Watershed Based Plan

Hanging Fork Watershed
Boyle, Lincoln, and Casey Counties, Kentucky

Prepared for
Kentucky Division of Water
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1. INTRODUCTION

1.1. Watershed Background

The Kentucky Division of Water (KDOW) began working in the Dix River Basin in 1998, as a result of the 1998 Clean Water Action Plan, produced jointly by KDOW, the Natural Resources Conservation Service (NRCS), and the Division of Conservation (DOC). The federal requirements were for the state to jointly select five priority watersheds in Kentucky for targeted water quality improvements. The criteria for selection included:

- Portions of watershed are listed as impaired on the 303(d) list to US Environmental Protection Agency (US EPA)
- Areas are included in NRCS 1998 Environmental Quality Incentives Program (EQIP) Priority Watershed List
- Nonpoint source pollution (NPS) issues are a priority
- Watershed area is a scale that can be managed
- History of demonstrated stakeholder support

Ultimately, the Dix River watershed was selected as one of several priority watersheds, which resulted in a doubling of 319(h) Nonpoint Source Funding to address the impairments in the watershed. The water quality problems in the Dix River watershed stem from documented impairments in Hanging Fork and Clarks Run and have contributed to impairments in Herrington Lake. Hanging Fork was originally 303(d) listed for pathogens in 2002 (KDOW 2003).

KDOW sought public involvement to address the water quality impairments in these watersheds. Two public meetings were held in Danville in January and March of 2006. Issues of concern were solicited and overwhelming pathogen contamination of the waterways was the most prominent concern of stakeholders.

From these meetings, interested individuals were recruited to form the Dix River Watershed Council. The first Council meeting was on May 9, 2006. The stated objectives of the group, at that time, were to:

- Provide input into watershed analysis and plan development
- Provide input into the development of the Total Maximum Daily Loads (TMDL) for Clarks Run, Hanging Fork and Herrington Lake
- Develop a more detailed watershed plan to reduce pollutants from point and nonpoint sources, including specific water quality management recommendations
- Identify funding sources to implement practices that can reduce pollutants
- Present draft watershed plan to stakeholders
- Implement remediation action identified in watershed plan

The Dix River Watershed Council has met regularly since its inception and sought public participation in a watershed planning process. On April 15, 2008, the Dix River Watershed Council suggested that subwatershed groups be formed to analyze the Clarks Run, Hanging Fork, and Upper Dix watershed areas in a more focused manner. The Hanging Fork watershed subgroup was organized to further investigate this watershed.

This watershed based plan presents the culmination of an extensive data collection and analysis effort, recruitment of partners and stakeholders in watershed interests, and remediation strategy development. The Dix River Council and Hanging Fork focus groups have outlined a comprehensive plan to address the watershed issues. This document is intended to address the nine minimum elements required in the US EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. These nine elements (a through h below) are as follows:

a) An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (*e.g.*, X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded stream bank needing remediation).
b) An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (*e.g.*, the total load reduction expected for dairy cattle feedlots; row crops; or eroded stream banks).
c) A description of the nonpoint source (NPS) management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.
d) An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, states should consider the use of their Section 319(h) programs, State Revolving Funds, The US Department of Agriculture's (USDA) EQUIP and Conservation Reserve Program, and other relevant federal, state, local and private funds that may be available to assist in implementing this plan.
e) An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.
f) A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.
g) A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.
h) 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 NPS TMDL has been established, whether the NPS TMDL needs to be revised.
i) A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

1.2. Goals

In March 2007, a questionnaire was distributed to concerned citizens and stakeholders in the Hanging Fork watershed. Based on the responses from representatives of agriculture, state and local government, and landowners, four goals for the Hanging Fork watershed have been developed:

1. Improve water quality in Hanging Fork to ensure that recreational use is safe and enjoyable for the community.
2. Educate the community on watershed issues to raise environmental awareness and create continuous lines of communication regarding watershed issues.
3. Improve the aquatic and riparian zone habitat in Hanging Fork to encourage increased diversity and density of wildlife in proximity to the stream.
4. Improve local government planning, codes, and ordinances to protect and improve water quality.

This document is intended to evaluate the Hanging Fork watershed against these goals and provide methods of addressing areas in which the watershed currently falls short.

1.3. Partners and Stakeholders

As previously mentioned, the watershed planning effort was funded by the US EPA under 319(h) of the Clean Water Act through KDOW. The Dix River Watershed Council, formed in May of 2006, and the Hanging Fork Focus Group, formed in April 2008, comprise the team of partners and stakeholders who will work together to support the plan sponsor, the Hanging Fork Focus Group, accomplish the remediation activities detailed in this plan. This group includes the following stakeholders and partners:

Company / Affiliation	Name
Kentucky Division of Water	John Webb
University of Kentucky Water Resources Research Institute (UKWRRI)	Malissa McAlister
Third Rock Consultants	Gerry Fister
Natural Resources Conservation Service (NRCS)	Bo Renfro
Lincoln County Health Department	Randall Carrier
Lincoln County Engineer	Alan Bowman
Lincoln County Magistrate District 1	David Faulkner
Bluegrass Area Development District (ADD)	David Dutlinger
Bluegrass PRIDE	June Bastin
Landowner/Farmer	Bill Payne

2. WATERSHED INFORMATION

2.1. General Watershed Description

2.1.1. Location

The Hanging Fork Watershed (Hydrologic Unit Code, or HUC, #05100205180) covers 96.4 square miles or 61,720 acres, primarily in northwestern Lincoln County (81 percent) but also in a small portion of southern Boyle County (14 percent) and eastern Casey County (5 percent). Municipalities in the watershed include Junction City and Hustonville. Danville is located north of the watershed and Stanford and Lancaster to the east. Exhibit 1 (page 5) shows the location of the Hanging Fork Watershed in relationship to the surrounding area.

2.1.2. Hydrology

Hanging Fork is a tributary to the Dix River, which is impounded near its confluence with the Kentucky River to form Herrington Lake. Two hundred thirty-four stream miles are located in the Hanging Fork watershed. Tributaries to Hanging Fork include Blue Lick Creek, Martin's Branch, Peyton Creek, Knoblick Creek, White Oak Creek, Harris Creek, Spears Creek, Baughman Branch, and Frog Branch. Numerous small farm ponds are also scattered throughout the region.

The land is primarily in the Outer Bluegrass physiographic region, characterized by undulating terrain, moderate to rapid surface runoff, and moderate rates of subsurface drainage. To the northwest and southeast, some of the land is located in the higher gradient Knobs and Hills regions.

Average annual precipitation estimates range from 48.87 inches from 1971 to 2000 (MRCC 2009) and 52.13 inches from 1961 to 1990 (NRCS 2006). Snowfall data for these same periods were 11.6 inches and 17.9 inches, respectively.

No US Geological Society (USGS) water gauging stations are currently located in the Hanging Fork watershed. The closest station is located on the Dix River near Danville (USGS gauge 03285000), upstream of the Clarks Run confluence. Basic statistics on the discharge at this station are provided in Table 1.

TABLE 1 – DISCHARGE STATISTICS AT USGS GAUGE 03285000, DIX NEAR DANVILLE

PARAMETER	STATISTIC
Period of Record	1943-2007
Drainage Area (mi^2)	441
Annual Mean Discharge (cfs)	469
Highest Daily Mean (cfs)	1184 (in 1979)
Lowest Annual Mean (cfs)	119 (in 1954)
Annual 7-day minimum	0 (in 1944)
Annual runoff (cfsm)	1.47
Annual runoff (inches)	20.03
10% discharge exceeds (cfs)	1060
50% discharge exceeds (cfs)	126
90% discharge exceeds (cfs)	3.2

Source: http://waterdata.usgs.gov/ , 2009

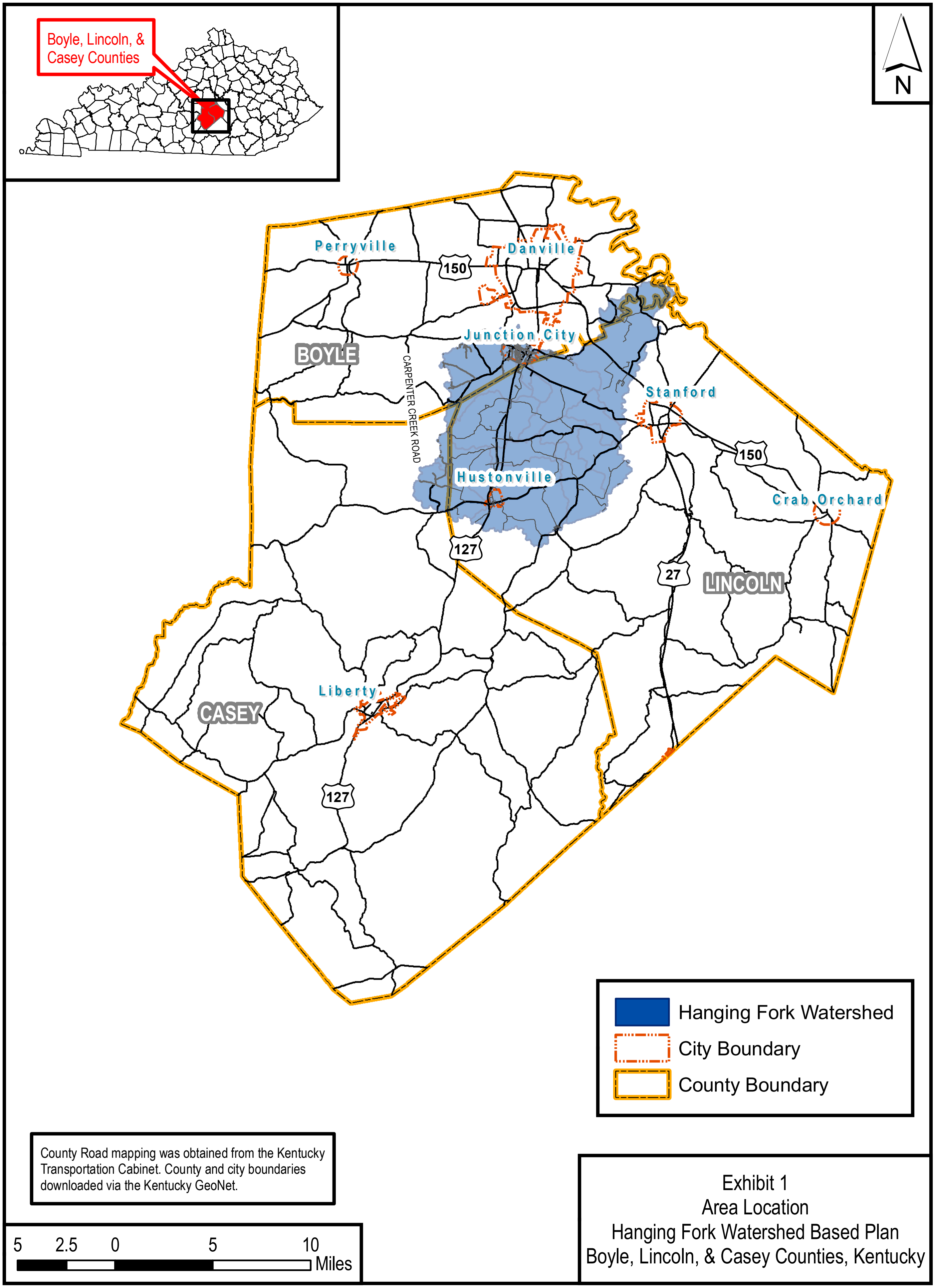

Exhibit 1
Area Location
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

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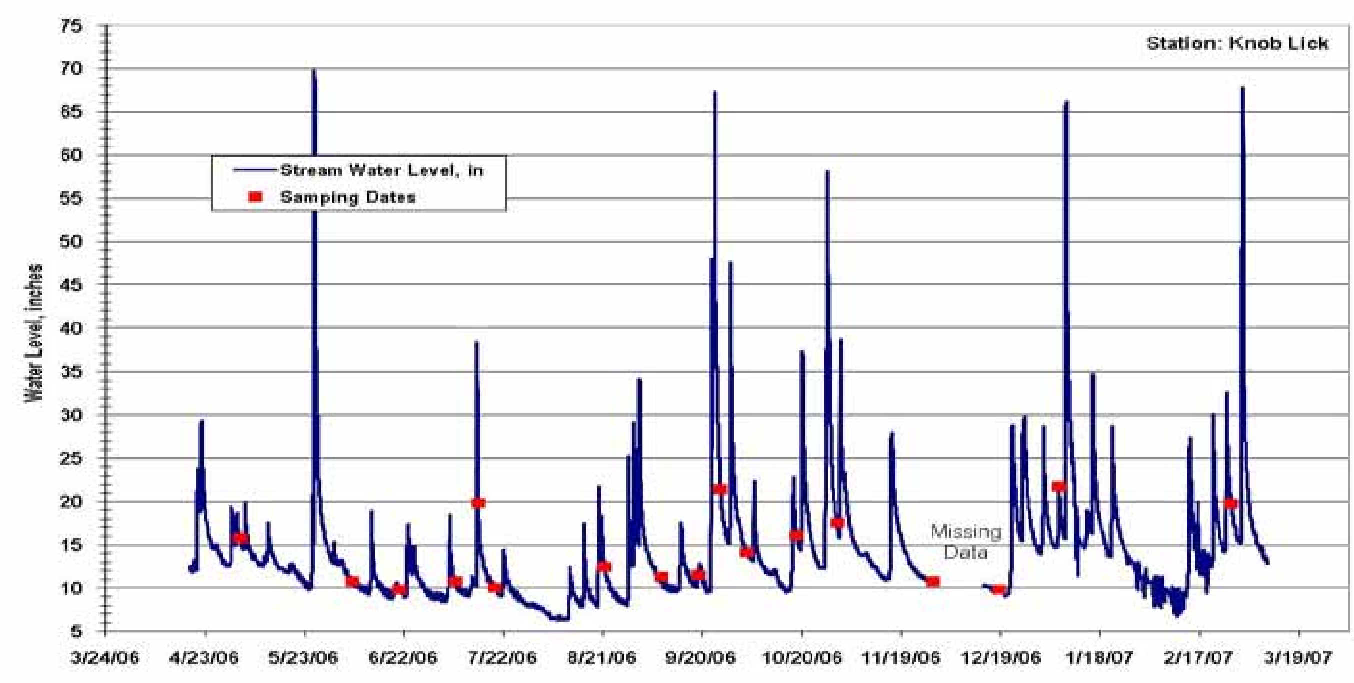
Although no USGS stations are located in the watershed, considerable flow data were collected at 14 sampling sites between March 2006 and February 2007. These data are summarized for use in the calculation of the loadings within the watershed.

As part of a yearlong water quality monitoring study in Hanging Fork, two water level data loggers were utilized to evaluate the relationship between the daily stream water depth and the flow data captured. These data loggers captured daily changes in the water level at the Knob Lick Station near the KY-300 overpass and at the US 150 overpass of Hanging Fork. Figures 1 and 2 (below and page 7) graphically illustrate the results of this study.

FIGURE 1 – WATER LEVEL AT KNOB LICK STATION 2006-2007

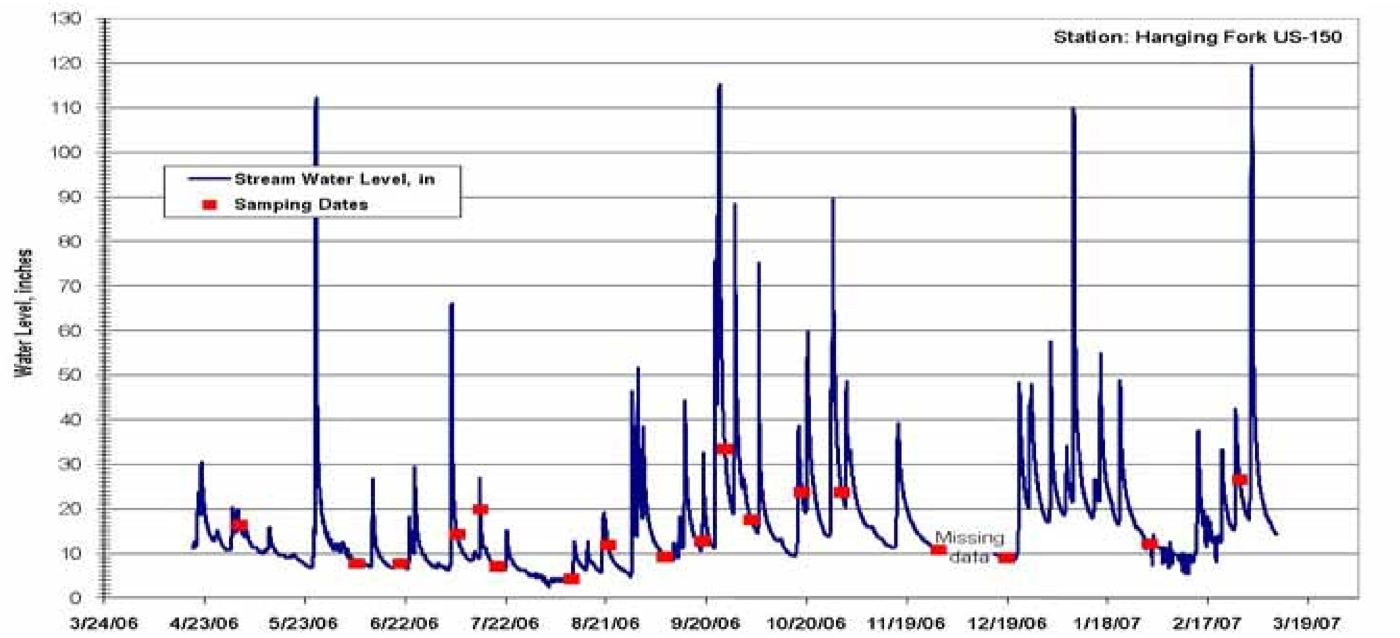


Cumulatively, Figures 1 and 2 indicate that the water levels in the stream show wide variance, increasing over 5 feet at Knob Lick and as much as 12 feet at Hanging Fork at US 150. The hydrographs show that the streams exhibit a flashy response to storm events, quickly rising and falling in response to the runoff and groundwater influx. As shown in these figures, the water quality sampling conducted concurrently with these water level readings were usually measured during the lowering of the water level to base flow conditions subsequent to a storm, although several events did capture rising stream conditions. The water quality study is discussed further in Section 2.1.8 of this document.

According to the 1976 Hustonville Wastewater Facilities Plan,

> "*nearly all the streams in the planning area flow directly on or near bedrock. During periods of no rainfall, streamflow is predominantly made up of base flow or groundwater discharge. During periods of rainfall or flooding, the groundwater is stored and then provides a source of flow in dry weather. When dry weather persists, these streams often reach a zero-flow condition.*"

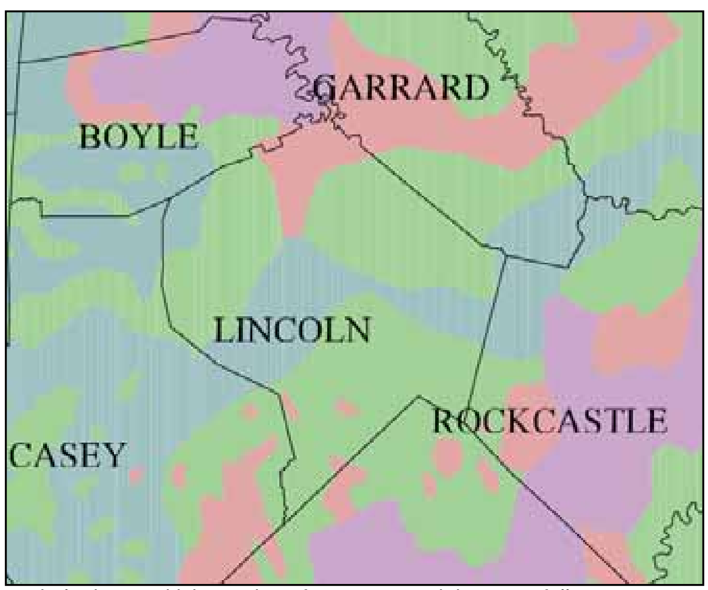
FIGURE 2 – WATER LEVEL AT HANGING FORK AT THE US 150 CROSSING, 2006-2007



2.1.3. Groundwater-Surface Interaction

In order to evaluate the sensitivity of groundwater resources to water pollution, KDOW developed a hydrologic sensitivity index to quantify the regions of Kentucky (Figure 3, Ray *et al.* 1994). Based on groundwater recharge, flow, and dispersion rates, the index ranges from 1 (low) to 5 (high).

FIGURE 3 – HYDROLOGIC SENSITIVITY INDEX MAP OF COUNTIES SURROUNDING THE DIX RIVER WATERSHED



Hydrologic Sensitivity Ratings from Low to High are as follows: Grey=1 (not shown), Blue = 2, Green=3, Pink=4, Purple=5

The sensitivity index in the Hanging Fork watershed is largely a product of the underlying geology. The hydrology is strongly influenced by the amount of shale in the subsurface, which generally impedes the infiltration of precipitation. As shown in Figure 3 (page 7), karst potential is higher (4) near the mouth of Hanging Fork due to greater limestone influence. The central area of the watershed with interbedded shales and limestone rates as a 3, with potential for karst but not extensive development. Water can easily move through fractured shales but very little water is stored therein. In the Knobs Region to the northwest and southeast, sensitivity is lower (2) with increased abundance of shales, dolomite, and sandstones.

The hydrologic sensitivity ratings are well correlated with the potential for karst areas and known groundwater features in the watershed as mapped by the Kentucky Geological Survey. As shown in Exhibit 2 (page 9), the areas of Ordovician limestone and shale in the southwest to northeast band along the path of Hanging Fork show moderate karst potential. Major karst potential is found near the mouth of the watershed. Springs are mostly found in these higher karst potential areas. The groundwater wells scattered throughout the watershed are used for domestic, heat pump, livestock, and water quality monitoring purposes.

2.1.4. Flooding

No Federal Emergency Management Agency (FEMA) floodplain maps are available to assess flooding related problems in the Hanging Fork Watershed.

2.1.5. Water Supply

Seven water suppliers provide drinking water connections to the Hanging Fork Watershed as shown in Exhibit 3 (page 10). The Hustonville Municipal Waterworks provides drinking water to the city area and extends service to the north along US 127 and adjoining roads and communities. The Junction City Municipal Water System serves the small area mostly in Boyle County, but extends along Airport Road in northern Lincoln County. The McKinney Water District supplies most of the rural areas in the southeastern portions of the watershed. Other water suppliers include the Stanford Water Commission, Parksville Water District, Danville City Water Works, and the East Casey County Water District. According to the Bluegrass ADD Water Resources Development Plan, 88 percent of the estimated population of 26,100 residents in Lincoln County will be on public water in 2020 (Water Resources Development Commission 1999). This estimate assumes 350 customers and 90 miles of water line will be added in Lincoln County from 2000 to 2020.

While these systems provide most of the drinking water in the watershed, domestic groundwater wells are also scattered throughout the watershed area. In the Hanging Fork watershed, most drilled wells will produce enough water for a domestic supply at depths of less than 100 feet. Wells located along the streams will produce enough water for a domestic supply, except during dry weather, while those in the upland areas will not unless they are located along geological drainage lines.

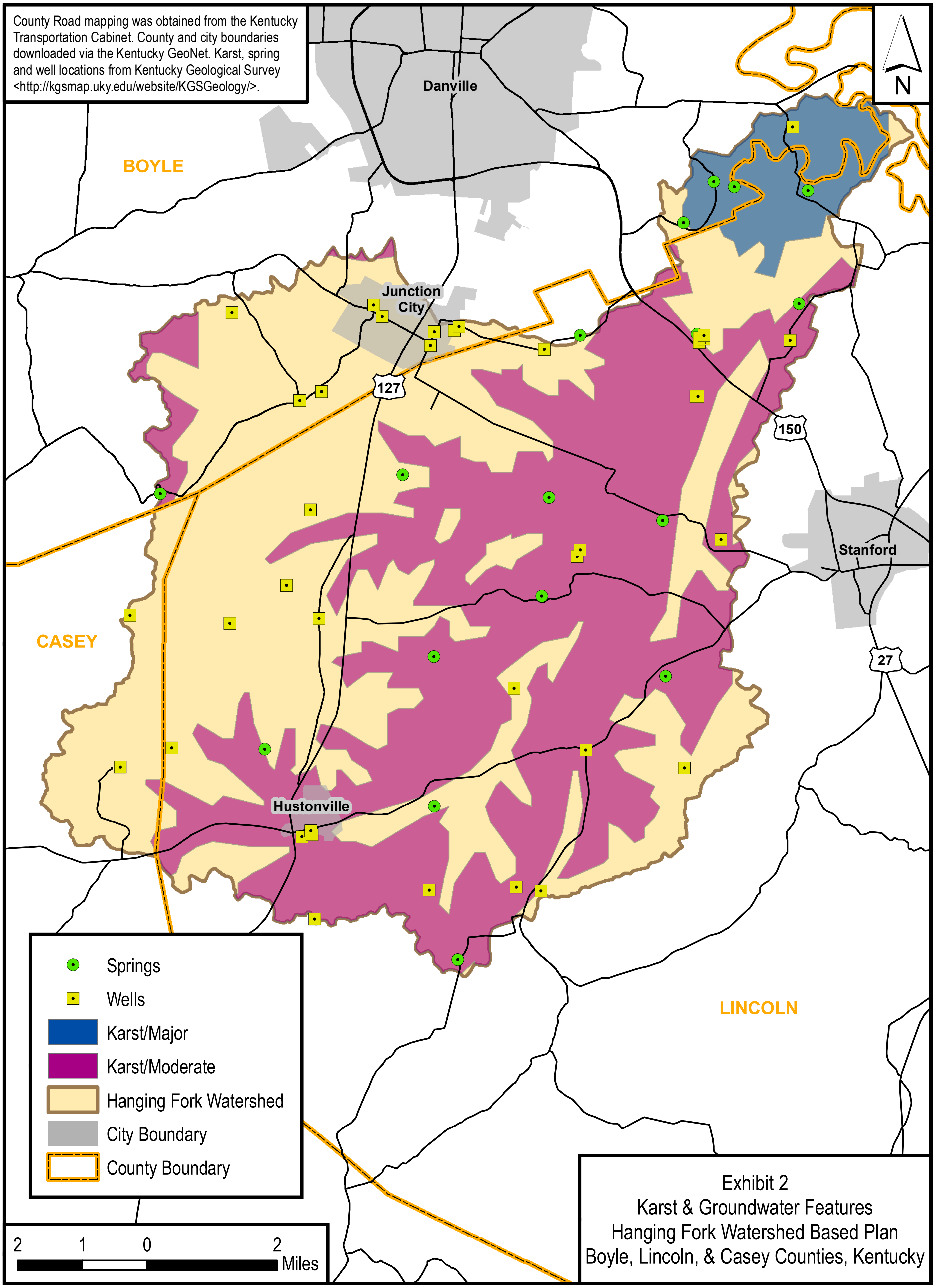


Exhibit 2
Karst & Groundwater Features
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

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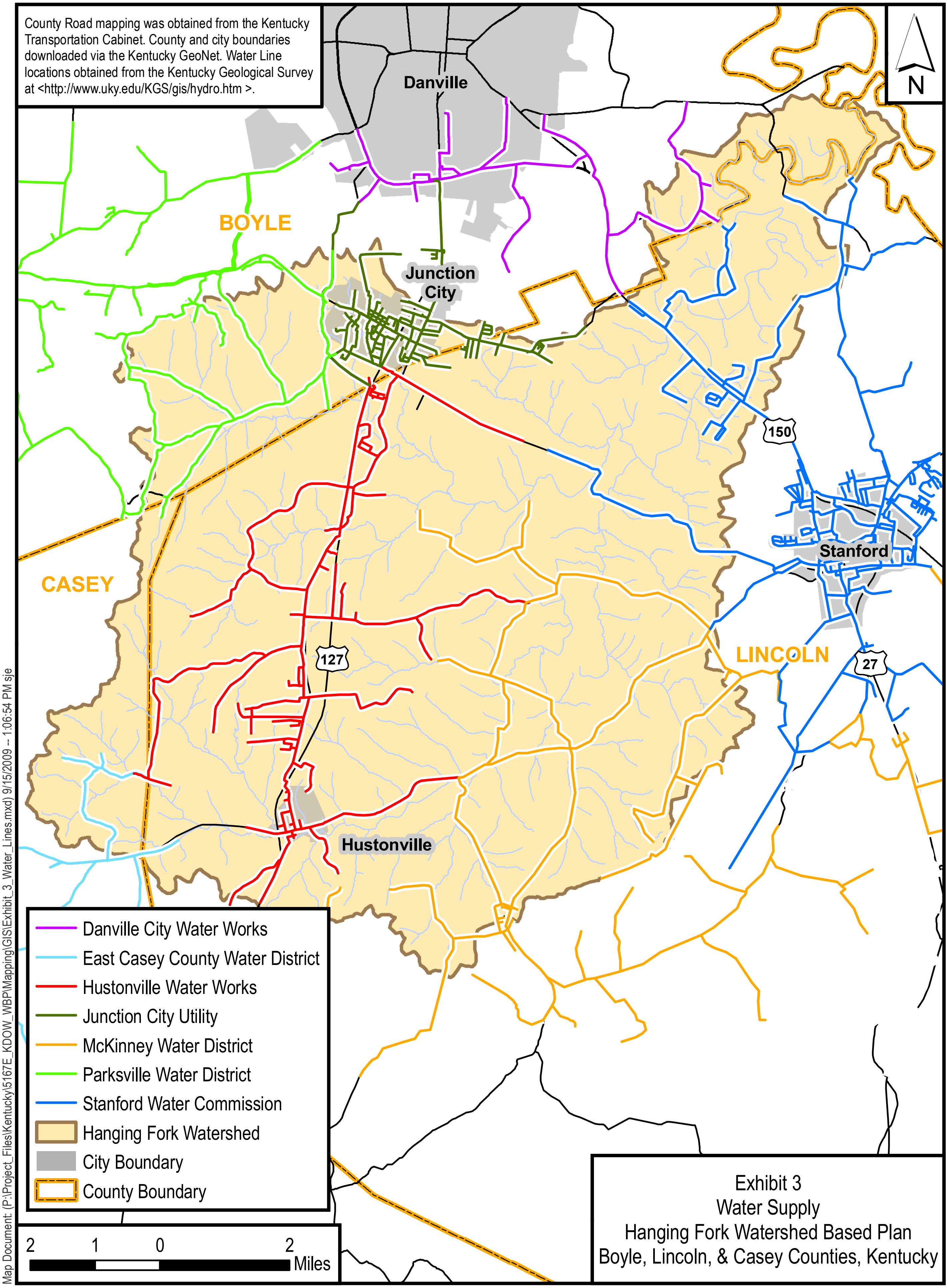

Exhibit 3
Water Supply
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

2.1.6. Watershed Management Activities

This document represents the first comprehensive watershed based plan for the Hanging Fork watershed. However, some water planning has occurred in the area in regards to water utilities.

In 1973, the Hustonville City Council elected to expand their water system and install a wastewater system. City officials were keenly aware of failures in the septic systems in the area and the potential health effects of such failures. As a result of this decision, a 201 Wastewater Facilities Plan was created for Hustonville, Kentucky on July 6, 1976 (Kennoy 1976). This plan was written as Step 1 of the grant process for the establishment of a wastewater collection, transportation, and disposal system for Hustonville, Moreland, and Milledgeville.

The 1976 Hustonville 201 Plan indicated that all wastewater systems in the area were septic systems, except for a package plant near Hustonville Elementary School and a land application system used by Kirkpatrick Laundromat. An investigation of the wastewater treatment alternatives found that the sewer system was the only acceptable method because "soils prohibited [land application by infiltration-percolation methods] because of the presence of clay layers beneath the top layers of soil. Shallow ground water tables and probability of groundwater contamination were also prohibitive." Although environmental stream data was scarce at the time, the plan notes that area streams were "known to carry high organic loading at initial stages of rainfall because of surface retention of septic tank effluents and other wastes associated with runoff." The most cost effective of the proposed solutions required 48,650 feet of 8-inch gravity lines, 15,650 feet of 4-inch force main, six 100 gallons per minute (GPM) pump stations, and one 175 GPM pump station to service an estimated 1,227 residents in the service area by the year 2000 at a cost of $2.17 million. Monthly customer costs were estimated at $25.74 with 75 percent grant funding and $11.00 with 90 percent grant funding.

The northern portion of the watershed is included in the 201 Facilities Plan for the City of Danville. Although a revised plan is currently under review, the most recent update of the plan (Bell Engineers 2006) covers the wastewater needs and orderly expansion of the system in Danville, Junction City, and Perryville through 2025. This facilities plan calls for a proposed expansion of the wastewater treatment system to include users along Airport Road. This expansion was scheduled to be addressed in the 3 to 10 year planning time frame (2009 to 2016).

The draft *Regional Wastewater Facilities Plan: Lincoln County, Kentucky* written by HMB, Inc. and currently under review by KDOW, proposes two alternatives to address the "odor, seepage, septic tank effluent discharge to streams and ground surfaces, and other potential health problems" in the City of Hustonville and Moreland area. The recommended alternative is "pumping the sewage from the City of Hustonville and Moreland to the City of Danville for treatment." The estimated cost for this alternative is $5.672 million. The second alternative is the construction of "a new 0.1 million gallons per day Package Plant located in Chicken Bristle that would be used to treat sewage from the City of Hustonville and Moreland area. The proposed discharge will be on the Hanging Fork Creek." This second alternative would include the installation of three pump-lift stations with approximately 38,000 linear feet of force main and approximately 40,000 linear feet of gravity sewer lines at an estimated cost of $5.813 million.

2.1.7. Regulatory Status of Waterways

Kentucky assigns designated uses to each waterway based on the ways in which a waterway is utilized. All streams in the Hanging Fork Watershed have four designated uses: warmwater aquatic habitat, domestic water supply, primary contact recreation, and secondary contact recreation. Warm water aquatic habitat use indicates that the stream provides suitable habitat for desirable fish and aquatic organisms. Primary contact recreational use indicates that people can swim without risks to their health and secondary contact use indicates that people can canoe or boat with only occasional contact with the water without health risks. No special use protected waters are located in the watershed. Domestic water supply indicates use as drinking water.

The 303(d) List of Surface Waters (KDOW 2008a) lists streams where the designated use water quality criteria are not met. This document lists the type of impairment as well as the pollutants and suspected sources of impairment. For the Hanging Fork Watershed, Table 2 (page 13) lists the streams that appear on the 303(d) list. A total of 64.75 miles of the 234 stream miles in the watershed (27.6 percent) are listed as impaired for primary contact recreation use due to *E. coli* pollution from various sources. These streams, shown in Exhibit 4 (page 14), include all of the higher order streams throughout the watershed. TMDLs are in development for each of these segments by KDOW.

2.1.8. Water Quality Data

2.1.8.1. Summary of Available Data

To evaluate the water quality within the Hanging Fork watershed, data was gathered from all available sources including scientific studies, government, and volunteer sources. As a result of this search, five significant sources of water quality data were located. These sources include a 319(h) grant funded study of Peyton Creek and Frog Branch, Kentucky River Watershed Watch (KRWW) volunteer sampling, a Kentucky PRIDE project identifying and replacing failing septic systems, the Kentucky Groundwater database, and a 319(h) funded comprehensive Hanging Fork watershed study by Third Rock Consultants, LLC (Third Rock). These studies were conducted over multiple years, geographic areas, and parameters. Exhibit 5 (page 15) shows the locations of the monitoring sites from which the water quality data was collected. Each of these studies is further described in the following sections.

2.1.8.2. Peyton Creek / Frog Branch Study

The Heritage Resource Conservation and Development Council (RC&D) was awarded a Section 319(h) Nonpoint Source Pollution grant to implement agricultural best management practices (BMPs) for proper manure handling and utilization and rotational grazing systems. This small sub-watershed of Hanging Fork watershed, within the larger Dix River watershed, is approximately 6 square miles, and was sampled at three locations. Frog Branch was sampled as the control in two locations. The area was predominately pastureland with small amounts of forest and residential areas. The monitoring network was designed to evaluate water quality changes associated with the BMP implementation. However, the report does not indicate whether the sampling was conducted pre-BMP or post-BMP installation. The number of grab samples collected at each sites and the mean total solids, suspended solids, and fecal coliform results are summarized in Table 3 (page 16).

TABLE 2 – 303(d) LISTED STREAMS IN THE HANGING FORK WATERSHED

STREAM NAME	RIVER MILES	POLLUTANT	SUSPECTED SOURCES	IMPAIRED USE
Baughman Creek into Hanging Fork Creek	0.0 to 4.6	E. coli	Unrestricted Cattle Access	PCR (Nonsupport)
Blue Lick Creek into Hanging Fork Creek	0.0 to 4.1	*E. coli*	Agriculture; Animal Feeding Operations (NPS)	PCR (Nonsupport)
Frog Branch into Hanging Fork Creek	0.0 to 3.4	*E. coli*	Agriculture; Animal Feeding Operations (NPS)	PCR (Nonsupport)
Hanging Fork into Dix River	27.6 to 32.2	*E. coli*	On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)	PCR (Nonsupport)
Hanging Fork into Dix River	24.15 to 27.6	*E. coli*	Municipal Point Source Discharges; On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)	PCR (Nonsupport)
Hanging Fork into Dix River	15.85 to 24.15	*E. coli*	Agriculture	PCR (Nonsupport)
Hanging Fork into Dix River	0.0 to 15.85	*E. coli* Fecal Coliform	Agriculture; Livestock (Grazing or Feeding Operations); Non-irrigated Crop Production; On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)	PCR (Nonsupport)
Knoblick Creek into Hanging Fork Creek	0.0 to 4.8	E. coli	Animal Feeding Operations (NPS); Unrestricted Cattle Access	PCR (Nonsupport)
Harris Creek into Knob Lick Creek	0.0 to 6.25	*E. coli*	Agriculture	PCR (Nonsupport)
White Oak Creek into Knob Lick Creek	0.0 to 3.4	*E. coli*	On-site Treatment Systems (Septic Systems and Similar Decentralized Systems); Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO)	PCR (Nonsupport)
McKinney Br. into Hanging Fork Creek	0.0 to 1.9	*E. coli*	Unrestricted Cattle Access	PCR (Nonsupport)
Peyton Creek into Hanging Fork Creek	0.0 to 4.1	*E. coli*	Animal Feeding Operations (NPS)	PCR (Nonsupport)

PCR = Primary Contact Recreational Use

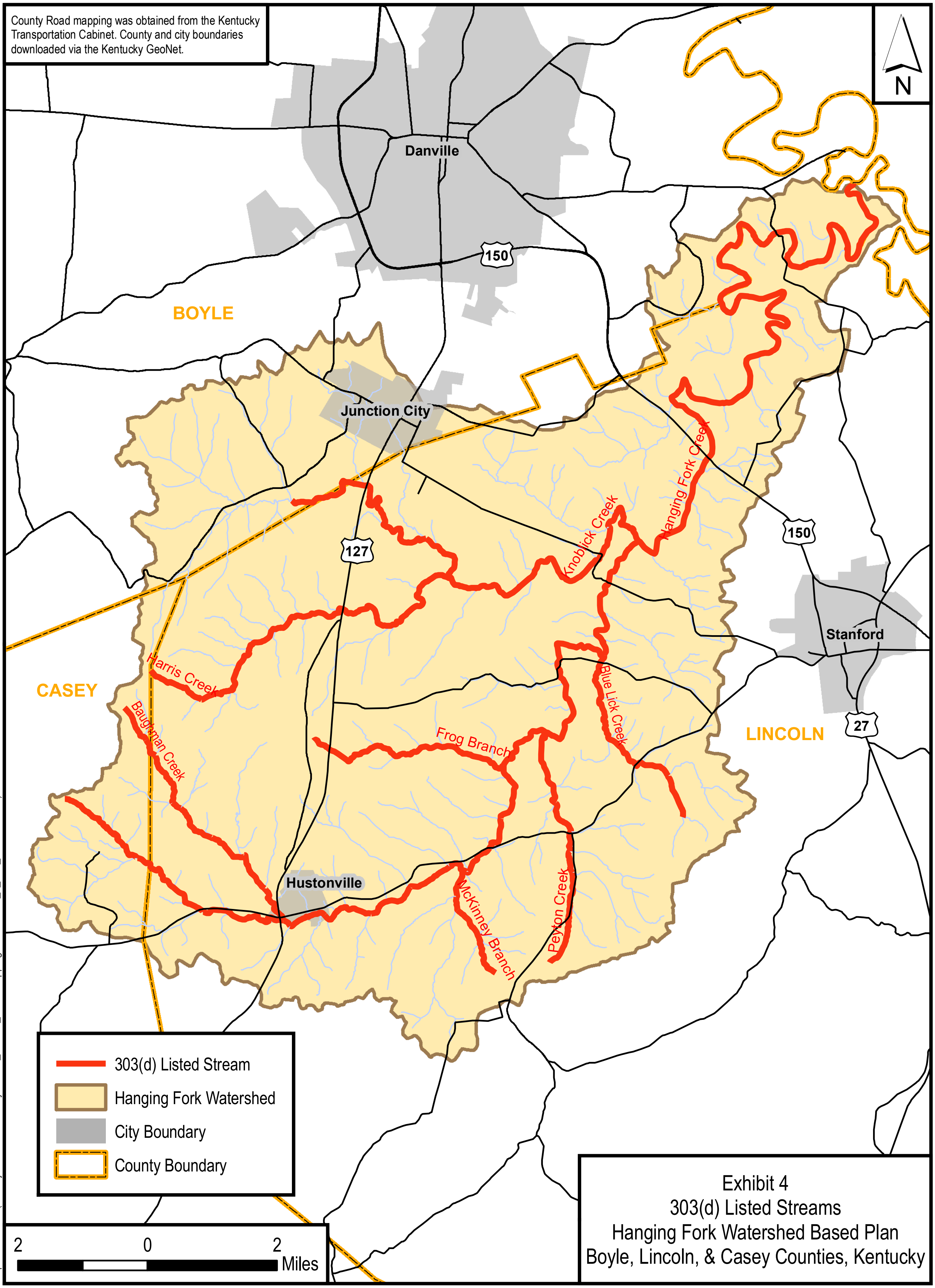

Exhibit 4
303(d) Listed Streams
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

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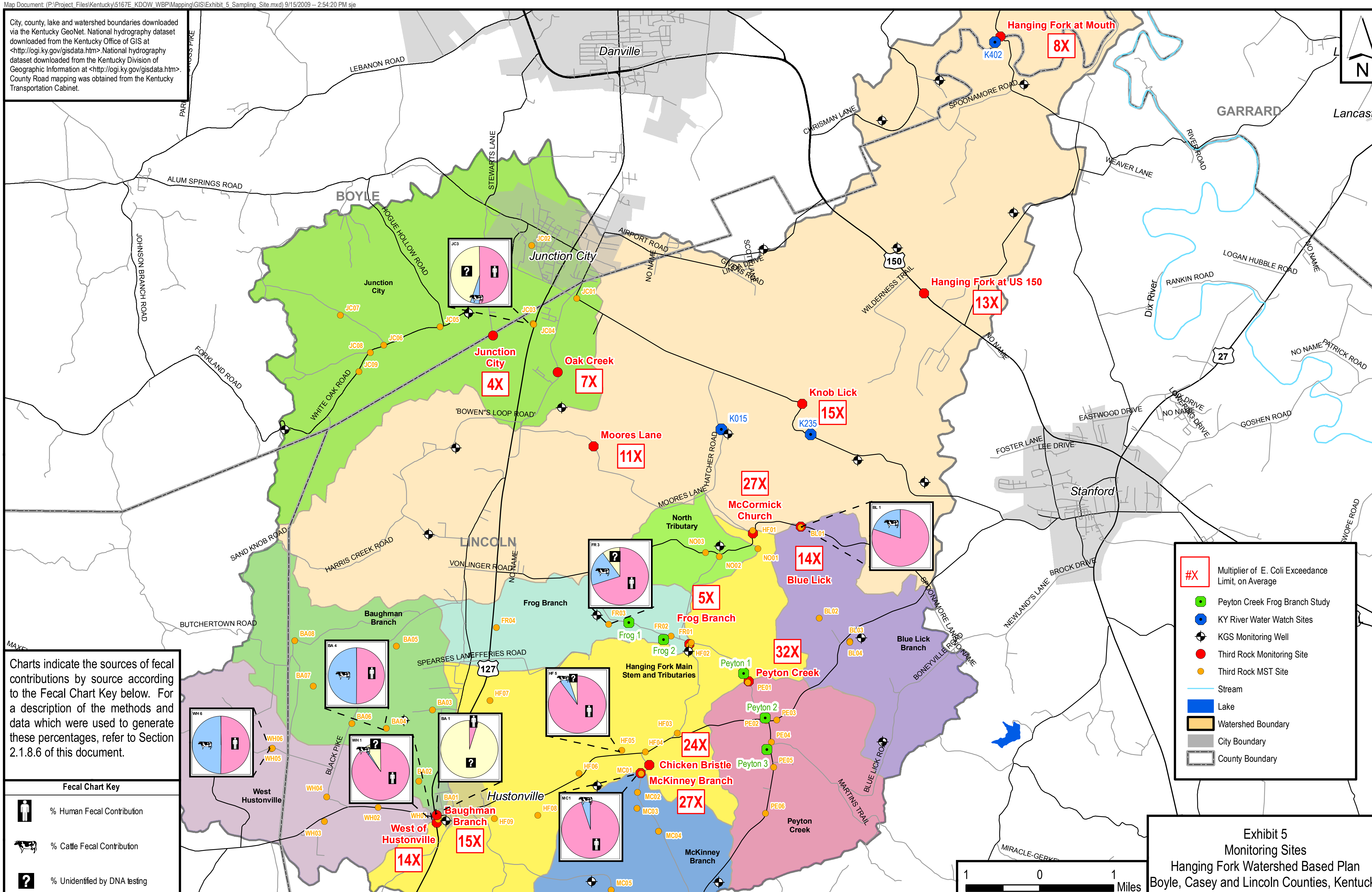


TABLE 3 – PEYTON CREEK / FROG BRANCH DATA SUMMARY

SITE	# SAMPLES	TOTAL SOLIDS (mg/L)	SUSPENDED SOLIDS (mg/L)	FECAL COLIFORM (CFU/100mLs)
Frog Branch – Control 1	7	330	98	12,636
Frog Branch – Control 2	4	245	10	3,843
Peyton Creek – BMP Site 1	12	565	282	14,721
Peyton Creek – BMP Site 2	5	283	19	24,916
Peyton Creek – BMP Site 3	5	333	22	25,478

Source: Jarrett, L. 2004. Results are arithmetic means of all sample results, as expressed in the text

The data generally indicate that Peyton Creek was more severely impacted than Frog Branch. Fecal coliform samples were consistently above acceptable levels in all sites; suspended solids were high at the Frog Branch Control Site 1 and Peyton Creek Site 1. Results for fecal coliform and suspended solids were uniformly high, exceeding state regulatory criteria for fecal coliform at all sites (400 CFU/100mLs for instantaneous sampling) and the Interior Plateau Ecoregion arithmetic average for suspended solids primarily at Frog Branch – Control 1 and Peyton Creek - BMP Site 1 (75.6 mg/L).

