South Fork Little River Watershed-Based Plan

Prepared for

LITTLE RIVER WATER QUALITY CONSORTIUM

Prepared by

THIRD ROCK CONSULTANTS

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I. INTRODUCTION

A. Background

The South Fork of Little River (SFLR) has been the subject of numerous water quality studies dating back to the late 1980's. Murray State University studied SFLR in 1988, 2001, and 2003; the U.S. Geological Survey (USGS) in 2003 to 2004; and the Kentucky Division of Water (KDOW) sampled select sites scattered throughout the entire Little River drainage area in 2003 to 2004. Based on these and other studies, KDOW listed SFLR as unsafe for swimming (primary contact recreation) due to pathogens and found it not providing aquatic habitat that promotes a healthy population of aquatic organisms due to nutrients (phosphorus and nitrogen), sediment, and other causes. In 2009, a total maximum daily load (TMDL) for pathogens was published by the KDOW. The pathogens TMDL identifies actions that, once implemented, should result in achieving applicable state water quality standards in the SFLR.

In response to concerns about the water quality in the area, the Little River Water Quality Consortium (LRWQC) was established in 2011. The LRWQC is comprised of representatives from:

- agriculture and industry;
- the Hopkinsville Surface and Stormwater Utility, Water Environment Authority, and City Council; *and*
- the Christian County Health Department and Fiscal Court.

Its purpose is to oversee and direct water quality monitoring and the prioritization and implementation of Best Management Practices (BMPs) within the Little River Watershed.

In cooperation with the LRWQC and KDOW, the USGS conducted a three-year study in the Upper Little River Basin to aid in understanding the occurrence and distribution of pathogens, nutrients, and sediment and their potential sources within the headwaters of the Little River Watershed. The SFLR was the primary focus of the study because of the higher percentage of cropland and increasing number of small dairy operations in the drainage basin. The USGS study utilized advanced scientific techniques to determine the relative pollutant contributions of different sources, the findings and conclusions of which were published in October 2017.

In 2016, the LRWQC received a Clean Water Act Section 319(h) grant from KDOW to develop a Watershed-Based Plan to provide a comprehensive assessment of the health of the SFLR basin, citizen and stakeholder concerns, watershed remediation strategies, and implementation plans for the future. The Hopkinsville Surface and Stormwater Utility, acting on behalf of the LRWQC, has partnered with Third Rock Consultants, LLC (Third Rock) to develop the plan.

This document is intended to address the nine minimum elements required in the USEPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA 2008) as follows:

1. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the pollutant load reductions estimated in this watershed-based plan

(and to achieve any other watershed goals identified in the watershed-based plan), as discussed under Item 2, below.

Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (*e.g.*, X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded stream bank needing remediation).

2. An estimate of the load reductions expected for the management measures is described under Item 3, below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as under Item 1, above (*e.g.,* the total load reduction expected for dairy cattle feedlots; row crops; or eroded stream banks).

3. A description of the nonpoint source management measures that will need to be implemented to achieve the load reductions estimated under Item 2, above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

4. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan. Sources of funding that should be considered include Kentucky's Section 319(h) grant program, State Revolving Funds, U.S. Department of Agriculture (USDA)/Natural Resources Conservation Service's (NRCS) Environmental Quality Incentives Program (EQIP) and Conservation Reserve Program (CRP), and other relevant federal, state, local, and private funds that may be available to assist in implementing this plan.

5. An information/education component that will be used to enhance public understanding of the project and encourage early and continued stakeholder participation in selecting, designing, and prioritizing the nonpoint source management measures that will be implemented.

6. A schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

7. A description of interim, measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a nonpoint source TMDL has been established, whether the nonpoint source TMDL needs to be revised.

9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under Item 8, above.

B. Partners and Stakeholders

This plan was developed under the direction of the LRWQC and Technical Advisory Committee.

1. LRWQC Members

Wayne Hunt, Chair	H&R Agri-Power (Agriculture Representative)
Steve Hunt	H&R Agri-Power (Agriculture Representative)
David Brame	Brame Farms Inc. (Agriculture Representative)
Paul Henson	Hopkinsville City Council (Ward 4)
David Collins	Christian County Fiscal Court
Chad Burch	Christian County Health Department
Mark Pyle	Christian County Health Department
Derrick Watson	Hopkinsville Water Environment Authority
Jenny Moss	Hopkinsville Water Environment Authority
Todd Perry	Siemer Milling Company (Industry Representative)
Dave Fernandez	Hopkinsville Surface and Stormwater Utility
Kelley Workman	Hopkinsville Surface and Stormwater Utility

2. Technical Advisory Committee

LRWQC Members	
Steve Bourne	Community Development Services (CDS)
John Rittenhouse	Community Development Services (CDS)
Jed Grubbs	Cumberland River Compact
Jay Stone	Christian County Extension Office
Kelly Jackson	Christian County Extension Office
Matt Futrell	Christian County Extension Office
Amanda Gumbert	UK Cooperative Extension Specialists
Brad Lee	UK Cooperative Extension Specialists
Steve Higgins	UK Cooperative Extension Specialists
Jason Scott	Kentucky Department of Fish and Wildlife Resources (KDFWR)
Wes McFaddin	Kentucky Department of Fish and Wildlife Resources (KDFWR)
Maggie Morgan	Jackson Purchase Foundation
Jim Roe	Kentucky Division of Water (KDOW)
Dave Roberts	Kentucky Dairy Development Council
Jamie Lawrence	Pennyrile Area Development District (PEADD)
Charles Turner	Pennyrile RC&D
Frank Yancey	USDA NRCS Service Center
Andy Radomski	US Fish and Wildlife Service (USFWS)
Angie Crain	USGS Kentucky Science Center

II. WATERSHED INFORMATION

A. Location

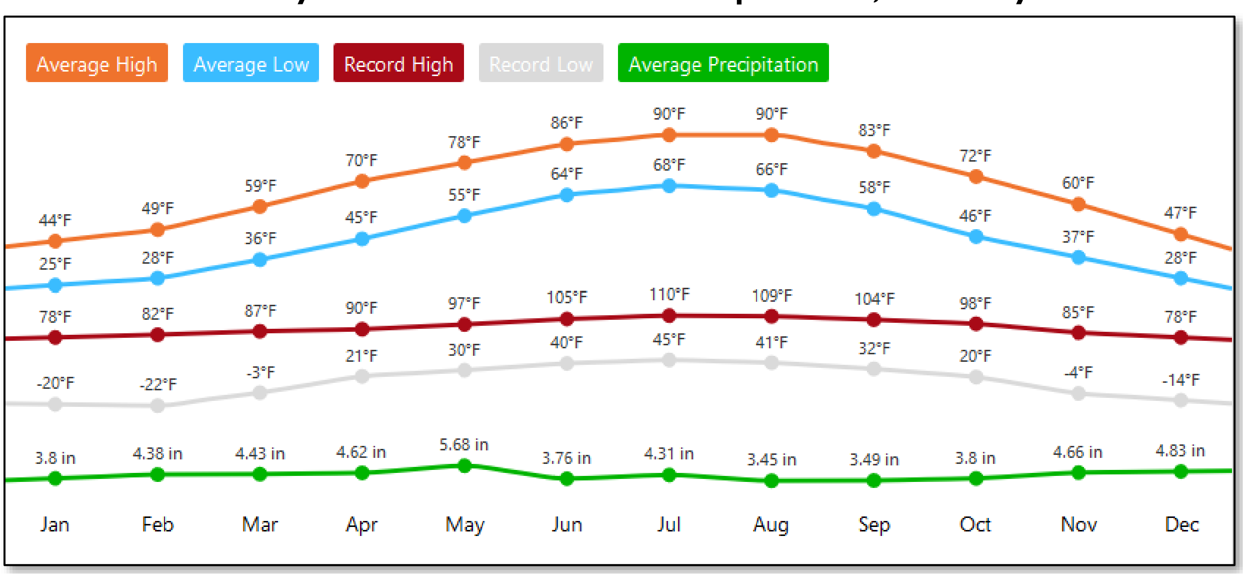
The SFLR watershed, Hydrologic Unit Code (HUC) 05130205050, is a 67.4 square mile (43,200 acres) watershed located primarily in Christian county, but partially extending into Todd county, Kentucky as shown on **Exhibit 1** (Appendix A). It is roughly bounded by KY-507 to the north, KY-115 to the east, KY-1027 to the south, and US-41 / KY-107 to the west. SFLR watershed includes agricultural and pasture lands, as well as commercial and developed lands. It contains the eastern portion of the City of Hopkinsville and extends near Pembroke and Fairview. It contains landmarks such as the Hopkinsville-Christian County Airport, Western State Hospital, Fort Campbell Memorial Park, Walmart Supercenter, Rogers Group, Inc. Quarry, University of Kentucky College of Agriculture's Christian County Cooperative Extension office, Hopkinsville Golf and Country Club, and Western Hills Municipal Golf Course. Pilot Rock, the highest point in both Christian and Todd counties, is located to the northeast of the watershed, on the Christian and Todd county line.

The SFLR is part of the Little River basin, which is a sub-basin to the Lower Cumberland River basin. SFLR watershed is approximately 30 miles to the east of the Land Between the Lakes National Recreation Area. One of the lakes, Lake Barkley, receives waters from the SFLR watershed.

B. Climate and Precipitation

Figure 1 shows the monthly averages for temperature and precipitation based on records from www.weather.com for Hopkinsville, Kentucky. On average, the warmest months are July and August, and the coolest month is January. A record high of 110 degrees Fahrenheit (˚F) occurred on July 13, 1936, while the record low of -22 (˚F) occurred on February 2, 1951. The average annual precipitation is 51.3 inches, with May being the wettest month, on average.

Figure 1
Monthly Weather Conditions for Hopkinsville, Kentucky[1]



[1] "Hopkinsville, KY Monthly Weather" (The Weather Company 2017)

C. Hydrology and Geomorphology

There are approximately 100 miles of stream within the SFLR watershed. Tributaries to SFLR include Warren's Fork, Rock Bridge Branch, and numerous unnamed tributaries. Surface runoff is the dominant source of streamflow for these streams with groundwater providing 30-50% of the streamflow based on USGS estimates from 2013-2014 (Crain *et al.* 2017).

Three USGS gaging stations continuously monitor the SFLR. The discharge records for these sites were compared in order to provide an overview of the flow conditions in the watershed. These are summarized in **Table 1**. Records indicate the SFLR goes dry in the summer and fall months in the upper reaches of the watershed (SF07 and SF09), while flow is maintained throughout the year along SFLR below US 41.

Table 1
Summary of Flow at USGS Gages

USGS Station ID (Location)	Field ID	Drainage Area (mi^2)	Data Record Analyzed	Flow			
				Low Flow (85% Flows Exceeding) (ft^3/s)	Mean Flow (50% Flows Exceeding) (ft^3/s)	High Flow (15% Flows Exceeding) (ft^3/s)	Maximum Flow (ft^3/s)
3437480 (Hwy 68/80)	SF07	18.7	2009-2017	0.36	7.7	45	21,800 (instantaneous)
3437495 (US 41)	SF09	35.9	2009-2017	1.22	23.4	89	5,140 (instantaneous)
3437500 (KY 107)	SF10	46.1	1949-1973, 2012-2017	1.74	33.4	124	3,780 (mean daily)

Parola *et al.* (2005) performed an evaluation of the geomorphological characteristics of streams in the physiographic region in which SFLR is located. They found that streams in this region tend to be affected by:

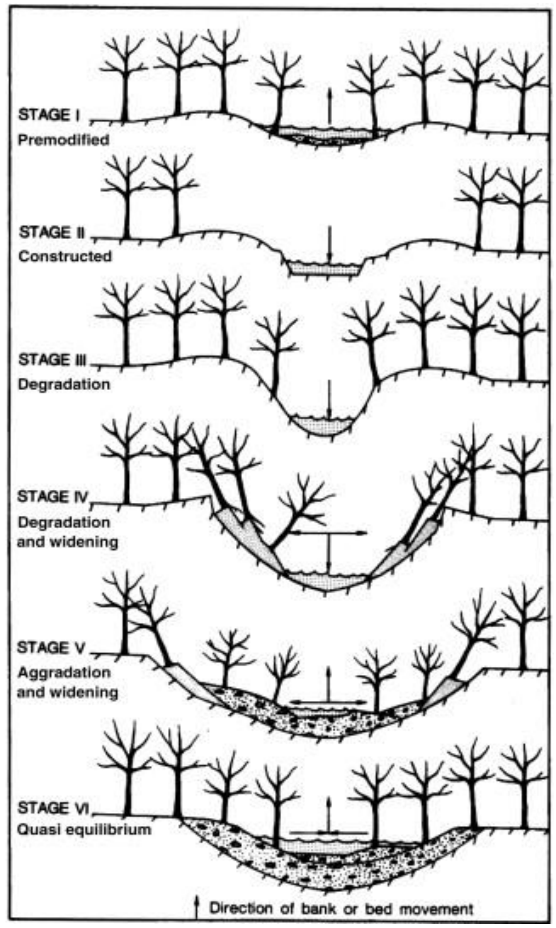
- straightening of tributaries near valley bottoms at their confluence with a receiving stream;
- changing of the base level at stream confluences, associated with main stem degradation; *and*
- channel shortening related to the relocation of streams closer to the valley hillside to increase available land for agriculture or development.

These factors can cause channel incision and exposure of bedrock in the channel beds. Channel incision reduces the stream's access to a floodplain during storm events. The changes in tributary channel geometry and in the sediment supply generated from channel incision and migrating headcuts (as streams adjust to lower base elevations) can be large. **Figure 2**, page 6, shows an example model of this process (Simon *et al.* 1986). When stream channels become channelized (Stage II) they change over time to re-stabilize through a process that involves incision/down-cutting (Stage III), mass erosion and bank failures (Stage IV), and widening and sedimentation (Stage V) before reaching new equilibrium conditions (Stage VI).

D. Groundwater-Surface Water Interaction

When limestone bedrock is near the ground surface, surface water and precipitation often pass through the soil into the limestone, where it is called groundwater. Over time, horizontal and vertical cracks in the rock can become enlarged by acids in the water to form a landscape characterized by sinkholes, springs, and caves, called karst topography. The SFLR watershed is located within the Western Pennyroyal karst area, and is a sinkhole dominated area.

Figure 2
Channel Evolution Model



To evaluate the sensitivity of groundwater resources to water pollution, KDOW developed a hydrologic sensitivity index to quantify the regions of Kentucky (Ray *et al.* 1994). Based on groundwater recharge, flow, and dispersion rates, the index ranges from 1 (low) to 5 (high). The SFLR watershed has a sensitivity rating of 4 to 5. This rating is typical for the Mississippian Plateau region where "domestic wells are common; although in some areas contaminated water is a problem because of polluted surface runoff into sinkholes and sinking streams. Yields to wells can vary greatly, depending on whether or not the well intersects fissures and conduits enlarged by the slow dissolving of limestone. Recharge, flow, and dispersion potential are usually characterized by high rates."

Exhibit 2 (Appendix A) shows the location of mapped karst groundwater basins in the Hopkinsville 30 x 60 Minute Quadrangle (Ray *et al.*, pending) as well as sinkholes that have been identified by the Kentucky Geological Survey (KGS). Dye testing to trace the direction of groundwater flow has only been performed in areas associated with the West Fork Red River watershed as part of a Karst Data Pilot Study (KDOW and KGS 2011). This study found that the groundwater generally flows in the same direction as the surface water for the areas investigated within SFLR, including the Cowherd Spring basin, Mosley Spring basin, and Johnston Spring basin. It is unknown whether such trends would be expected in other areas of the SFLR watershed.

E. Flooding

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

To identify a community's flood risk, the Federal Emergency Management Agency (FEMA) conducts a Flood Insurance Study. The study includes statistical data for river flow, storm tides, hydrologic / hydraulic analyses, and rainfall and topographic surveys. FEMA uses this data to create Flood Insurance Rate Maps (FIRMS) that indicate the flooding risk in a particular area. These digital flood hazard maps provide an official depiction of flood hazards for each community and for properties located within it. **Exhibit 3** (Appendix A) shows the 100-year and 500-year flood zones for the SFLR watershed. The 100-year flood is a flood event that has a 1% probability to occur in a given year, and is defined as the Special Flood Hazard Area (SFHA). The 100-year flood is predicted to have a flow of 14,400 cfs at the mouth of the SFLR.

The Hopkinsville Surface and Stormwater Utility (HSSU) was formed in November 2005 to address surface and river flooding issues within the City of Hopkinsville (http://www.hopkinsville-stormwater.com). The Utility has adopted the draft Flood Hazard Mitigation Plan (August 17, 2009), which was created to assist the City of Hopkinsville in making decisions related to surface and stormwater problems. The draft plan states that flooding of the SFLR affects approximately 72 homes and 42 commercial structures, and lists 1 of the causes of local drainage problems as the need for flood mitigation measures on the SFLR, which may include flood control facilities, home buyouts, increased flood storage of existing watershed lakes, and flood proofing (structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, and structures).

The FEMA Hazard Mitigation Grant Program (HMGP) provides grants to states, and states provide sub-grants to eligible applicants, to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. Project funding is available through the HMGP for acquisition and demolition of substantially damaged buildings located in the SFHA through this program for eligible applicants.

F. Geology

The SFLR watershed is located in the Church Hill, Hopkinsville, Pembroke, Honey Grove, and Kelly 7.5-minute geologic quadrangles, as shown in **Exhibit 4** (Appendix A). The surface geological units in the watershed include alluvium in the stream bottoms progressing uphill to Ste. Genevieve and Renault Limestone in the lands adjacent to the SFLR throughout most of its length. The geology of headwaters of the SFLR and Warrens Fork are primarily Paint Creek Limestone and Bethel Sandstones, with some areas of Big Clifty Sandstone, Cypress Sandstone, and Beech Creek Limestone.

G. Ecoregion and Topography

According to Woods *et al.* (2002), the SFLR watershed is located in the Crawford-Mammoth Cave Uplands (71a) and Western Pennyroyal Karst Plain (71e) ecoregions. The Crawford-Mammoth Cave Uplands ecoregion is described as “higher and more rugged than neighboring Ecoregions. Sandstone cliffs, dissected shale valleys, and less dissected limestone valleys with well-developed karst occur.” Its natural vegetation is a mosaic of oak–hickory forest in uplands, and forests with beech, sugar maple, southern red oak, white ash, and yellow poplar on mesic sites. Upland streams are rocky and often fed by groundwater. Many springs discharge into rivers that are deeply incised into bedrock (Woods *et al.* 2002).

The Western Pennyroyal Karst Plain is described as "underlain by Middle Mississippian limestones and is extensively farmed; it is both physiographically and lithologically distinct from surrounding ecoregions. Sinkholes, ponds, springs, sinking streams, and dry valleys occur." The natural vegetation is described as a mosaic of bluestem prairie and oak–hickory forest (Woods *et al.* 2002).

Exhibit 5 (Appendix A) shows the topography of the area. The Christian County Soil Survey (Froedge *et al.* 1980) describes the topography of Christian County and the Western Coal Fields Physiographic Region as follows:

> "The Western Coal Fields Physiographic Region is characterized by numerous faults and escarpments that have caused irregular hilly land with excessive relief. The side slopes and valley walls are dissected by numerous drainageways. Slopes are less than 100 feet to several hundred feet long. Gradient is sloping to steep, and runoff is rapid to very rapid. Elevation ranges from about 800 feet on some ridges to less than 450 feet in the valleys. Some ridgetops, however, are relatively broad and gently sloping, have generally low relief, and have medium to slow runoff."

The topography of Christian county is described by McGrain and Currens (1978) as follows:

> "Two distinct terrains characterize the topography of Christian county. The southern part of the county is a nearly flat to gently rolling limestone plain with numerous sinkholes, sinkhole ponds, springs, and sinking creeks. Elevations of the karst plain generally range between 530 and 600 feet. Little River and Red River, 2 principal streams crossing this area, are rarely entrenched more than 50 to 60 feet. Fractures in the rock are locally expressed as sinkhole alignments and rectilinear drainage patterns.
>
> The northern part of the county, generally north of U.S. 68, is a higher plateau, characterized by sandstone-capped hills and ridges that produce higher elevations and more rugged terrain. Normal stream drainage patterns prevail here. The highest elevations are associated with knobs perched on ridges in the vicinity of a drainage divide that separates north-flowing tributaries of the Pond and Tradewater Rivers from the south- and west-flowing tributaries of the Cumberland River. Pilot Rock, on the Christian-Todd county line, is the highest point at 966 feet. Pine Knob is 863 feet. Slopes associated with the sandstone-capped hills and ridges are commonly steep, and may be locally precipitous. Local reliefs may be as great as 300 to 400 feet, but are generally less."

H. Soils

The Christian county soil survey (Froedge *et al.* 1980) identifies the Caneyville-Frondorf-Zanesville, Sadler-Zanesville-Nicholson, Pembroke-Fredonia-Caneyville, and Pembroke-Crider associations as within the Little River watershed. The Caneyville-Frondorf-Zanesville association is described as moderately deep, sloping to steep, well-drained, loamy or clayey soils that are intermingled with limestone rock outcrop in most places, and moderately deep and deep, gently sloping to steep, well-drained and moderately well drained loamy soils. The Sadler-Zanesville-Nicholson association is described as deep, nearly level to sloping, moderately well drained loamy soils. The Pembroke-Fredonia-Caneyville association is described as deep and moderately deep, gently sloping and sloping, well drained loamy or clayey soils. The Pembroke-Crider association is described as deep, gently sloping, well drained loamy soils. Nearly all the watershed south of US 68 is within the Pembroke-Crider association. Most of the watershed north of US 68 is within the Sadler-Zanesville-Nicholson association, with the Caneyville-Frondorf-Zanesville and Pembroke-Fredonia-Caneyville associations restricted to isolated areas along US 68 immediately to the west and east of SFLR.

Soils are classified by the Natural Resource Conservation Service into 4 Hydrologic Soil Groups based on the soil's runoff potential (USDA NRCS 1986). The 4 Hydrologic Soils Groups are A, B, C and D, with "A" having high infiltration capacity (little runoff) and "D" very low infiltration capacity (high runoff). **Table 2** shows the infiltration rates associated with each soil and the relative abundance at which these soils are present in the watershed. The locations of the soils are shown in **Exhibit 2.6** (Appendix A).

Table 2
Relative Abundance of Soils by Hydrologic Soil Group[1]

Hydrologic Soil Group[2]	Type	Infiltration Capacity / Permeability	Infiltration Rate (in/hr)	Relative Abundance (%)
A	Sand, loamy sand, or sandy loam	High	> 0.30	0.5
B	Silt or loam	Moderate	0.15 - 0.30	47.3
C	Sandy clay loam	Low	0.05 - 0.15	31.5
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay	Very Low	0.00 - 0.05	20.0
Unavailable	Unknown	Unknown	Unknown	0.7

[1] Urban Hydrology for Small Watersheds TR-55 (USDA NRCS, 1986)
[2] Areas of soils noted as B/D or C/D were divided equally between these group types.

The most dominant Hydrologic Soil Group was Group B (47.3% of the watershed area), but Group C was also common (31.5%). Group A represents only 0.5% of the watershed area. Based on this information, nearly all soils will generate runoff when the rainfall intensity is more than 0.3 inches per hour. When the rate is above 0.15 inches per hour, about half of the soils in the watershed generate runoff. The headwaters north of KY 508 tend to have lower infiltration rates and therefore produce runoff sooner for a given rain event.

Areas of hydric soil are important because wetland restoration or expansion is more likely to be successful in these areas. Hydric soils are permanently or seasonally saturated by water. Wetlands provide key habitat for aquatic organisms, improve water quality through filtration, and provide flood water retention among other benefits. Newark silt loam, Lawrence silt loam, Dunning soils, Robertsville silt loam, Melvin silt loam, and Bonnie silt loam are listed as hydric soils occurring within Christian county (NRCS 2017) and comprise about 4.3% of the watershed land area. Within the watershed, existing wetlands are primarily located near streams.

I. Riparian Ecosystem

The riparian zone or riparian area is the vegetated area adjacent to the stream. Because this area forms a protective buffer for the stream water quality, it is often called a riparian buffer zone. Although riparian zones produce many water quality benefits, these benefits are dependent on the width of the riparian area, the size of the stream that it borders, and vegetative composition and density. The water quality functions provided by the riparian zone vary by stream size. Riparian areas on smaller, headwater streams provide the maximum nutrient removal, shading, and bank stabilization benefits (Palone *et al.* 1997). Fish habitat and aquatic ecosystem benefits are typically greatest for larger, main-stem streams while flood mitigation benefits of riparian buffers increase as stream size increases. Sediment control benefits remain relatively constant for all stream sizes.

The width of the riparian zone necessary to achieve these benefits varies depending on the function. The U.S. Army Corps of Engineers (Fischer and Fischenich 2000) recommends the following riparian buffer widths for various functions: 5 to 30 meters (16 to 100 feet) for water quality protection, 30 to over 500 meters (100 to over 1,600 feet) for riparian zone habitat, 10 to 20 meters (30 to 65 feet) for stream stabilization, 20 to 150 meters (65 to 500 feet) for flood attenuation, and 3 to 10 meters (10 to 30 feet) for detrital input.

An analysis of the actual riparian widths of streams within the SFLR watershed was compared against the minimum recommended buffer width for each function. Streams with riparian width of greater than 120 feet are labeled as "non-impacted," riparian widths of 20 to 120 feet are "moderately impacted", and riparian widths less than 20 feet are "heavily impacted." The riparian width for streams within the SFLR watershed was delineated from aerial photographs. Areas with forested canopy or overgrown vegetation were included in the riparian buffer zone. **Exhibit 7** (Appendix A) shows the locations of riparian zones and estimated widths as summarized in **Table 3**.

Table 3
Riparian Zones

Riparian Zone Width	Length of Stream (miles)	Percent of Total Measured
Non-impacted (>120 ft)	23.5	24%
Moderately Impacted (20-120 ft)	48.4	48%
Heavily Impacted (<20 ft)	27.9	28%
Total	99.7	100%

Within the SFLR watershed, of the 99.7 miles of mapped stream channel, 48% (48.4 miles) has moderately impacted (20 to 120 feet) riparian width. Heavily impacted riparian zones compose 28% (27.9 miles) of the stream length, and 24% (23.5 miles) of the streams are considered non-impacted. The heavily impacted riparian zones are located primarily on tributary streams in agricultural areas. In areas where a riparian zone is present, it may provide the full range of benefits to the streams. However, targeted planting efforts and buffer zones along many tributaries as well as the main stem of SFLR may be necessary for areas where no riparian zone is found.

J. Fauna and Flora

The SFLR watershed is located in the Church Hill, Hopkinsville, and Kelly 7.5-minute quadrangles. According to Kentucky Department of Fish and Wildlife Resources (KDFWR) species information (2017a), 287 species have been recorded in these quadrangles including 176 birds, 60 fish, 7 reptiles, 16 amphibians, 8 mammals, 11 mussels, 4 snails, and 5 crayfish. Of these species, 22 have been identified as state-listed threatened, endangered, or special concern species.

The U.S. Fish and Wildlife Service (USFWS 2017) Information for Planning and Conservation (IPaC) report generated for this project lists 8 federally threatened or endangered species that may occur within Christian and Todd Counties, including 3 bats and 5 mussels. **Table 4** summarizes both state and federally listed species with the possibility to occur within the SFLR watershed. In addition, the Kentucky State Nature Preserve Commission (KSNPC 2016) reports that 75 state-designated endangered, threatened, or special concern plants or animals have been recorded in Christian and Todd Counties. BMPs can create or enhance habitat for these species (e.g., stream restoration, tree plantings, wetland creation, etc.) and improve water quality (both within the watershed and in the receiving streams).

Table 4
Threatened, Endangered, and Special Concern Species

Scientific Name	Common Name	Listing Agency		US Status[1]	KY Status
		KDFWR	USFWS		
Fish					
Etheostoma microlepidum	Smallscale Darter	X		SOMC	E
Freshwater Mussels					
Cyprogenia stegaria	Fanshell		X	E	E
Obovaria retusa	Ring Pink		X	E	E
Pegias fabula	Littlewing Pearlymussel		X	E	E
Pleuronaia dolabelloides	Slabside Pearlymussel		X	E	X
Ptychobranchus subtentum	Fluted Kidneyshell		X	E	E
Villosa vanuxemensis vanuxemensis	Mountain Creekshell	X			T
Birds					
Accipiter striatus	Sharp-shinned Hawk	X			S
Actitis macularius	Spotted Sandpiper	X			E
Ammodramus henslowii	Henslow's Sparrow	X		SOMC	S
Anas clypeata	Northern Shoveler	X			E
Anas discors	Blue-winged Teal	X			T
Ardea alba	Great Egret	X			T
Bubulcus ibis	Cattle Egret	X			S
Certhia americana	Brown Creeper	X			E
Charadrius melodus	Piping Plover	X		T	N
Circus cyaneus	Northern Harrier	X			T
Fulica americana	American Coot	X			E
Haliaeetus leucocephalus	Bald Eagle	X			T
Junco hyemalis	Dark-eyed Junco	X			S
Lophodytes cucullatus	Hooded Merganser	X			T
Passerculus sandwichensis	Savannah Sparrow	X			S
Phalacrocorax auritus	Double-crested Cormorant	X			T

Table 4
Threatened, Endangered, and Special Concern Species *Cont*.

Scientific Name	Common Name	Listing Agency		US Status[1]	KY Status
		KDFWR	USFWS		
Podilymbus podiceps	Pied-billed Grebe	X			E
Pooecetes gramineus	Vesper Sparrow	X			E
Sitta canadensis	Red-breasted Nuthatch	X			E
Bats					
Myotis austroriparius	Southeastern Myotis	X		SOMC	E
Myotis grisescens	Gray Myotis	X	X	E	T
Myotis sodalis	Indiana Bat		X	E	E

[1] E = Endangered; T = Threatened; S = Special Concern; X = Extirpated; SOMC=Species of Management Concern

Many of the species included in **Table 4** are animals that depend on aquatic environments. Three of the species are fish, 10 are freshwater clams, 3 are species of crayfish, and 3 are amphibians, which require aquatic environments for at least a portion of their lives. Many of the birds included in the list also live in or near bodies of water. Of the species of freshwater mussels which are listed by state or federal agencies, the fanshell and ring pink are found in large rivers, so they would not be present in the SFLR watershed. Habitat for mussels adapted to small streams or moderately-sized rivers, such as the littlewing pearlymussel, slabside pearlymussel, fluted kidneyshell, and mountain creekshell, may be present within the SFLR or its tributaries.

The vegetation adjacent to stream channels can provide habitat for a diversity of plants and animals. The federally listed Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*) utilize floodplain, riparian, and upland forests for foraging and roosting habitat in the summer. This habitat does exist in the forested and agricultural portions of the watershed. Riparian trees adjacent to SFLR and its tributaries, wood lots, and fencerow trees in the agricultural portion of the watershed could provide potential summer roosting habitat for these bats.

While consideration of threatened and endangered species is important, consideration of exotic and invasive species in the watershed is also important. Exotic invasive species of plants can wreak havoc with ecological balance, creating trouble for rare and common species alike, and also degrade waterways and interfere with water uses. Exotic invasive species are a concern wherever ground is disturbed for management actives, such as stream restoration. Autumn and Russian Olive (*Elaeagnus umbellate, E. angustifolia*), bush honeysuckles (*Lonicera maackii, L. morrowi, L. tatarica*), crown vetch (*Coronilla varia*), garlic mustard (*Alliaria petiolata*), Japanese stiltgrass (Microstegium viminuem), Japanese honeysuckle (Lonicera japonica), KY 31 tall fescue (*Festuca elatior*), multiflora rose (*Rosa multiflora*), privet (*Ligustrum sinense, L. vulgare*), sericea lespedeza (*Lespedeza cuneata*), tree of heaven (*Ailanthus altissima*), and reed canary grass (*Phalaris arundinacea*) are all species that could occur within the SFLR watershed. These invasive species can replace diverse native plant communities with just a single species, greatly reducing the quality of wildlife habitat. In areas where stream restoration or riparian buffers are evaluated as BMPs, removal of invasive species will be key for long-term success.

Wildlife in the area, and its effect on water quality, is also important to consider. Wildlife can contribute pathogens to surface water. Flora and fauna in the SFLR watershed are primarily those adapted to agricultural and developed landscapes. According to the KDFWR (2017b), 2,773 white-tail deer were harvested in Christian county during the 2016 hunting season, which indicates that high populations of this species occur within the area. The Little River TMDL (KDOW 2009) cites the KDFWR as estimating there are 20 deer per square mile in Christian county, which is extrapolated to about 1,280 deer within the forested areas in the Littler River watershed.

K. Point Sources and Municipal Utilities

1. Water Supply

Drinking water utilities provide water for indoor purposes such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and outdoor purposes such as watering lawns and gardens. Raw water is withdrawn from surface or groundwater sources, treated for public consumption, and then distributed to area residents.

The Hopkinsville Water Environment Authority (HWEA) provides drinking water to most residents in the area by treating surface water withdrawn from Lake Barkley, North Quarry, and South Quarry. The location of these supply lines is shown in **Exhibit 8** (Appendix A). Because the SFLR drains to Lake Barkley, improvements to the water quality in SFLR will help protect this water source. Leaks or breaks along these water supply lines can discharge chlorinated water to streams, negatively impacting aquatic life.

Numerous groundwater wells used for domestic supply purposes are also scattered throughout the SFLR watershed. The drinking water drawn from these wells is not covered by regulations that protect the public drinking water systems. They can become contaminated through local land use practices (such as pesticide and chemical use, or animal feeding operations), malfunctioning wastewater treatment systems (sewer overflows or malfunctioning septic systems), or other sources. Owners of wells are responsible for well maintenance and testing to determine if the supply is safe. For concerned residents, the Christian County Health Department will collect and test private water supplies for bacterial contamination for a fee.

2. Permitted Dischargers

All dischargers to waters of Kentucky are required to obtain a Kentucky Pollutant Discharge Elimination System (KPDES) permit, including concentrated animal feeding operations (CAFOs), stormwater associated with municipal or industrial systems, sanitary wastewater treatment systems, mining operations, etc. The permitted facilities located within the SFLR watershed were obtained by a Freedom of Information Act (FOIA) request to the KDOW in February 2017. Twenty KDPES permitted facilities were identified as summarized in **Table 5**, page 14, and shown on **Exhibit 9** (Appendix A). The records from these facilities indicate that permitted dischargers are not contributing significant levels of pollution to the SFLR or its tributaries.

Table 5
Permitted Dischargers

KPDES No.	Map ID[1]	Permittee Name	Expiration Date	Permit Status	SIC Description
KY0105023	1	Commonwealth Agri Energy LLC	11/30/2019	Effective	Industrial Organic Chemicals, NEC
KY0109070	2	Ridley Feed Operations	4/30/2017	Terminated	Prepared Feed and Feed Ingredients for Animals and Fowls, Except Dogs and Cats
KYG110092	3	IMI South LLC	1/31/2020	Effective	Concrete Products, Except Block and Brick
KYG150006	4	Hopkinsville-Christian County Airport	8/31/2019	Effective	Airports, Flying Fields, and Airport Terminal Services
KYR000042	5	Copar Inc	9/30/2007	Terminated	Motor Vehicle Parts and Accessories
KYR000198	6	Meritor Suspension Systems Co Us	9/30/2007	Terminated	Steel Springs, Except Wire
KYR000272	7	Huhtamaki Inc	9/30/2007	Terminated	Folding Paperboard Boxes, Including Sanitary
KYR000280	8	Avantor Performance Materials	9/30/2007	Terminated	Plastics Products, NEC
KYR000980	9	Hopkinsville Asu	9/30/2007	Terminated	Minerals and Earths, Ground or Otherwise Treated
KYR001041	10	Metalsa Structural Products Inc	9/30/2007	Terminated	Motor Vehicle Parts and Accessories
KYR001179	11	United Parcel Service - Hopkinsville	9/30/2007	Terminated	Courier Services Except by Air
KYR001721	12	White Hydraulics Co	9/30/2007	Terminated	General Industrial Machinery and Equipment, NEC
KYR001799	13	Metokote Corp Plant 2	9/30/2007	Terminated	Motor Vehicle Parts and Accessories
KYR002195	14	IAC Madisonville LLC	9/30/2007	Terminated	Automotive Trimmings, Apparel Findings, and Related Products
KYR003110	15	Hopkinsville-Christian County Airport	5/31/2018	Terminated	Airports, Flying Fields, and Airport Terminal Services
KYR003188	16	Metokote Corp Plant 2	5/31/2018	Effective	Coating, Engraving, and Allied Services, NEC
KYR003766	17	IMI Southwest LLC - Owensboro 531	5/31/2018	Terminated	Concrete Products, Except Block and Brick
KYR003944	18	Mssc Us	5/31/2018	Effective	Steel Springs, Except Wire
KYR004111	19	Ridley Feed Operations	5/31/2018	Terminated	Flour and Other Grain Mill Products

[1] See Exhibit 9

3. Other Point Sources

a. Animal Feeding Operations

An animal feeding operation (AFO) is a lot or facility where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and where crops, vegetation forage growth, or post-harvest residues are not sustained over any portion of the lot or facility. AFOs with a liquid manure waste handling system are required to obtain a Kentucky No Discharge Operational Permit (KNDOP), valid for 5 years, to legally operate. Dry waste systems are not required to have a permit. Thirteen KNDOP permitted facilities are located within the SFLR watershed as shown on **Exhibit 9** (Appendix A).

b. Licensed Milk Producers

Although not required to obtain a permit because of their size, many small dairies are located throughout the SFLR watershed. According to the Kentucky Dairy Council, in 2017, 12 licensed milk producers were located within the SFLR watershed as shown on **Exhibit 9** (Appendix A). If not properly managed, runoff from dairy operations can contribute to elevated pathogen (bacteria) and nutrient concentrations.

4. Wastewater

Drainage systems transport wastewater whenever toilets are flushed or hands are washed in buildings and residential properties. Wastewater is generally properly addressed by 2 types of systems: public sanitary sewer systems or private onsite septic systems.

The public sanitary sewer is a system of underground pipes that carries sewage to a wastewater treatment plant where it is filtered, treated and discharged. While the Hopkinsville Water Environment Authority (HWEA) has extended lines to much of the urban portion of the SFLR watershed as shown in **Exhibit 10** (Appendix A), the majority of the watershed remains unsewered.

The Hammond-Wood Wastewater Treatment Plant, located on the southwest side of the City of Hopkinsville, treats the sewage from sanitary sewers located in the SFLR watershed. The plant was constructed in 1983, and upgraded and expanded in 1995 to increase the plant's capacity to 6 million gallons per day. According to HWEA, the plant generally removes 98.5% of all impurities via a 4-stage treatment process, and then releases the treated water into the North Fork of Little River. However, sanitary sewer overflows or line breaks can result in the discharge of sewage to area streams within the SFLR watershed, contributing to water pollution.

Residents located in unsewered areas should be utilizing onsite treatment of sewage through septic systems. Although records of residences and businesses with septic systems installed are not maintained, the location of all buildings outside of 1,000 feet of a sanitary sewer line was utilized to depict the potential abundance of septic systems in the SFLR watershed. These locations are shown in **Exhibit 10** (Appendix A). Many of these structures are located in close proximity to a stream or sinkhole, and therefore present a higher risk for potential contamination of groundwater or surface water. Properly functioning septic systems should not contribute to water pollution; however, improperly installed or poorly maintained systems can contribute to bacteria and nutrient pollution to streams and groundwater. In areas with karst geology, improperly maintained septic systems may not show evidence of failure at the surface; but, may drain into the groundwater system.

5. Stormwater Utilities

Stormwater runoff is water from rain or melting snow that does not soak into the ground. Instead, it flows from rooftops, across paved areas, and through sloped lawns. As stormwater runoff moves across these surfaces, it can pick up and carry along pollutants such as yard and pet waste, sediment, chemicals, oil, grease, and other contaminants.

The City of Hopkinsville is permitted as a Phase II Municipal Separate Storm Sewer System (MS4) by the KDOW under the Clean Water Act. The Phase II MS4 program requires the implementation of 6 minimum control measures designed to prevent harmful pollutants from being washed by stormwater runoff into local water bodies. The Hopkinsville Surface and Stormwater Utility (HSSU) is responsible for compliance with this permit. As of January 1, 2006, a monthly stormwater management service fee is imposed upon all real property in the City of Hopkinsville to fund stormwater management programs. More information on stormwater management may be obtained at http://hopkinsville-stormwater.com.

L. Nonpoint Sources and Land Use

1. Land Use

The land use of the SFLR watershed, according to the 2011 National Land Cover Database for Kentucky (Homer *et al.* 2015), is shown in **Exhibit 11** (Appendix A). The watershed is predominantly agriculture (62%) followed by forest (22%), while urban / suburban development represents about 13% of the land use within the watershed. Each land use has the potential to contribute different pollutants to the SFLR (and tributaries).

Because forested land cover acts as a natural filter for water, water quality tends to be better in areas surrounded by this use. However, natural erosion and improper timber harvesting methods can impact watershed quality. Generally, forested land uses contribute a lesser pollutant load than agricultural or urban / suburban development uses. Agriculture and urban / suburban uses are discussed in more depth below.

a. Agriculture

According to the 2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky (KDOW 2010), the leading source of stream impairments in Kentucky is agricultural-related sources. About 55% of the streams in Kentucky that are not supporting their designated uses have agricultural pollution as a source of impairment. Agricultural activities that cause nonpoint source pollution include poorly located or managed animal feeding operations; overgrazing; plowing too often or at the wrong time; and improper, excessive, or poorly timed application of pesticides, irrigation water, fertilizer, and animal manure. Pollutants can include sediment, nutrients, pathogens, pesticides, and metals. Agricultural practices can also be related to streambank degradation and in-stream habitat loss that causes streams to not support their designated uses.

Sedimentation in stream beds is one of the most prevalent agricultural pollutants due to soil erosion from fields. Nutrients, such as phosphorus, nitrogen, and potassium, are applied in the form of chemical fertilizers, manure, and sludge. When these sources exceed plant needs, or are applied just before it rains, nutrients can wash into streams. Pathogen sources can include livestock in streams or runoff from pastures as well as runoff from poorly managed animal feeding operations. Grazing livestock can degrade streambanks and destroy stream habitat. Pesticides, including insecticides, herbicides, and fungicides are used to kill agricultural pests, but can enter streams. Agricultural BMPs have been developed to address each of these pollutants, so with proper management the effect of this land use on streams may be minimized.

In the SFLR watershed, row cropping accounts for 40% (about 17,000 acres) and pasture accounts for 22% (about 9,000 acres) of the land use in the watershed according to 2011 National Land Cover Database. According to USDA National Agricultural Statistics Service Quick Stats (2017), Christian county had a total inventory of 29,000 cattle, including calves, in 2016 and Todd county had a total inventory of 20,000 cattle, including calves, in 2016. Assuming even distribution throughout the counties, an estimated 2,717 cattle would be present in the SFLR watershed.

The USDA National Agricultural Statistics Service (2014) provides a summary of the 2012 Census of Agriculture by county. **Table 6** summarizes this information for Christian and Todd counties, and estimates the number of each statistic within the SFLR watershed. This estimate is made with the assumption that the farms, livestock, and crops are evenly distributed throughout the un-zoned portions of these counties.

Table 6
2012 Agricultural Statistics, Christian and Todd Counties, Kentucky

Statistic	Christian County	Todd County	Estimated for SFLR Watershed[1]
Farms (No.)	1,179	603	97
Cattle and Calves Inventory (No.)	29,753	21,076	2,461
Beef Cows (No.)	9,738	4,862	799
Milk Cows (No.)	3034	3,783	256
Hogs and Pigs (No.)	235	3,566	30
Layers Inventory (No.)	58,779	No Data	4,734
Broilers and Other Meat Chickens Sold (No.)	2,495,690	1,223,520	204,774
Corn for Grain (Acres)	97,251	47,309	7,978
Wheat for Grain (Acres)	65,917	32,722	5,410
Total Cropland (Acres)	252,280	126,649	20,709

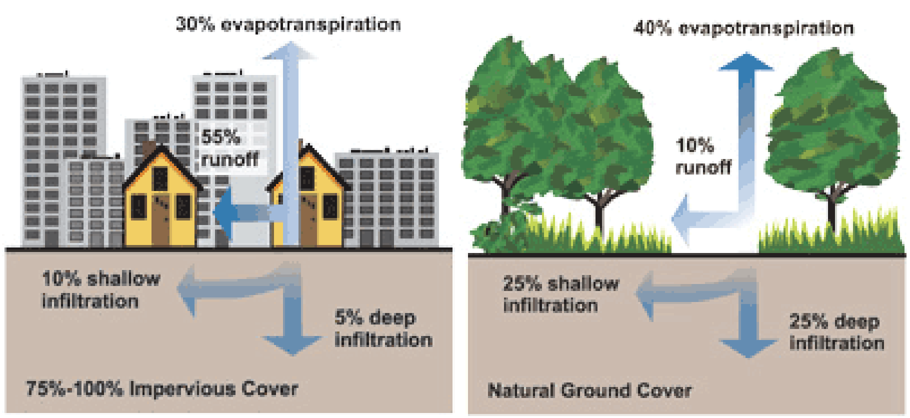
[1] Assuming even distribution throughout each of the 2 counties.

According to these statistics, Christian county is the top agricultural county in Kentucky in acres of farmland, cropland, harvested land, market value of crops sold, number of milk cow farms, and harvested acres of corn for grain, and all wheat production. Todd county is also within the top 5 counties in terms of market value of agricultural products sold, number of milk cow farms, and harvest acres of corn for silage, and all wheat production. Thus, row cropping for corn and wheat represent a large portion of the economy in these counties, and the concentration of milk cow farms (88 in Christian county and 72 in Todd county) is the highest in the state.

b. Urban / Suburban Development

The developed areas of the watershed (13%) may also be sources of pollution. One of the greatest sources of pollution in developed areas is runoff from impervious surfaces. Impervious surfaces, such as roadways and rooftops, are surfaces which water cannot penetrate. As these surfaces are unable to infiltrate water, they subject streams to extraordinarily high flows during storm events, leading to erosion and additional pollution. This relationship is illustrated in **Figure 3**. The percentage of impervious area, determined from National Land Cover Database (2011), within the SFLR watershed is 4%.

Figure 3
Relationship Between Impervious Cover and Surface Runoff



On impervious roadways, vehicles introduce numerous pollutants including oil, grease, rubber, and heavy metals (*e.g.*, lead, zinc, copper). Some of these pollutants also accumulate when the vehicles are idle on parking lots, driveways, and other parking areas. Most heavy metals tend to accumulate and remain within vegetated ditches adjacent to the surface. Other roadway pollutants tend to be more mobile. Research indicates that the amount of pollutants in surface waters is proportional to the amount of average daily traffic on nearby roadways. Also, in winter months, deicing salts transported with runoff can be a significant pollutant to surface waters. Roof runoff can also be high in certain metals and solids.

In residential areas, lawn fertilizers and pesticides, carried to streams through the storm sewer system, can also contribute to nonpoint source pollution. Lawn fertilizers (typically high in nitrogen and phosphorus), herbicides, and pesticides are commonly applied in residential areas to keep grass green. However, fertilizer that is not absorbed into the soil or used by the grass/plants may be carried into streams in runoff, resulting in nutrient pollution problems and subsequent algal blooms. Often, household pets are associated with residential areas and can contribute to fecal and nutrient pollution as well.

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

2. Zoning

As shown on **Exhibit 12** (Appendix A), the SFLR watershed contains 11 different zoned areas within its boundaries, consisting of nearly 14% of the watershed, all in vicinity of Hopkinsville. The majority, or 86% of the watershed, is un-zoned land located outside the city of Hopkinsville and used for agriculture or woodland.

Of the 5,853 acres of zoned land in the SFLR watershed, all are zoned for residential (2,334 acres, 40%), industrial uses (1,790 acres, 30%), business (1,729 acres, 30%), and professional (0.2 acres, 0%) uses. Poorly managed development of these lands would almost certainly lead to an increase of impervious surface in the watershed. The watershed-based plan should play a critical role in ensuring the developments do not negatively impact the health of the watershed.

Residential zones are the most abundant. Single-family residential zones (R-1 and R-2) account for 12% of all zoned land. In general, zones R-1 and R-2 have more “green” space associated with them and proportionately more pervious surface than higher density, multi-family housing. Zone R-3 (attached 1- and 2-family residential), and zones R-4 and R-5 (multi-family residential) would be expected to have increased amounts of impervious surface and thus are likely to produce more stormwater runoff. Industrial, business, and professional zoned areas typically have the largest area of impervious surface and thus contribute more runoff.

M. People and Communities

The quality of the water in the river, streams, and tributaries of the SFLR watershed is affected by the people and communities that live and work in the area. Therefore, understanding the community will aid in the outreach, education, and stakeholder engagement that is necessary to ensure a watershed-based plan is implemented successfully.

The urban / suburban portions of SFLR include portions of 6 of Hopkinsville’s Ward Districts, including large portions of wards 1, 7, 8, and 9 as well as small portions of wards 6 and 10. The SFLR watershed also receives drainage from 43 Hopkinsville neighborhood associations and subdivisions listed in **Table 7**, page 20. These wards, neighborhoods, and subdivisions are shown on **Exhibit 13** (Appendix A).

Table 7
Neighborhood Associations and Subdivisions

Map ID[1]	Neighborhood Association or Subdivision Name	Map ID[1]	Neighborhood Association or Subdivision Name
1	Palmyra Park	24	Jennette
2	Eagles Cove	25	Cayce Meade
3	Cedar Creek	26	Highland Park
4	Bruceview	27	Country Club Estates
5	Windsong	28	Skyline Park
6	Hunting Creek	29	Givens
7	Briarwood Estates	30	Faircrest
8	Holiday Park	31	Cox
9	South Fork Place	32	James Gregory
10	Thouroghbread Acres	33	Lovers Lane Estates
11	Cherokee Park	34	Countryside Estates
12	Lehigh Acres	35	Rivers End
13	Southgate	36	Oak Estates
14	Maplelawn	37	Pleasant Acres
15	Lealand Acres	38	Marjorie Parker
16	Spring Haven	39	Peartree Park
17	Virginia Gardens	40	Cherokee Trace Industrial Park
18	Annelle Park	41	Skyline Drive
19	Princess Elaine	42	Sheffield Downs
20	Brentwood	43	Reese Addition
21	Princess Elaine #2	44	Bryan Street
22	Southland	45	Durrett Ave
23	Orchard View	46	Attucks/Eastside

[1] See Exhibit 13

Christian county is also home to Amish and Mennonite communities. According to Amish America (2017), there are 2 Amish settlements in Christian county, 1 of which is located in the SFLR watershed. The settlement was founded in 1989 near Hopkinsville and Pembroke. Christian county is also home to an Old Order Mennonite community which has a sizeable produce auction in Fairview, Kentucky, near the SFLR watershed boundary.

Numerous schools, churches, and municipal facilities are located within the SFLR watershed and may prove useful for coordinated outreach events. Schools in the area include St. Peter and Paul School, Martin Luther King, Jr. Elementary, Children's Academy, Brown Mackie College of Hopkinsville, and

Murray State University Hopkinsville Regional Campus. Christian County Alternative School and Hopkinsville Community College are also located nearby and may be interested in doing environmental education about the area. Churches include Cumberland Presbyterian Church, First Christian Church of Hopkinsville, Hillcrest Baptist Church, Presbytery of Western Kentucky, All Nations House of Prayer, Eastview Baptist Church, Pleasant Hill Missionary Church, Casky Baptist Church, Little River Church, Set Free Ministries, Lakeview Baptist Church, and Vaughn Grove Methodist Church. Key municipal facilities include Pennyroyal Scuba Center / Blue Springs Resort, Hopkinsville Golf and Country Club, Western Hills Municipal Golf Course, Hopkinsville-Christian County Airport, Western State Hospital, Christian County Animal Shelter, and Fort Campbell Memorial Park.

1. Community Characteristics

The SFLR watershed spans 9 census tracts with a total population of 32,000; however, only portions of each tract are located within the watershed as shown on **Exhibit 14** (Appendix A). For example, while the total acreage of census tract "2012" is 46,000 acres, only 15,500 acres are within the watershed boundary. **Table 8** summarizes key statistics for each census tract area.

Table 8
2011-2015 Census Data[1]

Census Tract			Population		Age	Income		Education (≥25 years old)		Housing
ID	Total Acres	% Area in SFLR	No.	Density (No. per Acre)	% <18 Years	Per Capita	% Below Poverty	% High School Graduate	% College or Above	% Built Pre-1950
2001	887	4%	4,256	4.80	25%	$17,141	32%	84%	10%	40%
2003	10,542	84%	3,620	0.34	30%	$11,749	53%	72%	8%	10%
2004	1,193	91%	2,894	2.43	33%	$11,613	47%	76%	11%	14%
2005	2,572	95%	4,434	1.72	27%	$25,240	13%	87%	28%	10%
2006	3,120	31%	4,568	1.46	24%	$28,993	7%	93%	24%	2%
2009	58,680	<1%	5,877	0.10	31%	$28,950	5%	85%	28%	5%
2012	46,136	34%	2,684	0.06	34%	$18,677	13%	79%	8%	7%
2013	59,549	20%	2,965	0.05	31%	$22,157	11%	86%	20%	17%
2014	81,860	2%	2,852	0.03	31%	$26,193	8%	88%	23%	21%

[1] Data for 2011-2015 American Community Survey 5-Year Estimates was obtained from American Fact Finder 11-22-17.

The largest city within the watershed is Hopkinsville, Kentucky. According to data from the U.S. Census Bureau's 2011-2015 American Community Survey 5-Year Estimates (2017), the median income for families in Hopkinsville was $34,614, with around 18.5% of all families living below the poverty threshold (but percentages vary based on household size). For example, 49.2% of households led by a single female, with only related children under 5 years old in the home, were below the poverty threshold in census tracts within the SFLR. The percentage of all individuals living below the poverty threshold was 22.5%. It's worth noting that according to the U.S. Census Bureau's estimates, 84.9% of the population has a high school degree, or equivalency, or higher, with up to 28% in some areas having obtained a college degree.

Some of the areas have significant numbers of houses that were constructed prior to 1950. This is particularly in urban areas because PVC was not widely used until after 1970. Prior to that time, clay or orangeburg pipe was utilized for sanitary sewer construction, and unless the homeowners have repaired these systems these pipes can contribute to exfiltration of wastewater to the groundwater or surface water in areas with sanitary sewer service.

2. Little River Focus Group Community Concerns

In 2012, the Cumberland River Compact hosted a series of focus group meetings with stakeholders in the Little River Watershed. Three focus group meetings were held at the Lake Barkley State Resort Park in Cadiz, Kentucky, Jeffers Bend Environmental Center in Hopkinsville, Kentucky, and the Pennyrile Area Development District in Hopkinsville, Kentucky. According to meeting minutes (2012), a facilitator from the Center for Nonprofit Management led the discussion and asked the following questions:

- How is your community different today that it was as far back as you can remember living here?
- What impact have these changes had on water? How has this affected you personally?
- What actions could be taken by the community to make improvements to ensure that the water quality and quantity is protected? Are there current efforts underway in the watershed?
- In the best of all possible worlds, describe this watershed as you hope it will exist for future generations?

Based upon minutes from these meetings, the focus groups desired to see recreation along the entire river, with a changed community perception on the value of the river. They desired for the water quality and quantity to be restored to more sustainable and healthy levels, and for the population to accept some level of regulation of land use practices.

The focus groups noted a number of changes over their lifetimes. For agriculture, row cropping farming practices were seen to improve and irrigation levels increased. The number of dairies located in the area had grown and there was some concern about their management. The amount of industry in the area was noted to have increased over the last 20 years, but more land was also converted back into forest. There was some concern about the expansion of residential communities along lakes and fishing communities, and the lack of building control. The increase in impervious surfaces was viewed as a concern, as was a decrease in the riparian buffers in urban areas. In particular, the need for increased clearing of log jams and removal of trees along the banks of the stream were a concern. Failing septic systems were also cited as a concern.

Water quality-related changes centered on trash and debris, sedimentation, decreases in the base flow conditions, nutrient problems, and less recreation. The amount of trash and debris was a concern to several stakeholders primarily due to stormwater contributions. Some illegal dumping was known to still be occurring in the area but this was thought to have decreased.

Sedimentation due to erosion and other sources had increased in Barkley Lake, Casey Creek, and other streams. The water levels of Lake Barkley were thought to have decreased, and it was noted that the rivers and streams went dry more frequently and had lower base flow conditions. One stakeholder noted that it was harder to canoe the streams because the amount of portage required had increased. A canoe race was held in Cadiz historically but is no longer held. The lower water levels were thought to be due to increased irrigation, pumping, and withdrawals, as well as an increase in sinkholes in the area. Nutrients from homeowners and golf courses were a concern in the runoff. Recreation in the stream and lakes was thought to have decreased because of poor aesthetics, more frequent beach closures due to bacteria, and fishermen giving up the hobby.

The community wanted to see action to stem some of the problems they identified. For specific pollution issues, some recommendations were made. Stabilization was recommended to address erosion, education about lawn fertilization to reduce nutrients, installation of rain gardens and rain barrels to decrease runoff, and hosting clean up days to reduce the litter and debris; however, most solutions focused on education and outreach, land use planning, and the need for increased research.

Education and outreach efforts were the most frequently discussed need. Focus groups desired to have educational materials developed for houseboat use and for residents living along the lake. They also desired environmental education for the youth regarding water issues and how they contribute. Lastly, homeowner meeting coordination, volunteer cleanups, and the need for a central point of contact for environmental resources were discussed.

For land use planning, the focus groups believed that the current plans were poorly defined and unsustainable. They desired to see responsible water use, and to promote ecotourism in the area. They wanted to see more river-based activities and more investigation of financial incentives to increase forested land and promote a green belt. They were in favor of more research on topics including the water quality health, impacts on habitat and wildlife, reasons for the increased number of sinkholes, and ways to manage the land more sustainably.

N. Regulatory Status of Waterways

Kentucky assigns designated uses to each of its waterways, such as recreation, aquatic habitat, and drinking water. For each use, certain chemical, biological, or descriptive ("narrative") criteria apply to protect the stream so that its uses can safely continue. The criteria are used to determine whether a stream is listed as "impaired" on the 303(d) list (KDOW 2015) and therefore needs a watershed-based plan or TMDL computations and load allocations. **Exhibit 15** (Appendix A) shows the regulatory status of waterways in the watershed.

1. Designated Uses

The designated use of SFLR and its tributaries within Christian and Todd counties include warm water aquatic habitat (WAH), primary contact recreation (PCR), fish consumption, and secondary contact recreation (SCR). The WAH criteria are in place to protect aquatic life that inhabits streams. PCR criteria are in place to protect people engaged in recreation in a way that likely will result in full body immersion in the water body, such as swimming. SCR designated use criteria are in place to protect those recreational activities that are likely to result in incidental contact with water, such as boating, fishing, and wading. Fish consumption is not a designated use in Kentucky water quality standards, but the use is implied in 401 KAR 10:031 Section 2 and through human health criteria in Section 6. The fish consumption use is based on water body-specific monitoring and comparing the fish tissue body burden results for specific pollutants (*e.g.*, mercury, PCB, chlordane) in applicable water quality standards.

2. Designated Uses Impairment Status

Section 305(b) of the Clean Water Act requires Kentucky and other states to assess and report water quality conditions to the U.S. Environmental Protection Agency (USEPA) every 2 years. Streams are assessed to determine whether they support their designated uses. Based on assessment results, each stream receives 1 of 3 classifications to denote relative level of designated use support: fully supporting (good to excellent water quality); partially supporting (fair water quality, does not fully meet designated use); and non-supporting (poor water quality).

Kentucky assigns surface waters to reporting categories based on the results of the assessment. Category 1 waters are fully supporting all designated uses. Category 2 waters are fully supporting assessed designated uses, but not all uses have been assessed (2), the water is proposed to EPA for delisting but not yet approved (2B), or the water has reached supporting levels identified by a TMDL (2C). Category 3 waters have not yet been assessed. Category 4 waters have been found to be not supporting with an approved TMDL (4A), an approved alternative pollution control plan (4B), or the impairment is not attributable to a pollutant (4C). Category 5 waters have been found to be not supporting and require a TMDL (5) or insufficient data is available to support a specific listing determination (5B). Although streams in categories 4, 4B, 4C, 5, or 5B are all impaired due to either partially supporting or non-supporting their designated uses, only streams in category 5 or 5B are on the 303(d) list of impaired surface waters of Kentucky. Category 4, 4B, and 4C streams are still impaired, but have approved TMDLs.

According to the 2014 305(b) and 303(d) lists (KDOW 2015), SFLR is impaired from mile 0 to 10.3 for WAH (non-support), and PCR (non-support), impaired from mile 10.3 to 20.3 for WAH (partial support), and PCR (non-support), and impaired from mile 21.3 to 26.1 for WAH (non-support).

From mile 0 to 10.3, 3 pollutants listed as impairing the waterway are: nutrient/eutrophication biological indicators, sedimentation/siltation, and "other". Suspected sources are listed as agriculture and municipal point source discharges. An unknown source is listed as the suspected source for the "other" pollutant. From mile 10.3 to 20.3, 3 pollutants listed as impairing the waterway are: nutrient/eutrophication biological indicators, sedimentation/siltation, and "other". Suspected source is listed as agriculture. From mile 21.3 to 26.1, the pollutant is listed as impairing the waterway is "cause unknown". The suspected source is also listed as unknown.

Additionally, a tributary to SFLR, Warrens Fork, is impaired from mile 0 to 3.5 for WAH (partial support). The pollutant listed as impairing the waterway is "cause unknown." The suspected source is also listed as unknown.

3. Total Maximum Daily Load

In 2009 KDOW developed an approved TMDL for pathogens entitled “Final Total Maximum Daily Load for Pathogens: Little River Watershed, Lower Cumberland Basin, Kentucky” (2009 based upon data collected between 2000 and 2002. The “percent reduction” approach was used to express the TMDL for the Little River watershed. The percent reduction required to meet the water quality criteria was calculated based on the difference between the existing conditions and the TMDL Target for fecal coliform. Thus, the reduction is the percent difference between the 90th percentile of fecal coliform concentrations collected during the recreation season that exceed the TMDL Target (360 colonies/100ml fecal coliform). The results for the SFLR watershed are shown in **Table 9**.

Table 9
Little River Pathogen TMDL Load Allocations

Waterbody - Impaired River Miles (RM)	Monitoring Station ID	Waste Load Allocation (WLA) MS4 (% Reduction)	Load Allocations (LA) (% Reduction)	Margin of Safety	TMDL (% Reduction)
SFLR RM 0.0 – 10.3	LCTMDL01	83.3%	83.3%	10%	83.3%
SFLR RM 10.3 – 20.3	SFLR001	0	96.4	10%	96.4%

III. MONITORING

A. Historic Biological and Water Quality Monitoring

To evaluate the water quality within the SFLR watershed, historic monitoring data was gathered from all publicly available sources including academic and regulatory publications. Generators of surface water quality data for the SFLR watershed include KDOW; Murray State University, Hancock Biological Station and Center for Reservoir Research; USGS; Western Kentucky University (WKU); and the Kentucky Department of Fish and Wildlife Resources (KDFWR). Studies were conducted at 12 sites throughout the watershed, over multiple years, for different parameters as summarized in **Table 10** and **Table 11** (page 27) and illustrated on **Exhibit 16** (Appendix A). A detailed analysis of each study follows.

Table 10
Historic Biological and Water Quality Monitoring

Sponsor	Description	No. of Sites in SFLR Watershed	Monitoring Period	Parameter(s)								
				Macro / Habitat	Fish	Algae	Bacteria	Physicochemical	Nutrients	Pesticides	Sediment	Metals
KDOW	Little River and Donaldson Creek (Cumberland River Drainage) Biological and Water Quality Investigation. 1996	4	1988	X	X	X		X	X		X	
KDOW	Final Total Maximum Daily Load for Pathogens Little River Watershed, Lower Cumberland Basin, Kentucky. 2009	3	2000-2001				X	X				
KDOW	Monitoring for Nutrient TMDL. *Unpublished*	3	2001-2002					X	X		X	X
Murray State University	Biological Baseline Conditions in the Little River Watershed. 2001	3	2000-2001	X	X	X		X				
	Biological Baseline Conditions in the Little River Watershed (2003). 2006	3	2003-2004	X	X	X		X				
USGS	Assessment of Pesticides, Nutrients, and Suspended Sediment of the Little River Basin, Kentucky, 2003-04. 2006	1	2003-2004					X	X	X	X	
KDFWR	Fish Survey. *Unpublished*	1	2010		X							
KDOW	Probabilistic Monitoring, Biology and Field Data.	3	2008-2010 2015	X	X			X	X	X	X	
KDOW and WKU	Pennyroyal (71a) Nutrient Project. *Unpublished*	2	2008-2010					X	X			

Table 11
Historic Biological and Water Quality Monitoring Sites

Site ID	Location	Latitude	Longitude	Monitoring Effort
DOW20014001 USGS 03437600	SFLR @ KY 107	36.79830	-87.51420	KDOW, Biosurvey and TMDL fecal and Water Chemistry USGS, Pesticide, Nutrients, Sediment
KYC415-132	SFLR between KY 107 and Riverbend Rd	36.79992	-87.50778	KDOW, Probabilistic Biosurvey, Field and Water Chemistry Data
LCTMDL01	SFLR @ Riverbend Rd	36.79990	-87.49820	KDOW, TMDL Fecal and Water Chemistry
DOW20014006 SWD20044501	SFLR near US 68, Downstream of Pennyrile Pkwy	36.81659	-87.49287	KDOW, Biosurvey KDOW and WKU, Pennyroyal Nutrient Project KDFWR, Fish survey
SFLR002	SFLR @ US 41A	36.83960	-87.48100	KDOW, TMDL Fecal and Water Chemistry
CRR200005	SFLR @ Trail of Tears Commemorative Park	36.85292	-87.46967	Murray State, Biosurvey
DOW20014002	SFLR @ Airport Rd	36.85500	-87.46280	KDOW, Biosurvey and TMDL Fecal and Water Chemistry
SFLR001	SFLR @ Edward Mills Rd	36.84670	-87.41790	KDOW, TMDL Fecal and Water Chemistry
CRR200002	SFLR between HWY 68-80 and Little River Rd	36.84893	-87.37433	Murray State, Biosurvey
DOW20014003	SFLR @ Little River Rd	36.84970	-87.37830	KDOW, Biosurvey
CRR200001 DOW20014004	SFLR @ KY 508 Bridge	36.88170	-87.34030	Murray State, Biosurvey KDOW, Biosurvey and TMDL Fecal and Water Chemistry
DOW20014005	Warrens Fork above Vaughn's Grove Rd (KY 1843)	36.86347	-87.32524	KDOW and WKU, Pennyroyal Nutrient Project KDOW, Biosurvey

1. KDOW - Little River and Donaldson Creek (Cumberland River Drainage) Biological and Water Quality Investigation (1988)

KDOW's "Little River and Donaldson Creek (Cumberland River Drainage) Biological and Water Quality Investigation" (KDOW 1996) involved 4 sampling sites located within the SFLR Watershed: DOW20014001, DOW20014002, DOW20014003, and DOW20014004 (hereafter abbreviated as 14-1, 14-2, 14-3, and 14-4). Sites were sampled during 2 events (April 20 and August 9, 1988) for physicochemical parameters (dissolved oxygen, pH, conductivity, temperature); mercury; sediment (Kjeldahl nitrogen, volatile solids, COD, arsenic, ammonia, chromium, iron, lead, manganese, nickel, and zinc); and biology including fish, macroinvertebrates, and algae.

Dissolved oxygen, pH, and temperature were all within normal ranges, with conductivity ranging from 253 to 401 µS/cm. Mercury levels (0.0002 to 0.001 mg/L) were found in exceedance of chronic warm water aquatic habitat criteria (0.000012 mg/L) at all four (4) sites. In the spring, sediment samples were found to be polluted for Kjeldahl nitrogen (heavily at 14-1, 14-2, 14-3), arsenic (moderately at 14-4), ammonia (moderately at 14-1), lead (moderately at 14-2), manganese (heavily at 14-1, 14-2, and 14-4; moderately at 14-3), and volatile solids (moderately at 14-1). In the summer, sediment samples were found to be polluted for volatile solids (moderately at 14-1, heavily at 14-2 and 14-3), COD (heavily at 14-1 and 14-3), ammonia (moderately at 14-3), manganese (heavily at all sites), arsenic (heavily at all sites), and chromium (moderately at 14-3).

