoring locations and parameters

Site	Location	Parameters
CR01	Lexmark Park West	Bacteria, Sediment, Stage, Rainfall
CR02	Lexmark Park East	Bacteria, Sediment, Stage
CR03	Newtown Pike	Bacteria, Sediment, Stage
CR04	Highlands	Bacteria, Rainfall
CR05	Coldstream Park	Bacteria, Sediment, Stage, Rainfall
CR06	UK Farm South I-75	Bacteria, Sediment, Stage, Rainfall
CR07	UK Farm below Fasig-Tipton	Bacteria, Rainfall
CR08	UK Farm	Bacteria, Sediment, Stage, Rainfall
CR09	UK Farm below Lake	Bacteria
CR10	UK Farm above Confluence	Bacteria
CR11	Berea Road	Bacteria, Sediment, Stage, Rainfall
CR12	Lisle Road	Bacteria, Sediment, Stage, Rainfall
CR13	Loudon Avenue	Bacteria
CR14	Lexmark below Subdivision	Bacteria

Table 16. Cane Run Watershed Project monitoring samples collected

Site	2008		2009		2010	
	# Grab Samples	# Storm Samples	# Grab Samples	# Storm Samples	# Grab Samples	# Storm Samples
CR01	16	362	29	266	5	0
CR02	5	337	15	142	3	0
CR03	6	373	19	192	4	0
CR04						

Bacteria (*E. coli*) data collected as part of the University of Kentucky monitoring program were used to validate the Fecal Coliform TMDL developed by KWRRI for the Cane Run Watershed. Graphs of all of the *E. coli* concentrations for all monitored sites appear in Appendix R. As the bacteria data collected were *E. coli* and the TMDL was develop for fecal coliforms, an estimate of the equivalent fecal coliform values were obtained by using the following relationship developed by Ormsbee and Akasapu (2010)[10]:

$$EC=1.44*FC^{0.8093}$$

The equivalencies obtained with this relationship can be found in Table 17, and a summary of the results in relation to the primary and secondary *E. coli* standards can be found in Table 18

E. coli and TSS load duration curves were developed for monitoring locations CR01, CR02, CR03, CR05, CR06, CR08, CR11 and CR12. Measured flows from the USGS gage station at Berea Road were used in the development of these curves for all the monitoring locations. If no measurable flows were recorded at the Berea Road gaging station, then the USGS gage at Wolf Run was used. Flows at each monitoring site were estimated in a drainage proportional manner. Flows at the monitoring locations were computed by multiplying the flow at Wolf Run by the ratio of the monitoring site drainage area to the drainage area at the USGS gage station at Wolf Run. Load duration curves were also developed for CR03, CR06, CR11 and CR12 utilizing flow output from the calibrated HSPF model developed for the Fecal Coliform TMDL.

Table 17. Geometric mean *E. coli* concentrations at each CRWP monitoring site in 2008 and 2009.

Site	*E. coli* Geometric Mean (cfu/100mL)	Approximate Fecal Coliform Equivalence (cfu/100mL)
CR01	2970	12456
CR02	5223	25022
CR03	3076	13008
CR04	7003	35949
CR05	887	2798
CR06	3708	16386
CR07	1769	6566
CR08	1075	3548
CR09	716	2148
CR10	630	1834
CR11	431	1147
CR12	410	1078
CR13	10760	61119
CR14	1199	4061

[10]Ormsbee and Akasapu. 2010. Relationship Between Fecal Coliform and Within the Kentucky River Basin. Kentucky Water Resources Research Institute. University of Kentucky. Lexington, Kentucky.

Table 18. Number of samples at each site that exceed the primary and secondary surface water standards for *E. coli*

Site	No. Samples *E. coli* >240 MPN/100mL	No. Samples *E. coli* >676 MPN/100mL
CR01	43 (98%)	32 (73%)
CR02	19 (95%)	18 (90%)
CR03	21 (88%)	18 (75%)
CR04	44 (100%)	44 (100%)
CR05	28 (62%)	17 (38%)
CR06	14 (88%)	13 (81%)
CR07	36 (80%)	24 (53%)
CR08	31 (72%)	16 (37%)
CR09	23 (61%)	15 (39%)
CR10	8 (80%)	6 (60%)
CR11	6 (46%)	6 (46%)
CR12	21 (62%)	15 (44%)
CR13	33 (100%)	32 (97%)
CR14	14 (82%)	12 (71%)

At present, no TMDL exists for sediment in the Cane Run Watershed. As such, total suspended solids (TSS) concentrations were evaluated with respect to 200 mg/l. Sheeder and Evans (2004) calculated the suspended sediment threshold for biologic impairment in 29 Pennsylvania watersheds as approximately 200 mg/l[11]. Only grab sample concentrations were used to develop the load duration curves as stage-discharge relationship are presently under-development by the USGS.

Relationships between turbidity and TSS were developed for the monitoring sites CR01, CR02, CR03, CR05, CR06, CR08, CR11, and CR12. Turbidity is often used as a surrogate for determining TSS concentrations, primarily because turbidity is quicker to sample and it can be sampled continuously. Both grab and storm samples were used to develop these relationships. Due to presence of swallets in the stream bed and the conducting of surface water to ground water, the sampling of storm events decreased in the downstream direction. Table 19 gives a summary of the TSS data collected in the watershed.

Table 19. Summary of storm sample TSS data for the Cane Run Watershed

Site	No. Events Sampled	Peak >200 mg/L[1]	Mean >200 mg/L[2]	Geometric Mean >200 mg/L[3]	Mean per Event >200 mg/L[4]	Mean Time >200 mg/L (minutes)[5]
CR01	46	15 (33%)	2 (4%)	0 (0%)	<1	11

[11] Sheeder, S.A. and B.M. Evans. 2004. Estimating nutrient and sediment threshold criteria for biological impairment in Pennsylvania watersheds. JAWRA 40: 881-888.

Site	No. Events Sampled	Peak >200 mg/L[1]	Mean >200 mg/L[2]	Geometric Mean >200 mg/L[3]	Mean per Event >200 mg/L[4]	Mean Time >200 mg/L (minutes)[5]
CR02	31	9 (29%)	0 (0%)	0 (0%)	<1	9
CR03	26	6 (23%)	0 (0%)	0 (0%)	<1	7
CR05	13	2 (15%)	0 (0%)	0 (0%)	<1	2
CR06	16	4 (25%)	0 (0%)	0 (0%)	<1	11
CR08	9	3 (33%)	0 (0%)	0 (0%)	2	31
CR12	8	3 (38%)	0 (0%)	0 (0%)	2.6	34

[1]Mean number of storm events where the storm peak TSS concentration exceeded 200 mg/L.

[2]Mean number of storm events where the storm mean TSS concentration exceeded 200 mg/L.
[3]Mean number of storm events where the storm geometric mean TSS concentration exceeded 200 mg/L.

[4]Mean number of samples in each storm event that exceeded TSS concentration of 200 mg/L.

[5]Mean amount of time in each storm event where TSS concentration exceeded 200 mg/L.

The following conclusions pertain to the Cane Run Watershed as a whole. A catchment-by-catchment breakdown of this monitoring data is presented in Chapter VIII.

1. *E. coli* concentrations in the Cane Run Watershed routinely exceed primary and secondary contact standards. Concentrations generally run higher in proximity to urban areas and decrease downstream.
    a. High percentages of samples exceeding contact standards for bacteria are most notable at CR13 and CR06.
    b. Exceedance at CR06 is strongly linked to CR04.
2. Sediment concentrations and loading did not appear to be a problem in the Cane Run Watershed.
    a. The mean time storm events produced TSS concentrations in excess of 200 mg/l tended to increase in the downstream direction suggesting both streambank and overland erosion are increasing with increasing agricultural area and livestock activity.

Geomorphology

Geomorphology was also modeled with this project through the methods listed in the QAPP (Appendix O) and described below. The geomorphology data collected is presented by catchment in subsequent chapters.

Permanent cross-sections were installed throughout the upper portion of the Cane Run Watershed. At each cross-section, two steel posts (approx. 2 ft. in length) were installed above the bankfull elevation; one post was installed on the left bank while the other was installed along the right bank. Each cross-section was surveyed in June 2009 (Year 1) and June 2010 (Year 2) in accordance with methods outlined in Harrelson et al. (1994)[12]. Locations of the cross-sections were marked with a hand-held GPS unit.

Determination of bankfull elevation was done in the field and was confirmed using the Inner Bluegrass regional curve for bankfull cross-sectional area[13]. Bankfull parameters and bank erosion hazard index/near bank stress (BEHI/NBS) values were computed for each cross-section using RIVERMorph®. Particle size data were collected at only at the water quality monitoring points. Appendix Q contains summary information regarding cross-sectional surveys and particle size analyses.

Both lateral and vertical stability were assessed by overlaying Year 1 and Year 2 cross-sections. Lateral stability was assessed by examining the overlays for presence or absence of significant streambank erosion or deposition. Average annual rates of lateral change were computed via bank profiles. The bank height ratio (BHR) was computed for each cross-section to access vertical stability. A BHR between 1.0 and 1.1 was considered stable; 1.2 to 1.3 moderately unstable; 1.4 to 1.5 unstable; and greater than 1.5 highly unstable. A summary of the geomorphic data for the watershed can be found in Table 20.

Using the methodologies outlined in Rosgen (2001) [14] and Starr (2009)[15], BEHI values were computed and NBS values assessed for each streambank at each cross-section. These values were linked to average annual erosion rates (ft./yr.) to develop preliminary erosion-rate prediction curves for the Cane Run Watershed. All cross-sections were resurveyed in June 2011, and these data will be included in the curve development. As Cane Run behaves like an ephemeral channel and the UT to Cane Run is perennial, in the future once the USGS completes development of stage-discharge curves for select monitoring points, flow data will be used to evaluate these erosion prediction curves.

Table 20.Summary of CRWP geomorphic data

Catchment	Rosgen Classification	Bank Erosion Hazard Index (BEHI)	Near Bank Stress (NBS)	Narrative Assessment
1	E1	Low/Moderate	Low/Moderate	Stable
2	No data	No data	No data	No data
3	No data	No data	No data	No data
4	No data	High	Low/High	No data
5	No data	No data	No data	No data
6	C4	Moderate	Low/Moderate	Stable
7	No data	No data	No data	No data

12 Harrelson, C.C., C. Rawlins, and J. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Techniques. USDA Forest Service Rock Mountain Forest and Range Experiment Station General Technical Report RM245, 67 p.

13 Brockman, R.R., C.T. Agouridis, S.R. Workman, L.E. Ormsbee, and A.W. Fogle. In Press. Bankfull Regional Curves for the Inner and Outer Bluegrass Regions of Kentucky. JAWRA.

14 Rosgen, D.L. 2001. A Practical Method of Computing Streambank Erosion Rate. *Proceedings of the Seventh Federal Interagency Sedimentation Conference* 2:9-15.

15 Starr, R.R. 2009. Stream Assessment Protocol Anne Arundel County, Maryland. Stream Habitat Assessment and Restoration Program. U.S. Fish and Wildlife Service, Chesapeake Bay Field Office. CBFO-S01-09.

Catchment	Rosgen Classification	Bank Erosion Hazard Index (BEHI)	Near Bank Stress (NBS)	Narrative Assessment
8	C4, C6, E4, E6	Moderate/High	Low/Moderate	Unstable
9	B3	Moderate	Low	Stable
10	E, B	Moderate/High	Low/Moderate	Unstable

Hydrology

Precipitation, flow, and stage-discharge relationships were also modeled with this project through the methods listed in the QAPP (Appendix O).

For the 2008 monitoring period, rainfall totals were about 6.6 inches below normal with the largest differences occurring during the summer months of July and August. Rainfall amounts were more closely aligned with normal levels for the 2009 monitoring period. The 2009 annual rainfall was about 1.2 inches below normal. For a detailed breakdown of precipitation values at sampling sites in 2008 and 2009, see Table 21.

Sites CR01, CR05, CR08, and CR12 are perennial, with 100% flow. CRO1 is largely perennial, probably due to the discharges from Lexmark. The remaining sites (CR02, CR03, CR06, and CR11) are a mixture of intermittent and ephemeral flows, meaning that these streams flow intermittently in the winter and spring months and ephemerally in the summer and fall months. For a summary of flow data in the Cane Run Watershed, see Table 22.

Figure 23 shows a representative storm hydrograph for several of the CRWP monitoring sites. It shows 1.8 inches of rain falling over 6.8 hours, with an average intensity of 0.26 in/hr. The impact of urban impervious surfaces—high peak flow, low base flow—can easily be seen at CR03 and CR06. The effect of urbanization is damped at CR08 and CR12, where there is later peak or a longer time of concentration, and longer flow duration.

UK, in cooperation with the U.S. Geological Survey (USGS), also developed stage-discharge curves for the Cane Run. These curves, and the rating tables found in Appendix S, describe the relationship between the height of the stream (stage) with the discharge (amount of water) at a specific cross section of the stream (Figure 24, Figure 25, Figure 26, and Figure 27).

Table 21. CRWP precipitation data summary

Month		Monitoring Location								Normal Rainfall (1971-2000)[2]	Average of all monitoring sites	Difference
			CR04	CR05	CR06	CR07	CR08	CR11				
2008	July	*DI*[1]	*DI*	2.82	*DI*	*DI*	3.08	*DI*	*DI*	*4.81*	2.95	-1.86
	August	0.84	1.1	1.36	1.43	1.27	1.02	0.92	1.13	*3.77*	1.13	-2.64
	September	2.66	2.41	2.24	1.81	1.9	1.35	*DI*	1.36	*3.11*	1.96	-1.15
	October	1.37	1.58	1.51	1.47	*DI*	*DI*	*DI*	*DI*	*2.7*	1.48	-1.22
	November	2.33	2.5	2.45	2.45	*DI*	*DI*	*DI*	*DI*	*3.44*	2.43	-1.01
	December	5.47	5.33	5.91	*DI*	*DI*	5.65	5.07	4.47	*4.03*	5.32	+1.29
2009	January	2.64	1.95	3.06	*DI*	2.14	1.73	3.11	2.91	*3.34*	2.51	-0.83
	February	2.92	2.96	2.9	*DI*	2.96	3.13	3.07	2.65	*3.27*	2.94	-0.33
	March	1.96	*DI*	2.44	2.55	2.09	2.39	2.22	1.87	*4.41*	2.22	-2.19
	April	4.39	*DI*	5.03	4.98	DI	5.04	4.48	3.95	*3.67*	4.64	+0.97
	May	3.97	4.13	4.66	4.3	3.95	4.62	4.39	3.48	*4.78*	4.19	-0.59
	June	3.68	3.58	4.29	4.63	4.61	5.67	6.18	*DI*	*4.58*	4.66	+0.08
	July	3.21	6.12	5.9	6.05	5.92	5.77	5.64	*DI*	*4.81*	5.52	+0.71
	August	2.94	4.51	4.44	4.32	*DI*	4.74	3.6	3.55	*3.77*	4.01	+0.24
	September	4.5	5.77	5.98	*DI*	*DI*	5.96	2.68	4.04	*3.11*	4.82	+1.71
	October	5.48	*DI*	5.41	5.18	5	4.71	*DI*	5.54	*2.7*	5.22	+2.52
	November	1.01	*DI*	0.99	0.09	0.95	1	0.37	0.87	*3.44*	0.75	-2.69
	December	3.75	3.9	3.68	1.33	3.3	3.37	3.19	3.3	*4.03*	3.23	-0.80

[1]DI indicates insufficient data for monthly total due to equipment failure/power loss.
[2]http://www1.ncdc.noaa.gov/pub/data/ccd-data/nrmpcp.txt

Table 22. Days of flow for each CRWP monitoring point

Year	Month	Monitoring Site CR01		CR02		CR03		CR05		CR06		CR08		CR11		CR12	
2008	July	31	100.0%	7	22.6%	9	29.0%	31	100.0%	31	100.0%	31	100.0%	1	3.2%	31	100.0%
	August	31	100.0%	3	9.7%	6	19.4%	31	100.0%	25	80.6%	31	100.0%	1	3.2%	31	100.0%
	September	30	100.0%	5	16.7%	6	20.0%	30	100.0%	7	23.3%	30	100.0%	3	10.0%	30	100.0%
	October	31	100.0%	3	9.7%	5	16.1%	31	100.0%	1	3.2%	31	100.0%	0	0.0%	31	100.0%
	November	30	100.0%	7	23.3%	8	26.7%	30	100.0%	5	16.7%	30	100.0%	0	0.0%	30	100.0%
2009	April	30	100.0%	30	100.0%	30	100.0%	30	100.0%	27	90.0%	30	100.0%	27	90.0%	30	100.0%
	May	31	100.0%	24	77.4%	26	83.9%	31	100.0%	21	67.7%	31	100.0%	11	35.5%	31	100.0%
	June	30	100.0%	22	73.3%	26	86.7%	30	100.0%	14	46.7%	30	100.0%	7	23.3%	30	100.0%
	July	31	100.0%	15	48.4%	17	54.8%	31	100.0%	22	71.0%	31	100.0%	2	6.5%	31	100.0%
	August	31	100.0%	16	51.6%	24	77.4%	31	100.0%	17	54.8%	31	100.0%	12	38.7%	31	100.0%
	September	30	100.0%	14	46.7%	16	53.3%	30	100.0%	17	56.7%	30	100.0%	10	33.3%	30	100.0%
	October	31	100.0%	23	74.2%	29	93.5%	31	100.0%	23	74.2%	31	100.0%	21	67.7%	31	100.0%
	November	30	100.0%	9	30.0%	13	43.3%	30	100.0%	10	33.3%	30	100.0%	7	23.3%	30	100.0%
	December	31	100.0%	29	93.5%	30	96.8%	31	100.0%	24	77.4%	31	100.0%	24	77.4%	31	100.0%

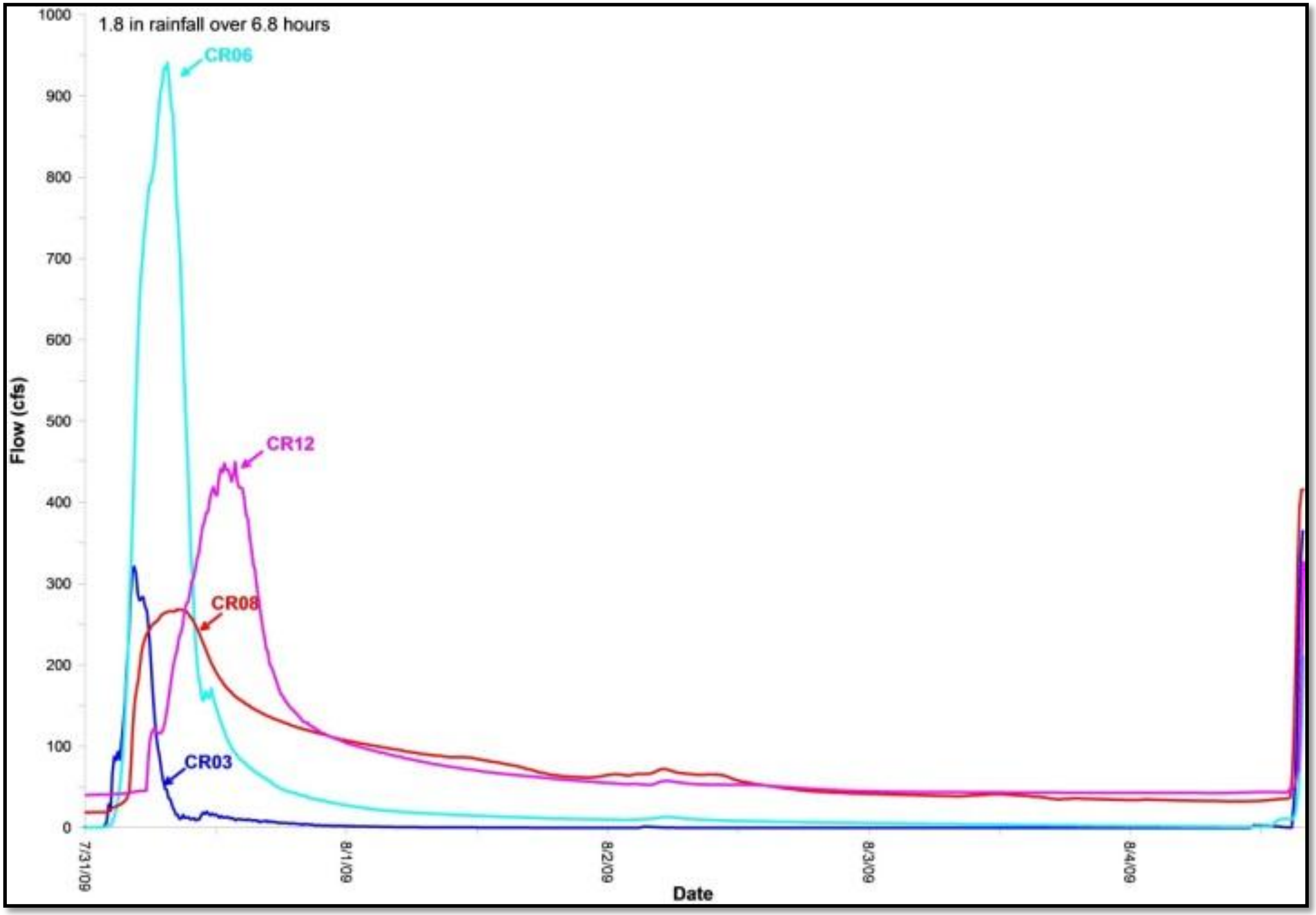

Figure 23. A representative storm hydrograph for several of the CRWP monitoring sites

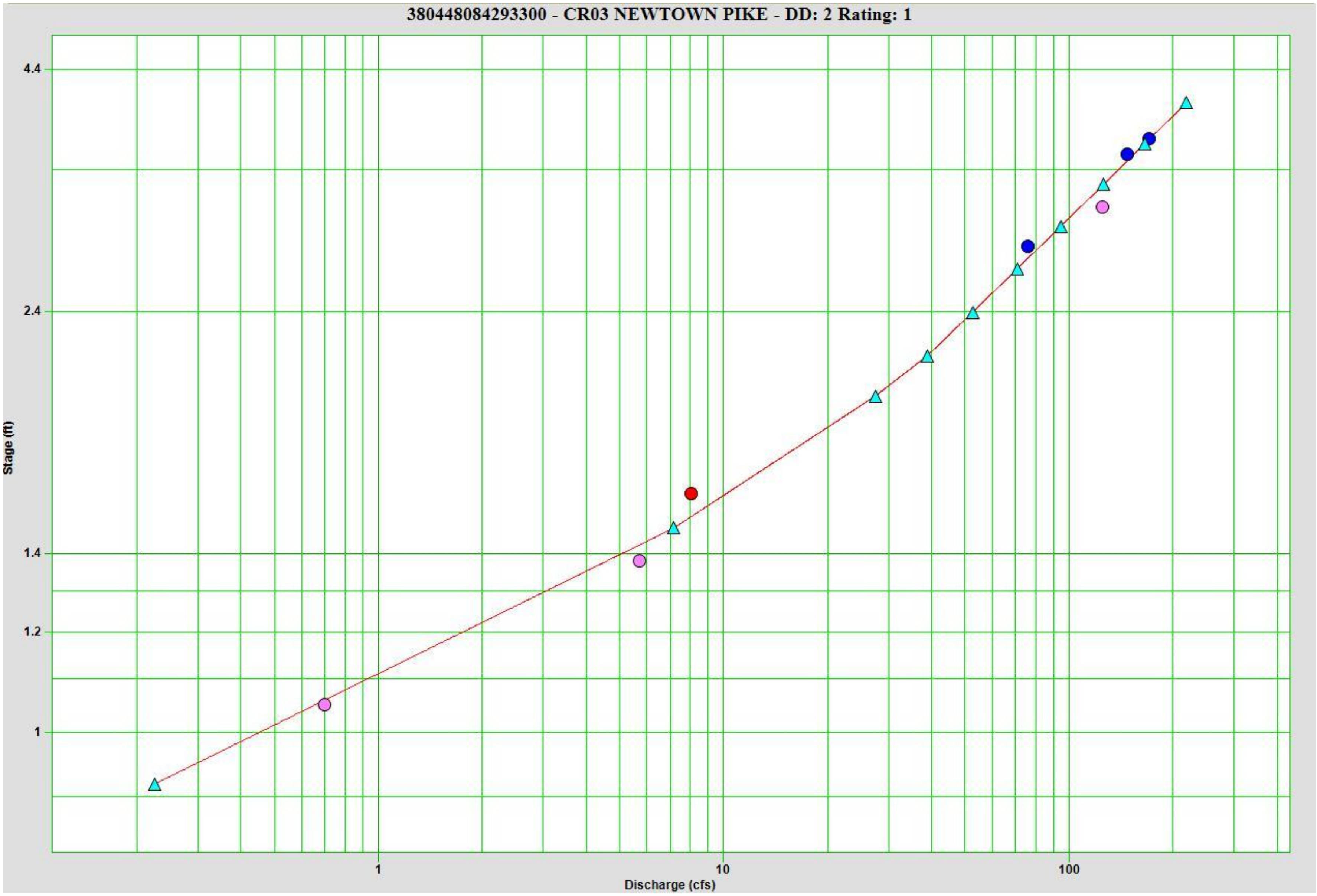

Figure 24. Stage-discharge curve for CR03

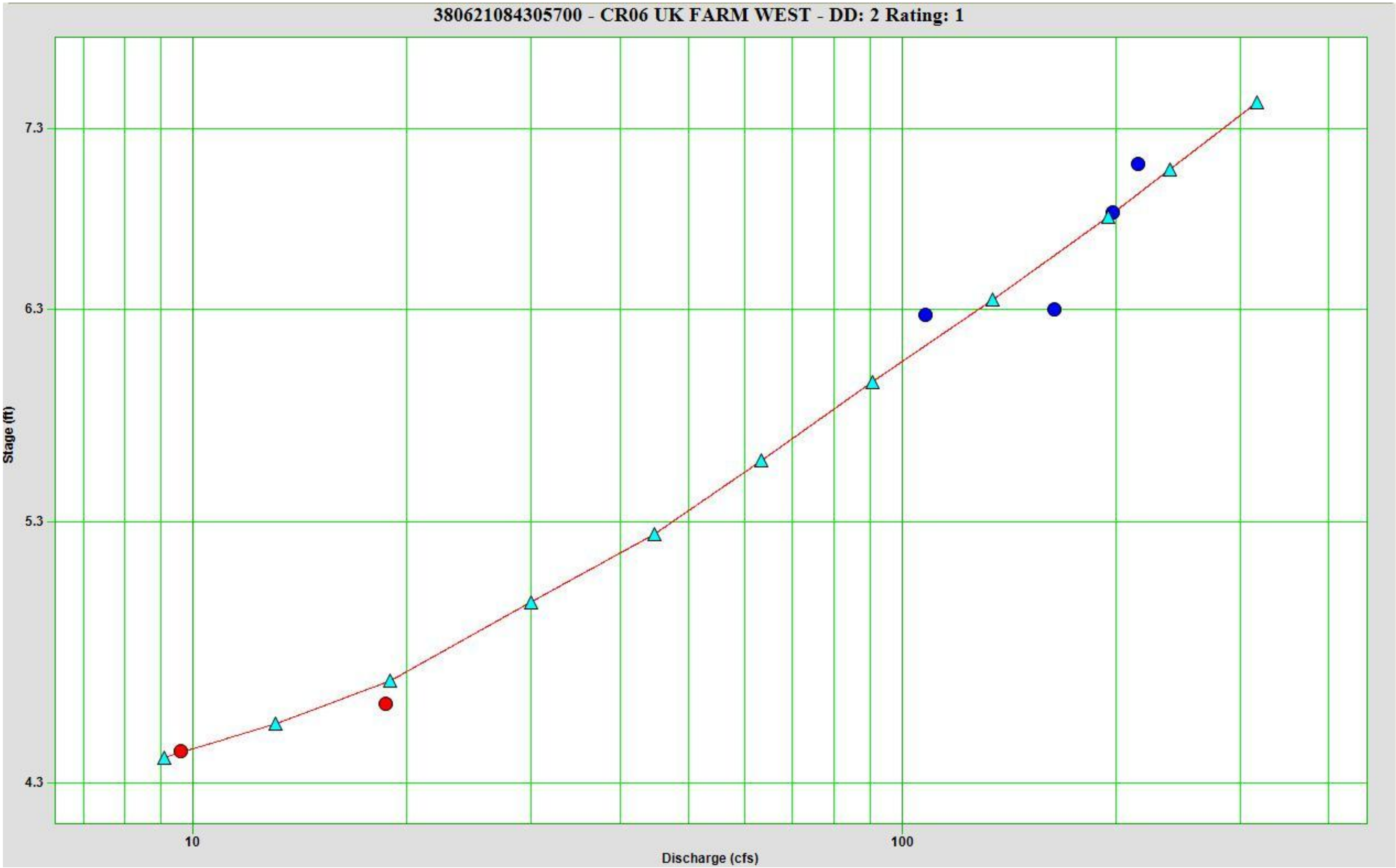

Figure 25. Stage-discharge curve for CR06

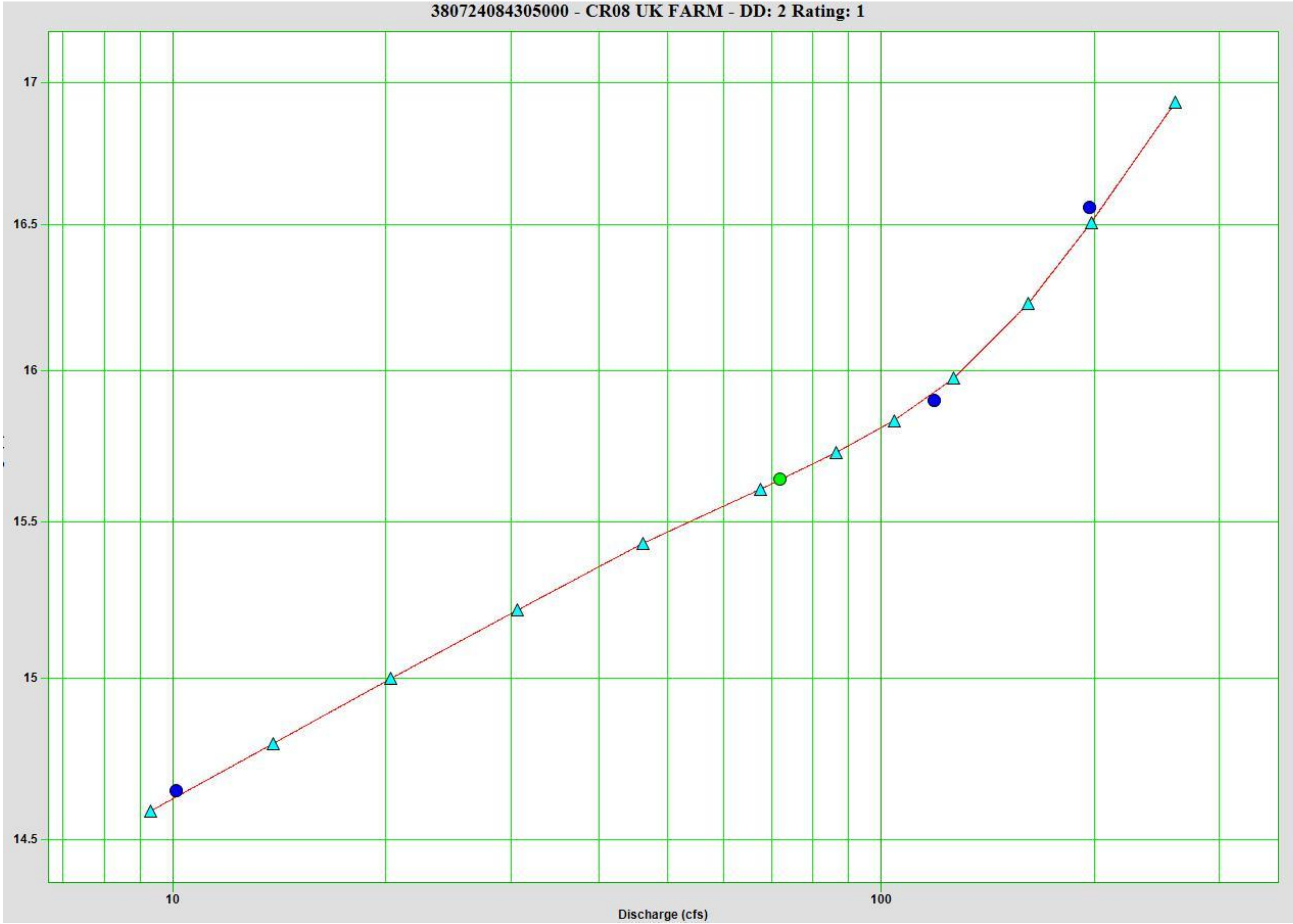

Figure 26. Stage-discharge curve for CR08

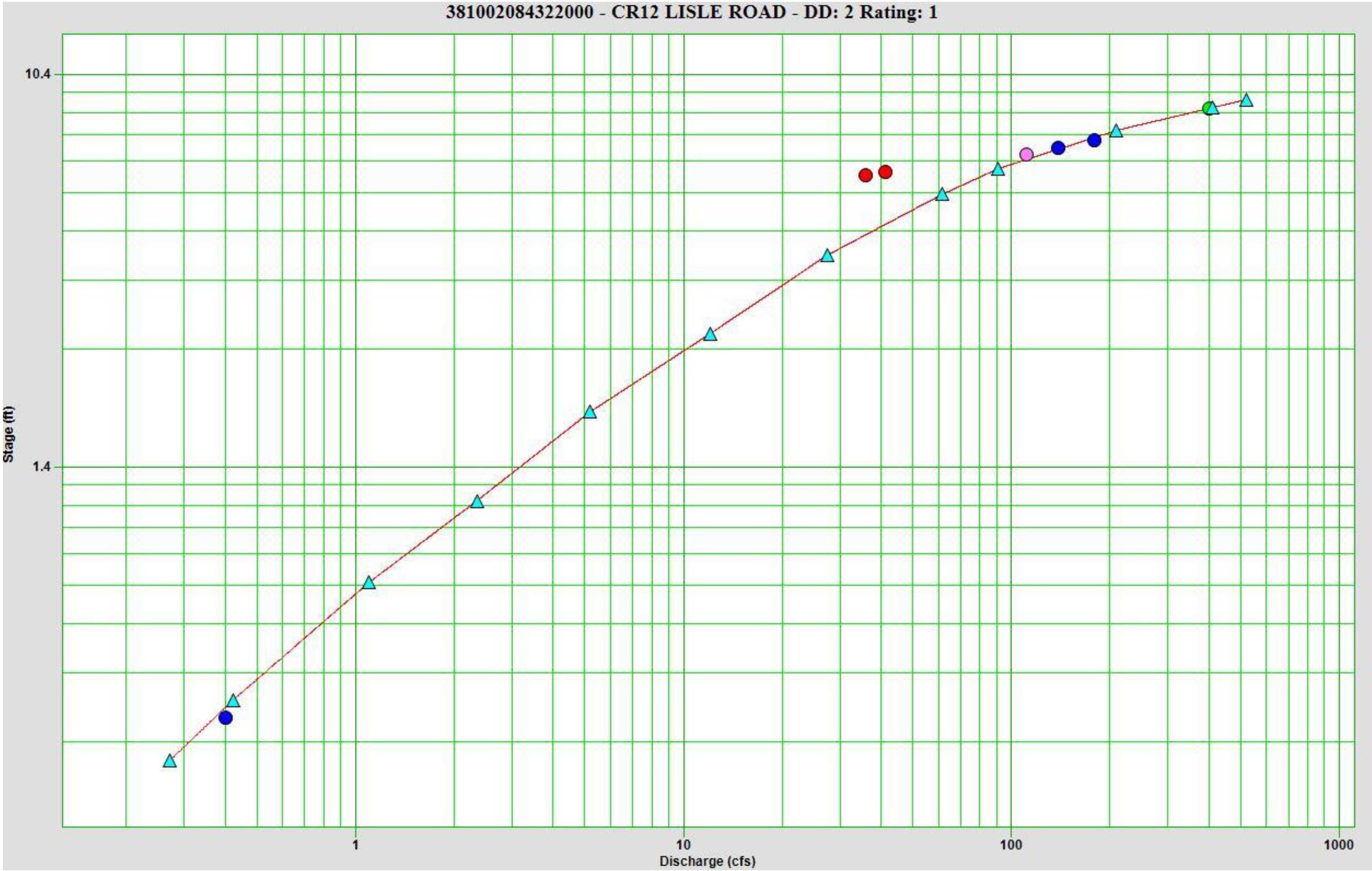

Figure 27. Stage-discharge curve for CR12

Cane Run Watershed Project Ground-Truthing

At the beginning of the summer of 2010, student interns with the Cane Run Watershed Project met with the Lexington-Fayette Urban County Government (LFUCG) Division of Water Quality to discuss the inspection of the storm water drainage system that discharges into the Cane Run Watershed. LFUCG provided the students with maps of the streams in the watershed, but were unable to provide them with the location of the stormwater drainage system because it had not yet been mapped in northern Lexington, the part of town that lies within the Cane Run Watershed. The students walked along all of the streams that run through urban areas to locate and identify stormwater infrastructure and also to inspect drainage grates in parking lots, manholes, and curb inlets (Figure 28). The following report details problems detected through this ground-truthing effort. An extended ground-truthing report that includes detailed maps and information on problem areas can be found in Appendix T, and an extensive photographic archive can be found in Appendix U.

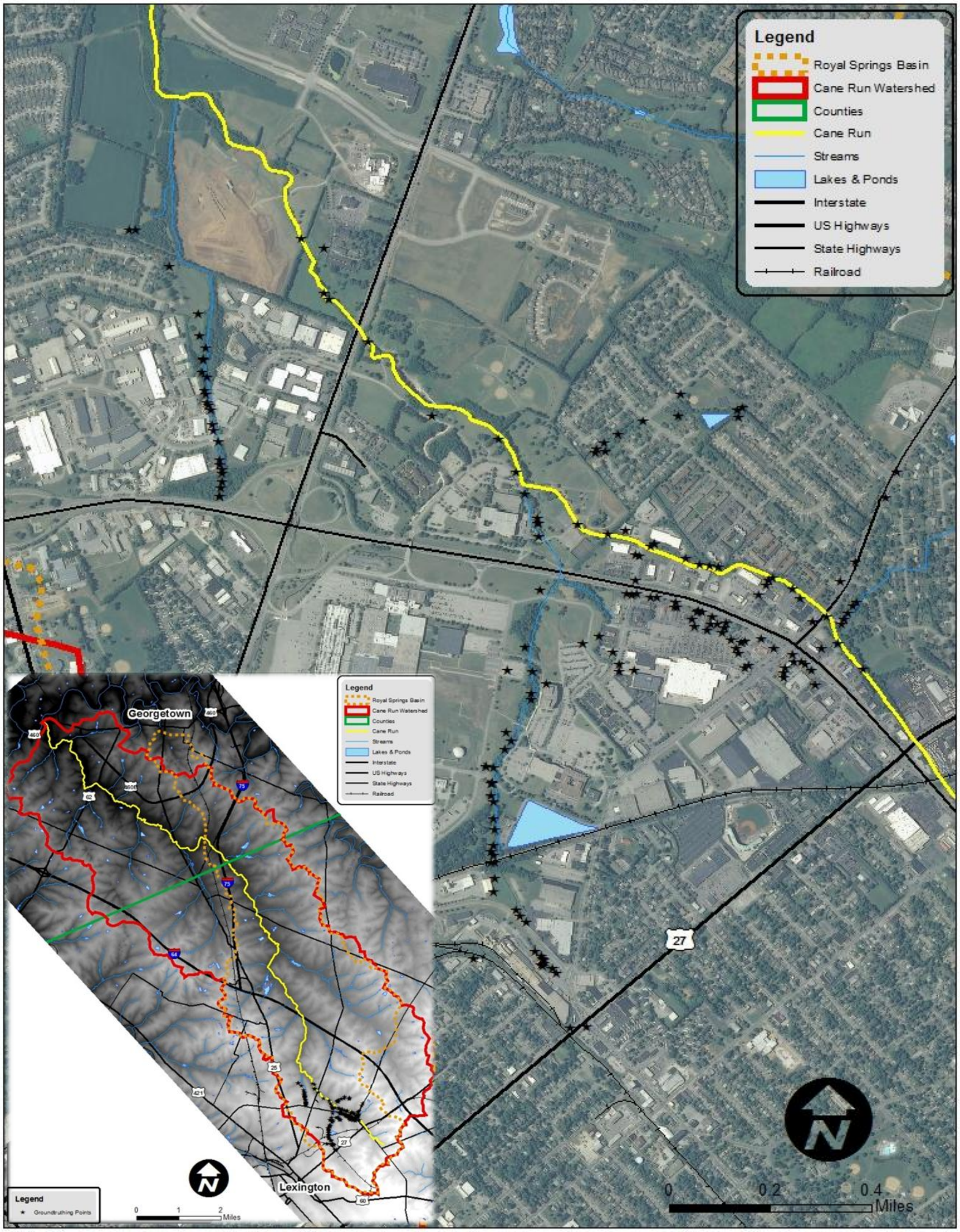

Figure 28. Problem areas located during ground-truthing investigation

The students began by inspecting the creeks and looking for signs of pollution, such as trash, sewage, and bank erosion. They walked the streams that ran through Lexmark Park, the Russell Cave Road/Hollow Creek Road area, the Nandino Boulevard area, the West Loudon Avenue area, and the Highlands subdivision. In order to supplement the limited information provided by LFUCG, the students were asked to locate and take GPS points of all pipes that discharge into the streams. Most pipes were located at concrete endwalls and had no flow; however, some endwalls were filled in with mud and vegetation or trash and debris (Figure 29).There were also several endwalls that had structural damage or around which the bank was eroded (Figure 30); these problems were reported to LFUCG.


Figure 29. Endwall filled with mud and vegetation; Endwall filled with trash and debris

Figure 30. Bank eroded around endwall

The students found that some pipes had water flowing out, but did not test for ammonia or detergent unless they saw signs of pollution. The pipes that exhibited signs of pollution were tested using the field tests. As Figure 31 shows, in one pipe there was a brown thick liquid accumulating at the endwall, which appeared to be a sign of pollution; however, upon testing, the students found a low level of ammonia and no detergent present. The endwall, also shown in Figure 31, is located in Lexmark Park, and the sudsy appearance of the water gave some indication of pollution. The water, when tested, contained 0.25 mg/L of ammonia and some detergent. The low levels of ammonia and detergent found at these two endwalls indicate that the discharge was not harmful.

Figure 31. Brown liquid discharging from endwall; Sudsy water discharging from endwall

The worst pipe discharge was found in the stream off of Russell Cave Road (Figure 32). The students smelled a very foul odor upon approaching this endwall. They tested the water and found ammonia levels greater than 8 mg/L and some detergent, which indicated that there might be sewage present. An environmental inspector from LFUCG was contacted and came out to inspect the pipe. He took a sample and tested it for *E. coli* and found very high levels. It was later determined that there was a sewer line break at the Paddock Apartments nearby. The apartment complex was issued a citation and the problem was fixed.

Figure 32. Sewer from line break; Construction on sewer line break

Just downstream from where the sewage was found, a faux rock endwall with a plastic pipe was found (Figure 33). The pipe was discharging a foul smelling liquid into the stream. The students tested the liquid and found it to contain greater than 8.0 mg/L of ammonia and some detergent. They followed the pipe up into a parking lot and found that it was connected to a drainage grate. The environmental inspector also checked this pipe and informed the students that there was not much that could be done about it.

Figure 33. Faux rock endwall

Several pipes of an unidentified origin were also found running into the streams. One such "pipe" was a 5-foot section of garden hose sticking out of the bank in a stretch of stream that runs parallel to New Circle Road (Figure 34). The students attempted to pull the hose out of the bank, thinking that it was just litter and had gotten stuck in the bank. The garden hose, however, would not budge, and they were unable to pull it from the bank, leading the students to believe that it was connected to something above the bank. The end of the garden hose appeared to be wet, but there was no flow, and the hose was not near the water in the stream.

Figure 34. Garden hose sticking out of side of bank

The students found a 10” PVC pipe protruding 3’ off of Nandino Boulevard (Figure 35). The pipe was sealed shut with what appeared to be some sort of plaster. The pipe was dripping, but the liquid had no odor or other sign of pollution and the students did not test it.

Figure 35. PVC pipe sealed shut

In addition to finding pipes that discharge into the stream, the students were also asked to locate and mark GPS points for the pipes that cross the streams, most of which were sanitary sewer pipes (Figure 36). Some were also assumed to be utility lines crossing the stream (Figure 37).

Figure 36. Sanitary sewer crossing

Figure 37. Utility line crossing stream

In all of the areas that were inspected, the dumping of trash, debris, and large items in the stream is a large problem. Trash can be found in every part of the watershed, especially in the urban areas. Many of the worst spots for trash occurred near homeless camps. During their exploration of the streams, the students found many locations where homeless people live near the streams. The worst one was in the West Loudon Avenue area, near the railroad track (Figure 38). Another major source of trash is located behind Jalapeño's Mexican Restaurant off of New Circle Rd (Figure 38).

Figure 38. Trash near stream by homeless encampment; Area where a major source of trash was found

The students found several locations where debris was clogged in the streams and underneath aerial pipes that crossed the streams (Figure 39). In several locations the stream was impassable, and the students were forced to climb out of the stream and bypass the obstruction (Figure 39).

Figure 39. Debris clogging around pipes; Possible area for LFUCG and UK Fusion Cleanups

Several additional dumping locations were also found. The students found shopping carts, refrigerators, lawn mowers, a moped, and excess railroad supplies dumped into the stream. Approximately 15 shopping carts were found on the bank of the stream behind the Family Dollar on New Circle Road (Figure 40). Another major dumping site was found near the railroad tracks in the West Loudon Avenue area, near the homeless camp, where a significant amount of excess railroad materials had been dumped (Figure 40).

Figure 40. One of many shopping carts; Railroad debris

In addition to these sources of pollution, the students found that dumpsters located near the streams posed a problem. In the stream located off of Nandino Boulevard, a large amount of trash and tires were found in one site. The students followed the trash up the bank to the source: a dumpster. Another dumpster that appeared to be a problem is located off New Circle Road behind the strip mall where Family Dollar is located. This dumpster was leaking a foul smelling, brown liquid that was running into the stream (Figure 41).

Figure 41. Leaking dumpster

While walking the stream behind the Carnahan House, running parallel to Citation Drive, the students spotted a manhole located approximately 30 feet from the stream (Figure 42). The lid of the manhole had fallen in, and upon examining the hole, it seemed to be some sort of a tank that the students could not identify. The tank held about 1 foot of water, and the lid could be seen in the bottom. The hole was at the entrance of a gate and could be hazardous to anyone who is walking or driving by. This was reported to LFUCG and UK, and the problem was fixed.

Figure 42. Manhole without cover

Although many problems of trash found in the streams were created as a result of direct human behavior, some problems, such as bank erosion, were occurring simply because of increased stormwater runoff caused by urbanization and impervious cover. In all sections of the streams, the students found areas of significant bank erosion. In many cases the erosion was so severe that the banks are overhanging (Figure 43). This photograph was taken in Shadybrook Park, which is located on Lexmark's property.

Figure 43. Bank erosion

After walking all of the streams, the students began checking curb inlets, storm sewer manholes, and drainage grates in parking lots. Several problems were found with curb inlets, especially in the New Circle Road and Russell Cave Road areas. Numerous broken curb inlets were found on Russell Cave Rd (Figure 44). One curb inlet was completely filled in with sediments, trash, and other debris (Figure 44). In all areas, trash could be seen in the curb inlets, but most did not contain a significant amount.

Figure 44. Broken curb inlet; Sediment-filled inlet

When beginning to look at storm drains, the students decided to focus on the businesses off of New Circle Road. This area is very congested and receives a lot of traffic on a daily basis. Upon checking the storm drains in the McDonald's parking lot, the students smelled a very foul odor coming from a drainage grate. The grate was pulled up, revealing water that had collected in the bottom of the grate (Figure 45). The students were unable to test the water because it was so deep. The students contacted LFUCG, who called the streets and roads department, who stated that it was a state line and not their responsibility. The next week the environmental inspector went out to look at the storm water drain to get a water sample. The water contained low levels of ammonia, no *E. coli* , and very high levels of fecal coliforms. This indicated to the inspector that it was just run-off from the parking lot and not a sewer leak; therefore, nothing else was done about this storm drain.

Figure 45. Source of foul odor

Just down the street from McDonald's the drainage grate in the Dairy Queen parking lot contained suspicious looking water. The water had a sheen and brown foam around the edges (Figure 46). Another problem was discovered in the Taco Bell parking lot on the corner of New Circle Road and Russell Cave Road. The students found water pooling around the drainage structure the day after a rainfall and assumed the drain was clogged up (Figure 46).

Figure 46. Water with sheen and brown foam; Water pooling around drain

On another corner of the same intersection by the old Hollywood Video building, the students discovered a pipe with water flowing out and flooding the nearby area (Figure 47). LFUCG was contacted and informed the students that it was a waterline clean-out. The pipe was inspected and fixed later on that same day.

Figure 47. Water overflowing

Upon checking storm drains in the Russell Cave and New Circle Road area, the students noticed a blue substance pooled up and draining into a storm drain in the Marathon gas station parking lot (Figure 48). The gas station employees were unable to identify the substance but claimed that it had leaked out of the back of a garbage truck that had been emptying the dumpster. LFUCG was notified about the substance but proposed that the gas station employees wash the rest of the substance down the storm drain because they did not have the tools or a quick enough response time to deal with the substance. Pictures of the spill were collected by the students. The blue substance smelled highly of some type of detergent.

Figure 48. Blue substance entering drain

Another storm drain that posed a major problem was found in the back parking lot of Golden Corral on New Circle Road. When arriving at that storm drain the students noticed a very foul odor and realized it was coming from the storm drain. As Figure 49 shows, the water in the storm drain was sudsy, thick, and very unpleasant looking. The Environmental Inspector from LFUCG was called, and he came out and checked the storm drain. Grease was leaking from a dumpster directly into the storm drain. The students were informed later on that the problem had been fixed.

Figure 49. Nasty water

Another major source of pollution to the storm drains was found behind O'Reilly's Auto Parts on New Circle Road. A significant amount of trash had been left in the parking lot (Figure 50), and when a large rainfall event occurred, the trash would be washed directly into the storm drain, which flows directly to the stream (Figure 50).

Figure 50. Trash in parking lot; Trash transported by large rainfall events

In several other locations, the students found storm drains that were completely filled with trash. Many of these storm drains were curb inlets located along the sides of the roads rather than in parking lots. Figure 51 shows a curb inlet off of New Circle Road.

Figure 51. Trash-filled drain

Cane Run Watershed Project Targeted Sampling

LFUCG Sub-Watershed Sampling

The Cane Run Watershed Project and LFUCG reached an agreement, which established that Cane Run Watershed Project interns would collect water samples from Cane Run tributaries that LFUCG would analyze and address. It was hoped that by sampling smaller tributaries, the Cane Run Watershed could be divided into several sub-watersheds, which would make it easier to determine the sources and quantities of pollution contributing to the Cane Run.

The first water sampling was conducted on July 13, 2010. A significant amount of rain had fallen that day, so the students were sent out to collect samples at predetermined locations (Figure 52 and Figure 53). One 100mL water sample was taken from each of the twelve different sites. At each sampling site**,** the students recorded locations with a handheld GPS unit (Table 23). After each sample was collected, the bottle was identified by its location and placed on ice. The students delivered the samples to LFUCG's testing lab where they were then analyzed for bacteria. Results from the testing showed *E. coli* levels too numerous to count and were recorded as greater than 60,000 CFU/100mL for over half the sites tested.

Because the July 13 samples may have been skewed by the heavy rain, it was suggested that the students take water samples again on a drier day. The second set of water samples was collected on July 19, 2010, and a third set was collected on July 20, 2010 after a moderate rainfall. Water was not flowing in three of the locations, and the students were unable to collect samples in those locations. The results from the other nine sites gave a more accurate *E. coli* count for most sites; however, the samples taken in the West Loudon Avenue area still contained levels that were too numerous to count. The results from all three days are shown in Table 24. As of February 2011, LFUCG has not addressed the data gained from this study or investigated to determine the sources of pollution.

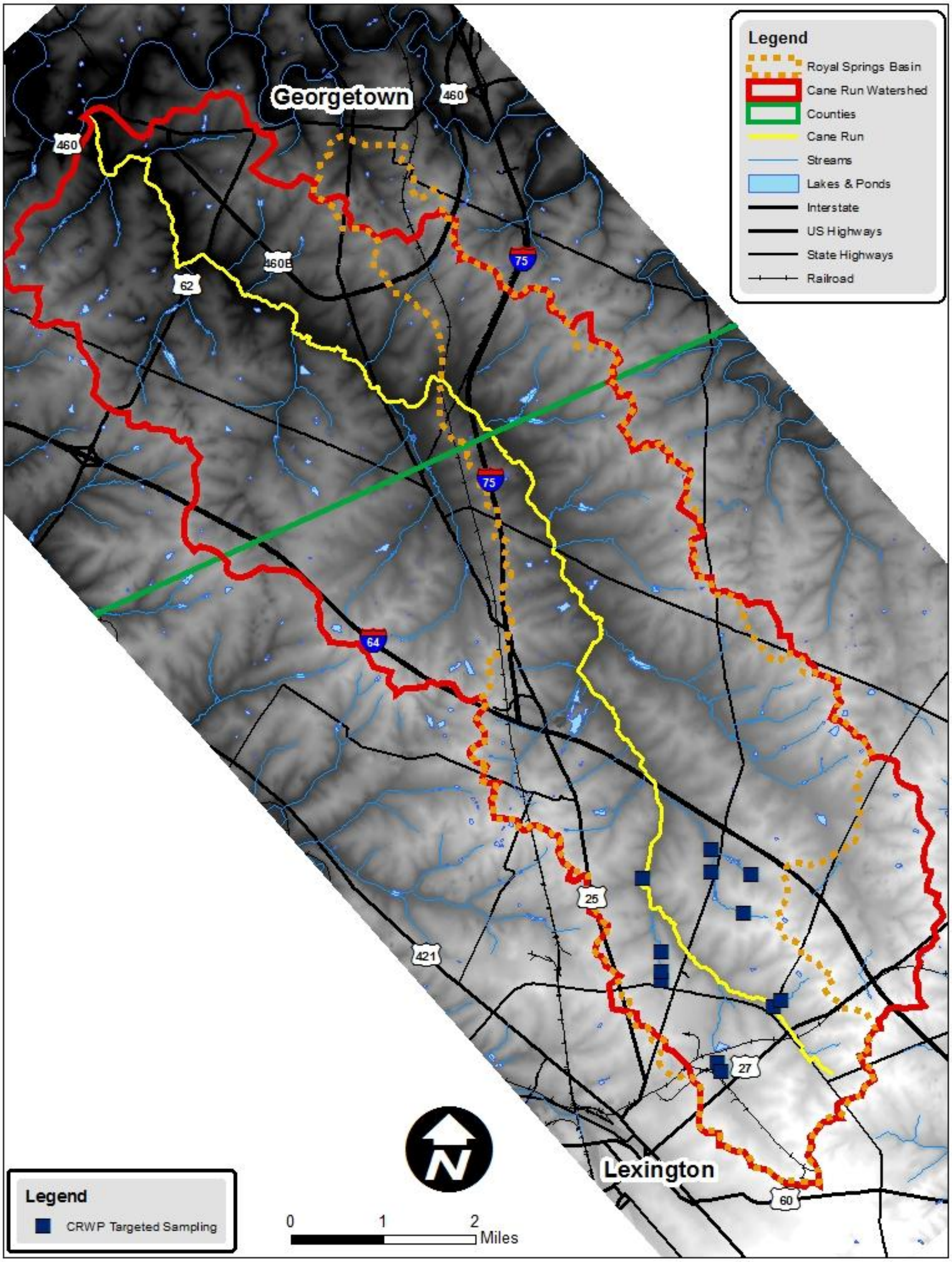

Figure 52. LFUCG and CRWP targeted sampling points

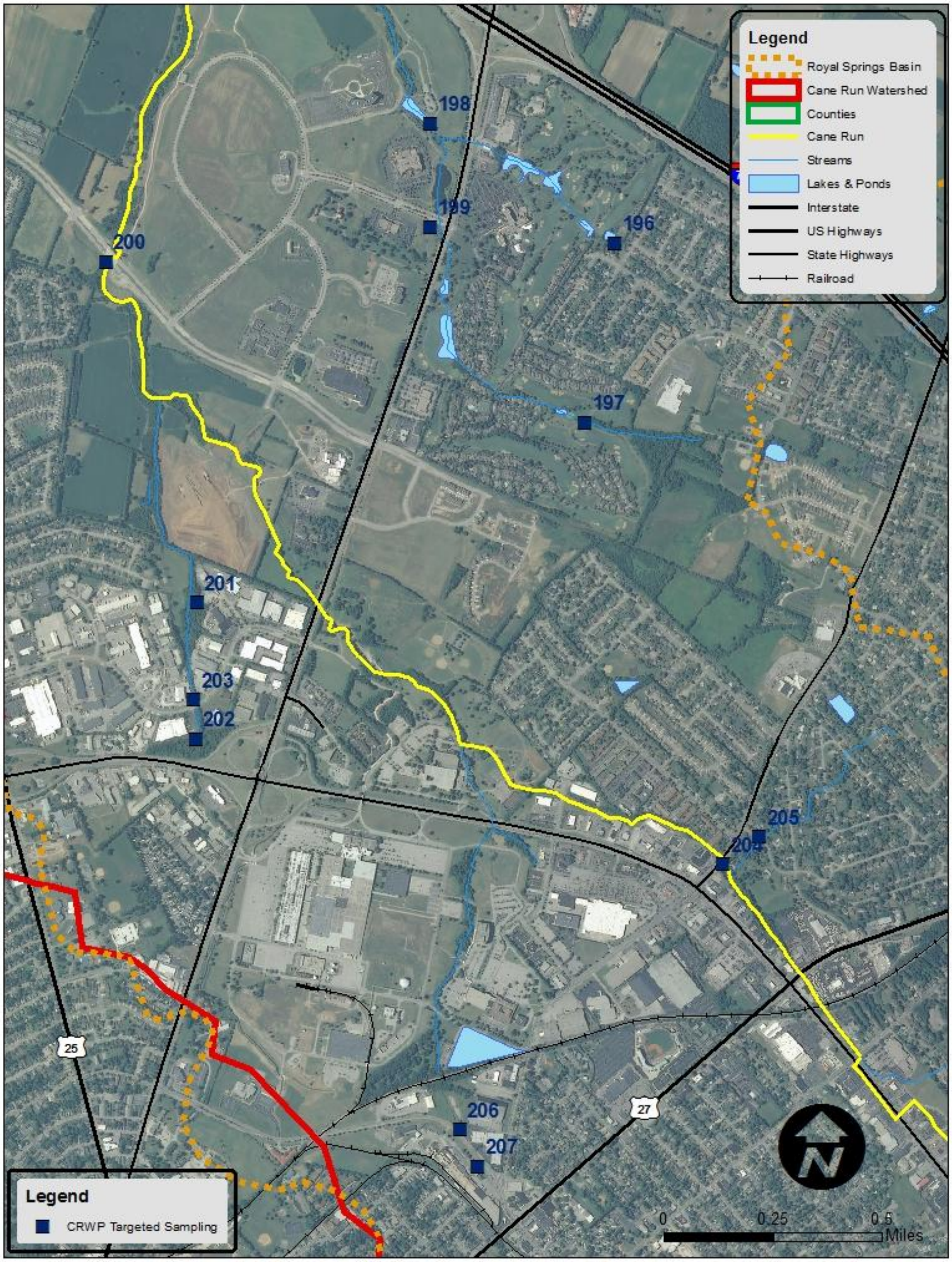

Figure 53. LFUCG and CRWP targeted sampling points and 2010 aerial imagery

Table 23. Cane Run Watershed Project water sampling site numbers and locations

Sampling Site Number	Location
WP196	Pond at Marriott Griffin Gate Golf Course
WP197	Stream at Marriott Griffin Gate
WP198	Stream between MedTech College and Embassy Suites off of Newtown Pike
WP199	Corner of Aristides Rd. and Newtown Pike
WP200	Downstream side of bridge on Citation Blvd.
WP201	End of Rushwood Dr.
WP202	Back Parking lot of Neogen off of Nandino Blvd.
WP203	Downstream side of bridge on Nandino Blvd.
WP204	Upstream side of bridge on Russell Cave Rd.
WP205	Upstream side of bridge on Hawthorne Rd.
WP206	Upstream side of West Loudon Rd.
WP207	Downstream side of West Loudon Rd.

Table 24. Cane Run Watershed Project targeted water sampling results (CFU/100mL)

	07/13/10		07/19/10		07/20/10	
Sampling Site	Other Coliforms	*E. coli*	Other Coliforms	*E. coli*	Other Coliforms	*E. coli*
WP196	60000	~8000	40000	~1273	60000	~16000
WP197	60000	~6200	40000	~700	~110000	4200
WP198	~38900	2800	21000	~1818	54000	2800
WP199	60000	60000	---	---	---	---
WP200	60000	60000	50000	2500	~65000	~9818
WP201	60000	~11900	---	---	---	---
WP202	60000	60000	46000	~1818	~90000	2300
WP203	60000	5800	28000	~1200	~64000	3000
WP204	60000	60000	22000	~600	~80000	4100
WP205	60000	60000	---	---	---	---
WP206	60000	60000	38000	~73000	60000	60000
WP207	60000	60000	60000	60000	60000	60000

Fasig-Tipton and Victory Haven Sampling

In late 2009 and early 2010, Cane Run Watershed Project partners detected extremely high bacteria levels in water samples taken from an un-named tributary as it entered the University of Kentucky Experiment Station. The sampling described in this section was conducted to trace the source of contamination above the Experiment Station.

Samples were taken at five points along small Cane Run tributaries on Fasig-Tipton and Victory Haven properties on January 21, 2010. Table 25 and Figure 54 show the sampling points and the water quality results, which point to Victory Haven as the pollution source. This sampling led to the creation of the research projects at Victory Haven described later in the plan.

Table 25. Water quality results from January 21, 2010 sampling

Sampling Point	Fecal Coliforms (cfu/100mL)	*E. coli*(cfu/100mL)
VSFT-2	8600	321
VSFT-3	4130	194
VSFT-4	11000	291
VSFT-5	5160	158
VSFT-6	14490	185

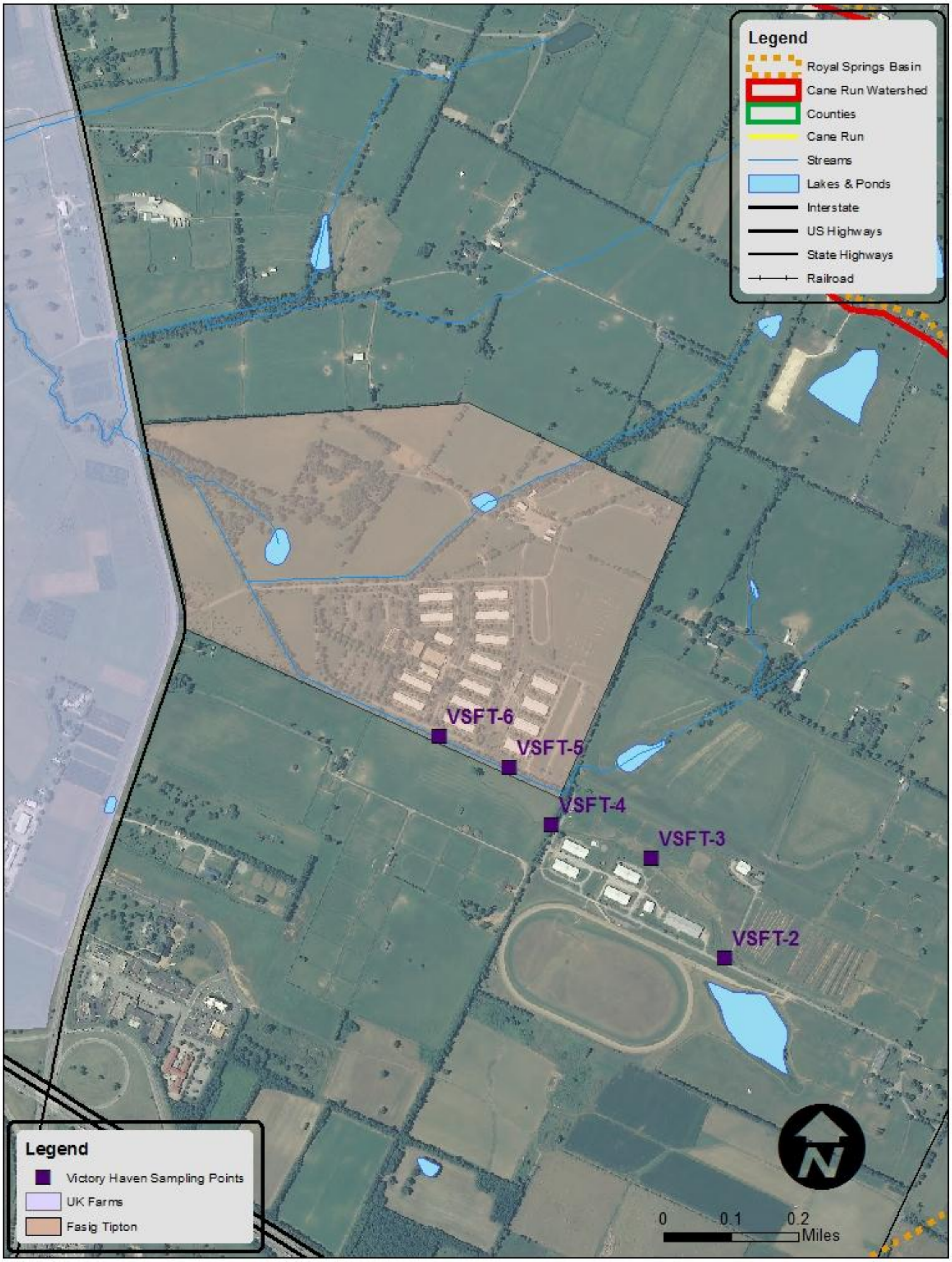

Figure 54. Sampling points near Fasig-Tipton and Victory Haven and 2010 aerial imagery

Data Gaps

Although extensive monitoring has been conducted throughout the watershed, there are specific areas in which additional monitoring could be focused to clarify pollutant sources.

- In the upper watershed, monitoring of even smaller sub-catchments would be helpful to identify specific sources of pollution within developed areas.
- In the lower watershed, extensive monitoring is needed to identify bacteria and nutrient pollutant sources, as little monitoring has been conducted in this part of the watershed. The data that does exist is vague and outdated.
    - One specific area of the lower watershed that needs to be monitored is Catchment 7, in which, as far as the Cane Run Watershed Project is aware, no monitoring has ever taken place.

VI. Watershed Goals

Management Objectives and Indicators

Goal Statement

The goal of the Cane Run and Royal Spring Watershed Assessment and Restoration Project is to identify watershed deficiencies and assemble all resources to work toward restoring the watershed to meet its designated uses. The goal of the remediation methodologies presented is to reduce the effects of point and nonpoint sources of pollution and allow the watershed to meet or exceed the water quality standards of the Commonwealth.

Milestones

The milestones and interim measures contained in Table 26 will be used to determine whether pollution management measures and other control actions are being implemented.

Table 26. Milestones for the implementation of the Cane Run Watershed Based Plan

Milestones	Interim Measures*	Timeline	Responsible Parties
Execute an interagency Cooperative Agreement for the Cane Run and Royal Spring Project	– **Maintain contacts across agencies** – **Meet regularly via steering committee meetings**	2008	– University of Kentucky – Kentucky Horse Park – USDA-NRCS – Lexmark – LFUCG – KY Dept. of Transportation
Form a Steering Committee (Watershed Council) for the Cane Run and Royal Spring Watershed Project	– **Meet quarterly or biennially** – **Involve constituencies within the watershed**	2008	– University of Kentucky – Kentucky Horse Park – USDA-NRCS – Lexmark – LFUCG – KY Dept. of Transportation – KDOW – Friends of Cane Run – Neighborhood Associations
Develop BMP Implementation Plan	– **Identify sites and BMPs** – **Obtain funding from project partners** – **Implement BMPs** – Evaluate BMP performance – Adapt BMPs based on performance	2008-2009	– University of Kentucky – Kentucky Horse Park – USDA-NRCS – Lexmark – LFUCG – KY Dept. of Transportation

Milestones	Interim Measures*	Timeline	Responsible Parties
Conduct watershed monitoring and assessments	– **Collect all existing water quality data and conduct gap analysis** – **Select monitoring locations** – **Develop a Quality Assurance Project Plan (QAPP)** – **Submit QAPP to KDOW for review and approval** – **Implement monitoring program** – **Analyze monitoring data** – **Interpret monitoring data to determine causes for pollution** – **Review monitoring results and analysis with KDOW and project partners**	2008-2010	– University of Kentucky – KDOW
Complete the Watershed Based Management Plan for Cane Run and Royal Spring	– **Obtain stakeholder input** – **Revise plan according to water quality data** – **Draft final version of Cane Run WBP** – **Submit final Cane Run WBP to KDOW for review and approval**	2008-2011	– University of Kentucky – KWRRI – KDOW
Complete TMDL Development	– **Submit draft bacteria TMDL for KDOW** – **As needed, revise draft bacteria TMDL based on KDOW and EPA comments** – **Submit draft nutrient TMDL for KDOW** – As needed, revise draft nutrient TMDL based on KDOW and EPA comments – Develop sediment TMDL	2008-2013	– University of Kentucky – KWRRI – KDOW

Milestones	Interim Measures*	Timeline	Responsible Parties
Provide education and outreach	– **Submit all education and outreach materials to KDOW for review and approval** – **Conduct workshops and tours for watershed professionals, agricultural producers, and student groups** – **Identify and contact potential members of the Cane Run and Royal Spring Watershed Restoration Steering Committee (Watershed Council)** – **Facilitate formation and activities of the Cane Run Watershed Council** – **Conduct quarterly Cane Run Watershed Council meetings** – **Conduct Cane Run Watershed Festival** – **Produce materials to target specific audiences** – **Develop educational materials that target specific audiences including watershed residents, businesses, schools, visitors, and the general public**	2008-2013	– University of Kentucky – LFUCG – Lexmark – Kentucky Horse Park

*Measures in bold have been completed or are being completed on a regular basis.

Key Pollutant Load Reduction Targets

The load reduction targets for key pollutants (bacteria and nutrients) in the Cane Run Watershed are in the process of being developed through the development of total maximum daily loads (TMDLs). Total maximum daily load is a term used to describe the maximum amount of a pollutant a stream can assimilate without violating water quality standards. The units of a load measurement are mass of pollutant per unit time (i.e. mg/hr., lbs. /day). Establishing the relationship between the in-stream water quality target and the pollution sources is a critical component of TMDL development, as it allows for the evaluation of management options that will achieve the desired source load reductions. Once a TMDL is developed for a watershed, it allows for effective watershed management, as the appropriate pollution level is known and pollution can be allocated to different sources.

Because the entire length of the Cane Run and several of its tributaries are listed as impaired on the Kentucky Division of Water's 303(d) list, TMDL development is required by law; therefore, a key aspect of the Cane Run Watershed Project is the completion of extensive modeling exercises necessary to develop TMDLs. When complete, these models piece together the hydrology of the watershed, making it possible to track the effects of land management changes throughout the watershed. The karst geology within the Cane Run and Royal Spring watershed is not easily modeled, but additional monitoring stations being installed as a part of the Cane Run Watershed Project will allow the models and the modeling approximations to be evaluated more accurately.

The development of TMDLs, and therefore the development of load reduction targets for bacteria and nutrients, is ongoing, and the results of each TMDL thus far are described in the sections below.

Bacteria

Initial work on the TMDL for Cane Run began in May of 2002. A stream sampling plan was developed for both the mainstream and tributaries of the watershed, and KWRRI sampling occurred June 2002 through September 2002. In an effort to account for the potential impact of both point and nonpoint bacteria sources, water quality samples were collected during rain and non-rain events. In addition to data collected by the KWRRI, data was also obtained from the Georgetown Municipal Water Company, the Lexington Fayette Urban County Government, and the University of Kentucky's Cane Run Watershed Project.

The in-stream fecal coliform target for primary recreational contact is a 30-day geometric mean of 200 colonies/100 ml, and an instantaneous maximum of 400 colonies/100 ml that must not be exceeded more than 20% of the time for the summer recreational period (i.e. May through October). For secondary contact recreation, the in-stream fecal coliform target is a geometric mean of 1000 colonies/100 ml, and an instantaneous maximum of less than or equal to 2000 colonies/100 ml 80% of the time, and this applies year round. Collectively the water quality data collected suggest that more than 90% of the time, bacteria values in Cane Run (and its tributaries) exceed the 30-day geometric limit set by Kentucky's Surface Water Standards (401 KAR 5:031) for primary contact recreation.

The Kentucky Water Resources Research Institute (KWRRI) submitted a draft bacteria TMDL based on this and later sampling to the Kentucky Division of Water for initial review in November 2010. Table 27 and Table 28 show the draft total maximum daily loads; however, the numbers presented in the final Cane Run

Bacteria TMDL may be different than the information presented here. The entire draft bacteria TMDL can be found in Appendix V.

Table 27. Total maximum daily loads and HSPF (hydrologic simulation program fortran) determined allocations

Subwatershed	TMDL (cfu/day)	WWTP Wasteload Allocation (cfu/day)	Developed MS4 Land Wasteload Allocation (cfu/day)	Load Allocation (cfu/day)
Lower Cane Run	1.30E+13	5.68E+08	1.31E+09	1.30E+13
River Mile 3.0-6.7	7.97E+12	5.68E+08	1.31E+09	7.96E+12
L1	2.09E+12	2.20E+08	0.00E+00	2.09E+12
L2	6.29E+11	3.48E+08	0.00E+00	6.29E+11
L3	1.37E+11		0.00E+00	1.37E+11
L4	1.18E+11		0.00E+00	1.18E+11
L5	4.99E+12		1.31E+09	4.99E+11
River Mile 0.0-3.0	5.06E+12		0.00E+00	5.06E+12
L6	5.06E+12		0.00E+00	5.06E+12
Upper Cane Run	1.07E+13		1.93E+10	1.07E+13
River Mile 9.6-17.4	5.85E+12		1.91E+10	5.83E+12
U1	2.40E+11		1.55E+10	2.25E+11
U2	9.19E+11		3.23E+10	9.16E+11
U3	2.12E+12		3.78E+10	2.12E+12
U4	2.02E+12		0.00E+00	2.02E+12
U5	5.45E+11		0.00E+00	5.45E+11
River Mile 6.7-9.6	4.85E+12		2.10E+08	4.85E+12
U6	3.44E+12		0.00E+00	3.44E+12
U7	1.10E+12		1.58E+07	1.10E+12
U8	3.03E+11		1.94E+08	3.03E+11
Royal Spring (Includes Upper Cane Run's Total)	1.11E+13		2.30E+10	1.10E+13
K3	3.74E+11		3.68E+09	3.71E+11

Table 28.Total maximum daily loads with MOS (margin of safety) enforced allocations

Subwatershed	TMDL (cfu/day)	MOS (cfu/day)	WWTP Wasteload Allocation (cfu/day)	Developed MS4 Land Wasteload Allocation (cfu/day)	Load Allocation (cfu/day)
Lower Cane Run	1.30E+13	1.30E+12	5.68E+08	1.18E+09	1.17E+13
River Mile 3.0-6.7	7.97E+12	7.97E+11	5.68E+08	1.18E+09	7.17E+12
L1	2.09E+12	2.09E+11	2.20E+08	0.00E+00	1.88E+12
L2	6.29E+11	6.29E+10	3.48E+08	0.00E+00	5.66E+11
L3	1.37E+11	1.37E+10		0.00E+00	1.23E+11
L4	1.18E+11	1.18E+10		0.00E+00	1.06E+11
L5	4.99E+12	4.99E+11		1.18E+09	4.49E+12
River Mile 0.0-3.0	5.06E+12	5.06E+11		0.00E+00	4.56E+12
L6	5.06E+12	5.06E+11		0.00E+00	4.56E+12
Upper Cane Run	1.07E+13	1.07E+12		1.74E+10	9.61E+12
River Mile 9.6-17.4	5.85E+12	5.85E+11		1.72E+10	5.24E+12
U1	2.40E+11	2.40E+10		1.40E+10	2.02E+11
U2	9.19E+11	9.19E+10		2.90E+09	8.24E+11
U3	2.12E+12	2.12E+11		3.40E+08	1.91E+12
U4	2.02E+12	2.02E+11		0.00E+00	1.82E+12
U5	5.45E+11	5.45E+10		0.00E+00	4.91E+11
River Mile 6.7-9.6	4.85E+12	4.85E+11		1.89E+08	4.36E+12
U6	3.44E+12	3.44E+11		0.00E+00	3.10E+12
U7	1.10E+12	1.10E+11		1.42E+07	9.93E+11
U8	3.03E+11	3.03E+10		1.75E+08	2.73E+11
Royal Spring (Includes Upper Cane Run's Total)	1.11E+13	1.11E+12		2.07E+10	9.94E+12
K3	3.74E+11	3.74E+10		3.31E+09	3.34E+11

The fecal coliform load reduction scenario used by this TMDL requires all NPDES permitted dischargers of fecal coliform bacteria to meet EPA stipulated water quality standards for disinfection. The TMDL also recommends 100% reduction of cattle access to streams, 50% reduction in urban (MS4-permitted and non-MS4 developed) loading, 50% reduction in livestock generated loads, and a 100% reduction in failing septic systems and in straight pipes for all catchments within the watershed. Table 29 summarizes the load reductions needed per catchment in three different land types: MS4 developed, MS4 non-developed, and non-MS4 total (developed and non-developed). The aforementioned reductions are included in these total reductions shown in this table.

Table 29. Bacteria TMDL load allocations and reductions

Subwatershed	MS4 Developed			MS4 Non-Developed			Non-MS4 Total		
	Existing Load counts/day	Wasteload Allocation counts/day	Percent reduction counts/day	Existing Load counts/day	Wasteload Allocation counts/day	Percent reduction counts/day	Existing Load counts/day	Wasteload Allocation counts/day	Percent reduction counts/day
Lower Cane Run									
L1	0.00E+00	0.00E+00	N/A	0.00E+00	0.00E+00	N/A	2.78E+12	2.09E+12	24.8
L2	0.00E+00	0.00E+00	N/A	0.00E+00	0.00E+00	N/A	8.38E+11	6.29E+11	24.9
L3	0.00E+00	0.00E+00	N/A	0.00E+00	0.00E+00	N/A	1.83E+11	1.37E+11	25.1
L4	0.00E+00	0.00E+00	N/A	0.00E+00	0.00E+00	N/A	1.57E+11	1.18E+11	24.8
L5	2.62E+09	1.31E+09	50	6.28E+11	4.60E+11	26.8	6.04E+12	4.53E+12	25.0
L6	0.00E+00	0.00E+00	N/A	4.70E+11	3.35E+11	28.8	6.30E+12	4.73E+12	24.9
Upper Cane Run									
U1	3.10E+10	1.55E+10	50	2.88E+11	2.25E+11	22.0	0.00E+00	0.00E+00	N/A
U2	6.45E+09	3.23E+10	50	9.53E+11	7.18E+11	24.7	2.63E+11	1.98E+11	24.7
U3	7.55E+08	3.78E+10	50	8.41E+11	6.33E+11	24.7	1.99E+12	1.49E+12	25.1
U4	0.00E+00	0.00E+00	N/A	1.33E+11	9.98E+10	25.0	2.56E+12	1.92E+12	25.0
U5	0.00E+00	0.00E+00	N/A	0.00E+00	0.00E+00	N/A	7.26E+11	5.45E+11	24.9
U6	0.00E+00	0.00E+00	N/A	0.00E+00	0.00E+00	N/A	4.59E+12	3.44E+12	25.1
U7	3.15E+07	1.58E+07	50	1.19E+11	8.37E+10	29.7	1.36E+12	1.02E+12	25.0
U8	3.88E+08	1.94E+08	50	2.94E+11	2.14E+11	27.2	1.18E+11	8.88E+10	24.7
K3	7.35E+09	3.68E+09	50	1.31E+11	7.68E+10	41.4	3.92E+11	2.94E+11	25.0

Nutrients

Initial work on the nutrient TMDL for the Cane Run Watershed began in May 2002. KDOW sampling occurred in 2006 and 2007. In an effort to account for the potential impact of both point and nonpoint phosphorus sources, water quality samples were collected during rain and non-rain events.

Phosphorus is considered to be the limiting nutrient for eutrophication in the Cane Run Watershed. The in-stream total phosphorus target for warm water aquatic habitat (WWAH) is 0.3 mg/L. The data shows that for 46% of all samples at all sites, phosphorus values in Cane Run and its tributaries exceed the numerical limit set forth by the Kentucky Division of Water.

The Kentucky Water Resources Research Institute (KWRRI) will submit a draft nutrient TMDL to the Kentucky Division of Water for initial review in December 2011. This TMDL accomplishes 100% compliance of the 0.3 mg/L annual geometric mean with modest reductions. Table 30, Table 31, Table 32, and Table 33 show the draft total maximum daily loads; however, the numbers presented in the final Cane Run Nutrient TMDL may be different than the information presented here. A preliminary (not final draft) nutrient TMDL can be found in Appendix W.

Table 30. Existing, reduced, and TMDL loads

Subwatershed	Existing Non-Developed Load (lbs/day)	Existing Developed Load (lbs/day)	Model Reduction Percentages, before MOS (lbs/day)	Reduced Non-Developed Load, before MOS (lbs/day)	Reduced Developed Load, before MOS (lbs/day)	KPDES Load (lbs/day)	TMDL [Sum of last three columns] (lbs/day)
Lower Cane Run	21.306	2.379		16.254	1.835	0.187	18.276
River Mile 3.0-6.7	17.711	2.143		13.558	1.658	0.187	15.403
L1	4.452	0.784	20%	3.562	0.627	0.112	4.301
L2	1.042	0.234	20%	0.834	0.187	0.075	1.096
L3	0.235	0.024	25%	0.176	0.018	0.000	0.194
L4	0.204	0.000	25%	0.153	0.000	0.000	0.153
L5	11.778	1.101	25%	8.834	0.826	0.000	9.660
River Mile 0.0-3.0	3.595	0.236		2.696	0.177	0.000	2.873
L6	3.595	0.236	25%	2.696	0.177	0.000	2.873
Upper Cane Run	18.987	8.903		15.115	7.123	0.000	22.238
River Mile 9.6-17.4	10.910	7.301		9.258	5.948	0.000	15.205
U1	0.650	4.835	20%	0.520	3.868	0.000	4.388
U2	1.602	0.663	0%	1.602	0.663	0.000	2.265
U3	5.078	0.750	25%	3.809	0.563	0.000	4.372
U4	2.570	0.258	0%	2.570	0.258	0.000	2.828
U5	1.010	0.794	25%	0.757	0.596	0.000	1.353
River Mile 6.7-9.6	8.078	1.602		5.857	1.175	0.000	7.032
U6	5.412	1.286	25%	4.059	0.965	0.000	5.024
U7	1.861	0.211	25%	1.396	0.158	0.000	1.554
U8	0.805	0.105	50%	0.403	0.052	0.000	0.455
Royal Spring (Includes Upper Cane Run's Total)	19.400	10.030		15.321	7.687	0.000	23.008
K3	0.413	1.127	50%	0.206	0.564	0.000	0.770

Table 31. Allocated loads and final reduction percentages

Subwatershed	TMDL (lbs/day)	10% MOS (lbs/day)	Total Reduced Load	Allocated Non-developed Load after MOS (lbs/day)	Allocated Developed Load after MOS (lbs/day)	Final Reduction Percentages after MOS
Lower Cane Run	18.276	1.828		14.613	1.649	
River Mile 3.0-6.7	15.403	1.540		12.186	1.490	
L1	4.301	0.430	89.7%	3.196	0.563	28.2%
L2	1.096	0.110	89.3%	0.744	0.167	28.6%
L3	0.194	0.019	90.0%	0.158	0.016	32.5%
L4	0.153	0.015	90.0%	0.138	0.000	32.5%
L5	9.660	0.966	90.0%	7.950	0.743	32.5%
River Mile 0.0-3.0	2.873	0.287		2.427	0.159	
L6	2.873	0.287	90.0%	2.427	0.159	32.5%
Upper Cane Run	22.238	2.224		13.603	6.411	
River Mile 9.6-17.4	15.205	1.521		8.332	5.353	
U1	4.388	0.439	90.0%	0.468	3.481	28.0%
U2	2.265	0.227	90.0%	1.442	0.597	10.0%
U3	4.372	0.437	90.0%	3.428	0.506	32.5%
U4	2.828	0.283	90.0%	2.313	0.232	10.0%
U5	1.353	0.135	90.0%	0.682	0.536	32.5%
River Mile 6.7-9.6	7.032	0.703		5.271	1.058	
U6	5.024	0.502	90.0%	3.653	0.868	32.5%
U7	1.554	0.155	90.0%	1.256	0.143	32.5%
U8	0.455	0.045	90.0%	0.362	0.047	55.0%
Royal Spring (Includes Upper Cane Run's Total)	23.008	2.301		13.789	6.918	
K3	0.770	0.077	90.0%	0.186	0.507	55.0%

Table 32. MS4 wasteload allocation and total load allocation

Subwatershed	Allocated Developed Load (lbs/day)	Percentage of Developed land that is MS4	Developed MS4 WLA (lbs/day)	Developed Non-MS4 LA (lbs/day)	Allocated Non-developed LA (lbs/day)	Total Load Allocation (lbs/day)
Lower Cane Run	1.649		0.496	1.153	14.613	15.766
River Mile 3.0-6.7	1.490	0.0%	0.496	0.993	12.186	13.180
L1	0.563	0.0%	0.000	0.563	3.196	3.759
L2	0.167	0.0%	0.000	0.167	0.744	0.911
L3	0.016	0.0%	0.000	0.016	0.158	0.175
L4	0.000	0.0%	0.000	0.000	0.138	0.138
L5	0.743	66.7%	0.496	0.247	7.950	8.197
River Mile 0.0-3.0	0.159		0.000	0.159	2.427	2.586
L6	0.159	0.0%	0.000	0.159	2.427	2.586
Upper Cane Run	6.411		4.311	2.100	13.603	15.703
River Mile 9.6-17.4	5.353		4.250	1.103	8.332	9.434
U1	3.481	100.0%	3.481	0.000	0.468	0.468
U2	0.597	100.0%	0.597	0.000	1.442	1.442
U3	0.506	34.0%	0.172	0.334	3.428	3.762
U4	0.232	0.0%	0.000	0.232	2.313	2.545
U5	0.536	0.0%	0.000	0.536	0.682	1.218
River Mile 6.7-9.6	1.058		0.061	0.997	5.271	6.269
U6	0.868	0.0%	0.000	0.868	3.653	4.521
U7	0.143	9.5%	0.014	0.129	1.256	1.385
U8	0.047	100.0%	0.047	0.000	0.362	0.362
Royal Spring (Includes Upper Cane Run's Total)	6.918		4.798	2.120	13.789	15.908
K3	0.507	96.1%	0.487	0.020	0.186	0.206

Table 33. Final TMDLs, wasteloads, and load allocations

Subwatershed	TMDL (lbs/day)	10% MOS (lbs/day)	KPDES WLA (lbs/day)	Developed MS4 WLA (lbs/day)	Load Allocation (lbs/day)
Lower Cane Run	18.276	1.828	0.187	0.496	15.766
River Mile 3.0-6.7	15.403	1.540	0.187	0.496	13.180
L1	4.301	0.430	0.112	0.000	3.759
L2	1.096	0.110	0.075	0.000	0.911
L3	0.194	0.019	0.000	0.000	0.175
L4	0.153	0.015	0.000	0.000	0.138
L5	9.660	0.966	0.000	0.496	8.197
River Mile 0.0-3.0	2.873	0.287	0.000	0.000	2.586
L6	2.873	0.287	0.000	0.000	2.586
Upper Cane Run	22.238	2.224	0.000	4.311	15.703
River Mile 9.6-17.4	15.205	1.521	0.000	4.250	9.434
U1	4.388	0.439	0.000	3.481	0.468
U2	2.265	0.227	0.000	0.597	1.442
U3	4.372	0.437	0.000	0.172	3.762
U4	2.828	0.283	0.000	0.000	2.545
U5	1.353	0.135	0.000	0.000	1.218
River Mile 6.7-9.6	7.032	0.703	0.000	0.061	6.269
U6	5.024	0.502	0.000	0.000	4.521
U7	1.554	0.155	0.000	0.014	1.385
U8	0.455	0.045	0.000	0.047	0.362
Royal Spring (Includes Upper Cane Run's Total)	23.008	2.301	0.000	4.798	15.908
K3	0.770	0.077	0.000	0.487	0.206

VII. Technical and Financial Assistance

Technical and financial assistance from various sources will be needed to ameliorate the poor water quality of the Cane Run Watershed and to account for the complexity of the watershed. The estimated cost to implement this plan between 2008 and 2013 is $1.8 million. This estimate includes the implementation of best management practices, education and outreach, monitoring, and reporting.