2.1.8.3. Kentucky River Watershed Watch

KRWW is a nonprofit organization that focuses on water quality monitoring and improvement efforts within the Kentucky River Basin. From 1999 to 2008, three sites within the Hanging Fork Watershed have been monitored by the KRWW at sporadic frequencies. As shown in Exhibit 5 (page 15), K235 is located on Hanging Fork near the KY 300 overpass, K402 is near the mouth of Hanging Fork, and K015 is on Knob Lick near the Hatcher Lane overpass. A summary of the survey data collected at these sites is provided in Table 4, page 17.

Given the sporadic nature of the data collection, it is difficult to make any definitive statements about the data and watershed trends. However, several parameters are worth noting. Fecal coliform levels and *Escherichia coli* (*E. coli*) levels were high at two of the sites measured, and chloropyrifos (an insecticide) exceeded the acute limit during the single event during which it was tested. Total suspended solid levels were routinely high at site K235. The single sample tested for metals also showed high results for selenium (0.008 mg/L) and silver (0.0085 mg/L).

TABLE 4 – KENTUCKY RIVER WATERSHED WATCH STUDY SUMMARY

Parameter	UNITS	# SAMPLES			AVERAGE RESULTS		
Site		K235	K402	K015	K235	K402	K015
Bacteriological							
Fecal Coliform	CFU/100mLs	8	2	3	3566	627	110
E. coli	CFU/100mLs	5	1	-	1524	142	-
Nutrient							
Total Phosphorus	mg/L	2	-	1	0.02	-	0.09
Sulfate	mg/L	4	-	1	36.6	-	14.2
Pesticide/Herbicide							
Alachlor	mg/L	-	-	1	-	-	0
Chloropyrifos	mg/L	1	1	-	0	0.16	-
Metolachlor	mg/L	1	1	-	0.09	1.07	1.15
Physical/ Chemical							
Dissolved Oxygen	mg/L	13	3	2	5.6	7.7	6.4
pH	SU	13	4	2	7.6	7.6	7.7
Temperature	C	15	4	2	23.3	19.8	27
Chlorides	mg/L	5	1	1	13.0	12.4	10
Conductivity	uS/cm	7	1	1	422	390	313
Hardness	mg/L	1	-	1	167	-	158
Total Organic Carbon	mg/L	-	-	1	-	-	5.3
Total Suspended Solids	mg/L	5	1	1	61.3	3	20
Metals							
Metals	mg/L	-	1	-	-	See Note	-

Note: Metals sample included 29 parameters of which all were below water quality limits except selenium (0.008 mg/L) and silver (0.0085 mg/L).
Results from: http://kgsmap.uky.edu/website/krww/viewer.asp

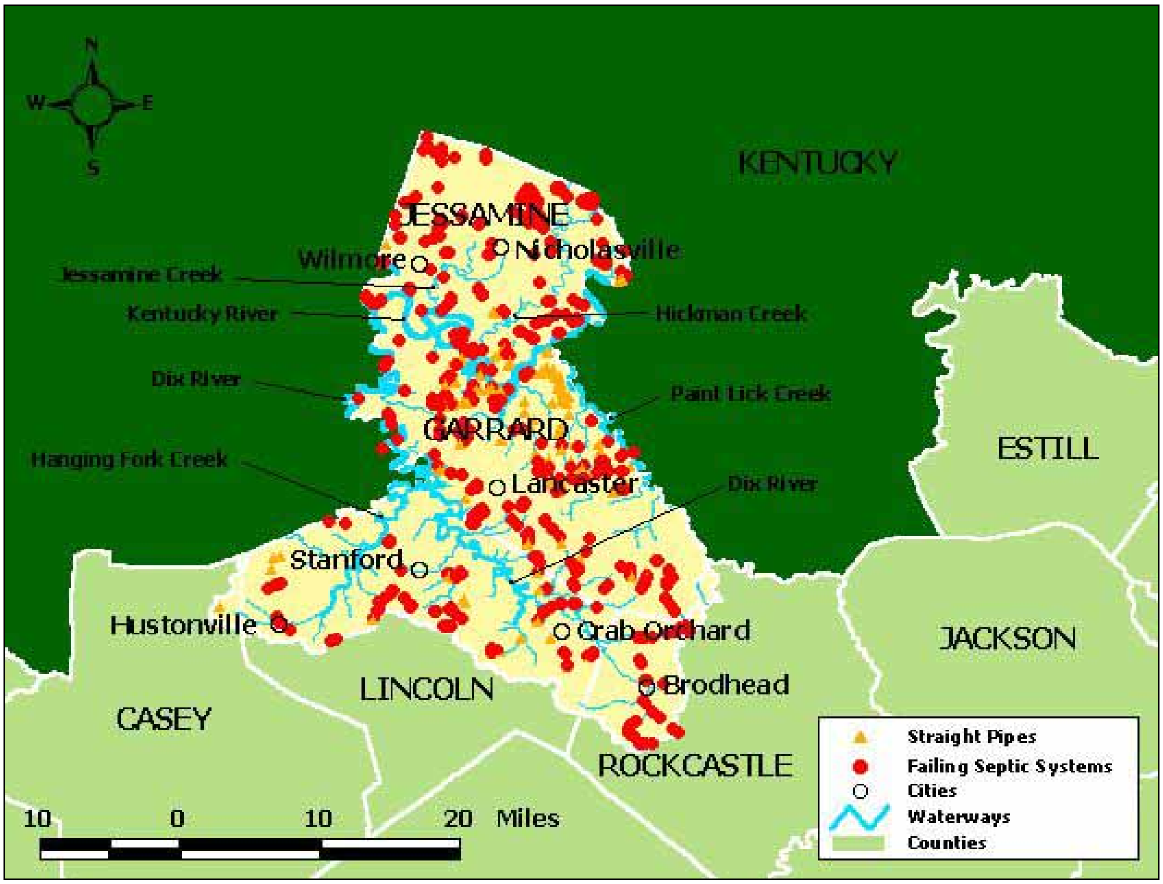
2.1.8.4. Kentucky Pride Sampling

As part of a 2002 investigation of the Kentucky River Basin, PRIDE worked in conjunction with the Bluegrass ADD to evaluate water quality problems. The Lincoln and Casey County areas of the Hanging Fork watershed were evaluated during this assessment. The University of Kentucky PRIDE Basin Assessment records the following about the Lower Fork of Kentucky River (05100205):

> "*Principal problems noted in the Kentucky River Basin are nutrients and silt from agricultural runoff, siltation from mining, and pathogens from untreated sewage. Bacteriological problems in the PRIDE area can be linked to four specific causes, all linked to improper disposal of sewage. Improper operation of wastewater treatment plants and small privately owned package plants may cause significant pathogen impairment problems. Package plants are small wastewater treatment facilities. Soils and terrain in the county are often inadequate to support traditional septic systems. The presence of numerous straight pipes is also a source of impairment of streams by pathogens. A straight pipe is a sewer line from a house or building that discharge raw sewage directly into a receiving stream or river. The final cause for bacteriological impairment is the failure of septic systems due to improper design and/or lack of maintenance. In many cases, such systems can have as significant impact on nearby streams as ineffective package plants or straight pipes*."

According to the Hanging Fork Creek Watershed Highlights in the 2002 Kentucky River Management Plan, "PRIDE identified 47 straight pipes or failing septic systems in the PRIDE part of the watershed." The location of these failing features is indicated in Figure 4.

FIGURE 4 – FAILING SEPTIC SYSTEMS AND STRAIGHT PIPES IN THE PRIDE REGION OF THE LOWER KENTUCKY RIVER WATERSHED



Source: http://pride.uky.edu/basinassessments/lowerkyriver.cfm

David Duttlinger and Don Hassel of the Bluegrass ADD indicated in personal correspondence that 40 of these failing systems were replaced with newly installed septic systems (Duttlinger 2009). These replacements were conducted under the Septic System Loan Program. Mr. Hassel indicated that he had professional objections to some of the installations because the soils were often not suitable for such treatment methods (Duttlinger 2009). Because some soils did not perk, little absorption and treatment was expected.

2.1.8.5. Kentucky Division of Water – Groundwater Database

Groundwater quality data from KDOW's consolidated groundwater database is summarized in Table 5 (page 19) (KDOW 2007). The data is compiled from 28 sites over the time period from 1953 to 2001. Because the data is so infrequently collected, it is of negligible value to the current analysis. However, it does show some historically high total dissolved solids, hardness, and conductivity levels.

TABLE 5 – GROUNDWATER DATABASE WATER QUALITY SUMMARY FOR THE HANGING FORK WATERSHED

PARAMETER	UNITS	MAXIMUM VALUE	AVERAGE VALUE	# SAMPLES
Alkalinity	mg/L	184	145.5	2
Conductivity	uS/cm	168,000	6,505*	28
Hardness	mg/L	110,000	97*	5
Nitrate-Nitrogen	mg/L	3.4	2.488	2
Nitrite-Nitrogen	mg/L	0.006	0.006	1
Orthophosphate-Phosphorus	mg/L	0.1	0.1	1
pH	SU	8.09	7.145	2
Total Dissolved Solids	mg/L	267,000	141	3

*Average after subtracting the maximum value

2.1.8.6. Division of Water – Third Rock Water Quality Monitoring Study and Microbial Source Tracking

Under a 319(h) grant from KDOW, Third Rock performed water quality monitoring from March 2006 to February 2007 on the Hanging Fork watershed as a part of a larger monitoring effort for the Dix River Watershed and Herrington Lake.

Fourteen stations in the Hanging Fork watershed were sampled on a monthly basis, at minimum, with intent to capture low, normal, and high flows. At all sites, monthly grab samples were collected and analyzed at Microbac Laboratories and CT Laboratories for the following parameters at all stations: ammonia (NH_3), total organic carbon (TOC), nitrate (NO_3), nitrite (NO_2), Kjeldahl nitrogen (TKN), orthophosphate (OP), total phosphorus (TP), total suspended solids (TSS), total coliform, and *E. coli*. At 6 selected sites, alkalinity, biochemical oxygen demand (BOD), chlorophyll *a*, and turbidity were collected monthly, chloride collected quarterly, and periphyton twice during the recreation season. While onsite, conductivity, depth, discharge, dissolved oxygen (DO), pH, and water temperature were measured. In order to evaluate aquatic habitat, US EPA Rapid Bioassessment Protocol (RBP) worksheets were completed at all sites during the initial and final site visits.

Because pathogens were a known concern in the Hanging Fork watershed, samples were collected while the streams were rising after a storm on September 18, 2006. Another storm event was captured on January 5, 2007 for all chemical parameters. To measure the fluctuations in stream water levels, continuously monitoring pressure transducers were installed at two sites in the Hanging Fork Watershed.

Due to the excessive total coliform and *E. coli* values observed during the initial monitoring, a portion of the Hanging Fork watershed was further investigated to identify and quantify the sources of pathogen pollution. The Microbial Source Tracking (MST) study involved compiling a Geographic Information System (GIS) dataset of human wastewater sources, identifying and characterizing sites for analysis, using *E. coli* and total coliform analysis for hotspot identification, and then utilizing DNA methods to trace the host sources.

Fifty-four sampling sites divided among nine sub-watersheds were characterized using the US EPA RBP habitat analysis and were surveyed for visual signs of fecal inputs in July 2007. Because of drought conditions in 2007, sampling for *E. coli* and total coliform was delayed until May of 2008, when a storm event and a normal flow event were sampled. *E. coli* was utilized to indicate the pathogen loading of the watershed and the atypical to typical coliform colony ratio analysis (AC/TC) associated with the total coliform to indicate the fecal age and the general source. From these sites, 10 “hotspots” were chosen for DNA analysis. Samples were collected for a storm event, normal flow event, or both during June and July of 2008 for laboratory analysis by Source Molecular Laboratories using the following methods.

- Human Enterococcus ID
- Human Bacteroidetes ID
- Cow Enterococcus ID
- Cow Bacteroidetes ID

All samples that tested positive for any of these parameters were further analyzed by quantitative polymerase chain reaction (qPCR) methodology to quantify the relative contribution of each host source to the total. The quantitative contributions were produced based on comparisons to samples collected from the Danville wastewater treatment plant and a commercial stockyard.

A complete list of all sampling results collected during the water quality portion of the monitoring is compiled in Appendix A. Table 6, on page 21, provides a summary of the average monthly water quality data for each site. A summary of the MST monitoring results is provided in Appendix B. All data was collected and analyzed in accordance with written Quality Assurance Project Plans (QAPP) in Appendix C. An evaluation of the data quality found all parameters acceptable for use except nitrogen and phosphorus, which had a known bias near the detection limit.

Based on this data, three key sources of impairment have emerged in the Hanging Fork watershed: habitat, pathogens, and algal blooms. Poor aquatic habitat is common throughout the watershed due to sparse vegetation surrounding streams. Risk of disease due to human sewage and animal waste is the most serious impairment to the watershed.

Habitat assessments of the 14 water quality sites are shown in Figure 5, on page 22. Of the 61 total sites surveyed in Hanging Fork, the majority (74 percent) was determined to have poor “not supporting” habitat with 15 percent only “partially supporting.”

The best habitat among water quality sites in the Hanging Fork watershed was located at the mouth of Hanging Fork. This wide bedrock stream had marginal riparian width, but offered a variety of velocity/depth regimes and stable, well-protected banks. The most common reason for poor habitat scores was the absence or underdevelopment of the riparian zone. Trends in these habitat scores indicate that the poorest habitats frequently occurred in streams that pass through pastures, often on first order streams.

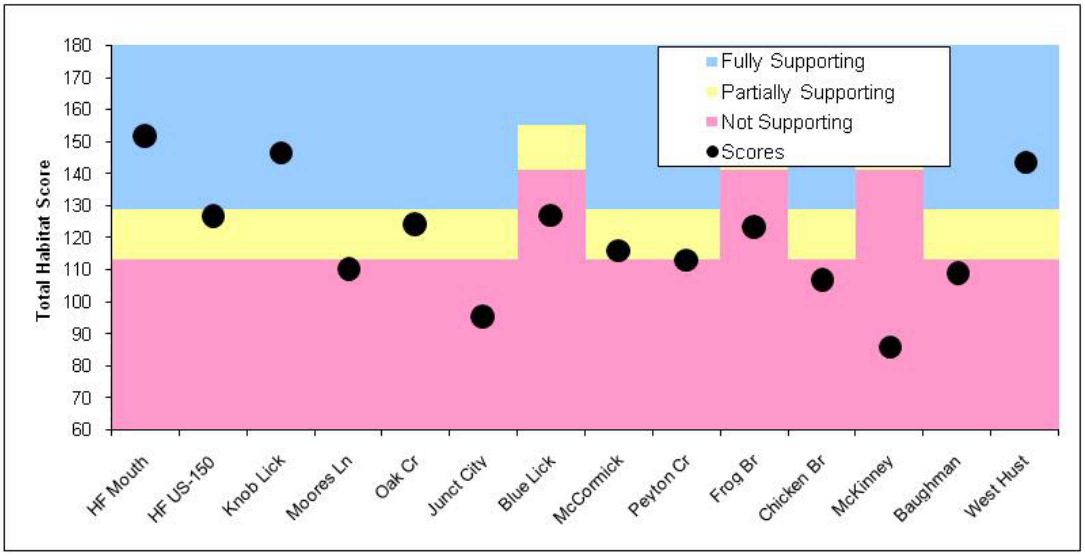
TABLE 6 – AVERAGE MONTHLY WATER QUALITY DATA FOR THIRD ROCK MONITORING, 2006-2007

SITE	UNIT	HF MOUTH	HF US 150	KNOB LICK	MOORES LANE	OAK CREEK	JUNCTION CITY	BLUE LICK	MCCORMICK CHURCH	PEYTON CREEK	FROG BRANC	CHICKEN BRISTLE	MCKINNEY BRANCH	BAUGHMAN BRANCH	WEST HUSTONVILLE
Conductivity	µS	328	308	309	264	273	150	352	348	374	370	332	391	297	276
DO	mg/L	10.7	10.0	11.6	16.0	10.1	11.2	11.9	9.8	12.3	11.3	11.9	11.9	12.0	11.8
pH	SU	8.25	8.03	8.39	8.89	7.91	7.80	8.15	7.98	8.30	8.10	8.01	8.11	8.01	8.15
Temperature	F	61.0	56.7	59.0	65.2	59.2	55.2	55.2	57.7	59.0	53.9	56.2	52.2	54.4	54.2
Turbidity	NTU	4.6	7.3	23.0	4.2	3.2	1.7	27.7	13.1	11.7	8.4	19.2	4.6	4.4	4.4
Alkalinity	mg/L	145		103	95	68			151			150			
BOD5	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
TOC	mg/L	1.9	1.8	2.0	2.3	2.2	1.5	1.9	1.9	1.4	57.2	1.9	70.6	1.8	84.0
Chloride	mg/L	8		8	7				8			7			
TKN	mg/L	0.38	0.45	0.40	0.53	0.27	0.20	0.38	0.51	0.40	2.41	0.48	0.40	0.39	0.28
NH3-N	mg/L	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	0.025	<0.023	<0.023	<0.023	<0.023	0.052	<0.023
Unionized NH-3	mg/L	0.004	0.002	0.009	0.017	0.001	0.002	0.003	0.002	0.005	0.002	0.003	0.003	0.002	0.003
NO3-N	mg/L	1.41	1.39	1.39	1.55	0.39	0.37	1.30	1.48	2.87	2.05	1.31	1.83	1.64	1.20
NO2-N	mg/L	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
OP	mg/L	0.06	0.05	0.02	0.03	<0.01	0.01	0.04	0.05	0.08	0.05	0.06	0.07	0.07	0.02
TP	mg/L	0.05	0.03	0.04	0.04	0.02	0.01	0.04	0.08	0.04	0.04	0.08	0.05	0.04	0.02
TSS	mg/L	6.6	8.1	10.9	30.6	11.3	4.7	8.8	23.2	8.4	6.0	17.0	5.3	4.6	3.8
Chlorophyll *a*	mg/m3	165.4		199.1	325.4	124.9			161.4			260.1			
Total Coliform	CFU/100mls	97661	71569	51639	59636	75405	26735	38694	79212	90095	65923	114829	65570	56412	31382
E.coli	CFU100mls	2777	3765	5886	3618	3074	1606	3656	6657	34393	2115	30232	5147	3576	3017

NOTE: Averages based on arithmetic means of all sampling events. For sample results below the detection limit, one half of the detection limit was used to calculate the average. Results greater than the range were not included in the averaging.
DO = Dissolved Oxygen, BOD5 = 5-day Biochemical Oxygen Demand, TOC= Total Organic Carbon, TKN = Total Kjeldahl Nitrogen, NH-3 = Ammonia, NO3-N = Nitrate, NO2-N = Nitrite, OP= Orthophosphorus, TP = Total Phosphorus, TSS = Total Suspended Solids.

E. coli was sampled as an indicator of sewage or animal wastes in streams within the Hanging Fork watershed. Results indicated that concentrations of *E. coli* often ranged from ten to one thousand times greater than the statewide acute warmwater limit of 240 cfu/100 mL. At their highest levels, some locations in the Hanging Fork watershed had *E. coli* levels similar to those found in the inflow to a wastewater treatment plant (greater than 250,000 cfu/100 mL). Overall, concentrations of *E. coli* were much higher in the southern portion of the watershed, averaging nearly double those found in the northern portion. Therefore, the additional MST study was focused in this area.

FIGURE 5 – TOTAL HABITAT SCORES FOR HANGING FORK WATER QUALITY SITES



Note: Habitat criteria reflect the site status as a headwater or wadeable stream.

Despite the dominant agricultural land use of the watershed, the MST study overwhelmingly showed that human waste is the source of fecal inputs at the 10 sites in which DNA testing was conducted. Generally, human inputs were found to contribute 75 percent of the fecal bacteria in the watershed. Cattle were identified as the second most abundant source, contributing 50 percent of fecal matter in some places, but averaging 25 percent or less watershed-wide. The source components in different geographical areas are shown in Exhibit 5 (page 15). It should be noted that these percentages of human and cattle fecal loading are based on sampling conditions representative of dry weather sources. During dry weather sampling, point sources are more often captured while wet weather sampling during runoff conditions typically captures nonpoint source impacts.

DNA markers indicated that multiple residences throughout each subwatershed contributed to the high fecal levels. Testing to indicate the freshness of the fecal sources supported this conclusion. Since no residences outside of Junction City are serviced by sewer systems, failing septic systems and straight pipes are the dominant source of these high fecal levels.

Algal blooms were observed throughout the watershed but were especially abundant at Moores Lane. Concentrations of chlorophyll *a*, an indicator of algal blooms, were above the statewide average at all sites in which it was measured. Concentrations even reached as high as 841 mg/m^3 at Chicken Bristle and 1,027 mg/m^3 at Moores Lane. The large algal blooms are the natural result of the high nutrient concentrations in stream reaches exposed to abundant sunlight due to a lack of riparian shading. Algal blooms impact streams in a number of ways. The unattractive appearance can detract from the recreational value of the stream, causing property values to decline. Because of their volume, they also reduce habitat for some aquatic species. Algal blooms can also reduce nighttime concentrations of dissolved oxygen, which can be deadly to fish. Because dissolved oxygen was not measured at night, it is unknown whether the algal blooms are producing toxic conditions. However, no fish kills were observed in the watershed.

Nitrogen concentrations were high at all sites except Oak Creek and Junction City. Concentrations were especially high for nitrate at Peyton Creek and Frog Branch. In addition, the pH was high throughout the watershed. Moores Lane, Knob Lick, and Oak Creek each exceeded regulatory limits for pH on at least one occasion.

2.1.8.7. Water Quality Data Gaps

Based on the evaluation of the known water quality data, several data gaps have emerged which will be important in furthering the goals of the watershed plan. These gaps represent either baseline data necessary to evaluate progress towards the watershed goals or data valuable in focusing remediation efforts. Two data gaps have been identified.

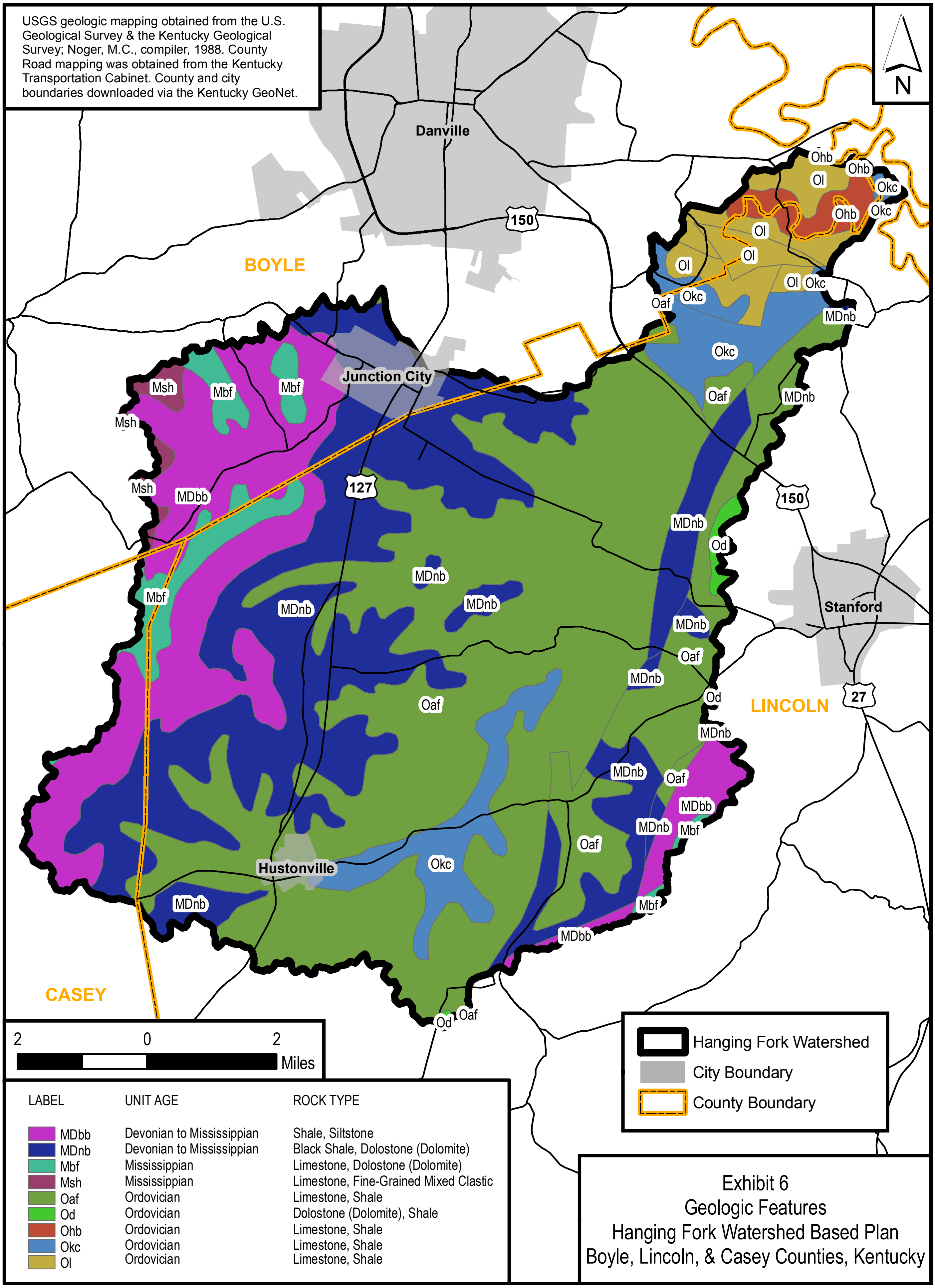
1. Straight pipe / septic tank survey: PRIDE completed a straight pipe survey in 2002 identifying multiple straight pipes in the Lincoln County portion of the Hanging Fork watershed. However because this data could not be retrieved, a survey for straight pipes and evidence of failing septic systems should be completed in order to focus remediation efforts.

2. Assessment of baseline benthic and fish community diversity: A baseline evaluation of the aquatic biological community and its relation to habitat and water quality should be conducted. Existing phytoplankton data may be evaluated in this assessment, but collection of fish and benthic macroinvertebrate samples are really necessary to make such evaluations.

2.2. Natural Features of the Watershed

2.2.1. Physiology and Geology

The Hanging Fork watershed is located entirely within the Interior Plateau Level III ecoregion (Woods *et al.* 2002). This ecoregion is subdivided into many smaller regions, four of which occur in the Hanging Fork watershed. The majority of the watershed (71 percent) is located within the Outer Bluegrass area, but the Knobs ecoregion in the western portion of the watershed near Casey and Boyle County and the southeastern corner of the watershed also covers a significant percentage of the area (20 percent). The Hills of the Bluegrass (7 percent) and Inner Bluegrass (2 percent) ecoregions encompass a minor area in the northeast of the watershed. Exhibits 6 and 7 (pages 24 and 25), respectively, show the geology and ecoregions/physiology of the watershed. Some elevations from communities in or around the watershed include Chicken Bristle, 921 feet; Hustonville, 974 feet; McKinney, 1,012 feet; and Moreland, 1,089 feet (Carey *et al.* 2004). The following discussion of these areas is based upon the data presented in Woods *et al.* 2002 and Carey *et al.* 2004.



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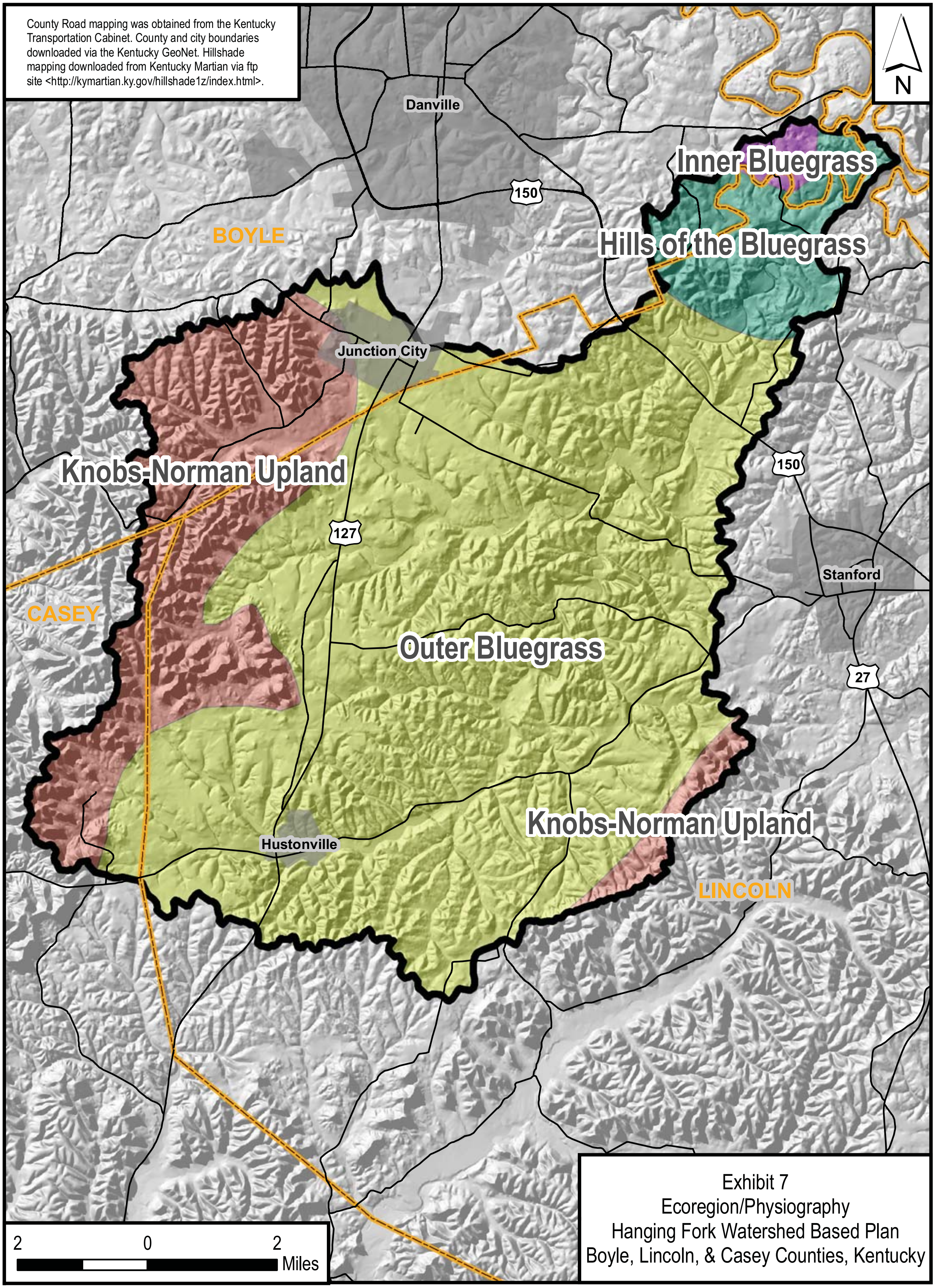

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The rolling to hilly Outer Bluegrass is known to contain sinkholes, springs, entrenched rivers, and intermittent and perennial streams over its entire range. Local relief is variable but is usually less than in the geomorphically distinct Knobs region in the western area of the watershed. Typical elevations are 1,000 feet or greater. The Outer Bluegrass ecoregion is mostly underlain by Upper Ordovician interbedded clay shales, siltstones, and limestones. This area is karst prone with intense karst potential near the mouth of Hanging Fork. Natural soil fertility is higher than in the shale-dominated Hills of the Bluegrass. Today, pastureland and cropland are widespread and dissected areas are wooded. At the time of settlement, open savanna woodlands were found on most uplands. On less fertile, more acidic soils derived from Silurian dolomite, white oak stands occurred and had barren openings. Cane grew along streams and was especially common in the east. Upland streams have moderate to high gradients and cobble, boulder, or bedrock substrates.

The Knobs ecoregion in the western and southeastern headwater areas of the watershed is underlain by Pennsylvanian-age through Silurian-age sedimentary rocks. Its characteristic rounded hills and ridges are mostly forested and divide the Bluegrass from the rest of the Interior Plateau. The highest elevations in the watershed are in this area, reaching over 1,400 feet. This ecoregion is characterized by high geological and topographical and ecological diversity. The more competent Mississippian sandstones and limestones on the surface of this area limit wells to low volumes of water produced through fractures in fine-grained sedimentary rocks, and very few springs exist. Those that do occur have small discharges, or are seasonal "wet-weather" springs. Surface runoff is a more significant input to stream discharge. Inceptisols and Ultisols occur on slopes and support mixed deciduous forests. Narrow, high gradient valleys are also common. In addition, a few wide, locally swampy valley floors occur and are used for livestock farming, row crop farming, and woodland. The density of perennial upland streams is far greater than on nearby limestone plains.

The small portion of the northeastern watershed area is located in the Hills of the Bluegrass ecoregion. It is lithologically unlike the Knobs or Outer Bluegrass. Rocks of this region typically contain higher percentages of shale layers, and therefore do not develop extensive karst features. Upland soils are fairly high in phosphorus, potassium, and lime but are not as naturally fertile as the Outer Bluegrass of which most of Hanging Fork is composed; they commonly support young, mixed forests rich in white oak, hickory, and cedar. The Hills of the Bluegrass has steeper terrain, droughtier soils, lower soil fertility, higher drainage density, and is more erosion prone than the Outer Bluegrass ecoregion.

2.2.2. Soils

Soils data were analyzed using GIS to determine the predominant soil types. Soils are typically assessed for various types of uses. The use types assessed are generally based on USDA soil property report descriptions (USDA/NRCS 2007b).

In the Hanging Fork Watershed, 6 percent of the watershed soils are susceptible to frequent flooding. Most of the watershed is rated as not prime farmland (49 percent), while 43 percent is rated as prime farmland or farmland of importance, making it one of the more suitable agricultural areas in the Dix Watershed. The area is relatively limited for construction and development purposes: 91 percent of the watershed is very limited for streets; 98 percent is limited or somewhat limited for excavation; 90 percent is limited or somewhat limited for commercial land uses. On-site wastewater management, through septic systems, is very or somewhat limited in 99 percent of the watershed, a challenge for managing rural wastewater. A summary of the top 10 soil types is presented in Table 7.

TABLE 7 – HANGING FORK WATERSHED AREA (AND PERCENTAGE) FOR TOP 10 SOIL TYPES

SOIL TYPE NAME	SQUARE MILES	% AREA
Lowell-Faywood complex, 12 to 25 percent slopes, eroded, rocky	12.91	13.4
Lowell silt loam, 6 to 12 percent slopes, eroded	11.15	11.6
Cynthiana-Faywood complex, 25 to 50 percent slopes, eroded, very rocky	6.71	7.0
Crider silt loam, 2 to 6 percent slopes	6.08	6.3
Faywood-Cynthiana complex, 12 to 25 percent slopes, eroded, very rocky	5.57	5.8
Tilsit silt loam, 2 to 6 percent slopes	5.27	5.5
Nolin silt loam, frequently flooded	3.16	3.3
Garmon channery silt loam, 25 to 80 percent slopes, rocky	2.98	3.1
Garmon silt loam, 25 to 60 percent slopes	2.44	2.5
Carpenter-Lenberg complex, 12 to 30 percent slopes, eroded	2.24	2.3
Total:	58.51	60.8

Source: US Department of Agriculture /NRCS, 2007a

2.2.3. Riparian Ecosystem

The riparian ecosystem is important because it provides wildlife habitat, reduces stream erosion, filters nutrients, traps sediment, and provides canopy cover (shading) to the stream. Under optimal conditions, the riparian zone within 60 feet of each stream bank should be covered with native species of canopy and understory trees, shrubs, and herbaceous groundcover to provide the best habitat.

The riparian zone in the Hanging Fork watershed is for the most part underdeveloped and often absent. A GIS analysis of USDA 2004 aerial images of the watershed indicated that 61 percent of the streams in the watershed are shaded, but only 32 percent of the streams are connected to some sort of contiguous forested area providing riparian habitat. Thus, 38 percent of the watershed has no riparian vegetation and about 30 percent has some canopy shading, but still provides little riparian habitat.

Cattle allowed to graze along the creek trample the banks and cause erosion that impacts aquatic habitat with sediment. Grazing reduces the filtering capacity of the riparian buffer due to organic layer compaction as well as a reduction in plant density due to consumption of the streamside vegetation. Typically, the worst habitat is linked with pastures while forested streams were generally in better condition. Habitat on first order streams, particularly in the southern portion of the watershed, was in general much more impacted than on the higher order main stem streams in the watershed.

2.2.4. Fauna

According to the Kentucky State Nature Preserves Commission (KSNPC), the Hanging Fork Portion of the Lincoln County contains several state and federally listed threatened, endangered, or special concern species (KSNPC 2009). Table 8 lists these species and communities. Management activities that increase the habitat of these species as well as the water quality are preferable and have greater opportunities for funding.

TABLE 8 – FEDERALLY LISTED SPECIES AND COMMUNITIES

CATEGORY	SCIENTIFIC NAME	COMMON NAME	KSNPC STATUS[1]	USESA STATUS[2]
Vascular Plants	*Bouteloua curtipendula*	Side-oats grama	S	
Vascular Plants	*Calopogon tuberosus*	Grass pink	E	
Vascular Plants	*Carex crawei*	Crawe's sedge	S	
Vascular Plants	*Carex tetanica*	Rigid sedge	E	
Vascular Plants	*Hydrophyllum virginianum*	Eastern waterleaf	T	
Vascular Plants	*Lespedeza capitata*	Round-head bush-clover	S	
Vascular Plants	*Lonicera prolifera*	Grape honeysuckle	E	
Vascular Plants	*Onosmodium hispidissimum*	Hairy false gromwell	E	
Vascular Plants	*Spiranthes magnicamporum*	Great Plains ladies'-tresses	T	
Vascular Plants	*Viola septemloba var. egglestonii*	Eggleston's violet	S	
Freshwater Mussels	*Simpsonaias ambigua*	Salamander mussel	T	SOMC
Freshwater Mussels	*Toxolasma lividus*	Purple lilliput	E	SOMC
Freshwater Mussels	*Villosa lienosa*	Little spectaclecase	S	
Fishes	*Noturus stigmosus*	Northern madtom	S	SOMC
Breeding Birds	*Passerculus sandwichensis*	Savannah sparrow	S	
Communities		Knobs shale barrens		
Communities		Limestone barrens		

[1] Kentucky State Nature Preserve Status: E=Endangered, T=Threatened, S=Special Concern
[2] US Fish and Wildlife Service: US Endangered Species Act (USESA) Status: SOMC=Species of Management Concern

2.3. Human Activities Affecting Water Resource Quality

2.3.1. Point Sources

Six permitted Kentucky Pollutant Discharge Elimination System (KPDES) facilities are or have been located in the Hanging Fork watershed as shown in Table 9 (page 29.) All dischargers to waters of Kentucky are required to obtain a KPDES permit including concentrated animal feeding operations (CAFO), combined sewer overflows (CSO), individual residences, Kentucky Inter-Municipal Operating Permits (KIMOP), mining, municipal, industrial, oil, and gas. These dischargers are shown on Exhibit 8 (page 30).

TABLE 9 – KPDES DISCHARGERS IN THE HANGING FORK WATERSHED

FACILITY	TYPE	KPDES ID
Hustonville Elderly Apartments	Operators of Apartment Buildings	KY0097713
Texas Eastern Trans Corp	Natural Gas Transmission	KY0096229
Hustonville Elementary School	Elementary and Secondary Schools	KY0073750
Kentucky Army National Guard	Water Supply	KYG640018
City of Junction City	Sewerage System	KYP000052
Hustonville-Danville Road	Highway & Street Construction, Exc. Elev Highway	KYR100057

Other potential point sources in the watershed could be due to the Junction City Sanitary Sewer System. The location of these sewer lines as well as pump stations, package plants, and the proposed expansion of the sewer services are shown on Exhibit 8 (page 30).

2.3.2. Nonpoint Sources

Sources of pollution in the watershed are primarily due to NPS. NPS pollution comes from many diffuse sources instead of one location like industrial discharge or sewage treatment plant. As runoff and groundwater from rainfall and snowmelt move across surfaces, they pick up pollutants and carry them to the streams.

Because sewer systems are largely absent from the watershed, one source of NPS pollution is onsite sewage treatment. While some illicit straight pipes (point sources) may be located in the watershed, most onsite treatment is conducted through septic systems. Typically, septic system failure can be detected by water falling back into the tanks when the tank is pumped, or by soil flooding due to lack of soil absorption. However in soils with karst or epikarst subsurfaces, such signs of failure may not be detected due to drainage into the groundwater system. While Health Department records did not indicate the location of septic systems, the number and geographic locations of these facilities were mapped, as shown in Exhibit 8 (page 30), through correspondence between GIS analysts and County Health Department personnel (Halcomb *et al.* 2007; Carrier *et al.* 2007).

Cattle or other livestock operations are also a source of NPS pollution. Through direct inputs of fecal material or through runoff, these animals can raise the pathogen and nutrient levels of streams. Because of an abundance of pasturelands with direct access to streams, this is a prominent source of nonpoint pollution. Other agricultural land uses, such as croplands or tree nurseries, add fertilizers and pesticides that may be carried through runoff to streams, creating NPS pollution.

Impervious surfaces, such as roadways, rooftops, and other surfaces which water cannot penetrate can be NPS pollution by carrying road salts, oils, and other pollutants to streams through runoff. Due to the rural nature of the watershed, which has relatively few roadways, this is not suspected to be a large cause of NPS pollution.

Despite many human related causes of NPS pollution, natural animal populations can also increase fecal loadings and nutrient concentrations in streams.

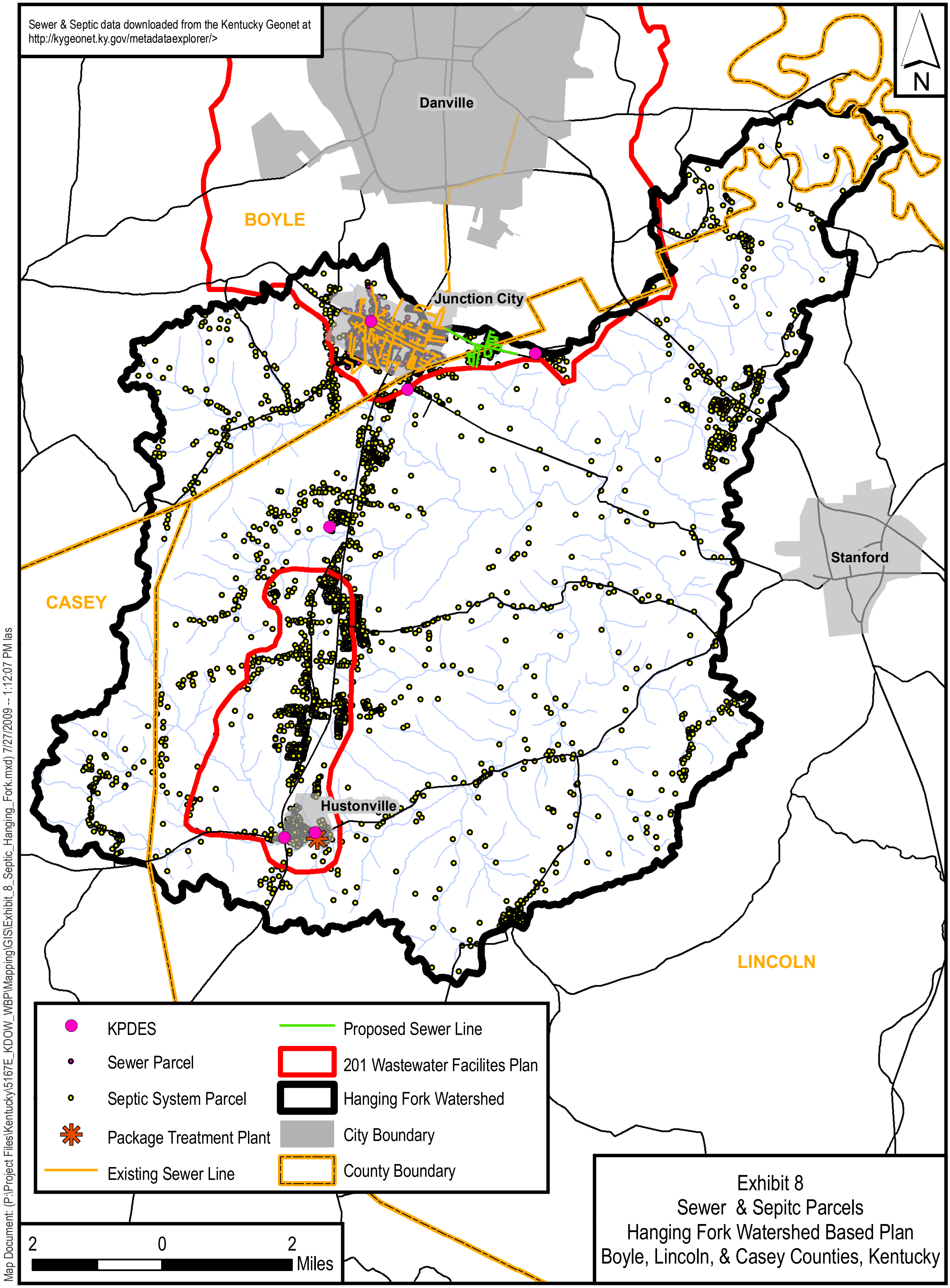


Exhibit 8
Sewer & Sepitc Parcels
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

2.4. Land Use

The land use in Hanging Fork watershed is dominated by agriculture (59 percent) most of which is pasture. Forest is the second most dominant land use in Hanging Fork (38 percent) according to 2000 National Land Cover Data Set estimates. Forested areas are primarily located either in the western portion of the watershed or in pockets along the stream corridor. Other land uses, including urban development, comprise a very small percentage of the land uses (3 percent). The location of each 2000 National Land Cover Data Set land use category and the relative percentages of each are shown in Exhibit 9 (page 32). Table 10 compares USGS data from 1992 and 2001 and to National Land Use data from 2000. The data provided in this table should not be utilized for indicating a change over time, but rather to give an estimate of the relative accuracy of the land use data. Differences in technology, categorization, and accuracy between these data sets cause apparent discrepancies between years. These land use estimates should be viewed cumulatively instead of individually to provide general estimates for the Hanging Fork area. The differences between land cover estimates reflect inaccuracies in the land cover database estimates rather than abundant changes in the watershed.