Using a scoring system that pre-dates current metrics used to evaluate biology, 14-3 ranked "good," 14-1 and 14-4 ranked "fair," and 14-2 ranked "poor." Three sites had "good" diatoms (14-1, 14-2, and 14-3) and 1 was "fair" (14-4). Macroinvertebrate community scores decreased from upstream to downstream: "good" at 14-3, "fair/good" at 14-4, and "fair" at 14-1 (14-2 was not evaluated for macroinvertebrates due to a lost sample). The fish community had the greatest impacts with "poor" scores at 14-1 and 14-2 and a "fair" score at 14-3 (14-4 was not sampled). Only 10 species of fish were collected in the SFLR.

2. KDOW - Pathogens and Nutrient Total Maximum Daily Load Monitoring (2000-2002)

The Little River, from river mile (RM) 23.6 to 61.0, was first listed on the 1998 303(d) List as impaired for pathogens, nutrients, and siltation. In 2000-2001, monitoring was conducted for fecal coliform to assess the primary contact recreation use of Little River and its tributaries. Additionally, from 2000-2002, nutrients and other pollutants (alkalinity, ammonia, hardness, nitrate, total Kjeldahl nitrogen, organic carbon, total phosphorus, sulfate, and total suspended solids) were sampled at these locations to assess the aquatic life impairment. Physicochemical parameters (water temperature, conductivity, pH, and dissolved oxygen) were also measured during each visit. Iron and mercury were also sampled at 1 location.

Three locations in SFLR were sampled during this effort: SFLR001 located at Edwards Mill Road, SFLR002 located at US 41A, and LCTMDL01 located at Riverbend Road.

The fecal coliform data was utilized to develop the "Final Total Maximum Daily Load for Pathogens. Little River Watershed, Lower Cumberland Basin, Kentucky" (KDOW 2009). The nutrient data was obtained by a Freedom of Information Act (FOIA) request from KDOW and has yet to be published. The results are summarized in **Table 12**, page 29.

Most field parameters were within the normal ranges. Water temperature ranged from 3.1 to 27.5˚C, pH from 6.25 to 8.10 SU, conductivity from 58 to 808 µS/cm, and dissolved oxygen ranged from 1.40 to 15.0 mg/L. Dissolved oxygen was found to drop below 4.0 mg/L, levels where the aquatic community may be impacted, at all sites, but frequently (26% of results) at SFLR002.

Table 12
KDOW Fecal Coliform and Nutrient Data Summary, 2000-2002

Site ID / Parameter	Count	Unit	Min	Max	Mean
SFLR001					
Fecal coliform	8	CFU/100mL	40	12000	346
Alkalinity	15	mg/L	27.9	204	96
Ammonia (as N)	15	mg/L	<0.05	0.42	0.09
Nitrate (as N)	15	mg/L	0.13	5.86	1.70
Organic Carbon	15	mg/L	1.25	13.7	4.6
Total Phosphorus (as P)	15	mg/L	<0.005	0.83	0.12
Sulfate (as S)	15	mg/L	<5	14.8	7.9
TKN (as N)	15	mg/L	<0.05	4.16	0.74
Total Suspended Solids	15	mg/L	2	720	37
SFLR002					
Fecal coliform	8	CFU/100mL	380	12000	1642
Alkalinity	15	mg/L	25.5	238	91
Ammonia (as N)	15	mg/L	<0.05	0.59	0.11
Nitrate (as N)	15	mg/L	0.59	5.03	1.63
Organic Carbon	14	mg/L	1.42	13.8	4.76
Total Phosphorus (as P)	15	mg/L	<0.005	0.97	0.15
Sulfate (as S)	15	mg/L	<5	33.6	9.8
TKN (as N)	15	mg/L	<0.05	5.56	1.00
Total Suspended Solids	15	mg/L	2	1420	90
LCTMDL01					
Fecal coliform	19	CFU/100mL	26	2400	261
Alkalinity	28	mg/L	28	223	130
Ammonia (as N)	29	mg/L	<0.05	0.71	0.08
Nitrate (as N)	29	mg/L	0.36	5.30	1.99
Organic Carbon	27	mg/L	1.32	11.4	3.15
Total Phosphorus (as P)	29	mg/L	<0.005	1.16	0.07
Sulfate (as S)	29	mg/L	<5	897	21.2
TKN (as N)	29	mg/L	<0.05	5.3	0.42
Total Suspended Solids	28	mg/L	<1	1880	24
Iron	11	mg/L	0.099	0.943	0.26
Mercury	11	mg/L	<0.00005	<0.00005	N/A

3. Murray State University - Biological Baseline Conditions in the Little River Watershed (2000)

Three sites in the SFLR watershed were sampled in 2000 by Murray State University, Hancock Biological Station and Center for Reservoir Research: CRR200001, CRR200002, and CRR200005 (hereafter abbreviated as CRR-1, CRR-2, and CRR-5). Sampling was conducted for physicochemical parameters (dissolved oxygen, pH, conductivity, temperature, oxidationreduction potential, turbidity, flow, and alkalinity) and biology, including fish, macroinvertebrates, algae, and habitat. The results are summarized in **Table 13**.

Field physicochemical samples were all within normal ranges, with conductivity ranging from 395 to 459 µS/cm. Habitat was non-supporting of warmwater aquatic habitat at 2 sites, and partially supporting at 1 site, with narrow riparian widths and some unstable banks contributing to lower scores. Algae scores were "good" to "excellent," but macroinvertebrate scores ranged from "fair" to "very poor," and fish scores from "fair / good" to "very poor."

Twenty fish species were collected from the SFLR during this study. The species collected were largescale stoneroller, striped shiner, scarlet shiner, golden shiner, bluntnose minnow, creek chub, white sucker, western creek chubsucker, yellow bullhead, blackspotted topminnow, mosquitofish, banded sculpin, rock bass, green sunfish, bluegill, longear sunfish, largemouth bass, fringed darter, Tennessee snubnose darter, and freshwater drum.

Table 13
Murray State University Monitoring Results, 2000

Site ID	Date	Temp (˚C)	DO (mg/L)	pH (SU)	Turb (NTU)	Cond (µS/cm)	Alkalinity (mg/L $CaCO_3$)	Habitat RBP	Algae DBI[1]	Macro MBI[2]	Fish IBI[3]
CRR-1	7/6/00	22.35	10.19	7.37	13.5	410	29.66	Partial Support	Good	Poor	Fair
CRR-2	7/3/00	21.32	8.25	8.25	38.3	395	23.86	Non-Support	Good	Fair	Fair / Good
CRR-2	9/14/00	19.82	7.21	7.21	5.8	431	33.03	-	Good	Fair	Fair
CRR-5	7/3/00	23.26	9.74	7.77	10.4	424	30.55	Non-Support	Good	Poor	Very Poor
CRR-5	9/7/00	22.35	7.20	7.73	11.2	459	27.56	-	Excellent	Very Poor	Very Poor / Poor

[1]Diatom Bioassessment Index; [2] Macroinvertebrate Bioassessment Index; [3] Index of Biotic Integrity

4. Murray State University - Biological Baseline Conditions in the Little River Watershed (2003)

According to "Biological Baseline Conditions in the Little River Watershed (2003)" (Hendricks *et al.* 2006), sites sampled in 2000 were re-sampled in 2003 by Murray State University, Hancock Biological Station and Center for Reservoir Research to compare with previous data and evaluate biological metrics and indicators. With the exception of alkalinity, the same parameters assessed in 2000 were assessed in 2003. The results are summarized in **Table 14**, page 31.

In general, habitat, algae, and macroinvertebrate scores were similar to the results from 2000, and the fish results were better. Although golden shiner and mosquitofish were not collected in 2003, a total of 22 species were collected, including four (4) species not previously collected in 2001: redear sunfish, spotted bass, greenside darter, and orangethroat darter.

Table 14
Murray State University Monitoring Results, 2003

Site ID	Date	Temp (˚C)	DO (mg/L)	pH (SU)	Turb (NTU)	Cond (µS/cm)	Habitat RBP	Algae DBI[1]	Macro MBI[2]	Fish IBI[3]
CRR-1	5/14/03	17.5	10.55	8.01	60.3	325	Partial Support	Good	Fair	Fair
CRR-1	9/05/03	19.6	9.15	8.15	23.9	321	Non-Support	Good	Fair	Good
CRR-2	5/14/03	16.3	9.95	7.95	10.2	362	Partial Support	Fair	Poor	Good
CRR-2	9/05/03	18.5	9.56	8.11	17.4	326	Non-Support	Good	Fair	Fair
CRR-5	5/14/03	15.2	10.00	7.3	-	402	Non-Support	Good	Poor	Good
CRR-5	9/05/03	19.9	8.26	7.8	41.8	316	Non-Support	Good	Poor	Fair

[1]Diatom Bioassessment Index; [2] Macroinvertebrate Bioassessment Index; [3] Index of Biotic Integrity

Data collected by Murray State University was also published in 3 *Journal of Kentucky Academy of Science* articles: "Benthic Diatom Species List and Environmental Conditions in the Little River Basin, Western Kentucky, USA" (Hendricks *et al.* 2006); "Benthic Algae Taxa (Exclusive of Diatoms) of Little River Basin, Western Kentucky, 2000-2003" (Hendricks and Luttenton 2007); and "Fish Species of the Little River Basin, Western Kentucky, 2000-2003" (Hendricks and Timmons 2008).

5. USGS - Assessment of Pesticides, Nutrients, and Suspended Sediment of the Little River Basin (2003-2004)

USGS conducted a study of pesticides, nutrients, and suspended sediment in the Little River watershed in 2003 and 2004. Of the 9 sites monitored, 1 was in SFLR near the mouth of the watershed (USGS 03437600 at KY 107). The results of the study were summarized in a project report to KDOW (Crain and Collins 2006), as well as 2 USGS Scientific Investigations Reports (Reports 2006-5124 and 2006-5204 by Crain).

Monitoring was conducted monthly (March to November 2003 and February to November 2004), as well as during an additional 3 high-flow events and 1 low-flow event. Field measurements of stream discharge, barometric pressure, air temperature, water temperature, specific conductance, pH, dissolved oxygen, turbidity, alkalinity, and bicarbonate were measured at the time of sampling. Continuously recording gages collected discharge, water temperature, specific conductance, pH, dissolved oxygen, and turbidity on 15-minute intervals.

Laboratory samples were collected for suspended sediment, nutrients (dissolved ammonia, nitrite plus nitrate, total phosphorus, and dissolved orthophosphate), and pesticides (a wide spectrum of herbicides, insecticides, and fungicides including acetochlor, atrazine, deethylatrazine, diazinon, metolachlor, prometon, and simazine). Pollutant loads were estimated using the USGS LOADEST software and are summarized in **Table 15**, page 32.

Table 15
USGS Pollutant Loading Summary, 2003-2004

Parameter	Mean Annual Load (lbs/day)	Mean Annual Yield (lbs/year)/mi²
Pesticide		
Acetochlor	193	3.3
Atrazine	620	10.9
Deethylatrazine	80	1.4
Diazinon	<4	<0.07
Metolachlor	11	0.19
Simazine	55	0.95
Nutrients		
Ammonia (as N), dissolved	-	-
Nitrite plus nitrate (as N), dissolved	780,000	13,000
Phosphorus (as P), total	32,000	550
Orthophosphorus (as P), dissolved	14,000	240
Suspended sediment	18,000,000	310,000

The report does not provide a breakdown of pollutant concentrations at each site. However, most detections of pesticides were at concentrations less than regulatory drinking water and health-advisory levels. Concentrations of atrazine exceeded its aquatic-life criterion (1.8 µg/L) in 32 samples collected from all sites. The concentration of atrazine in the storm sample collected from the SFLR site (22.4 µg/L) was more than 12 times its aquatic-life criterion; most of the high concentrations of atrazine occurred in storm samples. Carbaryl was detected at concentrations that exceeded the aquatic-life criterion (0.2 µg/L) in 12 samples (it is unknown if any of these samples were from the SFLR). Concentrations of diazinon exceeded their aquatic-life criterion (0.08 µg/L) in 2 samples collected in July 2004 at the North Fork Little River and at the SFLR sites. The SFLR site had the largest yields of commonly used row-crop herbicides (acetochlor, atrazine, and metolachlor). The estimated mean annual loads of acetochlor, atrazine, diazinon, metolachlor, and simazine were about 0.01% to 2.2% of the amount applied in the basin.

Of the sites sampled, SFLR has the largest mean annual nitrite plus nitrate yield, but was lower in all other categories. In fact, the SFLR had the lowest mean annual load and yield for suspended sediment. Nitrogen concentrations were found to be higher in the spring (March-May) after fertilizer application and runoff. Suspended sediment concentrations were also found to be highest during that time. The highest nitrogen concentration (5.7 mg/L) was measured at SFLR.

6. KDFWR - Fish Survey (2010)

Fifteen fish species were collected from SFLR across from Martin Place Drive bridge crossing in July 2010 by KDFWR. Species collected were largescale stoneroller, striped shiner, scarlet shiner, fathead minnow, blackspotted topminnow, banded sculpin, rock bass, green sunfish, bluegill, longear sunfish, greenside darter, rainbow darter, fringed darter, smallscale darter, and west rim darter. Of these species, west rim darter and fathead minnow had not been collected in previous survey efforts. The community would score as "fair" according to the Kentucky Index of Biotic Integrity (IBI), but the collection method was not performed according to Kentucky IBI protocol.

7. Other Historic Biological and Water Quality Monitoring (2008-2015)

A FOIA request to KDOW produced several other unpublished monitoring datasets collected by the KDOW and other entities through various programs, including the probabilistic monitoring program, TMDL program, Pennyroyal Nutrient Study (in conjunction with WKU). **Table 16** summarizes the biological results based upon KDOW metrics for fish, macroinvertebrates, and habitat.

Table 16
KDOW Biological Monitoring Results, 2008-2010

Site ID	Date	Fish Rating	Macro Rating	Habitat Rating
DOW20014005	5/13/2008	-	Fair	Poor
DOW20014005	7/29/2008	Excellent	Fair	Poor
DOW20014004	5/15/2009	-	Poor	Good
DOW20014001	9/02/2009	-	Poor	Poor
DOW20014002	9/02/2009	-	Poor	Poor
DOW20014006	7/20/2010	-	Poor	Poor

From 2007 to 2008, USGS sampled DOW20014005 on Warrens Fork for physicochemical parameters and nutrients on 10 occasions. Physicochemical parameters were all within normal ranges. The nutrient averages were as follows: ammonia - 0.003 mg/L, TKN - 0.25 mg/L, nitrate + nitrite – 4.38 mg/L, and total phosphorus 0.05 mg/L. KDOW also sampled this site for nutrients and other parameters during 2 collection events in 2008.

Western Kentucky University sampled DOW20014006 on SFLR near US 68, downstream of Pennyrile Parkway 3 times from November 2009 to June 2010 for nutrients. The nutrient averages were as follows: ammonia - 0.03 mg/L, TKN - 0.48 mg/L, nitrate + nitrite – 2.26 mg/L, and total phosphorus 0.05 mg/L. KDOW also sampled this site for nutrients and other parameters during the 2 biological collection events in 2010.

In 2015, KDOW sampled KYC415-132, near the mouth of SFLR, for biology as well as a variety of chemical parameters. The biological results were still in process, and most of the chemical results were below the detection limit or within normal ranges.

B. USGS - Multiple-Source Tracking (2013–2014)

In cooperation with the LRWQC and KDOW, USGS conducted a three-year study in the Upper Little River Basin to aid in understanding the occurrence and distribution of pathogens, nutrients, and sediment and their potential sources within the headwaters of the Little River watershed. The SFLR was the primary focus of the study because of the higher percentage of cropland and increasing number of small dairy operations in the drainage basin. The USGS study utilized advanced scientific techniques to determine the relative pollutant contributions of different sources, the findings and conclusions of which were published in "Multiple-source tracking – Investigating sources of pathogens, nutrients, and sediment in the Upper Little River Basin, Kentucky, water years 2013-14" (Crain *et al.* 2017).

Fourteen sites were monitored in the SFLR watershed between 2013 and 2014, as summarized in **Table 17** and illustrated on **Exhibit 17** (Appendix A). Five types of monitoring were conducted: routine monitoring, microbial source tracking, dual-nitrate isotope ratio analysis, sediment fingerprinting, and continuous streamflow monitoring.

Table 17
USGS Multiple-Source Tracking Monitoring Sites, 2013-2014

Site ID	USGS Station Number	Location	Drainage Area (mi²)	Sampling Type: Routine	Microbial-Source Tracking	Dual-nitrate isotope	Sediment Fingerprinting	Streamflow Gage	Latitude	Longitude
SF01	3437410	SFLR @ Pilot Rock Rd	0.40	X	X	X	X		36.912773	-87.335834
SF02	3437415	SFLR @ Butler Rd	4.01	X	X	X	X		36.881389	-87.340278
SF03	3437420	UNT @ Pilot Rock Rd	0.57	X		X			36.908558	-87.35365
SF04	3437425	UNT #2 @ Butler Rd	1.27	X	X				36.881393	-87.35722
SF05	3437435	UNT #1 @ Butler Rd	2.41	X		X			36.881667	-87.350278
SF06	3437450	Warrens Fork @ Vaughn-Grove-Fairview Rd	5.51	X	X	X	X		36.862778	-87.325556
SF07	3437480	SFLR @ Highway 68/80	18.70	X	X	X	X	X	36.849771	-87.352349
SF08	3437492	SFLR @ Little Church Rd	23.20	X					36.849722	-87.378333
SF09	3437495	SFLR @ US 68 Bypass	35.90	X		X	X	X	36.849254	-87.428983
SF10	3437500	SFLR @ US 41	46.10	X	X	X		X	36.839444	-87.481389
SF11	3437520	SFLR @ Eagle Way	48.50	X					36.818056	-87.489444
SF12	3437560	Rock Bridge Branch @ John Rivers Rd	4.00	X		X			36.790679	-87.427107
SF13	3437570	Rock Bridge Branch @ US 41	7.46	X	X	X	X		36.794436	-87.473595
SF14	3437600	SFLR @ KY 107	67.40	X	X	X	X		36.79855	-87.514174

Routine monitoring was conducted at all 14 sites. It consisted of grab sample collection for ammonia, organic nitrogen, nitrate plus nitrite, orthophosphate, total phosphorus, *E. coli* in water, *E. coli* in sediment, and suspended solids. Field measurements including air temperature, water temperature, barometric pressure, specific conductance, pH, dissolved oxygen, turbidity, and discharge were also measured during routine monitoring. *E. coli* was collected from April to October 2013 and from May to November 2014 under this study. Other parameters were collected monthly, if flow was present, from November 2012 to November 2014. The USGS utilized the S-LOADEST program to estimate the mean annual loads of nutrients and sediments for 2 locations in the SFLR.

Microbial source tracking was conducted at 8 sites. Fecal reference samples were collected from 4 potential host groups (human, canine, bovine, and waterfowl) and analyzed for genetic markers using quantitative polymerase chain reaction. Genetic markers tested included GenBac, a mixed source-associated *Bacteroidales* marker; HF183, a human-associated *Bacteroidales* marker; BacCan, a canine-associated *Bacteroidales* marker; BoBac, a ruminant-associated *Bacteroidales* marker; and GFD, a waterfowl-associated *Helicobacter* marker. Samples collected from the 8 sites were analyzed for the genetic markers to determine the source of the fecal-indicator bacteria at each of these locations. Between 9 and 14 microbial source tracking samples were collected at site.

Dual-isotope nitrate isotopes ($\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$) were utilized to help differentiate between inorganic sources (atmospheric and fertilizer) and organic sources (manure and septic waste) of nitrogen pollution. A total of 175 samples were collected from 11 sites.

Sediment fingerprinting monitoring was conducted at 7 sites. This approach quantifies the relative sediment contribution from cropland, pasture, riparian areas, and streambanks sources by using a set of indicators to distinguish a unique chemical "fingerprint" from each source and then relating that to the sediment collected in a flume within the stream. Forty-five potential tracers were examined to evaluate relationships.

Continuous monitoring (once per 15 minutes) of the streamflow was measured by gaging stations located at 3 sites.

Detailed analysis of the 2013-2014 USGS data and study results and is included in **Chapter IV**.

C. Monitoring Needs and Plan

Subsequent to the review of historic biological and water quality monitoring conducted in the SFLR watershed, as well as the 2013-2014 USGS study, it was determined that there was a need for supplemental field reconnaissance to document bank erosion and other issues within the watershed. While the USGS study revealed that riparian and streambank sediment sources were the most dominant, specific locations of erosion were not identified.

Third Rock undertook a severe erosion survey of perennial and intermittent streams within the SFLR watershed in accordance with the approved March 14, 2017 Quality Assurance Project Plan (QAPP) (Appendix B, *appendices excluded*). The goal of the survey was to generate data of sufficient quality and resolution to facilitate the identification of areas of severe bank erosion and prioritize those areas for implementation of bank stabilization or stream restoration Best Management Practices (BMPs).

ArcView GIS was used in advance of the survey effort to divide the watershed into multiple grids of equal area. Of those grids, review of topographic mapping revealed 183 target grids that contained perennial or intermittent stream segments. Severe erosion sites within 110 of those target grids (60%) were visually assessed in the field between July 25 and July 28, 2017. In locations where landowner permission could be obtained, sites were assessed on foot; where landowner permission could not be obtained, sites were assessed from public roadways. Sites within the remaining 73 target grids were assessed using GIS analysis of high-resolution aerial imagery.

In accordance with "Stream Corridor Assessment Survey-SCA Survey Protocols" (MDDNR 2001), field data and photo documentation were recorded for each site assessed on foot or from public roadways. Surveyors recorded the location, length of streambank affected by erosion, bank height, erosion type, severity of erosion, erosion correctability, and site accessibility. Erosion severity was ranked from 1 (most severe) to 5 (least severe); erosion correctability was ranked from 1 (best) to 5 (worst); and site accessibility was ranked from 1 (easy) to 5 (difficult) for each site.

Approximately 28,820 linear feet of severe erosion (27 sites) was assessed visually by foot or public roads as summarized in **Table 18**, page 37. An additional 21,500 linear feet (16 sites) was identified and quantified through GIS analysis of high-resolution aerial imagery. In total, of the roughly 526,525 linear feet of stream within the watershed, 50,320 linear feet of severe erosion was identified and ranked as illustrated on **Exhibit 18** (Appendix A).

Table 18
Third Rock Severe Erosion Survey Results, 2017

Site ID	Type	Probable Cause	Approx. Length (ft)	Avg. Bank Height (ft)	Threat to Infrastructure	Land Use		Ranking		
						Left Bank	Right Bank	Severity	Correctability	Accessibility
4A	Not Specified	Below Channelization	250	3	No	Lawn, Rock-Lined	Lawn, Rock-Lined	5	2	1
26A	Downcutting	Outfall	10	6	Yes	Pasture, Lawn	Pasture, Lawn	1	3	1
27A	Downcutting, Widening	Outfall, Below Road Crossing, Livestock	600	3	No	Pasture	Pasture	2	3	1
27B	Downcutting, Widening	Landuse	400	4	No	Lawn	Lawn	2	3	1
34A	Downcutting, Widening	Livestock	1000	4	No	Pasture	Pasture	1	3	1
40A	Downcutting, Widening	Below Channelization / Road Crossing	2000	5	No	Crop Field, Pasture, Lawn	Crop Field, Pasture, Lawn	2	3	1
56A/B	Unknown	Below Channelization	3000	5	No	Lawn	Lawn	4	3	1
57A	Widening	Unknown	500	4	No	Shrubs / Small Trees	Shrubs / Small Trees	3	3	3
57B	Downcutting, Widening	Land Use Change Upstream	3000	6	No	Lawn, Shrubs/Small Trees	Lawn, Shrubs / Small Trees	3	3	3
73A	Widening	Bend at Steep Slope	100	6	No	Forest	Forest	1	4	4
91A	Widening	Bend at Steep Slope	500	8	No	Forest	Forest	2	4	4
94A	Downcutting, Widening	Below Road Crossing	50	8	No	Forest	Forest	2	3	3
96A	Downcutting, Widening	Livestock	500	4	No	Pasture	Shrubs / Small Trees, Forest	1	3	1
96B	Downcutting, Widening	Bend at Steep Slope	100	8	No	Forest	Forest	1	4	3
123A	Downcutting	Channelized	1000	2	No	Crop Field	Crop Field	1	3	1
140A	Headcutting	Dam (Rip Rap)	10	2	No	Crop Field, Pasture	Crop Field, Pasture	5	2	1
147A	Widening	Unknown	200	4	No	Shrubs / Small Trees, Forest	Shrubs / Small Trees, Forest	2	3	4
148A	Downcutting, Widening	Culvert	250	3	No	Pasture	Pasture	3	3	1
159A	Widening	Channel Evolution	150	15	No	Lawn, Forest	Lawn, Forest	1	5	5
161A/DS	Downcutting	Culvert	400	6	No	Crop Field	Crop Field	2	3	1
161A/US	Widening	Culvert Downstream	300	1	No	Pasture, Forest	Pasture, Forest	2	3	1
162A	Widening	Livestock, Land Use Change Upstream	1500	4	No	Pasture	Pasture	2	3	1
165A	Downcutting, Widening	Entire Watershed Development	2000	8	No	Forest	Forest	2	5	5
166A	Downcutting, Widening	Livestock	2000	4	No	Pasture, Shrubs / Small Trees	Pasture, Shrubs / Small Trees	1	3	1
175A	Downcutting, Widening	Land Use Change Upstream	2000	6	No	Crop Field	Crop Field	1	3	1
179A	Downcutting, Widening	Land Use Change Upstream	2000	3	No	Crop Field, Pasture	Crop Field, Pasture	2	3	1
183A	Downcutting, Widening	Land Use Change Upstream	5000	6	No	Crop Field	Crop Field	1	3	1

IV. ANALYSIS

A. Aquatic Community and Habitat

Historic biological monitoring data summarized in **Chapter III** was analyzed to characterize the condition of the aquatic life community and stream habitat in the SFLR watershed.

1. Evaluation Benchmarks

Stream habitat, macroinvertebrate, and fish data was analyzed using KDOW aquatic impairment criteria including the Rapid Bioassessment Protocol (RBP) for habitat, the Macroinvertebrate Bioassessment Index (MBI) for macroinvertebrates, and the Kentucky Index of Biotic Integrity (KIBI) for fish. These indices utilize community metrics to evaluate stream health based on biotic indicators. These indices were developed by monitoring reference reach streams of excellent quality in different bioregions of the state and comparing with impacted streams in these regions. Criteria for the Pennyroyal Bioregion were utilized for this study (KDOW 2011). The criteria are summarized in **Table 19.**

Table 19
Biological Warmwater Aquatic Habitat Criteria

Rating	Habitat (RBP)	Macroinvertebrate (MBI) Drainage Area > 5.0 mi²	Macroinvertebrate (MBI) Drainage Area < 5.0 mi²	fish (IBI)
Excellent	N/A	≥ 81	≥ 72	≥ 67
Good	≥ 146	72-80	65-71	53-66
Fair	132-145	49-71	43-64	35-52
Poor	≤ 131	25-48	22-42	17-34
Very Poor	N/A	≤ 24	≤ 21	≤ 16

The habitat Rapid Bioassessment Protocol (RBP) evaluates 10 habitat parameters based on visual assessment. These parameters include 1) epifaunal substrate / available cover, 2) embeddedness, 3) velocity / depth regime, 4) sediment deposition, 5) channel flow status, 6) channel alteration, 7) frequency of riffles or bends, 8) bank stability, 9) vegetative protection, and 10) riparian vegetative zone width.

The Macroinvertebrate Bioassessment Index (MBI) utilizes 7 different benthic macroinvertebrate community metrics to assess stream health. These include 1) the number of different taxa (genus-level), 2) the number of taxa (genus-level) of stoneflies, mayflies, and caddisflies, 3) the percentage of stoneflies, mayflies, and caddisflies, 4) the modified Hilsenhoff Biotic Index (an indicator for organic enrichment), 5) percentage of worms and midges, 6) percentage of clingers, and 7) percentage of mayflies. Each of these metrics are weighted to generate an overall community score and rating.

The Kentucky Index of Biotic Integrity (KIBI) utilizes 7 different fish community metrics to assess stream health. These include 1) total number of native species, 2) the number of pollution sensitive darter, madtom, and sculpin species, 3) the number of pollution intolerant species, 4) the percentage pf simple lithophilic spawners (*i.e.* species that need clean gravel to lay eggs), 5) the percentage of insect-eating fish, 6) the percentage of pollution tolerant fish, and 7) the percentage of fish that are typically found in headwater streams. Each of these metrics are weighted to generate an overall community score and rating.

2. Habitat

Since 2000, only 1 of 15 habitat assessments conducted in the SFLR watershed has been "good," *i.e.* capable of fully supporting warmwater aquatic habitat use. Most assessments (11 of 15) were rated as "poor." This indicates that the stream habitat conditions in the SFLR watershed are degraded. As discussed by Hendricks *et al.* (2006) for the entire Little River Basin, "low habitat scores were the result of channelized streambeds, unstable banks, little vegetative protection, limited riparian corridor, and pool variability." For SFLR, narrow riparian width is consistently the lowest scoring parameter at the sites assessed. The aerial assessment of the riparian corridor in **Chapter II** identified numerous areas in which the riparian corridor could be expanded to improve stream habitat.

3. Macroinvertebrates

Since 2000, the macroinvertebrate community has never been measured above "fair" indicating that the macroinvertebrate community is at least partially impacted at all locations monitored. Murray State University found the 3 locations monitored along SFLR ranged from "fair" to "very poor" in 2000 and "fair" to "poor" in 2003. Macroinvertebrate assessments conducted by KDOW in 2009 and 2010 on SFLR were all found to be "poor," while a 2008 assessment of Warrens Fork found it to be "fair".

As discussed by Hendricks *et al.* (2006), macroinvertebrate results were not well correlated with habitat scores, indicating that other factors such as "siltation, habitat loss, and nutrient enrichment" were contributing to lower macroinvertebrate scores. "Fair" sites had higher total numbers of taxa and more stoneflies, mayflies, and caddisflies than poor sites.

4. Fish

Twenty-seven fish species have been collected from the SFLR in various studies. These species include the following: largescale stoneroller, striped shiner, scarlet shiner, rosefin shiner, golden shiner, bluntnose minnow, fathead minnow, creek chub, white sucker, western creek chubsucker, yellow bullhead, blackspotted topminnow, mosquitofish, banded sculpin, rock bass, green sunfish, bluegill, longear sunfish, redear sunfish, spotted bass, largemouth bass, greenside darter, fringed darter, Tennessee snubnose darter, west rim darter, orangethroat darter, and freshwater drum.

In 1988, the KDOW found the fish community to be "poor" in 2 locations on SLFR, and "fair" at 1 using a metric prior to the development of the KIBI. Fish community scores ranged from "fair/good" to "very poor" in 2000 but improved to "fair" to "good" in 2003 according to surveys conducted by Murray State University on SFLR. A 2008 study by KDOW of the fish community on Warrens Fork found the fish community to be "excellent." The only more recent study was conducted by KDFWR in 2010 using non-KIBI methods; however, the community is estimated to be "fair" when using the KIBI metrics to evaluate the KDFWR data.

A more current evaluation of the fish community in SFLR would be beneficial. However, results show that the fish community in SFLR is at least partially impacted by water quality conditions, although some tributaries may maintain excellent communities (no tributaries other than Warrens Fork have been evaluated).

B. Water Quality

2013-2014 USGS data (Crain *et al.* 2017) and the results of Third Rock's supplemental severe erosion survey (2017) were analyzed to characterize the influence of stream water quality on recreation and aquatic life uses in the SFLR watershed.

1. Evaluation Benchmarks

To evaluate the nature and extent of impairments due to pollutants in the SFLR watershed, water quality results were compared to applicable water quality benchmarks. These benchmarks also allow for comparisons between previous studies and monitoring performed for this watershed-based plan. Both regulatory water quality standards and scientific, non-regulatory reference points were used, as detailed below. Collectively these thresholds are referred to as "benchmarks" in this document.

a. Regulatory Water Quality Standards

The regulatory statute for surface waters in Kentucky is found in 401 KAR 10:031. The statute provides minimum water quality standards for all surface waters as well as specific standards that apply to particular designated uses. Water quality standards for warmwater aquatic habitat designated uses were utilized for pH, temperature, and dissolved oxygen. The water quality standard for warmwater aquatic habitat designated uses was also reviewed for the fraction of unionized Ammonia N present. Unionized Ammonia N should be less than 0.05 mg/L as N to protect aquatic life from toxicity. Standards for Primary Contact Recreation (PCR) were utilized for *E. coli,* as summarized in **Table 20**. For Secondary Contact Recreation (SCR), the regulatory standard applies to fecal coliform, which was not sampled in this study. Therefore, the relationship between *E. coli* and fecal coliform developed by Ormsbee and Akasapu (2010) was utilized to generate an *E. coli* equivalent standard as shown in **Table 20**.

Table 20
Regulatory Water Quality Standards

Parameter	Standard	Source	Description
pH (SU)	6.0 - 9.0	WAH	Not less than 6.0 SU, more than 9.0 SU, nor fluctuate more than 1.0 SU over 24 hours
Temperature °C (°F)	31.7 (89)	WAH	Instantaneous maximum shall not exceed 31.7 °C
Dissolved oxygen (mg/L)	4.0	WAH	Shall be above 5.0 mg/L as a 24-hour average; above 4.0 mg/L for instantaneous measurements

Table 20
Regulatory Water Quality Standards *Cont.*

Fecal coliform (MPN or CFU)	200	PCR[1]	Geometric mean based on ≥ 5 samples taken over a 30-day period.
	400		Not to exceed in 20% or more of all samples collected during a 30-day period. If < 5 samples are collected in a month, this standard applies.
	1000	SCR	Geometric mean based on ≥ 5 samples taken over a 30-day period.
	2000		Not to exceed in 20% or more of all samples taken during a 30-day period. If < 5 samples are taken in a month, this standard applies.
E. coli	130	PCR[1]	Geometric mean based on ≥ 5 samples taken over a 30-day period.
	240		Not to exceed in 20% or more of all samples taken during over a 30-day period. If < 5 samples are taken in a month, this standard applies.
	386[2]	SCR	Geometric mean based on ≥ 5 samples taken over a 30-day period.
	676[2]		Not to exceed in 20% or more of all samples taken over a 30-day period. If < 5 samples are taken in a month, this standard applies.

[1] May 1 through October 31
[2] Calculated relationship derived by Ormsbee and Akasapu. 2010. Relationship Between Fecal Coliform and within the Kentucky River Basin. Kentucky Water Resources Research Institute. University of Kentucky. Lexington, Kentucky.
E. coli=1.44*FC$^{0.8093}$

b. *Non-Regulatory Reference Points*

For other parameters, such as nutrients, specific conductance, suspended solids, or dissolved solids, no regulatory numeric standard has been established due to the variable relationship between biological integrity and concentration levels in different streams. KDOW provided recommended water quality benchmarks for the watershed based on reference reach and other data (Appendix C).

It is difficult to establish thresholds for these pollutants independent of other variables impacting aquatic habitat, such as poor riparian and instream habitat and poor hydrology / flow regime, higher using available data. However, more readily attainable concentration targets were established for nitrogen and phosphorus, and after consultation with the LRWQC and KDOW a phased approach was adopted for these non-regulatory reference points. KDOW data comparing good or excellent Macroinvertebrate Bioassessment Index (MBI) scores with stream Total Phosphorus and Total Nitrogen concentrations indicate that the higher, Phase 1 reference points should result in improved biological integrity, while still while recognizing limitations in the data set and practical considerations for meeting those limits (Appendix C). As progress is made towards these phased goals, the need for lower thresholds may be reassessed through the watershed planning process. If the designated uses do not become fully supported with the implementation plan efforts when the Phase 1 thresholds are achieved, consideration should be given to lowering the target thresholds (Phase 2 Reference Point). Phased goals are intended to provide achievable targets over time while still being protective of water quality. The non-regulatory reference points selected for SFLR are summarized in **Table 21**, page 42.

Table 21
Non-Regulatory Reference Points

Parameter	Unit	Phase 1 Reference Point	Phase 2 Reference Point
Specific Conductance	µS/cm	450	
Total Phosphorus as P	mg/L	0.09	0.07
Total Nitrogen as N	mg/L	7.5	5.5

The KDOW initially proposed a target concentration for suspended sediment. However, a non-concentration based target was selected as an alternative to this numeric target for several reasons. In-stream sediment is primarily mobilized during wet weather conditions when high stream flows cause bank erosion and sediment washes in from overland sources. In contrast, KDOW reference reach data to support a sediment threshold (as Total Suspended Solids) is primarily from dry, summer, stable flow periods, when sediment concentration is expected to be very low, thus it is not wholly applicable. Additionally, research linking sediment concentrations to impacts on aquatic life via a toxicological or dose-response approach has not been conducted as recommended by the EPA (Berry *et al.* 2003). Therefore, a concentration-based threshold would be arbitrary. As an alternative to a concentration-based target, locations of severe streambank erosion were identified visually to target best management practices at locations with high potential to contribute sediment to streams.

c. *Water Quality Health Grades*

To simplify water quality data for public audiences, the percentage of measured pollutant concentrations in exceedance of the benchmark values (regulatory water quality standards or non-regulatory reference points) was utilized to generate water quality health scores. These health scores, like report cards, assign letter grades to the frequency of exceedance at each site. Each parameter is "graded on a curve" such that letter scores for one parameter are similar to letter scores for other parameters. Letter grades for individual parameters are roughly based on KDOW's method for evaluating data for listing impairments or their TMDL Health Reports.

The percent exceedance and the corresponding grade for each parameter are shown in **Table 22**, page 43.

Table 22
Water Quality Health Grades

Parameter	Benchmark	% of Results Exceeding Benchmark				
		A	B	C	D	F
E. coli – PCR (Swimming)	240 MPN or CFU	0-10	11-20	21-33	34-66	67-100
E. coli – SCR (Wading)	676 MPN or CFU	0-10	11-20	21-33	34-66	67-100
pH	6-9 SU	0-5	6-10	11-25	26-66	67-100
Dissolved Oxygen	4 mg/L	0-5	6-10	11-25	26-66	67-100
Specific Conductance	450 µS/cm	0-10	11-25	26-50	51-66	67-100
Temperature	31.7 °C	0-10	11-25	26-50	51-66	67-100
Total Phosphorus as P	0.09 mg/L (phase 1); 0.07 mg/L (phase 2)	0-10	11-25	26-50	51-66	67-100
Total Nitrogen as N	7.5 mg/L (phase 1); 5.5 mg/L (phase 2)	0-10	11-25	26-50	51-66	67-100

2. Flow

Instantaneous and daily stream flow records measured and reported by USGS were available for 2 sites within the watershed, SF07 and SF09. A daily flow record (USGS) was also available for SF10; since instantaneous flow data was not available for this site, it could not be used to determine flow during a specific water quality sampling event. Thus, the data records for SF07 and SF09 were utilized to evaluate the flow during specific water quality monitoring events and the representativeness of the sampling events. The long-term records for SF07 and SF09 were used to make predictions of the flows at the ungaged monitoring locations. For each ungaged location, discharge measured during sampling events over the course of the USGS study was compared to the corresponding instantaneous discharge from either SF07 or SF09. Generally, ungaged stations located upstream of site SF07 were compared to SF07 and the remaining stations were compared to site SF09. This effort yielded an equation for predicting flow at each ungaged station based upon flow at a gaged station.

Flow duration curves were plotted for the long-term daily flow records for SF07 and SF09. The flow duration curve shows the percentage of time that flow in a stream is likely to equal or exceed some specified value of interest. In this study, it was used to break stream flow down into 3 categories: "high flow," "moderate flow," and "low flow." Some pollutants are highly correlated with streamflow, therefore evaluating pollutant loads for multiple categories of stream flow gives more accurate pollutant load predictions on an annual basis (compared to just using a mean annual flow, for example). Flows for the 3 categories were determined for the ungaged monitoring locations as described above. **Table 23**, page 44, summarizes the flow values for each flow category expected at each monitoring location. The flow duration curves for SF07 and SF09 will be presented in subsequent sections, with points representing water quality monitoring events highlighted.

Table 23
Flow Categories and Values for each USGS Water Quality Monitoring Location

Flow Description	Representative Range of Flows[1]	% Greater Than or Equal to for Flow Value[1]	Portion of Year Represented	Flow Value for Sites SF01 - SF07 (cfs)						
				SF01	SF02	SF03	SF04	SF05	SF06	SF07
"high flow"	0-30%	15%	0.3	0.5	7.2	0.6	3.2	1.2	14.1	45.0
"moderate flow"	30-70%	50%	0.4	0.09	1.2	0.1	0.6	0.2	2.4	7.7
"low flow"	70-100%	85%	0.3	0.004	0.06	0.005	0.03	0.01	0.1	0.4

Flow Description	Representative Range of Flows[1]	% Greater Than or Equal to for Flow Value[1]	Portion of Year Represented	Flow Value for Sites SF08 - SF14 (cfs)						
				SF08	SF09	SF10	SF11	SF12	SF13	SF14
"high flow"	0-30%	15%	0.3	40.3	86.8	124.1	144.5	8.4	31.6	189.6
"moderate flow"	30-70%	50%	0.4	10.9	23.4	33.4	38.9	2.3	8.5	51.1
"low flow"	70-100%	85%	0.3	0.6	1.2	1.7	2.0	0.1	0.4	2.7

[1] From Flow Distribution Curve

3. Pollutant Concentrations

a. Pathogens

To evaluate the representativeness of the *E. coli* sampling events, the daily flow values corresponding to a sampling day were highlighted on the flow duration curves for sites SF07 and SF09 (**Figures 4** and **5**, page 45). Based on where the points were located on the curve and other factors (*i.e.* analysis of storm data relative to sampling date), each sampling event was placed into categories so *E. coli* statistics could be evaluated for each type of flow condition (high, moderate, low). Geometric mean ("geomean") is generally the standard statistic used to summarize bacteria data, because mean or median data are so variable. The geomean value is not overly influenced by large fluctuations between one data point and another, and is a good way to get a sense of the *E. coli* impacts at a given site. For the SFLR *E. coli* dataset, average *E. coli* always exceeded the geomean of *E. coli* for each site, particularly during high flow events.

Table 24, page 46, presents the maximum, minimum, and geomean of all *E. coli* data for a given site, as well as the geomean of *E. coli* data for each flow category. In general, as flow increased, more impacts to recreation were observed – the geomean of *E. coli* exceeded the wading standard (676 CFU/100mL) at 7 sites during high flow, at 2 sites during moderate flow, and at no sites during low flow. At low flow conditions, a site was more likely to have an *E. coli* concentration considered safe for swimming or wading; 6 sites had a geomean of *E. coli* value that was less than 240 CFU/100mL, the criteria for PCR (swimming) at low flow.

Figure 4
SF07 Flow Distribution Curve with *E. coli* Sampling Events Highlighted

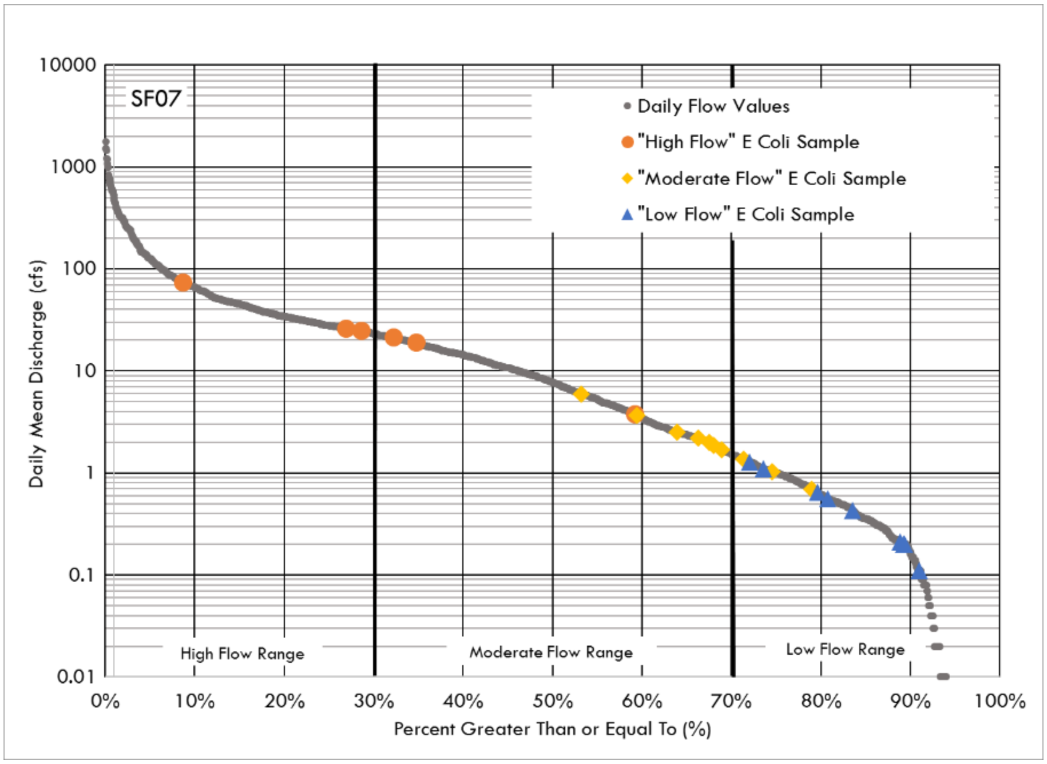


Figure 5
SF09 Flow Distribution Curve with *E. coli* Sampling Events Highlighted

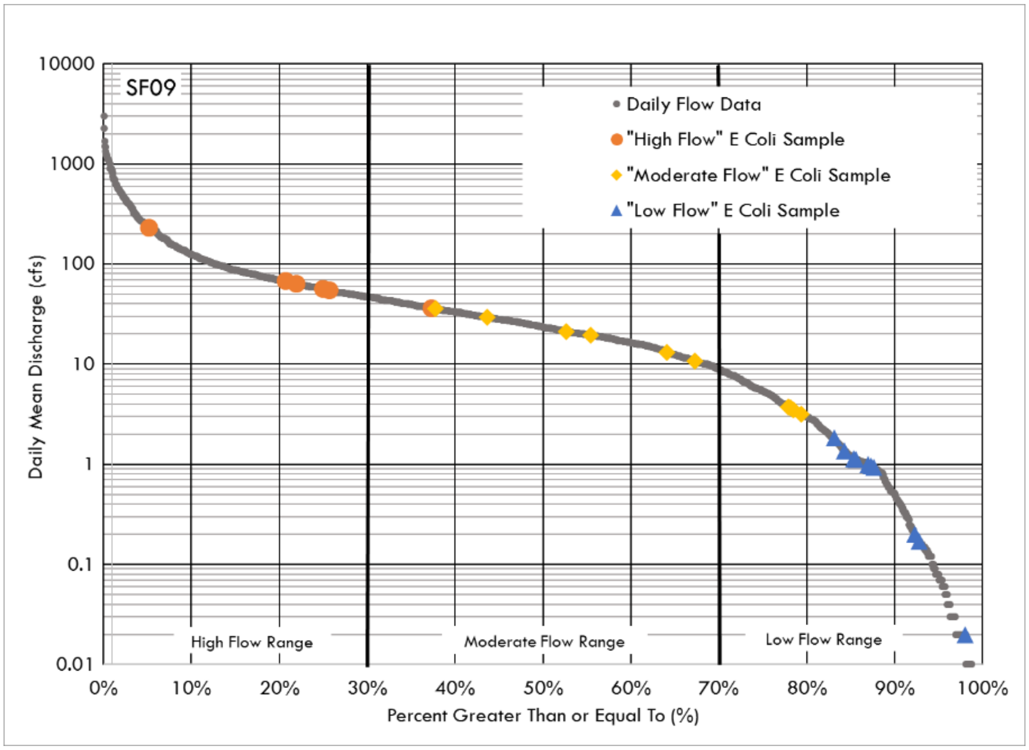


Table 24
Summary of *E. coli* Concentration Data and Health Grades Related to Recreation Uses

Site ID	Count	Max (CFU)	Min (CFU)	Geo-mean (CFU)	High Flow	Moderate Flow	Low Flow	% Exceeding PCR Limit (240 CFU)	% Exceeding SCR Limit (676 CFU)
					Geomean (CFU)				
SF01	13	1,200	10	110	104	86	135	31%	8%
SF02	11	23,000	110	609	1815	1,011	162	55%	36%
SF03	13	6,600	74	398	1100	494	174	62%	23%
SF04	7	12,000	20	668	315	1,417	670	71%	43%
SF05	9	1,900	<100	356	306	435	210	33%	22%
SF06	12	9,600	41	355	1,200	310	250	67%	17%
SF07	12[1]	19,000	31	555	1,645[1]	616	323	64%	45%
SF08	15	16,000	20	234	337	273	180	47%	20%
SF09	14	11,000	41	344	748	233	324	57%	21%
SF10	13	12,000	110	417	762	323	374	54%	23%
SF11	12	12,000	<100	246	552	174	207	33%	8%
SF12	13	17,000	63	404	436	380	421	46%	23%
SF13	13	1,300	30	398	603	315	447	77%	31%
SF14	13[1]	49,000	130	597	1,875[1]	394	426	73%	27%

[1] Count and geomeans include a predicted value from SF08 for May 15, 2013 due to failure to collect at this site on that date and a low number of high flow events for the site. Predicted value is based on ratio for other high flow events for these sites as compared to SF08.
Note: Shading indicates health grade for recreational uses, as indicated in **Table 22**.

An evaluation of the percentage of measured *E. coli* concentrations in exceedance of the benchmark values indicated that the majority of sites received a "D" grade or were "partially supporting" the PCR (swimming) use. For SCR (wading), most sites received a "C" grade, indicating they were also "partially supporting" the designated use. For the health grades, all *E. coli* data points were considered for each site. Three sites, SF01, SF06, and SF11 received either an "A" or "B" health grade for SCR, indicating that the wading recreation use is "fully supported" at those locations.

Measuring fecal-indicator bacteria concentrations can provide general information on the fecal contamination likely occurring at a given stream site; however, it does not identify the contamination source. Microbial source tracking was conducted at sites SF01, SF02, SF04, SF06, SF07, SF10, SF13, and SF14 to help determine the source of the fecal-indicator bacteria at each of these locations. Five genetic markers were used to test for mixed source, human, canine, ruminant/bovine (domestic cattle), and waterfowl sources. When a marker is detected in a water sample it is indicative of the presence of fecal waste from the given host. If enough copies of a marker are detected for a sample, the copies can be quantified and a value for "copies per 100 mL", analogous to "marker concentration", is reported for the sample. However, a given maker can be detected, but in such low amounts that the copies are "not quantifiable". It should be noted that these are individual methods of quantification for each marker – quantified values of one marker cannot be compared to quantified values of another maker. But, comparisons of quantified values for a given maker can be made among sites.

Icons representing humans, cow, and dogs are used on the *E. coli* load exhibits (**Exhibits 19** and **20,** Appendix A), presented in subsequent sections, to identify locations where the microbial source tracking study indicated these were the potential sources of fecal indicator bacteria.

Of the 95 samples evaluated for the human-associated marker in the SFLR watershed, 16 samples had concentrations of the marker above the detection limit, indicating some contribution of human waste in these samples. The human marker was detected at sites SF01, SF02, SF06, SF07, SF10, and SF14; thus, it was not detected at SF04 or SF13. Site SF07 had the highest rate of detections; the human marker was detected in 38% of samples from this site (5 of 13). However, the results suggest humans were not a major source of fecal contamination in the SFLR watershed. Data was such even though the human marker was detected, it was in such a low amount that it could not be quantified for most samples; thus, a median value of "marker concentration" for the study period could not be assigned at any site where detections occurred. For comparison, the only location in the study where a median "marker concentration" was assigned to the human marker data was at site NF02, located on the North Fork of the Little River downstream of the wastewater treatment plant, where sewage overflows have been recorded.

Of the 95 samples evaluated for the canine-associated marker in the SFLR watershed, 28 samples had concentrations of the marker above the detection limit, indicating some contribution of canine waste in these samples. The canine marker was detected at all 8 sites where microbial source tracking was conducted. However, data was such that a median value for the canine "marker concentration" could only be assigned at sites SF01 and SF02, indicating the concentration of canine waste could be higher at these 2 sites compared to the remaining 6 sites.

Of the 93 samples evaluated for the bovine-associated marker in the SFLR watershed, 57 samples had concentrations of the marker above the detection limit, indicating contribution of cattle waste in these samples. The bovine marker was detected at all 8 sites where microbial source tracking was conducted Data was such that a median value for the bovine "marker concentration" was computed for 5 sites (all but SF06 and SF10). Results indicated that the concentration of cattle-associated waste was highest at SF04; the next highest median value was observed at site SF02.

All samples evaluated for the waterfowl-associated marker in the SFLR watershed were below the detection limit; thus, it is likely that waterfowl are not a major source of fecal contamination in the area.

b. Nutrients

To evaluate the representativeness of the nutrient and sediment sampling events, the daily flow values corresponding to a sampling day were highlighted on the flow duration curves for sites SF07 and SF09 (**Figures 6** and **7**, pages 48 and 49, respectively). Based on where the points were located on the curve and other factors (*i.e.* analysis of storm data relative to sampling date), each sampling event was placed into categories such that nutrient and sediment statistics could be evaluated for each type of flow condition (high, moderate, low). The geomean statistic was also used to evaluate nutrient concentration data; the geomean value is less influenced by occasional very large values than the mean. Unlike with *E. coli*, the nutrient concentrations were not as correlated to flow conditions. Nonpoint-source-derived nutrients or pollutants are mainly transported during periods of runoff, thus higher nutrient concentrations are expected during high flow conditions in watersheds dominated by nonpoint sources. However, in general, geomean of Total N, Ammonia-N, and NO2+NO3-N do not vary much over the 3 flow conditions. Concentration of Total P and Ortho-P tend to be higher during high flow conditions, suggesting nonpoint sources as the primary sources of phosphorus. However, for sites SF09 and SF14, the USGS study did find a positive correlation to streamflow suggestive of nitrogen-enriched nonpoint source runoff during higher streamflow at these 2 sites.

Figure 6
SF07 Flow Distribution Curve with Nutrient and Sediment Sampling Events Highlighted

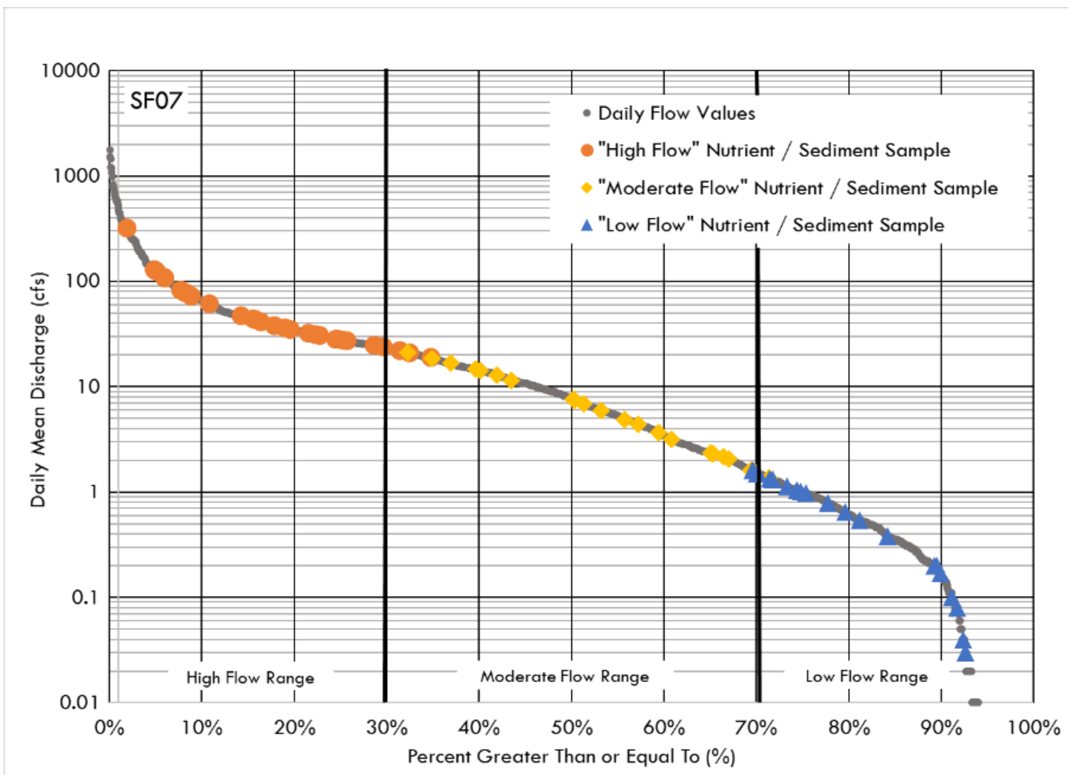
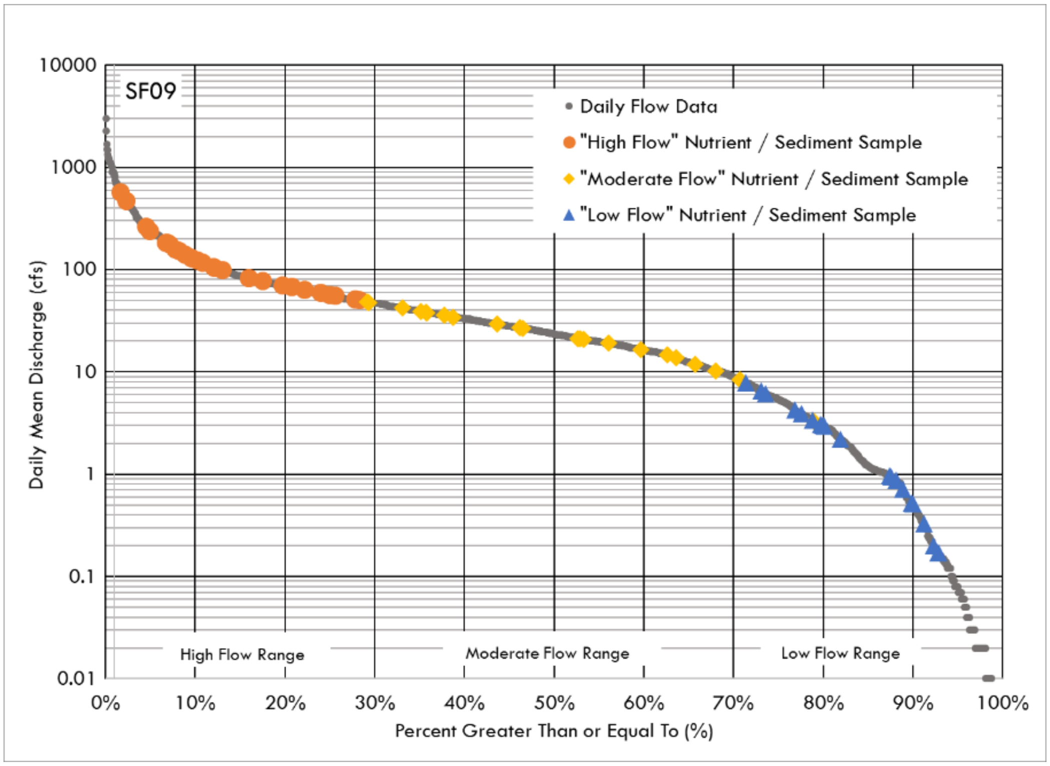


Figure 7
SF09 Flow Distribution Curve with Nutrient and Sediment Sampling Events Highlighted



Tables in subsequent sections present the maximum, minimum, and geomean of all nutrient data points for a given site, as well as the geomean of the nutrient parameter for each flow category.

i. Phosphorus

Table 25, page 50, summarizes the Total P data for each site. In general, a site was more likely to be impacted by Phosphorus at higher flow conditions; during high flow, the geomean Total P exceeded the Phase 2 benchmark at sites SF07, SF09, SF10, SF11, and SF14. When data is considered overall (not categorized by flow condition), the last 2 columns in **Table 25** present the "report card grades" based on Total P concentrations as it relates to supporting the warmwater aquatic habitat designated use. Grades are presented considering both the Phase 1 and Phase 2 benchmarks for Total P. Many headwater sites are performing in the A to B health range, while grades generally fall moving to downstream sites.

Table 25
Summary of Total Phosphorus Concentration Data

Site ID	Count	Max (mg/L)	Min (mg/L)	Geo-mean (mg/L)	High Flow	Moderate Flow	Low Flow	% Exceeding Phase I Benchmark (0.09 mg/L)	% Exceeding Phase 2 Benchmark (0.07 mg/L)
					Geo-mean (mg/L)				
SF01	23	0.56	< 0.020	0.025	0.030	0.020	0.023	4%	4%
SF02	22	0.45	0.020	0.056	0.062	0.048	0.056	23%	36%
SF03	23	0.09	< 0.020	0.027	0.030	0.022	0.027	4%	9%
SF04	19	0.78	< 0.020	0.055	0.061	0.050	0.046	16%	26%
SF05	18	0.26	0.020	0.049	0.062	0.033	0.040	22%	33%
SF06	22	0.13	< 0.020	0.042	0.046	0.036	0.045	18%	23%
SF07	24	0.46	< 0.020	0.084	0.095	0.058	0.093	42%	63%
SF08	22	0.36	0.020	0.065	0.087	0.051	0.060	23%	45%
SF09	22	0.81	0.030	0.067	0.113	0.051	0.047	27%	41%
SF10	24	0.98	0.030	0.087	0.103	0.097	0.064	46%	63%
SF11	22	0.40	0.030	0.075	0.103	0.068	0.060	41%	55%
SF12	17	0.09	< 0.020	0.032	0.041	0.027	0.027	6%	12%
SF13	21	0.17	0.030	0.064	0.079	0.056	0.060	29%	48%
SF14	45	0.85	0.020	0.071	0.091	0.082	0.059	31%	42%

Note: Shading indicates health grade for warmwater aquatic habitat use, as indicated in **Table 22**.

At most sites (with the exception of SF03 where the ratio is only 17%), the ratio of the geomean concentration of Ortho-P to Total P ranges from 23% to 57%, indicating that much of the Total P at each site is in the more reactive form of Ortho-P. This form is more bioavailable for algae and plant growth and can be carried into streams through runoff. **Table 26**, page 51, summarizes the dataset for Ortho-P at each site. Phosphates can enter streams though agricultural wastes, fertilizers, and soil erosion (attached to soil particles). Excessive concentrations of Ortho-P can cause eutrophication, the excessive growth of algae/aquatic plants, in freshwater systems. This overgrowth ultimately leads to periods of low dissolved oxygen, which can cause the demise of aquatic organisms. Phosphorus generally occurs in small quantities in the natural environment, therefore even small increases can negatively affect water quality and biological conditions.

Table 26
Summary of Ortho-Phosphorus Concentration Data

Site ID	Count	Max (mg/L)	Min (mg/L)	Geo-mean (mg/L)	High Flow	Moderate Flow	Low Flow
					Geomean (mg/L)		
SF01	23	0.481	< 0.004	0.006	0.007	0.005	0.005
SF02	22	0.327	< 0.004	0.019	0.022	0.022	0.011
SF03	23	0.011	< 0.004	0.004	0.005	0.004	0.004
SF04	19	0.549	< 0.004	0.018	0.018	0.019	0.019
SF05	18	0.165	< 0.004	0.015	0.021	0.009	0.004
SF06	22	0.09	< 0.004	0.018	0.023	0.013	0.018
SF07	24	0.195	< 0.004	0.040	0.040	0.033	0.045
SF08	22	0.108	< 0.004	0.032	0.033	0.031	0.033
SF09	22	0.293	< 0.004	0.029	0.044	0.028	0.018
SF10	24	0.298	< 0.004	0.048	0.038	0.061	0.047
SF11	22	0.245	< 0.004	0.043	0.040	0.052	0.040
SF12	17	0.047	< 0.004	0.013	0.017	0.014	0.007
SF13	21	0.086	0.016	0.036	0.037	0.039	0.029
SF14	45	0.249	< 0.004	0.035	0.031	0.059	0.034

ii. Nitrogen

Nitrogen is also a critical nutrient used by plants and is not characteristically present at high levels in streams, unless applied to adjacent lands as fertilizer or organic waste in amounts higher than can be incorporated into crops or lost to the atmosphere through volatilization or denitrification, received from a leaky or poorly functioning septic system, or discharged by a wastewater treatment plant. Nitrate is generally the dominant form of N where Total N levels are elevated; this is true of the SFLR dataset. At most sites (with the exception of SF03 where the ratio is only 22%), the ratio of the geomean concentration of Nitrate+Nitrite N to Total N ranges from 41% to 93%, indicating that most of the Total N at each site is in the more reactive, inorganic form of Nitrate+Nitrite N. Only sites SF05 and SF12 reported Nitrate+Nitrite N concentrations above the EPA drinking-water standard of 10 mg/L.

Nitrate and other forms of N in water can be from natural sources, but when N concentrations are elevated, the sources are typically associated with human activities. Nitrate can get into water directly as the result of runoff of fertilizers containing nitrate. Considering the dataset for the SFLR, it appears that the next most prevalent form of N in the streams (after Nitrate+Nitrite N) is Organic N, followed by Ammonia N, as is typical in surface waters. Where streams originate in areas of agricultural production, the Nitrate form of N is usually higher than Organic N. In forested areas, Organic N is typically higher.

Ammonia N is typically elevated near sources of human or animal waste discharge. Ammonia N represents the total of ammonia in both its ionized (NH_4^+) and unionized

(NH_3) forms. Ammonia N can be converted to Nitrate and Nitrite N by bacteria, and then used by plants. The unionized form of Ammonia N is more toxic to fish and other aquatic life and the percentage of the unionized form is related to temperature and pH. Higher temperature and/or pH increases conversion of Ammonia to the unionized form and in-stream toxicity increases. The fraction of total Ammonia N in the un-ionized form (mg/L) was calculated for sampling events where Ammonia N (mg/L), pH (SU), and temperature (°C) were available for a site using the following equations.

Equation 1. $pKa = 0.0902 + \left[\frac{2730}{273.2+Temp}\right]$

and

Equation 2. $Unionized\ Ammonia\ = 1.2\left[\frac{Ammonia\ N\ as\ N}{(1+10^{pKa-pH})}\right]$

Unionized ammonia was observed only 5 time during the entire data set, and 3 of those occurrences were in August when higher water temperatures were reported, coupled with elevated total Ammonia N values. **Table 27**, page 53, summarizes the values calculated for unionized ammonia at each site. Sites SF01, SF03, SF06, and SF08 were noted as having an exceedance of the WAH water quality standard (> 0.05 mg/L), but this happened very infrequently.

A study of dual-isotope nitrate isotopes ($\delta^{15}N_{NO3\ and}$ $\delta^{18}O_{NO3}$) was performed by the USGS to help differentiate between inorganic sources (atmospheric and fertilizer) and organic sources (manure and septic waste) of nitrogen pollution. A total of 175 samples were collected from the 11 sites (SF01, SF02, SF03, SF05, SF06, SF07, SF09, SF10, SF12, SF13, and SF14) in SFLR watershed; however, the general trends presented were for the SFLR watershed as a whole. Potential sources of Nitrate N in the watershed include atmospheric deposition, chemical fertilizer, soil-derived nitrate, manure, and septic waste. Most chemical fertilizer in the watershed is applied as anhydrous ammonia and urea, which can subsequently be biologically oxidized by soil bacteria to Nitrate N, and then used by plants. Low Nitrate N concentrations were observed for forested sites, with soil-derived nitrate being the likely dominant source. The agricultural sites had the highest Nitrate N concentrations, along with the highest variability; this is indicative of mixed sources of Nitrate N in the agricultural areas (chemical fertilizer, soil-derived, and manure/septic wastes). It was noted that atmospheric nitrate was not likely the dominant source of Nitrate N in the sampled streams. **Table 27 and Table 28**, page 53, and **Table 29**, page 54, summarize the data for each form of Nitrogen monitored at each site.