Potential Sources of Assistance

Potential programs that could be used to implement the Cane Run and Royal Spring Watershed Plan include federal and state government programs, as well as nongovernmental organizations. Many of these potentially helpful programs are briefly described in the following section.

KPDES Wastewater Permit Program

As part of the Clean Water Act (1972), all wastewater discharges into Kentucky surface waters are regulated under the National Pollution Discharge Elimination System (NPDES). This system is composed of a permit that is issued to the discharger and a requirement to monitor and report the constituents associated with the permit on a regular basis through a Discharge Monitoring Report (DMR). The authority to issue these permits in Kentucky has been delegated to the Kentucky Division of Water. These associated KPDES permits allow the state of Kentucky to regulate all point sources so as to be in compliance with the water quality regulations and any associated TMDLs for the associated receiving water body. More information on the Kentucky KPDES program can be found at: http://www.water.ky.gov.

KPDES Storm Water Permit Program

The Kentucky Department of Environmental Protection (DEP) is responsible for administering the state's storm water management program. Kentucky's storm water program is closely modeled after the federal NPDES program, which requires storm water be treated to the maximum extent practicable. Kentucky's DEP storm water program requires all construction sites disturbing more than one acre, many industrial sites, and Municipal Separate Storm Sewer Systems (MS4s) to obtain permit coverage. Permitted MS4s are responsible for establishing a Storm Water Management Program (SWMP) that implements all of the requirements established by the federal NPDES program. More information on the Kentucky KPDES storm water permit program may be found at: http://www.water.ky.gov. Numeric treatment requirements specific to storm water have not been established at the state level, but water quality parameters will be established on a site-by-site basis when the risk of contamination is present. More stringent treatment requirements exist at the county and local level, especially in Lexington-Fayette County where sensitive karst topography drives treatment objectives.

Kentucky Agriculture Water Quality Act

The Kentucky General Assembly passed the Kentucky Agriculture Water Quality Act (KAWQA) in 1994. The goal of the act is to protect surface and groundwater resources from pollution as a result of agriculture and silviculture (forestry) activities. The Agriculture Water Quality Act requires all landowner/land users with ten or more acres that are being used for agriculture or silviculture operations to develop and implement a water quality plan based upon guidance from the Kentucky Agriculture Water Quality Plan (KAWQP). Individual landowners/land users must have fully implemented applicable requirements of the Kentucky Agriculture Water Quality Plan by October 23, 2001. Various tools are available to help landowners develop their plan. After identifying the best management practices, landowners/land users implement these practices on their land. Assistance to implement the plan can be obtained through a variety of technical agencies. The Kentucky Agriculture Water Quality Plan consists of best management practices from six different areas - Silviculture, Pesticides and Fertilizers, Farmstead, Crops, Livestock, and Streams and Other Waters. Each BMP includes definitions and descriptions, regulatory requirements, Agriculture Water Quality Authority requirements, design information, practice maintenance, technical assistance, cost share assistance, recommendations and references.

The continued implementation of the KAWQA on farms throughout the Cane Run Watershed would greatly improve water quality by decreasing the input of agricultural pollutants such as nutrients, bacteria, and sediment to the stream system.

Kentucky 319(h) Program

The Clean Water Act (CWA) was enacted in 1972 to provide guidance and authority to address all pollutants to water quality. In 1987, Congress amended the CWA to establish the Section 319(h) Nonpoint Source Management Program and Grant Program. Resources are available through 319(h) funds to conduct watershed restoration for watersheds that have a Watershed Based Plan (WBP). In particular, according to the Federal Section 319(h) grant guidance, a major segment of future funds will only be available to watersheds that have a WBP[16].

Ground Water Protection Plan Regulation

401 KAR 5:037 was approved in 1994 by the Division of Water to aid in the protection of Kentucky's groundwater resources. This regulation states that anyone engaged in activities that have the potential to pollute groundwater must develop and implement a Groundwater Protection Plan. The purpose of these plans is to educate residents about the sensitivity of groundwater and help them identify best management practices that safeguard this valuable resource. KDOW offers technical assistance in the creation of these plans, and more information is available on their website http://water.ky.gov/.

The continued implementation of the groundwater protection plans on operations within the Cane Run Watershed would greatly improve water quality in both the Cane Run and the Royal Spring.

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[16] Nonpoint Source Program and Grants Guidelines for States and Territories, 2003, Federal Register 68:205 (October 23, 2003) p. 60653.

USDA Conservation Programs

The Conservation Reserve Program (CRP) is available to producers willing to set aside highly erodible, riparian, and other environmentally sensitive lands from crop production for 10-15 years. In addition to an annual CRP payment, USDA will provide a 50% cost share to establish the selected conservation practice.

The Wetlands Reserve Program (WRP) is available for restoring wetlands in the environment. Up to 100% of the cost for restoring a wetland is provided by the USDA. The wetland easement can be either a permanent easement, 30-yr easement, or no easement and a cost-share agreement.

Wildlife Habitat Incentives Program (WHIP) provides money for landowners to develop or improve wildlife habitat on private lands. USDA provides technical assistance and up to 75% cost share for installation. The agreement normally lasts for a minimum of 1 year.

Environmental Quality Incentive Program (EQIP) can provide assistance to landowners for addressing waste management, erosion, and other problems in areas where water quality is not meeting objectives. EQIP will provide up to 60% cost-share for restoration.

The implementation of these programs by farmers in the Cane Run Watershed would increase water quality substantially.

Kentucky Watershed Management Framework

A Watershed Management Framework approach to Water Quality Management (WQM) was adopted by KDOW. The plan divides Kentucky's major drainage basins into five groups of basins which are cycled through a five year staggered process which involves monitoring, assessment, prioritization, plan development, and plan implementation. The Kentucky River Basin was selected as the first river basin to be processed through the framework and Cane Run Creek emerged as one of the priority watersheds within the river basin[17]. As part of the watershed management framework process, a basin coordinator is assigned to each river basin that works with the citizens of the basin to develop local watershed management teams associated with each priority watershed. In addition to normal ambient monitoring, KDOW resources for state water quality assessment and monitoring have been coordinated to provide more detailed and focused sampling for one of the major river basins every five years. This program is an excellent source of water quality data for the Cane Run, especially because Cane Run is impaired and located within a priority watershed.

Non-Governmental Organizations (NGOs)

There are several NGOs operating in the Cane Run and nearby watersheds that may help in implementing water quality programs in Cane Run and Royal Spring, especially with regard to non-point source issues. These include Bluegrass PRIDE, Kentucky River Watershed Watch, and Friends of Cane Run, Inc.

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[17] Kentucky Energy and Environment Cabinet. 2011. http://water.ky.gov/watershed/Pages/WMSchedules.aspx.

Bluegrass PRIDE

Bluegrass PRIDE was established in the fall of 2001. More information about Bluegrass PRIDE can be found at: http://www.bgpride.org/.

Kentucky Watershed Watch

The Kentucky River Watershed Watch performs annual volunteer sampling throughout the Kentucky River Basin, including watersheds near the Cane Run. This sampling and the associated data can also be used to assess progress in meeting the designated use for the stream. Kentucky River Watershed Watch has also developed citizen's action plans for several sub-watersheds in the Kentucky River Basin. More information about Kentucky Watershed Watch can be found at: http://www.uky.edu/OtherOrgs/KRWW/

Friends of Cane Run, Inc.

The Friends of Cane Run, Inc. is a non-government organization. It consists of neighbors organized to protect and improve the Cane Run Watershed. More information can be found at http://kywater.net/canerun/.

Actual Sources of Assistance

Kentucky 319(h) Program

The Cane Run Watershed Project has received $599,915.68 from the 319(h) program between December 2007 and December 2010. This program is providing funding for the Cane Run Watershed Project from December 2007 through October 2012. Sixty percent of the grant money comes from this program, and 40% comes from a match provided by SB-271 funding, described below.

SB-271

Senate Bill 271 allocates money to the UK College of Agriculture each year to find ways to assess and improve water quality in agricultural settings through research, best management practice implementation, and education and outreach. The Cane Run Watershed Project has received $399,943.77 from SB-271 between December 2007 and December 2010 as the 40% match needed for the 319(h) program described above.

In addition to matching 319(h) funds, SB-271 has provided approximately $86,000 for BMP implementation and research in the Cane Run Watershed. Approximately $45,000 was allocated to the Kentucky Geological Survey for geological research in the Cane Run and Royal Spring watershed, and approximately $41,000 has been spent to renovate the dairy operation at UK's Experiment Station to improve stormwater and manure management.

KPDES Wastewater Permit Program

As a result of violations of this permitting program, a Consent Decree has been signed by LFUCG, the U.S. EPA, and KDOW to limit sanitary sewer overflows into the waters exiting the city of Lexington. The corrections required by this Consent Decree, when made by LFUCG, will greatly improve water quality in the Cane Run Watershed. The Consent Decree can be found in Appendix B.

KPDES Storm Water Permit Program

As a result of violations of this permitting program, a Consent Decree has been signed by LFUCG, the U.S. EPA, and KDOW. As part of this Consent Decree, stormwater systems in Lexington will be ameliorated, which will improve water quality in the Cane Run Watershed. The Consent Decree can be found in Appendix B.

USDA Conservation Programs

<u>Earmark</u>

The United States Department of Agriculture's Natural Resource Conservation Service has allocated a $359,681 earmark to a project titled "Development and Implementation of Stream Restoration and Riparian Corridor Techniques for Enhancing Water Quality in the Cane Run Watershed". This earmark is being used by University of Kentucky faculty, students, and staff to conduct four research projects within the Cane Run

Watershed that will not only restore stream sections within the Cane Run, but will add to the growing body of knowledge of stream restoration techniques that can be used for future restoration projects.

Conservation Reserve Program

The University of Kentucky Experiment Station was awarded $8,300 from the USDA's Conservation Reserve Program to establish a riparian buffer along an un-named tributary of the Cane Run.

The Kentucky Soil Erosion and Water Quality Cost Share Program

One landowner within the Cane Run Watershed has received funding through this program to implement water quality BMPs in 2011. The project and funded amount are protected information and are available only through a Freedom of Information Act request.

Kentucky American Water

Kentucky American Water provided approximately $2,500 for Cane Run Watershed signs that are posted around the watershed to educate residents and visitors.

University of Kentucky

In 2010, the Cane Run Watershed Project received a $10,000 Commonwealth Collaborative Award for additional education and outreach activities. These funds have been used for educational signage on the Legacy Trail and printing of brochures distributed at the 2010 World Equestrian Games.

Lexmark

Lexmark has committed to improving water quality in the Cane Run Watershed by allocating financial and personnel resources to projects that improve water quality such as stream clean-ups, invasive species removal, impervious surface removal, and stream restoration.

University of Kentucky – College of Agriculture

The College of Agriculture has donated land easements to the Legacy Trail that will be managed as no-mow zones, which will ultimately improve water quality in the Cane Run. The College of Agriculture has also allocated technical and financial assistance for water-quality-conscious land management.

The Commonwealth of Kentucky

In 2007, state legislator Jesse Crenshaw secured $2.6 million from the state legislature to address flooding and stormwater problems in the Green Acres and Hollow Creek neighborhoods. This money, when used by LFUCG, will have a large positive impact on water quality in the Cane Run Watershed.

LFUCG's Sump Pump Redirect Program

Sump pumps pump storm water out of basements, and in older properties this water is often discharged into the sanitary sewer. The sanitary sewer system works on gravity until it reaches a pump station that pumps sewage over the topography. It only takes 6 houses with sump pumps that discharge into the sanitary sewer to displace an 8-inch sewer pipe. By redirecting sump pump discharges to a rain garden or even to the storm sewer, the sanitary sewer system regains capacity. In an effort to redirect sump pump discharges, LFUCG has a sump pump redirect program that will pay the full cost of redirecting residential sump pumps. With this program, as of February 2011, approximately $150,000 has been used to redirect approximately 70 sump pumps in the Cane Run Watershed, which allows the sanitary sewer to gain capacity.

VIII. Catchment Analyses

In order to describe the key problems along the stream and identify potential BMPs, the watershed has been divided into catchments and then stream segments within those catchments. Pollution in the Cane Run Watershed comes from both point and nonpoint sources, and both are described below for each catchment. The monitoring data available for each catchment and the results of this monitoring is also discussed, followed by a segment-by-segment listing of priority BMPs to be implemented based on primary pollutant sources for each catchment. The BMPs actually implemented thus far are also described for each stream section in each segment.

Catchment 10

Pollutant Source Assessment

The 303(d) listed segment of Cane Run that begins in Catchment 10 (that also flows in Catchments 9 and 8) has been identified as having high levels of fecal coliform, nutrients, and sewage, with suspected sources including livestock and unspecified urban stormwater (Figure 55). Other point and nonpoint sources that could also contribute to this pollution are described below.

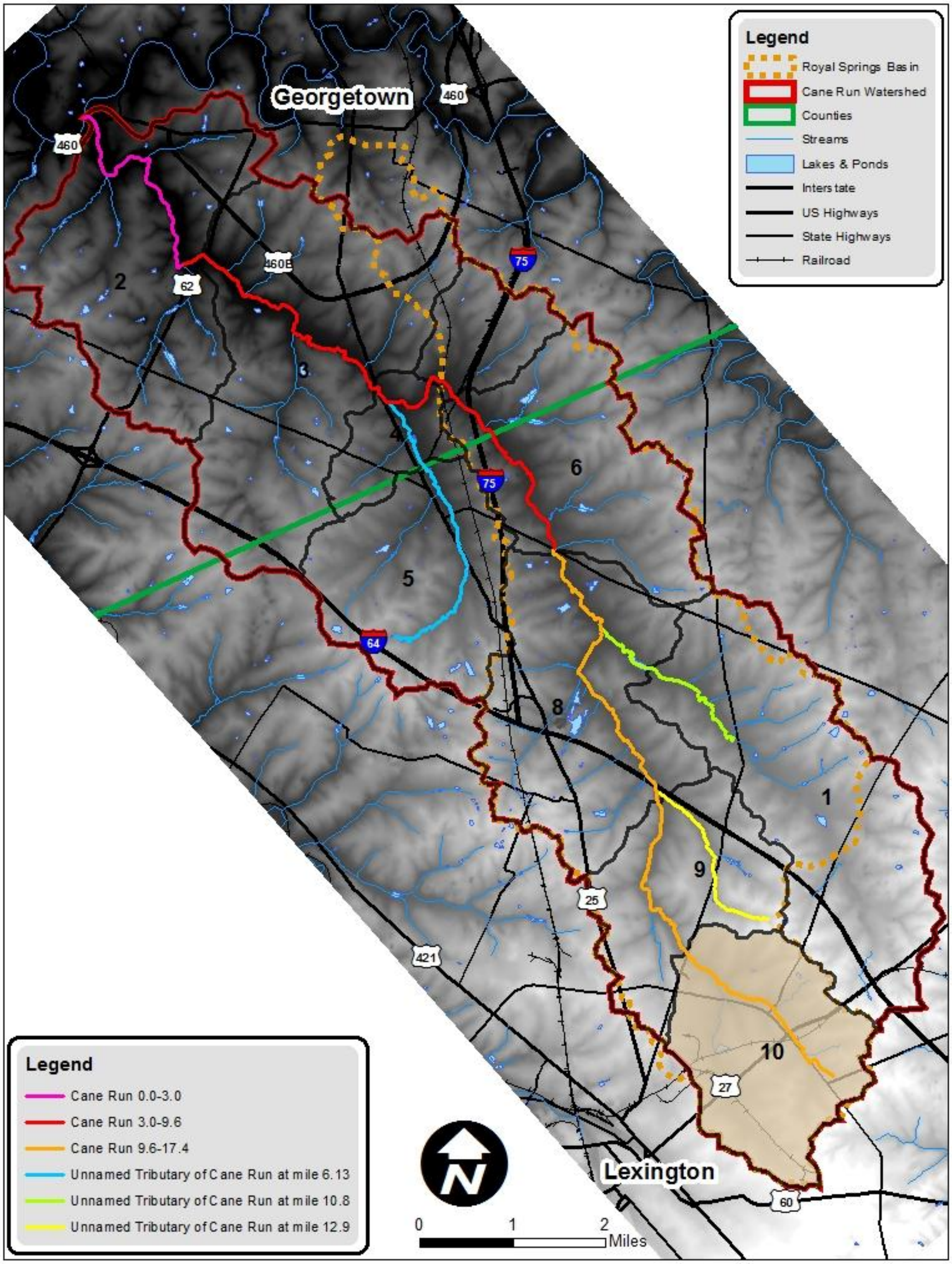

Figure 55. Impaired stream section in Catchment 10

Point Sources

There are several possible sources of point source pollution within Catchment 10, including KPDES-permitted facilities, Class V injection wells, sanitary sewer overflows, failing onsite wastewater treatment systems, and straight pipes (Figure 56). These point sources contribute mainly to bacteria and nutrient pollution. Ground-truthing conducted within the catchment also points to many point sources of trash and unknown discharges to the stream and storm sewer. A map of problem areas found within this catchment is shown in Figure 57, and Appendix T describes and gives a more detailed map of each problem area found through the ground-truthing effort of the University of Kentucky.

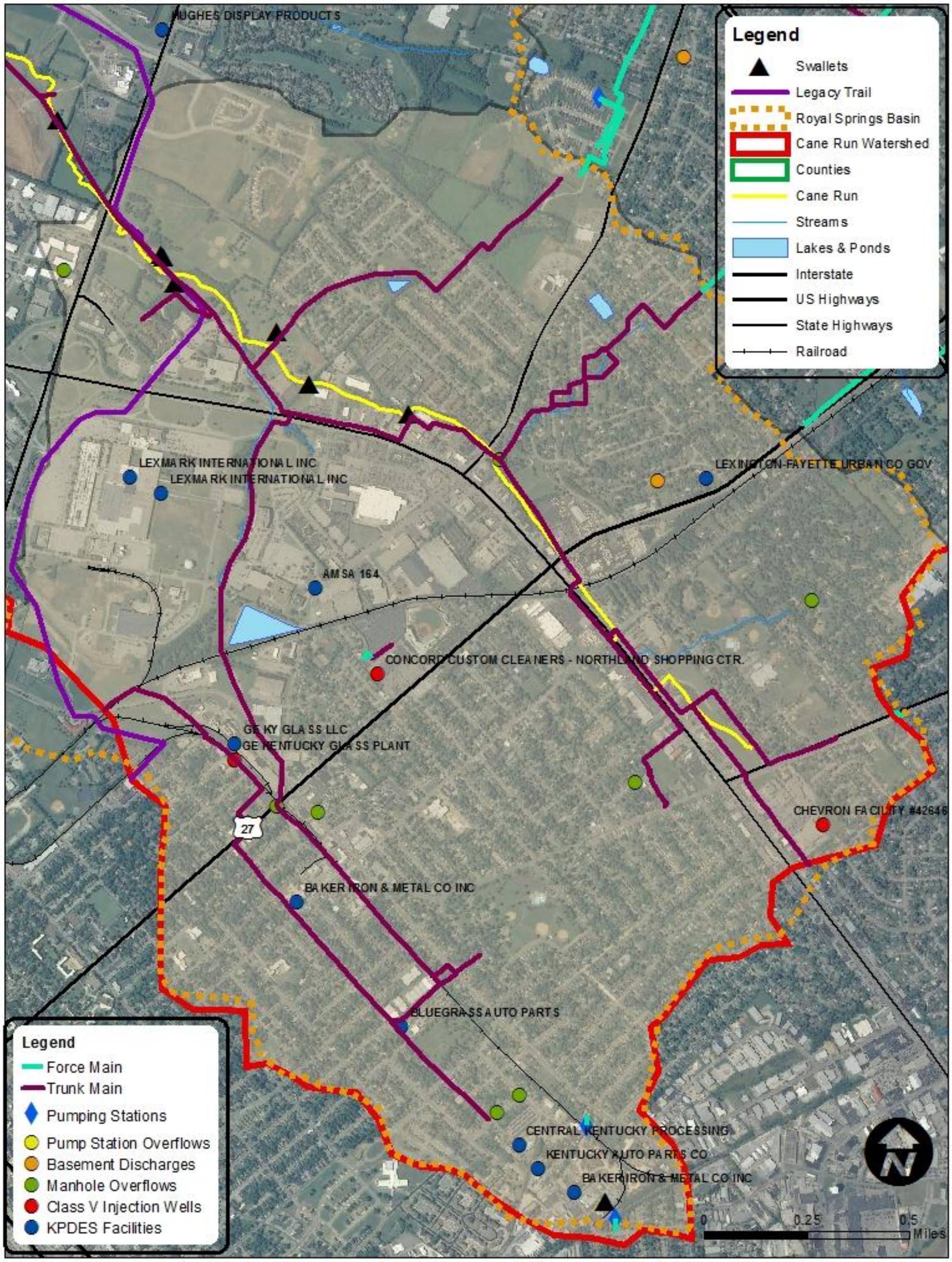

Figure 56. Potential point sources in Catchment 10

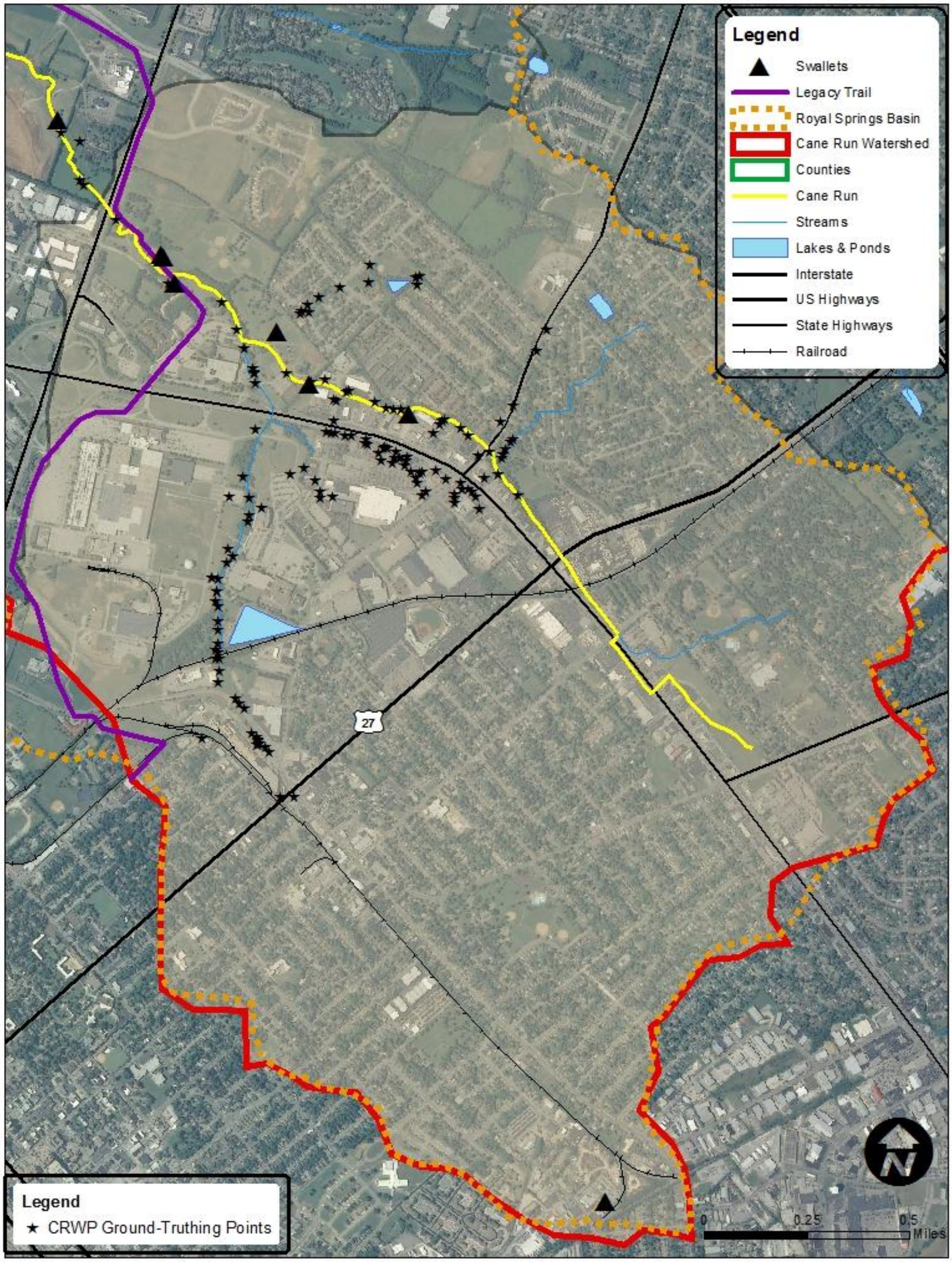

Figure 57. Problems found during CRWP ground-truthing in Catchment 10

KPDES-Permitted Facilities

There are 10 KPDES permitted facilities in Catchment 10, and the details of each facility can be found in Table 34. None of the KPDES facilities in this catchment discharge the major pollutants of concern for the Cane Run, which include bacteria and nutrients. Several facilities are monitored for parameters that could have an impact on sediment, but as the 303(d) listing and monitoring data indicate, sediment does not appear to be an issue for this catchment.

Table 34. KPDES facilities in Catchment 10

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences
KYR001740	AMSA 164	1051 Russell Cave Pike, Lexington, KY 40564	Kentucky River/City of Lexington	--	--	--
KYR001242	Baker Iron & Metal Co Inc.	757 E 7th St, Lexington, KY 40508	Lexington Storm Sewer	--	--	--
KYR001243	Baker Iron & Metal Co Inc.	723, 727, 701, 707-721 N Limestone & 115 W 7th St, Lexington, KY 40508	Lexington Storm Sewer	--	--	--
KYR001453	Bluegrass Auto Parts	351 E 7th St, Lexington, KY 40508	Lexington Storm Sewer	--	--	--
KYR001230	Central Kentucky Processing	657 E Seventh St, Lexington, KY 40505	Lexington Storm Sewer	--	--	--
KY0002739	GE KY Glass LLC	903 Russell Cave Rd, Lexington, KY 40505	Cane Run Creek/Unnamed Tributary	pH	Jan-08-Dec-10	None
				Flow	Jan-08-Dec-10	None
				Oil and grease	Jan-08-Dec-10	None
				Settleable solids	Jan-08-Dec-10	None
KYR001457	Kentucky Auto Parts Co	710 E 7th St, Lexington, KY 40505	Lexington Storm Sewer	--	--	--
KYR100596	Lexington-Fayette	North of New Circle Road and	Cane Run Stream	--	--	--

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences
	Urban Co Gov.	South of I-64/75, KY				
KY0001317	Lexmark International Inc.	740 W New Circle Rd, Lexington, KY 40550	Cane Run Creek/Unnamed Tributary	Total suspended solids	Jan-08-Dec-10	6
				Total residual chlorine	Jan-08-Dec-10	6
				Flow	Jan-08-Dec-10	2
				Hardness	Jan-08-Dec-10	2
				Oil and Grease	Jan-08-Dec-10	2
				pH	Jan-08-Dec-10	2
				Silver	Jan-08-Dec-10	1
				Zinc	Jan-08-Dec-10	2
				Copper	Jan-08-Dec-10	1
				Temperature	Jan-08-Dec-10	None
KY0097624	Lexmark International Inc.	740 W New Circle Rd, Lexington, KY 40550	Cane Run Creek/Unnamed Tributary	Total suspended solids	Jan-08-Dec-10	6
				Total residual chlorine	Jan-08-Dec-10	6
				Flow	Jan-08-Dec-10	2
				Hardness	Jan-08-Dec-10	2
				Oil and Grease	Jan-08-Dec-10	2
				pH	Jan-08-Dec-10	2
				Silver	Jan-08-Dec-10	1

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences
				Zinc	Jan-08-Dec-10	2
				Copper	Jan-08-Dec-10	1
				Temperature	Jan-08-Dec-10	None

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[18] There are many different types of Class V injection wells, but in Catchment 10, there are only two wells, both of which are used for aquifer remediation (Table 35). Aquifer remediation wells (ARW) are used to clean up, treat, or prevent the contamination of ground water and may be associated with RCRA or Superfund cleanup projects. Usually treated groundwater, bioremediation agents, or other recovery enhancement materials are pumped into these wells, and the potential for spills or illicit discharges is low, which makes the probability of point source pollution from Class V injection wells low in this catchment[19].

Table 35. Class V injection well locations in Catchment 10

EPA ID	Company Name	Address	Well Type
KYV067013	GE Kentucky Glass Plant	903 Russell Cave Rd, Lexington, KY	Aquifer remediation
KYV067013	Concord Custom Cleaners – Northland Shopping Ctr.	1245 North Broadway, Lexington, KY	Determined not to be a Class V well
KYV067014	Chevron Facility #42646	461 New Circle Rd East, Lexington, KY	Aquifer remediation

Sanitary Sewer Overflows

Point source pollution may originate from the existing wastewater collection infrastructure. All of the sewage in the Cane Run is typically collected by gravity systems that are then pumped via force mains into the adjacent Town Branch watershed where the Town Branch Wastewater Treatment plant is located. Much of the wastewater infrastructure runs parallel to or in natural drainage ways and streams, and leaks in the mains, manhole overflows, pump station overflows, and basement discharges can contribute significant amounts of pollution to surface water resources. Table 36 shows known locations of recurring sanitary sewer overflows and unpermitted discharges in Catchment 10. There are likely additional sources from broken or failing sanitary sewer lines in the older neighborhoods within the catchment.

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[18] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm
[19] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Aquifer remediation wells." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_aq_remed_wells.pdf

Table 36. Recurring locations of sanitary sewer overflows and unpermitted discharges in Catchment 10[20]

SSO Location	SSO Category	MH Number
1736 Hawthorne Ln.	Basement	--
Seventh and Jackson	Manhole	CR6-130A
Shelby St.	Manhole	CR6-132A
Edgelawn Ave.	Manhole	CR5-201
Cane Run/ Russell Cave Rd.	Manhole	CR4-15
Newtown Pike	Manhole	CR7-125
Deepwood Dr.	Manhole	CR5-25
Loudon Ave. (115)	Manhole	CR3-18C
772 N. Broadway	Cross connection	CR3-51

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. The U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[21]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[22]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 3 failing OWTSs in Catchment 10 that contribute a fecal coliform load of 1.22E+09 cfu/day.

[20]United States of America and the Commonwealth of Kentucky v. Lexington-Fayette Urban County Government, March 14, 2006, Consent Decree, Lodged in the United States District Court, Eastern District of Kentucky, Central Division at Lexington, Related to Civil Action No. 5:06-cv-00386. "Appendix A: Recurring Locations of SSOs and Unpermitted Discharges." Available at: http://www.lexingtonky.gov/Modules/ShowDocument.aspx?documentid=3571

[21] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.

[22] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 8 straight pipes in Catchment 10 that contribute a fecal coliform load of 6.06E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment contribute a phosphorus load of 0.567 lbs/day.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 10 of the Cane Run and Royal Spring Watershed. These nonpoint sources include mostly non-agricultural sources, as the majority of the land in this catchment is developed to some degree (Table 37 and Figure 58). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 37. Land cover in Catchment 10

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture/ Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	1.56	2342.70	5.34	94.30	15.57	1.33	203.49	10.45	1.33	**2676**
Percent	0.06	87.54	0.20	3.52	0.58	0.05	7.60	0.39	0.05	**100**

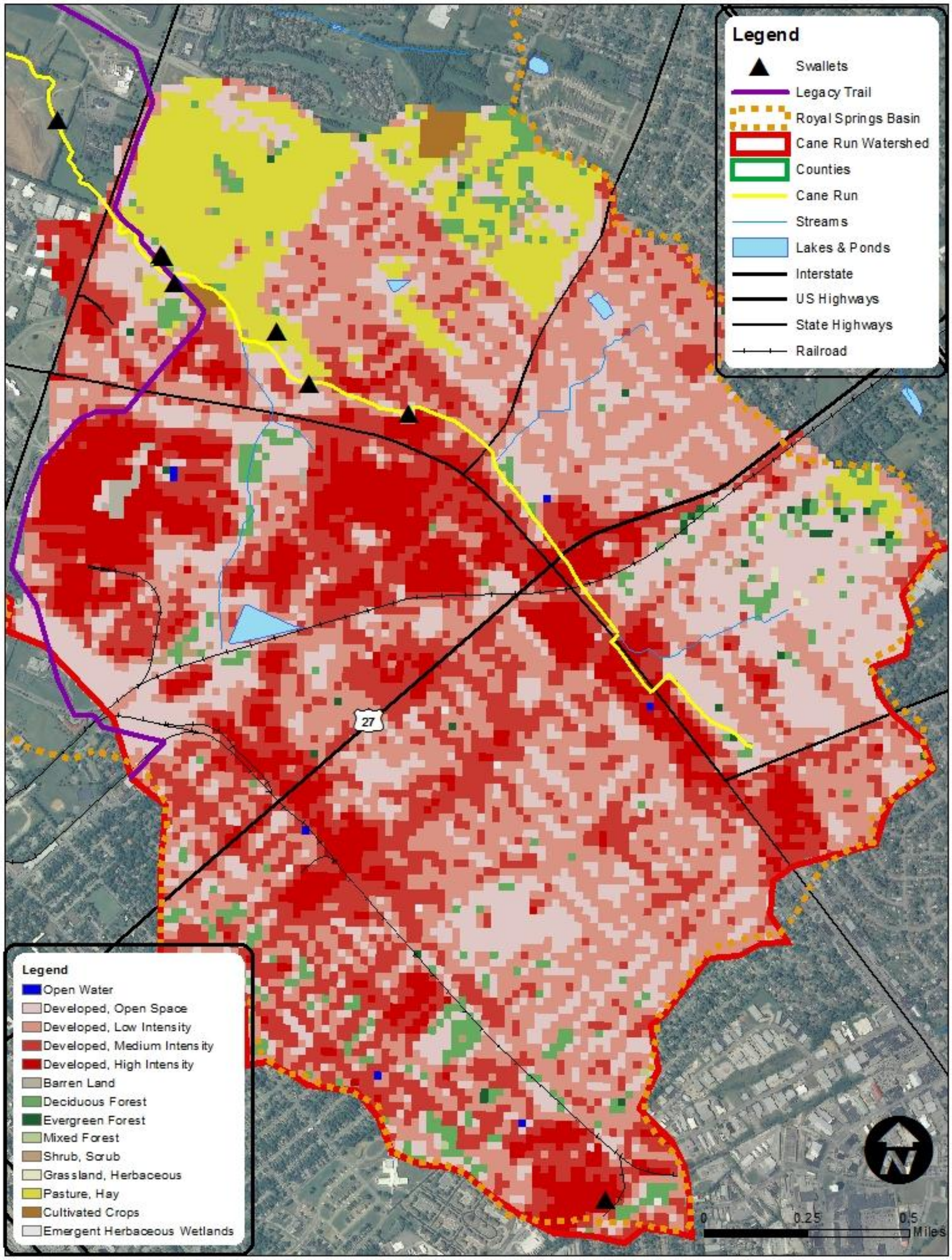

Figure 58. Land cover in Catchment 10

Stream Bank Erosion

Lack of sufficient runoff and erosion controls and a large amount of impervious surface result in increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability. Stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail. This is a problem in Catchment 10, as was identified by the CRWP ground-truthing effort, which found over 10 instances of bank erosion that are recorded in the report found in Appendix T.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 0.650 lbs/day. This contribution is low compared to other catchments, but this is likely because the amount of un-developed land in this catchment is extremely low.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[23]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 10 and their daily fecal coliform load contribution can be found in Table 38.

Table 38. Wildlife population estimates and daily fecal coliform load contribution for Catchment 10

Animal	Population	Fecal counts/day
Ducks	5	1.22E+10
Geese	3	1.47E+11
Deer	3	1.50E+09
Beavers	1	2.50E+08
Raccoons	3	3.75E+08

[23] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[24].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 10 and their daily fecal coliform load contribution can be found in Table 39.

Table 39. Livestock population estimates and daily fecal coliform load contribution for Catchment 10

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock, including cattle in streams)
Hogs	0	0.00E+00	--
Beef Cattle	32	2.25E+10	8.21E+10
Dairy Cattle	4	9.37E+09	--
Chickens	2	9.79E+07	--
Horses	30	1.57E+09	1.00E+10
Sheep	0	--	0.00E+00
Goats	0	--	0.00E+00

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this

[24] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

catchment, developed land contributes a phosphorus load of 4.835 lbs/day. This contribution is the highest of any catchment because it has the greatest area of developed land.

Domestic Pets

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[25]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential, and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 10 are the highest for any of catchment within the Cane Run Watershed and are shown in Table 40.

Table 40. Daily fecal coliform load contributions from developed land in Catchment 10

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
1.86E+09	5.72E+09	2.34E+10	1.84E+07

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 10. Fertilizers make their way into streams through stormwater runoff.

[25] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 10 (Table 41 and Figure 59).

Lexington-Fayette Urban County Government (LFUCG) has been performing bacteria sampling in this catchment in support of its KPDES Stormwater Permit since 1993.

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources.

In 2005, the city of Georgetown contracted with Dr. Gail Brion at the University of Kentucky to conduct a study within the Cane Run Watershed in an attempt to identify and rank potential sources of sewage contamination into the Royal Springs water supply. Monitoring points for this study were established in this catchment.

Water samples were taken at stations in this catchment in 2006 and 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development.

The University of Kentucky Biosystems and Agricultural Engineering Department established a monitoring network for bacteria and sediment in support of bacteria TMDL development, and sampled in this catchment in 2008, 2009, and 2010 as part of the Cane Run Watershed Project.

In the summer of 2010, University of Kentucky student interns with the Cane Run Watershed Project sampled smaller tributaries with the goal of dividing Cane Run Watershed into several sub-watersheds, making it easier to determine the sources and quantities of bacteria pollution contributing to the Cane Run. Some of this sampling was conducted in this catchment.

The University of Kentucky Biosystems and Agricultural Engineering Department established permanent cross-sections in this catchment to assess the physical condition of the stream.

The Kentucky Division of Water (KDOW) established bank pins (toe, bankfull and top of bank) in this catchment to assess the physical condition of the stream.

Table 41. Monitoring conducted in Catchment 10

Sampling Entity	Parameters	Sampling Dates	Site IDs
LFUCG	Bacteria	1993-present	S1, L2
KWRRI	Bacteria	2002	C0
City of Georgetown	Bacteria	2005	IBM
KDOW	Nutrients	2006-2007	04018009
CRWP	Bacteria, Sediment	2008-2010	CR13, CR01, CR02, CR14
CRWP (Targeted Sampling)	Bacteria	2010	204-207
CRWP	Geomorphology	2008-2010	CR01 (Riffle and Pool), CR02 (Riffle

Sampling Entity	Parameters	Sampling Dates	Site IDs
			and Pool), CR03 (Riffle and Pool)
KDOW	Geomorphology	2006-2007	20-23

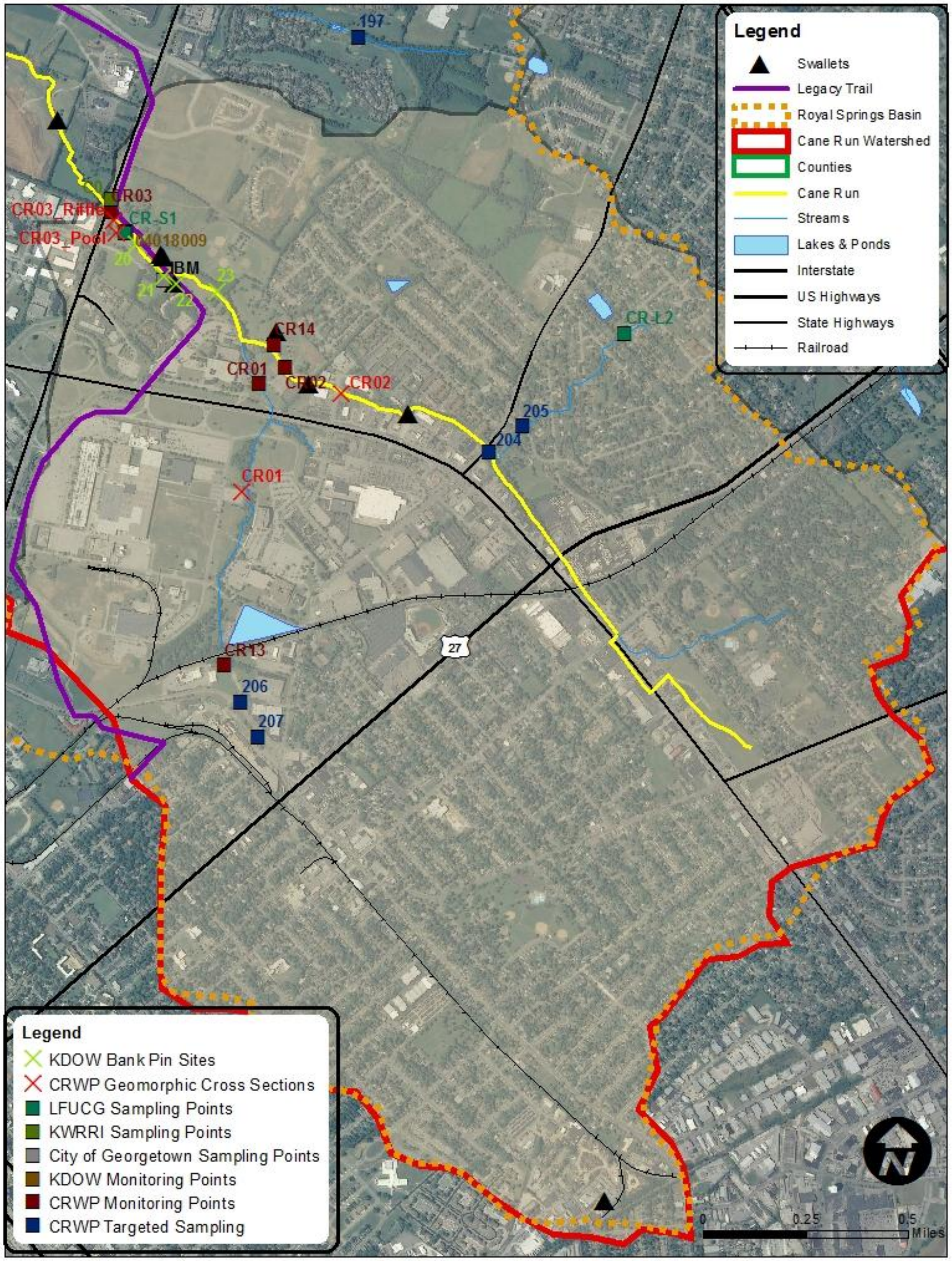

Figure 59. Monitoring points in Catchment 10

Monitoring Conclusions

<u>Geomorphology</u>

A total of eight cross-sections (two each at CR01, CR02 and CR03) were established in Catchment 10 along Cane Run in Lexmark Park. The CR01, CR02, and CR03 cross-sections are located at the water quality monitoring points CR01, CR02, and CR03, respectively. According to the Rosgen system of stream classification, the reaches at CR01 and CR02 classify as E stream types with CR01, having a bedrock streambed and CR02 having a gravel-dominated streambed. Due to channel incision along CR03, this reach immediately upstream of Newtown Pike classifies as a B stream type with a streambed dominated by gravel. Riparian vegetation at CR01 consists solely of grass while at CR02 sparse trees punctuate the grass riparian vegetation. From the confluence of the tributaries immediately downstream of CR01 and CR02, a row of trees and invasive species such as bush honeysuckle line the streambanks. In some areas along CR03, only grasses and weeds are found along the left streambank.

At both CR01 and CR02, bank height ratios (BHRs) are 1.1 or less at the riffles, indicating the stream is connected to its floodplain in some areas; however, for the pool cross-sections, BHRs are 1.4 or greater. At CR03, BHRs are 1.5 or greater, showing the decreased vertical streambank stability at this downstream section. Cross-sectional areas change little for CR02 (no 2010 data were available for CR01). At CR03, increases of 6.1 and 12.3 ft^2 were measured for the riffle and pool cross-sections, respectively, indicating that erosion is actively occurring. Bank erosion hazard index (BEHI) rankings at CR02_Riffle left were driven by the BHR and the bank angle which was greater than 90°. At other locations, BHR and lack of thick riparian vegetation resulted in the moderate and high BEHI rankings. A summary of these results can be found in Table 42.

Table 42. Average annual erosion/deposition rates within Catchment 10

Cross-section	Bank	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
CR02_Riffle	Left	High	Low	0.087
CR02_Riffle	Right	Low	Low/Moderate	0.1483
CR02_Pool	Left	Moderate	Moderate	-0.128
CR02_Pool	Right	High	Low/Moderate	0.123
CR03_Riffle	Left	Moderate	Low	0.115
CR03_Riffle	Right	Moderate	Low	0.064
CR03_Pool	Left	Moderate	Moderate	-0.413
CR03_Pool	Right	Moderate	High	1.459

The KDOW established bank pins (toe, bankfull and top of bank) at four locations upstream of CR03 and downstream of the confluence. The KDOW determined BEHI and near bank stress (NBS) values for each location and measured the amount of bank pin exposed for all recoverable bank pins (Table 43). No additional information (e.g. photographs and cross-sectional surveys) were provided by KDOW. University of Kentucky personnel could not locate these monitoring locations to collect additional data. These data, like that collected by the University of Kentucky, indicate erosion rates within this Catchment can be high along the main stem of Cane Run below the confluence.

Table 43. KDOW average annual erosion deposition rates in Catchment 10

Bank Pin Location	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
20	Very High	High/Extreme	0.677
21	Moderate	Low/Moderate	--[1]
22	Moderate	Extreme	0.622
23	Moderate	Low	0.115

[1]Not all bank pins were recovered.

Based on the results of the geomorphic assessment of Cane Run in Lexmark Park, much of this stream reach, with the exception of portion upstream of CR01, is exhibiting signs of instability due to high BHR. Upstream from the confluence at CR02 and along the left bank of the stream reach from the confluence to CR03, lack of deep rooting riparian vegetation is also a concern. Efforts should be undertaken to reduce the BHR through this reach (e.g. creation of bankfull benches), remove invasive vegetation, and establish a riparian buffer. Stream restoration from the confluence toward the Lexmark property line along CR02 has already accomplished much of this; however, the section below the confluence to CR03 would benefit from stream restoration. The reach along CR01 would likely benefit the most from the establishment of a tree-dominated riparian buffer.

Developed land accounts for about 94.4 percent of the land use at CR01 (Figure 60). As such, water temperatures in this reach are likely influenced by heat from impervious surfaces (e.g. solar radiation on pavement). Additionally, this reach receives cooling water from Lexmark. During the summer months, water temperatures at CR01 can reach 96°F (Table 44).

Developed land accounts for about 96 percent of the land use at CR02 (Figure 61). As such, temperatures in this reach are likely influenced by heat from impervious surfaces (e.g. solar radiation on pavement). During the summer months, water temperatures at CR02 can reach 83°F, which is about 10°F cooler than CR01 (Table 44).

Developed land accounts for about 88.1 percent of the land use at CR03 (Figure 62). As such, temperatures in this reach are likely influenced by heat from impervious surfaces (e.g. solar radiation on pavement). During the summer months, water temperatures at CR03 can reach 96°F (Table 44). The water temperature in this reach is largely affected by the cooling waters from Lexmark that are released into the CR01 reach.

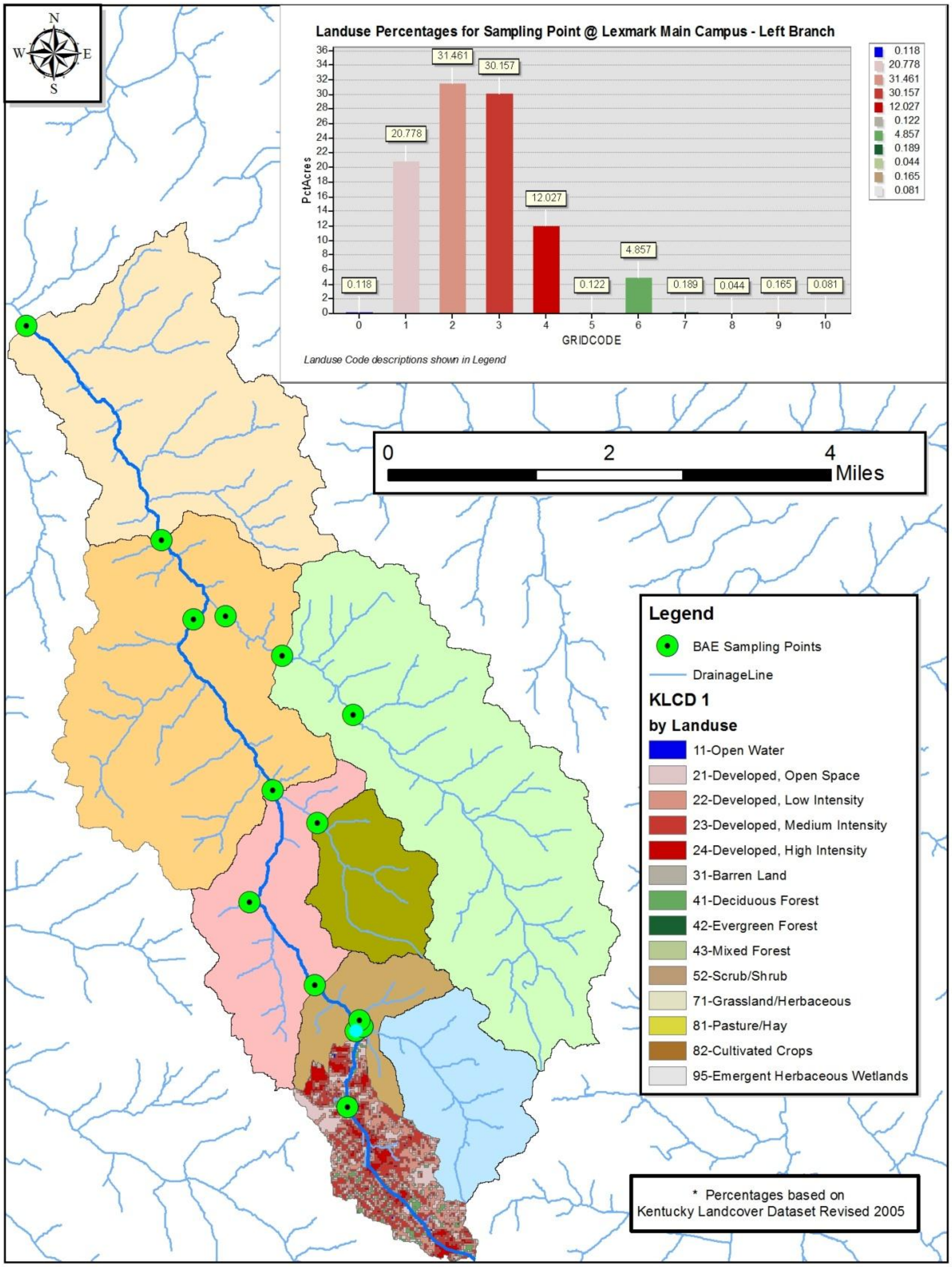

Figure 60. Land use for CR01 in Catchment 10

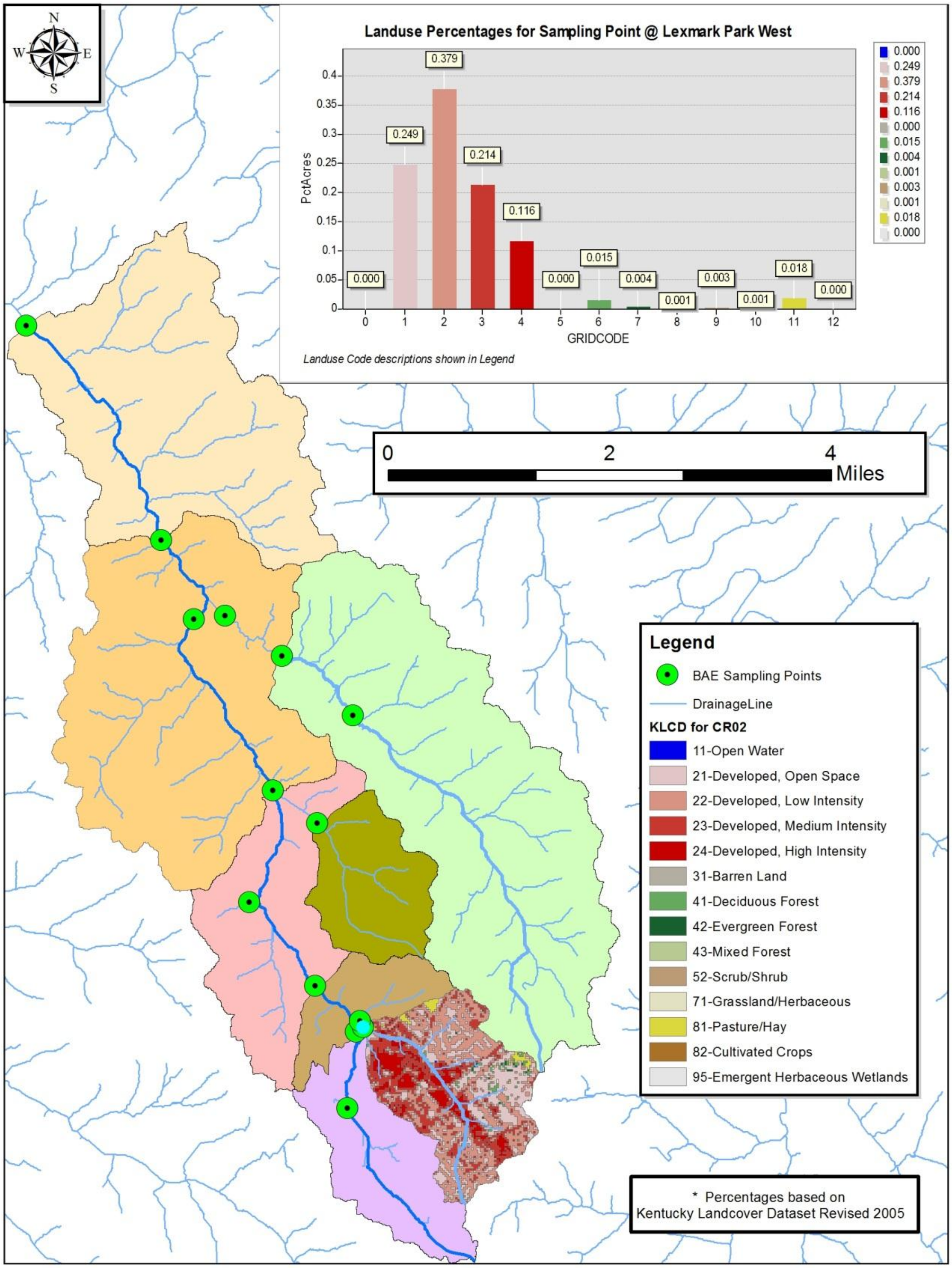

Figure 61. Land use for CR02 in Catchment 10

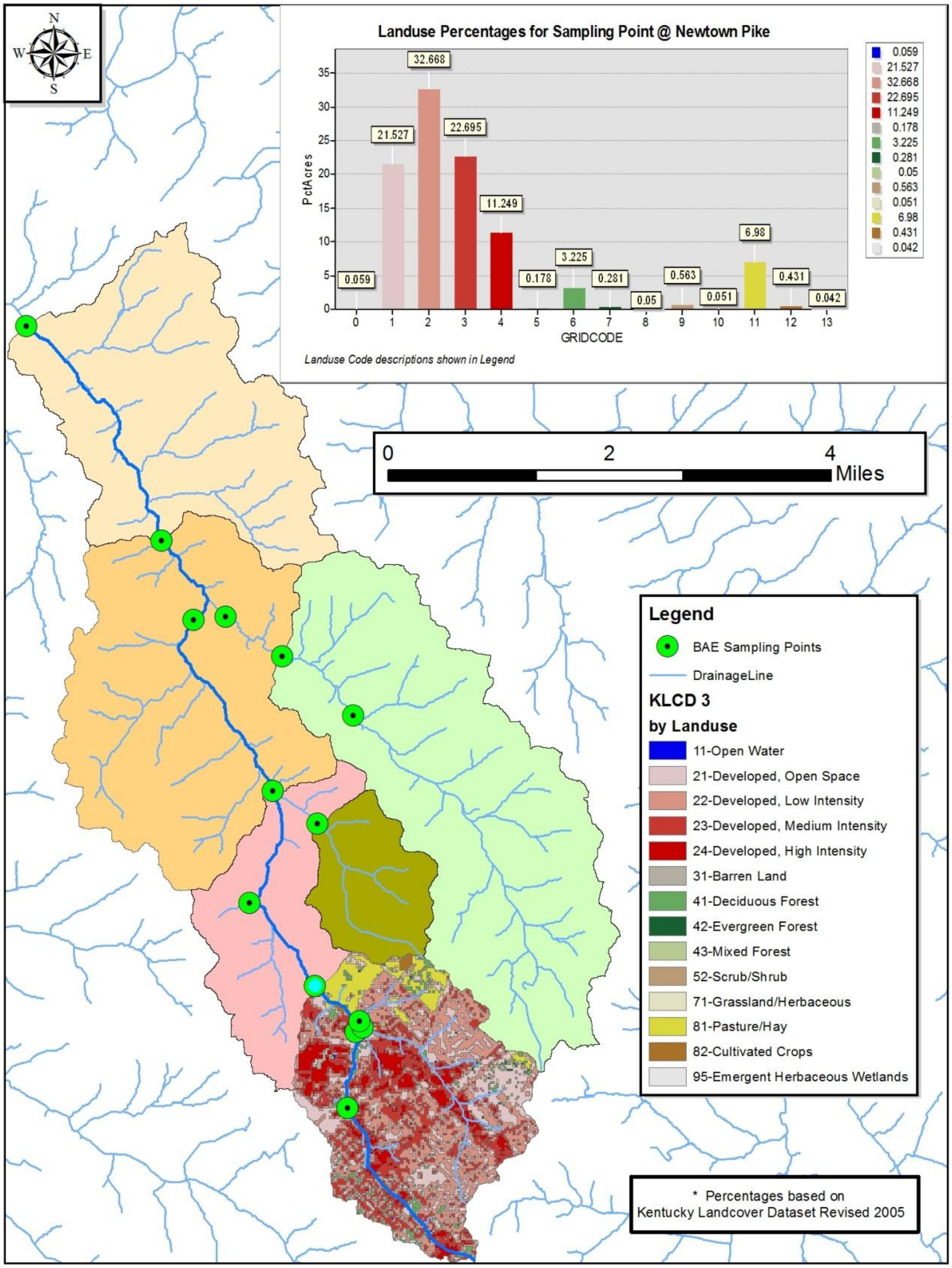

Figure 62. Land use for CR03 in Catchment 10

Table 44. Maximum water temperatures within Catchment 10

Year	Month	Maximum Temperature (°F) CR01	CR02	CR03
2008	June	84.0	81.8	70.9
	July	96.3	79.5	89.5
	August	96.3	79.1	86.6
	September	97.7	79.2	82.5
	October	88.0	66.4	74.0
	November	80.3	56.0	78.2
2009	April	68.3	78.9	76.6
	May	75.8	76.5	80.2
	June	83.0	83.3	86.7
	July	82.3	79.6	82.9
	August	81.1	79.5	84.2
	September	78.2	77.1	76.1
	October	67.5	68.6	67.3
	November	61.5	61.5	61.4
	December	58.2	55.6	56.4
2010	January	55.6	53.6	54.4
	February	53.8	52.8	55.9
	March	63.5	59.5	72.0
	April	72.1	74.1	77.2
	May	76.3	81.3	79.9
	June	87.7	81.1	88.7
	July	88.7	82.0	96.3
	August	92.5	83.2	82.6
	September	88.8	79.6	79.0
	October	86.4	70.1	64.7
	November	73.7	66.1	60.3

As seen in Figure 63, water temperatures quickly reached 76.5°F during a storm event on July 23, 2008 at the onset of stream flow from runoff (stream was dry prior to this storm event) before declining to 61°F nearly 24-hours later at CR02 when stream flow ceased. Also note that cooling waters released into CR01, which runs perennially, increased to more than 77°F. This flow was the predominate source of flow and hence water temperature at CR03 during this period after the storm event as CR02 did not have flow. For CR02, further reductions in water temperatures will most likely be achieved through storm water management techniques that encourage infiltration, allowing heated waters to cool before they reach the stream. Some small reductions in water temperatures may be achieved at CR01 through the establishment of a riparian buffer; however, any reductions are likely to be negligible compared to the temperature effects of the cooling waters from Lexmark.

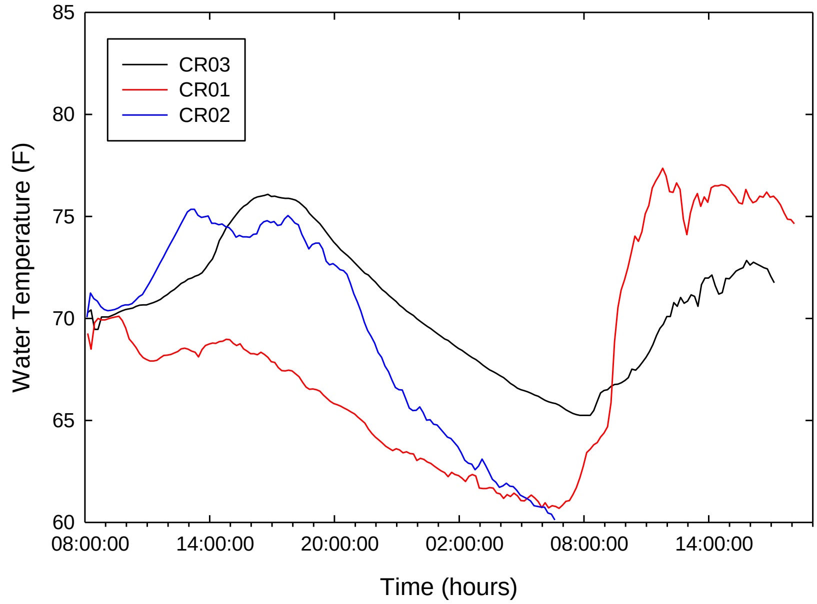

Figure 63. Elevated water temperatures resulting from urban runoff at CR01, CR02 and CR03 and cooling water at CR01. Storm event occurred on July 23, 2008.

Water Quality

Bacteria

The sampling conducted by KWRRI in 2002, by LFUCG from 1998 to 2003, by the City of Georgetown in 2005, and by the Cane Run Watershed Project in 2010 confirms the 303(d) listing for this section of stream for fecal coliform. Every sample taken at monitoring point C0 in Catchment 10 exceeded the primary contact standard (instantaneous maximum) of 400 colonies per 100 mL, and all exceeded the secondary standard of 2,000 colonies per 100 mL (Table 45). The geometric means of LFUCG's sampling at CR-L2 and CR-S1 far exceed the primary and secondary contact standard (geometric mean) of 200 cfu/100mL and 1,000 cfu/100mL (Table 46), and the geometric mean at the City of Georgetown's IBM site also exceeded the primary contact standard (Table 47). All of the samples collected at all four CRWP targeted sampling sites in this catchment exceeded the instantaneous maximum primary contact standard for *E. coli* (240 cfu/100mL), and nearly all exceeded the instantaneous maximum secondary standard of 676 cfu/100mL (Table 48). This sampling collectively demonstrates that fecal coliform pollution is a problem in Catchment 10.

Table 45. Fecal coliform data from KWRRI monitoring point C0

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	9,215	6,482	7,058	DRY	DRY	DRY	DRY	DRY	7,361	2,121

Table 46. LFUCG fecal coliform data in Catchment 10

Station ID	Station Description	Sampling Dates	Fecal Geometric Mean Cfu/100 ml
CR-L2	Silver Lane	Nov-01 to Dec-01	2,711
CR-S1	Lexmark	May-96 to Jun-02	5,755

Table 47. City of Georgetown fecal coliform data in Catchment 10

Site	Geometric mean *E. coli* (cfu/100mL)
IBM	243

Table 48. Cane Run Watershed Project targeted sampling results in Catchment 10

	07/13/10		07/19/10		07/20/10	
Sampling Site	Other Coliforms	*E. coli*	Other Coliforms	*E. coli*	Other Coliforms	*E. coli*
WP204	60000	60000	22000	~600	~80000	4100
WP205	60000	60000	---	---	---	---
WP206	60000	60000	38000	~73000	60000	60000
WP207	60000	60000	60000	60000	60000	60000

The monitoring conducted by the University of Kentucky from June 2008 to December 2009 also found that *E. coli* concentrations at each of the monitored locations exceeded the primary contact standard for a 30-day geometric mean of 130 cfu/100 ml (Table 49). Furthermore, nearly all of the grab samples at these monitoring locations exceeded the instantaneous maximum primary and secondary contact standards (Table 50). Examination of the *E. coli* load duration curves for CR01, CR02, and CR03 (Figure 64, Figure 65, Figure 66, and Figure 67) indicates that the primary contact standard was rarely achieved.

Table 49. Peak and geometric mean *E. coli* concentrations at monitoring locations within Catchment 10

Site	Year	No. Samples	Peak (MPN/100 ml)[1]	30-day Geometric Mean (MPN/100 ml)
CR01	2008	15	250,460	5,880
	2009	29	12,532	1,139
	2008-2009	44	--	2,104
CR02	2008	5	90,500	32,060
	2009	15	25,000	2,498
	2008-2009	20	--	4,728
CR03	2008	5	110,120	20,124

Site	Year	No. Samples	Peak (MPN/100 ml)[1]	30-day Geometric Mean (MPN/100 ml)
	2009	19	25,000	1,398
	2008-2009	24	--	2,437
CR13	2008	7	170,103	20,189
	2009	26	65,837	9,594
	2008-2009	33	--	11,234
CR14	2008	3	44,140	11,058
	2009	14	9,825	895
	2008-2009	17	--	1,395

[1]MPN = most probable number

Table 50. Number of samples at each site that exceeded the primary and secondary surface water samples for *E. coli*

Site	Year	No. Samples	Percent of Samples *E. coli* >240 MPN/100 ml[1]	Percent of Samples *E. coli* >676 MPN/100 ml
CR01	2008	15	100	87
	2009	29	97	66
	2008-2009	44	98	73
CR02	2008	5	100	100
	2009	15	93	87
	2008-2009	20	95	90
CR03	2008	5	100	100
	2009	19	84	68
	2008-2009	24	88	75
CR13	2008	7	100	86
	2009	26	100	100
	2008-2009	33	100	97
CR14	2008	3	100	100
	2009	14	79	64
	2008-2009	17	82	71

[1]MPN = most probable number

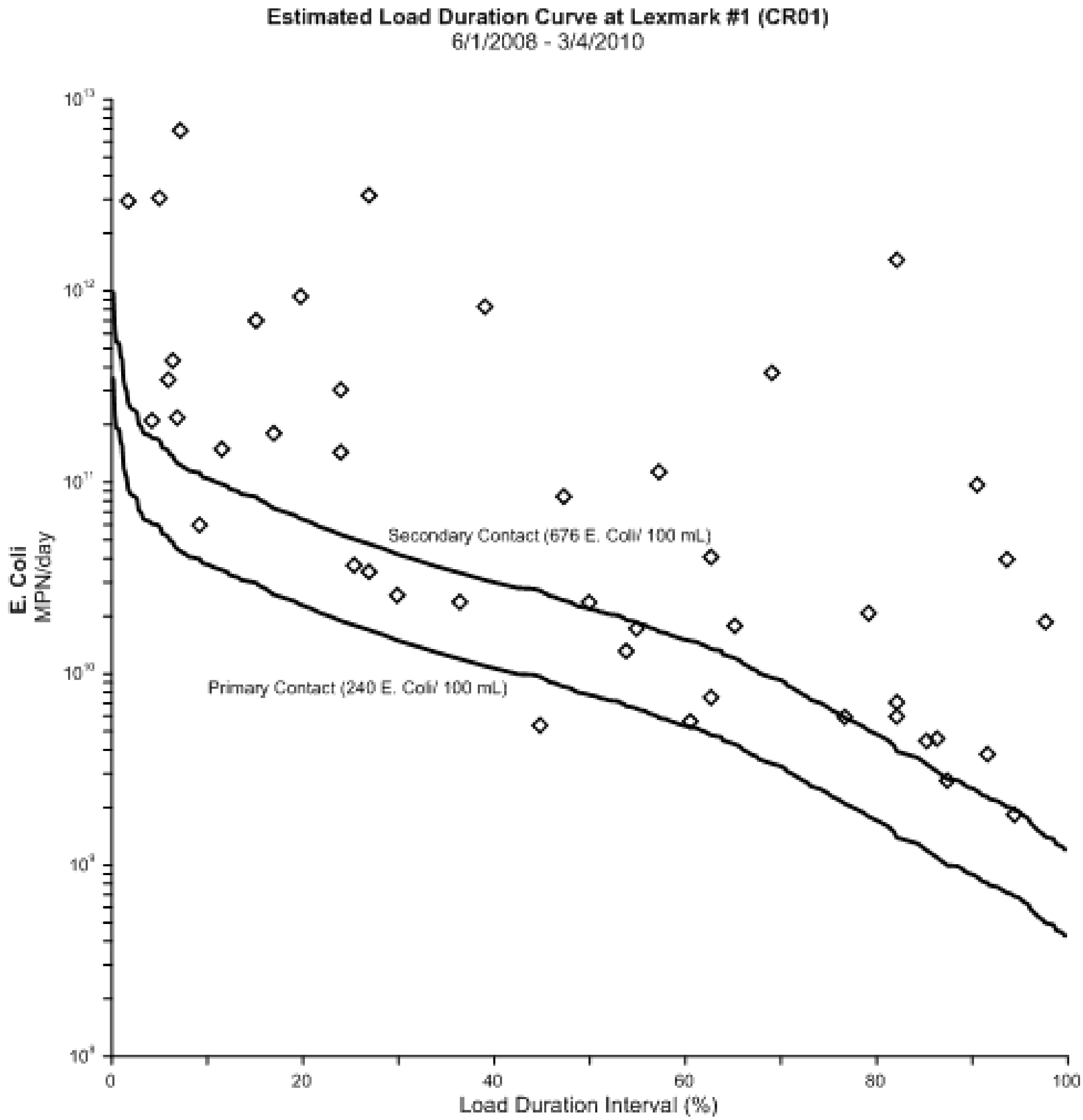

Figure 64. Estimated *E. coli* load duration curves at CR01

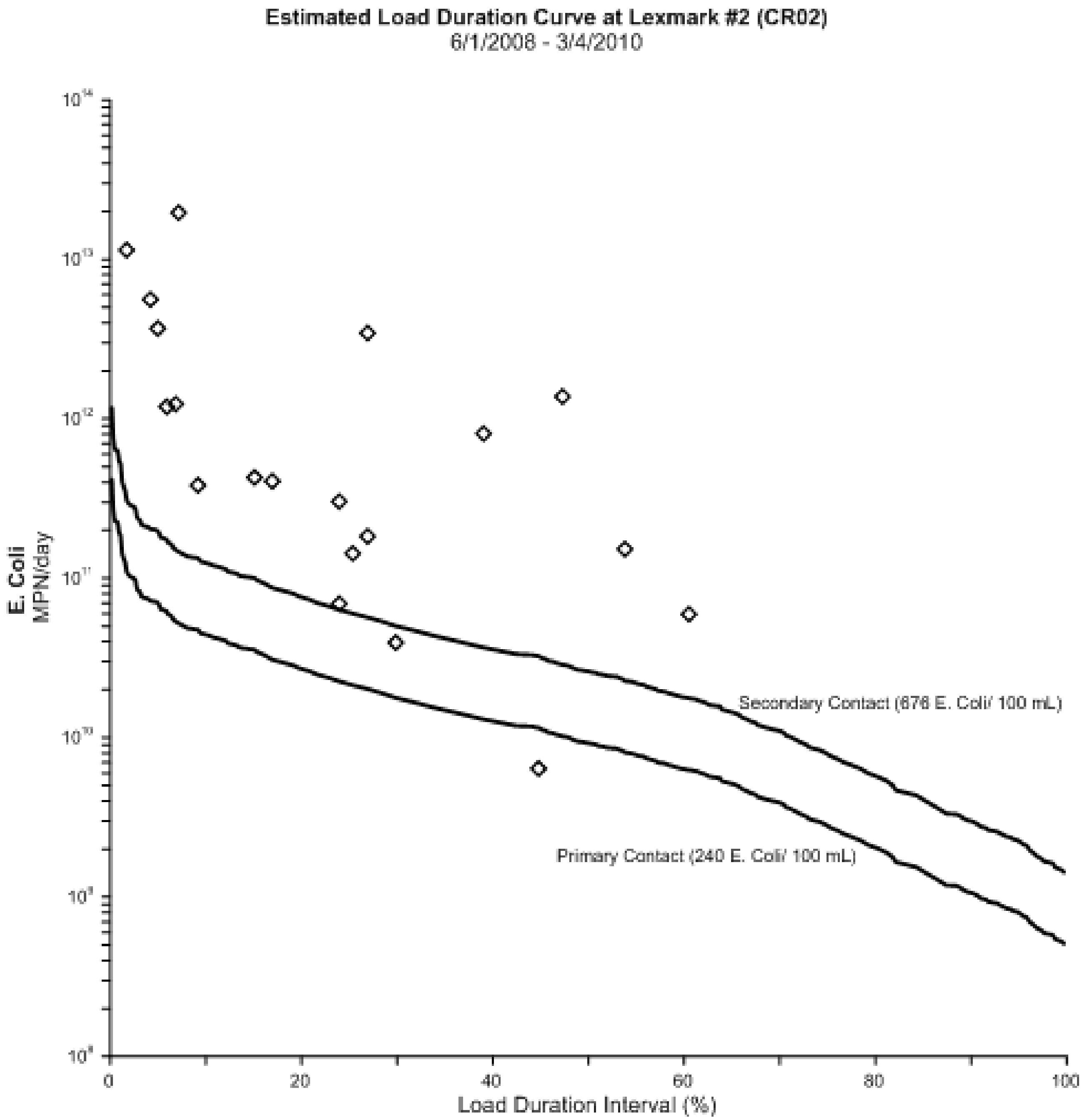

Figure 65. Estimated *E. coli* load duration curves at CR02

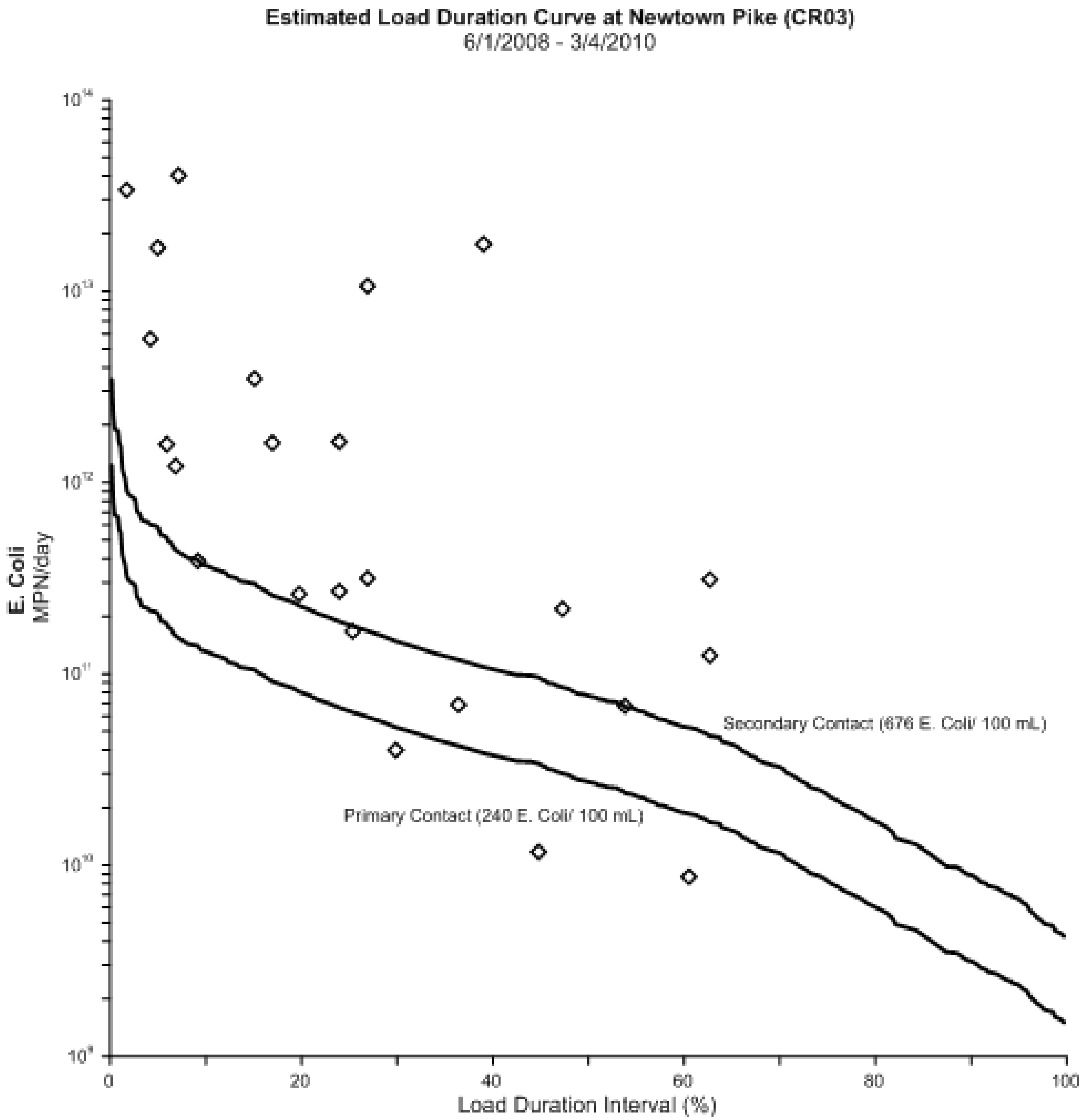

Figure 66. Estimated *E. coli* load duration curves at CR03.

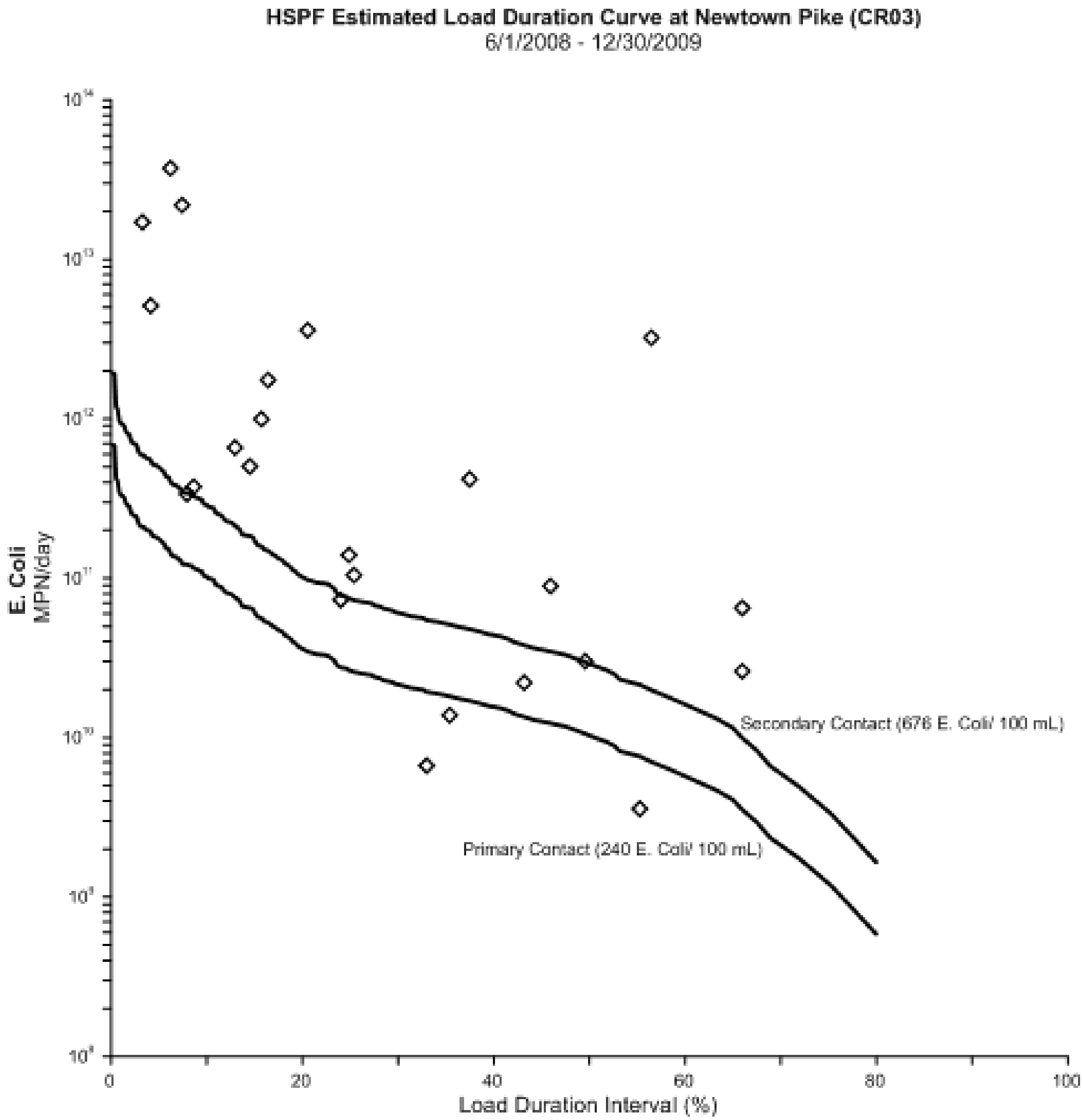

Figure 67. Estimated *E. coli* load duration curves at CR03 utilizing flows developed with the HSPF model

The areas draining to these five monitoring sites are highly developed, and as such, the most likely sources of bacteria are permitted dischargers, urban loading in the form of failing sewer lines and pet fecal matter, and failing septic systems and straight pipes. Within Catchment 10, ten KPDES permits have been identified, and six of these permitted discharges are located upstream of CR13 and subsequently CR01 and CR03. All three of these locations had the largest peak *E. coli* levels within the catchment in 2009. Also at CR13, all of the sampled *E coli* levels exceeded the primary contact standard.

In addition to KPDES permits, sanitary sewer trunk mains traverse along Cane Run and its tributaries. The monitoring sites are located in close proximity to the trunk mains. Examination of the *E. coli* concentration response to 48-hour prior rainfall indicated that all monitoring sites exhibited an increasing trend with the largest slopes and strongest relationships associated with CR02 and CR03 (Figure 68 and Figure 69). While CR13 and CR14 did not exhibit as strong a relationship between *E. coli* concentrations and rainfall as CR02 and CR03, a notable correlation was present (Figure 70 and Figure 71). Little correlation was noted for CR01 largely due to the high levels of *E. coli* even at low rainfalls (Figure 72).