TABLE 10 – LAND COVER IN HANGING FORK WATERSHED

LAND USE*	SQUARE MILES (%) IN 1992[1] **	SQUARE MILES (%) IN 2000[2] **	SQUARE MILES (%) in 2001[3] **
Forest	37.0 (38.3%)	36.5 (37.9%)	32.6 (33.9%)
Wetland	0.4 (0.4%)	0.4 (0.4%)	0.02 (0.02%)
Shrubland			0.2 (0.3%)
Natural Grassland			1.0 (1.1%)
Developed	1.3 (1.3%)	1.2 (1.3%)	0.6 (0.6%)
Barren	0.02 (0.02%)	0.02 (0.0%)	0.1 (0.1%)
Agriculture – Total	57.7 (59.9%)	56.8 (58.9%)	61.7 (64.1%)
Agriculture - Pasture	44.8 (46.5%)	45.5 (47.2%)	49.9 (51.8%)
Agriculture - Crop	11.6 (12.0%)	11.3 (11.8%)	7.2 (7.5%)
Agriculture - Other	1.3 (1.4%)		
Urban Greenspace		1.3 (1.4%)	4.6 (4.8%)

*Land cover categories changed as technology improved; this affected collection and reporting of data. The Urban Greenspace category was derived by Kentucky Division of Water staff; the original data were presented with all Urban Greenspace grouped within agricultural land categories, and thus is a subset of the Agricultural – Total category.
** Empty cells indicate that data for this category of land cover were not collected for that year.
[1] 1992 - US Geological Survey, 1999
[2]2000 – National Land Cover Data Set
[3]2001 - US Geological Survey, 2004

2.5. Demographics and Social Issues

The demographics of the Hanging Fork watershed provide an indication of how the watershed is expected to develop as well as where remediation education should be focused. According to the US Census Bureau, Lincoln County, in which most of the Hanging Fork watershed is located, is growing at a faster rate than the rest of Kentucky. As Table 11 (page 33) shows, the rural population of the watershed is generally poorer and less educated that the state as a whole.

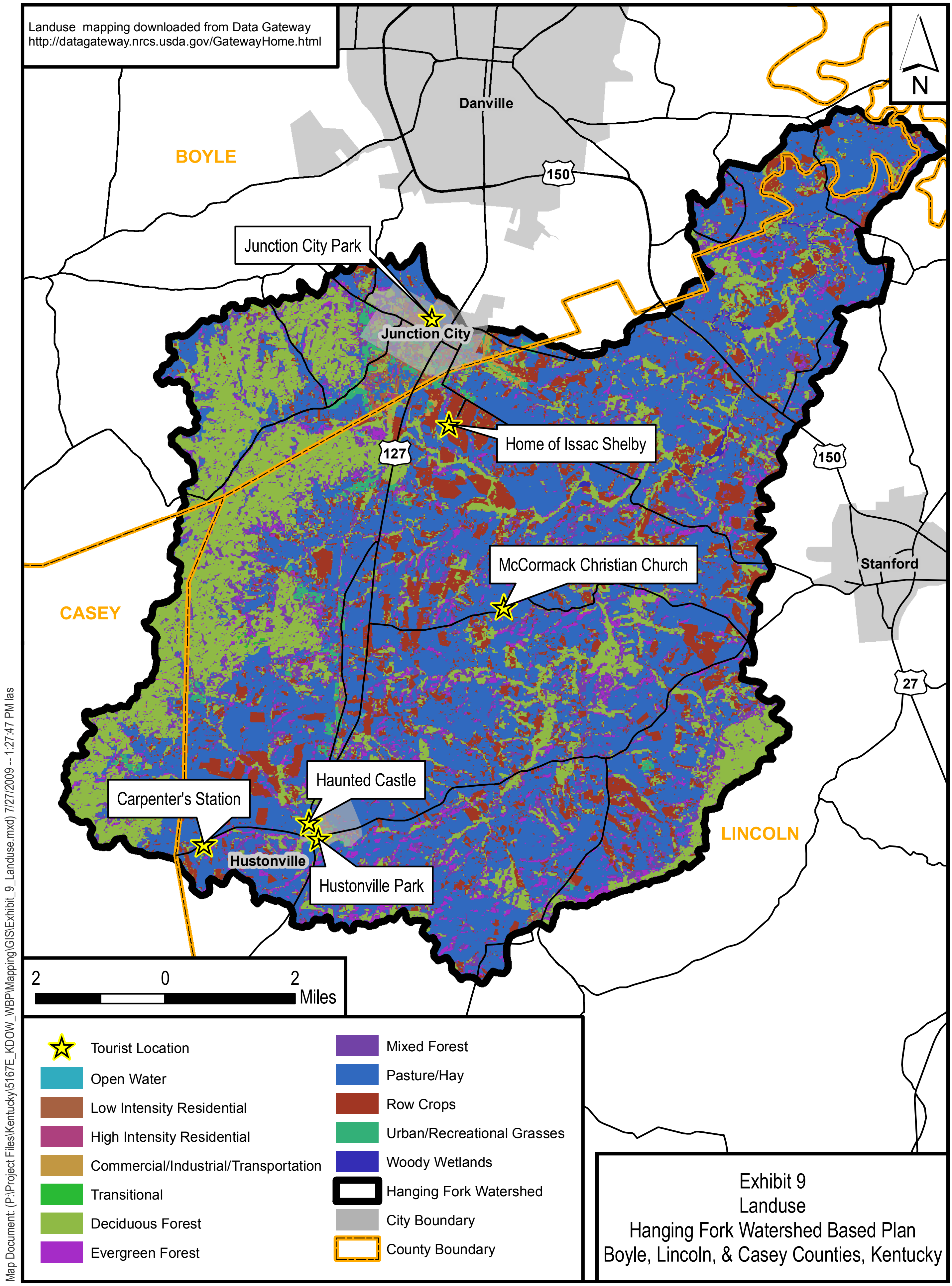


Exhibit 9
Landuse
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

TABLE 11 – COUNTY CENSUS DATA SUMMARY

	BOYLE COUNTY	LINCOLN COUNTY	KENTUCKY
Population	27,697	23,361	
Median age	36.9	36	
Average household size	2.38	2.51	2.47
Percent Change (2000 to 2008)*	4.5%	7.3%	5.6%
Education			
% High School Graduate or higher	76.6%	64.6%	74.1%
% Bachelor's degree or higher	19.3%	8.4%	17.1%
Income			
Median Household Income (2007)*	$41,739	$32,566	$40,299
% Population 16 years and older in Labor Force	58.9	58%	
Housing			
Total Housing Units	11,418	10,127	
Occupied Units	10,574	9,206	
% Owner Occupied	69.3%	78.9%	
% Renter Occupied	30.7%	21.1%	
% Mobile Homes	6%	22.8%	
Median value of specified owner-occupied units	$86,400	$65,100	$86,700

Unless otherwise stated, results are from the 2000 U.S. Bureau of Census
*Based on U.S. Census Bureau: State and County QuickFacts 2009

Although farming is not a dominant profession within the watershed, a majority of the land is used for farming. As shown in Table 12, the average farm size is approximately 140 acres with cattle farms being the most dominant use. Of the agricultural non-grazing farm use, hay production is most dominant, followed by corn and soybeans. Assuming that cattle distribution is uniform throughout the county, the county has 179 cattle per square mile. This would indicate approximately 17,214 cattle in the Hanging Fork watershed.

TABLE 12 – AGRICULTURAL CENSUS DATA BY COUNTY

	BOYLE COUNTY		LINCOLN COUNTY	
Farm Properties[1]	Year 2007	% Change*	Year 2007	% Change*
# of Farms	649	-9%	1,278	0%
Land in Farms (Acres)	94,233	-4%	178,315	+4%
Average Size of Farm (Acres)	145	+5%	140	+4%
Farm Production Statistics[2]	Year 2009			
Head of Cattle	24,300		60,000	
Acres All Hay Harvest	29,200		49,100	
Acres Corn Planted	2,500		10,000	
Acres Soybean Planted	1,600		4,800	

*Percent change from 2002 to 2007. Plus or minus sign denotes increase or decrease.
[1]Farm Properties data from: 2007 Census of Agriculture County Profile. USDA National Agricultural Statistics Service (NASS) www.agcensus.usda.gov
[2]Farm Production Statistics from: USDA NASS, Kentucky Field Office. http://www.nass.usda.gov/ky

According to personal communication with Rick Muse, Kentucky Fish and Wildlife Service Enforcement Officer, the Hanging Fork watershed is lightly fished, hunted, and trapped. Some light canoeing also occurs in the watershed. Within the watershed area, several recreational facilities, historically significant sites, and cultural attractions are also present which present opportunities for collaborative efforts to improve both the community and water quality. The location of each of these sites is shown on Exhibit 9 (page 32).

The Lincoln County Office of Tourism lists three sites on its “Heritage Highway” as occurring within the Hanging Fork watershed. The home of Isaac Shelby with the associated Isaac Shelby Cemetery State Historic Site, the McCormack Christian Church, and Carpenter’s Station are all historic sites. Two city parks are located in Junction City and Hustonville. Hustonville is also home to the “Haunted Castle,” a popular tourist attraction during Halloween holiday season.

2.6. Plan for Collecting More Data

The previous monitoring effort provided sufficient data to identify the sources and types of water pollution in the Hanging Fork watershed. However, the impairment to aquatic wildlife is currently unknown. Sampling of aquatic macroinvertebrates and fish should be conducted to determine the existing biological integrity.

Three sampling sites, one on Knoblick Creek, one at or below the McCormick Church site, and one near the mouth of Hanging Fork should be sampled according to the requirements of “Methods for Assessing the Biological Integrity of Surface Waters” (KDOW 2008b). Sampling should be conducted prior to BMP improvements in order to establish a baseline, and be monitored regularly thereafter to measure improvements over time. Further discussion of sampling is located in Section 6.

2.7. Summary and Conclusions

2.7.1. Watershed Problems

Based on the information collected in the Hanging Fork watershed, all streams analyzed had impairments. However, the impairments identified were primarily more exaggerated in the southern half of the Hanging Fork watershed. High *E. coli* concentrations were ubiquitous throughout the watershed but particularly high upstream of the McCormick Church sampling site. Habitat was typically the worst along first order streams passing through pastureland.

2.7.2. Healthy Stream and Watershed Areas

While no area of the watershed was found to be healthy, the main stem of Hanging Fork (downstream of Knoblick Creek to the mouth of Hanging Fork) is the healthiest region of the watershed. Elevated *E. coli* levels are primarily due to upstream sources, and the riparian zone is much wider, resulting in improved aquatic habitat.

2.7.3. Challenged Stream and Watershed Areas

Because of the rural setting of the watershed, finding cost effective methods of addressing the widespread pathogen problem due to human and cattle sources will be a challenge. Costs for extending a sewer system into some of the areas having the highest *E. coli* concentrations such as Peyton Creek are often prohibitive. Replacement of septic systems is difficult to address in a low-income area due to the high expense. Because of the widespread extent of impacted riparian areas, obtaining landowner cooperation and funding necessary for restoration will also be a challenge.

3. ANALYSIS OF IMPAIRMENTS

3.1. Analytical Methods

3.1.1. Water Quality Standards

In order to evaluate the nature and extent of impairments in the Hanging Fork watershed, results must be compared to applicable water quality benchmarks. The benchmarks used in this comparison were of multiple types, including legal limits as well as scientific evaluations.

For parameters are listed in 401 KAR 10:031, the legally binding surface water standards for warm water aquatic habitat in Kentucky were used as the benchmark. Specific criteria are listed for dissolved oxygen, pH, water temperature, chloride, unionized ammonia, fecal coliform, and *E. coli* as shown in Table 13. Water quality standards for metals and pesticides/herbicides are also available, but have not been listed herein due to the infrequency in the data collection of these parameters in this watershed. For specific conductance, flow, total suspended solids, and alkalinity, specific standards are not provided, but 401 KAR 10:031 indicates than levels “shall not be changed to the extent that the indigenous aquatic community is adversely affected.” Nutrients in surface waters are also to be regulated such that “where eutrophication problems may exist, nitrogen, phosphorus, carbon, and contributing trace element discharges shall be limited in accordance with: (1) the scope of the problem; (2) the geography of the affected area; and (3) relative contributions from existing and proposed sources.”

For total phosphorus and total nitrogen, KDOW has specified a numeric target for the nearby Clarks Run watershed in association with the development of total maximum daily loads (TMDL). The TMDL is the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards, thus the target is used as the benchmark for these parameters. The TMDL target for total phosphorus is 0.3 mg/L and for total nitrogen the target is 2.0 mg/L.

TABLE 13 – KENTUCKY SURFACE WATER STANDARDS

PARAMETER	UNIT	KY WQS		ADDITIONAL COMMENTS
		CHRONIC	ACUTE	
Dissolved Oxygen	mg/L	5	4	5.0mg/L is minimum daily average; 4.0 mg/L is instantaneous minimum
pH	SU	6.0/9.0		pH shall not fluctuate more than 1.0 SU over a period of 24 hours.
Temperature	deg. F		89	
Chloride	mg/L	600	1200	
Ammonia, unionized	mg/L		0.05	Unionized ammonia is determined based upon the pH, temperature, and total ammonia-N concentrations.
Fecal Coliform	cfu/100mls	200	400	There are not chronic and acute criteria for bacteria, but a geometric mean for five samples collected over 30-days and instantaneous criteria, respectively.
E. coli	cfu /100mls	130	240	

Where no specific legal standard was present, benchmarks are provided for comparison purposes and have no regulatory / legal force. The US EPA Storage and Retrieval (STORET) database was used to provide comparisons based on 39,576 results for the state of Kentucky and 18229 results from the Interior Plateau ecoregion of Kentucky collected between 1990 and 1997 (USEPA 2009a). For parameters for which data was sufficient data was available, Table 14 summarizes the number of sample results available, the arithmetic average, and the 25th, 50th, 75th, and 95th percentiles. Percentiles indicate the value at which that percentage of the results is below when all the results are ranked from lowest to highest (for example, 25% of the results are below the 25th percentile). These results were used to evaluate whether results are low, moderate, or high.

TABLE 14 – USEPA STORET DATABASE BENCHMARKS

PARAMETER	UNIT	INTERIOR PLATEAU						STATEWIDE					
		# SAMPLES	MEAN	PERCENTILE				# SAMPLES	MEAN	PERCENTILE			
				25TH	50TH	75TH	95TH			25TH	50TH	75TH	95TH
Ammonia Nitrogen, Total	mg/L	3052	0.06	0.02	0.02	0.05	0.195	5877	0.06	0.01	0.01	0.05	0.2
Nitrite and Nitrate	mg/L	3049	1.02	0.27	0.69	1.28	3.34	5893	0.75	0.19	0.44	0.93	2.61
Total Kjeldhal Nitrogen	mg/L	2635	0.52	0.24	0.42	0.645	1.34	5223	0.44	0.16	0.32	0.57	1.21
Phosphorus, Total	mg/L	2832	0.16	0.03	0.08	0.19	0.63	5707	0.11	0.01	0.03	0.11	0.45
Total Suspended Solids	mg/L	131	75.6	16.5	35	76	357	174	70.6	12.3	32	72	355.5
Turbidity	NTU	1732	32.1	10	21	37.3	120	4998	12.0	0.05	0.59	9	69
Conductivity	µS/cm	See Note						7044			295		771
Alkalinity, Total	mg/L							4334			100		202
Carbon, Total Organic	mg/L							4338			2.37		6.76
Sulfate	mg/L							4345			34		271

Note: Interior Plateau data not available for these parameters. Statewide values based on KDOW collected STORET data in USEPA 2006.

In cases where no STORET data was available, other applicable benchmarks were used to evaluate the water quality. The common KPDES permit of 10 mg/L was used to evaluate BOD levels. The conductivity level of 500 µS/cm is used as a benchmark considering levels above this limit may not be suitable for macroinvertebrates and fish (USEPA 2009b).

Habitat values are evaluated according to the standards found in KDOW's *Standard Methods for Assessing Biological Integrity of Surface Waters in Kentucky* (2008). Each habitat parameter is evaluated as "optimal," "suboptimal," "marginal," or "poor," and the total of these scores is evaluated as "fully supporting," "partially supporting," or "not supporting" according to the Bluegrass bioregion standards and the upstream watershed size, as shown in Table 15.

TABLE 15 – HABITAT CRITERIA FOR BLUEGRASS BIOREGION STREAMS

RATING LEVEL	WADEABLE STREAM (>5 mi2 watershed)	HEADWATER STREAM (<5 mi2 watershed)
Fully Supporting	130 and above	156 and above
Partially Supporting	114 – 129	142 – 155
Not Supporting	113 and below	141 and below

3.1.2. Comparison of Data to Water Quality Standards

Based on the water quality data collected, *E. coli* was found to exceed impairment levels throughout the watershed. Other parameters showed localized or infrequent exceedances of water quality benchmarks.

As shown in Table 16, all sites sampled in the Third Rock monitoring study averaged at least four times the geomean limit for *E. coli*. Seven sites never meet the criteria in any event sampled. The best sites only meet the criteria infrequently (3 events at Junction City). These results were also confirmed in the Peyton Creek – Frog Branch study where fecal coliform was tested and levels were routinely in excess of the limit of 400 cfu/100mLs.

TABLE 16 – SUMMARY OF CHEMICAL IMPAIRMENTS IN HANGING FORK

SITE NAME	ANNUAL GEOMEAN (CFU/100MLS)	EXCEEDANCES OF GEOMEAN LIMIT / COLLECTION EVENTS	AVERAGE MULTIPLE GREATER THAN LIMIT (130 CFU/100MLS)
Hanging Fork at Mouth	1030	14 / 15	8
Hanging Fork US 150	1743	14 / 15	13
Knob Lick	1983	14 / 15	15
Moores Lane	1372	12 / 14	11
Oak Creek	910	13 / 15	7
Junction City	482	11 / 14	4
Blue Lick	1808	18 / 18	14
McCormick Church	3570	15 / 15	27
Peyton Creek	4100	15 / 15	32
Frog Branch	700	13 / 15	5
Chicken Bristle	3155	15 / 15	24
McKinney Branch	3513	14 / 14	27
Baughman Branch	1945	15 / 15	15
West Hustonville	1809	15 / 15	14

Nitrate routinely exceeded the Interior Plateau mean at all sites except Oak Creek and Junction City. Average nitrate levels were highest at Peyton Creek. TKN levels exceeded the Interior Plateau mean values at Frog Branch and Moores Lane. Although these nitrogen concentrations are high, they will be addressed in the same manner as the *E.coli* impairments and so are not calculated for loading purposes. Although total organic carbon averages exceeded the mean at three stations, these high averages are due primarily to one high sampling event in February.

No other water quality parameters routinely exceeded benchmarks. Table 17, page 38, provides a summary of the relative concentrations of some water quality parameters that may be useful in prioritizing remediation activities for each subwatershed. Relative percentages of conductivity, turbidity, alkalinity, total organic carbon, chloride, total kjeldahl nitrogen, nitrate, unionized ammonia, total phosphorus, and total suspended solids are shaded from red, indicating the highest levels, to yellow, and to green, indicating the lowest levels.

TABLE 17 – ANNUAL AVERAGE AS A PERCENTAGE OF WATER QUALITY BENCHMARKS AT HANGING FORK MONITORING LOCATIONS

PARAMETER	UNIT	BENCHMARK	SOURCE[1]	HF MOUTH	HF US 150	KNOB LICK	MOORES LN	OAK CREEK	JUNCTION CITY	BLUE LICK	MCCORMICK	PEYTON CR	FROG BR	CHICKEN BR	MCKINNEY BR	BAUGHMAN BR	WEST HUSTONVILLE
Conductivity	µS/cm	500.0	EPA	66%	62%	62%	53%	55%	30%	70%	70%	75%	74%	66%	78%	59%	55%
Turbidity	NTU	32.1	IP Mean	14%	23%	72%	13%	10%	5%	86%	41%	36%	26%	60%	14%	14%	14%
Alkalinity	mg/L	202.0	KY 95th	72%	0%	51%	47%	34%	0%	0%	75%	0%	0%	74%	0%	0%	0%
TOC	mg/L	6.8	KY 95th	28%	26%	30%	33%	33%	22%	28%	28%	20%	846%	28%	1044%	26%	1243%
Chloride	mg/L	600.0	KAR	1%	0%	1%	1%	0%	0%	0%	1%	0%	0%	1%	0%	0%	0%
TKN	mg/L	0.52	IP Mean	74%	87%	78%	103%	51%	39%	74%	98%	78%	463%	92%	77%	75%	55%
Unionized NH3	mg/L	0.05	KAR	9%	4%	17%	33%	3%	4%	7%	3%	10%	4%	6%	5%	3%	5%
Nitrate	mg/L	1.02	IP Mean	138%	137%	136%	152%	38%	37%	127%	146%	281%	201%	128%	179%	161%	118%
TP	mg/L	0.160	IP Mean	32%	17%	27%	24%	12%	7%	22%	50%	26%	26%	47%	30%	22%	10%
TSS	mg/L	75.6	IP Mean	9%	11%	14%	40%	15%	6%	12%	31%	11%	8%	23%	7%	6%	5%

[1] Benchmark sources are as follows: EPA = USEPA 2009b; KAR = 401 KAR 10:031; IP Mean = EPA STORET Interior Plateau Mean; KY 95th = EPA STORET statewide 95th percentile.
NOTE: Green shading indicates values are low, yellow approaching the benchmark, and red exceeding the benchmark.

Junction City was notable lower than all other sites for conductivity and TSS. The highest TSS values were located at McCormick Church and Moores Lane. Moores Lane also had the highest average pH and temperature.

3.1.3. Stream Assessment

Of the 61 sites evaluated for habitat in the Hanging Fork watershed, 45 scored “not supporting,” 9 were “partially supporting,” and 7 were “fully supporting.” The location of each habitat score is shown in Exhibit 10 (page 39). Each of the ten categories assessed for habitat were rated from “optimal” to “poor” on a scale of 0 to 20. Figure 6 (page 40) shows the geometric average scores for each habitat category in relation to the poor to optimal ranges. Overwhelmingly, the streams scored suboptimal for all categories with the exception of bank vegetative protection (marginal) and riparian vegetative width (poor). With the geometric average near 2, the riparian vegetative width stands out as the most significant habitat impairment causing sites to be scored as “not supporting.”

Because non-supporting and partially supporting habitat scores were largely due to narrow or lacking riparian vegetation, the length of streams with impaired width was calculated to provide an estimate of the amount of habitat impacts in the watershed.

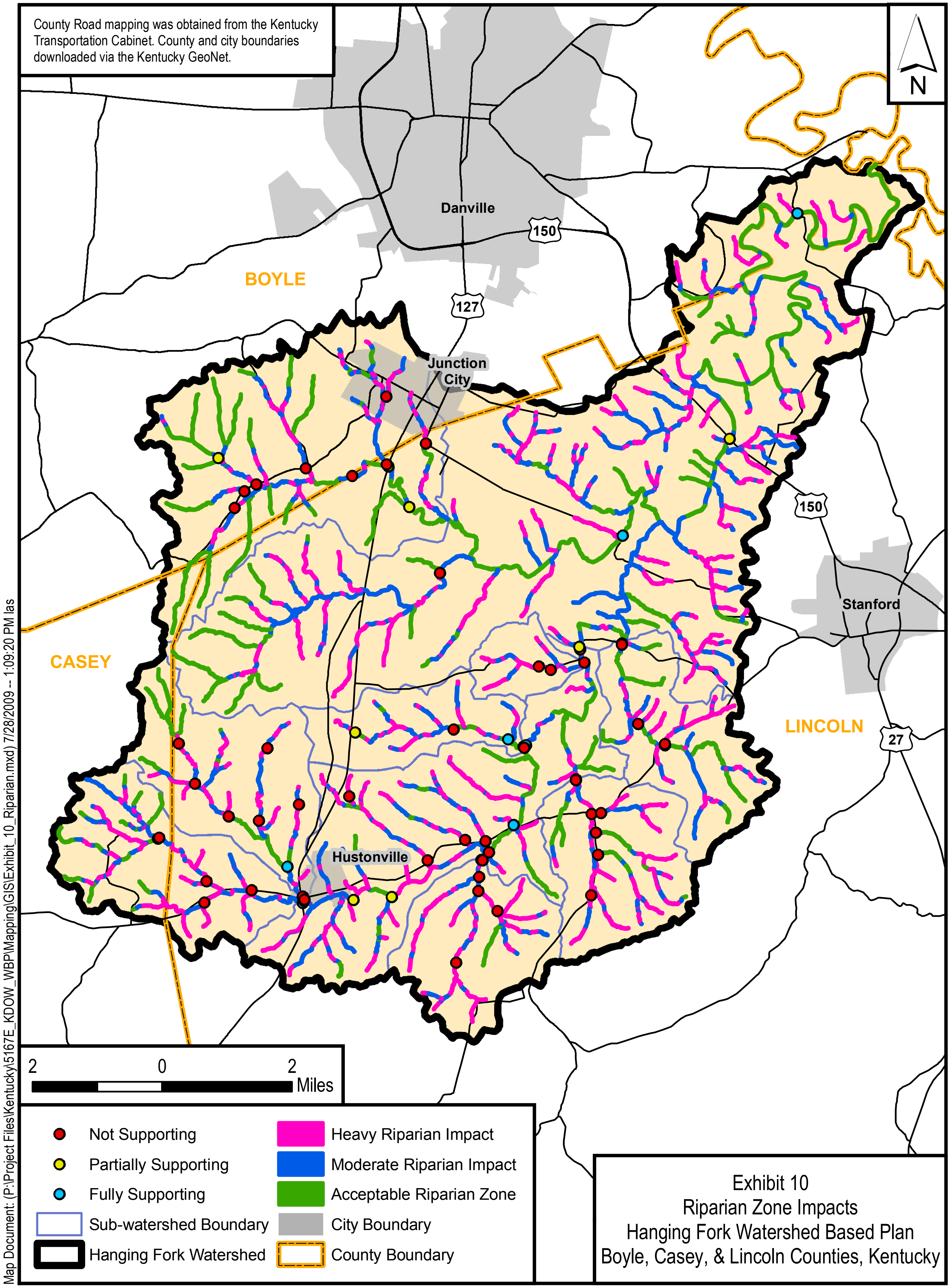
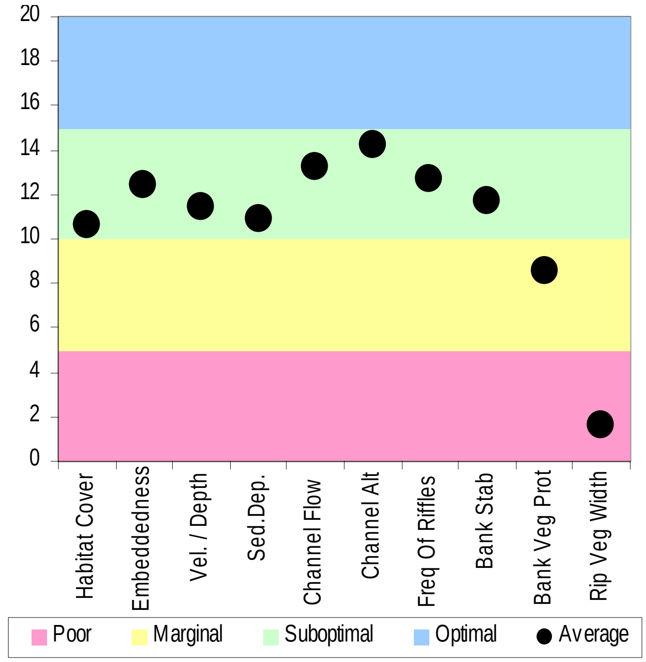


Exhibit 10
Riparian Zone Impacts
Hanging Fork Watershed Based Plan
Boyle, Casey, & Lincoln Counties, Kentucky

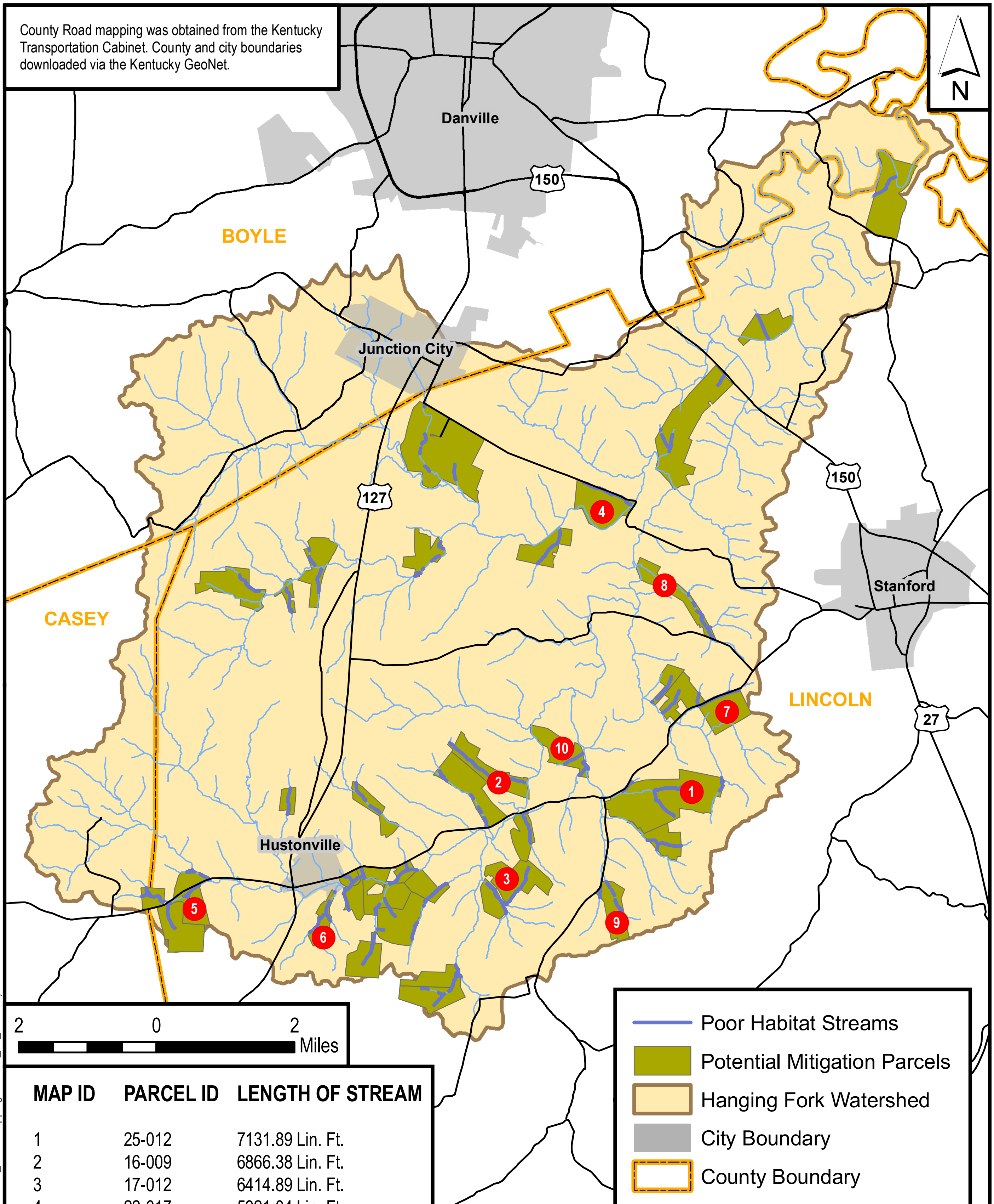
FIGURE 6 – AVERAGE HANGING FORK HABITAT SCORES BY CATEGORY



As shown in Exhibit 10 (page 39), the streams in Hanging Fork were divided into three categories of riparian zone impact based on a GIS analysis of riparian vegetation from aerial images. Each length of stream was classified either having "Heavy Impacts," "Moderate Impacts," or "Acceptable Riparian Zone."

Streams mowed or grazed to the stream edge and without canopy shading were classified in the "Heavy Riparian Impact" category. Heavy Impacts were found on 39 percent (approximately 91 miles) of Hanging Fork streams. Streams with overstory vegetation shading the stream but a narrow riparian zone were classified as "Moderate Riparian Impacts." Based on field surveys, shaded reaches passing through pasturelands or residential areas that do not border larger forested areas typically lack well developed understory, shrub, or herbaceous groundcover layers in the 60-foot riparian zone extending from each bank. Approximately 28 percent of Hanging Fork watershed streams (66 stream miles) are so classified. The remaining areas with canopy shading and extended riparian zones were classified as acceptable.

Based on the visual analysis of the correlation between the habitat scores and riparian impact zones, approximately 91 to 157 stream miles are impaired in some way for habitat use. The 91 miles of "Heavy Riparian Impacts" should be the primary target for remediation. Exhibit 11 (page 41) shows the top twenty land parcels containing the longest lengths of heavily impacted stream. The top ten of these parcels contain only 9 miles of the 91 most heavily impacted. Therefore, improving the habitat use in the Hanging Fork watershed will require wide scale participation from numerous landowners.



MAP ID	PARCEL ID	LENGTH OF STREAM
1	25-012	7131.89 Lin. Ft.
2	16-009	6866.38 Lin. Ft.
3	17-012	6414.89 Lin. Ft.
4	22-017	5921.04 Lin. Ft.
5	04-018	3903.84 Lin. Ft.
6	10-029	3734.85 Lin. Ft.
7	38-004	3470.89 Lin. Ft.
8	23-007H	3456.22 Lin. Ft.
9	26-001A	3433.51 Lin. Ft.
10	16-024	3397.53 Lin. Ft.

Exhibit 11
Priority Land Parcels for Riparian Improvement
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

Map Document: (P:\2005\5167E_KDOW_WBP\Mapping\GIS\HF_for_PP.mxd) 6/15/2009 -- 11:12:41 AM tdc

3.1.4. Pollutant Load Prediction

3.1.4.1. Discharge

In order to provide an indication of the variations in the hydrology of the watershed, a base flow for each watershed segment has been determined based on monthly sampling at 14 sites from 2006 to 2007. The adjusted discharge for each site was determined by first adjusting the monthly measurements to account for bias in the sampling techniques (float method biases high, velocity propeller method biases low, and electromagnetic current meter is the most accurate). All sampling conditions were included in this average. Then, the geometric average measured discharge from each site was adjusted so that upstream and downstream discharge values showed agreement. This method of discharge calculation was utilized because the association of the *E. coli* inputs relative to different flows were unknown and thus not categorized by flow events. Table 18 shows the discharge values throughout the watershed.

TABLE 18 – HANGING FORK *E. COLI* LOADING AND UPSTREAM REDUCTION GOALS

STATION	*E. COLI* GEOMETRIC AVERAGE (CFU/100mLs)	ADJUSTED DISCHARGE (CFS)	*E. COLI* LOADING (TRILLION CFU/YR)	*E.COLI* TARGET (TRILLION CFU/YR)	REDUCTION TO ACHIEVE TARGET (TRILLION CFU/YR)	% UPSTREAM REDUCTION TARGET
Hanging Fork at Mouth	1030	80	736	93	643	87%
Hanging Fork US 150	1743	70	1089	81	1008	93%
Knob Lick	1983	21	372	24	348	93%
Moores Lane	1372	7	86	8	78	91%
Oak Creek	910	10	81	12	70	86%
Junction City	482	5	22	6	16	73%
Blue Lick	1808	5	81	6	75	93%
McCormick Church	3570	41	1307	48	1259	96%
Peyton Creek	4100	6	220	7	213	97%
Frog Branch	700	4	25	5	20	81%
Chicken Bristle	3155	26	733	30	702	96%
McKinney Branch	3513	5	157	6	151	96%
Baughman Branch	1945	7	122	8	113	93%
West Hustonville	1809	7	113	8	105	93%

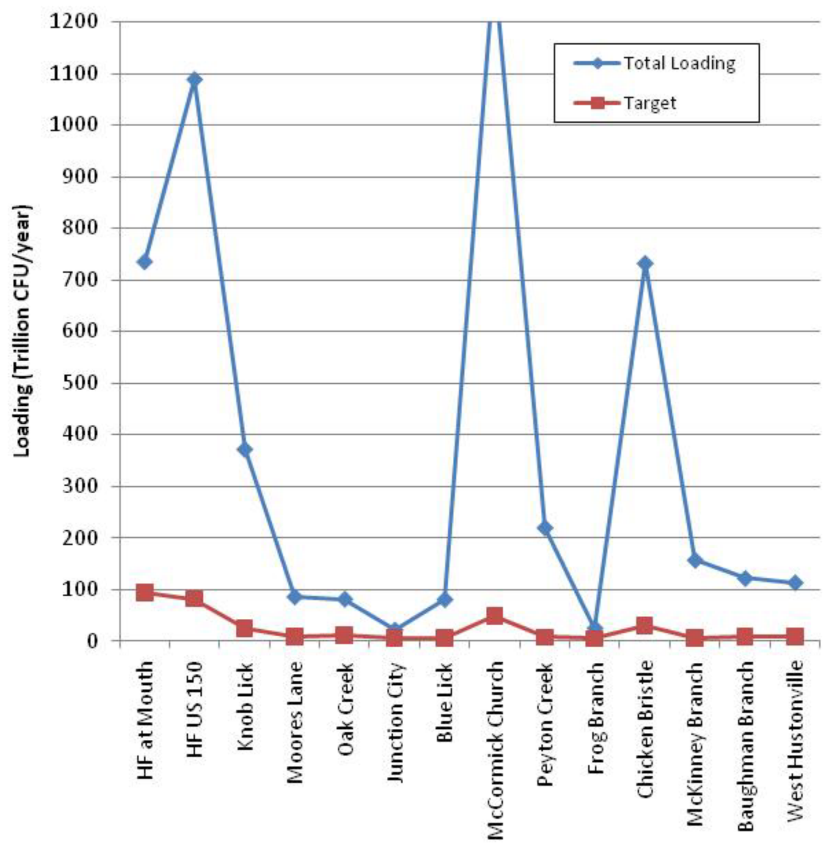
3.1.4.2. E. coli

A TMDL is currently in development by KDOW for the pathogen impairments in the Hanging Fork watershed, but in order to direct remediation in this watershed plan the *E. coli* loading for the watershed has been calculated from the data collected by Third Rock. The annual loading value was derived from the following equation:

E. coli Loading = Concentration x Discharge x 31,536,000 x 283.2
(cfu/year) (cfu/100mLs) (cfs) (seconds/ year) (100 mL/ cubic ft)

Table 18 (page 42) shows the *E. coli* loading for each of the 14 sites monitored during the Third Rock data collection study. The *E. coli* loadings are calculated using the geometric average concentrations to eliminate the bias towards high concentrations associated with the arithmetic average. The geometric mean limit of 130 cfu/100mls was used to calculate the reduction target. Reduction goals and the percent of upstream reduction necessary to reach this goal were calculated by taking the difference between loading and the reduction target. Figure 7 shows graphically the total loading and the reduction goal for each station.

FIGURE 7 – TOTAL *E. COLI* LOADING IN THE HANGING FORK WATERSHED



To calculate watershed reach specific loadings, the total loadings of upstream stations are subtracted from downstream sites. This reach specific loading provides a better indication of the geographic sources of load inputs. The loadings for each reach, and the reach specific reduction goals are shown in Figure 8 and Table 19 (both on page 44).

Based on the reach specific loading values, the subwatershed areas associated with Chicken Bristle and McCormick Church show the heaviest loadings in the watershed, followed by Peyton Creek, Knob Lick, McKinney Branch, Baughman Branch, and West Hustonville respectively. According to these calculations, the high concentrations at the mouth of Hanging Fork and at US 150 are solely the result of upstream inputs.

FIGURE 8 – *E. COLI* LOADING BY REACH IN THE HANGING FORK WATERSHED

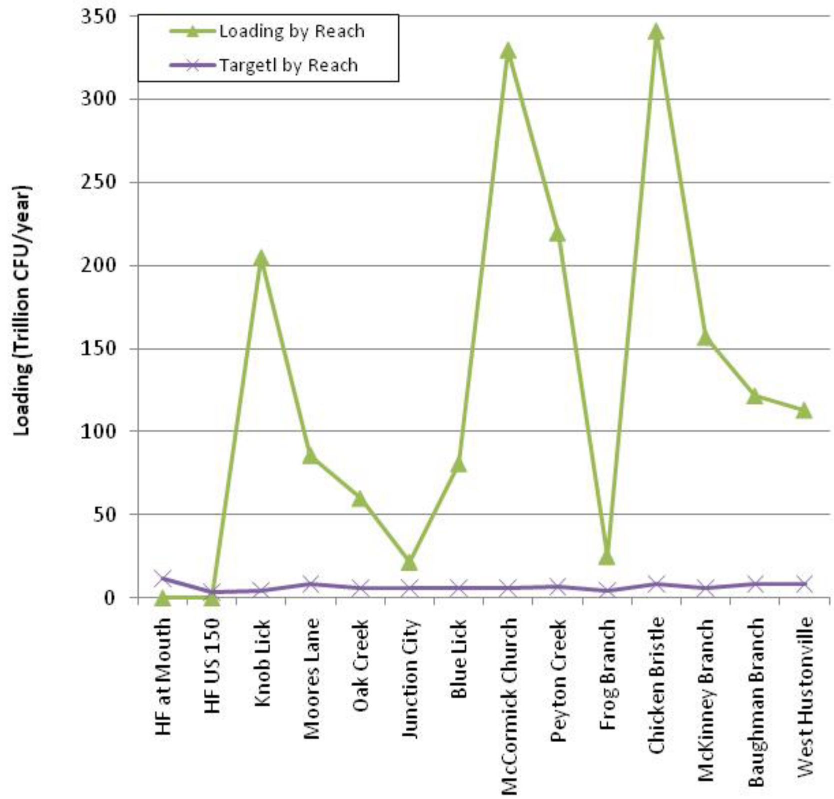


TABLE 19 – HANGING FORK REACH SPECIFIC *E. COLI* LOADING AND REDUCTION GOALS

STATION	*E. COLI* LOADING (TRILLION CFU/YR)	*E.COLI* TARGET (TRILLION CFU/YR)	REDUCTION TO ACHIEVE TARGET (TRILLION CFU/YR)	% REDUCTION BY REACH
HF at Mouth	0	12	0	0%
HF US 150	0	3	0	0%
Knob Lick	205	5	200	98%
Moores Lane	86	8	78	91%
Oak Creek	60	6	54	90%
Junction City	22	6	16	73%
Blue Lick	81	6	75	93%
McCormick Church	330	6	324	98%
Peyton Creek	220	7	213	97%
Frog Branch	25	5	20	81%
Chicken Bristle	341	8	333	98%
McKinney Branch	157	6	151	96%
Baughman Branch	122	8	113	93%
West Hustonville	113	8	105	93%

3.2. Sources and Locations of Waterway Impairments

3.2.1. Impairments

Based on the analysis, the 64.75 stream miles of *E. coli* impairments listed on the 2008 303(d) list are accurate, but the actual impairment to the watershed includes a greater number of stream miles as well as several other parameters. *E. coli* concentrations greater than the acute toxicity limit were found for 39.9 miles of previously unlisted streams during the MST sampling conducted in 2008. These unlisted impairments exceeded in-stream water quality criteria, but insufficient numbers of samples were collected in order to list the stream according to regulations (401 KAR 10:031). The *E. coli* impairments are shown on Exhibit 12, page 46. Habitat impairments were identified at 54 sites based on the comparison of the US EPA's RBP to KDOW Bluegrass Bioregion standard. Based on GIS analysis, these 54 sites of impaired habitat appear to be correlated to approximately 140 to 160 stream miles based on narrow riparian zone width. The geographic locations of the riparian impacts are shown on Exhibit 10 (page 39).

3.2.2. Causes and Sources

Based on the MST study of the Hanging Fork watershed, human sources provide the most prominent contribution to the *E. coli* exceedances in the watershed. Although wildlife such as deer, raccoons, muskrat, and other animals could contribute to the fecal loading in the watershed, DNA testing revealed that in most areas human and cattle sources alone explained the majority of the results. The percent contribution of human or cattle sources as well as the associated loading is shown in Tables 20 and 21 (page 47) for each subwatershed area. In subwatersheds where MST was not conducted, a 75 percent human and 25 percent cattle ratio was used based on an average of other results obtained. It should be noted that these ratios are based on normal flow conditions and not storm flow conditions. Because runoff composes a greater percentage of storm flow, it is likely that the contribution from cattle may be more significant in those conditions.

Because all human sources are assumed to be due to septic systems outside of the Junction City area, a rough estimation of the *E. coli* contribution per failing septic system was necessary to indicate the extent of mitigation necessary to meet watershed goals. While some straight pipes are probably present in the watershed, the number could not be estimated, so all residences not on sewer were assumed to be treated by septic systems. Horsely and Whitten's (1996) estimated concentration of 1.00E+6 fecal coliform CFU/100mL in septic overcharge was converted to an *E. coli* concentration using the ratio of the geometric mean standards for each indicator (200 fecal coliform to 130 *E. coli*). Assuming a septic overcharge of 70 gallons/day/person and the average household size of 2.5, the average fecal overcharge input from one home was calculated as 1.58 trillion CFU/year. This rate is intended to serve as a rough estimate since many variables including the soil type, groundwater interaction, temperature, concentration of *E. coli*, and distance from the stream may all affect the input rate. However without TMDL modeling of these variables, this estimate was used to approximate that 806 of the 2,672 septic systems in Hanging Fork are failing (Table 20, page 47). The location of these failing systems is shown in Exhibit 12 (page 46).