Table 30, page 54, summarizes the Total N data for each site. Total N is calculated as the sum of Ammonia N, Organic N, and Nitrate+Nitrite N. In general, a site was not more likely to be impacted by Nitrogen at higher flow conditions. Sites SF05, SF12, and SF13 were impacted by Total N during all flow conditions. When data is considered overall (not categorized by flow condition), the last 2 columns in **Table 30** present the "report card grades" based on Total N concentrations as it relates to supporting the warmwater aquatic habitat designated use. Grades are presented considering both the

Phase 1 and Phase 2 benchmarks for Total N. Most sites are performing in the A to B health range, while grades of F are seen at sites SF05, SF12, and SF13.

Table 27
Summary of Ammonia Nitrogen and Un-Ionized Ammonia Concentration Data

Site ID	Ammonia Nitrogen							Unionized Ammonia Nitrogen			
	Count	Max (mg/L)	Min (mg/L)	Geomean (mg/L)	High Flow Geomean (mg/L)	Moderate Flow Geomean (mg/L)	Low Flow Geomean (mg/L)	Count	Max (mg/L)	Min (mg/L)	Geomean (mg/L)
SF01	23	3.03	< 0.01	0.06	0.03	0.04	0.35	23	3.7E-01	1.9E-06	3.6E-04
SF02	22	1.36	< 0.01	0.06	0.05	0.03	0.37	22	4.0E-02	2.0E-05	6.9E-04
SF03	23	1.02	< 0.01	0.03	0.02	0.01	0.09	20	7.4E-02	2.5E-06	3.5E-04
SF04	19	1.70	< 0.01	0.04	0.03	0.05	0.05	18	4.5E-02	3.4E-05	5.5E-04
SF05	18	1.33	< 0.01	0.03	0.04	0.03	0.01	17	1.8E-02	3.0E-05	3.7E-04
SF06	22	2.04	< 0.01	0.05	0.04	0.04	0.08	21	5.3E-02	7.1E-06	4.7E-04
SF07	24	0.99	< 0.01	0.06	0.05	0.05	0.13	22	4.2E-02	2.7E-05	5.4E-04
SF08	22	1.49	< 0.01	0.05	0.05	0.03	0.14	20	6.7E-02	7.3E-05	8.1E-04
SF09	22	0.93	< 0.01	0.05	0.07	0.02	0.09	20	2.2E-02	5.0E-05	5.4E-04
SF10	24	2.40	< 0.01	0.05	0.08	0.03	0.04	19	1.3E-02	2.5E-12	1.6E-04
SF11	22	1.41	< 0.01	0.05	0.07	0.03	0.05	19	3.0E-02	1.7E-12	2.4E-04
SF12	17	0.49	< 0.01	0.02	0.01	0.01	0.04	17	1.0E-02	3.2E-06	2.0E-04
SF13	14	1.00	< 0.01	0.04	0.04	0.02	0.17	19	2.7E-02	7.2E-06	4.1E-04
SF14	45	1.73	< 0.01	0.05	0.08	0.03	0.05	41	4.8E-02	4.5E-05	8.0E-04

Note: Yellow shading indicates value in exceedance of 0.05 m/L unionized ammonia standard for WAH

Table 28
Summary of Ammonia Nitrogen and Organic Nitrogen Concentration Data

Site ID	Count	Max (mg/L)	Min (mg/L)	Geomean (mg/L)	High Flow Geomean (mg/L)	Moderate Flow Geomean (mg/L)	Low Flow Geomean (mg/L)
SF01	23	4.30	0.07	0.33	0.21	0.25	1.28
SF02	22	4.40	0.18	0.55	0.49	0.42	1.14
SF03	23	4.80	0.14	0.40	0.35	0.21	1.26
SF04	19	2.40	0.22	0.50	0.51	0.47	0.59
SF05	18	1.40	0.18	0.54	0.58	0.45	0.63
SF06	22	2.00	0.12	0.37	0.34	0.31	0.56
SF07	24	11.00	0.20	0.61	0.57	0.39	1.02
SF08	22	2.50	0.15	0.53	0.60	0.32	0.87
SF09	22	5.00	0.15	0.56	0.78	0.26	0.98
SF10	24	6.90	0.15	0.57	0.66	0.45	0.64
SF11	22	4.00	0.16	0.48	0.67	0.32	0.46
SF12	17	3.30	0.12	0.24	0.25	0.17	0.53
SF13	21	3.30	0.12	0.41	0.36	0.25	1.19
SF14	22	2.90	0.18	0.43	0.50	0.38	0.40

Table 29
Summary of Nitrate and Nitrite Nitrogen Concentration Data

Site ID	Count	Max (mg/L)	Min (mg/L)	Geomean (mg/L)	High Flow	Moderate Flow	Low Flow
					Geomean (mg/L)		
SF01	23	2.92	< 0.04	0.35	0.49	0.19	0.42
SF02	22	2.25	0.06	0.77	1.21	0.66	0.29
SF03	23	1.74	< 0.04	0.14	0.21	0.09	0.09
SF04	19	4.97	0.27	1.85	2.18	1.50	1.71
SF05	18	16.90	1.40	8.03	7.63	8.67	8.96
SF06	22	8.92	1.07	2.95	3.04	3.62	2.10
SF07	24	5.07	0.71	2.49	2.83	3.13	1.68
SF08	22	5.02	0.39	2.53	3.31	3.50	1.14
SF09	22	6.45	0.78	3.29	3.73	4.10	2.07
SF10	24	5.94	0.74	2.64	3.49	3.06	1.58
SF11	22	5.73	0.70	2.55	3.78	3.10	1.49
SF12	17	10.70	0.32	6.34	4.82	8.39	5.20
SF13	21	9.63	6.73	7.96	8.05	7.88	7.98
SF14	45	6.66	1.40	3.65	4.96	3.58	2.69

Table 30
Summary of Total Nitrogen Concentration Data

Site ID	Count	Max (mg/L)	Min (mg/L)	Geo-Mean (mg/L)	High Flow	Moderate Flow	Low Flow	% Exceeding Phase 1 Benchmark (7.5 mg/L)	% Exceeding Phase 2 Benchmark (5.5 mg/L)
					Geomean (mg/L)				
SF01	23	4.70	< 0.26	0.86	0.83	0.50	1.95	0%	0%
SF02	22	4.50	0.55	1.67	1.88	1.27	1.97	0%	0%
SF03	23	4.80	< 0.26	0.62	0.62	0.32	1.52	0%	0%
SF04	19	5.20	0.72	2.66	2.98	2.30	2.51	0%	0%
SF05	18	18.00	2.20	8.82	8.47	9.35	9.60	72%	94%
SF06	22	9.10	2.10	3.56	3.48	4.07	3.09	9%	9%
SF07	24	13.00	1.40	3.63	3.77	3.56	3.50	4%	13%
SF08	22	5.60	1.40	3.63	4.23	3.86	2.72	0%	9%
SF09	22	6.70	1.80	4.60	5.24	4.42	4.07	0%	41%
SF10	24	7.80	1.20	3.90	4.95	3.75	3.13	4%	13%
SF11	22	5.90	1.10	3.44	4.71	3.53	2.46	0%	14%
SF12	17	11.00	0.69	7.17	5.61	8.59	7.23	76%	94%
SF13	21	10.00	7.30	8.60	8.43	8.16	9.73	86%	100%
SF14	22	7.40	1.90	4.33	5.70	4.02	3.41	0%	18%

Note: Shading indicates health grade for warmwater aquatic habitat use, as indicated in **Table 22**.

c. *In-Situ Water Quality Data*

Table 31 summarizes the Temperature, Dissolved Oxygen, pH, and Specific Conductance / Conductivity data for each site. Data indicate:

- Temperature is not negatively impacting the warmwater aquatic habitat use in the SFLR watershed. All sites receive an A grade related to no/low exceedances of the Temperature benchmark (31.7°C/89°F);
- Low Dissolved Oxygen is not negatively impacting the warmwater aquatic habitat use in the SFLR watershed. All sites receive an A grade related to meeting the Dissolved Oxygen benchmark (4 mg/L or more Dissolved Oxygen observed in a majority of sampling events);
- pH is within benchmark range and is not negatively impacting the warmwater aquatic habitat use in the SFLR watershed. All sites receive an A grade except SF01 related to being within the desired stream pH range (6 to 9 SU). Site SF01 had only 3 of 21 measured pH values that were less than 6, but greater than 5 SU (grade B); and
- In general, Conductivity is not a problem at the headwater sites; however, sites SF09, SF10, SF11, SF12, SF13, and SF14 received a grade of C or lower related to exceedances of the Conductivity benchmark, which can have a negative effect on aquatic life. Conductivity is a measurement of the ability of water to carry an electrical current. Increases in Conductivity can indicate pollution, such as contributions from wastewater, agricultural runoff, or urban runoff that can negatively impact aquatic life.

Table 31
Summary of In-Situ Water Quality Data

Site ID	% Exceeding Temperature Benchmark (31.7°C/89°F)	% Below Dissolve Oxygen Benchmark (4 mg/L)	% Out of Range pH Benchmark (6.0 - 9.0 SU)	% Exceeding Conductivity Benchmark (450 µS/cm)
SF01	0%	0%	13%	0%
SF02	0%	5%	0%	0%
SF03	0%	0%	0%	0%
SF04	0%	5%	0%	15%
SF05	0%	0%	0%	22%
SF06	0%	0%	0%	10%
SF07	0%	0%	0%	22%
SF08	0%	0%	4%	17%
SF09	0%	0%	0%	33%
SF10	5%	0%	0%	50%
SF11	0%	0%	0%	48%
SF12	0%	0%	0%	76%
SF13	0%	0%	0%	90%
SF14	0%	0%	0%	58%

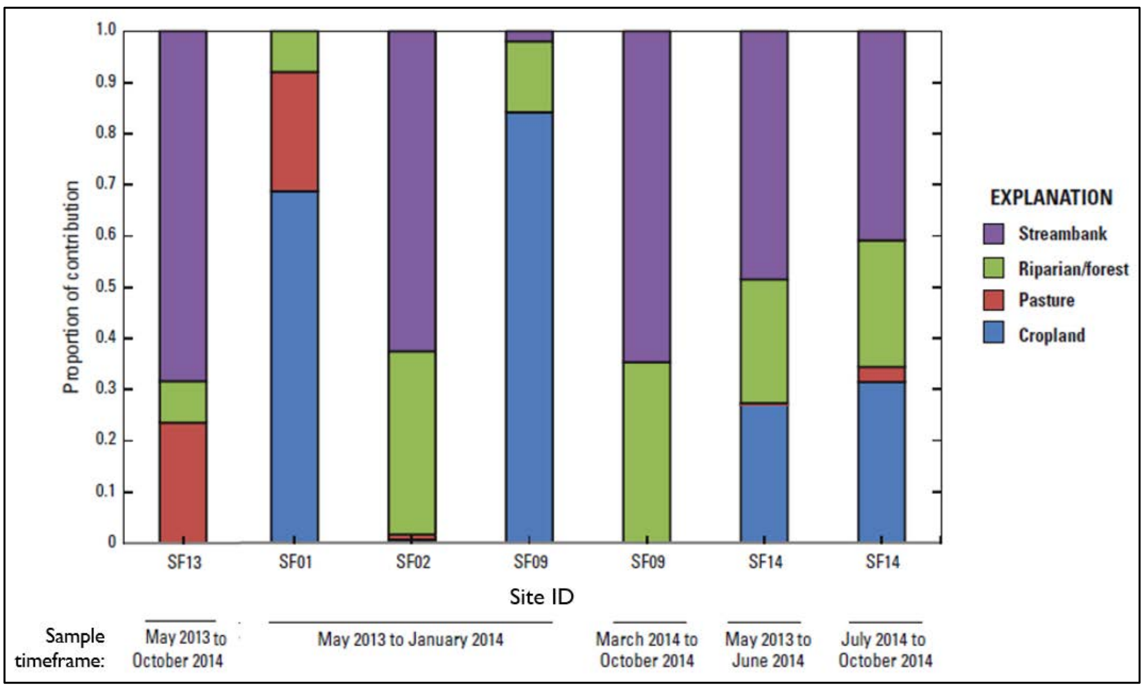
Note: Color coding indicates health grade for warmwater aquatic habitat use, as indicated in **Table 22**.

d. *Sediment and Severe Erosion*

Concentration data from the USGS study indicate suspended solids and turbidity are elevated. Elevated values are typically associated with higher flows, thus KDOW benchmarks were not applicable for watershed planning efforts (since reference data for suspended solids and turbidity are for low, stable flow periods). In lieu of using a KDOW benchmark for suspended solids, further study was performed to identify and prioritize sources of sediment in the SFLR watershed.

Recognizing there are sediment contributions to the streams of the SFLR watershed, USGS performed a sediment fingerprinting study to evaluate the sources of suspended sediment in the streams. **Figure 8** displays the relative proportions of the fine sediment sources identified in the fingerprinting study for each site. As noted in the figure, sites SF09 and SF14 were studied during two different time periods.

Figure 8
Proportions of Fine Sediment Sources
Identified in Sediment Fingerprinting Study
(Figure adapted from Fig. 25 in USGS report)



At site SF01(headwater site), the primary source of fine stream sediment was traced to cropland (68%), followed by pasture (24%), then riparian/forest (8%), for the monitoring period of May 2013 to January 2014. For the same sampling period at site SF02, located downstream of SF01, streambanks contributed the majority of fine sediment (63%) and riparian/forest contributed 36%. At SF09, from March 2014 to October 2014, streambanks were shown to be the largest contributor of fine sediment (65%), however during the monitoring period from May 2013 to January 2014, cropland was by far the largest contributor (84%). Notably, the sampling period at SF09 included winter data collection, when the soil was most likely to be exposed. The variability of the contributions between sampling periods potentially reflects tillage practices, land use cover, and prevalence of high stream flows, etc. that change throughout the year. Similarly, at SF13 from May 2013 to October 2014, data indicated streambanks (68%) contributed the most to fine sediment, with pasture the next largest contributor (24%). At the watershed outlet, SF14, the proportions of fine sediment were similar for each sampling period (May 2013 to June 2014 and July 2014 to October 2014), with streambanks as the largest contributor, followed by cropland and riparian/forest sources; pasture was a minor, but identifiable contributor.

The USGS study, along with sediment-source tracking studies in other locations, indicate that streambanks are frequently the largest contributor to instream suspended sediment. Thus, an additional effort to document areas of bank erosion in the watershed was performed for this watershed plan as described in **Chapter III**. Surveyors recorded locations of eroding streambanks, severity of erosion observed, correctability, and site accessibility. The location and severity of severe bank erosion in the watershed are summarized in **Table 18**, page 37, and illustrated on **Exhibit 18** (Appendix A).

e. *Summary Grades (Concentration Data)*

Based on the pollutant concentrations observed in the USGS water quality data, **Table 32** summarizes the overall grades due to key pollutants at each site. Throughout the watershed, streams were found to not support the primary contact recreational use (swimming). Many streams were partially to fully impacted for secondary contact recreation (wading, splashing). This indicates there is a risk of illness associated with contacting pathogens in these waters. Streams throughout the watershed were also found to not support a healthy and diverse ecosystem (warmwater aquatic habitat use). Lack of habitat, including narrow riparian corridors and areas of bank erosion, contributes to the streams not supporting aquatic life, in additional to potential impacts from excessive nutrients and elevated stream Conductivity.

Table 32
Summary of Water Quality Data

Parameter:	*E. coli* CFU/100mL		Total Phosphorus mg/L as P		Total Nitrogen mg/L as N		Conductivity µS/cm
Benchmark:	240	676	0.09 Phase 1	0.07 Phase 2	7.5 Phase 1	5.5 Phase 2	450
SF01	31%	8%	4%	4%	0%	0%	0%
SF02	55%	36%	23%	36%	0%	0%	0%
SF03	62%	23%	4%	9%	0%	0%	0%
SF04	71%	43%	16%	26%	0%	0%	15%
SF05	33%	22%	22%	33%	72%	94%	22%
SF06	67%	17%	18%	23%	9%	9%	10%
SF07	64%	45%	42%	63%	4%	13%	22%
SF08	47%	20%	23%	45%	0%	9%	17%

Table 32
Summary of Water Quality Data *Cont.*

Parameter:	*E. coli* CFU/100mL		Total Phosphorus mg/L as P		Total Nitrogen mg/L as N		Conductivity µS/cm
Benchmark:	240	676	0.09 Phase 1	0.07 Phase 2	7.5 Phase 1	5.5 Phase 2	450
SF09	57%	21%	27%	41%	0%	41%	33%
SF10	54%	23%	46%	63%	4%	13%	50%
SF11	33%	8%	41%	55%	0%	14%	48%
SF12	46%	23%	6%	12%	76%	94%	76%
SF13	77%	31%	29%	48%	86%	100%	90%
SF14	73%	27%	31%	42%	0%	18%	58%

Note: Shading indicates health grade for warmwater aquatic habitat use, as indicated in **Table 22**.

4. Pollutant Loads and Target Reductions

Pollutant load is the mass (*i.e.* pound) of given pollutant moving past a given point (*i.e.* monitoring site) per unit of time (*i.e.* year). The USGS study predicted annual nutrient loads at only 2 locations within the SFLR watershed, SF09 and SF14, using a version of the USGS LOADEST software. To achieve the goals of the watershed plan and have information to develop a site-specific BMP implementation plan, it was necessary to develop pollutant loads for each sampling location. To calculate pollutant loads and target reductions needed at each site, this watershed plan performed loading calculations for each site. The geomean pollutant concentrations calculated for each flow condition were multiplied by the flow value for each of the flow conditions, the proportion of the year that each flow condition was assumed to occur, and appropriate conversions.

<u>Annual Load = Sum of Loading for Each Flow Type:</u>

Geomean Sample Concentration x Representative Flow x Portion of the Year Represented x Conversion Factors

This allowed for the calculation of an annual load at each site for each pollutant. Based upon analyses of available USGS long-term flow records, the high flow conditions represented 30% of the year, the moderate flow conditions represented 40% of the year, and the low flow conditions represented 30% of the year. The flow value used for each site for each flow conditions is included in **Table 23**, page 44. To calculate the target or benchmark load for each site, the same process was utilized, substituting the benchmark pollutant concentration for the measured geomean concentration.

<u>Benchmark Load = Sum of Loading for Each Flow Type:</u>

Benchmark Concentration x Representative Flow x Portion of the Year Represented x Conversion Factor

This target annual load was subtracted from the measured annual load to determine the load reduction needed to reach the target. The percent reduction is the load reduction needed divided by the existing total load. Incremental reductions are the load reductions per sub-catchment drainage area (load reductions that can be obtained upstream of a given site are subtracted out).

a. Pathogens

The annual loads calculated for *E. coli* (total and per flow condition) are summarized in **Table 33**, page 60, along with the target loads for both the PCR and SCR benchmarks (per water quality standards) and the reductions required to meet those targets. All sites except SF01 require *E. coli* reductions to meet PCR uses, while many sites already meet SCR use based on *E. coli* load. Sites SF02 and SF07 require the largest *E. coli* reductions to meet safe conditions for swimming and wading. **Exhibits 19** and **20** (Appendix A) illustrate the health grade (based on *E. coli* concentration data) for both PCR and SCR uses, load reduction needed to achieve both uses, and potential sources of fecal-related bacteria based on the microbial source tracking results.

For *E. coli*, the high flow loading represents the majority (49 to 94%) of the total annual loading at each site. Little of the total annual *E. coli* is transported during low flow conditions; at most only 1% of the total annual load for a given site was transported during low flow conditions. Therefore, BMPs that target wet weather sources of pathogens should have greater impact on achieving load reductions.

Table 33
Summary of *E. Coli* Annual Loads and Reductions Needed

Site ID	Load				PCR Standard (240 CFU)				SCR Standard (676 CFU)			
	High Flow (CFU/yr)	Mod. Flow (CFU/yr)	Low Flow (CFU/yr)	Total (CFU/yr)	Target Load (CFU/yr)	Reduction to Meet Standard (CFU/yr)	Reduction to Meet Standard (%)	Incremental Reduction to Meet Standard (CFU/yr)	Target Load (CFU/yr)	Reduction to Meet Standard (CFU/yr)	Reduction to Meet Standard (%)	Incremental Reduction to Meet Standard (CFU/yr)
SF01	1.40E+11	2.66E+10	1.45E+09	1.68E+11	4.01E+11	-	-	-	1.13E+12	-	-	-
SF02	3.49E+13	4.44E+12	2.49E+10	3.93E+13	5.70E+12	3.36E+13	86%	3.36E+13	1.61E+13	2.33E+13	59%	2.33E+13
SF03	1.83E+12	1.88E+11	2.32E+09	2.02E+12	4.94E+11	1.53E+12	76%	1.53E+12	1.39E+12	6.29E+11	31%	6.29E+11
SF04	2.71E+12	2.79E+12	4.61E+10	5.55E+12	2.55E+12	2.99E+12	54%	2.99E+12	7.20E+12	-	-	0.00E+00
SF05	9.91E+11	3.23E+11	5.45E+09	1.32E+12	9.63E+11	3.56E+11	27%	-	2.71E+12	-	-	-
SF06	4.55E+13	2.69E+12	7.57E+10	4.82E+13	1.12E+13	3.70E+13	77%	3.70E+13	3.17E+13	1.66E+13	34%	1.66E+13
SF07	1.98E+14	1.70E+13	3.11E+11	2.16E+14	3.58E+13	1.80E+14	83%	1.06E+14	1.01E+14	7.51E+13	53%	7.51E+13
SF08	3.64E+13	1.06E+13	2.73E+11	4.73E+13	3.56E+13	1.17E+13	25%	-	1.00E+14	-	-	-
SF09	1.74E+14	1.94E+13	1.06E+12	1.94E+14	7.67E+13	1.18E+14	61%	1.18E+14	2.16E+14	-	-	0.00E+00
SF10	2.53E+14	3.86E+13	1.75E+12	2.93E+14	1.10E+14	1.84E+14	63%	6.62E+13	3.09E+14	-	-	0.00E+00
SF11	2.14E+14	2.43E+13	1.13E+12	2.39E+14	1.28E+14	1.11E+14	47%	4.52E+13	3.59E+14	-	-	0.00E+00
SF12	9.83E+12	3.08E+12	1.34E+11	1.30E+13	7.44E+12	5.61E+12	43%	5.61E+12	2.09E+13	-	-	-
SF13	5.10E+13	9.58E+12	5.32E+11	6.11E+13	2.79E+13	3.33E+13	54%	2.77E+13	7.85E+13	-	-	0.00E+00
SF14	9.52E+14	7.19E+13	3.04E+12	1.03E+15	1.67E+14	8.60E+14	84%	7.87E+14	4.72E+14	5.56E+14	54%	5.56E+14

b. Nutrients

i. Phosphorus

The annual loads calculated for Total P (total and per flow condition) are summarized in **Table 34**, page 63, along with the target loads for both the Phase 1 (0.09 mg/L) and Phase 2 (0.07 mg/L) benchmarks and the reductions required to meet those targets. Most sites already meet the Phase 1 target load, and half of the monitored sites meet the Phase 2 target load. Sites SF09 and SF10 require the largest Total P reductions to meet the target water quality loads aiming to protect instream aquatic life conditions. **Exhibit 21** (Appendix A) illustrates the health grade (based on concentration data) and load reductions needed to achieve the Phase 1 benchmark. **Exhibit 22** (Appendix A) illustrates the health grade and load reductions needed to achieve the Phase 2 benchmark.

For Total P, the high flow loading represents the majority (74 to 89%) of the total annual loading at each site. Little of the total annual Total P is transported during low flow conditions; at most only 1% of the total annual load for a given site was transported during low flow conditions. Therefore, BMPs that target wet weather / nonpoint sources of phosphorus should have greater impact on achieving load reductions.

For comparison, the estimates of mean annual load of Total P exported at sites SF09 and SF14 by USGS using their LOADEST software and measured data were higher than those estimated by this watershed plan. The USGS predicted 25,900 and 36,500 lbs/year of Total P load at SF09 and SF14, respectively. The loading estimates developed in this plan are considered more refined, since this plan calculates the annual load of each pollutant at each monitoring location using a representative flow for 3 flow conditions (low, moderate, and high) paired with calculated geomean nutrient concentrations for each of those 3 flow conditions. The Total P loads predicted by this plan for sites SF09 and SF14 are 6,776 and 13,554 lbs/year, respectively, which is lower than those predicted by USGS for those locations. The USGS estimate was based on mean data, which tends to bias the results toward higher values.

ii. Nitrogen

The annual loads calculated for Total N (total and per flow condition) are summarized in **Table 35**, page 64, along with the target loads for both the Phase 1 (7.5 mg/L) and Phase 2 (5.5 mg/L) benchmarks and the reductions required to meet those targets. Most sites already meet the Phase 1 and 2 target loads for Total N. Sites SF05 and SF13 require the largest Total N reductions to meet the target water quality loads aiming to protect instream aquatic life conditions. **Exhibit 23** (Appendix A) illustrates the health grade (based on concentration data) and load reductions needed to achieve the Phase 1 benchmark. **Exhibit 24** (Appendix A) illustrates the health grade and load reductions needed to achieve the Phase 2 benchmark.

For Total N, the high flow loading represents the majority (64 to 88%) of the total annual loading at each site. Little of the annual Total N is transported during low flow conditions; at most only 2% of the total annual load for a given site was transported during low flow conditions. Therefore, BMPs that target wet weather / nonpoint sources of nitrogen should have greater impact on achieving load reductions; however, concentration data indicated that nitrogen concentration did not increase with increasing flow to the same magnitude as for pathogens and phosphorus.

For comparison, the estimates of mean annual load of Total N exported at sites SF09 and SF14 by USGS using their LOADEST software and measured data were higher than those estimated by this watershed plan. The USGS predicted 560,000 and 1,080,000 lbs/year of Total N load at SF09 and SF14, respectively, while this plan estimated 804,979 lbs/year and 13,554 lbs/year of Total N load at SF09 and SF14, respectively. The USGS estimate was based on mean data, which tends to bias the results toward higher values, compared to using calculations based on geomean concentrations (used here). Additionally, as noted above for Phosphorus, the load results presented here are refined based on 3 flow conditions.

c. *Sediment and Other Pollutants*

Pollutant loads and reductions needed were not calculated for sediment; a non-concentration based target was selected as an alternative to a numeric target for sediment (as described in previous section, Non-Regulatory Reference Points). The sediment load shall be addressed through implementation of BMPs and remediation/restoration projects to address sources identified in the USGS sediment fingerprinting study as well as the specific eroding stream banks identified by this watershed plan (severe erosion study).

By reducing other pollutant contributions through the implementation of site-specific best management practices, it is probable that exceedances of the stream Conductivity benchmark will likewise be reduced.

Since Conductivity is affected by the presence of dissolved ions, removing other pollutants that contain inorganic dissolved solids should improve Conductivity. However, elevated stream Conductivity can be affected by the geology of the area and may continue to be elevated.

5. Pollutant Sources

Pollutant load reductions needed to achieve the target loads for *E. coli*, phosphorus, and nitrogen, as well as reduce the number of benchmark exceedances for conductivity and suspended sediment, were performed on a subwatershed basis to lay the groundwork for identifying the sources of pollutants on this spatial scale as well. The sources of pollution in the SFLR watershed were identified based on the available data and analysis presented in above sections, along with on-the-ground knowledge of project stakeholders.

The following sections identify and allocate specific sources of impairment within each subwatershed and identify specific BMPs to address those sources and achieve PCR (*E. coli*) and Phase 1 and 2 (nutrients) water quality goals within the streams of the SFLR watershed.

Table 34
Summary of Annual Total Phosphorus Loads and Reductions Needed

Site ID	Load				Phase 1 Benchmark (0.09 mg/L)				Phase 2 Benchmark (0.07 mg/L)			
	High Flow (lb/yr)	Mod. Flow (lb/yr)	Low Flow (lb/yr)	Total (lb/yr)	Target Load (lb/yr)	Reduction to Meet Benchmark (lb/yr)	Reduction to Meet Benchmark (%)	Incremental Reduction to Meet Benchmark (lb/yr)	Target Load (lb/yr)	Reduction to Meet Benchmark (lb/yr)	Reduction to Meet Benchmark (%)	Incremental Reduction to Meet Benchmark (lb/yr)
SF01	9	1	0	10	33	-	-	-	26	-	-	-
SF02	264	47	2	313	471	-	-	-	366	-	-	-
SF03	11	2	0	13	41	-	-	-	32	-	-	-
SF04	116	22	1	138	211	-	-	-	164	-	-	-
SF05	45	5	0	50	80	-	-	-	62	-	-	-
SF06	386	69	3	458	929	-	-	-	723	-	-	-
SF07	2,535	354	20	2,908	2,956	-	-	-	2,299	609	21%	609
SF08	2,075	436	20	2,532	2,940	-	-	-	2,287	245	10%	-
SF09	5,797	946	34	6,776	6,333	443	7%	443	4,925	1,851	27%	1,851
SF10	7,524	2,550	65	10,140	9,050	1,089	11%	646	7,039	3,101	31%	1,250
SF11	8,742	2,092	72	10,905	10,539	366	3%	-	8,197	2,708	25%	1,459
SF12	206	49	2	256	614	-	-	-	478	-	-	-
SF13	1,472	372	16	1,861	2,304	-	-	-	1,792	69	4%	69
SF14	10,164	3,297	92	13,554	13,830	-	-	-	10,757	2,797	21%	1,270

Table 35
Summary of Annual Total Nitrogen Loads and Reductions Needed

Site ID	Load				Phase 1 Benchmark (7.5 mg/L)				Phase 2 Benchmark (5.5 mg/L)			
	High Flow (lb/yr)	Mod. Flow (lb/yr)	Low Flow (lb/yr)	Total (lb/yr)	Target Load (lb/yr)	Reduction to Meet Benchmark (lb/yr)	Reduction to Meet Benchmark (%)	Incremental Reduction to Meet Benchmark (lb/yr)	Target Load (lb/yr)	Reduction to Meet Benchmark (lb/yr)	Reduction to Meet Benchmark (%)	Incremental Reduction to Meet Benchmark (lb/yr)
SF01	247	34	5	286	2,759	-	-	-	2,023	-	-	-
SF02	7,962	1,228	67	9,256	39,244	-	-	-	28,779	-	-	-
SF03	226	27	4	258	3,400	-	-	-	2,493	-	-	-
SF04	5,648	1,000	38	6,686	17,590	-	-	-	12,899	-	-	-
SF05	6,053	1,528	55	7,636	6,627	1,009	13%	1,009	4,860	2,776	36%	2,776
SF06	29,078	7,764	206	37,049	77,428	-	-	-	56,781	-	-	-
SF07	100,045	21,614	743	122,402	246,352	-	-	-	180,658	-	-	-
SF08	100,674	33,040	911	134,625	245,026	-	-	-	179,686	-	-	-
SF09	268,242	81,313	2,934	352,488	527,732	-	-	-	387,003	-	-	-
SF10	362,221	98,615	3,219	464,055	754,182	-	-	-	553,066	-	-	-
SF11	401,545	108,080	2,953	512,578	878,251	-	-	-	636,543	-	-	-
SF12	27,870	15,350	505	43,726	51,190	-	-	-	39,636	6,187	14%	6,187
SF13	157,111	54,632	2,549	214,292	191,989	22,304	10%	22,304	102,865	73,501	34%	67,314
SF14	637,891	161,729	5,358	804,979	1,152,513	-	-	-	845,177	-	-	-

a. *Causes and Sources of Pathogens*

Results from microbial source tracking indicated that human markers indicative of human fecal waste were detected at the majority of sites monitored, but at low levels. Canine markers were detected at all sites monitored, but generally at low levels. Bovine markers were detected at all sites monitored, at levels higher than for the human or canine markers. Based on the knowledge gained from microbial source tracking results and landuse / watershed inventory data, the predominant sources of *E. coli* considered for remediation across the SFLR watershed were from (1) livestock animals in the form dairy cattle, (2) livestock animals in the form of grazing cattle, (3) human sources in the form of failing onsite septic systems, and (4) pet waste.

The potential *E. coli* load from each of these sources was spatially distributed to each subwatershed based on known subwatershed land use characteristics, animal estimates, and estimates of households with septic systems. *E. coli* loading rates were developed from published literature values based on daily feces production and its *E. coli* content (**Table 36**). This was the basis for the subwatershed-specific estimates of *E. coli* loads "available for reduction" in each subwatershed.

Table 36
***E. coli* Loading Rates per Potential Pollutant Source**

Potential Pollutant Source	*E. coli* Loading Rate	Units	Source
Cattle (Dairy & Grazing)	2.25 E+09	CFU/animal/day	KDOW 2013
Failing Septic Systems (Human)	1.72 E+09	CFU/person/day	Horsley & Whitten 1996
Pets	1.00 E+07	CFU/acre residential development/day	KDOW 2014

i. *Dairy Cattle*

The number of dairy cattle was estimated within for the entire SFLR watershed using USDA (2014) statistics (**Table 6,** page 17). This estimate of dairy cattle was distributed to each subwatershed based on the known dairy license data for each subwatershed (**Exhibit 9**, Appendix A); the dairy cattle were distributed evenly to each known dairy license location. The *E. coli* loading rates (**Table 36**, page 65) were multiplied by the number of dairy animals in each subwatershed to calculate the maximum potential *E. coli* load associated with dairy animals within each subwatershed; load was converted to CFU per year. **Table 37**, page 68, tabulates the total potential *E. coli* reductions estimated for each subwatershed if all estimated dairy cows are addressed. Subsequently, the percentage of animals whose waste needs to be eliminated to meet PCR goals was determined. Recommended management strategies to achieve *E. coli* load reductions are presented in **Chapter V**.

ii. Grazing Cattle

The number of grazing cattle was estimated within for the entire SFLR watershed using USDA (2014) statistics for cattle and calves less the animal estimates for dairy cows (**Table 6,** page 17). This estimate of grazing cattle was distributed to each subwatershed based on the known amount of hay/pasture landuse within each subwatershed (**Exhibit 11**, Appendix A). The *E. coli* loading rates (**Table 36**, page 65) were multiplied by the number of grazing cattle animals in each subwatershed to calculate the maximum potential *E. coli* load associated with grazing cattle animals within each subwatershed; load was converted to CFU per year. **Table 37**, page 68, tabulates the total potential *E. coli* reductions estimated for each subwatershed if all estimated grazing cattle are addressed. Subsequently, the percentage of animals whose waste needs to be eliminated to meet PCR goals was determined. Recommended management strategies to achieve *E. coli* load reductions are presented in **Chapter V**.

iii. Human – Failing Septic Systems

The number of potential residences utilizing onsite treatment of sewage was considered in **Chapter II** (page 16) and within **Exhibit 10** (Appendix A). Any residences not within 1,000 feet of a mapped a sanitary sewer line were assumed to utilize septic systems. For potential *E. coli* load reduction calculations, only high-risk locations, within 500 feet of a stream or sinkhole, were considered; the number of high-risk septic systems were tabulated per subwatershed. Per discussion within stakeholders, additional septic systems were added to subwatershed SF14 for this effort, compared to those presented in **Exhibit 10** because the methodology used to produce that exhibit likely underestimated the number of residences on septic systems. The actual number of failing septic systems is unknown; however, the number of failing septic tanks in each subwatershed was calculated using the failure rate of 2.5% (KDOW 2013). This rate was used to calculate the potential annual *E. coli* load in each subwatershed from failing septic systems using the quantity of *E. coli* expected in effluent from a failing system. Load calculation was performed using the inputs listed below with proper conversions (KDOW 2015, Horsely & Whitten 1996).

- 70 gallons/day of effluent produced per person
- 6.5 E+05 CFU/100 mL concentration of *E. coli* in septic effluent
- The above values yield the *E. coli* loading rate of 1.72 E+09 CFU/day given in **Table 36**, page 65.
- 2.5 people per household

Table 37, page 68 tabulates the total potential *E. coli* reductions estimated for each subwatershed if all high-risk, failing septic systems estimated are addressed. Subsequently, the percentage of failing septic systems to be eliminated to meet PCR goals was determined. Recommended management strategies to achieve *E. coli* load reductions are presented in **Chapter V**.

iv. Pets

The potential *E. coli* loading due to pets in each subwatershed was estimated by first tabulating the number of residences within each subwatershed. It was assumed that each residence had ¼ acre of area contributing pet waste. Then, the *E. coli* loading rate of 1.00 E+07 CFU/acre/day (**Table 36**, page 65) was multiplied by the number of residential acres estimated for each subwatershed to calculate the maximum potential *E. coli* load associated with pets within each subwatershed; load was converted to CFU per year (KDOW 2013). **Table 3**, page 68, tabulates the total potential *E. coli* reductions estimated for each subwatershed if all residential-associated pets are addressed. Subsequently, the percentage of residences whose pet waste needs to be eliminated to meet PCR goals was determined. Recommended management strategies to achieve *E. coli* load reductions are presented in **Chapter V**.

Table 37
Total Calculated Potential *E. coli* Loads per Subwatershed from Each Evaluated Pollutant Source

	Potential Dairy Cattle Sources			Potential Grazing Cattle Sources			Potential Septic Sources within 500 ft of Stream/Sinkhole		Potential Residential Pet Waste Sources		
Site ID	No. of Dairy Licenses	No. of Dairy Cattle	Potential *E. coli* Reduction from Dairy Cattle Sources (CFU/yr)	Hay / Pasture Landuse (ac)	No. of Grazing Cattle / Calves	Potential *E. coli* Reduction from Grazing Cattle Sources (CFU/yr)	No. of Potential Septic Sources within 500 ft of Stream / Sinkhole [1]	Potential *E. coli* Reduction from Septic Sources within 500 ft of Stream / Sinkhole (CFU/yr)	No. of Residences	Potential *E. coli* Reduction from Pet Waste Sources (CFU/yr)	TOTAL Potential *E. coli* Reduction (Trillion CFU/year)
SF01				101	14	1.13E+13			3	2.74E+09	11.3
SF02	5	64	5.26E+13	1,036	142	1.17E+14	37	1.57E+12	65	5.94E+10	170.7
SF03				50	7	5.60E+12	8	1.57E+12	18	1.65E+10	7.2
SF04	1	13	1.05E+13	212	29	2.39E+13	2	1.57E+12	14	1.28E+10	36.0
SF05	4	51	4.20E+13	380	52	4.28E+13	15	1.57E+12	28	2.56E+10	86.4
SF06	1	13	1.05E+13	1,268	174	1.43E+14	14	1.57E+12	59	5.39E+10	154.8
SF07	1	13	1.05E+13	1,073	147	1.21E+14	60	3.14E+12	105	9.60E+10	134.5
SF08				744	102	8.37E+13	27	1.57E+12	49	4.48E+10	85.3
SF09	6	77	6.31E+13	1,475	202	1.66E+14	70	3.14E+12	226	2.07E+11	232.4
SF10				1,843	252	2.07E+14	101	4.71E+12	2,814	2.57E+12	214.6
SF11				241	33	2.71E+13		0.00E+00	1,633	1.49E+12	28.6
SF12				519	71	5.83E+13	23	1.57E+12	42	3.84E+10	59.9
SF13	2	26	2.10E+13	129	18	1.45E+13	15	1.57E+12	64	5.85E+10	37.2
SF14				1,193	163	1.34E+14	218	7.86E+12	678	6.20E+11	142.7
TOTAL			**2.05E+14**			**1.15E+15**		**3.14E+13**		**5.30E+12**	**1,401.7**

[1] 2.5% of these are assumed failing and contributing to the *E. coli* load; decimal values for failing septic sources were all rounded up to 1

b. Causes and Sources of Nutrients

Based on watershed inventory data, the predominant sources of nutrients in the SFLR watershed considered were cropland and hay/pasture land. The approaches to reduction of nitrogen and phosphorus considered for the SFLR watershed were from (1) 35-foot wide grass buffers of cultivated crops, (2) streambank stabilization and fencing within cropland, (3) controlled drainage of cropland, (4) nutrient management of cropland (5) streambank stabilization and fencing within hay/pasture land, (6) livestock exclusion within hay/pasture land, and (7) pasture renovation. For *E. coli*, potential reductions were directly tied to estimates of livestock numbers within each subwatershed, however the nutrient reductions associated with animal management BMPs were calculated "indirectly", based on area of the BMP implementation. For the grass buffers of cropland and the streambank stabilization within cropland, the area available for consideration of these BMPs was the area of cropland within 100-feet of a stream. For controlled drainage and nutrient management, the remainder of cropland was considered available for the implementation of these BMPs. For the streambank stabilization and fencing within hay/pasture land and livestock exclusion within hay/pasture land, the area available for consideration for these BMPs was the area of hay/pasture land within 100-feet of a stream. For pasture renovation, the remainder of hay/pasture land was considered available for the implementation of this BMP. For each subwatershed, the area of cropland within 100-feet of a stream, the remainder of cropland area, the area of hay/pasture 100-feet of a stream, and the remainder of hay/pasture land was tabulated and used for the calculation of nutrient reductions associated with the above BMPs.

The potential nutrient loads from each of cropland and hay/pasture land sources was spatially distributed to each subwatershed based on known subwatershed land use characteristics. Total N and Total P loading rates were developed using measured nutrient yields (lb/ac-yr) along with STEPL modeling (USEPA 2018). To simplify the effort, an average Total N and Total P yield was calculated for the entire SFLR watershed (**Table 38**, page 70). Then, STEPL modeling was performed for each subwatershed in the SFLR watershed using these basic inputs:

- Project location, Christian County, Kentucky
- Acres of each landuse within each subwatershed (urban, cropland, pastureland, and forest)
- Estimates of beef and dairy cattle within each subwatershed
- Numbers of septic systems (used same information on failing, "high risk" septic systems as use above for calculation of *E. coli* reductions.
- Hydrologic soil group; used "C", the average soil group of the SFLR watershed
- Used default STEPL values for nutrient concentrations

Nutrient export results from this STEPL model were compared to measured results; generally Total N load predicted by the STEPL model was less that that measured for each subwatershed and measured Total P Total N load predicted by the STEPL model was less that that measured for each subwatershed. This model was not calibrated to better match measured and predicted nutrient loads, but was utilized to proportion the measured Total N and Total P loads between cropland and hay/pasture landuses (**Table 38**). Per the STEPL modeling, on average across the entire watershed cropland and pastureland contributed 65% and 17% of the Total N load, respectively. Per the STEPL modeling, on average across the entire watershed Cropland and Pastureland contributed 78% and 9% of the Total P load, respectively. These proportions were applied to measured Total N and Total P yields, estimating that, on average, cropland exports 23 lb/ac-yr Total N and 0.5 lb/ac-yr Total P; pastureland exports 6 lb/ac-yr Total N and 0.1 lb/ac-yr Total P (**Table 38**).

Table 38
Nutrient Loading Rates per Potential Pollutant Source (Landuse)

Site ID	Incremental Measured Total N Load (lb/yr)	Incremental Measured Total P Load (lb/yr)	Incremental Drainage Area (ac)	Incremental Measured Total N Yield (lb/ac-yr)	Incremental Measured Total P Yield (lb/ac-yr)
SF01	286	10	393	0.7	0.03
SF02	8,970	302	2,171	4.1	0.1
SF03	258	13	365	0.7	0.0
SF04	6,686	138	812	8.2	0.2
SF05	7,378	37	1,178	6.3	0.0
SF06	37,049	458	3,529	10.5	0.1
SF07	62,319	1,972	3,519	17.7	0.6
SF08	72,306	560	2,898	24.9	0.2
SF09	280,182	6,216	8,100	34.6	0.8
SF10	183,872	3,923	6,559	28.0	0.6
SF11	328,706	6,982	1,535	214.1	4.5
SF12	43,726	256	2,561	17.1	0.1
SF13	170,567	1,604	2,212	77.1	0.7
SF14	305,706	4,967	7,347	41.6	0.7
Average				34.7	0.6
STEPL-predicted proportions of N and P load per landuse:					
Cropland				65%	78%
Pastureland				17%	9%
STEPL-predicted proportions of N and P load per landuse applied to measured total N and P Yields to distribute measured yields among these 2 landuses:					
				Total N Yield (lb/ac-yr)	Total P Yield (lb/ac-yr)
Cropland				23	0.5
Pastureland				6	0.1

This was the basis for the subwatershed-specific estimates of Total N and P loads "available for reduction" in each subwatershed. The loads available for reduction were divided into 2 categories for cropland for each subwatershed - the area of cultivated crops within 100-feet of a mapped stream and the remaining area of cultivated crops. Likewise, the loads available for reduction were divided into 2 categories for hay/pasture land for each subwatershed - the area of hay/pasture land within 100-feet of a mapped stream and the remaining area of hay/pasture land. The datasets for the land uses and the mapped streams are those presented in **Exhibits 11** and **Exhibit 5** (and other exhibits), respectively (**Exhibit A**). **Table 39**, page 72, tabulates estimates of total potential nutrient reductions for each subwatershed if all cropland and hay/pasture land are addressed. Thus, the potential nutrient load from each category of landuse was calculated by multiplying the area of that land use by the estimated nutrient yields for that landuse (cropland exports 23 lb/ac-yr Total N and 0.5 lb/ac-yr Total P; pastureland exports 6 lb/ac-yr Total N and 0.1 lb/ac-yr Total P; **Table 38**). Subsequently, crop and hay/pasture BMPs were evaluated to quantify BMPs needed to meet Phase 1 and Phase 2 water quality goals. Recommended management strategies to achieve nutrient load reductions are presented in **Chapter V**.

Table 39
Total Calculated Potential Nutrient loads per Subwatershed from Each Evaluated Pollutant Source

Site ID	Cropland						Hay/Pasture Land					
	Area of Cropland not within 100-ft of Stream (ac)	Potential N Load from Cropland not within 100-ft of Stream (lb/yr)	Potential P load from Cropland not within 100-ft of Stream (lb/yr)	Area of Cropland within 100-ft of Stream (ac)	Potential N load from Cropland within 100-ft of Stream (lb/yr)	Potential P load from Cropland within 100-ft of Stream (lb/yr)	Area of Hay/Pasture Land not within 100-ft of Stream (ac)	Potential N load from Hay/Pasture Land not within 100-ft of Stream (lb/yr)	Potential P load from Hay/Pasture Land not within 100-ft of Stream (lb/yr)	Area of Hay/Pasture Land within 100-ft of Stream (ac)	Potential N load from Hay/Pasture Land within 100-ft of Stream (lb/yr)	Potential P load from Hay/Pasture Land within 100-ft of Stream (lb/yr)
SF01	0	0.0	0	0	0.0	0	97	580.1	9.7	4	23.4	0.4
SF02	200	4,596.9	100	26	607.2	13.2	956	5,735.4	95.6	80	478.8	8.0
SF03	10	240.1	5	0	0.0	0	47	283.5	4.7	3	15.3	0.3
SF04	411	9,459.2	206	64	1,481.2	32.2	187	1,121.0	18.7	25	151.7	2.5
SF05	333	7,657.0	166	43	982.1	21.4	360	2,161.5	36.0	20	121.2	2.0
SF06	666	15,317.5	333	33	754.4	16.4	1,204	7,225.1	120.4	64	385.6	6.4
SF07	1122	25,814.4	561	17	395.6	8.6	1,056	6,337.6	105.6	17	101.8	1.7
SF08	1158	26,639.0	579	56	1,285.7	28.0	705	4,231.8	70.5	39	231.3	3.9
SF09	4311	99,156.7	2,156	448	10,304.0	224.0	1,445	8,668.6	144.5	30	181.6	3.0
SF10	1299	29,878.0	650	18	414.0	9.0	1,802	10,813.3	180.2	41	245.5	4.1
SF11	172	3,957.2	86	2	39.1	0.9	241	1,443.7	24.1	1	3.4	0.1
SF12	1504	34,596.5	752	108	2,481.7	54.0	515	3,088.0	51.5	4	23.1	0.4
SF13	1696	39,014.5	848	7	149.5	3.3	125	751.0	12.5	4	22.7	0.4
SF14	3291	75,702.8	1,646	324	7,447.4	161.9	1,151	6,903.4	115.1	42	254.5	4.2
TOTAL	16,175	372,030	8,088	1,145	26,342	573	9,891	59,344	989	373	2,240	37

V. BMP IMPLEMENTATION STRATEGY

A. Goals and Objectives

In order to identify and prioritize the goals and objectives for this watershed planning effort, several methods were employed. First and foremost were frequent meetings with the LRWQC and Basin Coordinator throughout the planning process. As described in Chapter 1, the LRWQC was established in 2011 with the primary purpose of overseeing and directing water quality monitoring and implementation of BMPs in the SFLR Watershed.

The Technical Advisory Committee also formally convened on February 21 and March 28, 2018 to examine the results of the data analyses, provide input on the likely sources of the pollution observed, develop goals and objectives for the watershed, and offer recommendations regarding BMPs. The Technical Advisory Committee consisted of representatives with local and technical knowledge of the watershed, practices and land uses contributing to pollution, and programs and opportunities to remediate the pollution/problems identified as described in **Chapter 1**.

A public meeting was held and surveys were distributed to assess community interest in the SFLR Watershed and the planning process. The public meeting was held July 31, 2017 at the Christian County Extension Office as advertised in advance in the local newspaper the Kentucky New Era. The on-line survey was published to give interested citizens the opportunity to provide feedback on their perceived water quality concerns, what they feel a healthy watershed should look, and their interest in becoming involved in the watershed implementation process. The survey was made available both in hard copy at the public meeting and subsequently on-line via the SFLR web page and a targeted mailing.

Twelve surveys were completed the results of which are illustrated on **Figures 9** and **10** (page 64). Results indicate that most respondents were primarily interested in agriculture/farming and government/regulatory issues. Respondents noted that positive actions they saw occurring in the watershed related to achieving a healthier watershed were (1) the increased focus on water quality with the development of the LRWQC, (2) increased application of no-till and minimum-till farming practices, (3) improved solutions to human and animal waste issues, (4) implementation of water and sediment control basins and riparian zones, and (5) the work of agencies such as USDA-NRCS and the Farm Service Agency (FSA). When asked about specific concerns for SFLR watershed, responses included sanitary sewer leaks, flooding, and livestock waste.

Goals identified as a result of the process are as follows (listed in order of priority):

1. decrease bacteria levels to allow for safe recreational use;
2. reduce nutrient concentrations (nitrogen and phosphorus) to healthy levels;
3. improve the stream habitat to support a healthy aquatic ecosystem;
4. restore streams to stable, natural channel conditions reducing the rate of flooding, erosion, and sedimentation;
5. remove trash and debris clogging waterway; and
6. educate the local community about the importance of water resources and how they can help to improve water quality.

Figure 9
Stakeholder Interests

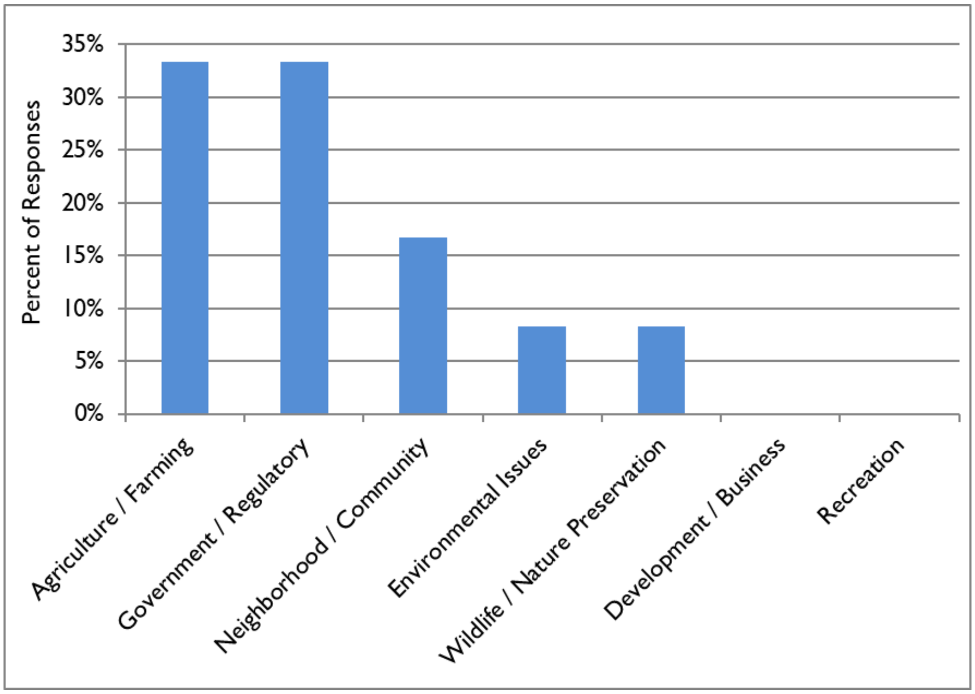
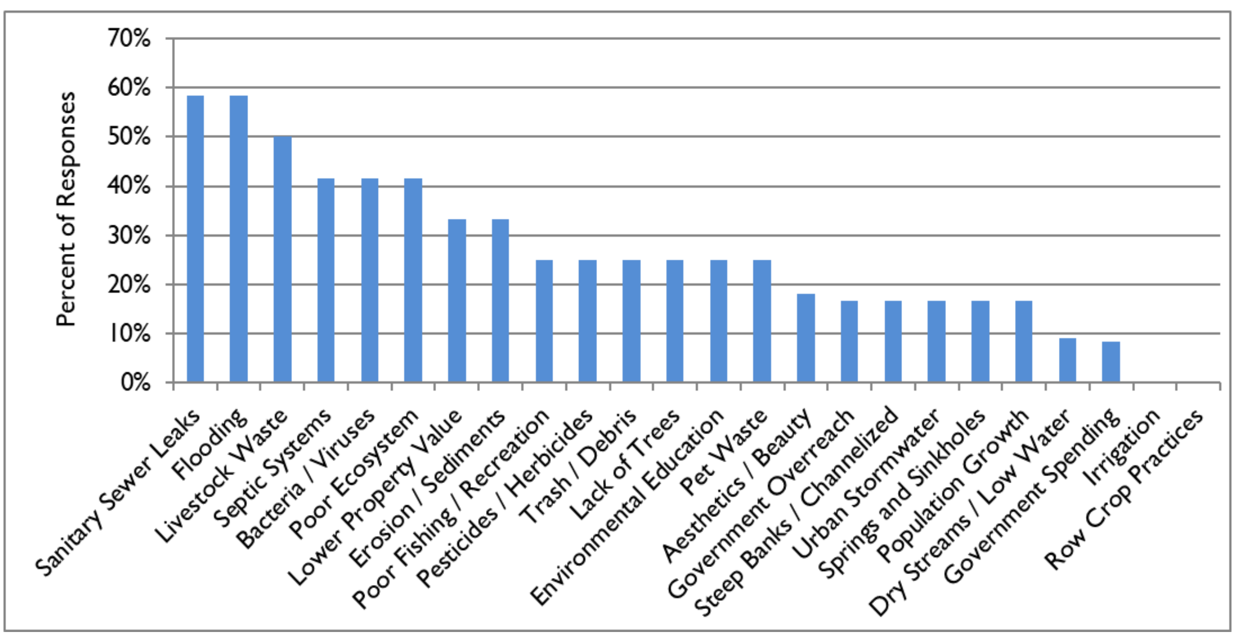


Figure 10
Stakeholder Concerns



For each goal, the pollutant source or cause, measurable indicator of success, and objectives are identified and summarized in **Table 40**, page 81. The reduction of bacteria levels in the watershed was considered the greatest priority due to the risk of human illness during recreational use and water quality data indicate that the majority of sites received a “D” grade for supporting the PCR use. Measurable indicators of success were selected due to regulatory standards for comparison (such as *E. coli*) or impairments indicated in the watershed monitoring. Other parameters may be utilized, as appropriate, to gage overall success in reducing pollutant loading or linking a loading to a source. However, to evaluate overall progress in water quality improvement, the measurable indicators specified should be utilized.

Table 40
SFLR Watershed-Based Plan Goals and Objectives

Goal	Source / Cause Considered for Remediation	Measurable Indicator	Objectives
G1. Decrease in-stream bacteria levels to allow for safe recreational use	• Dairy cattle • Grazing cattle • Residential septic system failure • Residential pet waste	• *E. coli*	• Exceed *E. coli* instantaneous criteria in < 20% of samples • Remove dairy waste from streams (may be achieved by updating/improving agricultural water quality and nutrient management plans, providing adequate waste storage/handling, and excluding dairy animals from streams) • Remove grazing cattle waste from streams (may be achieved by excluding grazing animals from streams) • Implement a septic system evaluation/maintenance/repair program • Implement a residential pet waste educational program; provide pet waste stations in high-risk locations
G2. Reduce in-stream nutrients (nitrogen and phosphorus) and sediment to healthy levels	• Cultivated cropland • Livestock grazing on hay/ pasture land • Stream bank erosion	• Total nitrogen • Total phosphorus • Visual assessment of in-stream sediment deposition	• Buffer cultivated cropland • Implement controlled drainage of cropland • Implement nutrient management on cropland • Stabilize stream banks (with fencing) along cropland • Implement livestock exclusion fencing along streams within hay/pasture land • Implement pasture renovation (hay/pasture land planting) • Stabilize stream banks (with fencing) along hay/pasture land
G3. Improve stream habitat to support a healthy aquatic ecosystem	• Narrow riparian width • Unstable banks / Erosion	• Macroinvertebrates • RBP habitat • Visual bank assessment	• Improve the quality and width of riparian buffer zones • Stabilize and/or restore eroding stream banks

Table 40
SFLR Watershed-Based Plan Goals and Objectives *Cont.*

Goal	Source / Cause Considered for Remediation	Measurable Indicator	Objectives
G4. Remove trash and debris clogging waterways	• Woody debris / log jams from storm damage and bank failure • Trash and litter	• Number to log jams • Estimated trash / debris removed (in pickup truck loads)	• Document routine locations of trash and debris accumulation • Organize groups to remove trash and debris from watershed on a routine basis • Remove woody debris by chainsaw without disturbing the stream bed material
G5. Educate the community about the importance of water resources and how they can help to improve water quality	• Lack of education • Continuation of practices that cause or facilitate impairment	• Number of interactions • Educational materials distributed	• Increase public knowledge about water quality impairments • Develop targeted educational materials for each problem area • Reach targeted audience about opportunities for implementation on their property • Perform ongoing monitoring of stream health conditions

B. BMP Implementation Plan

Detailed water quality analyses and computation of pollutant loads and reductions to meet water quality goals were used, along with stakeholder-developed watershed goals and objectives, to guide the selection of BMPs needed to address pollutant sources.

A selection of technically valid and locally accepted BMPs were quantified to address the total potential *E. coli* and nutrient loads for each subwatershed, as presented in **Chapter IV**. This effort is intended to guide BMP implementation and represent the scope and type of effort that will be required to meet watershed goals. Specific locations and prioritization of specific BMPs is not included in the watershed-based plan; however, a separate BMP Implementation Plan document is being developed parallel to this plan. The BMP Implementation Plan will provide specific locations for BMP implementation opportunities and provide an approach for prioritization of those projects, as well as identification of specific roles and obligations of parties responsible for each specific BMP implementation. Once the BMP Implementation Plan is developed, it is expected to be implemented under the direction of a South Fork of Little River Watershed Coordinator in collaboration with the Four Rivers Basin Coordinator, LRWQC, Technical Advisory Committee, and other relevant entities.

1. Plan Promotion and Coordination

Addressing nonpoint sources of pollution within this watershed will require targeted outreach and program promotion by a LRWQC representative. As a result, successful implementation of the BMP plan will be contingent upon the LRWQC hiring a SFLR Watershed Coordinator to work with the LRWQC, Technical Advisory Committee, Basin Coordinator, and local stakeholders to promote and coordinate BMP implementation as described generally within this watershed-based plan, and more specifically within the separate BMP Implementation Plan.

2. Pathogen Best Management Practices

Chapter IV presents the annual loads calculated for E. coli, along with the target loads for both the PCR and SCR limits for each subwatershed. Additionally, Chapter IV identifies sources of E. coli for treatment consideration as dairy cattle, grazing cattle, failing septic systems (human), and residential pets, along with the total potential *E. coli* reduction possible in each subwatershed if each of these sources is addressed. This chapter presents quantification of the selected BMPs needed to achieve the *E. coli* load reductions to meet PCR standards. **Table 41**, page 81, summarizes the amount of reduction calculated for each subwatershed by implementation of the 4 categories of pathogen BMPs; the goal was to achieve enough incremental *E. coli* load reduction to meet the PCR benchmark for each subwatershed. Quantification of BMPs to only meet the SCR limits was not presented, since meeting PCR is the priority. Reduction of pathogens due to selected BMPs was considered separately and by a different approach than reductions of nutrients, though in reality there is overlap and potential *E. coli* and nutrient sources will be indirectly addressed through other management recommendations (i.e. waste reductions to reduce *E. coli* also reduce nutrients). *E. coli* reductions were solely based on the quantified elimination of animals or human sources and nutrient reductions were quantified differently, as indicated in subsequent sections.

a. Human – Failing Septic Systems

In all subwatersheds in need of incremental *E. coli* reductions to meet PCR goals, it was assumed that 100% of high-risk, failing septic systems should be addressed due to the health risks associated with contacting human-sourced pathogens. A program shall be developed to identify failing septic systems in high risk locations (within 500 feet of a stream or sinkhole), and to subsequently inspect and repair/replace the failing systems bring them into compliance with local requirements. The Watershed Coordinator will work in conjunction with responsible parties and others to develop a program to assist homeowners with failing septic systems in maintaining, repairing, or replacing these systems. Other counties and regions have implemented such programs that provide templates for identifying and prioritizing projects. A ranking system for implementation would include, but not be limited to, proximity to a stream, severity of the failure, and need for financial assistance. A key component is homeowner reports to a non-regulatory entity for project consideration. Relevant responsible parties may include the LRWQC and Christian County Health Department. At the rates indicated for each subwatershed (**Table 41**), an annual loading reduction of 2.99E+13 CFU of *E. coli* is expected for the entire SFLR watershed due to repairing/replacing septic systems.

Next, dairy and grazing cattle eliminations were considered; see proposed rates of treatment for each subwatershed indicated in **Table 41**. At the proposed rates, an annual *E. coli* loading reduction of 6.51E+13 CFU is expected from eliminating dairy cattle sources and 4.73E+14 CFU is expected from eliminating grazing cattle sources for the entire SFLR watershed. BMPs shall be selected specifically to eliminate the waste from the proposed number of dairy and grazing animals and can include exclusion of animals from riparian zones and streams, as well as BMPs to protect streams from inadequate or failing waste storage/treatment areas (i.e. within dairy operations). The Watershed Coordinator will work in conjunction with responsible parties and others, utilizing the separate BMP Implementation Plan document, to identify grazing areas with cattle access to streams. Solutions to eliminate the required amount of waste from grazing animals may include planned grazing systems, riparian area protection, and fencing livestock out of streams. Dairies, which require concentrated waste storage, can be evaluated for farm-specific BMPs that will best address eliminating waste from the quantified number of animals needed to achieve water quality goals. Offerings could include educational clinics, technical design expertise, contractor/construction work, and on-farm demonstration projects. Farms with undersized or deficient facilities, deficient handing/application methods, lack of or inefficient diversion of clean runoff from waste areas, *etc.* shall be identified for improvements. The Watershed Coordinator will work in conjunction with relevant parties to implement specific BMPs identified in the separate BMP Implementation Plan document. Relevant responsible parties may include LRWQC, District conservationists for USDA-NRCS, University of Kentucky Agricultural Extension Agents, Christian County Conservation District, and Kentucky Dairy Development Council. At the rates indicated for each subwatershed (**Table 41**), an annual loading reduction of 1.08E+14 CFU and 8.67E+14 CFU of *E. coli* is expected for the entire SFLR watershed due to the elimination of waste from dairy cattle and grazing cattle, respectively.

Finally, in subwatersheds containing more development (SF10, SF11, SF14), residential pet sources were considered for reductions. **Table 41** quantifies the sources that should be treated to reach PCR goals. Cleaning up dog waste and disposing of it properly can be a very simple, yet effective, way to reduce *E. coli*. BMPs shall be selected specifically to eliminate the pet waste from the proposed number of animals (dogs) and can include educational programs to promote pet waste pick-up and proper disposal and/or provision of pet waste stations in areas of where people frequently exercise their dogs. Adoption of this practice is not widespread and will require efforts to encourage implementation; the Watershed Coordinator will work in conjunction with relevant parties to implement specific BMPs identified in the separate BMP Implementation Plan document. Relevant responsible parties may include neighborhood associations, the LRWQC, City of Hopkinsville, Hopkinsville Surface and Stormwater Utility, and Christian County Health Department. At the rates indicated for each subwatershed (**Table 41**), an annual loading reduction of 5.13E+12 CFU of *E. coli* is expected for the entire SFLR watershed due to addressing residential pet waste.

In all but 2 subwatersheds, SF11 and SF14, the incremental *E. coli* reduction needed to meet the PCR benchmark was achieved by proposed reductions associated with dairy cattle, grazing cattle, failing septic systems (human), and residential pet sources. Subwatershed SF11 is just upstream of SF14. The inability to meet the reduction goals with the selected BMPS in these areas likely indicates that there may be sources of *E. coli* not identified and quantified in this watershed-based plan, such as municipal sanitary sewer or wildlife. However, as indicated in **Table 41**, this plan considers additional BMPs in areas upstream and/or downstream of SF11 and SF14 to deal with not meeting incremental load reduction goals for those subwatersheds. Thus, BMPS were implemented to "help" achieve overall SFLR watershed goals even though they were not needed to achieve the incremental target load reductions in the given subwatershed. These "extra" *E. coli* BMPs were also included in subsequent sections for budget-planning purposes. The solutions presented in this watershed-based plan are intended to be starting points for achieving water quality goals, thus additional study could be performed in these portions of the SFLR watershed to gain more insight on additional sources of *E. coli* and potential management solutions.

Table 41
Total Calculated Potential *E. coli* Load Reductions per Subwatershed from Each Evaluated Pollutant Source

Site ID	Proposed Dairy Cattle Reductions			Proposed Failing Septic Reductions (within 500 ft of Stream / Sinkhole)			Proposed Residential Pet Waste Reductions			Proposed Grazing Cattle Reductions			Total Potential *E. coli* Reduction Trillion CFU/year		
	No. of Dairy Animals	% of Dairy Cattle with Waste Eliminated	*E. coli* Reduction from Dairy Cattle Sources (CFU/yr)	No. of Failing Septic Sources	% of Failing Septic Sources Eliminated	*E. coli* Reduction from Failing Septic Sources (CFU/yr)	No. of Residences	% of Residences with Pet Waste Eliminated	*E. coli* Reduction from Residential Pet Sources (CFU/yr)	No. of Grazing Cattle / Calves	% of Grazing Cattle / Calves with Waste Eliminated	*E. coli* Reduction from Grazing Cattle Animal Sources (CFU/yr)	Total *E. coli* Reduction from all 4 Sources (Trillion CFU/yr)	Incremental *E. coli* Reduction Required to Meet PCR Benchmark (Trillion CFU/yr)	Difference in Total Proposed Reducion and Incremental Reduction Required (Trillion CFU/yr) [1]
SF01	-	-	-	-	-	-	3	0%	0.00E+00	14	0%	-	-	-	-
SF02	64	20%	1.05E+13	1	100%	1.57E+12	65	0%	0.00E+00	142	18.5%	2.15E+13	33.6	33.6	0
SF03	-	-	-	1	100%	1.57E+12	18	0%	0.00E+00	7	0%	-	1.6	1.5	0
SF04	13	4%	4.20E+11	1	100%	1.57E+12	14	0%	0.00E+00	29	4.2%	9.99E+11	3.0	3.0	0
SF05	51	0%	-	1	0%	-	28	0%	0.00E+00	52	0%	-	-	-	-
SF06	13	25%	2.63E+12	1	100%	1.57E+12	59	0%	0.00E+00	174	23%	3.28E+13	37.0	37.0	0
SF07	13	100%	1.05E+13	2	100%	3.14E+12	105	100%	9.60E+10	147	100%	1.21E+14	106.3	106.3	(28.2)
SF08	-	-	-	1	100%	1.57E+12	49	100%	4.48E+10	102	100%	8.37E+13	-	-	(85.3)
SF09	77	100%	6.31E+13	2	100%	3.14E+12	226	100%	2.07E+11	202	100%	1.66E+14	117.7	117.7	(114.6)
SF10	-	-	-	3	100%	4.71E+12	2,814	100%	2.57E+12	252	100%	2.07E+14	66.1	66.2	(148.5)
SF11	-	-	-	-	-	-	1,633	100%	1.49E+12	33	100%	2.71E+13	28.6	45.2	16.6
SF12	-		-	1	100%	1.57E+12	42	100%	3.84E+10	71	100%	5.83E+13	5.7	5.6	(54.3)
SF13	26	100%	2.10E+13	1	100%	1.57E+12	64	100%	5.85E+10	18	100%	1.45E+13	27.6	27.7	(9.5)
SF14	-	-	-	5	100%	7.86E+12	678	100%	6.20E+11	163	100%	1.34E+14	142.7	787.0	644.3
TOTAL			1.08E+14			2.99E+13			5.13E+12			8.67E+14	570.0	1,231	

[1] Difference of zero indicates that reduction goal was met by the BMPs; Shading indicates that the incremental E. coli reduction needed to meet the PCR benchmark was not met by the proposed BMPs; negative value indicates additional BMP reductions at a station to offset not meeting required reductions at an upstream or downstream station

3. Nutrient Best Management Practices

Chapter IV presents the annual loads calculated for Total N and Total P, along with the target loads for both the Phase 1 and Phase 2 benchmarks for each subwatershed. Additionally, **Chapter IV** identifies sources of nutrients for treatment consideration as cultivated cropland and hay/pasture land, along with the total potential Total N and Total P reductions possible in each subwatershed if each of these sources is fully addressed. This chapter presents quantification of the selected BMPs needed to achieve the nutrient load reductions needed to meet established benchmarks.