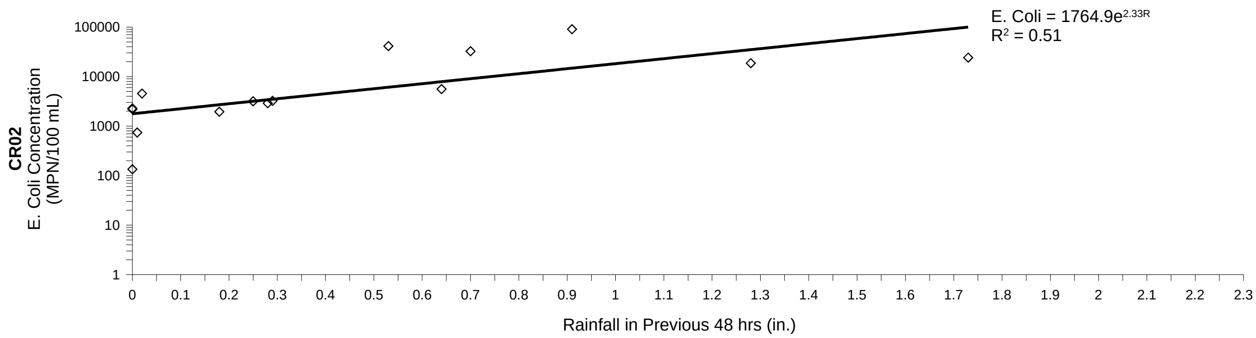

Figure 68. *E. coli* concentration response to 48-hour prior total rainfall for CR02

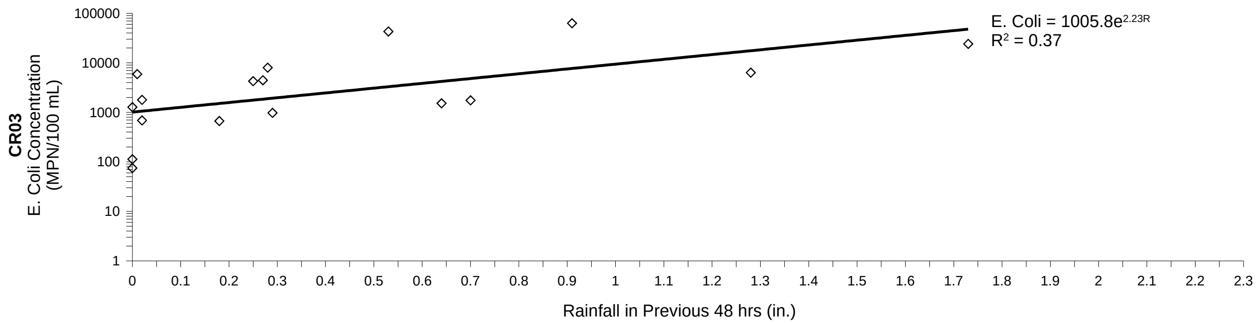

Figure 69. *E. coli* response to 48-hour prior total rainfall for CR03

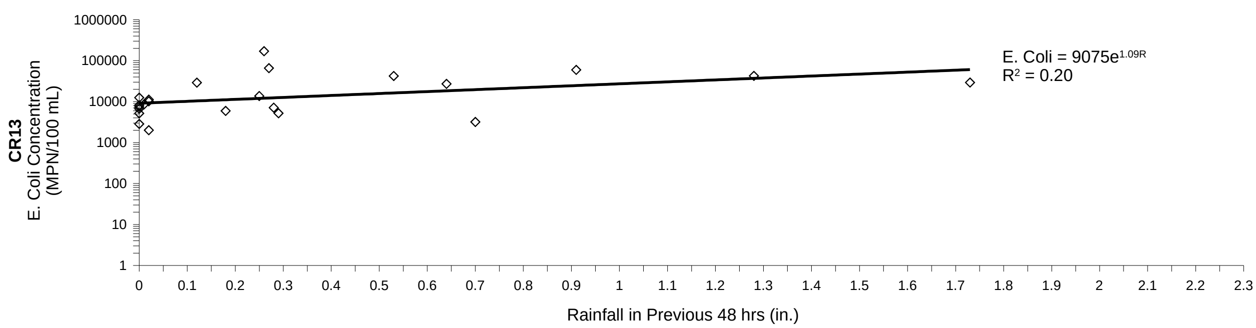

Figure 70. *E. coli* concentration response to 48-hour prior total rainfall for CR13

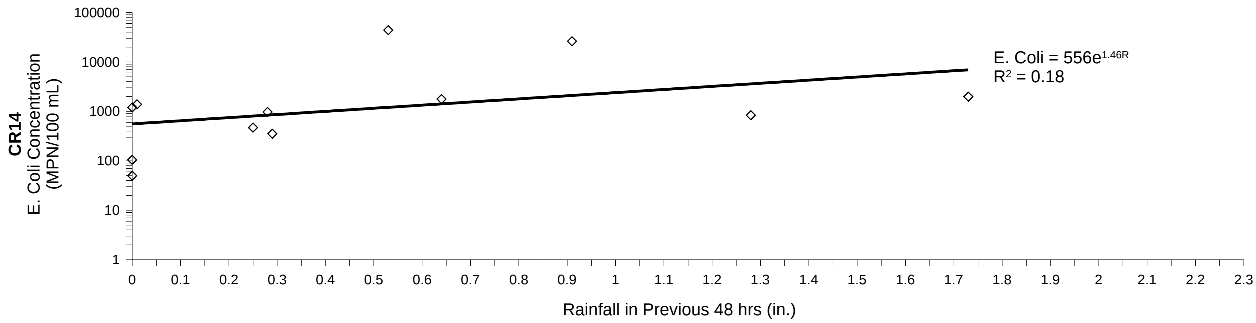

Figure 71. *E. coli* concentration response to 48-hour prior total rainfall for CR14

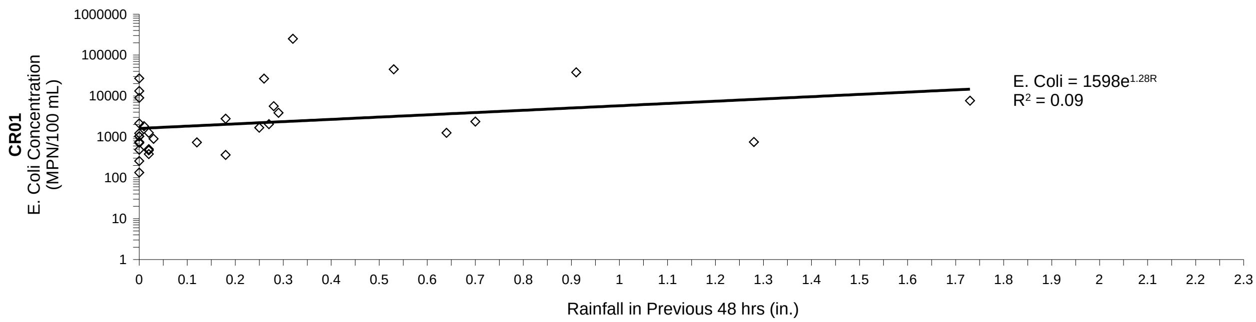

Figure 72. *E. coli* concentration response to 48-hour prior total rainfall for CR01

Based on the bacteria data, it is suspected that *E. coli* levels at CR02, CR013, and CR14 are most likely linked to failing sewer lines and other sewer infrastructure. The increasing concentration of *E. coli* at these sites, with increasing rainfall, suggests that sewage is being discharged into the storm sewer system. At CR01, the high *E. coli* levels during periods without rainfall, suggests that part of the bacteria load is from a KPDES permitted source or some other sort of constant source. CR03 appears to be a combination of all activities in the catchment, though its concentrations more closely parallel CR02. The reason for this is likely due to the large sinkhole located upstream of CR03 and downstream of CR01 and CR03. Due to this large sinkhole, the flows at CR03 are predominately storm flows. Note that while flows are perennial at CR01 due to KPDES discharges, these flows rarely reach CR03 during non-storm event periods.

To reduce bacteria loads in Catchment 10, it is recommended that all sanitary sewer lines be inspected and replaced if failures are found. The areas above CR13 (Loudon Avenue) and above CR02 (Colesbury Circle and possibly Russell Cave) should especially be targeted for sewer inspection. Septic systems should also be inspected, and if failing, repaired or removed. Efforts should be undertaken to examine permitted KPDES discharged waters to ensure all sources are in compliance. Efforts for this activity should be focused on the reach downstream of CR13 and upstream of CR01.

Nutrients

The monitoring conducted in 2006 and 2007 by KDOW demonstrates a problem with nutrient pollution, specifically phosphorus, in this catchment. The geometric mean for DOW04018009 is above the total phosphorus target of 0.3 mg/L (Table 51), and most of the individual samples taken by KDOW at this point exceed this total phosphorus target (Appendix K).

Table 51. Nutrient geometric means for DOW04018009

Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
0.070	4.46	2.04	2.91	0.209	0.381	5.3	0.458

Sediment

CR01 was the only monitoring site that had storm events (n=2) where the mean TSS concentration exceeded 200 mg/l (Table 52). TSS load duration curves indicated that no samples exceeded a 200 mg/l threshold or even a 100 mg/l threshold (Figure 73, Figure 74, and Figure 75).

Based on the monitoring data, suspended sediments are not a large concern in Catchment 10; however, areas of streambank erosion should be addressed as these soils are likely contributing nutrients to the watershed. Additionally, areas of upland erosion should be addressed, in part by the establishment of riparian buffers along waterways.

Table 52. Summary of storm sample TSS data for Catchment 10

Monitoring Location	No. Events Sampled	Peak >200 mg/l[1]	Mean >200 mg/l[2]	Geometric Mean >200 mg/l[3]	Mean per Event >200 mg/l[4]	Mean Time >200 mg/l (minutes)[5]
CR01	46	15 (33%)	2 (4%)	0 (0%)	<1	11
CR02	31	9 (29%)	0 (0%)	0 (0%)	<1	9
CR03	26	6 (23%)	0 (0%)	0 (0%)	<1	7

[1]Mean number of storm events where the storm peak TSS concentration exceeded 200 mg/L.

[2]Mean number of storm events where the storm mean TSS concentration exceeded 200 mg/L.

[3]Mean number of storm events where the storm geometric mean TSS concentration exceeded 200 mg/L.

[4]Mean number of samples in each storm event that exceeded TSS concentration of 200 mg/L.

[5]Mean amount of time in each storm event where TSS concentration exceeded 200 mg/L.

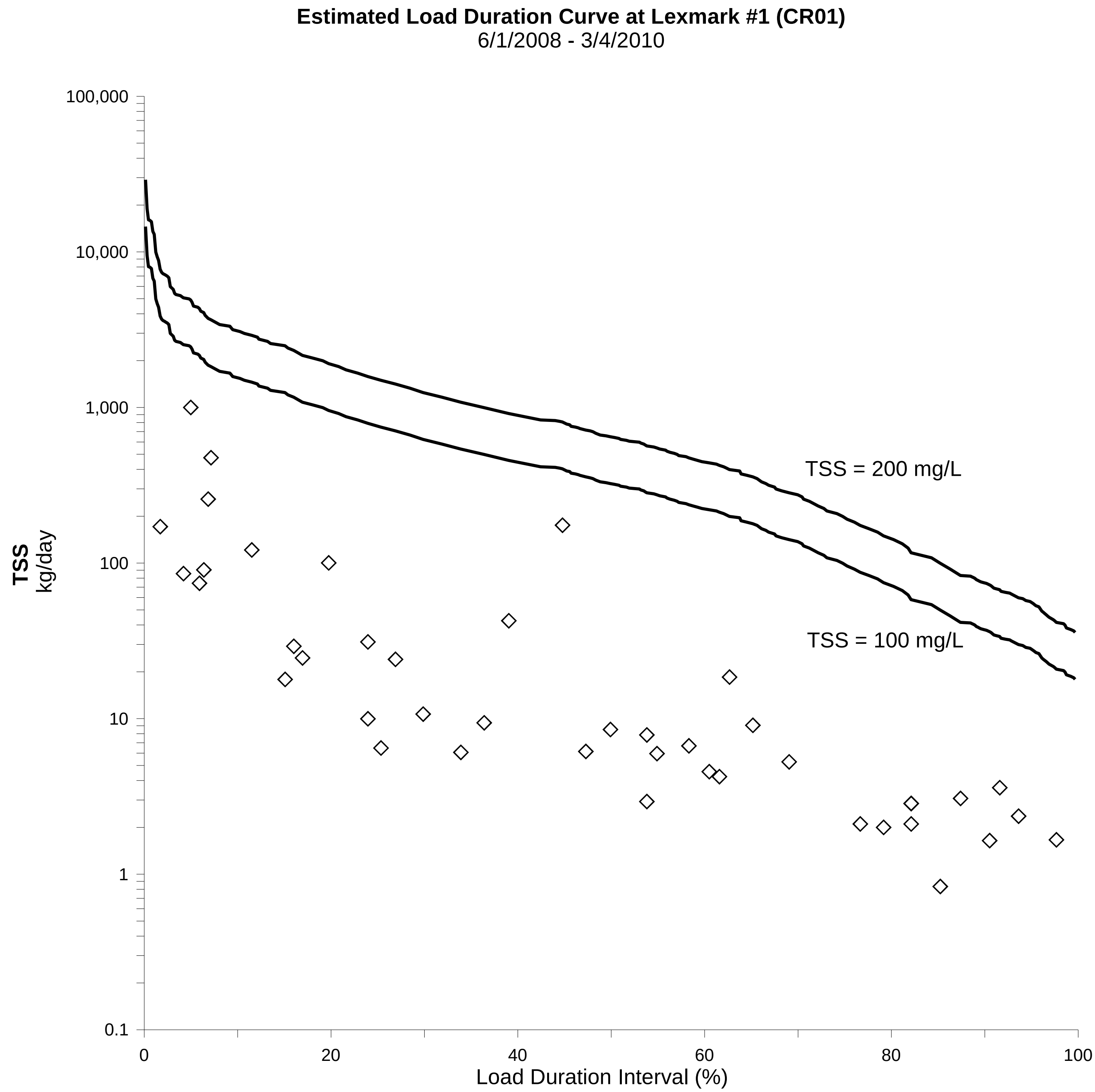

Figure 73. Estimated TSS load duration curve at CR01

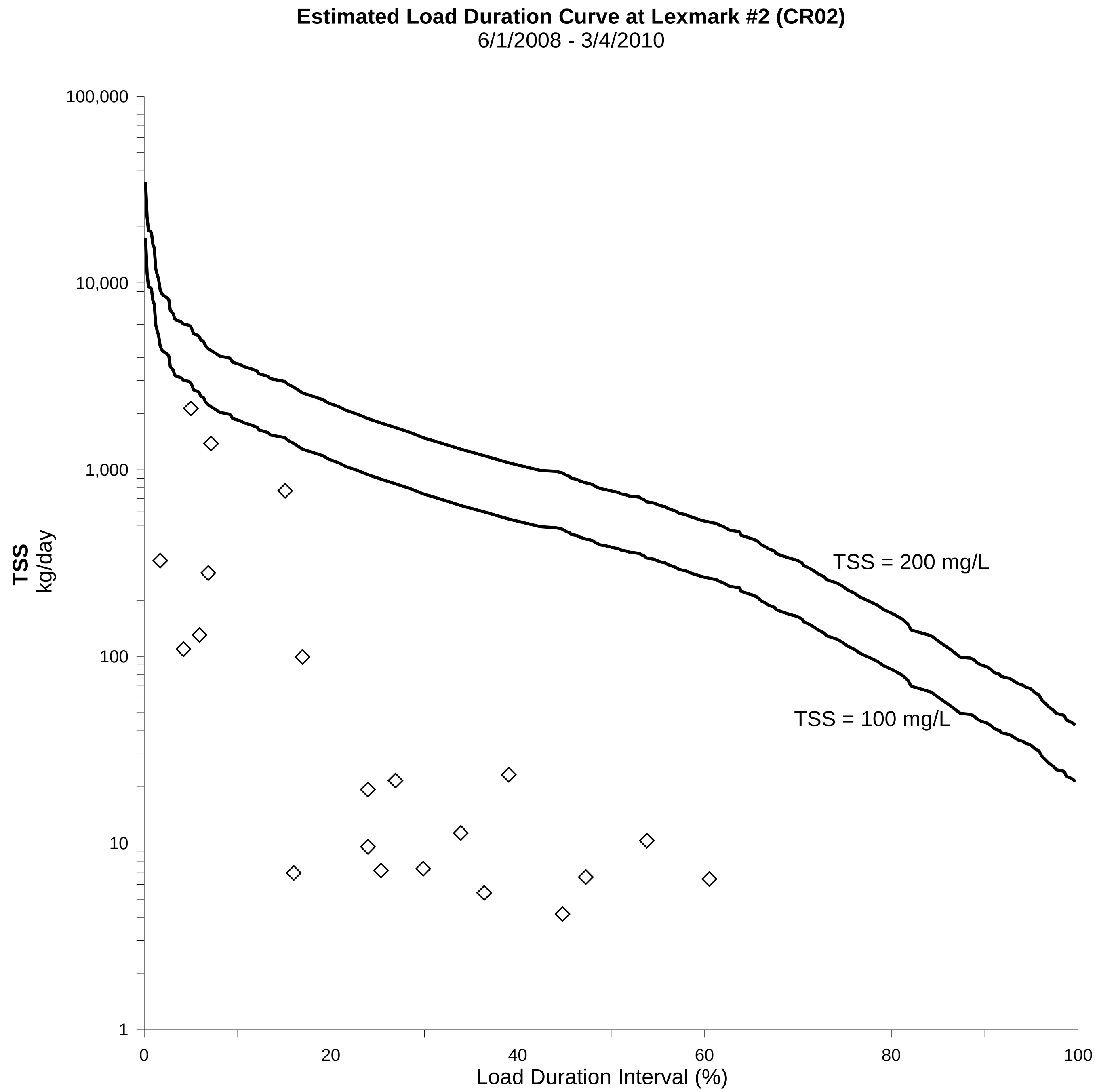

Figure 74. Estimated TSS load duration curve at CR02

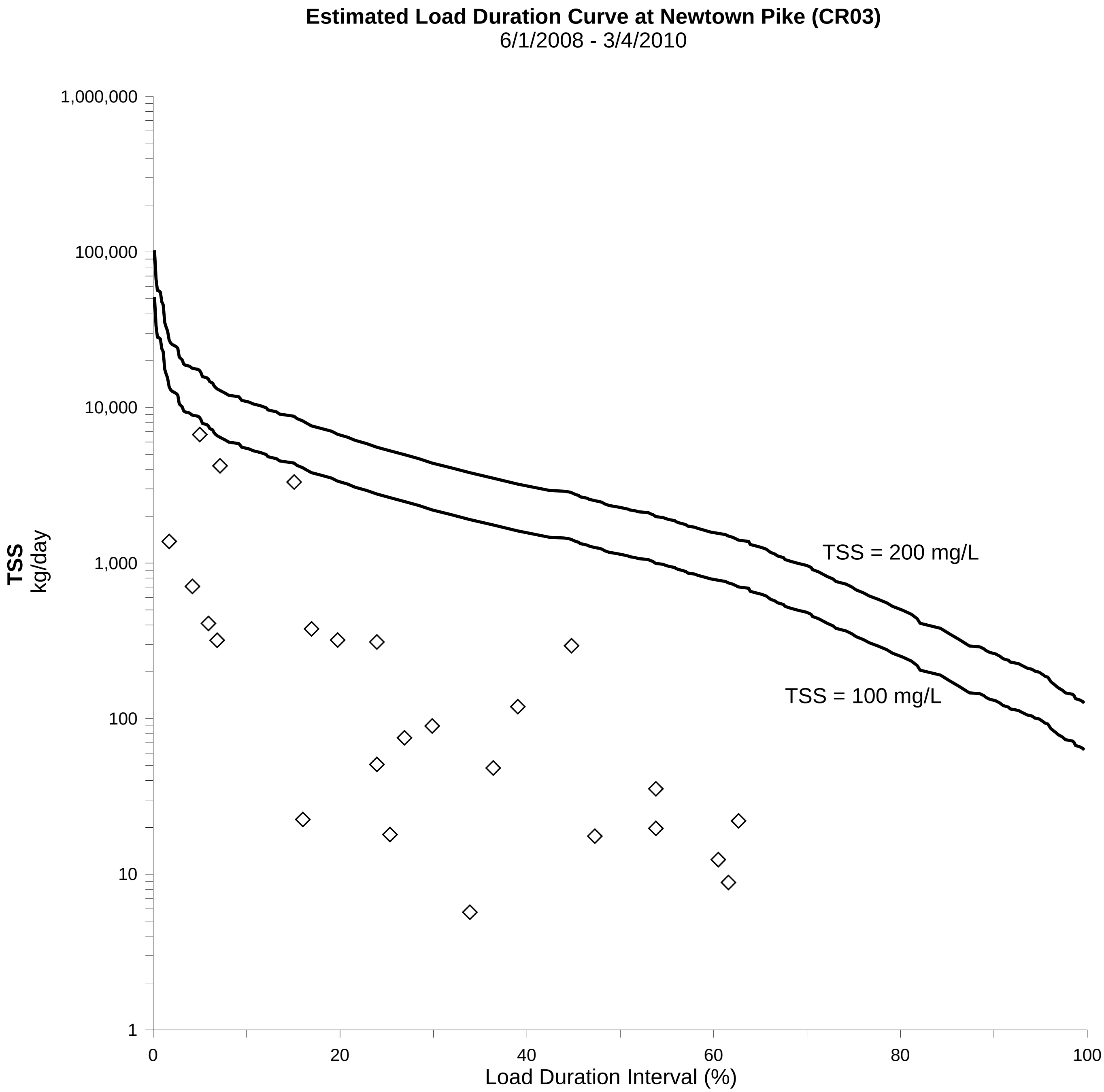

Figure 75. Estimated TSS load duration curve at CR03

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge, and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

In addition to physical characteristics of the watershed, there are many projects and partnerships already underway that will also guide BMP implementation efforts. The upper Cane Run Watershed is unique in not only its geology, but by the few, large, public landowners, which includes Lexmark International and the Kentucky Transportation Cabinet in Catchment 10.

There are situations where this project cannot address water quality issues because of the continued Consent Decree litigation between the Lexington Fayette Urban County Government (LFUCG), U.S. EPA, and Kentucky Division of Water. Although BMPs in the headwater catchments, including Catchment 10, would have a great influence on downstream areas, some may not be addressed by Cane Run Watershed Project 319(h) funds based on their inclusion in the Consent Decree.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform, nutrients, sewage, and trash. The most likely sources of these pollutants in Catchment 10 that should be addressed include urban (especially residential) stormwater, KPDES-permitted facilities, sanitary sewer overflows, lawn fertilizers and pesticides, and septic systems. Although sediment has been determined to not be a problem in this catchment, bank erosion is still an issue and could be contributing nutrients to the stream.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 10, the MS4 developed land loading must be reduced by 50 percent and the MS4 non-developed loading must be reduced by 22.0 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes. The BMPs recommended and implemented within this catchment will help to achieve these reduction goals.

Because Catchment 10 lies within the scope of the Royal Spring aquifer of the Cane Run Watershed, BMPs were selected for this catchment that most effectively address the primary pollutants and their suspected sources, land use, property owner and/or stakeholder acceptance, and sources of potential funding, as well as technical and community support. This section includes a map and detailed description of proposed and implemented BMPs and a table summarizing these BMPs, their effectiveness, costs, and possible implementation partners.

For additional information about BMP implementation in the entire Cane Run Watershed, please reference the Cane Run and Royal Spring BMP Implementation Plan in Appendix X.

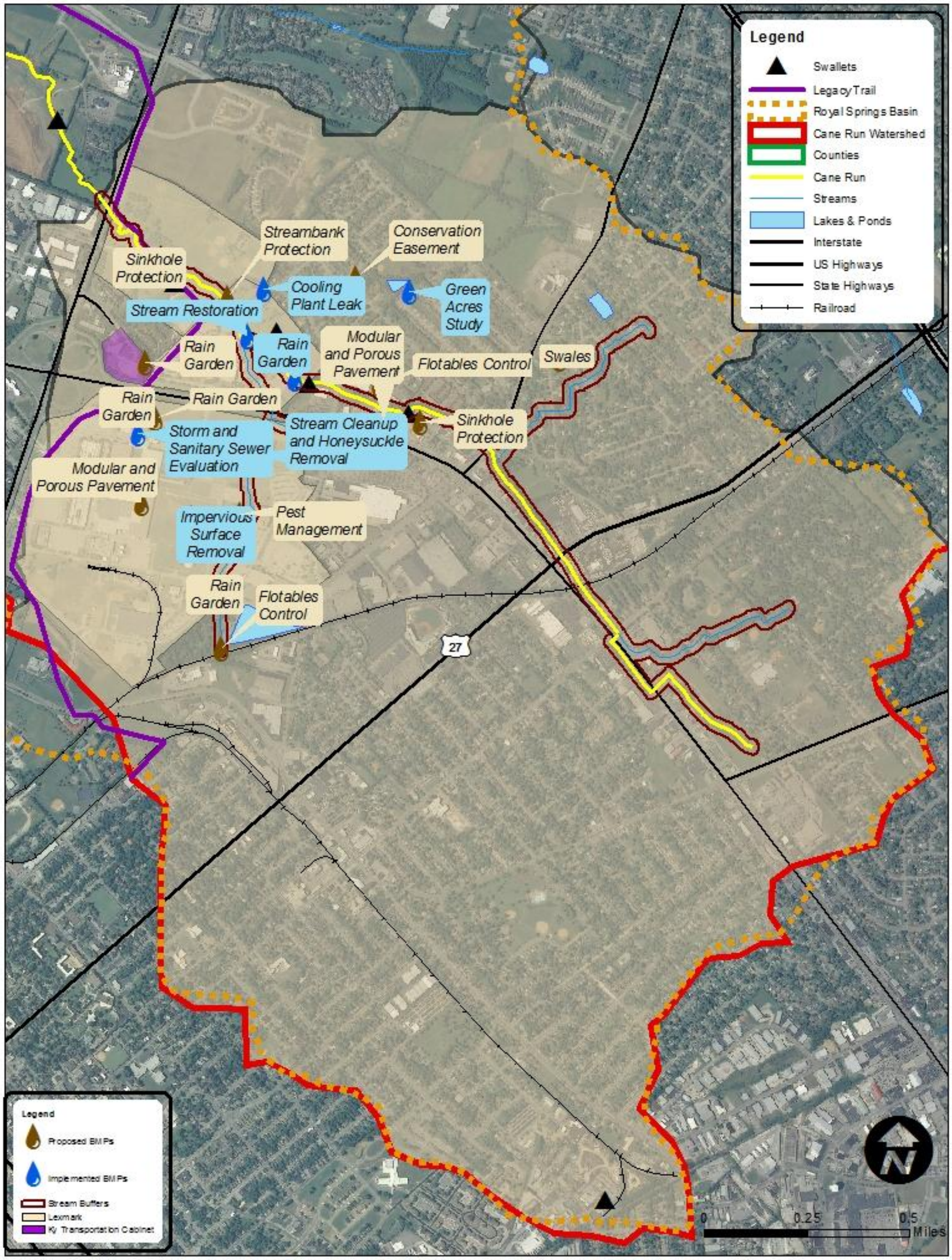

Figure 76. Priority BMP locations for Catchment 10

Cane Run Headwaters (Green Acres neighborhood)

Proposed

The Green Acres neighborhood sits along the upper reach of Cane Run Creek along a heavily urbanized corridor of New Circle Road at the intersection of Russell Cave Rd. This stream segment flows underground at times, is highly channelized, and is partially lined with concrete.

There are a number of BMPs to be implemented along this reach. Modular and porous pavement, bioretention systems (rain gardens), swales, and downspout connections could be installed at businesses and homes in the area to reduce the storm surge and provide pollutant filtration. These BMPs would decrease the pollution originating from urban areas, and more specifically, residential stormwater, a pollutant of interest in this catchment. Conservation easements could be used to gain access to the riparian corridor for enhancement, which would provide filtration of stormwater pollutants and provide shade and stability, which would help improve the physical features of and habitat provided by the stream. A pollutant of concern for this catchment is trash, and this area contributes a concentrated amount of trash to the stream. This could be ameliorated with the use of floatable control structures and education and outreach. This area of the watershed will be targeted for resident education and outreach, working through the neighborhood associations, to reduce trash and bacteria loads from residential areas. LFUCG has also deemed this area to be a source of storm water and sanitary sewer problems, and fixing these infrastructure problems as mandated by the Consent Decree would greatly decrease bacteria loading in this catchment. CDP Engineers and LFUCG are working together to determine and implement the most appropriate BMPs for the stream reach.

Implemented

GREEN ACRES/HOLLOW CREEK STORMWATER IMPROVEMENT PROJECT

On October 30, 2007 LFUCG received $2.6 million from the state legislature to address flooding and stormwater problems in the Green Acres and Hollow Creek neighborhoods.

The project includes two phases. Phase one began in 2007 with a study of the area that was meant to determine potential remediation strategies and stakeholder input titled the "Green Acres Study". The study was completed in March 2009, and problems identified in this study included trash and debris, flooding in yards, streets, and basement crawlspaces, and poor water quality.

Phase two of the project is underway as of January 2011 and includes implementation of projects such as residential floodproofing, sanitary sewer redirection, storm sewer rehabilitation, trash and debris cleanup, and major flooding/stream restoration projects. Several homes have been purchased and demolished in order to reduce flooding and to clear land for the installation of a functioning riparian buffer. See Figure 77 for a map of implemented and planned projects.

As of January 2011, there is approximately $1.3 million remaining to fund projects that will be started in the summer of 2011 and completed by 2012. In conjunction with this project, LFUCG is directing additional resources to the area as a part of the Consent Decree to mitigate storm water concerns.

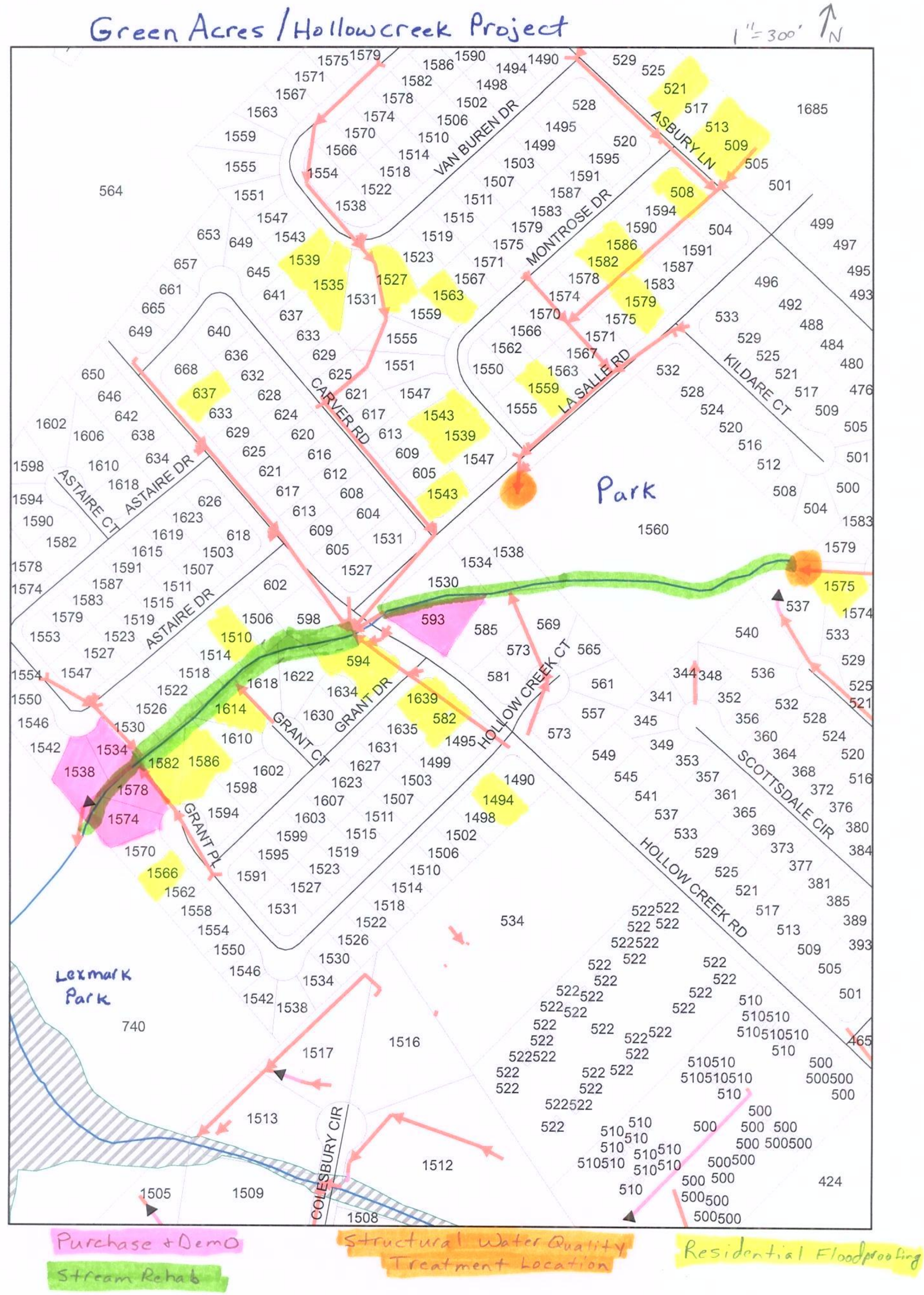

Figure 77. LFUCG planned and implemented work in the Green Acres/Hollow Creek neighborhood

Tributary to Cane Run and Cane Run (above Newtown Pike, Lexmark property)

Proposed

A tributary enters the Cane Run near New Circle Road just past the Green Acres subdivision. The tributary drains the area that includes the Loudon Avenue and North Broadway intersection. This stream section drains a large urban area and is susceptible to fluctuations from storm surges and sanitary sewer overflows.

One of the noteworthy partners in the Cane Run Watershed is Lexmark International. Lexmark owns a significant portion of land on the urban fringe of Lexington at the confluence of a large tributary to the Cane Run and has worked to improve water quality on significant reaches of the upper sections of the watershed. The large expanse of open green space along the main channel and tributary is used for recreation. Streambank protection is important to Lexmark, as safety is a concern. Along this section of stream, failing banks contribute to sediment and nutrient (phosphorous) pollution. Sections of the tributary also exhibit incised channels that are overgrown with invasive exotic species, and while invasive exotic species themselves are not harmful to water quality, their existence can choke the stream. In conjunction with the incised channel, these species make the floodplain less accessible and less effective for healthy stream conditions. Invasive exotic species removal and stream restoration would improve the riparian area, reduce pollution, and increase public perception that the streams are being improved.

Lexmark International has three additional concerns, which include the amount of trash coming from the headwaters of the tributary, the bacteria in the stream, and the safety of employees and guests in the green space along the stream. If possible, a floatables control device could be installed on curb inlets in the urban area. A control device prior to a culvert that passes under the railroad line near Loudon Avenue is also recommended.

The subsequent reach of Cane Run is important as it comes after the confluence of the two urban reaches just described. An abandoned LFUCG pump station is located near the channel on this reach of the stream. This area of the Lexmark property is much more open than the tributary section detailed above; therefore, any of the BMPs selected for the tributary area could be sized for a larger scale and installed with fewer construction constraints. Reductions of the storm surge from the urban areas at this location will help to enhance this and other downstream stream sections. Additional invasive exotic vegetation needs to be removed along a portion of the stream, and the area will require native grasses and plantings for the riparian area.

LFUCG has also deemed this area to be a source of storm water and sanitary sewer problems, and fixing these infrastructure problems as mandated by the Consent Decree would greatly decrease bacteria loading in this catchment.

Implemented

IMPERVIOUS SURFACE REMOVAL

In 2008 and 2009 Lexmark demolished its large Ink Ribbon Manufacturing Buildings and its primary Receiving Building, along with all associated docks, concrete, and blacktop surfaces. These reclaimed areas were then covered in high grade top soil and replanted with grass. Two thousand trees were also planted in conjunction with this reclamation, and a large rain garden was constructed on the site of one former building. The total reduction in impervious surfaces is approximately 705,000 square feet, just over 16 acres, which will significantly reduce the amount and greatly increase the quality of stormwater runoff coming into the Cane Run in this catchment.

STREAM RESTORATION

Lexmark negotiated with the Kentucky Department of Fish and Wildlife Resources (KDFWR) and the Mitigation Review Team to implement a complete stream restoration on this section of stream in summer 2008; however, the project was not accepted for KDFWR money because KDFWR did not see the value in restoring this stream section without remediating storm and sanitary sewer issues upstream.

In the summer of 2010, Lexmark Facilities Engineering spent over $100,000 to restore a 1,500 foot section of the Cane Run and its primary tributary, as both streams pass through Lexmark's Shady Brook Park (Figure 78). The project included the use of flat stone to reinforce banks and create pools and riffles as typically seen in natural streams and creeks, and despite extreme drought, a high percentage of wild flower seed flourished along the banks and provided a gorgeous first bloom. The project even included a rain garden. This stream restoration project will help reduce sediment contributions to the stream, which will also reduce nutrient contributions such as nitrogen and phosphorus. For more information on this restoration, see Appendix Y.

Figure 78. Cane Run tributary before Lexmark restoration; Cane Run tributary after Lexmark restoration

COOLING PLANT LEAK

In November of 2009, volunteers conducting work on the stream reported a sewage odor that was at first thought to be attributable to a sewage leak near a Lexmark building. Through investigation by LFUCG, Lexmark, and Lagco (Lexmark's plumbing contractor), it was determined that there was a discharge from a Lexmark cooling tower of about 5,400 gallons per day. Lexmark fixed the leak immediately, and subsequent water quality tests of the creek outfall tested low for ammonia and fecal coliform. A Notice of Violation was filed by LFUCG on December 14, 2009, and one month after its issuance (January 15, 2010), the compliance actions had been completed to a satisfactory level by Lexmark. For more information about this incident, see Appendix Z.

STREAM CLEANUP AND BUSH HONEYSUCKLE REMOVAL

Since 2008, about 50 Lexmark and UK volunteers have participated in a day long "Cane Run Cleanup Event" during Earth Week each April (Figure 79). This event provides the opportunity for Lexmark employees to show their appreciation for clean water and riparian stewardship. LFUCG has supplied Lexmark with roll off boxes each year in support of the event. Each year 3 to 4 roll off boxes are filled with trash collected along the stream from WLEX - TV to Newtown Pike.

In 2010, bush honeysuckle was also targeted for removal. UK's Cane Run Watershed Project staff assisted Lexmark volunteers with pulling litter out of the Cane Run tributary and removing bush honeysuckle from nearly 1,650 linear feet of streambank. Eliminating honeysuckle not only improves the aesthetics of the stream but also helps re-establish a natural ecosystem throughout the watershed.

Figure 79. Lexmark employees removing trash and bush honeysuckle; Bush honeysuckle being chipped into a roll-off box, which is to be hauled off site

STORM AND SANITARY SEWER EVALUATION

As LFUCG was reaching its Consent Decree agreement with EPA, Lexmark realized that, to be a good corporate citizen, it had to take the initiative to evaluate the condition of its own 5-decade old storm and sanitary sewer system. In 2010, Black & Veatch was contracted to conduct a site-wide inspection of both systems and to put together a corrective action plan. Lexmark has set aside $10,000,000 to repair and replace sewer lines over the next 10 years. By January 2011, work had already begun. Open trenches throughout Lexmark's campus indicate new sewer line installation, and over $2,000,000 had already been spent. This effort will reduce bacteria pollution in the Cane Run.

Table 53. Catchment 10 priority BMPs¹

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Pest Management	– Improve vegetative BMP establishment and effectiveness – Increase visibility of water quality initiatives	– N/A	– Toxic Chemicals: High[e]	– $143.85/acre[h]	– $0.00	– UK – Friends of Cane Run – Lexmark – Volunteers – LFUCG
Riparian Buffer	– Nutrient, Sediment, Pesticide, and Organic Material filtration and reduction	– Nitrogen: 68% – Bacteria: 60% – Sediment: 80% – Phosphorus: 42%[ajp]	– Nitrogen: Medium – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	– $65.28/acre-$826.26/acre[h]	– $68.99/acre	– UK – Lexmark – Green Acres Neighborhood Association – KDFWR – NRCS – LFUCG – Reforest the Bluegrass
Streambank Protection	– Increase storage capacity of streambank channel – Increase effectiveness of downstream BMPs	– Nitrogen: 68% – Bacteria: 60% – Sediment: 80% – Phosphorus: 42%[ajp]	– Nitrogen: Medium – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	– $52.40/linear foot[h]	– $0.51/linear foot	– Lexmark – UK – KDFWR
Conservation Easements	– Improve maintenance and operation success of installed	– N/A+	– N/A°	– N/A	– N/A	– LFUCG – Lexmark – Friends of Cane Run – Bluegrass

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
	BMPS					Partnership for a Green Community Water Team – Neighborhood Associations
Bioretention Systems **(Rain Gardens)**	– Increase infiltration – Sediment nutrient, and bacteria – removal	– Nitrogen: 49%[z] – Bacteria: 70%[lk] – Sediment: 65%[lk] – Phosphorus: 76%[z]	– Nitrogen: Medium – Bacteria: Medium – Sediment: Medium – Phosphorus: High[e]	– $2,239.00/ERU[z] (1 Stormwater ERU = 2,500 ft^2	– $167.93/ERU (Maintenance = 7.5% of construction cost)	– Lexmark – CDP Engineers – Green Acres Residents – Bluegrass Rain Garden Alliance
Floatables Control	– Improve downstream BMP performance – Reduce excessive solid waste input to stream	– Pollutant removal dependent upon technology chosen	– Efficiency of practice is highly variable depending on proper selection and maintenance; potential to remove a high amount of solid waste entering surface and groundwater[aa]	– Cost will vary depending on location[aa]	– N/A	– LFUCG – CDP Engineers – Lexmark
Sinkhole Protection	– Increase groundwater recharge quality – Sediment, bacteria, and nutrient filtration and removal	– Nitrogen: N/A+ – Bacteria: 90%[q] – Sediment: N/A+ – Phosphorus: N/A+	– Nitrogen: High – Bacteria: High – Sediment: High – Phosphorus: High[e]	– $3,407.06/unit[h]	– $97.19/unit	– UK – Lexmark – Friends of Cane Run

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction[+]	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Swales	– Increase infiltration and groundwater recharge – Sediment and nutrient filtration and removal	– Nitrogen: 38% – Bacteria: N/A[+] – Sediment: 81% – Phosphorus: 29%[m]	– Nitrogen: Medium – Bacteria: Low – Sediment: Medium – Phosphorus: Medium[e]	– $4,929.59/acre[h]	– $47.86/acre	– Lexmark – LFUCG – UK – Bluegrass Partnership for a Green Community Water Team
Modular and Porous Pavement	– Increase infiltration and groundwater recharge – Sediment and pollutant filtration and reduction	– Nitrogen: 82.5% – Bacteria: N/A[+] – Sediment: 88.5% – Phosphorus: 65%[st]	– Nitrogen: High – Bacteria: N/A° – Sediment: High – Phosphorus: Medium[st]	– $16,250.00/ERU[st] (1 Stormwater ERU = 2,500 ft^2)	– $200.00/ERU	– UK – Lexmark – LFUCG

¹The studies referenced in this table can be found in Appendix AA.

*BMPs for each catchment are listed by magnitude of priority based on 1) their implementation in the upper reaches of the watershed, 2) their pollutant removal effectiveness, 3) legal restrictions that may hinder their use, 4) stakeholder participation, 5) the availability of additional funding or technical support. BMPs listed in bold have been implemented as described in narrative.

[+]Estimated Load Reduction: provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend exclusively on site-specific variables such as soil type, topography, climate, and production system.

°Effectiveness: Abstracted from USDA Agriculture Information Bulletin No. 598 and NRCS conservation practice physical effects (CPPE) documents. NOTE: Because of the general nature of these documents, there may be situations and sites where practices will not perform as indicated.

Catchment 9

Pollutant Source Assessment

The 303(d) listed segment of Cane Run that flows through Catchment 9 (that also flows in Catchments 10 and 8) has been identified as having high levels of fecal coliform, nutrients, and sewage, with suspected sources including livestock and unspecified urban stormwater (Figure 80). The unnamed tributary of Cane Run that begins in and flows solely through Catchment 9 has been identified as having high levels of phosphorus, with suspected sources including managed pasture grazing, non-irrigated crop production, and unspecified urban stormwater. Other point and nonpoint sources that could also contribute to this pollution are described below.

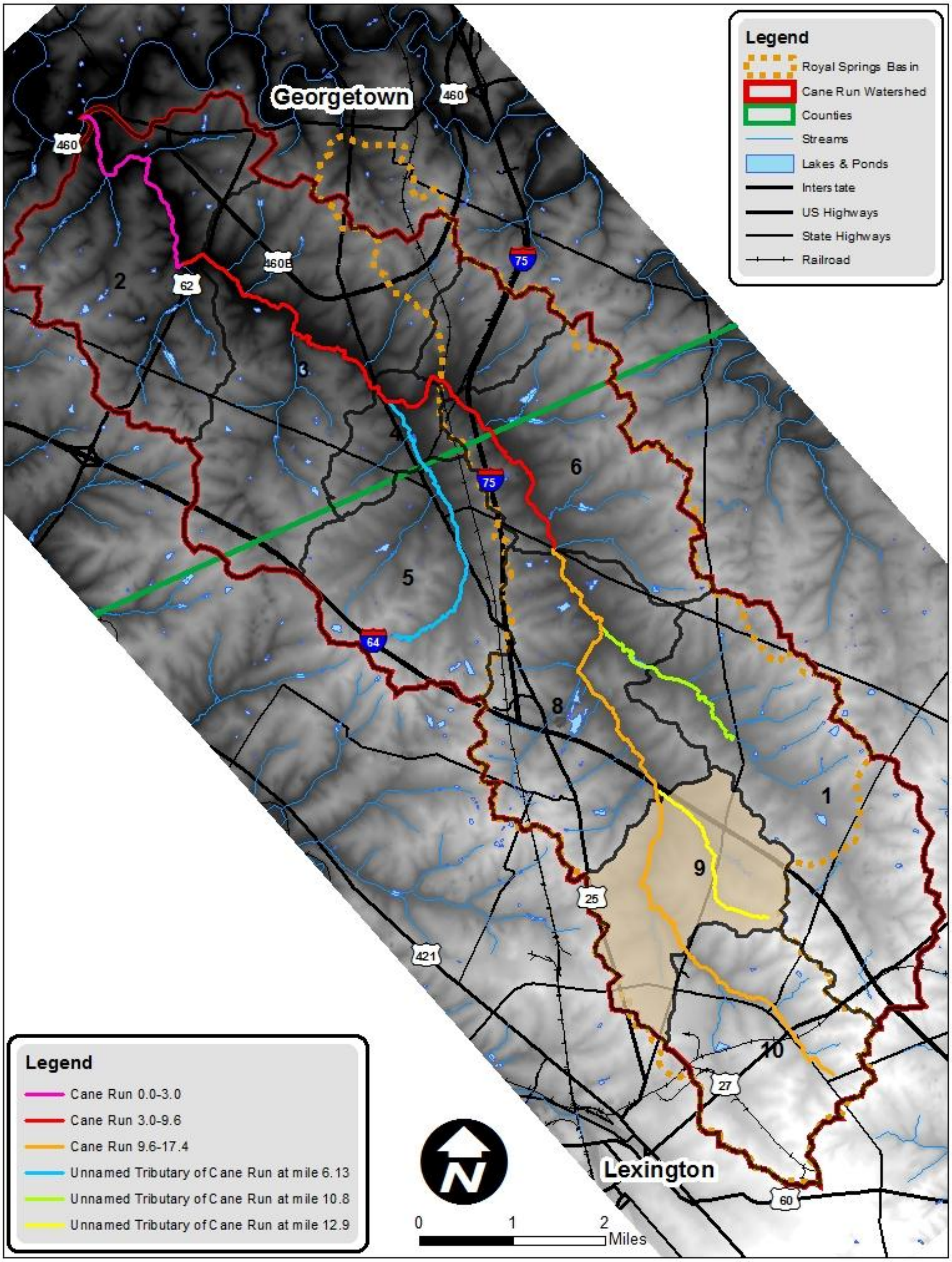

Figure 80. Impaired stream section in Catchment 9

Point Sources

There are several possible sources of point source pollution within Catchment 9, including KPDES-permitted facilities, Class V injection wells, sanitary sewer overflows, and failing onsite wastewater treatment systems (Figure 81). These point sources contribute mainly to bacteria and nutrient pollution. Ground-truthing conducted within the catchment also points to many point sources of trash and unknown discharges to the stream and storm sewer. A map of problem areas found within this catchment is shown in Figure 82, and Appendix T describes and gives a more detailed map of each problem area.

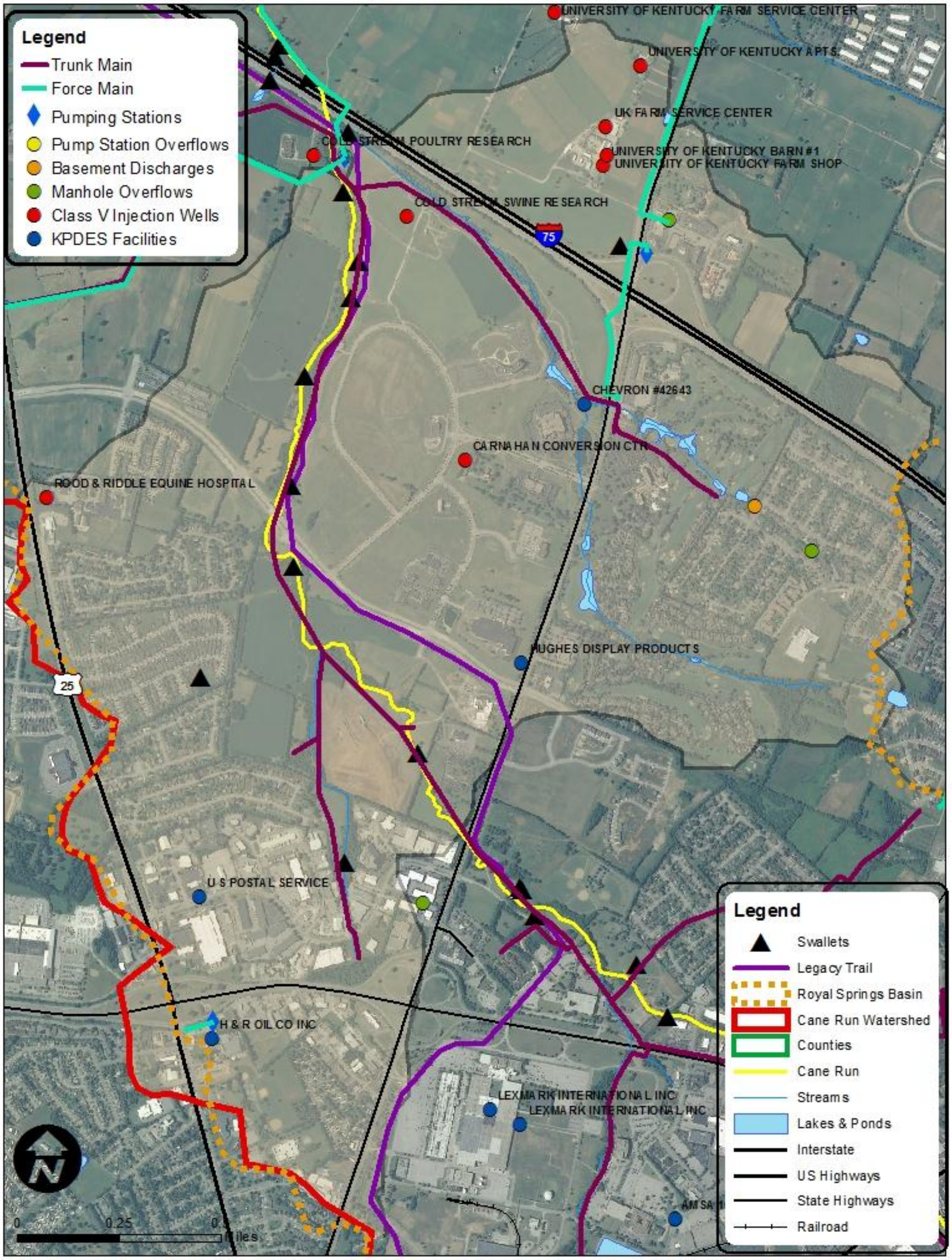

Figure 81. Potential point sources in Catchment 9

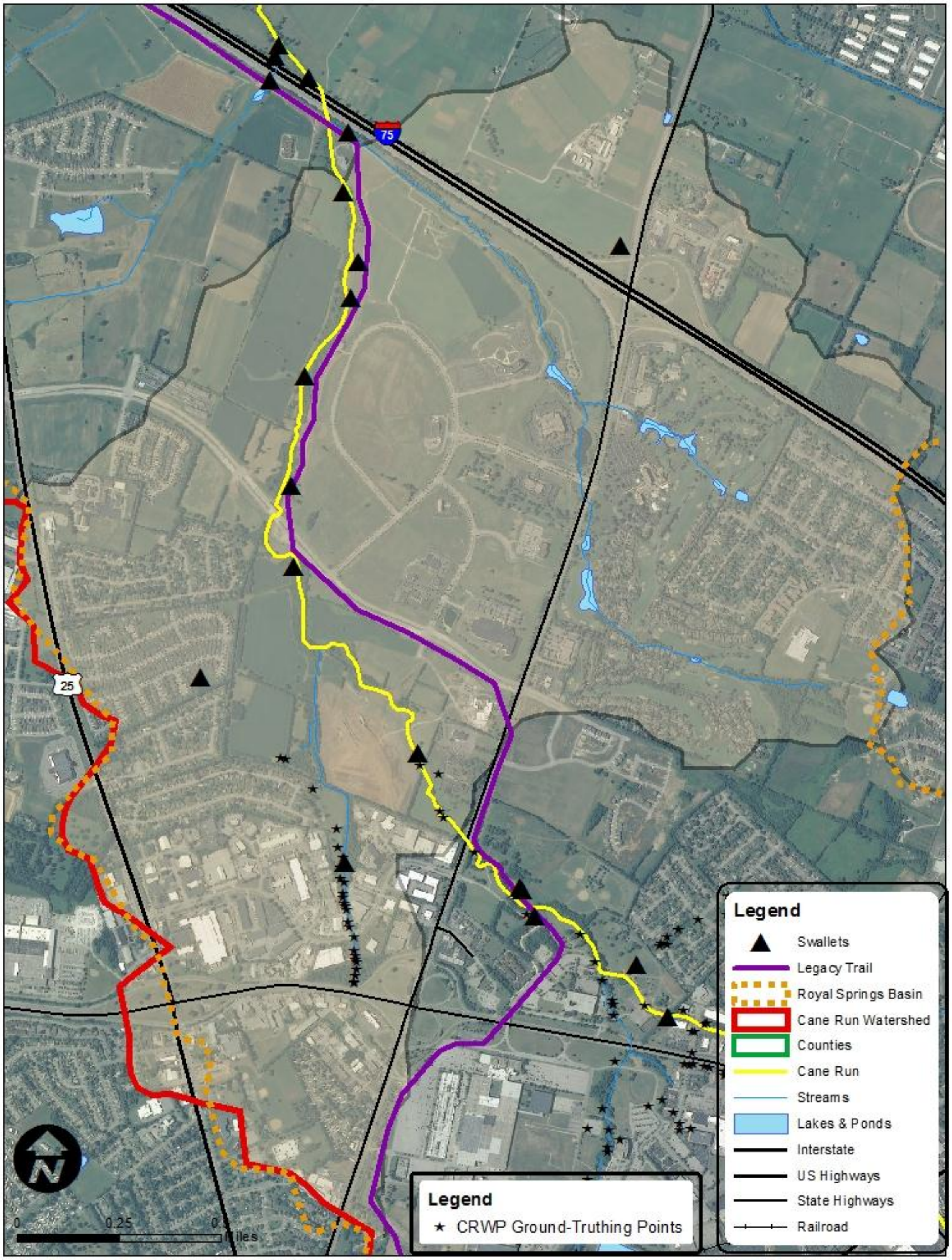

Figure 82. Problems found during CRWP ground-truthing in Catchment 9

KPDES-Permitted Facilities

There are 4 KPDES permitted facilities in Catchment 9, and the details of each permittee can be found in Table 54. None of the KPDES facilities in this catchment discharge the major pollutants of concern for the Cane Run, which include bacteria and nutrients. One facility is monitored for parameters that could have an impact on sediment, but as the 303(d) listing and monitoring data indicate, sediment does not appear to be an issue for this catchment.

Table 54. KPDES facilities in Catchment 9

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences
KYG91003	Chevron #42643	1900 Newtown Pike, Lexington, KY 40511	Cane Run	--	--	--
KY0100960	H & R Oil Co Inc.	1144 Finney Dr., Lexington, KY 40511	Unnamed Tributary/ Cane Run	pH	Jan-08-Dec-10	2
				Benzene	Jan-08-Dec-10	8
				Chlorine	Jan-08-Dec-10	None
				Total suspended solids	Jan-08-Dec-10	7
				Ethylbenzene	Jan-08-Dec-10	None
				Flow	Jan-08-Dec-10	None
				Naphthalene	Jan-08-Dec-10	None
				Oil and grease	Jan-08-Dec-10	None
				Toulene	Jan-08-Dec-10	None
				Xylene	Jan-08-Dec-10	1
KYR00075	Hughes Display Products	1501 Newtown Pike, Lexington, KY 40511	North Elkhorn Creek	--	--	--
KYR001527	US Postal Service	1088 Nandino Blvd, Lexington, KY 40511	Cane Run Creek	--	--	--

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[26] There are many different types of Class V injection wells, but in Catchment 9, there are six wells, all of which are large capacity septic systems (LCSS) (Table 55). LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is relatively high[27].

Table 55. Class V injection well locations in Catchment 9

EPA ID	Company Name	Address	Well Type
KYV067007	Rood and Riddle Equine Hospital	2150 Georgetown Rd, Lexington, KY	Large capacity septic system
KYV067008	University of Kentucky Barn #1	2099 Newtown Pike, Lexington, KY	Large capacity septic system
KYV067008	University of Kentucky Farm Shop	2099 Newtown Pike, Lexington, KY	Large capacity septic system
KYV067008	University of Kentucky Apartments	2099 Newtown Pike, Lexington, KY	Large capacity septic system
KYV067009	Carnahan Conversion Ctr.	1701 Newtown Pike, Lexington, KY	Large capacity septic system
KYV067009	Coldstream Swine Research	1825 Newtown Pike, Lexington, KY	Large capacity septic system

Sanitary Sewer Overflows

Point source pollution may originate from the existing wastewater collection infrastructure. All of the sewage in the Cane Run is typically collected by gravity systems that are then pumped via force mains into the adjacent Town Branch watershed where the Town Branch Wastewater Treatment plant is located. Much of the wastewater infrastructure runs parallel to or in natural drainage ways and streams, and leaks in the mains, manhole overflows, pump station overflows, and basement discharges can contribute significant amounts of

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[26] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm

[27] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf

pollution to surface water resources. Table 56 shows known locations of recurring sanitary sewer overflows and unpermitted discharges in Catchment 9. There are likely additional sources from broken or failing sanitary sewer lines in the older neighborhoods within the watershed, as Figure 83 and **Error! Reference source not found.** show. The sanitary sewer smoke testing conducted by LFUCG in the Highlands neighborhood uncovered many connections between the sanitary and storm sewers.

Table 56. Recurring locations of sanitary sewer overflows and unpermitted discharges in Catchment 9[28]

SSO Location	SSO Category	MH Number
1698 Costigan Dr.	Basement	--
Stanton Way	Manhole	CR7-134
Chris Dr.	Manhole	CR2-161

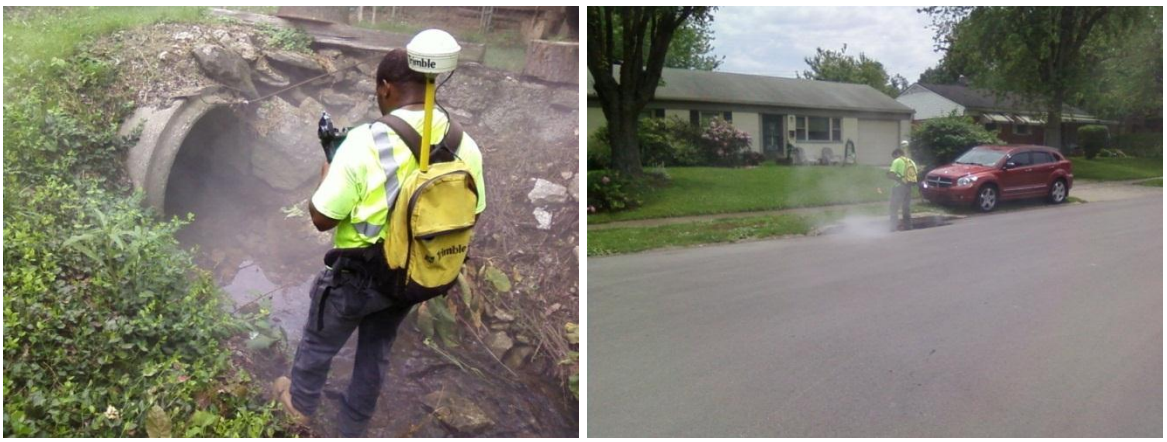

Figure 83. LFUCG sanitary sewer smoke testing coming out of storm sewer

Figure 84. LFUCG sanitary sewer smoke testing coming out of storm sewer

[28]United States of America and the Commonwealth of Kentucky v. Lexington-Fayette Urban County Government, March 14, 2006, Consent Decree, Lodged in the United States District Court, Eastern District of Kentucky, Central Division at Lexington, Related to Civil Action No. 5:06-cv-00386. "Appendix A: Recurring Locations of SSOs and Unpermitted Discharges." Available at: http://www.lexingtonky.gov/Modules/ShowDocument.aspx?documentid=3571

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. The U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[29]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[30]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 2 failing OWTSs in Catchment 9 that contribute a fecal coliform load of 8.10E+08 cfu/day and 0.061 lbs/day of phosphorus.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 9 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 57 and Figure 85). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 57. Land cover in Catchment 9

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture /Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	2.22	1191.36	1.11	41.14	11.79	1.33	741.91	212.61	0.22	**2204**
Percent	0.10	54.06	0.05	1.87	0.53	0.06	33.67	9.65	0.01	**100**

29 U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.
30 U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

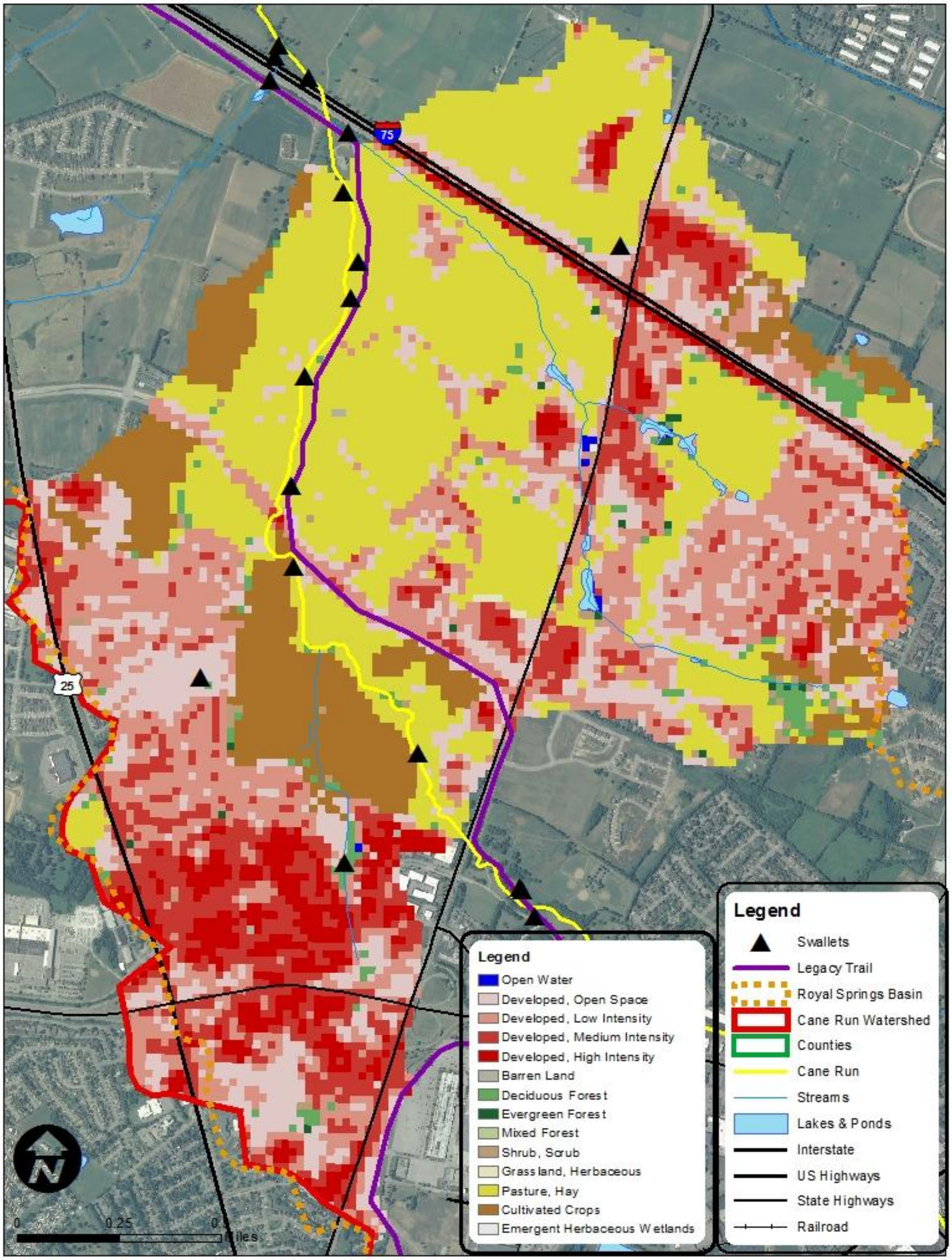

Figure 85. Land cover in Catchment 9

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail. This is a problem in Catchment 9, as was identified by the CRWP ground-truthing effort, which found several instances of bank erosion that are recorded in the report found in Appendix T.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 1.602 lbs/day. This contribution is low compared to other catchments, but this is likely because the amount of non-developed land in this catchment is relatively low.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 9. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 9 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil's holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these

areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[31]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 9 and their daily fecal coliform load contribution can be found in Table 58.

Table 58. Wildlife population estimates and daily fecal coliform load contribution for Catchment 9

Animal	Population	Fecal counts/day
Ducks	21	5.10E+10
Geese	10	4.90E+11
Deer	10	5.00E+09
Beavers	2	5.00E+08
Raccoons	10	1.25E+09

Livestock

Livestock are generally pastured for grazing throughout the Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[32].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 9 and their daily fecal coliform load contribution can be found in Table 59.

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[31] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[32] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

Table 59. Livestock population estimates and daily fecal coliform load contribution for Catchment 9

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock including cattle in streams)
Hogs	2	1.07E+10	--
Beef Cattle	130	9.14E+10	3.34E+11
Dairy Cattle	14	3.28E+10	--
Chickens	241	1.18E+10	--
Horses	122	6.37E+09	4.08E+10
Sheep	1	--	1.20E+10
Goats	3	--	3.60E+10

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 0.663 lbs/day. This contribution is low because it has a relatively small area of developed land.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[33]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 9 are shown in Table 60 and are the third highest developed land loads out of all of the catchments.

Table 60.Daily fecal coliform load contributions from developed land in Catchment 9

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util

[33]U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
9.07E+08	7.35E+08	4.74E+09	6.34E+07

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 9, is used for industrial development because of the close proximity to highway infrastructure. Coldstream Research Park and adjacent areas located near the Newtown Pike and I-75/I-64 interchange continue to undergo significant development.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 9. There is also one large golf course in this catchment that could contribute an excess amount of fertilizers to the Cane Run. Fertilizers make their way into streams through stormwater runoff.

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 9 (Table 61 and Figure 86).

Lexington-Fayette Urban County Government (LFUCG) has been performing bacteria sampling in this catchment in support of its KPDES Stormwater Permit since 1993.

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources.

In 2005, the city of Georgetown contracted with Dr. Gail Brion at the University of Kentucky to conduct a study within the Cane Run Watershed in an attempt to identify and rank potential sources of sewage contamination into the Royal Springs water supply. Monitoring points for this study were established in this catchment.

Water samples were taken at stations in this catchment in 2006 and 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development.

The University of Kentucky Biosystems and Agricultural Engineering Department established a monitoring network for bacteria and sediment in support of bacteria TMDL development, and sampled in this catchment in 2008, 2009, and 2010 as part of the Cane Run Watershed Project.

In the summer of 2010, University of Kentucky student interns with the Cane Run Watershed Project sampled smaller tributaries with the goal of dividing Cane Run Watershed into several sub-watersheds, making it easier to determine the sources and quantities of bacteria pollution contributing to the Cane Run. Some of this sampling was conducted in this catchment.

The University of Kentucky Biosystems and Agricultural Engineering Department established permanent cross-sections in this catchment to assess the physical condition of the stream.

Table 61. Monitoring conducted in Catchment 9

Sampling Entity	Parameters	Sampling Dates	Site IDs
LFUCG	Bacteria	1993-present	L1, S2
KWRRI	Bacteria	2002	C1[1]
City of Georgetown	Bacteria	2005	Highland Springs, Newtown Exchange
KDOW	Nutrients	2006-2007	04018010[1]
CRWP	Bacteria, Sediment	2008-2010	CR04, CR05, CR06[1]
CRWP (Targeted Sampling)	Bacteria	2010	196-203
CRWP	Geomorphology	2008-2010	CR05 (Riffle and Pool), CR06 (Riffle)

[1]This monitoring point is actually located in a different catchment, but it is located at the most downstream point of this catchment, and will therefore be used to evaluate the water quality of this catchment.

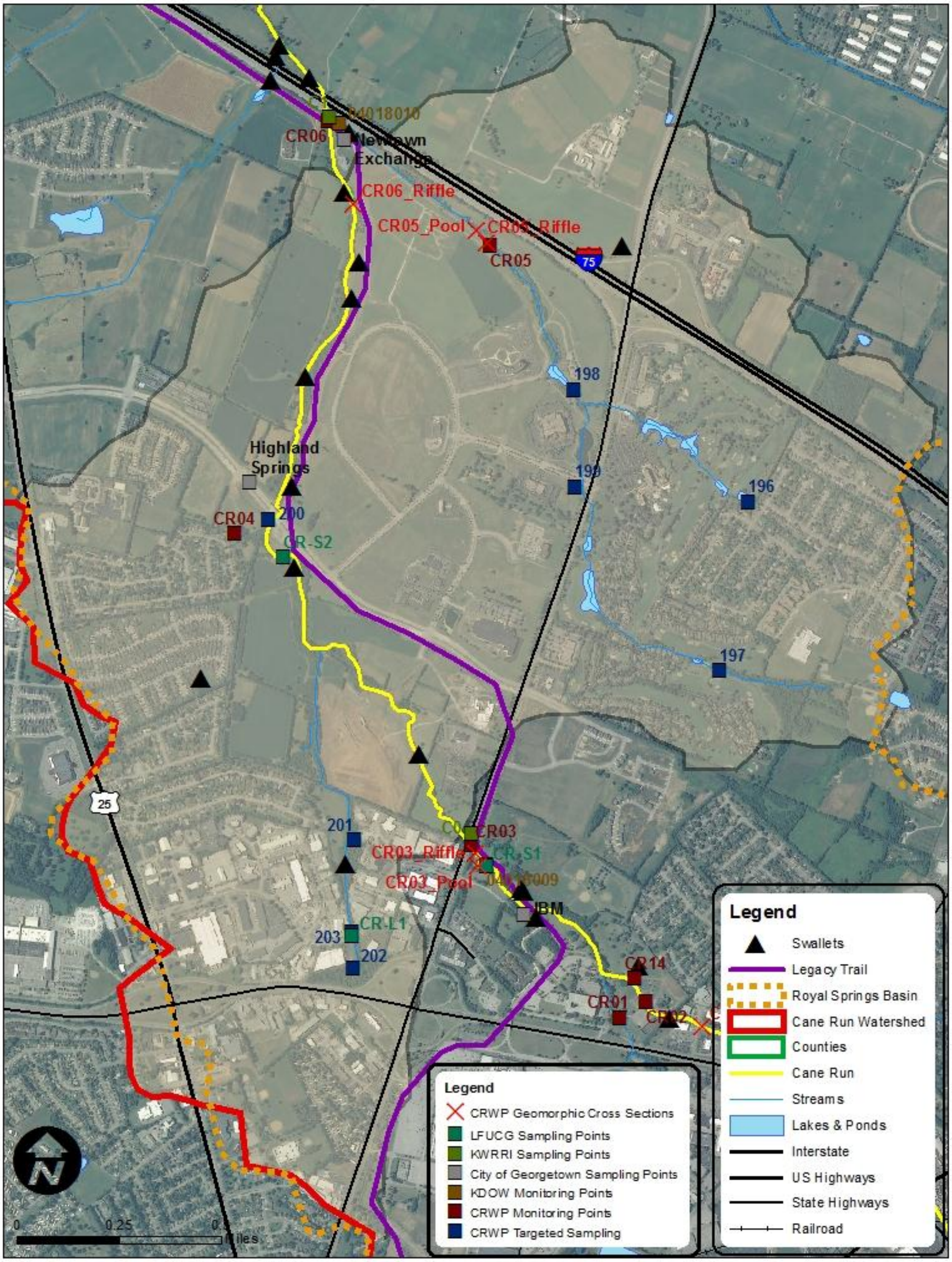

Figure 86. Monitoring points in Catchment 9

Monitoring Conclusions

Geomorphology

Two cross-sections (CR05) were established in Catchment 9 along Cane Run. The CR05 cross-sections are located at the water quality monitoring point CR05. This reach classifies as a B3 according to the Rosgen system of stream classification. The adjacent riparian area is confined by I-75 and a park trail. Riparian vegetation consists largely of a narrow band of trees and grasses. This UT to Cane Run appears to have been channelized in the past to accommodate agricultural practices and development.

For each cross-section, the bank height ratio (BHR) was greater than 2.0, indicating the streambanks are vertically unstable. However, the extensive riparian vegetation along the streambanks resulted in a reduction in cross-sectional area at the riffle and pool from Year 1 to Year 2. Bank erosion hazard index (BEHI) rankings were moderate at each cross-section due to the large BHR; however NBS values were mostly low (Table 62). Streambank erosion is not a concern for this stream reach except for in localized areas; however, the portions of the UT to Cane Run upstream of CR05 lack the extensive riparian vegetation present for the reach downstream of CR05. This riparian section is dominated by grasses and notably lacks trees.

Table 62. Average annual erosion/deposition rates within Catchment 9

Cross-section	Bank	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
CR05_Riffle	Left	Moderate	Low	-0.142
CR05_Riffle	Right	Moderate	Low	-0.013
CR05_Pool	Left	Moderate	Moderate/High	0.444
CR05_Pool	Right	Moderate	Low	-0.033

Developed land accounts for 56 percent of the land use at this monitoring point (Figure 87). As such, water temperatures in this UT to Cane Run are likely influenced by heat from these impervious surfaces (e.g. solar radiation on pavement). Data collected from the Level Troll 500 located at CR05 indicates that water temperatures can reach nearly 84°F in the summer months (Table 63).

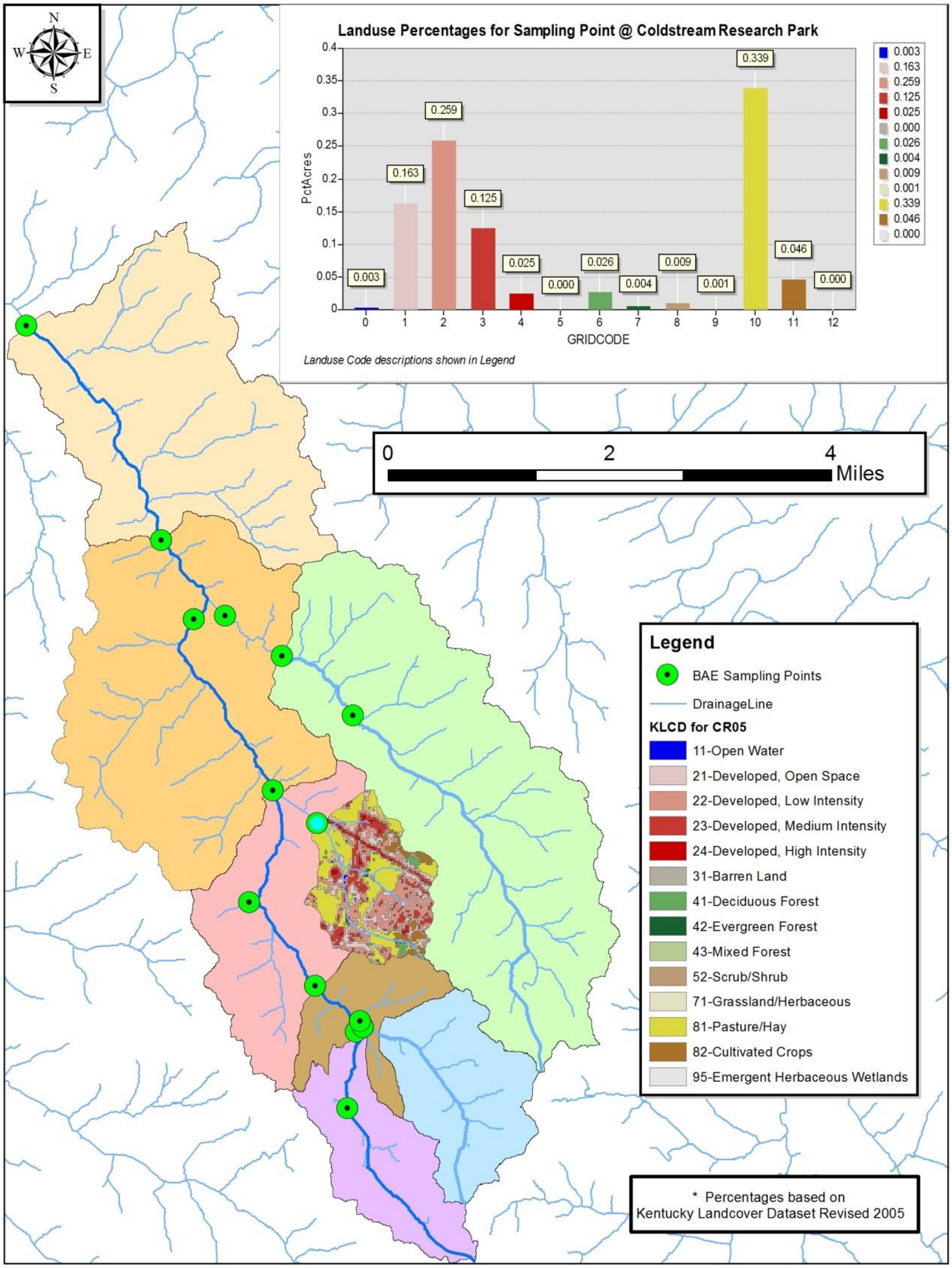

Figure 87. Land use for CR05 in Catchment 9

Table 63. Maximum water temperatures at CR05 within Catchment 9

Year	Month	Maximum Temperature (°F)
2008	June	81.3
	July	82.1
	August	79.8
	September	81.7
	October	72.1
	November	64.0
2009	April	73.1
	May	75.2
	June	80.9
	July	78.4
	August	82.1
	September	74.4
	October	67.2
	November	61.6
	December	51.7
2010	January	48.6
	February	51.6
	March	65.4
	April	75.1
	May	79.1
	June	83.0
	July	83.2
	August	83.6
	September	79.3
	October	71.9
	November	63.9

As seen in Figure 88, water temperatures quickly reached 77 °F for a storm event on July 23, 2008 before dropping below 65°F at the tail end of the hydrograph. Further reductions in water temperatures will most likely be achieved through a combination of shading of the stream via riparian vegetation such as trees and storm water management techniques that encourage infiltration, allowing heated waters to cool before they reach the stream.

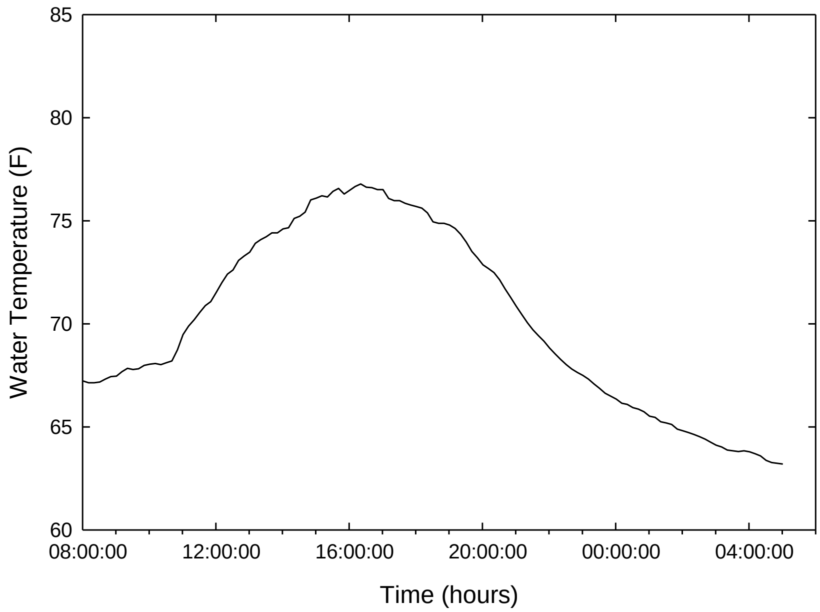

Figure 88. Elevated water temperatures resulting from urban runoff at CR05. Storm event occurred on July 23, 2008.

Water Quality

The University of Kentucky established two water quality monitoring locations established in Catchment 9: CR04 and CR05. Though water quality monitoring station CR06 is located in Catchment 8, it is at the most upstream point to Catchment 8 and the most downstream point to Catchment 9. As such, CR06 will be evaluated with Catchment 9. Bacteria samples were collected at all locations. Sediment samples were collected only at CR05 and CR06.

Bacteria

The sampling conducted by KWRRI in 2002, by LFUCG from 1998 to 2003, by the City of Georgetown in 2005, and by the Cane Run Watershed Project in 2010 confirms the 303(d) listing for this section of stream for fecal coliform. Every sample taken at monitoring point C1 in Catchment 9 exceeded the primary contact standard of 200 colonies per 100 mL, and nearly all exceeded the secondary standard of 1,000 colonies per 100 mL (Table 64). The geometric means of LFUCG's sampling at CR-L1 and CR-S2 far exceed the primary and secondary contact standard (Table 65). The geometric mean of the City of Georgetown's Highland Springs site also exceeded the primary contact standard (Table 66). All of the samples collected at all eight CRWP targeted sampling sites in this catchment exceeded the primary contact standard, and all exceeded the secondary standard (Table 67). This sampling collectively demonstrates that fecal coliform pollution is a problem in Catchment 9.

Table 64. Fecal coliform data from KWRRI monitoring point C1

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	2,289	4,469	DRY	DRY	DRY	DRY	DRY	DRY	DRY	721

Table 65. LFUCG fecal coliform data in Catchment 9

Station ID	Station Description	Sampling Dates	Fecal Geometric Mean Cfu/100 ml
CR-L1	Nandino Blvd	Dec-01 to Apr 02	4,240
CR-S2	Cold Stream Farm	May-96 to Oct-96	36,037

Table 66. City of Georgetown fecal coliform data in Catchment 9

Site	Geometric mean *E. coli* (cfu/100mL)
Highland Springs	454
Newtown Exchange	20

Table 67. Cane Run Watershed Project targeted sampling results in Catchment 9

	07/13/10		07/19/10		07/20/10	
Sampling Site	Other Coliforms	*E. coli*	Other Coliforms	*E. coli*	Other Coliforms	*E. coli*
WP196	60000	~8000	40000	~1273	60000	~16000
WP197	60000	~6200	40000	~700	~110000	4200
WP198	~38900	2800	21000	~1818	54000	2800
WP199	60000	60000	---	---	---	---
WP200	60000	60000	50000	2500	~65000	~9818
WP201	60000	~11900	---	---	---	---
WP202	60000	60000	46000	~1818	~90000	2300
WP203	60000	5800	28000	~1200	~64000	3000

The monitoring conducted by the University of Kentucky from June 2008 to December 2009 also found that *E. coli* concentrations at each of the monitored locations exceeded the primary contact standard for a 30-day geometric mean of 130 cfu/100 ml (Table 68). Furthermore, all grab samples at CR04, nearly all of the grab samples at CR06, and about half of the grab samples at CR05 exceeded the instantaneous maxium priamary and secondary contact standards (Table 69). Examination of the *E. coli* load duration curves for CR06 (Figure 89 and Figure 90) indicates that the primary contact standard was rarely achieved. For CR05, the load duration curve indicates the primary contact standard was achieved about half of the time (Figure 91). This indicates that while the concentrations are high at CR06, TMDL loading rates can be achieved at this location most of the time.