Map Document: (P:\Project_Files\Kentucky\5167E_KDOW_WBP\Mapping\GIS\Exhibit_11_Ecoli.mxd) 9/15/2009 -- 3:14:45 PM sje

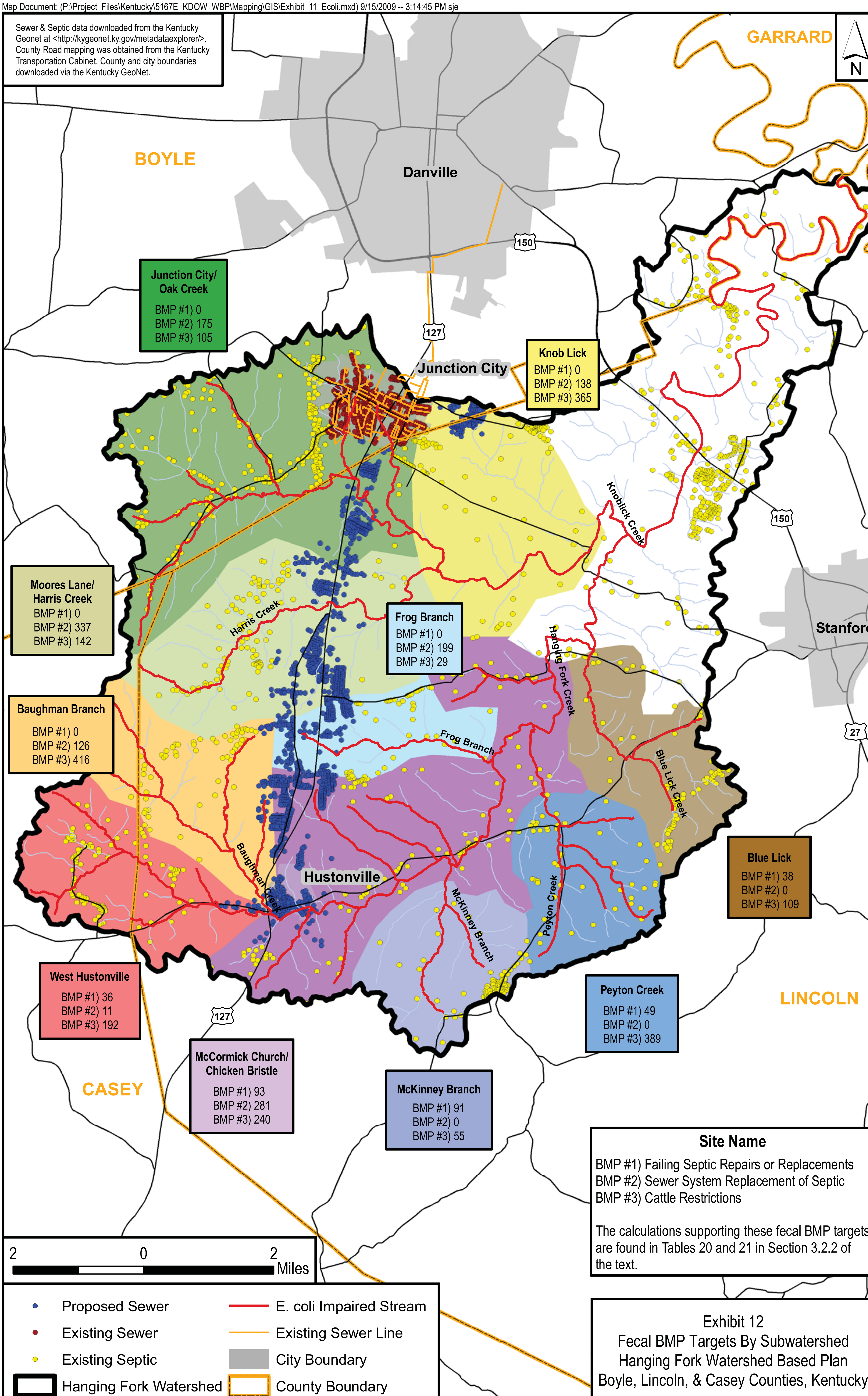


Exhibit 12
Fecal BMP Targets By Subwatershed
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

TABLE 20 –HUMAN SOURCES OF *E. COLI* LOADING BY SUBWATERSHED AREA

SUBWATERSHED	LOAD REDUCTION TO MEET REACH GOAL (TRILLION CFU/YR)	% HUMAN	HUMAN LOADING (TRILLION CFU/YR)	# SEPTIC SYSTEMS	# FAILING SEPTIC SYSTEMS[1]
HF at Mouth	0	N/A	0	557	95
HF US 150	0	N/A	0		
Knob Lick	200	75%*	150		
Moores Lane	78	75%*	59	475	37
Oak Creek	54	75%*	41	458	31
Junction City	16	50%	8		
Blue Lick	75	80%	60	71	38
McCormick Church	324	90%	292	398	374
Chicken Bristle	333	90%	300		
Peyton Creek	213	75%*	160	49	49
Frog Branch	20	70%	14	238	9
McKinney Branch	151	95%	143	103	91
Baughman Branch	114	50%	57	209	36
West Hustonville	105	70%	74	114	47
Total	1683	81%	1356	2672	806

*Assumed a 75% Human, 25% Cattle ratio based on the watershed average
[1] Assumes each septic system contributes 1.58 trillion CFU/year

TABLE 21 – CATTLE SOURCES OF *E. COLI* LOADING BY SUBWATERSHED AREA

SUBWATERSHED	LOAD REDUCTION TO MEET REACH GOAL (TRILLION CFU/YR)	% CATTLE	REDUCTION OF CATTLE LOADING (TRILLION CFU/YR)	ESTIMATED CATTLE IN WATERSHED[1]	APPROX. # CATTLE RESTRICTIONS REQUIRED[2]	ESTIMATED % CATTLE TO BE RESTRICTED
Knob Lick	200	25%*	50	1414	365	26%
Moores Lane	78	25%*	19	1593	142	9%
Oak Creek	54	25%*	13	627	99	16%
Junction City	16	5%	1	1557	6	0%
Blue Lick	75	20%	15	895	109	12%
McCormick Church	324	5%	16	1074	118	11%
Chicken Bristle	333	5%	17	895	122	14%
Peyton Creek	213	25%*	53	591	389	66%
Frog Branch	20	20%	4	1396	29	2%
McKinney Branch	151	5%	8	806	55	7%
Baughman Branch	113	50%	57	1074	416	39%
West Hustonville	105	25%	26	1074	192	18%
Total	1682	17%	279	16826	2042	12%

[1]Assumes uniform distribution of cattle throughout county for data from USDA NASS, Kentucky Field Office. http://www.nass.usda.gov/ky
[2]Assumes rate of yearly in-stream deposition of 0.137 trillion CFU *E. coli* / beef cow.

Sources of cattle fecal contributions to the watershed include both direct inputs and runoff. In order to provide an estimate of the reductions to cattle loadings necessary to meet the water quality goals, literature sources, field observations, and laboratory results were used to indicate the number of cattle to be excluded from the stream. Riparian corridor fencing can be used to restrict cattle access and direct deposition, and vegetative planting can decrease the loading in runoff.

According to the Metcalf and Eddy (1991) reference utilized in the BASINS modeling tool, beef cattle produce an average of 5.4 billion fecal coliform CFU/day/animal. Using the ratio between the water quality benchmarks for fecal coliform and *E. coli* (200:130), the daily fecal rate per head is calculated to be 3.51 billion CFU *E. coli*. In July and August, cattle are estimated to spend up to one third of their time in streams while they spend approximately one tenth of the time the rest of the year if access is available. This indicates that on a yearly basis, 0.137 trillion CFU *E. coli* / beef cow is the estimated direct deposition to streams. Using the estimate of 179 cattle per square mile, an approximate numbers of cattle restrictions per watershed were calculated in Table 21, page 47. In total, approximately 12 percent or 2,042 head of cattle in the watershed require fencing from the streams in order to meet watershed goals. The location of these cattle restrictions is shown in Exhibit 12 (page 46).

As stated previously, habitat impairments are primarily due to narrow or lacking riparian vegetated widths. In residential areas, the narrow riparian zone is usually due to yard maintenance to the stream edge. In cattle pasture areas, grazing and trampling as well as mowing can lead to the narrow riparian width. Because the primary land use in the watershed is livestock grazing, it is also the most common source of habitat impairment. In some localized areas, livestock trampling impaired the stream such that a restoration may be necessary in addition to restrictions to the stream corridor in order to improve habitat to acceptable conditions.

3.2.3. Present and Future Stressors on the Watershed

At present, the greatest stressors in the watershed are human sewage treatment and cattle access to stream riparian areas, and the future forecasts that these stressors will remain dominant.

According to census data, the population increase from 2000 to 2008 in Lincoln County was 7.3 percent, so future expansion into this area is likely. Because of the limited sewer collection system access, future residents will mostly treat their sewage using septic tank installation. However, with the poor soils throughout the watershed and past failures of septic replacements as noted in the PRIDE data, it is likely that these additional septic systems will increase the fecal loading unless addressed.

Cattle production continues to be a dominant land use in the watershed and is not projected to decrease as such. Decreasing the detrimental influence of cattle grazing on stream habitat and water quality is currently a challenge and will continue to be one in the future.

4. IMPLEMENTATION PLAN

4.1. Goals and Objectives

As stated previously, the watershed-planning group has established four goals for the Hanging Fork watershed. These goals are:

- Improve water quality for safe recreational use
- Improve community watershed education
- Increase diversity and density of aquatic and terrestrial wildlife in the stream riparian zone
- Improve codes and ordinances to protect and improve water quality

These goals are intended to indicate the major concerns and desires of the community in relation to the waterbody, and objectives are required in order to achieve these goals. Objectives indicate specific problems in the watershed that need to be addressed and the causes of these problems. For the listed goals, the objectives are as follows:

- Reduce human fecal inputs from septic tanks to achieve water quality standards for pathogens.
- Reduce fecal inputs from livestock to achieve water quality standards for pathogens.
- Reduce algal blooms by increasing the stream shading.
- Improve stream habitat by expanding the riparian vegetated width.
- Increase knowledge of water quality issues such that citizens and local officials can address impairments with appropriate codes, ordinances, and other practices.

The order in which these objectives are listed indicates the importance of meeting these objectives based on discussion at the June 16, 2009 focus group meeting. At this same meeting, partners and stakeholders were presented a list of available best management practices (BMPs) to reach the watershed goals and stated objectives. BMPs are practices utilized to change behavior, regulations, or physically alter the watershed with the water quality goals. Recommended BMPs were evaluated and prioritized by the watershed group so that the most effective, feasible, and affordable methods were employed. Table 22, page 50, lists the BMPs and action items associated with each objective that was selected as a result of this meeting.

Although stakeholders were asked to numerically rank each BMP individually, time constraints and the depth of discussion allowed only qualitative discussion and evaluation. BMPs involving Planning and Zoning ordinances were not expected to be cost-effective or feasible in most cases because the tension between urban and rural interests left these offices without broad based public support. Stream restoration was originally recommended, but dropped due to the high cost versus low effectiveness at accomplishing the project goals. Although the use of cost share programs to improve shading, riparian width, and reduce livestock pathogen input was acknowledged as effective, the difficulty of gathering participation in these programs was viewed as the chief obstacle in their successfulness. A local health department official believes that replacing historic and failing septic systems with modernized systems could be an effective method of human treatment (Carrier 2009), but that the sewer connections would probably be the most cost effective method of reducing human fecal inputs because of the likelihood of long-term improvement.

TABLE 22 – BEST MANAGEMENT PRACTICES AND ACTION ITEMS

<table>
<tr><th>OBJECTIVE</th><th>BMP</th><th>ACTION ITEMS</th></tr>
<tr><td rowspan="6">#1: Reduce human fecal inputs from septic tanks</td><td rowspan="4">1) Address failing and improperly maintained septic systems</td><td>1) Field identification of approximately 307 failing systems outside of the proposed sewer corridor in Blue Lick (38), McCormick Church and Chicken Bristle (93), Peyton Creek (49), McKinney Branch (91), and West Hustonville (36) watershed areas.</td></tr>
<tr><td>2) Notify approximately 307 landowners and health department of field confirmed failing septic systems to allow for correction or enforcement.</td></tr>
<tr><td>3) Educate community on septic tank maintenance and indicators of poor performance through distribution of the "Homeowner's Guide to Septic Systems" and household mailer.</td></tr>
<tr><td>4) Rehabilitate 307 failing systems identified by field surveys</td></tr>
<tr><td rowspan="2">2) Replace septic systems with a sanitary sewer collection system</td><td>5) Remove over 1,250 septic systems through an extension of Danville's sanitary sewer collection system to the Hustonville/Moreland area</td></tr>
<tr><td>6) Write letters to local officials and newspaper articles encouraging the construction of a package plant in the McKinney area to address high density of failing septic systems.</td></tr>
<tr><td rowspan="2">#2: Reduce fecal inputs from livestock</td><td>3) Restrict agricultural grazing from the riparian zone</td><td rowspan="4">7) Host a workshop or presentation on water quality issues at the Cattleman's Association and other agricultural organizations.
8) Develop a list of landowners with the largest portions of stream for targeted encouragement to improve riparian shading, vegetation, or fencing.
9)Utilize NRCS Cost Share practices for fencing (Practice #382), livestock exclusion (#472), filter strip (#393), riparian forested buffer (#391) and tree planting (#612).</td></tr>
<tr><td>4) Install filter strips along waterways to reduce fecal input from runoff.</td></tr>
<tr><td>#3: Increase the stream shading.</td><td>5) Conduct riparian tree and shrub planting</td></tr>
<tr><td>#4: Increase riparian vegetated width.</td><td>6) Conduct re-vegetation of riparian width through mowing restrictions and plantings</td></tr>
<tr><td rowspan="9">#5: Increase knowledge of water quality issues such that citizens and local officials can address impairments with appropriate codes, ordinances, and other practices.</td><td>7) Hire a local water quality advocate for planning decisions</td><td>10) Utilize the Office of Surface Mining VISTA program to acquire a watershed coordinator</td></tr>
<tr><td rowspan="2">8) Increase public education by increasing accessibility to water quality related information</td><td>11) Develop an environmental resources display for the Lincoln County Public Library and host an education event.</td></tr>
<tr><td>12) Organize a minimum of 2 annual radio announcements, 3 newspaper editorials, and personal communication with 100 landowner interactions about watershed impairments and BMPs.</td></tr>
<tr><td rowspan="4">9) Encourage community interest in stream improvement</td><td>13) Encourage Hustonville Elementary, McKinney Elementary, and Lincoln County Middle and High Schools to utilize Bluegrass PRIDE K-12 water quality curriculum.</td></tr>
<tr><td>14) Install signage along roadways and parks identifying streams and water quality issues</td></tr>
<tr><td>15) Sponsor KRWW volunteer monitoring of subwatershed areas</td></tr>
<tr><td>16) Identify greenspace areas for public parks along creek and outdoor classroom areas.</td></tr>
<tr><td rowspan="2">10) Examine and recommend updates to local codes and ordinances.</td><td>17) Develop local codes and ordinances to reduce the impact on riparian areas.</td></tr>
<tr><td>18) Encourage the county and cities to use water quality modeling in making planning decisions.</td></tr>
</table>

4.2. Action Items

In order to help achieve the project goals and objectives, the responsible parties, technical assistance, costs and funding, indicators of success, and measurable milestones are listed for each action item in Table 24 (shown on pages 52 through 56). Exhibit 12 (page 46) indicates the locations of fecal reduction targets and Exhibit 13 (page 57) the location of habitat improvement target areas. Outreach events and community education events, as an essential component of watershed remediation, are included in this list.

To achieve Objective 1, 806 failing septic systems or straight pipes need to be rehabilitated or replaced. The most effective method of addressing these systems due to soil conditions and long-term improvements is replacement of these systems by the proposed sewer line (BMP 2: Action Item 4). Based on GIS analysis of the proximity of residences to the proposed sewer corridor, it is estimated that a sewer line from Danville to Hustonville would replace 1,267 septic systems, as shown in Table 23, at a cost of $5.813 million. Though this is the most effective method of addressing this pollutant source, 307 failing systems lie outside of the proposed sewer line corridor, as shown in Table 23. These should be rehabilitated by repair, maintenance, or most likely replacement (BMP 1). Assuming each of these systems must be replaced rather than repaired (worst-case scenario), the cost for replacement is estimated at $1.228 million.

TABLE 23 – SUMMARY OF HUMAN FECAL AND CATTLE BMP TARGETS BY SUBWATERSHED

SUBWATERSHED	# FAILING SEPTIC SYSTEMS	BMP 1: # SEPTIC REPAIRS OR REPLACEMENTS	BMP 1: COST ($4000/ REPLACEMENT)	BMP 2: # REPLACED BY SEWER SYSTEM ($5.813 MILLION)	BMP 3: CATTLE RESTRICTIONS		
					APPROX. # CATTLE RESTRICTIONS REQUIRED	ESTIMATED LENGTH OF FENCE REQUIRED (FT)	COST ($2/FT OF FENCE)
Knob Lick	95			138	365	21,164	$42,329
Moores Lane / Harris Creek	37			337	142	8,254	$16,508
Junction City / Oak Creek	31			175	105	6,688	$13,376
Blue Lick	38	38	$152,000		109	6,349	$12,699
McCormick Church / Chicken Bristle	374	93	$372,000	281	240	13,905	$27,810
Peyton Creek	49	49	$196,000		389	22,540	$45,080
Frog Branch	9			199	29	1693	$3,386
McKinney Branch	91	91	$364,000		55	3,196	$6,392
Baughman Branch	36			126	416	24,127	$48,255
West Hustonville	47	36	$144,000	11	192	11,111	$22,223
Total	806	307	$1,228,000	1267	2042	119,028	$238,056

TABLE 24 – ACTION ITEM WORKSHEET

Objective 1: Reduce human fecal inputs from septic tanks to achieve water quality standards for pathogens

RESPONSIBLE PARTY	TECHNICAL ASSISTANCE	TOTAL COSTS	FUNDING MECHANISM	INDICATORS	MILESTONES			
					SHORT < 1 YEAR	MID 1-3 YEARS	LONG 3-7 YEARS	EXTENDED 20+
BMP 1: Address failing and improperly maintained septic systems								
Action Item 1: Field Scouting to identify approximately 307 failing septic systems to allow for correction or enforcement. Field determination of failures will be determined based on health department indicators of failure with support from field conductivity readings. Field surveys and notifications will be pursued in areas where the future sewer collection system is not projected to replace failing septic systems. Specifically the following lists of watershed areas and the expected number of failing systems should guide the survey effort: Blue Lick (38), McCormick Church and Chicken Bristle (93), Peyton Creek (49), McKinney Branch (91), and West Hustonville (36) watershed areas.. Actually numbers may be higher or lower based on field verification. Due to discharging into groundwater systems, identification may be difficult in areas, in which case the oldest systems should be investigated.								
CREEC, HLCL, or VISTA volunteer	Lincoln County Health Dept	N/A	N/A	Conductivity, field indicators of failure	Identification of 50 failing systems	Identification of 257 failing systems	As necessary	-
Action Item 2: Notify approximately 307 landowners and health department of field confirmed failing septic systems to allow for correction or enforcement as noted in Action Item #1. Actually numbers may be higher or lower based on field verification. Notifications would involve written letters or conversation with the landowner as well as a formal letter to the Lincoln County Health Department.								
CREEC, HLCL, or VISTA volunteer	Lincoln County Health Dept	N/A	N/A	Documented notifications of landowners	50 documented notifications	257 notifications	As necessary	-
Action Item 3: Educate community on septic tank maintenance and indicators of poor performance through distribution of the "Homeowner's Guide to Septic Systems" and household mailer. The Homeowner's Guide should be distributed during door to door field surveys. A mailer containing the results of the data collection effort specific to each watershed area, sources and causes, and solutions should be sent to each household in the watershed with the exception of those on sewer or in the US 150 or Hanging Fork Mouth watershed areas.								
CREEC, HLCL, or VISTA volunteer	Lincoln County Health Dept	N/A	N/A	Volume of material distributed.	Mailer to 1000 septic tank owners, Guide distributed during field notifications	Homeowners Guide distributed during notifications	-	-
Action Item 4: Rehabilitate (through repair, maintenance, or replacement) approximately 307 septic systems as identified in Action Item #1.								
Landowner	Lincoln County Health Dept	If all replaced, at $4000 each, $1.22 million	Landowner Expense	*E.coli*	50 improvements	150 improvements	107 improvements	-

TABLE 25 – ACTION ITEM WORKSHEET, CONTINUED

Objective 1: Reduce human fecal inputs from septic tanks to achieve water quality standards for pathogens								
					MILESTONES			
RESPONSIBLE PARTY	TECHNICAL ASSISTANCE	TOTAL COSTS	FUNDING MECHANISM	INDICATORS	SHORT < 1 YEAR	MID 1-3 YEARS	LONG 3-7 YEARS	EXTENDED 20+
BMP 2: Replace septic systems with a sanitary sewer collection system								
Action Item 5: Remove over 1250 septic systems through an extension of Danville's sanitary sewer collection system to the Hustonville/Moreland area. Currently the Phyben village construction project is projected to remove approximately 138 sewer systems in the Knob Lick watershed drainage area. Future expansion of a collection system along US-127 as listed in the Regional Wastewater Facilities Plan would replace the following numbers of septic systems by watershed: Junction City (175), Moore's Lane (337), Frog Branch (199), Baughman Branch (126), McCormick Church and Chicken Bristle (281), and West Hustonville (11).								
Bluegrass ADD, City & County Government	Available in Regional Wastewater Facilities Plan	$5.813 million	Multiple Grants	*E.coli*	Removal of 138 systems	-	Removal of ~1110 systems	-
Action Item 6: Write letters to local officials and newspaper articles encouraging the construction of a package plant in the McKinney area to address high density of failing septic systems. Over 70 systems in the Hanging Fork portion of McKinney which could be treated more efficiently.								
Bluegrass ADD Representative, VISTA volunteer	N/A	N/A	N/A	Documented letters and published articles	Letters and articles	-	-	-

TABLE 25 – ACTION ITEM WORKSHEET, CONTINUED

Objectives 2,3,4: Reduce fecal inputs from livestock, increase the stream shading, and riparian vegetated width.								
Responsible Party	Technical Assistance	Total Costs	Funding Mechanism	Indicators	Milestones			
					Short < 1 Year	Mid 1-3 Years	Long 3-7 Years	Extended 20+
BMP 3: Restrict agricultural grazing from the riparian zone.								
BMP 4: Install filter strips along waterways to reduce fecal input from runoff.								
BMP 5: Conduct riparian tree and shrub planting.								
BMP 6: Conduct re-vegetation of riparian width through mowing restrictions and plantings.								
Action Item 7: Host a workshop or presentation on water quality issues at the Cattleman's Association and other agricultural organizations. Intended audience are livestock farmers from throughout Hanging Fork. Presentation or workshop would present the results of the watershed plan and the areas of impairment, the BMPs which can be utilized for remediation, advantages for livestock health, and funding availability through the NRCS.								
Bill Payne coordinate, Third Rock Consultants present	Third Rock Consultants	N/A	N/A	Sign In address list for the presentation	1 workshop	1 workshop	-	-
Action Item 8: Develop a list of landowners with the largest portions of stream for targeted encouragement to improve riparian shading, vegetation, or fencing. Such a list may be compiled by cross referencing PVA parcels with impaired stream length to personally approach landowners with the largest stream lengths about BMP implementation. Personal communication with these landowners may aid in increasing participation in cost share practices.								
VISTA volunteer	Third Rock Consultants	N/A	N/A	Map / List	Map / List	-	-	-
Action Item 9: Utilize NRCS Cost Share practices for fencing (Practice #382), livestock exclusion (#472), filter strip (#393), riparian forested buffer (#391) and tree planting (#612). The need for each respective practice should be determined by the location of the property as well as the farmer's need. Fencing, exclusion, and filter strips will be most effective in reducing fecal inputs; riparian forested buffer and tree planting at increasing shading; and fencing, riparian forested buffer, and tree planting at increasing the riparian vegetated width. Exhibit 11 and 13 should be used in focusing efforts.								
Cattle farmers	NRCS	$240,245 for fencing, additional for tree planting, etc.	NRCS EQIP Cost share*	Length of stream enhanced	3,000 feet of stream (6,000 feet of fence) per year over 20 years			
BMP 7: Hire a local water quality advocate for planning decisions								
Action Item 10: A watershed coordinator would be responsible for building watershed organization, initiating outreach, improving community education on watershed issues, and coordinating remediation of impairments. The Office of Surface Mining-AmeriCorps/VISTA Program describes the activities of their volunteers under similar terms and may provide a watershed coordinator to direct activities in the Hanging Fork watershed. This program requires community support from local government officials.								
UKWRRI / Lincoln Co. Magistrate District 1	N/A	$1,000	Local Government	N/A	N/A			

TABLE 25 – ACTION ITEM WORKSHEET, CONTINUED

Objectives 5: Increase knowledge of water quality issues such that citizens and local officials can address impairments with appropriate codes, ordinances, and other practices.								
Responsible Party	Technical Assistance	Total Costs	Funding Mechanism	Indicators	Milestones			
					Short < 1 Year	Mid 1-3 Years	Long 3-7 Years	Extended 20+
BMP 8: Increase public education by increasing accessibility to water quality related information								
Action Item 11: Develop an environmental resources display for the Lincoln County Public Library and host an education event.								
Bluegrass PRIDE, UKWRRI, VISTA volunteer	Bluegrass PRIDE, UKWRRI, VISTA volunteer	N/A	N/A	Exhibit and event	-	Exhibit and event	-	-
Action Item 12: Organize a minimum of 2 annual radio announcements, 3 newspaper editorials, and personal communication with 100 landowner interactions about watershed impairments and BMPs.								
Bluegrass PRIDE, UKWRRI, VISTA volunteer	N/A	N/A	N/A	Documentation of public relations interactions	Annual public relations goals			
BMP 9: Encourage community interest in stream improvement								
Action Item 13: Encourage Hustonville Elementary, McKinney Elementary, and Lincoln County Middle and High Schools to utilize Bluegrass PRIDE's water quality education curriculum in their classrooms.								
Bluegrass PRIDE, HLCL, Teachers, VISTA volunteer	Bluegrass PRIDE	N/A	N/A	Local water quality education	-	Use in classrooms	-	-
Action Item 14: Install signage along roadways and parks identifying streams and water quality issues. Signs should be located in parks or at roadway stream crossings.								
KYTC, Lincoln County Magistrate District 1	N/A	$750	KYTC, KRA Watershed Grant	Signs	-	4 signs	-	-
Action Item 15: Sponsor KRWW volunteer monitoring of subwatershed areas								
KRWW	KRWW	N/A	N/A	Biannual monitoring for *E. coli*	Biannual monitoring at subwatershed locations			
Action Item 16: Identify greenspace areas for public parks along creek and outdoor classroom areas.								
Lincoln County Planning and Zoning	UKWRRI, Bluegrass PRIDE	N/A	N/A	N/A	N/A			

TABLE 25– ACTION ITEM WORKSHEET, CONTINUED

Objectives 5: Increase knowledge of water quality issues such that citizens and local officials can address impairments with appropriate codes, ordinances, and other practices.								
Responsible Party	Technical Assistance	Total Costs	Funding Mechanism	Indicators	Milestones			
					Short < 1 Year	Mid 1-3 Years	Long 3-7 Years	Extended 20+
BMP 10: Examine and recommend updates to local codes and ordinances.								
Action Item 17: Develop local codes and ordinances to reduce the impact on riparian areas. The Center for Watershed Protection has developed the ordinance manual "Better Site Design: A Handbook for Changing Development Rules in Your Community" (available at www.cwp.org) which may be used to improve ordinances. The Southeast Watershed Forum also offers Growth Readiness workshops which may assist in watershed protection in conjunction with growth.								
Lincoln County Planning and Zoning	Center for Watershed Protection, Southeast Watershed Forum	N/A	N/A	N/A	N/A			
Action Item 18: Encourage the county and cities to use water quality modeling in making planning decisions.								
Lincoln County Planning and Zoning	KDOW Water Educator	N/A	N/A	N/A	N/A			

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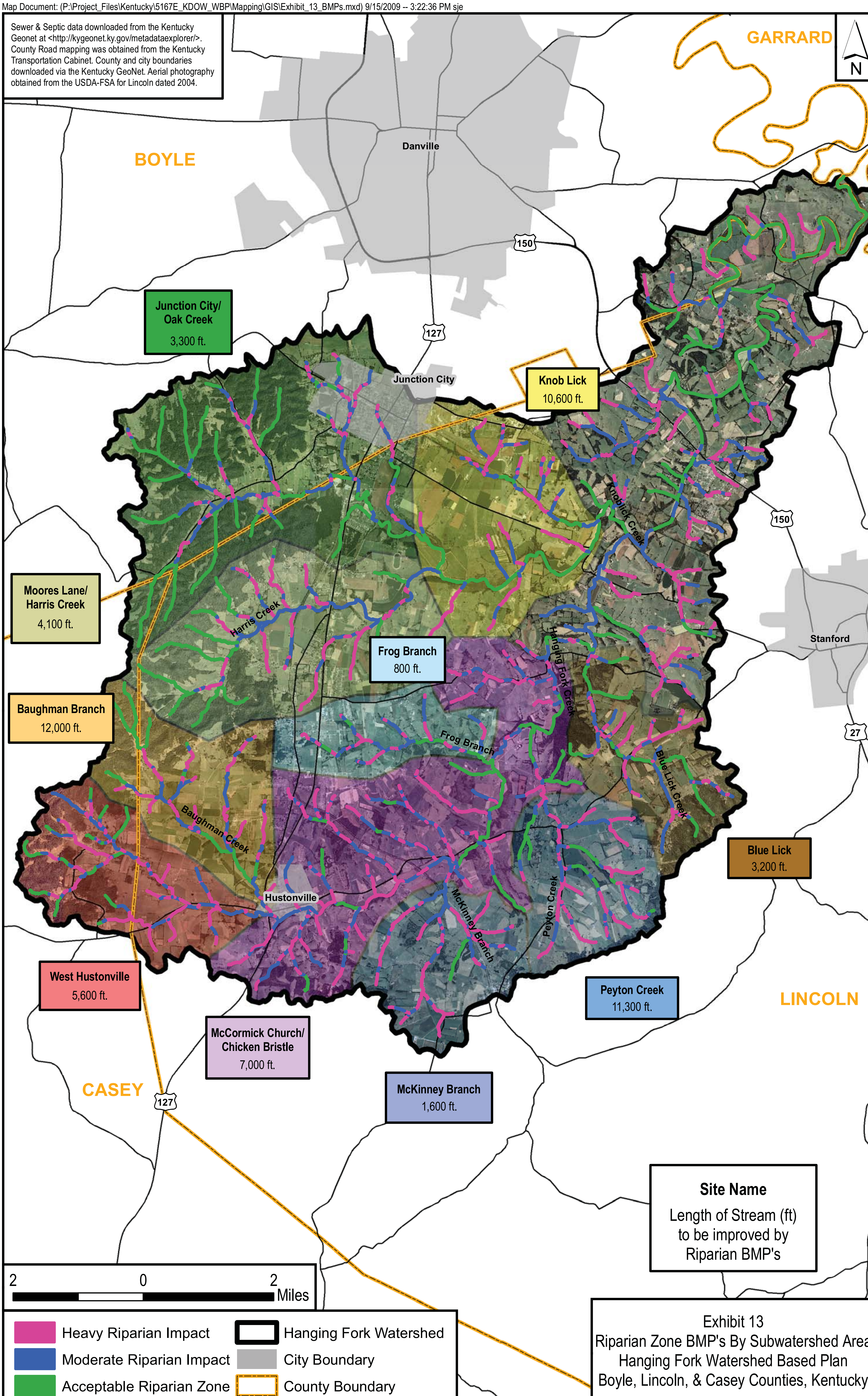

Exhibit 13
Riparian Zone BMP's By Subwatershed Area
Hanging Fork Watershed Based Plan
Boyle, Lincoln, & Casey Counties, Kentucky

To address Objective 2, target goals for the number of cattle restrictions per watershed have been provided in Table 23 (page 51). These goals assume that all reductions will be achieved through exclusion of cattle from the stream. If other agricultural BMPs can be utilized to reduce the input of cattle fecal material into Clarks Run, these estimates would be decreased. However, these estimates are provided in order to project the scope of work required to achieve the water quality goals.

In order to estimate the cost for excluding 2,042 cattle from the stream, the total length of stream flowing through agricultural lands in the impacted areas (93 miles) was estimated by multiplying the total stream length in areas with cattle impairments (154 miles) by the percentage of agriculture in the watershed (60 percent). Since an estimated 12 percent of cattle in the watershed require stream access restriction in order to meet water quality goals, it was projected that both sides of 12 percent of this stream length or about 11 miles of stream would need to be fenced. According to a local NRCS agent (Renfro 2009), the current rate of fencing is about $2 per foot, giving an estimated total cost of near $238,000 for cattle exclusion in Hanging Fork, as shown in Table 23 (page 51). This cost estimate includes only cost-share assistance through the NRCS EQIP and excludes additional landowner costs, and other potential costs due to alternate water sources, improved stream crossings, and land easements. Such costs cannot be predicted without additional information on in stream cattle locations. As previously mentioned, actual costs may also vary if agricultural BMPs other than fencing are utilized or if post BMP monitoring indicates greater or lesser reductions than assumed in this document.

In total, the estimated cost of remediation of the impairments of the Hanging Fork Watershed is $7.28 million. Because this cost is based on estimates of the amount of fecal inputs from individual cattle and septic systems, the actual reduction and cost associated with replacement of septic systems of restriction of cattle may be greater or less than this predicted cost. However, this provides the best estimate of the cost of addressing the pathogen impairment in the Hanging Fork watershed with the data currently available.

4.3. Expected Outcomes and Load Reductions

The numerical load reductions expected to be achieved through the BMP implementation are summarized in Table 25 (page 59). Interim goals of reduction over 1, 3, and 7 year time periods are specified in terms of either *E. coli* loading or length of stream habitat restored. These load reductions were calculated based on the methods indicated in Sections 3 and 4.2. When livestock are excluded from the stream, it is assumed that the riparian area inside the fenced area will remain unmowed and either planted with trees or allowed to be populated with volunteer tree species which will gradually increase the stream shading.

In order to monitor whether fecal load reductions are achieved, monitoring for *E. coli* concentration and stream discharge should be conducted subsequent to the these time periods. The Lincoln County Engineer in conjunction with the local NRCS offices should track improvements to the riparian corridor. The Interim Goals in Table 25 (page 59) assume a rate of 3,000 feet of stream per year in the Hanging Fork watershed will be addressed by cost share practices. At this rate, 11.36 miles would be addressed over this time period. While this is far short of the total length of stream requiring improvement, this length of stream habitat improvement is the maximum expected to be feasible within this time period.

TABLE 25 – LOAD REDUCTIONS BY OBJECTIVE

WATERSHED AREA	INDICATORS TO MEASURE PROGRESS	REDUCTION TARGET (REACH SPECIFIC) (TRILLION CFU/YEAR)	INTERIM GOALS		
			SHORT-TERM < 1 YEAR	MID-TERM 1-3 YEARS	LONG-TERM 3-7 YEARS
Objective 1: Reduce human fecal inputs from septic tanks					
Knob Lick	E. coli	150	150	-	-
Moores Lane		59	-	-	59
Oak Creek		41	-	-	41
Junction City		8	-	-	8
Blue Lick		60	7	22	31
McCormick Church / Chicken Bristle		592	-	-	592
Peyton Creek		160	23	46	91
Frog Branch		14	-	-	14
McKinney Branch		143	20	40	83
Baughman Branch		57	-	-	57
West Hustonville		74	10	20	44
Objective 2: Reduce fecal inputs from livestock					
Knob Lick	E. coli	50	2	5	9
Moores Lane		19	1	2	4
Oak Creek		13	1	1	3
Blue Lick		15	1	1	3
McCormick Church / Chicken Bristle		33	2	3	6
Peyton Creek		53	2	5	10
Frog Branch		4	1	1	2
McKinney Branch		8	1	1	2
Baughman Branch		57	3	5	11
West Hustonville		26	1	3	5
Objective 3 and 4: Increase the stream shading and riparian width					
Knob Lick	Fenced Stream, Planted or Volunteer Trees, Increased Riparian Width (Feet of Stream)	10600	500	1000	2000
Moores Lane		4100	200	400	800
Oak Creek		3000	150	300	600
Junction City		300	100	100	100
Blue Lick		3200	150	300	600
McCormick Church / Chicken Bristle		7000	350	700	1400
Peyton Creek		11300	600	1200	2400
Frog Branch		800	100	200	500
McKinney Branch		1600	100	200	400
Baughman Branch		12000	600	1200	2400
West Hustonville		5600	250	500	1000

5. ORGANIZATION

As listed in Table 24 (pages 52 through 56), the implementation of the BMPs will include many individuals, agencies, officials, and volunteers. Involved in the implementation are the following individuals and organizations:

Bluegrass ADD Representative
Bluegrass PRIDE
Cattle Farmers
Center for Watershed Protection
Clarks Run Environmental and Educational Corporation (CREEC)
Herrington Lake Conservation League (HLCL)
Kentucky Division of Water (KDOW)
Kentucky River Watershed Watch (KRWW)
Kentucky Transportation Cabinet
Landowners
Lincoln County Planning and Zoning
Lincoln County Magistrate District 1
Southeast Watershed Forum
Third Rock Consultants
University of Kentucky Water Resource Research Institute (UKWRRI)
AmeriCorps VISTA volunteer

6. MONITORING PLAN

The goal of this watershed plan is to improve the water quality of the Hanging Fork Watershed using the guidance of this plan. Extensive background data has been collected in order to generate this document, but in order to evaluate progress on the effectiveness of the BMP implementation, additional data collection will be necessary. Should additional Section 319(h) program funding be sought for this proposed data collection effort, a QAPP meeting federal standards would need to be provided.

In order to evaluate the progress on the *E. coli* reduction goals, 10 sites shall be monitored at the mouth of each of the subwatershed areas identified on Exhibit 12 (page 46). On an annual basis, five collection events should be conducted at these sites within a thirty-day period during the Primary Contact Recreation period (May 1 through October 31) in accordance with 401 KAR 10:031. Discharge and *E. coli* should be collected at each site. The geometric average discharge and *E. coli* concentration should be input into the formula in Section 3.1.4.2. to calculate the loading. The loading from upstream site locations shall be subtracted from downstream sites in order to allow the calculation of loading by watershed reach. Sampling will be conducted by Health Department personnel or an environmental consultant with reports presented to the Hanging Fork Watershed Focus Group.

In addition to the *E. coli* sampling, benthic macroinvertebrate and fish surveys should be conducted at three locations (one on Knoblick Creek, one at or below the McCormick Church site, and one near the mouth of Hanging Fork). Sampling should be conducted in year 1 prior to BMP improvements in order to establish a baseline, and be monitored at the 1-year, 3-year, 7-year, and 20-year milestones thereafter to measure improvements over time. An environmental consultant should be contracted to conduct such sampling.

The macroinvertebrate community at each station should be sampled using methods developed by KDOW (KDOW 2008b). The semi-quantitative sampling method should involve the collection of two separate samples, riffle and multihabitat, at each station. The riffle sample should consist of four 0.25 meters^2 (m^2) samples collected from two separate riffles at each station. Riffle collections at each station should be composited to form one semi-quantitative sample. The qualitative, multihabitat sample should include three leafpacks; three jabs (with dipnet) in sticks/wood; three jabs in soft sediment; three jabs into undercut banks/submerged roots; three jabs into aquatic macrophyte beds; hand-picking of 15 rocks (large cobble/small boulder) from riffles, runs and pools; and visual searches of approximately 10 to 20 linear feet of large woody debris. Sub-samples from each qualitative microhabitat should be combined to form one composite sample for each station. Samples are to be preserved in 95 percent ethanol and returned to the laboratory for processing and identification. Identification should be performed on random 300-specimen subsamples from the riffle and multihabitat samples as described by KDOW (2008b). All organisms should be identified to the lowest possible taxonomic level so that macroinvertebrate community metrics can be calculated.

The fish community at each station should sampled using either electroshock or seining techniques. A stream reach of approximately 30 times the stream width is to be sampled at each station. Fish are to be identified, enumerated, recorded, and released unharmed. The fish communities should be evaluated using the Index of Biotic Integrity (IBI) developed by Karr (1981), Karr *et al.* (1986) and modified for Kentucky streams by KDOW (2008b).

Field observations and measurements provide data valuable for water quality assessment and modeling. Field sample collection directly affects the analytical results generated. The following standards apply:

- All field measurements and sampling are to be performed such that the sample taken is representative of the stream sampled.
- Trained individuals shall collect all field data.
- During sampling, datasheets are used to record visual status of the habitat.
- GPS positioning and photographs are taken to accurately locate the sampling stations.
- Chain of Custody forms for samples are to be properly completed and maintained.
- Samples shall be protected by proper packing and transportation, preservation, and handling techniques before analysis.
- Flow computations will be based on velocity measurements at intervals across the stream cross-section.
- Any applicable field equipment will be calibrated regularly in accordance with the manufacturer's instructions.

7. EVALUATION PLAN

7.1. Approach

At minimum, the implementation plan addressed in this watershed plan should be addressed at each of the interim goal periods 1, 3, and 7 years after the publication of this document. The Hanging Fork Focus Group and all partners in implementation should meet with KDOW to evaluate the success of this implementation plan. At this meeting, the effectiveness of the BMPs will be evaluated and alternative approaches will be considered where effectiveness or feasibility is minimal. The watershed plan is intended to be a living document, so developments in the watershed, new or changing partners and stakeholders, and even shifts in goals will need to be incorporated into the plan as time progresses.

7.2. Implementation

At these interim evaluation meetings, the progress on the Action Items listed in Section 4 will be evaluated. This evaluation could include examining if the action is achieving its desired goal and/or determine whether the indicator or the stakeholder involved is the most effective for the task. As time passes, certain action items may also decrease in importance and may no longer need to be pursued. Other Action Items may need to be added to address developing issues, objectives, and goals. The effectiveness and frequency of the monitoring results should also be discussed during this evaluation meeting.

7.3. Adaptive Management

As time progresses, the willingness of certain stakeholders to continue participation may change and other stakeholders may desire ways in which they can participate in the watershed improvement. Certain water quality goals may be quickly achieved while others may be found to be out of range. Changing concerns of stakeholders and participants should be noted and incorporated into the watershed plan along it to be flexible in addressing the changing concerns of the community.

8. PRESENTATION

This plan will be presented to political leaders, stakeholders, and the public through three means. A physical presentation of the plan will be given to the Hanging Fork Watershed Focus Group, and other groups as deemed appropriate. A copy of the plan will be placed in the Lincoln County public library and in the Hustonville city hall. The plan will also be posted online at www.dixriverwatershed.org. As updates to the plan occur, updated versions of the plan and associated documents will be maintained at these three locations.