Reduction of nutrients due to selected BMPs was considered separately and by a different approach than reductions of *E. coli*. *E. coli* reductions were solely based on the quantified elimination of animals or human sources, where nutrient reductions were based on treating nutrients expected to be exported from crop and hay/pasture landuses. Thus, nutrient reductions presented for BMPs in this watershed-based plan are exclusively are tied to the acreage of crop and hay/pasture landuses within each subwatershed.

Table 42, page 83, details the Total N and Total P annual reductions per acre of applicable landuse used to calculate the nutrient load reductions associated with the 7 BMPs that were considered. The Total N and Total P BMP treatment efficiencies used are default values obtained from the STEPL model (USEPA 2018). These efficiencies were multiplied by the Total N and Total P yields (lb/ac-yr) presented in **Chapter IV** (**Table 38**, page 70) to come up with the Total N and Total P treatment possible, which was subsequently multiplied by the applicable landuse acreage to compute the Total N and Total P reduction (lb/yr) associated with each BMP in each subwatershed.

Tables 43, page 84 and **Table 44**, page 85, summarizes the amount of reduction calculated for each subwatershed by implementation of 7 nutrient BMPs with the goal of achieving enough incremental Total N and Total P load reduction to meet the Phase 1 benchmarks for each subwatershed, respectively. In general, the greatest Total N and Total P reductions for the entire SFLR watershed were computed for the Nutrient Management BMP (applied to Cropland), with 20,229 lb/yr and 1,285 lb/yr reductions calculated for Total N and Total P, respectively.

Subsequently, this effort was repeated to quantify the BMPs and reductions needed in each subwatershed to meet the Phase 2 (more stringent) nutrient benchmarks (**Table 45**, page 86 and **Table 46**, page 87).

The Watershed Coordinator will work in conjunction with relevant parties to implement specific cropland and hay/pasture land BMPs identified in the separate BMP Implementation Plan document. Relevant responsible parties may include LRWQC, District conservationists for USDA-NRCS, University of Kentucky Agricultural Extension Agents, Christian County Conservation District, and Kentucky Dairy Development Council.

Table 42
Nutrient BMP Treatment Efficiencies and Amounts

		STEPL Default BMP Efficiencies		Derivation of Treatment per BMP			
Nutrient BMP	Applied Landuse	Total N Treatment Efficiency	Total P Treatment Efficiency	Total N Yield per Landuse (lb/ac-yr)	Total P Yield per Landuse (lb/ac-yr)	Total N Treatment per BMP (lb/ac-yr)	Total P Treatment per BMP (lb/ac-yr)
1. Buffer - Grass, 35-ft wide	Cropland within 100-ft of Stream	0.338	0.435	23	0.5	7.774	0.218
2. Controlled Drainage	Cropland not within 100-ft of Stream	0.388	0.350	23	0.5	8.924	0.175
3. Nutrient Management	Cropland not within 100-ft of Stream	0.154	0.450	23	0.5	3.542	0.225
4. Streambank Stabilization and Fencing	Cropland within 100-ft of Stream	0.750	0.750	23	0.5	17.250	0.375
5. Streambank Stabilization and Fencing	Hay/Pasture Land within 100-ft of Stream	0.750	0.750	6	0.1	4.500	0.075
6. Livestock Exclusion Fencing	Hay/Pasture Land within 100-ft of Stream	0.203	0.304	6	0.1	1.218	0.030
7. Hay/Pasture Land Renovation	Hay/Pasture Land not within 100-ft of Stream	0.181	0.150	6	0.1	1.086	0.015

Table 43
Calculated Total N Load Reductions per Subwatershed from Each Evaluated BMP to Reach Phase 1 Benchmarks

	Cropland-Applied BMPs										Hay/Pasture Land-Applied BMPs								Phase 1 - Total N Reductions Needed			
			(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)			(5)	(5)	(6)	(6)	(7)	(7)				
Site ID	Area of Cropland Within 100-ft of Stream (ac)	Area of Cropland Not Within 100-ft of Stream (ac)	% of Cropland Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Buffer Grass, 35-ft Wide (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Controlled Drainage (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Nutrient Mgmt (lb/yr)	% of Cropland Within 100-ft of Stream that BMP is applied (lb/yr)	Reduction from Streambank Stab. and Fencing (lb/yr)	Area of Hay/ Pasture Land Within 100-ft of Stream (ac)	Area of Hay/ Pasture Land Not Within 100-ft of Stream (ac)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Stream-bank Stab. and Fencing (lb/yr)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Livestock Exclusion (lb/yr)	% of Hay/ Pasture Land Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Hay/ Pasture Renovation (lb/yr)	Calculated Total N Reductions from All BMPs (lb/yr)[1]	Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark–Calculated Total N Reducions from All BMPs (lb/yr)[2]
SF01	0	0	0%		0%		0%		0%		4	97	0%		0%		0%		-	-	-	-
SF02	26	200	0%		0%		0%		0%		80	956	0%		0%		0%		-	-	-	-
SF03	0	10	0%		0%		0%		0%		3	47	0%		0%		0%		-	-	-	-
SF04	64	411	0%		0%		0%		0%		25	187	0%		0%		0%		-	-	-	-
SF05	43	333	35%	116.2	0%		39%	457.8	35%	257.8	20	360	35%	31.8	35%	8.6	35%	136.9	1,009	1,009	1,009	0
SF06	33	666	0%		0%		0%		0%		64	1,204	0%		0%		0%		-	-	-	-
SF07	17	1,122	0%		0%		0%		0%		17	1,056	0%		0%		0%		-	-	-	-
SF08	56	1,158	0%		0%		0%		0%		39	705	0%		0%		0%		-	-	-	-
SF09	448	4,311	59%	2064.1	0%		60%	9162.1	60%	4636.8	30	1,445	60%	81.7	60%	22.1	60%	941.4	16,908	-	-	(16,908)
SF10	18	1,299	100%	139.9	0%		100%	4601.2	100%	310.5	41	1,802	100%	184.2	100%	49.8	100%	1957.2	7,243	-	-	(7,243)
SF11	2	172	0%		0%		0%		0%		1	241	0%		0%		0%		-	-	-	-
SF12	108	1,504	0%		0%		0%		0%		4	515	0%		0%		0%		-	-	-	-
SF13	7	1,696	100%	50.5	100%	15137.6	100%	6008.2	100%	112.1	4	125	100%	17.1	100%	4.6	100%	135.9	21,466	22,304	22,304	838
SF14	324	3,291	0%		3%	838.0	0%		0%		42	1,151	0%		0%		0%		838	-	-	(838)
TOTAL	1,145	16,175		2,371		15,976		20,229		5,317	373	9,891		315		85		3,171				

1 Values here when no incremental Total N load reduction needed because these BMPs were needed to meet incremental reductions of Total P
2 Difference of zero indicates that reduction goal was met by the BMPs; Shading indicates that the incremental nutrient reduction needed to meet the Phase 1 benchmark was not met by the proposed BMPs; negative value indicates additional BMP reductions at a station were proposed to offset not meeting required reductions at an upstream or downstream station (or required to meet Total P reductions)

Table 44
Calculated Total P Load Reductions per Subwatershed from Each Evaluated BMP to Reach Phase 1 Benchmarks

	Cropland-Applied BMPs										Hay/Pasture Land-Applied BMPs								Phase 1 - Total N Reductions Needed			
			(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)			(5)	(5)	(6)	(6)	(7)	(7)				
Site ID	Area of Cropland Within 100-ft of Stream (ac)	Area of Cropland Not Within 100-ft of Stream (ac)	% of Cropland Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Buffer Grass, 35-ft Wide (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Controlled Drainage (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Nutrient Mgmt (lb/yr)	% of Cropland Within 100-ft of Stream that BMP is applied (lb/yr)	Reduction from Streambank Stab. and Fencing (lb/yr)	Area of Hay/ Pasture Land Within 100-ft of Stream (ac)	Area of Hay/ Pasture Land Not Within 100-ft of Stream (ac)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Stream-bank Stab. and Fencing (lb/yr)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Livestock Exclusion (lb/yr)	% of Hay/ Pasture Land Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Hay/ Pasture Renovation (lb/yr)	Calculated Total N Reductions from All BMPs (lb/yr)[1]	Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark–Calculated Total N Reducions from All BMPs (lb/yr)[2]
SF01	0	0	0%		0%		0%		0%		4	97	0%		0%		0%		-	-	-	-
SF02	26	200	0%		0%		0%		0%		80	956	0%		0%		0%		-	-	-	-
SF03	0	10	0%		0%		0%		0%		3	47	0%		0%		0%		-	-	-	-
SF04	64	411	0%		0%		0%		0%		25	187	0%		0%		0%		-	-	-	-
SF05	43	333	35%	3.3	0%		39%	29.1	35%	5.6	20	360	35%	0.5	35%	0.2	35%	1.9	41	-	-	(41)
SF06	33	666	0%		0%		0%		0%		64	1,204	0%		0%		0%		-	-	-	-
SF07	17	1,122	0%		0%		0%		0%		17	1,056	0%		0%		0%		-	-	-	-
SF08	56	1,158	0%		0%		0%		0%		39	705	0%		0%		0%		-	-	-	-
SF09	448	4,311	59%	57.7	0%		60%	582.0	60%	100.8	30	1,445	60%	1.4	60%	0.6	60%	13.0	755	443	443	(312)
SF10	18	1,299	100%	3.9	0%		100%	292.3	100%	6.8	41	1,802	100%	3.1	100%	1.2	100%	27.0	334	1,089	646	312
SF11	2	172	0%		0%		0%		0%		1	241	0%		0%		0%		-	366	-	-
SF12	108	1,504	0%		0%		0%		0%		4	515	0%		0%		0%		-	-	-	-
SF13	7	1,696	100%	1.4	100%	296.8	100%	381.7	100%	2.4	4	125	100%	0.3	100%	0.1	100%	1.9	685	-	-	(685)
SF14	324	3,291	0%		3%	16.4	0%		0%		42	1,151	0%		0%		0%		16	-	-	(16)
TOTAL	1,145	16,175		66		313		1,285		116	373	9,891		5		3		44				

[1] Values here when no incremental Total P load reduction needed because these BMPs were needed to meet incremental reductions of Total N
[2] Difference of zero indicates that reduction goal was met by the BMPs; Shading indicates that the incremental nutrient reduction needed to meet the Phase 1 benchmark was not met by the proposed BMPs; negative value indicates additional BMP reductions at a station were proposed to offset not meeting required reductions at an upstream or downstream station (or required to meet Total N reductions)

Table 45
Calculated Total N Load Reductions per Subwatershed from Each Evaluated BMP coReach Phase 2 Benchmarks

	Cropland-Applied BMPs										Hay/Pasture Land-Applied BMPs								Phase 1 - Total N Reductions Needed			
			(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)			(5)	(5)	(6)	(6)	(7)	(7)				
Site ID	Area of Cropland Within 100-ft of Stream (ac)	Area of Cropland Not Within 100-ft of Stream (ac)	% of Cropland Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Buffer Grass, 35-ft Wide (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Controlled Drainage (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Nutrient Mgmt (lb/yr)	% of Cropland Within 100-ft of Stream that BMP is applied (lb/yr)	Reduction from Streambank Stab. and Fencing (lb/yr)	Area of Hay/ Pasture Land Within 100-ft of Stream (ac)	Area of Hay/ Pasture Land Not Within 100-ft of Stream (ac)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Stream-bank Stab. and Fencing (lb/yr)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Livestock Exclusion (lb/yr)	% of Hay/ Pasture Land Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Hay/ Pasture Renovation (lb/yr)	Calculated Total N Reductions from All BMPs (lb/yr)[1]	Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark–Calculated Total N Reducions from All BMPs (lb/yr)[2]
SF01	0	0	0%		0%		0%	0.0	0%		4	97	0%		0%		0%		0	-	-	-
SF02	26	200	50%	102.6	0%		52%	371.0	60%	273.2	80	956	60%	215.5	60%	58.3	60%	622.9	1,643	-	-	(1,643)
SF03	0	10	0%		0%		20%	7.4	0%		3	47	20%	2.3	20%	0.6	23%	11.7	22	-	-	(22)
SF04	64	411	50%	250.3	0%		51%	742.9	60%	666.5	25	187	60%	68.2	60%	18.5	60%	121.7	1,868	-	-	(1,868)
SF05	43	333	100%	331.9	0%		100%	1,179.2	100%	736.6	20	360	100%	90.9	100%	24.6	100%	391.2	2,754	2,776	2,776	22
SF06	33	666	50%	127.5	0%		51%	1,203.0	60%	339.5	64	1,204	60%	173.5	60%	47.0	60%	784.6	2,675	-	-	(2,675)
SF07	17	1,122	100%	133.7	0%		100%	3,975.4	100%	296.7	17	1,056	100%	76.4	100%	20.7	100%	1,147.1	5,650	-	-	(5,650)
SF08	56	1,158	100%	434.6	0%		100%	4,102.4	100%	964.3	39	705	100%	173.5	100%	47.0	100%	766.0	6,488	-	-	(6,488)
SF09	448	4,311	100%	3,482.8	0%		100%	15,270.1	100%	7,728.0	30	1,445	100%	136.2	100%	36.9	100%	1,569.0	28,223	-	-	(28,223)
SF10	18	1,299	100%	139.9	0%		100%	4601.2	100%	310.5	41	1,802	100%	184.2	100%	49.8	100%	1,957.2	7,243	-	-	(7,243)
SF11	2	172	100%	13.2	0%		100%	609.4	100%	29.3	1	241	100%	2.5	100%	0.7	100%	261.3	916	-	-	(916)
SF12	108	1,504	75%	629.1	0%		72%	3,847.9	70%	1,302.9	4	515	70%	12.1	70%	3.3	70%	391.2	6,187	6,187	6,187	0
SF13	7	1,696	100%	50.5	100%	15137.6	100%	6,008.2	100%	112.1	4	125	100%	17.1	100%	4.6	100%	135.9	21,466	73,501	67,314	45,848
SF14	324	3,291	90%	2,265.5	95%	27904.1	90%	10,536.0	95%	5,306.3	42	1,151	95%	181.3	95%	49.1	90%	1,124.6	47,367	-	-	(47,367)
TOTAL	1,145	16,175		7,962		43,042		52,454		18,066	373	9,891		1,334		361		9,285				

[1] Values here when no incremental Total N load reduction needed because these BMPs were needed to meet incremental reductions of Total P
[2] Difference of zero indicates that reduction goal was met by the BMPs; Shading indicates that the incremental nutrient reduction needed to meet the Phase 1 benchmark was not met by the proposed BMPs; negative value indicates additional BMP reductions at a station were proposed to offset not meeting required reductions at an upstream or downstream station (or required to meet Total P reductions)

Table 46
Calculated Total P Load Reductions per Subwatershed from Each Evaluated BMP to Reach Phase 2 Benchmarks

	Cropland-Applied BMPs										Hay/Pasture Land-Applied BMPs								Phase 1 - Total N Reductions Needed			
			(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)			(5)	(5)	(6)	(6)	(7)	(7)				
Site ID	Area of Cropland Within 100-ft of Stream (ac)	Area of Cropland Not Within 100-ft of Stream (ac)	% of Cropland Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Buffer Grass, 35-ft Wide (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Controlled Drainage (lb/yr)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Nutrient Mgmt (lb/yr)	% of Cropland Within 100-ft of Stream that BMP is applied (lb/yr)	Reduction from Streambank Stab. and Fencing (lb/yr)	Area of Hay/ Pasture Land Within 100-ft of Stream (ac)	Area of Hay/ Pasture Land Not Within 100-ft of Stream (ac)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Stream-bank Stab. and Fencing (lb/yr)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Livestock Exclusion (lb/yr)	% of Hay/ Pasture Land Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Reduction from Hay/ Pasture Renovation (lb/yr)	Calculated Total N Reductions from All BMPs (lb/yr)[1]	Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark (lb/yr)	Incremental Reduction to Meet Benchmark–Calculated Total N Reducions from All BMPs (lb/yr)[2]
SF01	0	0	0%		0%		0%		0%		4	97	0%		0%		0%		-	-	-	-
SF02	26	200	50%	2.9	0%		52%	23.6	60%	5.9	80	956	60%	3.6	60%	1.5	60%	8.6	46	-	-	(46)
SF03	0	10	0%		0%		20%	0.5	0%		3	47	20%	0.04	20%	0.02	23%	0.2	1	-	-	(1)
SF04	64	411	50%	7.0	0%		51%	47.2	60%	14.5	25	187	60%	1.1	60%	0.5	60%	1.7	72	-	-	(72)
SF05	43	333	100%	9.3	0%		100%	74.9	100%	16.0	20	360	100%	1.5	100%	0.6	100%	5.4	108	-	-	(108)[3]
SF06	33	666	50%	3.6	0%		51%	76.4	60%	7.4	64	1,204	60%	2.9	60%	1.2	60%	10.8	102	-	-	(102)
SF07	17	1,122	100%	3.7	0%		100%	252.5	100%	6.5	17	1,056	100%	1.3	100%	0.5	100%	15.8	280	609	609	328
SF08	56	1,158	100%	12.2	0%		100%	260.6	100%	21.0	39	705	100%	2.9	100%	1.2	100%	10.6	308	245	-	(308)
SF09	448	4,311	100%	97.4	0%		100%	970.0	100%	168.0	30	1,445	100%	2.3	100%	0.9	100%	21.7	1,260	1,851	1,851	590
SF10	18	1,299	100%	3.9	0%		100%	292.3	100%	6.8	41	1,802	100%	3.1	100%	1.2	100%	27.0	334	3,101	1,250	915
SF11	2	172	100%	0.4	0%		100%	38.7	100%	0.6	1	241	100%	0.04	100%	0.02	100%	3.6	43	2,708	1,459	1,415
SF12	108	1,504	75%	17.6	0%		72%	244.4	70%	28.3	4	515	70%	0.2	70%	0.1	70%	5.4	296	-	-	(296)[3]
SF13	7	1,696	100%	1.4	100%	296.8	100%	381.7	100%	2.4	4	125	100%	0.3	100%	0.1	100%	1.9	685	69	69	(616)
SF14	324	3,291	90%	63.4	95%	547.2	90%	669.3	95%	115.4	42	1,151	95%	3.0	95%	1.2	90%	15.5	1,415	2,797	1,270	(145)
TOTAL	1,145	16,175		219.9		844.0		3332.1		386.9	374	9,891		22.28		9.04		128.2				

[1] Values here when no incremental Total P load reduction needed because these BMPs were needed to meet incremental reductions of Total N
[2] Difference of zero indicates that reduction goal was met by the BMPs; Shading indicates that the incremental nutrient reduction needed to meet the Phase 1 benchmark was not met by the proposed BMPs; negative value indicates additional BMP reductions at a station were proposed to offset not meeting required reductions at an upstream or downstream station (or required to meet Total N reductions)
[3] Note the Total P reductions for the proposed BMPs at this station somewhat exceeds the measured Total annual P load at this station, but these BMPs are needed for adequate Total N reduction in this subwatershed

4. Sediment Best Management Practices

As described in previous chapters, locations of severe streambank erosion were identified visually to target best management practices at locations with high potential to contribute sediment to streams (as an alternative to a concentration-based target for sediment). The location and severity of severe bank erosion in the watershed are summarized in **Table 18**, page 37, and illustrated on **Exhibit 18** (Appendix A). The reaches of stream included were given a priority rating; **Table 47** indicates the linear feet of medium and high priority stream within each subwatershed that should be addressed for stabilization to reduce the potential for streambank erosion (and thus sediment load to streams).

Table 47
Priority Stream Reaches for Reducing Streambank Erosion per Subwatershed (from Severe Erosion Study)

	Approx. Length of Eroding Stream (ft)	
Site ID	Medium Priority	High Priority
SF02	1,000	1,010
SF09	550	
SF10	6,000	2,000
SF12		5,000
SF13		2,000
SF14	900	6,500
TOTAL	8,450	16,510

The Watershed Coordinator will work in conjunction with relevant parties to implement specific stream and riparian BMPs identified in the separate BMP Implementation Plan document; these BMPs may include stream crossing protection, stream bank stabilization / protection, riparian buffer creation / enhancement / protection, and stream restoration with natural channel design. Relevant responsible parties may include the LRWQC, District conservationist for USDA-NRCS, US Fish and Wildlife Service, Kentucky Department of Fish and Wildlife Resources, and Cumberland River Compact. Field efforts shall identify where these locations overlap with sites where streambank stabilization and fencing BMPs are proposed to achieve *E. coli* and/or nutrient reduction goals. As part of this process, the Watershed Coordinator can also work in conjunction with responsible parties and others to identify healthy riparian zones and execute conservation easements to protect those areas.

Per the USGS sediment fingerprinting study, cropland and pasture land also seasonally contribute sediment load to streams within the watershed. Many of the BMPs proposed for *E. coli* and nutrient treatment will also reduce sediment in the streams. Additionally, by reducing other pollutant contributions through the implementation of site-specific best management practices, it is probable that exceedances of the stream Conductivity benchmark will likewise be reduced.

5. Trash and Debris Best Management Practices

Trash and debris blockages on South Fork Little River and tributaries shall be targeted for identification and removal. The extent of this effort has not been quantified for this watershed-based plan. The Watershed Coordinator, with technical assistance from LRWQC and Hopkinsville Surface and Stormwater Utility, shall develop and implement specific BMPs identified in the separate BMP Implementation Plan document. Generally, the Watershed Coordinator will work in conjunction with responsible parties and others to identify areas with large trash and debris accumulations in need of removal; this may be performed on an annual basis. The Hopkinsville Surface and Stormwater Utility, who performs Little River flyovers for identifying log jams for removal, will be a relevant partner.

The Watershed Coordinator will work with relevant parties and other volunteer groups willing to participate to organize and schedule cleanup events and determine how materials will be disposed. Relevant responsible parties may include the LRWQC and Hopkinsville Surface and Stormwater Utility. Local businesses may be willing to sponsor cleanup events and pay for supplies / refreshments in return for publication in local media. Each event should be coordinated so that appropriate equipment is available for the site conditions. The Watershed Coordinator will document each event and publicize the results. Removal of woody debris from streams should be supervised by ecologists or water quality professionals to ensure that stream bed material is not disturbed. Large debris may be used for stabilization in other areas if feasible or appropriate.

6. Education and Outreach

Continued delivery of education and outreach resources to watershed stakeholders is critical for the successful implementation of the watershed-based plan. The Watershed Coordinator, in conjunction with other relevant parties, will work to implement this watershed-based plan and the BMP Implementation plan. Additionally, in conjunction with these efforts, the Watershed Coordinator will develop and implement education and outreach opportunities, such as compiling educational brochures, flyers, and other media on water quality problems and solutions for distribution to public at community roundtables, events, field days, and targeted workshops. Example materials may include summaries of the watershed issues, detailed information about specific land uses and their effect on water systems, environmental tips or factoids that can be published by local papers, and factsheets on the benefits of BMPs.

The Watershed Coordinator and other parties will work with local media outlets to announce upcoming events, watershed council meetings, field days, and educational sessions. Local media will also be utilized to update the community on the progress of the project. These media outlets will include the Kentucky New Era and local radio stations. In addition, flyers promoting events will be placed at locations visible to the community. Events will also be publicized via the LRWQC Facebook and web pages.

The Watershed Coordinator will schedule and convene quarterly Technical Advisory Committee meetings for the purpose of soliciting technical support and guidance. The Watershed Coordinator will work with other parties to organize, schedule and convene bi-annual SFLR

Watershed Council meetings to promote plan components and engage the community in ongoing plan implementation and success.

The Watershed Coordinator will coordinate, schedule, and promote a field day to showcase successful implementation BMPs.

C. BMP Cost Estimates

Costs for the quantities of *E. coli* and nutrient BMPs need to achieve water quality goals, as presented in previous sections, were computed per subwatershed. **Table 48** summarizes the unit costs utilized in this effort.

Table 48
BMP Unit Costs Used for Budget Preparation

BMP	Assumed Unit Cost for Budgeting	Source
Pathogen BMP		
1. Dairy Cattle Waste Elimination	$7,500/dairy[1]	Discussions with Technical Advisors/Typical cap for Ky State Cost Share program for a relevant BMP
2. Repair / Replacement of High Risk, Failing Septic Systems	$4,000/failing septic source	Discussions with Technical Advisors
3. Residential Pest Waste Elimination	$50/residence	Discussions with Technical Advisors
4. Grazing Cattle Waste Elimination	$2/linear foot for fencing[2]	Typical fencing cost in the area; applied to % of linear ft of stream within area being treated
Nutrient BMP		
1. Buffer - Grass, 35-ft wide of Cropland	$175/ac	Lynch & Tjaden 2000; includes site preparation, seeds, planting, mowing/herbicide; applied to % of linear ft of stream within area being treated
2. Controlled Drainage of Cropland	$275/ac	Tyndall & Bowman 2016; includes design, structures, installation
3. Nutrient Management of Cropland	$10/ac	Virginia DCR; includes writing/revising nutrient management plan and nutrient management through soil testing and sidedressing certain nutrient applications
4. Streambank Stabilization and Fencing within Cropland	$77/linear ft	Discussions with Technical Advisors; applied to % of linear ft of stream within area being treated
5. Streambank Stabilization and Fencing within Hay/Pasture Land	$77/linear ft	Discussions with Technical Advisors; applied to % of linear ft of stream within area being treated
6. Livestock Exclusion Fencing within Hay/Pasture Land	$2/linear foot for fencing [1]	Typical fencing cost in the area; does not include any other costs that might be associated with livestock exclusion, such as stream crossings or alternative watering sources; applied to % of linear ft of stream within area being treated

Table 48
BMP Unit Costs Used for Budget Preparation *Cont.*

BMP	Assumed Unit Cost for Budgeting	Source
7. Hay/Pasture Land Renovation	$215/ac	Barnhart and Duffy 2012; represents an average value for various renovation types

[1] This assumes that BMP(s) applied to each dairy will treat the number of dairy animals required to meet water quality targets
[2] When not already applied to total length of known stream within 100 ft stream buffer of hay/pasture for nutrient reduction

The unit costs, above, coupled with the quantification of required BMPs, were used to produce estimates of the total costs to achieve water quality goals per subwatershed, both for Phase 1 and **Phase 2 nutrient goals. The cost estimate for achieving Phase 1 pathogen and nutrient goals** compared to the higher cost of meeting the Phase 2 goals is summarized in **Table 49**. In total, the estimated cost of remediation of the pathogen and nutrient impairments of in the entire SFLR watershed is $5.83 million to reach the first phase water quality goals based on the data currently available and analyzed by this watershed planning effort. Actual costs may be greater or less than this predicted cost, but this is a valuable starting point for allocating funds for the remediation efforts.

Detailed costs per BMP for each subwatershed are included in subsequent tables (**Table 50**, page 92; **Table 51**, page 93; **Table 52**, page 94; and **Table 53**, page 95).

Table 49
Estimate of Total BMP Costs for Achieving Phase 1 & 2 Water Quality Goals

BMPs	Phase 1 Water Quality Goals	Phase 2 Water Quality Goals
Pathogens	$ 588,467	$ 476,550
Nutrients	$ 5,246,470	$ 17,636,911
TOTAL	$ 5,834,937	$ 18,113,461

Table 50
BMP Costs for Achieving Phase 1 Water Quality Goals (Pathogens)

Pathogen BMPs														
	Proposed Dairy Cattle Reductions			Proposed Failing Septic Reductions (within 500 ft of Stream / Sinkhole)			Proposed Residential Pet Waste Reductions			Proposed Grazing Cattle Reductions				
Site ID	# Dairy Licenses	% of Dairy Cattle with Waste Eliminated	Cost Estimate for Eliminating Dairy Cattle Sources ($)	No. of Failing Septic Sources	% of Failing Septic Sources Eliminated	Cost Estimate for Repair/ Replacement of Failing Septic Sources ($)	No. of Residences	% of Residences with Pet Waste Eliminated	Cost Estimate for Elimination of Residential Pet Sources ($)	Length of Stream Within 100 ft of Stream Buffer of Hay/Pasture (ft)	No. of Grazing Cattle / Calves	% of Grazing Cattle / Calves with Waste Eliminated	Cost Estimate for Elimination of Grazing Cattle Animal Sources ($)[1]	Total Cost Estimate
SF01		-	$ -	-	-	$ -	3	0%	$ -	501	14	0%	$ -	$ -
SF02	5	20%	$ 37,500	1	100%	$ 4,000	65	0%	$ -	15,952	142	18.5%	$ 31,904	$ 73,404
SF03		-	$ -	1	100%	$ 4,000	18	0%	$ -	333	7	0%	$ -	$ 4,000
SF04	1	4%	$ 7,500	1	100%	$ 4,000	14	0%	$ -	5,518	29	4.2%	$ 11,036	$ 22,536
SF05	4	0%	$ -	1	0%	$ -	28	0%	$ -	4,431	52	0%	$ -	$ -
SF06	1	25%	$ 7,500	1	100%	$ 4,000	59	0%	$ -	13,706	174	23%	$ 27,412	$ 38,912
SF07	1	100%	$ 7,500	2	100%	$ 8,000	105	100%	$ 5,250	2,490	147	100%	$ 4,979	$ 25,729
SF08		-	$ -	1	100%	$ 4,000	49	100%	$ 2,450	8,143	102	100%	$ 16,286	$ 22,736
SF09	6	100%	$ 45,000	2	100%	$ 8,000	226	100%	$ 11,300	5,347	202	100%	$ -	$ 64,300
SF10		-	$ -	3	100%	$ 12,000	2,814	100%	$ 140,700	6,915	252	100%	$ -	$ 152,700
SF11		-	$ -	-	-	$ -	1,633	100%	$ 81,650	56	33	100%	$ 112	$ 81,762
SF12			$ -	1	100%	$ 4,000	42	100%	$ 2,100	982	71	100%	$ 1,965	$ 8,065
SF13	2	100%	$ 15,000	1	100%	$ 4,000	64	100%	$ 3,200	1,097	18	100%	$ -	$ 22,200
SF14		-	$ -	5	100%	$ 20,000	678	100%	$ 33,900	9,111	163	100%	$ 18,223	$ 72,123
TOTAL			$ 120,000			$ 76,000			$ 280,550		1406		$ 111,917	$ 588,467

[1]Fencing costs not included here when all of stream length estimated within 100 ft buffer of hay/pasture already trested with BMP for nutrient reductions

Table 51
BMP Costs for Achieving Phase I Water Quality Goals (Nutrients)

Nutrient BMPs																				
	Cropland-Applied BMPs										Hay/Pasture Land-Applied BMPs									
			(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)				(5)	(5)	(6)	(6)	(7)	(7)	
Site ID	Area of Cropland Not Within 100-ft of Stream (ac)	Length of Stream Within 100 ft of Stream Buffer for Cultivated Cropland (ft)	% of Cropland Within 100 ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Buffer – Grass, 35-ft Wide ($)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Controlled Drainage ($)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Nutrient Mgmt ($)	% of Cropland Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Stream-bank Stab. & Fencing ($)	Area of Hay/ Pasture Land Within 100-ft of Stream (ac)	Area of Hay/ Pasture Land Not Within 100-ft of Stream (ac)	Length of Stream Within 100 ft of Stream Buffer of Hay/Pasture (ft)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Stream-bank Stab. & Fencing ($)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Livestock Exclusion ($)	% of Hay/ Pasture Land Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Hay/ Pasture Renovation (lb/yr)	Total Cost Estimate
SF01	0	0	0%	$ -	0%	$ -	0%	$ -	0%	$ -	4	97	501	0%	$ -	0%	$ -	0%	$ -	$ -
SF02	200	3,749	0%	$ -	0%	$ -	0%	$ -	0%	$ -	80	956	15,952	0%	$ -	0%	$ -	0%	$ -	$ -
SF03	10	0	0%	$ -	0%	$ -	0%	$ -	0%	$ -	3	47	333	0%	$ -	0%	$ -	0%	$ -	$ -
SF04	411	7,119	0%	$ -	0%	$ -	0%	$ -	0%	$ -	25	187	5,518	0%	$ -	0%	$ -	0%	$ -	$ -
SF05	333	3,706	35%	$ 182	0%	$ 32,043	39%	$ 1,292	35%	$ 99,877	20	360	4,431	35%	$119,411	35%	$ 3,102	35%	$ 27,108	$ 283,015
SF06	666	4,785	0%	$ -	0%	$ -	0%	$ -	0%	$ -	64	1,204	13,706	0%	$ -	0%	$ -	0%	$ -	$ -
SF07	1,122	3,684	0%	$ -	0%	$ -	0%	$ -	0%	$ -	17	1,056	2,490	0%	$ -	0%	$ -	0%	$ -	$ -
SF08	1,158	7,876	0%	$ -	0%	$ -	0%	$ -	0%	$ -	39	705	8,143	0%	$ -	0%	$ -	0%	$ -	$ -
SF09	4,311	34,601	59%	$ 2,883	0%	$ 702,643	60%	$ 25,867	60%	$1,598,585	30	1,445	5,347	60%	$247,035	60%	$ 6,416	60%	$ 186,375	$2,769,805
SF10	1,299	2,353	100%	$ 33	0%	$ 357,237	100%	$ 12,990	100%	$ 181,166	41	1,802	6,915	100%	$532,483	100%	$13,831	100%	$ 387,478	$1,485,516
SF11	172	401	0%	$ -	0%	$ -	0%	$ -	0%	$ -	1	241	56	0%	$ -	0%	$ -	0%	$ -	$ -
SF12	1,504	7,175	0%	$ -	0%	$ -	0%	$ -	0%	$ -	4	515	982	0%	$ -	0%	$ -	0%	$ -	$ -
SF13	1,696	1,441	100%	$ 203	100%	$ 466,478	100%	$ 16,963	100%	$ 110,934	4	125	1,097	100%	$ 84,453	100%	$ 2,194	100%	$ 26,910	$ 708,134
SF14	3,291	22,274	0%	$ -	3%	$ -	0%	$ -	0%	$ -	42	1,151	9,111	0%	$ -	0%	$ -	0%	$ -	$ -
TOTAL	16,175			$ 3,599		$ 1,558,401		$ 57,113		$1,990,561	373	9,891			$983,382		$ 25,542		$ 627,871	$ 5,246,470

Table 52
BMP Costs for Achieving Phase 2 Water Quality Goals (Pathogens)

Pathogen BMPs														
	Proposed Dairy Cattle Reductions			Proposed Failing Septic Reductions (within 500 ft of Stream / Sinkhole)			Proposed Residential Pet Waste Reductions			Proposed Grazing Cattle Reductions				
Site ID	# Dairy Licenses	% of Dairy Cattle with Waste Eliminated	Cost Estimate for Eliminating Dairy Cattle Sources ($)	No. of Failing Septic Sources	% of Failing Septic Sources Eliminated	Cost Estimate for Repair/ Replacement of Failing Septic Sources ($)	No. of Residences	% of Residences with Pet Waste Eliminated	Cost Estimate for Elimination of Residential Pet Sources ($)	Length of Stream Within 100 ft of Stream Buffer of Hay/Pasture (ft)	No. of Grazing Cattle / Calves	% of Grazing Cattle / Calves with Waste Eliminated	Cost Estimate for Elimination of Grazing Cattle Animal Sources ($)[1]	Total Cost Estimate
SF01		-	$ -	-	-	$ -	3	0%	$ -	501	14	0%	$ -	$ -
SF02	5	20%	$ 37,500	1	100%	$ 4,000	65	0%	$ -	15,952	142	18.5%	$ -	$ 41,500
SF03		-	$ -	1	100%	$ 4,000	18	0%	$ -	333	7	0%	$ -	$ 4,000
SF04	1	4%	$ 7,500	1	100%	$ 4,000	14	0%	$ -	5,518	29	4.2%	$ -	$ 11,500
SF05	4	0%	$ -	1	0%	$ -	28	0%	$ -	4,431	52	0%	$ -	$ -
SF06	1	25%	$ 7,500	1	100%	$ 4,000	59	0%	$ -	13,706	174	23%	$ -	$ 11,500
SF07	1	100%	$ 7,500	2	100%	$ 8,000	105	100%	$ 5,250	2,490	147	100%	$ -	$ 20,750
SF08		-	$ -	1	100%	$ 4,000	49	100%	$ 2,450	8,143	102	100%	$ -	$ 6,450
SF09	6	100%	$ 45,000	2	100%	$ 8,000	226	100%	$ 11,300	5,347	202	100%	$ -	$ 64,300
SF10		-	$ -	3	100%	$ 12,000	2,814	100%	$ 140,700	6,915	252	100%	$ -	$ 152,700
SF11		-	$ -	-	-	$ -	1,633	100%	$ 81,650	56	33	100%	$ -	$ 81,650
SF12			$ -	1	100%	$ 4,000	42	100%	$ 2,100	982	71	100%	$ -	$ 6,100
SF13	2	100%	$ 15,000	1	100%	$ 4,000	64	100%	$ 3,200	1,097	18	100%	$ -	$ 22,200
SF14		-	$ -	5	100%	$ 20,000	678	100%	$ 33,900	9,111	163	100%	$ -	$ 53,900
TOTAL			$ 120,000			$ 76,000			$ 280,550		1406		$ -	$ 476,550

[1]Fencing costs not included here when all of stream length estimated within 100 ft buffer of hay/pasture already trested with BMP for nutrient reductions

Table 53
BMP Costs for Achieving Phase 2 Water Quality Goals (Nutrients)

	Nutrient BMPs																					
	Cropland-Applied BMPs										Hay/Pasture Land-Applied BMPs											
			(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)				(5)	(5)	(6)	(6)	(7)	(7)	
Site ID	Area of Cropland Not Within 100-ft of Stream (ac)	Length of Stream Within 100 ft of Stream Buffer for Cultivated Cropland (ft)	% of Cropland Within 100 ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Buffer – Grass, 35-ft Wide ($)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Controlled Drainage ($)	% of Cropland Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Nutrient Mgmt ($)	% of Cropland Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Stream-bank Stab. & Fencing ($)	Area of Hay/ Pasture Land Within 100-ft of Stream (ac)	Area of Hay/ Pasture Land Not Within 100-ft of Stream (ac)	Length of Stream Within 100 ft of Stream Buffer of Hay/Pasture (ft)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Stream-bank Stab. & Fencing ($)	% of Hay/ Pasture Land Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Livestock Exclusion ($)	% of Hay/ Pasture Land Not Within 100-ft of Stream that BMP is Applied (lb/yr)	Cost Estimate for Hay/ Pasture Renovation (lb/yr)	Total Cost Estimate
SF01	0	0	0%	$ -	0%	$ -	0%	$ -	0%	$ -	4	97	501	0%	$ -	0%	$ -	0%	$ -	$ -
SF02	200	3,749	50%	$ 264	0%	$ 27,481	52%	$ 1,047	60%	$ 173,213	80	956	15,952	60%	$ 736,981	60%	$ 19,142	60%	$ 123,311	$ 1,081,440
SF03	10	0	0%	$ -	0%	$ -	20%	$ 21	0%	$ -	3	47	333	20%	$ 5,133	20%	$ 133	23%	$ 2,313	$ 7,601
SF04	411	7,119	50%	$ 501	0%	$ 56,549	51%	$ 2,097	60%	$ 328,907	25	187	5,518	60%	$ 254,931	60%	$ 6,622	60%	$ 24,101	$ 673,707
SF05	333	3,706	100%	$ 521	0%	$ 91,551	100%	$ 3,329	100%	$ 285,362	20	360	4,431	100%	$ 341,175	100%	$ 8,862	100%	$ 77,452	$ 808,252
SF06	666	4,785	50%	$ 336	0%	$ 91,572	51%	$ 3,396	60%	$ 221,072	64	1,204	13,706	60%	$ 633,229	60%	$ 16,447	60%	$ 155,340	$ 1,121,392
SF07	1,122	3,684	100%	$ 518	0%	$ 308,651	100%	$ 11,224	100%	$ 283,653	17	1,056	2,490	100%	$ 191,701	100%	$ 4,979	100%	$ 227,097	$ 1,027,823
SF08	1,158	7,876	100%	$ 1,107	0%	$ 318,510	100%	$ 11,582	100%	$ 606,460	39	705	8,143	100%	$ 627,006	100%	$ 16,286	100%	$ 151,641	$ 1,732,592
SF09	4,311	34,601	100%	$ 4,865	0%	$ 1,185,569	100%	$ 43,112	100%	$ 2,664,308	30	1,445	5,347	100%	$ 411,724	100%	$ 10,694	100%	$ 310,626	$ 4,630,898
SF10	1,299	2,353	100%	$ 331	0%	$ 357,237	100%	$ 12,990	100%	$ 181,166	41	1,802	6,915	100%	$ 532,483	100%	$ 13,831	100%	$ 387,478	$ 1,485,516
SF11	172	401	100%	$ 56	0%	$ 47,314	100%	$ 1,721	100%	$ 30,908	1	241	56	100%	$ 4,311	100%	$ 112	100%	$ 51,734	$ 136,156
SF12	1,504	7,175	75%	$ 757	0%	$ 310,240	72%	$ 10,864	70%	$ 386,754	4	515	982	70%	$ 52,948	70%	$ 1,375	70%	$ 77,457	$ 840,395
SF13	1,696	1,441	100%	$ 203	100%	$ 466,478	100%	$ 16,963	100%	$ 110,934	4	125	1,097	100%	$ 84,453	100%	$ 2,194	100%	$ 26,910	$ 708,134
SF14	3,291	22,274	90%	$ 2,819	95%	$ 814,628	90%	$ 29,746	95%	$ 1,629,372	42	1,151	9,111	95%	$ 666,494	95%	$ 17,312	90%	$ 222,633	$ 3,383,005
TOTAL	16,175			$ 12,278		$ 4,075,781		$ 148,092		$ 6,902,108	373	9,891			$4,542,571		$ 117,989		$ 1,838,093	$17,636,911

For sediment BMPs, stream stabilization and restoration efforts can cost upward of $200 per linear foot to design and construct, depending on the size of the stream and the complexity of the solution. These locations will overlap with sites where streambank stabilization and fencing BMPs are proposed; however, if repairing these areas of severe erosion was performed as an isolated effort it could cost nearly $5 million dollars or more (assuming at least $200/ft cost for addressing a total of 24,960 linear feet of eroding stream equals an estimated cost of $4,992,000).

A lump sum cost estimate was allotted for trash and debris BMPs; for planning purposes at least $2,000 per year should be allotted for the next 10 years (thus $20,000 budgeted for these efforts). Costs include trash bags and gloves for small trash and debris pickups. Chainsaws and/or large equipment rental may be necessary for large blockages. Disposal costs (trucks, landfill fees) may be required.

For education and outreach, a lump sum cost estimate was allotted for funding the Watershed Coordinator and providing additional fund for the implementation of education and outreach activities. Ideally, the Watershed Coordinator would be funded for the duration of the implementation efforts, and thus the budget reflects this idealized condition. For planning purposes at least $325,000 should be allotted for the next 10 years for these efforts (**Table 54**).

Table 54
Education and Outreach Cost Estimate

BMP	Unit Cost per Year	Number Implemented per 10-Year Timeframe	Cost Estimate for Coordinator and Education/Outreach
Watershed Coordinator	$ 45,000	10	$ 450,000
Education and Outreach	$ 2,500	10	$ 25,000
TOTAL		$ 475,000	

Costs for individual BMPs may be developed in the separate BMP Implementation Plan, as specific projects are identified; however, for long-range planning purposes, approximately $6.3 million dollars should be allocated over the next decade to implement BMPs (**Table 55**).

Table 55
Summary of Phase 1 Cost Estimate

BMPs	Estimated Cost to Implement
E. coli and Nutrients (Phase 1; rounded value)	$ 5,835,000
Sediment (Stream stabilization/restoration)	$ 5,000,000
Trash and Debris	$ 20,000
Education and Outreach	$ 475,000
TOTAL (without Sediment BMPs)	$ 6,330,000

D. Funding Sources

Successful implementation of this watershed-based plan will require significant financial resources (**Table 55**). Diverse funding sources will need to be sought for BMP implementation and resources leveraged where possible to extend the positive impacts of the acquired implementation funds. Specific funding sources for individual projects will be provided in the separate BMP Implementation Plan. Sources of funding that are applicable to this plan will be sought as appropriate; known funding resources are listed below.

1. USDA-NRCS EQIP Program

The Environmental Quality Incentive Program (EQIP) provides financial and technical assistance to agricultural producers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation or improved or created wildlife habitat. Eligible program participants that rank well can receive financial and technical assistance to implement conservation practices that address natural resource concerns on their land. Visit your local USDA Service Center to apply or visit www.nrcs.usda.gov/getstarted.

2. State Cost Share

The Kentucky Soil Erosion and Water Quality Cost Share Program and the Kentucky Soil Stewardship Program were created to help agricultural operations protect the soil and water resources of Kentucky and to implement their agriculture water quality plans. The program helps landowners address existing soil erosion, water quality and other environmental problems associated with their farming or woodland operation.

The 1994 Kentucky General Assembly established this financial and technical assistance program. Kentucky Revised Statute 146.115 establishes that funds be administered by local conservation districts and the Kentucky Soil and Water Conservation Commission with priority given to animal waste-related problems, agricultural district participants and to producers who have their Agriculture Water Quality plans on file with their local conservation districts. Funding comes from the Kentucky General Assembly through direct appropriations to the program from the Tobacco Settlement Funds and from funds provided by the Kentucky Department of Agriculture.

Practices eligible for cost share are agriculture and animal waste control facilities; streambank stabilization; animal waste utilization; vegetative filter strips; integrated crop management; pesticide containment; sinkhole protection; pasture and hay land forage quality; heavy use area protection; rotational grazing system establishment; water well protection; forest land and cropland erosion control systems; closure of agriculture waste impoundment; on-farm fallen animal composting; soil health management; precision nutrient management; strip intercropping system; livestock stream crossing and riparian area protection.

3. US EPA 319(h) Grants

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

4. FEMA Hazard Mitigation Grant

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

5. Kentucky Department of Fish and Wildlife's Stream Team Program

The Stream Team offers landowners free repairs to eroding and unstable streams and wetlands. Their task is to identify and undertake stream restoration projects statewide. The Stream Team, which includes stream restoration specialists in the Kentucky Department of Fish and Wildlife Resources (KDFWR), works with private landowners and others to identify stream restoration projects. Projects are funded from the Mitigation Fund held in trust solely for repairing streams and wetlands. No state tax general funds or hunting/fishing license dollars are used.

Landowners must meet certain criteria to qualify including a minimum of 1,000 feet of stream with unstable, eroding banks and agreement to a permanent easement typically at least 50 feet wide on each side of the restored stream. In general, both sides of the stream must be available for work, and often several landowners may be involved to provide access to both banks and appropriate protection. Typical projects are on small streams ranging in size from the smallest that may go dry in late summer downstream to those that have permanent flow. Landowner considerations may be and often are included with the projects to meet the needs of property owners. These often include the construction of fords across the stream, fencing, and access to water for livestock. More information about this program is available at http://fw.ky.gov/Fish/Pages/Stream-Team-Program.aspx.

6. Partners for Fish and Wildlife Program

The Partners for Fish & Wildlife program works with private landowners to improve fish and wildlife habitat on their lands. They are leaders in voluntary, community-based stewardship for fish and wildlife conservation. The future of the nation's fish and wildlife depends on private landowners – more than 90% of land in Kentucky is in private ownership. Providing more high-quality habitat not only helps wildlife - by contributing to a healthy landscape, you create a conservation legacy to pass on to future generations.

To accomplish this work, the Partners for Fish & Wildlife team up with private conservation organizations, state and federal agencies and tribes. Together, with the landowner, this collective share funding, materials, equipment, labor and expertise to meet both the landowner's restoration goals and their conservation mission.

7. City of Hopkinsville Stormwater Management Fund

A monthly service fee is imposed upon all real property in the City of Hopkinsville to fund stormwater management programs. Funds may be used for purposes related to managing, maintaining, and improving stormwater facilities, including water quality monitoring and programs, retrofitting developed areas for pollution control, and public education related to stormwater issues. It may be possible for projects identified or developed through this watershed-based plan to seek funding from the Hopkinsville Surface and Stormwater Utility.

VI. IMPLEMENTATION OVERSIGHT AND SUCCESS MONITORING

Upon approval of this WBP, focus will transition from planning to implementation. Oversight of implementation activities and the means and methods used to monitor and evaluate success will be key to ensuring the effective implementation of BMPs as outlined in Chapter V. This Chapter defines oversight responsibilities and describes the means and methods selected to evaluate success.

A. Organization

BMP implementation will be overseen and monitored by a Watershed Coordinator and Council as follows:

1. Watershed Coordinator

Implementing this watershed-based plan will require significant time, resources, and effort. A full-time coordinator will support the implementation of this plan. The strategic implementation strategy outlined in Chapter V was developed primarily at the programmatic, rather than site-specific, level. A separate BMP Implementation Plan is being developed to provide more specific information that will guide BMP implementation. Addressing nonpoint sources of pollution within the SFLR Watershed will require targeted outreach and program promotion by a Watershed Coordinator to be funded, at least in part, by Section 319 funds.

The SFLR Watershed Coordinator will serve as a single point of contact as the WBP is implemented. The coordinator will be responsible for working with stakeholders to identify funding opportunities, develop funding applications, administer projects, keep stakeholders engaged, and coordinate educational programming. He/she will work under the direction of the LRWQC and HSSU to implement BMPs in accordance with Chapter V and the separate BMP Implementation Plan, and track and report progress and success to the Watershed Council via monthly email updates and a bi-annual SFLR Watershed Council meetings.

2. Watershed Council

Members of the LRWQC and Technical Advisory Committee, as well as the KDOW Basin Coordinator and local stakeholders / citizens will comprise the SFLR Watershed Council. At present, it is anticipated that individuals will be invited by the Watershed Coordinator to participate in the Watershed Council based upon their affiliation with LRWQC or the WBP Technical Advisory Committee or their previous interest and/or involvement in the planning process. Those individuals and current contact information are summarized in **Appendix D**.

B. Education and Outreach

Once approved, hard copies of this plan will be made available for review by the public Monday through Friday, 8:00am until 5:00pm at the following locations:

Hopkinsville Community Development Services
710 South Main Street, Hopkinsville Kentucky

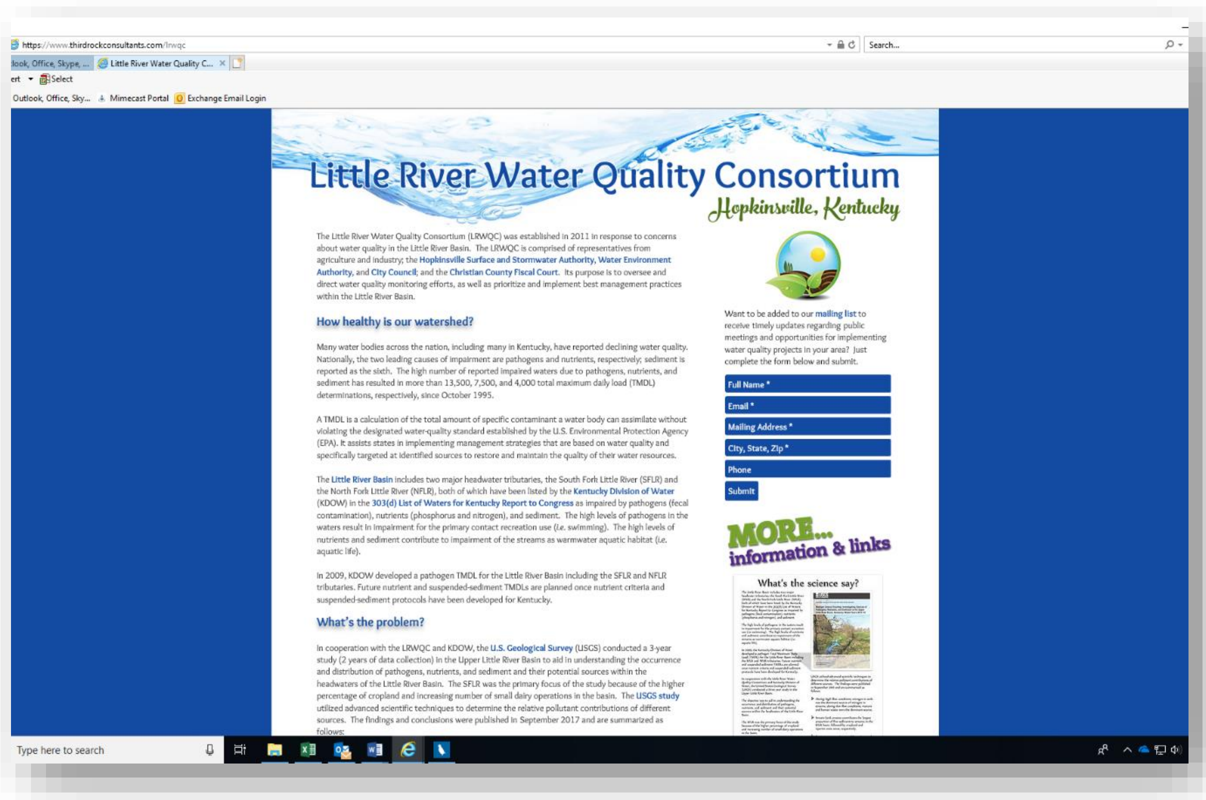
Christian County Agricultural Extension Office
2850 Pembroke Road, Hopkinsville, Kentucky

The Watershed Coordinator will be responsible for the creation and maintenance of targeted outreach and education materials; some examples follow:

1. **SFLR WBP Web Page**

Third Rock currently maintains a SFLR WBP web page that will be transferred to Watershed Coordinator for future updates and maintenance. At present, the web page is viewable at www.thirdrockconsultants.com\lrwqc.

A PDF copy of the approved WBP will be available for viewing and download from the web page. The Watershed Coordinator will also use the web page to publicize and promote the BMP implementation strategy, solicit individuals and/or business willing to implement BMPs on their property, announce Watershed Council meeting dates and locations, and provide timely and relevant updates related to implementation activity in the SFLR.



2. **SFLR WBP Educational/Promotional Pieces**

The Watershed Coordinator will update and maintain pieces previously developed by Third Rock (examples of which are included in **Appendix E**) and draft and produce supplemental pieces that showcase BMP activities once implemented. All pieces produced with 319 funds will be provided to KDOW in advance of publication for review and approval and will contain the following funding statement "*Funding provided, in part, by a grant from the U.S. Environmental Protection Agency to the Kentucky Division of Water as authorized by the Clean Water Act Amendments of 1987, Section §319(h) Nonpoint Source Implementation Grant # PPG xxxx*."

C. Schedule and Milestones

Implementing the SFLR watershed-based plan, with a focus on meeting Phase 1 water quality goals, will occur over a 10-year period. Additional time may be needed as identified through adaptive management as this plan is implemented and/or it is identified that Phase 2 water quality goals need to be achieved in order to restore healthy, functioning, sustainable conditions to streams of the SFLR watershed. The schedule and milestones associated with planned implementation were discussed and developed in coordination with the LRWQC and the Technical Advisory Committee. **Table 56, page 104,** identifies anticipated implementation milestones and schedule that can be used to track implementation progress. Milestone and schedule adjustments shall be made, if needed, to ensure that goals are met if this strategy becomes infeasible or ineffective.

D. Monitoring Success

Success will be monitored and evaluated in terms of implementation progress, load reductions achieved, education and behavior change, and water quality sampling results.

1. Tracking Implementation

The Watershed Coordinator will track BMP implementation progress over time. Both BMP-specific and programmatic data will be recorded and publicized. The identification of a responsible party(ies), funding allocated, geographic location (latitude and longitude), design and / or construction timeline(s), and photo documentation will be recorded and reported/updated for individual BMPs at least quarterly on the WBP web page. In addition, measurable, watershed-wide indicators of success such as the number of BMPs implemented/installed, length of stream stabilized/buffered, etc. will also be publicized on the web page and at each bi-annual Watershed Council meeting.

The Watershed Coordinator will track progress toward achieving the needed load reductions to meet water quality goals. In addition to the documentation indicated above for each BMP, load reductions achieved by each implemented BMP will be recorded and maintained and will serve as a tool to determine progress made toward implementing this watershed-based plan.

2. Tracking Education and Outreach

The Watershed Coordinator will maintain a record of those in attendance at all Watershed Council meetings, as well as document and publicize meeting minutes. In addition, an on-line survey will be developed and electronically distributed/promoted at the end of the first full year of plan implementation. The goal of the survey will be to solicit input from Watershed Council members and other citizens of the SFLR Watershed related to perceptions regarding implementation activities and suggestions for future implementation.

3. Water Quality Monitoring

When sufficient implementation has occurred within a given subwatershed that suggests that enough load reductions have been achieved to show an improvement in water quality, then water quality monitoring will be conducted to evaluate the effectiveness of the implementation efforts. The determination of whether enough implementation has occurred to pursue water quality monitoring shall be made using the database of estimates of overall BMP load reductions cumulated from implemented BMPs relative to the required load reductions to meet water quality goals in a given subwatershed.

Additional funding will be sought to conduct water quality monitoring, using the parameters listed in **Table 40 (Chapter V)**, to measure reductions in pathogen and nutrient concentrations. Results will be used to document progress toward meeting water quality goals or lack thereof. The most appropriate approach to monitoring will be selected based on BMPs/efforts that have been implemented. Specific sampling approach, duration, frequency, and objectives will be determined at the time monitoring is warranted.

Table 56
Schedule of Milestones

	Milestone	Expected Begin	Expected Completion
1	Hire watershed coordinator	Apr 2019	May 2019
2	Develop and/or compile educational materials	May 2019	June 2019
3	Plan and convene quarterly Technical Advisory Committee meeting	May, Aug, Nov 2019	Feb, May Aug, Nov 2029
4	Re-connect with watershed stakeholders / host educational activity	June 2019	July 2019
5	Plan and convene SFLR Watershed Council meeting, report implementation progress, 2 times per year	May and Sept 2020, 2024, 2028	May and Sept 2020, 2024, 2028
6	Plan and convene SFLR Watershed Field Day to showcase successful implementation projects	June 2020, 2024, 2028	June 2020, 2024, 2028
7	Plan / initiate dairy cattle pathogen BMPs	July 2019	Dec 2019
8	Implement dairy cattle pathogen BMPs	Jan 2020	Jan 2029
9	Plan initiate grazing cattle pathogen BMPs	July 2019	Dec 2019
10	Implement grazing cattle pathogen BMPs	Jan 2020	Jan 2029
11	Develop plan to find and prioritize failing residential septic systems	July 2019	Dec 2019
12	Implement failing septic system repairs	Jan 2020	Dec 2022
13	Develop plan to educate on proper pet waste disposal	Jan 2020	Mar 2020
14	Educate on proper pet waste disposal	April 2020	April 2021
15	Develop plan to implementation pet waste disposal stations in applicable areas	Jan 2020	Mar 2020
16	Implement plan to install pet waste disposal stations in applicable areas	April 2020	April 2021
17	Plan / initiate nutrient BMPs on crop and hay/pasture lands	July 2019	Dec 2019
18	Implement nutrient BMPs on crop and hay/pasture lands	Jan 2020	Jan 2029
19	Plan / initiate annual trash and debris clean-up effort	Jan of each year, 2020-2029	Jan of each year, 2020-2029
20	Implement annual trash and debris clean-up effort	Once each year, 2020-2029	Once each year, 2020-2029
21	Perform monitoring as indicated by tracking BMP load reductions	Apr 2024	Apr 2029
22	Revise / update watershed-based plan, if warranted	Apr 2024	June 2024
23	Revise / update watershed-based plan, if warranted	Apr 2029	June 2029

E. Evaluating and Updating the Plan

Changes in water quality are influenced by many factors and implementation efforts may take a considerable time before changes can be observed by monitoring data. Thus, sufficient time should be allowed for implementation to occur before adaptive management of project implementation or plan updates ensue.

The goals, objectives, and BMP implementation strategy included in this plan were based upon the best available information and projected needs of the community at the time of plan development. It will be the responsibility of the Watershed Coordinator and Council to revisit and supplement the SFLR WBP on or before the 5-year anniversary of plan approval, if it is warranted.

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APPENDIX A
EXHIBITS

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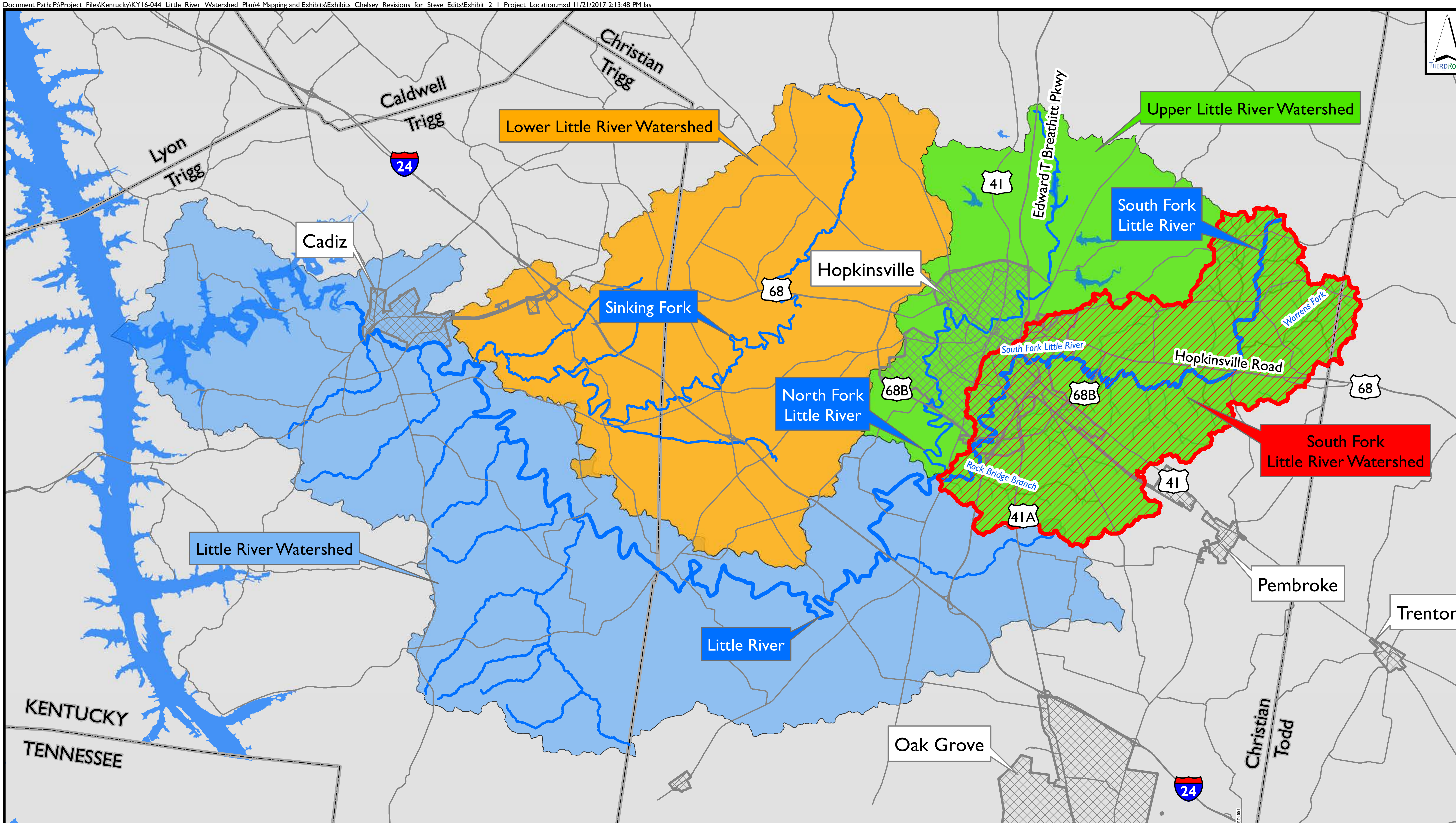

Prepared by:
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- South Fork Little River Watershed
- Lower Little River Watershed
- Upper Little River Watershed
- Little River Watershed
- County Boundary
- Incorporated Boundary
- Street
- Stream

Exhibit 1 - Project Location
South Fork of Little River Watershed Plan

0 5 10 Miles

Prepared for:
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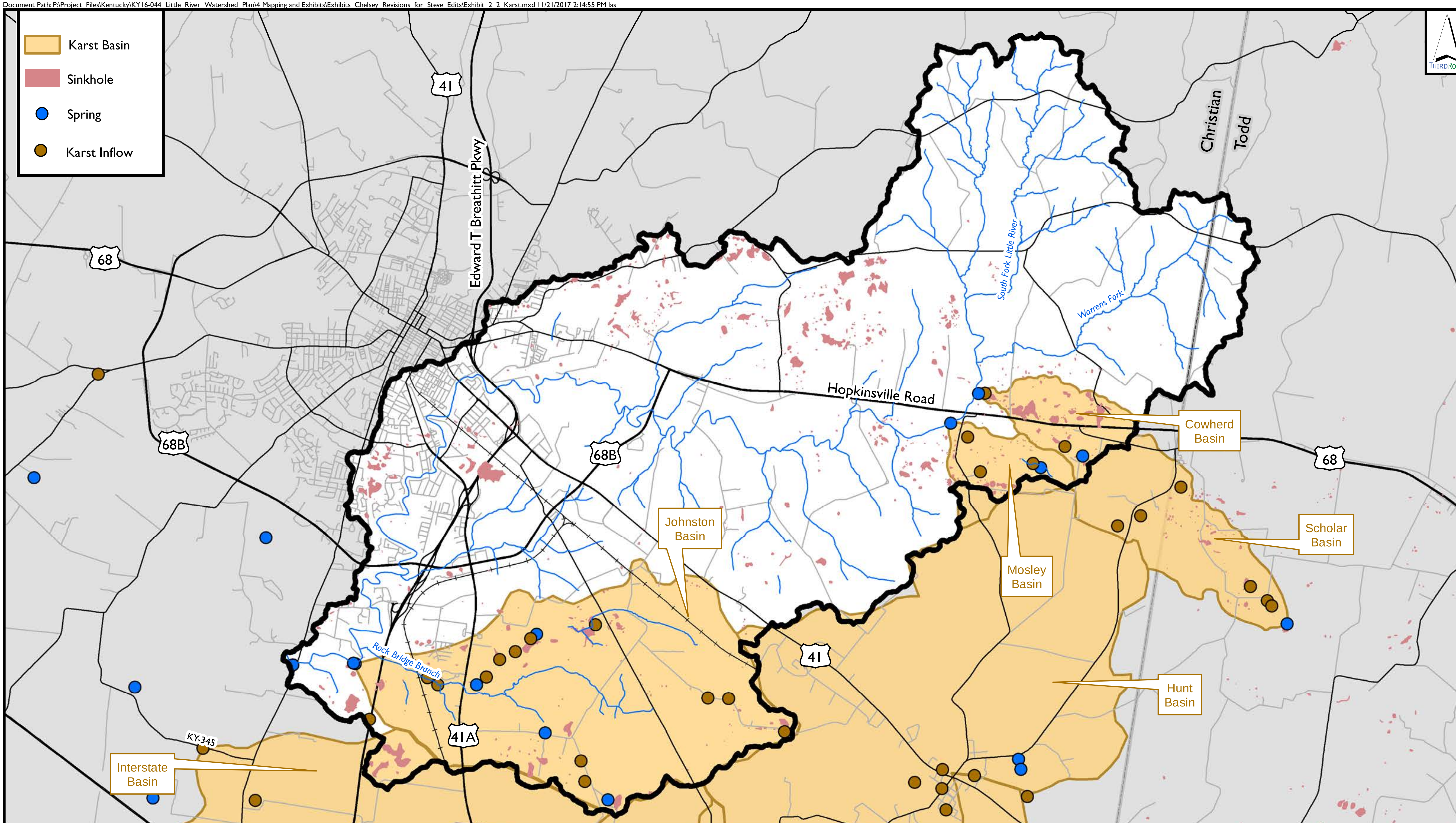
Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240



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South Fork Little River — Street
County Boundary — Railroad
Stream

Note: Karst mapping was obtained from Kentucky Geological Survey.