Table 68. Peak and geometric mean *E. coli* concentrations at monitoring locations within Catchment 9

Site	Year	No. Samples	Peak (MPN/100 ml)[1]	30-day Geometric Mean (MPN/100 ml)
CR04	2008	15	83,225	10,292
	2009	29	969,020	9,283
	2008-2009	44	--	10,115
CR05	2008	16	51,050	3,294
	2009	29	7,076	169
	2008-2009	45	--	515
CR06	2008	4	126,237	13,467
	2009	12	15,286	1,414
	2008-2009	16	--	2,484

[1]MPN = most probable number

Table 69. Number of samples at each site that exceeded the primary and secondary surface water samples for *E. coli*

Site	Year	No. Samples	Percent of Samples *E. coli*> 240 MPN/100 ml[1]	Percent of Samples *E. coli*> 676 MPN/100 ml
CR04	2008	15	100	100
	2009	29	100	100
	2008-2009	44	100	100
CR05	2008	16	100	69
	2009	29	41	21
	2008-2009	45	62	38
CR06	2008	4	100	100
	2009	12	83	75
	2008-2009	16	88	81

[1]MPN = most probable number

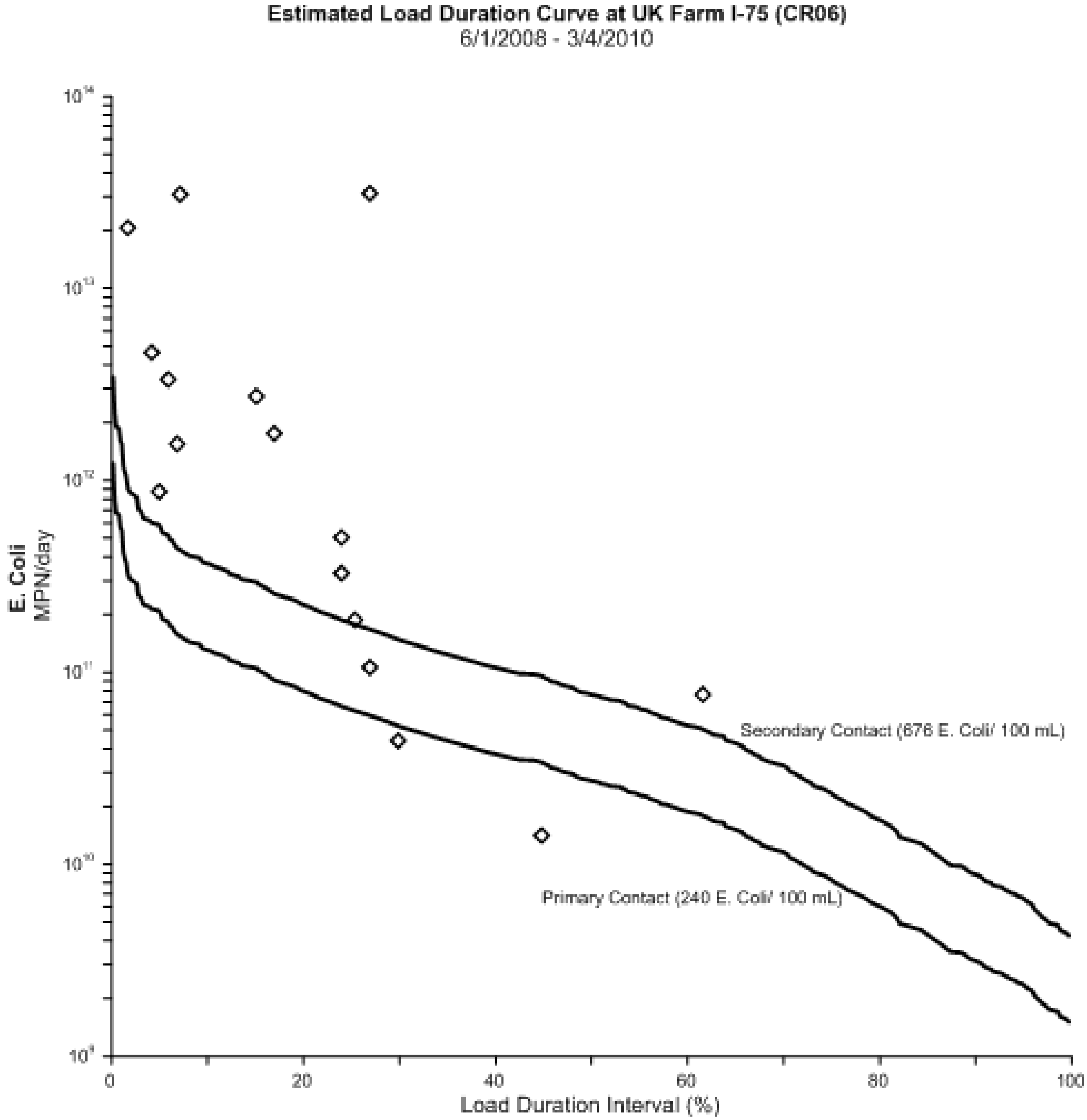

Figure 89. Estimated *E. coli* load duration curves at CR06

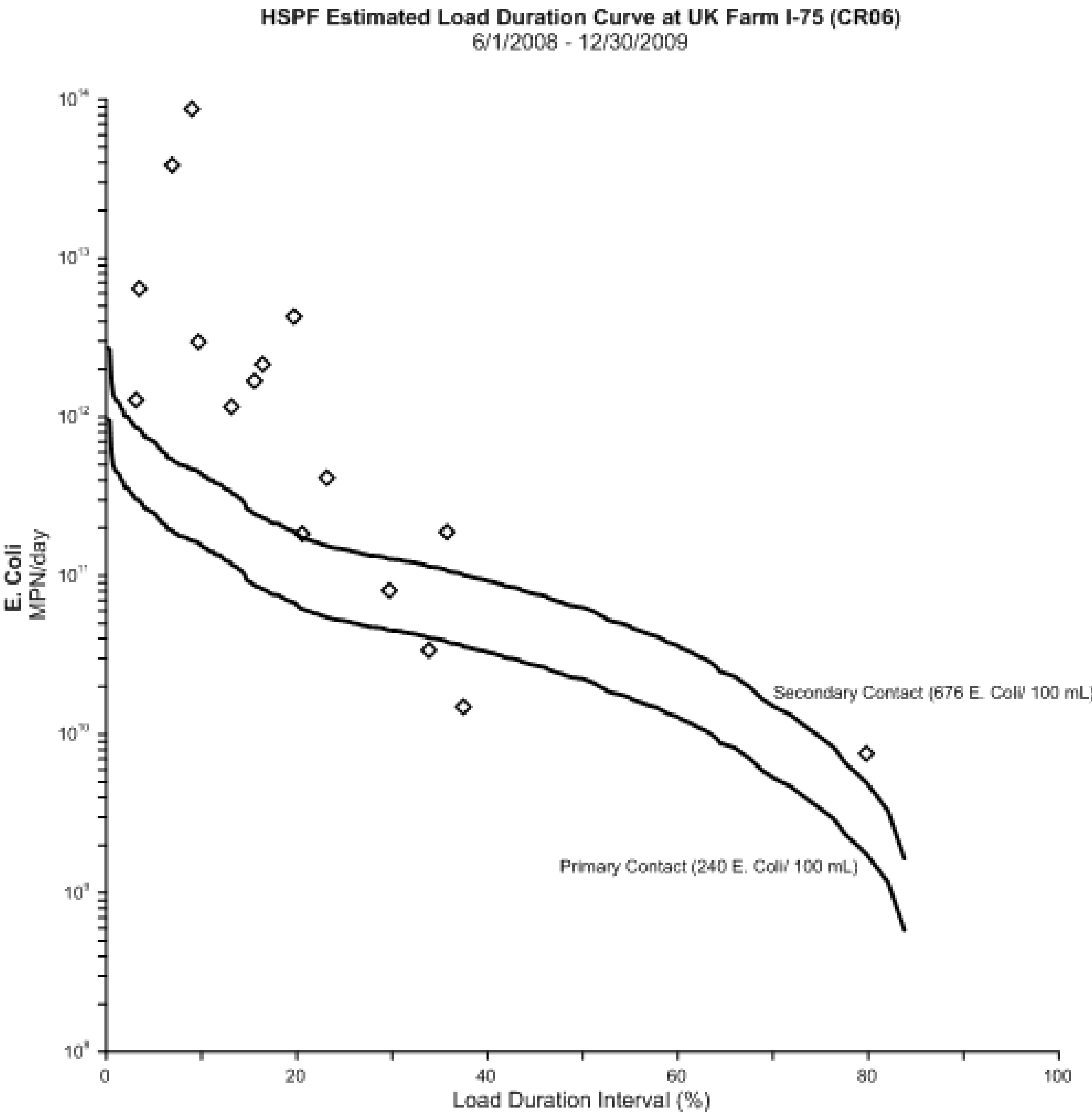

Figure 90. Estimated *E. coli* load duration curves at CR06 utilizing flows developed with the HSPF model

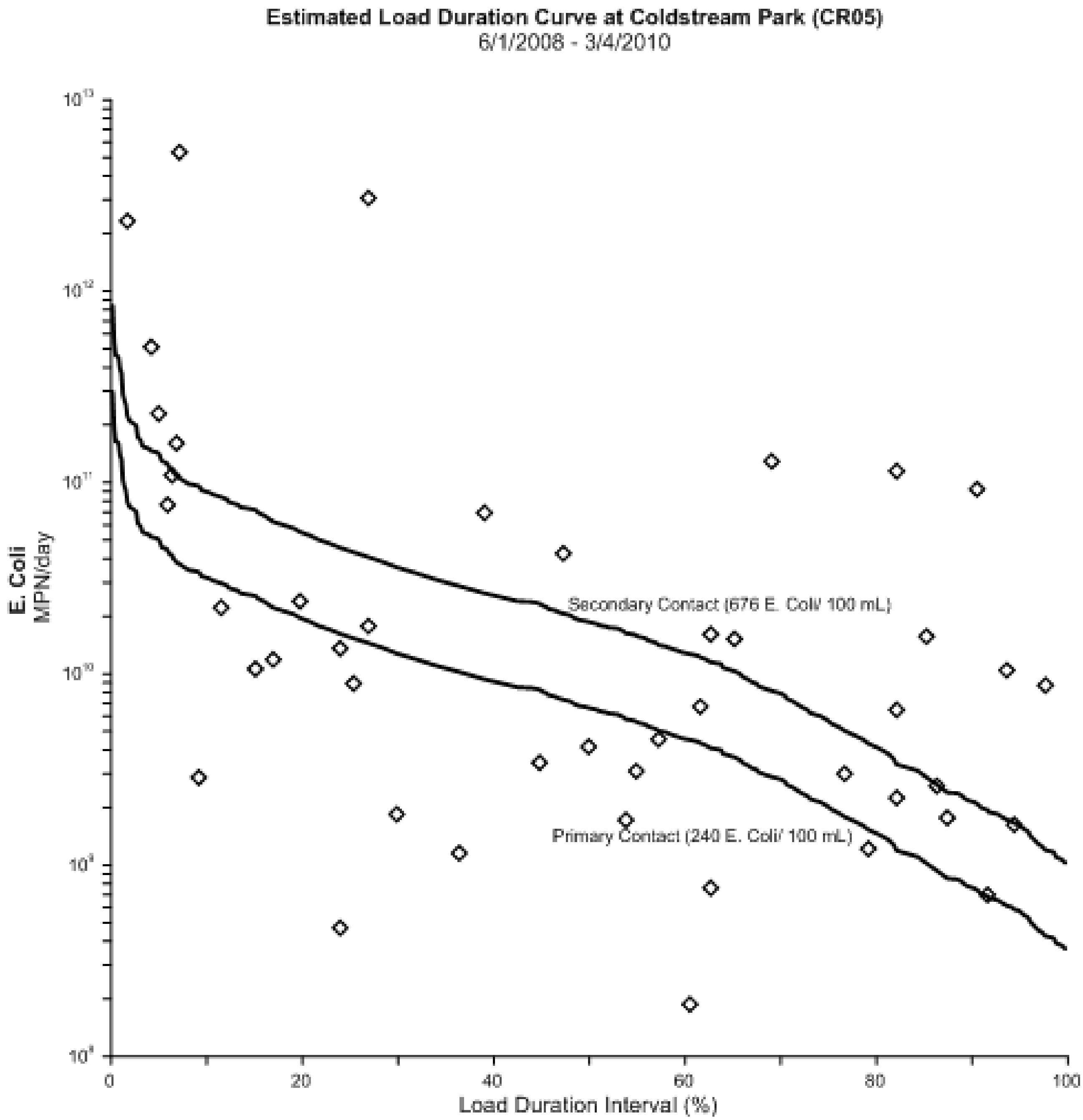

Figure 91. Estimated *E. coli* load duration curves at CR05

The areas draining to these three monitoring sites are highly developed, and as such, the most likely sources of bacteria are permitted dischargers, urban loading in the form of failing sewer lines and pet fecal matter, and failing septic systems and straight pipes. In Catchment 9, there are four KPDES permits that have been identified. Two of these permitted discharges are located up-gradient of CR04 and subsequently CR06.

In addition to KPDES permits, sanitary sewer trunk mains traverse along Cane Run and its tributaries. The monitoring sites are located in close proximity to the trunk mains. Examination of the *E. coli* concentration response to 48-hour prior rainfall indicated that CR05 exhibited an increasing trend (Figure 92) while CR04 and CR06 showed no change (Figure 93 and Figure 94).

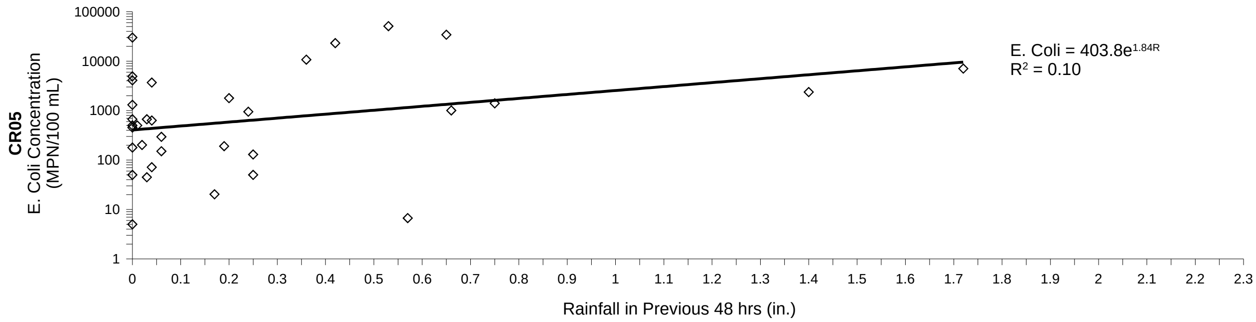

Figure 92. *E. coli* concentration response to 48-hour prior total rainfall for CR05

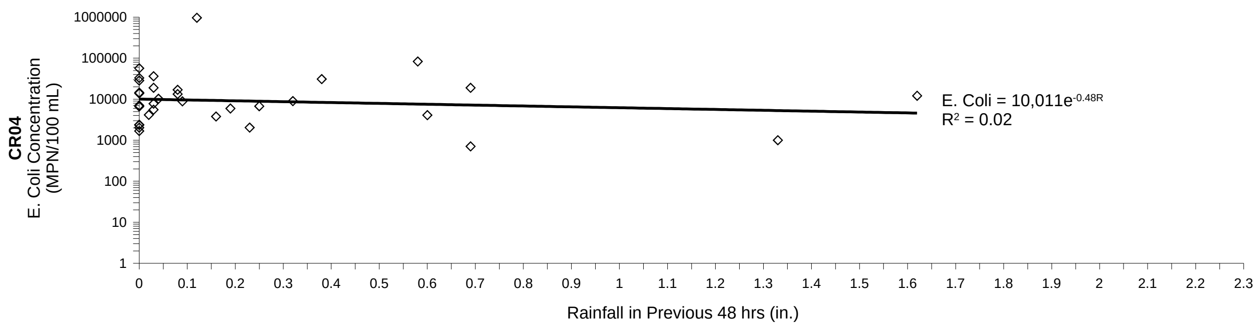

Figure 93. *E. coli* concentration response to 48-hour prior total rainfall for CR04

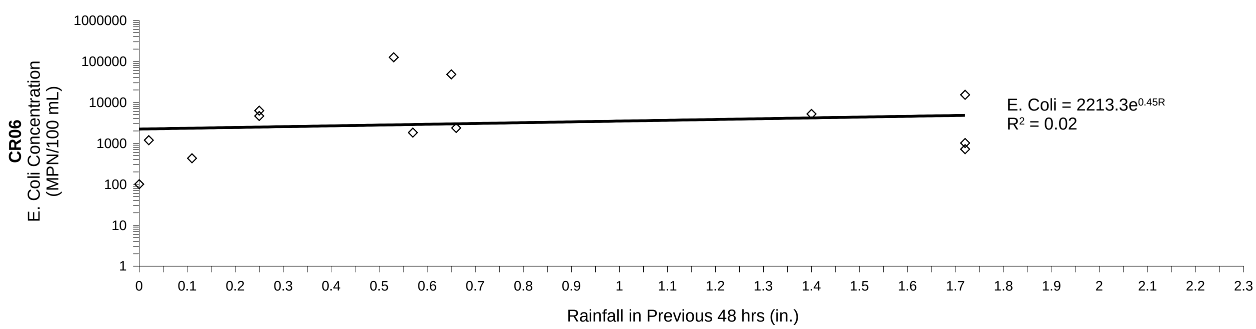

Figure 94. *E. coli* concentration response to 48-hour prior total rainfall for CR06

Based on the bacteria data, it is suspected that *E. coli* levels at CR05 are most likely linked to failing septic systems, sewer lines and other sewer infrastructure. The increasing concentration of *E. coli* at these sites, with increasing rainfall, suggests that sewage is being discharged into the storm sewer system. At CR04, the high *E. coli* levels, during periods without rainfall, suggests that part of the bacteria load is from a KPDES permitted source or some other sort of constant source. CR06 appears to be a combination of all activities in the catchment though its concentrations more closely parallel CR04. The reason for this may have to do with the large constant load of bacteria originating from sources upstream of CR04, in comparison to sources upstream of CR05.

To reduce bacteria loads in Catchment 9, it is recommended that all sanitary sewer lines be inspected and replaced if failures are found. The Highlands Subdivision and the Winburn area should specifically be investigated for sewer infrastructure problems. Septic systems should also be inspected, and if failing, repaired or removed. Efforts should be undertaken to examine permitted KPDES discharged waters to ensure all sources are in compliance. Efforts for this activity should first be focused on the watershed draining to CR04 as this is the source of the highest concentrations. Similar efforts should be focused at CR05 to meet primary contact standards load durations.

Nutrients

The monitoring conducted in 2006 and 2007 by KDOW demonstrates a problem with nutrient pollution, specifically phosphorus, in this catchment. The geometric mean for DOW04018010 is not above the total phosphorus target of 0.3 mg/L (Table 70), but several of the individual samples taken by KDOW at this point equal this total phosphorus target (Appendix K).

Table 70. Nutrient geometric means for DOW04018010

Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
Not detected	Not detected	0.927	1.94	0.106	0.221	4.1	0.364

Sediment

The mean TSS concentration did not exceed 200 mg/l at CR05 and CR06 for any monitored storm event (Table 71). TSS load duration curves indicated that no samples exceeded a 200 mg/l threshold, and only one storm event at CR06 exceeded the 100 mg/l threshold (Figure 95 and Figure 96).

Based on the monitoring data, suspended sediments are not a large concern in Catchment 9. However, areas of streambank erosion should be addressed as these soils are likely contributing nutrients to the watershed. Additionally, areas of upland erosion should be addressed, in part by the establishment of riparian buffers along waterways.

Table 71. Summary of storm sample TSS data for Catchment 9

Monitoring Location	No. Events Sampled	Peak >200 mg/l[1]	Mean >200 mg/l[2]	Geometric Mean >200 mg/l[3]	Mean per Event >200 mg/l[4]	Mean Time >200 mg/l (minutes)[5]
CR05	13	2 (15%)	0 (0%)	0 (0%)	<1	2
CR06	16	4 (25%)	0 (0%)	0 (0%)	<1	11

[1]Mean number of storm events where the storm peak TSS concentration exceeded 200 mg/L.

[2]Mean number of storm events where the storm mean TSS concentration exceeded 200 mg/L.

[3]Mean number of storm events where the storm geometric mean TSS concentration exceeded 200 mg/L.

[4]Mean number of samples in each storm event that exceeded TSS concentration of 200 mg/L.

[5]Mean amount of time in each storm event where TSS concentration exceeded 200 mg/L.

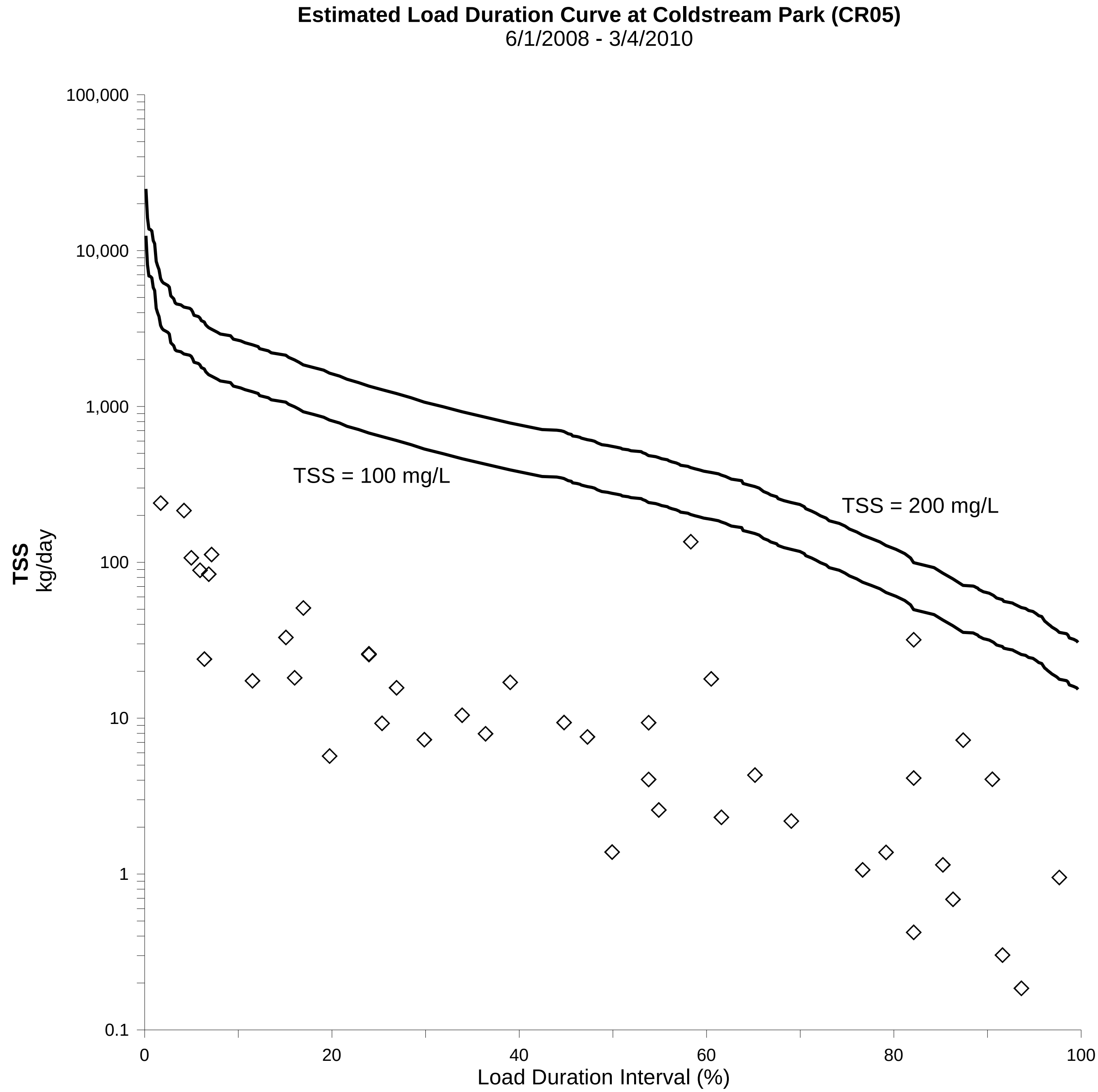

Figure 95. Estimated TSS load duration curve at CR05

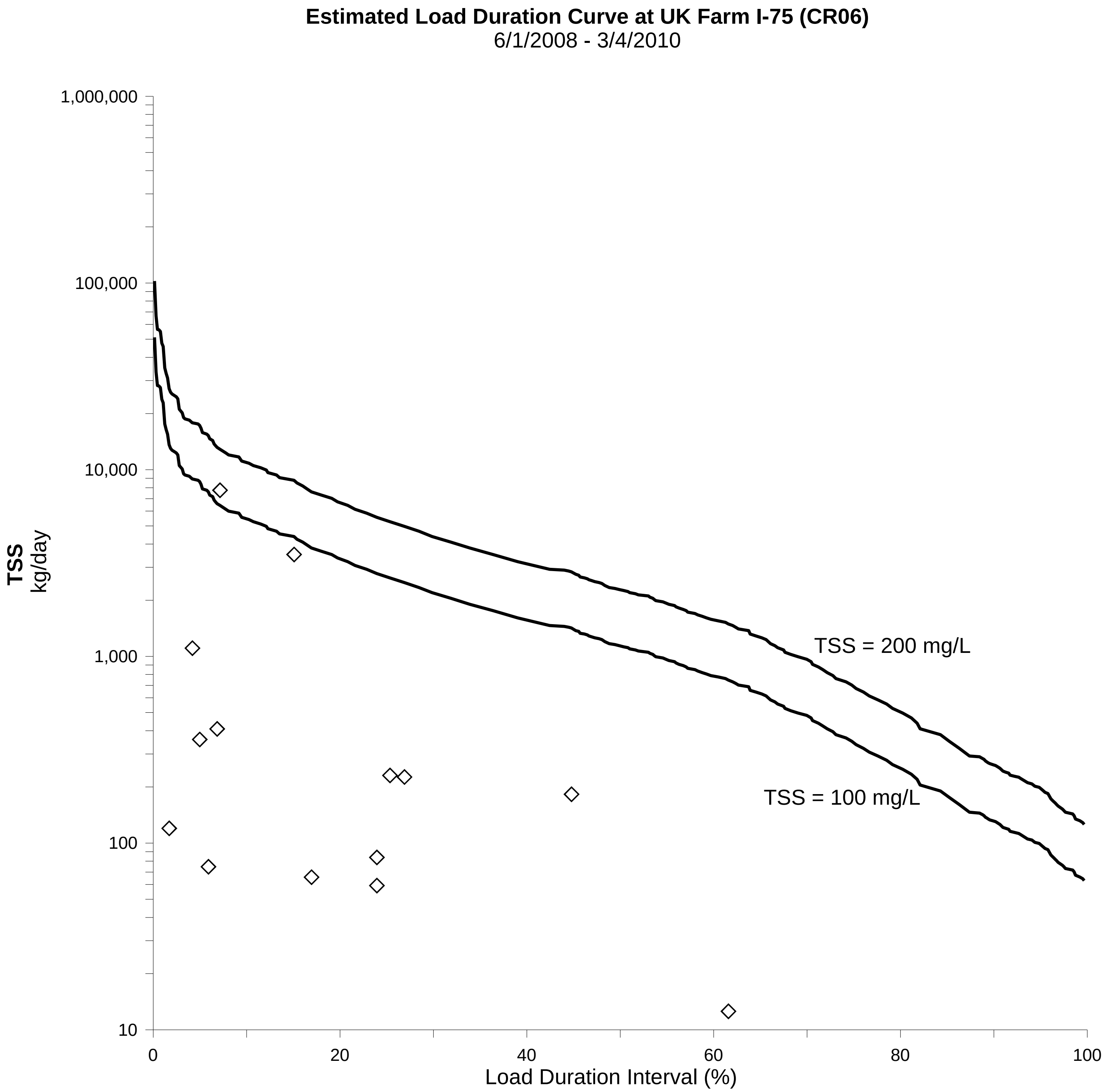

Figure 96. Estimated TSS load duration curve at CR06

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

In addition to physical characteristics of the watershed, there are many projects and partnerships already underway that will also guide BMP implementation efforts. The upper Cane Run Watershed is unique in not only its geology, but by the few, large, public landowners. In Catchment 9 these include University of Kentucky's Agricultural Experiment Station (the largest single landowner on the stream), LFUCG, and Marriott Griffin Gate Resort.

There are situations where this project cannot address water quality issues because of the continued Consent Decree litigation between the Lexington Fayette Urban County Government (LFUCG), US EPA, and Kentucky Division of Water. Although BMPs in the headwater catchments, including Catchment 9, would have a great influence on downstream areas, some may not be addressed by Cane Run Watershed Project 319(h) funds based on their inclusion in the Consent Decree.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform, nutrients (specifically phosphorus), and sewage. The most likely sources of these pollutants in Catchment 9 that should be addressed include livestock (pasture grazing and land application), crop production, urban (especially residential and transportation infrastructure) stormwater, KPDES-permitted facilities, sanitary sewer overflows, lawn fertilizers and pesticides, septic systems, Class V injection wells, and urban development and construction. Although sediment has been determined to not be a problem in this catchment, bank erosion is still an issue and could be contributing nutrients to the stream.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 9, the MS4 developed land loading must be reduced by 50 percent, the MS4 non-developed loading must be reduced by 24.7 percent, and the non-MS4 loading must be reduced by 24.7 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes. The BMPs recommended and implemented within this catchment will help to achieve these reduction goals.

Because Catchment 9 lies within the scope of the Royal Spring aquifer of the Cane Run Watershed, BMPs were selected that most effectively address the primary pollutants and their suspected sources, land use, property owner and/or stakeholder acceptance, and sources of potential funding, as well as technical and community support. This section includes a map and detailed description of proposed and implemented BMPs and a table summarizing these BMPs, their effectiveness, costs, and possible implementation partners.

For additional information about BMP implementation in the entire Cane Run Watershed, please reference the Cane Run and Royal Spring BMP Implementation Plan in Appendix X.

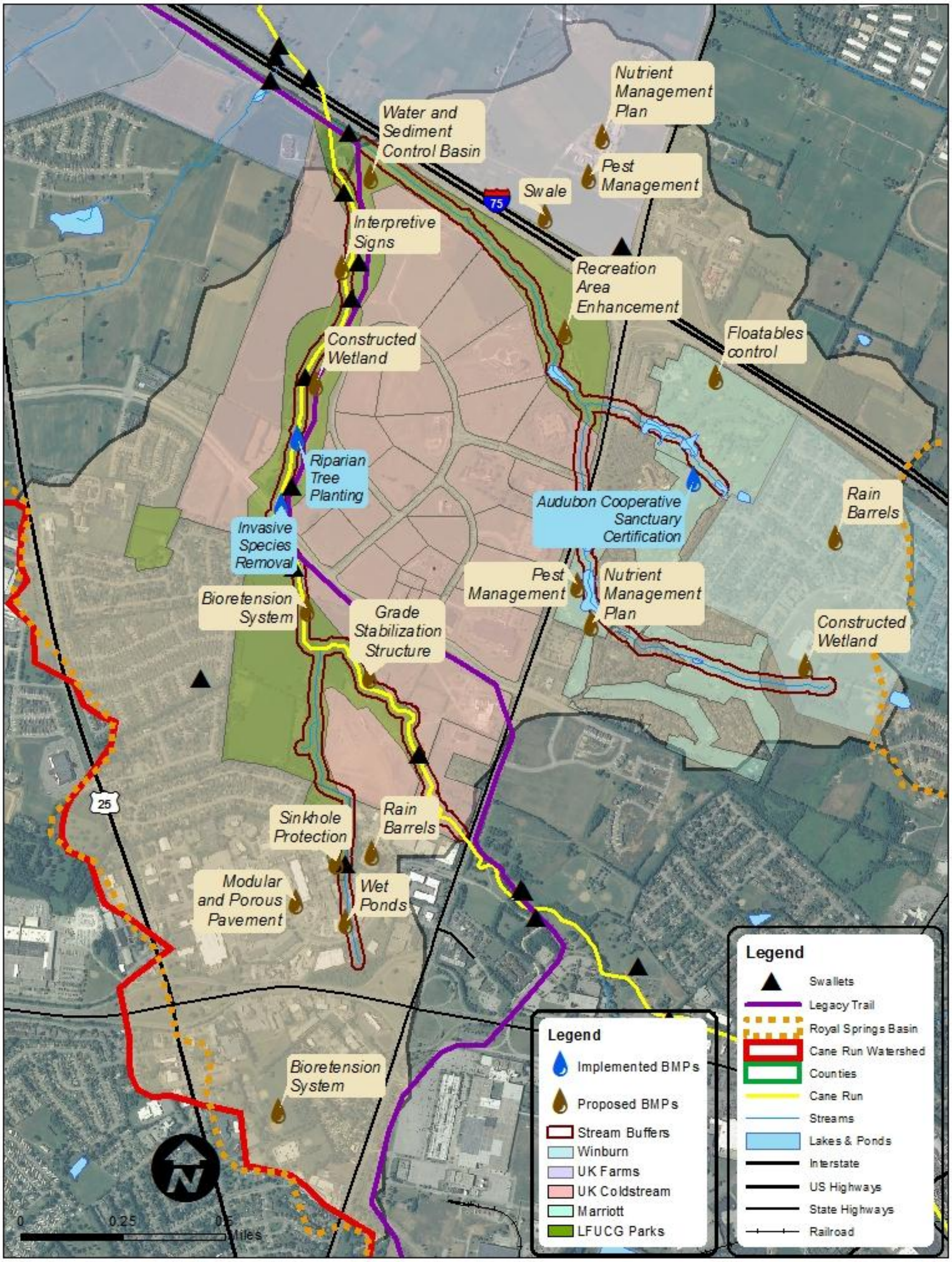

Figure 97. Priority BMP locations for Catchment 9

Cane Run (between Newtown Pike and Coldstream Park)

Proposed

This stream section represents the upper extent of the Royal Spring aquifer. There are a number of strategies and BMPs to be implemented in this reach. If access is obtained, invasive exotic vegetation could be removed and the riparian buffer could be enhanced to reduce nutrient and bacteria pollution originating from runoff. Potential enhancements include sinkhole protection, which would address agricultural pollutants such as pesticides, fertilizers, and manure, pest management, including invasive species removal, and the purchase of conservation easements that would provide an uninterrupted riparian corridor from Lexmark to UK property. A series of easements along the Cane Run would filter all types of pollutants found in stormwater runoff. Wet ponds could be constructed to reduce storm peaks in the stream. Modular and porous pavement, bioretention systems, and rain barrels could be installed by businesses along Nandino Boulevard to reduce the storm surge into the Cane Run and therefore reduce incoming nonpoint source pollution.

Implemented

No best management practices have been implemented along this section as of December 2011.

Cane Run (Coldstream Park)

Proposed

Two small tributaries join the Cane Run within this reach. One originates from the industrial area along Nandino Boulevard and the other originates from the Highlands subdivision.

Engineering work funded by LFUCG has identified locations for wet ponds and extended detention basins along the Cane Run in Coldstream Park. Large volumes of runoff water could be diverted with the installation of structures for water control, collected along the reach and filtered through vegetated filter strips, grassed waterways or swales, sinkhole protection, and bioretention systems. The basins and swales would decrease the volume of runoff that quickly passes through the watershed and would increase the base flow and groundwater flows in the Royal Spring, all while reducing nutrient and bacteria pollution present in stormwater runoff. LFUCG controls a portion of the UK Coldstream Research Park where streamside management can be incorporated.

Pest management activities, such as invasive species removal, should be routine maintenance for a riparian buffer, and they increase public perception that our streams are being taken care of and water quality is being improved. This area will be a possible location for volunteer projects that involve the community in stream stewardship efforts, specifically invasive removal. Interpretative signage could also be placed along the walking/biking trail to highlight activities and educate users about stream functions.

The portion of this reach north of the Citation Boulevard bridge has been identified for a $1 million Supplemental Environmental Project (SEP) in conjunction with the LFUCG Consent Decree (Appendix BB).

Implemented

RIPARIAN TREE PLANTING

This section of LFUCG property was one of the first sites of the annual Reforest the Bluegrass event. Here thousands of trees were planted by community volunteers in 1999. These trees help take up stormwater and reduce loading coming from urban runoff.

INVASIVE SPECIES REMOVAL

In 2009, 15 UK students volunteering with UK Fusion worked to remove honeysuckle and other invasive species along this creek section. This allows a more natural ecosystem to establish along the creek.

Tributary to Cane Run (Winburn subdivision and Marriott Griffin Gate)

Proposed

A tributary of the Cane Run originates in the Winburn subdivision, passes through the Griffin Gate area, through Coldstream Park, and intersects with the Cane Run. Educational programs will be conducted with Winburn Middle School, and, if possible, enhancements to Winburn Park will be made to include a constructed wetland area for science instruction. Bioretention systems and rain barrels that would reduce the amount of stormwater runoff that enters the Cane Run will be demonstrated and encouraged for the neighborhood.

Marriott Griffin Gate Resort has a golf course in a portion of the watershed, and they are looking forward to becoming Audubon Certified. To become certified, a golf facility is required to demonstrate that it is maintaining the highest degree of environmental quality in several areas including environmental planning, wildlife & habitat management, outreach and education, chemical use reduction and safety, water conservation, and water quality management. Efforts along this reach will include education about nutrient management as well as obstruction removal, and pest management. These efforts will address nutrient and pesticide pollution in the catchment.

An additional concern along this reach is the I-75/I-64 highway corridor. The highway runs parallel to the tributary and represents a source of contaminants such as automotive pollutants, trash, and road salt. Adjacent to the interstate, emphasis will be on floatables control and swales that can control these pollutants.

Implemented

AUDUBON COOPERATIVE SANCTUARY CERTIFICATION

In 2008 the Marriott Griffin Gate Golf Club was certified as an Audubon Cooperative Sanctuary. This certification enables golf facilities to protect the environment by enhancing precious natural areas and wildlife habitats. The property’s certification includes bat boxes, bluebird houses, and a butterfly garden. Wildlife corridors were also created throughout the property to encourage the movement of wildlife throughout the course. The increase in vegetation as a result of this certification will help reduce pollutant loading from urban runoff.

Table 72. Catchment 9 priority BMPs[1]

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction[+]	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Nutrient Management	– Minimize nonpoint source pollution of surface and groundwater resources – Maintain or improve soil function to aid in BMP effectiveness	– Nitrogen: 15% – Bacteria: N/A[+] – Sediment: N/A[+] – Phosphorus: 35%	– Nitrogen: High – Bacteria: Low – Sediment: Low – Phosphorus: High[e]	– $1,662.40/each[h]	– $0.00	– UK – NRCS – Bluegrass PRIDE – Marriott Griffin Gate Golf Club
Pest Management	– Improve vegetative BMP establishment and effectiveness – Increase visibility of water quality initiatives	– N/A[+]	– Toxic Chemicals: High[e]	– $143.85/acre[h]	– $0.00	– UK – Friends of Cane Run – Volunteers – LFUCG
Riparian Buffer	– Improve habitat for aquatic organisms – Sediment, nutrient, and bacteria filtration and removal	– Nitrogen: 68% – Bacteria: 60% – Sediment: 80% – Phosphorus: 42%[ajp]	– Nitrogen: Medium – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	– $65.28/acre-$826.26/acre[h]	– $68.99/acre	– UK – NRCS – LFUCG – Volunteers
Bioretention System	– Increase infiltration – Sediment, nutrient, and bacteria	– Nitrogen: 49%[z] – Bacteria: 70%[lk] – Sediment: 65%[lk] – Phosphorus:	– Nitrogen: Medium – Bacteria: Medium – Sediment:	– $2,239.00/ERU[z] (1Stormwater ERU = 2,500ft^2)	– $167.93/ERU (Maintenance = 7.5% of construction cost)	– Bluegrass Rain Garden Alliance – Bluegrass Partnership for a Green

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction⁺	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
	removal	76%[z]	Medium – Phosphorus: High[e]			Community Water Team – Bluegrass PRIDE
Constructed Wetland	– Increase infiltration – Sediment, nutrient, and bacteria removal	– Nitrogen: 44% – Bacteria: 77% – Sediment: 77% – Phosphorus: 50%[f]	– Nitrogen: High – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	– Small: $1,455.25/each[g] – Large: $29,593.99/acre[h]	– Small: $7.39/each – Large: $20.39/each	– Winburn Middle School – Bluegrass PRIDE – UK – LFUCG – NRCS
Rain Barrels	– Encourages infiltration by reducing storm surge and direct deposition of stormwater pollutants	– Nitrogen: 45% – Bacteria: N/A⁺ – Sediment: N/A⁺ – Phosphorus: 70%[i]	– Nitrogen: High – Bacteria: High – Sediment: High – Phosphorus: High[e]	– $30-$130/each – $8.01/foot for piping and additional materials[h]	– $0.43/foot	– Bluegrass PRIDE – LFUCG
Floatables Control	– Improve downstream BMP performance – Reduce excessive solid waste input to stream	– Pollutant removal dependent upon technology chosen	– Efficiency of practice is highly variable depending on proper selection and maintenance; potential to remove a high amount of solid waste entering surface and groundwater[aa]	– Cost will vary depending on location[aa]	– N/A	– Department of Transportation – LFUCG
Recreation Area Enhancement	– Increase attractiveness and usefulness of recreation	– Sediment: N/A⁺	– Slight to substantial improvement for sediment deposition[a]	– $357.60/acre[h]	– $68.99/acre	– LFUCG – UK – Bluegrass PRIDE

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
	areas and protect soil and plant resources					
Interpretive Signs	– Raise awareness of water quality issues – Identify restoration techniques and practices – Display the partnerships and organizations involved in the watershed.	– N/A+	– Increase awareness and education; improve BMP performance	– Cost depends on size sign and number created	– N/A	– LFUCG – UK – Bluegrass PRIDE – Friends of Cane Run – Bluegrass Partnership for a Green Community Water Team
Obstruction Removal	– Enhance BMP effectiveness and conservation practices	– N/A+	– N/A°	– This practice involves removing a broad range of obstruction; cost is extremely variable based on site specific conditions. Expected costs must take equipment and labor into consideration.	– N/A	– NRCS – UK
Sinkhole Protection	– Increase groundwater recharge quality	– Nitrogen: N/A+ – Bacteria: 90%[q] – Sediment: N/A+	– Nitrogen: High – Bacteria: High – Sediment: High – Phosphorus:	– $3,407.06/each[h]	– $97.19/each	– UK – NRCS

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction[+]	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
	– Sediment, bacteria, and nutrient filtration and removal	– Phosphorus: N/A[+]	High[e]			
Wet Pond	– Increase infiltration and groundwater recharge – Sediment, nutrient, and bacteria filtration and removal	– Nitrogen: 31% – Bacteria: 65% – Sediment: 67% – Phosphorus: 48%[cc]	– Nitrogen: Low – Bacteria: High – Sediment: High – Phosphorus: Medium[e]	– $45,700/acre[cc]	– $1828.00/acre (EPA average of 4% of construction cost)	– Coldstream Businesses – Bluegrass Partnership for a Green Community Water Team
Swale	– Increase infiltration and groundwater recharge – Sediment and nutrient filtration and removal	– Nitrogen: 38% – Bacteria: N/A[+] – Sediment: 81% – Phosphorus: 29%[m]	– Nitrogen: Medium – Bacteria: Low – Sediment: Medium – Phosphorus: Medium[e]	– $4,929.59/acre[h]	– $47.86/acre	– Coldstream Businesses – Bluegrass Partnership for a Green Community Water Team – UK
Grade Stabilization Structure	– Reduces erosion potential – Sediment removal	– Nitrogen: 10% – Bacteria: N/A[+] – Sediment: 35% – Phosphorus: 30%[k]	– Nitrogen: Low – Bacteria: N/A – Sediment: Medium – Phosphorus: Low[e]	– $2,380.74/each[h]	– $23.11/each	– UK – NRCS – LFUCG
Water and Sediment Control Basin	– Sediment and nutrient filtration and removal	– Nitrogen: N/A[+] – Bacteria: N/A[+] – Sediment: 70%[r] – Phosphorus: N/A[+]	– Nitrogen: Medium – Bacteria: Low – Sediment: High – Phosphorus: Medium[e]	– $1,901.34/each[h]	– $18.46/each	– UK – Coldstream Businesses

¹The studies referenced in this table can be found in Appendix AA.

*BMPs for each catchment are listed by magnitude of priority based on 1) their implementation in the upper reaches of the watershed, 2) their pollutant removal effectiveness, 3) legal restrictions that may hinder their use, 4) stakeholder participation, 5) the availability of additional funding or technical support. BMPs listed in bold have been implemented as described in narrative.

+Estimated Load Reduction: provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend exclusively on site-specific variables such as soil type, topography, climate, and production system.

°Effectiveness: Abstracted from USDA Agriculture Information Bulletin No. 598 and NRCS conservation practice physical effects (CPPE) documents. NOTE: Because of the general nature of these documents, there may be situations and sites where practices will not perform as indicated.

Catchment 1

Pollutant Source Assessment

The 303(d) listed unnamed tributary of the Cane Run that begins in and flows through Catchment 1 (that also flows in Catchments 8) has been identified as having high levels of nitrogen and phosphorus, with suspected sources including managed pasture grazing and non-irrigated crop production (Figure 98). Other point and nonpoint sources that could also contribute to this pollution are described below.

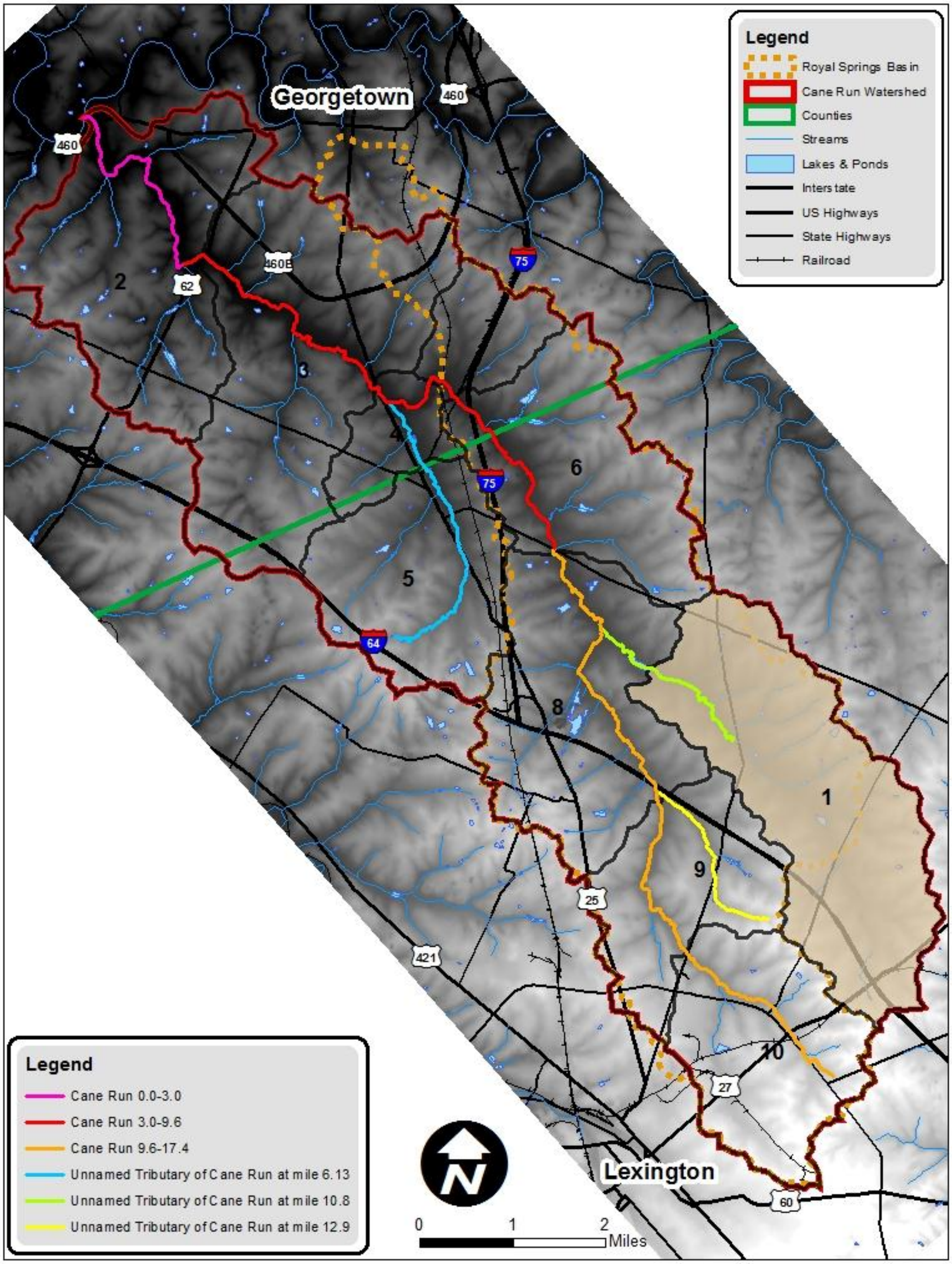

Figure 98. Impaired stream section in Catchment 1

Point Sources

There are several possible sources of point source pollution within Catchment 1, including Class V injection wells, sanitary sewer overflows, failing onsite wastewater treatment systems, and straight pipes (Figure 99). These point sources contribute mainly to bacteria and nutrient pollution.

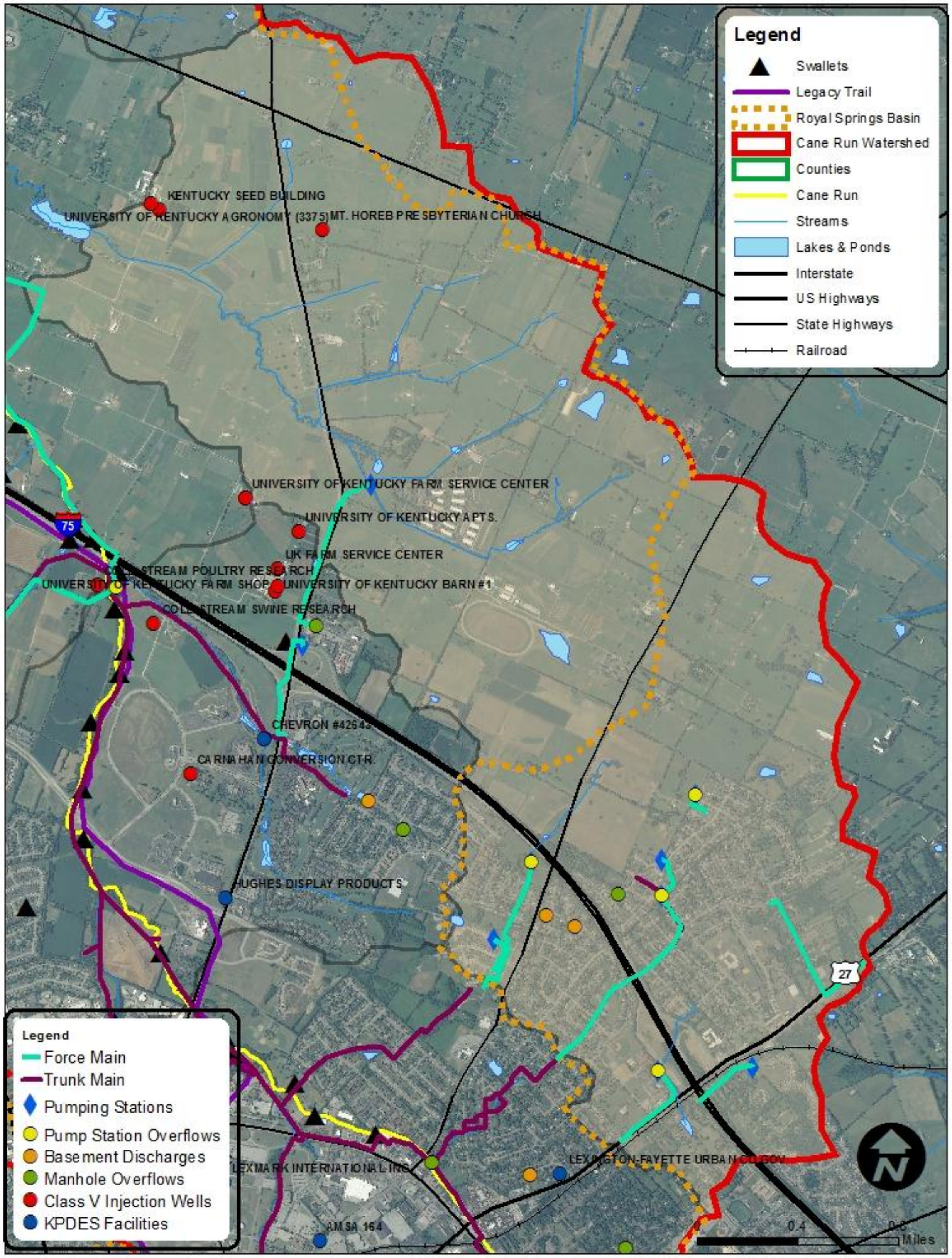

Figure 99. Potential point sources in Catchment 1

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[34] There are many different types of Class V injection wells, but in Catchment 1, there are three wells, all of which are large capacity septic systems (LCSS) (Table 73). LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is relatively high[35].

Table 73. Class V injection well locations in Catchment 1

EPA ID	Company Name	Address	Well Type
KYV067000	Mt. Horeb Presbyterian Church	2793 Iron Works Pike, Lexington, KY	Large capacity septic system
KYV067008	Kentucky Seed Building	3250 Iron Works Pike, Lexington, KY	Large capacity septic system
KYV067008	University of Kentucky Agronomy (3375)	3250 Iron Works Pike, Lexington, KY	Large capacity septic system

Sanitary Sewer Overflows

Point source pollution may originate from the existing wastewater collection infrastructure. All of the sewage in the Cane Run is typically collected by gravity systems that are then pumped via force mains into the adjacent Town Branch watershed where the Town Branch Wastewater Treatment plant is located. Much of the wastewater infrastructure runs parallel to or in natural drainage ways and streams, and leaks in the mains, manhole overflows, pump station overflows, and basement discharges can contribute significant amounts of pollution to surface water resources. Table 74 shows known locations of recurring sanitary sewer overflows and unpermitted discharges in Catchment 1.

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[34] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm

[35] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf

Table 74. Recurring locations of sanitary sewer overflows and unpermitted discharges in Catchment 1[36]

SSO Location	SSO Category	MH Number
Winburn, Colchester Dr./ Feltner Ct.	Pump Station	--
Thoroughbred Acres, Parkside & Cabot	Pump Station	--
Shandon Park #2, Kingston Rd	Pump Station	--
Sharon Village, N. Broadway/ I-75	Pump Station	--
245 Radcliffe Rd.	Basement	--
209 Radcliffe Rd.	Basement	--
Pierson Dr.	Manhole	CR4-175

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. The U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[37]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[38]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 2 failing OWTSs in Catchment 1 that contribute a fecal coliform load of 8.10E+08 cfu/day.

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[36] United States of America and the Commonwealth of Kentucky v. Lexington-Fayette Urban County Government, March 14, 2006, Consent Decree, Lodged in the United States District Court, Eastern District of Kentucky, Central Division at Lexington, Related to Civil Action No. 5:06-cv-00386. "Appendix A: Recurring Locations of SSOs and Unpermitted Discharges." Available at: http://www.lexingtonky.gov/Modules/ShowDocument.aspx?documentid=3571

[37] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.

[38] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 7 straight pipes in Catchment 1 that contribute a fecal coliform load of 5.30E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 0.855 lbs/day.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 1 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 75 and Figure 100). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 75. Land cover in Catchment 1

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture /Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	8.45	1260.75	0.22	116.53	42.25	94.52	2898.24	57.38	0.00	**4478**
Percent	0.19	28.15	0.00	2.60	0.94	2.11	64.72	1.28	0.00	**100**

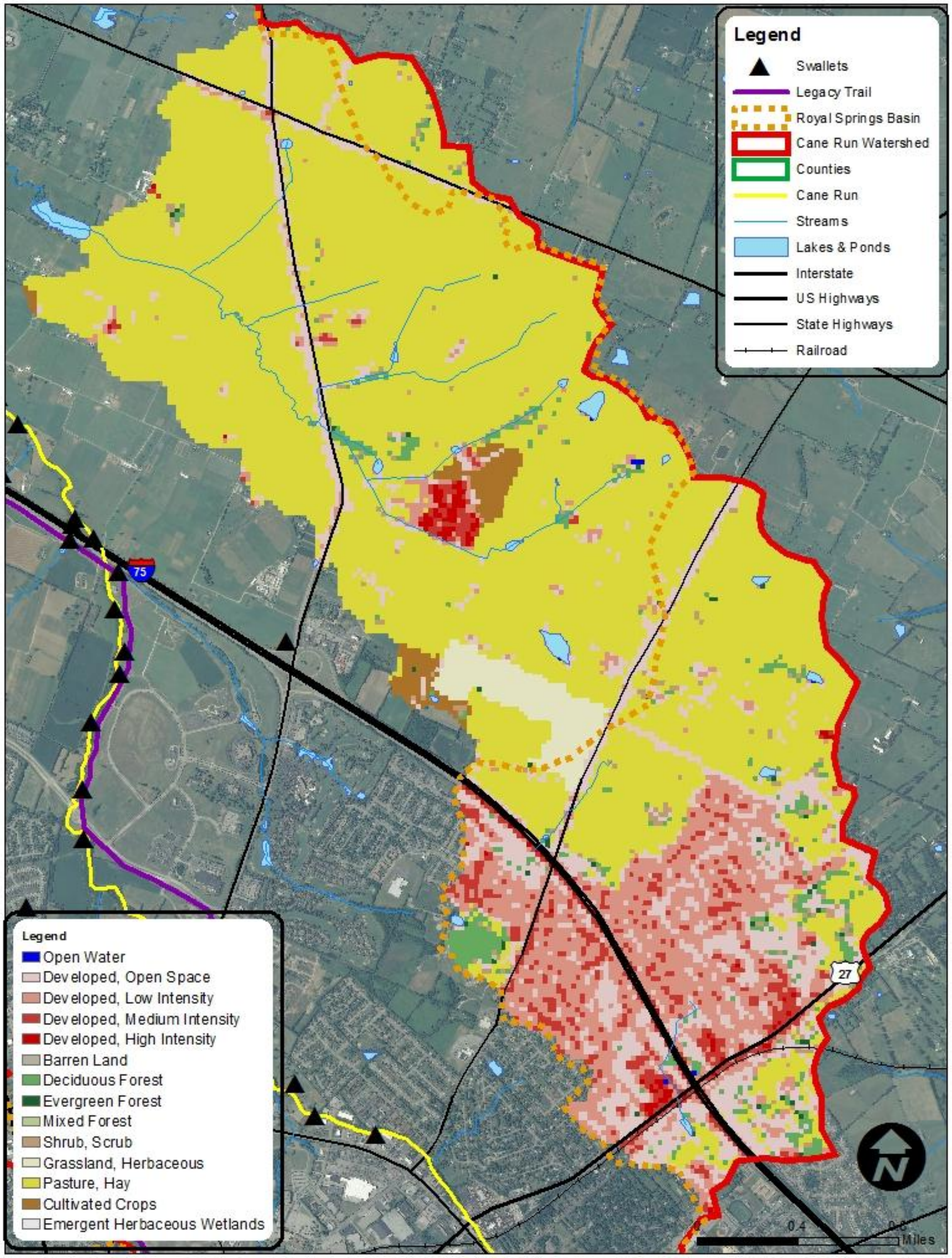

Figure 100. Land cover in Catchment 1

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 2.570 lbs/day.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 1. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 1 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil’s holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[39]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 1 and their daily fecal coliform load contribution can be found in Table 76.

Table 76. Wildlife population estimates and daily fecal coliform load contribution for Catchment 1

Animal	Population	Fecal counts/day
Ducks	27	6.56E+10
Geese	13	6.37E+11
Deer	13	6.50E+09
Beavers	3	7.50E+08
Raccoons	13	1.63E+09

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[40].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 1 and their daily fecal coliform load contribution can be found in Table 77. This catchment ranks first in the number of chickens, third in the number of beef cattle, and third in the number of horses, which makes livestock an important part of nonpoint source pollution in Catchment 1.

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[39] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[40] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

Table 77. Livestock population estimates and daily fecal coliform load contribution for Catchment 1

Animal	Population	Fecal count/day (land application)	Fecal count/day (grazing livestock, including cattle in streams)
Hogs	2	3.74E+10	--
Beef Cattle	165	1.16E+11	4.24E+11
Dairy Cattle	18	4.22E+10	--
Chickens	1398	6.84E+10	--
Horses	154	8.04E+09	5.15E+10
Sheep	0	--	1.20E+10
Goats	15	--	1.80E+11

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 0.258 lbs/day.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[41]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 1 are shown in Table 78.

Table 78. Daily fecal coliform load contributions from developed land in Catchment 1

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
1.06E+08	1.81E+08	2.39E+09	2.80E+06

[41] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 1.

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 1, is used for industrial development because of the close proximity to highway infrastructure. The FEI 2010 World Equestrian Games has brought a widening of Newtown Pike north of I-75 and additional construction around the Ironworks Pike interchange with I-75.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 1 (Table 79 and Figure 101).

The University of Kentucky Biosystems and Agricultural Engineering Department established a monitoring network for bacteria and sediment in support of bacteria TMDL development, and sampled in this catchment in 2008, 2009, and 2010 as part of the Cane Run Watershed Project.

University of Kentucky staff took water samples at five points along small Cane Run tributaries on Fasig-Tipton and Victory Haven properties on January 25, 2010 to trace the source of bacterial contamination above the University of Kentucky Experiment Station.

The University of Kentucky Biosystems and Agricultural Engineering Department established permanent cross-sections in this catchment to assess the physical condition of the stream.

Table 79. Monitoring conducted in Catchment 1

Sampling Entity	Parameters	Sampling Dates	Site IDs
CRWP	Bacteria, Sediment	2008-2010	CR08, CR07
CRWP (Victory Haven)	Bacteria	2010	VSFT-2-VSFT-6
CRWP	Geomorphology	2008-2010	CR08 (Riffle and Pool), WP23-WP26

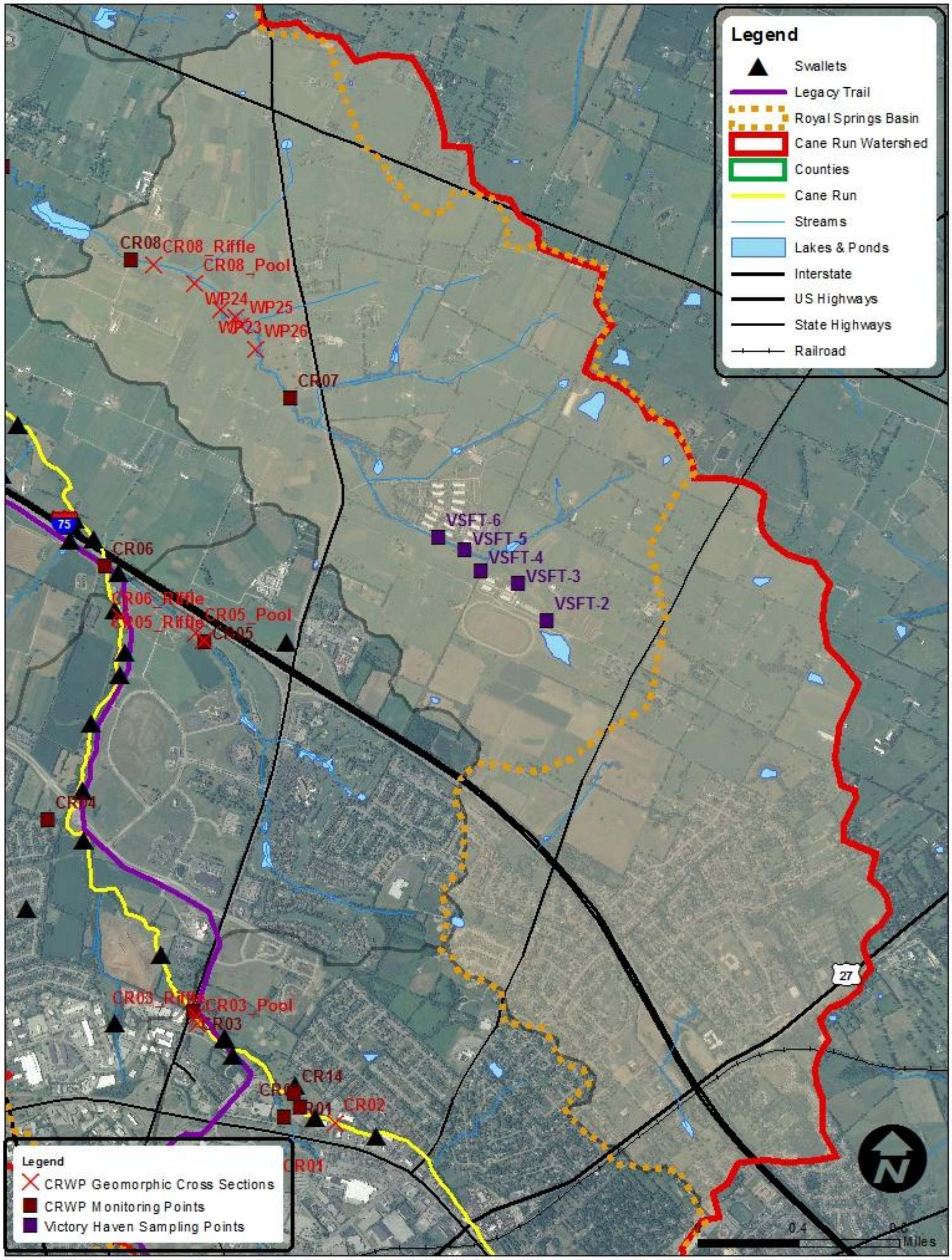

Figure 101. Monitoring points in Catchment 1

Monitoring Conclusions

Geomorphology

Six cross-sections (two at CR08; one each at WP23, WP24, WP25, and WP26) were established in Catchment 1 along a perennial UT to Cane Run. The CR08 cross-sections are located at the water quality monitoring point CR08. This reach classifies as a C1 stream type according to the Rosgen system of stream classification. The adjacent riparian area is dominated by grasses. Cross-sections WP23, WP24, WP25 and WP26 are located along a meandering section of the UT. For this section of the stream, the riparian area is lined with mature trees. This reach classifies as E1 stream type according to the Rosgen system of stream classification.

For each cross-section, the bank height ratio (BHR) was 1.1 or less indicating the streambanks are vertically stable at these measured locations. And as the stream bed is comprised of bedrock, this stream will not incise. Changes in cross-sectional area from Year 1 to Year 2 were small ranging from -0.8 to +1.2 ft^2. With the exception of two streambanks, bank erosion hazard index (BEHI) values were low or moderate (Table 80). The streambanks with the highest erosion rates largest had greater near bank stress (NBS). As BHRs were low, reducing the NBS through lowering of the streambank (i.e. creating a bankfull bench) is not a feasible option.

Based on the results from the geomorphic assessment of the UT to Cane Run from Newtown Pike to Agronomy Drive (CR08), this stream reach is stable. It is recommended that the riparian buffer along with reach be managed to prevent or minimize vehicular and livestock traffic (e.g. no mow zones and grazing exclusion). Further consideration should also be given to establishing and maintaining the riparian buffer for temperature modification, such as one dominated by trees. Data collected from the Level Troll 500 located at CR08 indicates that water temperatures can reach 90° F during the summer months (Table 81).

Table 80. Average annual erosion/deposition rates within Catchment 1

Cross-section	Bank	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
CR08_Riffle	Left	Low	Low	-0.178
CR08_Riffle	Right	Low	Low/Moderate	0.124
CR08_Pool	Left	Moderate	High	0.711
CR08_Pool	Right	Low	Low/Moderate	0.197
WP23	Left	Low	Moderate	0.500
WP23	Right	Low	Moderate	0.479
WP24	Left	High	High	0.516
WP24	Right	Low	Moderate	-0.090
WP25	Left	Moderate	Moderate	0.352
WP25	Right	Low	Low	-0.042
WP26	Left	High	Low/Moderate	0.098
WP26	Right	Very Low	Moderate	-0.551

Table 81. Maximum water temperatures at CR08 within Catchment 1

Year	Month	Maximum Temperature (°F)
2008	June	89.6

Year	Month	Maximum Temperature (°F)
	July	89.5
	August	90.8
	September	87.9
	October	78.0
	November	63.7
2009	April	73.2
	May	80.6
	June	85.6
	July	84.4
	August	83.6
	September	79.0
	October	65.6
	November	61.2
	December	53.4
2010	January	51.4
	February	54.1
	March	68.2
	April	80.9
	May	74.3
	June	90.3
	July	89.0
	August	88.8
	September	80.4
	October	68.8
	November	61.7

Water Quality

Bacteria

Over the monitoring period, which spanned from June 2008 to December 2009, *E. coli* concentrations at each of the monitored locations exceeded the primary contact standard for a 30-day geometric mean of 130 cfu/100 ml (Table 82). In 2008, nearly all grab samples at CR07 exceeded the instantaneous maximum primary and secondary primary contact standards (Table 83). For the sampling period, both peak, 30-day geometric mean, and number of samples exceeding the primary contact standard were greater for CR07 than CR08 suggesting that load reduction possibly via dilution is occurring between these two monitoring locations. Examination of the *E. coli* load duration curve for CR08 (Figure 102) indicates that the primary contact standard was achieved nearly 25 percent of the time at this location.

Table 82. Peak and geometric mean *E. coli* concentrations at monitoring locations within Catchment 1

Site	Year	No. Samples	Peak (MPN/100 ml)[1]	30-day Geometric Mean (MPN/100 ml)

Site	Year	No. Samples	Peak (MPN/100 ml)[1]	30-day Geometric Mean (MPN/100 ml)
CR07	2008	16	164,767	4,619
	2009	29	10,109	471
	2008-2009	45	--	1,061
CR08	2008	15	26,597	2,005
	2009	28	7,290	327
	2008-2009	43	--	657

[1]MPN = most probable number

Table 83. Number of samples at each site that exceeded the primary and secondary surface water samples for *E. coli*

Site	Year	No. Samples	Percent of Samples *E. coli* >240 MPN/100 ml[1]	Percent of Samples *E. coli* >676 MPN/100 ml
CR07	2008	16	100	94
	2009	29	69	31
	2008-2009	45	80	53
CR08	2008	15	93	60
	2009	28	61	25
	2008-2009	43	72	37

[1]MPN = most probable number

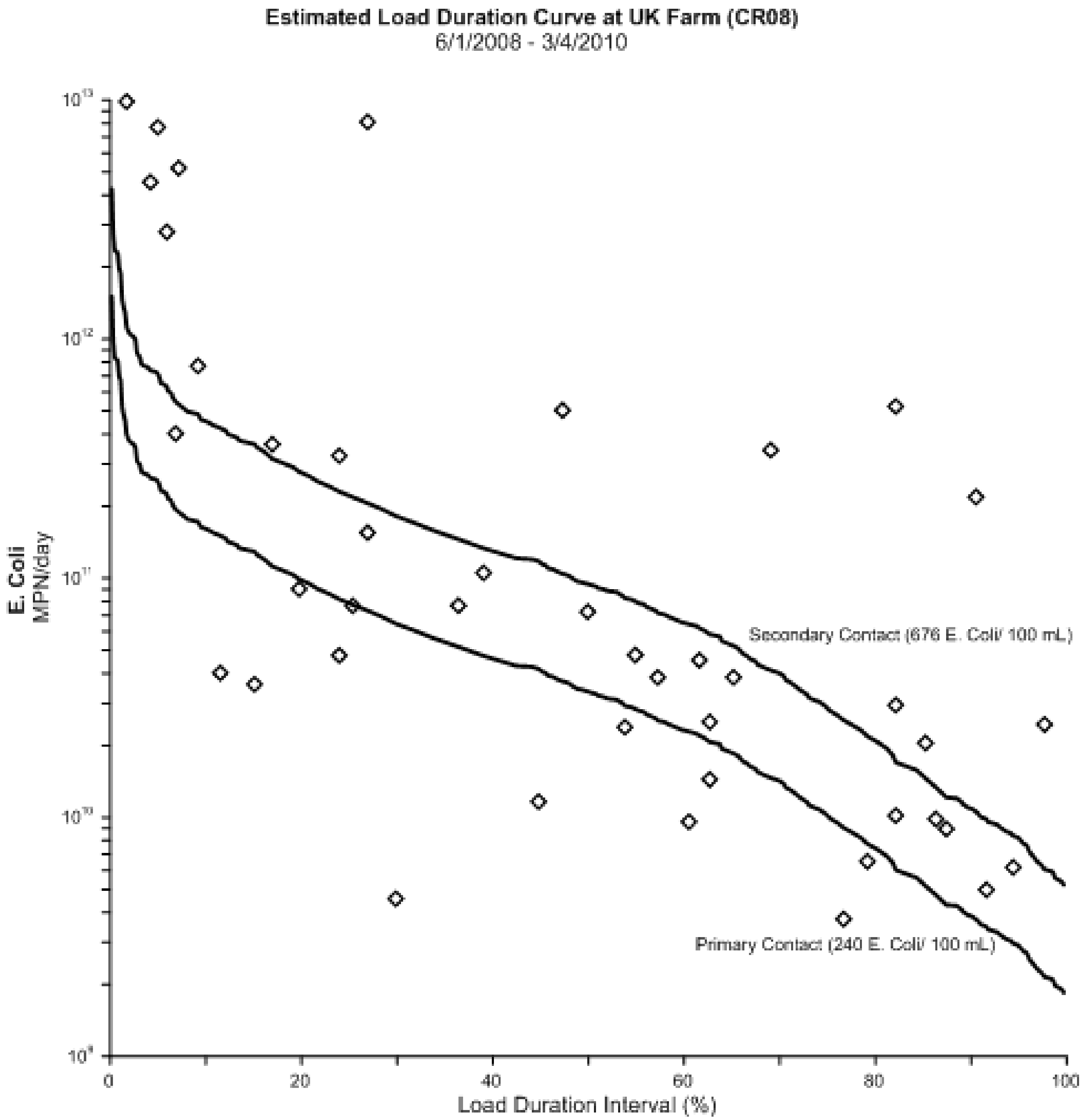

Figure 102. Estimated *E. coli* load duration curves at CR08

The areas draining to these two monitoring sites are largely agriculture (58 percent at CR07 and 65 percent at CR08) with low levels of development (Figure 103 and Figure 104). The developed areas are located mostly in the headwaters of Catchment 1; however, this portion of the watershed normally exits Catchment 1 through karst structures. As such, the most likely sources of bacteria are livestock and wildlife and potentially failing septic systems. Some trunk mains, force mains, and pumping stations are located in the headwaters of the watershed.

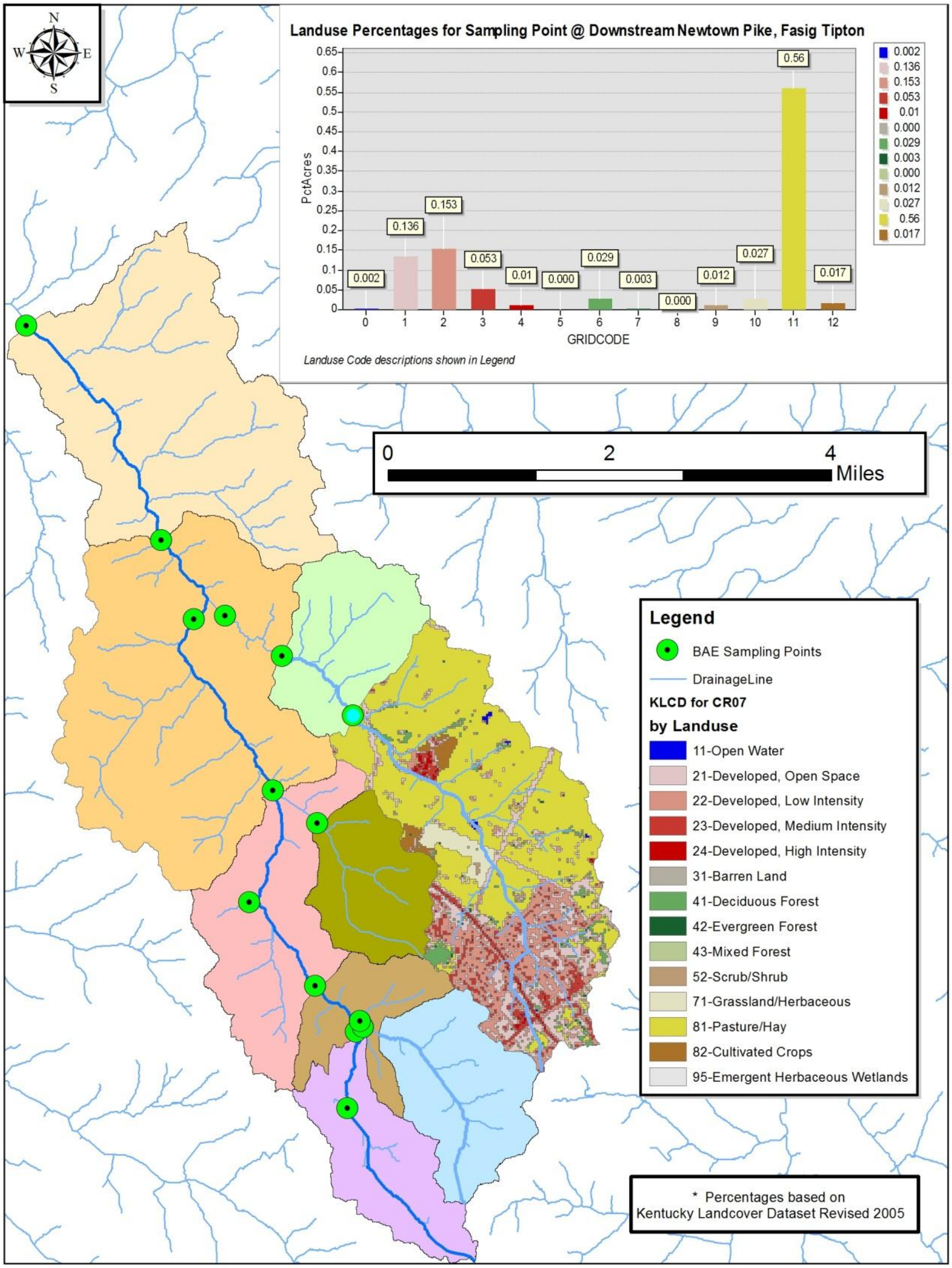

Figure 103. Land use for CR07 in Catchment 1

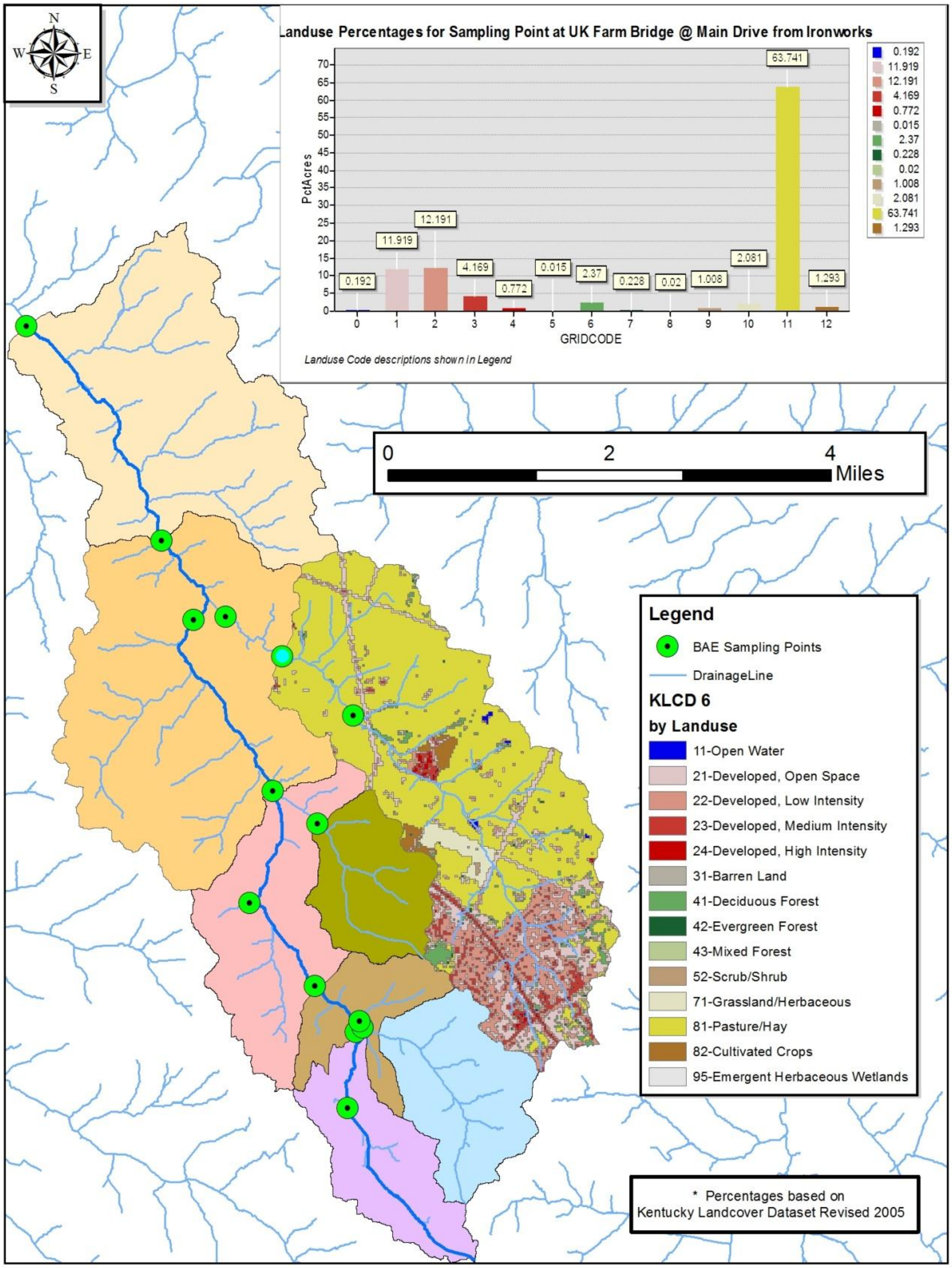

Figure 104. Land use for CR08 in Catchment 1

C

Sampling Point	Fecal Coliforms (cfu/100mL)	*E. coli*(cfu/100mL)
VSFT-5	5160	158
VSFT-6	14490	185

To reduce bacteria loads in Catchment 1, it is recommended that all livestock be prohibited from grazing along the stream and that a riparian buffer be established along as many tributaries within the catchment as possible. Due to the high connectivity of surface and ground waters in karst geology, it is also recommended that sinkholes be protected from livestock access. Efforts should also focus on reducing bacteria loads from sources upstream of CR07 such as the horse training and composting facility.

Sediment

The mean TSS concentration did not exceed 200 mg/l at CR08 for any monitored storm event (Table 85). TSS load duration curves indicated that only one sample exceeded a 200 mg/l threshold (Figure 107).

Based on the monitoring data, suspended sediments are not a large concern in Catchment 1. However, areas of streambank erosion should be addressed as these soils are likely contributing nutrients to the watershed. Additionally, areas of upland erosion should be addressed, in part by the establishment of riparian buffers along waterways.

Table 85. Summary of storm sample TSS data for Catchment 1

Monitoring Location	No. Events Sampled	Peak >200 mg/l[1]	Mean >200 mg/l[2]	Geometric Mean >200 mg/l[3]	Mean per Event >200 mg/l[4]	Mean Time >200 mg/l (minutes)[5]
CR08	9	3 (33%)	0 (0%)	0 (0%)	2	31

[1]Mean number of storm events where the storm peak TSS concentration exceeded 200 mg/L.

[2]Mean number of storm events where the storm mean TSS concentration exceeded 200 mg/L.

[3]Mean number of storm events where the storm geometric mean TSS concentration exceeded 200 mg/L.

[4]Mean number of samples in each storm event that exceeded TSS concentration of 200 mg/L.

[5]Mean amount of time in each storm event where TSS concentration exceeded 200 mg/L.

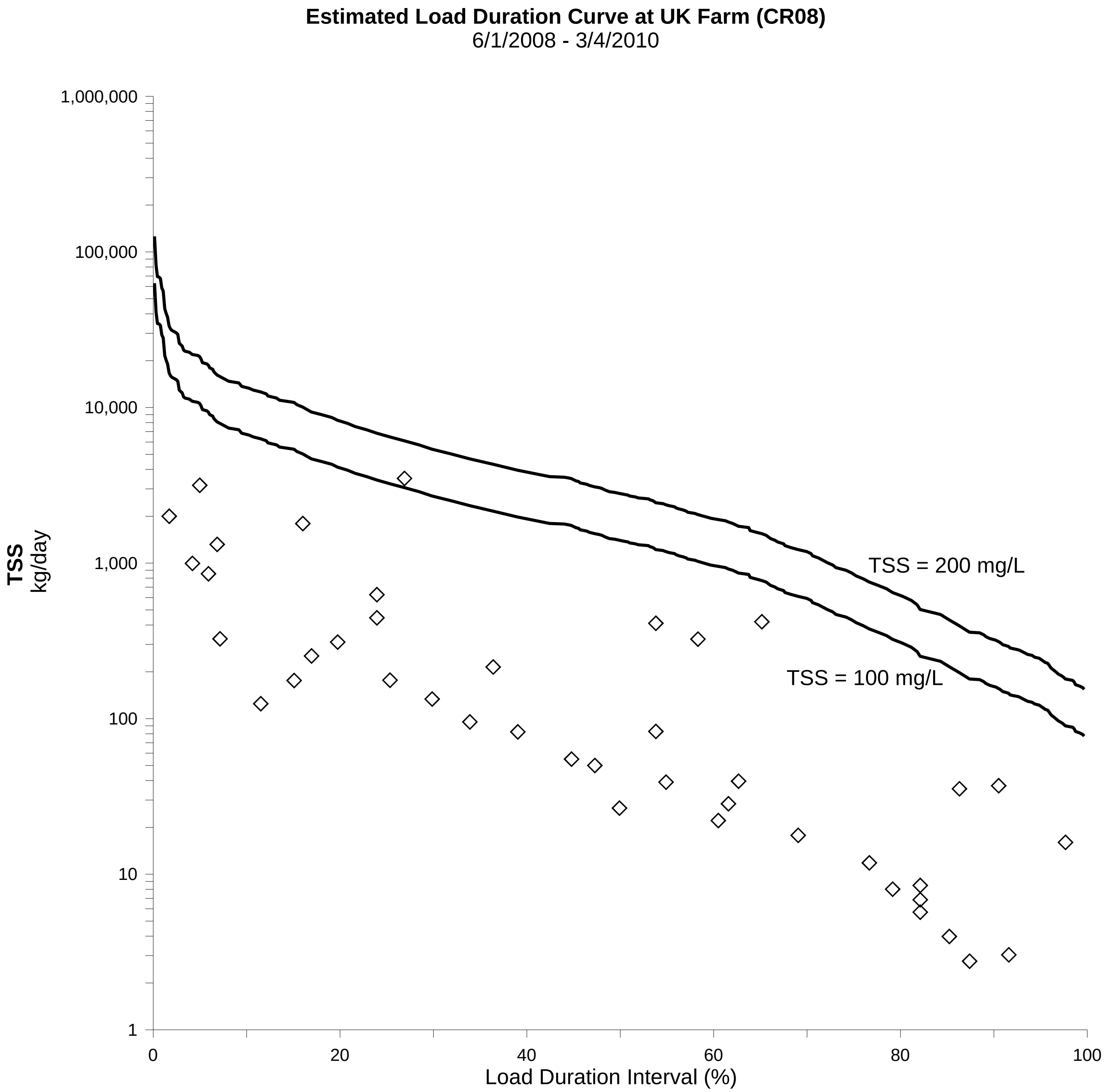

Figure 107. Estimated TSS load duration curve at CR08

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

In addition to physical characteristics of the watershed, there are many projects and partnerships already underway that will also guide BMP implementation efforts. The upper Cane Run Watershed is unique in not only its geology, but by the few, large, public landowners. In Catchment 1 these include University of Kentucky's Agricultural Experiment Station (the largest single landowner on the stream) and Fasig Tipton.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include nitrogen and phosphorus. The most likely sources of these pollutants in Catchment 1 that should be addressed include livestock (pasture grazing and land application), crop production, sanitary sewer overflows, Class V injection wells, urban development and construction, lawn fertilizers and pesticides, livestock, wildlife, and septic systems. Although sediment has been determined to not be a problem in this catchment, high stream temperatures and stream bank erosion are still an issue, and could be contributing to poor aquatic habitat and nutrient deposition.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 1, the MS4 non-developed loading must be reduced by 25.0 percent, and the non-MS4 loading must be reduced by 25.0 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes. The BMPs recommended and implemented within this catchment will help to achieve these reduction goals.