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APPENDICES

APPENDIX A – THIRD ROCK MONTHLY WATER QUALITY DATA, 2006 – 2007

Results for Water Quality Sites

Hanging Fork Watershed — HANGING FORK MOUTH

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			8.45	46.2		124.84		< 2	1.73	8.518	0.3653	< 0.1	0.005	2.104	< 0.2	0.0392	0.0438	< 3	93.5111	450	40		
4/13/2006	292.3	12.22	8.74	70.3		122		< 2	2.4		0.28	< 0.1	0.023	0.84	< 0.15	0.0375	0.0521	5	139.72	2010	240	55.76	15.4
5/3/2006	304.5	12.05	8.4	65.4		127		< 2	3		0.4046	< 0.1	0.010	0.7	< 0.11	0.0579	0.0802	13	217	> 2010	1650	266.02	20.9
6/7/2006	334.4	8.14	7.94	68	5	150		< 2	1.8	8.4	0.35	< 0.023	0.001	0.94	< 0.07	0.087	0.092	10.2	516.11	5040	300	18.13	9.1
6/20/2006																				13000	420		
7/7/2006		9.5	8.4	70				< 2	2.9		0.55	< 0.023	0.003	2.3	< 0.07	0.12	0.044	16.6	62.323	100000	4950	272.42	19.7
7/14/2006								< 2						1.2	< 0.07	0.093							
7/19/2006																				72300	1550		
8/10/2006	322	4.69	7.38	81.2	4.9	140		< 2	4.3		0.64	< 0.023	0.000	0.22	< 0.07	0.15	0.11	3.4	95.8	29600	500	10.3	1.2
8/21/2006																				82500	2500		
9/7/2006	389	9.8	8.1	68.3	4.6	180		< 2	1.6	8.4	0.33	< 0.023	0.001	1.6	< 0.07	0.11	< 0.01	5.2	232.476	102300	1000	29.47	11
9/18/2006																				137750	500		
9/25/2006																				433200	5400		
10/3/2006	362.8	10.06	8.14	62.8	1.3	170		< 2	1.1		0.43	< 0.023	0.001	2.3	< 0.07	0.13	0.093	3.8	101.97	61700	1500	588.75	33.9
10/18/2006																				324000	20100		
10/30/2006																				3400	1000		
11/28/2006	347.3	12.86	8.13	45.8	0.1	150		< 2	0.79		0.36	< 0.023	0.001	1.2	< 0.07	< 0.01	< 0.01	< 2	254			33.43	14.2
12/18/2006	318.4	13.97	8.66	48.2	0.3	150		< 2	1.4	7.4	0.42	< 0.023	0.002	0.78	< 0.07	< 0.01	< 0.01	3.8	3.193			45	11
1/5/2007						150		< 2	< 0.7		0.14	< 0.023		2.1	< 0.07	< 0.01	0.077	7					
2/27/2007	285	14.11	8.36	45.3	16.3	130		< 2	1.2	6.8	0.33	< 0.023	0.001	2	< 0.07	< 0.01	< 0.01	8.6	103.585			222.55	4.7
Geometric Average	326.9	10.29	8.24	59.8	1.8	143.8		<2	1.7	7.873	0.3619	0.033	0.002	1.196	0.08	0.0431	0.0366	5.6303	105.1636	24892	1030		
Standard Deviation	33.8	2.91	0.38	12.5	5.6	18.6		0	1.1	0.765	0.1262	0.035	0.007	0.7	0.04	0.0511	0.0372	4.494	139.0904	126496	5060		

Hanging Fork Watershed — HANGING FORK US-150

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			8.11	42.4				<2	1.69		0.1934	< 0.1	0.002	2.04	< 0.2	0.0316	0.0396	9		1450	250	59.47	
4/13/2006	299.2	12.87	8.46	69.1					2.4		0.6002	< 0.1	0.013	0.93	< 0.15	0.0367	0.0521	< 5		> 2010	380	45.21	27. 6
5/3/2006	61.9	9.46	8.01	61.9					3.7		0.4079	< 0.1	0.004	0.65	< 0.11	0.0489	0.0687	< 5		> 2010	1650	97.26	31. 9
6/7/2006	338.3	6.92	7.78	65.7					1.9		0.42	< 0.023	0.001	0.99	< 0.07	0.098	0.096	10.2		5310	< 100	14.29	22.1
6/20/2006																				13000	3440		
7/7/2006	320	8.5	8	68					1.8		0.57	< 0.023	0.001	2.2	< 0.07	0.095	0.015	14		> 100000	8900	58.6	29.9
7/14/2006														0.75	0.083	0.092							
7/19/2006																				18200	1000		
8/10/2006	371	3.01	7.45	75					2.7		0.72	0.082	0.001	0.24	< 0.07	0.12	0.023	10		36900	3750	9.2	12.6
8/21/2006																				100000	7500		
9/7/2006	401	8.16	7.91	65.4	6.4				1.4		0.37	< 0.023	0.001	1.6	< 0.07	< 0.01	< 0.01	4		24800	500	25.4	12.2
9/18/2006																				408200	8000		
9/25/2006																				145450	4850		
10/3/2006	361.3	9.2	7.99	62.2	2.1				0.85		0.45	< 0.023	0.001	2.3	< 0.07	< 0.01	0.016	7.2		57700	1000	103.67	35
10/18/2006																				113000	12700		
10/30/2006																				45500	2500		
11/28/2006	345.7	12.28	8.22	46	0.9				0.94		0.41	< 0.023	0.001	1.3	< 0.07	< 0.01	< 0.01	< 2				32	30.7
12/18/2006	314.8	14.36	8.63	49.5	0.7				1.9		0.75	< 0.023	0.002	0.83	< 0.07	< 0.01	< 0.01	15				16.49	22.8
1/30/2007	306	15.11	7.88	33.3	3.9				< 0.7		0.14	< 0.023	0.000	2.2	< 0.07	< 0.01	< 0.01	3.4					
2/26/2007	271.1		7.87	42.4	30				1.4		0.38	< 0.023	0.000	2.1	< 0.07	0.054	< 0.01	18				256.59	12.2
Geometric Average	284.0936	9.19	8.02	55.168	3.1573				1.6034		0.4095	0.0369	0.001	1.1828	0.0844	0.0316	0.021	7.1206		25407	1825		
Standard Deviation	89.4406	3.7	0.309	13.325	11.307				0.8517		0.1852	0.036	0.003	0.712	0.0406	0.0403	0.0285	5.0703		125046	4115		

Results for Water Quality Sites

Hanging Fork Watershed — KNOB LICK

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			9.38	56.8	6.3	87.29		< 2	2.42	7.534	0.2794	< 0.1	0.045	2.507	< 0.2	0.0211	0.0267	4	164.45	1180	20	6.31	
4/13/2006	255.4	12.15	8.81	71.3		85		< 2	2.7		0.4633	< 0.1	0.027	0.68	< 0.15	0.0138	0.028	< 5	264.18	> 2010	360	15.41	28.4
5/3/2006	243.3	10.98	8.15	59.8	80	81		< 2	3.3		0.3588	< 0.1	0.005	0.46	< 0.11	0.0185	0.0293	< 5	459	> 2010	1450	28.58	30.3
6/6/2006	328.9	8.77	8.02	65.6		130		< 2	1.1	8.6	0.47	< 0.023	0.001	1.2	< 0.07	0.051	0.079	15.8	391.076	5600	800	7	25.6
6/20/2006																				9450	1370		
7/7/2006	325	9.4	8.2	69				< 2	3.5		0.41	< 0.023	0.002	1.1	< 0.07	0.05	< 0.01	13	169.719	31200	5550	3.19	14.2
7/14/2006								3.4						0.87	< 0.07	< 0.01							
7/19/2006					4.3															26600	1000		
8/10/2006																						0	0
8/21/2006																				34400	6850		
9/7/2006	394	9.14	7.92	64.7	0.1	130		< 2	1.6	9.4	0.42	< 0.023	0.001	1.7	< 0.07	< 0.01	< 0.01	2.8	248.404	49250	2050	8.64	14.6
9/18/2006																				273750	37950		
9/25/2006																				156500	8000		
10/3/2006	349.8	9.95	7.96	61.3	1.2	140		< 2	1.2		0.21	< 0.023	0.001	2.5	< 0.07	< 0.01	< 0.01	4.2	28.739	50700	4800	27.11	29.1
10/18/2006					1.8															64800	11200		
10/30/2006																				15500	1000		
11/28/2006	307.3	13.94	8.55	48.3	26.8	110		< 2	1.1		< 0.1	< 0.023	0.002	1.3	< 0.07	< 0.01	< 0.01	2.6	222			12.06	
12/18/2006	268.4	16.3	9	50.9	6.3	100		< 2	1.5	7.7	0.43	< 0.023	0.004	0.84	< 0.07	< 0.01	< 0.01	2	2.817			7.22	
1/5/2007						94		< 2	2		0.97	< 0.023		1.7	< 0.07	0.062	0.28	57					
2/26/2007		13.39	7.95	41.9	80	77		< 2	1.8	7.7	0.39	< 0.023	0.000	1.8	< 0.07	< 0.01	< 0.01	14	40.675			92.34	25.2
Geometric Average	305.3	11.32	8.38	58.2	3.9	101.2		2.1	1.86	8.157	0.3592	0.034	0.002	1.237	0.08	0.0175	0.0216	6.6	109.2	18957	1983		
Standard Deviation	51.2	2.58	0.51	9.5	29.2	22.8		0.4	0.86	0.797	0.2183	0.036	0.015	0.668	0.04	0.0194	0.0804	15.9	151.4	75716	9831		

Hanging Fork Watershed — MOORES LANE

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
4/13/2006	238.2	16.41	9.36	75.3		78		< 2	3		0.4996	< 0.1	0.066	0.93	< 0.15	0.0132	0.0278	< 5	134.34	> 2010	90	5.4	3.5
5/2/2006	250.6	14.72	9.06	65.9		89		< 2	3.3		0.6349	< 0.1	0.035	0.8	< 0.15	0.0249	0.0442	6	503	> 2010	> 2010	16.04	4.3
6/6/2006	265.9	20.37	9.59	79.4	6.8	76		< 2	2.1	8.2	0.76	< 0.023	0.020	1.2	0.1	0.15	0.05	170	908.008	5300	300	2.4	2
6/20/2006																				2540	100		
7/7/2006	360	12.6	8.8	69				< 2	2.9		0.4	< 0.023	0.006	1.5	0.09	< 0.01	< 0.01	2.2	1027.011	23900	1550	2.27	3.9
7/14/2006								3.7						1.1	0.081	0.091							
7/19/2006																				39100	4950		
8/9/2006	264.8	20.34	9.48	84.7	8.1	94		< 2	4.6		0.65	< 0.023	0.019	0.24	< 0.07	< 0.01	< 0.01	17	61.4	50500	500	1.1	2
8/21/2006																				64900	2100		
9/5/2006	170	11.45	8.11	63.7	0.8	140		< 2	1.1	7.2	0.24	< 0.023	0.001	2.6	< 0.07	< 0.01	< 0.01	3.4	4.8	47950	500	6.71	3.9
9/18/2006																				324400	22050		
9/25/2006																				80800	3150		
10/2/2006	339.3	11.51	8.19	61.6	0.1	140		< 2	0.94		0.59	< 0.023	0.001	3.1		< 0.01	0.021	2.6	110.734	54300	3650	8.85	3.9
10/18/2006																				63700	3700		
10/30/2006																				73500	6000		
11/27/2006	281	14.92	7.93	52.5		88		< 2	0.92		0.37	< 0.023	0.000	2	< 0.07	< 0.01	< 0.01	4.4	463			3.66	3.2
12/18/2006	236	21.41	9.78	57.4	0.5	81		< 2	1.4	6.9	0.49	< 0.023	0.017	1.3	< 0.07	< 0.01	< 0.01	2	4.823			1.61	3.5
1/5/2007						66		2.3	3.4		1.1	< 0.023		1.3	< 0.07	< 0.01	0.25	120					
2/28/2007	237	16.32	8.61	42.1	9.1	93		< 2	1.1	6.2	0.15	< 0.023	0.001	2.5	< 0.07	< 0.01	< 0.01	6.2	37.343			13.56	4.3
Geometric Average	259.2	15.62	8.87	64	1.6	92		2.1	1.9	7.1	0.4731	0.03	0.007	1.3	0.09	0.0166	0.0208	8.2	105.54	25645	1410		
Standard Deviation	54.1	3.69	0.66	12.8	4.2	25		0.5	1.3	0.8	0.2608	0.031	0.021	0.84	0.03	0.04434	0.07079	57.7	383.4	81139	5629		

Results for Water Quality Sites

Hanging Fork Watershed — OAK CREEK

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			7.93	46.7		40.6		< 2	2.18		0.1091	< 0.1	0.002	0.8	< 0.2	< 0.0094	< 0.0094	< 3	94.1532	160	10	11.7	
4/13/2006	213.7	11.99	8.4	67.9		46		< 2	2.1		0.2272	< 0.1	0.001	0.37	< 0.15	< 0.01	< 0.01	< 5	141.15	1300	90	8.05	15.4
5/2/2006	225.6	10.36	7.83	61.6		52		< 2	5		0.7576	< 0.1	0.002	0.23	< 0.15	0.0414	0.0521	13	231	> 2010	> 2010	33.84	19.7
6/6/2006	266.6	8.13	8.1	68.6	1.7	73		< 2	0.92		0.16	< 0.023	0.001	0.2	< 0.07	< 0.01	0.051	< 2	195.765	10900	200	3.6	14.2
6/20/2006																				4060	200		
7/7/2006	288	7.6	8	66				< 2	3		0.22	< 0.023	0.001	0.3	< 0.07	< 0.01	< 0.01	3.6	99.028	20300	1550	1.34	13
7/14/2006								< 2						0.61	< 0.07	< 0.01							
7/19/2006																				33000	1550		
8/10/2006	425	4.37	7.16	77.9	0.5	130		< 2	2.5		0.18	< 0.023	0.000	0.086	< 0.07	< 0.01	< 0.01	4	69.2	31200	2100	2	11
8/21/2006																				72300	3200		
9/5/2006	384	8.22	7.58	63.9	3.6	95		< 2	1.9		0.23	< 0.023	0.000	0.43	< 0.07	< 0.01	< 0.01	7.8	1.273	505600	4300	2.26	14.2
9/18/2006																				324400	23200		
9/25/2006																				26950	1000		
10/3/2006	299	9.14	7.84	62.2	2.9	80		3.6	2.6		0.32	< 0.023	0.001	0.62	< 0.07	< 0.01	< 0.01	4	78.737	19400	500	4.7	15.4
10/18/2006																				21000	3700		
10/30/2006																				58500	2500		
11/27/2006	238	12.97	7.24	47.2		84		< 2	1		< 0.1	< 0.023	0.000	0.23	< 0.07	< 0.01	< 0.01	75	418			4.61	15.4
12/18/2006	221.2	14.04	9.02	52.5	4.8	56		< 2	1.5		0.31	< 0.023	0.005	0.14	< 0.07	< 0.01	< 0.01	< 2	2.657			4.3	15
1/5/2007						49		< 2	2.5		0.48	< 0.023		0.41	< 0.07	< 0.01	0.075	19					
2/28/2007	169.7	14.12	7.93	36.7	5.9	40		< 2	1.3		0.16	< 0.023	0.000	0.65	< 0.07	< 0.01	< 0.01	3.2	42.522			18.56	18.1
Geometric Average	263.5	9.58	7.9	58	2.5	63.2		2.1	2		0.229	0.033	0.001	0.33	0.09	0.0111	0.0155	5.8	56.7	17032	960		
Standard Deviation	79.4	3.18	0.51	12	2	27.9		0.4	1.1		0.1856	0.035	0.001	0.22	0.04	0.00872	0.02309	20.5	121	143524	5731		

Hanging Fork Watershed — JUNCTION CITY

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			7.8	49.4				<2	1.79		< 0.1	< 0.1	0.001	0.73	< 0.2	0.01	< 0.0094	6.7		700	10	7.1	
4/13/2006	123.4	10.58	8.42	71.2					1.8		0.1835	< 0.1	0.013	0.31	< 0.15	< 0.01	< 0.01	< 5		1300	60	4.17	18.5
5/2/2006	130.6	10.09	7.92	65.2					4.3		0.7254	< 0.1	0.003	0.2	< 0.15	0.0247	0.0385	6		> 2010	> 2010	18.88	21.7
6/5/2006	175	8.93	7.7	65.4					< 0.7		< 0.1	< 0.023	0.000	0.13	< 0.07	< 0.01	0.045	< 2		2900	< 100	3.3	9.5
6/20/2006																				7380	100		
7/7/2006	193	7.9	7.8	66					1.6		0.24	< 0.023	0.001	0.25	< 0.07	< 0.01	< 0.01	25		1900	500	2.6	7.9
7/14/2006														0.59	< 0.07	< 0.01							
7/19/2006																				33000	1550		
8/9/2006																						0	0
8/21/2006																				39100	2100		
9/5/2006	209.4	8.3	7.52	64.7	0.3				1.3		0.13	< 0.023	0.000	0.24	< 0.07	< 0.01	< 0.01	2.4		124750	2050	0.89	5.9
9/18/2006																				43900	2050		
9/25/2006																				26050	500		
10/3/2006	176.1	9.53	7.7	61.2					1.3		0.24	< 0.023	0.000	0.48	< 0.07	< 0.01	< 0.01	< 2		19000	9450	3.65	7.5
10/18/2006																				16800	1550		
10/30/2006																				55500	500		
11/27/2006	137	12.45	7.6	49					1		0.32	< 0.023	0.000	0.18	< 0.07	< 0.01	< 0.01	< 2				4.03	6.7
12/18/2006	137.4	14.06	8.15	47					1.2		0.15	< 0.023	0.001	0.13	< 0.07	< 0.01	< 0.01	< 2				0.99	5.9
1/30/2007	110.9	15.25	7.38	32.2	1.3				< 0.7		< 0.1	< 0.023	0.000	0.66	< 0.07	< 0.01	< 0.01	< 2				4.59	7.1
2/28/2007	109.4	14.51	7.8	35.8	3.6				1.2		0.11	< 0.023	0.000	0.59	< 0.07	< 0.01	< 0.01	3.6				13.81	7.9
Geometric Average	146.5968	10.87	7.794	53.56	1.1198			<2	1.3468		0.1768	0.0343	0.001	0.3138	0.0867	0.0108	0.0129	3.6177		10653	560		
Standard Deviation	35.3898	2.71	0.289	13.22	1.6921				0.99		0.1833	0.036	0.004	0.221	0.0454	0.0042	0.013	6.7555		33484	2410		

Results for Water Quality Sites

Hanging Fork Watershed — BLUE LICK

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			8.18	39.2				<2	2.79		0.3194	< 0.1	0.002	1.626	< 0.2	0.0377	0.0434	3.7		>2010	340	3.39	
4/13/2006	310.7	13.97	8.66	71.9					2.3		0.3727	< 0.1	0.021	0.67	< 0.15	0.039	0.0479	< 5		> 2010	220	3.05	16.1
5/2/2006	309.7	11.11	8.2	59.4					3.3		0.33	< 0.1	0.005	0.5	< 0.15	0.0458	0.0666	6		> 2010	> 2010	6.16	18.1
6/5/2006	393.2	9.47	8.11	69.4					2.9		0.49	< 0.023	0.001	0.51	< 0.07	0.13	0.11	3		4800	2500	1	14.2
6/20/2006																				11800	640		
7/6/2006	343	9.4	8.3	68					2.5		0.64	< 0.023	0.002	2.6	< 0.07	0.11	0.067	8.4		> 20100	4530	9.93	18.1
7/19/2006																				44300	6200		
8/9/2006																				72300	4950		
8/21/2006																				66650	3150		
9/7/2006	437	8.09	7.76	62.8	4.3				2.1		0.35	< 0.023	0.001	0.24	< 0.07	< 0.01	< 0.01	3		208000	26050	0.22	12.6
9/18/2006																				111200	3750		
9/25/2006																				33500	1550		
10/2/2006	354.1	10.12	8.1	61.4					1.3		0.17	< 0.023	0.001	2.4	< 0.07	0.1	0.031	6.6		46700	1550	7.5	18.5
10/18/2006																				50500	3000		
10/30/2006																				> 2010	220		
11/27/2006	398	12.21	6.89	46.8					0.76		0.47	< 0.023	0.000	1.4	< 0.07	< 0.01	< 0.01	11		> 2010	> 2010	2.2	15
12/18/2006	356.6	14.19	8.56	50.3	86				1.4		0.51	< 0.023	0.002	0.54	< 0.07	< 0.01	< 0.01	41		4800	2500	0.48	3.1
1/30/2007	328.1	16.02	8.28	33.4	3.9				< 0.7		< 0.1	< 0.023	0.000	1.9	< 0.07	< 0.01	< 0.01	3		11800	640	3.37	15.7
2/26/2007	289.4	14.79	8.64	44.9	16.6				1.3		0.56	< 0.023	0.002	1.9	< 0.07	< 0.01	< 0.01	8.6				11.94	30.7
Geometric Average	349.3	11.66	8.14	53.7	12.4			<2	1.7		0.351	0.034	0.001	1.012	0.09	0.0284	0.026	6.3		21159	2228		
Standard Deviation	46.1	2.7	0.5	13	39.3				0.9		0.163	0.036	0.006	0.842	0.05	0.0454	0.033	10.9		56203	6503		

Hanging Fork Watershed — McCORMICK CHURCH

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			8.12	38.3		132.97		< 2	2.3	8.278	0.2493	< 0.1	0.002	2.098	< 0.2	0.0351	0.04	6	204.22	>2010	450	30	
4/13/2006	317.3	9.44	8.07	60.8		141		< 2	2		0.4799	< 0.1	0.004	1.2	< 0.15	0.0426	0.0541	< 5	162.7	> 2010	1090	28.23	18.1
5/2/2006	323.7	8.33	8.08	61		146		< 2	3		0.4983	< 0.1	0.004	0.84	< 0.15	0.0498	0.0721	< 5	317	> 2010	> 2010	39.02	19.7
6/6/2006	378.3	7.22	8.02	64.7	7.5			< 2	1.7	9.3	0.55	< 0.023	0.001	0.9	< 0.07	0.092	0.11	14.4	280.107	5000	900	4.99	15.4
6/20/2006																				14500	4060		
7/6/2006	309	9.1	8.08	65.5	50			< 2	2		0.63	< 0.023	0.001	2.6	< 0.07	0.11	0.031	23.4	24.458	> 20100	10900	121.81	28.4
7/19/2006																				47300	5550		
8/9/2006	379.1	5.7	7.71	82.1	8.2	170		< 2	3		0.7	0.063	0.003	0.21	< 0.07	< 0.01	< 0.01	4.2	37.8	33000	3000	2.9	9.1
8/21/2006																				34500	7500		
9/6/2006	396	8.95	8.02	68	2.9	190		< 2	1.7	8.1	0.24	< 0.023	0.001	1.5	< 0.07	0.086	< 0.01	5.6	424.786	32850	4900	16.99	16.1
9/18/2006																				706800	34750		
9/25/2006																				98400	4900		
10/2/2006	362.2	9.71	8	60.2	3	170		< 2	0.79		0.19	< 0.023	0.001	2.3	< 0.07	0.14	0.07	8.4	33.066	72300	1550	84.66	24
10/18/2006																				114000	17300		
10/30/2006																				3400	1000		
11/27/2006	370	12.79	6.93	45.8		180		< 2	0.84		0.46	< 0.023	0.000	1.4	< 0.07	< 0.01	< 0.01	3.8	241			20.38	12.2
12/18/2006	333.4	13.89	8.57	48.5	3.6	160		< 2	1.2	7	0.44	< 0.023	0.002	0.85	< 0.07	< 0.01	0.073	4	2.656			9.31	14.6
1/5/2007						66		< 2	3.4		1.1	< 0.023		1.9	< 0.07	< 0.01	0.25	120					
1/5/2007						160		2.3	1.9		0.77	< 0.023		1.3	< 0.07	0.11	0.32	98					
2/27/2007	306	12.85	8.16	40.2	16.2	150		< 2	0.89	6.2	0.33	< 0.023	0.000	2.2	< 0.07	< 0.01	< 0.01	8.4	48.079			78.55	14.6
Geometric Average	346.0743	9.48	7.969	56.315	7.669	146.866		2.0216	1.7132	7.6997	0.4564	0.0349	0.001	1.2735	0.0853	0.0345	0.0438	10.3165	82.3368	20294	3436		
Standard Deviation	33.1722	2.62	0.401	13.217	16.945	33.0452		0.0832	0.8561	1.2006	0.2503	0.0338	0.001	0.6998	0.044	0.0468	0.0965	38.5717	142.9641	177203	8988		

Results for Water Quality Sites

Hanging Fork Watershed — PEYTON CREEK

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/21/2006			8.63	43				<2	0.76		0.1488	< 0.1	0.007	3.298	< 0.2	0.078	0.0822	8		>2010	1450	7.19	
4/12/2006	327.1	11.41	8.63	67.5					1.9		0.5521	< 0.1	0.017	2.4	< 0.15	0.0688	0.0804	7		> 2010	1650	5.58	7.1
5/1/2006	337.8	11.14	8.85	67					2.7		0.4926	< 0.1	0.025	2.2	< 0.15	0.0917	0.1256	8		> 2010	> 2010	6.01	6.7
6/5/2006	433.6	10.51	8.42	68.6					1.1		0.37	< 0.023	0.003	2.9	0.091	0.13	0.13	14.4		20200	1500	1.83	5.5
6/20/2006																				16500	1640		
7/6/2006	357	9.5	8.2	68					1.4		0.77	< 0.023	0.002	5.5	0.081	0.097	0.029	10.8		> 20100	6240	16.62	5.5
7/19/2006																				59200	3200		
8/9/2006	431.6	8.04	8.06	80.7					4.6		0.6	< 0.023	0.002	0.094	< 0.07	< 0.01	< 0.01	9.8		101000	3000	0.15	2
8/21/2006																				45300	4200		
9/6/2006	433	12.59	8.22	68.6	4.4				0.88		0.24	< 0.023	0.002	1.9	< 0.07	0.08	< 0.01	2.6		55950	500	1.9	2
9/18/2006																				505600	456950		
9/25/2006																				343350	8750		
10/2/2006	348.9	10.33	8.11	61.8					0.93		0.32	< 0.023	0.001	3.5	< 0.07	0.14	0.02	8.6		67700	2600	14.06	9.8
10/18/2006																				58000	19700		
10/30/2006																				52500	2500		
11/27/2006	404	15.92	7.22	46.9					< 0.7		0.52	< 0.023	0.000	2.9	< 0.07	< 0.01	< 0.01	5.6				2.32	4.7
12/18/2006	382.8	16.68	8.71	51.6	1.6				0.91		0.41	< 0.023	0.003	2.3	< 0.07	< 0.01	< 0.01	2.2				0.46	3.9
1/30/2007	336.5	14.99	8.11	35.3	4.6				< 0.7		0.17	< 0.023	0.000	3.7	< 0.07	0.29	< 0.01	2.2				7.11	4.7
2/26/2007	316.7	13.86	8.48	49.1	36.2				< 0.7		0.25	< 0.023	0.001	3.7	< 0.07	< 0.01	< 0.01	21				11.48	5.9
Geometric Average	371.1	11.98	8.29	57.5	6.7			<2	1.2		0.3605	0.033	0.002	2.24	0.09	0.0492	0.0251	6.7		31477	3910		
Standard Deviation	45.2	2.78	0.43	13.5	5.4				1.2		0.1893	3.453	0.008	1.3	0.044	0.0798	0.0473	5.4		142039	116994		

Hanging Fork Watershed — FROG BRANCH

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/22/2006			8.07	36.5				<2	1.96		0.4848	< 0.1	0.001	2.599	< 0.2	0.0334	0.0361	< 3		>2010	210	3.77	
4/13/2006	368.9	10.32	8.1	57.4					1.6		0.2531	< 0.1	0.004	1.5	< 0.15	0.0378	0.0526	< 5		> 2010	430	1.96	9.8
5/1/2006	359.9	11.19	8.36	61.7					3.6		0.6169	< 0.1	0.008	1.3	< 0.15	0.0571	0.1222	< 5		> 2010	> 2010	2.57	13.4
6/5/2006	382.5	8.32	8.21	62.9					1.6		0.51	< 0.023	0.001	1.5	< 0.07	0.099	0.083	11.8		7400	300	0.32	9.8
6/20/2006																				9450	420		
7/6/2006	330	9.5	8.3	64.5					1.8		0.62	< 0.023	0.002	2.6	< 0.07	0.08	< 0.01	13		> 20100	9450	2.76	24.4
7/19/2006																				44300	< 500		
8/9/2006	446.4	6.46	7.83	73.7					2.7		0.21	< 0.023	0.001	0.26	< 0.07	0.073	< 0.01	10		72000	0	1.1	5.9
8/21/2006																				23800	3000		
9/6/2006	385	9.1	8.01	64.1	8.3				< 0.7		24	< 0.023	0.001	2.5	< 0.07	< 0.01	< 0.01	4.8		39700	2600	1.78	11
9/18/2006																				205300	3700		
9/25/2006																				153800	3700		
10/2/2006	358	9.89	8.08	59.1					< 0.7		0.14	< 0.023	0.001	2.8	< 0.07	0.14	0.069	7		52300	3150	9.02	18.1
10/18/2006																				89100	1000		
10/30/2006																				28000	1500		
11/27/2006	412	14.31	6.96	44.6					< 0.7		1.2	< 0.023	0.000	2.2	< 0.07	< 0.01	0.097	5.4				1.37	10.6
12/18/2006	365.5	15.21	8.62	48	4.1				1.2		0.38	< 0.023	0.002	1.6	< 0.07	< 0.01	< 0.01	3				1.04	7.9
1/30/2007	343.9	15.67	8.26	33.2	4.1				< 0.7		0.13	< 0.023	0.000	2.8	< 0.07	< 0.01	< 0.01	2				14.06	12.2
2/27/2007	316	13.91	8.34	41.4	16.9				670		0.34	< 0.023	0.001	2.9	< 0.07	< 0.01	< 0.01	8				5.94	16.9
Geometric Average	368.222	9.71	8.085	52.424	7			<2	2.2512		0.514	0.0332	0.001	1.7824	0.0867	0.0302	0.0267	5.6243		22051	1330		
Standard Deviation	36.6696	3.06	0.411	12.786	6				192.961		6.8063	0.0348	0.002	0.8119	0.0454	0.043	0.0406	3.5476		59450	2440		

Results for Water Quality Sites

Hanging Fork Watershed — CHICKEN BRISTLE

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/21/2006			8.7	41.9		120.78		< 2	< 0.7	7.468	< 0.1	< 0.1	0.007	1.775	< 0.2	0.0304	0.0465	< 3	80.0729	>2010	830	21.05	
4/12/2006	302	13.88	8.55	61.9		130.65		< 2	2		0.2587	< 0.1	0.012	1.3	< 0.15	0.0325	0.039	< 5	91.5189	> 2010	360	17.6	19.7
5/1/2006	292.7	11.97	8.43	57.8		127		< 6	4.9		0.6409	< 0.1	0.008	0.79	< 0.15	0.0438	0.0734	5	634	> 2010	> 2010	35.06	20.5
6/6/2006	348.3	6.78	7.93	63	3.4	150		< 2	1.8	8.7	0.52	< 0.023	0.001	0.62	< 0.07	0.07	0.097	21.2	401.501	7800	1100	4.5	14.2
6/20/2006																				14500	990		
7/6/2006	291	9.6	8	64	100			4.5	2.4		0.35	< 0.023	0.001	2.2	< 0.07	0.079	0.023	16	43.027	> 20100	5040	103.87	28.4
7/19/2006																				41600	1550		
8/10/2006	352	12.87	6.89	75.1	11	160		< 2	3.4		0.75	< 0.023	0.000	0.32	< 0.07	0.14	0.035	5	198	72300	6200	2.7	14.2
8/21/2006																				27100	1000		
9/6/2006	406	9.17	7.95	64.7	4.3	190		< 2	0.92	7.4	0.21	< 0.023	0.001	1.4	< 0.07	0.069	< 0.01	2.6	841.113	47950	3150	20.33	18.1
9/18/2006																				> 1209800	408200		
9/25/2006																				76450	7200		
10/2/2006	351.6	9.98	8.03	58.5	2	170		2.6	1.2		0.28	< 0.023	0.001	2	< 0.07	0.076	0.027	9	121.526	69800	1500	48.28	20.1
10/18/2006																				71500	9850		
10/30/2006																				57500	4500		
11/27/2006	370	14.38	6.73	44.2		170		< 2	< 0.7		0.4	< 0.023	0.000	1.2	< 0.07	< 0.01	< 0.01	2.4	380			6.74	13
12/18/2006	325.4	15.11	8.57	47.1	3	150		< 2	1.1	6.4	0.42	< 0.023	0.002	0.66	< 0.07	< 0.01	< 0.01	5	4.364			4.19	18.9
1/5/2007						140		3	3.4		1.2	0.029		1.5	< 0.07	0.14	0.54	130					
2/27/2007	285	15.2	8.37	40	10.7	140		< 2	0.89	5.6	0.22	< 0.023	0.001	1.9	< 0.07	< 0.01	< 0.01	4.2	66.383			44.8	16.9
Geometric Average	330.3	11.54	7.99	55.1	7.23	148.5		2.4	1.59	7.035	0.367	0.034	0.001	1.144	0.09	0.0413	0.0327	7.2	129.97	26231	3062		
Standard Deviation	39.9	2.88	0.66	11.3	35.82	21.1		1.3	1.34	1.175	0.302	0.035	0.004	0.606	0.04	0.0457	0.1484	35.94	273.07	304214	104599		

Hanging Fork Watershed — McKINNEY BRANCH

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/21/2006			8.5	42.2				<2	1		0.3098	< 0.1	0.005	2.055	< 0.2	0.0843	0.083	< 3		>2010	>2010	5.61	
4/12/2006	349.2	12.04	8.41	59.7					2		0.3711	< 0.1	0.008	1.9	< 0.15	0.0682	0.0757	< 5		> 2010	590	7.06	11
5/1/2006	361.4	11.75	8.45	57.7					3.1		0.5575	< 0.1	0.008	1.4	< 0.15	0.0885	0.1284	9		> 2010	> 2010	11.69	13
6/5/2006	390.3	8.75	8.27	63.7					1.8		0.36	< 0.023	0.002	0.48	< 0.07	0.14	0.11	2		7000	1400	0.91	6.7
6/20/2006																				16500	9450		
7/6/2006	366	9.4	8.2	64					3.8		0.83	< 0.023	0.001	3.5	0.085	0.15	0.068	14.4		> 20100	13000		
7/19/2006																				100000	3750	18.93	14.6
8/21/2006																				64900	1000		
9/6/2006	467	9.25	8.03	64	3.1				1.2		0.32	< 0.023	0.001	1.2	< 0.07	0.11	< 0.01	6.4		42750	3150	3.11	7.5
9/18/2006																				217600	13950		
9/25/2006																				119100	3750		
10/2/2006	412.6	10.09	8.17	58.8					1.2		0.32	< 0.023	0.001	2.4	< 0.07	0.12	0.035	9.4		83500	1000	7.99	15
10/18/2006																				183000	12500		
10/30/2006																				57500	4500		
11/27/2006	444	13.34	6.55	43.8					0.83		0.49	< 0.023	0.000	1.6	< 0.07	< 0.01	< 0.01	4.2				1.49	11.4
12/18/2006	376.3	14.14	8.47	47.4	3.1				0.8		0.39	< 0.023	0.001	0.8	< 0.07	< 0.01	< 0.01	< 2				0.55	12.2
1/30/2007	378.1	15.84	7.76	32.8	3.8				< 0.7		0.2	< 0.023	0.000	2.4	< 0.07	< 0.01	< 0.01	2.2				3.7	5.9
2/27/2007	366.9	14.84	8.45	40.4	8.4				760		0.24	< 0.023	0.001	2.4	< 0.07	< 0.01	< 0.01	5.6					
Geometric Average	389.6	11.7	8.09	51	4.2			<2	2.5		0.3704	0.034	0.001	1.62	0.09	0.0447	0.0305	4.7		27164	3243		
Standard Deviation	38.4	2.53	0.57	11.2	2.6				228.6		0.1752	0.036	0.003	0.86	0.05	0.055	0.0448	3.9		68997	4875		

Results for Water Quality Sites

Hanging Fork Watershed — BAUGHMAN BRANCH

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/21/2006			8.27	42.5				< 2	1		0.144	0.1479	0.004	1.96	< 0.2	0.0972	0.0731	< 3		> 2010	1450	12.25	
4/12/2006	275.9	11.28	8.11	54.6					1.9		0.53	<0.1	0.003	1.3	< 0.15	0.0808	0.0652	< 5		> 2010	340	6.51	7.5
5/1/2006	242.2	11.93	8.15	56.1					5.7		0.67	<0.1	0.004	0.77	< 0.15	0.0319	0.0566	< 5		> 2010	> 2010	8.95	7.1
6/5/2006	324.9	9.86	8.2	63.8					1.7		0.29	<0.023	0.001	1.2	< 0.07	0.061	0.068	4		10900	3400	3.53	6.7
6/20/2006																				16500	2380		
7/6/2006	274.6	9.22	7.77	63.7					2.2		0.64	<0.023	0.001	2.9	< 0.07	0.065	< 0.01	11.4		> 20100	5910	37	13.4
7/19/2006																				64900	13600		
8/9/2006	435.1	9.09	7.7	76.8					2.7		0.36	<0.023	0.001	1.3	0.11	0.18	0.13	8.4		59000	500	0.19	3.2
8/21/2006																				64900	2650		
9/5/2006	357	9.95	7.93	63.6	1.3				0.97		0.26	<0.023	0.001	1.8	< 0.07	< 0.01	< 0.01	4.2		95900	1000	4.35	7.1
9/18/2006																				289700	13600		
9/25/2006																				112350	3750		
10/2/2006	292	10.01	7.78	57.8					1.2		0.26	<0.023	0.000	2.2	< 0.07	< 0.01	< 0.01	5		29200	500	12.24	12.2
10/18/2006																				37200	2050		
10/30/2006																				39500	500		
11/27/2006	294	13.73	7.39	48.5					< 0.7		0.43	0.048	0.000	1.4	< 0.07	< 0.01	< 0.01	5.6				4.1	7.9
12/18/2006	289.2	16.32	8.64	47.6	1.5				1.6		0.38	<0.023	0.002	0.92	< 0.07	< 0.01	< 0.01	2				1.05	7.1
1/30/2007	256.6	15.41	7.81	33	4				< 0.7		0.32	0.24	0.002	2.1	< 0.07	0.3	< 0.01	2				6.17	8.3
2/27/2007	227.4	15.13	8.41	45.2	10.9				1.3		0.38	<0.023	0.001	1.8	< 0.07	< 0.01	< 0.01	5.8				13.02	12.2
Geometric Average	292.5	9.55	8.01	53.2	3.04			<2	1.5		0.36	0.0444	0.001	1.54	0.09	0.0364	0.0232	4.55		25080	1945		
Standard Deviation	58.3	2.69	0.35	11.8	4.49				1.4		0.16	0.0691	0.001	0.6	0.04	0.0881	0.0395	2.65		72958	4339		

Hanging Fork Watershed — WEST HUSTONVILLE

Date	Cond µS	DO mg/L	pH SU	Temp F	Turb NTU	Alk mg/L	BOD15 mg/L	BOD5 mg/L	TOC mg/L	Cl mg/L	TKN mg/L	NH3-N mg/L	Unionized NH3 mg/L	NO3N mg/L	NO2N mg/L	OP mg/L	TP mg/L	TSS mg/L	Chl A mg/m3	TC #/100mls	E.coli #/100mls	Discharge cfs	Depth in
3/21/2006			8.49	42.1				<2	0.81		< 0.1	< 0.1	0.005	1.398	< 0.2	0.0175	0.0299	< 3		>2010	>2010	5.61	
4/12/2006	237.7	13.01	8.57	55.7					1.8		0.4025	< 0.1	0.010	1.1	< 0.15	0.0171	0.0194	< 5		> 2010	530	14.04	5.1
5/1/2006	211	12.51	8.57	56.6					4.2		0.4777	< 0.1	0.010	0.53	< 0.15	0.02	0.039	< 5		> 2010	2010	11.66	5.1
6/5/2006	337	8.94	8.16	64.2					1.6		0.29	< 0.023	0.001	0.45	< 0.07	0.091	0.058	5.8		5600	500	1.8	3.2
6/20/2006																				11800	990		
7/6/2006	228	9.5	7.9	63					2.4		0.42	< 0.023	0.001	1.3	< 0.07	0.055	< 0.01	8.6		> 20100	2710	43.8	6.7
7/19/2006																				33000	1550		
8/9/2006	423.2	7.14	7.82	75.2					3.3		0.52	< 0.023	0.001	0.46	< 0.07	< 0.01	< 0.01	4.8		21500	500	0.67	0.4
8/21/2006																				31200	500		
9/5/2006	350	9.54	7.9	63.4	1.9				1		0.26	< 0.023	0.001	1.4	< 0.07	< 0.01	< 0.01	4		39700	4850	4.69	5.1
9/18/2006																				75750	9450		
9/25/2006																				124050	9950		
10/2/2006	270.2	10.1	7.88	57.4					1.1		0.15	< 0.023	0.001	1.8	< 0.07	< 0.01	< 0.01	4.6		29300	2600	10.37	9.5
10/18/2006																				50700	6100		
10/30/2006																				22000	1000		
11/27/2006	282	12.64	7.15	48.2					< 0.7		0.23	< 0.023	0.000	1.5	< 0.07	< 0.01	< 0.01	2.6				1.95	7.9
12/18/2006	275.9	14.77	8.54	46.2	3.4				1.2		0.29	< 0.023	0.001	0.95	< 0.07	< 0.01	< 0.01	2.4				2.54	5.9
1/30/2007	227.6	16	8.04	32.8	3.1				< 0.7		< 0.1	< 0.023	0.000	1.9	< 0.07	< 0.01	< 0.01	< 2				6.34	5.9
2/27/2007	198.3	16.1	8.79	45.6	9.2				990		0.27	< 0.023	0.002	1.6	< 0.07	< 0.01	< 0.01	5.4				16.73	8.3
Geometric Average	269.3604	11.48	8.139	52.982	3.7			<2	2.4624		0.2576	0.0332	0.001	1.0755	0.0867	0.0161	0.015	4.0955		17019	1821		
Standard Deviation	68.7808	3.01	0.462	11.676	3.3				285.297		0.1396	0.0348	0.004	0.5064	0.0454	0.0251	0.0156	1.8247		32683	3164		

APPENDIX B – THIRD ROCK MST SAMPLING DATA, 2008

HANGING FORK WATERSHED DIVISION MST RESULTS

Watershed Division: JUNCTION CITY

Habitat Assessments:

Best Site: JC3

Worst Site: JC8

One of the sites in Junction City was rated as “fully supporting” in its designated habitat use, two were “partially supporting,” and six were “not supporting.” Riparian width was narrow throughout the area, with the exception of JC3, which received the best overall score. The worst site, JC8, was severely eroding and widening, with trees falling into the stream from both banks, and it contained little vegetated riparian width.

Field Observed Fecal Inputs:

Potential human input from residential sources in close proximity to the stream was the most common source observed. Although pipes were observed near JC08, these were probably not sewer related. Evidence of cattle input was observed, but livestock sources are expected to contribute to a lesser degree than in other watershed areas.

MST Results:

In comparison to other watershed divisions, the Junction City division had some of the lowest *E. coli* concentrations, although six of the eight sites exceeded the Kentucky recreational water maximum limit of 240 cfu/100mls for both sampling events. JC7 met the water quality criteria during both events, as did JC8 and JC9 during the wet event.

AC/TC ratios indicate that the fecal inputs could be indicative of human or cattle sources, with a range of 2 to 4 during the wet event, but fresher at below 3 for the dry. Sources upstream of JC2 and JC3 provided the highest concentrations geographically. DNA testing indicated that during the dry MST event approximately 50% of the fecal contribution is due to humans, with less than 5% due to cattle upstream of JC3. Residences along the tributary monitored by JC3 are serviced by sewer systems in the east towards the city and septic tanks toward the west. Further testing is necessary to clarify the nature of the human inputs in this area.

Watershed Division: JUNCTION CITY

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	JC1	JC2	JC3	JC4	JC5	JC6	JC7	JC8	JC9
Date	7/27	7/27	7/27	7/27	7/27	7/27	7/30	7/30	7/30
Epifaunal Substrate / Available Cover	13	11	17	14	12	12	19	7	11
Embeddedness	19	16	19	15	16	17	18	13	15
Velocity / Depth Regime	15	6	14	17	13	8	10	10	10
Sediment Deposition	17	12	16	11	16	15	16	12	14
Channel Flow Status	13	16	5	11	5	10	11	11	12
Channel Alterations	14	15	15	15	14	14	15	11	12
Frequency Of Riffles (or Bends)	17	10	17	11	16	18	19	16	16
Bank Stability - Left Bank	6	6	6	6	6	6	8	1	4
Bank Stability - Right Bank	6	6	6	7	8	6	9	2	5
Bank Vegetation Protection - Left Bank	6	7	9	9	3	7	7	1	2
Bank Vegetation Protection - Right Bank	6	7	9	8	6	7	7	1	5
Riparian Vegetation Zone Width - Left Bank	0	2	6	9	0	3	2	1	1
Riparian Vegetation Zone Width - Right Bank	0	2	9	2	2	2	2	1	1
Total Habitat Assessment Score	132	116	148	135	117	125	143	87	108

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
JC1	7/27/2007	X	X						Livestock downstream, residences upstream
JC2	7/27/2007	X							Drains a residential community
JC3	7/27/2007		X						Cattle upstream
JC4	7/27/2007				X				Wooded stream corridor
JC5	7/27/2007	X						X	Lawns mowed to stream edge
JC6	7/27/2007	X							Residences bordering stream
JC7	7/30/2007		X						Livestock upstream
JC8	7/30/2007	X							Two pipes found draining into stream
JC9	7/30/2007				X				Wooded stream corridor

MST Results:

Site		JC1	JC2	JC3	JC4	JC5	JC6	JC7	JC8	JC9
Dry Event	*E. coli* (CFU/100mls)	2300	2900	12000	410	2400	1490	50	590	400
	AC/TC Ratio	0.6	2.9	1.2	0.4	1.7	1.5	2.7	1.8	-
	%Human			~50						
	%Cattle			<5						
Wet Event	*E. coli* (CFU/100mls)	2100	13100	13800	850	1320	330	60	220	200
	AC/TC Ratio	2.2	1.8	2.4	3.4	3.4	2.2	5.3	3.8	2.9
	%Human			NIL						
	%Cattle			NIL						

Watershed Division: BLUE LICK

Habitat Assessments:

Best Site: BL2 – downstream view

Worst Site: BL3

All of the sites in Blue Lick were scored as "not supporting" their designated habitat use. BL3 was one of the lowest rated streams in the entire project area, with heavy siltation, lack of habitat, no significant riparian width, and unstable banks with little vegetative protection. Although the riparian zone was poor on BL2, stable banks, frequent riffles, and variable flow regimes maintained the optimal status ranking.

Field Observed Fecal Inputs:

Cattle, dogs, wildlife, and residences on septic systems were all observed in the watershed area. Wildlife influence may be more prevalent in this watershed than in others due to the large percentage of forested land.

MST Results:

All sites exceed the Kentucky recreational water maximum limit of 240cfu/mls, although BL2 and BL3 approached this limit for the dry event. Wet event concentrations were often a hundredfold higher that the dry event, indicating stormwater sources such as runoff significantly contribute to the impairment of the streams by pathogens.

During the wet event, *E. coli* concentrations increased downstream, indicating a cumulative effect of sources throughout the reach. As these are fresh inputs (as indicated by the AC/TC ratios around 2), these contributions are most likely due to runoff from livestock areas.

MST testing at BL01 during a dry event indicated that 80% of the contribution was due to human sources, with the remaining 20% due to cattle. As the majority of residences are along Boneyville Road upstream of BL03, these residences are indicated as the main human source contributors from either straight pipes or leeching septic systems.

Watershed Division: BLUE LICK

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	BL1	BL2	BL3	BL4
Date	7/18	7/18	7/18	7/18
Epifaunal Substrate / Available Cover	16	8	3	15
Embeddedness	12	13	5	7
Velocity / Depth Regime	16	8	7	15
Sediment Deposition	14	13	3	5
Channel Flow Status	16	17	8	13
Channel Alterations	15	19	16	18
Frequency Of Riffles (or Bends)	14	20	16	20
Bank Stability - Left Bank	8	10	2	8
Bank Stability - Right Bank	7	10	2	6
Bank Vegetation Protection - Left Bank	5	7	0	10
Bank Vegetation Protection - Right Bank	4	7	0	6
Riparian Vegetation Zone Width - Left Bank	1	3	0	8
Riparian Vegetation Zone Width - Right Bank	1	1	0	1
Total Habitat Assessment Score	**129**	**136**	**62**	**132**

Field Observed Fecal Inputs:

Site		BL1	BL2	BL3	BL4
Dry Event	*E. coli* (CFU/100mls)	1330	250	280	2800
	AC/TC Ratio	3.8	0.0	15.7	0.4
	%Human	~80			
	%Cattle	~20			
Wet Event	*E. coli* (CFU/100mls)	73000	52000	10900	6800
	AC/TC Ratio	2.1	1.9	1.0	2.1
	%Human	NIL			
	%Cattle	NIL			

MST Results:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
BL1	7/18/2007	X	X		X	X			Adjacent residences, cattle, dogs, wildlife abundant
BL2	7/18/2007				X				-
BL3	7/18/2007		X		X				Cattle, horses, dogs – more abundant
BL4	7/18/2007		X		X				Cattle, horses, dogs – less abundant than at BL3

Watershed Division: HANGING FORK MAIN STEM & TRIBUTARIES

Habitat Assessments:

Best Site: HF2

Worst Site: HF4

Two sites in the "Hanging Fork Main Stem and Tributaries" area rated "fully supporting" in their designated habitat use, three were "partially supporting," and, four were "not supporting." Small riparian widths and unstable, eroding banks were the poorest scoring categories among the reaches surveyed. HF2, the best site in the area, scored optimal or suboptimal in all categories. The worst site in the area, HF4, flows through a grazed pasture, contains little habitat, is eroding and unstable due to the lack of riparian width, and is relatively free from fluctuations in velocity/depth regimes.

Field Observed Fecal Inputs:

The most commonly observed fecal input in the area was cattle or other livestock with access to the streams. Several sites were in proximity to residential areas, such as HF7. A large bird population under the bridge near HF1 could also contribute to the loading.

Heavy cattle traffic at HF9

MST Results:

AC/TC ratios establish that most fecal inputs are fresh, all below 4 with the exception of HF7 in the wet event. *E. coli* concentrations are rather well distributed geographically throughout the watershed and were significantly higher during the wet event with the exception of the HF5. All sites exceeded the Kentucky recreational water maximum limit of 240 cfu/100mls during both events.

At HF5, source contributions were primarily human, with both DNA methods indicating about 90% human contribution and less than 5% cattle contribution, despite the heavily agricultural land use in the area. DNA methods were below detection for both events at the HF01 site, possibly due to a dilution effect. Therefore, the areas of the watershed not tested with DNA methodologies may be suspected of being elevated due to human contributions, but further studies should be conducted to confirm these predictions.