Exhibit 2 - Karst
South Fork of Little River Watershed Plan

0 — 2.5 — 5 Miles

Prepared for:
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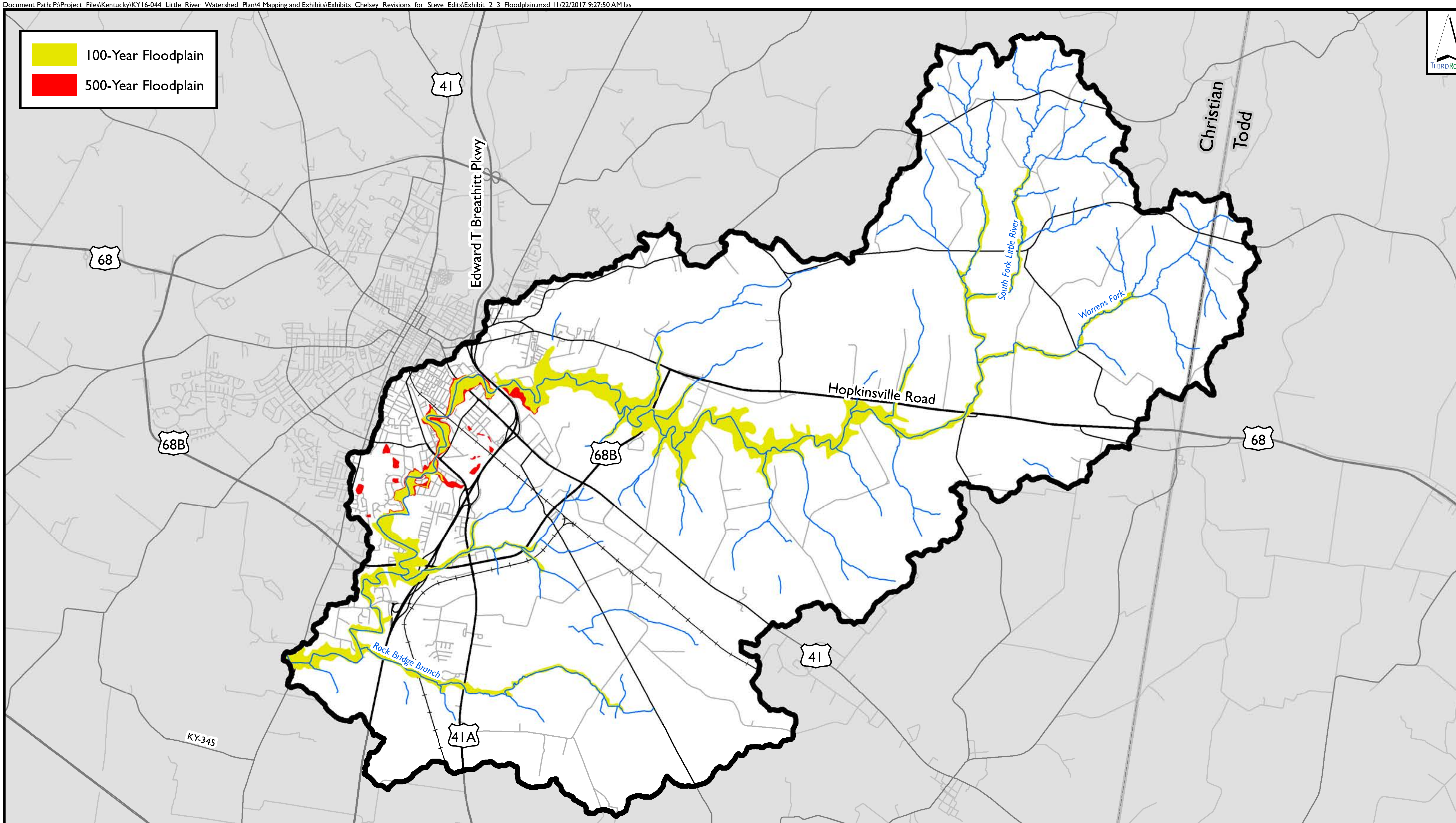
Hopkinsville, KY 42240



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South Fork Little River
County Boundary
Street
Railroads
Stream

Note: Floodplain data was obtianed from FEMA.

Exhibit 3 - Floodplain
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
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710 South Main Street
Hopkinsville, KY 42240

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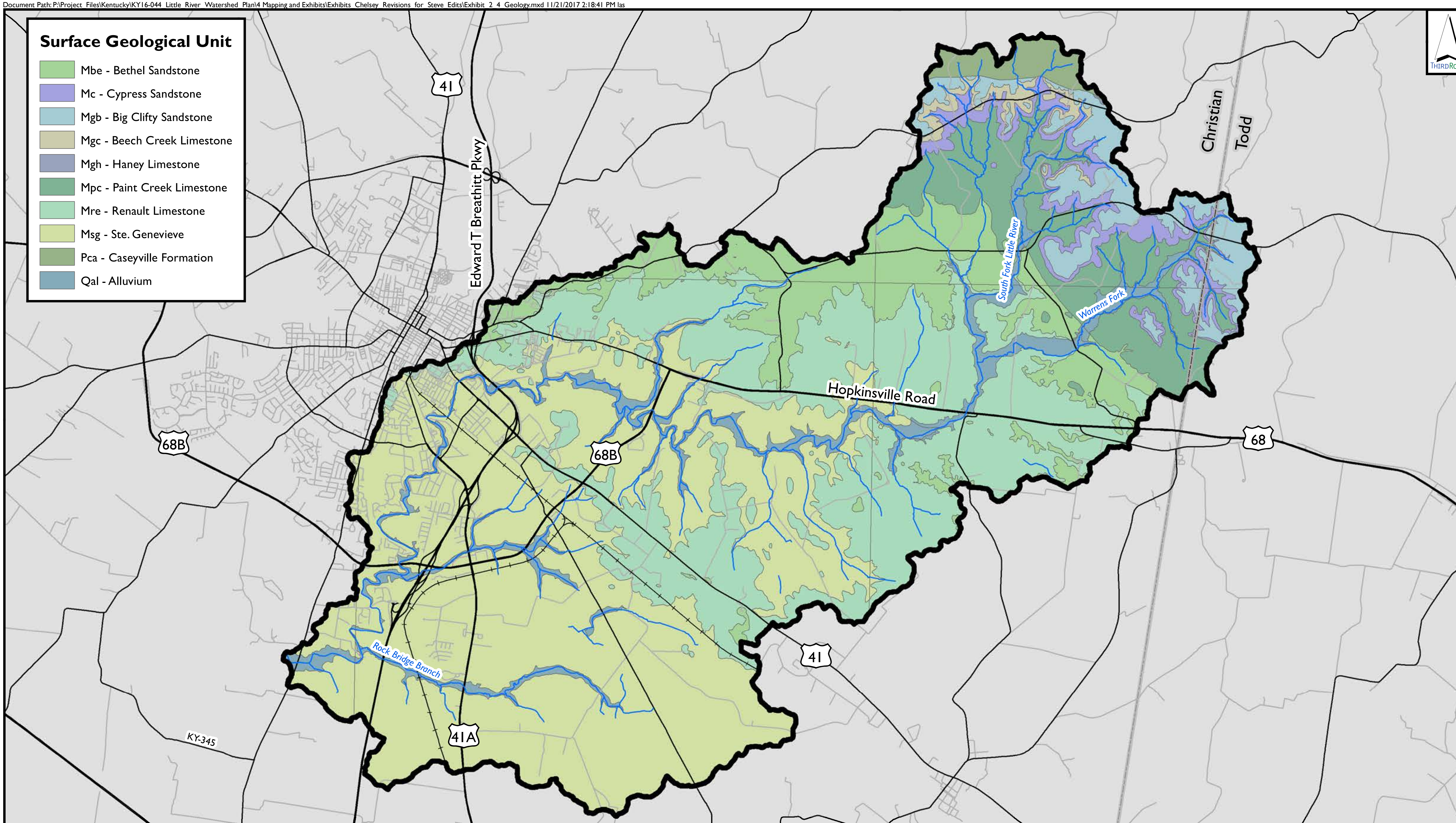

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South Fork Little River
County Boundary
Street
Railroad
Stream

Note: Geologic Shapefiles obtained from KGS.

Exhibit 4 - Geology
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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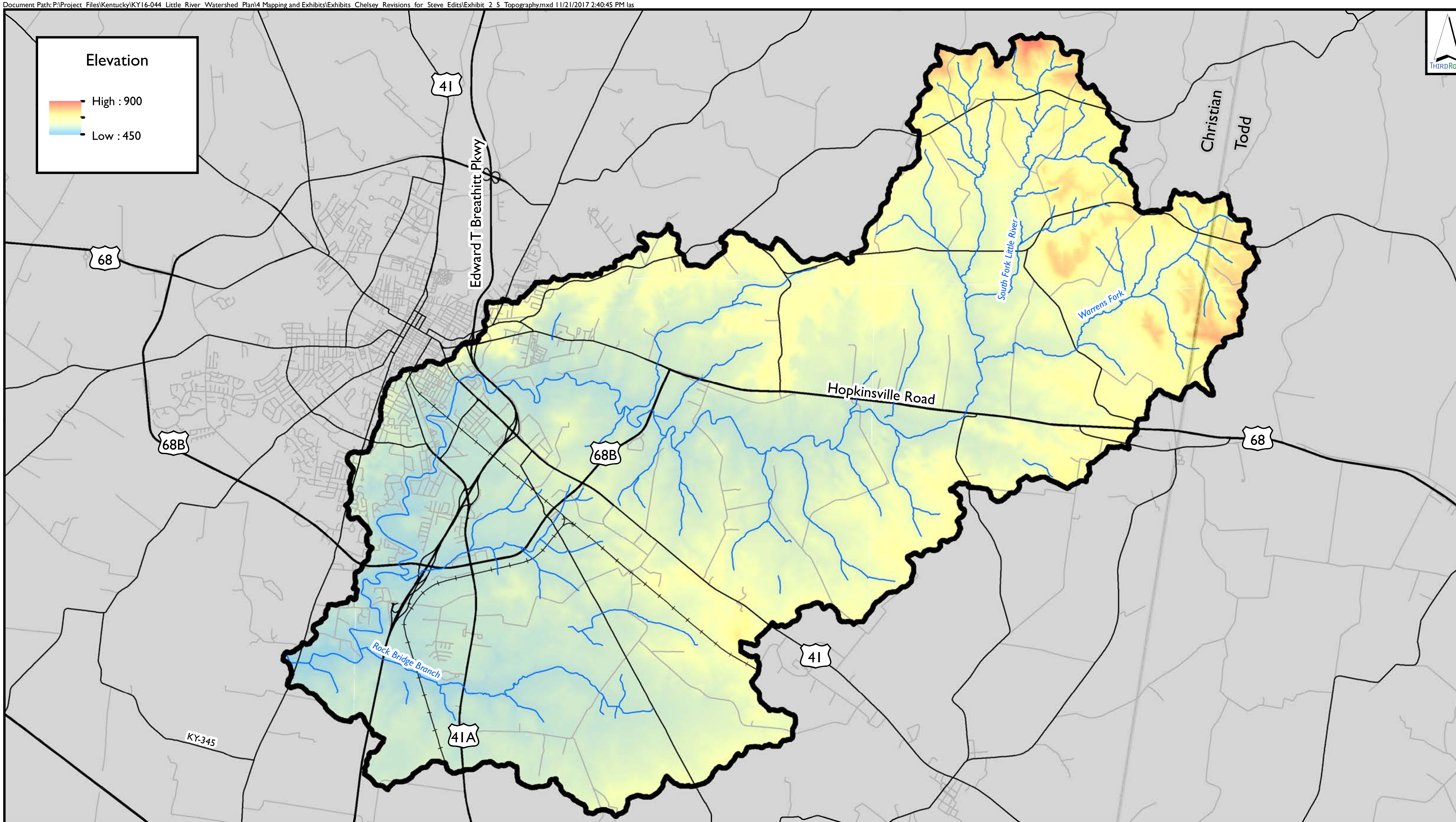

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South Fork Little River
County Boundary
Street
Railroad
Stream

Note: Elevation data was obtained from the KGS.

Exhibit 5 - Topography
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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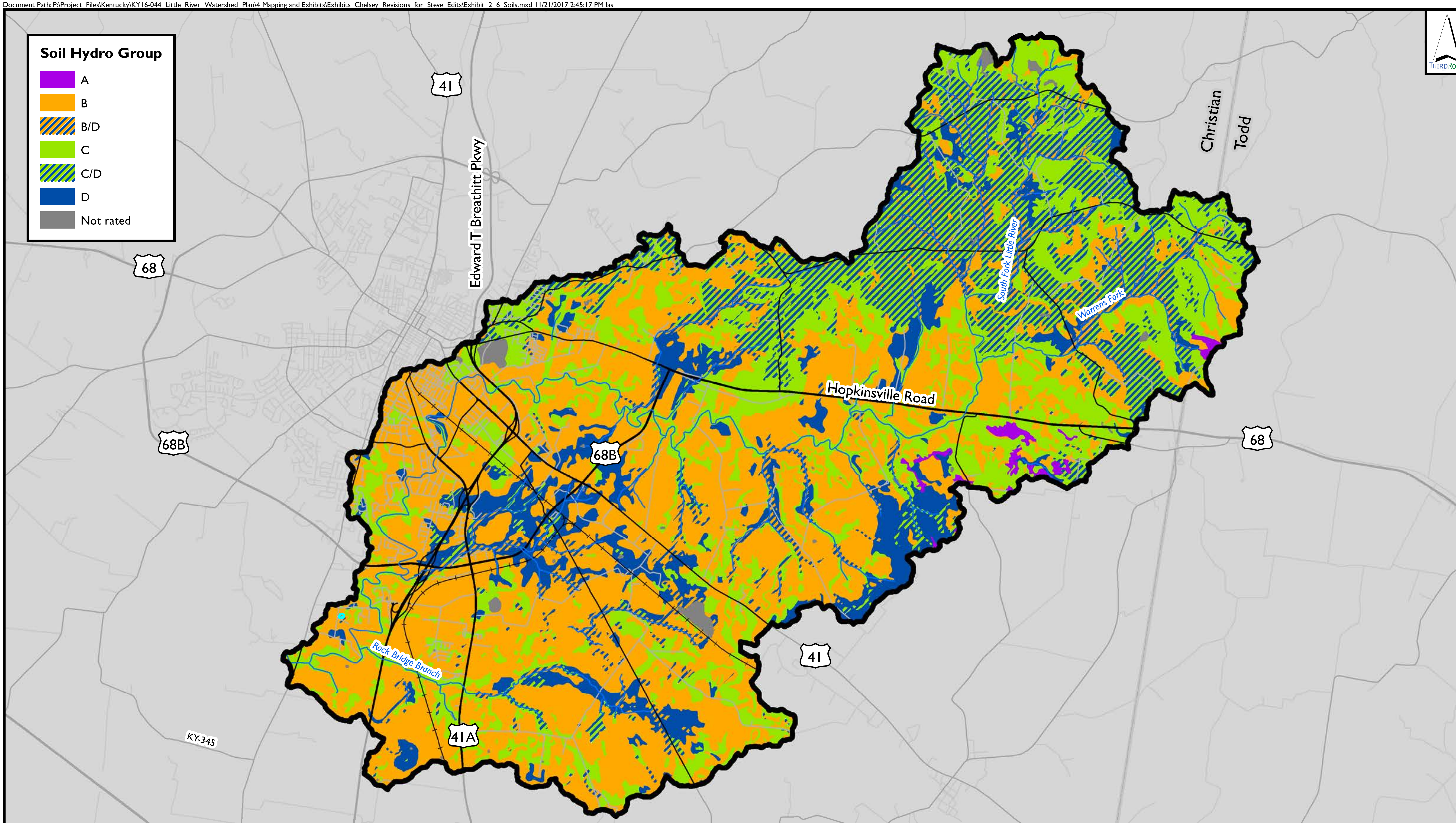

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South Fork Little River
County Boundary
Street
Railroads
Stream

Note: Soil data was obtained from the USDA/NRCS.

Exhibit 6 - Soils
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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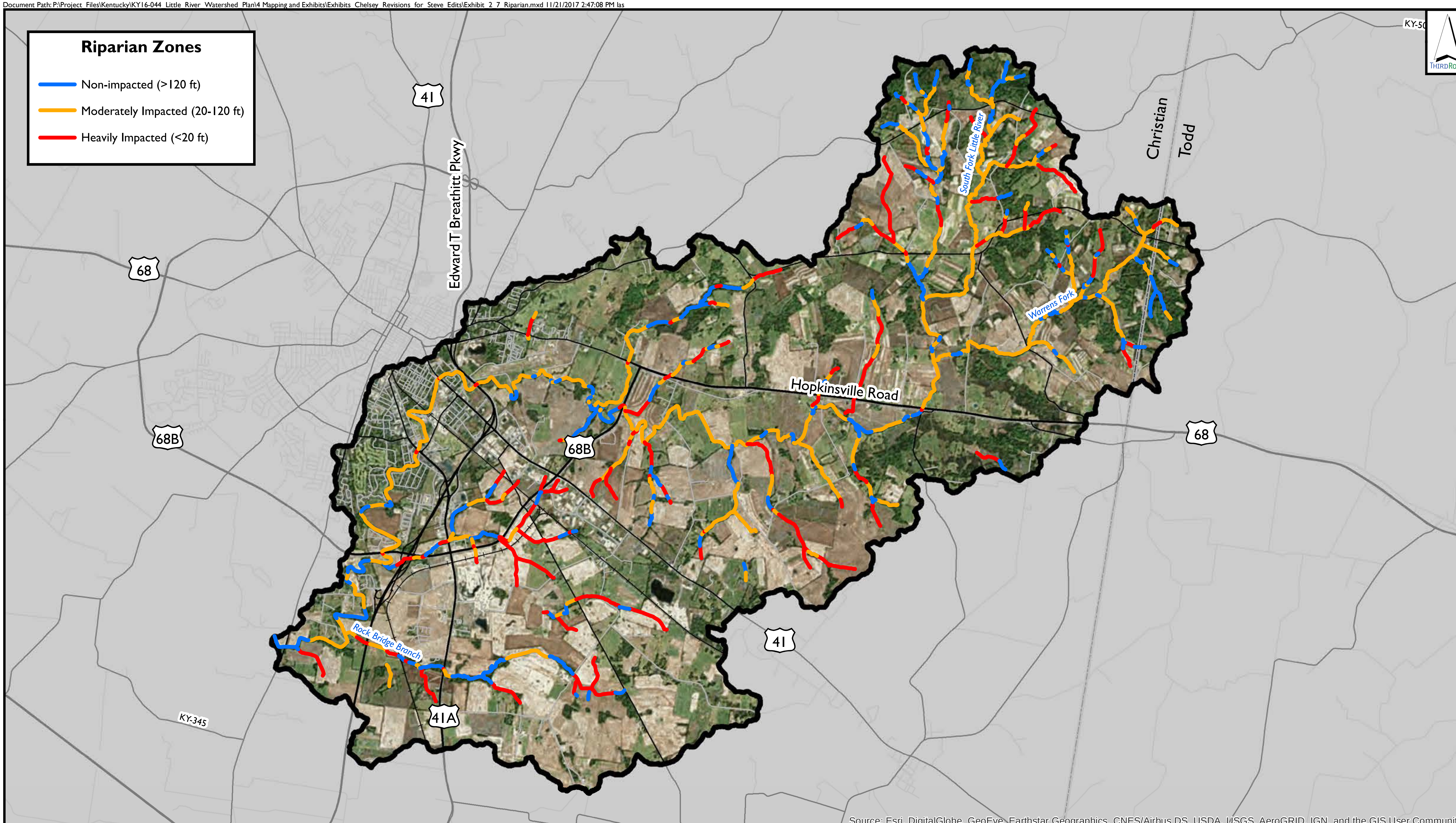

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South Fork Little River
County Boundary
Street
Railroads
Stream

Note: Soil data was obtained from the USDA/NRCS.

Exhibit 7 - Riparian
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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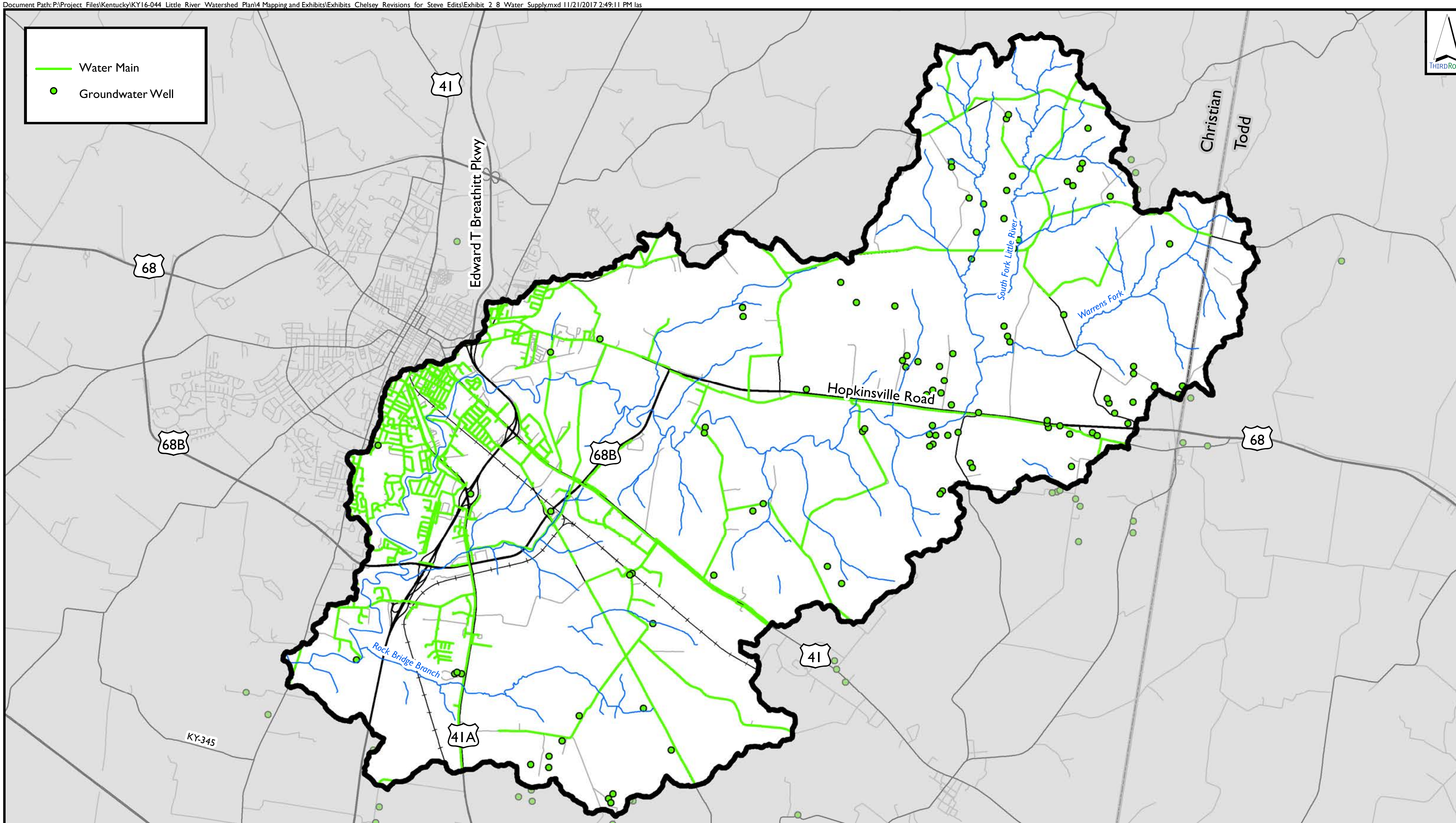


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

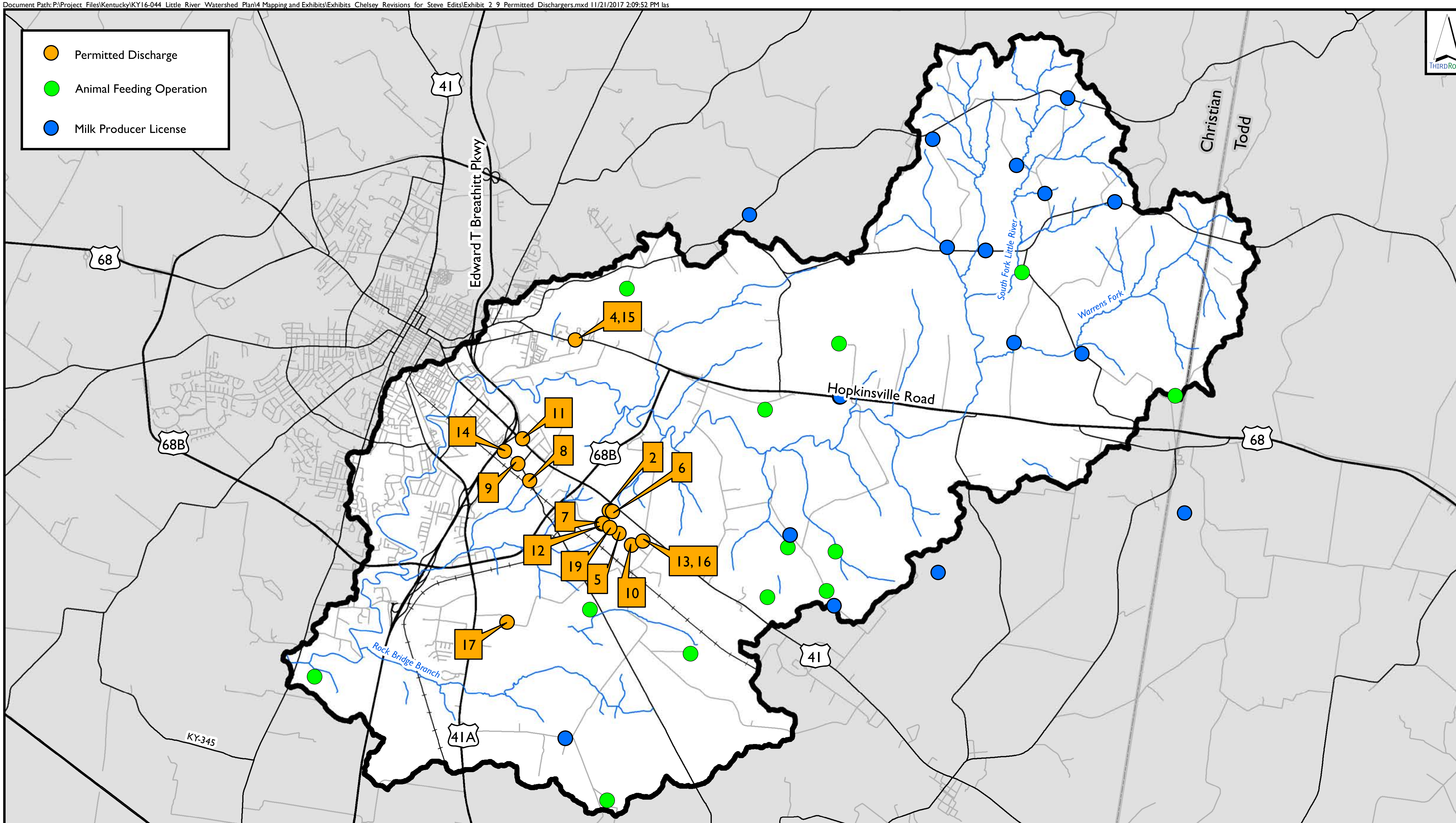
Note: Water line were obtained from HSSU. Groundwater wells from KDOW.

Exhibit 8 - Water Supply
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_9_Permitted_Dischargers.mxd 11/21/2017 2:09:52 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

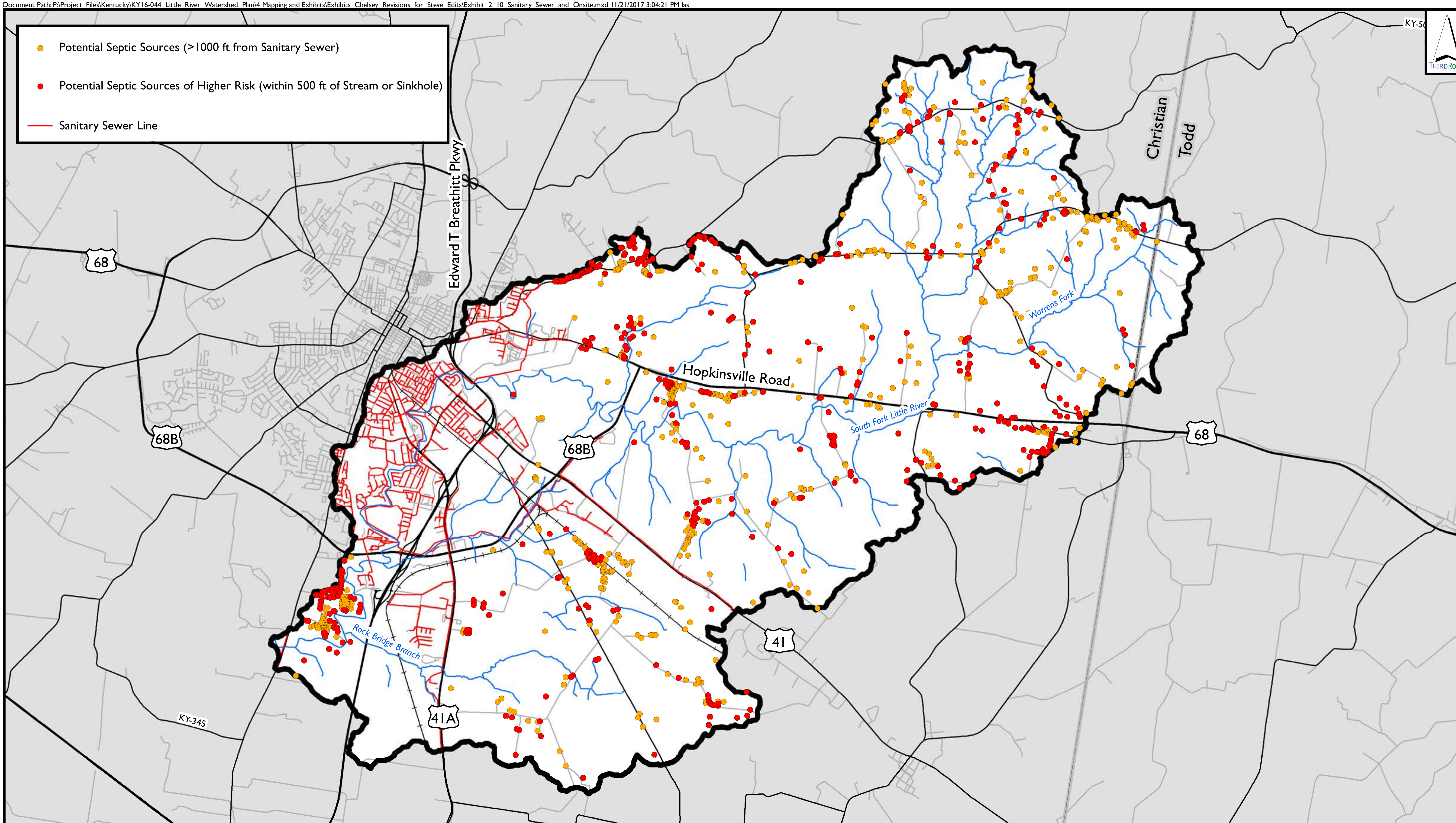
South Fork Little River
County Boundary
Street
Railroad
Stream

Exhibit 9 - Permitted Dischargers and Other Point Sources
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and
Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_10_Sanitary_Sewer_and_Onsite.mxd 11/21/2017 3:04:21 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroad
Stream

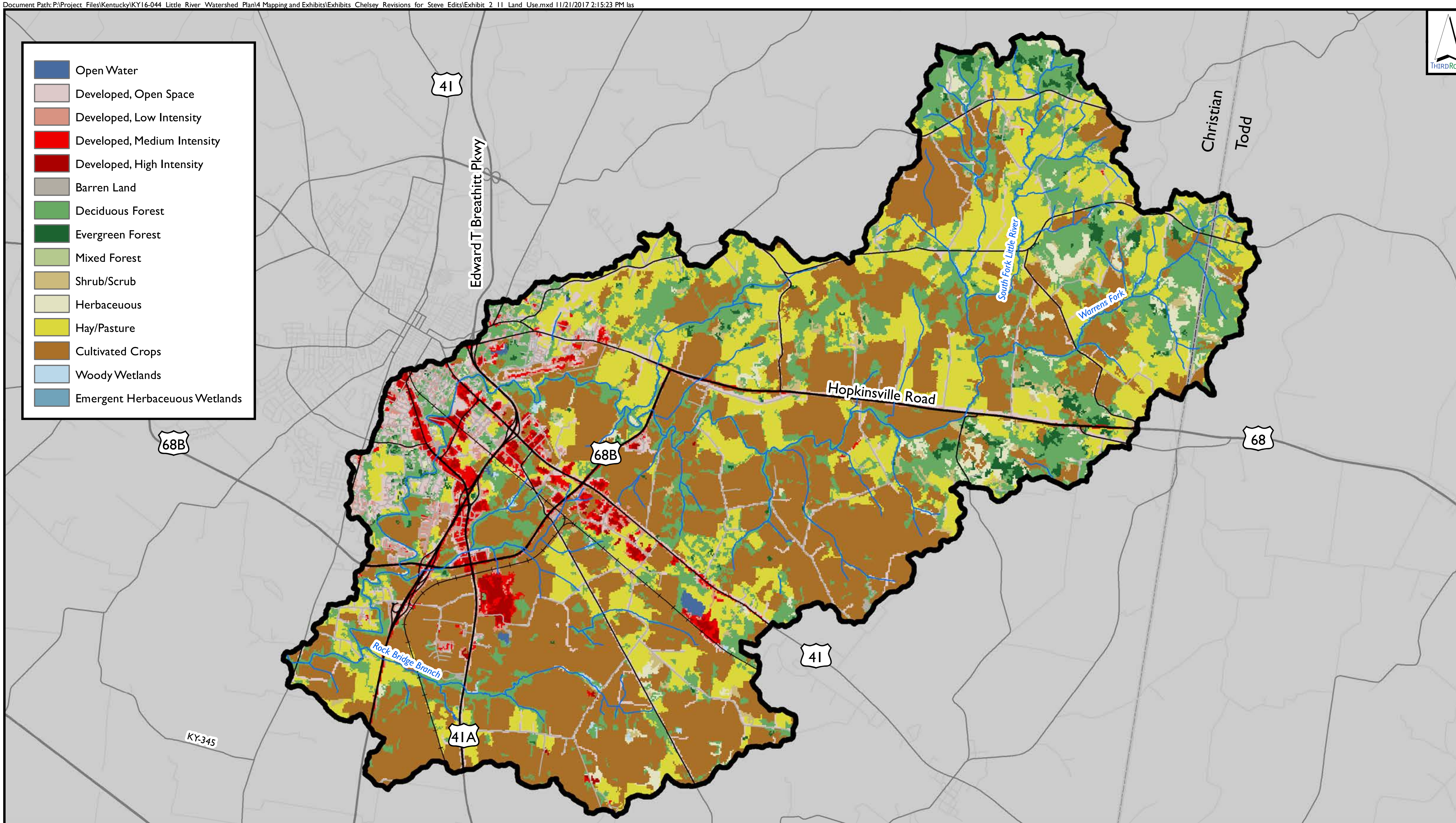
Note: Structures and Sanitary Sewer data obtained from HSSU.

Exhibit 10 - Wastewater
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and
Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_11_Land_Use.mxd 11/21/2017 2:15:23 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroad
Stream

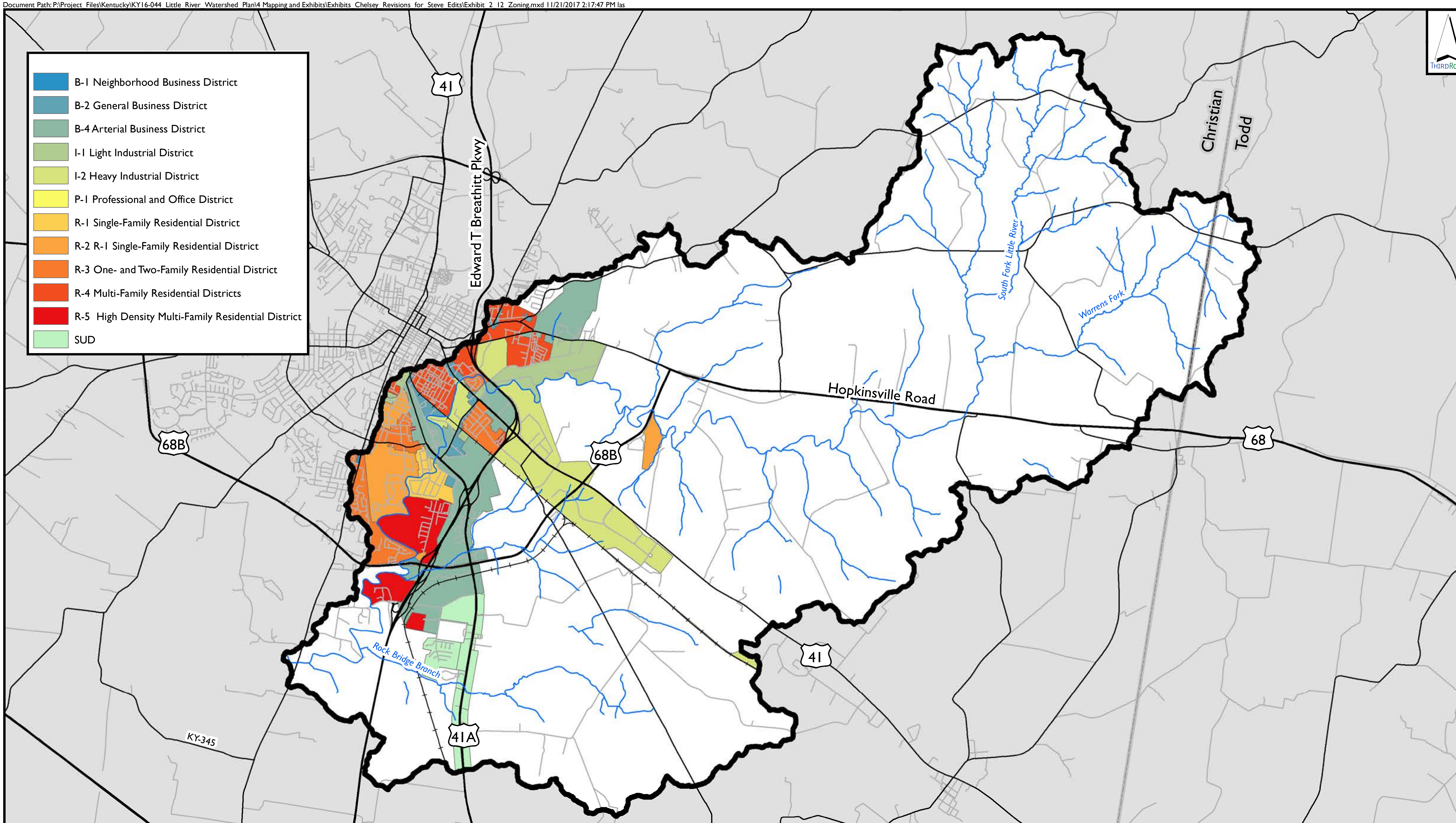
Note: Soil data was obtained from the USDA/NRCS.

Exhibit 11 - Land Use
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_12_Zoning.mxd 11/21/2017 2:17:47 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

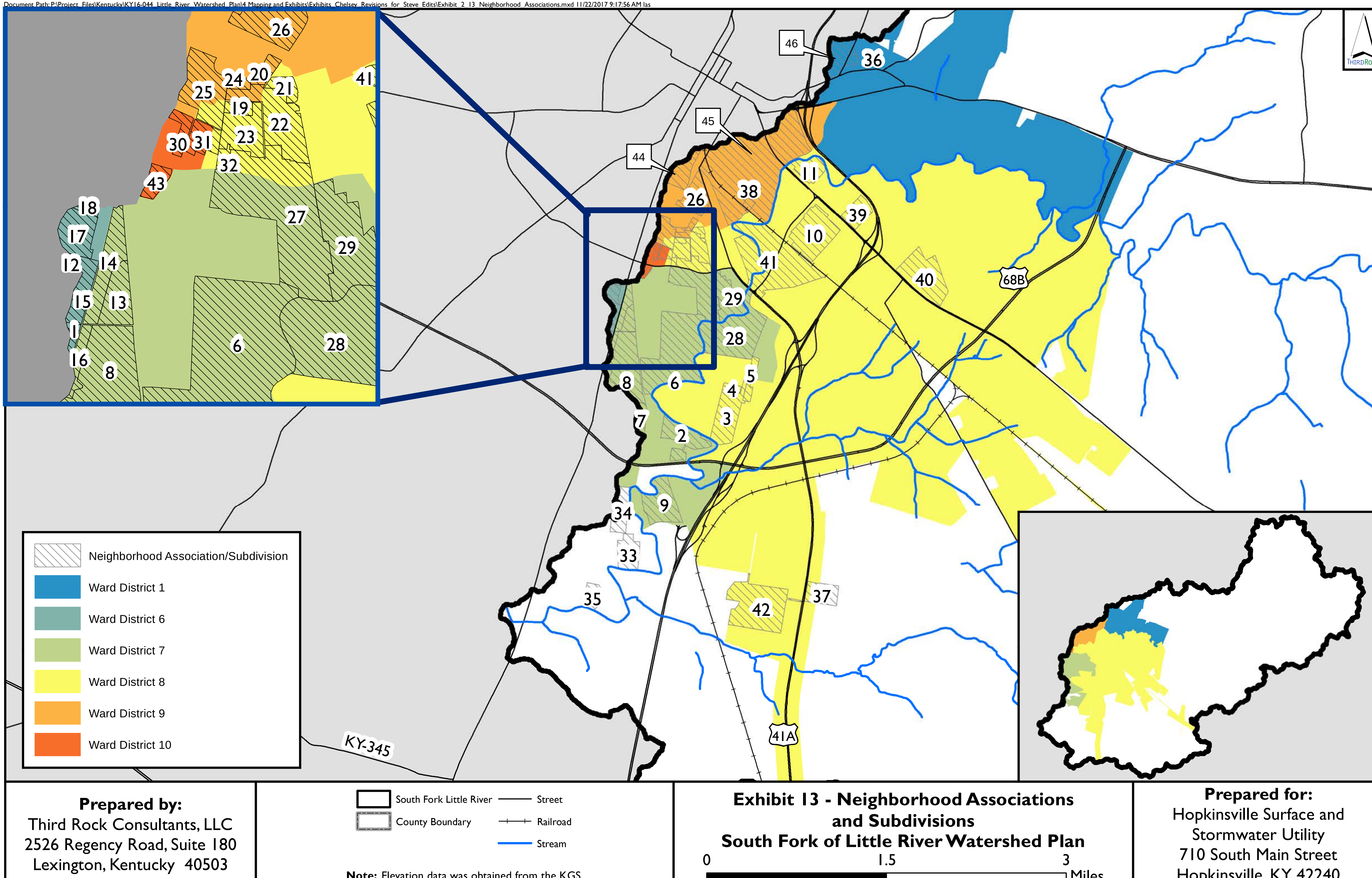
Note: Zoning shapefiles were obtained from the City of Hopkinsville.

Exhibit 12 - Zoning
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_13_Neighborhood_Associations.mxd 11/22/2017 9:17:56 AM las



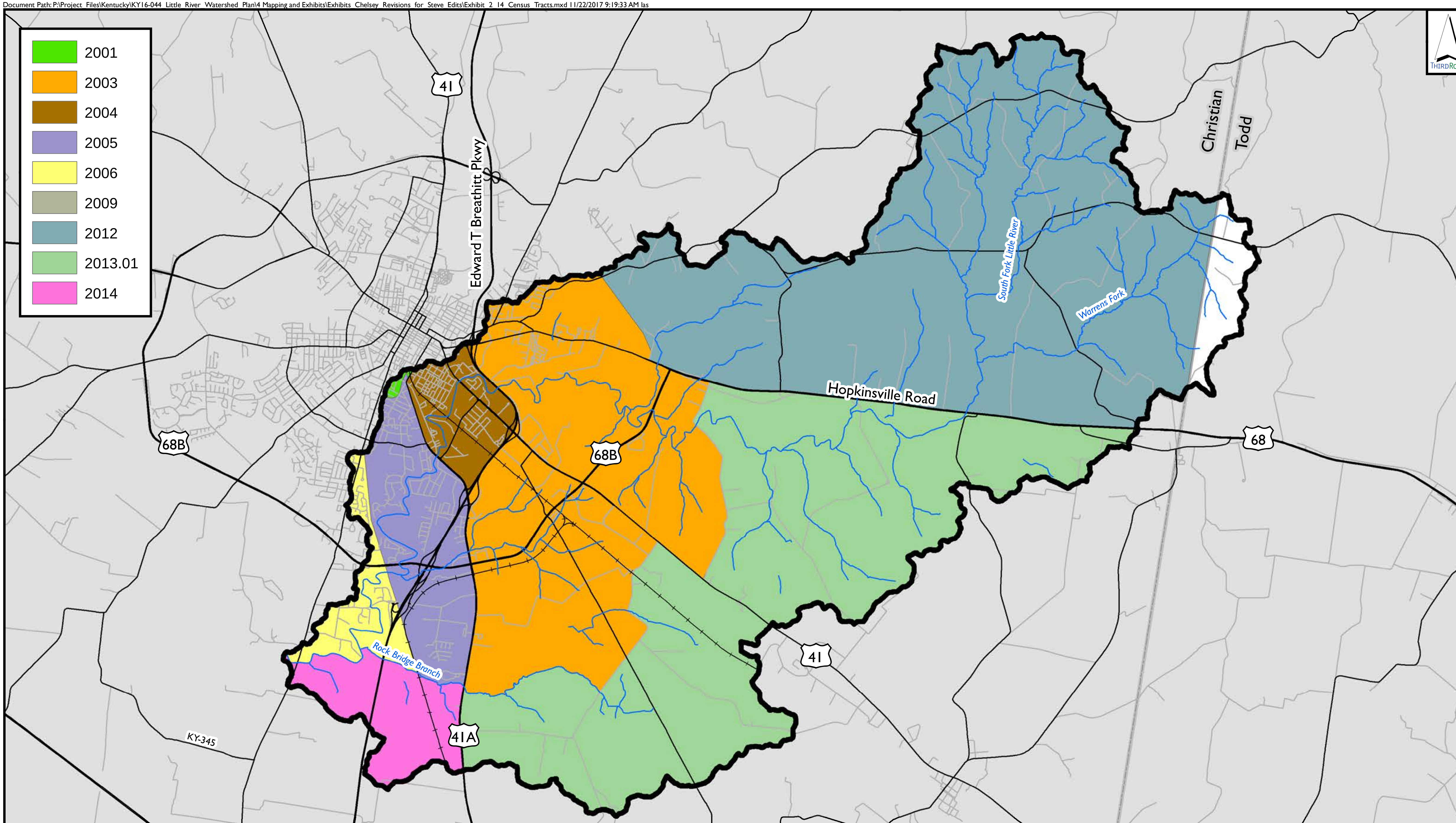
Note: Elevation data was obtained from the KGS.

Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

Exhibit 13 - Neighborhood Associations and Subdivisions
South Fork of Little River Watershed Plan

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_14_Census_Tracts.mxd 11/22/2017 9:19:33 AM las



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2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

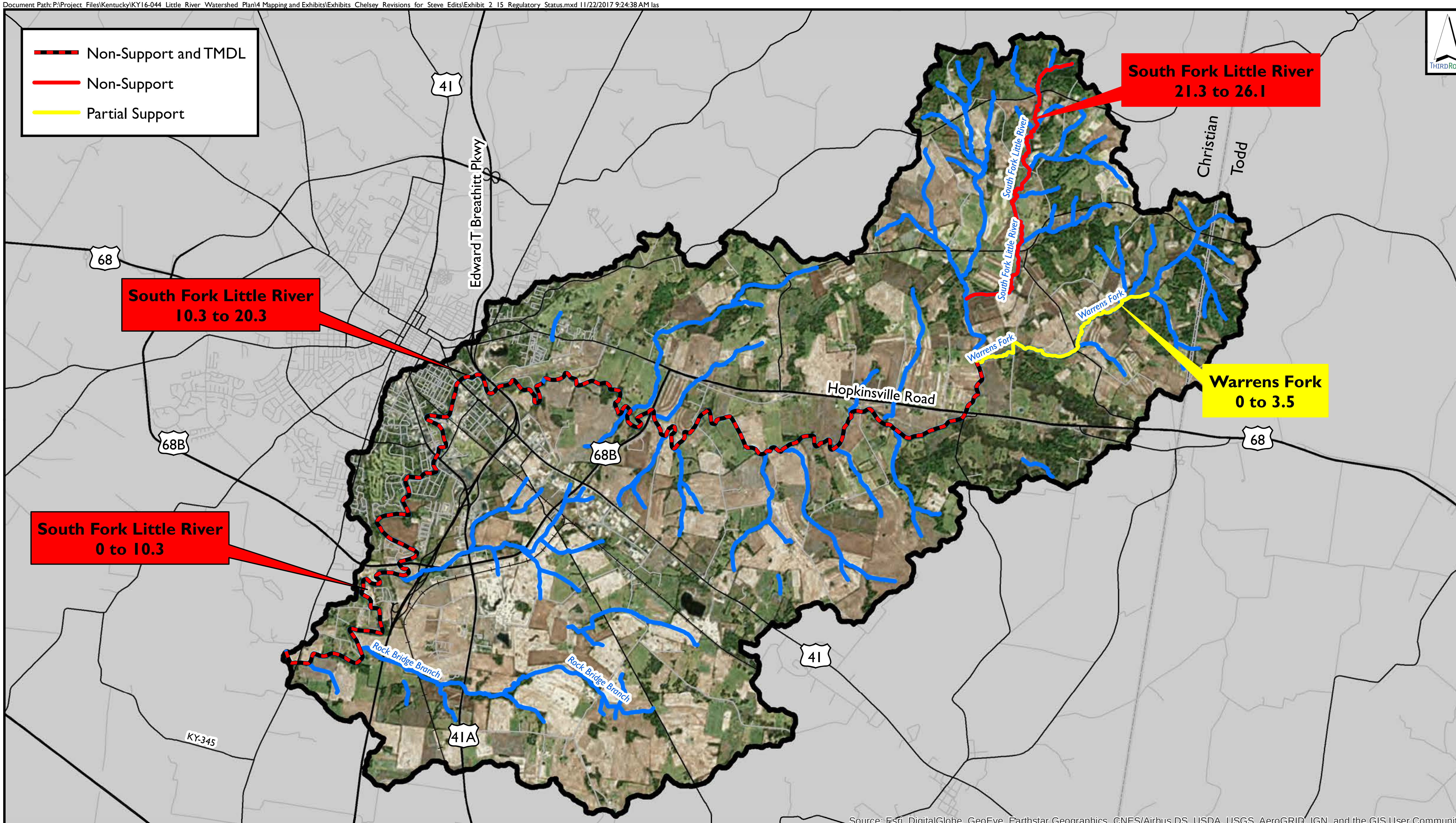
Note: Census tract shapefiles were obtained from the city of Hopkinsville for the 2010 census.

Exhibit 14 - Census Tracts
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_15_Regulatory_Status.mxd 11/22/2017 9:24:38 AM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

Exhibit 15 - Regulatory Status
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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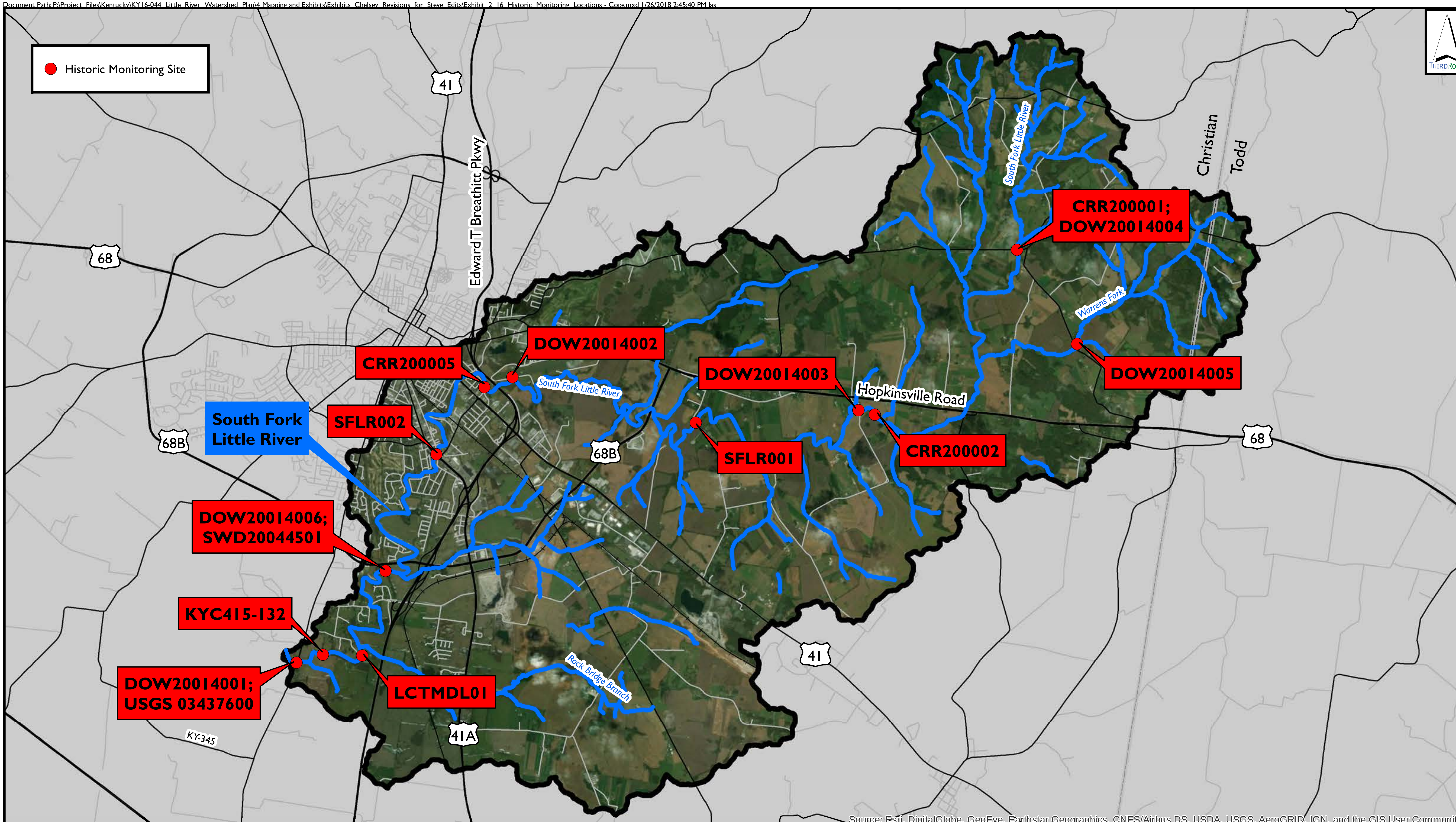
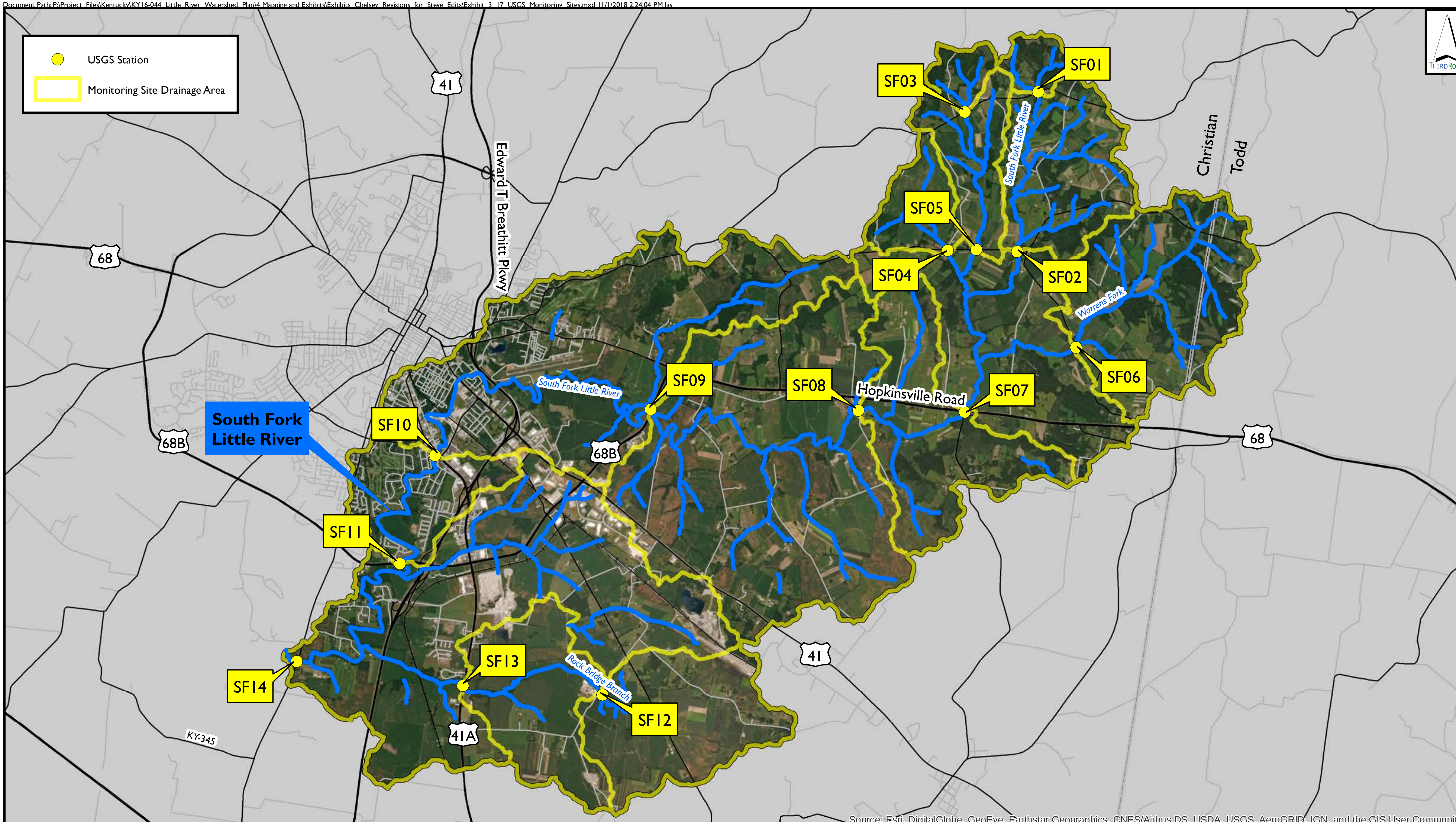


Prepared by:			Prepared for:
Prepared by: Third Rock Consultants, LLC 2526 Regency Road, Suite 180 Lexington, Kentucky 40503	South Fork Little River County Boundary Street Railroad Stream	**Exhibit 16 - Historic Monitoring Sites** **South Fork of Little River Watershed Plan** 0 2.5 5 Miles	**Prepared for:** Hopkinsville Surface and Stormwater Utility 710 South Main Street Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_3_17_USGS_Monitoring_Sites.mxd 11/1/2018 2:24:04 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

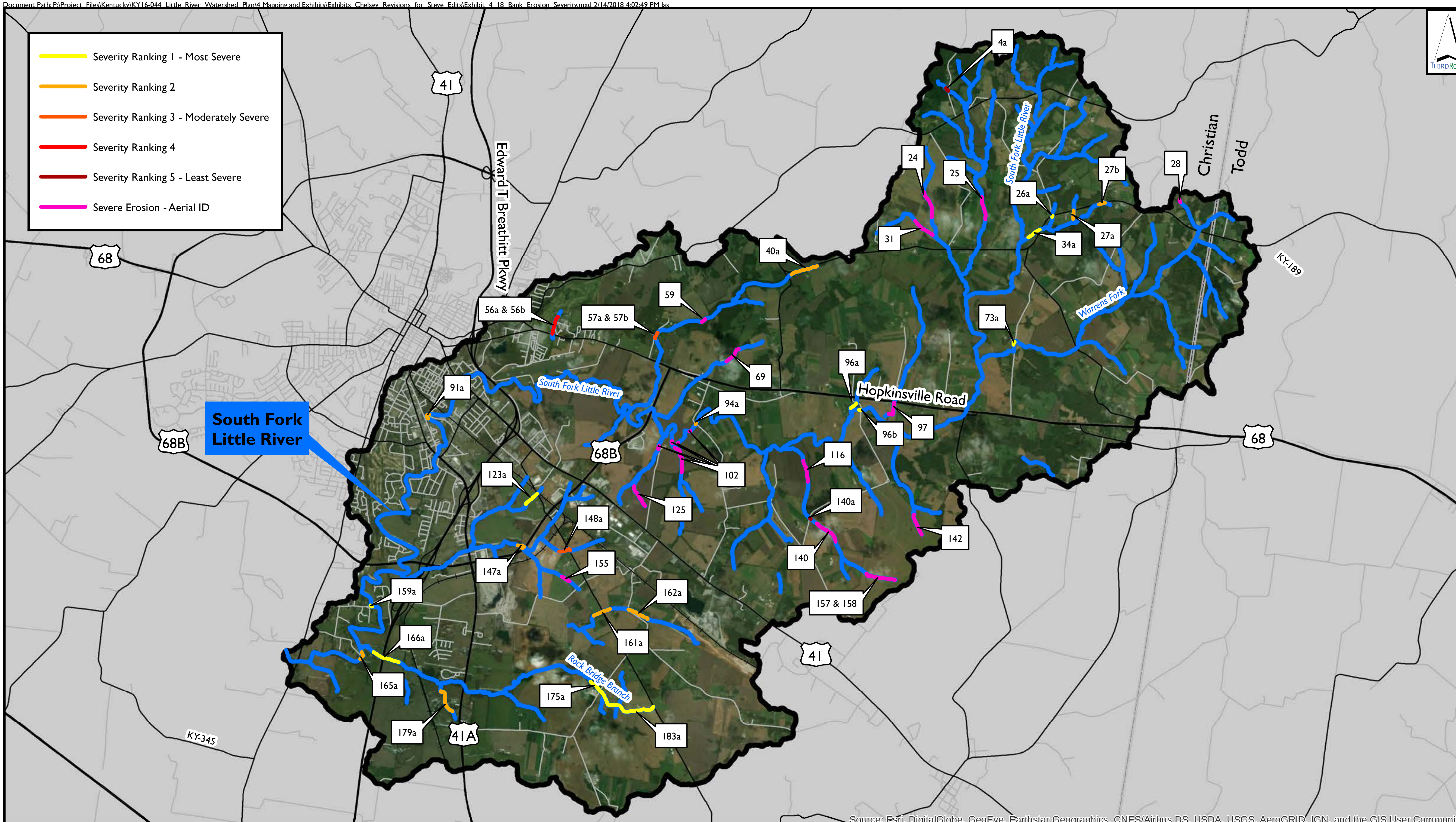
South Fork Little River | Street
County Boundary | Railroad
Stream

Exhibit 17 - USGS 2013-2014 Monitoring Sites
South Fork of Little River Watershed Plan

0 | 2.5 | 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_4_18_Bank_Erosion_Severity.mxd 2/14/2018 4:02:49 PM las



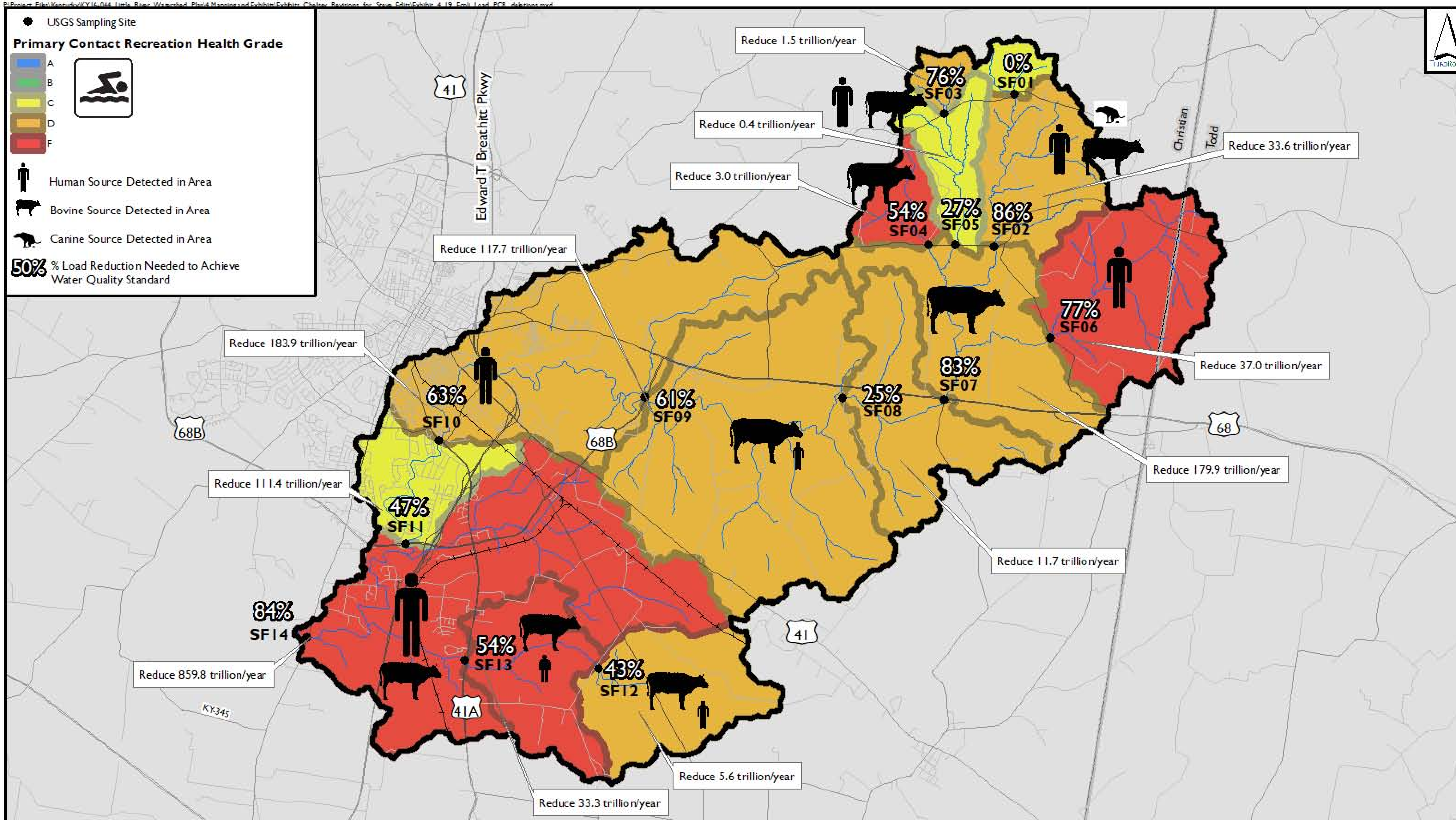
Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroad
Stream

Exhibit 18 - Locations and Severity of Known Bank Erosion
South Fork of Little River Watershed Plan