Because Catchment 1 lies within the scope of the Royal Spring aquifer of the Cane Run Watershed, BMPs were selected that most effectively address the primary pollutants and their suspected sources, land use, property owner and/or stakeholder acceptance, and sources of potential funding, as well as technical and community support. This section includes a map and detailed description of proposed and implemented BMPs and a table summarizing these BMPs, their effectiveness, costs, and possible implementation partners.

For additional information about BMP implementation in the entire Cane Run Watershed, please reference the Cane Run and Royal Spring BMP Implementation Plan in Appendix X.

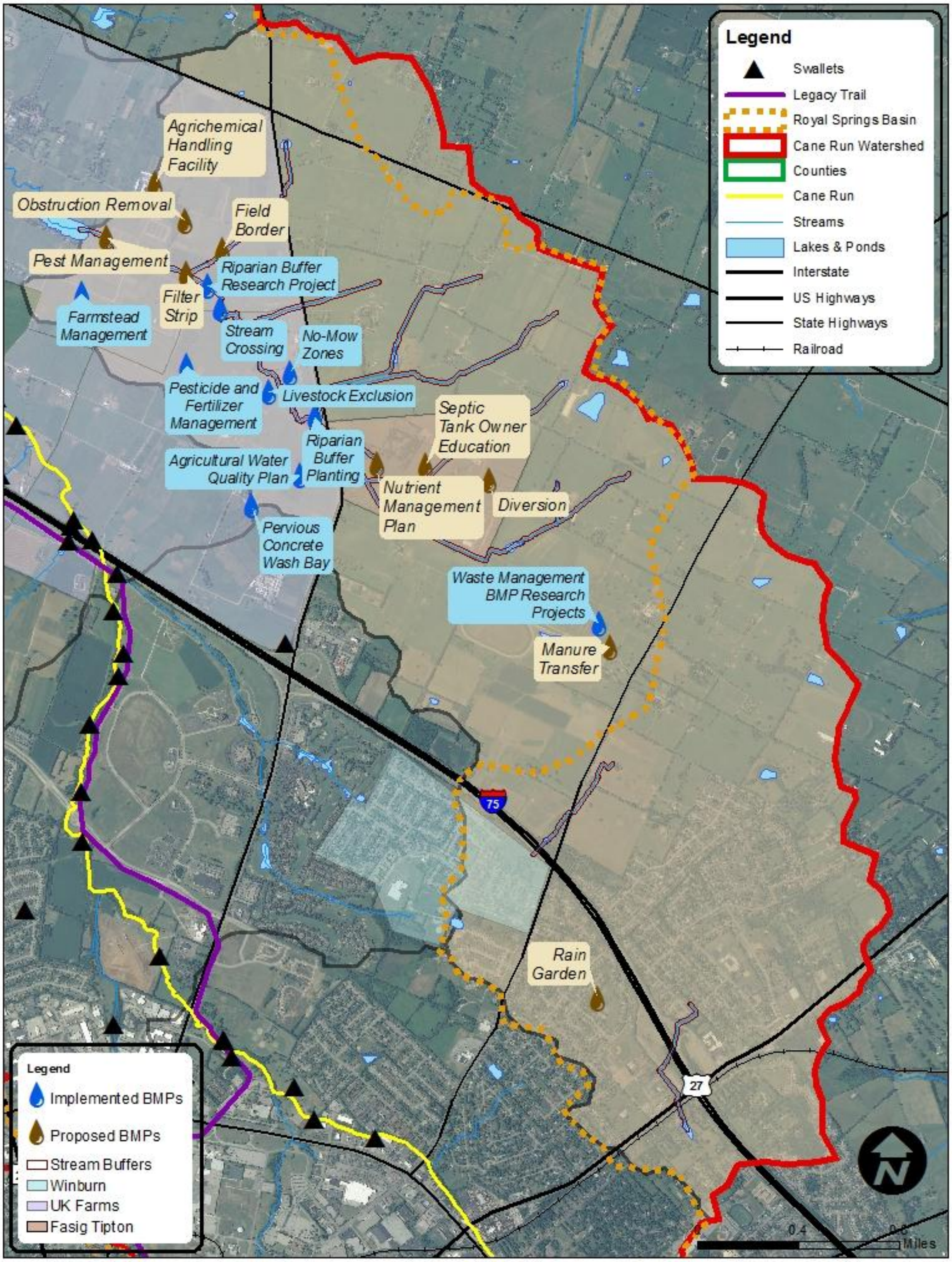

Figure 108. Priority BMP locations for Catchment 1

Tributary to Cane Run (Fasig-Tipton and Maine Chance Farm)

Proposed

A tributary originates near the Fasig-Tipton property and crosses Newtown Pike onto the Equine Campus of the University of Kentucky at the Maine Chance Farm. The stream section on Maine Chance represents one of the best "natural" stream segments in the watershed.

The headwaters of the tributary include primarily agricultural (equine) activities. BMPs such as nutrient management plans, waste storage facilities, obstruction removal, filter strips, and septic tank owner education would be optimal for this area, as they could significantly reduce nutrient and bacteria pollution, which is of great concern in this catchment.

Implemented

WASTE MANAGEMENT BMP RESEARCH PROJECTS

There are two research projects going on at the Victory Haven Training Center, located off Russell Cave Road in Fayette County, where large volumes of horse muck are generated from horse boarding and training facilities. These projects are being funded through a USDA NRCS earmark project titled "Development and Implementation of Stream Restoration and Riparian Corridor Techniques for Enhancing Water Quality in the Cane Run Watershed." These projects will provide valuable techniques for management and designs of composting areas and muck storages. They will also improve water quality by reducing the amount of bacteria and nutrients in stormwater runoff.

The first project, titled "Evaluating the Effectiveness of Weep Berm Systems for Treating Runoff from the Composting of Horse Muck", will design, construct, and assess a modified weep berm-grass filter at a horse muck composting operation. The objective of the second project, titled "Control and Treatment of Runoff from a Muck Storage Pad using a Permeable Containment Basin and Phytotechnologies", is to design and construct a muck storage structure with a permeable containment basin and runoff treatment system. This site currently contains several muck storage pads that are in close proximity to the Cane Run stream. This project will construct three structures using the modified design and compare runoff and water quality parameters from these to three existing structures built using the traditional NRCS design.

LIVESTOCK EXCLUSION

Before the implementation of this BMP in 2007, horses along this section had full access to the creek, and at that time, their only source of water was the creek that ran through the paddock (Figure 109). By fencing horses out of the stream, providing them with a city waterer, and leaving a substantial buffer between pasture and stream, nutrient and bacteria deposition near the stream was eliminated and the project described below could be pursued.

Figure 109. Horses with full access to the creek

Riparian Buffer Planting

In the fall of 2007, a riparian area located on UK's Experiment Station in the Animal and Food Science–Horse Area was enrolled in the NRCS's Conservation Reserve Program (CRP). This area encompasses approximately 7 acres, and in 2009, over 2,000 trees were planted within the riparian area. In the spring of 2010, two tree planting projects further enhanced these existing riparian buffers. The stream section, enrolled in an NRCS Conservation Reserve Program, utilized 1,800 hardwood saplings, and on the opposite bank, over 1,950 linear feet of riparian buffer was planted with a variety of hardwood saplings. Species used in both plantings include Swamp White Oak, Hickory, Shumard Oak, and Bur Oak. This project will develop a contiguous riparian forest corridor and will provide ample canopy cover and deep shade for years to come. This BMP will also filter runoff before it hits the stream, removing bacteria and nutrients that decrease water quality. The stream section will also be utilized as a teaching laboratory and demonstration site for stream corridor function (Figure 110).

Figure 110. Educational sign near riparian planting

PERVIOUS CONCRETE WASH BAY

UK has developed and installed a horse washing area at the equine pavilion on the Experiment Station. The floor of the washing area is made of pervious concrete, which allows the water to filter through, works as a solid-liquid separation system, and provides storage for holding wash water. Since the concrete is made from dolomitic limestone, the high pH practically destroys fecal bacteria upon contact, which prevents local water bodies from receiving those pollutants.

STREAM CROSSINGS

Along this stream section, one stream crossing, previously used for vehicular traffic on UK's Experiment Station, was permanently closed in late 2010. This will reduce the amount of sediment and other pollutants introduced to the stream.

RIPARIAN BUFFER RESEARCH PROJECT

A graduate student project titled "Management Techniques to Improve the Hydrologic and Structural Properties of Riparian Buffer Soils" is being conducted along this un-named tributary of the Cane Run on UK's Experiment Station. The objective of this project is to determine if mowing regime and native grass establishment in the riparian buffer zone influence the vertical and lateral transport of waters from adjacent lands. This project is being funded through a USDA NRCS earmark project titled "Development and Implementation of Stream Restoration and Riparian Corridor Techniques for Enhancing Water Quality in the Cane Run Watershed," and it will provide insights about riparian corridor management that allows for pollutant removal and soil stability.

AGRICULTURAL WATER QUALITY PLAN

One of the most important best management practices that the University of Kentucky Experiment Station could implement is a legitimate Agricultural Water Quality Plan (AWQP). It is especially important that the Experiment Station develop and implement a water quality plan because of its location within the environmentally-sensitive Cane Run Watershed. One goal of the Cane Run Watershed Project is to encourage the Experiment Station to adopt and implement all required BMPs, as well as facilitate and demonstrate the development of new BMPs. BMPs installed and demonstrated on the Experiment Station address a variety of pollutants, including bacteria, nutrients, and sediment. In keeping with state law and the goals of this project, the creation of an AWQP for the Experiment Station began in January 2010, and the final document is complete as of January 2011. The full plan is available in Appendix CC.

Included as part of the developed Agricultural Water Quality Plan, the University of Kentucky's Experiment Station has developed a nutrient management plan that provides basic information regarding how the manure produced by this operation is applied to agricultural fields, and how it will be utilized. The plan is based on the site conditions and management operations documented in the plan, as of the date indicated by the signatures of the plan developer and the farm manager. Soil tests for the North Farm showed that the soils contained a level of available phosphorus that did not require supplementation. This is typical of soils (Maury-McAfee series) in Central Kentucky formed by phosphatic limestone parent material. The location of animal enterprises on these soils provides the University of Kentucky College of Agriculture the opportunity to demonstrate the influence of best management practices (BMPs) and alternative manure management practices, and to show that animal manure additions to these soils can be made without negatively impacting air, soil, and water resources. The complete Nutrient Management Plan for UK's Experiment Station can be found in Appendix DD.

As part of the Experiment Station's Nutrient Management Plan, all of the waste associated with livestock on the UK Experiment Station is now collected in a roofed transfer station and hauled away by a contractor to be composted. Placing the manure under a covered stack pad prevents rain from hitting stockpiled manure and creating contaminated runoff from the site, and hauling the waste away provides an opportunity to remove nutrients produced by horses, poultry and dairy from the farm. The cost, covered by the College of Agriculture, to haul away the manure is approximately $40,000 per year.

NO-MOW ZONES

No-mow zones are areas adjacent to water bodies that are left un-mowed by maintenance crews. Formerly these riparian areas were mowed to the water's edge (Figure 111), but the installation of a no-mow zone allows vegetation to grow without restriction, which provides a vegetative buffer between pollutants such as sediment, nutrients, and bacteria and the water. It is common to believe that no-mow zones are improper on the Experiment Station because they make the farm look unkempt; however, no-mow zones are valuable features that control and trap pollutants before they reach surface waters. It is also a cost effective practice. Equipment can be damaged while mowing riparian slopes, and not mowing these areas saves fuel, equipment, and labor. In addition, many of these sections are wet areas where equipment can easily become stuck in the mud.

Figure 111. Example of stream before the installation of the no-mow zone policy

No-mow zones have been established along all streams and water bodies across the entire farm, with the exception of several small stream sections and Lake Mildred (Figure 112 and Figure 113). These buffers are approximately 50-feet wide on each side of the water body and add up to a cumulative 27 acres of land on the Experiment Station. As a result of this stewardship, original populations of riparian flora such as Great Blue Lobelia, Swamp Milkweed, sedges, Woodland Sunflower, and Arrow Arum are being revived. In 2010, signs and markers were posted to help delineate no-mow zones and conservation buffer areas and to help describe the practices to users and visitors of the farm (Figure 113).

Figure 112. A Cane Run no-mow zone one year after implementation

Figure 113. This early no-mow zone provided an example for the entire Experiment Station; No-mow sign with bluebird house to delineate riparian buffer zone

FARMSTEAD MANAGEMENT

Because septic systems and impervious surfaces can contribute to bacteria pollution in the Cane Run, the Experiment Station has demolished houses and removed mobile homes, which includes the removal of existing septic systems. So far, the Experiment Station has removed seven residences and apartment buildings, totaling over 6,000 square feet, and their corresponding septic systems.

PESTICIDE AND FERTILIZER MANAGEMENT

Pesticides are necessary to the research, extension, and teaching missions of the Kentucky Agricultural Experiment Station. When managed properly, pesticides can provide effective mitigation of pest outbreaks as well as routine control of agricultural pests (weeds, insects, and diseases); however, the proper storage and use of pesticides require due diligence on the part of the faculty, staff, and students working on the research farms. The Experiment Station is situated on an environmentally sensitive watershed, and as such, necessitates careful management of fertilizers and pesticides.

Empty containers are being recycled using Rinse and Return system. Excess fertilizers and pesticides can create unnecessary storage and disposal issues. The purchasing and ordering has been adjusted to accept only the minimum amount of pesticides and fertilizers needed for research and crop production purposes use in the short term.

Pesticides have been inventoried. The unusable or unneeded pesticides and fertilizers have been identified. In the last two years, approximately 6,700 pounds of surplus pesticides have been removed from the Experiment Station and have been properly disposed of, which reduces the risk of accidental discharge into surface water.

Table 86. Catchment 1 priority BMPs¹

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction[+]	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Nutrient Management	– Minimize nonpoint source pollution of surface and groundwater resources – Maintain or improve soil function to aid in BMP effectiveness	– Nitrogen: 15% – Bacteria: N/A[+] – Sediment: N/A[+] – Phosphorus: 35%[o]	– Nitrogen: High – Bacteria: Low – Sediment: Low – Phosphorus: High[e]	– $1,662.40/each[h]	– $0.00	– NRCS – Fasig Tipton – Private Landowners – UK
Waste Storage Facility	– Prevent bacteria and nutrient runoff	– Nitrogen: 65% – Bacteria: 90% – Sediment: 70% – Phosphorus: 60%[i]	– Nitrogen: High – Bacteria: High – Sediment: High – Phosphorus: High[e]	– $9,805.67/each[h]	– $95.20/each	– NRCS – UK – Private Landowners – Fasig Tipton
Diversion	– Reduce erosion potential, prevent runoff pollution	– Nitrogen: 45% – Bacteria: N/A[+] – Sediment: 70%[i] – Phosphorus: N/A[+]	– Nitrogen: Low – Bacteria: Medium – Sediment: Medium – Phosphorus: Low[e]	– $2.54/linear foot[h]	– $0.03/linear foot	– Fasig Tipton – NRCS – Private Landowners – UK
Manure Transfer	– Reduce nutrient and bacteria loading	– Nitrogen: 80% – Bacteria: 85% – Sediment: 60% – Phosphorus: 90%[n]	– Nitrogen: High – Bacteria: High – Sediment: Medium – Phosphorus: High[e]	– Cost is variable based on type of waste management system utilized. Expected costs must take manure hauling, loading, and containment facilities into consideration.	– N/A	– UK – Fasig Tipton – Private Landowners – NRCS

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Pest Management	– Improve vegetative BMP establishment and effectiveness – Increase visibility of water quality initiatives	N/A+	– Toxic Chemicals: High[e]	– $143.85/acre[h]	– $0.00	– UK – Volunteers – NRCS
Filter Strip	– Sediment and nutrient removal and filtration	– Nitrogen: 70% – Bacteria: 70% – Sediment: 65% – Phosphorus: 75%[k]	– Nitrogen: Medium – Bacteria: Medium – Sediment: Medium – Phosphorus: Medium[e]	– $406.40/acre[h]	– $68.99/acre	– Fasig Tipton – Private Landowners – NRCS
Field Border	– Reduce erosion – Sediment, and nutrient filtration and removal	– Nitrogen: 70% – Bacteria: N/A+ – Sediment: 65% – Phosphorus: 75%[d]	– Nitrogen: Medium – Bacteria: Medium – Sediment: Medium – Phosphorus: Medium[e]	– $368.50/acre[b]	– $18.68/acre	– UK – NRCS
Fence	– Sediment, nutrient, and bacteria removal	– Nitrogen: 54% – Bacteria: N/A+ – Sediment: 90% – Phosphorus: 81%[j]	– Nitrogen: Medium – Bacteria: N/A° – Sediment: High – Phosphorus: Medium[e]	– $2.77/linear foot[h]	– $0.03/linear foot	– UK – NRCS
Bioretention System	– Increase infiltration – Sediment, nutrient, and bacteria	– Nitrogen: 49%[z] – Bacteria: 70%[lk] – Sediment: 65%[lk] – Phosphorus:	– Nitrogen: Medium – Bacteria: Medium – Sediment:	– $2,239.00/ERU[z] (1Stormwater ERU = 2,500 ft^2)	– $167.93/ERU (Maintenance = 7.5% of construction cost)	– Bluegrass Rain Garden Alliance – UK – LFUCG

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
	removal	76%[z]	Medium – Phosphorus: High[e]			
Agrichemical Handling Facility	– Reduce pollution to surface water, groundwater, air, and/or soil.	Chemical and nutrient spills and leaching prevented	– Substantial improvements to surface and groundwater quality[a]	– $28.64/square foot[b]	– $1.45/square foot	– UK – NRCS
Septic Tank Owner Education	– Identify maintenance needs – Nutrient and bacteria removal	N/A+	– Increase awareness and education; improves BMP performance	– N/A	– N/A	– UK – Private Landowners – Fasig Tipton
Stream Crossing	– Reduce sediment, nutrient, and bacteria loading	– Nitrogen: N/A+ – Bacteria: N/A+ – Sediment: 50%[j] – Phosphorus: N/A+	– Nitrogen: N/A° – Bacteria: N/A° – Sediment: Medium[e] – Phosphorus: N/A°	– $2,308.87/each[h]	– $22.42/each	– NRCS – UK
Obstruction Removal	– Enhance BMP effectiveness and conservation practices	N/A	N/A	– This practice involves removing a broad range of obstructions; cost is extremely variable based on site specific conditions. Expected costs must take equipment and labor into consideration.	– N/A	– Fasig Tipton – UK – Private Landowners – Volunteers

[1]The studies referenced in this table can be found in Appendix AA.

*BMPs for each catchment are listed by magnitude of priority based on 1) their implementation in the upper reaches of the watershed, 2) their pollutant removal effectiveness, 3) legal restrictions that may hinder their use, 4) stakeholder participation, 5) the availability of additional funding or technical support. BMPs listed in bold have been implemented as described in narrative.

+Estimated Load Reduction: provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend exclusively on site-specific variables such as soil type, topography, climate, and production system.

°Effectiveness: Abstracted from USDA Agriculture Information Bulletin No. 598 and NRCS conservation practice physical effects (CPPE) documents. NOTE: Because of the general nature of these documents, there may be situations and sites where practices will not perform as indicated.

Catchment 8

Pollutant Source Assessment

The 303(d) listed segment of Cane Run that flows through Catchment 8 (that also flows through Catchments 9 and 10) has been identified as having high levels of fecal coliform, nutrients, and sewage, with suspected sources including livestock and unspecified urban stormwater (Figure 114). The 303(d) listed unnamed tributary of Cane Run that flows through Catchment 8 (but begins in Catchment 1) has been identified as having high levels of nitrogen and phosphorus, with suspected sources including managed pasture grazing and non-irrigated crop production. Other point and nonpoint sources that could also contribute to this pollution are described below.

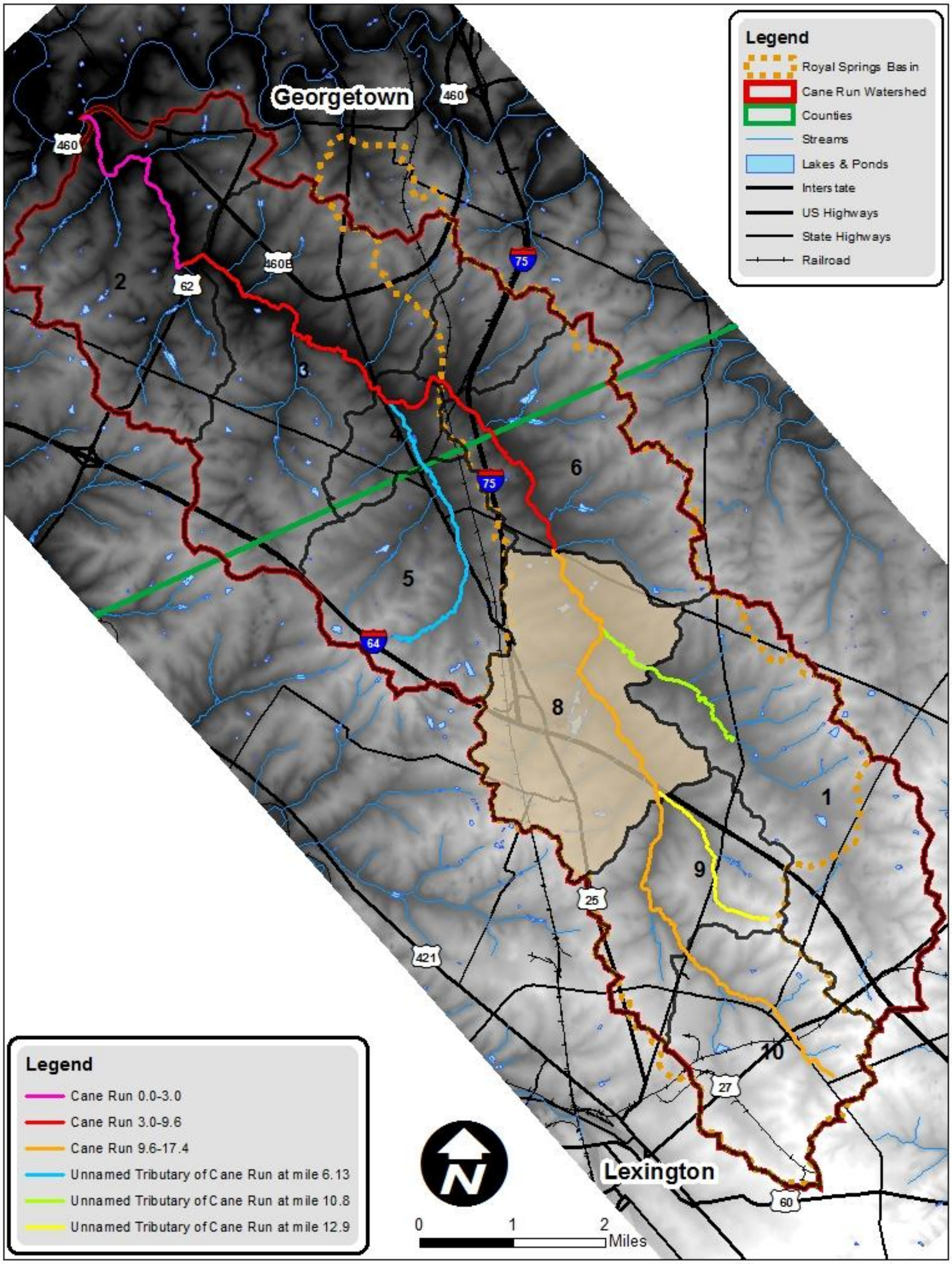

Figure 114. Impaired stream section in Catchment 8

Point Sources

There are several possible sources of point source pollution within Catchment 8, including KPDES-permitted facilities, Class V injection wells, sanitary sewer overflows, failing onsite wastewater treatment systems, and straight pipes (Figure 115). These point sources contribute mainly to bacteria and nutrient pollution.

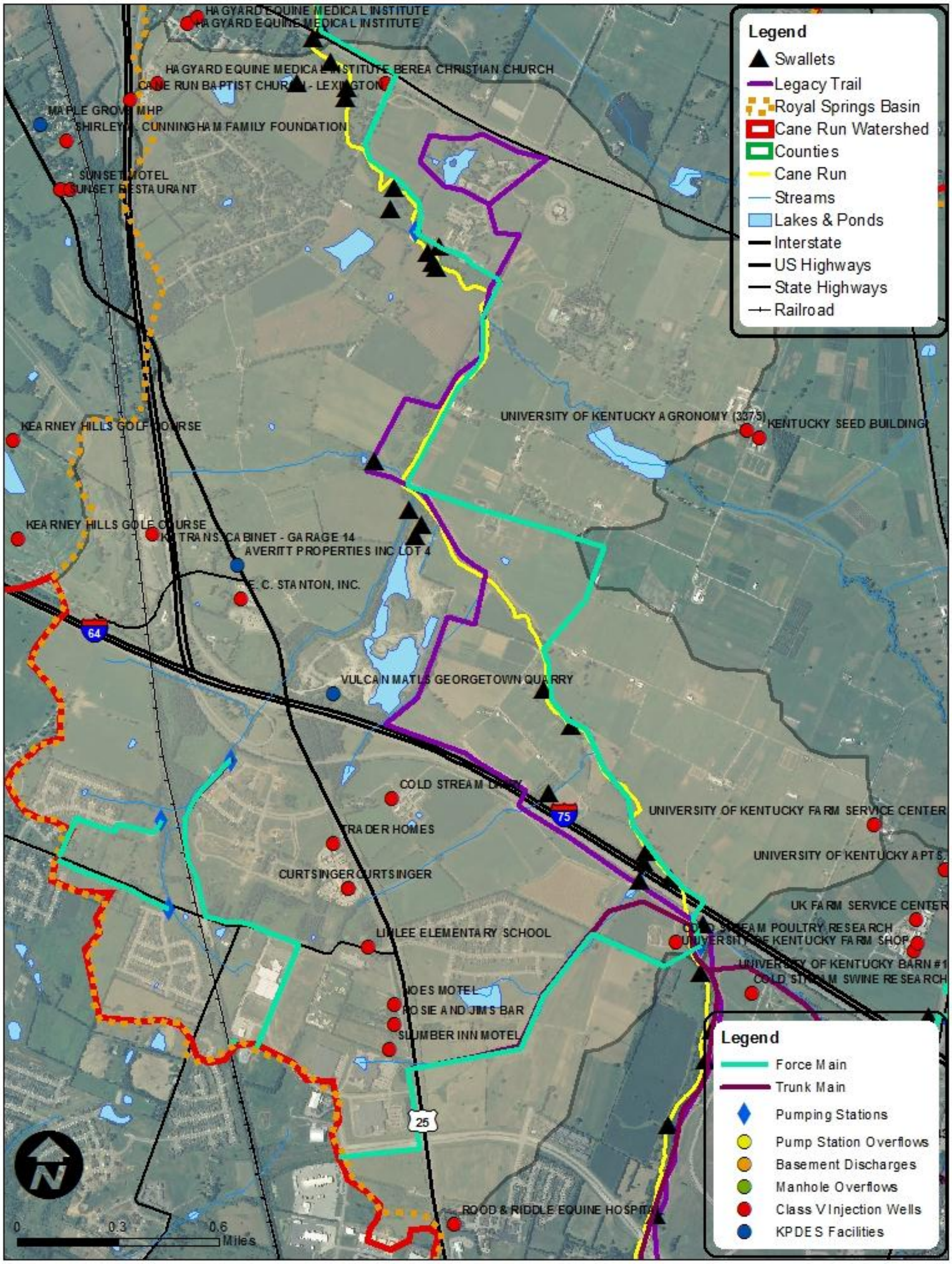

Figure 115. Potential point sources in Catchment 8

KPDES-Permitted Facilities

There are 2 KPDES permitted facilities in Catchment 8, and the details of each permittee can be found in Table 87. None of the KPDES facilities in this catchment discharge the major pollutants of concern for the Cane Run, which include bacteria and nutrients.

Table 87. KPDES facilities in Catchment 8

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences
KYR10418	Averitt Properties Inc., Lot 4	2151 Georgetown Rd., Lexington, KY 40511	Town Branch/ Kentucky River	--	--	--
KYG840002	Vulcan Materials, Georgetown Quarry	1280 Old Frankfort Pike, Lexington, KY 40504	Town Branch	--	--	--

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[42] There are many different types of Class V injection wells, but in Catchment 8, there are 14 wells, all but one of which are large capacity septic systems (LCSS) (Table 88).

LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is relatively high[43].

The one non-LCSS Class V injection well in Catchment 8 is classified as veterinary, kennel, or pet grooming and receives sanitary and vet waste. The potential for contamination from this type of well is unknown.

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[42] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm

[43] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf

Table 88. Class V injection well locations in Catchment 8

EPA ID	Company Name	Address	Well Type
KYV067007	Rosie and Jim's Bar	2461 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067007	Slumber Inn Motel	2462 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067007	Noes Motel	2509 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067007	Linlee Elementary School	2545 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067008	University of Kentucky Farm Service Center	2099 Newtown Pk., Lexington, KY	Large capacity septic system
KYV067008	Curtsinger	2741 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067008	Curtsinger	2741 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067008	Trader Homes	2803 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067009	Coldstream Dairy	2810 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067009	Coldstream Poultry Research	Newtown Pk., Lexington, KY	Large capacity septic system
KYV067016	KY Transportation Cabinet – Garage 14	3115 Kearny Rd., Lexington, KY	Large capacity septic system
KYV067016	E.C. Stanton, Inc.	3271 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067016	Berea Christian Church	2689 Berea Rd., Lexington, KY	Large capacity septic system
KYV067016	Hagyard Equine Medical Institute	4250 Ironworks Pike, Lexington, KY	Veterinary, kennel, pet grooming

Sanitary Sewer Overflows

Point source pollution may originate from the existing wastewater collection infrastructure. All of the sewage in the Cane Run is typically collected by gravity systems that are then pumped via force mains into the adjacent Town Branch watershed where the Town Branch Wastewater Treatment plant is located. Much of the wastewater infrastructure runs parallel to or in natural drainage ways and streams, and leaks in the mains, manhole overflows, pump station overflows, and basement discharges can contribute significant amounts of pollution to surface water resources. Table 89 shows known locations of recurring sanitary sewer overflows and unpermitted discharges in Catchment 8.

Table 89. Recurring locations of sanitary sewer overflows and unpermitted discharges in Catchment 8[44]

SSO Location	SSO Category	MH Number
Lower Cane Run, Coldstream Station	Pump Station	--

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. The U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[45]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[46]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 4 failing OWTSs in Catchment 8 that contribute a fecal coliform load of 1.63E+09 cfu/day.

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census

[44]United States of America and the Commonwealth of Kentucky v. Lexington-Fayette Urban County Government, March 14, 2006, Consent Decree, Lodged in the United States District Court, Eastern District of Kentucky, Central Division at Lexington, Related to Civil Action No. 5:06-cv-00386. "Appendix A: Recurring Locations of SSOs and Unpermitted Discharges." Available at: http://www.lexingtonky.gov/Modules/ShowDocument.aspx?documentid=3571

[45] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.

[46] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 3 straight pipes in Catchment 8 that contribute a fecal coliform load of 2.27E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 0.833 lbs/day.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 8 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 90 and Figure 116). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 90. Land cover in Catchment 8

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture /Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	16.46	864.22	1.78	85.62	19.79	12.01	2213.71	442.79	0.44	**3657**
Percent	0.45	23.63	0.05	2.34	0.54	0.33	60.54	12.11	0.01	**100**

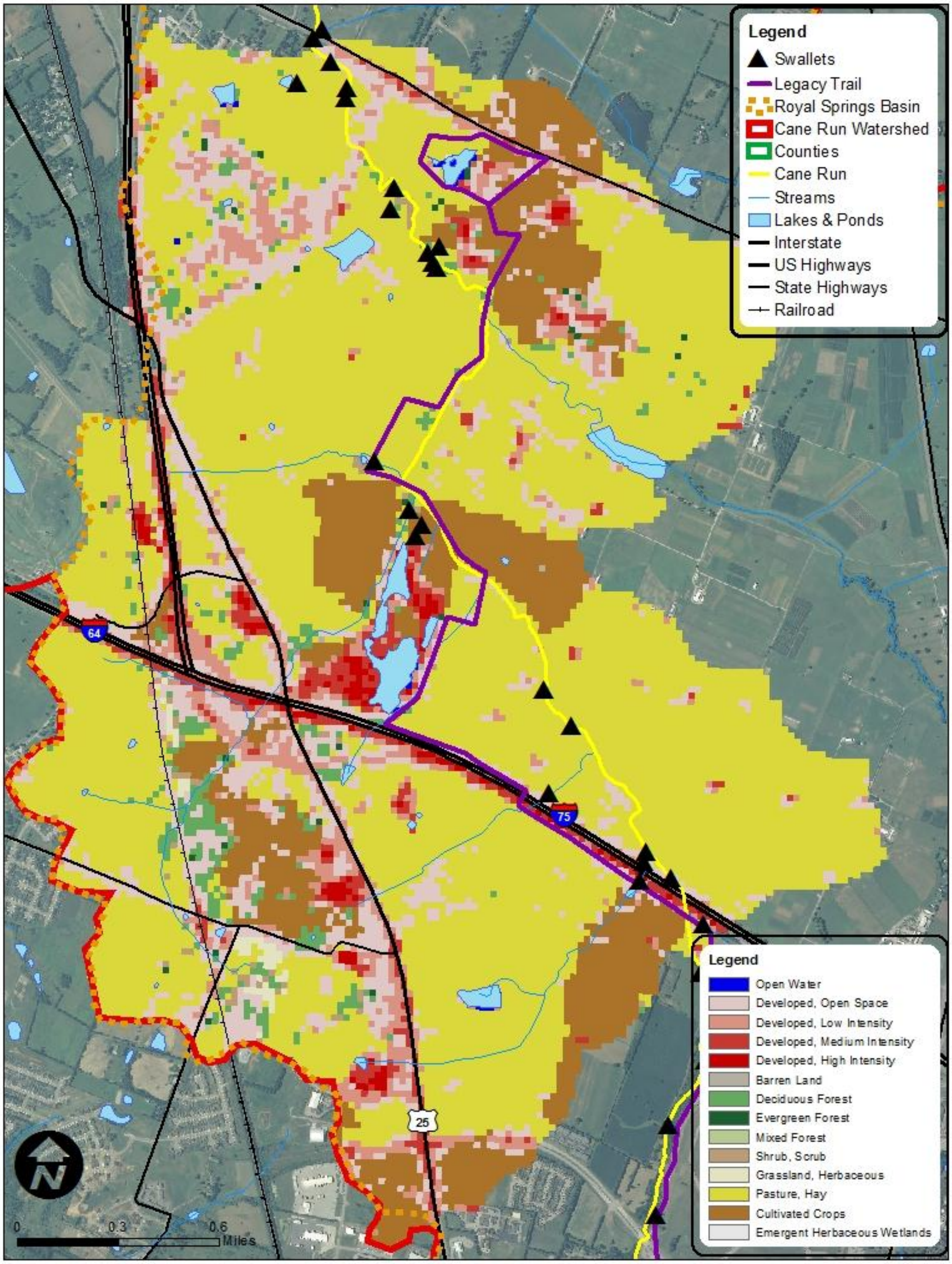

Figure 116. Land cover in Catchment 8

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 6.088 lbs/day. This contribution is high compared to other catchments, but this is likely because the amount of un-developed land in this catchment is relatively high.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 8. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 8 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil’s holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these

areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[47]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 8 and their daily fecal coliform load contribution can be found in Table 91. The fecal contribution from wildlife is the third highest of any Cane Run catchment.

Table 91. Wildlife population estimates and daily fecal coliform load contribution for Catchment 8

Animal	Population	Fecal counts/day
Ducks	42	1.02E+11
Geese	20	9.80E+11
Deer	20	1.00E+10
Beavers	4	1.00E+09
Raccoons	20	2.51E+09

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[48].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 8 and their daily fecal coliform load contribution can be found in Table 92. This catchment ranks second in the

[47] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[48] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

number of chickens, and second in the number of beef cattle, and first in the number of horses, which makes livestock as a nonpoint pollution source extremely important in Catchment 8.

Table 92. Livestock population estimates and daily fecal coliform load contribution for Catchment 8

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock, including cattle in streams)
Hogs	13	6.94E+10	--
Beef Cattle	259	1.79E+11	
Dairy Cattle	29	6.79E+10	--
Chickens	1174	5.75E+10	--
Horses	242	1.26E+10	8.09E+10
Sheep	1	--	1.20E+10
Goats	15	--	1.80E+11

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 1.544 lbs/day.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[49]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 8 are shown in Table 93.

[49] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Table 93. Daily fecal coliform load contributions from developed land in Catchment 8

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
6.83E+07	0.00E+00	2.46E+09	4.82E+07

LAWN FERTILIZERS

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 8.

URBAN DEVELOPMENT AND CONSTRUCTION SITE EROSION

Much of the Cane Run Watershed, and especially Catchment 8, is used for industrial development because of the close proximity to highway infrastructure. The Georgetown Road corridor within the Cane Run Watershed has seen increased housing development over the last 10 years.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 8 (Table 94 and Figure 117).

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources.

In 2005, the city of Georgetown contracted with Dr. Gail Brion at the University of Kentucky to conduct a study within the Cane Run Watershed in an attempt to identify and rank potential sources of sewage contamination into the Royal Springs water supply. Monitoring points for this study were established in this catchment.

Water samples were taken at stations in this catchment in 2006 and 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development.

The University of Kentucky Biosystems and Agricultural Engineering Department established a monitoring network for bacteria and sediment in support of bacteria TMDL development, and sampled in this catchment in 2008, 2009, and 2010 as part of the Cane Run Watershed Project.

The University of Kentucky Biosystems and Agricultural Engineering Department established permanent cross-sections in this catchment to assess the physical condition of the stream.

The Kentucky Division of Water (KDOW) established bank pins (toe, bankfull and top of bank) in this catchment to assess the physical condition of the stream.

Table 94. Monitoring conducted in Catchment 8

Sampling Entity	Parameters	Sampling Dates	Site IDs
KWRRI	Bacteria	2002	C2
City of Georgetown	Bacteria	2005	Spindletop
KDOW	Nutrients	2006-2007	04018006, 04018007, 04018011
CRWP	Bacteria, Sediment	2008-2010	CR09-CR11
CRWP	Geomorphology	2008-2010	WP12-WP16, WP18
KDOW	Geomorphology	2006-2007	14-19

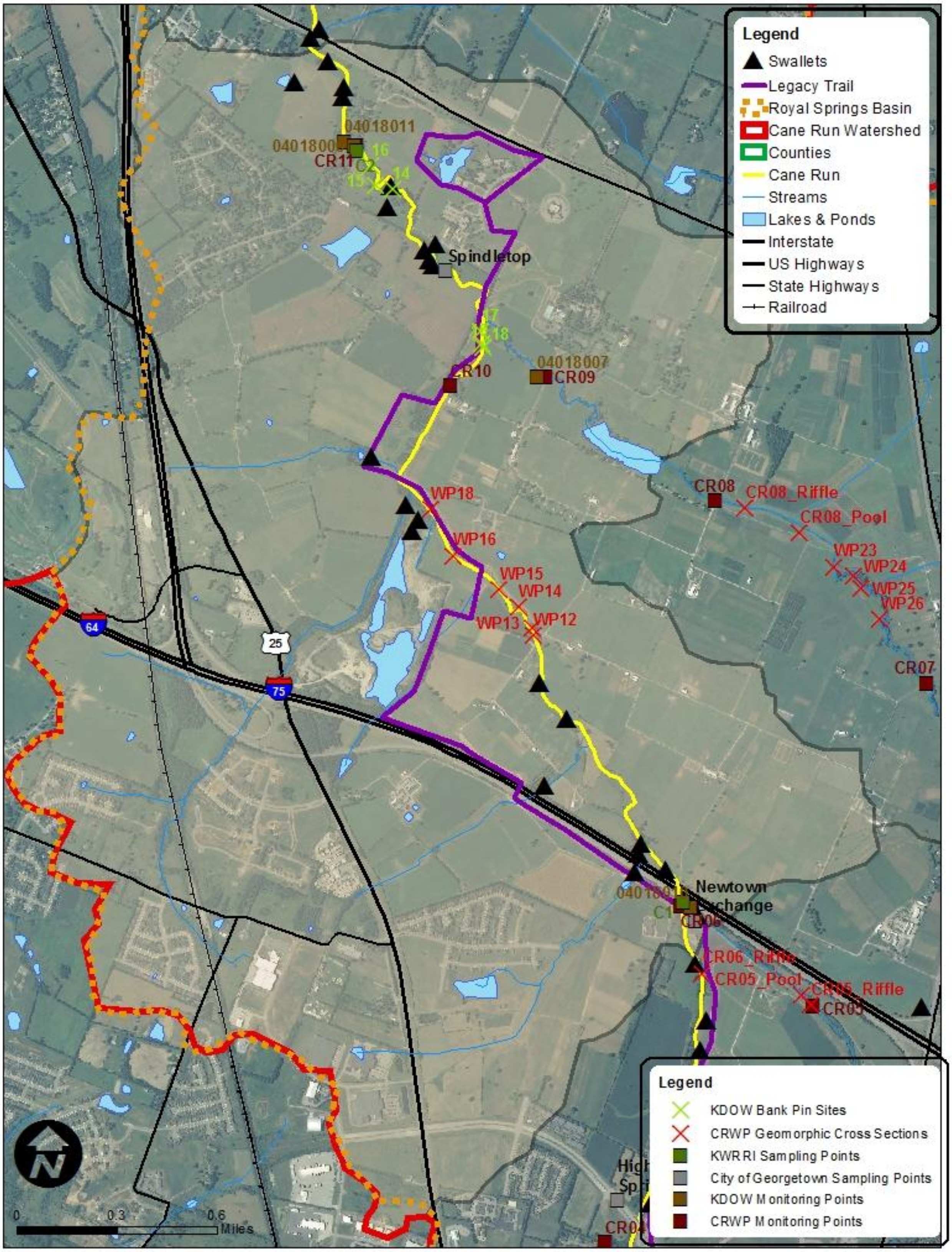

Figure 117. Monitoring points in Catchment 8

Monitoring Conclusions

Geomorphology

A total of eight cross-sections (two at CR06; one each at WP12, WP13, WP14, WP15, WP16, and WP18) were established in Catchment 8 along Cane Run. The CR06 cross-sections are located at the water quality monitoring point CR06. This reach of the Cane Run has multiple classifications according to the Rosgen system of stream classification, ranging from C4 to C6 to E4 and E6. Width-to-depth ratios range from 9 to 17 depending on the location, but tend to be below 12. Such low width-to-depth ratios require thick riparian vegetation to maintain lateral streambank stability. South of I-75, the median bed material is gravel; however, north of I-75, sand dominates the bed material. The source of this finer sediment, though not fingerprinted, is likely attributable to agricultural practices within the adjacent uplands. Overgrazing of livestock such as horses, especially during the winter periods, produces large unvegetated areas (Figure 118). These areas likely contribute a sizeable load of fine sediments to the Cane Run as evident in the bed material. Additionally, a low water bridge or stream crossing immediately upstream of WP12 has resulted in downstream erosion, and bank hardening in the form of concrete has been used to counteract the erosion (Figure 119).

Figure 118. Overgrazing produces large unvegetated areas that can contribute to sediment pollution in surface waters.

Figure 119. Erosion caused by a low water bridge; Concrete used to prevent erosion near low water bridge

CR06 is located south, or upstream, of I-75. This cross-section has a bank height ratio (BHR) of 1.4, which indicates vertical instability. The stream reach is not well connected to the floodplain. However, this reach does have thick vegetation resulting in a low bank erosion hazard index (BEHI) ranking (Table 95). From Year 1 to Year 2, bankfull cross-sectional area increased by 12.1 ft^2 at CR06. The other cross-sections (WP12, WP13, WP14, WP15, and WP16) are located on the University of Kentucky's Spindletop Farm and are located south or downstream of I-75. With the exception of WP18, these cross-sections have BHRs of 1.1 or less. Changes in bankfull cross-sectional area from Year 1 to Year 2 ranged from -3.9 to +3.5 ft^2. At WP18, the streambanks are extremely unstable with a BHR of 2.0. High or moderate BEHI values were the result of sparse riparian vegetation that mostly consisted of weeds and grasses with few trees. The bankfull cross-sectional area decreased by 8.2 ft^2 despite lateral erosion on the left bank at WP18. This decrease was due to sediment deposition along the stream bed.

Downstream of WP12, riparian vegetation is quite sparse due to overgrazing by horses. As horses were located in this pasture year-round in 2009, permanent cross-sections were not established so erosion rates were not measured for this section of Cane Run.

Table 95. Average annual erosion/deposition rates within Catchment 8

Cross-section	Bank	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
CR06_Riffle	Left	Low	Low	0.304
CR06_Riffle	Right	Low	Low	-0.193
WP12	Left	High	Moderate	0.279
WP12	Right	Moderate	Low	0.056
WP13	Left	Moderate	Low	-0.909
WP13	Right	High	Moderate	0.301
WP14	Left	Moderate	Moderate	-0.143
WP14	Right	High	High	0.515
WP15	Left	Low	Low	-0.299

Cross-section	Bank	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
WP12	Right	Low	Low	-0.182
WP16	Left	High	Moderate	0.289
WP16	Right	Moderate	Moderate	-0.493
WP18	Left	High	Moderate	0.419
WP18	Right	Moderate	Low	-0.072

The KDOW established bank pins (toe, bankfull and top of bank) at six locations on the Cane Run within this catchment in November 2008. Three study banks were established on the Cane Run upstream of the confluence with the UT that traverses the University of Kentucky's Spindletop farm. Three additional sites were established on the Cane Run downstream of Berea Road. The KDOW determined BEHI and near bank stress (NBS) values for each location and measured the amount of bank pin exposed for all recoverable bank pins (Table 96). No additional information (e.g. photographs and cross-sectional surveys) were provided by KDOW. University of Kentucky personnel could not locate these monitoring locations to collect additional data. These data indicate the erosion rates within this catchment for 2008-2009 are higher than those recorded in other sections of Cane Run for 2009-2010. Average annual erosion rates are higher near the confluence of the UT to Cane Run and Cane Run for the monitored period. The reach of Cane Run downstream of Berea Road also exhibits erosion largely due to overgrazing of cattle.

Table 96. KDOW average annual erosion deposition rates in Catchment 8

Bank Pin Location	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
14	Moderate	Low	0.616[1]
15	High	Low	0.130[1]
16	High/Very High	High/Extreme	0.285
17	Very High	Moderate	0.555
18	Moderate	Low/Moderate	0.314
19	Moderate	Extreme	0.462

[1]Not all bank pins were recovered.

Based on the results of the geomorphic assessment of Cane Run from just south of I-75 to the 90° bed in Cane Run immediately downstream of Vulcan Materials, the stream reach is unstable in a number of areas, particularly where BHR exceeds 1.1 and riparian vegetation is limited. It is recommended that livestock grazing along the stream cease. Efforts should be undertaken to reduce the BHR through this reach (e.g. creation of bankfull benches), remove invasive vegetation, and establish a riparian buffer. Data collected from the Level Troll 500 located at CR06 indicates water temperatures in Catchment 6 reach up to 80°F during the summer months (Table 97), when water is present in the stream. This stream reach, which spans the section from CR03 until CR06, is largely shaded by trees, shrubs and invasive species such as bush honeysuckle.

Table 97. Maximum water temperatures at CR06 within Catchment 8

Year	Month	Maximum Temperature (°F)

Year	Month	Maximum Temperature (°F)
2008	June	77.3
	July	80.7
	August	80.2
	September	76.6
	October	65.0
	November	52.6
2009	April	74.2
	May	79.1
	June	80.6
	July	78.7
	August	80.2
	September	74.2
	October	67.0
	November	60.9
	December	55.9
2010	January	53.9
	February	52.6
	March	64.8
	April	76.1
	May	76.6
	June	78.7

Developed land accounts for about 72.5 percent of the land use at this monitoring point (Figure 120). As such, water temperatures in this section of Cane Run are likely influenced by heat from these impervious surfaces (e.g. solar radiation on pavement). As seen in Figure 121, water temperatures quickly reached 76.5°F for a storm event on July 23, 2008 at the onset of stream flow from runoff (stream was dry prior to this storm event) before declining to 62°F nearly 24-hours later when stream flow ceased. Further reductions in water temperatures will most likely be achieved through storm water management techniques that encourage infiltration, hence allowing heated waters to cool before they reach the stream.

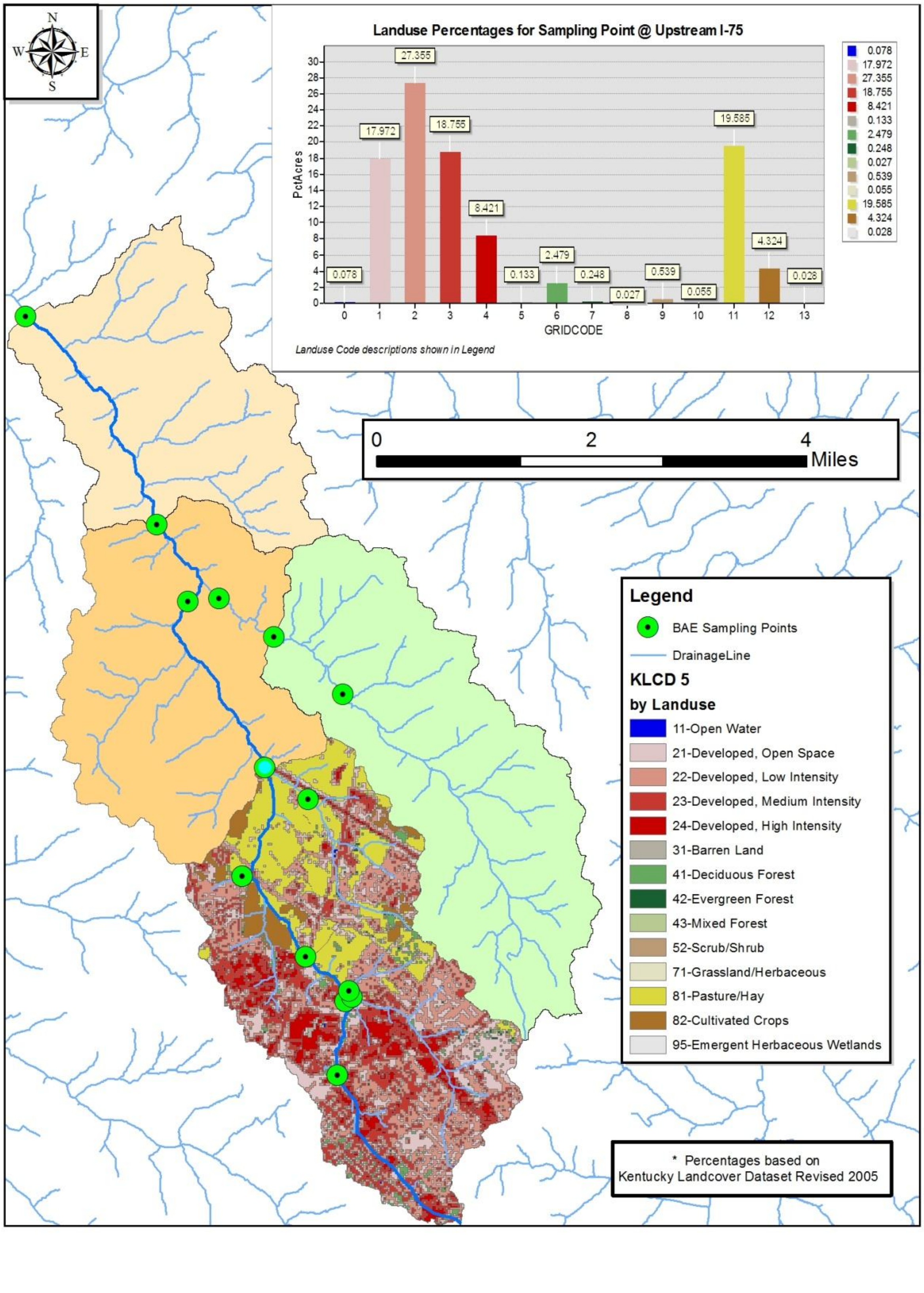

Figure 120. Land use for CR06 in Catchment 8

The remaining reaches of Cane Run, within Catchment 6, also exhibit areas of erosion due to a number of factors such as lack of deep rooting riparian vegetation, overgrazing, and/or higher shear stresses. If funding is available and landowner cooperation can be obtained, it is recommended that stream restoration be explored as an option to reduce erosion rates in the Cane Run from I-75 to Ironworks Pike.

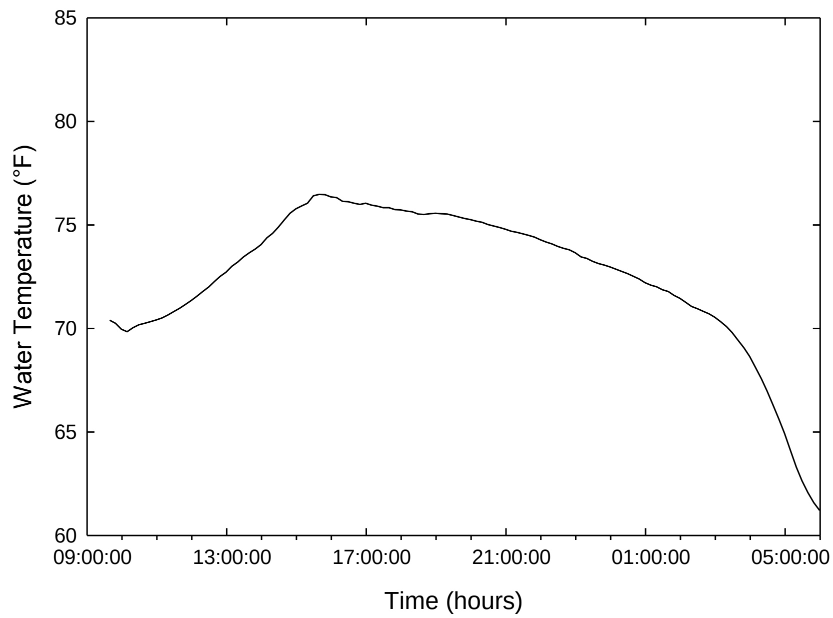

Figure 121. Elevated water temperatures resulting from urban runoff at CR06. Storm event occurred on July 23, 2008.

Water Quality

Bacteria

The monitoring conducted by KWRRI in 2002 and by the City of Georgetown in 2005 does not necessarily confirm the 303(d) listing for this section of stream for fecal coliform. No samples could be taken at KWRRI's 2002 monitoring point C2 in Catchment 8 because the stream was dry (Table 98), and the geometric mean at the City of Georgetown's Spindletop site did not exceed the primary contact standard (Table 99); however, the monitoring conducted by the University of Kentucky from June 2008 to December 2009 found that *E. coli* concentrations at each of the monitored locations exceeded the primary contact standard for a 30-day geometric mean of 130 cfu/100 ml (Table 100).

Table 98. Fecal coliform data from KWRRI monitoring point C2

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY

Table 99. City of Georgetown fecal coliform data in Catchment 8

Site	Geometric mean *E. coli* (cfu/100mL)
Spindletop	20

Table 100. Peak and geometric mean *E. coli* concentrations at monitoring locations within Catchment 8

Site	Year	No. Samples	Peak (MPN/100 ml)[1]	30-day Geometric Mean (MPN/100 ml)
CR09	2008	9	16,600	3,679
	2009	29	17,574	197
	2008-2009	38	--	415
CR10	2008	2	4,577	1,809
	2009	8	10,708	688
	2008-2009	10	--	835
CR11	2008	1	4,160	4,160
	2009	12	15,286	417
	2008-2009	13	--	498

[1]MPN = most probable number

In 2008, all grab samples at CR09, CR10 and CR11 exceeded the primary contact standard (Table 101). For the sampling period, both peak, 30-day geometric mean, and number of samples exceeding the primary contact standard were greater for CR09 than CR10 and CR11, suggesting that load reduction via dilution is occurring between these two monitoring locations. Little difference was noted between *E. coli* peak concentrations at CR10 and CR11, so it is anticipated that no large sources of bacteria exists along this reach. Examination of the *E. coli* load duration curve for CR11 (Figure 122 and Figure 123) indicates that the primary contact standard was achieved about half of the time at this location.

Table 101. Number of samples at each site that exceeded the primary and secondary surface water samples for *E. coli*

Site	Year	No. Samples	Percent of Samples *E. coli* >240 MPN/100 ml[1]	Percent of Samples *E. coli* >676 MPN/100 ml
CR09	2008	9	100	89
	2009	29	48	24
	2008-2009	38	61	39
CR10	2008	2	100	100
	2009	8	75	50
	2008-2009	10	80	60
CR11	2008	1	100	100
	2009	12	42	42
	2008-2009	13	46	46

[1]MPN = most probable number

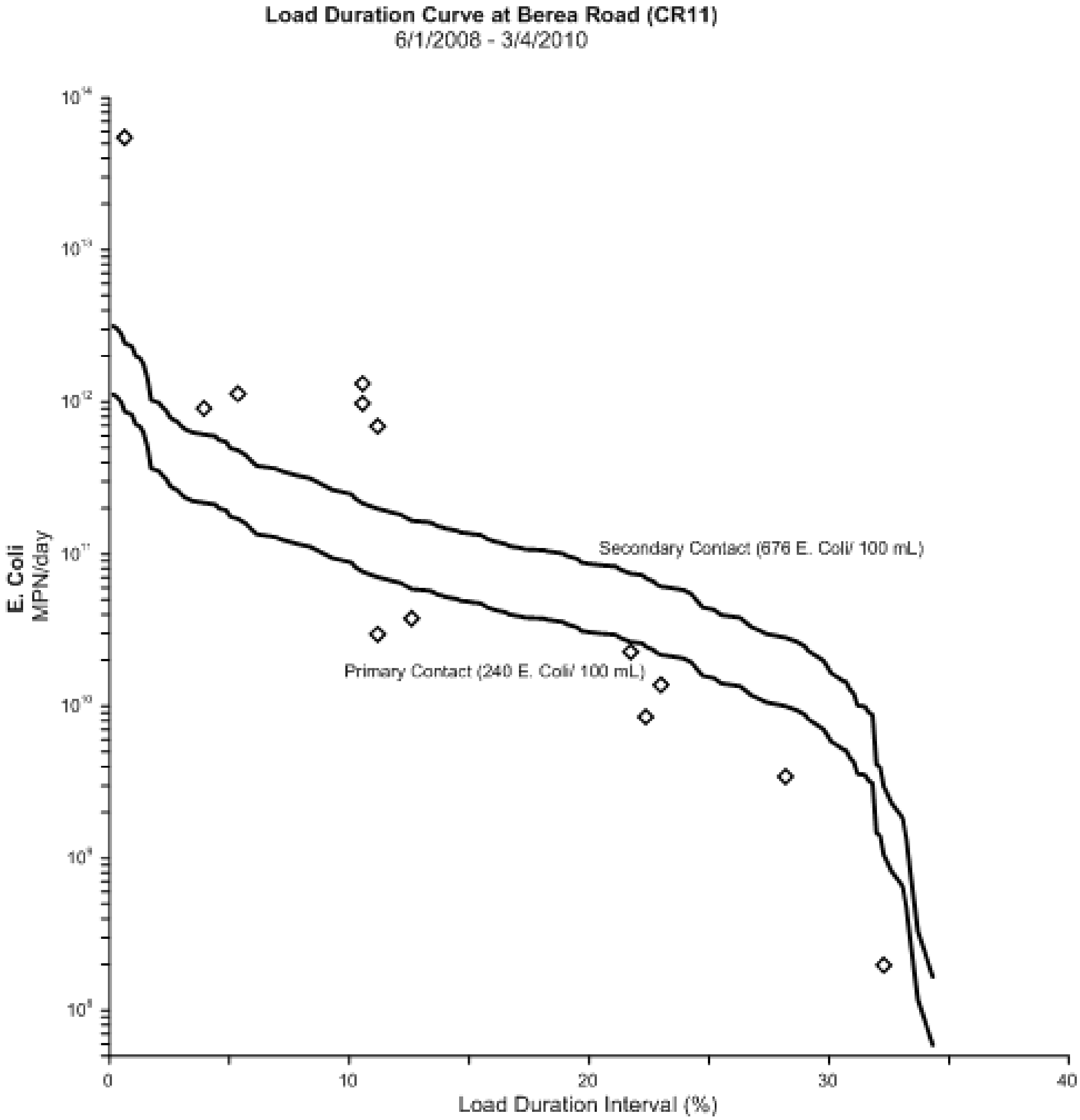

Figure 122. Estimated *E. coli* load duration curves at CR11

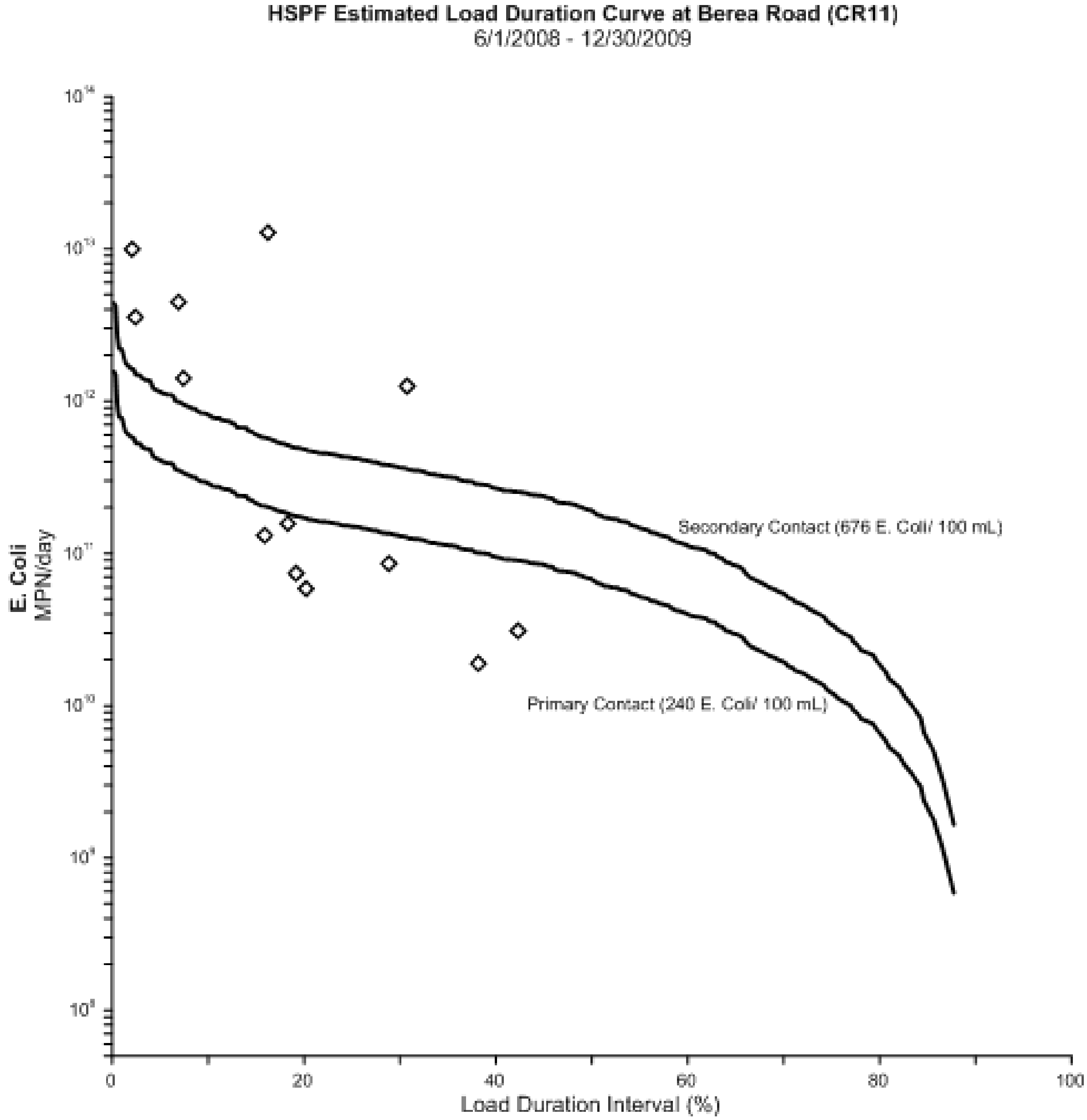

Figure 123. Estimated *E. coli* load duration curves at CR11 utilizing flows developed with the HSPF model

The areas draining these three monitoring sites are largely agriculture (66 percent at CR09, 39 percent at CR10, and 50 percent at CR11) (Figure 124, Figure 125, and Figure 126). For CR09, the most likely sources of bacteria are livestock and wildlife. Interestingly, this monitoring point, which is downstream of CR08, has higher bacteria concentrations. The increase is likely due to livestock, as a highly stocked horse pasture is located immediately upstream of CR09. The large pond immediately upstream of CR09 may also be a source as it serves as an attractant for geese and other wildlife. Unlike CR09, both CR10 and CR11 are located on the Cane Run, and as such, are more heavily influenced by upstream urban contributions. Both CR10 and 11 are near force mains. Two KDPES permits have been identified on tributaries that interest the Cane Run upstream of CR10. Additionally, the runoff from the University of Kentucky Dairy is discharged into Cane Run upstream of CR10.

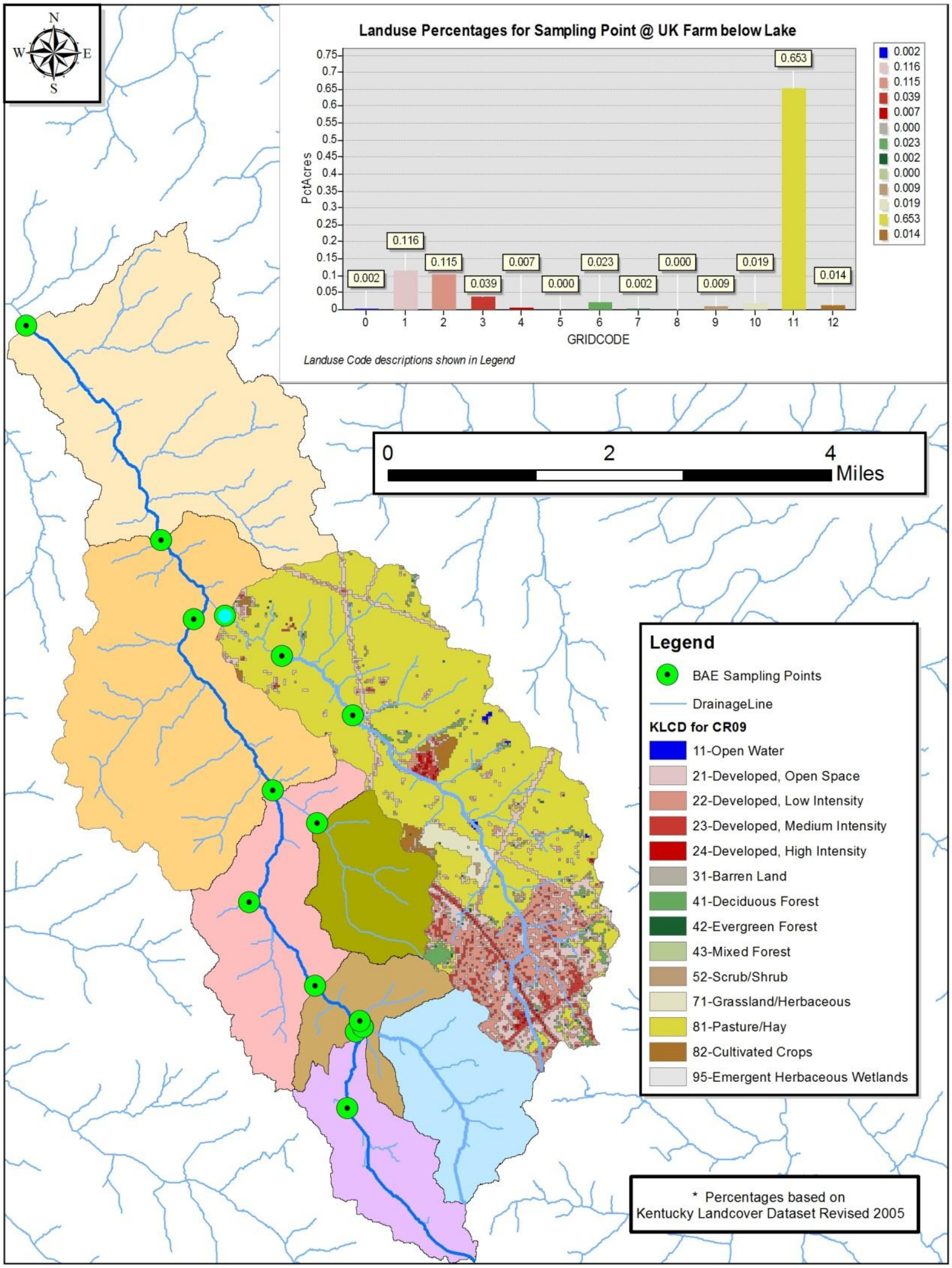

Figure 124. Land use for CR09 in Catchment 8

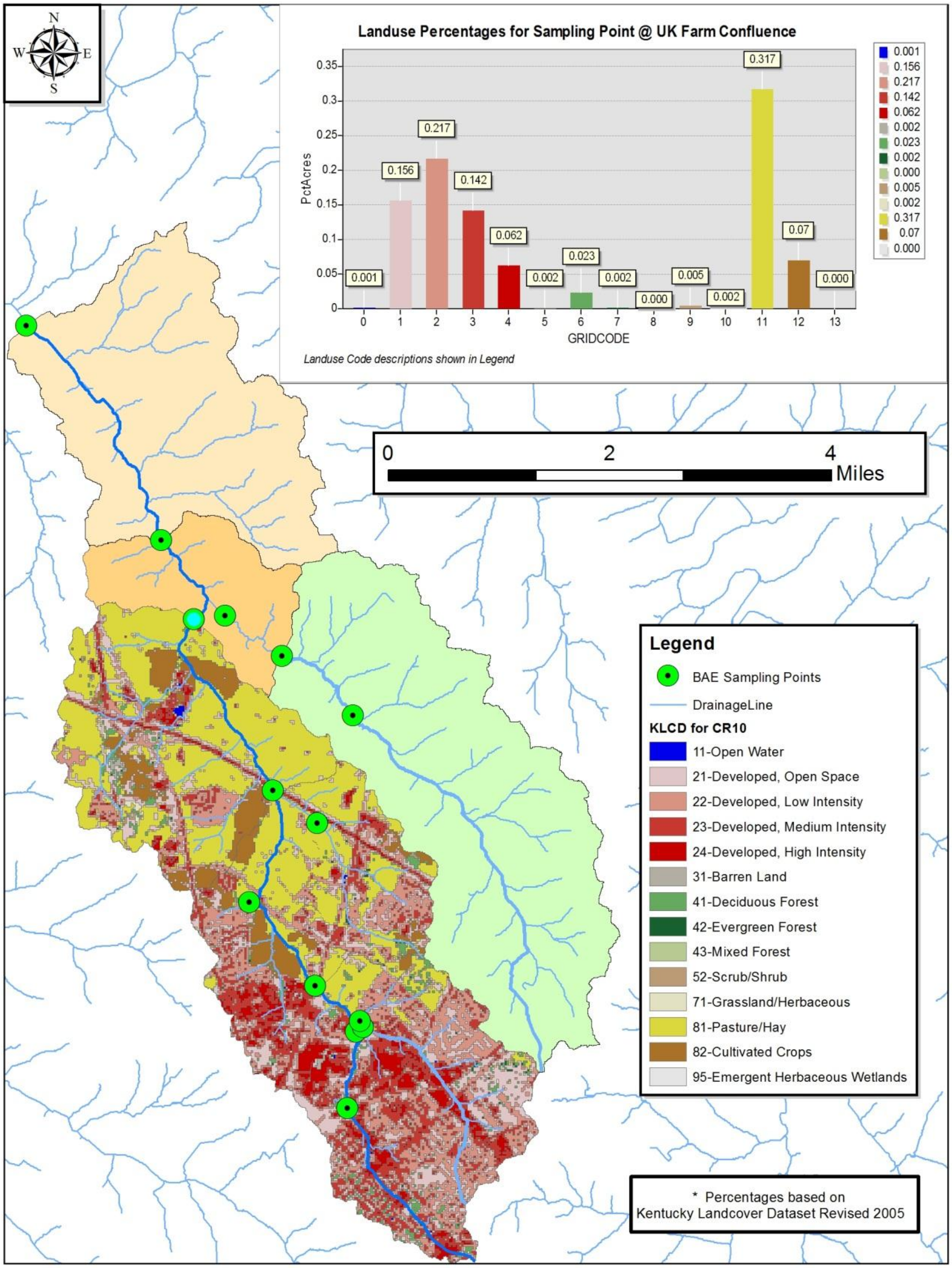

Figure 125. Land use for CR10 in Catchment 8

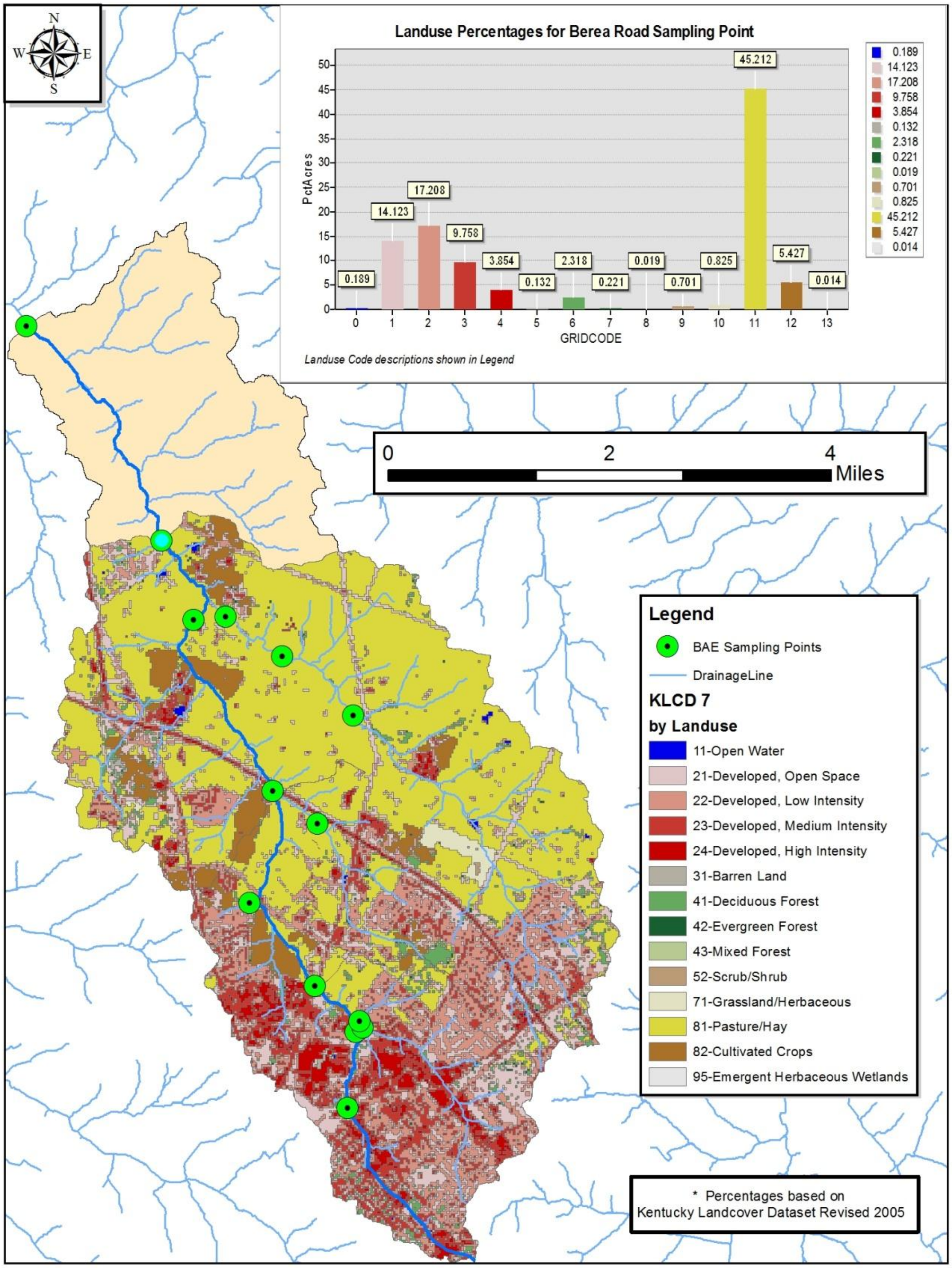

Figure 126. Land use for CR11 in Catchment 8

Examination of the *E. coli* concentration response to 48-hour prior rainfall indicated that CR10 exhibited a strong increasing trend (Figure 127, Figure 128, and Figure 129). This trend is likely due to both point sources from the urban area extending an influence on this reach as well as non-point sources such as runoff from agricultural lands.

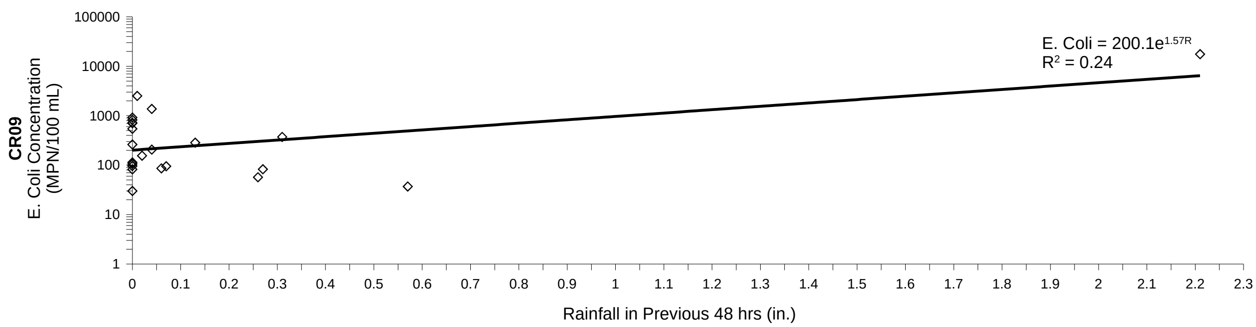

Figure 127. *E. coli* concentration response to 48-hour prior total rainfall for CR09

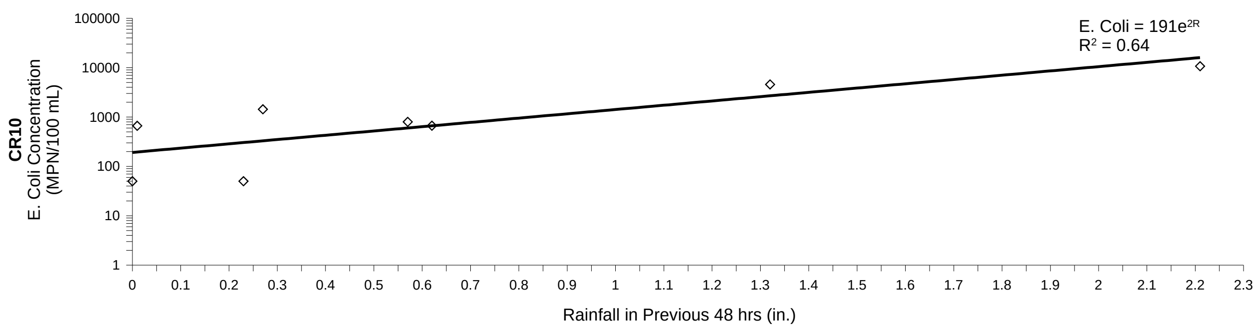

Figure 128. *E. coli* concentration response to 48-hour prior total rainfall for CR10

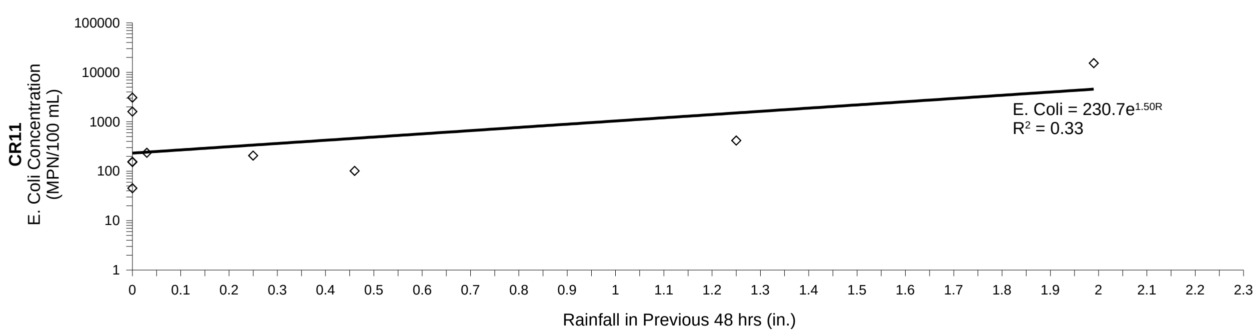

Figure 129. *E. coli* concentration response to 48-hour prior total rainfall for CR11

To reduce bacteria loads in Catchment 8, it is recommended that all livestock be prohibited from grazing along the stream and that a riparian buffer be established along as many tributaries within the catchment as possible, including the large pond upstream of CR09. It is recommended that geese be discouraged from using the pond for extended periods of time outside normal migration patterns. Due to the high connectivity of surface and ground waters in karst geology, it is also recommended that sinkholes be protected from livestock access. Efforts should be taken to implement a nutrient management plan at the University of Kentucky Dairy.

Nutrients

The monitoring conducted in 2006 and 2007 by KDOW demonstrates a problem with nutrient pollution, specifically phosphorus, in this catchment. The geometric mean for DOW04018007 is near the total phosphorus target of 0.3 mg/L (Table 102), and half of the individual samples taken by KDOW at this point exceed this total phosphorus target (Appendix K).

Table 102. Nutrient geometric means for DOW04018007

Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
0.049	Not detected	0.867	1.80	0.144	0.279	4.0	0.303

Sediment

No storm event samples were collected at CR09, CR10 or CR11. TSS load duration curves indicated that no samples exceeded a 200 mg/l threshold (Figure 130).

Based on the monitoring data, suspended sediments are not a large concern in Catchment 8. However, areas of streambank erosion should be addressed as these soils are likely contributing nutrients to the watershed. Additionally, areas of upland erosion should be addressed, in part by the establishment of riparian buffers along waterways.