Watershed Division: HANGING FORK MAIN STEM AND TRIBUTARIES

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	HF1	HF2	HF3	HF4	HF5	HF6	HF7	HF8	HF9
Date	7/18	7/23	7/23	7/23	7/23	7/23	7/23	7/18	7/20
Epifaunal Substrate / Available Cover	11	18	17	5	11	16	6	16	8
Embeddedness	11	15	7	7	10	11	2	12	12
Velocity / Depth Regime	15	16	16	10	11	11	11	10	14
Sediment Deposition	12	15	11	6	10	6	5	16	9
Channel Flow Status	13	12	11	11	7	13	8	14	12
Channel Alterations	17	15	20	14	15	15	13	20	19
Frequency Of Riffles (or Bends)	13	13	16	12	18	20	20	20	17
Bank Stability - Left Bank	6	6	3	2	4	5	2	9	7
Bank Stability - Right Bank	6	7	3	2	4	5	2	9	4
Bank Vegetation Protection - Left Bank	5	10	8	3	4	8	10	8	7
Bank Vegetation Protection - Right Bank	5	10	8	3	5	8	10	8	3
Riparian Vegetation Zone Width - Left Bank	1	6	3	0	0	7	3	2	2
Riparian Vegetation Zone Width - Right Bank	1	6	7	0	3	4	6	2	2
Total Habitat Assessment Score	116	149	130	75	102	129	98	146	116

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
HF1	7/18/2007	X	X				X		Adjacent residences, upstream dairy operation, significant swallow population under bridge
HF2	7/18/2007		X						Cattle upstream about 1000 yrds
HF3	7/23/2007		X						Upstream cattle
HF4	7/23/2007		X			X			Cattle/horse in field
HF5	7/23/2007		X		X				Cattle direct access
HF6	7/18/2007	X			X				New residence, raccoon tracks
HF7	7/18/2007	X							Subdivision is potential source
HF8	7/18/2007				X				Deer and raccoon tracks in stream
HF9	7/20/2007		X						Cattle fecal matter and tracks throughout reach

MST Results:

Site		HF1	HF2	HF3	HF4	HF5	HF6	HF7	HF8	HF9
Dry Event	*E. coli* (CFU/100mls)	10000	440	1650	2300	37000	4200	1150	3000	3000
	AC/TC Ratio	1.3	3.7	0.3	2.8	0.4	1.0	0.4	1.0	0.7
	%Human	NIL				~90				
	%Cattle	NIL				<5				
Wet Event	*E. coli* (CFU/100mls)	170000	108000	188000	65000	7100	22000	370	179000	84000
	AC/TC Ratio	3.7	1.1	1.2	0.6	1.5	2.3	8.7	3.5	0.6
	%Human	NIL								
	%Cattle	NIL								

Watershed Division: NORTH TRIBUTARY OF HANGING FORK

Habitat Assessments:

Worst Site: NO1

All of the sites on the Northern Tributary of the Hanging Fork watershed division were scored as "not supporting" their designated habitat use. All of the sites had poor riparian width and poor or marginal bank stability and vegetative protection. NO2 and NO3 were adjacent to roadways while NO1 crossed a pasture.

Field Observed Fecal Inputs:

Residences on septic systems are scattered along the stream and may contribute through leeching. Cattle were observed in the stream at NO3 and had access at the other sites. Wildlife, including deer, and domestic dogs are also contributors in the area.

Cattle in stream at NO3

MST Results:

All sites exceeded the Kentucky recreational water maximum limit of 240 cfu/100mls during both events with results increasing from 1,350cfu/mls upstream at NO3 to 78,000 downstream at NO1.

DNA testing methodologies were not analyzed for this watershed division, but *E. coli* concentrations and AC/TC ratios indicate that the inputs are fresh. Additional testing should be conducted to identify the source contributions in this area. Cattle and leeching septic systems are suspected as the main contributors.

Watershed Division: NORTH TRIBUTARY OF HANGING FORK

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	NO1	NO2	NO3
Date	7/23	7/18	7/18
Epifaunal Substrate / Available Cover	17	11	13
Embeddedness	2	7	9
Velocity / Depth Regime	11	8	10
Sediment Deposition	4	10	6
Channel Flow Status	9	15	13
Channel Alterations	16	20	20
Frequency Of Riffles (or Bends)	16	19	19
Bank Stability - Left Bank	4	2	3
Bank Stability - Right Bank	4	2	2
Bank Vegetation Protection - Left Bank	3	2	4
Bank Vegetation Protection - Right Bank	3	2	5
Riparian Vegetation Zone Width - Left Bank	1	1	1
Riparian Vegetation Zone Width - Right Bank	2	0	2
Total Habitat Assessment Score	**92**	**99**	**107**

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
NO1	7/18/2007	X	X		X				Cattle, deer, residences
NO2	7/18/2007	X	X		X	X			Residential septic systems, cattle with stream access, dogs and wildlife
NO3	7/18/2007	X	X		X	X			Residential septic systems, lots of dogs, deer tracks, cattle in stream

MST Results:

Site		NO1	NO2	NO3
Dry Event	*E. coli* (CFU/100mls)	45000	10100	1350
	AC/TC Ratio	-	1.3	0.8
Wet Event	*E. coli* (CFU/100mls)	78000	3600	2400
	AC/TC Ratio	1.6	3.3	6.1

Watershed Division: PEYTON CREEK

Habitat Assessments:

Best Site: PE2

Worst Site: PE6

All of the sites in Peyton Creek were scored as "not supporting" their designated use. Most category scores were in the suboptimal range at all sites. No specific trends were applicable to all sites.

Field Observed Fecal Inputs:

Cattle in stream at PE4

PE2: Raccoon and bird tracks

Cattle were found in the stream at every site except PE5. Tracks indicate that raccoons and birds may contribute to the loading to a lesser degree.

MST Results:

Producing the second highest *E. coli* concentrations of any watershed division during the wet event, this primarily agricultural watershed was expected to be contaminated largely by cattle inputs. Geographically, concentrations were highest at the mouth near PE1 and PE2, as well as in the headwaters near PE6, but all sites except PE5 exceeded the Kentucky recreational water maximum limit during both events. DNA testing methods did not detect the presence of any markers at PE1 for either event, and therefore the identification of the source in the area remains unknown. Field observations seem to indicate cattle, however, the area is similar to McKinney Branch, which was found to be largely due to human contributions in this study. Wildlife in the area could also potentially have a contribution. Further analysis is necessary to identify fecal sources in this area.

Watershed Division: PEYTON CREEK

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor

Supporting Use: Fully, Partially, Not Supporting

Site Name	PE1	PE2	PE3	PE4	PE5	PE6
Date	7/18	7/18	7/18	7/18	7/18	7/17
Epifaunal Substrate / Available Cover	13	11	11	12	11	7
Embeddedness	11	14	10	13	12	16
Velocity / Depth Regime	16	15	12	15	15	10
Sediment Deposition	13	14	9	12	9	14
Channel Flow Status	17	14	12	15	11	8
Channel Alterations	15	11	8	15	15	11
Frequency Of Riffles (or Bends)	18	18	16	14	16	17
Bank Stability - Left Bank	2	6	5	5	6	7
Bank Stability - Right Bank	2	8	6	8	6	4
Bank Vegetation Protection - Left Bank	2	8	6	6	7	5
Bank Vegetation Protection - Right Bank	1	8	4	8	7	3
Riparian Vegetation Zone Width - Left Bank	1	4	4	8	7	2
Riparian Vegetation Zone Width - Right Bank	0	6	2	5	4	1
Total Habitat Assessment Score	**111**	**137**	**105**	**136**	**126**	**105**

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
PE1	7/18/2007		X						Cattle in stream
PE2	7/18/2007		X		X				Cattle upstream, wildlife downstream
PE3	7/18/2007		X						Cattle in stream
PE4	7/18/2007		X		X				Cattle downstream of site, wooded stream corrridor
PE5	7/18/2007							X	Wooded stream corridor
PE6	7/18/2007		X						Cattle in stream

MST Results:

Site		PE1	PE2	PE3	PE4	PE5	PE6
Dry Event	*E. coli* (CFU/100mls)	2400	680	1510	620	140	3000
	AC/TC Ratio	0.5	0.3	0.4	0.0	6.0	0.9
	%Human	NIL					
	%Cattle	NIL					
Wet Event	*E. coli* (CFU/100mls)	220000	248000	12000	9800	5500	89000
	AC/TC Ratio	0.9	0.7	5.4	5.8	3.6	1.1
	%Human	NIL					
	%Cattle	NIL					

Watershed Division: FROG BRANCH

Habitat Assessments:

Best Site: FR2

Worst Site: FR1

One site surveyed in Frog Branch was scored as "fully supporting" its designated habitat use, one "partially," and two "not supporting." Most poor ratings were due to a riparian width less than 15 feet wide. FR1 was also somewhat unstable and lacked vegetation on the banks.

Field Observed Fecal Inputs:

Livestock were observed adjacent to the streams at two of the sites surveyed. Residences near FR4 could contribute inputs, as could wildlife in the forested areas near FR2 and FR3.

MST Results:

All sites exceeded the Kentucky recreational water maximum limit of 240 cfu/100mls with results ranging from 70,000cfu/100mls at FR3 to 420cfu/100mls at FR4.

DNA testing from Frog's Branch at site FR3, which had the highest *E. coli* concentrations during both events, indicates that human sources caused 70% of the contribution and cattle 20% during the dry MST event, as confirmed by low AC/TC ratios. As the contribution from the residences upstream of FR4 is insignificant, the neighborhood south of KY 1194, between FR4 3 and FR4, most likely has septic system failures contributing to the high loading. Cattle throughout the watershed are also contributing the loading to a lesser degree, probably more so during periods with storm related runoff.

Watershed Division: FROG BRANCH

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	FR1	FR2	FR3	FR4
Date	7/23	7/23	7/23	7/23
Epifaunal Substrate / Available Cover	16	17	11	15
Embeddedness	11	11	12	11
Velocity / Depth Regime	17	16	10	8
Sediment Deposition	9	15	14	11
Channel Flow Status	14	10	11	11
Channel Alterations	15	20	20	20
Frequency Of Riffles (or Bends)	17	20	17	20
Bank Stability - Left Bank	5	8	10	10
Bank Stability - Right Bank	5	8	10	10
Bank Vegetation Protection - Left Bank	5	10	7	8
Bank Vegetation Protection - Right Bank	4	10	7	10
Riparian Vegetation Zone Width - Left Bank	1	3	1	1
Riparian Vegetation Zone Width - Right Bank	1	10	2	8
Total Habitat Assessment Score	**120**	**158**	**132**	**143**

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
FR1	7/18/2007		X						Cattle in adjacent field
FR2	7/18/2007				X				
FR3	7/18/2007							X	
FR4	7/18/2007	X	X						Horses next to stream - large subdivision in area

MST Results:

Site		FR1	FR2	FR3	FR4
Dry Event	*E. coli* (CFU/100mls)	710	2900	70000	420
	AC/TC Ratio	1.4	3.9	0.1	0.2
	%Human			~70	
	%Cattle			~20	
Wet Event	*E. coli* (CFU/100mls)	33000	12600	24000	850
	AC/TC Ratio	1.4	0.7	1.2	4.0
	%Human	NIL		NIL	
	%Cattle	NIL		NIL	

Watershed Division: McKINNEY BRANCH

Habitat Assessments:

Best Site: MC2

Worst Site: MC1

All of the sites in McKinney Branch were ranked as "not supporting" of their designated habitat use. One of the worst sites, MC5, had poor habitat cover, embeddedness, and siltation, with few riffles or bends and marginal riparian width. Riparian width was poor for most sites, and in general most sites were sub-optimal in most other categories.

Field Observed Fecal Inputs:

Cattle in stream at MC1

Cattle in stream at MC4

Numerous cattle were observed in the streams at MC1 and MC4, and to a lesser degree in MC3. In other areas, no apparent fecal contributors were observed.

MST Results:

All sites exceeded the Kentucky recreational water maximum limit of 240 cfu/100mls. The dry events had *E. coli* concentrations ranging from 280cfu/100mls to 2900cfu/100mls, while the wet event samples were the highest of any area, exceeding 200,000 cfu/100mls in all sites except MC3.

With land use primarily pasture and urban developments occurring only in the southeastern headwaters of this watershed, field observations seemed to indicate that cattle would be the main contributor to the fecal pollution in this watershed division. With some of the highest *E. coli* concentrations of any watershed (>200,000cfu/mL for 4 sites during the wet event), and low ACTC ratios, direct cattle input seemed plausible. However, both DNA testing methods sampled from MC1 indicated that 90% of the dry event and 100% of the wet event contributions were due to fecal material from human sources. This would indicate that serious septic system failures or possibly straight pipe discharges are the main contributors to the fecal inputs in this area.

Watershed Division: McKINNEY BRANCH

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	MC1	MC2	MC3	MC4	MC5
Date	7/20	7/20	7/24	7/20	7/20
Epifaunal Substrate / Available Cover	7	15	11	13	1
Embeddedness	8	14	12	13	3
Velocity / Depth Regime	7	10	10	14	6
Sediment Deposition	6	13	10	10	3
Channel Flow Status	13	12	11	17	16
Channel Alterations	15	19	13	15	16
Frequency Of Riffles (or Bends)	15	16	20	18	2
Bank Stability - Left Bank	2	8	3	4	9
Bank Stability - Right Bank	2	3	6	6	10
Bank Vegetation Protection - Left Bank	2	7	5	5	6
Bank Vegetation Protection - Right Bank	3	7	5	6	6
Riparian Vegetation Zone Width - Left Bank	1	6	3	1	3
Riparian Vegetation Zone Width - Right Bank	1	9	0	1	3
Total Habitat Assessment Score	**82**	**129**	**109**	**123**	**84**

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
MC1	7/20/2007		X		X				Cattle fecal matter and footprints observed in creek
MC2	7/20/2007							X	-
MC3	7/23/2007		X						Cattle access to stream - marginal
MC4	7/20/2007		X						About 40 cattle upstream - heavy impact
MC5	7/20/2007							X	-

MST Results:

Site		MC1	MC2	MC3	MC4	MC5
Dry Event	*E. coli* (CFU/100mls)	820	1600	280	2400	2900
	AC/TC Ratio	3.5	3.4	1.6	5.5	9.7
	%Human	~90				
	%Cattle	~10				
Wet Event	*E. coli* (CFU/100mls)	>200000	>200000	9500	>200000	251000
	AC/TC Ratio	1.0	0.3	1.9	0.3	3.0
	%Human	~100			NIL	
	%Cattle	NIL			<5	

Watershed Division: BAUGHMAN BRANCH

Habitat Assessments:

Best Site: BA2

Worst Site: BA05

All but one of the sites in Baughman Branch were scored as “not supporting” their designated use. The remaining site, BA2, was “fully supporting”. Many sites had narrow vegetated riparian areas extending less than 15 feet from the stream. BA5 rated lower than other sites due to the lack of channel flow variation (only standing pools.) Very little embeddedness was present in the area.

Field Observed Fecal Inputs:

BA5: Cattle manure

BA6: Raccoon scat under bridge

Cattle were often observed adjacent to or in the streambeds. Many of the sites were forested, and therefore wildlife fecal input is expected. In some areas raccoon scat was observed. As BA4 is within a nursery, it is expected that fertilizer may indirectly contribute to the loading here.

MST Results:

All sites exceeded the Kentucky recreational water maximum limit of 240cfu/mls, except the wet event at BA8. The AC/TC ratios are mostly below 2, indicating a fresh human source more so than cattle. Areas with higher AC/TC ratios are more likely influenced by livestock fecal inputs.

The highest concentrations, found at BA4 and BA5 along Spears Creek, were found to be a hundred times greater than the limit and pose a definite health risk for recreational use. Source tracking samples from BA4 indicate that the contribution of human and cattle sources is approximately equal. BA4 is adjacent to the nursery, which may contribute some loading in addition to cattle inputs upstream. The other portion of the loading is due to residences in the headwaters of Spears Creek that are all on septic systems, some of which are apparently not functioning properly.

E. coli concentrations are lower in the headwaters of Baughman Creek upstream of BA7 and BA8, increasing downstream at BA6 and toward the confluence of Spears Creek. Cattle appear to be the main fecal contributor based on land use and field observations.

The eastern tributary monitored by BA2 and BA3 is most likely influenced by the residences on septic systems along Holtzclaw Lane as well as the livestock grazing in the area.

Watershed Division: BAUGHMAN BRANCH

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8
Date	7/18	7/19	7/19	7/19	7/19	7/19	7/19	7/19
Epifaunal Substrate / Available Cover	10	17	7	11	10	12	15	11
Embeddedness	15	16	10	18	16	17	17	15
Velocity / Depth Regime	15	13	7	8	5	10	10	10
Sediment Deposition	10	16	10	18	11	15	13	12
Channel Flow Status	10	15	15	14	5	9	15	11
Channel Alterations	6	17	14	16	16	11	19	13
Frequency Of Riffles (or Bends)	16	17	7	16	12	15	16	15
Bank Stability - Left Bank	7	8	8	5	6	8	7	5
Bank Stability - Right Bank	7	8	8	7	8	8	7	4
Bank Vegetation Protection - Left Bank	5	9	5	5	6	6	6	5
Bank Vegetation Protection - Right Bank	5	9	5	5	7	6	5	5
Riparian Vegetation Zone Width - Left Bank	1	8	1	2	1	3	6	1
Riparian Vegetation Zone Width - Right Bank	1	8	1	2	1	3	4	1
Total Habitat Assessment Score	**108**	**161**	**98**	**127**	**104**	**123**	**140**	**108**

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
BA1	7/18/2007				X				Raccoon tracks in stream
BA2	7/19/2007							X	Wooded stream corridor
BA3	7/19/2007	X	X						Cattle in stream, many surrounding homes
BA4	7/19/2007	X	X						Cattle upstream - none present at visit, nursery adjacent
BA5	7/19/2007		X						Cattle in stream
BA6	7/19/2007		X		X				Cattle upstream, raccoon scat observed
BA7	7/19/2007				X				Wooded stream corridor
BA8	7/19/2007		X						Pastureland, but no cattle present

MST Results:

Site		BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8
Dry Event	*E. coli* (CFU/100mls)	2700	4700	5600	47000	19000	11900	780	960
	AC/TC Ratio	1.6	0.9	-	2.4	4.1	1.0	5.1	7.6
	%Human	<5			~50				
	%Cattle	NIL			~50				
Wet Event	*E. coli* (CFU/100mls)	110000	11300	900	84000	13000	7400	1150	180
	AC/TC Ratio	0.3	1.7	1.3	0.3	1.6	1.1	3.1	9.8
	%Human				NIL				
	%Cattle				NIL				

Watershed Division: HANGING FORK WEST OF HUSTONVILLE

Habitat Assessments:

Best Site: WH5

Worst Site: WH2

Four of the sites in Hanging Fork West of Hustonville were scored as “not supporting” their designated habitat use, one was “partially supporting,” and one was “fully supporting. WH2 received the lowest habitat score of any site examined, as it was embedded and silted, lacking variable flow regimes and habitat, and was grazed by goats to the edge of the water. Other sites were found to have poor riparian zone widths and marginal vegetative bank protection.

Goats behind vegetation at WH2

Field Observed Fecal Inputs:

Cattle were observed in the stream or have had prior access at WH3, WH4, and WH6. Goats were observed in the stream at WH2. Residences are located largely in the headwaters of the watershed and near the confluence of WH1 and WH2, but are also scattered throughout the area.

MST Results:

All sites exceeded the Kentucky recreational water maximum limit of 240 cfu/100mls, with *E. coli* concentrations found to be elevated (>10,000 cfu/mL) at WH01 and WH03 during the wet event from the 840 - 4800cfu/mL range at the other sites. Most of the AC/TC results indicate the inputs are fresh.

WH1, at the mouth of this watershed division, was found to have a >90% human source contribution, as confirmed by both MST methods and less than 1% from cattle sources based on Enterococci DNA results. Thus, the properties between WH1 and WH2 most likely have leeching septic systems.

The *Bacteroidetes* methodologies indicated that 50% of the fecal pollution at WH6 is due to human contribution and 50% to cattle. As the residences in upstream of WH5 are in Casey County, the type of treatment system in use is unknown, but is suspected to be septic.

Watershed Division: HANGING FORK WEST OF HUSTONVILLE

Habitat Assessment: Optimal, Suboptimal, Marginal, Poor
Supporting Use: Fully, Partially, Not Supporting

Site Name	WH1	WH2	WH3	WH4	WH5	WH6
Date	7/19	7/24	7/19	7/19	7/19	7/19
Epifaunal Substrate / Available Cover	17	2	10	5	12	5
Embeddedness	13	1	15	18	19	16
Velocity / Depth Regime	14	5	10	8	10	8
Sediment Deposition	14	3	15	17	15	11
Channel Flow Status	17	6	19	13	15	6
Channel Alterations	8	13	16	20	18	18
Frequency Of Riffles (or Bends)	19	5	13	10	17	17
Bank Stability - Left Bank	7	6	5	9	6	7
Bank Stability - Right Bank	7	6	8	9	9	4
Bank Vegetation Protection - Left Bank	7	5	3	7	8	5
Bank Vegetation Protection - Right Bank	7	5	5	5	10	3
Riparian Vegetation Zone Width - Left Bank	2	0	0	3	3	1
Riparian Vegetation Zone Width - Right Bank	7	0	0	1	9	1
Total Habitat Assessment Score	**139**	**57**	**118**	**125**	**151**	**102**

Field Observed Fecal Inputs:

Site Name	Date	Human	Cattle/Horse	Goats	Wildlife	Domestic Pets	Avian	None Observed	Description
WH1	7/23/2007							X	
WH2	7/19/2007			X	X				Goats with direct access
WH3	7/19/2007		X		X				Cattle footprints in stream - observed upstream
WH4	7/19/2007		X						Cattle in stream at time of visit
WH5	7/19/2007							X	
WH6	7/19/2007		X						Cattle footprints in stream

MST Results:

Site		WH1	WH3	WH4	WH5	WH6
Dry Event	*E .coli* (CFU/100mls)	2100	2600	2100	840	4800
	AC/TC Ratio	0.6	0.5	1.9	2.5	2.0
	%Human	>90				~50
	%Cattle	<1				~50
Wet Event	*E. coli* (CFU/100mls)	28000	11500	2400	1420	2100
	AC/TC Ratio	0.4	1.0	14.0	1.4	3.4
	%Human	NIL				
	%Cattle	NIL				

Watershed Division: OTHER MST SITES

MST Results:

Site		Drakes Creek	Logan Creek	White Oak Creek
Wet Event	%Human	~70	>70	~100
	%Cattle	NIL	NIL	NIL

APPENDIX C – QUALITY ASSURANCE PROJECT PLAN

Quality Assurance Project Plan

Monitoring, Assessment, and TMDL Development for the Dix River Watershed

Prepared for
Kentucky Environmental and Public Protection Cabinet
May 17, 2006
Revised August 30, 2006

Prepared by
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Quality Assurance Project Plan

Monitoring, Assessment, and TMDL Development for the
Dix River Watershed

for

Kentucky Environmental and Public Protection Cabinet
Department for Environmental Protection
Division of Water
14 Reilly Road
Frankfort, KY 40601

May 18, 2006
Revised August 30, 2006

THIRD ROCK CONSULTANTS

www.thirdrockconsultants.com

Environmental Analysis & Restoration

Distribution and Review List

Quality Assurance Program Plan for Dix River Watershed
Revision: 1, Dated: August 30, 2006

1) Third Rock Consultants, LLC

President and QA Manager

Molly Foree — Date: August 30, 2006

Project Administrator

Gerry Fister — Date: August 30, 2006

Data Manager

Marcia Wooton — Date: August 30, 2006

Water Quality Modeler

Jennifer Shelby — Date: August 30, 2006

2) GRW Engineers, Inc.

Water Quality Modeler

Mary Beth Robson — Date: August 30, 2006

3) CT Laboratories

Laboratory Director

David Berwanger — Date: August 30, 2006

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APPENDICES – FIGURES AND TABLES

1. Project Management

1.1 Introduction

This Quality Assurance Project Plan (QAPP), prepared by Third Rock Consultants, LLC (Third Rock), was approved by the Kentucky Division of Water (KDOW). This QAPP covers the planning, implementation, and assessment procedures necessary to meet the minimum data quality objectives (DQOs) for the monitoring, assessment, and TMDL development for the Dix River Watershed, Kentucky.

Third Rock is committed to producing quality data that will assist the Division of Water in the development of their watershed plan. This QAPP is designed to provide a complete plan for achieving all project data quality objectives. However, effective communication is required to ensure all parties properly implement the plan. Any quality feedback, questions, or concerns related to the project should be communicated to the project administrator or quality manager to facilitate appropriate analysis and resolution.

1.2 Project Organization

1.2.1 Kentucky Division of Water, Primary Data User

The monitoring, assessment, and TMDL development activities conducted by Third Rock Consultants, LLC for the Dix River Watershed will be under the jurisdiction and oversight of the Kentucky Division of Water (KDOW) Watershed Management Branch. Lee Colten serves as the KDOW Project Manager, providing overall direction and guidance to the project. Third Rock's project administrator will communicate directly with Mr. Colten to ensure that all project objectives are satisfied.

Eric Liebenauer serves as the KDOW Water Quality Modeler. In this capacity, he provides guidance for Third Rock's Water Quality Modeling for Clark's Run and will perform the modeling for the Hanging Fork based on the data provided by Third Rock.

1.2.2 Third Rock Personnel and QA Responsibilities

The implementation of the project plan requires effective operation of the project team. Figure 1, Dix River Organizational Chart, identifies the parties that comprise the Dix River Project Team and the lines of authority and communication under which this team operates. The specific roles and responsibilities of each key party are documented below.

- ***Project Administrator***

Gerry Fister will serve as the Project Administrator. Mr. Fister is responsible for the overall completion of the project to the requirements of the KDOW. In this capacity, he is responsible for overall project administration, personnel, scheduling, and completion of all data quality objectives. Additionally, he maintains project financials and contracts and submits reports to the KDOW. Mr. Fister serves as the primary contact with the Kentucky Division of Water.

- ***Field Logistics Coordinator***

Tony Miller will serve as the field logistics coordinator. Mr. Miller visually assessed the watershed for nonpoint source pollutants and determined site selection per the TMDL modeling requirements. He additionally researched and built the equipment associated with the Periphyton sampling. Mr. Miller is responsible for report generation, internal technical assistance, and public communications.

- ***Water Quality Modelers***

Jennifer Shelby in conjunction with Mary Beth Robson of GRW Engineers will serve as the Water Quality Modelers. Together they are responsible for the TMDL modeling of the Clark's Run load allocation and training of the KDOW on modeling calibration, application, and manipulation. In the modeling capacity, they are responsible for selection and setup of the modeling reaches, setup of modeling climate, calibration of the model for all parameters, preparation of the modeling summary, and selection of sensitivity scenarios. As trainers, they are responsible to enable the Division of Water staff to evaluate the effects of the new nutrient criteria on the load allocations.

- ***Quality Assurance Manager***

Molly Foree will serve as the Quality Assurance Manager. Ms. Foree is responsible for review of the QAPP, field operations procedures, and data documentation procedures that will help ensure field and laboratory data generated meet data quality objectives. Ms. Foree will remain independent of the data collection. She is responsible for the maintenance and distribution of the approved QAPP.

- ***Data Manager and Sampling Coordinator***

Marcia Wooton will serve as the Data Manager and Sampling Coordinator. Ms. Wooton is responsible for the review of laboratory analytical results and coordination of sampling events. As sampling coordinator, she is responsible to ensure that the sampling procedures and schedule is implemented by the sampling technicians. Ms. Wooton communicates with the laboratories to ensure holding requirements and other data quality objectives are met. Additionally, she notifies the laboratory of sampling bottle preparation needs. As Data Manager, Ms. Wooton reviews analytical data generated by the laboratory and the field, including the COMPASS tables, and ensures that it conforms to the requirements of this QAPP.

- ***Sampling Technicians***

Cory Bloyd will serve as the Primary Sampling Technician with the support of John Davis, Dan Miller, Tony Miller, Johnny Varner, and Steve Evans. Sampling Technicians are responsible for implementing the sampling procedures and schedule as coordinated by the Data Manager and Sampling Coordinator.

1.2.3 Subcontractor Responsibilities

1.2.3.1 CT Laboratories of Baraboo, Wisconsin

The analytical subcontractors for the laboratory portion of this project will be CT Laboratories of Baraboo, Wisconsin for all laboratory parameters except Total Coliform / *E. coli* which will be provided by Microbac Laboratories of Lexington, Kentucky. The laboratory will be responsible for analysis of samples delivered such that data quality objectives are met. The laboratory will implement and document QA/QC activities to support the results of the analyses performed on the samples. All analyses are expected to be conducted in accordance with the specified analytical methods, the laboratories QA manual, and this QAPP. Eric Korthals, laboratory project manager, is responsible for ensuring conformance of the laboratory.

The following provides a general summary of the QA responsibilities of key laboratory personnel:

- ***Laboratory Director***

David Berwanger will serve as the Laboratory Director for CT Laboratories. The Laboratory Director is responsible for the supervision of all functional aspects of the laboratory and has authority in a legally binding capacity for all laboratory decisions and operational issues. Responsibilities may include, but are not limited to, overseeing personnel training, equipment and systems maintenance, laboratory safety, monitoring scheduling and status of work, approval of Standard Operating Procedures, implementing preventive and corrective actions, and cost control. The Laboratory Director is responsible for ensuring laboratory personnel implement internal lab QA/QC procedures and comply with applicable regulations.

- ***Laboratory Quality Assurance Director***

Dan Elwood will serve as the Laboratory Quality Assurance Director for CT Laboratories. The Laboratory Quality Assurance Director has authority over and is responsible for the direction of all laboratory QA activities, and is independent of laboratory production functions. The Laboratory Quality Assurance Director's responsibilities include development, documentation, and evaluation of quality assurance/quality control (QA/QC) procedures and policy. He/she conducts internal audits, reviews data reports, compiles and evaluates method performance, trains staff in QA/QC requirements, tracks non-conformances and corrective actions, prepares quality documents and reports, reviews standard operating procedures, and reports findings and quality issues to the Laboratory Director. A primary responsibility of the Quality Assurance Director is to verify that all personnel have a clear understanding of the QA program, know their roles relative to one another, and appreciate the importance of their roles to the overall success of the program.

- ***Laboratory Information System Managers***

David Berwanger and Jason Remley will serve as the Information Systems (IS) Managers for CT Laboratories. The IS Manager's responsibility includes development and maintenance of the software and hardware components of laboratory operations. He/she ensures all systems are operating and validates any computer programs involved in the data reduction, generation and reporting process. The IS Manager serves as the database administrator for the Laboratory Information Management System(LIMS). The IS Manager is responsible for producing data in COMPASS format for this project.

- ***Laboratory Project Manager***

Eric Korthals will serve as the Laboratory Project Manager for CT Laboratories. Project Managers are the Third Rock's primary point of contact for laboratory analytical services. The Laboratory Project Manager's duties involve performing as a client-laboratory liaison for project work, working with customers to identify project-specific requirements, and aiding them, throughout the laboratory, to meet their data quality objectives. Project managers review analytical results to ensure project data and QC requirements have been satisfied, prepare narrative reports where applicable, and monitor project work so deadlines are met. They are responsible for seeing that clients are informed of any quality problems as soon as possible. Project Managers work directly with the laboratory managers and laboratory staff involved in their assigned projects to keep staff informed of QA/QC requirements and to monitor work progress. They also work closely with Third Rock and KDOW to develop work plans and DQOs for current and future work.

1.3 Problem Definition and Background

Herrington Lake, in the Kentucky River Basin, was formed by the impoundment of the Dix River. As is common with many reservoirs, Herrington Lake is subject to excessive nutrient loading resulting from point and nonpoint source contributions within the watershed. The Dix River watershed has 24 permitted wastewater-discharge sites and Herrington Lake directly receives wastewater from 6 of the 24 wastewater-discharge sites. In addition, the Dix River watershed contains failing septic systems, agricultural activities including numerous cattle with free access to streams, and development / construction activities. This abundant nutrient input has lead to the deterioration of water quality, problematic algal blooms, and subsequent fish kills.

Herrington Lake was listed in the 2004 303(d) report as 1st priority impaired waterbody for aquatic life (non-support) and fish consumption (partial-support). The major tributaries to the reservoir, Dix River, Clarks Run, and Hanging Fork, were also cited in the 2004 303(d) report as having segments listed as 1st priority impaired in regards to aquatic life support and primary contact (non-support and partial support). The cited reasons for impairment are primarily low levels of dissolved oxygen (DO) and high levels of bacteria. Sources of both impairments stem from agricultural runoff, septic-tank leakage, urban/suburban stormwater runoff, and wastewater treatment plant (WWTP) discharges (USGS 2000).

As part of KDOW's 1998 Clean Water Action Plan, the Natural Resources Conservation Service (NRCS) and KDOW jointly selected five priority watersheds in Kentucky for targeted water quality improvement. The Dix River was selected as one of these priority watersheds. KDOW has committed to form a watershed council to provide input on watershed analysis and plan development. Between 2006 and 2007, KDOW intends to:

- Develop TMDLs for subwatersheds of the Dix River including Clarks Run, Hanging Fork and Herrington Lake (a TMDL, or Total Maximum Daily Load, identifies pollutant sources and the amount of pollutants from each source, and makes recommendations for pollutant loads a stream can handle without violating water quality standards).
- Develop a watershed plan to reduce pollutants from point and non-point sources
- Identify funding sources to implement practices that can reduce pollutants
- Present a draft watershed plan to the watershed council and various stakeholders, and
- Begin implementing remediation actions identified in watershed plan

In order to assist the KDOW in meeting these goals, Third Rock Consultants, LLC has been contracted to identify nutrient and bacteria sources throughout the Dix River watershed and conduct a modeling study in support of a TMDL for nutrients and dissolve oxygen for Clarks Run. Additionally, KDOW will calculate a TMDL for bacteria for Hanging Fork from data provided by the Third Rock sampling effort.

1.4 Project Description

1.4.1 Summary

Third Rock Consultants' ultimate goal coincides with the Kentucky Division of Water: to remove the tributaries upstream of Herrington Lake (and ultimately Herrington Lake) from the 303(d) list of impaired streams by providing information that will focus water quality improvement actions.

In order to accomplish this goal, specific project tasks of Third Rock are as follows:
1. Identify sites for monitoring on the Dix River watershed that includes Clarks Run and Hanging Fork
2. Perform monitoring and laboratory analysis of the Dix River Watershed providing provide high quality water data for the purpose of determining the source and extent of impairment in the tributaries of Herrington Lake
3. Prioritize sources of impairments and develop a TMDL modeling study for nutrients and dissolved oxygen on Clarks Run.
4. Provide training to KDOW staff on TMDL model
5. Generate ideas for non-point source solutions

Figure 2, Dix River Project Schedule, in the appendix, provides the scheduled time period over which these objectives are expected to be achieved. In general, the sampling effort will last twelve calendar months followed by a 90-day modeling effort and modeling report composition. Additionally, Third Rock will provide continued support to the DOW after TMDL modeling with the further development of allocations, load reductions, and an implementation plan. For each of the goals specified above, a summary of the tasks associated with accomplishing each goal is presented in more detail in the following sections.

1.4.2 Site Identification and Preparation

Prior to the establishment of monitoring locations, all major reaches in Clarks Run and Hanging Fork (Hydrologic Unit Level 14 Code (HUC14) and smaller) were visually surveyed to optimally locate sampling stations relative to nonpoint and point source contribution. The sites were marked with GPS waypoints and photographed.

Site locations on the Dix River, Clarks Run, and Hanging Fork were chosen by Third Rock in conjunction with KDOW to characterize the dissolve oxygen, nutrients, sediment, and coliform loadings and to facilitate modeling of these parameters. Sites are located downstream of known problem areas to quantify potential pollutant contribution. Two types of sampling sites are located in the watershed, *select* and *non-select* stations.

Non-select stations

Non-select stations are sampled during low, normal, and high flows. Permanent monuments (survey pins) were established to standardize water collection, flow measurement, and photograph locations at each station. Cross-section measurements were completed at each station to support discharge computation. For each cross-section, three reference points were established. Two of the points, located on opposite sides of the bank, were located for subsequent section measurements. The third point will be located for reference of stage readings. Stage reference points may be located on a bridge, established with pins (rebar), or a sturdy overhanging limb. Water samples will be collected from all identified stream stations throughout the entire watershed according to the monthly field schedule prepared by the Data Manager and Sampling Coordinator.

Select stations

All sampling and preparation that applies to non-select stations also applies to select stations with the addition of several parameters. Select stations additionally have a stormwater sampling component. Passive high flow samplers will be used to assess the peak nutrient and bacterial contribution during heavy rainfall events. Passive high flow sampling device locations will be determined and installed by October 2006. Select stations will also sampled for additional analytical parameters (see Table 1). Six select stations will additionally be mounted with continuous monitoring pressure transducer water level recorders; Drakes Creek, Dix Above, Knob Lick, Hanging Fork 150, Clarks Run Bypass, and Balls Branch Mouth.

The locations of all sampling stations are mapped on either Figure 3, Watershed Overview Map; Figure 4, Hanging Fork and Clarks Run Map; or Figure 5, Dix River Map found in the appendix. For each subwatershed, the following summarizes the station locations and considerations in their establishment.

Clarks Run

Eight sites (four select and four non-select) in the Clarks Run subwatershed were established.

Hanging Fork

In the Hanging Fork watershed, fourteen stations (six select and eight non-select) were established.

Dix River

Seven stations (one select and six non-select) in this section of the watershed were located upstream of the Hanging Fork convergence with the Dix River.

1.4.3 Monitoring

Monitoring, which includes, field observations and measurements, provide data valuable for water quality assessment and modeling. Field sample collection directly affects the analytical results generated by the laboratories. Effective monitoring is essential to determining the source and extent of the impairments in the tributaries of Herrington Lake and Dix River Watershed.

For twelve months, monthly *grab samples* will be taken at *all sampling stations and analyzed* as listed in Table 1, Sample / Results Summary for Dix River Watershed. Grab samples from all sites are collected for laboratory analysis for total and ortho-phosphorus, nitrate and nitrite, total kjeldahl nitrogen, ammonia, total organic carbon (TOC), total suspended solids (TSS), total coliform and *E. coli*. Field measurements for dissolved oxygen, temperature, conductivity, flow, and pH will be made at all sites as well.

In addition to these parameters, some sites will have further analysis. The Hanging Fork select stations and all Clark Run stations will be analyzed for 5-day biochemical oxygen demand (BOD5) for the dissolved oxygen modeling. Also, grab samples from the Clarks Run select stations will be analyzed for 15-day BOD. Chlorophyll *a* and alkalinity will be collected monthly and chlorides quarterly for all select stations.

Sampling events for these collections shall coincide adequately with high, low, and medium flow events. The high-flow samples at the *select stations* will be collected using the *passive high flow sampling* for all of the above chemical parameters. Sampling periods will coincide with elevated flow from November to April with a goal of capturing one high flow event per month following a seven day dry period. The schedule will also be managed to ensure that low and medium flow events are captured. Methods for passive high flow sampling will consist of a low-tech sampler based on methods presented in Subcommittee on Sedimentation, 1961. Sample bottles are mounted on an in-stream frame and filled as the stream rises. Once the stream recedes samples will be collected for analysis.

During the recreational period (May – October), Third Rock will dispatch sampling technicians to collect samples from Hanging Fork during a high flow period. Because the passive high flow samplers would bias total coliform and *E. coli* results, technicians will be in the watershed as the storm event occurs to allow collection of these samples during the hydrographic rise of the stream. This storm event should occur after a relatively dry period.

Periphyton: Periphyton will be collected from natural substrate at the select stations and measured from chlorophyll *a* and multihabitat samples. Chlorophyll *a* will be collected by agitating 0.25m^2 of natural substrate, according to KDOW protocol. Multihabitat periphyton samples will be collected twice per year (critical period) for species identification. The in-stream substrate will be selected for sampling relative to its occurring abundance in order to accurately represent periphyton taxa from different habitat.

Dissolved Oxygen: Dissolved oxygen will be measured during every sampling event. During the low-flow summer period, 24 hour diurnal dissolved oxygen will be measured once at two select sites, one of which will be located at Clarks Run / KY52. The other site will be determined based on results of initial sampling.

Flow: Discharge, or flow, will be determined at all sites during each of the monthly site visits. Velocity and depth will be measured at intervals sufficient to characterize stream flow. Discharge will be computed as the sum of each velocity times the corresponding flow area. Pressure transducers are additionally mounted at six sites.

Physical Habitat Assessment: An EPA Rapid Bioassessment Protocol (RBP) worksheet will be completed at each site twice during the sampling year, once during the initial reconnaissance and once at the end of the year. Estimates of type, density, and aerial coverage of rooted aquatic plants (or lack thereof) will be determined by observation during monthly field visits. Physical channel condition will be characterized using Rosgen classification during this same period. For determining correlates for emergent plant and periphyton growth, canopy cover will be estimated using a spherical densitometer once during peak leaf out and turbidity will be measured using a turdidimeter during periphyton (chlorophyll *a*) sampling.

1.4.4 Modeling

The TMDL modeling study of Clarks Run will address the following:

- Nutrients (nitrogen and phosphorus)
- Biochemical Oxygen Demand (as an indicator of organic enrichment)
- Dissolved Oxygen

The EPA model, Qual2K, will be used to predict pollutant concentrations based on environmental conditions during critical periods. Qual2K is a modernized version of Qual2E and is a one-dimensional steady state model.

Third Rock will deliver a TMDL document using the format outlined in the guidance document titled *Requirements for Kentucky DOW TMDL Documents*. This document includes descriptions of all relevant background information, summary, water body details, monitoring history, current monitoring effort, and modeling report. The steps required in creating this document are outlined below:

- Select modeling reach
  - Review existing in-stream data
    - Data will include all biological, chemical, and flow.
  - Find known point and nonpoint source pollutants.
    - Review land use mapping and aerials
    - Review available source loading data
    - Develop prediction tool for nonpoint source loading and relation to field data
- Segment reaches
  - Using land use cover and items above
- Select target time period (periods)
  - Review measured data, load data
  - Review all available flow data and precipitation records
  - Determine critical flow
- Set up Model Reaches
  - Input downstream point, lat/long, elevation (either USGS topographic or other available data)
  - Select velocity/depth computation method for each reach. Assign algae, SOD coverage coefficients.
    - Use Excel/VBA program named 'Shade.xls' or other estimate of daily shade factors
    - Review site photographs.
- Set up Model Climate: air temperature, dew point, wind speed (and height of measurement) and cloud cover
  - Find hourly data source close to project
  - Obtain data, format, QA/QC, input into model
  - Light and heat coefficients

- Point sources
  - Assign flow and chemical constituents (average of discharge monitoring report data, monthly operating data, or other)
  - Make assumptions about missing data, defend
  - Tributaries are not modeled explicitly but can be represented as point sources
- Non Point Sources
  - Assign flow and chemical constituents
- Select Rates: determine rates, constants, coefficients to use;
  - Calibrate model for spatial concentrations
  - Calibrate model for temporal dissolved oxygen concentrations
- Run sensitivity analyses for any parameters for which Third Rock does not have data and other parameters to determine model sensitivity
- Prepare modeling summary (estimate 20 pages)
- Select sensitivity scenarios for TMDL
  - Meet with KDOW to discuss load reductions
  - Run 10 scenarios
  - Summarize results

1.4.5 Training

After TMDL completion, Third Rock will provide continued support to KDOW with the further development of allocations, load reductions, and an implementation plan.

Two days of training regarding the model are anticipated with KDOW staff. This training will serve to describe the calibration of the model, the appropriate applications of the model, and the techniques for changing loads and parameters within the model. The training will include hands-on demonstration of the water quality model and creation of output tables and graphs. Training will also demonstrate how to apply the model to the anticipated, but not yet promulgated, nutrient criteria. This training will enable Division of Water staff to evaluate the effects of new nutrient criteria on load allocations.

1.4.6 Nonpoint Source Pollution Abatement

Practical solutions for known impairments will be recommended for the most significant pollutant sources. The feasibility of these solutions will be judged by cost, landowner cooperation, and long-term predicted success. Solutions will include on-the-ground best management practices, as well as potential funding options and the agencies responsible for implementing the funding.

1.5 Quality Assurance Objectives

1.5.1 General Quality Objectives

The overall project data quality objective (DQO) is to provide information that will lead to improved water quality and the removal of the tributaries upstream of Herrington Lake (and ultimately Herrington Lake) from the 303(d) list of impaired streams and reservoirs. Reaching this objective requires that data generated and used for modeling must be of sufficient quantity and quality to support:

- Determination of the source and extent of impairment to the tributaries of Herrington Lake.
- Development of a TMDL model for nutrients on Clarks Run by Third Rock.
- Development of a TMDL model for pathogens on Hanging Fork by KDOW

The following items detail the performance criteria for the measurement process associated with water quality sampling, water quality processing, and TMDL development for this project.

1.5.2 Field Objectives

Field observations and measurements provide data valuable for water quality assessment and modeling. Field sample collection directly affects the analytical results generated by the laboratories. The following specific tasks apply:

- Chain of Custody forms are to be completed such that custody of samples is traceable and accurate from the time of sampling until received by the laboratory.
- Samples are to be protected by proper packing and transportation, preservation and handling techniques in order to maintain the integrity of the sample.
- Cross-sectional measurements shall be sufficient to accurately characterize the flow area.
- Temporary markers and GPS positioning are established to ensure maximum repeatability in data collection position and to facilitate locating the sites by multiple parties.
- Field equipment will be calibrated in accordance with the manufacturer's instructions in order to meet the specified accuracy and precision criteria. Equipment calibration logs will be maintained.
- Grab collections are made to obtain samples chemically representative of the site during the time period and flow rate during which it is sampled.
- Total organic carbon shall be sampled with minimum headspace in order to minimize the impact of the volatilization of organic carbon.
- Habitat assessments are conducted in order to provide stream supporting capabilities, context to analytical assessments, record visual changes in the habitat and reference to measure remediation impact.

- EPA Rapid Bioassessment Protocol (RBP) are measured in order to provide a quantitative score of the waterbody indicating the quality of the environment.
- Photographs are taken to indicate and provide visualization for significant changes in the habitat throughout the duration of the sampling.
- Flow shall be measured with sufficient quality to determine the loadings of individual parameters at the time of collection.
- Periphyton and chlorophyll *a* sampling shall be conducted such that the surfaces sampled are representative of the site surfaces, algal speciation and growth levels.
- Passive high flow sampling shall be conducted such that the non-point nutrient runoff is captured at its peak.
- The pressure water level recorder measurements are used to establish more comprehensive flow measurements throughout the sampling period. These recorders are downloaded at a frequency to ensure all measurements are gathered.