0 — 2.5 — 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240



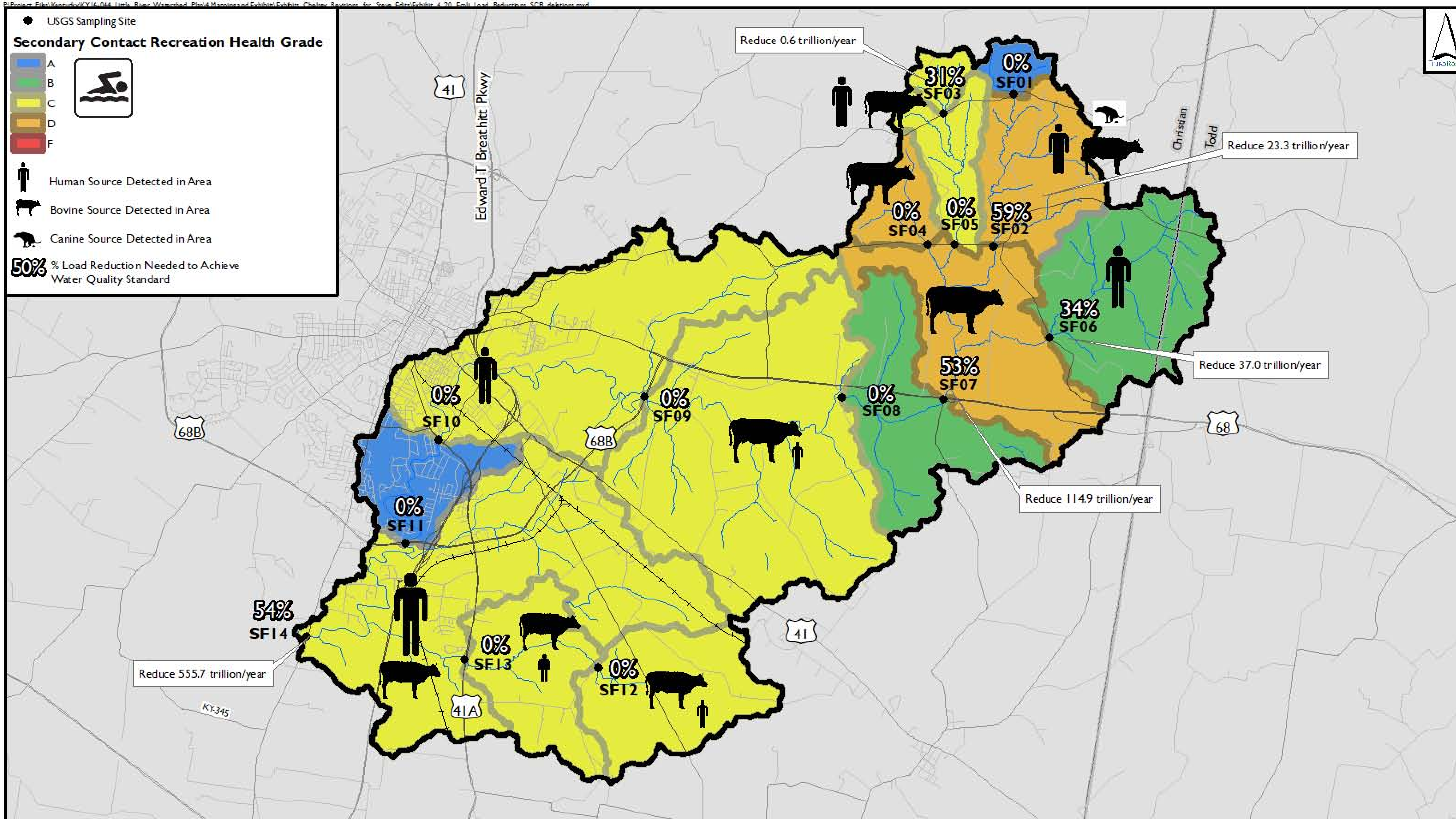
Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 19 - E.coli Grade and Load Reductions (PCR)
South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 20 - E.coli Grade and Load Reductions (SCR)
South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
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710 South Main Street
Hopkinsville, KY 42240

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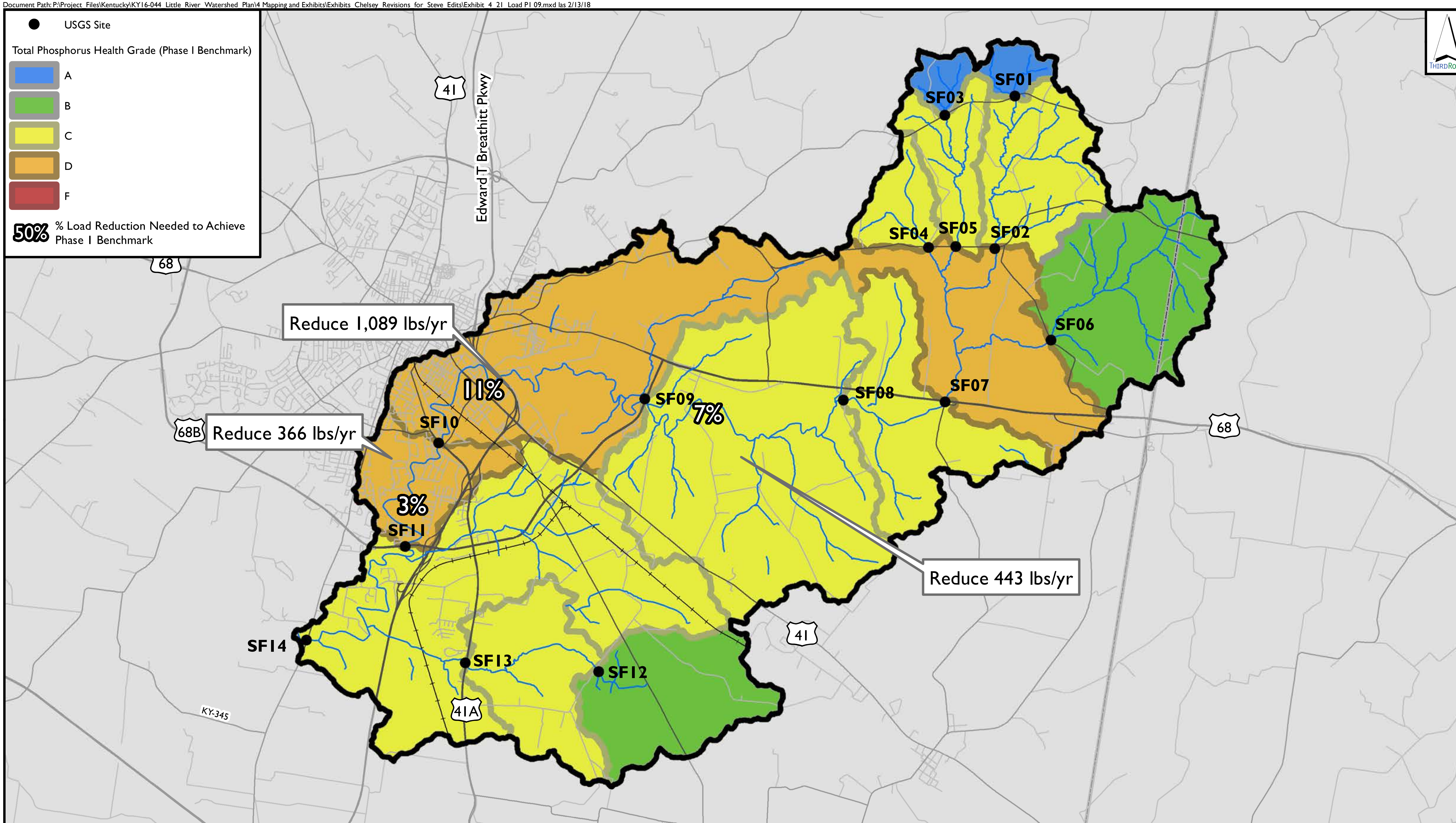

Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 21 - Total Phosphorus Grade and Load Reduction For Phase I Benchmark of 0.09 mg/L South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

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Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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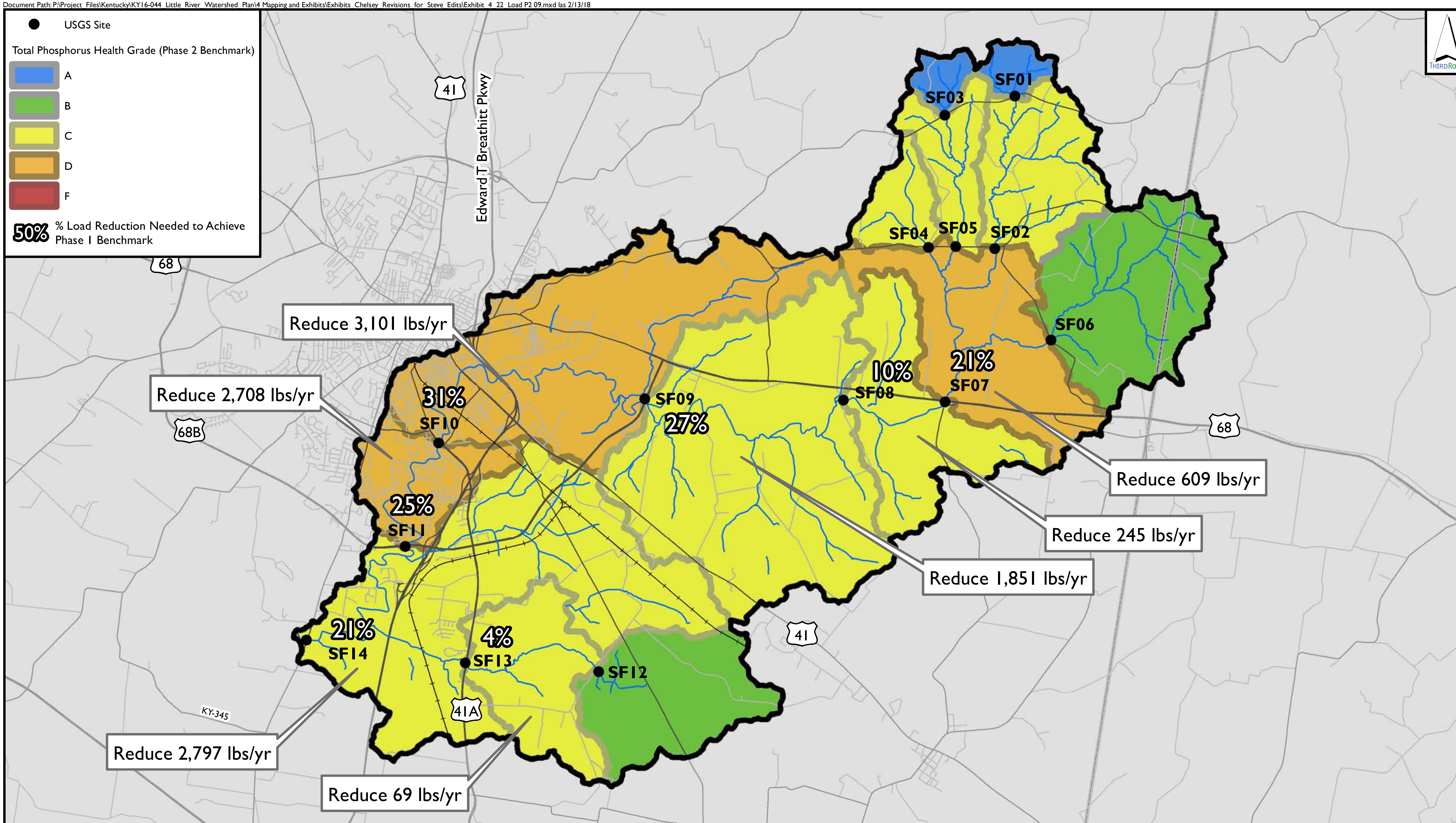


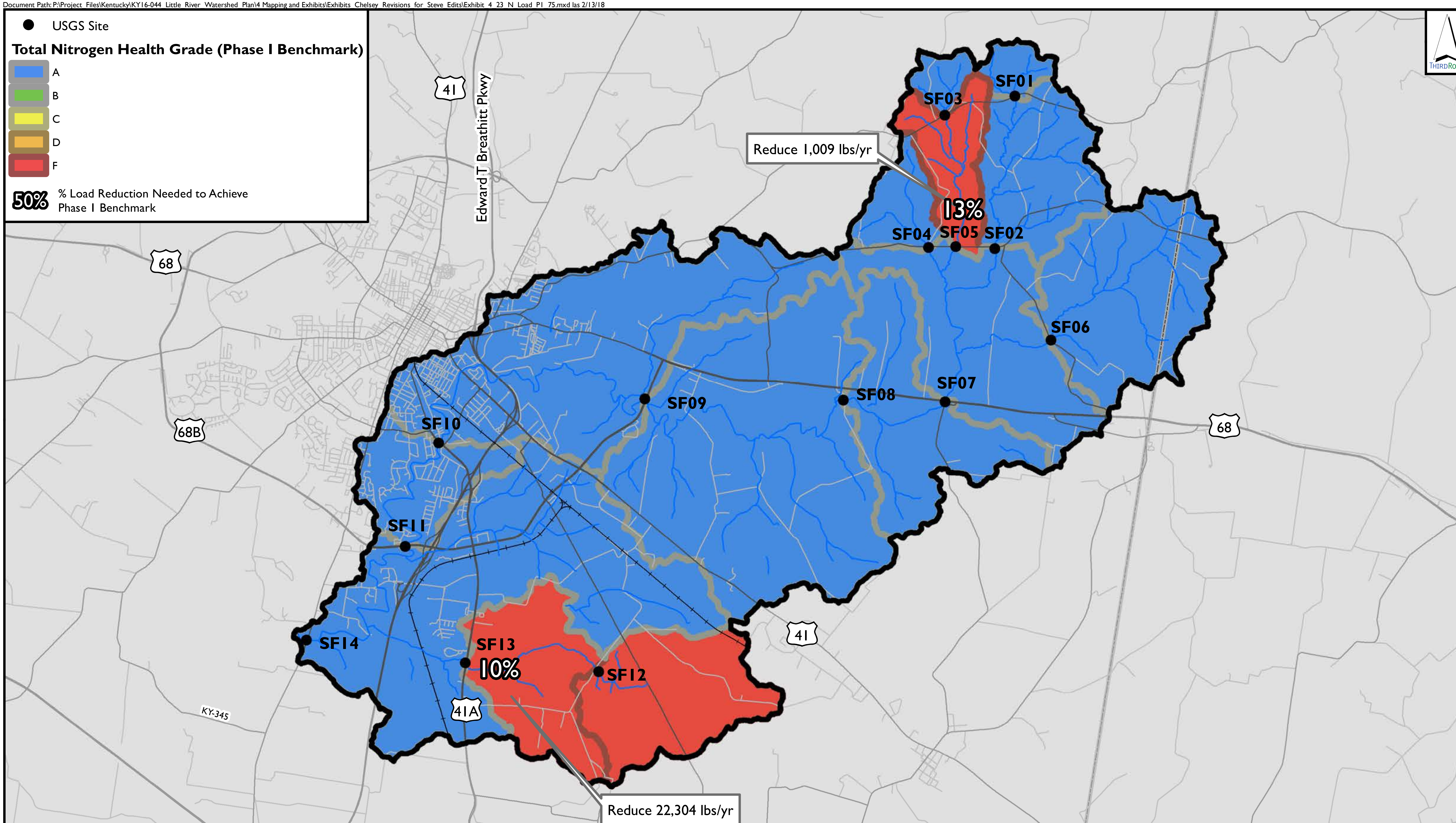
Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 22 - Total Phosphorus Grade and Load Reduction For Phase 2 Benchmark of 0.07 mg/L
South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 23 - Total Nitrogen Grade and Load Reductions For Phase I Benchmark of 7.5 mg/L
South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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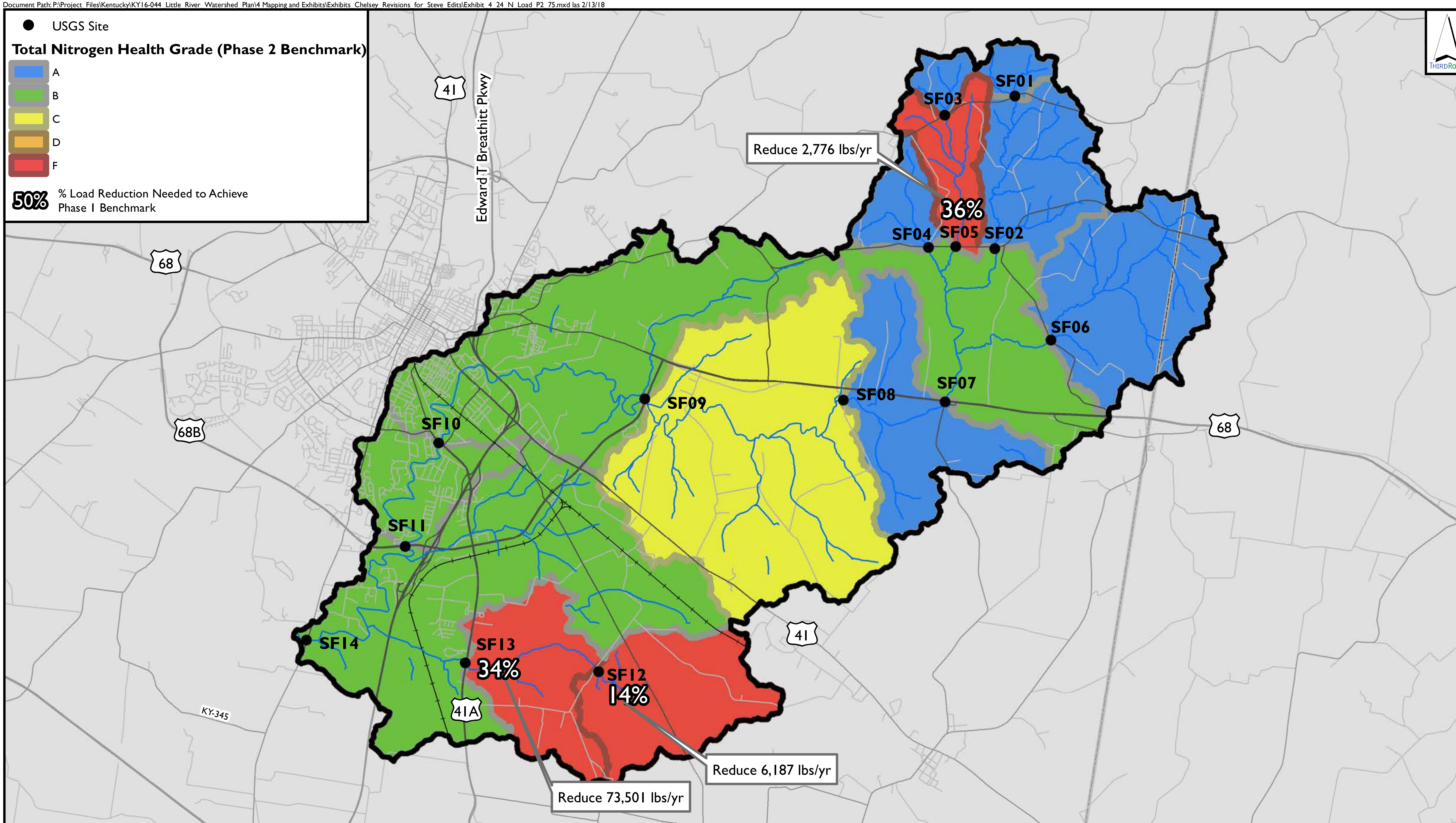


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 24 - Total Nitrogen Grade and Load Reductions For Phase 2 Benchmark of 5.5 mg/L
South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

APPENDIX B
QAPP (*APPENDICES OMITTED*)

South Fork of the Little River Watershed Severe Erosion Survey Quality Assurance Project Plan

Prepared by:

Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

Prepared for:

Hopkinsville Surface and Stormwater Utility
710 South Main Street, P.O. Box 588
Hopkinsville, Kentucky 42241-0588

March 14, 2017

Table of Contents

Appendices

Action by	Action	Date	Signature
Bert Remley, *Aquatic Ecologist* Third Rock Consultants, LLC	Authored	3/15/17	Bert Remley
Steven Evans, *Data Manager* Third Rock Consultants, LLC	Reviewed	3/15/17	[signature]
Steve Bourne, *AICP* Community and Development Services	Approved	3/3/17	[signature]
Lisa Hicks, Quality Assurance Officer Kentucky Division of Water	Approved	4/4/17	Lisa Hicks
James Roe, *Supervisor* Kentucky Division of Water Non-Point Source Branch	Approved	4/10/2017	[signature]

Appendix B

MATTHEW G. BEVIN
GOVERNOR

CHARLES G. SNAVELY
SECRETARY

ENERGY AND ENVIRONMENT CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

AARON B. KEATLEY
COMMISSIONER

300 SOWER BOULEVARD
FRANKFORT, KENTUCKY 40601

March 14, 2017

Mr. Steve Evans
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, KY 40503

Mr. Evans,

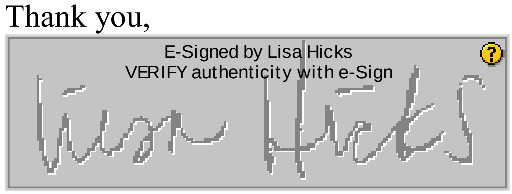
I have reviewed the Quality Assurance Project Plan (QAPP) for the South Fork of the Little River Watershed Sever Erosion Survey project, developed for the Hopkinsville Surface and Storm water Utility.

I have one question that can be addressed in a revision of the QAPP, Section 1.2. No additional signatures will need to be obtained after the revision, and the surveys can begin as soon as needed.

1. Will the soil erosion survey results be included in the overall watershed plan that is discussed in Section 1.2? If so, please include a brief statement how these erosion surveys fir into the overall watershed plans: how they relate to other data, how they relate to the overall goal of the watershed plan and how these data will add to the overall data set for the watershed plan.

After submission and receipt by the Division of Water of the revised Section 1.2, this QAPP will be considered accepted and should be part of the documentation for the project and watershed plan.

Thank you,



Lisa Hicks
Quality Assurance Officer
Kentucky Division of Water

c. Jim Roe
Mike Reed
Maggie Morgan

Date	Section(s) and Page(s) Revised	Explanation
March 14, 2017	Section 1.2, page 5	Expanded description of how the data will fit into the watershed based plan and relates to other data.

The following individuals will receive the approved Quality Assurance Project Plan (QAPP) and any subsequent revisions.

1. James Roe, Supervisor, Nonpoint Source and Basin Team Sections
   James.Roe@ky.gov

2. Lisa Hicks, Quality Assurance Officer
   Lisa.Hicks@ky.gov

   Kentucky Division of Water
   300 Sower Boulevard, 3rd Floor
   Frankfort, KY 40601
   502-564-3410

3. Steven Evans, Data Manager
   sevans@thirdrockconsultants.com

4. Bert Remley, Aquatic Ecologist
   bremley@thirdrockconsultants.com

   Third Rock Consultants, LLC
   2526 Regency Road, Suite 180
   Lexington, KY 40503
   859-977-2000

5. Steven Bourne, AICP, Director
   sbourne@comdev-services.com

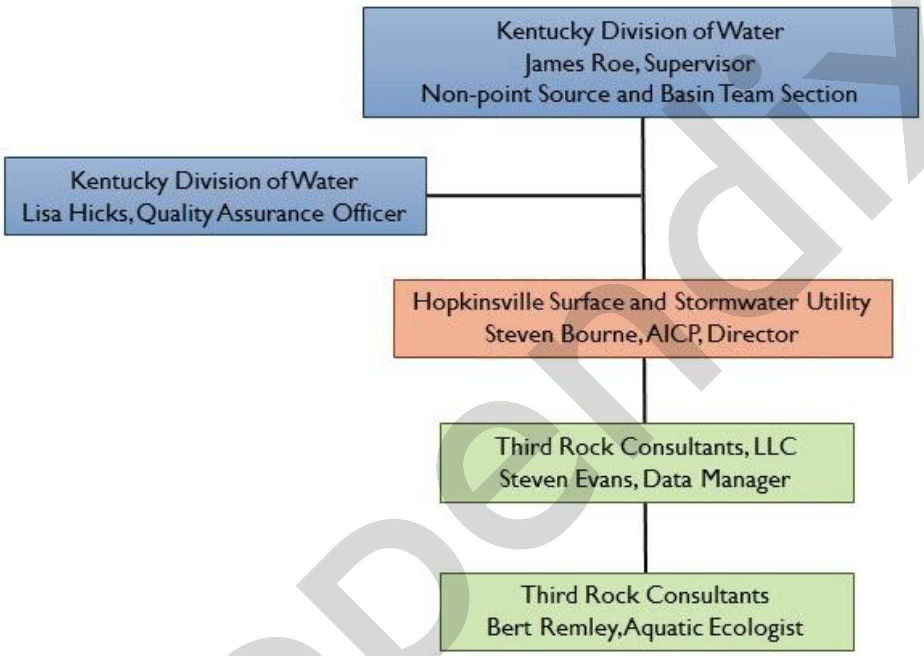
   Hopkinsville Surface and Stormwater Utility
   710 South Main Street
   P.O. Box 588
   Hopkinsville, KY 42241-0588
   270-887-4285

1. Project Management

1.1 Project / Task Organization

The key personnel of the project team are summarized in **Figure 1** as well as the lines of authority with regards to the execution of the project. For purposes of this Quality Assurance Project Plan (QAPP), the following acronyms will apply: Kentucky Division of Water (KDOW); Hopkinsville Surface and Stormwater Utility (HSSU); and Third Rock Consultants, LLC (Third Rock). Roles and responsibilities of specific personnel are summarized below.

FIGURE 1 – ORGANIZATIONAL CHART



<u>James Roe, Supervisor, KDOW Nonpoint Source and Basin Team Sections</u>

Mr. Roe will be responsible for ensuring that the monitoring performed under this project is in compliance with the KDOW and EPA requirements.

<u>Lisa Hicks, Quality Assurance Officer, KDOW</u>

Ms. Hicks will be responsible for reviewing and approving the QA Project Plan. She may provide technical input on proposed sampling design, analytical methodologies, and data review.

<u>Steven Bourne, AICP, Director, HSSU</u>

Mr. Bourne will be responsible for project management and reviewing the final report.

Steve Evans, Data Manager, Third Rock

Mr. Evans will be responsible for coordinating development of the QAPP. He will ensure that the severe erosion surveys are coordinated as specified in the QAPP. He will review and approve all data generated for the project and prepare QA reports as required by the project. He will also be responsible for managing the data generated.

Bert Remley, Aquatic Ecologist, Third Rock

Mr. Remley_will be responsible for writing the QAPP and conducting and supervising severe erosion surveys. He will conduct data analysis and will be responsible for QA of all data generated from the field. He will report to Third Rock Consultants Data Manager and QA Manager.

1.2 Project Background and Overview

This South Fork Little River Severe Erosion Survey QAPP has been developed to ensure data generated under this QAPP is of sufficient quality to achieve project goals for the watershed based plan. From 2012-2014, the USGS conducted a study of sources of pathogens, nutrients, and sediment in the Upper Little River Basin which includes South Fork Little River. By using sediment-fingerprinting, the study found that stream bank erosion contributes the largest proportion of fine sediment to streams in the South Fork Little River followed by cropland and riparian-zone areas, respectively. However, the study did not identify specific reaches of stream with erosion problems or specific sediment sites. The overall goal for this QAPP is to generate data of sufficient quality and resolution to facilitate the identification of specific areas of severe bank erosion, and prioritize these areas for implementation of bank stabilization or stream restoration BMPs in the South Fork Little River Watershed (HUC#051302050501 and 051302050502). The USGS study will provide the data to quantify pollution sources in the watershed. This study will identify some of the largest sources of sediment such that the watershed based plan can target improvements to those areas.

The study area is the entirety of the South Fork Little River Watershed that is located in Christian and Todd Counties. A Severe Erosion Survey, either by visual assessment or windshield survey, is the monitoring element that will be performed.

1.3 Project / Task Description and Schedule

Perennial and intermittent streams within the South Fork Little River Watershed (HUC#051302050501, #051302050502) will be surveyed for areas of severe erosion. Where permission is gained to access property, streams will be inspected on foot by Third Rock personnel. In areas where permission cannot be gained, a windshield survey will be conducted from public roadways.

Surveyors will follow the *Stream Corridor Assessment Survey- SCA Survey Protocols (MDDNR 2001)* during the survey, recording length of erosion, bank height, and cause, and ranking the severity, correctability, and access. Streams will be walked where permission is granted, but surveyors will otherwise perform the survey from roadways. Surveyors will mark locations of severe erosion on a high resolution aerial map, as well as areas that could not be accessed. For this survey, severe erosion is defined as areas where erosion greatly exceeds average reach conditions or threatens property and infrastructure. Photographs will be made of each location and the length of the erosion marked with GPS waypoints where access allows. Current state of stream channel evolution (i.e. sloughing banks, incised channel) at erosional areas will be documented. An erosion field datasheet will be completed in the field for areas of severe erosion.

Additionally, areas prone to flooding and potential blockages (i.e. log jams at road culverts) will be documented and photographed. Additionally, sources of *Escherichia coli* and sediment inputs to the South Fork Little River watershed that are observed during severe erosion surveys will be recorded and marked on the aerial map or with GPS waypoints.

The results of the survey activities will be conveyed through multiple deliverable types, including reports, maps, and data analysis. Erosional areas in need of bank stabilization or stream restoration will be prioritized and displayed on mapping and summarized in a Severe Erosion Survey Report. The survey results may also be incorporated into a comprehensive Watershed Based Plan following the completion of the monitoring. The survey and report will be generated by June 30, 2017.

1.4 Data Quality Objectives and Measurement Criteria

Data quality is determined primarily based on data quality objectives (DQOs) and data quality indicators (DQIs). DQOs are qualitative and quantitative statements that indicate the objectives or goals for the data. Data Quality Indicators (DQIs) are qualitative and quantitative measures of data that indicate whether the data is of sufficient quality to meet the DQOs. The specific DQOs and DQIs for this project are stated in the following sections.

The overall Quality Assurance / Quality Control (QA/QC) objective for the South Fork Little River QAPP is to generate data of sufficient quality and resolution to facilitate the identification and prioritization of severe bank erosion locations on streams within the South Fork Little River watershed.

1.4.1 Data Quality Objectives (DQO)

The data quality objectives in this QAPP are related to field surveying. This plan is intended to focus on field surveying activities. The data quality objective for the severe erosion survey activities is to prioritize stream reaches that require bank stabilization or stream restoration, and to identify sources of *E. coli* and sediment input.

1.4.2 Action Limits / Levels

Not applicable.

1.4.3 Measurement and Performance Criteria / Acceptance Criteria

Not applicable.

1.5 Special Training Requirements

Documentation of training will be maintained by the Data Manager. In order to perform severe erosion surveys, field investigators must read and understand this QAPP and associated protocols.

1.6 Documentation and Records

In order to provide quality data that meets the project objectives, traceability and maintenance of documentation and records is essential. All records relating to the collection, analysis, or reporting data associated with the project shall be made available upon request by the KDOW.

Proper documentation of all field activities is essential to ensure that data quality objectives are achieved. Field crews are expected to document unusual or anomalous conditions that may later be useful for data interpretation and analysis. The forms described below are those that will be utilized in the sampling effort.

Data collected for this project will be recorded in field notebooks or standardized forms. All data recorded in field notebooks are to be scanned and maintained electronically in project files. The following standardized field forms will be utilized in the sampling effort and are included in **Appendix A**:

- Erosion Site Datasheet
- Photo Log Datasheet

Field methods are included in **Appendix B** (MDDNR. 2001. *Stream Corridor Assessment Survey – SCA Survey Protocols*. Watershed Restoration Division Chesapeake & Coastal Watershed Services Maryland Dept. of Natural Resources, Annapolis, MD).

Field documentation may include photography or video to document current field conditions. Photographs will also be used to document severe erosion areas, *E. coli* sources, sedimentation sources, stream blockages, and flood prone areas. All documentation will be retained electronically until September 2022.

This QAPP will be distributed to all individuals on the distribution list, subsequent to updating. A list of changes between revisions will be maintained in the document. All field data will ultimately be submitted in the Severe Erosion Report. However, all field notes will be retained until September 2022.

2. Data Acquisition

2.1 Sampling Experimental Design

A systematic sampling design has been utilized for these activities, wherein the sample locations and parameters have been selected based upon evaluation needs.

This survey plan is for the South Fork Little River Watershed (HUC#051302050501, #051302050502) in its entirety, including portions in both Christian and Todd Counties.

The monitoring elements chosen for this project are intended to identify sources of sedimentation and *E. coli* to the South Fork Little River Watershed. Severe erosion surveys are intended to provide general locations of erosion such that Best Management Practices can be targeted to areas in need of stabilization.

2.2 Sampling Procedures and Requirements

The following paragraph provides a summary of the sampling method and equipment associated with the surveying activities. Surveys for severe erosion areas within the South Fork Little River Watershed will generally follow Maryland Department of Natural Resource's *Stream Corridor Assessment Survey-SCA Survey Protocols* (MDDNR 2001). A complete discussion of the survey method is provided in the above mentioned SOP. During all surveying activities, the sampler personnel are to bring the following materials at a minimum: waterproof field notebook, pencils, ink pens, sampling protocols, appropriate field forms, gloves, waders or boots, and a digital camera. Other equipment or materials specific to the severe erosion surveys are recorded in the sections that follow.

2.2.1 Equipment

Equipment for severe erosion surveys includes the following: camera, GPS Unit, field maps (**Appendix C**), pencil, Sharpie marker, field datasheets, clipboard, field notebook, tape measure, and binoculars.

2.2.2 Methods

The South Fork Little River Watershed will be surveyed for areas of severe erosion either on foot or by a windshield survey from public roads. For the purpose of this project, severe erosion is defined as areas where erosion greatly exceeds average reach conditions or threatens property and infrastructure. In locations where permission can be obtained, Third Rock staff will walk stream segments in rural Christian and Todd counties to identify areas of severe erosion. In areas where permission to access streams cannot be obtained, surveys will be conducted from public roadways with the aid of binoculars when necessary.

The objective is not to provide quantitative estimates of sediment contribution but to identify high priority areas for implementation of bank stabilization or stream restoration BMPs. To the extent access allows, the following will be recorded on an Erosion Site Field Datasheet during the survey:

- Type of Impact (*downcutting, widening, headcutting, unknown*)
- Cause (*bend at slope, pipe outfall, below channelization, road crossing, livestock, landuse change upstream, other*)
- Length of Erosion
- Exposed Bank Height (*average*)
- Left and Right Bank Land Use
- Threat to Infrastructure
- Severity
- Correctability
- Access

Surveyors will mark locations of severe erosion on a high resolution aerial map. Photographs will be made of each location and the length of the erosion marked with GPS waypoints where access allows. Length of impact will be estimated in the field and verified by GIS in the office.

On the datasheet, severity, correctability, and access are rated for each severe erosion area. Severity is ranked from 1 (severe) to 5 (minor); correctability ranked from 1 (best) to 5 (worst); access 1 (best) to 5 (worst). Factors used to determine erosion severity rating include:

- Length of impact
- Height of stream bank
- Erosion in both bends and run sections
- Erosion rates along stream banks
- Stream channel unstable and readjusting
- Unconsolidated gravel, sands, and silts in the banks
- Stratified soil in the banks
- Stream channel eroded below the root zone of the vegetation along the banks

Examples of severity rating provided by MDDNR (2001) are as follows:

"Severe rating (1): A long section of stream (>1000 ft.) that had incised several feet, with banks on both sides of the stream that are unstable and eroding at a fast rate.
Usually this occurs in areas where there are soft unconsolidated sediments (gravel, sand and/or silts) and the stream has eroded below the root zone of the bank vegetation."

"Moderate rating (3): Either a long section of stream (>1000 ft.) that has a moderate erosion problem, or a shorter stream reach (between 1000 and 300 ft.) with very high banks (> 4 ft.), and evidence that the stream is eroding at a fast rate."

"Minor rating (5): A short section of stream (<300 ft.) where the erosion is limited to one or two meander bends or a site where an erosion problem is being caused by a pipe outfall and the area affected is fairly limited."

Factors used to determine correctability rating:

- Length of impact
- Adjacent land use, access and construction staging
- Heavy equipment needed
- How much material (i.e., earth, stone) will be required to be moved
- Funding required

Examples of correctability rating provided by MDDNR (2001) are provided below:

"Best Correctability (1): A short stream reach (< 200 ft.) where the erosion problem can be corrected by simple bioengineering techniques using volunteers in one or two days."

"Moderate Correctability (3): An erosion problem that could be corrected by a work crew over several weeks, using primarily a backhoe or other small piece of construction equipment. The project may involve using some small rock (< 100 lbs.) to stabilize the toe of a stream bank but most of the work would rely on vegetation and biodegradable material to stabilize the stream banks."

"Worst Correctability (5): A long reach of stream (i.e., several thousand feet) that had deeply incised several feet and any attempt to actively restore the stream channel would require not only significant funding (i.e., several hundred thousand dollars) but would also involve a large amount of earth moving and disturbance to the riparian corridor."

Factors determining accessibility rating:

- Land ownership
- Surrounding land use
- Safe access
- Heavy equipment access through existing roads or trails

Examples of accessibility rating provided by MDDNR (2001) are provided below:

"Rating of 1 is for a site that is easily accessible both by car or on foot. Examples would include a problem in an open area inside a public park where there is sufficient room to park safely near the site. If heavy equipment was needed, it could easily access the site using existing roads or trails."

"Rating of 3 is for sites that are easily accessible by foot but not easily accessible by a vehicle. Examples would include a stream section that could be reached by crossing a large field or a site that was accessible only by 4-wheel drive vehicles."

"Rating of 5 is for sites that are difficult to reach both on foot and by a vehicle. Examples would include a site on private land where there are no roads or trails nearby. To reach the site it would be necessary to hike over a mile. If equipment were needed to do the restoration work, an access road would need to be built over a long distance through rough terrain."

2.3 Sample Handling and Custody Requirements

Not Applicable.

2.4 Analytical Methods Requirements

Not Applicable.

2.5 Quality Control Requirements

Length estimates of severe erosion areas, recorded on aerial field maps in the field, will be verified in the office using ArcView GIS.

2.6 Requirements for Equipment and Supplies

Not applicable.

2.7 Data Acquisition Requirements for Non-Direct Measurements

Aerial mapping, a non-direct measurement, will be utilized to identify and record areas of severe erosion and to estimate length of these areas. In areas in which access to property cannot be obtained, aerials may be utilized to assess severe erosion without field confirmation.

2.8 Data Management Requirements

For severe erosion data, data will be collected in the field and recorded in field notebooks, and on field data sheets. The field samplers are responsible to ensure that all hard copies are scanned and saved electronically in Third Rock's project files. Additionally, hard copies are to be stored in the project files. Third Rock's Data Manager will be responsible for reviewing all field results, and ensuring field data sheet completeness.

Severe erosion data will be published in the Severe Erosion Summary Report.

3. Data Assessment

Data assessment and response action are necessary to ensure that this QAPP will be implemented as approved. Data assessment and management reports to be utilized for this project are summarized in **Table 1**.

Table 1 – Data Assessment and Management Reports

Type	Purpose / Frequency	Party(ies) Responsible for Performing	Party(ies) Responsible for Responding	Reporting Method
QAPP Revision	As necessary to address non-conformances or errors in the QAPP	Project Team Members	Data Manager	Distribution of amended QAPP
Project Quality Assurance	At the conclusion of the project to document all quality controls for all field results, and compare the data produced to project DQIs	Data Manager	KDOW	Severe Erosion Survey Report

If at any time a project team member finds an error or non-conformance in the QAPP, the QAPP will be revised and redistributed to those on the distribution list subsequent to approval.

Upon receipt of the results, a review of the field data shall be performed by the Data Manager or his designee to ensure that the project DQOs have been satisfied. Email shall be utilized to communicate the results found in these evaluations. The quality of the data collected shall be reviewed and summarized in the Quality Assurance Project Report.

4. Review, Evaluation and Reporting

Data verification, data validation, and data usability are terms used to describe data review and evaluation. Data verification is the review of data sets for completeness, correctness, and conformance/compliance for a specific data set against the method, procedural, or contractual specifications. Data validation is an analyte and sample-specific process that determines the quality of a specific data set relative to its end use. Validation notes any deviations from the QAPP. Data usability is a determination of the adequacy of the data based on verification and validation, to ensure the QAPP criteria are met.

4.1 Validation and Verification Methods

The EPA guidance document *Guidance on Environmental Data Verification and Validation* (EPA QA/G-8) (EPA 2002) guides the overall process by which data will be validated and verified.

The sampler will perform data review for all field data initially before submitting to the Data Manager.

The Data Manager will document non-conformances in the data via email and in the Severe Erosion Report. This review will be submitted to the KDOW in the final report. The Data Manager will be responsible for making decisions concerning data quality and acceptability. KDOW may also make determinations on data acceptability, depending on data analysis and review of the Severe Erosion Report.

The final report will receive an internal peer review to evaluate the content, calculations, and data analysis in the report. The report will also undergo an internal grammatical review to look for grammatical errors and formatting. Lastly, the final report will receive a review from the Data Manager prior to submission to the KDOW to ensure that all project objectives are achieved.

4.2 Reconciliation with Project Requirements

In the report, descriptions of all relevant background information, summary, waterbody details, monitoring results, recommended solutions, and implementation plans will be detailed. Included in these documents will be an overall assessment of the data quality and the uncertainty involved in the results.

5. References and Citations

EPA. 2002. Guidance on Environmental Data Verification and Validation (EPA QA/G-8). Office of Environmental Information, Washington, DC. EPA/240/R-02/004

MDDNR. 2001. Stream Corridor Assessment Survey – SCA Survey Protocols. Watershed Restoration Division Chesapeake & Coastal Watershed Services Maryland Dept. of Natural Resources, Annapolis, MD.

APPENDIX C
KDOW BENCHMARK RECOMMENDATIONS

South Fork Little River Watershed Plan
Benchmark Recommendations
Kentucky Division of Water
4/14/17

Benchmark recommendations given here represent the best information available to the Kentucky Division of Water (KDOW) at this time. The goal is to provide estimates of typical in-stream concentrations below which it is unlikely that the given parameter would be a cause of aquatic life use impairment. As such, benchmarks are useful in identifying sub-basins with potential issues when setting priorities for further monitoring or for developing strategies for load reductions. In making these recommendations we considered regional and watershed-specific reference conditions, regional-scale patterns in biological effects, and relevant published literature. In this case, benchmark selection relied heavily on reference stream data for reasons discussed below. These benchmarks may be different than final targets for management endpoints; watershed-specific characteristics, practical considerations, and insight gained from early phase monitoring might suggest alternate values for that purpose. The Watershed Group may wish to discuss with KDOW alternative benchmarks and/or targets based on local information or consultation with experts with specific experience in the watershed. The benchmarks for Total Nitrogen and Nitrate/Nitrite-N should be reviewed especially closely given the uncertainty in what levels might be achievable and what levels are likely to lead to improvements in the health of aquatic life.

Benchmark Recommendations

Total P mg/L	0.05
Nitrate+Nitrite-N mg/L	5.0
Total N mg/L	5.5
Conductivity µS/cm at @25	450
TSS mg/L	8*
Turbidity NTU	4*

* *Because of the limited reference stream data for TSS and Turbidity at higher flows, these benchmarks should be interpreted as average values for summer stable flow periods only for the purposes of screening data. If TSS and Turbidity targets are needed for the watershed plan please consult with the TA to determine an appropriate target.*

Background Information

Ecoregional Reference Reaches

The Reference Reach network of streams represents the least-impacted conditions for aquatic life in wadeable streams in the respective ecoregions. The project area straddles the Western Pennyroyal Karst Plain and the Crawford-Mammoth Cave Uplands (ecoregions 71e and 71a), but since more than half of the watershed is in the Western Pennyroyal Karst Plain, this was the ecoregion selected as the most appropriate for comparisons. KDOW's Reference Reach grab sample data for ecoregion 71 e are summarized on the following page.

Note: the majority of the samples from reference reach program are grab samples during biological sampling events, generally during summertime stable flows. Only a few samples are from wet weather.

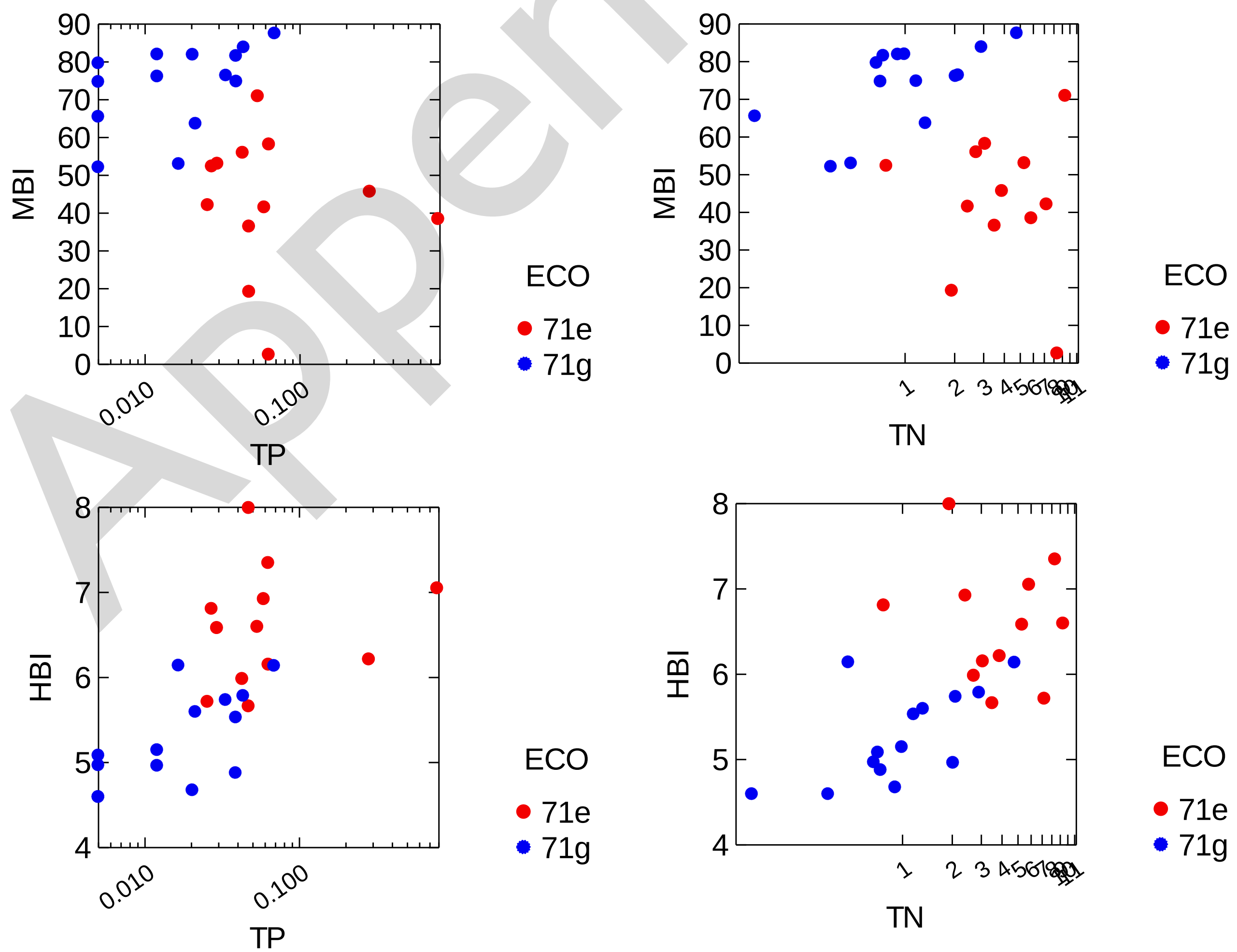
KDOW's Reference Reach Grab Sample Data

	Eco-Region	No. of Samples	MIN	MED	75th Percentile	90th Percentile	MAX
TP(mg/L)	71e	23	<0.010	0.029	0.053	0.089	0.988
NN-N(mg/L)	71e	24	2.190	5.220	5.7	7.259	8.740
TKN(mg/L)	71e	24	<0.200	<0.200	<0.200	<0.500	4.200
TN(mg/L)	71e	24	2.290	5.385	5.868	7.509	9.150
Conductivity µS/cm	71e	18	254	431	456	470	503
TSS mg/L	71e	16	1.5	3.75	4.5	7.5	9.0
Turbidity NTU	71e	11	0.50	2.06	3.125	3.65	4.46

Effects-based (Empirical) Threshold

A search was done to gather grab sample data associated with non-reference biology samples in 71e that scored on the Good or Excellent on the Macroinvertebrate Bioassessment Index (MBI). This set had fewer samples than the reference set above and substantial overlap, producing similar numbers as above.

DOW conducted focused data collection in 71e and 71g Ecoregions in 2010 (Pennyroyal Nutrient Project). MBI scores and component metrics from this project showed strong associations with TP and TN in many cases, with thresholds in the range of 0.030-0.040 mg/L TP and 2-3 mg/L TN. However, thresholds in MBIs and metrics usually corresponded to ecoregion as well as being associated with higher nutrient concentrations. It is not clear if these regions should be assumed to have similar response along the continuous gradient observed in the combined data.



Literature-Based Thresholds

Literature guidelines for the boundary between oligotrophic and mesotrophic conditions are TP 0.025 mg/L and TN 0.700 mg/L. The boundary between mesotrophic and eutrophic conditions are given as TP 0.075 mg/L and 1.5 mg/L. Reference Reaches and watershed reference data summarized above suggest 71e streams that support healthy aquatic communities are in the mesotrophic range for TP but well above the eutrophic boundary for TN. In this case, trophic boundaries are minimally useful in guiding benchmark recommendations.

APPENDIX D
PROPOSED WATERSHED COUNCIL

Name			Title	Organization / Business	LRWQC	Tech Adv	Address	Phone	Email
Mr.	David	Brame	Owner	Brame Farms Inc	x		7900 Striped Bridge Road, Hopkinsville, KY 42240	(270) 8858832	Davidbrame1952@gmail.com
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Name			Title	Organization / Business	LRWQC	Tech Adv	Address	Phone	Email
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APPENDIX E
EDUCATIONAL AND PROMOTIONAL PIECES

What's the science say?

The Little River Basin includes two major headwater tributaries, the South Fork Little River (SFLR) and the North Fork Little River (NFLR), both of which have been listed by the Kentucky Division of Water in the 303(d) List of Waters for Kentucky Report to Congress as impaired by pathogens (fecal contamination), nutrients (phosphorus and nitrogen), and sediment.

The high levels of pathogens in the waters result in impairment for the primary contact recreation use (*i.e.* swimming). The high levels of nutrients and sediment contribute to impairment of the streams as warmwater aquatic habitat (*i.e.* aquatic life).

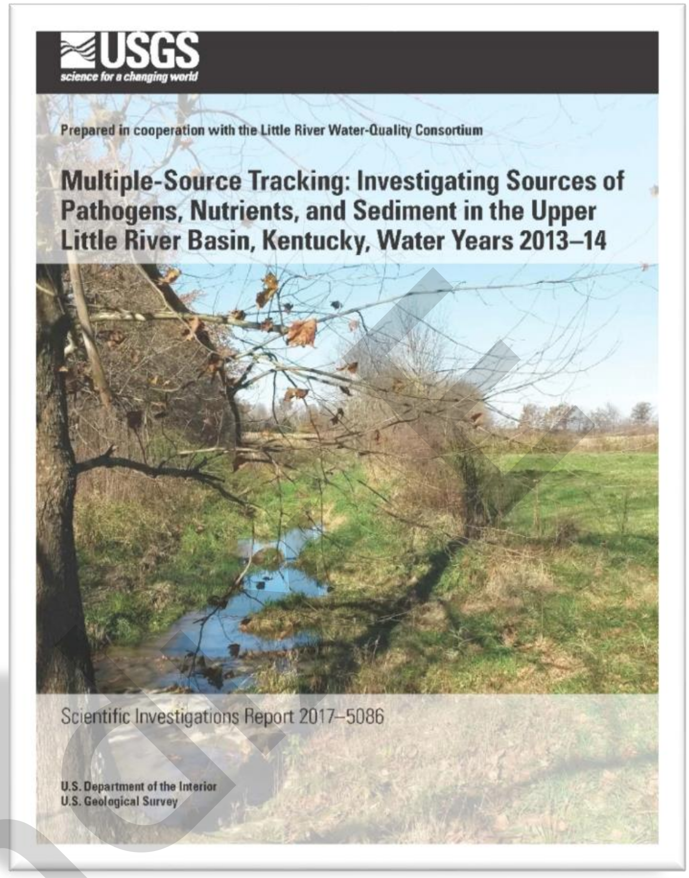
In 2009, the Kentucky Division of Water developed a pathogen Total Maximum Daily Load (TMDL) for the Little River Basin including the SFLR and NFLR tributaries. Future nutrient and suspended-sediment TMDLs are planned once nutrient criteria and suspended-sediment protocols have been developed for Kentucky.

In cooperation with the Little River Water Quality Consortium and Kentucky Division of Water, the United States Geological Survey (USGS) conducted a three-year study in the Upper Little River Basin.

The objective was to aid in understanding the occurrence and distribution of pathogens, nutrients, and sediment and their potential sources within the headwaters of the Little River Basin.

The SFLR was the primary focus of the study because of the higher percentage of cropland and increasing number of small dairy operations in the basin.

The SFLR watershed is a 67.4 square mile (43,200 acres) watershed located primarily in Christian county, but partially extending into Todd county. The watershed contains developed areas of Hopkinsville, extensive agricultural areas, and some forested land.



USGS utilized advanced scientific techniques to determine the relative pollutant contributions of different sources. The findings were published in September 2017 and are summarized as follows:

- *During high flow conditions*, nitrogen in soils was the dominant source of nitrogen in streams; *during low flow conditions*, manure and human waste were the dominant source.
- Stream bank erosion contributes the largest proportion of fine sediment to streams in the SFLR basin, followed by cropland and riparian-zone areas, respectively.
- Ruminant sources (cows and horses) were the most prominent source of pathogens in streams, but humans and dogs were also contributors.

For more information or to view the entire USGS Report, visit www.thirdrockconsultants.com\lrwqc.

Funding provided, in part, by a grant from the U.S. Environmental Protection Agency to the Kentucky Division of Water as authorized by the Clean Water Act Amendments of 1987, Section §319(h) Nonpoint Source Implementation Grant # PPG 95469714.

Where does your water shed?

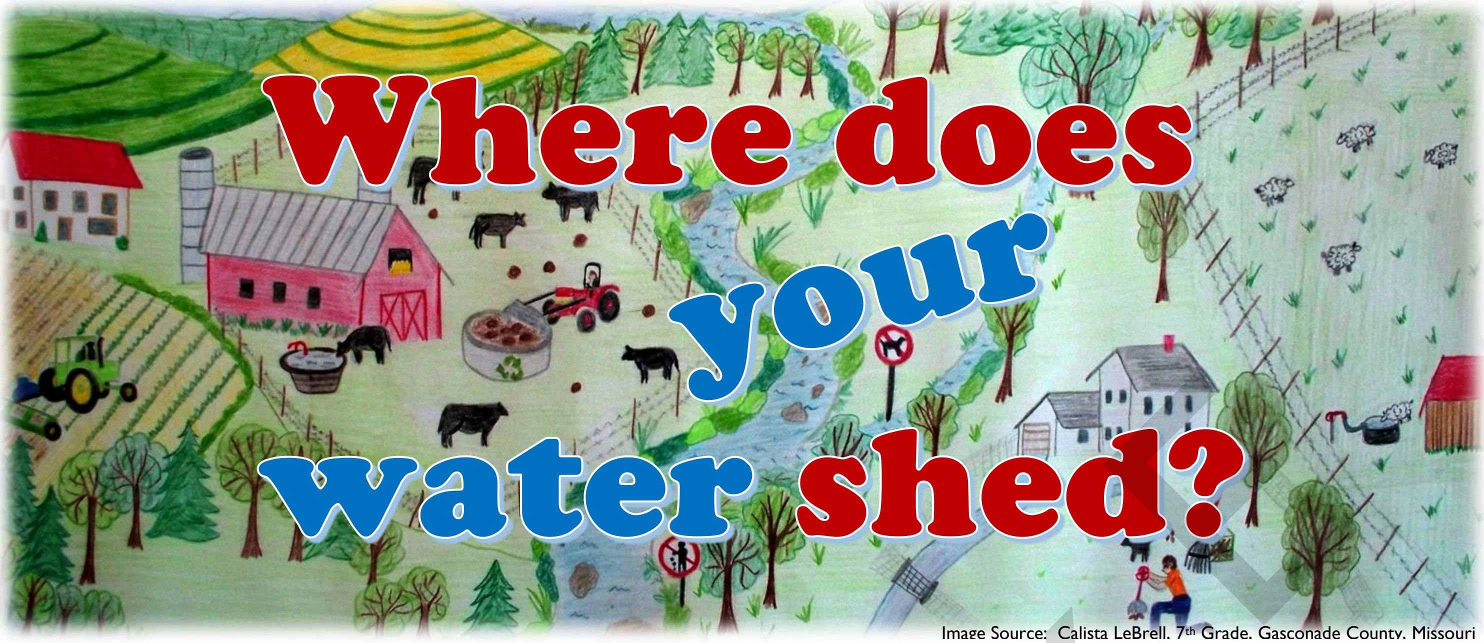


Image Source: Calista LeBrell, 7th Grade, Gasconade County, Missouri

The Little River Watershed runs right through the heart of Christian County - your county. It includes the South Fork and North Fork of the Little River, both of which have been listed by the Kentucky Division of Water as impaired by pathogens (fecal contamination), nutrients (phosphorus and nitrogen), and sediment, making them unsafe for recreational use (such as swimming) and unable to support aquatic habitat.

In 2011, members of the agriculture community joined forces with the Hopkinsville Surface and Stormwater Authority, Water Environment Authority, and City Council and the Christian County Fiscal Court to form the Little River Water Quality Consortium (LRWQC). LRWQC has since addressed the problems in the watershed head-on, initiating voluntary water quality monitoring and securing Federal Clean Water Act funding through the Kentucky Division of Water to develop a Watershed-Based Plan for the South Fork Little River Watershed.

In 2016 LRWQC hired Lexington environmental consulting group Third Rock Consultants, LLC to develop the Plan. Once complete, the Plan will include a comprehensive assessment of the watershed and remediation strategies. Over the course of the last two years, Third Rock water quality specialists have worked closely with LRWQC, the Kentucky Division of Water, and various technical partners to turn LRWQC's vision into a reality. The planning process is underway. Based upon Third Rock's assessment of the watershed, a strategy to implement best management practices (BMPs) to remediate the watershed has been drafted.

So, what's a BMP? The term "Best Management Practices," or BMPs, was coined nearly 35 years ago to describe acceptable practices that can be implemented to protect water quality and promote soil conservation. A BMP can be a structural "thing" that's installed on-the-ground, such as a silt fence or stream buffers and groundcover vegetation over bare soil areas. Or, a BMP can be part of the "process" used to plan and conduct your business or farming operation.

Third Rock has identified the most appropriate BMPs to serve as tools in LRWQC's toolbox to address water quality problems in the watershed. At this point, *they need your help*. Specifically, they need your input, suggestions, and feedback. Would you be willing to install a BMP on your property? Or agree to incorporate BMPs into your farming operation? Or help LRWQC spread the word, make contacts, and engage as many as possible in the watershed?

Log onto www.thirdrockconsultants.com\lrwqc today to see what's happening in your watershed. Join the mailing list, give your feedback, engage in the process. Together, we can turn LRWQC's vision into a reality!

Funding provided, in part, by a grant from the U.S. Environmental Protection Agency to the Kentucky Division of Water as authorized by the Clean Water Act Amendments of 1987, Section §319(h) Nonpoint Source Implementation Grant # PPG 95469714.

What can you do?

Our Goal	The Causes	How do we get there?
Decrease in-stream bacteria levels to allow for safe recreational use	• Manure use and management • Livestock grazing / pasture • Wildlife and other sources • Septic system failure • Sanitary sewer failure	• Draft or update an **Agricultural Water Quality** and **Nutrient Management Plans** • Implement **agricultural BMPs** • Increase infiltration and reduce runoff through **stormwater BMPs** • Support and petition local efforts to study and/or **improve sanitary sewer system** to reduce unintentional pollution • Support and petition local efforts to study and/or improve sanitary sewer system to reduce unintentional pollution
Reduce in-stream nutrients (nitrogen and phosphorus) and sediment to healthy levels	• Row cropping • Stream bank erosion • Manure use and management • Livestock grazing • Septic system failure • Sanitary sewer failure	• Draft or update an **Agricultural Water Quality** and **Nutrient Management Plans** • Stabilize and/or **restore eroding stream banks** • Implement **agricultural BMPs** • Increase infiltration and reduce runoff through **stormwater BMPs** • Support and petition local efforts to study and/or improve sanitary sewer system to reduce unintentional pollution
Improve stream habitat to support a healthy aquatic ecosystem	• Narrow riparian zones • Unstable stream banks • Eroding stream banks • Livestock access to streams • Channelization and entrenchment	• **Improve the quality and width of riparian zones** by native plantings and exotic invasive treatment • Restore stream **attachment to the floodplain** and reduce channelization • Stabilize and/or **restore eroding stream banks** • **Restore stream habitat** including riffles/pools and epifaunal substrate
Restore streams to stable, natural channel conditions reducing the rate of flooding, erosion, and sedimentation	• Channelization and entrenchment • Stream bank erosion • Channel alteration including straightening and livestock access • Increased runoff from impervious surfaces in developed areas	• **Restore channel dimensions, pattern, and profile** • Restore habitat to the streams including riffles/pools and epifaunal substrate • Restore stream attachment to a floodplain and reduce channelization • Stabilize or restore eroding stream banks • Improve the quality and width of riparian zones by native plantings and exotic invasive removal • **Reduce the runoff rate from impervious surfaces** in the watershed through infiltration or storage.
Remove trash and debris clogging waterways	• Woody debris / log jams from storm damage and bank failure • Trash and litter	• Document routine locations of trash and debris accumulation • **Organize groups to remove trash** from watershed on a routine basis • Remove woody debris without disturbing the stream bed material
Educate the community about how they can help improve water quality	• Lack of information • Continuation of practices that cause or facilitate impairment	• Increase public knowledge about water quality impairments • **Perform ongoing monitoring** of stream health conditions

Funding provided, in part, by a grant from the U.S. Environmental Protection Agency to the Kentucky Division of Water as authorized by the Clean Water Act Amendments of 1987, Section §319(h) Nonpoint Source Implementation Grant # PPG 95469714.

APPENDIX A
EXHIBITS

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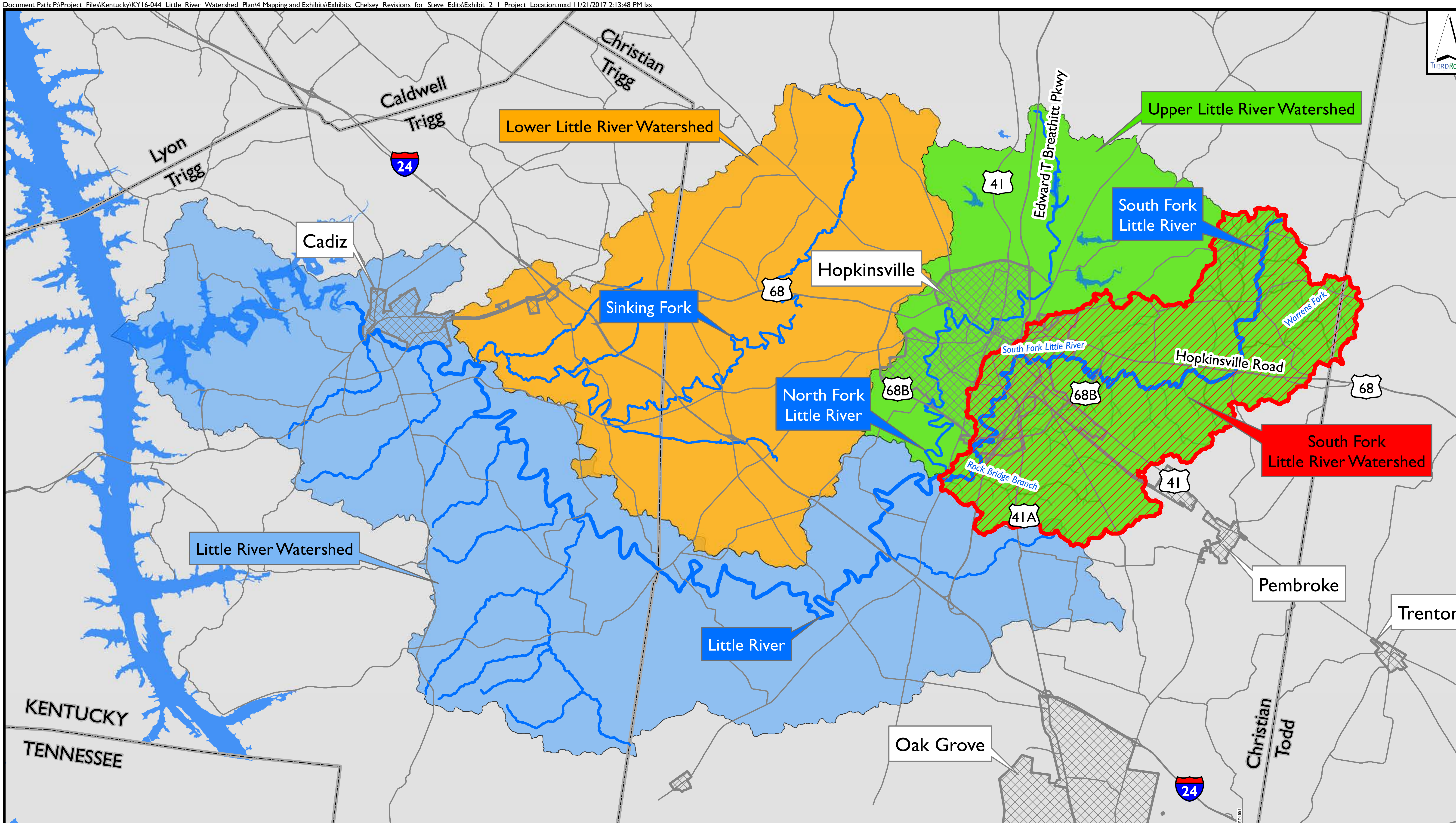


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

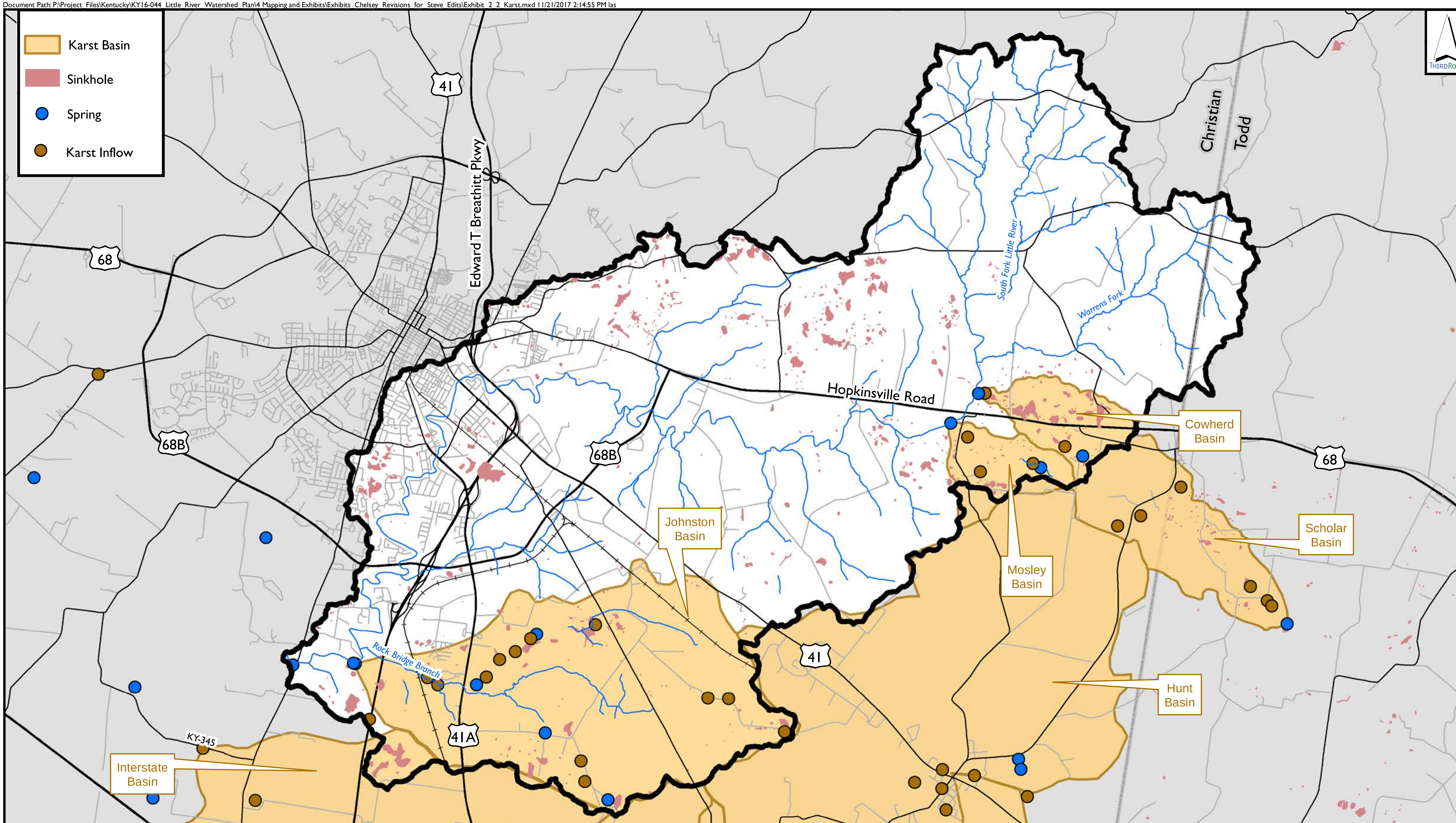
South Fork Little River Watershed	County Boundary
Lower Little River Watershed	Incorporated Boundary
Upper Little River Watershed	Street
Little River Watershed	Stream

Exhibit 1 - Project Location
South Fork of Little River Watershed Plan

0 5 10 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_2_Karst.mxd 11/21/2017 2:14:55 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

Note: Karst mapping was obtained from Kentucky Geological Survey.