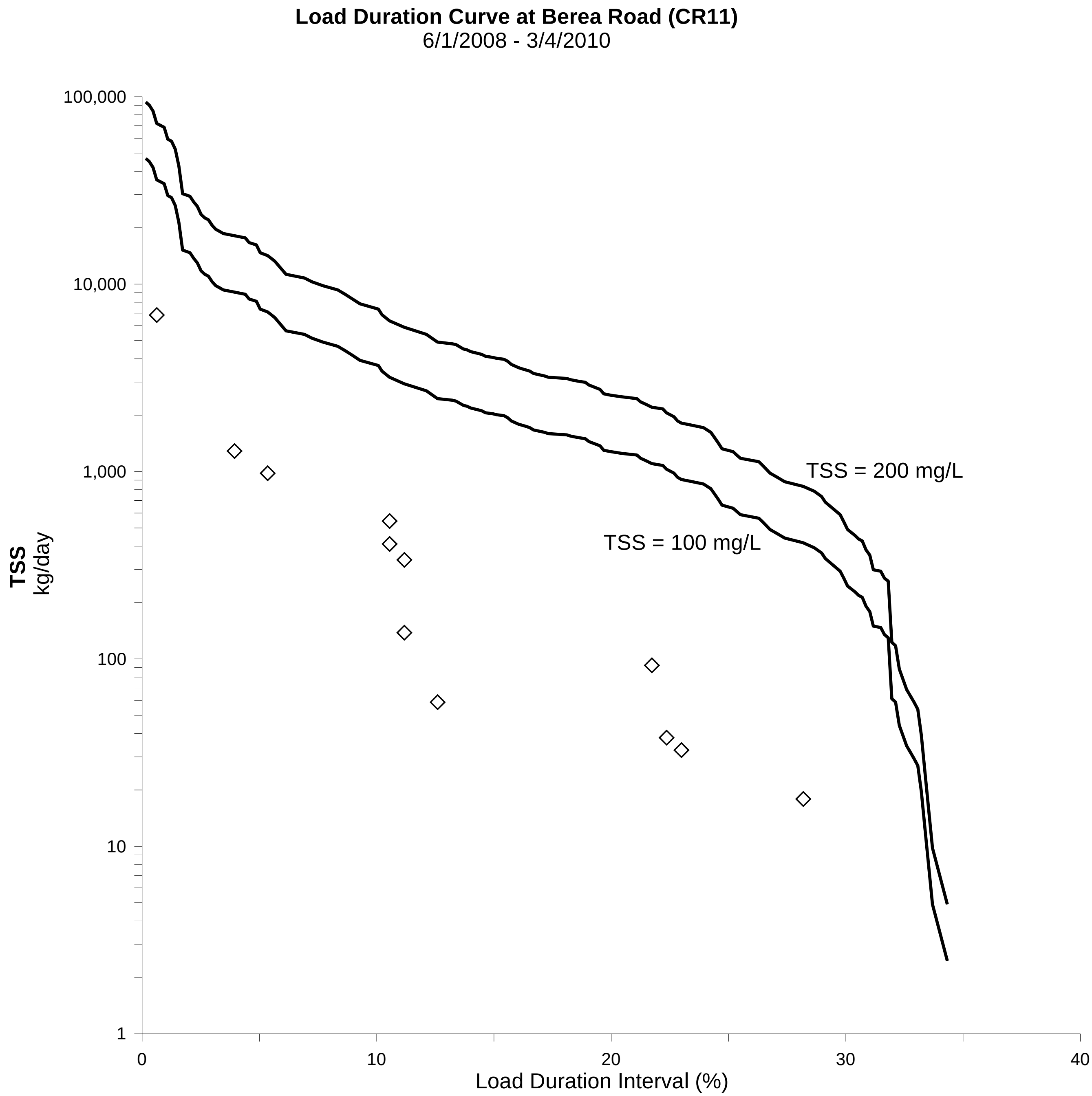

Figure 130. Estimated TSS load duration curve at CR11

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run.

In addition to physical characteristics of the watershed, there are many projects and partnerships already underway that will also guide BMP implementation efforts. The upper Cane Run Watershed is unique in not only its geology, but by the few, large, public landowners. In Catchment 8, these include University of Kentucky's Agricultural Experiment Station (the largest single landowner on the stream), the Council of State Governments, LFUCG, Barton Brothers Farms, Kentucky River Properties, and Vulcan Materials.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform, sewage, and nutrients, specifically nitrogen and phosphorus. The most likely sources of these pollutants in Catchment 8 that should be addressed include managed pasture grazing, crop production, unspecified urban stormwater, Class V injection wells, sanitary sewer overflows, urban development and construction, lawn and agricultural fertilizers and pesticides, wildlife, and agricultural erosion. Although sediment has been determined to not be a problem in this catchment, stream bank erosion is still an issue that could be contributing to nutrient pollution.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 8, the MS4 developed land loading must be reduced by 50 percent, the MS4 non-developed loading must be reduced by 24.7 percent, and the non-MS4 loading must be reduced by 25.1 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes. The BMPs recommended and implemented within this catchment will help to achieve these reduction goals.

Because Catchment 8 lies within the scope of the Royal Spring aquifer of the Cane Run Watershed, BMPs were selected that most effectively address the primary pollutants and their suspected sources, land use, property owner and/or stakeholder acceptance, and sources of potential funding, as well as technical and community support. This section includes a map and detailed description of proposed and implemented BMPs and a table summarizing these BMPs, their effectiveness, costs, and possible implementation partners.

For additional information about BMP implementation in the entire Cane Run Watershed, please reference the Cane Run and Royal Spring BMP Implementation Plan in Appendix X.

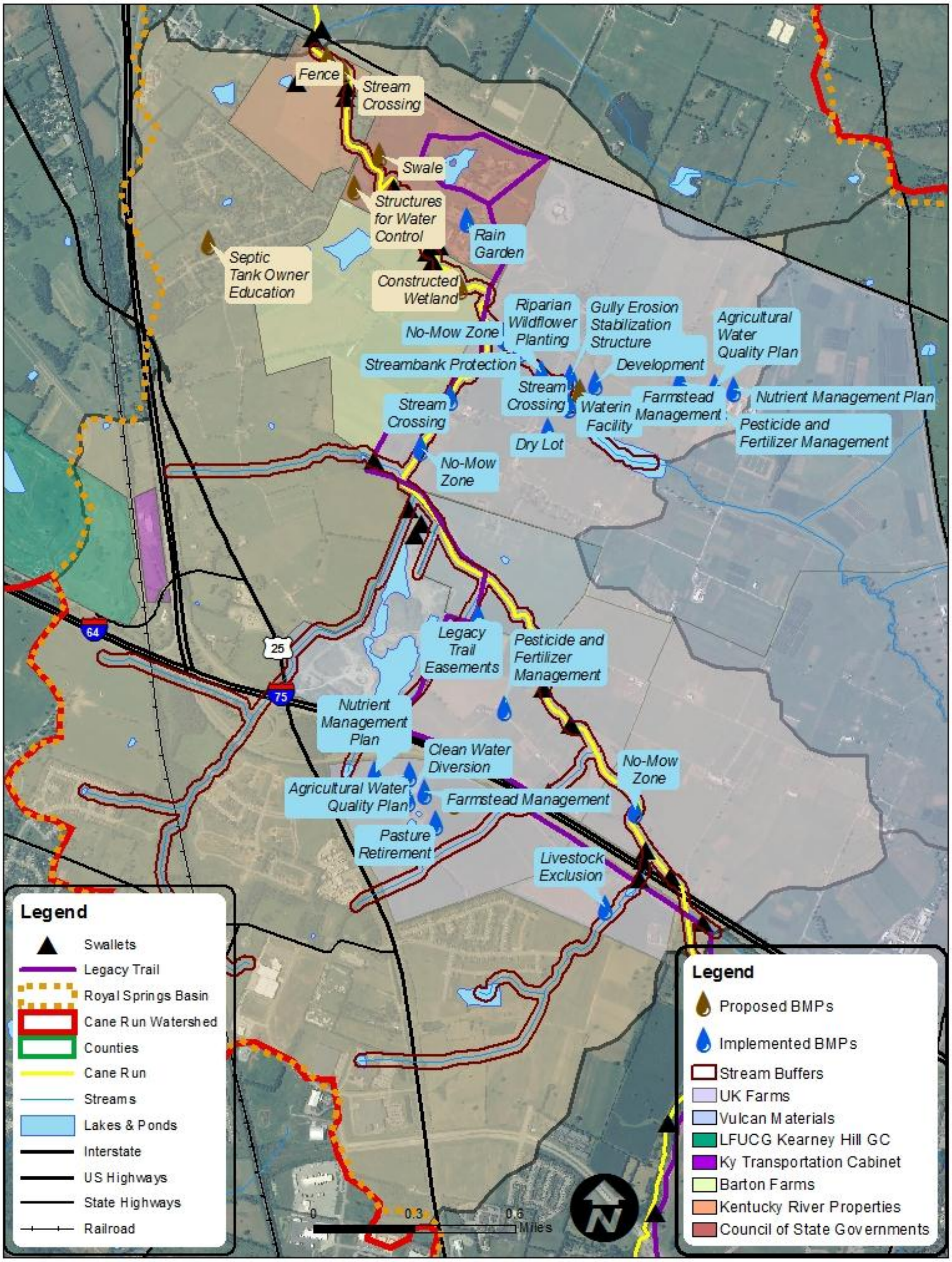

Figure 131. Priority BMP locations for Catchment 8

Tributary to Cane Run (Spindletop Farm)

Proposed

The tributary from Maine Chance continues across the Spindletop Farm and joins the Cane Run prior to exiting the UK property. The stream channel flows through the Plant and Soil Science section of the farm, which is primarily row crop agriculture. Since the row crops are contained in research plots, there are a significant number of grass filter strips located throughout the area. Alternative riparian buffer strategies that reduce nutrient, sediment, and bacteria pollution in runoff could be demonstrated along the stream reach to minimize overshadowing of research plots while maintaining a good riparian buffer with adequate stream shading.

The reach contains one of the few subsurface drained areas in the watershed. Structures for water control could be inserted in the drainage mains to manage the discharge of subsurface water. The control structures can be used to limit water discharge during the winter months.

The tributary continues along the Spindletop Farm and passes through the Veterinary Sciences section. Horses could be excluded from the stream by fence to limit bacteria, sediment, and nutrient deposition directly into the stream. A stream crossing could be installed to prevent erosion and subsequent sediment pollution, and NRCS personnel plan to study spring development in the paddock for use as an alternative watering facility, which would incentivize fencing the livestock out of the stream. Many unused pesticides are in the process of being removed from the farm, and there is the potential to install an agrichemical handling facility for use of mixing fertilizers and pesticides in the future, which would reduce the pollution potential of pesticides and fertilizers on the farm.

Implemented

RIPARIAN WILDFLOWER PLANTING

In the fall of 2010, approximately 1,600 Kentucky native perennials and grasses were planted within a 3,800 ft^2 section of the riparian buffer along the main tributary that runs through the University's North Farm (Figure 132). This will not only to improve aesthetics and acceptance of the no-mow buffer, which filters pollutants in runoff such as nutrients, bacteria, and sediment, but also will increase natural biodiversity and restore plants that would typically be found along a Central Kentucky stream corridor. Many of these plants will provide food and habitat for birds, butterflies, pollinators and aquatic organisms.

Figure 132. Cardinal Flower and Swamp Milkweed planted within a no-mow zone; Plantings of Cardinal Flower and Rose Mallow increase biodiversity

GULLY EROSION STABILIZATION STRUCTURE

Vegetation that slows and uptakes polluted runoff can be lost due to unprotected drainage traversing through paddocks and cropped fields. This is commonly referred to as gully erosion (Figure 133). Typically, producers install roll bales or tree debris into these areas to reverse the process, although these remedies never seem to last or correct the problem. A gully erosion structure (also known as a drop structure or grade stabilization structure) does correct this problem, and one of these structures was installed in a veterinary sciences paddock on UK's Experiment Station in the summer of 2008 (Figure 133).

The purpose of a drop structure is to allow water to move to a lower elevation while managing the energy and velocity, so that erosion can be controlled. Erosion control decreases the amount of sediment and nutrient pollution entering nearby surface waters. Unlike weirs and dams, drop structures are usually not built for water impoundment or diversion or to raise the water level. They are mostly built on small or minor waterways that have steep channel gradients. The structure created in the vet sciences paddock also works to prevent the waters of the confluence from eroding soil in the adjacent channel.

Figure 133. Eroded banks and washed out soil in a gully area near a Cane Run tributary; The grade stabilization structure prevents pollutants from entering the stream.

Livestock Exclusion

Horses on UK's Experiment Station have been excluded from this stream section since 2008, allowing for the establishment of a no-mow riparian buffer zone and a reduction in bacteria, sediment, and nutrient water pollution.

Stream Crossings

In the summer of 2008, along this stream section, a hardened stream crossing for livestock was installed on UK's Experiment Station based on NRCS guidelines using geotextile fabric and rock (Figure 134). This crossing also includes gates to exclude livestock when the crossing is not in use and gates across the stream that open during high flow events to allow debris to pass through. Hardened stream crossings decrease sediment, and therefore nutrient, pollution into the streams through which they cross by decreasing erosion.

Figure 134. This hardened stream crossing prevents damage from livestock crossing

Spring Development as an Alternative Water Source

A developed spring was installed in a veterinary sciences paddock on UK's Experiment Station in 2008 and 2009 (Figure 135). Developing a spring as an alternative water source allows livestock to be excluded from the creek, which decreases bacteria, sediment, and nutrient loading, while still using a local, low-cost water source. Development of a spring can also remove excess water from a saturated area within the pasture, allowing the area to be safely grazed by livestock while also providing drinking water for the livestock. Spring developments may also improve the ability to implement rotational grazing, which can increase overall pasture productivity and conserve soil resources. The developed spring and several other implemented BMPs in this catchment can be seen in Figure 136.

Figure 135. This watering tank is fed by the fenced developed spring in the background.

Figure 136. This comparison of 2006 (left) and 2010 (right) shows the implementation of a stream crossing, livestock exclusion, and spring development.

Dry Lot

A dry lot was constructed in a veterinary science paddock on UK's Experiment Station in late 2006. Without a dry lot, congregating horses (and other livestock) around feeding and watering areas create mud, increase soil compaction, eliminate desired vegetation, and lead to increased weed infestation. The runoff from these compacted, vegetation-free areas can also pollute nearby surface water bodies. The purpose of a dry lot is to provide a hardened area for the traffic associated with obtaining water and feed and to eliminate many of the negative impacts that livestock have on water quality.

Agricultural Water Quality Plan

One of the most important best management practices that the University of Kentucky Experiment Station could implement is a legitimate Agricultural Water Quality Plan (AWQP). An AWQP is required by law for all landowners and land users with ten or more acres under agricultural or woodland production. The goal of an AWQP is to protect surface and groundwater resources from pollution as a result of agricultural and forest-related activities. These plans consist of best management practices (BMPs) from six different areas—silviculture, pesticides and fertilizers, farmstead, crops, livestock, and streams and other waters. The prescribed BMPs are considered the minimum practices that landowners and land users should implement.

It is especially important that the Experiment Station develop and implement a water quality plan because of its location within the environmentally-sensitive Cane Run Watershed. One goal of the Cane Run Watershed Project is to encourage the Experiment Station to adopt and implement all required BMPs, as well as facilitate and demonstrate the development of new BMPs. BMPs installed and demonstrated on the Experiment Station address a variety of pollutants, including bacteria, nutrients, and sediment. In keeping with state law and the goals of this project, the creation of an AWQP for the Experiment Station began in January 2010, and the final document is complete as of January 2011. The full plan is available in Appendix CC.

Included as part of the developed Agricultural Water Quality Plan, the University of Kentucky's Experiment Station has developed a nutrient management plan that provides basic information regarding how the manure produced by this operation is applied to agricultural fields, and how it will be utilized. The plan is based on the site conditions and management operations documented in the plan, as of the date indicated by the signatures of the plan developer and the farm manager. Soil tests for the North Farm showed that the soils contained a level of available phosphorus that did not require supplementation. This is typical of soils (Maury-McAfee series) in Central Kentucky formed by phosphatic limestone parent material. The location of animal enterprises on these soils provides the University of Kentucky College of Agriculture, the opportunity to demonstrate the influence of best management practices (BMPs) and alternative manure management practices, and to show that animal manure additions to these soils can be made without negatively impacting air, soil, and water resources. The complete Nutrient Management Plan for UK's Experiment Station can be found in Appendix DD.

As part of the Experiment Station's Nutrient Management Plan, all of the waste associated with livestock on the UK Experiment Station is now collected in a roofed transfer station and hauled away by a contractor to be composted. Placing the manure under a covered stack pad prevents rain from hitting stockpiled manure and creating contaminated runoff from the site, and hauling the waste away provides an opportunity to remove nutrients produced by horses, poultry and dairy from the farm. The cost, covered by the College of Agriculture, to haul away the manure is approximately $40,000 per year.

No-Mow Zones

No-mow zones are areas adjacent to water bodies that are left un-mowed by maintenance crews. Formerly these riparian areas were mowed, but the installation of a no-mow zone allows vegetation to grow without restriction, which provides a vegetative buffer between pollutants such as sediment, nutrients, and bacteria and the water. It is common to believe that no-mow zones are improper on the Experiment Station because they make the farm look unkempt; however, no-mow zones are valuable features that control and trap pollutants before they reach surface waters. It is also a cost effective practice. Equipment can also be damaged while mowing riparian slopes, and not mowing these areas saves fuel, equipment, and labor. In addition, many of these sections are wet areas where equipment can easily become caught and stuck in the mud.

No-mow zones have been established along all streams and water bodies across the entire farm, with the exception of the several small stream sections and Lake Mildred. These buffers are approximately 50-feet wide on each side of the water body and add up to a cumulative 27 acres of land on the Experiment Station. As a result of this stewardship, original populations of riparian flora such as Great Blue Lobelia, Swamp Milkweed, sedges, Woodland Sunflower, and Arrow Arum are being revived. In 2010, signs and markers were posted to help delineate no-mow zones and conservation buffer areas and to help describe the practices to users and visitors of the farm.

Farmstead Management

Because septic systems can contribute to bacteria pollution in the Cane Run, the Experiment Station has demolished houses and removed mobile homes, which includes the removal of existing septic systems. So far, the Experiment Station has removed several residences and apartment buildings and their corresponding septic systems.

Pesticide and Fertilizer Management

Pesticides are necessary to the research, extension, and teaching missions of the Kentucky Agricultural Experiment Station. When managed properly, pesticides can provide effective mitigation of pest outbreaks as well as routine control of agricultural pests (weeds, insects, and diseases); however, the proper storage and use of pesticides require due diligence on the part of the faculty, staff, and students working on the research farms. The Experiment Station is situated on an environmentally sensitive watershed, the Cane Run Watershed, and as such, necessitates careful management of fertilizers and pesticides.

Empty containers are being recycled using Rinse and Return system. Excess fertilizers and pesticides can create unnecessary storage and disposal issues. The purchasing and ordering has been adjusted to accept only the minimum amount of pesticides and fertilizers needed for research and crop production purposes use in the short term.

Pesticides have been inventoried. The unusable or unneeded pesticides and fertilizers have been identified. In the last two years, approximately 6,700 pounds of surplus pesticides have been removed from the Experiment Station and have been properly disposed of.

<u>Cane Run (University of Kentucky Property)</u>

Proposed

Along this reach, the main stem of the Cane Run flows directly over the Royal Spring conduit with numerous swallets representing direct connections between surface and ground water. Geophysical methods will be used to locate the conduit and a monitoring well will be installed to track water table changes within the conduit. Other than flows that occur directly after rainfall and/or runoff events, the stream channel often appears as an intermittent stream or grassed waterway. In addition to the lack of significant flow, the channel was straightened and deepened in the past, which increased the velocity of runoff flows and may encourage the close connection to the Royal Spring conduit. Sinkhole protection from nutrient, sediment, and bacteria pollution sources and grade stabilization structures that address erosion will be useful BMPs in this sensitive area.

A tributary originates from a location near the current UK Dairy complex and enters the Cane Run along this reach. A nutrient management plan will be developed for the dairy, and use exclusion and fencing will be utilized to limit animal admittance to the tributary and minimize excess nutrients, sediments, and bacteria from reaching the stream. As part of the nutrient management plan, stocking rates will be monitored to help demonstrate proper grazing management, and a stream crossing will be installed to limit further streambank degradation due to animal and vehicle traffic.

Proactive BMPs offer a low-cost option to either reduce pollutant sources (such as prescribed grazing or obstruction removal), restrict transport to the waterway or contain pollutants (riparian forest buffer and waste storage facility) or provide less damaging alternatives (stream crossing, spring development, and watering facilities). These BMPs were selected because of the diverse situations along the UK property, and the opportunity for public exposure. The selected BMPs will serve to meet requirements of Kentucky Agriculture Water Quality Act regulations.

One of the best opportunities for community education and outreach will be provided by the Legacy Multi-Use Trail. This trail will follow Cane Run from the Kentucky Horse Park, across the UK property and toward Lexington. Along the UK section, there will be opportunities for interpretative signs to identify, locate and explain BMPs along the Trail.

Implemented

LEGACY TRAIL EASEMENTS

The University of Kentucky granted an easement for the Legacy Trail on the North Farm Experiment Station. The specifications were for a 50 foot easement, but as part of the Cane Run Watershed Project, additional acreage was included in the trail area. These areas are now maintained as no-mow zones, and approximately 35,000 square feet have been planted in wild flowers and native grasses to form multiple buffer zones along portions of the Legacy Trail that meanders through the University's Experiment Station. The buffer zones/no mow zones will filter runoff before the water reaches the streams, capturing sediment, nutrients, and bacteria. Buffer zones also reduce soil erosion by creating a dense root system that will hold soil in place. Diverse plants in the buffer zone provide aesthetically pleasing color and structure to the landscape, attracting wildlife such as birds, frogs, salamanders, and butterflies.

LIVESTOCK EXCLUSION

In February 2010, dairy cows were restricted from a creek section running through their paddock, to which they had previously enjoyed full access, and a 30-foot riparian buffer was created (Figure 137). Shortly afterwards, ponies in a paddock controlled by Veterinary Sciences, were restricted from a creek section. In the spring of 2010, the dairy cows were fenced off from a tributary of the Cane Run. The restricted area includes a thirty-foot buffer that will be maintained in vegetation. All together, these projects totaled about 6,000 feet of protected stream bank, and considering that cattle like to loaf in the stream, this practice will greatly reduce the bacteria, nutrient, and sediment loading that was occurring on this stream section.

Figure 137. Livestock grazing in creek before exclusion; Enhanced riparian area after removal of livestock

STREAM CROSSINGS

Along this stream section, one stream crossing has been permanently closed, and one stream crossing was hardened based on NRCS guidelines using geotextile fabric and rock. These practices will reduce erosion and removal of streamside vegetation, and therefore sediment and nutrient pollution.

CLEAN WATER DIVERSION

At the dairy on UK's Experiment Station, manure and contaminated stormwater are stored in large basins. More than one-quarter of the liquid in the storage basins (>500,000 gallons) comes from the barn roofs and surrounding areas. This is essentially clean water that should be diverted away from the storage basins. Using approximately $41,000 of SB-271 funds, new gutters have been placed on barns and the entire area has been re-graded to divert clean stormwater runoff away from the storage basins (Figure 138). Clean water is now prevented from coming into contact with manure and other contaminated sources by redirecting roof drainage, driveways, and surface flows away from livestock areas, which reduces bacteria loading to nearby surface waters of the Cane Run Watershed.

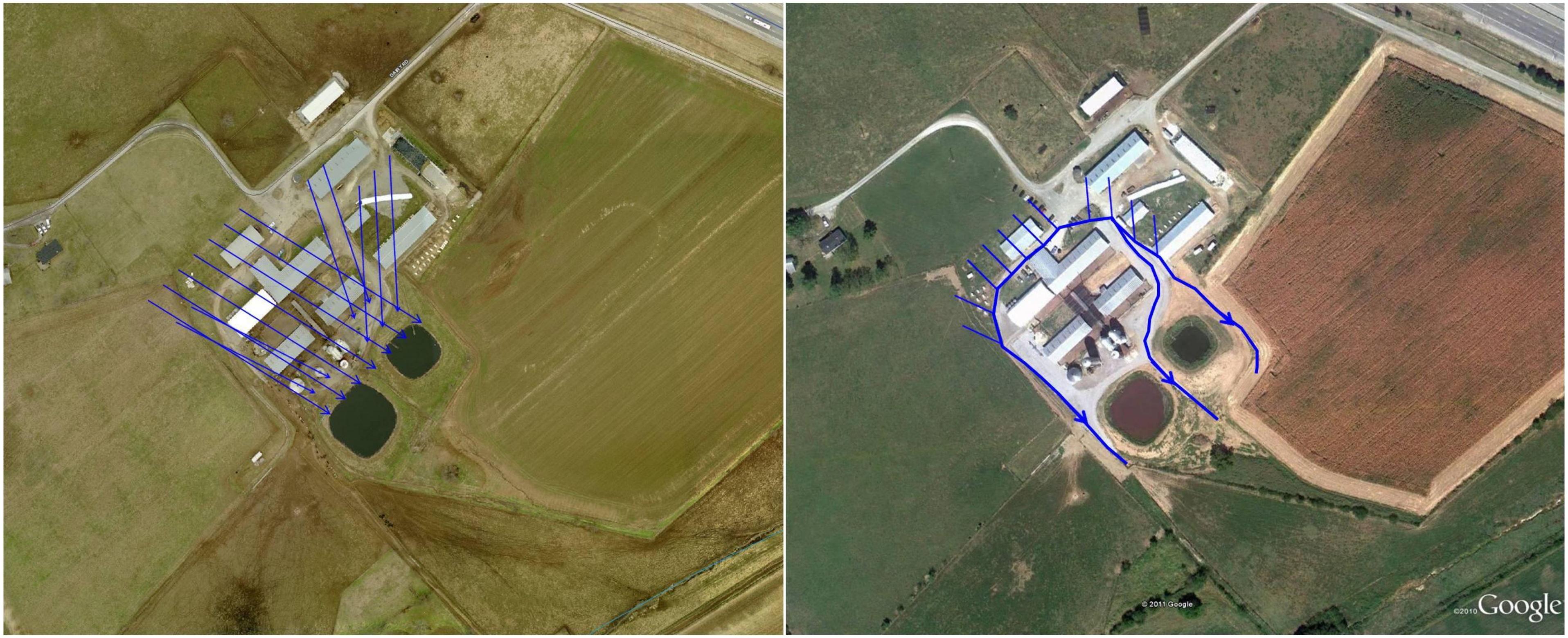

Figure 138. This comparison of 2008 (left) and 2010 (right) shows the implementation of clean water diversion.

Pasture Retirement

A pasture used for grazing does not provide removal of nutrients, as the nutrients consumed by livestock are then deposited again on the same land. Before the implementation of this management practice, all pastures contained high levels of nutrients that indicated they should not be used for pasture. In 2010, all fields around the Dairy Unit of UK's Experiment Station were converted to corn or hay to remove phosphorus and other nutrients from the soil. This conversion from pasture to cropland will take up nutrients from the soil, which reduces possible contamination to surface and ground water resources.

Agricultural Water Quality Plan

One of the most important best management practices that the University of Kentucky Experiment Station could implement is a legitimate Agricultural Water Quality Plan (AWQP). An AWQP is required by law for all landowners and land users with ten or more acres under agricultural or woodland production. The goal of an AWQP is to protect surface and groundwater resources from pollution as a result of agricultural and forest-related activities. These plans consist of best management practices (BMPs) from six different areas—silviculture, pesticides and fertilizers, farmstead, crops, livestock, and streams and other waters. The prescribed BMPs are considered the minimum practices that landowners and land users should implement.

It is especially important that the Experiment Station develop and implement a water quality plan because of its location within the environmentally-sensitive Cane Run Watershed. One goal of the Cane Run Watershed Project is to encourage the Experiment Station to adopt and implement all required BMPs, as well as facilitate and demonstrate the development of new BMPs. BMPs installed and demonstrated on the Experiment Station address a variety of pollutants, including bacteria, nutrients, and sediment. In keeping with state law and the goals of this project, the creation of an AWQP for the Experiment Station began in January 2010, and the final document is complete as of January 2011. The full plan is available in Appendix CC.

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No-Mow Zones

No-mow zones are areas adjacent to water bodies that are left un-mowed by maintenance crews. Formerly these riparian areas were mowed, but the installation of a no-mow zone allows vegetation to grow without restriction, which provides a vegetative buffer between pollutants such as sediment, nutrients, and bacteria and the water. It is common to believe that no-mow zones are improper on the Experiment Station because they make the farm look unkempt; however, no-mow zones are valuable features that control and trap pollutants before they reach surface waters. It is also a cost effective practice. Equipment can also be damaged while mowing riparian slopes, and not mowing these areas saves fuel, equipment, and labor. In addition, many of these sections are wet areas where equipment can easily become caught and stuck in the mud.

No-mow zones have been established along all streams and water bodies across the entire farm, with the exception of the several small stream sections and Lake Mildred. These buffers are approximately 50-feet wide on each side of the water body and add up to a cumulative 27 acres of land on the Experiment Station. As a result of this stewardship, original populations of riparian flora such as Great Blue Lobelia, Swamp Milkweed, sedges, Woodland Sunflower, and Arrow Arum are being revived. In 2010, signs and markers were posted to help delineate no-mow zones and conservation buffer areas and to help describe the practices to users and visitors of the farm.

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Because septic systems can contribute to bacteria pollution in the Cane Run, the Experiment Station has demolished houses and removed mobile homes, which includes the removal of existing septic systems. So far, the Experiment Station has removed several residences and apartment buildings and their corresponding septic systems.

Pesticide and Fertilizer Management

Pesticides are necessary to the research, extension, and teaching missions of the Kentucky Agricultural Experiment Station. When managed properly, pesticides can provide effective mitigation of pest outbreaks as well as routine control of agricultural pests (weeds, insects, and diseases); however, the proper storage and use of pesticides require due diligence on the part of the faculty, staff, and students working on the research farms. The Experiment Station is situated on an environmentally sensitive watershed, the Cane Run Watershed, and as such, necessitates careful management of fertilizers and pesticides.

Empty containers are being recycled using Rinse and Return system. Excess fertilizers and pesticides can create unnecessary storage and disposal issues. The purchasing and ordering has been adjusted to accept only the minimum amount of pesticides and fertilizers needed for research and crop production purposes use in the short term.

Pesticides have been inventoried. The unusable or unneeded pesticides and fertilizers have been identified. In the last two years, approximately 6,700 pounds of surplus pesticides have been removed from the Experiment Station and have been properly disposed of.

Cane Run (Barton Brothers Farm and Council of State Government Properties)

Proposed

The large tributary passing through the Spindletop Farm joins the Cane Run as the main stem enters the Barton property. Some minor riparian buffer corridor restoration work is possible along the Barton property to minimize erosion and resulting sediment and nutrient pollution. The Council of State Governments will be working with the project team to reforest a portion of the riparian buffer along its property. A significant problem with this reach is the deep, incised channel. Only very large runoff events can use the floodplain. The floodplain on the southwest side of the stream has the potential for structures for water control, water and sediment control basins, constructed wetlands, and swales that minimize the amount of stormwater, and the pollutants it contains, that makes it to the stream.

Implemented

RAIN GARDEN

Staff from the University's Center for Applied Energy Research (CAER) approached the Cane Run Watershed Project for technical assistance and support for creating a rain garden. The Center is located on State-owned property beside the University's North Farm and borders the main channel of Cane Run. This facility has recently completed construction of one new building, and the construction of a second adjacent building is underway as of February 2011. These two buildings were designed to feed stormwater runoff into a shared basin that would drain into existing stormwater infrastructure. CAER staff realized the current stage of construction would be an opportunity to develop a water quality feature to mitigate runoff from the new increase in impervious surface. Cane Run Watershed Project staff calculated water quality volumes, assessed soil characteristics, developed basin dimensions and capacity, specified plant material, provided a project cost estimate, and presented an estimated load reduction. Although CAER will not be using the Cane Run Watershed Project design due to contractual obligations, a large rain garden and swale that will collect the water from two buildings are currently under construction at this location. This rain garden will reduce stormwater runoff, which will lessen the sediment, nutrient, and bacteria pollution coming from runoff.

Cane Run (Between Berea Road and Iron Works Pike)

Proposed

Kentucky River Properties controls a portion of the stream section along this reach. Presently the area is used to graze cattle with unlimited access to the stream. UK staff with the Cane Run Watershed Project will work with the property owner to install best management practices along the stream reach including use exclusion, fencing, and a nutrient management plan. These BMPs will reduce nonpoint source pollutants such as sediment, nutrients, and bacteria. Since the land is an investment property, redevelopment of the riparian buffer may be seen as a property enhancement.

Spindletop Estates is a semi-rural subdivision of Lexington located near this reach. At present, the homes in the subdivision utilize septic tanks for sewage treatment. The homeowners will be educated through workshops and meetings about septic tank operation and low-input lawn care, which could potentially reduce levels of bacteria, fertilizers, and pesticides in stormwater runoff and groundwater. These workshops could also include information about financial assistance for soil testing and proper environmental stewardship.

Implemented

Cane Run Watershed Project staff approached Kentucky River Properties, who at the time was not interested in cooperating with the project, and no other best management practices have been implemented along this reach as of February 2011.

Table 103. Catchment 8 priority BMPs¹

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Fence	– Sediment, nutrient, and bacteria removal	– Nitrogen: 54% – Bacteria: N/A+ – Sediment: 90% – Phosphorus: 81%[j]	– Nitrogen: Medium – Bacteria: N/A° – Sediment: High – Phosphorus: Medium[e]	– $2.77/linear foot[h]	– $0.03/linear foot	– NRCS – UK – Private Landowners
Prescribed Grazing	– Reduce soil erosion and sediment loading from livestock	– Nitrogen: 70% – Bacteria: 70% – Sediment: 65% – Phosphorus: 75%[k]	– Slight to substantial improvement for all impairments[a]	– $12.55/acre[h]	– Cost estimate for first year	– UK – NRCS
Use Exclusion	– Maintain or improve the quantity and quality of water resources	– Nitrogen: 54% – Bacteria: N/A+ – Sediment: 90% – Phosphorus: 81%[j]	– Nitrogen: Medium – Bacteria: N/A° – Sediment: High – Phosphorus: Medium[e]	– $90.00/acre[h]	– $0.00	– Private Landowners – NRCS – UK
Sinkhole Protection	– Increase groundwater recharge quality – Sediment, bacteria, and nutrient filtration and removal	– Nitrogen: N/A+ – Bacteria: 90%[q] – Sediment: N/A+ – Phosphorus: N/A+	– Nitrogen: High – Bacteria: High – Sediment: High – Phosphorus: High[e]	– $3,407.06/each[h]	– $97.19/each	– UK – NRCS – Council of State Governments
Structures for Water Control	– Maintain desired water surface elevation – Increase groundwater recharge	– Nitrogen: 10% – Bacteria: N/A+ – Sediment: 35% – Phosphorus: 30%[k]	– Nitrogen: Low – Bacteria: Low – Sediment: Medium – Phosphorus: Low[e]	– $2,380.74/each[h]	– $23.11/each	– UK – NRCS
Riparian	– Improve	– Nitrogen: 68%	– Nitrogen:	– $65.28/acre-	– $68.99/acre	– KY Division of

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Forest Buffer	habitat for aquatic organisms – Sediment, nutrient, and bacteria filtration and removal	– Bacteria: 60% – Sediment: 80% – Phosphorus: 42%[ajp]	Medium – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	$826.26/acre[h]		Forestry – UK – NRCS – Council of State Governments
Filter Strips	– High sediment and nutrient removal and filtration	– Nitrogen: 70% – Bacteria: 70% – Sediment: 65% – Phosphorus: 75%[k]	– Nitrogen: Medium – Bacteria: Medium – Sediment: Medium – Phosphorus: Medium[e]	– $406.40/acre[h]	– $68.99/acre	– UK – NRCS
Stream Crossing	– Reduce sediment, nutrient, and bacteria loading – Limit animal access to stream	– Nitrogen: N/A+ – Bacteria: N/A+ – Sediment: 50%[j] – Phosphorus: N/A+	– Nitrogen: N/A° – Bacteria: N/A° – Sediment: Medium[e] – Phosphorus: N/A°	– $2,308.87/each[h]	– $22.42/each	– NRCS – UK – Private Landowners
Spring Development	– Increase surface stream recharge – Improve water resource for livestock	– Nitrogen: 54% – Bacteria: N/A+ – Sediment: 90% – Phosphorus: 81%[j]	– Nitrogen: Medium – Bacteria: N/A° – Sediment: High – Phosphorus: High[e]	– $1,213.81/each[h]	– $11.79/each	– UK – NRCS
Watering Facility	– Protect stream from erosion and livestock contamination	– Nitrogen: 54% – Bacteria: N/A+ – Sediment: 90% – Phosphorus: 81%[j]	– Nitrogen: Medium – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	– $2,431.61/foot[h]	– $23.60/foot	– UK – NRCS
Streambank	– Increase	– Nitrogen: 68%	– Nitrogen:	– $52.40/linear	– $0.51/linear	– UK

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Protection	storage capacity of streambank channel – Increase effectiveness of downstream sediment removal BMPs	– Bacteria: 60% – Sediment: 80% – Phosphorus: 42%[ajp]	Medium – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	foot[h]	foot	– NRCS
Septic Tank Owner Education and Assistance	– Identify maintenance needs – Nutrient and bacteria removal	– N/A	– Increase awareness and education; improve BMP performance	– N/A	– N/A	– Private Landowners – Neighborhood Associations – UK – KDOW
Swale	– Increase infiltration and groundwater recharge – Sediment and nutrient filtration and removal	– Nitrogen: 38% – Bacteria: N/A+ – Sediment: 81% – Phosphorus: 29%[m]	– Nitrogen: Medium – Bacteria: Low – Sediment: Medium – Phosphorus: Medium[e]	– $4,929.59/acre[h]	– $47.86/acre	– UK – NRCS – Council of State Governments
Constructed Wetlands	– Increase infiltration – Sediment, nutrient, and bacteria removal	– Nitrogen: 44% – Bacteria: 77% – Sediment: 77% – Phosphorus: 50%[f]	– Nitrogen: High – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	– Small: $1,455.25/each[g] – Large: $593.99/acre[h]	– Small: $7.39/each – Large: $20.39/each	– Private landowners – UK – NRCS

[1]The studies referenced in this table can be found in Appendix AA.

*BMPs for each catchment are listed by magnitude of priority based on 1) their implementation in the upper reaches of the watershed, 2) their pollutant removal effectiveness, 3) legal restrictions that may hinder their use, 4) stakeholder participation, 5) the availability of additional funding or technical support. BMPs listed in bold have been implemented as described in narrative.

+Estimated Load Reduction: provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend exclusively on site-specific variables such as soil type, topography, climate, and production system.

°Effectiveness: Abstracted from USDA Agriculture Information Bulletin No. 598 and NRCS conservation practice physical effects (CPPE) documents. NOTE: Because of the general nature of these documents, there may be situations and sites where practices will not perform as indicated.

Catchment 6

Pollutant Source Assessment

The 303(d) listed segment of Cane Run that flows through Catchment 6 (that also flows through Catchments 3, 4, and 7) has been identified as having high levels of fecal coliform, nutrients, and specific conductance, with suspected sources including highways, roads, bridges, infrastructure (new construction), landfills, livestock, package plant, and other permitted small flows discharges (Figure 139). Other point and nonpoint sources that could also contribute to this pollution are described below.

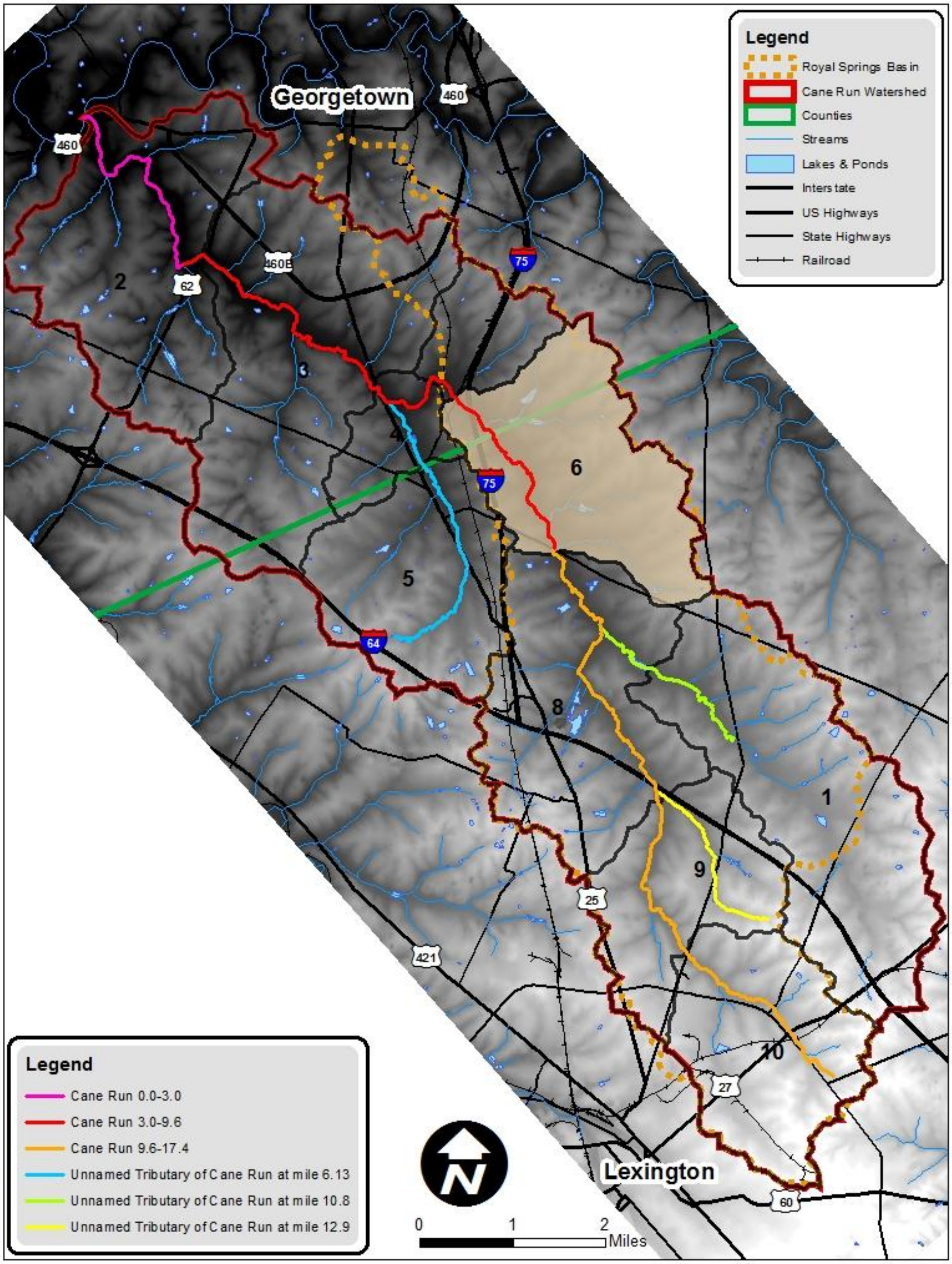

Figure 139. Impaired stream section in Catchment 6

Point Sources

There are several possible sources of point source pollution within Catchment 6, including Class V injection wells, sanitary sewer overflows, failing onsite wastewater treatment systems, and straight pipes (Figure 140). These point sources contribute mainly to bacteria and nutrient pollution.

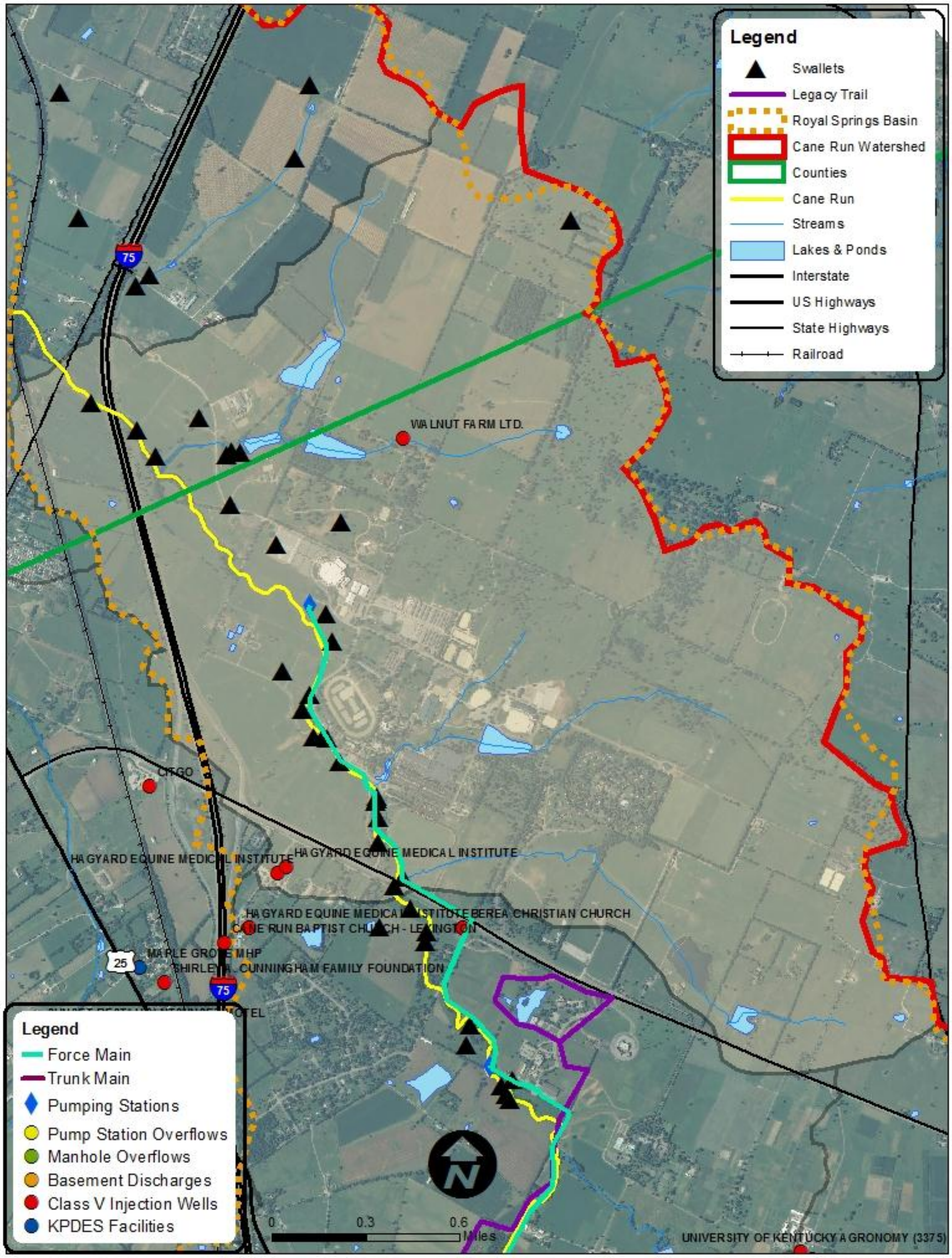

Figure 140. Potential point sources in Catchment 6

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[50] There are many different types of Class V injection wells, but in Catchment 6, there are three wells, all but one of which are large capacity septic systems (LCSS) (Table 104).

LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is relatively high[51].

The one non-LCSS Class V injection well in Catchment 6 is classified as veterinary, kennel, or pet grooming and receives sanitary and vet waste. The potential for contamination from this type of well is unknown.

Table 104. Class V injection well locations in Catchment 6

EPA ID	Company Name	Address	Well Type
KYV067013	Walnut Farm Ltd.	2461 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067016	Hagyard Equine Medical Institute	2462 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV067016	Hagyard Equine Medical Institute	2509 Georgetown Rd., Lexington, KY	Veterinary, kennel, pet grooming

Sanitary Sewer Overflows

Point source pollution may originate from the existing wastewater collection infrastructure. All of the sewage in the Cane Run is typically collected by gravity systems that are then pumped via force mains into the adjacent Town Branch watershed where the Town Branch Wastewater Treatment plant is located. Much of the wastewater infrastructure runs parallel to or in natural drainage ways and streams, and leaks in the mains, manhole overflows, pump station overflows, and basement discharges can contribute significant amounts of pollution to surface water resources. There are no known locations of recurring sanitary sewer overflows or

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[50] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm

[51] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf

unpermitted discharges, but there a section of force main and one pumping station in Catchment 6 that have the potential to degrade and cause a discharge.

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. THE U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[52]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[53]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 3 failing OWTSs in Catchment 6 that contribute a fecal coliform load of 1.22E+09 cfu/day.

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 3 straight pipes in Catchment 6 that contribute a fecal coliform load of

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[52] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.

[53] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

2.27E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 0.678 lbs/day.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 6 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 105 and Figure 141). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 105. Land cover in Catchment 6

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture /Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	23.80	372.73	0.44	72.06	34.92	1.33	1925.93	541.97	1.78	**2975**
Percent	0.80	12.53	0.01	2.42	1.17	0.04	64.74	18.22	0.06	**100**

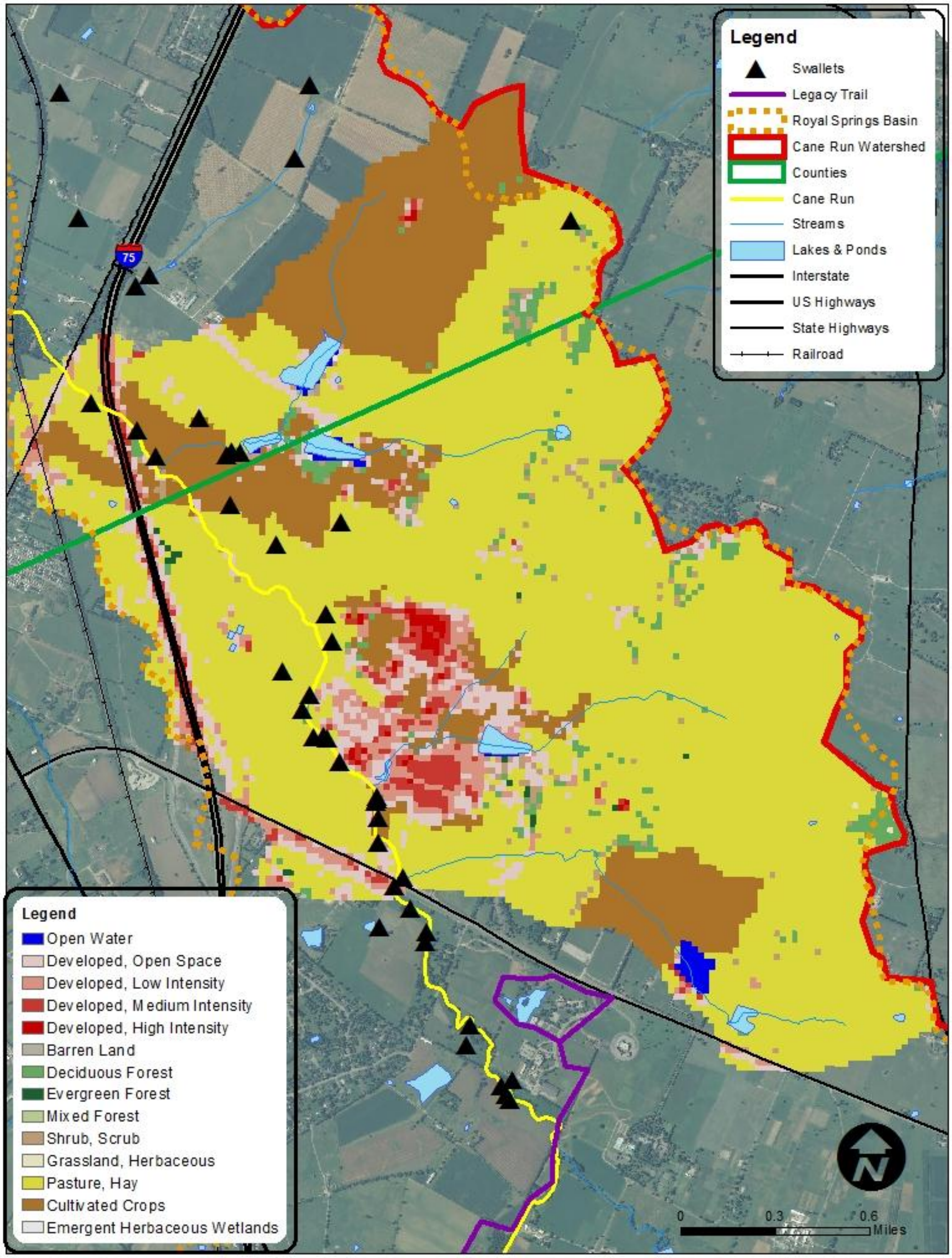

Figure 141. Land cover in Catchment 6

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 5.412 lbs/day. This contribution is high compared to other catchments, but this is likely because the amount of un-developed land in this catchment is relatively high.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 6. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 6 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil's holding capacity.

Wildlife

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these

areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

THE U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[54]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 6 and their daily fecal coliform load contribution can be found in Table 106.

Table 106. Wildlife population estimates and daily fecal coliform load contribution for Catchment 6

Animal	Population	Fecal counts/day
Ducks	37	8.99E+10
Geese	18	8.82E+11
Deer	18	9.00E+09
Beavers	4	1.00E+09
Raccoons	18	2.25E+09

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[55].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 6 and their daily fecal coliform load contribution can be found in Table 107. This catchment ranks first in the

[54] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[55] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

number of beef cattle and second in the number of horses, which makes livestock as a nonpoint pollution source extremely important in Catchment 6.

Table 107. Livestock population estimates and daily fecal coliform load contribution for Catchment 6

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock including cattle in streams)
Hogs	5	2.67E+10	--
Beef Cattle	326	2.29E+11	8.37E+11
Dairy Cattle	36	8.44E+10	--
Chickens	19	9.30E+08	--
Horses	223	1.16E+10	7.45E+10
Sheep	2	--	2.40E+10
Goats	1	--	1.20E+10

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 1.286 lbs/day.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[56]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 6 are shown in Table 108.

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[56] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Table 108. Daily fecal coliform load contributions from developed land in Catchment 6

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
2.17E+09	0.00E+00	1.94E+09	2.32E+07

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 6.

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 6, is used for industrial development because of the close proximity to highway infrastructure. The FEI 2010 World Equestrian Games has brought a widening of Newtown Pike north of I-75 and additional construction around the Ironworks Pike interchange with I-75.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 6 (Table 109 and Figure 142).

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources.

In 2005, the city of Georgetown contracted with Dr. Gail Brion at the University of Kentucky to conduct a study within the Cane Run Watershed in an attempt to identify and rank potential sources of sewage contamination into the Royal Springs water supply. Monitoring points for this study were established in this catchment.

Water samples were taken at stations in this catchment in 2006 and 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development.

The University of Kentucky Biosystems and Agricultural Engineering Department established a monitoring network for bacteria and sediment in support of bacteria TMDL development, and sampled in this catchment in 2008, 2009, and 2010 as part of the Cane Run Watershed Project.

The University of Kentucky Biosystems and Agricultural Engineering Department established permanent cross-sections in this catchment to assess the physical condition of the stream.

Table 109. Monitoring conducted in Catchment 6

Sampling Entity	Parameters	Sampling Dates	Site IDs
KWRRI	Bacteria	2002	C3
City of Georgetown	Bacteria	2005	Barton Springs, Pristine Spring, Retention Pond
KDOW	Nutrients	2006-2007	04018005, 04018012
CRWP	Bacteria, Sediment	2008-2010	CR12
CRWP	Geomorphology	2008-2010	CR12 (Riffle and Pool)

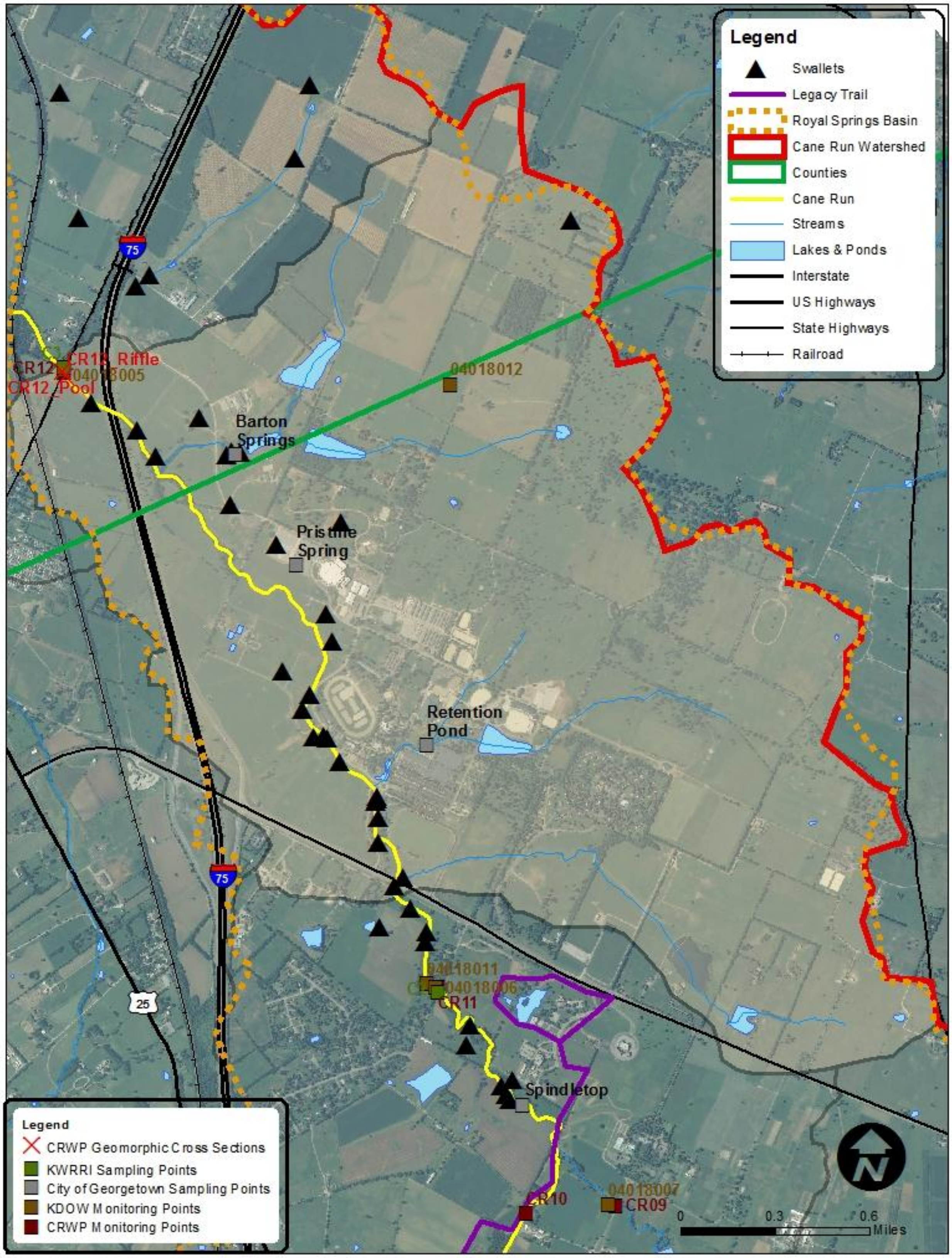

Figure 142. Monitoring points in Catchment 6

Monitoring Conclusions

Geomorphology

Two cross-sections (CR12) were established in Catchment 6 along Cane Run. The CR12 cross-sections are located at the water quality monitoring point CR12. This reach classifies as a C4 stream type according to the Rosgen system of stream classification. The adjacent riparian area is dominated by row crops (e.g. corn) and as such is very narrow. This reach from I-75 to Lisle Road appears to have been channelized to accommodate agricultural practices. As such, stream bed features such as pools and riffles are not well developed.

For each cross-section, the bank height ratio (BHR) was 1.1 indicating the streambanks are vertically stable at these measured locations. The riffle cross-section experienced an increase of 5.7 ft^2 in cross-sectional area from Year 1 to Year 2 while the pool cross-section decreased by 4.6 ft^2. These differences may be within a normal range of yearly variation as no evidence of active degradation and aggradation, respectively, was seen in the field. Bank erosion hazard index (BEHI) rankings were mostly moderate (Table 110). Streambank erosion rates were greatest in the area where near bank stress (NBS) was moderate/high. In areas of low NBS, deposition occurred.

Riparian vegetation along the Cane Run through Catchment 6 is largely comprised of mowed grasses with some crops. The reach of Cane Run in this catchment lies predominately within the boundaries of the Kentucky Horse Park. The lack of canopy cover over the stream results in elevated water temperature, particularly during the summer months. Data collected from the Level Troll 500 located at CR12 indicates that water temperatures can reach 95°F in the summer months (Table 111).

Table 110. Average annual erosion/deposition rates within Catchment 6

Cross-section	Bank	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
CR12_Riffle	Left	Moderate	Moderate/High	0.494
CR12_Riffle	Right	Low	Low	-0.231
CR12_Pool	Left	Moderate	Low	-0.213
CR12_Pool	Right	Moderate	Low	0.056

Table 111. Maximum water temperatures at CR12 within Catchment 6

Year	Month	Maximum Temperature (°F)
2008	June	82.8
	July	91.5
	August	91.1
	September	90.3
	October	88.1
	November	84.3
2009	April	77.6
	May	77.1
	June	80.9
	July	78.1

Year	Month	Maximum Temperature (°F)
	August	88.6
	September	80.0
	October	67.1
	November	66.8
	December	61.7
2010	January	49.2
	February	56.5
	March	72.1
	April	81.8
	May	79.9
	June	89.3
	July	92.2
	August	93.4
	September	95.0
	October	92.4
	November	84.5

Water Quality

Bacteria

The monitoring conducted by KWRRI in 2002 and by the City of Georgetown in 2005 confirms the 303(d) listing for this section of stream for fecal coliform. Every sample taken at monitoring point C3 in Catchment 6 exceeded the primary contact standard of 200 colonies per 100 mL, and half exceeded the secondary standard of 1,000 colonies per 100 mL (Table 112); however, the geometric means at the City of Georgetown's Barton Springs, Pristine Springs, and Retention Pond sites did not exceed the primary contact standard (Table 113).

Table 112. Fecal coliform data from KWRRI monitoring point C3

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	334	250	391	204	1,055	1,030	5,239	6,088	986	1,179

Table 113. City of Georgetown fecal coliform data in Catchment 10

Site	Geometric mean *E. coli* (cfu/100mL)
Barton Springs	40
Pristine Springs	13

Site	Geometric mean *E. coli* (cfu/100mL)
Retention Pond	18

The monitoring conducted by the University of Kentucky from June 2008 to December 2009 also found that *E. coli* concentrations at each of the monitored locations exceeded the primary contact standard for a 30-day geometric mean of 130 cfu/100 ml (Table 114). In 2008, all grab samples at CR12 exceeded the primary contact standard though only 50 percent did so in 2009 (Table 115). For the sampling period, the peak concentration at CR12 was greater than that at CR11; however, 30-day geometric mean was greater at CR12. Examination of the *E. coli* load duration curve for CR12 (Figure 143 and Figure 144) indicates that the primary contact standard was achieved about half of the time at this location.

Table 114. Peak and geometric mean *E. coli* concentrations at monitoring locations within Catchment 6

Site	Year	No. Samples	Peak (MPN/100 ml)[1]	30-day Geometric Mean (MPN/100 ml)
CR12	2008	8	1,611	10,890
	2009	26	282	14,601
	2008-2009	34	425	--

[1]MPN = most probable number

Table 115. Number of samples at each site that exceeded the primary and secondary surface water samples for *E. coli*

Site	Year	No. Samples	Percent of Samples *E. coli* >240 MPN/100 ml[1]	Percent of Samples *E. coli* >676 MPN/100 ml
CR12	2008	8	100	75
	2009	26	50	35
	2008-2009	34	62	44

[1]MPN = most probable number

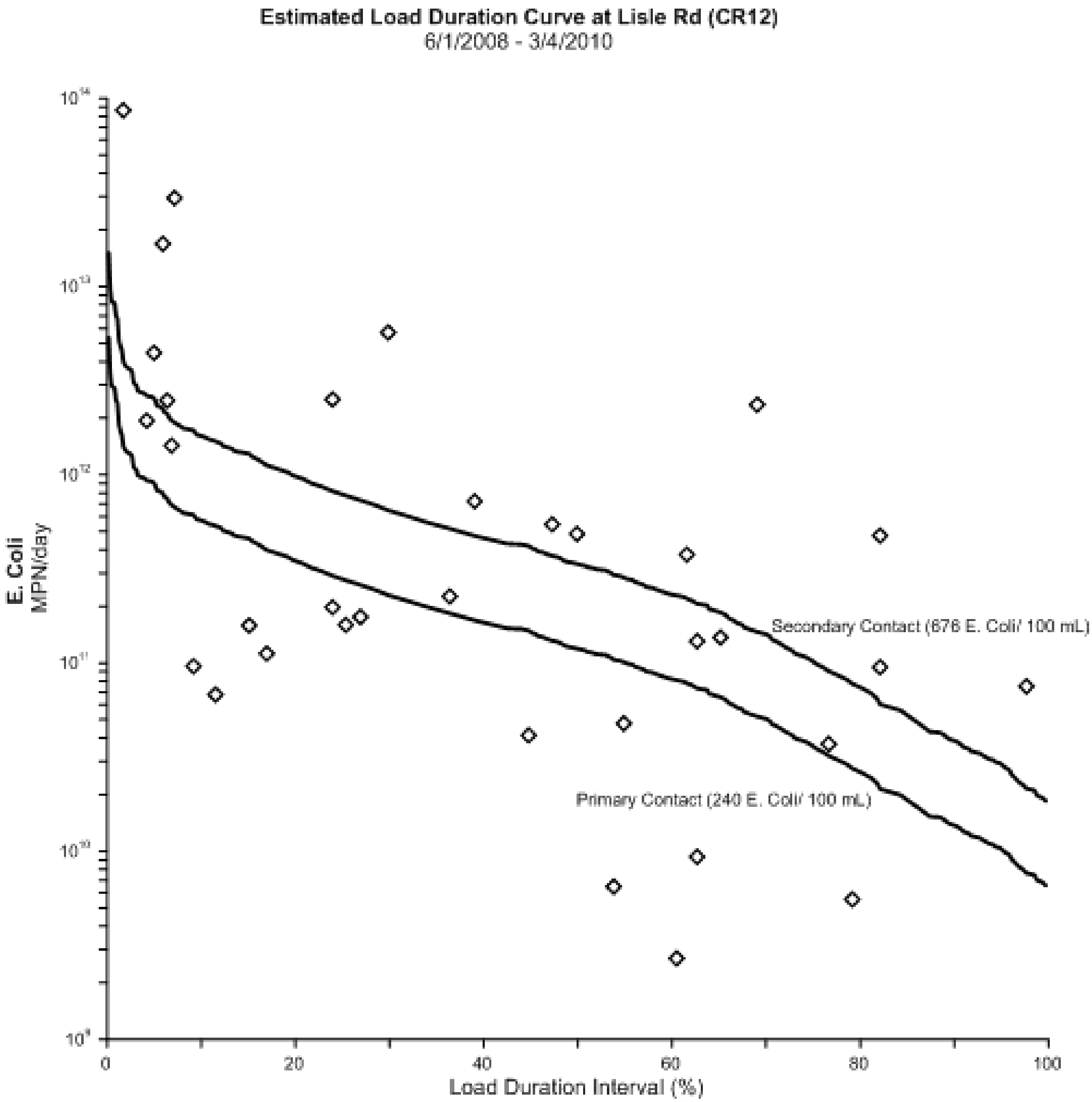

Figure 143. Estimated *E. coli* load duration curves at CR12

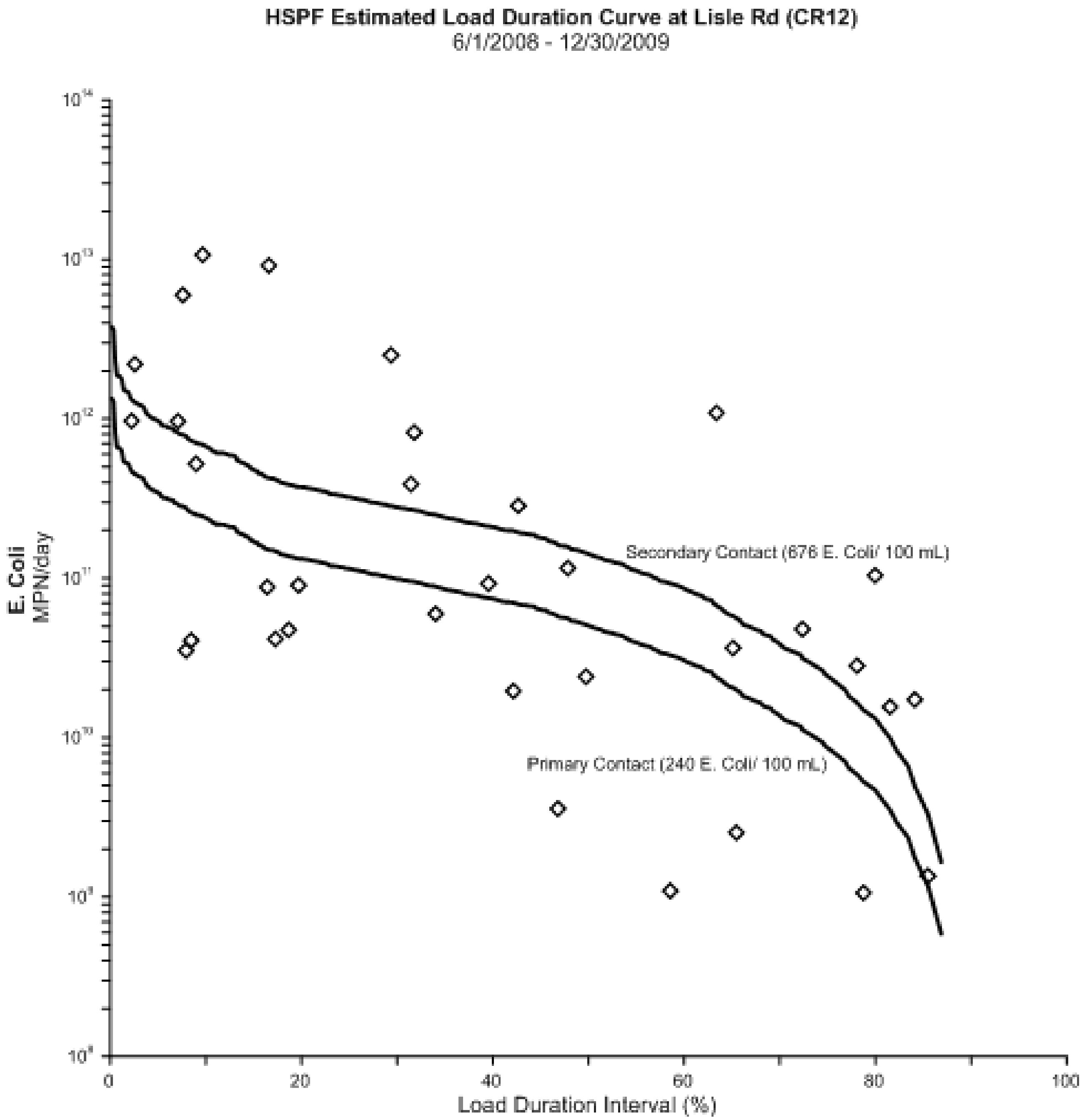

Figure 144. Estimated *E. coli* load duration curves at CR12 utilizing flows developed with the HSPF model

The area draining to CR12 is largely agriculture (56.9 percent) (Figure 145). While predominately in the headwaters, developed areas are also located near CR12 and include the Kentucky Horse Park. In Catchment 6, no KPDES permits have been identified. Some force mains and a pumping station are located in Catchment 6.

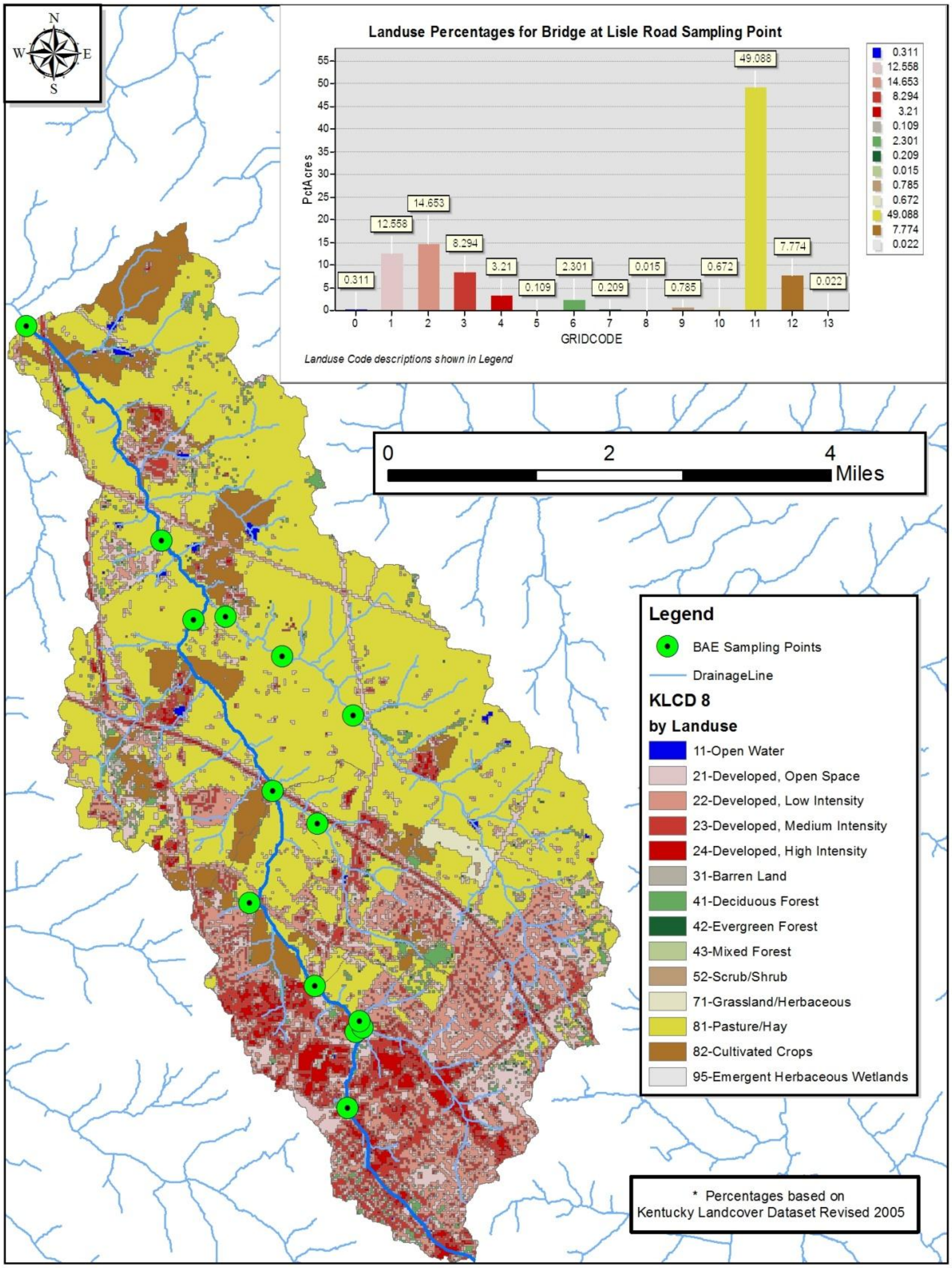

Figure 145. Land use for CR12 in Catchment 6

Examination of the *E. coli* concentration response to 48-hour prior rainfall indicated that CR12 exhibited an increasing trend (Figure 146). As the Kentucky Horse Park and a large pasture area with unlimited cattle grazing is located upstream of CR12, it is anticipated that runoff from these areas a major source of bacteria within this catchment.

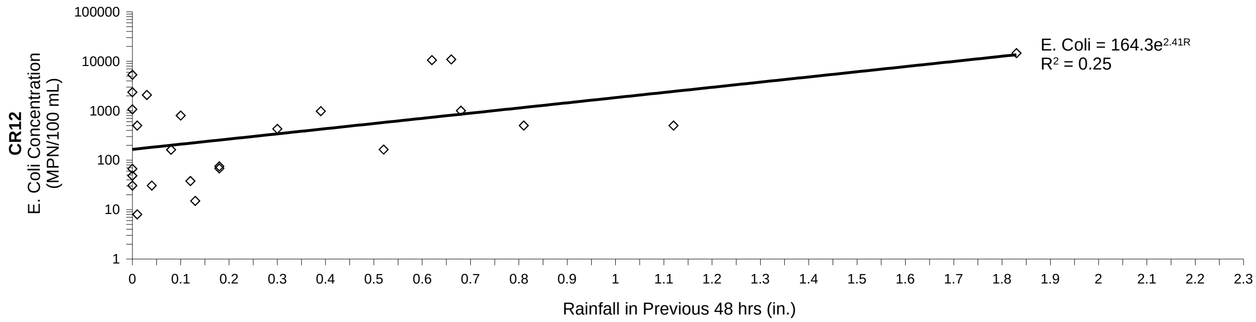

Figure 146. E. coli concentration response to 48-hour prior total rainfall for CR12

To reduce bacteria loads in Catchment 6, it is recommended that all livestock be prohibited from grazing along the stream and that a riparian buffer be established along as many tributaries within the catchment as possible. Due to the high connectivity of surface and ground waters in karst geology, it is also recommended that sinkholes be protected from livestock access. Efforts should also focus on reducing bacteria loads from sources upstream of CR12 such as the Kentucky Horse Park and cattle-grazed pastures.

Nutrients

The monitoring conducted in 2006 and 2007 by KDOW demonstrates a problem with nutrient pollution, specifically phosphorus, in this catchment. The geometric mean for DOW04018012 is near the total phosphorus target of 0.3 mg/L (Table 116), and several of the individual samples taken by KDOW at this point far exceed this total phosphorus target (Appendix K).

Table 116. Nutrient geometric means for DOW04018012

Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
0.070	2.21	0.869	1.46	0.149	0.292	6.1	0.467

Sediment

The mean TSS concentration did not exceed 200 mg/l at CR12 for any monitored storm event (Table 117). TSS load duration curves indicated that no samples exceeded a 200 mg/l threshold (Figure 147).

Based on the monitoring data, suspended sediments are not a large concern in Catchment 6. However, areas of streambank erosion should be addressed as these soils are likely contributing nutrients to the watershed. Additionally, areas of upland erosion should be addressed, in part by the establishment of riparian buffers along waterways.

Table 117. Summary of storm sample TSS data for Catchment 6

Monitoring Location	No. Events Sampled	Peak >200 mg/l[1]	Mean >200 mg/l[2]	Geometric Mean >200 mg/l[3]	Mean per Event >200 mg/l[4]	Mean Time >200 mg/l (minutes)[5]
CR12	8	3 (38%)	0 (0%)	0 (0%)	2.6	34

[1]Mean number of storm events where the storm peak TSS concentration exceeded 200 mg/L.

[2]Mean number of storm events where the storm mean TSS concentration exceeded 200 mg/L.

[3]Mean number of storm events where the storm geometric mean TSS concentration exceeded 200 mg/L.

[4]Mean number of samples in each storm event that exceeded TSS concentration of 200 mg/L.

[5]Mean amount of time in each storm event where TSS concentration exceeded 200 mg/L.

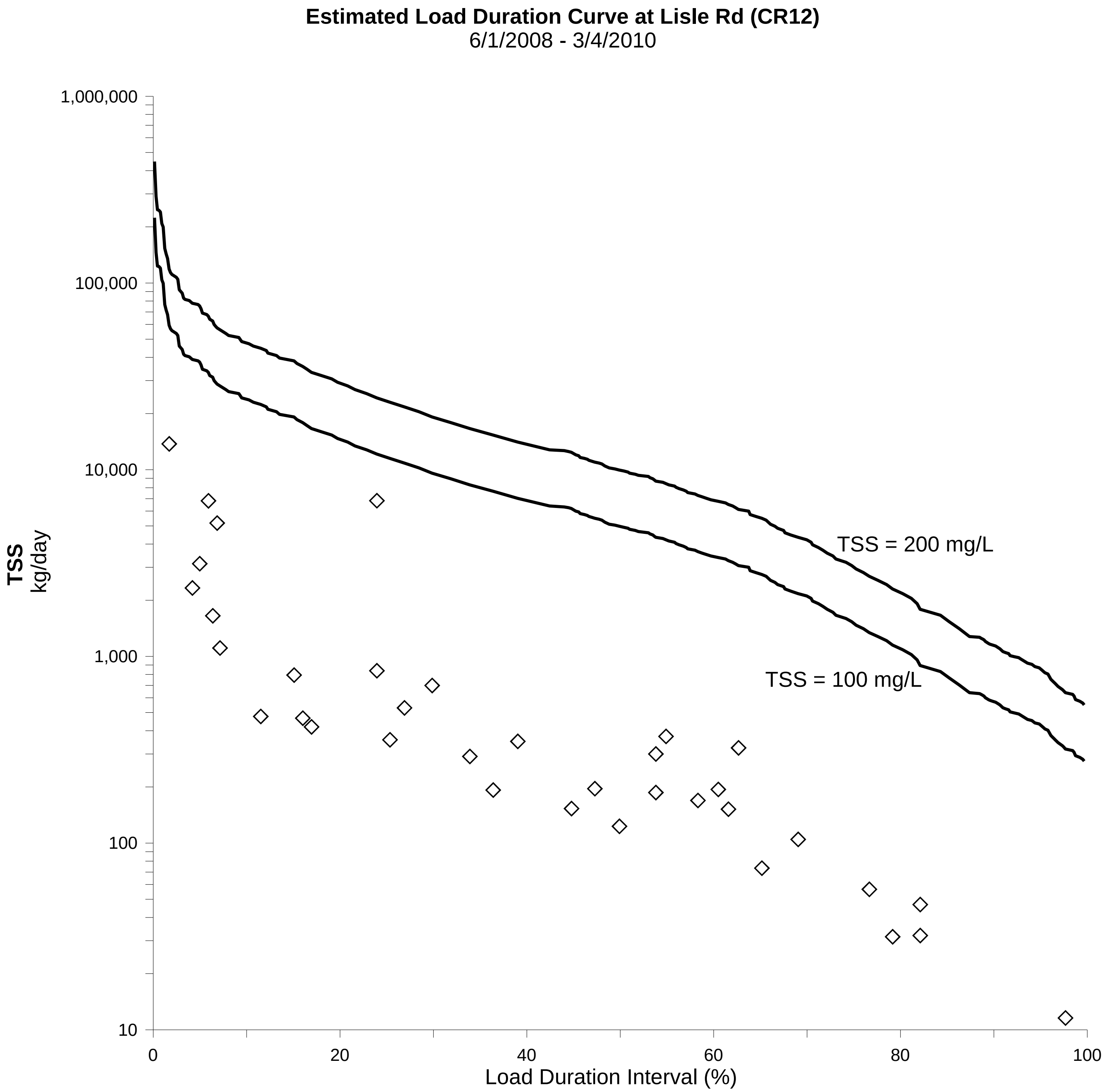

Figure 147. Estimated TSS load duration curve at CR12

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

In addition to physical characteristics of the watershed, there are many projects and partnerships already underway that will also guide BMP implementation efforts. The Cane Run Watershed is unique in not only its geology, but by the few, large, public landowners. In Catchment 6 these include the Kentucky Horse Park (the second largest landowner on the stream) and Barton Brothers Farms.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform, nutrients, specifically nitrogen and phosphorus, and specific conductance. The most likely sources of these pollutants in Catchment 6 that should be addressed include transportation infrastructure, new construction, landfills, livestock, package plants, other small flows discharges, Class V injection wells, urban development and construction, agricultural fertilizers and pesticides, wildlife, and agricultural erosion. Although sediment has been determined to not be a problem in this catchment, stream bank erosion is still an issue that could be contributing to nutrient pollution.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 6, the non-MS4 loading must be reduced by 25.1 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes. The BMPs recommended and implemented within this catchment will help to achieve these reduction goals.

Because Catchment 6 lies within the scope of the Royal Spring aquifer of the Cane Run Watershed, BMPs were selected that most effectively address the primary pollutants and their suspected sources, land use, property owner and/or stakeholder acceptance, and sources of potential funding, as well as technical and community support. This section includes a map and detailed description of proposed and implemented BMPs and a table summarizing these BMPs, their effectiveness, costs, and possible implementation partners.

For additional information about BMP implementation in the entire Cane Run Watershed, please reference the Cane Run and Royal Spring BMP Implementation Plan in Appendix X.

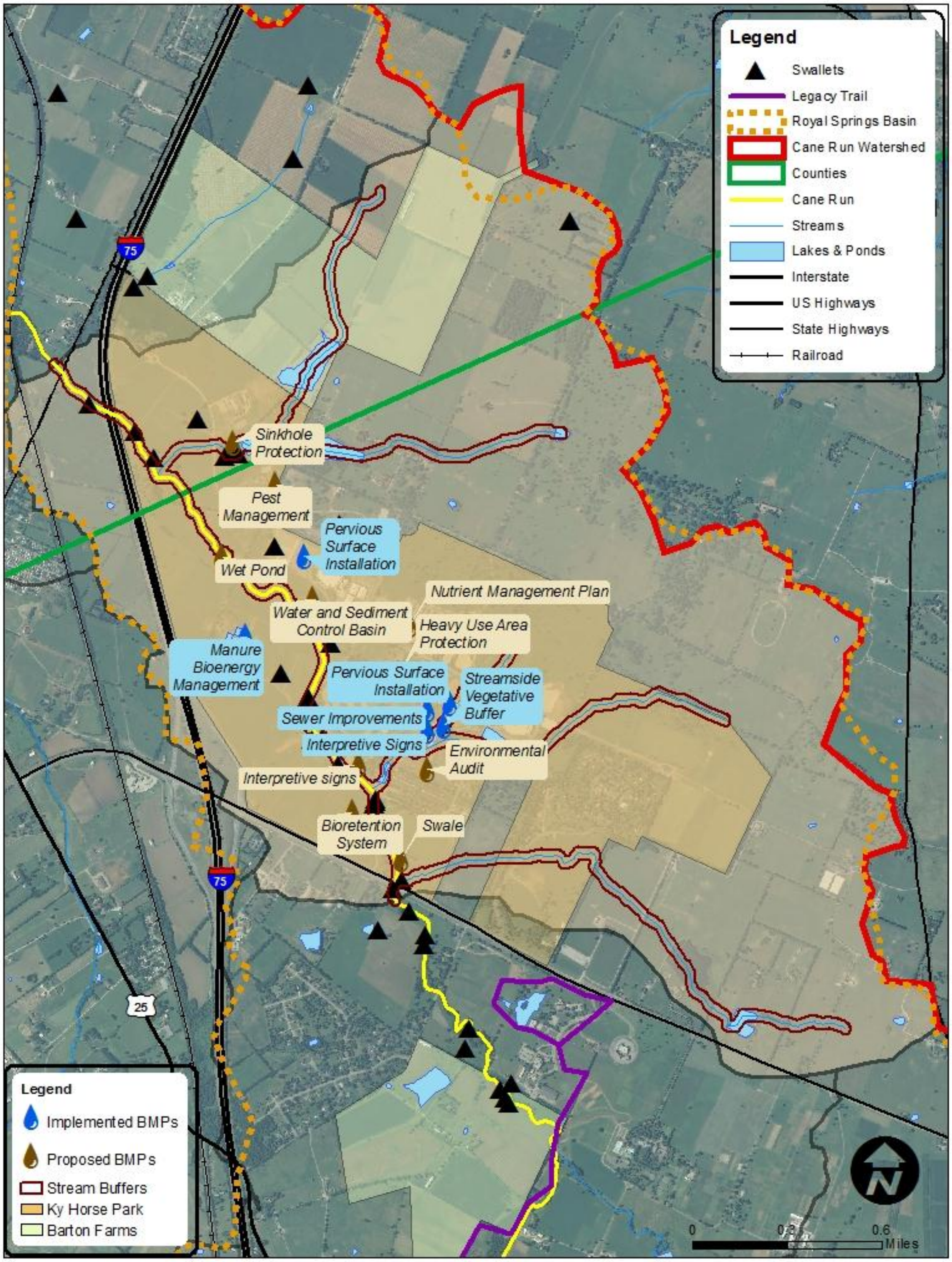

Figure 148. Priority BMP locations for Catchment 6

Cane Run (Kentucky Horse Park)

Proposed

The second largest landowner within the Cane Run Watershed is the Kentucky Horse Park, who agreed to work with the Cane Run Watershed Project as construction activities increased in preparation for the FEI World Equestrian Games (WEG) that were held in September 2010. The KY Horse Park is a key cooperator on the project, and the project team has met with park officials on numerous occasions.