1.5.3 Laboratory Analytical Objectives

The objective of the analytical parameters is to identify numeric or measurable indicators and target values that can be used to evaluate the TMDL and the restoration of water quality. Each parameter has a specific purpose that fits into this overall objective and shall meet the quality standards established in Table 2, Methods, Analytes, and Data Quality Indicators for the Dix River Watershed, and below.

- For modeling purposes, nutrient sampling will be conducted during varying flow events. The results of the nutrient samples will be used for modeling purposes and to rank and assess source pollutant levels. Nutrient sampling detection levels are similar to recent studies in the area (Lake Herrington study) and are adequate for modeling purposes.
- 15-day biochemical oxygen demand will be measured to determine the slow-acting oxygen demand, typically exerted by the nitrogenous components. It will be used as part of the oxygen balance of the stream and will indicate the downstream impact of oxygen demanding pollutant sources.
- 5-day carbonaceous biochemical oxygen demand will be measured to determine the short to moderated acting oxygen demand. It will also be used as part of the oxygen balance of the stream.
- Total suspended solids indicate a broad class of substances that may originate from natural or pollution sources. TSS may include phytoplankton, non-living particles containing nutrients and inorganic solids. As such, they affect the oxygen and nutrient balances (by mechanisms such as settling, recycling and light extinction).
- Total phosphorus will be measured to determine the phosphorus present in organic and inorganic forms. Phosphorus is a necessary nutrient for algae growth and contributes to eutrophication in Herrington Lake. It also affects the oxygen balance.
- Ortho phosphorus will be measured to determine the dissolved, inorganic phosphorus. This is the form most readily available for organism (algae) uptake. It is present in wastewater and is released during decay and recycling of particulate material.

- Nitrite as N is an intermediate product in both the nitrification and denitrification reactions that occur in natural waters. It is also a component of the total amount of nitrogen available, and as such affects algae growth and the oxygen balance.
- Nitrate as N is a form of nitrogen available for algae growth. As such it represents a pollutant contributing to eutrophication of Herrington Lake and impacts the oxygen balance. It is formed by the nitrification reaction in natural streams and is a pollutant found in agricultural runoff and wastewater.
- Ammonia as N is another form of nitrogen available for algae growth. It is present in sewage and agricultural runoff and affects the oxygen balance.
- Chloride is a conservative compound (*i.e.,* it does not react, settle or otherwise leave the water column) and may be used as a tracer for water flow. It contributes to specific conductance levels.
- Total Kjeldahl nitrogen is a measurement of the sum of total organic nitrogen plus ammonia. These forms of nitrogen represent nearly all the oxidizable nitrogen and therefore affect the oxygen balance of the stream.
- Total organic carbon measures living and dead organic matter, as well as indicating possible presence of herbicides and pesticides (which are generally organic compounds). Carbon is important for algae growth and organic particles can bind with nutrients and toxics.
- Alkalinity is the measure of the buffering capacity of the water, measured as calcium carbonate. Alkalinity is related to hardness, which affect metals' toxicity to fish.
- Total coliforms and *E. coli* samples will be collected to determine primary bacterial input locations. This sampling will be performed in Hanging Fork and Clarks Run to ensure that bacterial loadings are estimated for the bulk of the Dix River watershed. The analytical objective for both total coliform and *E. coli* is to establish a dilution series yielding real values for both analytes. To this end, the minimum detection limit is set at 1 MPN and the maximum as necessary to achieve real numbers. This dilution series will be continuously monitored and adjusted to achieve real numbers. For values reported as "greater than," modeling constraints will determine the proper use of the values.
- Chlorophyll *a* is an essential component of photosynthesis and is used as an indicator of phytoplankton concentration.
- Periphyton will be collected from natural substrate for two purposes:
    - First, monthly samples will be collected for chlorophyll *a* analysis. Results will be extrapolated to determine an algal biomass estimate as an indirect indicator of nutrient loading.
    - Second, because dominance of certain algal taxa can also indicate nutrient loading, multihabitat periphyton samples will be taken for species identification. The in-stream substrate will be collected relative to its occurring abundance in order to accurately represent periphyton taxa from different habitat.
- 24-hour Diurnal Dissolved Oxygen will be measured to examine the temporal dissolved oxygen dynamics. While algae (and other green plants) are photosynthesizing during the day, they produce oxygen. During the night, they respire and consume oxygen. Measuring the changes in oxygen demand over 24 hours will illustrate this and indicate

the amount of oxygen demand caused by photosynthetic organisms. (Note, temperature also influences the oxygen cycle and will also be measured during the 24-hour period.)

1.5.4 Data Quality Indicators

Data Quality Indicators (DQIs) are qualitative or quantitative descriptors of data quality. The quality of field and analytical data is most often assessed in terms of the DQIs including: Precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity. A review of these indicators follows.

For laboratory data, the laboratory performs the initial review of the results and compares them with the DQIs. Cause analysis and corrective actions are taken if necessary and deviations from the DQIs are noted with appropriate data qualifiers. The Data Manager performs a secondary review of the data to assess the conformance of the laboratory data in conjunction with field quality controls to the DQIs.

For field data, the Data Manager provides the initial review of data quality, and additional review is provided as the data is compiled and evaluated by the modelers, et al.

1.5.4.1 Precision

Precision is the measure of agreement among repeated measurements of the same property under identical, or substantially similar conditions; calculated as either the range or as the standard deviation. Precision uncertainties will be measured through the collection of duplicate and split samples on 10 percent of collections that provide the overall measurement precision. The laboratory additionally performs duplicate samples with each analysis batch and is required to meet the requirements in Table 2, Methods, Analytes, and Data Quality Indicators for the Dix River Watershed. Subtracting the analytical precision from the overall precision provides the sampling precision.

The precision of RBP scores and general habitat assessment precision is controlled by the level of experience of the personnel conducting the assessment. Since the accuracy of the result is determined by the experience of the personnel recording the measurement, precision of results is also to be controlled by employment of high quality personnel. The initial and final RBP scores are assessed by personnel with a Master's degree and 5 years of experience in fieldwork. All personnel involved in assessment have been trained to properly conduct these assessments.

1.5.4.2 Bias

Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction. Laboratories control bias by performing regular QC charting with which the acceptance windows for accuracy measurements are adjusted.

1.5.4.3 Accuracy

Accuracy is a measure of the overall agreement of a measurement to a known value; it includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations. Accuracy will be determined in the field through the use of spiked samples (10 percent of samples). For the laboratory, laboratory control samples (LCS) of known value and matrix spikes are used to measure accuracy according to Table 2.

1.5.4.4 Representativeness

Representativeness is a qualitative term that expresses the degree to which a portion accurately and precisely represents the whole. Representativeness in the field is achieved by adherence to applicable KDOW and EPA sampling methods. Homogenization of sample before analysis in the laboratory achieves representativeness. Samples are expected to be as representative as possible throughout the field and laboratory process.

1.5.4.5 Comparability

Comparability is a qualitative term that expresses the measure of confidence that one data set can be compared to another and can be combined for decisions to be made. Comparability of water chemistry results will be ensured through strict adherence to KDOW and EPA sampling and laboratory methods. Comparability of physio-chemical results will be ensured through regular probe calibration. Comparability of habitat data will be ensured through strict adherence to sampling protocols developed by the KDOW for in-stream habitat.

1.5.4.6 Completeness

Completeness is a measure of the amount of valid data needed to be obtained from a measurement system. It is expected that planned sampling will be 100 percent completed unless stream sites dry during summer months. Sites will not be relocated to avoid sampling overlap. A dry site will reflect zero nutrient and bacterial contribution of that section of the watershed.

1.5.4.7 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of variable interest. Sensitivity for this project is achieved by adherence to the reporting limits listed in Table 2. Reporting limits are determined by a calculation based upon the method detection limit for analytical methods and instrumentation.

Sensitivity of sampling methods depends on the technique as well as the intent. The passive high-flow samplers will be constructed to simulate a grab sample but will be sensitive to the rate of water rise such that the analytical impact will be minimal.

1.6 Documentation and Records

1.6.1 General

In order to provide quality consulting to the KDOW, traceability and maintenance of documentation and records is essential. All records relating in any manner whatsoever to the project, or any designated portion thereof; which are in the possession of Third Rock shall be made available, upon request of the KDOW. Additionally, these records shall be available to any applicable regulatory authority and such authorities may review, inspect and copy these records. These records shall be retained for at least 3 years after the project is approved and closed by the EPA.

Third Rock will deliver a TMDL document using the format outlined in the guidance document titled *Requirements for Kentucky DOW TMDL Documents*. This document includes descriptions of all relevant background information, summary, water body details, monitoring history, current monitoring effort, and modeling report. Additionally, Third Rock will provide continued support to KDOW after TMDL Proposed Scope of Work completion with the further development of allocations, load reductions, and an implementation plan.

Third Rock will also deliver analytical data in a COMPASS format for all sampled stations. The number of stations and laboratory parameters for all project-monitoring stations is detailed on the attached spreadsheet. Hardcopy of data will also be presented to KDOW if requested. A specific list of the documentation to be included in the final report is listed below.

1.6.2 QAPP Management and Distribution

Key to these goals is the distribution of the most recent version of this QAPP to all parties listed on the distribution list once the QAPP has been reviewed and approved. The QA manager is responsible for ensuring that all applicable parties perform documented review of the QAPP. If, because of deviations in the QAPP, revisions are required, the QA manager shall ensure that all parties review the revised version. The current revision and the date of the revision shall be documented in the upper left hand corner of the QAPP pages. The QAPP shall be redistributed after all parties have reviewed the document.

1.6.3 Information Included in the Reporting Packages

A reporting package will consists of field data, chain-of-custody forms, and analytical laboratory reports. Specifically the final package will include copies of the following:

- Field observations recorded in the Sampling Technicians' field notebook
- EPA Rapid Bioassessment Protocol (RBP) worksheet (Figure 6)
- Data characterization and water quality datasheet (Figure 7)
- GPS Positioning and photographs
- Completed Chain-of-custody forms (Figure 8, uncompleted example)
- Analytical Laboratory Reports (Figure 9)

- Chlorophyll *a* Datasheets (Figure 10)

1.6.4 Data Reporting Package Format and Documentation Control

Data reporting packages will contain a consistent format and will be compiled initially during the quarterly meetings with KDOW and ultimately within the final report. Electronic data will be presented in Microsoft Word and/or Access (COMPASS format).

1.6.5 Data Reporting Package Archiving and Retrieval

The original copies of all field notes, field data sheets, lab sheets, chain-of-custody forms, and lab reports will be maintained and stored at Third Rock Consultants for the required document retention period for the grant. At the end of the required period, the documents will be archived in Third Rock's warehouse. Copies of all electronic data will be archived in specified Third Rock computer files. The laboratory shall also maintain all records associated with the analytical results including laboratory notebooks, bench sheets, instrument calibration and sequence logs, preparation logs, maintenance logs, etc. for the retention period of the grant.

2 Data Generation and Acquisition

2.1 Sampling

2.1.1 Sampling Process Design

The total area of the Dix River Watershed includes approximately 282,000 acres in central Kentucky and has been divided into several sub basins for the purposes of this project, as seen in Figure 3.

The lower Dix River Watershed includes the western edge of Garrard County, part of northern Lincoln County, and eastern portions of Boyle and Mercer Counties. The land is characterized by undulating terrain and moderate rates of both surface runoff and groundwater drainage. Most of the watershed lies above thick layers of easily dissolved limestone. Groundwater flows through channels in the limestone, so caves and springs are common in regions with this geology. Land use in the watershed is 90 percent agricultural and 5 percent residential. The surface waters of the watershed supply the drinking water for the municipal system in Danville. Businesses and organizations hold permits for discharges into the creeks. For the purposes of this project this watershed has been further divided into the Herrington Lake, Clarks Run, and Hanging Fork subwatersheds. Clarks Run and Hanging Fork are of particular concern for this project.

The lower Dix River watershed includes the river itself from the confluence with the Kentucky River near High Bridge to the mouth of Gilberts Creek southwest of Lancaster. Herrington Lake makes up much of this stretch of the Dix River. Among the creeks that feed the river within this watershed are Hawkins Branch, Boone Creek, White Oak Creek, McKecknie Creek, Tanyard Branch, Cane Run, and Rocky Fork. The watershed also receives water from the Dix River (upper), Logan Creek, Spears Creek, Mocks Branch, Hanging Fork Creek which drains approximately 18,000 acres, and Clarks Run which drains approximately 61,000 acres.

The assessed river segments in this watershed fully support their designated uses, based on biological and/or water-quality data. Herrington Lake does not support its designated uses, because of excess nutrient enrichment from a variety of sources. Phosphorus levels in the Dix River are elevated enough to cause potential nutrient enrichment problems (> 0.1 mg/L).

The upper Dix River watershed covers approximately 202,000 acres, in southern Garrard County, western Rockcastle County, and eastern Lincoln County. The land is characterized by undulating terrain, moderate to rapid surface runoff, and moderate rates of groundwater drainage. The watershed lies partly above fractured shales through which groundwater can easily move but which stores very little water.

The upper watershed of the Dix River includes the headwaters down to the mouth of Gilberts Creek just west of Gilbert (at US 27 between Lancaster and Stanford). Among the creeks that feed it are Negro Creek, Turkey Creek, Copper Creek, Fall Lick, Drakes Creek, Harmons Lick, Walnut Flat Creek, Cedar Creek, Stingy Creek, Turkey Creek, and Gilberts Creek. Land use in the Upper Dix watershed is

60 percent agricultural and almost 40 percent rural and wooded. Businesses and organizations hold permits for discharges into within this watershed.

In order to assess the load allocations for these areas, the following site types and as well as anticipated site visits are allocated as follows:

Watershed	Select Sites	Non-select Sites	Sampling Events
Clarks Run	4	4	96
Hanging Fork	6	8	168
Upper Dix River	1	7	96

The sampling and processing schedule is detailed in Table 1, on a monthly basis. From March 2006 to March 2007, monthly *grab samples* will be taken at *all stream stations.* From November to April, *passive high flow sampling* will be conducted at the *select stations* with a goal of capturing one high-flow per month with a seven-day antecedent dry period. Because of the requirements to sample low, medium, and high flow events, the sampling events will be scheduled on a monthly basis by the Data Manager and Sampling Coordinator to maximize the potential of capturing these flow events. Scheduling of the sampling is on Third Rock's Work Schedule, which represents a comprehensive scheduling of all projects for which Third Rock is employed.

Site locations for the Dix River, Clarks Run, and Hanging Fork were chosen by Third Rock and GRW to specifically characterize the pollutant loadings and to facilitate modeling of these parameters in conjunction with dissolved oxygen. Spatial and temporal assumptions have specifically determined sampling location and the timing of sampling event. Stations will characterize pollutant contribution associated with specific sources of concern. Timing of sampling events will look at varying pollutant concentrations that could fluctuate with stream flow and volume. Samples will coincide will low, normal, and high flows. To determine nutrient loading associated with storm run-off, *passive high flow sampling* will be conducted at the *select stations* for all chemical parameters. Sampling periods will coincide with elevated storm-water flow with a goal of capturing one high-flow per month during that period that has a seven-day antecedent dry period though actual high flow sampling will be determined by rain intensity. Methods for passive high flow sampling will consist of a low-tech sampler.

During the elevated storm water flow, total coliform and *E. coli* will be sampled directly since the passive high flow sampling technique would bias the results. Technicians will be dispatched just prior to the storm to ensure the samples are collected during the elevated period.

2.1.1.1 Sampling Station Locations and Specifications

The specific criteria for site location are discussed below. Due to logistical constraints, stations are commonly located in close proximity to bridge crossings or culverts. Care is taken when locating stations so that sampling sites are far enough away from the bridges or culverts to minimize the influence of the inherent hydrologic modification caused by the anthropogenic modifications. A photograph of each sampling location (above each site) as well as the latitude and longitude (in that order) and a brief summary of the site conditions are included.

Clarks Run

Sites in the Clarks Run subwatershed have been located to discern nutrient and bacterial contributions from non-point sources (primarily cattle and residential), industrial facilities, potential sewage collection failures, and point-source contributions. The specific reasons for site selection are described below:

Corporate Drive- This non-select site is located in the headwater of Clarks Run. Based on land use, the location of this site corresponds primarily to NPS nutrient and bacterial contributions consisting primarily of agriculture with some residential sources. Located at 37.627177,-84.797265.

<u>Clarks Run Bypass</u> - Non-select site at the Danville US127 Bypass for characterizing potential nutrient and bacterial contribution from industrial and some residential sources. Located at 37.627177, -84.797265.

<u>Second Street/Clarks Run</u> – Select site to characterize the nutrient and bacterial levels directly attributed to a suspected sewage influx and before the W WTP outfall. This site is just downstream of Second Street. The extra storm-water sampling component of this select site will help insure an accurate representation of the pollutant loadings due to nonpoint source (NPS) and sewage contributions. Located at 37.635754,-84.772877.

<u>Clarks Run/KY52</u> – The primary select site, located above the KY52 bridge and above the confluence with Balls Branch, will assess the nutrient additions attributed to the Danville WWTP. Storm-water sampling at this select station will assess how nutrient concentrations from many sources vary with flow. Located at 37.631264, -84.735969.

<u>Clarks Run/Hwy 150</u> – Select Site to identify the nutrient and bacteria concentrations and potential industrial pollutants above the Danville WWTP. Storm water sampling could also discern the increased pollutant loads associated with heavy rainfall events. This site is located immediately downstream of a quarry discharge and just below the Highway 150 bridge. Located at 37.628470, -84.746087.

<u>DOW Clarks</u> - Select site at a historical DOW sampling location that will estimate the combined nutrient and bacterial contribution of Clarks Run and Balls Branch at all flow regimes. This site is just below Goggin Rd Bridge. Located at 37.638916, -84.721632.

<u>Balls Branch Mouth</u>- Select site to specifically characterize the NPS pollutant contribution from the entire Balls Branch watershed. Located at near the Balls Branch – Clarks Run confluence, 37.630455, -84.733358

***Balls Branch West* - Non-select site further up the watershed for pinpointing potential NPS contributions. Located at a Balls Branch bridge, 37.600947, -84.757055.**

Hanging Fork

The Hanging Fork watershed is characterized primarily by agriculture (graze land) with a scattering of small communities having sanitary sewer outfalls. Stations are positioned to help pinpoint the location of major sources of nutrient and bacteria contribution from this watershed.

***West Hustonville* – Non-select site located in the upper reach of Hanging Fork. This station is positioned to estimate nutrient and bacterial loadings from headwater contributions upstream from Hustonville's WWTP outfall. Located at 37.470801, -84.821043**

<u>Baughman Creek</u> - Non-select site located to estimate nutrient loading attributed to Baughman Creek watershed. This site is located immediately downstream of a school permitted discharge and before the Hustonville WWTP outfall. Located at 37.471207, -84.820744.

<u>McKinney Branch</u> - Non-select site located on a medium sized sub-watershed expected to have a significant NPS pollutant contribution. Located at 37.479748, -84.771170.

<u>Chicken Bristle</u> - Select site on the main stem of Hanging Fork located to characterize the nutrient and bacterial contributions of point and non-point sources and specifically the contributions from Hustonville's WWTP outfall. Located at 37.481364, -84.769010.

<u>Frog Branch</u> - Non-select site characterizing NPS loading in a distinct sub-watershed of Hanging Fork. Located at 37.505012, -84.758855.

<u>Peyton Creek</u> - Non-select characterizing NPS loading in a distinct sub-watershed. Located at 37.497558, -84.744313.

<u>McCormick Church</u> - Select site situated at this location for the purpose of estimating nutrient and bacterial loadings (point and non-point) from a group of several small drainages. Located at 37.526615, -84.742887.

<u>Blue Lick</u> - Non-select site located to estimate the agricultural NPS component of a medium sized drainage. Located at 37.527845, -84.731109.

<u>Junction City</u> - Non-select site that drains a residential/agricultural area west of Junction City. Located at 37.566007, -84.806433.

Oak Creek - This select site will catch the urban runoff (and outfall) from the majority of Junction City as well as an agricultural drainage. Located at 37.558674, -84.790585.

Moores Lane - Non-select site to determine specific sub-watershed contribution of Harris Creek. Located at 37.544012, -84.781899.

Knob Lick Creek - Select site will catch some additional drainage from Junction City plus the accumulation of potential pollutants from all the sites above. Located at 37.551944, -84.730426.

Hanging Fork/Hwy 150 - Non-select site located here to estimate the accumulation of potential pollutants near the convergence of two large subwatersheds. Located at 37.573390, -84.700117.

Hanging Fork Mouth - Select site located to estimate the total loading of nutrients and bacteria attributed to the Hanging Fork watershed. Located at 37.623639, -84.680562.

Upper Dix River

The sites in this section of the watershed are located upstream of the Hanging Fork confluence with the Dix River. Similar to the Hanging Fork subwatershed, this area contains primarily agricultural grazed with rural residences and small communities (with WWTP outfalls). Though the data from these sites will not specifically be used for TMDL calculation, the resultant information will help determine and rank the significance of nutrient, TSS, and bacteria contribution of this drainage to Herrington Lake.

Gum Sulfur – This non-select station was located to account for the nutrient contribution of a W WTP outfall at Brodhead. Located at 37.427359, -84.452234.

Copper Creek - This non-select station was located at the mouth of Copper Creek to account for NPS runoff from a significant subwatershed with an abundance of cattle. The stream section immediately upstream of the site is listed as partially supporting for aquatic life. Located at 37.455167, -84.471822.

Crab Orchard – This non-select station was located to account for a Dix River W W outfall from the community of Crab Orchard. Due to lack of access, station could not be located directly below outfall. The first available sampling location was determined to be the KY 39 bridge because of braided channel issues directly upstream. Located 37.490419, -84.512426.

Drakes Creek - This non-select site encompasses two large drainages with an abundance of cattle (Drakes and Harmons Creeks). Located at 37.504822, -84.518456.

Gilberts Creek - Site was located to catch the pollutant contribution of the Gilberts Creek drainage (primarily NPS) and also an unnamed tributary with a point-source (KPDES storm water discharge) that carries urban runoff for the city of Lancaster. Located at 37.571167. -84.596938.

<u>White Oak</u> - Located directly below Lancaster's WWTP outfall. Data from this site will characterize nutrients and bacteria level contributions from the facility. Located at 37.605136, -84.592481.

<u>Dix above HF</u> - This select station will measure the NPS nutrient runoff associated with the Dix River above Hanging Fork. Located at 37.602466, -84.634587.

<u>Dix DOW (below HF)</u> - Non-select site at a historic DOW location. Data from this site will estimate the pollutant loads from the combination Dix and Hanging Fork. Located at 37.640959, -84.662930.

2.1.1.2 Inaccessibility Contingency Planning

If sample sites must be relocated due to unseen issues, the site will be relocated to best suit the desired goal of the project. New sites will be given new names and IDs to maintain consistency of results.

If samples cannot be collected at a station due to dry conditions, the station will not be relocated. The effective loading of pollutants will be zero and modeled as such. If a site cannot be reached during the specified sampling period, a re-sampling event will be scheduled as soon as possible to best estimate the conditions at the time of the specified sampling period.

2.1.1.3 Critical vs. Non-Critical Parameters

Critical Parameters are those parameters that are absolutely necessary for the completion of the project. The high-flow samples from select stations (using passive high flow samplers) will be designated as "critical" due to the importance in timing the collection and retrieval of the water sample.

Because they are directly tied to the objectives of the study, the following parameter are also considered critical:

- Biochemical Oxygen Demand, 5-Day Carbonaceous
- Phosphorus, Total and Ortho
- Nitrate as N

- Ammonia as N
- Total Kjeldahl Nitrogen
- Total coliforms and *E. coli*
- Chlorophyll *a*
- Physiochemical Measurements
- Habitat, at least once
- Photographs, at least once
- Flow

All other parameters are either supplemental or could be estimated (derived) from the other measurements based on previous monitoring or typical surface water interactions and are therefore designated as non-critical.

2.1.1.4 Sources of Variability

Sources of variability associated with field sampling are inherent and often unquantifiable. For example, environmental conditions associated with climate (e.g., microhabitat fluctuations in temperature, rainfall, etc. between stations) and flow (e.g., timing of samples in regards to measuring the transport of pollutants in an identical water mass as it travels downstream) are typical forms of variability in a field sampling project of this type and often cannot feasibly be accounted for. The variability associated with environmental conditions in this project will be lessened to a degree by the efficient timing of sample collection during specific weather conditions and flow regimes. Using three teams for data collection will reduce temporal variation in samples.

In the field, variability associated with equipment is primarily limited to the water quality probes and measuring devices. Variability associated with these devices can be found in Table 2. The Hydrolab DS5 multi-probe is equipped with four primary sensors, pH, dissolved oxygen, conductivity, and temperature. Turbidity may also be measured on the Hydrolab or by turbidimeter. The velocity current meter may fitted with two propellers depending on the depth and the amount of flow present. The smaller propeller requires less depth to measure the velocity but is less sensitive. Variance in flow measurements may additionally be compounded by objects in the stream which impede flow (i.e. algal growth) or by the number of points sampled across the flow area.

To reduce the variability associated with flow measurements made by velocity meter, several procedures are conducted. To increase accuracy in streams with large variables in depth or velocity, measurement intervals are reduced from 3 ft to sizes that better characterize the entire cross-section. The first and last velocities are also measured closer to the banks to reduce error. Because water velocities may change at larger depths, streams deeper than 2.5 ft are measured at two depths. Algal growth that may interfere with the proper functioning of the propeller of the velocity current meter is scraped away from the location of the measurement to reduce this variability. Repeating the float technique three times reduces variability in simple float estimation of velocity.

In addition to field equipment, the Rapid Bioassessment Protocol (RBP) worksheets can be a source of potential variability during physical stream assessment. The intrinsic subjectivity of the physical habitat scoring using the EPA RBP method is a concern for the Dix River Watershed project. To ensure consistency and accuracy with this assessment, Third Rock staff undergoes yearly in-house training that strictly pertains to the EPA RBP scoring protocol. Training methods are based on tutorials provided first-hand to Third Rock by U.S. Army Corps of Engineers (Louisville District). In addition to this training, sampling stations on the Dix River project RBP sheets are also consistently filled out by the same experienced biologist at all sites. Assessments are performed by personnel with a Master's degree and 5 years of experience in fieldwork.

Variability in regards to water sample collection will be minimized by a strict adherence to collection protocols. Consistent field personnel will also reduce variability associated with collection.

2.1.2 Sampling Methods

During all sampling activities, sampling methods and gear will utilized is analogous to EPA and KDOW recommendations. Specific methods are detailed in the following sections. All samples are to be collected in bottles according to the analytical methods referenced in Table 3, Summary of Project Sampling and Analytical Requirements.

2.1.2.1 Grab Sample Collection

Samples shall be collected directly from the source. When collecting samples, latex gloves shall be used to prevent contamination. The sampling technician will collect the sample by submersing a decontaminated rinsed stainless-steel bucket into source as to obtain a representative aliquot. Submersion shall only be to the bucket mid-depth, taking caution not to scrape the bottom of the source minimizing excess solids. An appropriate sized bucket relative to the bottle(s) being collected shall be used. The bucket size should be sufficient to completely fill the sample bottle(s) from a single submersion. Take care to avoid overfilling in bottles containing preservative. Fill pre-labeled collection bottle(s), per method specifications, directly from the bucket.

Stream samples will be collected from the thalweg (or low water channel) just above the stream bottom. Bottles will be filled to near 100 percent capacity. Efforts will be made not to stir up sediments during collection. Proper field data sheets will be completed. Samples will be labeled accordingly, placed on ice, and delivered to CT Laboratories Laboratory within the required holding time(s). Proper chain-of-custody procedures will be followed to ensure accuracy in sample reporting. Field quality controls, as specified in Section 2.3: Quality Control will be collected at this time.

Care will be taken when filling total organic carbon (TOC) sample bottles to avoid unnecessary agitation of water and to ensure complete filling of bottle, as headspace in the bottle will cause bias of results due to volatilization of organic carbon.

2.1.2.2 On-site Assessment

During initial setup of the site locations, several tasks were completed at each station:

- Permanent monuments (survey pins) were established to standardize water collection, flow measurement, and photograph locations at each station.

- Passive high flow storm-water sampling device locations were determined and installed (select stations only).
- Cross-sectional measurements were completed at each station to support discharge computation. For each cross-section, three reference points were established. Two of the points, located on opposite sides of the bank, were located for subsequent section measurements. The third point was located for reference of stage (tape-down) readings. Stage reference points may be located on a bridge, established with pins (rebar), or a sturdy overhanging limb.

This work was done to aid in the measurements as listed below:

2.1.2.2.1 Habitat

During habitat assessment, at the initial and final station visits, a thirty-minute visual inspection will be completed at each stream sampling station or reach. Ten habitat parameters will be assessed, according to Methods of Assessing Biological Integrity of Surface Waters in Kentucky (KDOW 2002), including epifaunal substrate (quantity and variety of substrate), embeddedness and pool substrate characterization (measurement of silt accumulation and type and condition of bottom substrate, respectively), velocity/depth regime & pool variability (combination of slow-deep, slow-shallow, fast-deep, and fast-shallow habitats and measurement of the mixture of pool types, respectively), sediment deposition (accumulation in pools), channel flow status (the degree that the channel is filled with water), channel alteration (measurement of large-scale changes in the shape of the channel), frequency of riffles & channel sinuosity (sequence of riffles and meandering of the stream, respectively), bank stability (measure of erosion), bank vegetation (amount of vegetative protection), and riparian vegetative zone width (width of the natural vegetation from the edge of the stream bank through the riparian zone). All of these criteria are rated (1 to 10) and combined to obtain a habitat score (0 to 200) that can be compared to a reference condition. Use attainment can be estimated based on the habitat score.

Once during the period of peak leaf out, the canopy cover will be estimated using a spherical densitometer. To use the spherical densitometer, the instrument is held level, 12 to 18 inches in front of the body and at elbow height so that the Sample Technicians head is just outside of the grid area. Each square on the grid is divided in four and systematically counted for canopy openings. The total count is multiplied by 1.04 to obtain a percent of the overhead area NOT occupied by canopy. The difference between this number and 100 provides the estimated percent canopy coverage. Four readings shall be recorded and averaged while facing north, south, east, and west.

2.1.2.2.2 Flow

In order to determine stream discharge or flow (Q), measure the flow area (A) and water velocity (V). Flow is calculated according to the following equation for increments across the stream.

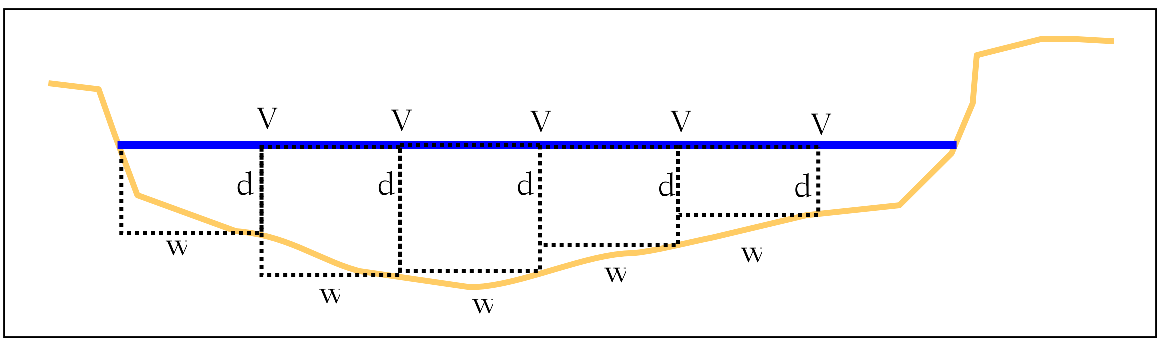
$$Q = V * A$$

where:
Q = Discharge or Flow (ft^3/sec)
V = Velocity (ft/sec)
A = Flow Area (ft^2)

In order to measure the flow area, three methods are used. For all stations, a stream cross section is surveyed (via Total Station). For six select stations, this information can be used in conjunction with a pressure transducer water level recorder (Infinities USA) to determine the flow area. If the water level is measured at the cross-section with a staff gauge or marked with pins on the stream bank, the flow area can also be calculated. Alternatively, the stream may be waded at the cross-section to determine depth and breadth at the time of the sampling visit. Velocity can be measured by a current meter or a floating object.

On a monthly basis, the flow for all streams low enough to wade will be measured according to USGS 2000. Velocity and water depth are measured at intervals across the stream sufficient to characterize discharge. A 100-ft tape is stretched across the stream in the established cross-section to indicate the intervals. Typically, stream depth and velocity are measured at 3 ft intervals across the stream. The interval is adjusted as necessary to thoroughly characterize the entire cross-section of flow. Points should be closer together if there is a lot of variation in the depth or velocity of the cross-section. Notes are made during the data collection to indicate any special conditions observed.

The approximate area of each flow box is the depth of water at a given point multiplied by the width of the flow box. This concept is illustrated in the figure below. The convention for calculating flow is to apply a measured velocity and stream depth to the width between that station and the previous station. To increase the accuracy of flow calculation, the first and last velocity and depth measurements should be made as close to the banks as is feasible.



Stream cross-section showing intervals where water depth and velocity are measured. Flow will be calculated for each "box" (flow area for each box is d * w) and summed to obtain the flow for the entire stream.

At each station within the cross-section, velocity is measured with a General Oceanic current meter mounted on a rod, where velocity is indicated by the number of revolutions of the propeller over a given time interval. The individual using the velocity meter should hold the rod vertically in the profile with the meter parallel to the direction of stream flow and stand at least 1 ft downstream and to the side of the velocity meter so as not to interfere with the current. Velocity is measured for approximately 60 seconds.

Average velocity is measured at 0.6 of total stream depth when the depth is less than 2.5 ft. When the stream is deeper than 2.5 ft, velocity is measured at 0.2 and 0.8 of the total depth and the average of the two readings is used as the average velocity at that point for discharge calculations. Discharge (Q) is calculated for each interval of the stream where velocity and depth are measured and total stream discharge is calculated as the summation of the discharge from each interval. Water depth is also recorded at a single known point in the stream during each visit.

When the stream is too deep to wade with the current meter, stream velocity is roughly estimated using a floating object. The float can be any buoyant object, such a partially filled plastic water bottle. Ideally, it needs to be heavy enough so that about an inch of it is below the water line. When the floating object cannot be retrieved from the stream, a "weighty" yet compact piece of stick/wood is used. When feasible, a 50 ft section of stream is measured for the float test. The float is released out into the stream in a location most representative of the entire stream and the time is recorded for it to travel the known distance. If the float moves too fast for accurate measurement, a longer travel distance will be measured. The simple float estimation of velocity will be repeated for a total of three trials. The surface velocity values obtained by this method are corrected to represent mid-depth velocity (Daugherty *et al*. 1985).

$$mid - depth\ stream\ velocity = 0.8 \times surface\ velocity$$

Discharge during high flow is estimated using this velocity measurement, cross-section information, and depth measured from the pressure transducer water level recorder, staff gauge, or pins on the bank.

At stream velocities below the measurable range of the current meter, the propeller will not turn. If the stream velocity is too low to be accurately measured by the current meter, it may be necessary to estimate stream velocity using the simple float. If the velocity is below the limit of the current meter, the stream will still be waded and water depth will be recorded at intervals across the stream. The velocities obtained by the float test (three trials) during low flow conditions will be compared to the known lower limit of the meter.

2.1.2.2.3 Physio-chemical measurements

Temperature, dissolved oxygen, conductivity, and pH will be measured during field sampling of the streams with a Hydrolab water quality instrument. Operation of the Hydrolab instrument is conducted in conformance to the Hydrolab operation manual (Hydrolab, 1997).

During the low-flow summer period, 24 hour diurnal dissolved oxygen will be measured with the Hydrolab once at two select sites, one of which will be located at Clarks Run / KY52. The other site will be determined based on results of initial sampling. The Hydrolab will be deployed for a 24-hour period during which its data-logging feature will store the dissolved oxygen data.

Global Positioning System coordinates will be obtained using a Garmin GPS or the equivalent, accurate to ±5-40m. Readings are measured in NAD83. Internal SOPs and manufacturer's instructions will be followed to record these measurements.

2.1.2.3 Periphyton Sampling

Periphyton sampling is to be done in accordance with the *Methods for Assessing Biological Integrity of Surface Waters in Kentucky* (KDOW 2002). To meet these objectives, the Sampling Logistics Coordinator built a Periphyton Substrate Vacuum. Based on KDOW 2002 methods, this vacuum consists of a 3-inch diameter PVC pipe used in conjunction with a neoprene rubber gasket attached to a hand operated pump. To sample periphyton from stations, the gasket end of the PVC is pressed against the bedrock substrate so that the periphyton within the area enclosed can be dislodged with a stiff bristle brush. The hand operated pump is then inserted into the PVC pipe (still being pressed against the bedrock) and the periphyton is pumped into a filer flask using the hand operated pump. Five replicates are taken for a total area of 0.25m^2. This portion is sent to the laboratory for analysis by a modified version of Douglas 1958.

2.1.2.4 Chlorophyll *a*

Chlorophyll *a* samples will be filtered in Third Rock's lab before transporting to CT Laboratories for analysis. Initially, the time, date, and volume of the sample will be recorded on a Third Rock bench sheet (Figure 10). A measured volume of water from each sample will be filtered through 0.45µm cellulose membrane filters. For each sample, water will be filtered and particulate matter will be collected on three membrane filters, folded in half and enclosed within aluminum foil. Each sample will then be placed in a zip-lock bag, labeled with the filtered volume of water, and frozen before delivery to the lab. The bench sheet will accompany the filtered sample with the information regarding date/time of collection, date/time of filtration, volume of filtered sample and area of aspiration.

2.1.2.5 Passive High Flow Sampling

Sampling periods will include an elevated storm flow between November and April with a goal of capturing one high flow per month during that period with a seven-day antecedent dry period. Methods for passive high flow sampling will consist of a low-tech sampler based on methods presented in Subcommittee on Sedimentation, 1961. Sample bottles are mounted on an in-stream frame. Bottles fill with water as the stream rises. Once the bottles fill, samples will be collected for analysis. Technicians will frequently observe the sites when conditions are optimum for filling the bottles from the high flow.

2.1.2.6 Pressure Transducer Water Level Recorder

At 6 of the 11 select locations, stream water level is continuously monitored using a pressure water level recorder (Infinities, USA). These sites include Drakes Creek, Dix Above, Knob Lick, Hanging Fork 150, Clarks Run Bypass, and Balls Branch Mouth. The pressure sensor measures water depth and digitally records the data on a user defined interval. For this project, the device records water level readings every 20 minutes. The pressure sensor is accurate to +/- 0.1 percent of the measurement range and the resolution is 0.01 inches.

2.1.2.7 Sampling Equipment

For the purposes of this project, the following equipment will be utilized in the sampling effort:

- Periphyton Substrate Vacuum
- Filtration Apparatus
- Hydrolab MS5 and associated probes
- Rising stage passive high flow sampling apparatus
- Infinities USA continuous pressure transducer water level recorder
- General Oceanic current meter
- Garmin GPS
- Turbidimeter
- Spherical Densiometer

2.1.2.8 Decontamination and Sample Integrity

During all sampling events, precautions will be taken to ensure the integrity of the collected sample. These tasks include:

- Labeling sample bottles with time and date before filling with water to ensure ink legibility.
- Traceable custody shall be documented from the time of sampling until delivered to the laboratory.
- Wearing latex gloves during all sampling events to avoid potential sample contamination.
- Rinsing sampling equipment between sites with deionized water
- Avoidance of streambed sediment agitation during sample collection
- Immediate placement of sample bottles in ice-filled coolers
- Wrapping chlorophyll *a* bottles in aluminum foil (until filtered) to block light penetration
- Prompt delivery to laboratory for analysis

Cleaning and decontamination of the sampling equipment includes:

- For standard collection parameters, the stainless steel collection bucket will be rinsed three times with site stream water.
- The Hydrolab is to be rinsed with soapy water and rinsed with D.I. water daily. The instrument is to be rinsed with D.I. water between use at each sampling site.
- All rinsate is to be disposed of into the watershed, downstream of the sampling site, as the constituents do not represent a threat to the watershed area.

2.1.2.9 Problems and Corrective Action

Known or suspected deviations from sampling methods, the protocols of this QAPP, or other applicable protocols are to be reported to the Project Administrator. These incidents are documented by email to the project folder and the Project Administrator. All project related emails are to be sent to a central project electronic folder for recall and storage. If the deviation represents a serious flaw with sampling methodology, sampling results, or modeling methods, corrective action will be taken based on recommendations the project administrator receives from the KDOW.

2.1.3 Sample Handling and Custody

2.1.3.1 Chain-of-Custody

Chain-of-custody (COC) forms will be completed for all samples collected in the field and will follow each sample throughout sample processing. A Chain-of-Custody form is a controlled document used to record sample information and ensure the traceability of sample handling and possession is maintained from the time of collection through analysis and final disposition. A sample is considered in custody if it is:

- In the individual's physical possession,
- In the individual's sight,
- Secured in a tamper-proof way by that individual, or secured in an area restricted to authorized personnel.

The Data Manager and Sampling Coordinator shall create COCs and provide to the Sampling Technicians. All information shall be documented on the COC in black or blue waterproof permanent ink including field physio-chemical measurements and custody information.

The Sampling Technician shall initiate sample custody at the time the sample is collected. Field custody documentation shall include:

- Verification of Sample Identification
- Number of Sample Bottles Collected
- Collection Date
- Collection Time
- Collector's Signature

The Sampling Technician shall maintain possession of the sample until custody is transferred to the laboratory or another party. The COC shall accompany the sample from the time of collection until it is relinquished. Field custody is relinquished by signature, with date and time, of the Sampling Technician in the designated area on the COC.

2.1.3.2 Sample Handling and Transport

The Sampling Technician is responsible to ensure that lids to all bottles are secured properly and tight to prevent leakage. All samples shall be collected and preserved as specified in Table 3, Summary of Project Sampling and Analytical Requirements. Glass bottles are placed in appropriate bubble wrap material to protect against breakage during shipment.

Sample bottles are placed in coolers lid side up. Samples are transported according to method storage requirements. Samples requiring storage at 4 ± 2°C are placed inside plastic bags to ensure that sample labels stay dry during transport. The bagged samples are placed in an appropriately sized cooler in order best pack the samples with an adequate amount of ice, ensuring the appropriate temperature is maintained until arrival at the laboratory. Additionally, loose ice is placed around the bagged samples.

Samples coolers should be of adequate size to allow ice to surround all sample bottles. It is the responsibility of the Sampling Technician to ensure that coolers are properly packed and that they have sufficient cooler space on their vehicle for their daily sample load. Coolers shall be secured during transport such that significant disturbance of the samples is avoided.

Upon receipt at the laboratory, the sample custodian shall review the COC for completeness and accuracy. Anomalies shall be documented. The laboratory shall measure sample temperature upon receipt; determine if sample aliquots have been placed in appropriate bottles and properly preserved, by verification with pH strips, as applicable; findings shall be documented on COC, and inspect the sample for proper identification and bottle integrity; any discrepancies and/or bottle damage shall be documented on the COC.

2.1.3.3 Sample Labeling and Identification

Empty samples bottles are shipped from the analytical laboratory with preprinted information to assist in the proper identification of samples. These labels indicate Third Rock's name and project identification, and the expected parameters to be analyzed from that bottle. Sampling Technicians are responsible for recording the sampling station, which serves as the sample identifier, as well as the date and time of the collection on each sample bottle as well as on the COC. In the event that a preprinted label could not be obtained from the laboratory, the Sampling Technician would be responsible for recording the information listed on these labels on the sample. If possible, apply labels before sampling as moisture on the sampling bottles can make adhesion of the label to the bottle difficult.

2.2 Analytical Procedures

Water samples will be analyzed for several parameters following standard methodology as listed in Table 3. Modifications to the prescribed and/or pre-approved analytical methods will not be made without the knowledge and consent of Third Rock's Project Administrator.

As current regulations do not specify specific target limits for the analytes involved, the laboratories regular reporting limits were cited for this project. The reporting limits of the analytical laboratory are recorded in Table 2, along with other performance criteria, and are for analyses of samples within the calibration ranges for the individual methods. The reporting limits of individual sample may be raised if a dilution is required to quantify the target compound(s) within the acceptance range.

Since dissolved oxygen is of special concern for this project, three types of analyses for biochemical oxygen demand were selected. BOD-5 is the standard analysis of biochemical oxygen demand over a period of 5 days. BOD-15 is a modification of the BOD-5 in which the samples are allowed to incubate for a period of 15 days.

In order to properly analyze the parameters associated with the project, the laboratory is required to calibrate and maintain instrumentation and equipment. A list of the key equipment / instrumentation includes:

- Spectrophotometer
- Inorganic Flow or Discrete Autoanalyzer
- Ion Chromatograph
- Air Incubator
- Carbon Elemental Analyzer
- Dissolved Oxygen Meter

2.2.1 Problem Resolution and Corrective Action

The laboratory is required to maintain a corrective action and cause analysis system in order to address deviations and client complaints. When a deviation from an internal procedure or external method or protocol is found or a client has a complaint about the data results or service, the laboratory shall document these incidents and begin a cause analysis to determine the source or sources of the problem. Once the source(s) is (are) identified, the laboratory shall institute corrective action to achieve compliance. Evidence of completion of this corrective action and follow up evaluation of the effectiveness of the action, as necessary shall demonstrate compliance.

2.2.2 Sample Disposal Procedures

In general, samples are disposed of 30 days after results have been reported to the client. All sample bottle labels are removed or obliterated prior to disposal.

Hazardous wastes are returned to the client for disposal. The lab maintains status as a limited quantity generator of hazardous waste. As such, other hazardous solid wastes are disposed of in a hazardous waste designated dumpster and sent directly to an in state permitted landfill.

Non-hazardous aqueous samples are disposed of by pouring the neutralized sample into a conventional drain to the municipal sewage treatment system. Non-hazardous solid wastes (including emptied bottles from aqueous samples) are disposed of by placing in a dumpster for municipal landfill disposal.

2.2.3 Turn around Times

It is the expectation of Third Rock Consultants that laboratory analyses are completed before the next scheduled sampling event, where possible.

2.3 Quality Control

Chemical data quality will be ensured through strict adherence to KDOW (2002b, 1995). Approximately 10 percent of water samples will be duplicated or split and sent to CT Laboratories for analysis.

- Field Duplicate Sample

Approximately five percent of all samples taken in the field are duplicated. To perform a field duplicate, the Sampling Technician shall consecutively collect two representative aliquots, independent of one another, from the same source by the grab collection technique.

- Field Split Sample

Approximately five percent of all samples taken in the field are split. To perform a field split sample, the Sampling Technician shall evenly divide the contents of one grab collection into two sets of sampling bottles. To ensure the split is representative, sample bottles are each filled in three rounds of filling each bottle one third of the total volume.