Exhibit 2 - Karst
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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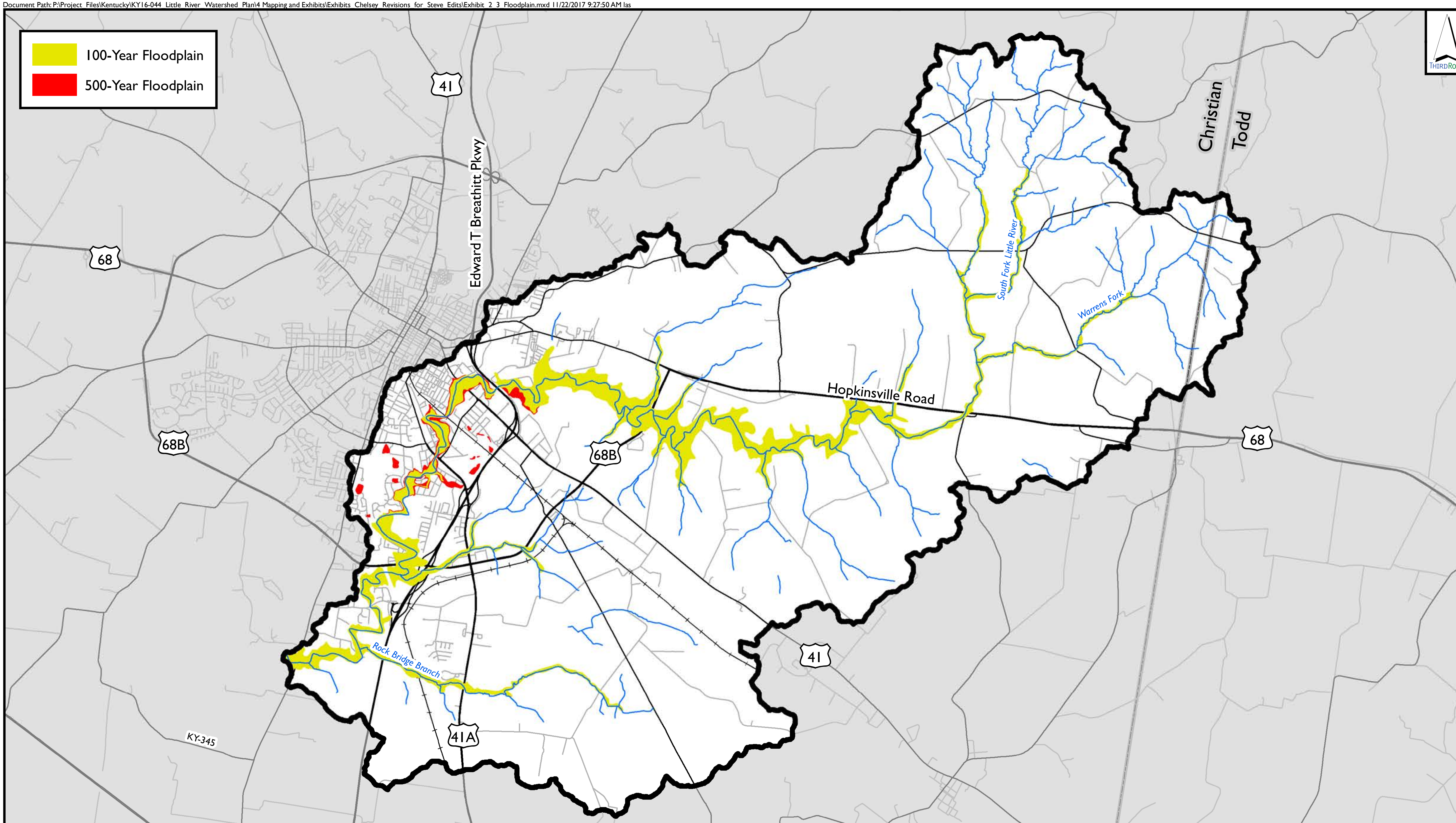


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroads
Stream

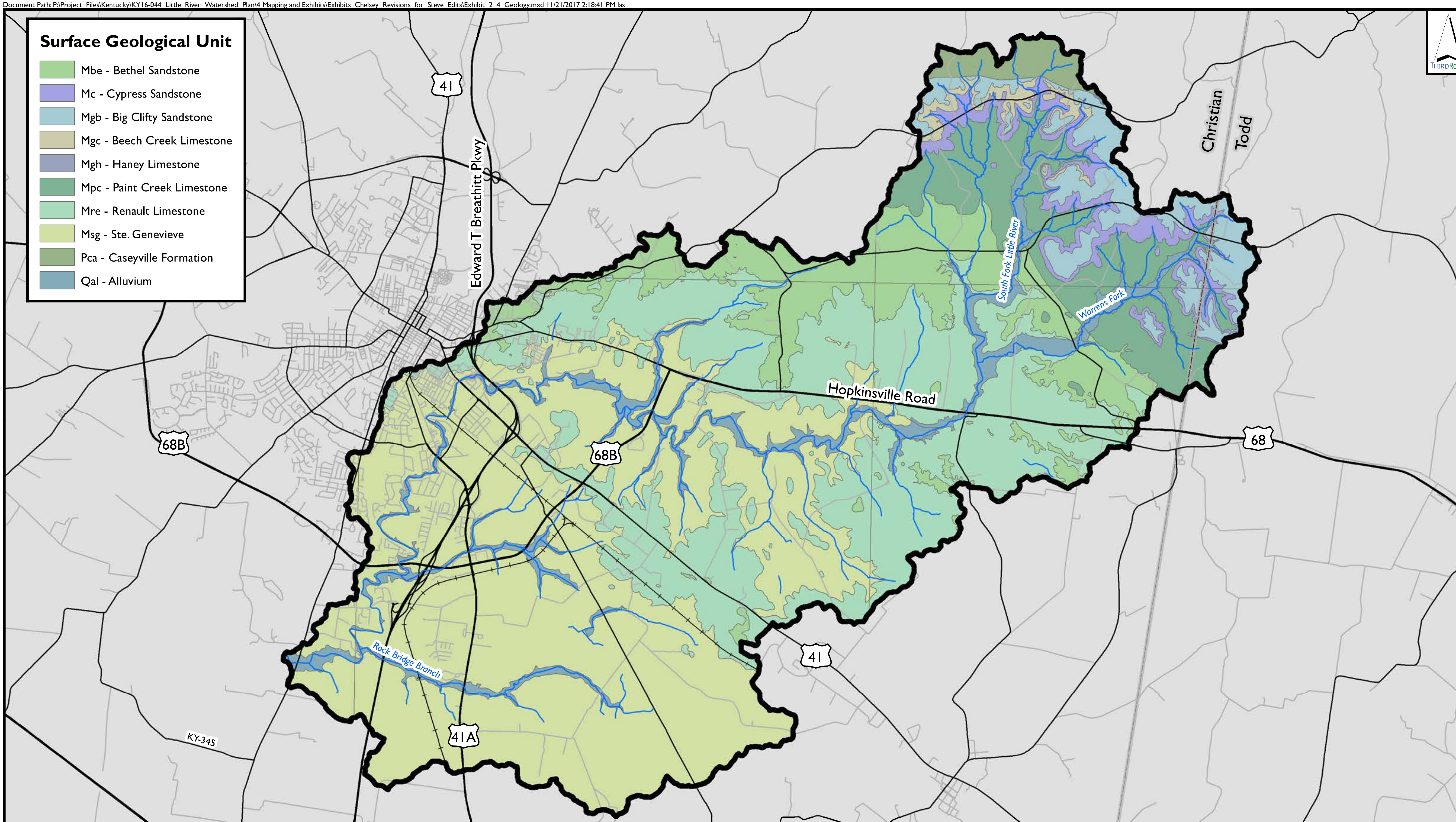
Note: Floodplain data was obtianed from FEMA.

Exhibit 3 - Floodplain
South Fork of Little River Watershed Plan

0 — 2.5 — 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_4_Geology.mxd 11/21/2017 2:18:41 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

Note: Geologic Shapefiles obtained from KGS.

Exhibit 4 - Geology
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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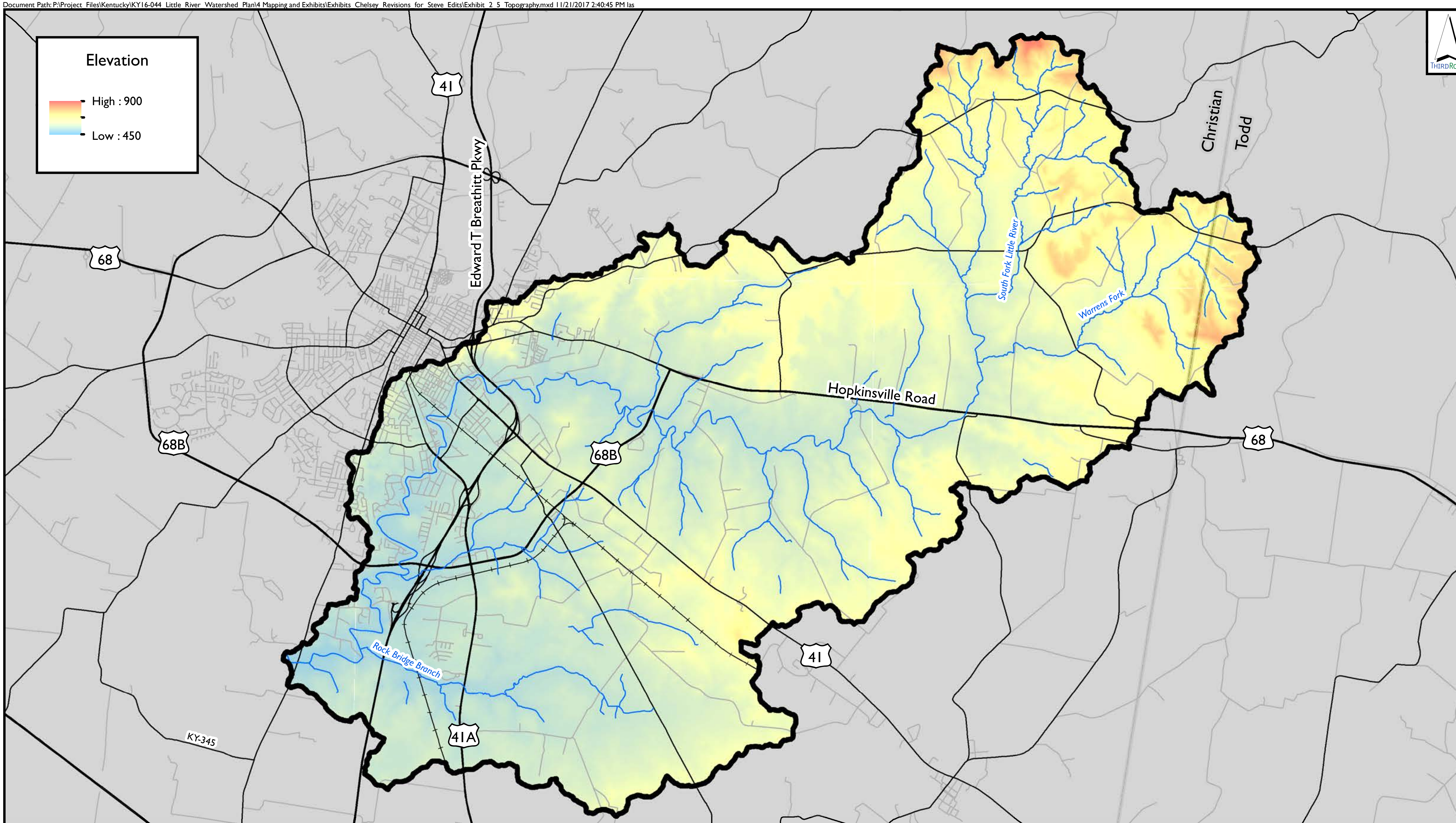


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

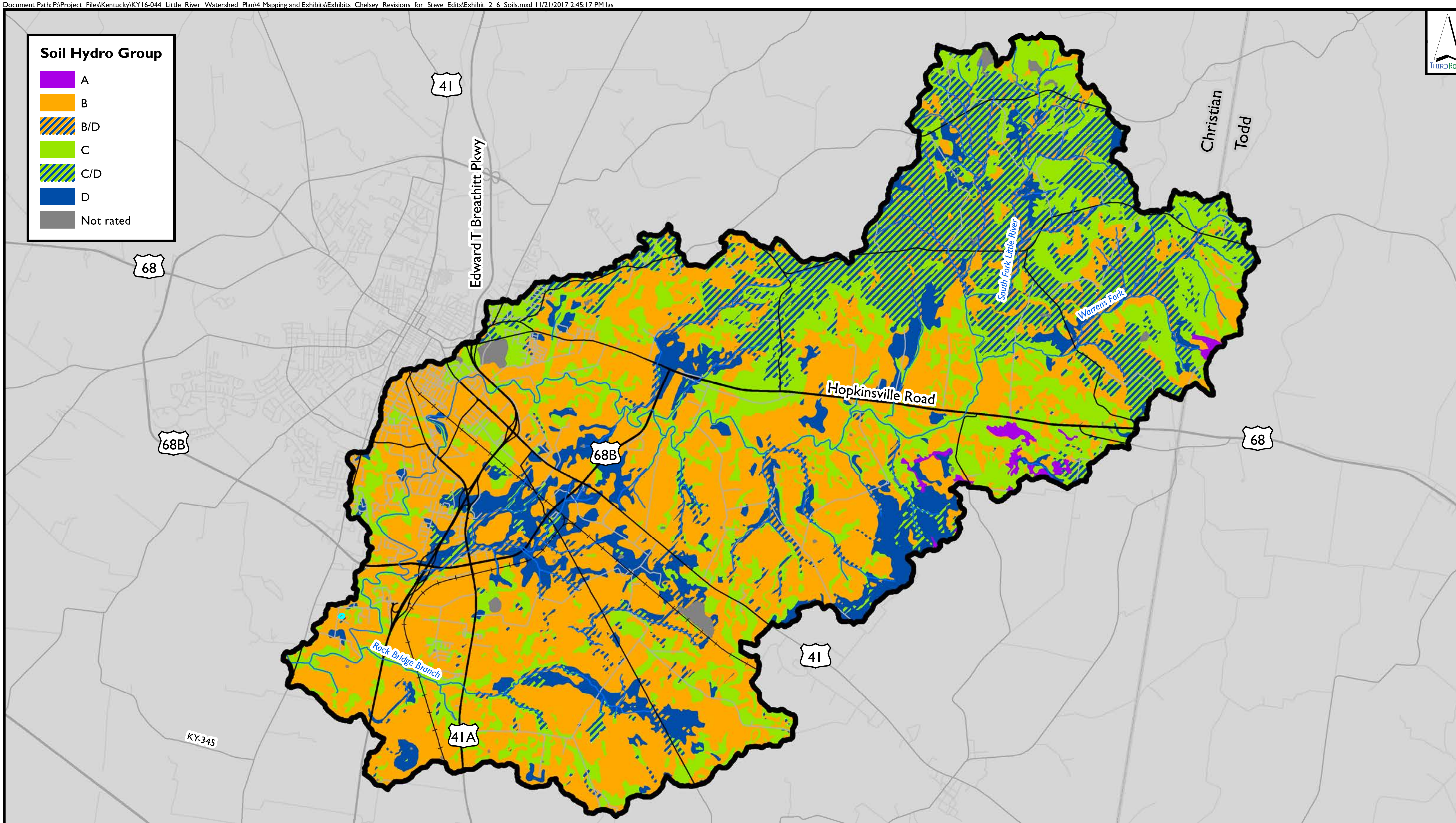
South Fork Little River
County Boundary
Street
Railroad
Stream

Note: Elevation data was obtained from the KGS.

Exhibit 5 - Topography
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Note: Soil data was obtained from the USDA/NRCS.

Exhibit 6 - Soils
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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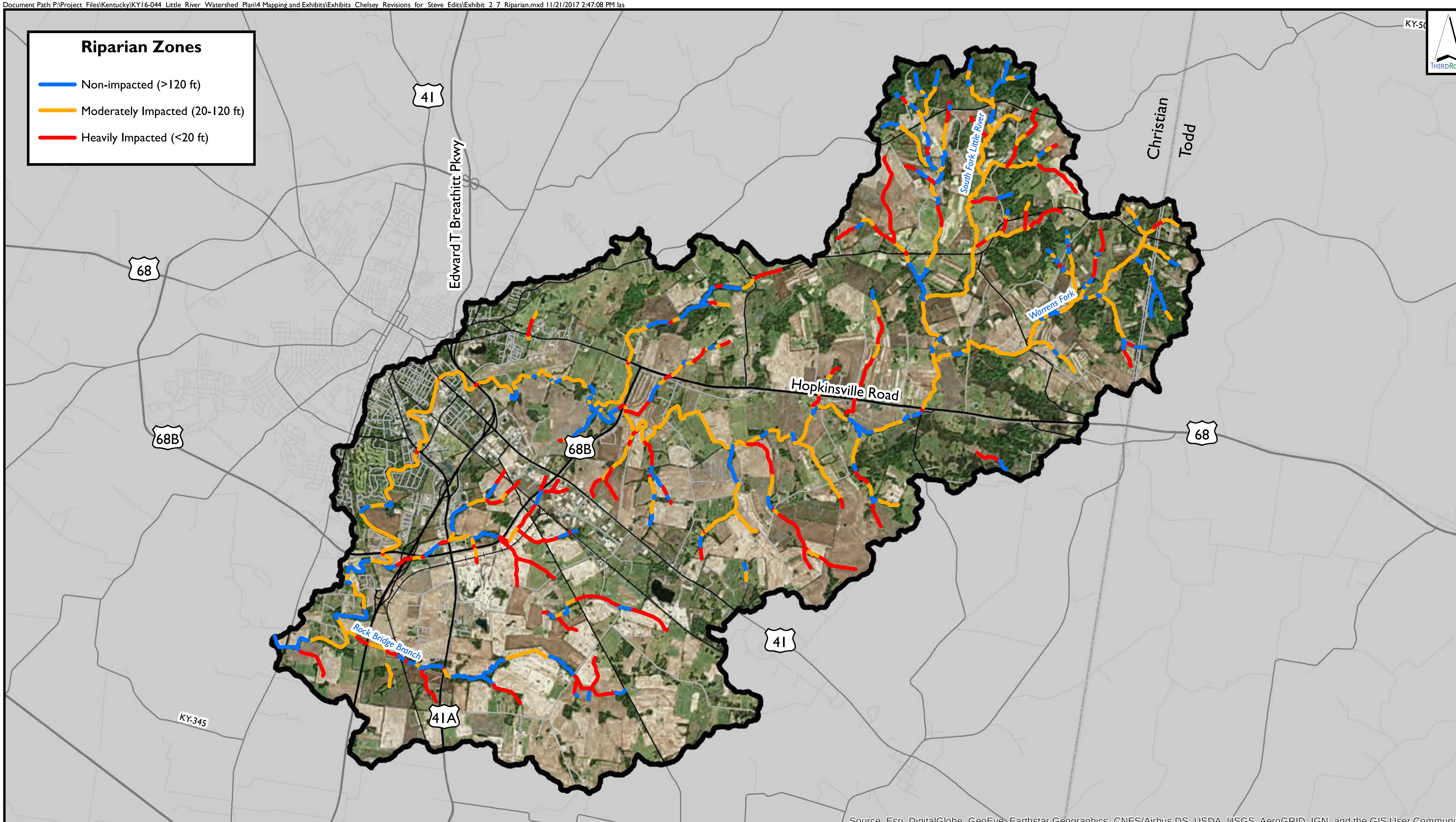


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

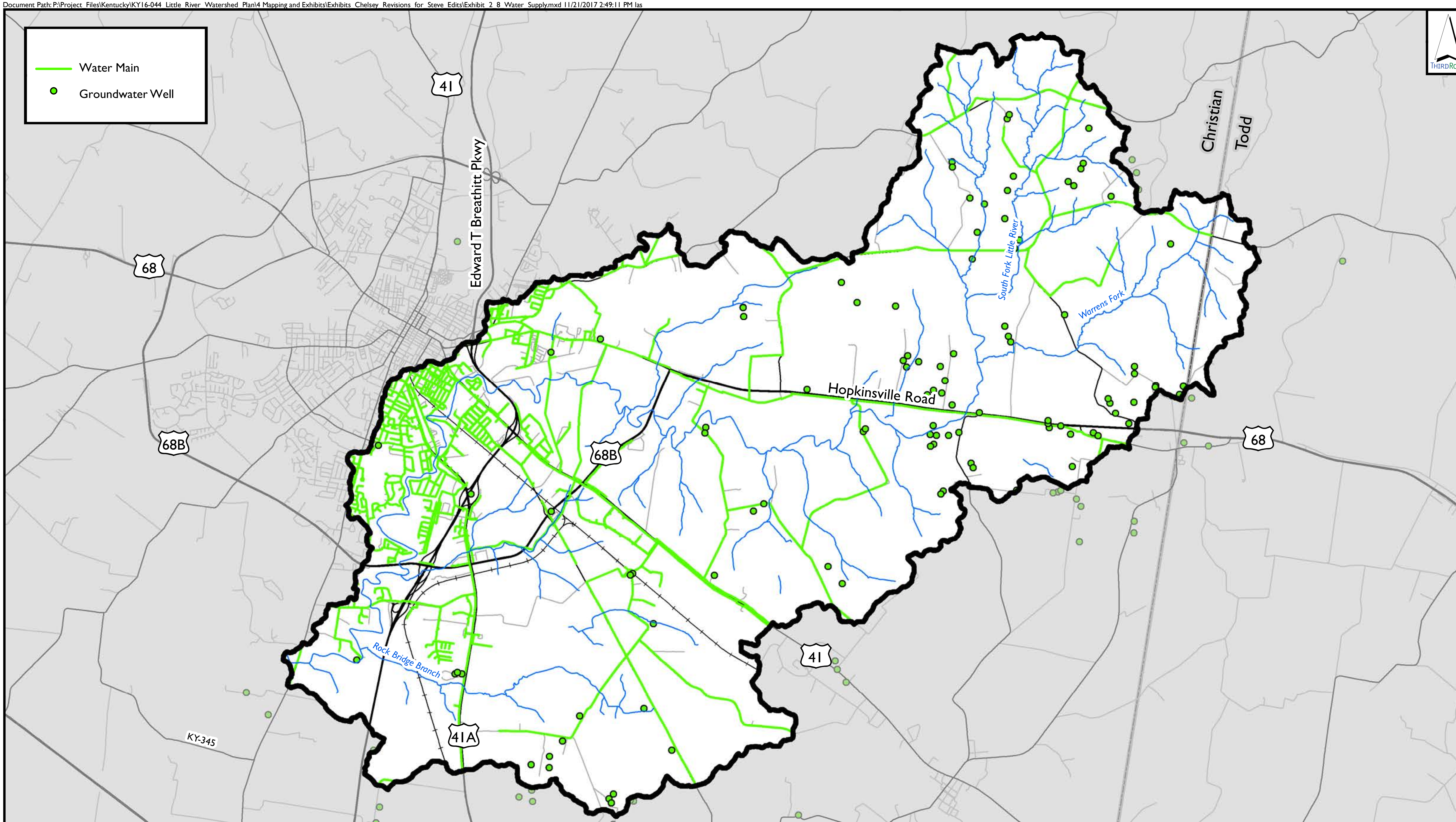
Note: Soil data was obtained from the USDA/NRCS.

Exhibit 7 - Riparian
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_8_Water_Supply.mxd 11/21/2017 2:49:11 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

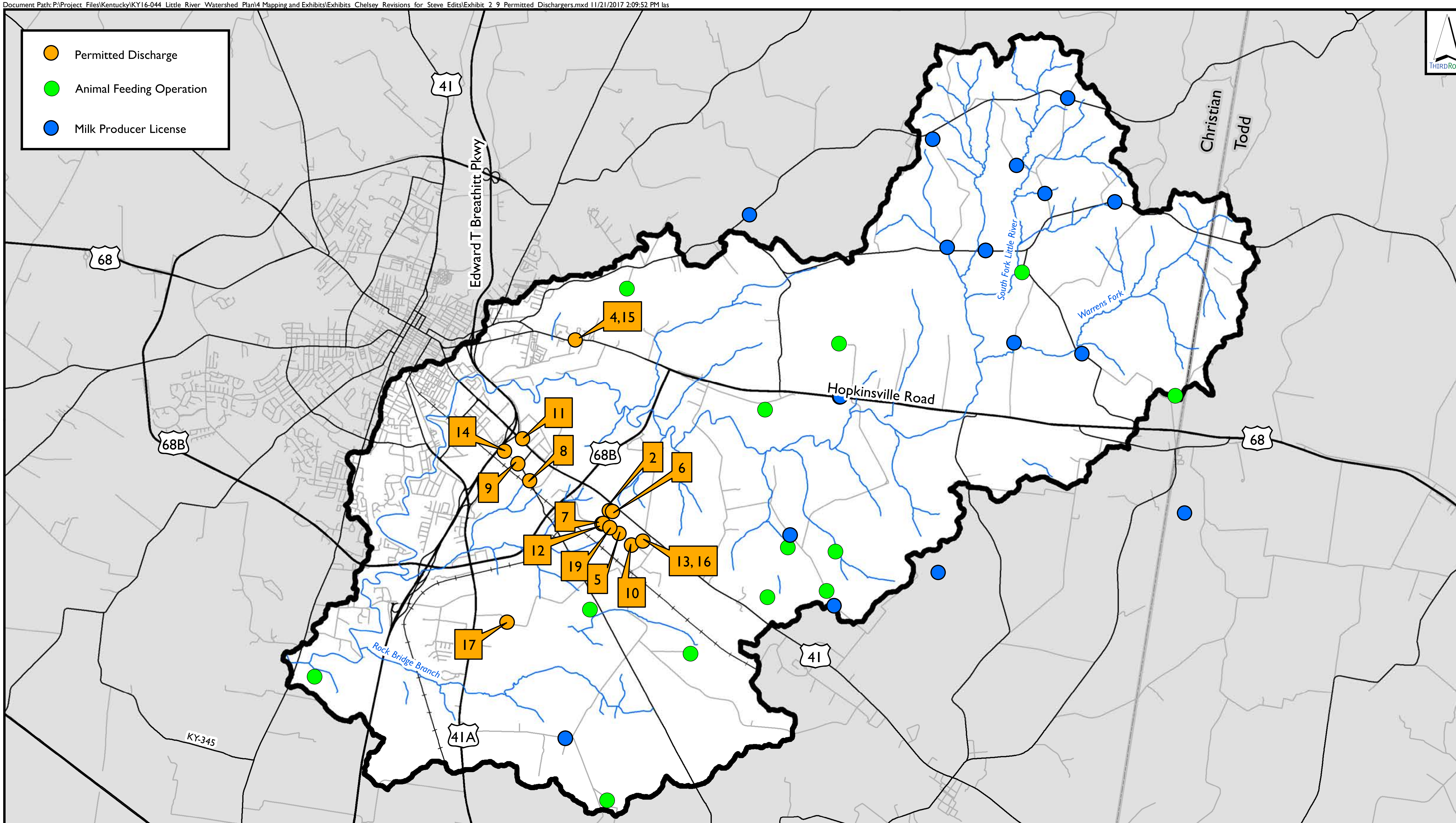
Note: Water line were obtained from HSSU. Groundwater wells from KDOW.

Exhibit 8 - Water Supply
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_9_Permitted_Dischargers.mxd 11/21/2017 2:09:52 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

Exhibit 9 - Permitted Dischargers and Other Point Sources
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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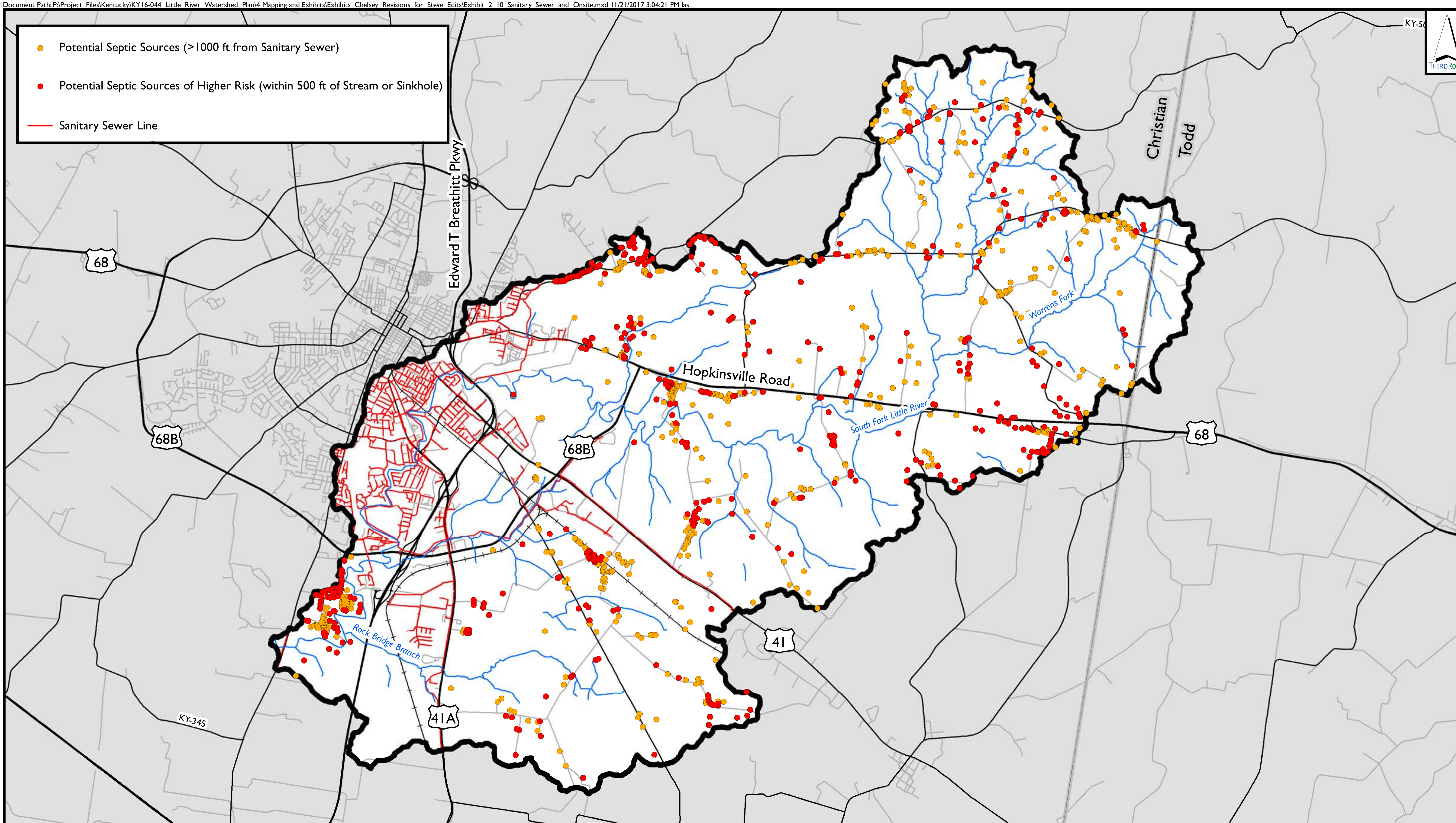

Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroad
Stream

Note: Structures and Sanitary Sewer data obtained from HSSU.

Exhibit 10 - Wastewater
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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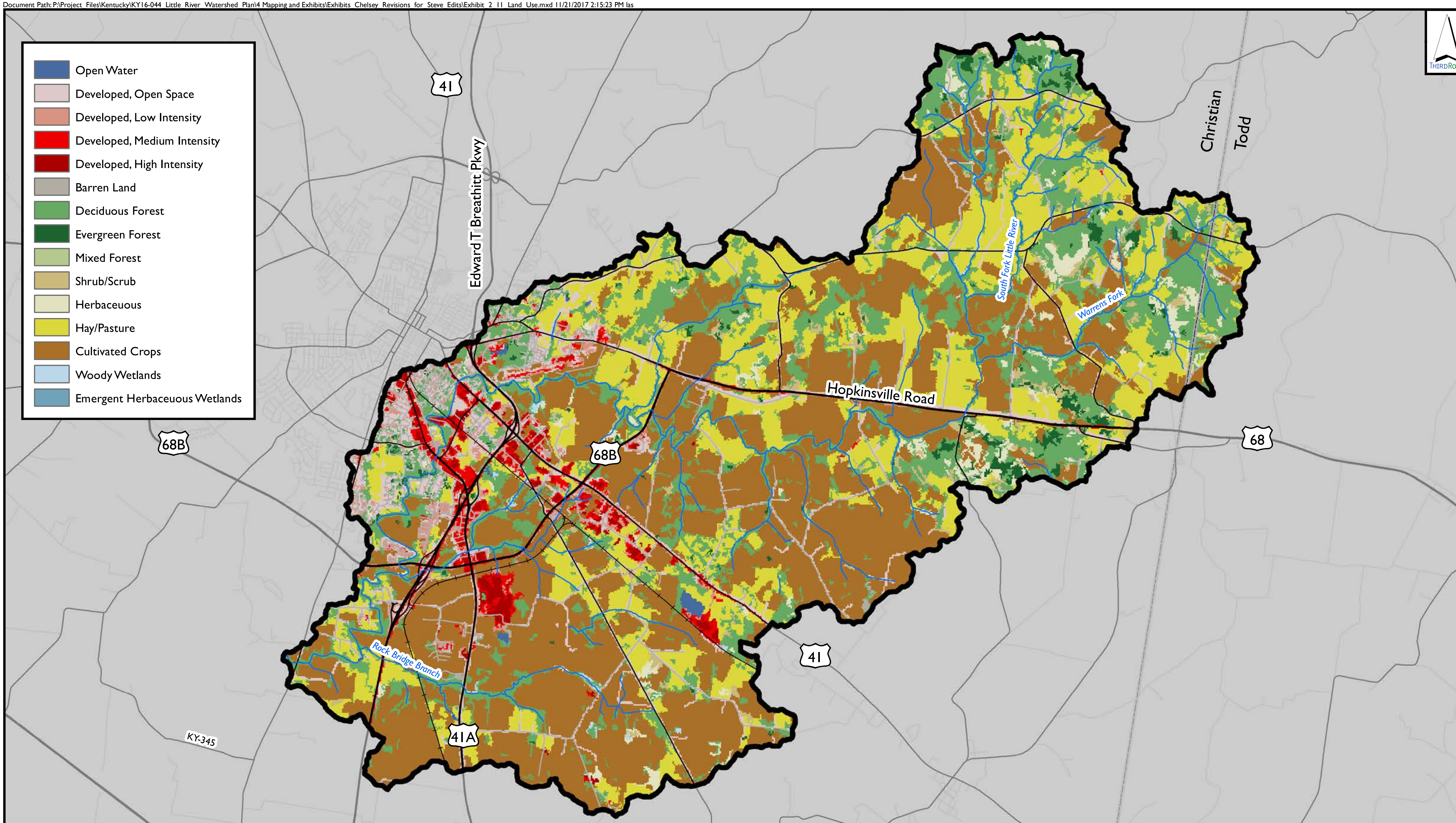


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroad
Stream

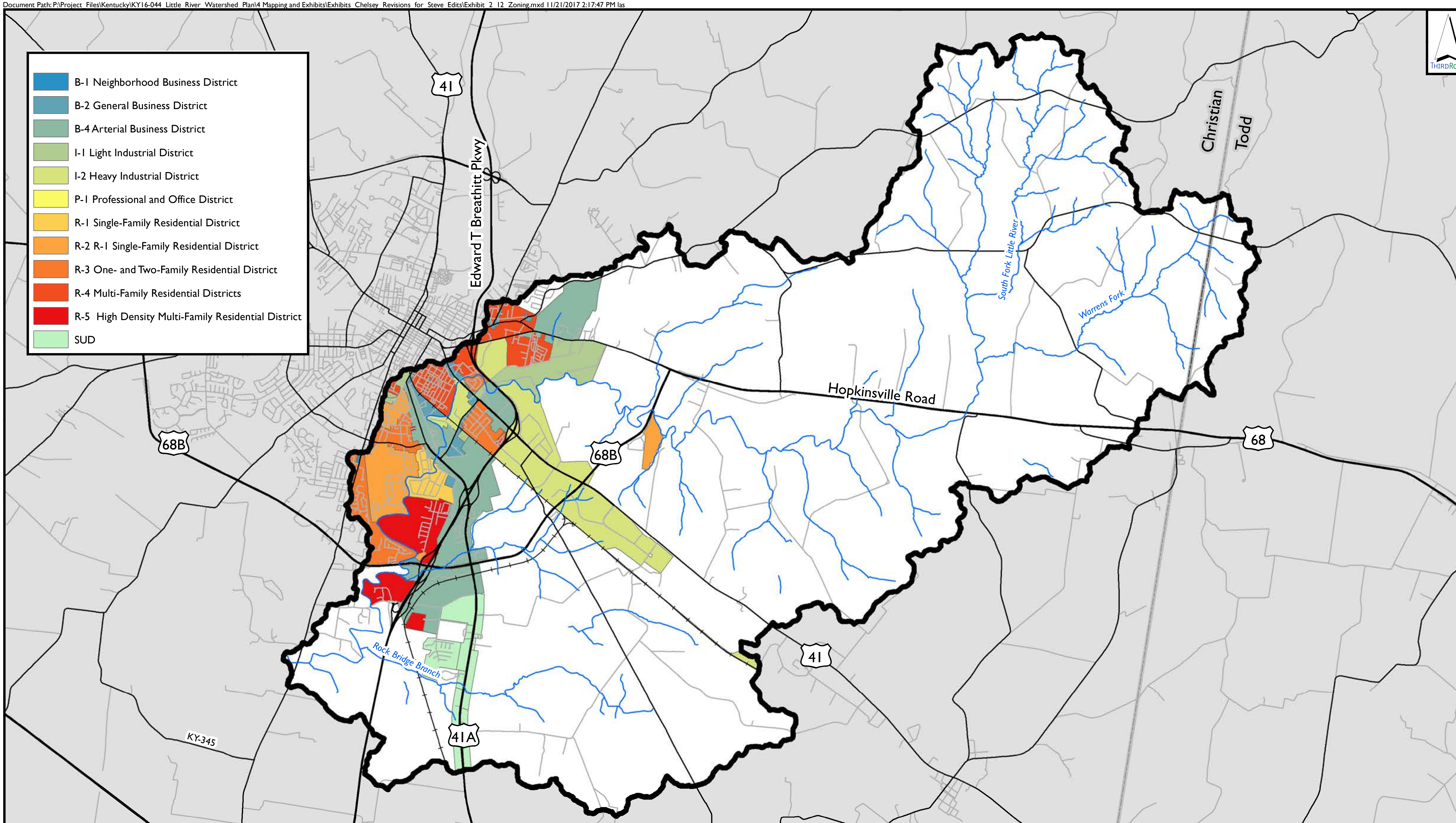
Note: Soil data was obtained from the USDA/NRCS.

Exhibit 11 - Land Use
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and
Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_12_Zoning.mxd 11/21/2017 2:17:47 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

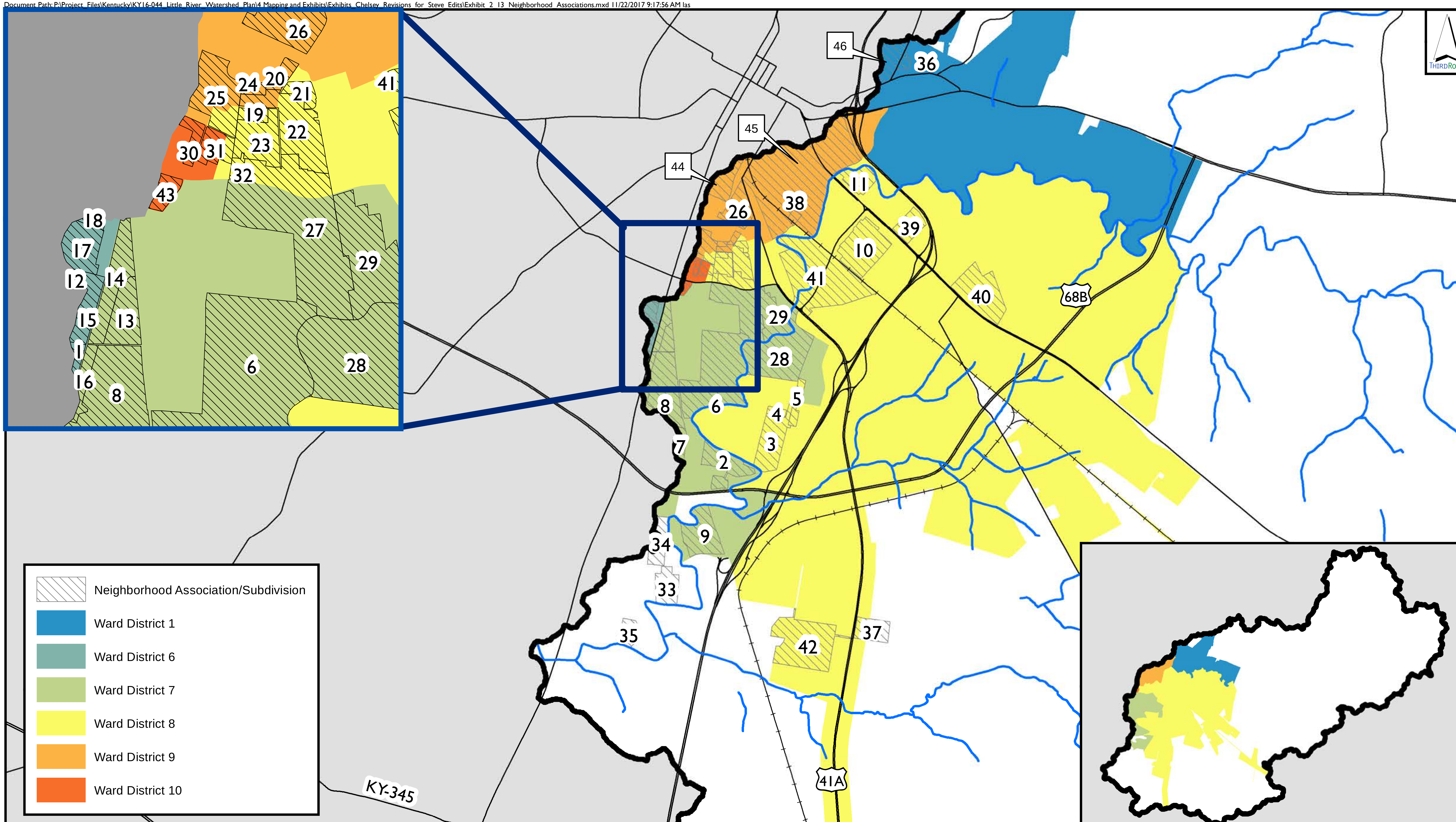
Note: Zoning shapefiles were obtained from the City of Hopkinsville.

Exhibit 12 - Zoning
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_13_Neighborhood_Associations.mxd 11/22/2017 9:17:56 AM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroad
Stream

Note: Elevation data was obtained from the KGS.

Exhibit 13 - Neighborhood Associations and Subdivisions
South Fork of Little River Watershed Plan

0 1.5 3 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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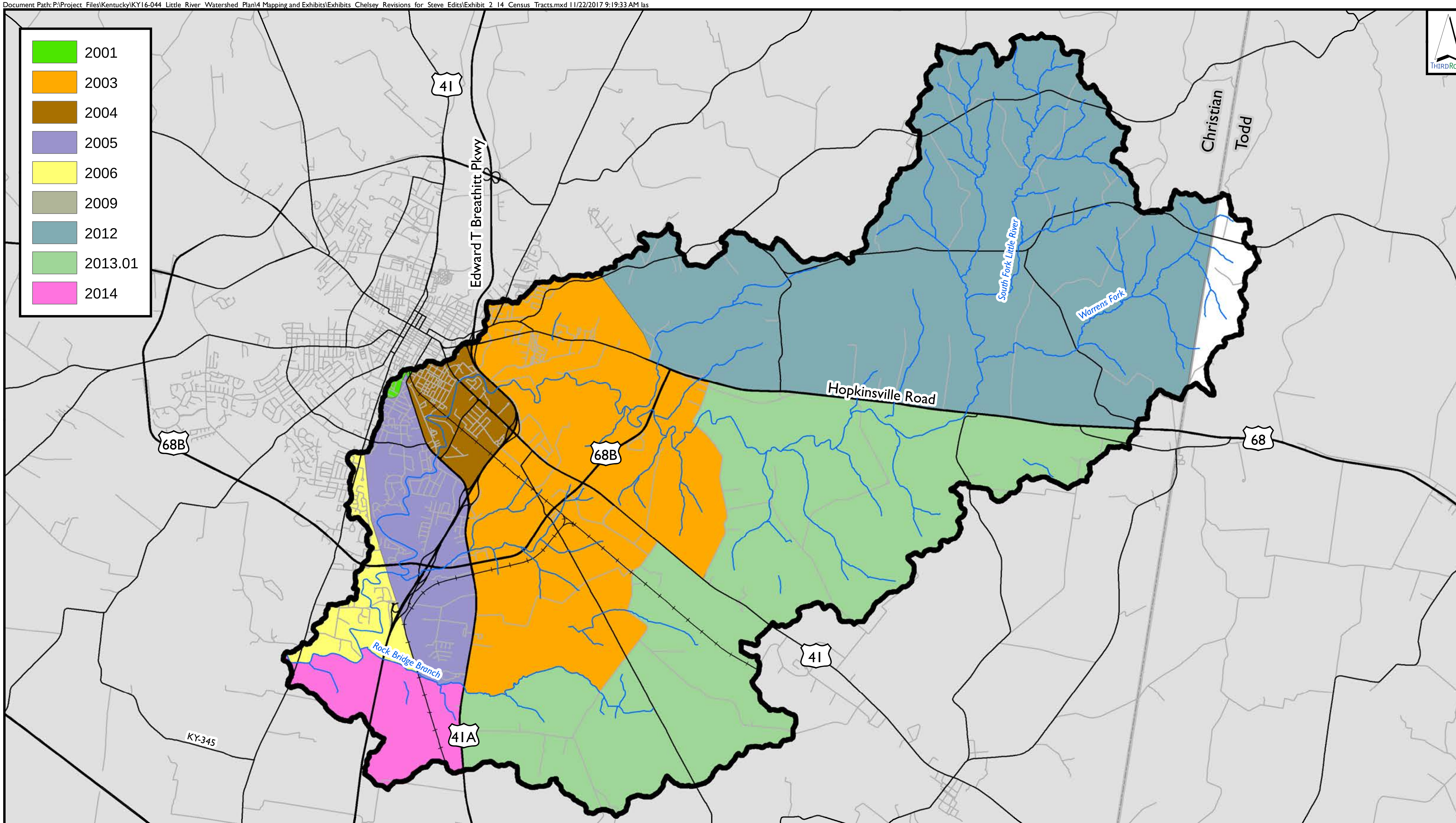

Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River — Street
County Boundary — Railroad
Stream

Note: Census tract shapefiles were obtained from the city of Hopkinsville for the 2010 census.

Exhibit 14 - Census Tracts
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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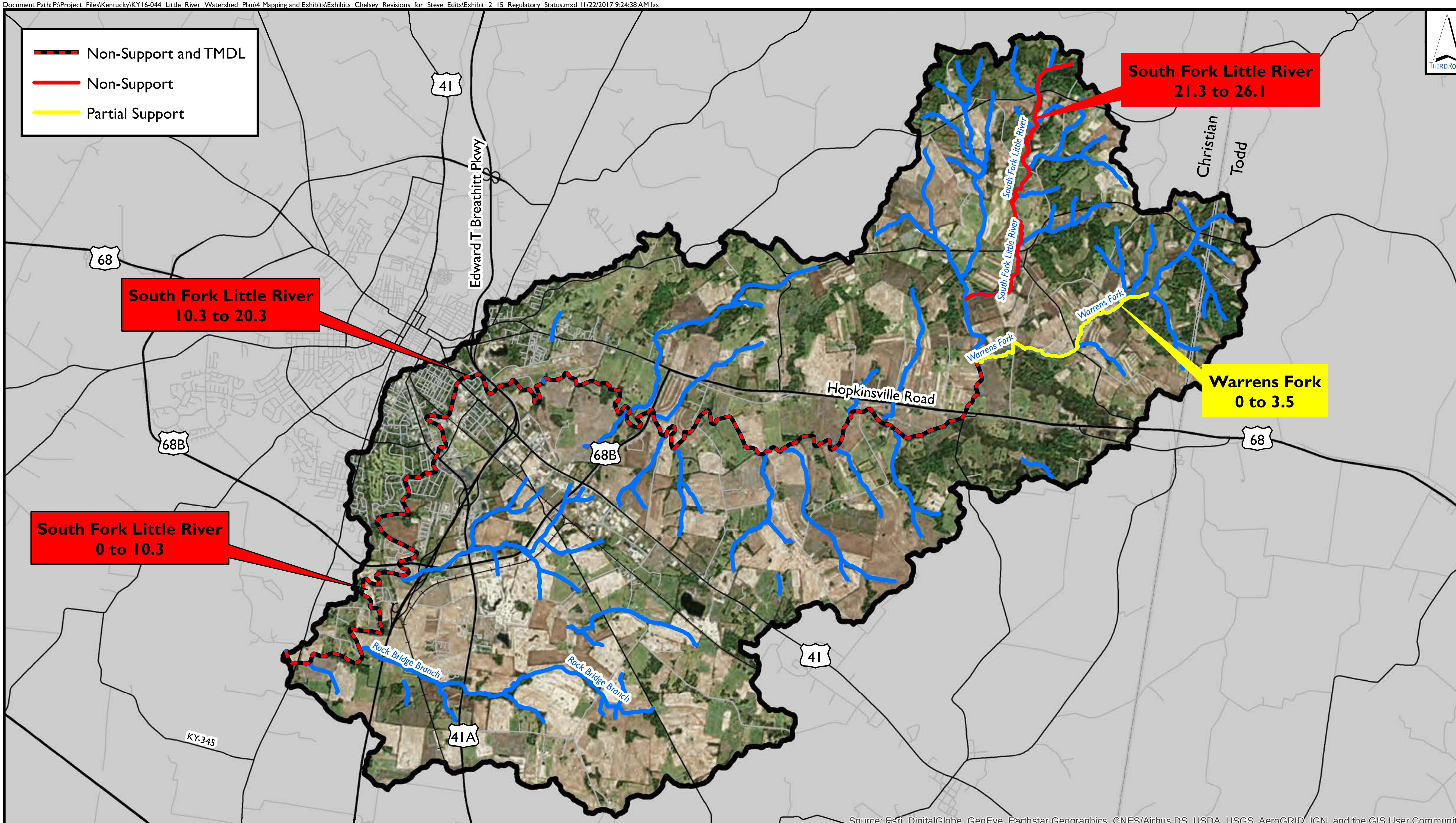


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

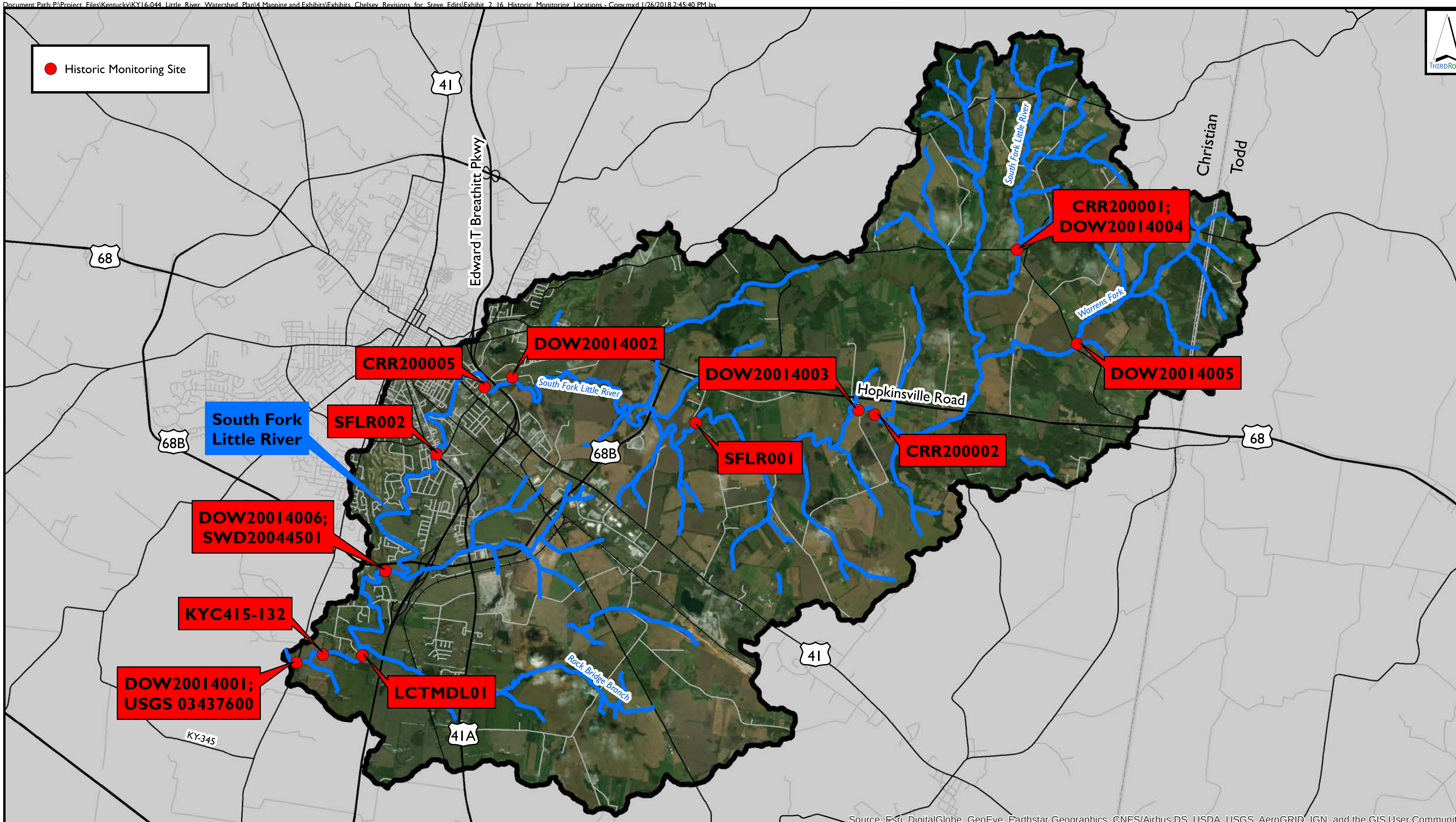
South Fork Little River
County Boundary
Street
Railroad
Stream

Exhibit 15 - Regulatory Status
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_2_16_Historic_Monitoring_Locations - Copy.mxd 1/26/2018 2:45:40 PM las



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

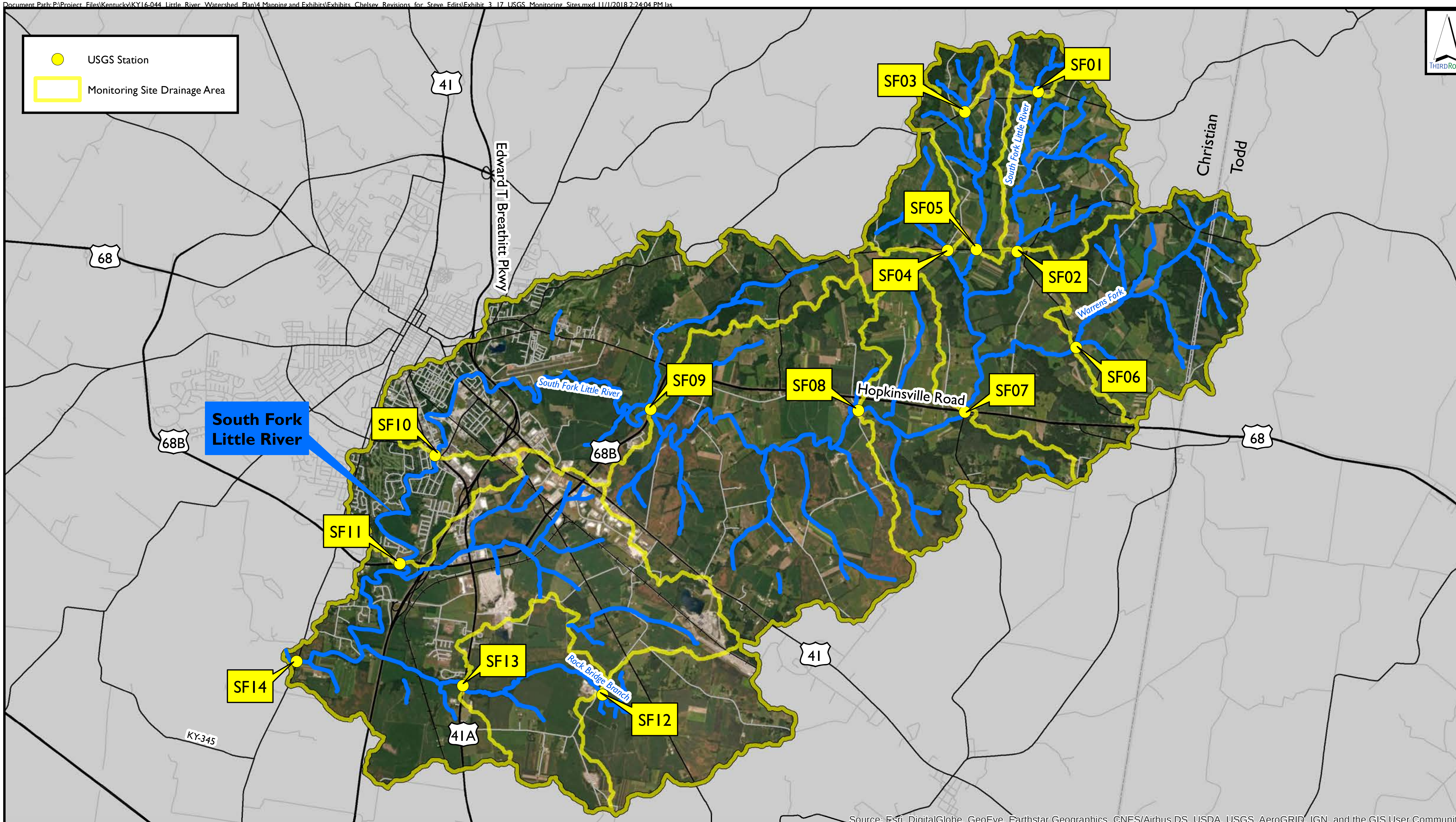
South Fork Little River
County Boundary
Street
Railroad
Stream

Exhibit 16 - Historic Monitoring Sites
South Fork of Little River Watershed Plan

0 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_3_17_USGS_Monitoring_Sites.mxd 11/1/2018 2:24:04 PM las

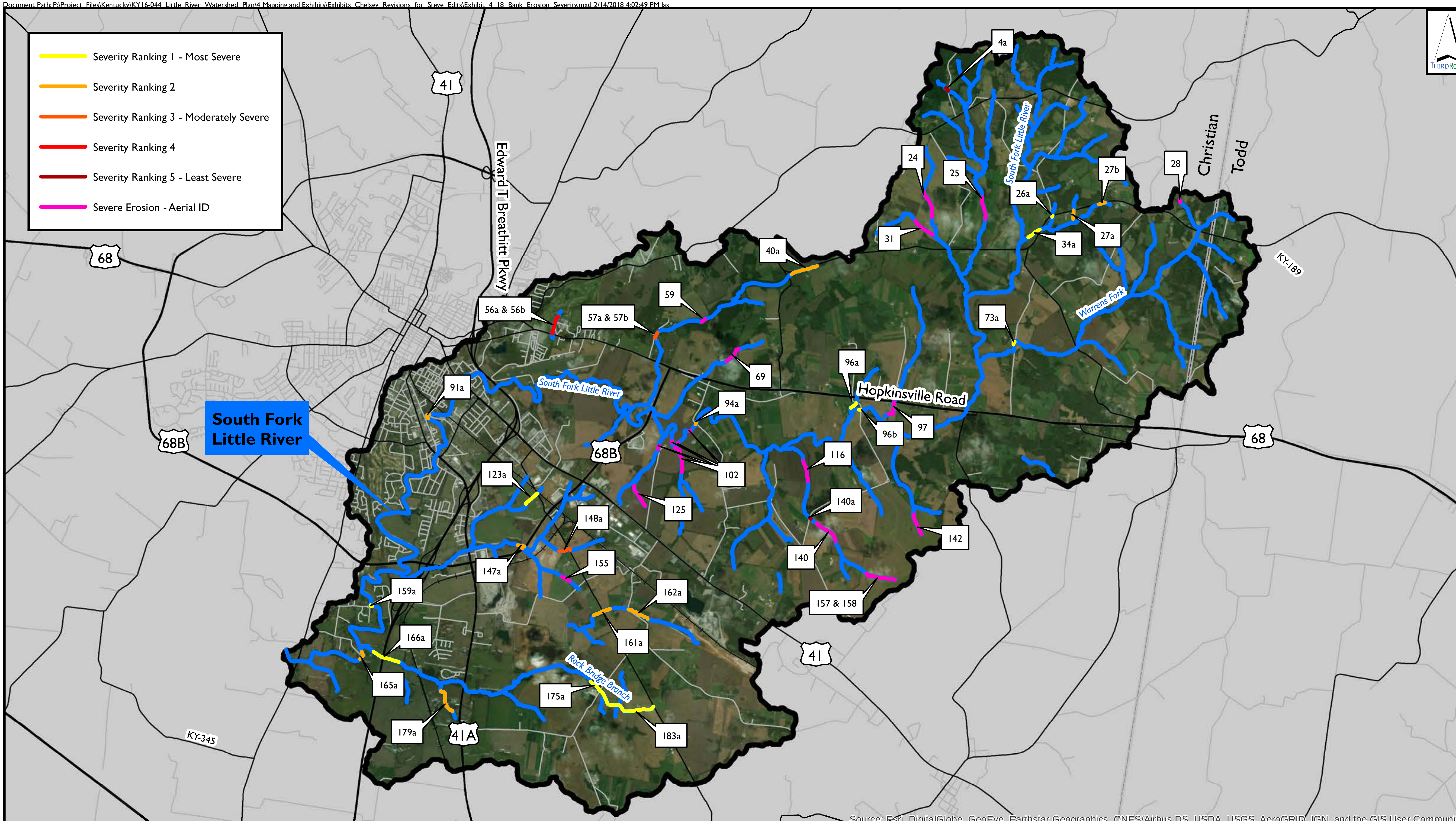


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

Exhibit 17 - USGS 2013-2014 Monitoring Sites
South Fork of Little River Watershed Plan

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_4_18_Bank_Erosion_Severity.mxd 2/14/2018 4:02:49 PM las



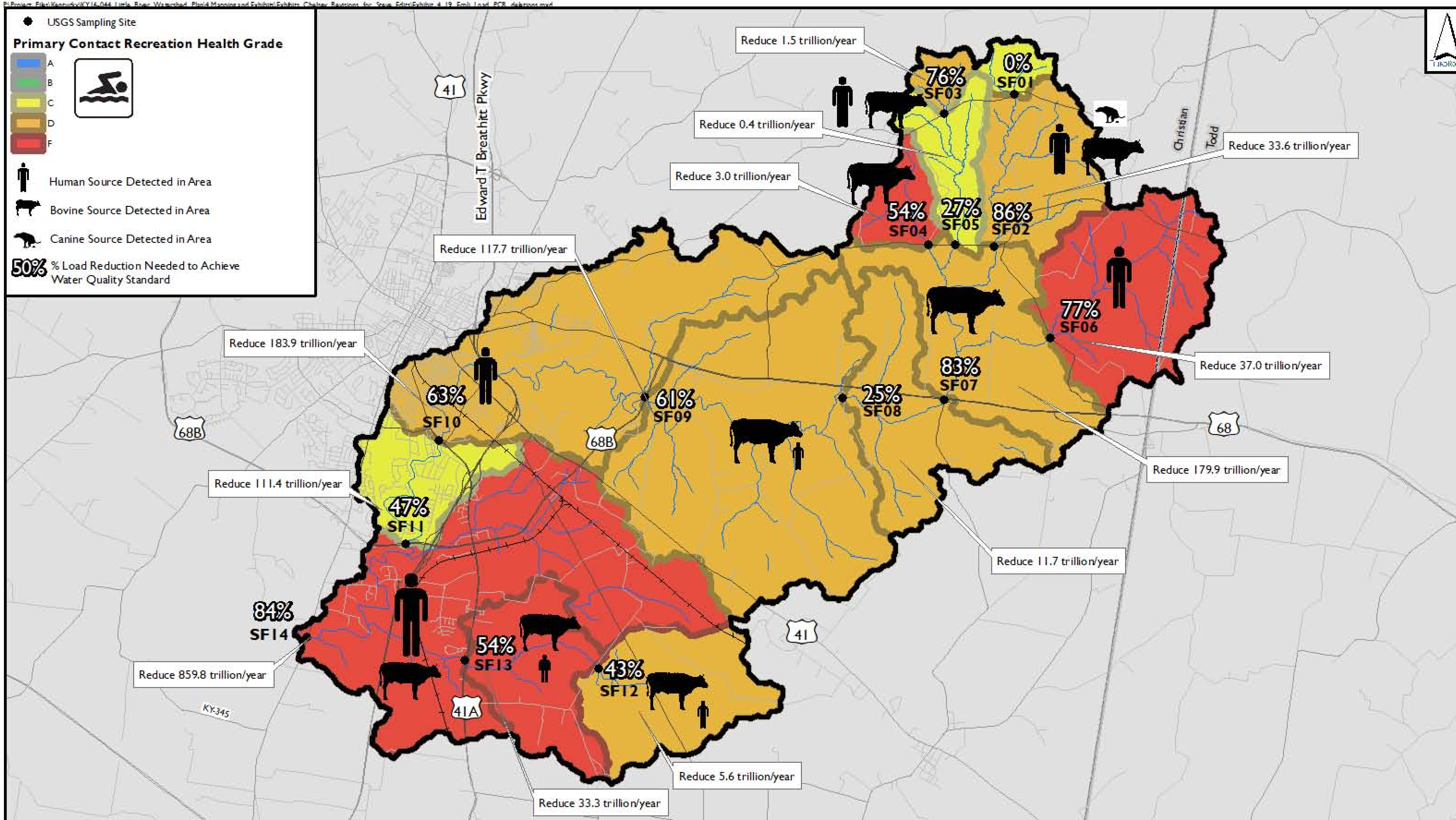
Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroad
Stream