The stream section passing through the Horse Park runs through the entrance area, where many of the swallets that connect to the Royal Spring conduit are located. The lower portion of this stream section is located where the Royal Spring conduit diverges away from the Cane Run. This entire reach is significant, as flood flows pass quickly through the channel. Alterations in the stream channel (structure for water control, water and sediment control basin) could make the stream more effective in transporting the flood flows and also maintain channel dimensions for the lower discharge events.

A concern for this reach is the sediment discharge during storm flows while construction is on-going at the Horse Park. There is the potential to install urban BMPs at the Horse Park to control stormwater runoff and its associated pollutants from existing and expanding park facilities. These BMPs include bioretention systems, sand filters, swales, wet ponds, and modular and porous pavement. Agricultural BMPs such as heavy use protection areas, riparian forest buffers, nutrient management plans, and sinkhole protections could also be installed before (and after) the WEG to control sediment, nutrient, and bacteria nonpoint source pollution associated with both developed and agricultural areas.

In 2010 the Horse Park served as one of the most visited facilities within the Cane Run Watershed, making the Horse Park a unique opportunity to educate thousands of Kentuckians and guests as to the steps and innovative measures the watershed project has taken to restore Cane Run.

Implemented

STREAMSIDE VEGETATIVE BUFFER

In the spring of 2010, a streamside vegetative buffer was planted along an unnamed tributary of Cane Run on Kentucky Horse Park property that was previously mowed to the banks (Figure 149). Streamside vegetation, including trees, grasses, and wildflowers, was established in order to prevent bank erosion and reduce the nutrient, bacteria, and sediment run-off from adjacent horse paddocks and the parking lot. All plants that were planted are native to Kentucky. In addition to the plants, a path along the stream was constructed, and educational signs were placed along the path.

This project is a result of a partnership between the Bluegrass Partnership for a Green Community, the Kentucky Horse Park, M2D Design and UK. The project is located in a central area of the park and covers well over 500 linear feet of an unnamed tributary to Cane Run. High visibility, opportunities for community participation, and a large audience for education regarding water quality BMPs installed within the Cane Run Watershed will make this BMP one of the most unique within the Cane Run Watershed.

Figure 149. A Cane Run tributary before the installation of a vegetated riparian buffer

This project uses trees, shrubs, and wildflowers along the stream to filter out sediment and trash from roads, parking areas and arenas, as well as reduce some of the excessive nutrients in the tributary from manure (Figure 150). This planting will also have additional water quality benefits. The dense root systems will hold soil in place to reduce bank erosion. Increased tree and shrub canopy along the banks will help shade and cool waterways to increase dissolved oxygen for aquatic organisms. The native planting will reduce mowing as well as provide a food source and breeding habitat for birds, butterflies, essential pollinators and aquatic organisms.

Figure 150. The streamside vegetated buffer along a tributary of the Cane Run under construction and completed

The installation of the Kentucky Horse Park streamside vegetative buffer strip consisted of planting over 9,000 ft^2 with 39 trees, over 100 willow stakes, 77 shrubs and 4,000 wildflowers, grasses, rushes and sedges. On May 10, 2010, planting of the wildflowers was undertaken with 25 volunteers from a variety of organizations within the region. Participants included individuals from Cane Run Watershed Council, UK College of Agriculture, UK Center for Community Outreach, Alpha Phi Omega student service organization, Midway College, KCTCS, KWRRI, Glasgow Garden Club, KY Federation of Garden Clubs, and Master Gardeners. The planting continued with the support of UK BAE Interns, additional State grounds keepers and, of course, KHP grounds staff and trustees.

In addition to the attractive plants, the project includes a path through the buffer, interpretative signs, and brochures about the project (Figure 151). The literature available at the project site will not only help inform the general public, but also will help horse owners learn how they can create their own streamside plantings. Robinson Scholars also toured the project as part of their watershed training. The education and outreach potential of this site will have some of the highest visibility for years to come. For more information about the education and outreach conducted at this site, see Chapter IX.

Figure 151. Educational signage placed at the KHP streamside vegetated buffer

SEWER IMPROVEMENTS

The existing Kentucky Horse Park sanitary sewer system was in disrepair and has historically been impacted by the infiltration and inflow when it rains. This has caused the sewer bills to rise for this facility disproportionally when compared to the potable water consumption. This project includes repair of the sanitary sewer manholes and repair/replacement of the sewer piping and will provide for approximately $149,000 dollars per year in savings on the sewer bill and prevent bacteria pollution to surface water in the Cane Run Watershed. This equates to approximately 26 million of gallons of waste water that will not have to be processed by the LFUCG sewer plant. This is a big win for the Kentucky Horse Park, the LFUCG sewer district that serves this park, and the Cane Run Watershed.

PERVIOUS SURFACE INSTALLATION

Approximately 97,000 square feet of porous asphalt was installed in a parking lot at the Kentucky Horse Park in 2010. Under the porous asphalt is a detention basin of clean stone whereby the amount of storm water entering the sinkhole can be controlled to pre-developed levels. The detention area under the pavement is approximately 2 to 5 feet in depth and covers the entire area of the porous asphalt. Benefits of the porous asphalt installed include: less storm water runoff to control, no storm pipe drainage system to install, the recharging of groundwater systems as if the pavement was not there, a reduction in the amount of snow removal required, less ice buildup on pavement, and a reduction of storm water fees paid to LFUCG.

There was also about 7,500 square feet of porous pavers installed in a parking area near an unnamed tributary of the Cane Run. Porous pavers are one way to allow more water to percolate back in to the soil rather than running off as quickly as possible to the nearest stream. This parking area is very close to a creek that already had some significant drainage issues (i.e. it runs very slow and is easily inundated). Porous pavers at the low edge of the parking was one way to slow down the additional run off from the new paved / asphalt parking areas being constructed near the creek, to allow more time for water to make its way down the creek, and make it less likely for the run-off from the new pavement to inundate the creek. In addition to slowing down run-off to the creek, the porous paver system provides some filtering of storm run-off from the parking lot, through the various layers of stone beneath the pavers. The porous pavers used also have a higher solar reflectance than asphalt, meaning they create less of a heat island in the parking lots.

Manure Bioenergy Management

The Kentucky Horse Park generates a lot of waste through maintaining the facility; a major portion of the waste comes from cleaning out the stalls and removing the muck that the horses generate. Kentucky Horse Park’s current solution for disposal of this waste is hauling the muck to a landfill.

The Manure Bioenergy Management facility that was installed at the Kentucky Horse Park will provide a local solution for the disposal of horse generated muck. This practical and sustainable solution promotes environmental stewardship and achieves value for investment by eliminating many of the costs of disposal. The productive reuse of horse muck to generate electricity could substantially offset electric charges incurred at this time. The conversion of waste to energy will advance the reuse of waste material. This system will foster public relations by demonstrating a true interest in enhancing the environment. The Kentucky Horse Park Manure Bioenergy Management system is truly an environmentally friendly energy alternative.

The basic concept of the system is treatment of the muck through the process of biomass gasification. Biomass gasification, a century old technology, is viewed today as an alternative to conventional fuel. In the gasification process, agricultural waste and other biomass materials are gasified to produce so called ‘producer gas’ for thermal power and/or electricity generation. A gasification system, such as one for utilizing horse muck as fuel, basically consists of a gasifier unit and energy converters – burner or engine. Generators can be driven by the gasification unit making use of the proven biomass gasification technology to provide electricity.

Energy from waste produces less greenhouse gas than the continued transport of muck waste to the landfill. The current practice of muck disposal to a landfill has many problems. The increasing cost associated with a landfill, increasing waste volumes and depletion of available landfill space are major concerns. However, the need to meet higher standards to avoid environmental contamination is a major factor.

The project will serve the Cane Run Watershed and provide regional water quality benefits to the area. On-site manure storage will not contribute to ground or surface water bacteria pollution. This will help in maintaining the unnamed tributaries to Cane Run, which is a major tributary of North Elkhorn Creek.

Table 118. Catchment 6 priority BMPs¹

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Nutrient Management	– Minimize nonpoint source pollution of surface and groundwater resources – Maintain or improve soil function to aid in BMP effectiveness	– Nitrogen: 15% – Bacteria: N/A+ – Sediment: N/A+ – Phosphorus: 35%	– Nitrogen: High – Bacteria: Low – Sediment: Low – Phosphorus: High[e]	– $1,662.40/each[h]	– $0.00	– Private Landowners – NRCS – UK – KHP
Riparian Forest Buffer	– Improve habitat for aquatic organisms – Sediment, nutrient, and bacteria filtration and removal	– Nitrogen: 68% – Bacteria: 60% – Sediment: 80% – Phosphorus: 42%[ajp]	– Nitrogen: Medium – Bacteria: Medium – Sediment: High – Phosphorus: Medium[e]	– $65.28/acre-$826.26/acre[h]	– $68.99/acre	– Private Landowners – NRCS – UK – KYHP
Filter Strips	– Sediment and nutrient removal and filtration	– Nitrogen: 70% – Bacteria: 70% – Sediment: 65% – Phosphorus: 75%[k]	– Nitrogen: Medium – Bacteria: Medium – Sediment: Medium – Phosphorus: Medium[e]	– $406.40/acre[h]	– $68.99/acre	– UK – NRCS – KHP
Pest Management	– Improve vegetative BMP establishmen t and effectiveness – Increase	– N/A	– Toxic Chemicals: High[e]	– $143.85/acre[h]	– $0.00	– UK – Volunteers – KHP

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction[+]	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
	visibility of water quality initiatives					
Sinkhole Protection	– Increase groundwater recharge quality – Sediment, bacteria, and nutrient filtration and removal	– Nitrogen: N/A[+] – Bacteria: 90%[q] – Sediment: N/A[+] – Phosphorus: N/A[+]	– Nitrogen: High – Bacteria: High – Sediment: High – Phosphorus: High[e]	– $3,407.06/acre[h]	– $97.19/acre	– UK – KHP – NRCS
Bioretention System	– Increase infiltration – Sediment, nutrient, and bacteria removal	– Nitrogen: 49%[z] – Bacteria: 70%[lk] – Sediment: 65%[lk] – Phosphorus: 76%[z]	– Nitrogen: Medium – Bacteria: Medium – Sediment: Medium – Phosphorus: High[e]	– $2,239.0 – 0/ERU[z] (1Stormwater ERU = 2,500ft[2]	– $167.93/ERU (Maintenance = 7.5% of construction cost)	– UK – KHP – Bluegrass Rain Garden Alliance – Bluegrass Partnership for a Green Community Water Team
Heavy Use Area Protection	– Increase infiltration and groundwater recharge – Sediment, nutrient, and bacteria filtration and removal	– N/A	– Slight to moderate improvements to surface water quality for all impairments[a]	– $1.43/square foot[h]	– $0.01/sq. foot	– UK – Private Landowners – NRCS – KHP – Thoroughbred RC&D
Interpretive Signs	– Raise awareness of water quality issues – Identify restoration	– N/A	– Increase awareness and education; improve BMP performance	– Cost depends on size sign and number created	– N/A	– LFUCG – UK – Bluegrass PRIDE – KHP

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
	techniques and practices – Display the partnerships and organizations involved in the watershed.					
Structure for Water Control	– Maintain desired water surface elevation – Increase groundwater recharge	– Nitrogen: 10% – Bacteria: N/A+ – Sediment: 35% – Phosphorus: 30%[k]	– Nitrogen: Low – Bacteria: Low – Sediment: Medium – Phosphorus: Low[e]	– $2,380.74/each[h]	– $23.11/each	– UK – KHP – NRCS
Water and Sediment Control Basin	– Sediment and nutrient filtration and removal	– Nitrogen: N/A+ – Bacteria: N/A+ – Sediment: 70%[r] – Phosphorus: N/A+	– Nitrogen: Medium – Bacteria: Low – Sediment: High – Phosphorus: Medium[e]	– $1,901.34/each[h]	– $18.46/each	– KHP – Private Landowners – UK – NRCS
Modular and Porous Pavement	– Increase infiltration and groundwater recharge – Sediment and Pollutant filtration and reduction	– Nitrogen: 82.5% – Bacteria: N/A+ – Sediment: 88.5% – Phosphorus: 65%[st]	– Nitrogen: High – Bacteria: N/A° – Sediment: High – Phosphorus: Medium[st]	– $16,250.00/ERU[st] (1Stormwater ERU = 2,500ft^2)	– $200.00/ERU	– UK – Lexmark – LFUCG

Priority BMP*	Water Quality Enhancement	Estimated Load Reduction+	Estimated Effectiveness°	Estimated Installation Cost	Estimated Maintenance Cost	Partners and Potential Cost Share Providers
Swales	– Increase Infiltration and groundwater recharge – Sediment and nutrient filtration and removal	– Nitrogen: 38% – Bacteria: N/A+ – Sediment: 81% – Phosphorus: 29%[m]	– Nitrogen: Medium – Bacteria: Low – Sediment: Medium – Phosphorus: Medium[e]	– $4,929.59/acre[h]	– $47.86/acre	– Lexmark – LFUCG – UK
Wet Ponds	– Increase infiltration and groundwater recharge – Sediment, nutrient, and bacteria filtration and removal	– Nitrogen: 31% – Bacteria: 65% – Sediment: 67% – Phosphorus: 48%[cc]	– Nitrogen: Low – Bacteria: High – Sediment: High – Phosphorus: Medium[e]	– $45,700/acre[cc]	– $1,828.00 (EPA average of 4% of construction cost)	– KHP – UK – LFUCG

¹The studies referenced in this table can be found in Appendix AA.

*BMPs for each catchment are listed by magnitude of priority based on 1) their implementation in the upper reaches of the watershed, 2) their pollutant removal effectiveness, 3) legal restrictions that may hinder their use, 4) stakeholder participation, 5) the availability of additional funding or technical support. BMPs listed in bold have been implemented as described in narrative.

+Estimated Load Reduction: provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend exclusively on site-specific variables such as soil type, topography, climate, and production system.

°Effectiveness: Abstracted from USDA Agriculture Information Bulletin No. 598 and NRCS conservation practice physical effects (CPPE) documents. NOTE: Because of the general nature of these documents, there may be situations and sites where practices will not perform as indicated.

Catchment 7

Pollutant Source Assessment

The 303(d) listed segment of Cane Run that flows through Catchment 7 (that also flows through Catchments 3, 4, and 6) has been identified as having high levels of fecal coliform, nutrients, and specific conductance, with suspected sources including highways, roads, bridges, infrastructure (new construction), landfills, livestock, package plant, and other permitted small flows discharges (Figure 152). Other point and nonpoint sources that could also contribute to this pollution are described below.

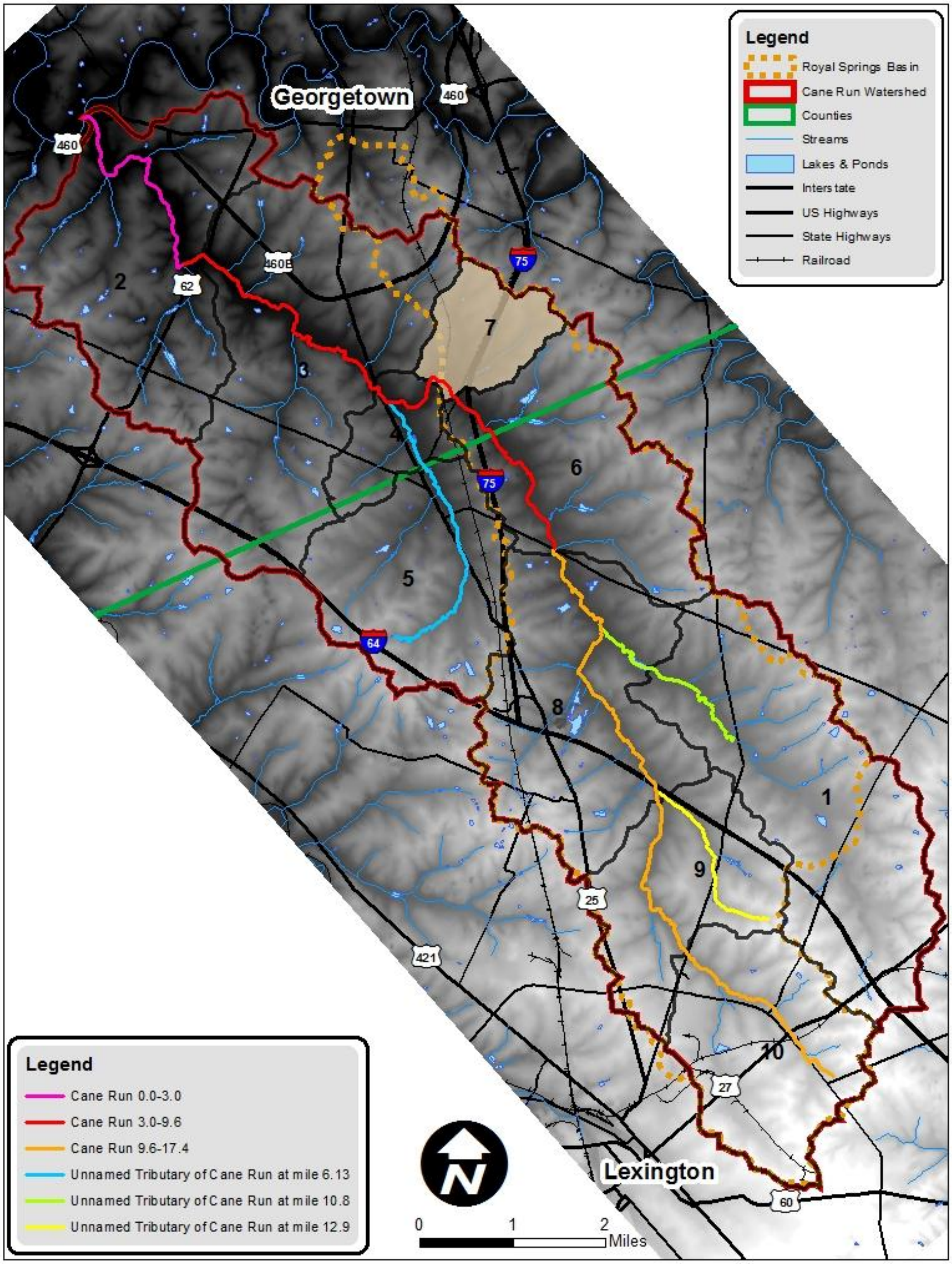

Figure 152. Impaired stream section in Catchment 7

Point Sources

There are several possible sources of point source pollution within Catchment 10, including failing onsite wastewater treatment systems and straight pipes. These point sources contribute mainly to bacteria and nutrient pollution.

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. THE U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[57]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[58]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there is 1 failing OWTS in Catchment 7 that contribute a fecal coliform load of 4.07E+08 cfu/day.

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 8 straight pipes in Catchment 7 that contribute a fecal coliform load of

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[57] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.
[58] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

6.06E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 0.329 lbs/day.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 7 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 119 and Figure 153). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 119. Land cover in Catchment 7

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture/ Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	0.00	119.20	0.00	7.56	2.22	0.00	524.85	270.65	0.00	**924**
Percent	0.00	12.89	0.00	0.82	0.24	0.00	56.77	29.28	0.00	**100**

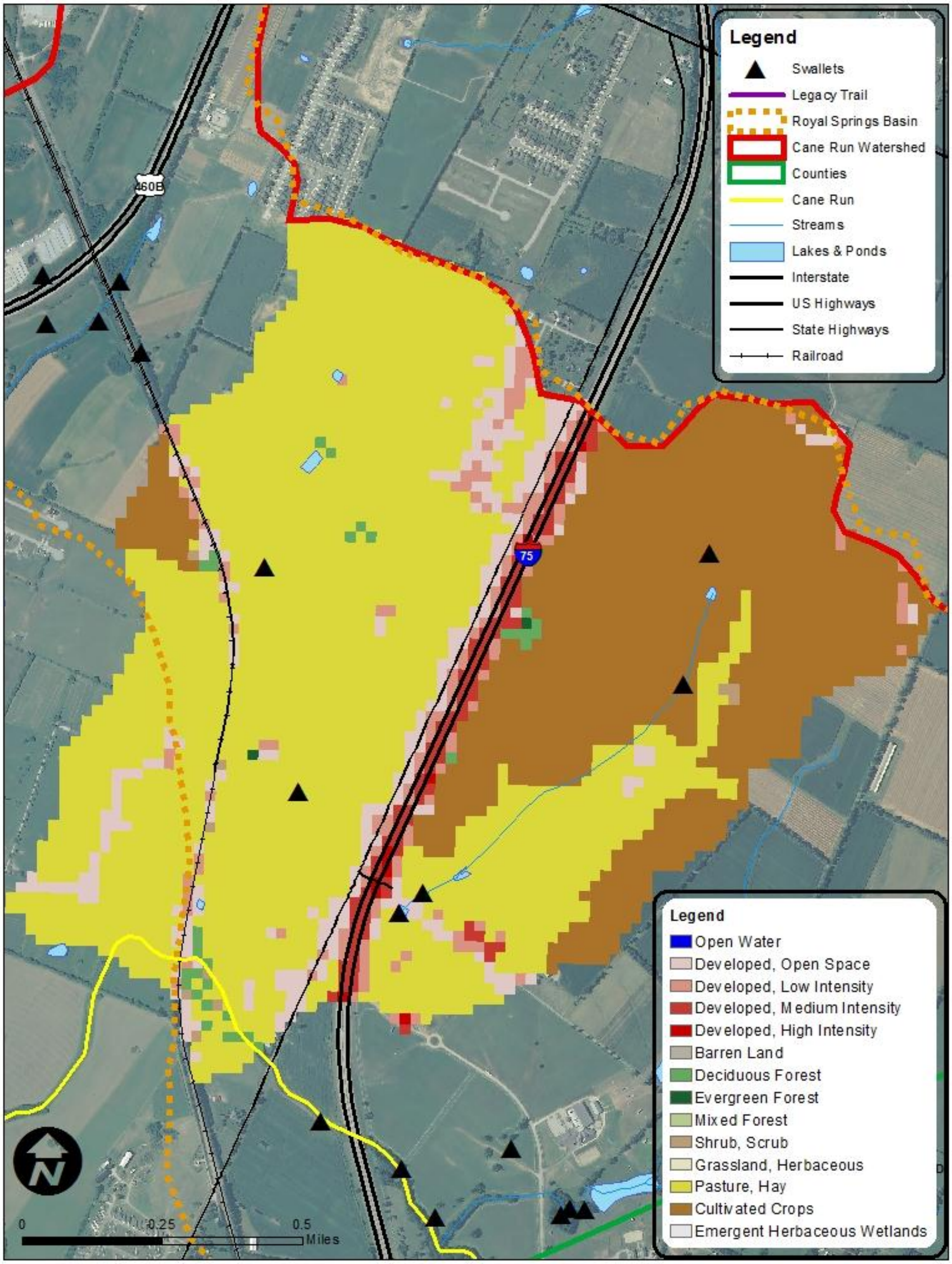

Figure 153. Land cover in Catchment 7

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 1.861 lbs/day.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 7. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 7 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil's holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[59]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 7 and their daily fecal coliform load contribution can be found in Table 120.

Table 120. Wildlife population estimates and daily fecal coliform load contribution for Catchment 7

Animal	Population	Fecal counts/day
Ducks	13	3.16E+10
Geese	6	2.94E+11
Deer	16	3.00E+08
Beavers	1	2.50E+08
Raccoons	6	7.50E+08

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[60].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 7 and their daily fecal coliform load contribution can be found in Table 121.

[59] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[60] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

Table 121. Livestock population estimates and daily fecal coliform load contribution for Catchment 7

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock, including cattle in streams)
Hogs	0	0.00E+00	--
Beef Cattle	122	8.58E+10	3.13E+11
Dairy Cattle	14	3.28E+10	--
Chickens	3	1.47E+08	--
Horses	19	9.92E+08	6.35E+09
Sheep	2	--	2.40E+10
Goats	5	--	6.00E+10

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 0.211 lbs/day. This contribution is low when compared to other catchments because it has a relatively small area of developed land.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[61]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 7 are shown in Table 122.

[61] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Table 122. Daily fecal coliform load contributions from developed land in Catchment 7

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
0.00E+00	0.00E+00	3.17E+08	1.52E+07

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 7.

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 7, is used for industrial development because of the close proximity to highway infrastructure.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

No water quality data has been collected in this catchment.

Monitoring Conclusions

Geomorphology

No cross-sections were established in Catchment 7.

Water Quality

No monitoring points have been established in Catchment 7, nor are there any samples on record that detail water quality in this catchment.

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

In addition to physical characteristics of the watershed, there are many projects and partnerships already underway that will also guide BMP implementation efforts. The Cane Run Watershed is unique in not only its geology, but by the few, large, public landowners. In Catchment 7 these include the Kentucky Horse Park and Barton Brothers Farms.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing, the most important pollutants to address in this catchment include fecal coliform, nutrients, and specific conductance. The most likely sources of these pollutants in Catchment 7 that should be addressed include transportation infrastructure, new construction, landfills, livestock (pasture grazing and land application), and package plants and other small discharges.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 7, the MS4 developed land loading must be reduced by 50 percent, the MS4 non-developed loading must be reduced by 29.7 percent, and the non-MS4 loading must be reduced by 25.0 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes.

Because Catchment 7 lies outside of the scope of the Royal Spring aquifer of the Cane Run Watershed, the Cane Run Watershed Project has not proposed or implemented any BMPs in this catchment.

Catchment 5

Pollutant Source Assessment

The 303(d) listed unnamed tributary of Cane Run that begins in and flows through Catchment 5 (that also flows through Catchment 4) has been identified as having high levels of fecal coliform, nitrogen, and phosphorus with suspected sources including livestock, managed pasture grazing, non-irrigated crop production, package plant, or other permitted small flows discharges (Figure 154). Other point and nonpoint sources that could also contribute to this pollution are described below.

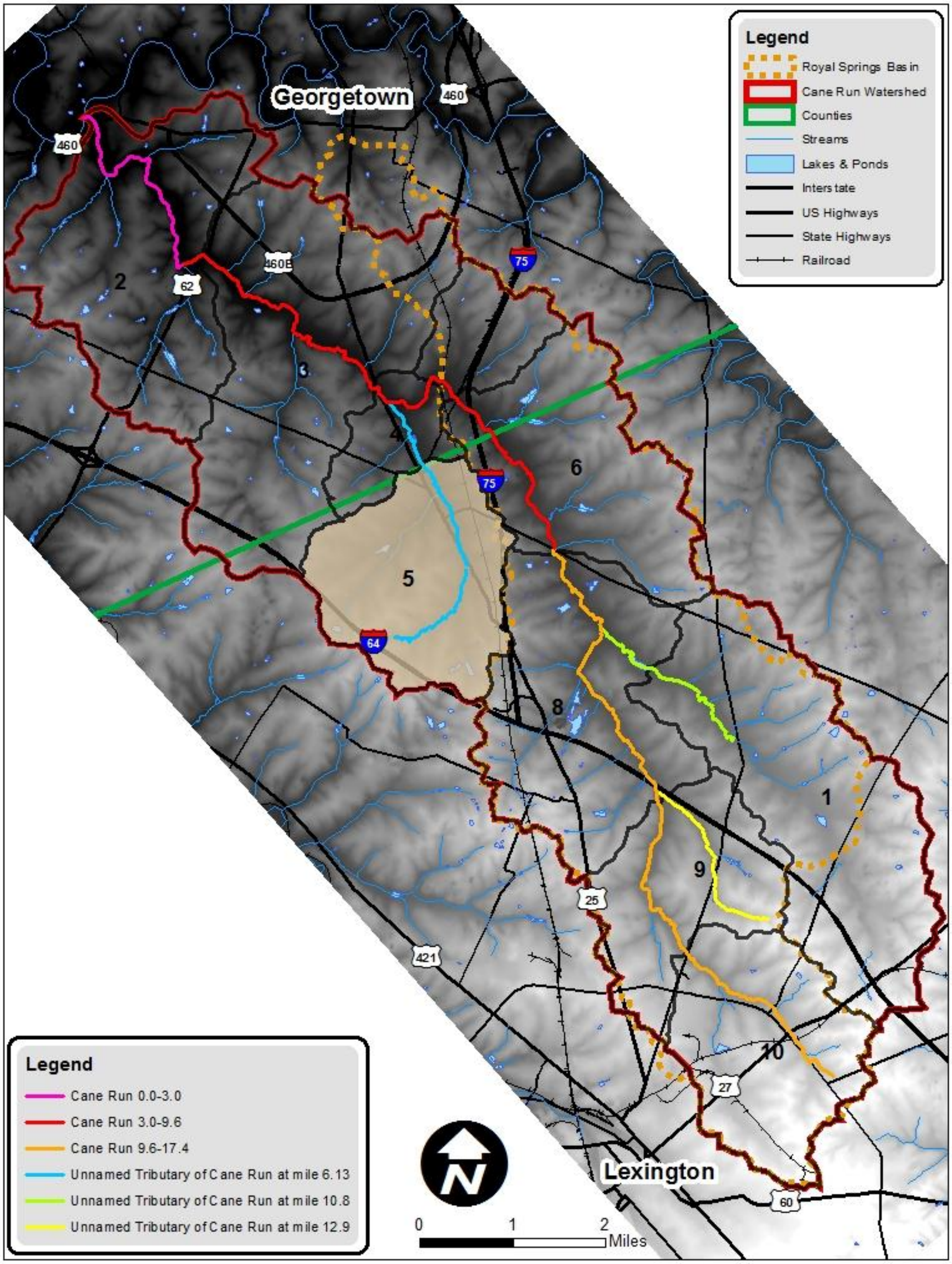

Figure 154. Impaired stream section in Catchment 5

Point Sources

There are several possible sources of point source pollution within Catchment 5, including KPDES-permitted facilities, Class V injection wells, failing onsite wastewater treatment systems, and straight pipes (Figure 155). These point sources contribute mainly to bacteria and nutrient pollution.

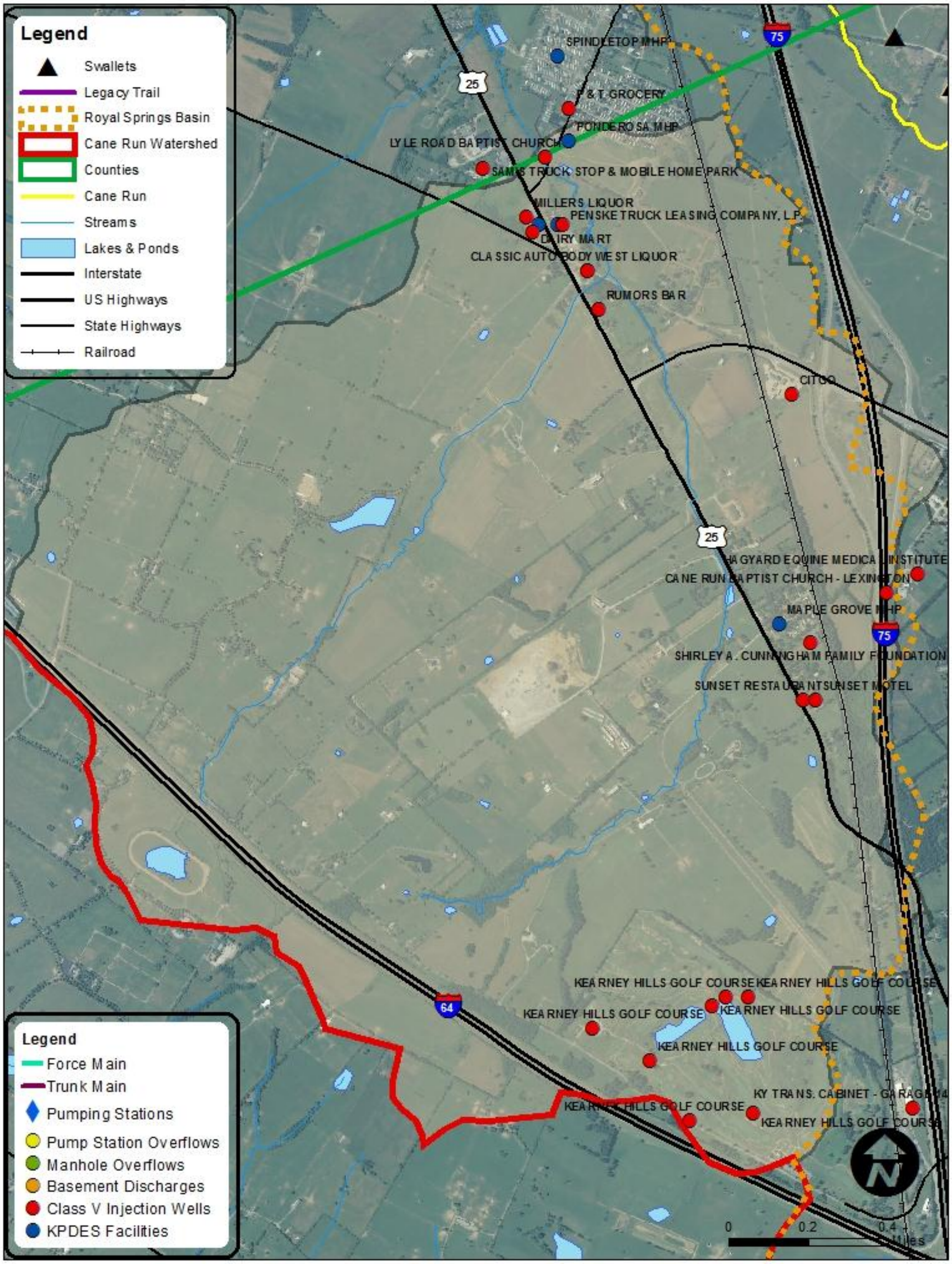

Figure 155. Potential point sources in Catchment 5

KPDES-Permitted Facilities

There are 4 KPDES permitted facilities in Catchment 5, and the details of each permittee can be found in Table 123. There are two KPDES facilities—Maple Grove MHP and Ponderosa MHP—t hat are regulated for pollutants of concern in the Cane Run Watershed, including bacteria and nutrients. Both of these facilities have had numerous violations involving fecal coliform, *E. coli*, and nitrogen; however, the long-term geometric means for both facilities for fecal coliform are well below the permit limit.

Table 123. KPDES facilities in Catchment 5

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences	Design Discharge (mgd)[1]	Permit Limit[1]	2003 Historical Geomean[1]	Assumed Loading[1]
KYR00161	G.F. Vaughan Tobacco Co. Inc.	4321 Georgetown Rd., Lexington, KY 40501	Elkhorn Creek	--	--	--	--	--	--	--
KY0083321	Maple Grove MHP	4130 Georgetown Rd., Lexington, KY 40511	Cane Run Creek/ Unnamed Tributary	BOD	Jan-08-Dec-10	16	--			
				Chlorine	Jan-08-Dec-10	6	--	--	--	--
				Fecal coliform	**Jan-08-Dec-10**	**1**	**--**	**200 cfu/100mL**	**12 cfu/100mL**	**2.20E+08 cfu/day**
				E. coli	**Jan-08-Dec-10**	**7**	--	--	--	--
				Nitrogen	**Jan-08-Dec-10**	**12**	--	--	--	--
				Phosphorus[2]	**--**	**--**	**--**	**0.3 mg/L**	**--**	**--**
				Flow	Jan-08-Dec-10	5	0.029	--	--	--
				DO	Jan-08-Dec-10	5	--	--	--	--
				pH	Jan-08-Dec-10	5	--	--	--	--
				Total suspended solids	Jan-08-Dec-10	21	--	--	--	--
KY0103691	Penske Truck	4700 Georgetown	Cane Run/	Aluminum	Jan-08-Dec-10	None	--	--	--	--

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences	Design Discharge (mgd)[1]	Permit Limit[1]	2003 Historical Geomean[1]	Assumed Loading[1]
	Leasing Co LP	Rd., Lexington, KY 40511	Unnamed Tributary	BOD	Jan-08-Dec-10	7	--	--	--	--
				Chloride	Jan-08-Dec-10	None	--	--	--	--
				Flow	Jan-08-Dec-10	2	--	--	--	--
				Hardness	Jan-08-Dec-10	None	--	--	--	--
				Iron	Jan-08-Dec-10	12	--	--	--	--
				Nitrogen	Jan-08-Dec-10	None	--	--	--	--
				Oil and grease	Jan-08-Dec-10	3	--	--	--	--
				pH	Jan-08-Dec-10	None	--	--	--	--
				Total suspended solids	Jan-08-Dec-10	5	--	--	--	--
				Surfactants	Jan-08-Dec-10	None	--	--	--	--
				Zinc	Jan-08-Dec-10	3	--	--	--	--
KY0081221	Ponderosa MHP	E. of Lisle Rd., N. or US Hwy. 25, Georgetown, KY 40324	Cane Run Creek	pH	Jan-08-Dec-10	7	--	--	--	--
				BOD	Jan-08-Dec-10	8	--	--	--	--
				Chlorine	Jan-08-Dec-10	6	--	--	--	--
				Fecal	**Jan-08-**	**1**		**200**	**10**	**1.21E+08**

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences	Design Discharge (mgd)[1]	Permit Limit[1]	2003 Historical Geomean[1]	Assumed Loading[1]
				Coliform	**Dec-10**			**cfu/100mL**	**cfu/100mL**	**cfu/day**
				E. Coli	**Jan-08-Dec-10**	**17**	--	--	--	--
				Nitrogen	**Jan-08-Dec-10**	**24**	--	--	--	--
				Phosphorus[2]	**--**	**--**	**--**	**0.30 mg/L**	**--**	**--**
				Flow	Jan-08-Dec-10	6	0.016	--	--	--
				DO	Jan-08-Dec-10	16	--	--	--	--
				Total Suspended Solids	Jan-08-Dec-10	25	--	--	--	--

[1]Metrics used in TMDL calculation
[2]Parameter not included in KPDES permit but included in nutrient TMDL calculation

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[62] There are many different types of Class V injection wells, but in Catchment 5, there are 20 wells, all but five of which are large capacity septic systems (LCSS) (Table 124).

LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is relatively high[63].

The five non-LCSS Class V injection wells in Catchment 5 are classified as improved sinkholes and receive human waste. The potential for contamination from this type of well is unknown.

Table 124. Class V injection well locations in Catchment 5

EPA ID	Company Name	Address	Well Type
KYV0670002	Cane Run Baptist Church – Lexington	4526 Iron Works Pike, Lexington, KY	Large capacity septic system
KYV0670065	Sunset Restaurant	4020 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV0670066	Sunset Motel	4020 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV0670067	Rumors Bar	4578 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV0670068	Classic Auto Body	4684 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV0670069	West Liquor	4694 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV0670070	Penske Truck Leasing Company, L.P.	4700 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV0670071	Dairy Mart	4731 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV0670072	Millers Liquor	4811 Georgetown	Large capacity septic

[62] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm
[63] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf

EPA ID	Company Name	Address	Well Type
		Rd., Lexington, KY	system
KYV0670073	Citgo	4550 Iron Works Pike, Lexington, KY	Large capacity septic system
KYV0670125	Kearney Hills Golf Course	3402 Kearney Rd., Lexington, KY	Large capacity septic system
KYV0670126	Kearney Hills Golf Course	3402 Kearney Rd., Lexington, KY	Large capacity septic system
KYV0670127	Kearney Hills Golf Course	3402 Kearney Rd., Lexington, KY	Improved sinkhole
KYV0670128	Kearney Hills Golf Course	3402 Kearney Rd., Lexington, KY	Improved sinkhole
KYV0670129	Kearney Hills Golf Course	3402 Kearney Rd., Lexington, KY	Improved sinkhole
KYV0670130	Kearney Hills Golf Course	3402 Kearney Rd., Lexington, KY	Improved sinkhole
KYV0670131	Kearney Hills Golf Course	3402 Kearney Rd., Lexington, KY	Improved sinkhole
KYV067017	Shirley A. Cunningham Family Foundation	4050 Georgetown Rd., Lexington, KY	Large capacity septic system
KYV209003	Lyle Road Baptist Church	Lyle Rd., Georgetown, KY	Large capacity septic system

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. The U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[64]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in

[64] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.

the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[65]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 3 failing OWTSs in Catchment 5 that contribute a fecal coliform load of 1.22E+09 cfu/day.

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 3 straight pipes in Catchment 5 that contribute a fecal coliform load of 2.27E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 2.983 lbs/day, which is among the highest phosphorus contributions from illegal point sources among the catchments.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 5 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 125 and Figure 156). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 125. Land cover in Catchment 5

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture/ Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	12.23	373.40	0.22	57.16	19.13	0.00	2065.37	94.52	0.44	**2622**
Percent	0.47	14.24	0.01	2.18	0.73	0.00	78.76	3.60	0.02	**100**

[65] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

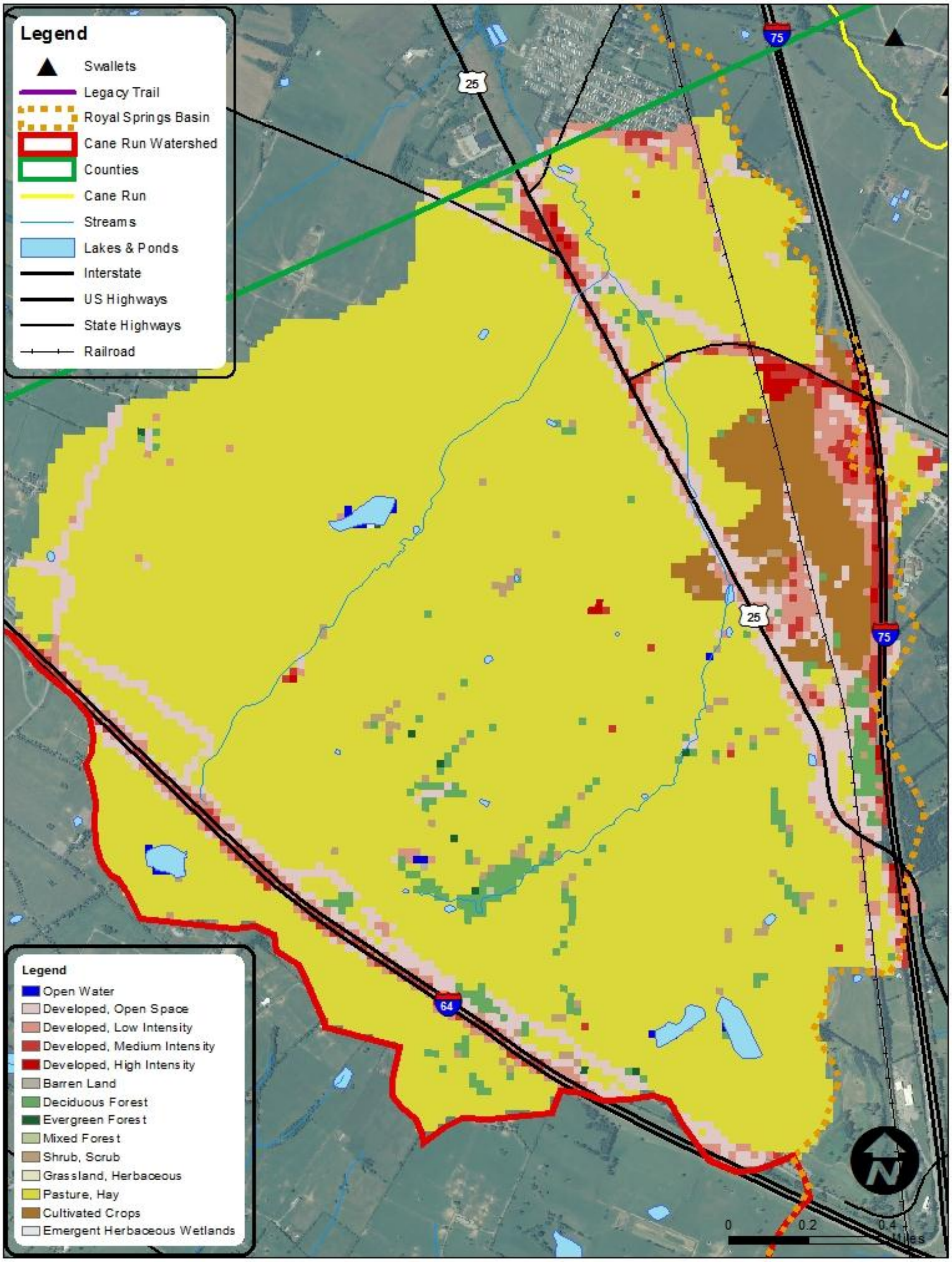

Figure 156. Land cover in Catchment 5

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 4.452 lbs/day. This contribution is high compared to other catchments, but this is likely because the amount of un-developed land in this catchment is relatively high.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 5. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 5 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil's holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these

areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[66]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 5 and their daily fecal coliform load contribution can be found in Table 126.

Table 126. Wildlife population estimates and daily fecal coliform load contribution for Catchment 5

Animal	Population	Fecal counts/day
Ducks	35	8.51E+10
Geese	17	8.33E+11
Deer	17	8.50E+09
Beavers	3	7.50E+08
Raccoons	17	2.13E+09

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[67].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 5 and their daily fecal coliform load contribution can be found in Table 127.

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[66] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[67] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

Table 127. Livestock population estimates and daily fecal coliform load contribution for Catchment 5

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock, including cattle in streams)
Hogs	0	0.00E+00	--
Beef Cattle	120	8.44E+10	3.08E+11
Dairy Cattle	13	3.05E+10	--
Chickens	3	1.47E+08	--
Horses	19	9.92E+08	6.35E+09
Sheep	2	--	2.40E+10
Goats	4	--	4.80E+10

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 0.784 lbs/day.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[68]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 5 are shown in Table 128.

Table 128. Daily fecal coliform load contributions from developed land in Catchment 5

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util

[68] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
0.00E+00	0.00E+00	1.27E+09	6.08E+07

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 5.

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 5, is used for industrial development because of the close proximity to highway infrastructure. The Georgetown Road corridor within the Cane Run Watershed has seen increased housing development over the last 10 years.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources (Table 129 and Figure 157).

Table 129. Monitoring conducted in Catchment 5

Sampling Entity	Parameters	Sampling Dates	Site IDs
KWRRI	Bacteria	2002	C4

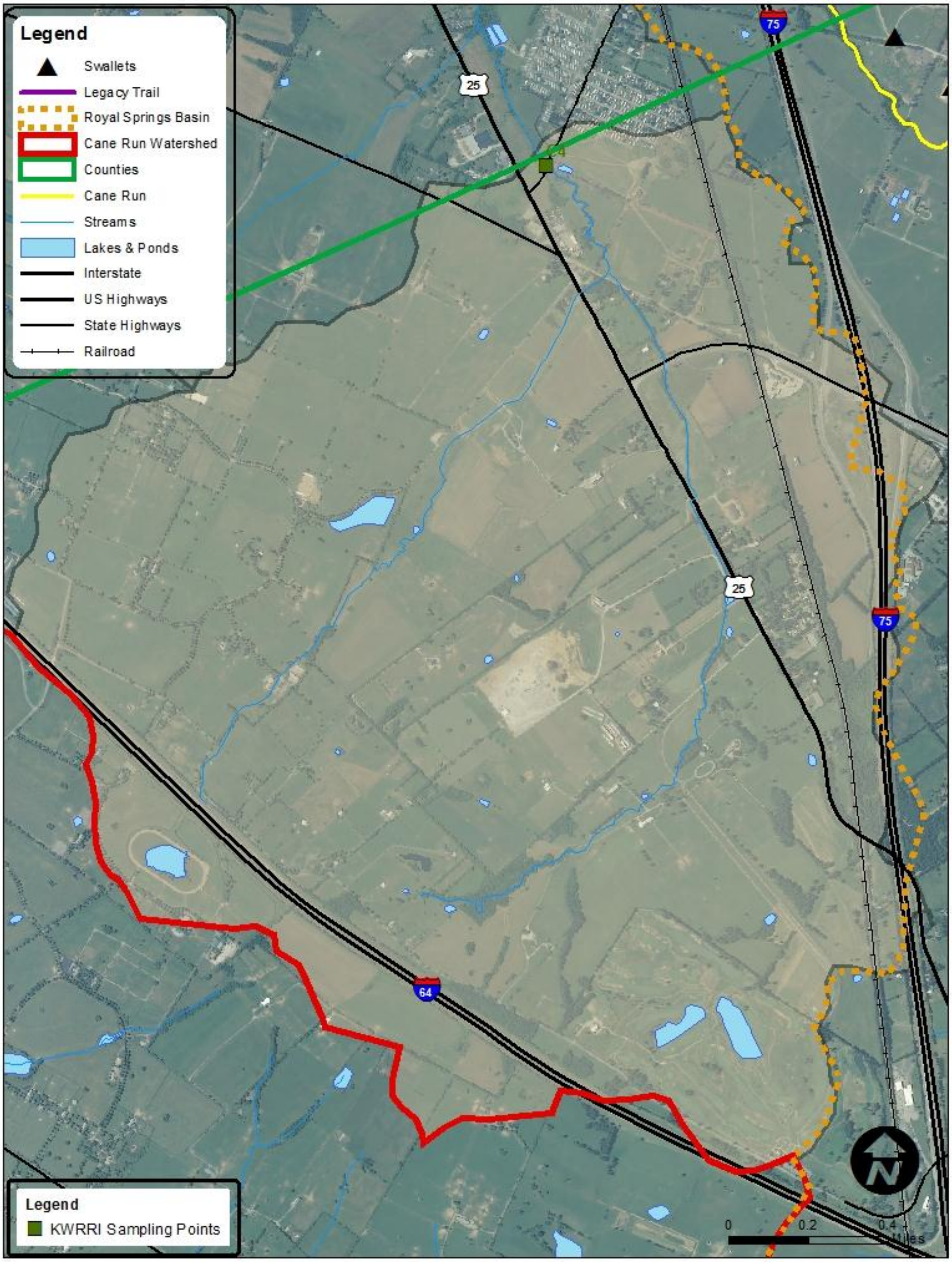

Figure 157. Monitoring points in Catchment 5

Monitoring Conclusions

<u>Geomorphology</u>

No cross-sections were established in Catchment 5.

<u>Water Quality</u>

Bacteria

The monitoring conducted by KWRRI in 2002 confirms the 303(d) listing for this section of stream for fecal coliform. Every sample taken at monitoring point C4 in Catchment 5 exceeded the primary contact standard of 200 colonies per 100 mL and several exceeded the secondary standard of 1,000 colonies per 100 mL (Table 130). This sampling demonstrates that fecal coliform pollution is a problem in Catchment 5.

Table 130. Fecal coliform data from KWRRI monitoring point C4

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	832	723	3,972	7,470	34,605	18,624	441	362	414	909

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

In addition to physical characteristics of the watershed, there are many projects and partnerships already underway that will also guide BMP implementation efforts. The Cane Run Watershed is unique in not only its geology, but by the few, large, public landowners. In Catchment 5, this includes LFUCG.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform and nutrients, specifically nitrogen and phosphorus. The most likely sources of these pollutants in Catchment 5 that should be addressed include crop production, livestock (pasture grazing and land application), package plants and other small discharges, Class V injection wells, KPDES-permitted facilities, agricultural erosion.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 5, the non-MS4 loading must be reduced by 24.8 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes.

Because Catchment 5 lies outside of the scope of the Royal Spring aquifer of the Cane Run Watershed, the Cane Run Watershed Project has not proposed or implemented any BMPs in this catchment.

Catchment 4

Pollutant Source Assessment

The 303(d) listed section of Cane Run that flows through Catchment 4 (that also flows through Catchments 6 and 3) has been identified as having high levels of fecal coliform, nutrients, and specific conductance, with suspected sources including highways, roads, bridges, infrastructure (new construction), landfills, livestock, package plants, or other permitted small flows discharges (Figure 158). The 303(d) listed unnamed tributary of Cane Run that flows through Catchment 4 (that also flows through Catchment 5) has been identified as having high levels of fecal coliform, nitrogen, and phosphorus with suspected sources including livestock, managed pasture grazing, non-irrigated crop production, package plant, or other permitted small flows discharges. Other point and nonpoint sources that could also contribute to this pollution are described below.

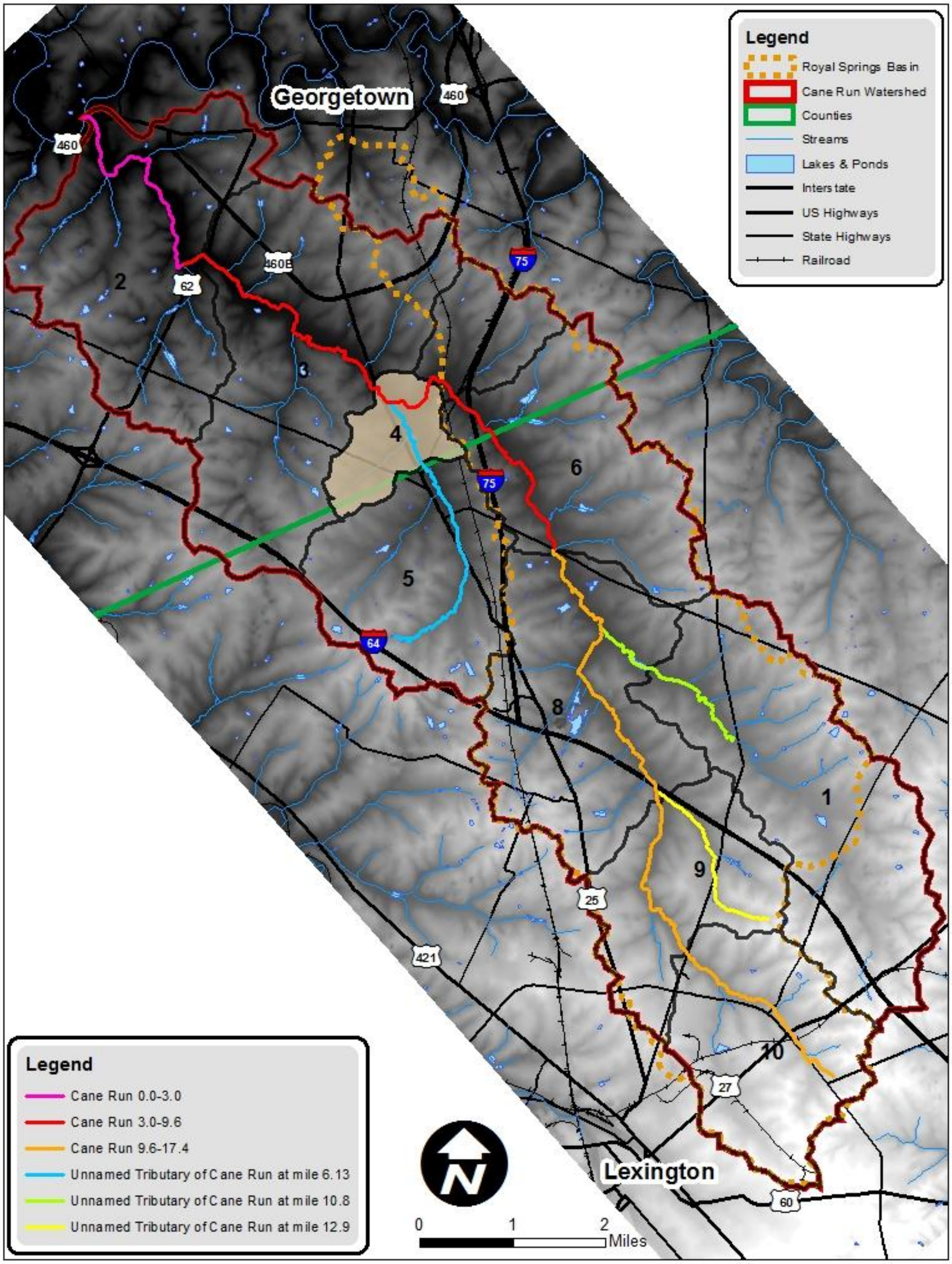

Figure 158. Impaired stream section in Catchment 4

Point Sources

There are several possible sources of point source pollution within Catchment 4, including KPDES-permitted facilities, Class V injection wells, failing onsite wastewater treatment systems, and straight pipes (Figure 159). These point sources contribute mainly to bacteria and nutrient pollution.

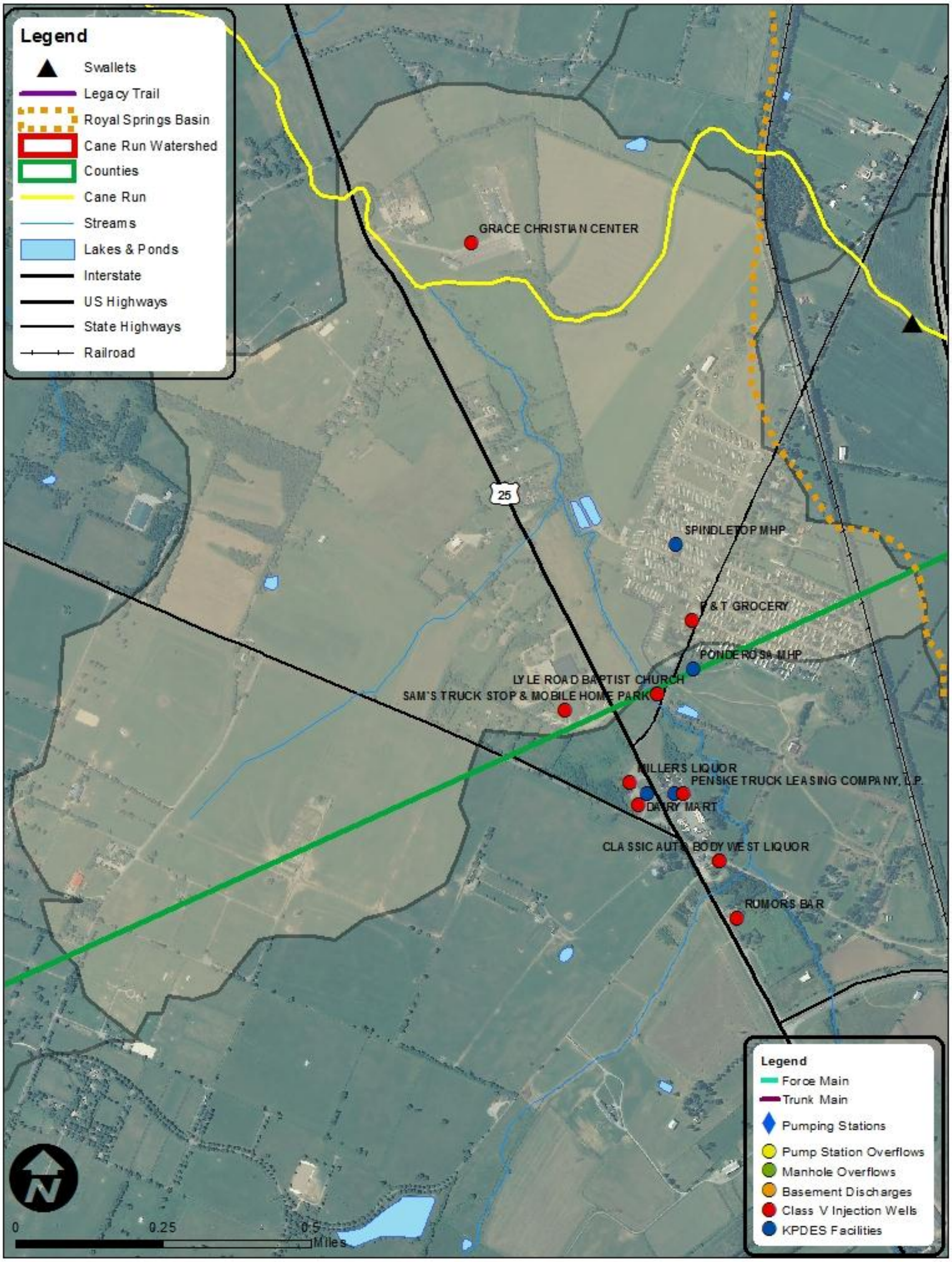

Figure 159. Potential point sources in Catchment 4

KPDES-Permitted Facilities

There is one KPDES permitted facility in Catchment 4, and the details of this permittee can be found in Table 131. There is one KPDES facility—Spindletop MHP—that is regulated for pollutants of concern in the Cane Run Watershed, including bacteria and nutrients. This facility has had numerous violations involving fecal coliform, *E. coli*, and nitrogen; however, the long-term geometric mean for fecal coliform is well below the permit limit.

Table 131. KPDES facilities in Catchment 4

Site ID	Facility	Address	Receiving Water Body	Parameters	Sampling Period	Violations/ Exceedences	Design Discharge (mgd)[1]	Permit Limit[1]	2003 Historical Geomean[1]	Assumed Loading[1]
KYR0081213	Spindletop MHP	Lisle Rd. Off US Hwy. 25 S.	Cane Run Creek	pH	Jan-08-Dec-10	10	--	--	--	--
				BOD	Jan-08-Dec-10	20	--	--	--	--
				Chlorine	Jan-08-Dec-10	6	--	--	--	--
				Fecal Coliform	**Jan-08-Dec-10**	**1**	**--**	**200 cfu/100 mL**	**49 cfu/100 mL**	**2.27E+08 cfu/day**
				E. Coli	**Jan-08-Dec-10**	**28**	**--**	**--**	**--**	**--**
				Nitrogen	**Jan-08-Dec-10**	**37**	**--**	**--**	**--**	**--**
				Phosphorus[2]	**--**	**--**	**--**	**0.30 mg/L**	**--**	**--**
				DO	Jan-08-Dec-10	18	--	--	--	--
				Total Suspended Solids	Jan-08-Dec-10	24	--	--	--	--
				Flow		6	0.030			

[1]Metrics used in TMDL calculation
[2]Parameter not included in KPDES permit but included in nutrient TMDL calculation

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[69] There are many different types of Class V injection wells, but in Catchment 4, there are 3 wells, all of which are large capacity septic systems (LCSS) (Table 132).

LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is relatively high[70].

Table 132. Class V injection well locations in Catchment 4

EPA ID	Company Name	Address	Well Type
KYV209002	Grace Christian Center	1648 Lexington Rd., Georgetown, KY	Large capacity septic system
KYV209003	Sam's Truck Stop and Mobile Home Park	US 25 South, Georgetown, KY	Large capacity septic system
KYV209005	P & T Grocery	1147 Lisle Rd., Georgetown, KY	Large capacity septic system

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. The U.S. EPA (2002a) states that properly functioning OWTSs can remove

[69] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm

[70] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf

fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[71]. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[72]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there is 1 failing OWTS in Catchment 4 that contribute a fecal coliform load of 4.07E+08 cfu/day.

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 7 straight pipes in Catchment 4 that contribute a fecal coliform load of 5.30E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 0.862 lbs/day.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 4 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 133 and Figure 160). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

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[71] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.
[72] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Table 133. Land cover in Catchment 4

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture/ Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	0.00	208.16	1.56	9.34	4.89	0.00	597.57	0.00	0.00	**822**
Percent	0	25.34	0.19	1.14	0.60	0.00	72.74	0.00	0.00	**100**

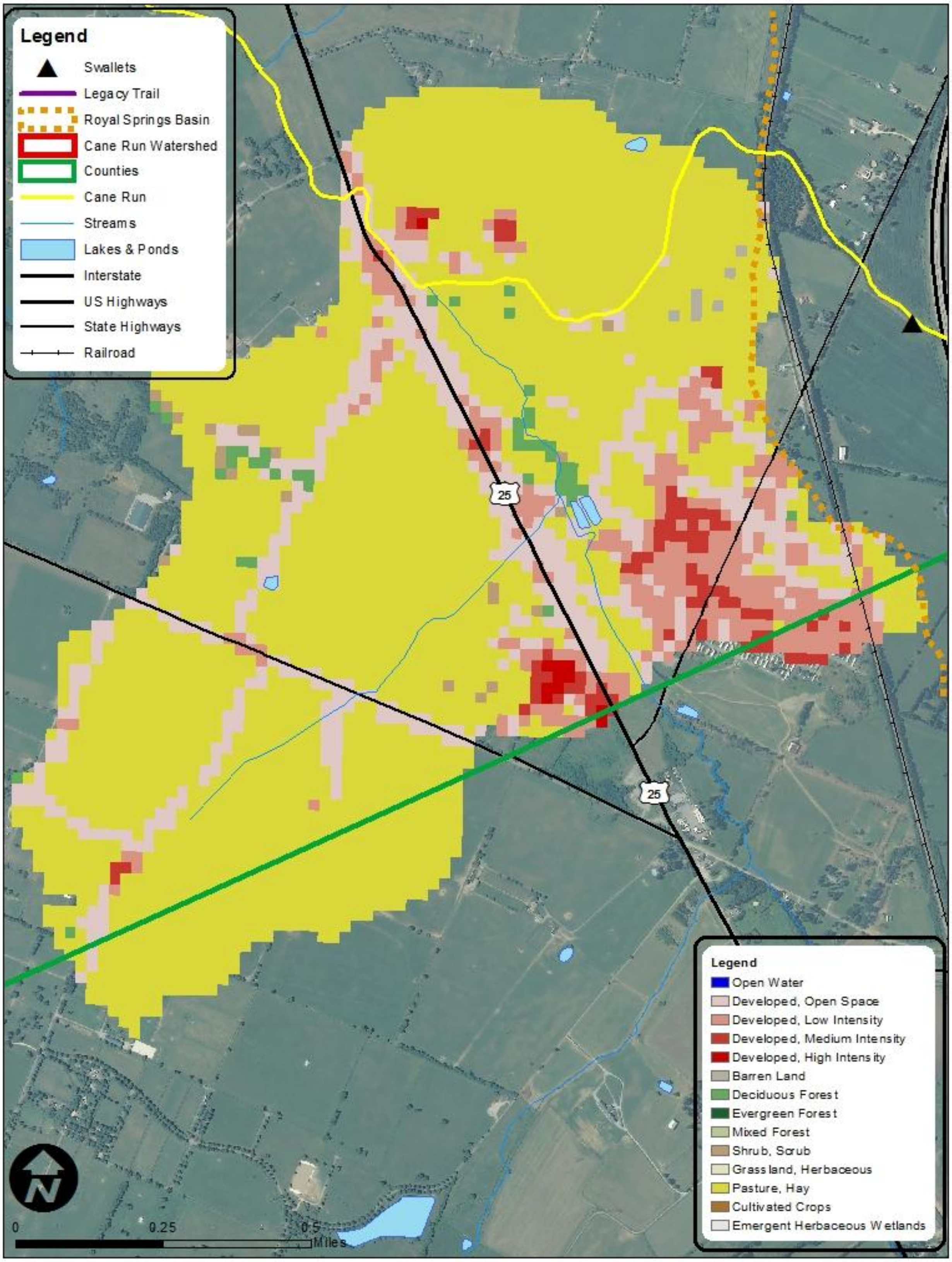

Figure 160. Land cover in Catchment 4

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 1.481 lbs/day.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 4. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 4 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil's holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[73]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 4 and their daily fecal coliform load contribution can be found in Table 134.

Table 134. Wildlife population estimates and daily fecal coliform load contribution for Catchment 4

Animal	Population	Fecal counts/day
Ducks	11	2.67E+10
Geese	6	2.94E+11
Deer	6	3.00E+09
Beavers	1	2.50E+08
Raccoons	6	7.50E+08

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[74].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 4 and their daily fecal coliform load contribution can be found in Table 135.

[73] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html
[74] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

Table 135. Livestock population estimates and daily fecal coliform load contribution for Catchment 4

Animal	Population	Fecal county/day (land application)	Fecal county/day (grazing livestock, including cattle in streams)
Hogs	0	0.00E+10	--
Beef Cattle	68	4.78E+10	1.75E+11
Dairy Cattle	16	1.88E+10	--
Chickens	3	1.47E+08	--
Horses	17	8.88E+08	5.69E+09
Sheep	1	--	1.20E+10
Goats	0	--	0.00E+00

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 0.258 lbs/day.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[75]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 4 are shown in Table 136.

Table 136. Daily fecal coliform load contributions from developed land in Catchment 4

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
1.24E+07	1.13E+07	1.99E+09	1.00E+06

[75] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 4.

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 4, is used for industrial development because of the close proximity to highway infrastructure. The Georgetown Road corridor within the Cane Run Watershed has seen increased housing development over the last 10 years.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 4 (Table 137 and Figure 161).

Lexington-Fayette Urban County Government (LFUCG) has been performing bacteria sampling in this catchment in support of its KPDES Stormwater Permit since 1993.

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources.

Water samples were taken at stations in this catchment in 2006 and 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development.

The Kentucky Division of Water (KDOW) established bank pins (toe, bankfull and top of bank) in this catchment to assess the physical condition of the stream.

Table 137. Monitoring conducted in Catchment 4

Sampling Entity	Parameters	Sampling Dates	Site IDs
LFUCG	Bacteria	1993-present	S3
KWRRI	Bacteria	2002	C5
KDOW	Nutrients	2006-2007	04018003, 04018004
KDOW	Geomorphology	2006-2007	1, 9-12

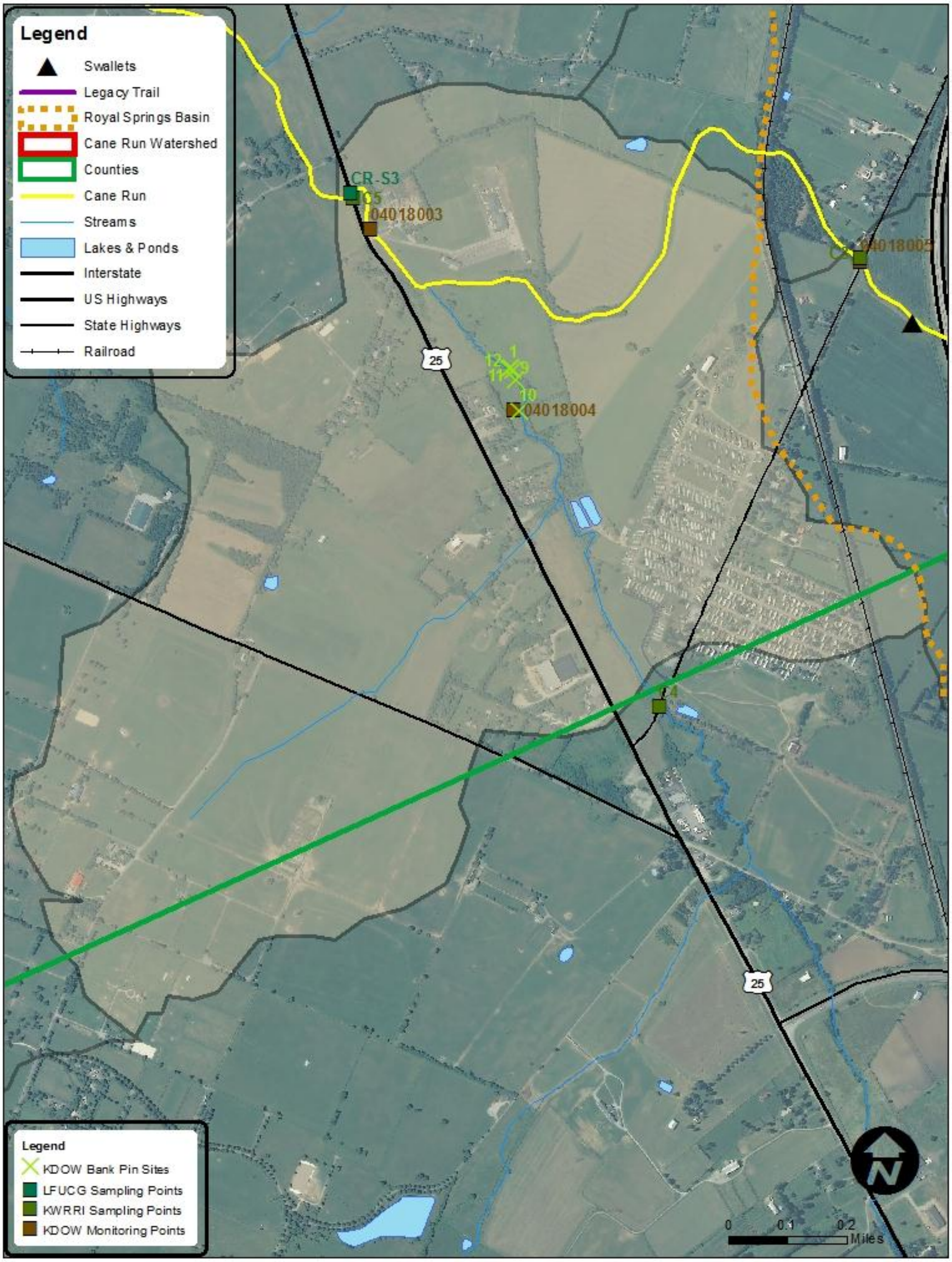

Figure 161. Monitoring points in Catchment 4

Monitoring Conclusions

Geomorphology

Kentucky Division of Water (KDOW) established bank pins (toe, bankfull and top of bank) at four locations on an UT to Cane Run within this catchment in November 2008. The UT is located off US25. The KDOW determined BEHI and NBS values for each location and measured the amount of bank pin exposed for all recoverable bank pins (Table 138). No additional information (e.g. photographs and cross-sectional surveys) was provided by KDOW. University of Kentucky personnel could not locate these monitoring locations to collect additional data. These data indicate the erosion rates within this catchment are quite variable ranging from 1 to 5.3 inches of lateral erosion per year.

Table 138. KDOW average annual erosion deposition rates in Catchment 4

Bank Pin Location	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
9	High	High/Extreme	0.295
10	High	Moderate/High	0.093[1]
11	High	Low	0.438
12	High	Moderate/Low	0.085

[1]Not all bank pins were recovered.

Water Quality

Bacteria

The monitoring conducted by KWRRI in 2002 and by LFUCG from 1998 to 2003 confirms the 303(d) listing for this section of stream for fecal coliform. Every sample taken at monitoring point C5 in Catchment 4 exceeded the primary contact standard of 200 colonies per 100 mL and one exceeded the secondary standard of 1,000 colonies per 100 mL (Table 139), and the geometric mean of LFUCG's sampling at CR-S3 far exceeds the primary contact standard (Table 140). This sampling demonstrates that fecal coliform pollution is a problem in Catchment 4.

Table 139. Fecal coliform data from KWRRI monitoring point C5

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	387	373	840	612	704	672	425	1,270	221	282

Table 140. LFUCG fecal coliform data

Station ID	Station Description	Sampling Dates	Fecal Geometric Mean Cfu/100 ml
CR-S3	US-25	May-98 to Nov-03	629

Nutrients

The monitoring conducted in 2006 and 2007 by KDOW demonstrates a problem with nutrient pollution, specifically phosphorus, in this catchment. The geometric mean for DOW04018004 is well above the total phosphorus target of 0.3 mg/L (Table 141), and all of the individual samples taken by KDOW at this point exceed this total phosphorus target (Appendix K).

Table 141. Nutrient geometric means for DOW04018004

Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
0.246	2.96	2.60	2.55	0.361	0.575	6.0	0.713

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform, nutrients, specifically nitrogen and phosphorus, and specific conductance. The most likely sources of these pollutants in Catchment 4 that should be addressed include transportation infrastructure, landfills, livestock (pasture grazing and land application), package plants and other small discharges, crop production, KPDES-permitted facilities, and Class V injection wells.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 4, the non-MS4 loading must be reduced by 25.0 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes.

Because Catchment 4 lies outside of the scope of the Royal Spring aquifer of the Cane Run Watershed, the Cane Run Watershed Project has not proposed or implemented any BMPs in this catchment.

Catchment 3

Pollutant Source Assessment

The 303(d) listed section of Cane Run that flows through Catchment 3 (that also flows through Catchments 4, 6, and 7) has been identified as having high levels of fecal coliform, nutrients, and specific conductance, with suspected sources including highways, roads, bridges, infrastructure (new construction), landfills, livestock, package plants, or other permitted small flows discharges (Figure 162). Other point and nonpoint sources that could also contribute to this pollution are described below.

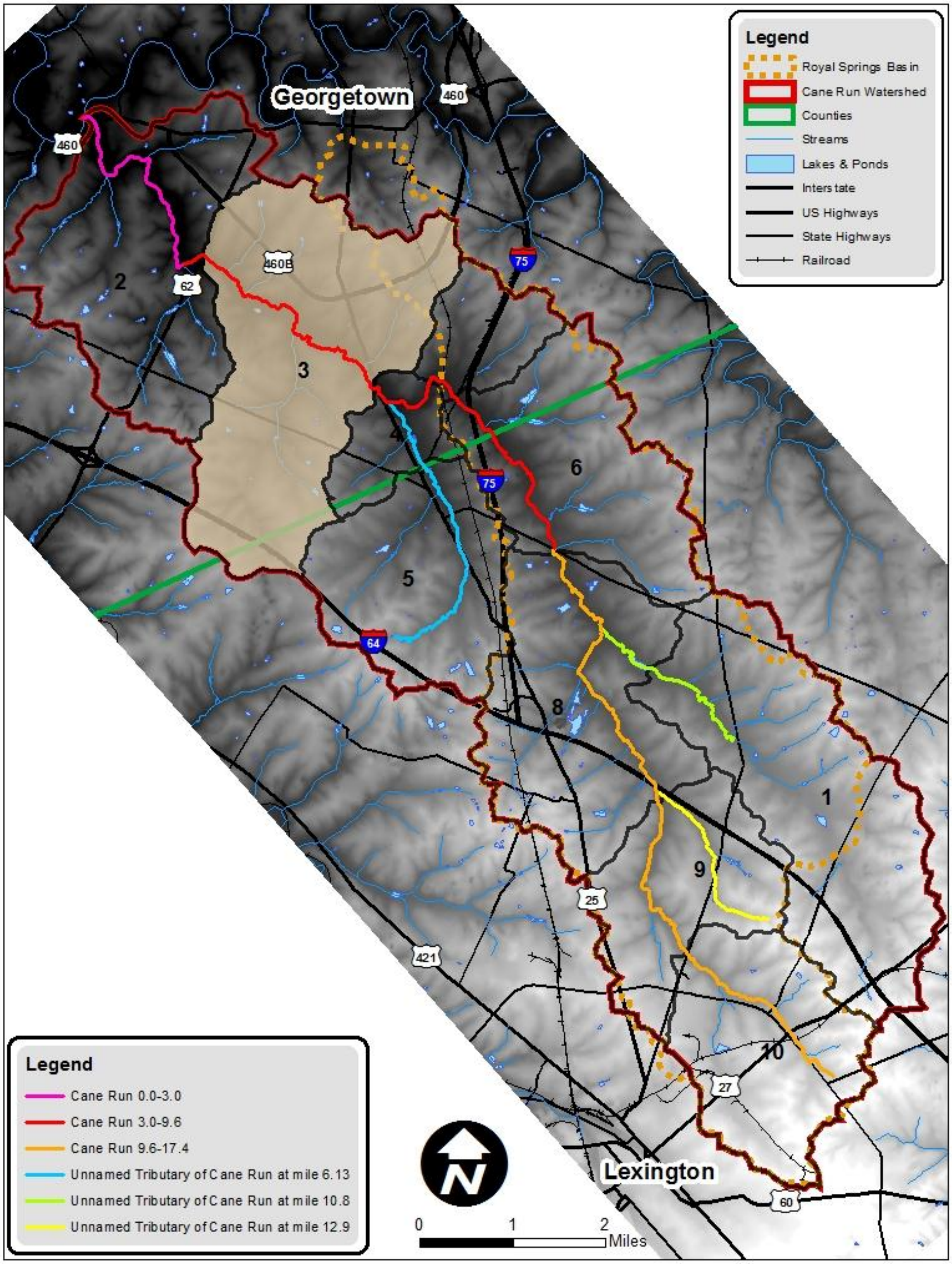

Figure 162. Impaired stream section in Catchment 3

Point Sources

There are several possible sources of point source pollution within Catchment 3, including Class V injection wells, failing onsite wastewater treatment systems, and straight pipes (Figure 163). These point sources contribute mainly to bacteria and nutrient pollution.

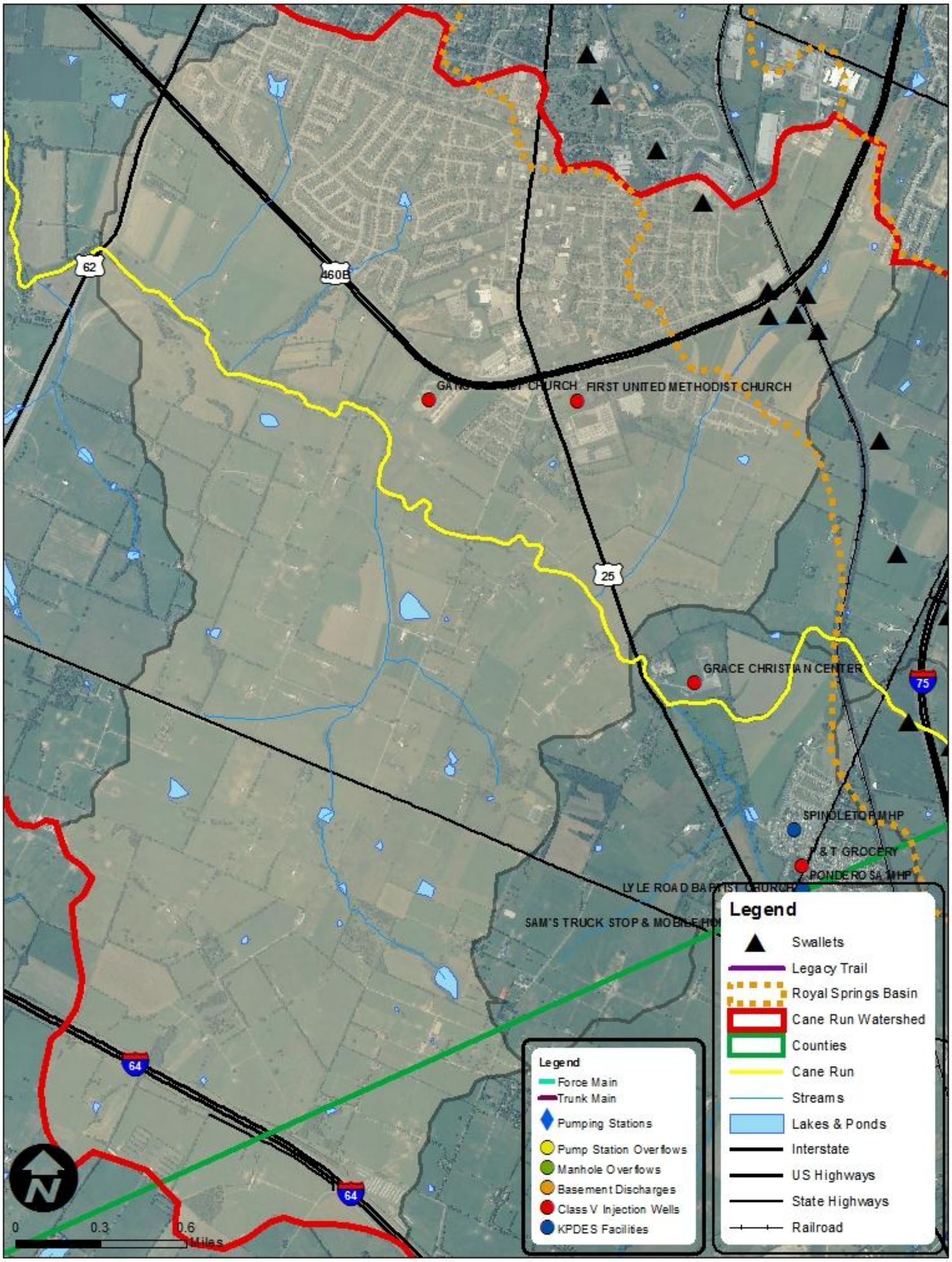

Figure 163. Potential point sources in Catchment 3

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[76] There are many different types of Class V injection wells, but in Catchment 4, there are 3 wells, all of which are large capacity septic systems (LCSS) (Table 142).

LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is relatively high[77].

Table 142. Class V injection well locations in Catchment 3

EPA ID	Company Name	Address	Well Type
KYV209003	First United Methodist Church	1280 Lexington Rd., Georgetown, KY	Large capacity septic system
KYV209005	Gano Baptist Church	212 Bevins Ln., Georgetown, KY	Large capacity septic system

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. THE U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[78]. Failing OWTSs are assumed to have a removal efficiency of zero.

[76] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm
[77] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf
[78] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[79]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 4 failing OWTSs in Catchment 3 that contribute a fecal coliform load of 1.63E+09 cfu/day.