Exhibit 18 - Locations and Severity of Known Bank Erosion
South Fork of Little River Watershed Plan

0 2.5 5 Miles

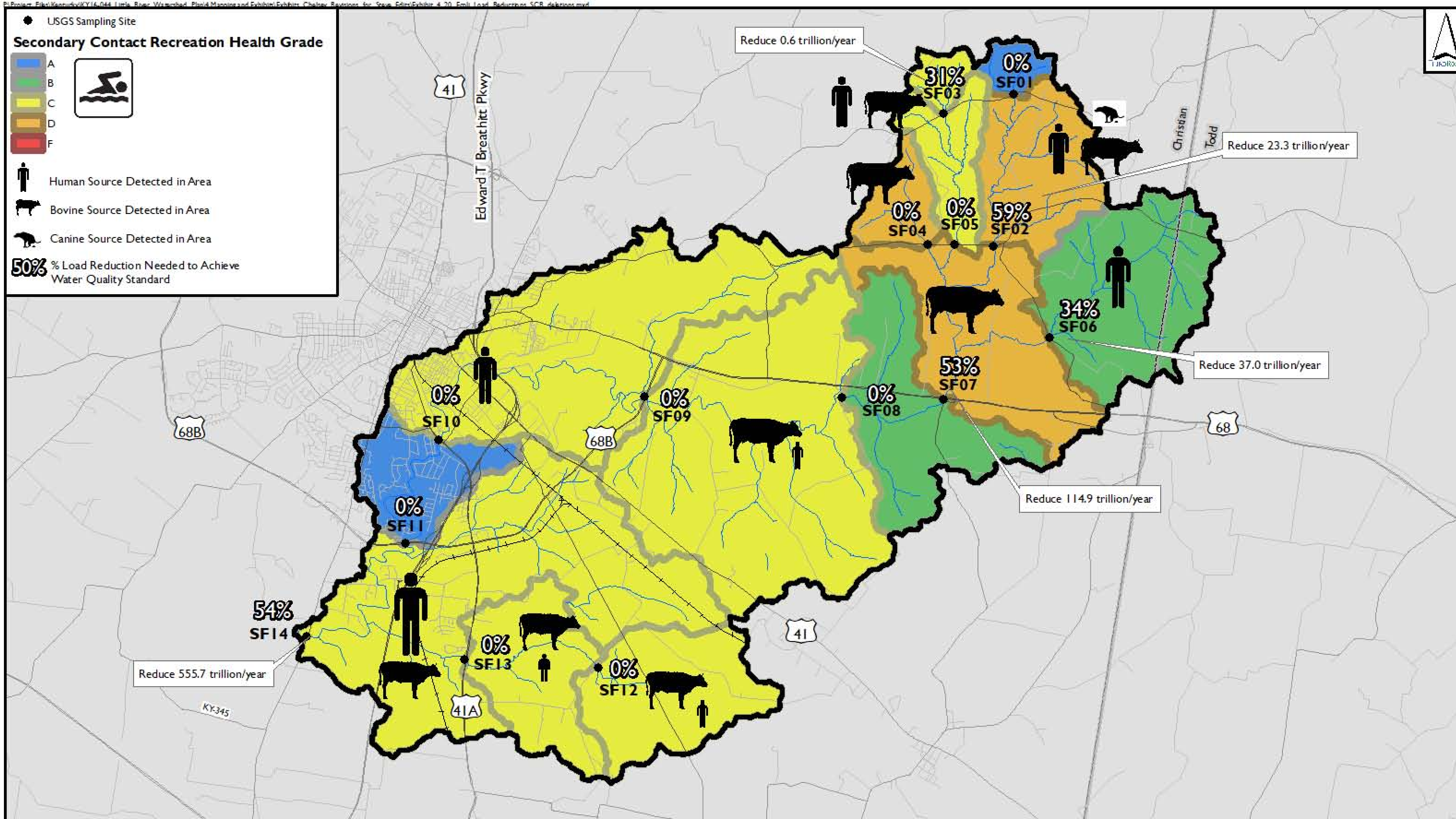
Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

Exhibit 19 - E.coli Grade and Load Reductions (PCR)
South Fork of Little River Watershed Plan

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

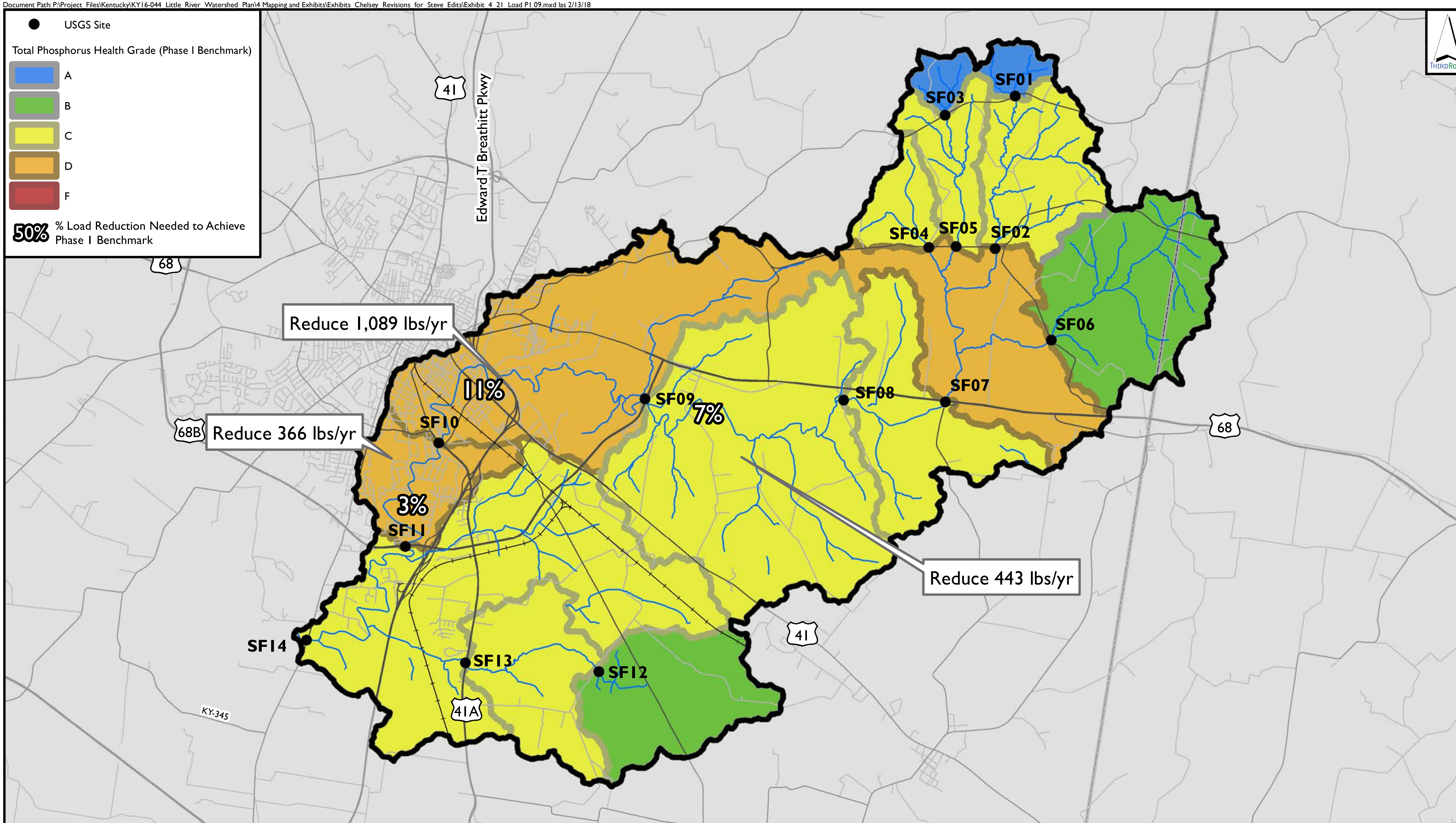
South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 20 - E.coli Grade and Load Reductions (SCR)
South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_4_21_Load P1 09.mxd las 2/13/18



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

Exhibit 21 - Total Phosphorus Grade and Load Reduction For Phase I Benchmark of 0.09 mg/L South Fork of Little River Watershed Plan

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

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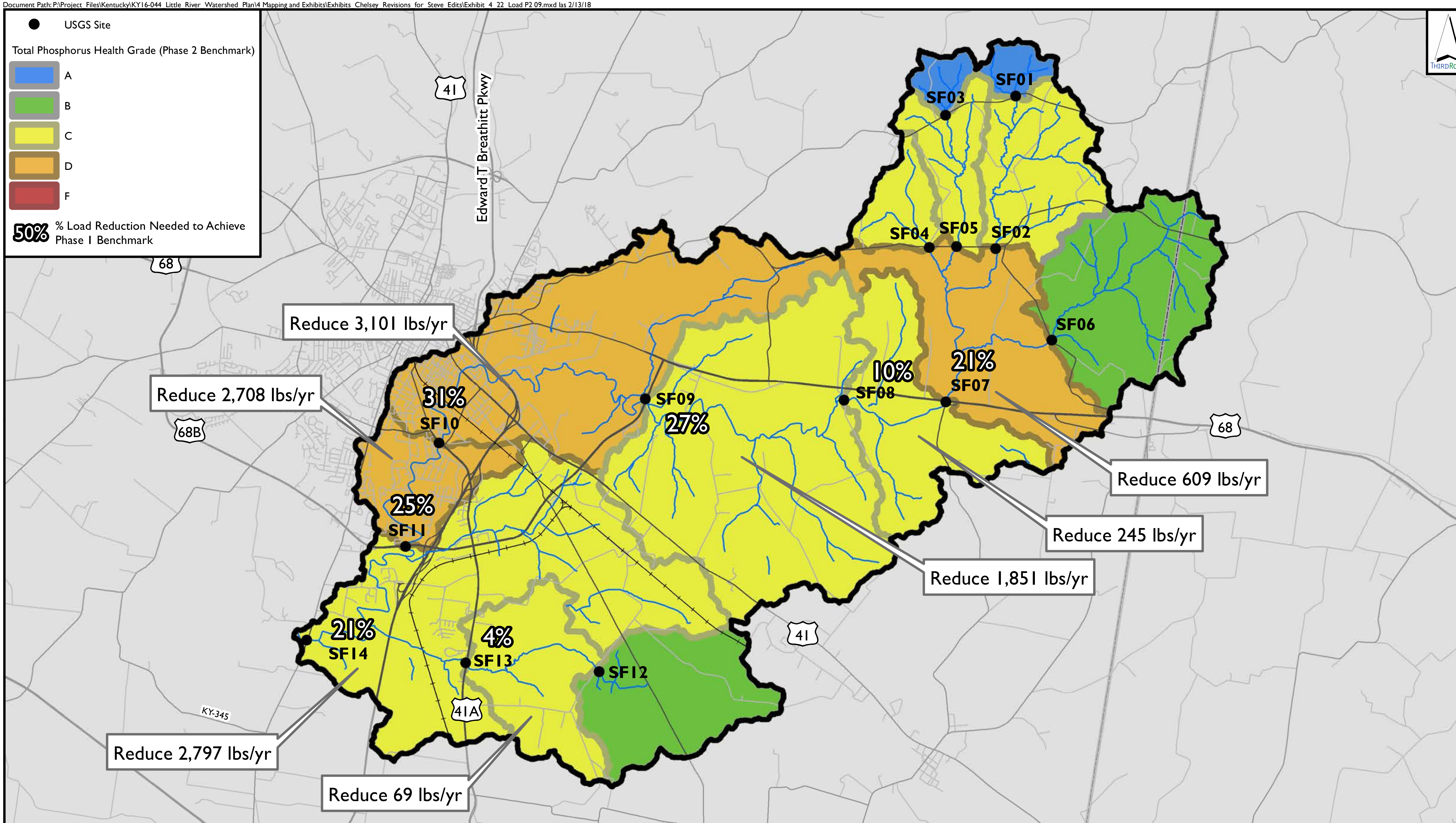


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

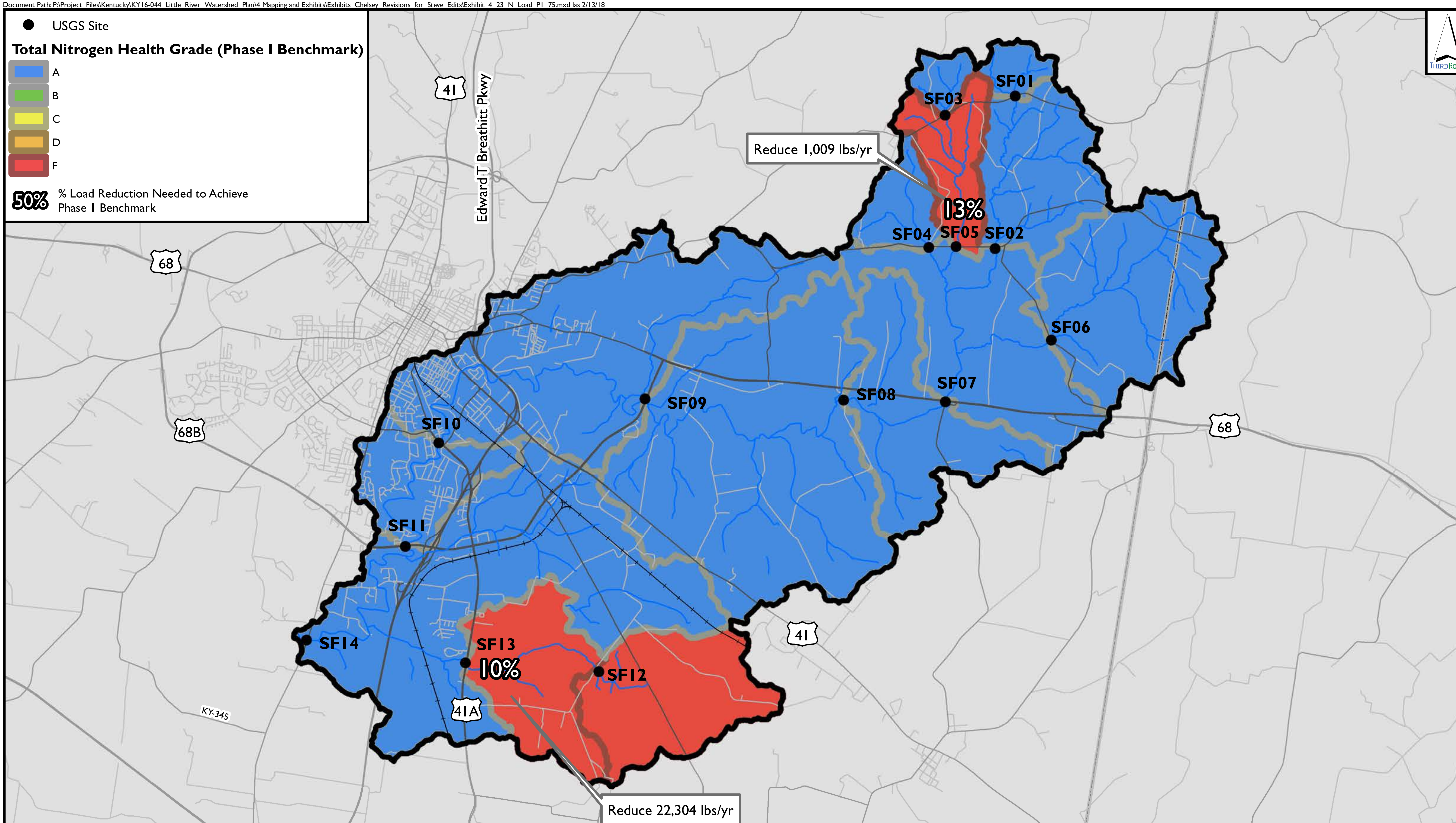
South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 22 - Total Phosphorus Grade and Load Reduction For Phase 2 Benchmark of 0.07 mg/L South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project_Files\Kentucky\KY16-044_Little_River_Watershed_Plan\4 Mapping and Exhibits\Exhibits_Chelsey_Revisions_for_Steve_Edits\Exhibit_4_23_N_Load_P1_75.mxd las 2/13/18

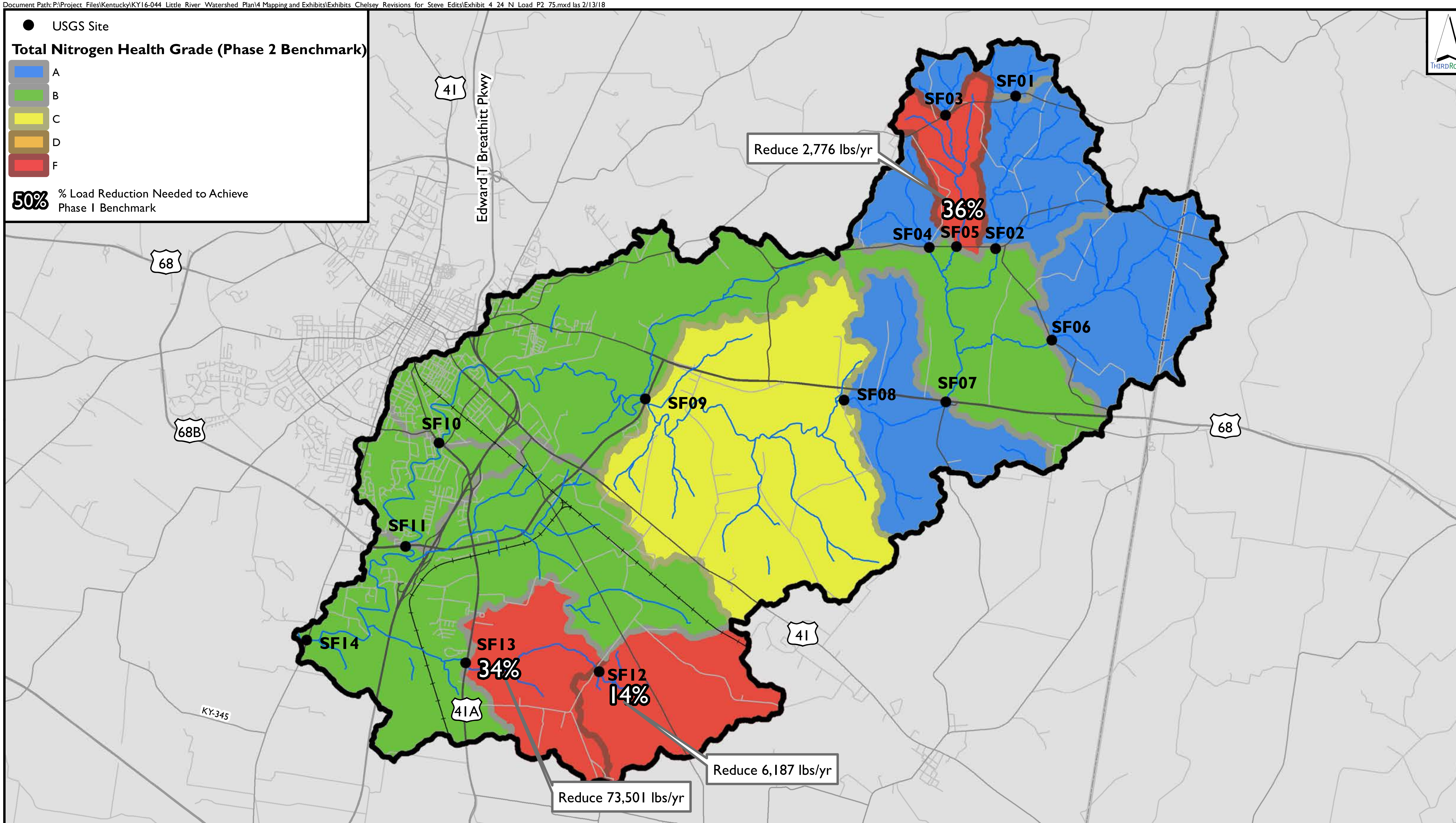


Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

Exhibit 23 - Total Nitrogen Grade and Load Reductions For Phase I Benchmark of 7.5 mg/L
South Fork of Little River Watershed Plan

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

Document Path: P:\Project Files\Kentucky\KY16-044 Little River Watershed Plan\4 Mapping and Exhibits\Exhibits Chelsey Revisions for Steve Edits\Exhibit 4 24 N Load P2 75.mxd las 2/13/18



Prepared by:
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

South Fork Little River
County Boundary
Street
Railroads
Stream

Exhibit 24 - Total Nitrogen Grade and Load Reductions For Phase 2 Benchmark of 5.5 mg/L South Fork of Little River Watershed Plan

0 1.25 2.5 5 Miles

Prepared for:
Hopkinsville Surface and Stormwater Utility
710 South Main Street
Hopkinsville, KY 42240

APPENDIX B
QAPP (*APPENDICES OMITTED*)

South Fork of the Little River Watershed Severe Erosion Survey Quality Assurance Project Plan

Prepared by:

Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, Kentucky 40503

Prepared for:

Hopkinsville Surface and Stormwater Utility
710 South Main Street, P.O. Box 588
Hopkinsville, Kentucky 42241-0588

March 14, 2017

Table of Contents

Appendices

Action by	Action	Date	Signature
Bert Remley, *Aquatic Ecologist* Third Rock Consultants, LLC	Authored	3/15/17	Bert Remley
Steven Evans, *Data Manager* Third Rock Consultants, LLC	Reviewed	3/15/17	[signature]
Steve Bourne, *AICP* Community and Development Services	Approved	3/3/17	[signature]
Lisa Hicks, Quality Assurance Officer Kentucky Division of Water	Approved	4/4/17	Lisa Hicks
James Roe, *Supervisor* Kentucky Division of Water Non-Point Source Branch	Approved	4/10/2017	[signature]

MATTHEW G. BEVIN
GOVERNOR

CHARLES G. SNAVELY
SECRETARY

ENERGY AND ENVIRONMENT CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

AARON B. KEATLEY
COMMISSIONER

300 SOWER BOULEVARD
FRANKFORT, KENTUCKY 40601

March 14, 2017

Mr. Steve Evans
Third Rock Consultants, LLC
2526 Regency Road, Suite 180
Lexington, KY 40503

Mr. Evans,

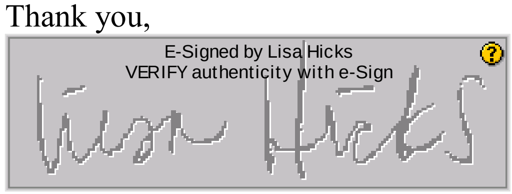
I have reviewed the Quality Assurance Project Plan (QAPP) for the South Fork of the Little River Watershed Sever Erosion Survey project, developed for the Hopkinsville Surface and Storm water Utility.

I have one question that can be addressed in a revision of the QAPP, Section 1.2. No additional signatures will need to be obtained after the revision, and the surveys can begin as soon as needed.

1. Will the soil erosion survey results be included in the overall watershed plan that is discussed in Section 1.2? If so, please include a brief statement how these erosion surveys fir into the overall watershed plans: how they relate to other data, how they relate to the overall goal of the watershed plan and how these data will add to the overall data set for the watershed plan.

After submission and receipt by the Division of Water of the revised Section 1.2, this QAPP will be considered accepted and should be part of the documentation for the project and watershed plan.

Thank you,



Lisa Hicks
Quality Assurance Officer
Kentucky Division of Water

c. Jim Roe
Mike Reed
Maggie Morgan

Date	Section(s) and Page(s) Revised	Explanation
March 14, 2017	Section 1.2, page 5	Expanded description of how the data will fit into the watershed based plan and relates to other data.

The following individuals will receive the approved Quality Assurance Project Plan (QAPP) and any subsequent revisions.

1. James Roe, Supervisor, Nonpoint Source and Basin Team Sections
   James.Roe@ky.gov

2. Lisa Hicks, Quality Assurance Officer
   Lisa.Hicks@ky.gov

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   300 Sower Boulevard, 3rd Floor
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3. Steven Evans, Data Manager
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4. Bert Remley, Aquatic Ecologist
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5. Steven Bourne, AICP, Director
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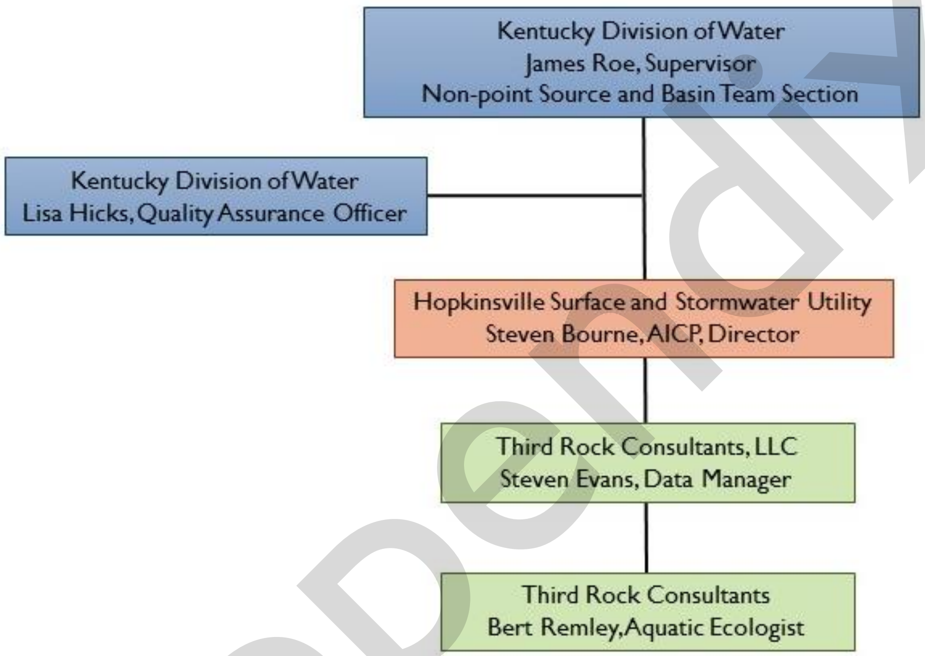
   Hopkinsville Surface and Stormwater Utility
   710 South Main Street
   P.O. Box 588
   Hopkinsville, KY 42241-0588
   270-887-4285

1. Project Management

1.1 Project / Task Organization

The key personnel of the project team are summarized in **Figure 1** as well as the lines of authority with regards to the execution of the project. For purposes of this Quality Assurance Project Plan (QAPP), the following acronyms will apply: Kentucky Division of Water (KDOW); Hopkinsville Surface and Stormwater Utility (HSSU); and Third Rock Consultants, LLC (Third Rock). Roles and responsibilities of specific personnel are summarized below.

FIGURE 1 – ORGANIZATIONAL CHART



James Roe, Supervisor, KDOW Nonpoint Source and Basin Team Sections

Mr. Roe will be responsible for ensuring that the monitoring performed under this project is in compliance with the KDOW and EPA requirements.

Lisa Hicks, Quality Assurance Officer, KDOW

Ms. Hicks will be responsible for reviewing and approving the QA Project Plan. She may provide technical input on proposed sampling design, analytical methodologies, and data review.

Steven Bourne, AICP, Director, HSSU

Mr. Bourne will be responsible for project management and reviewing the final report.

Steve Evans, Data Manager, Third Rock

Mr. Evans will be responsible for coordinating development of the QAPP. He will ensure that the severe erosion surveys are coordinated as specified in the QAPP. He will review and approve all data generated for the project and prepare QA reports as required by the project. He will also be responsible for managing the data generated.

Bert Remley, Aquatic Ecologist, Third Rock

Mr. Remley will be responsible for writing the QAPP and conducting and supervising severe erosion surveys. He will conduct data analysis and will be responsible for QA of all data generated from the field. He will report to Third Rock Consultants Data Manager and QA Manager.

1.2 Project Background and Overview

This South Fork Little River Severe Erosion Survey QAPP has been developed to ensure data generated under this QAPP is of sufficient quality to achieve project goals for the watershed based plan. From 2012-2014, the USGS conducted a study of sources of pathogens, nutrients, and sediment in the Upper Little River Basin which includes South Fork Little River. By using sediment-fingerprinting, the study found that stream bank erosion contributes the largest proportion of fine sediment to streams in the South Fork Little River followed by cropland and riparian-zone areas, respectively. However, the study did not identify specific reaches of stream with erosion problems or specific sediment sites. The overall goal for this QAPP is to generate data of sufficient quality and resolution to facilitate the identification of specific areas of severe bank erosion, and prioritize these areas for implementation of bank stabilization or stream restoration BMPs in the South Fork Little River Watershed (HUC#051302050501 and 051302050502). The USGS study will provide the data to quantify pollution sources in the watershed. This study will identify some of the largest sources of sediment such that the watershed based plan can target improvements to those areas.

The study area is the entirety of the South Fork Little River Watershed that is located in Christian and Todd Counties. A Severe Erosion Survey, either by visual assessment or windshield survey, is the monitoring element that will be performed.

1.3 Project / Task Description and Schedule

Perennial and intermittent streams within the South Fork Little River Watershed (HUC#051302050501, #051302050502) will be surveyed for areas of severe erosion. Where permission is gained to access property, streams will be inspected on foot by Third Rock personnel. In areas where permission cannot be gained, a windshield survey will be conducted from public roadways.

Surveyors will follow the *Stream Corridor Assessment Survey- SCA Survey Protocols (MDDNR 2001)* during the survey, recording length of erosion, bank height, and cause, and ranking the severity, correctability, and access. Streams will be walked where permission is granted, but surveyors will otherwise perform the survey from roadways. Surveyors will mark locations of severe erosion on a high resolution aerial map, as well as areas that could not be accessed. For this survey, severe erosion is defined as areas where erosion greatly exceeds average reach conditions or threatens property and infrastructure. Photographs will be made of each location and the length of the erosion marked with GPS waypoints where access allows. Current state of stream channel evolution (i.e. sloughing banks, incised channel) at erosional areas will be documented. An erosion field datasheet will be completed in the field for areas of severe erosion.

Additionally, areas prone to flooding and potential blockages (i.e. log jams at road culverts) will be documented and photographed. Additionally, sources of *Escherichia coli* and sediment inputs to the South Fork Little River watershed that are observed during severe erosion surveys will be recorded and marked on the aerial map or with GPS waypoints.

The results of the survey activities will be conveyed through multiple deliverable types, including reports, maps, and data analysis. Erosional areas in need of bank stabilization or stream restoration will be prioritized and displayed on mapping and summarized in a Severe Erosion Survey Report. The survey results may also be incorporated into a comprehensive Watershed Based Plan following the completion of the monitoring. The survey and report will be generated by June 30, 2017.

1.4 Data Quality Objectives and Measurement Criteria

Data quality is determined primarily based on data quality objectives (DQOs) and data quality indicators (DQIs). DQOs are qualitative and quantitative statements that indicate the objectives or goals for the data. Data Quality Indicators (DQIs) are qualitative and quantitative measures of data that indicate whether the data is of sufficient quality to meet the DQOs. The specific DQOs and DQIs for this project are stated in the following sections.

The overall Quality Assurance / Quality Control (QA/QC) objective for the South Fork Little River QAPP is to generate data of sufficient quality and resolution to facilitate the identification and prioritization of severe bank erosion locations on streams within the South Fork Little River watershed.

1.4.1 Data Quality Objectives (DQO)

The data quality objectives in this QAPP are related to field surveying. This plan is intended to focus on field surveying activities. The data quality objective for the severe erosion survey activities is to prioritize stream reaches that require bank stabilization or stream restoration, and to identify sources of *E. coli* and sediment input.

1.4.2 Action Limits / Levels

Not applicable.

1.4.3 Measurement and Performance Criteria / Acceptance Criteria

Not applicable.

1.5 Special Training Requirements

Documentation of training will be maintained by the Data Manager. In order to perform severe erosion surveys, field investigators must read and understand this QAPP and associated protocols.

1.6 Documentation and Records

In order to provide quality data that meets the project objectives, traceability and maintenance of documentation and records is essential. All records relating to the collection, analysis, or reporting data associated with the project shall be made available upon request by the KDOW.

Proper documentation of all field activities is essential to ensure that data quality objectives are achieved. Field crews are expected to document unusual or anomalous conditions that may later be useful for data interpretation and analysis. The forms described below are those that will be utilized in the sampling effort.

Data collected for this project will be recorded in field notebooks or standardized forms. All data recorded in field notebooks are to be scanned and maintained electronically in project files. The following standardized field forms will be utilized in the sampling effort and are included in **Appendix A**:

- Erosion Site Datasheet
- Photo Log Datasheet

Field methods are included in **Appendix B** (MDDNR. 2001. *Stream Corridor Assessment Survey – SCA Survey Protocols*. Watershed Restoration Division Chesapeake & Coastal Watershed Services Maryland Dept. of Natural Resources, Annapolis, MD).

Field documentation may include photography or video to document current field conditions. Photographs will also be used to document severe erosion areas, *E. coli* sources, sedimentation sources, stream blockages, and flood prone areas. All documentation will be retained electronically until September 2022.

This QAPP will be distributed to all individuals on the distribution list, subsequent to updating. A list of changes between revisions will be maintained in the document. All field data will ultimately be submitted in the Severe Erosion Report. However, all field notes will be retained until September 2022.

2. Data Acquisition

2.1 Sampling Experimental Design

A systematic sampling design has been utilized for these activities, wherein the sample locations and parameters have been selected based upon evaluation needs.

This survey plan is for the South Fork Little River Watershed (HUC#051302050501, #051302050502) in its entirety, including portions in both Christian and Todd Counties.

The monitoring elements chosen for this project are intended to identify sources of sedimentation and *E. coli* to the South Fork Little River Watershed. Severe erosion surveys are intended to provide general locations of erosion such that Best Management Practices can be targeted to areas in need of stabilization.

2.2 Sampling Procedures and Requirements

The following paragraph provides a summary of the sampling method and equipment associated with the surveying activities. Surveys for severe erosion areas within the South Fork Little River Watershed will generally follow Maryland Department of Natural Resource's *Stream Corridor Assessment Survey-SCA Survey Protocols* (MDDNR 2001). A complete discussion of the survey method is provided in the above mentioned SOP. During all surveying activities, the sampler personnel are to bring the following materials at a minimum: waterproof field notebook, pencils, ink pens, sampling protocols, appropriate field forms, gloves, waders or boots, and a digital camera. Other equipment or materials specific to the severe erosion surveys are recorded in the sections that follow.

2.2.1 Equipment

Equipment for severe erosion surveys includes the following: camera, GPS Unit, field maps (**Appendix C**), pencil, Sharpie marker, field datasheets, clipboard, field notebook, tape measure, and binoculars.

2.2.2 Methods

The South Fork Little River Watershed will be surveyed for areas of severe erosion either on foot or by a windshield survey from public roads. For the purpose of this project, severe erosion is defined as areas where erosion greatly exceeds average reach conditions or threatens property and infrastructure. In locations where permission can be obtained, Third Rock staff will walk stream segments in rural Christian and Todd counties to identify areas of severe erosion. In areas where permission to access streams cannot be obtained, surveys will be conducted from public roadways with the aid of binoculars when necessary.

The objective is not to provide quantitative estimates of sediment contribution but to identify high priority areas for implementation of bank stabilization or stream restoration BMPs. To the extent access allows, the following will be recorded on an Erosion Site Field Datasheet during the survey:

- Type of Impact (*downcutting, widening, headcutting, unknown*)
- Cause (*bend at slope, pipe outfall, below channelization, road crossing, livestock, landuse change upstream, other*)
- Length of Erosion
- Exposed Bank Height (*average*)
- Left and Right Bank Land Use
- Threat to Infrastructure
- Severity
- Correctability
- Access

Surveyors will mark locations of severe erosion on a high resolution aerial map. Photographs will be made of each location and the length of the erosion marked with GPS waypoints where access allows. Length of impact will be estimated in the field and verified by GIS in the office.

On the datasheet, severity, correctability, and access are rated for each severe erosion area. Severity is ranked from 1 (severe) to 5 (minor); correctability ranked from 1 (best) to 5 (worst); access 1 (best) to 5 (worst). Factors used to determine erosion severity rating include:

- Length of impact
- Height of stream bank
- Erosion in both bends and run sections
- Erosion rates along stream banks
- Stream channel unstable and readjusting
- Unconsolidated gravel, sands, and silts in the banks
- Stratified soil in the banks
- Stream channel eroded below the root zone of the vegetation along the banks

Examples of severity rating provided by MDDNR (2001) are as follows:

"Severe rating (1): A long section of stream (>1000 ft.) that had incised several feet, with banks on both sides of the stream that are unstable and eroding at a fast rate.
Usually this occurs in areas where there are soft unconsolidated sediments (gravel, sand and/or silts) and the stream has eroded below the root zone of the bank vegetation."

"Moderate rating (3): Either a long section of stream (>1000 ft.) that has a moderate erosion problem, or a shorter stream reach (between 1000 and 300 ft.) with very high banks (> 4 ft.), and evidence that the stream is eroding at a fast rate."

"Minor rating (5): A short section of stream (<300 ft.) where the erosion is limited to one or two meander bends or a site where an erosion problem is being caused by a pipe outfall and the area affected is fairly limited."

Factors used to determine correctability rating:

- Length of impact
- Adjacent land use, access and construction staging
- Heavy equipment needed
- How much material (i.e., earth, stone) will be required to be moved
- Funding required

Examples of correctability rating provided by MDDNR (2001) are provided below:

"Best Correctability (1): A short stream reach (< 200 ft.) where the erosion problem can be corrected by simple bioengineering techniques using volunteers in one or two days."

"Moderate Correctability (3): An erosion problem that could be corrected by a work crew over several weeks, using primarily a backhoe or other small piece of construction equipment. The project may involve using some small rock (< 100 lbs.) to stabilize the toe of a stream bank but most of the work would rely on vegetation and biodegradable material to stabilize the stream banks."

"Worst Correctability (5): A long reach of stream (i.e., several thousand feet) that had deeply incised several feet and any attempt to actively restore the stream channel would require not only significant funding (i.e., several hundred thousand dollars) but would also involve a large amount of earth moving and disturbance to the riparian corridor."

Factors determining accessibility rating:

- Land ownership
- Surrounding land use
- Safe access
- Heavy equipment access through existing roads or trails

Examples of accessibility rating provided by MDDNR (2001) are provided below:

"Rating of 1 is for a site that is easily accessible both by car or on foot. Examples would include a problem in an open area inside a public park where there is sufficient room to park safely near the site. If heavy equipment was needed, it could easily access the site using existing roads or trails."

"Rating of 3 is for sites that are easily accessible by foot but not easily accessible by a vehicle. Examples would include a stream section that could be reached by crossing a large field or a site that was accessible only by 4-wheel drive vehicles."

"Rating of 5 is for sites that are difficult to reach both on foot and by a vehicle. Examples would include a site on private land where there are no roads or trails nearby. To reach the site it would be necessary to hike over a mile. If equipment were needed to do the restoration work, an access road would need to be built over a long distance through rough terrain."

2.3 Sample Handling and Custody Requirements

Not Applicable.

2.4 Analytical Methods Requirements

Not Applicable.

2.5 Quality Control Requirements

Length estimates of severe erosion areas, recorded on aerial field maps in the field, will be verified in the office using ArcView GIS.

2.6 Requirements for Equipment and Supplies

Not applicable.

2.7 Data Acquisition Requirements for Non-Direct Measurements

Aerial mapping, a non-direct measurement, will be utilized to identify and record areas of severe erosion and to estimate length of these areas. In areas in which access to property cannot be obtained, aerials may be utilized to assess severe erosion without field confirmation.

2.8 Data Management Requirements

For severe erosion data, data will be collected in the field and recorded in field notebooks, and on field data sheets. The field samplers are responsible to ensure that all hard copies are scanned and saved electronically in Third Rock's project files. Additionally, hard copies are to be stored in the project files. Third Rock's Data Manager will be responsible for reviewing all field results, and ensuring field data sheet completeness.

Severe erosion data will be published in the Severe Erosion Summary Report.

3. Data Assessment

Data assessment and response action are necessary to ensure that this QAPP will be implemented as approved. Data assessment and management reports to be utilized for this project are summarized in **Table 1**.

Table 1 – Data Assessment and Management Reports

Type	Purpose / Frequency	Party(ies) Responsible for Performing	Party(ies) Responsible for Responding	Reporting Method
QAPP Revision	As necessary to address non-conformances or errors in the QAPP	Project Team Members	Data Manager	Distribution of amended QAPP
Project Quality Assurance	At the conclusion of the project to document all quality controls for all field results, and compare the data produced to project DQIs	Data Manager	KDOW	Severe Erosion Survey Report

If at any time a project team member finds an error or non-conformance in the QAPP, the QAPP will be revised and redistributed to those on the distribution list subsequent to approval.

Upon receipt of the results, a review of the field data shall be performed by the Data Manager or his designee to ensure that the project DQOs have been satisfied. Email shall be utilized to communicate the results found in these evaluations. The quality of the data collected shall be reviewed and summarized in the Quality Assurance Project Report.

4. Review, Evaluation and Reporting

Data verification, data validation, and data usability are terms used to describe data review and evaluation. Data verification is the review of data sets for completeness, correctness, and conformance/compliance for a specific data set against the method, procedural, or contractual specifications. Data validation is an analyte and sample-specific process that determines the quality of a specific data set relative to its end use. Validation notes any deviations from the QAPP. Data usability is a determination of the adequacy of the data based on verification and validation, to ensure the QAPP criteria are met.

4.1 Validation and Verification Methods

The EPA guidance document *Guidance on Environmental Data Verification and Validation* (EPA QA/G-8) (EPA 2002) guides the overall process by which data will be validated and verified.

The sampler will perform data review for all field data initially before submitting to the Data Manager.

The Data Manager will document non-conformances in the data via email and in the Severe Erosion Report. This review will be submitted to the KDOW in the final report. The Data Manager will be responsible for making decisions concerning data quality and acceptability. KDOW may also make determinations on data acceptability, depending on data analysis and review of the Severe Erosion Report.

The final report will receive an internal peer review to evaluate the content, calculations, and data analysis in the report. The report will also undergo an internal grammatical review to look for grammatical errors and formatting. Lastly, the final report will receive a review from the Data Manager prior to submission to the KDOW to ensure that all project objectives are achieved.

4.2 Reconciliation with Project Requirements

In the report, descriptions of all relevant background information, summary, waterbody details, monitoring results, recommended solutions, and implementation plans will be detailed. Included in these documents will be an overall assessment of the data quality and the uncertainty involved in the results.

5. References and Citations

EPA. 2002. Guidance on Environmental Data Verification and Validation (EPA QA/G-8). Office of Environmental Information, Washington, DC. EPA/240/R-02/004

MDDNR. 2001. Stream Corridor Assessment Survey – SCA Survey Protocols. Watershed Restoration Division Chesapeake & Coastal Watershed Services Maryland Dept. of Natural Resources, Annapolis, MD.

APPENDIX C
KDOW BENCHMARK RECOMMENDATIONS

South Fork Little River Watershed Plan
Benchmark Recommendations
Kentucky Division of Water
4/14/17

Benchmark recommendations given here represent the best information available to the Kentucky Division of Water (KDOW) at this time. The goal is to provide estimates of typical in-stream concentrations below which it is unlikely that the given parameter would be a cause of aquatic life use impairment. As such, benchmarks are useful in identifying sub-basins with potential issues when setting priorities for further monitoring or for developing strategies for load reductions. In making these recommendations we considered regional and watershed-specific reference conditions, regional-scale patterns in biological effects, and relevant published literature. In this case, benchmark selection relied heavily on reference stream data for reasons discussed below. These benchmarks may be different than final targets for management endpoints; watershed-specific characteristics, practical considerations, and insight gained from early phase monitoring might suggest alternate values for that purpose. The Watershed Group may wish to discuss with KDOW alternative benchmarks and/or targets based on local information or consultation with experts with specific experience in the watershed. The benchmarks for Total Nitrogen and Nitrate/Nitrite-N should be reviewed especially closely given the uncertainty in what levels might be achievable and what levels are likely to lead to improvements in the health of aquatic life.

Benchmark Recommendations

Total P mg/L	0.05
Nitrate+Nitrite-N mg/L	5.0
Total N mg/L	5.5
Conductivity µS/cm at @25	450
TSS mg/L	8*
Turbidity NTU	4*

* *Because of the limited reference stream data for TSS and Turbidity at higher flows, these benchmarks should be interpreted as average values for summer stable flow periods only for the purposes of screening data. If TSS and Turbidity targets are needed for the watershed plan please consult with the TA to determine an appropriate target.*

Background Information

Ecoregional Reference Reaches

The Reference Reach network of streams represents the least-impacted conditions for aquatic life in wadeable streams in the respective ecoregions. The project area straddles the Western Pennyroyal Karst Plain and the Crawford-Mammoth Cave Uplands (ecoregions 71e and 71a), but since more than half of the watershed is in the Western Pennyroyal Karst Plain, this was the ecoregion selected as the most appropriate for comparisons. KDOW's Reference Reach grab sample data for ecoregion 71 e are summarized on the following page.

Note: the majority of the samples from reference reach program are grab samples during biological sampling events, generally during summertime stable flows. Only a few samples are from wet weather.

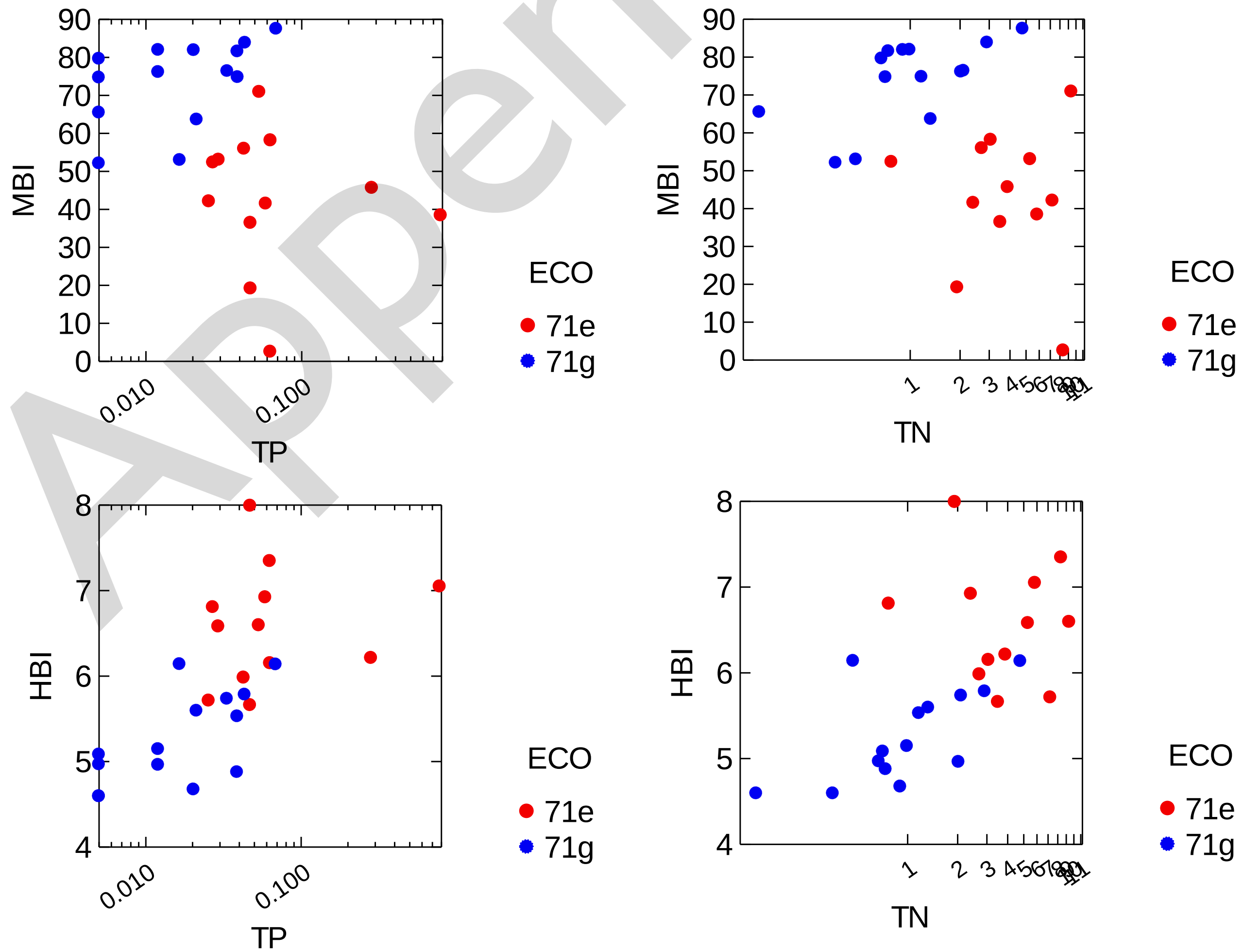
KDOW's Reference Reach Grab Sample Data

	Eco-Region	No. of Samples	MIN	MED	75th Percentile	90th Percentile	MAX
TP(mg/L)	71e	23	<0.010	0.029	0.053	0.089	0.988
NN-N(mg/L)	71e	24	2.190	5.220	5.7	7.259	8.740
TKN(mg/L)	71e	24	<0.200	<0.200	<0.200	<0.500	4.200
TN(mg/L)	71e	24	2.290	5.385	5.868	7.509	9.150
Conductivity µS/cm	71e	18	254	431	456	470	503
TSS mg/L	71e	16	1.5	3.75	4.5	7.5	9.0
Turbidity NTU	71e	11	0.50	2.06	3.125	3.65	4.46

Effects-based (Empirical) Threshold

A search was done to gather grab sample data associated with non-reference biology samples in 71e that scored on the Good or Excellent on the Macroinvertebrate Bioassessment Index (MBI). This set had fewer samples than the reference set above and substantial overlap, producing similar numbers as above.

DOW conducted focused data collection in 71e and 71g Ecoregions in 2010 (Pennyroyal Nutrient Project). MBI scores and component metrics from this project showed strong associations with TP and TN in many cases, with thresholds in the range of 0.030-0.040 mg/L TP and 2-3 mg/L TN. However, thresholds in MBIs and metrics usually corresponded to ecoregion as well as being associated with higher nutrient concentrations. It is not clear if these regions should be assumed to have similar response along the continuous gradient observed in the combined data.



Literature-Based Thresholds

Literature guidelines for the boundary between oligotrophic and mesotrophic conditions are TP 0.025 mg/L and TN 0.700 mg/L. The boundary between mesotrophic and eutrophic conditions are given as TP 0.075 mg/L and 1.5 mg/L. Reference Reaches and watershed reference data summarized above suggest 71e streams that support healthy aquatic communities are in the mesotrophic range for TP but well above the eutrophic boundary for TN. In this case, trophic boundaries are minimally useful in guiding benchmark recommendations.

APPENDIX D
PROPOSED WATERSHED COUNCIL

Potential SFLR Watershed Council Members Based upon Involvement in Planning Process (8-1-18) Page 1 of 2

Name			Title	Organization / Business	LRWQC	Tech Adv	Address	Phone	Email
Mr.	David	Brame	Owner	Brame Farms Inc	x		7900 Striped Bridge Road, Hopkinsville, KY 42240	(270) 8858832	Davidbrame1952@gmail.com
Mr.	Chad	Burch	Preparedness Program Manager	Christian County Health Department	x		PO Box 647 / 1700 Canton Street, Hopkinsville, KY 42240	(270) 887-4160	chadb.burch@ky.gov
Mr.	David	Collins	District 7 Magistrate	Christian County Fiscal Court	x		511 South Main Street, Hopkinsville, KY 42240	(270) 887-4105	david.collins@hragripower.com
Mr.	Dave	Fernandez		Hopkinsville Surface and Stormwater Utility	x		PO Box 588, Hopkinsville, KY 42241	(270) 887-4035	davef1@bellsouth.net
Mr.	Paul	Henson		Hopkinsville City Council (Ward 4) Hopkinsville Electric System	x		715 South Virginia Street, Hopkinsville, KY 42240	(270) 348-4772	ward4@hopkinsvilleky.us pnhenson@hesenergy.net
Mr.	Wayne	Hunt	Owner	H&R Agri-Power	x		4900 Eagle Way, Hopkinsville, KY 42240	(270) 886-3918	whunt@hragripower.com
Mr.	Steve	Hunt		H&R Agri-Power	x		1700 Nashville Road, Russellville, KY 42276	(270) 726-4545	shunt@hragripower.com
Ms.	Jenny	Moss	Director of Water and Wastewater	Hopkinsville Water Environment Authority	x		PO Box 628, 401 E. 9th Street, Hopkinsville, Kentucky 42240	(270) 887-4246	jmoss@hwea-ky.com
Mr.	Todd	Perry		Siemer Milling Company	x		315 Quintin Court, Hopkinsville, KY 42240	(270) 475-9990	
Mr.	Mark	Pyle	Public Health Director	Christian County Health Department	x		PO Box 647 / 1700 Canton Street, Hopkinsville, KY 42240	(270) 887-4160	mark.pyle@ky.gov
Mr.	Derrick	Watson	President & CEO	Hopkinsville Water Environment Authority	x		PO Box 628, 401 E. 9th Street, Hopkinsville, Kentucky 42240	(270) 887-4246	dwatson@hwea-ky.com
Ms.	Kelley	Workman		Hopkinsville Surface and Stormwater Utility	x		PO Box 588, Hopkinsville, KY 42241	(270) 887-4035	Kelley.Workman@plantersbankonline.com
Mr.	Steven	Bourne		Community Development Services		x	PO Box 1125, 710 South Main Street, Hopkinsville, Kentucky 42240	(270) 887-4285	sbourne@comdev-services.com
Ms.	Angie	Crain	Hydrologist	USGS Kentucky Science Center		x	9818 Bluegrass Parkway, Louisville, KY 40299	(502) 493-1943	Angie Crain, ascrain@usgs.gov
Mr.	Matt	Futrell	Agriculture Agent	Christian County Extension Office		x	2850 Pembroke Road, Hopkinsville, KY 42240	(270) 886-6328	matthew.futrell@uky.edu
Mr.	Jed	Grubbs		Cumberland River Compact		x	2 Victory Avenue, Suite 300, Nashville, TN 37213	(615) 837-1151	jed.grubbs@cumberlandrivercompact.org
Ms.	Amanda	Gumbert	Water Quality	UK Cooperative Extension Specialists		x	Christian County Office, 2850 Pembroke Road, Hopkinsville, KY 42240	(270) 886-6328	amanda.gumbert@uky.edu
Mr.	Steve	Higgins	Ag Research	UK Cooperative Extension Specialists		x	Christian County Office, 2850 Pembroke Road, Hopkinsville, KY 42240	(270) 886-6328	shiggins@uky.edu
Ms.	Kelly	Jackson	Horticulture Agent	Christian County Extension Office		x	2850 Pembroke Road, Hopkinsville, KY 42240	(270) 886-6328	kelly.jackson@uky.edu
	Jamie	Lawrence	Water Management Coordinator	Pennyrile Area Development District		x	300 Hammond Drive, Hopkinsville, KY 42240	(270) 886-9484	
Mr.	Brad	Lee	Urban / MS4	UK Cooperative Extension Specialists		x	Christian County Office, 2850 Pembroke Road, Hopkinsville, KY 42240	(270) 886-6328	brad.lee@uky.edu
Mr.	Wes	McFaddin	Private Lands Biologist	Kentucky Department of Fish and Wildlife Resources		x	1 Sportsmans Lane, Frankfort, KY 40601	(270) 488-3254	Wes.McFaddin@ky.gov
Ms.	Maggie	Morgan	Basin Coordinator	Jackson Purchase Foundation		x	P.O. Box 1154, Benton, KY 42025	(270) 559-4422	maggie.morgan@jpf.org
Mr.	Andy	Radomski	Private Lands Biologist	US Fish and Wildlife Service		x	91 US Hwy 641N, Benton, KY 42025	(270) 703-4114	andrew_radomski@fws.gov
Mr.	John	Rittenhouse		Community Development Services		x	PO Box 1125, 710 South Main Street, Hopkinsville, Kentucky 42240	(270) 887-4285	
Mr.	Dave	Roberts		Kentucky Dairy Development Council		x	176 Pasadena Drive, Lexington, KY 40503	(859) 516-1129	roberts@kydairy.org

Name			Title	Organization / Business	LRWQC	Tech Adv	Address	Phone	Email
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APPENDIX E
EDUCATIONAL AND PROMOTIONAL PIECES

What's the science say?

The Little River Basin includes two major headwater tributaries, the South Fork Little River (SFLR) and the North Fork Little River (NFLR), both of which have been listed by the Kentucky Division of Water in the 303(d) List of Waters for Kentucky Report to Congress as impaired by pathogens (fecal contamination), nutrients (phosphorus and nitrogen), and sediment.

The high levels of pathogens in the waters result in impairment for the primary contact recreation use (*i.e.* swimming). The high levels of nutrients and sediment contribute to impairment of the streams as warmwater aquatic habitat (*i.e.* aquatic life).

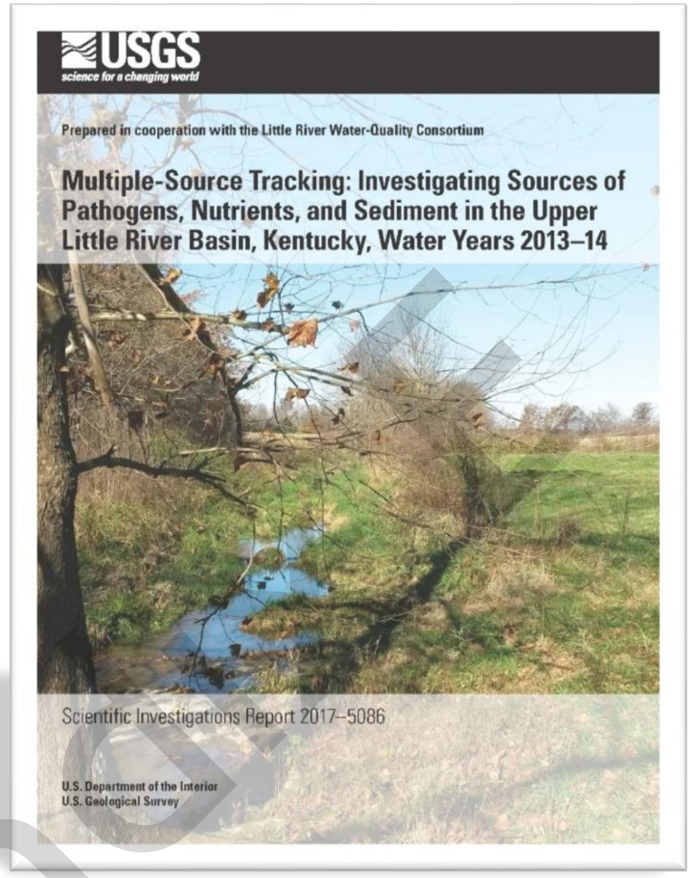
In 2009, the Kentucky Division of Water developed a pathogen Total Maximum Daily Load (TMDL) for the Little River Basin including the SFLR and NFLR tributaries. Future nutrient and suspended-sediment TMDLs are planned once nutrient criteria and suspended-sediment protocols have been developed for Kentucky.

In cooperation with the Little River Water Quality Consortium and Kentucky Division of Water, the United States Geological Survey (USGS) conducted a three-year study in the Upper Little River Basin.

The objective was to aid in understanding the occurrence and distribution of pathogens, nutrients, and sediment and their potential sources within the headwaters of the Little River Basin.

The SFLR was the primary focus of the study because of the higher percentage of cropland and increasing number of small dairy operations in the basin.

The SFLR watershed is a 67.4 square mile (43,200 acres) watershed located primarily in Christian county, but partially extending into Todd county. The watershed contains developed areas of Hopkinsville, extensive agricultural areas, and some forested land.



USGS utilized advanced scientific techniques to determine the relative pollutant contributions of different sources. The findings were published in September 2017 and are summarized as follows:

- *During high flow conditions*, nitrogen in soils was the dominant source of nitrogen in streams; *during low flow conditions*, manure and human waste were the dominant source.
- Stream bank erosion contributes the largest proportion of fine sediment to streams in the SFLR basin, followed by cropland and riparian-zone areas, respectively.
- Ruminant sources (cows and horses) were the most prominent source of pathogens in streams, but humans and dogs were also contributors.

For more information or to view the entire USGS Report, visit www.thirdrockconsultants.com\lrwqc.

Funding provided, in part, by a grant from the U.S. Environmental Protection Agency to the Kentucky Division of Water as authorized by the Clean Water Act Amendments of 1987, Section §319(h) Nonpoint Source Implementation Grant # PPG 95469714.

Where does your water shed?

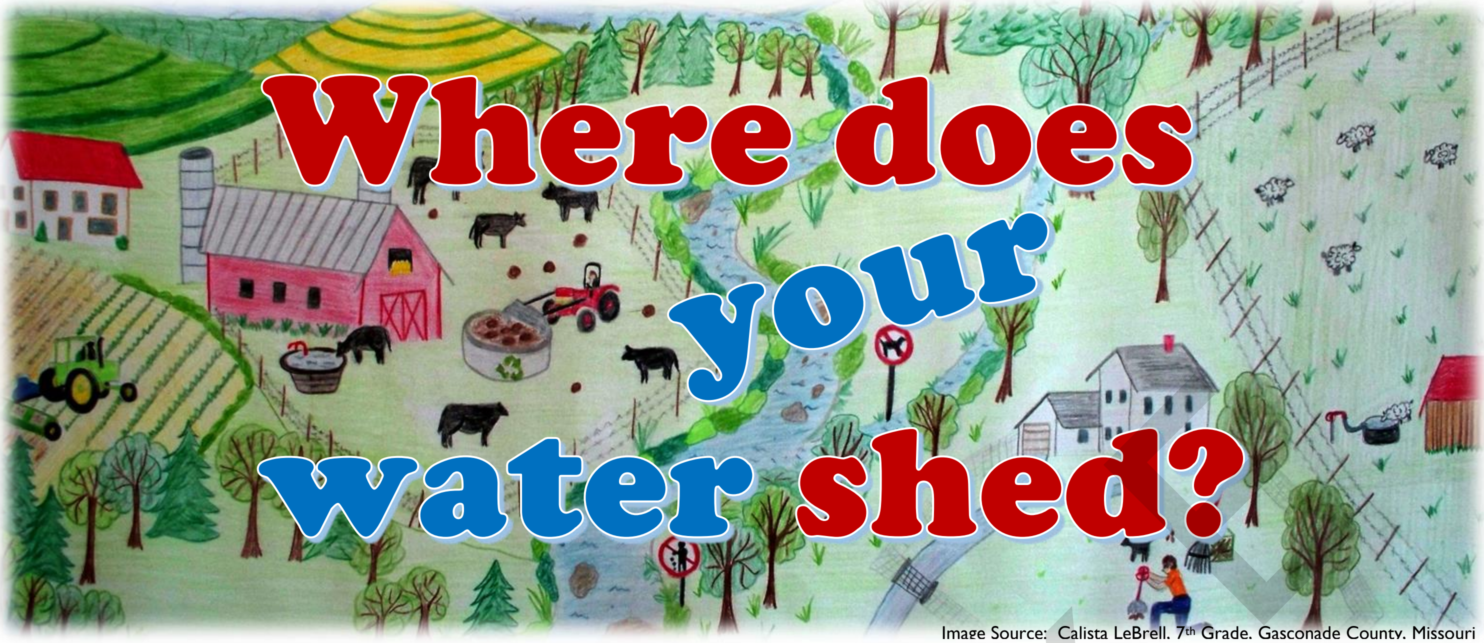


Image Source: Calista LeBrell, 7th Grade, Gasconade County, Missouri

The Little River Watershed runs right through the heart of Christian County - your county. It includes the South Fork and North Fork of the Little River, both of which have been listed by the Kentucky Division of Water as impaired by pathogens (fecal contamination), nutrients (phosphorus and nitrogen), and sediment, making them unsafe for recreational use (such as swimming) and unable to support aquatic habitat.

In 2011, members of the agriculture community joined forces with the Hopkinsville Surface and Stormwater Authority, Water Environment Authority, and City Council and the Christian County Fiscal Court to form the Little River Water Quality Consortium (LRWQC). LRWQC has since addressed the problems in the watershed head-on, initiating voluntary water quality monitoring and securing Federal Clean Water Act funding through the Kentucky Division of Water to develop a Watershed-Based Plan for the South Fork Little River Watershed.

In 2016 LRWQC hired Lexington environmental consulting group Third Rock Consultants, LLC to develop the Plan. Once complete, the Plan will include a comprehensive assessment of the watershed and remediation strategies. Over the course of the last two years, Third Rock water quality specialists have worked closely with LRWQC, the Kentucky Division of Water, and various technical partners to turn LRWQC's vision into a reality. The planning process is underway. Based upon Third Rock's assessment of the watershed, a strategy to implement best management practices (BMPs) to remediate the watershed has been drafted.

So, what's a BMP? The term "Best Management Practices," or BMPs, was coined nearly 35 years ago to describe acceptable practices that can be implemented to protect water quality and promote soil conservation. A BMP can be a structural "thing" that's installed on-the-ground, such as a silt fence or stream buffers and groundcover vegetation over bare soil areas. Or, a BMP can be part of the "process" used to plan and conduct your business or farming operation.

Third Rock has identified the most appropriate BMPs to serve as tools in LRWQC's toolbox to address water quality problems in the watershed. At this point, *they need your help*. Specifically, they need your input, suggestions, and feedback. Would you be willing to install a BMP on your property? Or agree to incorporate BMPs into your farming operation? Or help LRWQC spread the word, make contacts, and engage as many as possible in the watershed?

Log onto www.thirdrockconsultants.com\lrwqc today to see what's happening in your watershed. Join the mailing list, give your feedback, engage in the process. Together, we can turn LRWQC's vision into a reality!

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What can you do?

Our Goal	The Causes	How do we get there?
Decrease in-stream bacteria levels to allow for safe recreational use	• Manure use and management • Livestock grazing / pasture • Wildlife and other sources • Septic system failure • Sanitary sewer failure	• Draft or update an **Agricultural Water Quality** and **Nutrient Management Plans** • Implement **agricultural BMPs** • Increase infiltration and reduce runoff through **stormwater BMPs** • Support and petition local efforts to study and/or **improve sanitary sewer system** to reduce unintentional pollution • Support and petition local efforts to study and/or improve sanitary sewer system to reduce unintentional pollution
Reduce in-stream nutrients (nitrogen and phosphorus) and sediment to healthy levels	• Row cropping • Stream bank erosion • Manure use and management • Livestock grazing • Septic system failure • Sanitary sewer failure	• Draft or update an **Agricultural Water Quality** and **Nutrient Management Plans** • Stabilize and/or **restore eroding stream banks** • Implement **agricultural BMPs** • Increase infiltration and reduce runoff through **stormwater BMPs** • Support and petition local efforts to study and/or improve sanitary sewer system to reduce unintentional pollution
Improve stream habitat to support a healthy aquatic ecosystem	• Narrow riparian zones • Unstable stream banks • Eroding stream banks • Livestock access to streams • Channelization and entrenchment	• **Improve the quality and width of riparian zones** by native plantings and exotic invasive treatment • Restore stream **attachment to the floodplain** and reduce channelization • Stabilize and/or **restore eroding stream banks** • **Restore stream habitat** including riffles/pools and epifaunal substrate
Restore streams to stable, natural channel conditions reducing the rate of flooding, erosion, and sedimentation	• Channelization and entrenchment • Stream bank erosion • Channel alteration including straightening and livestock access • Increased runoff from impervious surfaces in developed areas	• **Restore channel dimensions, pattern, and profile** • Restore habitat to the streams including riffles/pools and epifaunal substrate • Restore stream attachment to a floodplain and reduce channelization • Stabilize or restore eroding stream banks • Improve the quality and width of riparian zones by native plantings and exotic invasive removal • **Reduce the runoff rate from impervious surfaces** in the watershed through infiltration or storage.
Remove trash and debris clogging waterways	• Woody debris / log jams from storm damage and bank failure • Trash and litter	• Document routine locations of trash and debris accumulation • **Organize groups to remove trash** from watershed on a routine basis • Remove woody debris without disturbing the stream bed material
Educate the community about how they can help improve water quality	• Lack of information • Continuation of practices that cause or facilitate impairment	• Increase public knowledge about water quality impairments • **Perform ongoing monitoring** of stream health conditions

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