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 37 straight pipes in Catchment 3 that contribute a fecal coliform load of 2.80E+11 cfu/day. This is by far the highest number of straight pipes in any catchment within the Cane Run Watershed and accounts for nearly half of the estimated straight pipes in the entire watershed. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 0.567 lbs/day, which is among the highest phosphorus loadings from illegal point sources.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 3 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 143 and Figure 164). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

[79] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Table 143. Land cover in Catchment 3

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture /Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	5.12	1176.46	0.89	66.72	33.36	0.00	3133.75	400.98	0.89	**4818**
Percent	0.11	24.42	0.02	1.38	0.69	0.00	65.04	8.32	0.02	**100**

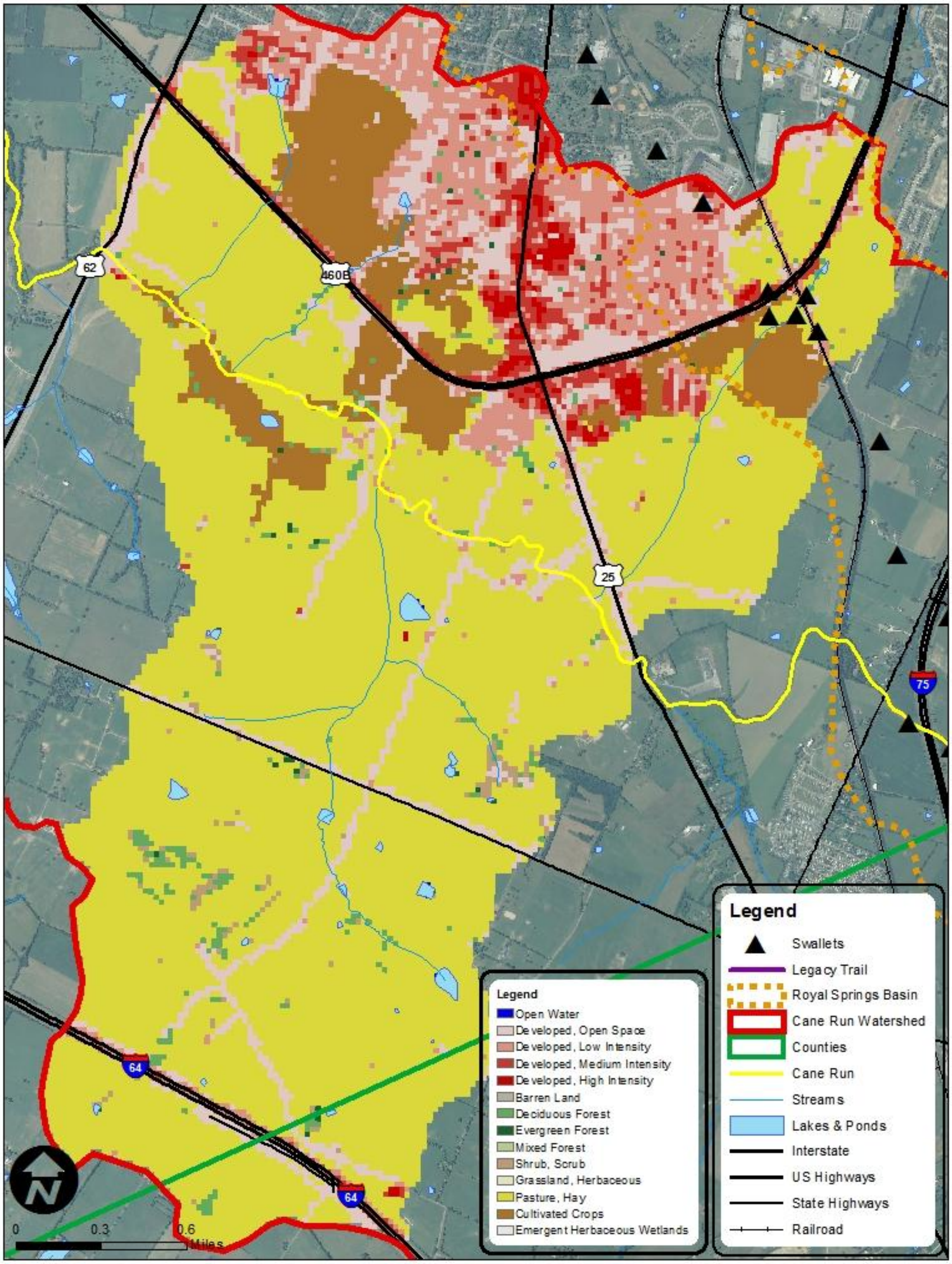

Figure 164. Land cover in Catchment 3

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 12.583 lbs/day. This contribution is extremely high compared to other catchments, and although this catchment does have a relatively high amount of non-developed land, the phosphorus contribution is still extremely high.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 3. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 3 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil's holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these

areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[80]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 3 and their daily fecal coliform load contribution, which is the highest in the entire Cane Run Watershed, can be found in Table 144.

Table 144. Wildlife population estimates and daily fecal coliform load contribution for Catchment 3

Animal	Population	Fecal counts/day
Ducks	66	1.60E+11
Geese	34	1.67E+12
Deer	34	1.70E+10
Beavers	17	1.75E+09
Raccoons	34	4.26E+09

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[81].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 3 and their daily fecal coliform load contribution can be found in Table 145. Catchment 3 has the highest fecal

[80] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[81] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

coliform contribution of any Cane Run catchment for grazing livestock, making it an important pollutant source.

Table 145. Livestock population estimates and daily fecal coliform load contribution for Catchment 3

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock, including cattle in streams)
Hogs	2	5.34E+09	--
Beef Cattle	559	3.59E+11	1.31E+12
Dairy Cattle	62	1.34E+11	--
Chickens	16	7.34E+08	--
Horses	108	5.22E+09	3.34E+10
Sheep	8	--	8.40E+10
Goats	0	--	0.00E+00

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 1.206 lbs/day.

DOMESTIC PETS

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[82]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 3 are shown in Table 146.

[82] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Table 146. Daily fecal coliform load contributions from developed land in Catchment 3

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
7.70E+08	0.00E+00	3.51E+09	2.86E+07

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 3.

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 3, is used for industrial development because of the close proximity to highway infrastructure. The Georgetown Road corridor within the Cane Run Watershed has seen increased housing development over the last 10 years.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 3 (Table 147 and Figure 165).

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources.

Water samples were taken at stations in this catchment in 2006 and 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development.

Table 147. Monitoring conducted in Catchment 3

Sampling Entity	Parameters	Sampling Dates	Site IDs
KWRRI	Bacteria	2002	C7
KDOW	Nutrients	2006-2007	04018001

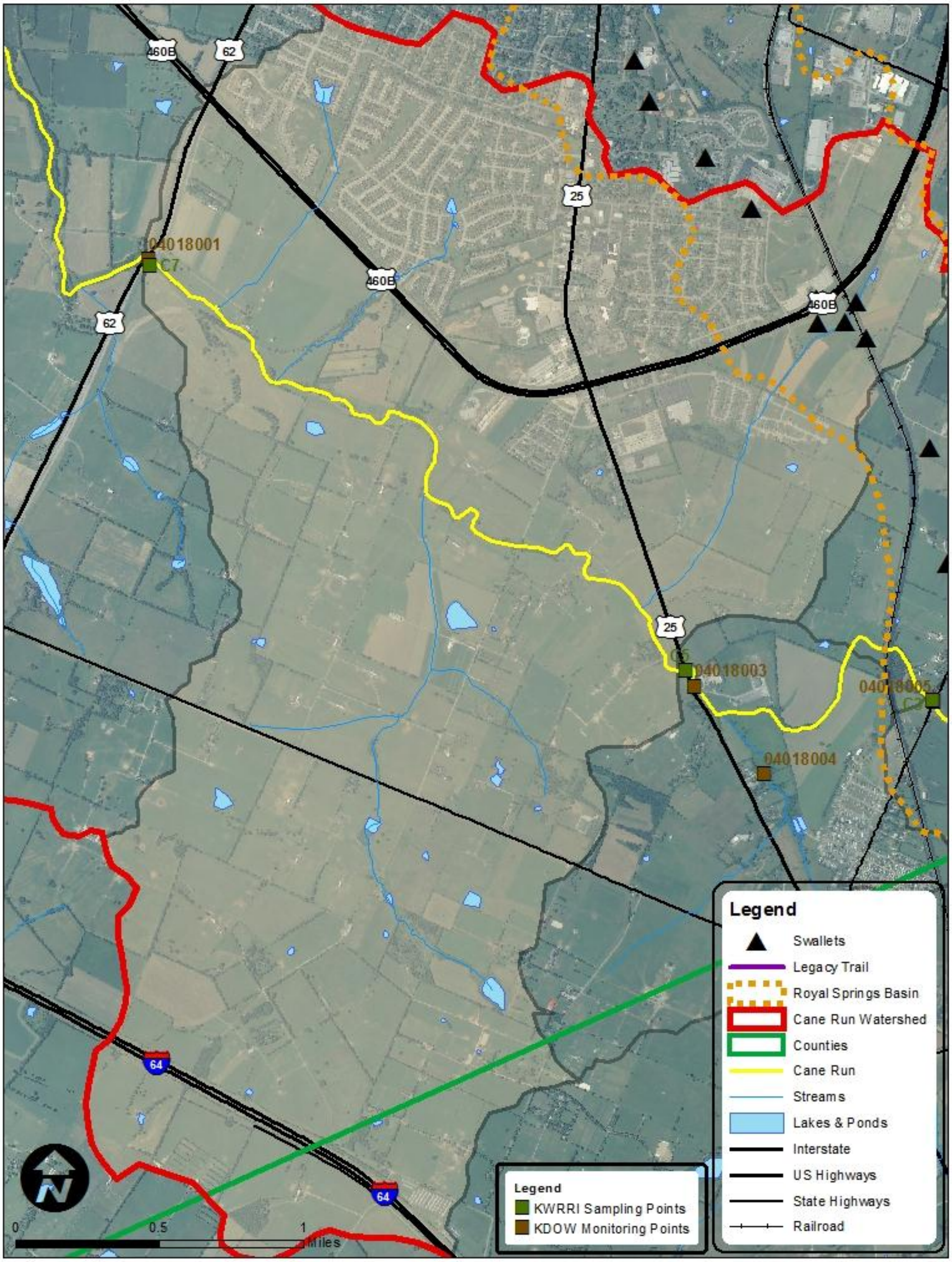

Figure 165. Monitoring points in Catchment 3

Monitoring Conclusions

Geomorphology

No cross-sections were established in Catchment 3.

Water Quality

Bacteria

The monitoring conducted by KWRRI in 2002 confirms the 303(d) listing for this section of stream for fecal coliform. Nearly every sample taken at monitoring point C7 in Catchment 3 exceeded the primary contact standard of 200 colonies per 100 mL and several exceeded the secondary standard of 1,000 colonies per 100 mL (Table 148).This sampling demonstrates that fecal coliform pollution is a problem in Catchment 3.

Table 148. Fecal coliform data from KWRRI monitoring point C7

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	4,697	698	1,930	495	552	519	2,116	199	201	519

Nutrients

The monitoring conducted in 2006 and 2007 by KDOW demonstrates a problem with nutrient pollution, specifically phosphorus, in this catchment. The geometric mean for DOW04018001 does not exceed the total phosphorus target of 0.3 mg/L (Table 149), but several of the individual samples taken by KDOW exceed this total phosphorus target (Appendix K).

Table 149. Nutrient geometric means for DOW04018001

Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
0.107	Not detected	1.84	1.99	0.118	0.263	4.2	0.528

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform, nutrients, and specific conductance. The most likely sources of these pollutants in Catchment 3 that should be addressed include transportation infrastructure, landfills, grazing livestock, package plants and other small discharges, Class V injection wells, straight pipes, and wildlife.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 3, the MS4 developed land loading must be reduced by 50 percent, the MS4 non-developed loading must be reduced by 26.9 percent, and the non-MS4 loading must be reduced by 25.0 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes.

Because Catchment 3 lies outside of the scope of the Royal Spring aquifer of the Cane Run Watershed, the Cane Run Watershed Project has not proposed or implemented any BMPs in this catchment.

Catchment 2

Pollutant Source Assessment

The 303(d) listed section of Cane Run that flows through Catchment 2 has been identified as having high levels of fecal coliform, nutrients, and sediment, with suspected sources including livestock, managed pasture grazing, non-irrigated crop production, package plants, other permitted small flows discharges, and unspecified urban stormwater (Figure 166). Other point and nonpoint sources that could also contribute to this pollution are described below.

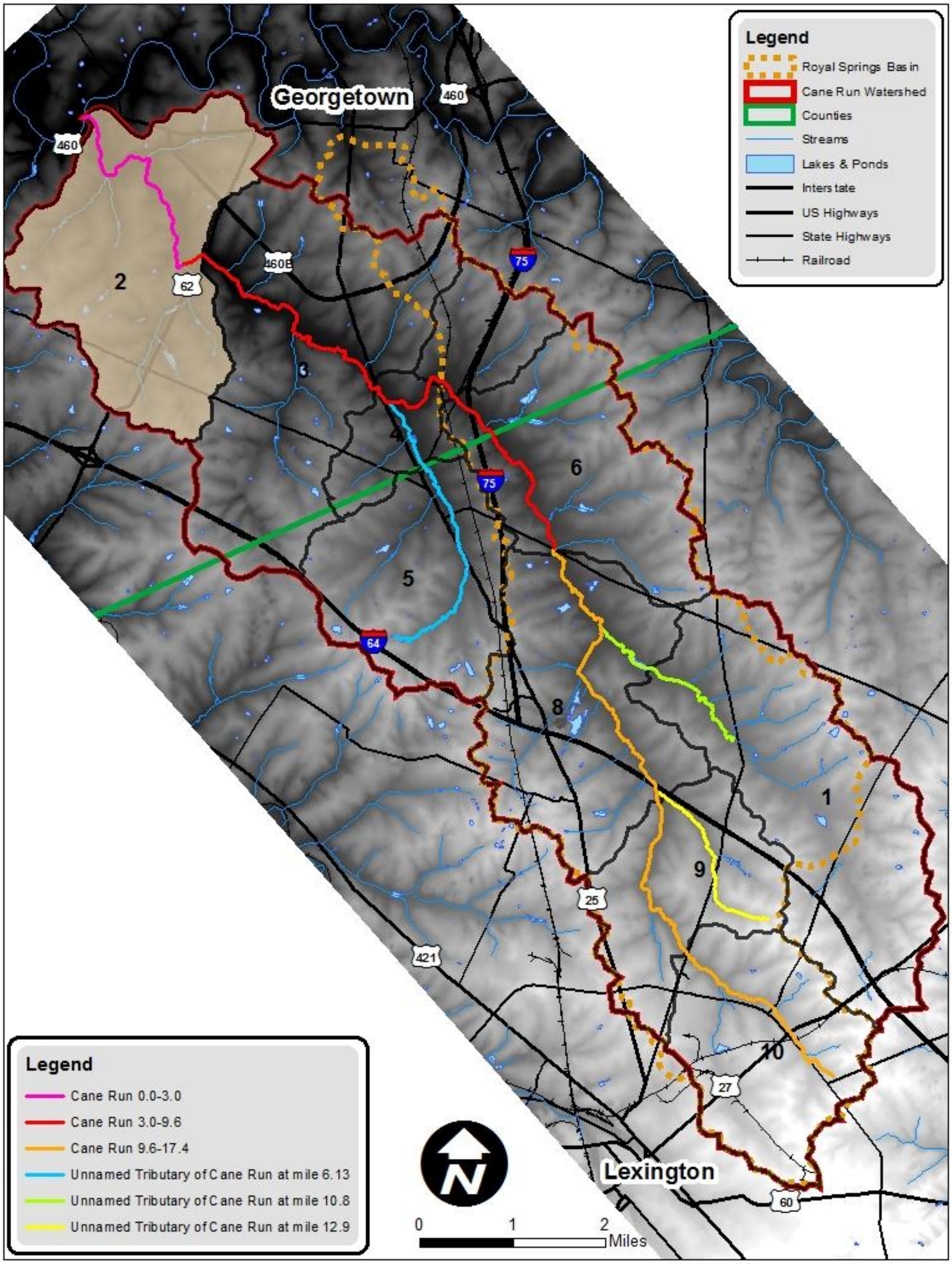

Figure 166. Impaired stream section in Catchment 2

Point Sources

There are several possible sources of point source pollution within Catchment 3, including Class V injection wells, failing onsite wastewater treatment systems, and straight pipes (Figure 167). These point sources contribute mainly to bacteria and nutrient pollution.

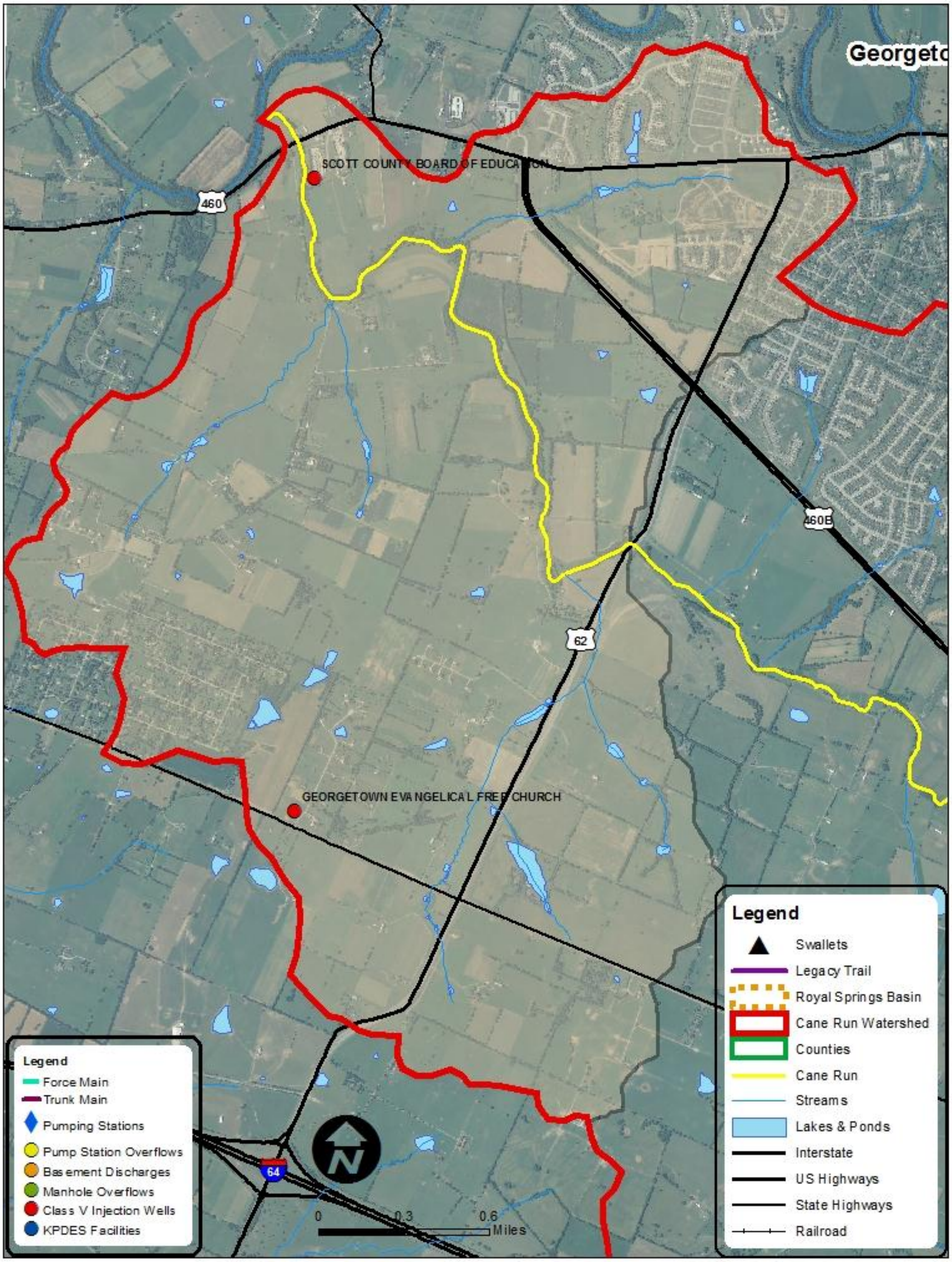

Figure 167. Potential point sources in Catchment 2

Class V Injection Wells

Class V injection wells are used to dispose of non-hazardous fluids into or above underground sources of drinking water and can pose a threat to ground water quality if not managed properly. Most Class V wells are shallow disposal systems that depend on gravity to drain fluids directly in the ground.[83] There are many different types of Class V injection wells, but in Catchment 2, there are 2 wells, both of which are large capacity septic systems (LCSS) (Table 150).

LCSSs are an on-site method for partially treating and disposing of sanitary wastewater. Many conventional LCSSs consist of a gravity fed, underground septic tank or tanks, an effluent distribution system, and a soil absorption system. LCSSs may also include grease traps, several small septic tanks, a septic tank draining into a well, connections to one large soil absorption system, or a set of multiple absorption systems that can be used on a rotating basis. Fluid typically injected into LCSSs includes sanitary wastewater from a wide variety of establishments, and the characteristics of the sanitary wastewater from these establishments vary in terms of biological loadings and flow, which makes LCSSs vulnerable to spills; therefore, the probability of point source pollution originating from Class V injection wells in this catchment is high[84].

Table 150. Class V injection well locations in Catchment 2

EPA ID	Company Name	Address	Well Type
KYV209001	Scott County Board of Education	2168 Frankfort Rd., Georgetown, KY	Large capacity septic system
KYV209001	Georgetown Evangelical Free Church	101 Grayson Way, Georgetown, KY	Large capacity septic system

Failing Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (OWTSs) include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g. septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. THE U.S. EPA (2002a) states that properly functioning OWTSs can remove fecal coliforms with an efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column[85]. Failing OWTSs are assumed to have a removal efficiency of zero.

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[83] U.S. Environmental Protection Agency. "Well Types." Retrieved on May 9, 2011 from: http://water.epa.gov/type/groundwater/uic/class5/types.cfm

[84] U.S. Environmental Protection Agency. "Class V UIC Study Fact Sheet: Large-Capacity Septic Systems." Retrieved on May 9, 2011 from: http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_lg_sept_wells.pdf

[85] U.S. Environmental Protection Agency. 2001. Onsite Wastewater Treatment Systems Manual. 2002. EPA 625-R-00-008. U.S. Environmental Protection Agency.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the Cane Run Watershed. Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). This was necessitated due to the lack of relevant sewage disposal survey data in the 2000 census data. For the purposes of this study, it was assumed that 2.5% of the septic systems were failing[86]. To be conservative, fractional numbers were rounded up to the nearest integer. Based on these assumptions, there are 4 failing OWTSs in Catchment 2 that contribute a fecal coliform load of 1.63E+09 cfu/day.

Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into Cane Run, although the exact number and location are unknown.

Estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. Based on these assumptions, there are 4 straight pipes in Catchment 2 that contribute a fecal coliform load of 3.03E+10 cfu/day. These straight pipes, along with the failing OWTSs in the catchment, contribute a phosphorus load of 3.624 lbs/day, which is the highest phosphorus loading from illegal point sources out of all of the catchments.

Nonpoint Sources

There are several potential nonpoint sources of pollution within Catchment 2 of the Cane Run and Royal Spring Watershed. These nonpoint sources include agricultural and non-agricultural sources, as there is both developed and agricultural land in this catchment (Table 151 and Figure 168). Land uses and management practices that possibly contribute pollutants to the catchment are listed in the sections below.

Table 151. Land cover in Catchment 2

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture /Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Acres	11.34	483.04	1.11	60.05	28.91	0.00	3330.57	2.67	1.11	**3919**

[86] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

	Open Water	Developed	Barren Land	Forest	Scrub/ Scrub	Grassland/ Herbaceous	Pasture /Hay	Cultivated Crops	Emergent Herbaceous Wetlands	Total
Percent	0.29	12.33	0.03	1.53	0.74	0.00	84.99	0.07	0.03	**100**

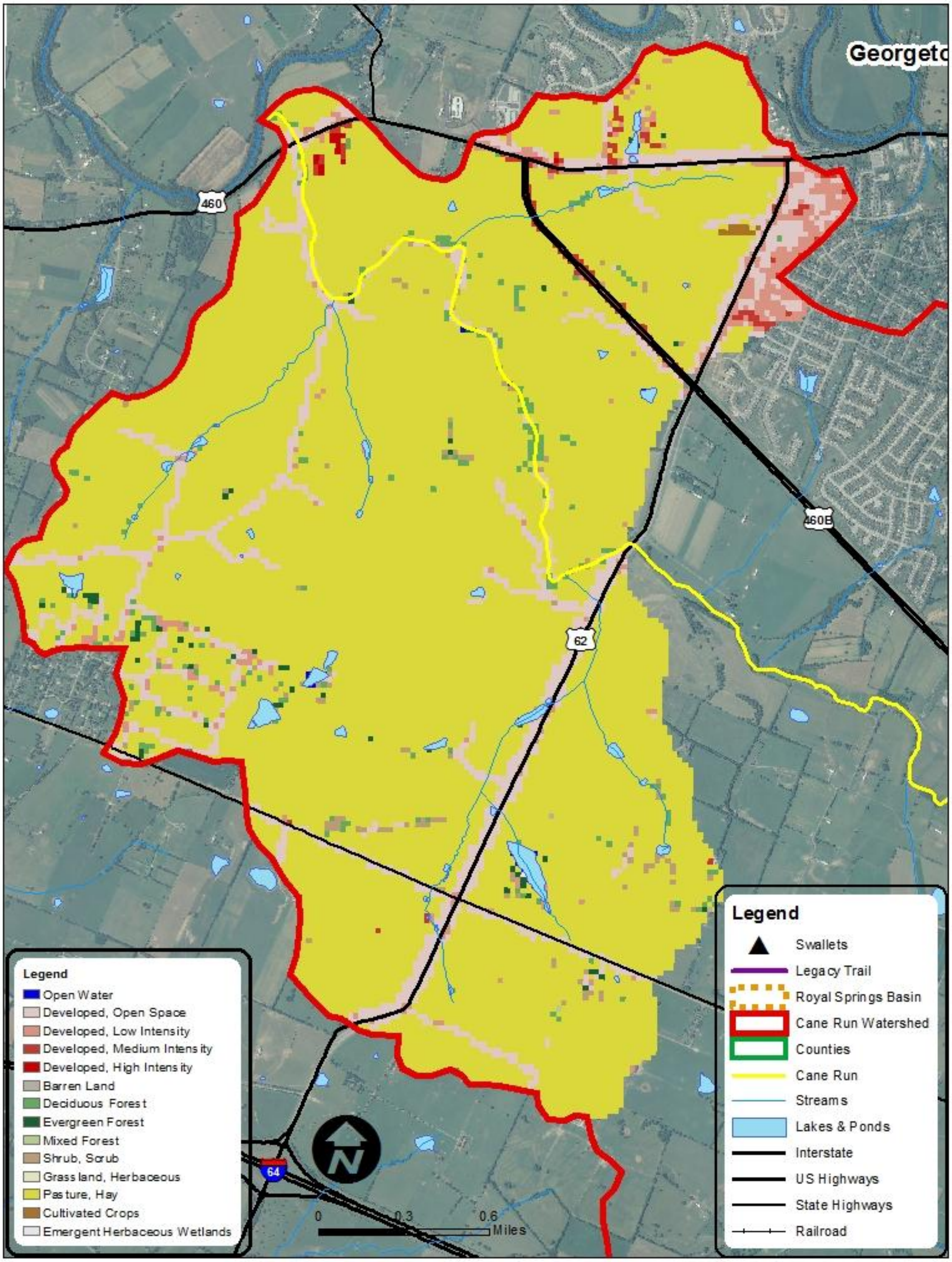

Figure 168. Land cover in Catchment 2

Stream Bank Erosion

Lack of sufficient runoff and erosion controls produces increased stream flow. Even small increases in stream flow can have dramatic effects on stream bank stability: stream depth is often decreased, which forces flow towards the stream banks, and stream banks that are not stabilized by riparian vegetation can break down or even fail.

Non-Developed Land

Stormwater from non-developed land can carry pollutants from a variety of different sources, including agriculture and wildlife. Bacteria loads have been broken down by specific source and are discussed below; however, phosphorus loads have been calculated for all non-developed land together, and in this catchment, non-developed land contributes a phosphorus load of 3.595 lbs/day.

AGRICULTURAL EROSION

In agricultural settings, sediment originates from eroding cropland and overgrazing of pastureland and woodland areas. Most farmers manage their woodland and riparian areas as part of their pastureland, which causes damage to the vegetation and to soil resources. Some agricultural lands within the Cane Run Watershed are overgrazed, including those found in Catchment 2. When overgrazing occurs, vegetation is lost. Vegetation holds soil in place, and when it is lost, soil is left bare, and the potential for erosion increases. When soil erodes, it is detached from the ground, carried by wind or water, and deposited, often in surface water resources. Sediment and the accompanying nutrients and pesticides can dramatically affect the aquatic habitat.

AGRICULTURAL FERTILIZERS

Manure and fertilizers used within Catchment 2 to promote agricultural production add phosphorus and other nutrients to soils that are already near their holding capacity. Horse muck, obtained from horse stalls, also contributes nutrients to the Cane Run Watershed through the improper disposal of muck in unmanaged piles on remote areas of farms. Lawn fertilizers to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing. Nutrients from all of these sources make their way into streams through stormwater runoff, which picks up nutrients left on the surface. Once in streams, nutrients can cause eutrophication, a state in which little oxygen exists in the water and aquatic life cannot survive. These nutrients can also leach through the soil and into the groundwater when applied beyond the soil’s holding capacity.

WILDLIFE

The Cane Run Watershed is home to a variety of wildlife, including ducks, geese, deer, beavers, and raccoons. Wildlife tends to congregate in riparian corridors or near water bodies in the watershed, because these areas provide water, food, and a respite from urban development. As a result, wildlife, and the associated waste, can have an impact on bacterial numbers in the streams.

The U.S. EPA's Bacterial Indicator Tool (BIT) provides a population density for each kind of animal for a particular land use[87]. The number of acres associated with each non-developed land use in each catchment can be multiplied by the corresponding population densities for each animal then aggregated to get the wildlife population by catchment. The estimated wildlife population present in Catchment 2 and their daily fecal coliform load contribution, which is the second highest in the Cane Run Watershed, can be found in Table 152.

Table 152. Wildlife population estimates and daily fecal coliform load contribution for Catchment 2

Animal	Population	Fecal count/day
Ducks	56	1.36E+11
Geese	28	1.37E+12
Deer	28	1.40E+10
Beavers	6	1.50E+09
Raccoons	28	3.50E+09

LIVESTOCK

Livestock are generally pastured for grazing throughout Cane Run Watershed. Manure, deposited by grazing cattle and horses onto pastureland, is washed off in stormwater runoff, and pollutants from this manure are delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. In many cases, grazing animals have access to the streams in the area and deposit fecal materials directly to the stream.

When not grazing, animals may be confined to stalls or other confined spaces. Under these circumstances, manure or muck is typically collected into piles or deposited in remote parts of a farm, sometimes in sinkholes. In some instances, this manure may be used on-site as fertilizer. In recent years, a few horse farms in the Cane Run Watershed have begun composting their horse muck prior to application as fertilizer, which helps decrease the potential for pollution coming from this waste[88].

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment, (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). These population estimates for Catchment 2 and their daily fecal coliform load contribution can be found in Table 153. Catchment 2 has the highest fecal coliform load contribution for grazing cattle in all of the Cane Run Watershed, making it an important pollutant source.

[87] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

[88] Oldfield, Carolyn, (2002), Equine Waste BMP Demonstration Project – Demonstrating New Technologies for Composting Stable Muck Onsite and for Handling Stable Muck to Offsite Facilities. Kentucky Division of Water Non-point Source Project Final Report: project number 95-08; Memorandum of Agreement Number M-99004156, 27 pp.

Table 153. Livestock population estimates and daily fecal coliform load contribution for Catchment 2

Animal	Population	Fecal counts/day (land application)	Fecal counts/day (grazing livestock, including cattle in streams)
Hogs	1	5.34E+09	--
Beef Cattle	548	3.85E+11	1.41E+12
Dairy Cattle	61	1.43E+11	--
Chickens	15	7.34E+08	--
Horses	88	4.60E+09	2.94E+10
Sheep	7	--	8.40E+10
Goats	4	--	4.80E+10

Developed Land

Stormwater from developed land carries pollutants from a variety of different sources, including pet waste, lawn fertilizers, and atmospheric deposition. Bacteria loads are attributed mainly to domestic pets and are discussed below; however, phosphorus loads have been calculated for all developed land together, and in this catchment, developed land contributes a phosphorus load of 0.236 lbs/day.

Domestic Pets

In the model used for TMDL development, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. For the purposes of this TMDL, fecal coliform buildup rates for urban areas were determined using the U.S. EPA's Bacterial Indicator Tool (BIT)[89]. For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. The fecal loads from developed land use in a catchment can be estimated by summing the products of the number of acres for each urban land use and its fecal load rate. The resulting loads for Catchment 2 are shown in Table 154.

Table 154. Daily fecal coliform load contributions from developed land in Catchment 2

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util

[89] U.S. Environmental Protection Agency. 2001. Bacterial Indicator Tool available with Basins v. 3.1. Download from EPA website http://www.epa.gov/waterscience/ftp/basins/system/BASINS2/bit.html

Commercial and Services	Mixed Urban	Residential	Trans, Comm, Util
0.00E+00	0.00E+00	3.94E+09	0.00E+00

Lawn Fertilizers

Lawn fertilizers that are used to maintain lawns, business landscaping, and turf production on golf courses are often applied unnecessarily, without prior soil testing on developed lands such as those that cover part of Catchment 2.

Urban Development and Construction Site Erosion

Much of the Cane Run Watershed, and especially Catchment 2, is used for industrial development because of the close proximity to highway infrastructure.

Construction sites are potential sources of erosion: removing vegetation and working with bare soil causes soil to run off in even the smallest storm events. This soil is carried with the water to the Cane Run, polluting the water with sediment. In addition to causing erosion, construction also changes the hydrology of the landscape and increases the quantity and timing of runoff to streams. Urban development brings additional impervious surface, which prevents stormwater from absorbing into the ground. This increases the volume of runoff and decreases the time between a storm event and the typical increase in stream flow.

Monitoring Data Available

A variety of water quality data that gives clarity to these pollution sources has been collected in Catchment 2 (Table 155 and Figure 169).

The Kentucky Water Resources Research Institute (KWRRI) collected in-stream samples in this catchment on a weekly basis from May to October of 2002 to determine the location and magnitude of potential bacteria sources.

Water samples were taken at stations in this catchment in 2006 and 2007 by the Kentucky Division of Water (KDOW) in support of nutrient TMDL development.

The Kentucky Division of Water (KDOW) established bank pins (toe, bankfull and top of bank) in this catchment to assess the physical condition of the stream.

Table 155. Monitoring conducted in Catchment 2

Sampling Entity	Parameters	Sampling Dates	Site IDs
KWRRI	Bacteria	2002	C6
KDOW	Nutrients	2006-2007	04018002
KDOW	Geomorphology	2006-2007	2-8

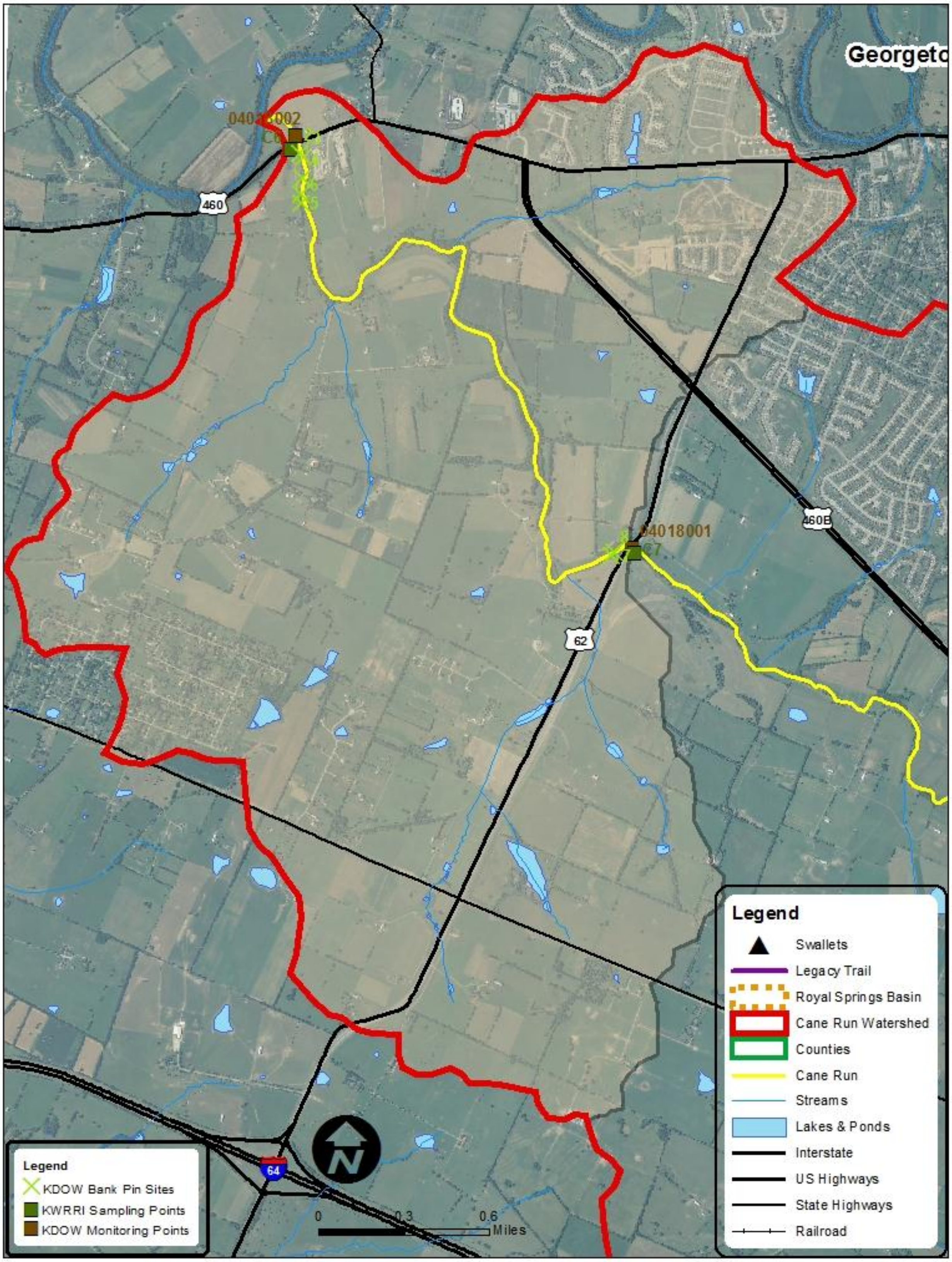

Figure 169. Monitoring points in Catchment 2

Monitoring Conclusions

Geomorphology

The Kentucky Division of Water (KDOW) established bank pins (toe, bankfull and top of bank) at eight locations on the Cane Run within this catchment in November 2008. Six bank pin locations were above the US 460 bridge while two were below the US 62 bridge. The KDOW determined BEHI and NBS values for each location and measured the amount of bank pin exposed for all recoverable bank pins (Table 156). No additional information (e.g. photographs and cross-sectional surveys) were provided by KDOW. University of Kentucky personnel could not locate these monitoring locations to collect additional data. These data indicate the erosion rates within this catchment are quite variable ranging from 0.9 to 7.7 inches of lateral erosion per year with the highest rates generally occurring in areas where NBS was higher.

Table 156. KDOW Average annual erosion deposition rates in Catchment 1

Bank Pin Location	BEHI Ranking	NBS Ranking	Average Annual Erosion/Deposition Rate (ft./yr.)
1	Moderate/High	Low	0.094[1]
2	High	Low	--[1]
3	High	Low/Moderate	0.103
4	Moderate/High	High	0.490
5	Moderate	Low	0.500
6	Moderate	Moderate/High	0.643
7	Moderate	High	0.071[1]
8	Moderate	Moderate/High	0.193

[1]Not all bank pins were recovered.

Water Quality

Bacteria

The monitoring conducted by KWRRI in 2002 confirms the 303(d) listing for this section of stream for fecal coliform. Nearly every sample taken at monitoring point C6 in Catchment 2 exceeded the primary contact standard of 200 colonies per 100 mL and half exceeded the secondary standard of 1,000 colonies per 100 mL (Table 157). This sampling demonstrates that fecal coliform pollution is a problem in Catchment 2.

Table 157. Fecal coliform data from KWRRI monitoring point C6

Date	6/11	6/14	7/2	7/9	7/15	7/22	7/29	9/9	9/23	9/30
Fecal Coliform (cfu/100 mL)	1,497	1,294	4,176	290	5,385	1,144	572	137	789	997

Nutrients

The monitoring conducted in 2006 and 2007 by KDOW demonstrates a problem with nutrient pollution, specifically phosphorus, in this catchment. The geometric mean for site DOW04018002 is above the total phosphorus target of 0.3 mg/L (Table 158), and over half of the individual samples taken by KDOW exceed this total phosphorus target (Appendix K).

Table 158. Nutrient geometric means for DOW04018002

Ammonia (as N, mg/L)	CBOD-5 (mg/L)	Nitrate/ Nitrite (as N, mg/L)	Total Organic Carbon (mg/L)	Orthophosphate (as P, mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Total Kjeldhal Nitrogen (mg/L)
0.059	Not detected	1.35	2.38	0.197	0.326	4.8	0.558

BMP Recommendations and Implementation

The goal of this project is to coordinate watershed efforts and resources to maximize improvements in water quality. Additional benefits will include wildlife habitat restoration, stormwater runoff reduction, an increase in soil infiltration and potentially a reduction in storm surge and increased base flow volumes of water in the stream. Because the Cane Run and its watershed is a highly diverse and dynamic system, it will require a variety of BMPs to meet these water quality goals.

The single overriding aspect to water quality enhancement of the Cane Run Watershed is the linkage between the karst geology (Royal Spring) and the surface stream (Cane Run). Sinkholes and swallets located throughout the upper watershed transmit water directly to the conduit systems associated with the Royal Spring. Only during high flow periods is flow available as surface runoff in many reaches of Cane Run. The largest historical difference in the watershed's upper reaches is the increase in impervious areas such as parking lots, buildings, and homes. The lack of large groundwater recharge areas in the headwaters of the watershed limits the amount of base flow in many stream segments, dramatically reducing aquatic habitats.

The pollutants of interest in the watershed are bacteria, nutrients, and sediment, which require a combination of BMPs to reduce. Based on the 303(d) listing and the water quality data collected in this catchment, the most important pollutants to address in this catchment include fecal coliform, nutrients, and sediment. The most likely sources of these pollutants in Catchment 2 that should be addressed include livestock (grazing and land application), crop production, package plants and other small discharges, unspecified urban stormwater, Class V injection wells, and wildlife.

In order to achieve the total maximum daily loading (TMDL) for bacteria in Catchment 2, the MS4 non-developed loading must be reduced by 28.8 percent and the non-MS4 loading must be reduced by 24.9 percent. These reductions can be achieved by eliminating cattle access to streams, reducing urban loading by 50 percent, reducing overall livestock-generated loads by 50 percent, and eliminating failing septic systems and straight pipes.

Because Catchment 2 lies outside of the scope of the Royal Spring aquifer of the Cane Run Watershed, the Cane Run Watershed Project has not proposed or implemented any BMPs in this catchment.

IX. Information and Education

Watershed restoration is more than just stabilizing stream banks and planting trees. To ensure the long-term stability of a watershed restoration project and to maintain a healthy watershed, the human dimension must be incorporated. Watershed managers must recognize that people are equally important as sound science is for the long-term success of watershed restoration[90]. Considering this, the Cane Run and Royal Spring Watershed Plan should include substantial efforts in education and outreach.

Goals

The Cane Run and Royal Spring Watershed Plan seeks to improve and protect the overall water quality of the watershed such that the stream meets its designated uses, and subsequently is removed from the Clean Water Act Section 303(d) list of impaired waters. To accomplish this goal, education and outreach to watershed stakeholders is essential. The education and outreach goals for this project include:

- Increase awareness of the watershed and potential stream pollutants (non-point source) among stakeholders and visitors
- Increase awareness of human interaction and impact on the watershed
- Increase awareness of best management practices that improve and protect water quality
- Increase awareness of the importance of source water protection
- Increase awareness of healthy streams and methods of restoring impaired streams

Partnerships

To accomplish these educational and outreach efforts, significant collaboration will be necessary. Potential partners include, but are not limited to, the following organizations: University of Kentucky (UK), UK Cooperative Extension Service, Tracy Farmer Center for the Environment, Lexington-Fayette Urban County Government, Kentucky Division of Water, Kentucky Division of Conservation, Kentucky River Watershed Watch, Bluegrass PRIDE, Bluegrass Partnership for a Green Community, Fayette County Conservation District, Fayette County Public Schools, Scott County Public Schools, Cane Run Watershed Council, Friends of Cane Run, Lexmark, Inc., Kentucky Department of Transportation, Bluegrass Rain Garden Alliance, KY Excel businesses, neighborhood associations, KDFWR, 2010 WEG Foundation, Thoroughbred Resource Conservation and Development Council, and the Kentucky Horse Park.

Implementation

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[90] United States Department of Agriculture. U.S. Forest Service. *Wildland Waters: The Social Side of Watershed Restoration*. Spring 2006. FS-848.

Considering the mixed-use nature of the Cane Run Watershed, it is important to have a diverse education and outreach toolbox. Activities will be tailored to fit specific interest groups as described in the following sections. Each section is divided into proposed activities and implemented activities.

Watershed Residents

Proposed

- Educate residents about the importance of keeping pet waste out of the stream
- Educate residents on low-input lawn care, and lawn care practices that are environmentally friendly
- Provide a means for residents to recycle used oil
- Educate residents on the importance of keeping waste out of storm drains
- Educate residents about proper septic tank installation and maintenance
- Utilize local community centers, schools, and libraries to disseminate information
- Educate landowners about the Kentucky Agriculture Water Quality Act, and assist landowners in completing Agriculture Water Quality Plans as applicable
- Produce low-literacy and bilingual publications and educational materials to distribute to residents

Implemented

- A meeting was organized in conjunction with the Spindletop Estates Neighborhood Association to introduce residents to the watershed project on October 7th, 2008. Several members of the Spindletop Estates Neighborhood Association are members of the Cane Run Watershed Council.
- In July 2009 UK employees associated with the Cane Run Watershed Project met with the property manager at Paddock Apartments about water quality issues and the Cane Run Watershed and installed a watershed sign on their property.
- In January 2010 UK employees associated with the Cane Run Watershed Project met with Fayette Co 2nd District neighborhood association presidents to discuss work in through their organizations on the Cane Run project.
- Lexington-Fayette Urban County Government (LFUCG) partnered with UK's Cane Run Watershed Project to conduct a watershed festival in the Cane Run on August 20, 2010. This festival included workshops on watersheds (and the Cane Run Watershed specifically), displays and booths for local environmental organizations, music, and free food (Figure 170 and Figure 171). Over 300 people attended.

Figure 170. Workshops at the Cane Run Watershed Festival; A watershed resident participating in the Cane Run Watershed Festival

Figure 171. Watershed residents at the Cane Run Watershed Festival

- On August 23, 2010, 25 students and 3 staff members from the University of Kentucky participated in a water quality education and outreach program within Catchment One of the Cane Run Watershed.
  - This event was held in the Green Acres Neighborhood and coordinated as a partnership between UK and LFUCG Division of Environmental Policy. The goal was to create a community outreach opportunity for UK students that would provide information to residents of Green Acres about how they can improve water quality.
  - The event began with providing the students with the definition of a watershed, a description of the Cane Run Watershed, its water quality issues and what steps both the University and LFUCG are taking towards improved water quality. More specifically, issues related to the Green Acres Neighborhood were discussed, as well as the recent Watershed Festival.
  - The group was then provided with literature produced by LFUCG and UK. This included one tri-fold brochure titled "Cane Run Watershed Assessment and Restoration Project", one bi-lingual

info sheet on the “Do’s and Don’ts of FOG (Fats, Oils, and Grease)” and one sheet called “Storm Drain Stenciling in Your Neighborhood” (Figure 172).

Figure 172. Literature provided to Green Acres residents during UK Fusion event

- After educating the volunteers on the issues, they were then instructed on how to interact with the residents and how to paint the storm drain stencils (Figure 173). They were also provided with plastic lids to distribute in combination with the FOG literature. These lids are used with any typical can to contain fats, oils and greases for proper disposal.
- The volunteers were divided into three teams and given maps of the neighborhood surrounding Green Acres Park. Each team covered a different area and was provided with literature and lids to distribute to homeowners, a stencil kit to paint storm drains and trash bags to collect trash or recyclables. As a result, the volunteers were able to stencil 45 storm drains and spoke with nearly 64 residents.

Figure 173. Volunteers learning how to paint storm drain stencils

- To conclude the project, volunteers discussed their observations, interactions with residents, and feedback received. Because the event occurred between noon and 2:00pm, over half of the residents were at work rather than at home. However, most homeowners the volunteers spoke with were receptive to the information and seemed appreciative of the work. Some of the residents mentioned they had attended the watershed festival and were already aware of the water quality issues. The volunteers provided suggestions to improve the event and concluded that the project was an overall success.

- A Cane Run cleanup was held September 18, 2010 by Cane Run Watershed Council members and volunteer residents as a follow-up to watershed festival in August. Ten participants from five neighborhoods were present.
- In November 2010, UK employees associated with the Cane Run Watershed Project worked with the Paddock Apartments manager and LFUCG personnel to address invasive vegetation removal along main channel of Cane Run creek near the Paddock Apartments.
- In the spring of 2011, UK employees associated with the Cane Run Watershed Project met with the Castlewood Neighborhood Association to promote the Cane Run Watershed Project and engage the residents in the planned 2011 watershed festival.
- In the spring and summer of 2011, the Cane Run Watershed Council planned for the second annual Cane Run Watershed Festival to be held August 12, 2011.
- UK staff associated with the Cane Run Watershed Project, in conjunction with the Cane Run Watershed Council, LFUCG, and other partners held the second annual Cane Run Watershed Festival on August 12, 2011. Two hundred and forty-four people attended, and workshop topics included green lawn care,

green auto care, watersheds 101, rain gardens, rain barrels, fats/oils/grease, and recycling (Figure 174 and Figure 175).

Figure 174. Sponsors of the 2011 Cane Run Watershed Festival; Activities at the 2011 Cane Run Watershed Festival

Figure 175. Activities at the 2011 Cane Run Watershed Festival; Workshop tents at the 2011 Cane Run Watershed Festival

Businesses

<u>Proposed</u>

- Promote local recycling programs to business owners
- Educate business owners about litter abatement
- Educate business owners about low-impact development and landscaping options
- Educate business owners about storm water issues

<u>Implemented</u>

- UK employees associated with the Cane Run Watershed Project helped to plan and participated in Lexmark's Cane Run cleanup event during Earth Week (April) in 2008, 2009, 2010, and 2011.
- In January 2010, UK employees associated with the Cane Run Watershed Project met with KY Horse Park staff to prepare for the installation of additional streamside vegetation BMPs.
- In March 2010, UK employees associated with the Cane Run Watershed Project gave a presentation at Lexmark's Sustainability Lunch Series on Cane Run project and Lexmark's involvement in honeysuckle removal and stream clean-up.
- In July 2010, UK employees associated with the Cane Run Watershed Project met with WLEX-TV officials and assisted in their application for an incentive grant from LFUCG. This grant, described in the "Visitors and General Public" section below, was awarded in November 2010.
- In the spring of 2011, UK employees associated with the Cane Run Watershed Project met with Lexmark to coordinate spring cleanup events.
- In the spring of 2011, UK employees associated with the Cane Run Watershed Project met with the Lexington Art League to discuss possible partnership opportunities for the Cane Run Watershed Festival planned for August 12, 2011.

Schools

<u>Proposed</u>

- Provide professional development opportunities focused on watersheds and water quality protection for teachers in the watershed
- Partner with Fayette County Public Schools and Scott County Public Schools in the watershed to involve students in community-based science projects.
  - Community-based science projects engage teachers and students in real world issues in their local communities. The projects apply science concepts to field experiences, and help students learn how science is conducted and how citizens can become involved in and have an impact on their own neighborhoods.
  - We will work with a variety of schools in the Cane Run Watershed to conduct professional development for teachers and develop community watershed projects with the students. The students will help design the projects by asking questions such as:
    - What is a watershed?
    - What is my watershed?
    - How do I impact my watershed?
    - How do urban activities impact the Cane Run?
    - How does agriculture impact the Cane Run Watershed?

    - How will the 2010 World Equestrian Games impact the Cane Run Watershed?
    - What does the rural/urban interface look like in the Cane Run? What does this mean for Georgetown's water supply?
- The teachers and students will work side by side with natural resource professionals to answer these and other questions throughout the school year. Students will participate in a culminating event, such as a watershed symposium or mini-conference, to share their new knowledge with other students, teachers, and schools.

<u>Implemented</u>

- Steve Workman, of the Cane Run Watershed Project, participated in the Water Issues in the Bluegrass panel discussion on April 23, 2008, as part of UK's Earthdays in the Bluegrass.
- UK employees associated with the Cane Run Watershed Project displayed information about the Cane Run Watershed at the UK Sustainability Showcase in the springs of 2009 and 2010.
- In July 2009 and July 2010, UK employees associated with the Cane Run Watershed Project conducted a four-day educational workshop for UK's Robinson Scholars program focused on the Cane Run Watershed. Twenty-nine high school juniors participated each year. Students produced videos about the Cane Run, including their suggestions for improving water quality.
- In October 2009, UK employees associated with the Cane Run Watershed Project piloted the Southern Region 4-H_2O Ambassador Program in the Cane Run Watershed with fourth and fifth graders at Russell Cave Elementary School. The program included four units, each of which focused on a specific question related to watersheds and water quality. Each unit included hands-on, investigative activities that were conducted at school and during an overnight environmental camp. After students completed all units, they became Southern Region 4-H_2O Ambassadors and were required to develop and implement a community-based service project.
- In the fall of 2009, spring 2010, and fall 2010, UK employees associated with the Cane Run Watershed Project presented Cane Run project information to UK Natural Resources Conservation and Management courses.
- In January 2010 and 2011, conducted a water quality tour on the UK farm in context of the Cane Run Watershed for a UK Agroecology course.
- In March 2010, UK employees associated with the Cane Run Watershed Project assisted teachers and students at Russell Cave Elementary to design and conduct the community service project component of the 4H_2O Ambassador Program. Students cleaned up the Green Acres Park and a Cane Run tributary and performed watershed skits in English and Spanish (Figure 176).

Figure 176. Students learning about watersheds; Students participating in the cleanup of Green Acres Park

- In April 2010, UK employees associated with the Cane Run Watershed Project presented Cane Run project information to a UK Civil Engineering Watershed Management class.
- In the spring of 2010, fifth graders at Royal Springs Middle School were introduced to the topic of riparian buffers. UK staff used the school's streamside buffer as a teaching facility to identify trees and to explain biodiversity and the relationship between vegetation and water quality. The children were engaged in conversation to identify prominent locations within the Cane Run Watershed, discuss water issues and present ideas and practices to promote better watershed stewardship.
- In September 2010, UK employees associated with the Cane Run Watershed Project met with a high school environmental science teacher at Bryan Station High School to plan a watershed education module for spring 2011.
- In October 2010, UK employees associated with the Cane Run Watershed Project presented Cane Run Watershed overview for Bryan Station High School Environmental Science class.
- UK employees associated with the Cane Run Watershed Project coordinated a Cane Run clean up with the Alpha Phi Omega service fraternity on November 13, 2010 near the Paddock Apartments.
- On January 21, 2011, UK employees associated with the Cane Run Watershed Project conducted a water quality tour on the UK farm in context of the Cane Run Watershed. Twenty UK Agroecology students participated.
- In February 2011, UK employees associated with the Cane Run Watershed Project participated in the University of Kentucky's Center for Applied Energy Research's Energy Fair for elementary school

students by demonstrating the definition of a watershed and the water quality problems in the Cane Run Watershed.

- In the spring of 2011, a UK employee associated with the Cane Run Watershed Project presented Cane Run riparian buffer information as part of the UK Soil Science Seminar series.
- In the spring of 2011, UK employees associated with the Cane Run Watershed Project coordinated a creek clean up and willow planting event with Alpha Phi Omega service fraternity. The event took place on March 25, 2011 near the Paddock Apartments, and 14 students participated.
- In the summer of 2011, 31 UK students cut down honeysuckle along the Cane Run as part of the Great American Cleanup and learned about the Cane Run Watershed.
- In the summer of 2011, 22 high school FFA students removed honeysuckle along the Cane Run as their Day of Service at their state convention.
- In the summer of 2011, 22 Bryan Station High School environmental science students were given a tour of the Cane Run Watershed and also conducted water testing in the stream.
- In the summer of 2011, UK staff associated with the Cane Run Watershed Project conducted a four-day educational workshop for UK's Robinson Scholars program focused on the Cane Run Watershed. Twenty-nine high school students participated and produced videos about the Cane Run, including their suggestions for improving water quality.
- In late August 2011, student volunteers with UK Fusion worked in the Cane Run Watershed. One group conducted storm drain stenciling and educational material distribution, while the other group worked at the Kentucky Horse Park, maintaining the riparian buffer created in the summer of 2010.
- UK staff associated with the Cane Run Watershed Project presented Cane Run project information to a senior-level UK Natural Resources and Environmental course in August 2011.
- In September of 2011, UK staff associated with the Cane Run Watershed Project represented the project at Big Blue Goes Green, a sustainability showcase at the University of Kentucky.

2010 FEI World Equestrian Games

Proposed

- Work with the WEG planning committee to implement low-impact development and riparian area protection during pre-Games construction
- Promote proper horse muck composting and/or disposal to the WEG planning committee.
- Create educational exhibits to be displayed at 2010 FEI World Equestrian Games
- Work with Kentucky Horse Park to install watershed signage inside the park

Implemented

- In March and April 2010, UK employees associated with the Cane Run Watershed Project worked with KY Horse Park and M2D Designers on education/outreach component of the stream vegetation project at the Horse Park.
- UK employees associated with the Cane Run Watershed Project hosted students from UK's Alpha Phi Omega service fraternity at the Kentucky Horse Park. Students installed willow stakes at the riparian buffer vegetation project site April 9, 2010 (Figure 177).

Figure 177. Students in a UK service fraternity planting willow stakes

- UK employees associated with the Cane Run Watershed Project conducted a volunteer planting event for the stream vegetation project at the Kentucky Horse Park on May 10, 2010 (Figure 178).

Figure 178. Volunteers planting a riparian buffer at the Kentucky Horse Park

- UK employees associated with the Cane Run Watershed Project provided a guided tour of the Kentucky Horse Park stream vegetation project for Egyptian Sustainability delegation on September 11, 2010.
- Kentucky Horse Park stream vegetation project was featured in a Lexington Herald-Leader news article and kyGREENtv news clip on greening of the World Equestrian Games in September 2010 (http://seebluegogreen.wordpress.com/2010/10/04/ky-horse-park-and-legacy-trail-going-green/)
- To reduce the environmental impact of the Alltech FEI World Equestrian Games (WEG), UK staff served as attendants and volunteer coordinators for "Eco-stations" within the park during the Games (September 2010-October 2010). These stations consisted of separate bins for compost, recyclables and trash. Eco-station attendants assisted WEG visitors with separating their waste and disposing of the right material into the proper receptacle.
- The Kentucky Horse Park Stream Vegetation Project received an LFUCG Environmental Commission award on October 22, 2010.

Visitors and General Public

<u>Proposed</u>

- Install watershed signs that will identify the watershed, and create a sense of place for residents and visitors
- Create and install project-specific signs, identifying best management practices implemented
- Host field days in the watershed for county Extension agents, state and federal agency personnel, watershed professionals, and residents to share successes and demonstrate watershed protection efforts
- Create educational materials to distribute to watershed residents, students, visitors, and professionals

Implemented

- The Cane Run Watershed Council was formed in December 2007 in an effort to involve all stakeholders in the development of this WBP and the subsequent implementation of the proposed activities. The Cane Run Watershed Council held its first meeting on 12/18/07. The second meeting was held on 4/9/08 with an election of officers for the Friends of Cane Run. UK employees associated with the Cane Run Watershed Project have conducted and attended quarterly Cane Run Watershed Council meetings since the Council's inception in December 2007.
- Beginning in 2008, UK employees associated with the Cane Run Watershed Project have developed and enhanced the Cane Run Watershed website: www.canerunwatershed.org.
- Steve Higgins, of the Cane Run Watershed Project, presented an overview of the Cane Run Project at the Kentucky Water Resources Research Institute Annual Meeting on March 17, 2008.
- UK employees associated with the Cane Run Watershed Project displayed Cane Run Watershed information at Lexington's Reforest the Bluegrass volunteer tree planting event in April 2009 and April 2010.
- UK employees associated with the Cane Run Watershed Project gave a presentation at the National Water Quality Conference on the Cane Run Robinson Scholars education project, February 2010.
- UK employees associated with the Cane Run Watershed Project conducted a tour of the Cane Run Watershed for the Campus Community Partnerships for Sustainability conference on April 18, 2010.
- Video, audio and print media releases of the 4H2O project were created by UK's Agriculture Communications department. Audio spotlight was featured on WUKY's Spotlight on UK segment in the spring of 2010.
- UK employees associated with the Cane Run Watershed Project received a University of Kentucky Commonwealth Collaborative award for further education and outreach in the Cane Run Watershed in the spring of 2010.
- UK employees associated with the Cane Run Watershed Project promoted the Cane Run Watershed project and KY Horse Park stream vegetation project at a Turner Foundation fundraising event at the Governor's mansion on May 15, 2010.
- UK employees associated with the Cane Run Watershed Project represented the Cane Run project at a press conference promoting pervious concrete on the Legacy Trail on June 8, 2010.
- Two tri-fold brochures were developed in July and August 2010 by UK employees associated with the Cane Run Watershed Project for education and outreach: Streamside Buffer Zones (http://www.ca.uky.edu/enri/PUBS/Streamside%20buffer%20zones%208-4-10.pdf) and Stream Management for Horse Owners (http://www.ca.uky.edu/enri/PUBS/Stream%20Management%20tri-fold%207-16%20(2).pdf). These brochures were made available for visitors to the World Equestrian Games. See Appendix EE for complete copies of these brochures.

- UK employees associated with the Cane Run Watershed Project met, on multiple occasions, with the Legacy Trail narrative committee to present important information about the Cane Run Watershed and develop sign text and graphics. Three permanent Cane Run Watershed signs were finalized and installed along the Legacy Trail in September 2010 (Figure 179 and Figure 180). At present, the entire Legacy Trail is located within the Cane Run Watershed. It starts at the Isaac Murphy Memorial Art Garden on Loudon Avenue and terminates at the Kentucky Horse Park. Much of the 12-mile trail runs along the main channel of Cane Run and its tributaries. For more information about the Legacy Trail, see Appendix FF.

Figure 179. Cane Run Watershed educational signs posted along the Legacy Trail

Figure 180. Cane Run Watershed educational signs posted along the Legacy Trail

- UK employees associated with the Cane Run Watershed Project displayed information about the Cane Run Watershed at the grand opening event for the Legacy Trail on September 12, 2010.
- WLEX-18 is a television station located within the Cane Run Watershed and has been identified as a key partner in potential education and outreach programs. In November 2010, WLEX-18 was awarded a

Class B Education Grant from LFUCG's Stormwater Quality Projects Incentive Grant Program worth $115,869.06. This grant will fund a 10-month campaign titled "Water Quality is Everyone's Responsibility", which will include writing, production, and airing of 30-second vignettes on water quality and stormwater issues. These vignettes will be distributed throughout LEX18 programming with an emphasis on news and will also run on the Fuel View two times per hour at 13 Fayette County Shell gas stations. The LEX18.com website will be updated with a water quality splash-page, which will include "how-to" information, water quality protection tips, links, and the vignettes. This project will be further enforced by other activities outside of the grant project, including quarterly or monthly water quality segments by local reporters on LEX18 News @ 12:30 p.m. This project shows WLEX-18's commitment to water quality in the Cane Run Watershed and throughout Lexington and will be able to provide sound water quality information for the citizens of Central Kentucky in an accessible way.

- As part of a series addressing stormwater, UK employees, some associated with the Cane Run Watershed Project, developed a new UK Cooperative Extension publication on rain barrels. The new manual, *Building a Rain Barrel (Publication HENV-201, http://www.ca.uky.edu/agc/pubs/henv/henv201/henv201.pdf)*, is now available to download from the College of Agriculture website. More often, paying $100 or more for a pre-fabricated rain barrel appears to be a barrier for many people to engage in this water-wise practice. This information will be used as a manual for anyone interested in building their own rain barrel. Step by step instructions, a materials list and an illustrative diagram will help many people to address water issues with their own hands. This publication will serve water quality improvements to not only Cane Run, but also watersheds across the Commonwealth. To review the full document, see Appendix GG.
- UK employees associated with the Cane Run Watershed Project gave a poster presentation on the overall progress of the Cane Run Watershed Project at the 2011 National Water Conference.
- In the spring of 2011, UK employees associated with the Cane Run Watershed Project represented the Cane Run Watershed Project at the UK Watershed Center of Excellence press conference and planning meeting.
- In the spring of 2011, UK employees associated with the Cane Run Watershed Project gave a poster presentation on the overall progress of the Cane Run Watershed Project at the Kentucky Water Resources Research Institute's Annual Symposium.
- In March 2011, UK employees associated with the Cane Run Watershed Project created a UK Cane Run YouTube page: http://www.youtube.com/user/UKCaneRun.
- In the spring of 2011, the Cane Run Watershed Project shared Cane Run Watershed signage with the Wolf Run Watershed Project for use in the Wolf Run watershed.
- On April 16, 2011, UK employees associated with the Cane Run Watershed Project shared information about the Cane Run at Reforest the Bluegrass.
- On April 20, 2011, UK employees associated with the Cane Run Watershed Project shared information about the Cane Run at the Wolf Run Watershed Cleanup and Festival.

- In May 2011, UK employees associated with the Cane Run Watershed Project gave a tour of the Cane Run Watershed to attendees of the Kentucky/Southeast Exotic Pest Plant Council.
- In May 2011, UK employees associated with the Cane Run Watershed Project gave a tour of the Cane Run Watershed to the Kentucky Fish and Wildlife Stream Mitigation Group.
- On May 21, 2011, UK employees associated with the Cane Run Watershed Project shared information about the Cane Run at McConnell Springs Founders Day.
- In June 2011, UK employees associated with the Cane Run Watershed Project created a Facebook page for the Cane Run Watershed: http://www.facebook.com/#!/pages/Cane-Run-Watershed/161109487292474.
- In August 2011, UK employees associated with the Cane Run Watershed Project created and installed watershed signage along the Legacy Trail (Figure 181).

Figure 181. A Cane Run identification sign near a bridge along the Legacy Trail

- Various BMPs installed at the University of Kentucky North Farm as part of this project were highlighted in the Fall 2011 edition of The. Ag. Magazine, published by the University of Kentucky College of Agriculture (http://www.ca.uky.edu/agcomm/magazine/2011/FALL2011/Articles/NewsInBrief.htm).
- UK staff associated with the Cane Run Watershed Project provided a watershed tour and field trip for the Midwest Groundwater Conference.

X. Future Work

Catchment Prioritization for BMP Implementation

BMP implementation and other projects that improve water quality can be prioritized by catchment based on the water quality data collected in and the TMDLs developed for the Cane Run Watershed. Based on this data (discussed in the catchment analyses in Chapter VIII), the following prioritization has been compiled for the upper Cane Run Watershed. Future work will be prioritized based on these priority catchments, and the work planned for the near future is also included for each of these catchments. Lower watershed catchments cannot be included in this prioritization, as insufficient water quality data has been collected.

1. Catchment 10

Current State

All of the monitoring data collected in Catchment 10 indicates that the catchment is extremely polluted, and the pollution source assessment indicates that much of this pollution likely stems from a faulty sanitary and storm sewer system. LFUCG plans to spend approximately $800 million dollars over the next 30 years to upgrade the sanitary sewer system throughout the county, which will improve the water quality in Catchment 10. Because much of the land area within Catchment 10 is covered by the Consent Decree between LFUCG and the EPA, BMPs cannot be implemented in this area using Kentucky 319(h) Program funds; however, LFUCG and other stakeholders within the catchment can implement a diverse array of projects that would improve water quality once the sanitary and storm sewer infrastructure is improved.

Planned Work

Lexington Fayette Urban County Government

SANITARY AND STORM SEWER REPAIRS

LFUCG will continue to find and fix sanitary and storm sewers within the Cane Run Watershed as part of the Consent Decree (Appendix B). UK and KDOW will work in conjunction with LFUCG to prioritize sanitary sewer issues in the Cane Run Watershed. A remedial measures plan for the Cane Run sewershed is expected by the fall of 2011. Over the next 30 years LFUCG will spend $800 million to repair failing sanitary and stormwater systems throughout the county.

SANITARY AND STORM SEWER DATABASE

The Lexington-Fayette Urban County Government (LFUCG) Division of Water Quality is required, by the United States Environmental Protection Agency (U.S. EPA) and the Commonwealth of Kentucky, to comply with environmental laws and regulations relating to the operation and maintenance of sanitary and storm water sewer systems. LFUCG has agreed to a Consent Decree that requires Lexington to study, design and implement various projects and to repair sewer pipes and to improve wastewater treatment plants to bring the city in compliance with the Clean Water Act. The city will track all aspects of those projects and repairs as well as the day-to-day activities associated with properly maintaining the sanitary and storm water sewer systems. The city will centralize data from various sources and employ technology to monitor, manage and report per the EPA compliance requirements.

Currently, when LFUCG receives a work order for the storm or sanitary sewer system in the Cane Run Watershed, it takes an average of 177 days for the work order to be addressed, and the records of each work order vary in quality and accessibility. In order to ensure compliance with the Consent Decree and improve response time and system organization, LFUCG has contracted with Accela Inc. to develop a way to monitor and manage all activity relating to the inspection, repair and maintenance of both the sanitary and storm sewer systems. Accela's software platform will provide a single web-based application for use by LFUCG staff in managing the operation and maintenance of the sanitary sewer and stormwater conveyance systems. It will also fully integrate LFUCG's GIS-based database inventories (e.g. mapping) of the City's stormwater and sanitary sewer system assets with parcel data, maintenance work order systems, customer service requests, preventative maintenance scheduling, inspections, and new development.

Lexmark

General Goals

Lexmark has been committed to projects that have a positive impact on the Cane Run Watershed and plans to remain committed to new projects that will continue to improve the water quality of the Cane Run. As future work progresses, Lexmark's goal is to open the stream to more filtered light and other types of tree growth. The entire ecosystem has improved as a result of previous work that exposed the stream (invasive species removal), which also increased vegetation growth and the numbers of fish, crawfish, duck, raccoon, weasel, kingfish, and hawk on Lexmark's main campus.

Stream Cleanup and Honeysuckle Removal

In the coming years, Lexmark would like to focus restoration and cleanup efforts on the section of the Cane Run that leaves Shady Brook Park and extends to the Newtown Pike/Nandino Boulevard intersection. At this location, the Legacy Trail crosses the Cane Run with a small bridge. This entire section has a very dense thicket of bush honeysuckle, and Lexmark would like to clear this entire area so that the stream could be visible from the trail. Lexmark has already seen the improved creek conditions that this type of activity has resulted in at the Main Plant Site and would like to use the Legacy Trail bridge as an opportunity to address issues affecting this section of the creek. Lexmark sees this site as a potential area for future Cane Run Cleanups and honeysuckle removal efforts and also as an opportunity to partner with UK, LFUCG, and other entities interested in improving the quality of the Cane Run Watershed.

WLEX-TV Partnership

Lexmark would also like to focus on the section of Cane Run located between Lexmark, WLEX-TV, and the Loudon Extension and is considering a partnership with WLEX-TV on this project.

2. Catchment 9

Current State

All of the monitoring data collected in Catchment 9 indicates that the catchment is polluted, and the pollution source assessment indicates that much of this pollution likely stems from a faulty sanitary and storm sewer system. LFUCG plans to spend approximately $800 million dollars over the next 30 years to upgrade the sanitary sewer system throughout the county, which will improve the water quality in Catchment 9. Because much of the land area within Catchment 9 is covered by the Consent Decree between LFUCG and the EPA, BMPs cannot be implemented in this area using Kentucky 319(h) Program funds; however, LFUCG and other stakeholders within the catchment can implement a diverse array of projects that would improve water quality once the sanitary and storm sewer infrastructure is improved.

Planned Work

Lexington Fayette Urban County Government

SANITARY AND STORM SEWER REPAIRS

LFUCG will continue to find and fix sanitary and storm sewers within the Cane Run Watershed as part of the Consent Decree (Appendix B). UK and KDOW will work in conjunction with LFUCG to prioritize sanitary sewer issues in the Cane Run Watershed. A remedial measures plan for the Cane Run sewershed is expected by the fall of 2011. Over the next 30 years LFUCG will spend $800 million to repair failing sanitary and stormwater systems throughout the county.

SANITARY AND STORM SEWER DATABASE

The Lexington-Fayette Urban County Government (LFUCG) Division of Water Quality is required, by the United States Environmental Protection Agency (U.S. EPA) and the Commonwealth of Kentucky, to comply with environmental laws and regulations relating to the operation and maintenance of sanitary and storm water sewer systems. LFUCG has agreed to a Consent Decree that requires Lexington to study, design and implement various projects and to repair sewer pipes and to improve wastewater treatment plants to bring the city in compliance with the Clean Water Act. The city will track all aspects of those projects and repairs as well as the day-to-day activities associated with properly maintaining the sanitary and storm water sewer systems. The city will centralize data from various sources and employ technology to monitor, manage and report per the EPA compliance requirements.

Currently, when LFUCG receives a work order for the storm or sanitary sewer system in the Cane Run Watershed, it takes an average of 177 days for the work order to be addressed, and the records of each work order vary in quality and accessibility. In order to ensure compliance with the Consent Decree and improve response time and system organization, LFUCG has contracted with Accela Inc. to develop a way to monitor and manage all activity relating to the inspection, repair and maintenance of both the sanitary and storm sewer systems. Accela's software platform will provide a single web-based application for use by LFUCG staff in managing the operation and maintenance of the sanitary sewer and stormwater conveyance systems. It will also fully integrate LFUCG's GIS-based database inventories (e.g. mapping) of the City's stormwater and sanitary sewer system assets with parcel data, maintenance work order systems, customer service requests, preventative maintenance scheduling, inspections, and new development.

University of Kentucky Experiment Station

The University of Kentucky will continue to implement many best management practices on the Experiment Station that promote water quality. Some of these plans include continued maintenance of stream buffers, enhanced pasture management, and additional demolition of approximately 18 buildings and septic systems. The Experiment Station also houses several Class V injection wells that the University plans to close as soon as possible.

Coldstream Research Park

A bioswale is planned for construction at Coldstream Research Park. This bioswale will serve as a stormwater management model for future development in the park and will include educational signage for visitors of the Legacy Trail nearby. Another possible project within the park is the enhancement of a wetland. A proposal, put together by The University of Kentucky, EcoGro, and Ridgewater, providing the design and construction cost estimates for the bioswale is included in Appendix HH.

3. Catchment 1

Current State

The monitoring data collected in Catchment 1 indicates that the catchment is polluted, and the pollution source assessment indicates that some of this pollution likely stems from a faulty sanitary and storm sewer system. LFUCG plans to spend approximately $800 million dollars over the next 30 years to upgrade the sanitary sewer system throughout the county, which will improve the water quality in Catchment 1. Because some of the land area within Catchment 1 is covered by the Consent Decree between LFUCG and the EPA, BMPs cannot be implemented in these areas of Catchment 1 using Kentucky 319(h) Program funds; however, LFUCG and other stakeholders within the catchment can implement a diverse array of projects that would improve water quality once the sanitary and storm sewer infrastructure is improved.

Most of the land in this catchment not covered by the Consent Decree is agricultural, and installing BMPs that curb nonpoint source pollution stemming from agricultural operations such as crop production and livestock would improve water quality in this catchment.

Planned Work

Lexington Fayette Urban County Government

SANITARY AND STORM SEWER REPAIRS

LFUCG will continue to find and fix sanitary and storm sewers within the Cane Run Watershed as part of the Consent Decree (Appendix B). UK and KDOW will work in conjunction with LFUCG to prioritize sanitary sewer issues in the Cane Run Watershed. A remedial measures plan for the Cane Run sewershed is expected by the fall of 2011. Over the next 30 years LFUCG will spend $800 million to repair failing sanitary and stormwater systems throughout the county.

Sanitary and Storm Sewer Database

The Lexington-Fayette Urban County Government (LFUCG) Division of Water Quality is required, by the United States Environmental Protection Agency (U.S. EPA) and the Commonwealth of Kentucky, to comply with environmental laws and regulations relating to the operation and maintenance of sanitary and storm water sewer systems. LFUCG has agreed to a Consent Decree that requires Lexington to study, design and implement various projects and to repair sewer pipes and to improve wastewater treatment plants to bring the city in compliance with the Clean Water Act. The city will track all aspects of those projects and repairs as well as the day-to-day activities associated with properly maintaining the sanitary and storm water sewer systems. The city will centralize data from various sources and employ technology to monitor, manage and report per the EPA compliance requirements.

Currently, when LFUCG receives a work order for the storm or sanitary sewer system in the Cane Run Watershed, it takes an average of 177 days for the work order to be addressed, and the records of each work order vary in quality and accessibility. In order to ensure compliance with the Consent Decree and improve response time and system organization, LFUCG has contracted with Accela Inc. to develop a way to monitor and manage all activity relating to the inspection, repair and maintenance of both the sanitary and storm sewer systems. Accela's software platform will provide a single web-based application for use by LFUCG staff in managing the operation and maintenance of the sanitary sewer and stormwater conveyance systems. It will also fully integrate LFUCG's GIS-based database inventories (e.g. mapping) of the City's stormwater and sanitary sewer system assets with parcel data, maintenance work order systems, customer service requests, preventative maintenance scheduling, inspections, and new development.

University of Kentucky Experiment Station

The University of Kentucky will continue to implement many best management practices on the Experiment Station that promote water quality. Some of these plans include continued maintenance of stream buffers, enhanced pasture management, and additional demolition of approximately 18 buildings and septic systems. The Experiment Station also houses several Class V injection wells that the University plans to close as soon as possible.

4. Catchment 8

Current State

The monitoring data collected in Catchment 8 indicates that the catchment is polluted, and the pollution source assessment indicates that some of this pollution likely stems from livestock and wildlife. Most of the land in this catchment is agricultural, and installing BMPs that curb nonpoint source pollution stemming from agricultural operations such as crop production and livestock would improve water quality in this catchment.

Planned Work

University of Kentucky Experiment Station

BMP Implementation

The University of Kentucky will continue to implement many best management practices on the Experiment Station that promote water quality. Some of these plans include continued maintenance of stream buffers, enhanced pasture management, and additional demolition of approximately 18 buildings and septic systems. The Experiment Station also houses several Class V Injection Wells that the University plans to close as soon as possible.

Legacy Trail

The presence of the Legacy Trail on the Experiment Station will continue to prompt management changes. Invasive species removal is planned along the trail section that passes through the Experiment Station. Enhanced no-mow buffers between the trail and the Experiment Station property are also planned.

Stream Restoration Research Project

A project titled “Examining the Effects of Stream Restoration and Riparian Buffer Development on Water Quality of a Small Spring-Fed Stream” will begin on the Experiment Station. The objective of this project is to evaluate the effect of restoring a small spring-fed channel (drainage area of 0.2 mi^2), which was degraded by intensive horse-grazing and farm machinery traffic, on water quality (Figure 182). This project is being funded through a NRCS earmark project titled “Development and Implementation of Stream Restoration and Riparian Corridor Techniques for Enhancing Water Quality in the Cane Run Watershed.”

Figure 182. This stream on UK's Experiment Station will be restored as part of research.

5. Catchment 6

Current State

The monitoring data collected in Catchment 6 indicates that the catchment is polluted, and the pollution source assessment indicates that some of this pollution likely stems from livestock. Most of the land in this catchment is agricultural, and installing BMPs that curb nonpoint source pollution stemming from livestock operations could improve water quality in this catchment.

Planned Work

Kentucky Horse Park

Additional riparian buffers will be installed in the next few years, along with educational signage. The Bluegrass Partnership for a Green Community's Green Games Committee will contribute $1,500 for these projects and the KY Horse Park Foundation has expressed interest in contributing funds to these efforts. The project will feature native plants and volunteer planting events.

Water Quality Monitoring

Currently there are no funds secured for future surface water quality monitoring in the Cane Run Watershed, as money originally allocated for monitoring in the 2008 Cane Run Watershed Project 319(h) grant is now planned to be allocated for BMP implementation; however, the Cane Run Watershed Project plans to seek funding in future years for monitoring that will gauge the effectiveness of implemented BMPs.

There is always a lag time between the implementation of BMPs and a measureable improvement in water quality. This lag time is highly variable, and it depends on site-specific variables and the pollutants involved. The lag time may range from months to years for relatively short-lived contaminants such as bacteria, years to decades for phosphorus in agricultural areas, and decades or more for sediment accumulated in stream systems[91]. For example, installing livestock exclusion fencing along a stream could result in significant nutrient and fecal bacterial reductions in the first post-treatment year; however, vegetative buffers that depend on the establishment of plant communities may take years to become fully effective[92]. Even when reductions of pollutant loads are observed relatively quickly, the response time of the receiving water body may cause a significant lag time between measureable load reductions and restoration of impaired uses, as it could take much longer for macroinvertebrates, fish, vegetation, and other ecosystem components to fully re-establish[93].

Additional monitoring in the Cane Run should take place no sooner than 5 years after BMP implementation and should take place throughout the watershed on a catchment, or even source, scale. Additional monitoring could also be implemented on a sub-catchment basis within the upper watershed to fill in data gaps. Grab samples may be taken before future monitoring projects begin in order to pinpoint sources of pollution throughout the watershed.

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[91] Meals, D.W., S.A. Dressing, and T.E. Davenport. 2010. Lag Time in Water Quality Response to Best Management Practices: A Review. Journal of Environmental Quality 39:85-96. Available at: http://lshs.tamu.edu/research/bibliography.

[92] Meals, D.W., S.A. Dressing, and T.E. Davenport. 2010. Lag Time in Water Quality Response to Best Management Practices: A Review. Journal of Environmental Quality 39:85-96. Available at: http://lshs.tamu.edu/research/bibliography.

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Education and Outreach

Bluegrass Pride

Bluegrass Pride and other watershed partners are planning the production of a documentary on the Cane Run Watershed. This will become a key part of education and outreach activities in the watershed in coming years.

Cane Run Watershed Council

The Council plans to continue the Cane Run Watershed Festival annually in some form, as budgets allow.

University of Kentucky Experiment Station

The presence of the Legacy Trail on the Experiment Station will continue to prompt education and outreach opportunities. Educational signage is planned along enhanced no-mow buffers between the trail and the Experiment Station property. In addition, a mural with a water quality theme is planned for display on an Experiment Station shed that faces the Legacy Trail.

Lexington Fayette Urban County Government

LFUCG will continue to partner with the Cane Run Watershed Council and the Cane Run Watershed Project to plan and execute an annual Watershed Festival and other educational activities along the Legacy Trail and throughout the watershed.

WLEX-TV

WLEX-TV is partnering with the Cane Run Watershed Council for publicity associated with the August 2011 watershed festival.

XI. Appendices

A. ***Challenges of Using Electrical Resistivity Method to Locate Karst Conduits – A Field Case in the Inner Bluegrass Region, Kentucky***

B. ***LFUCG Consent Decree***

C. ***LFUCG Monitoring Data***

D. ***Georgetown Water Royal Spring Data***

E. ***QA/QC for: Development of Bacteria TMDL's for four 303(d) Listed Streams in the Kentucky River Basin: South Elkhorn Creek in Scott County, Kentucky and Town Branch, Cane Run, and Wolf Run in Fayette County, Kentucky***

F. ***KWRRI Sampling Results***

G. ***Report to the City of Georgetown: Water Quality Analysis Project 2005***

H. ***Quality Assurance Project Plan: Water Quality Monitoring and Data Analysis for Nutrients, Organic Enrichment and Sediment in the Cane Run Watershed***

I. ***Cane Run of North Elkhorn Creek TMDL Nutrient Monitoring Plan***

J. ***KDOW Water Quality Data (1)***

K. ***KDOW Water Quality Data (2)***

L. ***KDOW Habitat Data***

M. ***KDOW Benthic Data***

N. ***The Kentucky Macroinvertebrate Bioassessment Index***

O. ***Cane Run and Royal Spring Watershed Based Plan Quality Assurance Project Plan***

P. ***UK College of Agriculture Sampling Results***

Q. ***Watershed Assessment of River Stability and Sediment Supply (WARSSS) BEHI Calculations***

R. ***E. Coli Concentrations at Various Locations in the Cane Run Watershed***

S. ***Cane Run Rating Tables***

T. ***Extended Ground-Truthing Report***

U. ***Ground-Truthing Pictures***

V. ***Development of Fecal Coliform TMDL for 303(d) Listed Stream in the Kentucky River Basin: Cane Run in Fayette County, Kentucky***

W. ***Development of Nutrient TMDL for 303(d) Listed Stream in the Kentucky River Basin: Cane Run in Fayette County, Kentucky***

X. ***Cane Run and Royal Spring BMP Implementation Plan***

Y. ***Stream Bank Repair: Shady Brook Park***

Z. Lexmark Cooling Plant Leak Work Order

AA. Complete List of Studies for Priority BMP Tables

BB. LFUCG Consent Decree Appendix J: Supplemental Environmental Project

CC. University of Kentucky North Farm Agricultural Water Quality Plan

DD. University of Kentucky North Farm Nutrient Management Plan

EE. Informational Brochures: Streamside Management for Horse Owners and Streamside Buffer Zones

FF. Legacy Trail Information

GG. University of Kentucky Cooperative Extension Publication: Building a Rain Barrel [HENV-201]

HH. Proposal for Bioswale Design and Construction Cost Estimate: Coldstream Research Campus, University of Kentucky