To ensure that data of known and documented quality are generated in the laboratory , the QC criteria described in this section must be met for all analyses, as applicable. The Laboratory QA Director is responsible for monitoring and documenting procedure performance, including the analysis of control samples, blanks, matrix spikes, and duplicates.

- Blanks

A method blank (MB) is prepared at a frequency of one per 20 field samples depending on the specific method. The MB is analyzed at the beginning of every analytical run and prior to the analysis of any samples. MB results are acceptable if the concentrations of the target analyte does not exceed the reporting limit (RL). If any target analyte concentration in the MB exceeds the RL, the source of contamination must be identified and eliminated. Analysis of samples cannot proceed until a compliant MB is obtained.

- Duplicates

A duplicate sample (DUP) or duplicate matrix spike sample (MSD) is prepared at a frequency of one per 20 field samples depending on the specific method. The relative percent difference (RPD) between duplicate samples, for samples having analyte concentrations greater than their respective reporting limit, or between a matrix spike (MS) and matrix spike duplicate (MSD), must be within the acceptance ranges. If the QC criteria for duplicate sample or spike analyses are not satisfied, the cause of the problem must be determined and corrected. If the problem adversely affected the entire analysis batch, all samples in the batch must be reanalyzed.

- Matrix Spikes

Spikes (MS) are prepared every 20 field samples for each matrix, depending on the specific method. Spike recoveries must fall within the acceptance ranges. If the QC criteria for the matrix spike analyses are not satisfied, the cause of the problem must be determined and corrected. If the problem adversely affected the entire analysis batch, all samples in the batch must be reanalyzed.

- Laboratory Control Samples

A laboratory control sample (LCS) is second-source to the calibration standards and must be prepared at a frequency of one per every 20 field samples depending on the specific method requirements. The LCS results are acceptable if the percent recovery of each analyte is within the determined acceptance range. If the LCS results do not meet specification, sample analyses must be stopped until the problem is corrected, and all associated samples in the analysis batch must then be reanalyzed.

2.3.1 Calculations

The following calculations are used in the interpretation of the data provided by the quality controls:

- Accuracy

For LCSs, calibration standards or additional QC samples of known concentration, accuracy is quantified by calculating the *percent recovery* (%R) of analyte from a known quantity of analyte as follows:

$$\%R = \frac{V_m}{V_t} \times 100$$

where:

V_m = measured value (concentration determined by analysis)
V_t = true value (concentration or quantity as calculated or certified by the manufacturer)

A matrix spike (MS) sample or a matrix spike duplicate (MSD) sample is designed to provide information about the effect of the sample matrix on the digestion and measurement methodology. A known amount of the analyte of interest is added to a sample prior to sample preparation and instrumental analysis. To assess the effect of sample matrix on accuracy, the %R for the analyte of interest in the spiked sample is calculated as follows:

$$\% R = \frac{(SSR - SR)}{SA} \times 100$$

where:
SSR = spiked sample result
SR = sample result
SA = spike added

- Precision

When calculated for duplicate sample analyses, precision is expressed as the *relative percent difference* (RPD), which is calculated as:

$$RPD (\%) = \frac{| S - D |}{(S + D) / 2} \times 100$$

where:
S = first sample value (original result)
D = second sample value (duplicate result)

2.4 Instrument / Equipment Maintenance and Calibration

All sampling equipment will be maintained and calibrated according to manufacturer recommendation.

The Hydrolab runs on battery power and thus the charge must be maintained by charging on a daily basis. Calibration shall be completed in accordance with the user manual (Hydrolab, 1997) on a weekly basis.

All supplies are acquired through Third Rock Consultants' vendors. The members on this vendor list have applied quality control measures that have resulted in recurring quality.

All maintenance on laboratory equipment is conducted in accordance with manufacturers' recommendations. These requirements are described in the laboratories' standard operating procedures and appropriate instrument maintenance manuals. The applicable laboratory is responsible for ensuring that timely maintenance is conducted and that sufficient spare parts are on hand for necessary maintenance and repair procedures.

The frequency of maintenance performed depends on the equipment; laboratory maintenance is scheduled and conducted daily, monthly, weekly, quarterly, semiannually, and annually, as required. A few maintenance needs (e.g., accidental breakage, part failure) are not covered by the general maintenance schedule, and such maintenance is performed as needed.

Specific instrument calibration requirements can and do vary slightly depending on the particular method and the project and regulatory requirements for the project. Detailed descriptions of specific calibration requirements are provided in the laboratory analytical method SOP for each method.

2.5 Non-Direct Measurements

Non-direct measurements include any measurements or data that will be used during this project that will not be directly measured by Third Rock or its subcontracted partners.

The EPA model, Qual2K, will be used to predict pollutant concentrations based on environmental conditions during critical periods. Qual2K is a modernized version of Qual2E and is a one-dimensional steady state model. When modeling, weather data will be obtained from a third party source, such as the National Climatic Data Center. Also pollutant source assessment relies on non-direct measures (i.e. land use, watershed characterization) when modeling loads from nonpoint sources.

2.6 Data Management

Records are to be stored until 3 years after the close of the project. An efficient and effective data management system is necessary to maintain and store all project related data.

The laboratory is expected to maintain all records associated with the analytical results; including laboratory notebooks, bench sheets, instrument calibration and sequence logs, preparation logs, maintenance logs, etc.; for the retention period of the grant according to their internal data management procedures.

All field and laboratory data and results will be reviewed, organized, and stored by Third Rock's Data Manager and Sampling Coordinator. In order to accomplish this task, the sampling technician shall submit completed field datasheets and copies of measurements in field notebooks to the Data Manager upon return to the office. The Data Manager will calculate all flows and review the datasheets for completeness. If the sampling technician submits samples to the laboratory, he/she shall obtain a copy of the relinquished COC and submit it to the Data Manager. If the sampling technician relinquishes the COC to the Data Manager, the Data Manager shall similarly obtain a copy of the relinquished COC to retain for recording purposes.

The field data and the COC are stored by the Data Manager until results are received from the analytical laboratory. Hardcopy of the results from the laboratory are reviewed for completeness and for outlier results (i.e. ortho-phosphorus less than total phosphorus, dissolved organic carbon less than total organic carbon, etc). Laboratory results and field measurements are then entered into an electronic "Analytical Monthly Summary" spreadsheet to be submitted, by the Project Administrator, to KDOW once all data for a month is received and entered. Once the "Analytical Monthly Summary" has been submitted to the KDOW, the Data Manager organizes and stores the hardcopies of all information in the designated project folder in the central files.

Third Rock will also deliver analytical data in a COMPASS format to the KDOW as each COC is completed for all sampled stations. The laboratory is responsible to submit the data in the required COMPASS template to the Data Manager once the analytical COC is completed. The Data Manager then enters the field measurements into this database and forwards the database to the Project Administrator. The Project Administrator reviews the file for completeness and then submits the file to the KDOW.

To ensure that data entry is accurate and consistent between the pdf laboratory reports, electronic COMPASS template and the monthly analytical results review, the Data Manager is responsible to hand enter all results from the pdf report into the monthly analytical results review. Using a custom designed verification program within the Access data entry template, a report is generated showing deviations between the COMPASS template and the monthly analytical results. Each deviation is documented and investigated by the Data Manager.

All project related correspondence is documented by an email system. All project related emails are "CC"ed to the Third Rock assigned project file folder for traceability and storage. All other electronic files are stored on a central project drive accessible to the appropriate Third Rock personnel.

3 Assessment and Oversight

3.1 Assessment and Response Actions

Assessment and response actions are necessary to ensure that this QAPP is being implemented as approved. For a general summary of these assessments see Table 4 Dix River Watershed Assessment and Management Reports. The Kentucky Division of Water (KDOW) quality assurance officer (QAO) may freely review all field and laboratory techniques as requested. Any identified problems will be corrected based on recommendations by the QAO. The KDOW will also review analytical results on a monthly basis.

3.1.1 Laboratory Assessments

To ensure conformance with this QAPP and the applicable regulations, certifications, and methods by which the laboratory operates, the laboratory performs several assessment measures. To ensure that the analyst is capable of performing the requested analytical methods to specifications, each analyst is required to acceptably demonstrate this ability prior to conducting sample analyses. The analyst must conduct four replicate analyses of a known standard and achieve precision and accuracy equal to or better than the acceptance ranges for laboratory duplicates and laboratory control samples, respectively.

The laboratory is also required to participate in at least one blind performance evaluation study each year. Performance Evaluation (PE) studies provide an independent assessment of the accuracy of its analyses and maintain laboratory accreditations. All PE analyses performed by the laboratory are performed by the same analysts and using the same procedures that are used for routine sample analyses for the analyte(s) of interest. The PE results must satisfy the PE acceptance criteria specified by the PE provider. After an evaluation of the PE results is received, any results outside of acceptance limits are investigated and corrective actions taken to prevent recurrence of the problem. All findings must be documented and available for review.

The laboratory is also required to have routinely scheduled internal and external audits. The laboratory QA Director or their appointee on an annual basis performs internal audits. Certification bodies usually on a biannual basis perform external audits. In each case, the findings of the audit, both positive and negative are documented, and the corrective response to the cited deviations is required within thirty days of receipt of the audit report. Corrective actions are submitted to the auditing body for review and approval.

3.1.2 Field Assessments

The QA manager is responsible for the overall conformance of Third Rock to the general procedures, protocols, and methods established by this QAPP and internal project related procedures. To ensure overall conformance to this QAPP, the QA manager schedules and manages a weekly status meeting for this project. At this meeting, the status of progress on project related objectives is discussed and concerns addressed. The Project Administrator is responsible for compiling the minutes of these meetings for review by the QA Manager. These minutes are stored electronically in the project files. The QA Manager may apply spot assessments including supervision of field activities or requests for documentation of the reviews specified herein. The QA Manager may also periodically review the project correspondence files to ensure that all deviations are properly documented and resolved.

To ensure accurate data entry for flow calculations and field data entry into COMPASS templates, all entries and calculations are verified by an independent review. Deviations are documented and corrected accordingly. For those COMPASS entries that are also in the monthly analytical results table, quality assurance is maintained by use of the verification report as in the laboratory data entry.

The Field Logistics Coordinator conducts field procedural audits at the project level. On a quarterly basis, at minimum, the Field Logistics Coordinator will supervise and assess the sampling technicians the following for conformance:

- Calibration and maintenance of field equipment
- Sample collection techniques
- Field measurements and documentation
- Sample handling and custody documentation

The Field Logistics Coordinator will document the review of these items in emails to the Project Administrator. Deviations for the methods specified will be noted, and if necessary, corrective actions will be implemented as specified by the Project Manager. Spot assessments may be applied to ensure that an action is properly corrected. All corrective actions will similarly documented by email correspondence in the project file.

3.2 Reports to Management

Third Rock will prepare a final report that includes the TMDL modeling results and will describe all methods and findings of this project. The final report will satisfy all requirements for the grant.

Prior to the completion of that report, reports on the progress and assessment of the project objectives are produced as summarized in Table 4. All reports are expected to list the personnel or organization responsible for producing the report and the date prepared for traceability purposes.

4 Data Validation and Usability

4.1 Data Review, Verification, and Validation

Initial review of all analytical data is performed by the laboratory against the data quality indicators specified in this QAPP. Corrective actions are taken, if possible while the samples are still within the method specified holding time. Data quality flags are applied to the laboratory results that do not meet these requirements.

Third Rock's Data Manager performs an additional review of the laboratory data as well as the field data. This review, performed within one week of receipt of the results, assesses the completeness and accuracy of the data. Evaluation of the data is made against the DQIs as listed in Table 2. Any data points that seem suspect or require additional analysis are identified during this review. Decisions to reject or additionally qualify the data will be made at the discretion of Third Rock.

4.2 Verification and Validation Methods

The Water Quality Modelers will conduct Third Rock's final review of all data associated with the modeling of the Clarks Run. In this review, they will incorporate all necessary data into a final TMDL document to submit to the KDOW. The final review of all data not associated with this modeling effort will be conducted by the KDOW.

Statistical measures will be used to quantify differences between observed data and model predictions. Such techniques as comparisons of means, regression analysis, and relative error can provide information of model adequacy and error. In addition, model sensitivity analysis will be conducted to determine the effect of model input parameters

The QA Manager will also inspect the final documents to ensure each document is complete and that consistent and appropriate formatting is applied.

4.3 Reconciliation with User Requirements

In the final TMDL document, descriptions of all relevant background information, summary, water body details, monitoring history, current monitoring effort, modeling report, and public involvement will be detailed. Included in this document will be an overall assessment of the data quality and the uncertainty involved in the results.

Load calculations developed from the data will show loads for point sources and nonpoint sources. Example calculations will exhibit the manner in which these loads were calculated. Documentation will be provided for any assumptions made during these calculations, including any data that was rejected or qualified.

In the calculation of the TMDLs specific methodology utilized and any limitations of the model or calculations and of existing data, including data gaps, will be provided.

Based on the model provided by Third Rock, the Division of water will work with the stakeholders in the community to assign the specific load allocations. Margins of Safety are built into assignment of these loads. An implementation plan to reduce the loads will be formulated by KDOW.

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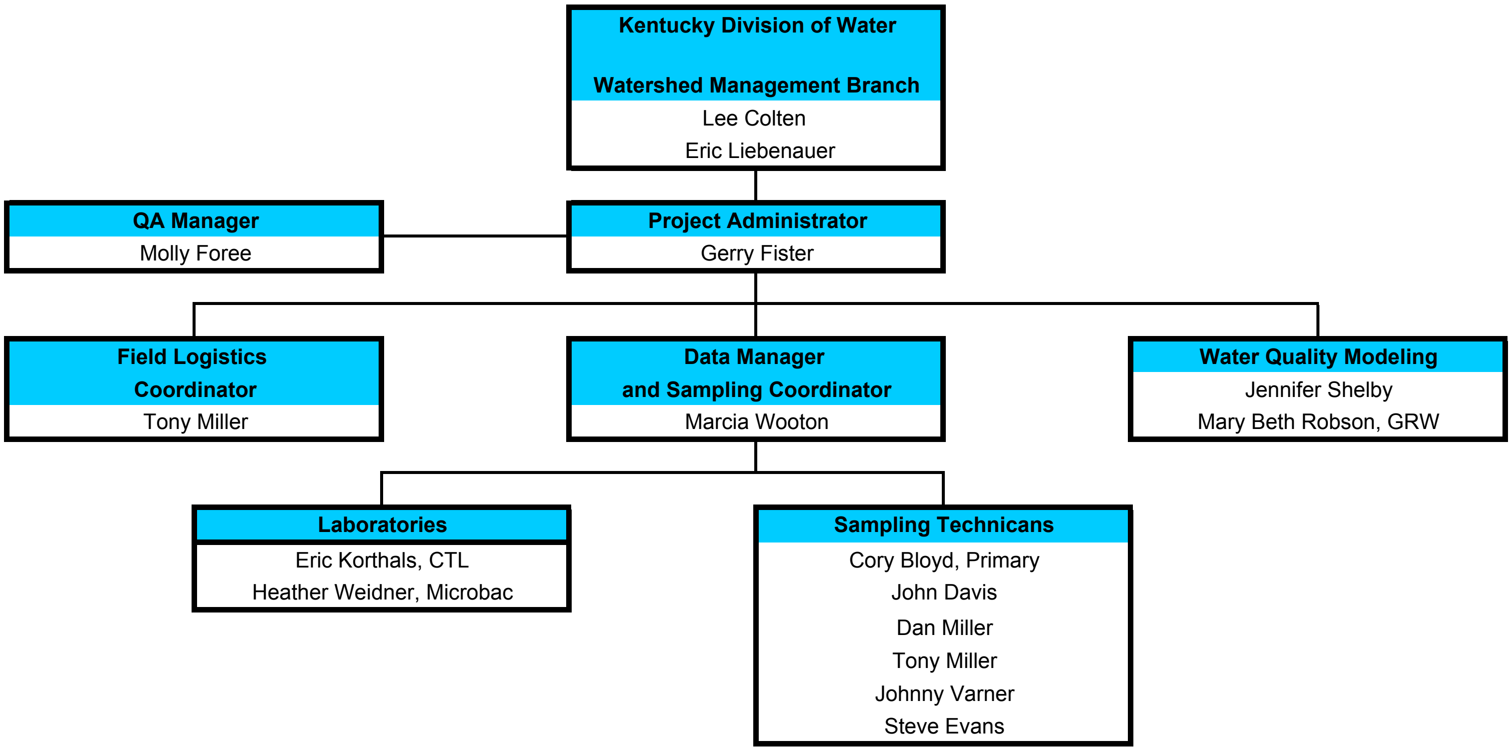
APPENDICES

APPENDIX A

FIGURE 1:
DIX RIVER ORGANIZATIONAL CHART

Figure 1: Dix River Organizational Chart



APPENDIX B

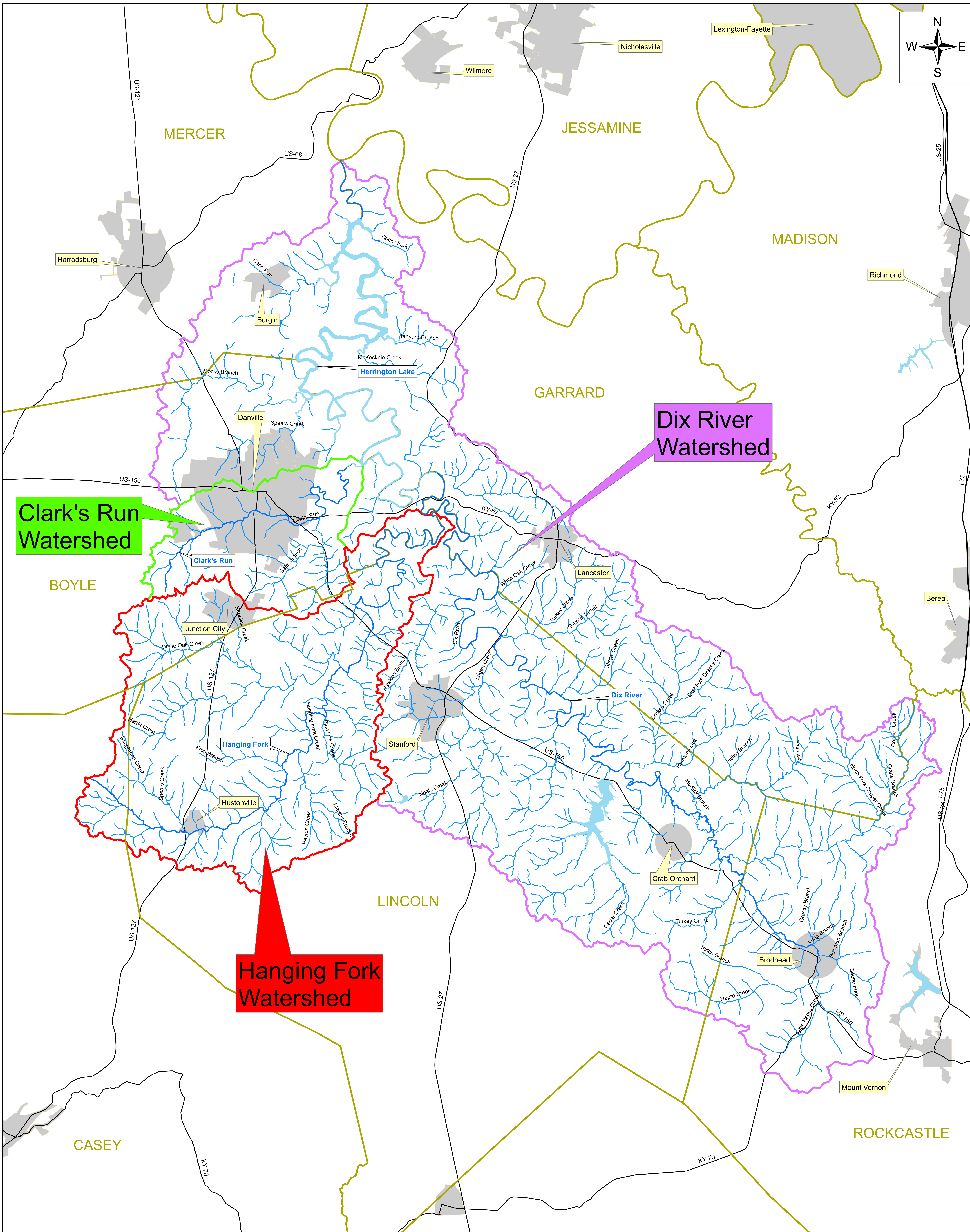
FIGURE 2:
DIX RIVER PROJECT SCHEDULE

Figure 2: Dix River Project Schedule

Event	Project Schedule
Site Identification and Preparation	January - February 2006
Monitoring and Laboratory Analysis	March 2006 - March 2007
Grab Sampling	March 2006 - March 2007
Passive High Flow Sampling	November 2006 - April 2007
Canopy Coverage	Summer 2006
24 hour Dinural Dissolve Oxygen	Summer 2006
EPA Rapid Bioassessment Protocol	March 2006, March 2007
TMDL modeling on Clarks Run.	April 2007
TMDL model training to KDOW staff	May 2007
Nonpoint Source Pollution Abatement	May 2007

APPENDIX C

FIGURE 3:
WATERSHED OVERVIEW MAP



SHEET 1 OF 1

0 1.5 3 6 Miles

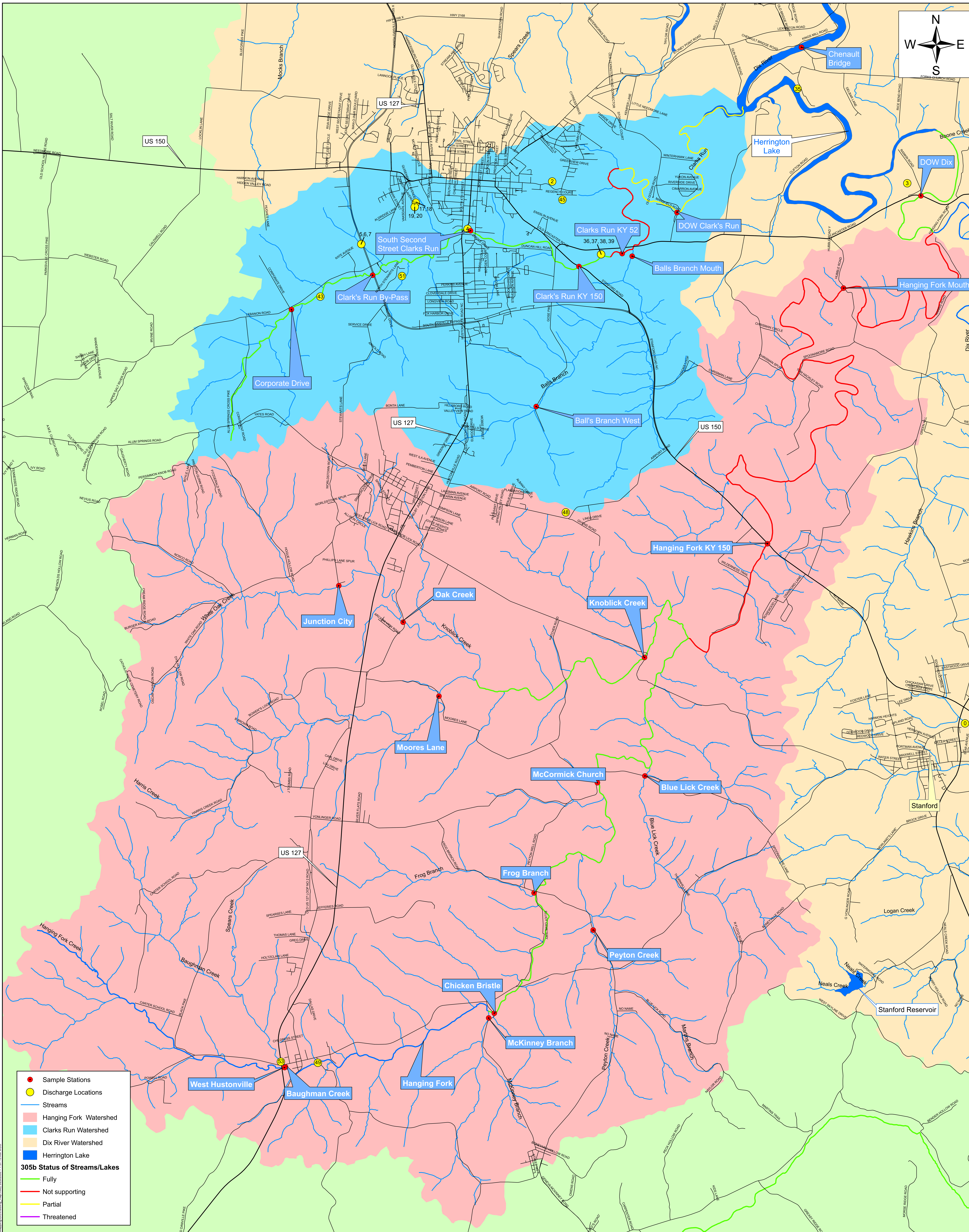
Watershed Overview

Kentucky UNBRIDLED SPIRIT

THIRDROCK CONSULTANTS

APPENDIX D

FIGURE 4:
HANGING FORK AND CLARKS RUN MAP



SHEET
1 OF 1

0 0.5 1 2 Miles

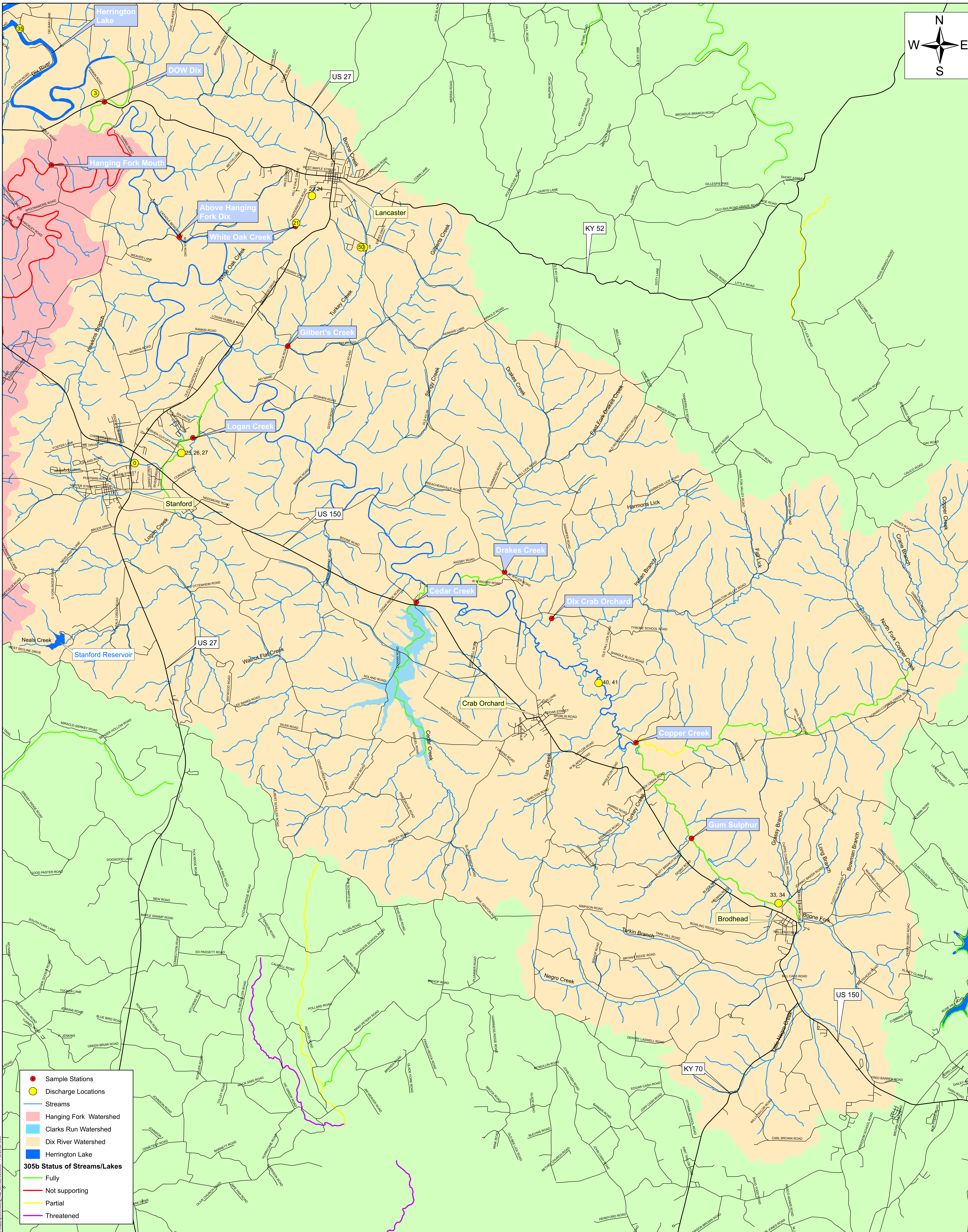
Hanging Fork and Clarks Run

Kentucky UNBRIDLED SPIRIT

THIRDROCK CONSULTANTS

APPENDIX E

FIGURE 5:
DIX RIVER MAP



SHEET 1 OF 1

0 0.5 1 2 Miles

Dix River

Kentucky UNBRIDLED SPIRIT

THIRDROCK CONSULTANTS

APPENDIX F

FIGURE 6:
EPA RAPID BIOASSESSMENT PROTOCOL (RBP) WORKSHEET

DIX RIVER PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

Station ID:	**Stream Name:**	**Project #:**
Station type (select/nonselect):	**Watershed:**	**Form Completed by:**
Collection Date/Time:	**Investigators:**	**Location:**

Picture #s:

WEATHER CONDITIONS	**Now** / **Past 24 Hours** ☐ storm (heavy rain) ☐ ☐ rain (steady rain) ☐ ☐ showers (intermittent) ☐ ____% ☐ % cloud cover ☐____% ☐ clear/sunny ☐ **Has there been a heavy rain in the last 7 days?** ☐ Yes ☐ No Air Temperature ______°F Other______________________________________
STREAM CHARACTERIZATION	**Stream Subsystem** ☐ Perennial ☐ Intermittent **Estimate # of intermittent tributaries above this station _________** **Do the tributaries appear to contribute to any NPS pollution? _____** **If yes, explain: _________________________**
INSTREAM FEATURES	**Estimated Reach Length __________** yards **Estimated Stream Width:** Pools:__________ Runs:__________ Riffles:__________ **High Water Mark: _____** ft **Estimated Stream Depth:** Pools:__________ Runs:__________ Riffles:__________ **Proportion of reach represented by Morphology Types** ☐ Riffle______% ☐ Run _______% ☐ Pool _______% **Channelized** ☐ Yes ☐ No **Stream Flow:** ☐ Flooding ☐ Bankful ☐ High ☐ Normal ☐ Low ☐ Pooled ☐ Dry
AQUATIC VEGETATION/FUNGUS	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☐ Rooted submergent ☐ Rotted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **Indicate the macrohabitats sampled for periphyton:** ☐ Riffle ☐ Run ☐ Pool **Indicate the microhabitat sampled for periphyton and its relative proportion:** Rocks_____ Woody Debris ____ Bedrock ____ Vegetation ____ Artificial Substrate ____ Other ____ **Estimate periphyton coverage:** ☐ Dense (>75%) ☐ Moderate (50-75%) ☐ Sparse (15-50%) ☐ Absent (<15%) **Is the periphyton coverage consistent over entire reach? ____** **If no, describe differences in bottom coverage:** **Is sewage fungus preset?** ☐ Yes ☐ No **Describe the extent of the fungus coverage:** ☐ Dense (>75%) ☐ Moderate (50-75%) ☐ Sparse (15-50%) ☐ Absent (<15%) **Describe the extent of organic sediment accumulation:** ☐ Dense (>75%) ☐ Moderate (50-75%) ☐ Sparse (15-50%) ☐ Absent (<15%)

.

WATER QUALITY	**Temperature**__________°F **Specific Conductance**____________μS/cm **Dissolved Oxygen** ______mg/L, ______% Sat **pH**_______________ (Standard Units) **Turbidity** ___________NTU **WQ Instrument Used**_______________ ☐ Hydrolab MS5 ☐ Hydrolab Quanta ☐ Lamotte 2020 (turb) ☐ Other_____________ **Water Odors** ☐ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other _________ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ None ☐ Other ___________________________ **Turbidity (if not measured)** ☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other ________
SEDIMENT/ SUBSTRATE	**Odors** ☐ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other ____________________________ **Oils** ☐ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper Fiber ☐ Sand ☐ Relict Shells ☐ Other ______________ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No **Sedimentation:** ☐ Heavy ☐ Moderate ☐ Slight ☐ None

Modified RBP Worksheet

Riparian Vegetation: Dominate Type: Dom. Tree/Shrub Taxa: ❑ Trees ❑ Shrubs ❑ Grasses ❑ Herbaceous Number of strata ____	Canopy Cover: ❑ Fully Exposed (0-25%) ❑ Partially Exposed (25-50%) ❑ Partially Shaded (50-75%) ❑ Fully Shaded (75-100%)	**Note the approximate length of stream that is affected by the following:** Stream diversion________________ Stream straightening________________ Concrete streambank/bottom___________

Substrate ❑Est. ❑P.C.	**Riffle**_______%	**Run**_______%	**Pool**_______%
Silt/Clay (<0.06 mm)			
Sand (0.06 – 2 mm)			
Gravel (2-64 mm)			
Cobble (64 – 256 mm)			
Boulders (>256 mm)			
Bedrock			

Habitat	**Condition Category**			
Parameter	**Optimal**	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Sow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8.Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE _____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE _____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE _____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score

LAND USES IN THE WATERSHED

1. Specific uses identified (check as many as apply)

	Streamside	100—200 Yards
Residential:		
Single-family housing	☐	☐
Apartment building	☐	☐
Lawns	☐	☐
Playground	☐	☐
Parking lot	☐	☐
Other ______________	☐	☐
Commercial / Industrial / Institutional:		
Commercial development	☐	☐
(stores, restaurants)	☐	☐
Auto repair/gas station	☐	☐
Factory/Power plant	☐	☐
Sewage treatment facility	☐	☐
Water treatment facility	☐	☐
Institution (e.g., school, offices)	☐	☐
Landfill	☐	☐
Automobile graveyard	☐	☐
Bus or taxi depot	☐	☐
Other ______________	☐	☐
Forest / Parkland:		
Recreational park	☐	☐
National/State Forest	☐	☐
Woods/Greenway	☐	☐
Other ______________	☐	☐
Agricultural / Rural:		
Grazing land	☐	☐
Cropland	☐	☐
Animal feedlot	☐	☐
Isolated farm	☐	☐
Old (abandoned) field	☐	☐
Fish hatchery	☐	☐
Tree farm	☐	☐
Other ______________	☐	☐

2. Additional activities in the watershed (check as many as apply)

	Streamside	100—200 Yards
Construction	☐	☐
Building construction	☐	☐
Roadway	☐	☐
Bridge construction	☐	☐
Other ______________	☐	☐
Logging		
Selective logging	☐	☐
Intensive logging	☐	☐
Lumber treatment facility	☐	☐
Other ______________	☐	☐
Mining		
Strip mining	☐	☐
Pit mining	☐	☐
Abandoned mine	☐	☐
Quarry	☐	☐
Other ______________	☐	☐

Recreation

Biking/Off-road vehicle trails ☐ ☐
Horseback riding trail ☐ ☐
Boat ramp ☐ ☐
Jogging paths/hiking trail ☐ ☐
Swimming area ☐ ☐
Fishing area ☐ ☐
Picnic area ☐ ☐
Golf course ☐ ☐
Campground/trailer park ☐ ☐
Power boating ☐ ☐
Other ______________ ☐ ☐

VELOCITY MEASUREMENT DATA

Infinity Depth and Time:

Notes: **LEOW =** **REOW =** **DEPTH =**

** 0 = Left Bank (when looking downstream)

Distance from L Bank (ft)	Total Depth (ft)	Depth of Avg. Velocity (0.6, 0.2, or 0.8D)	Starting Count	Ending Count	Time (~1min)	Notes
						Total Stream Discharge (ft^3/sec) =

* Stand at least 1' downstream of meter

* When D<2.5', avg V occurs at 0.6D

* When D>2.5', measure V at 0.2D and 0.8D (then will average these values)

Updated 5/10/06 mlw

APPENDIX G

FIGURE 7:
DATA CHARACTERIZATION AND WATER QUALITY DATASHEETS

DIX RIVER PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

Station ID:	**Stream Name:**	**Project #:**
Station type (select/nonselect):	**Watershed:**	**Form Completed by:**
Collection Date/Time:	**Investigators:**	**Location:**

Picture #s:

WEATHER CONDITIONS	**Now** / **Past 24 Hours** ☐ storm (heavy rain) ☐ ☐ rain (steady rain) ☐ ☐ showers (intermittent) ☐ ____% ☐ % cloud cover ☐____% ☐ clear/sunny ☐ **Has there been a heavy rain in the last 7 days?** ☐ Yes ☐ No Air Temperature ______°F Other_____________________________________
STREAM CHARACTERIZATION	**Stream Subsystem** ☐ Perennial ☐ Intermittent **Estimate # of intermittent tributaries above this station _________** **Do the tributaries appear to contribute to any NPS pollution? _____** **If yes, explain: _________________________**
INSTREAM FEATURES	**Estimated Reach Length __________** yards **Estimated Stream Width:** Pools:__________ Runs:__________ Riffles:__________ **High Water Mark: _____** ft **Estimated Stream Depth:** Pools:__________ Runs:__________ Riffles:__________ **Proportion of reach represented by Morphology Types** ☐ Riffle_______% ☐ Run ________% ☐ Pool ________% **Channelized** ☐ Yes ☐ No **Stream Flow:** ☐ Flooding ☐ Bankful ☐ High ☐ Normal ☐ Low ☐ Pooled ☐ Dry
AQUATIC VEGETATION/FUNGUS	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☐ Rooted submergent ☐ Rotted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **Indicate the macrohabitats sampled for periphyton:** ☐ Riffle ☐ Run ☐ Pool **Indicate the microhabitat sampled for periphyton and its relative proportion:** Rocks_____ Woody Debris ____ Bedrock ____ Vegetation ____ Artificial Substrate ____ Other ____ **Estimate periphyton coverage:** ☐ Dense (>75%) ☐ Moderate (50-75%) ☐ Sparse (15-50%) ☐ Absent (<15%) **Is the periphyton coverage consistent over entire reach? ____** **If no, describe differences in bottom coverage:** **Is sewage fungus preset?** ☐ Yes ☐ No **Describe the extent of the fungus coverage:** ☐ Dense (>75%) ☐ Moderate (50-75%) ☐ Sparse (15-50%) ☐ Absent (<15%) **Describe the extent of organic sediment accumulation:** ☐ Dense (>75%) ☐ Moderate (50-75%) ☐ Sparse (15-50%) ☐ Absent (<15%)

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WATER QUALITY	**Temperature**__________°F **Specific Conductance**____________µS/cm **Dissolved Oxygen** ______mg/L, ______% Sat **pH**_______________ (Standard Units) **Turbidity** ___________NTU **WQ Instrument Used**_______________ ☐ Hydrolab MS5 ☐ Hydrolab Quanta ☐ Lamotte 2020 (turb) ☐ Other_____________ **Water Odors** ☐ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other _________ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ None ☐ Other ___________________________ **Turbidity (if not measured)** ☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other ________
SEDIMENT/ SUBSTRATE	**Odors** ☐ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other ____________________________ **Oils** ☐ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper Fiber ☐ Sand ☐ Relict Shells ☐ Other ______________ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No **Sedimentation:** ☐ Heavy ☐ Moderate ☐ Slight ☐ None

VELOCITY MEASUREMENT DATA

Infinity Depth and Time:

Notes: **LEOW =** **REOW =** **DEPTH =**

** 0 = Left Bank (when looking downstream)

Distance from L Bank (ft)	Total Depth (ft)	Depth of Avg. Velocity (0.6, 0.2, or 0.8D)	Starting Count	Ending Count	Time (~1min)	Notes
						Total Stream Discharge (ft^3/sec) =

* Stand at least 1' downstream of meter

* When D<2.5', avg V occurs at 0.6D

* When D>2.5', measure V at 0.2D and 0.8D (then will average these values)

Updated 5/10/06 mlw

APPENDIX H

FIGURE 8:
CHAIN-OF-CUSTODY FORMS

COC# **CHAIN OF CUSTODY** **PAGE 1 OF 1**

Client:
Project Name:
Project #:
Collected By: Third Rock Consultants -
Third Rock Consultants Project Contact: Marcia L. Wooton
Third Rock Consultants Phone #: 859-977-2000

Third Rock Consultants

COMPASS Reporting

Project Code/Short Name: HERTMDL

Medium: Water - ambient surface

Sample Purpose Description: Sampling effort to collect nutrients, pathogens, and other water quality data in Herrington Lake and associated tributaries.

EXAMPLE Chain of Custody

(customized per event i.e. watershed, parameters, laboratory specifics, etc.)

	* * Preservation Type								
Preservation	-	-	-	SA	SA	-	SH/ZA		
Requested Analysis	CBOD5, TSS, SO4	CBOD5, SO4	TSS, SO4	TKN, NH3, P-T	TOC	P-O, NO2, NO3	Sulfide		

* * Preservation Code
- AA - Ascrobic Acid
- AC - NH4Cl
- E - EnCore
- HA - HCl
- M - Methanol
- NA - HNO3
- SA - H2SO4
- SH - NaOH
- SS - Na2SO3
- ST - Na2S2O3
- ZA - Zinc Acetate
- O - Other ________________

Sample I.D.	Station Name	County	Zone-Depth	Collection Date	Collection Time	Grab / Comp	Filt'd Y/N	32oz P	32oz P	32oz P	8oz P	4oz P	16oz P	16oz P			Lab #	Comments

Reliquished By:	Date/Time	Received By:	Date/Time

Properly Preserved: Yes / No

Bottles Intact: Yes / No

Temp. @ Receipt: _____ °C By: _____________

Laboratory: ADD "day", highlighted in yellow, to sample id (without any spaces).

COMPASS Reporting Notes: Previous information provided for Project Level Data Description is now the Sample Purpose Description; Project Level Data Description field is now for Case Narrative from laboratory.

APPENDIX I

FIGURE 9:
ANALYTICAL LABORATORY REPORTS

EnviroData Group
Accredited Lab Data for Today's Environment

Microbac

2520 Regency Rd.
Lexington, KY 40503
Phone: 859-276-3506
Toll Free: 800-489-3506
Fax: 859-278-5665
E-mail: info@envirodatagroup.com

Analytical Results

Third Rock Consultants
Attn: Marcia Wooton
2514 Regency Rd

Lexington, KY 40503

cc: pdf

Chain of Custody: 45643
Project Name: Dix River TMDL-Hanging Fork
Project Number: 5167
Report Reference:45643-20060426103701

Date/Time Received: 04/13/2006 09:05
Temperature Upon Receipt: 2 C

Collector: Client
Client Manager: Heather Weidner

Laboratory Sample #: 482663 **Client Sample ID:** Chicken Bristle **Sampled:** 04/12/2006 13:45
Sample Replicate # 1

Biochemical Oxygen Demand-Carbonaceous **Method:** EPA 405.1 **Prep. Method:** N/A
Analyzed by CDP on April 14, 2006 at 08:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Oxygen Demand, Biochemical, 5-Day/	< 2.00	mg/L	2.00	N/A	

Total Coliform **Method:** SM9223 **Prep. Method:** N/A
Analyzed by TWL on April 13, 2006 at 15:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Total Coliform	> 2,010	MPN	0	N/A	D
Ecoli	360	MPN	0	N/A	D

Specific Conductance (Field) **Method:** EPA120.1 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 13:45.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Specific Conductance (Field)	302.0	umhos/cm	N/A	N/A	

Dissolved Oxygen (Field) **Method:** EPA360.1 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 13:45.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Dissolved Oxygen (Field)	13.88	mg/L	N/A	N/A	

pH (Field) **Method:** EPA150.1/SW9045 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 13:45.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
pH (Field)	8.55	S.U.	N/A	N/A	

Temperature F (field) **Method:** EPA170.1 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 13:45.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Temperature (Field)	61.9	Fahrenheit	N/A	N/A	

Turbity (Field) **Method:** **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 13:45.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Turbidity	NA			N/A	

Results reported on a Wet Weight Basis

Issued: 4/26/2006

EnviroData Group

Accredited Lab Data for Today's Environment

Microbac

Chain of Custody: 45643
Project Name: Dix River TMDL-Hanging Fork
Project Number: 5167

Laboratory Sample #: 482663 **Client Sample ID:** Chicken Bristle **Sampled:** 04/12/2006 13:45

Sample Replicate # 1

Inorganic Anions **Method:** EPA 300 **Prep. Method:** N/A

Analyzed by KTL on April 14, 2006 at 11:05.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Nitrite	< 0.150	MG/L	0.15	N/A	
Nitrogen, Nitrate	1.30	MG/L	0.11	N/A	

Carbon, Total Organic Sub **Method:** N/A **Prep. Method:** N/A

Analyzed by SUB LAB on at .

Carbon, Total Organic	2.00	mg/L	N/A	N/A	

Ammonia Nitrogen **Method:** EPA 350.1 **Prep. Method:** N/A

Analyzed by JEE on April 18, 2006 at 10:33.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Ammonia	< 0.100	mg/L	0.100	N/A	

Ortho-Phosphate Phosphorus **Method:** EPA 365.2 **Prep. Method:** N/A

Analyzed by JPM on April 14, 2006 at 09:55.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Ortho-Phosphate	0.033	mg/L as P	0.010	N/A	

Total Phosphorus **Method:** EPA 365.1 **Prep. Method:** EPA365.1

Analyzed by JPM on April 14, 2006 at 14:51. Prepped by JPM on April 14, 2006 at 10:50.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Total	0.039	mg/L as P	0.010	N/A	

Total Kjeldahl Nitrogen **Method:** EPA 351.2 **Prep. Method:** EPA 351.2

Analyzed by JPM on April 18, 2006 at 16:16. Prepped by JPM on April 18, 2006 at 11:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Total Kjeldahl	0.259	mg/L	0.100	N/A	

Total Suspended Solids **Method:** EPA 160.2/160.4 **Prep. Method:** N/A

Analyzed by KTL on April 17, 2006 at 18:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Solids, Total Suspended	< 5.00	MG/L	5	N/A	

Total Alkalinity **Method:** EPA 310.1 **Prep. Method:** N/A

Analyzed by JEE on April 14, 2006 at 12:15.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Alkalinity, Total	131	mg/L CaCO3	5.00	N/A	

Laboratory Sample #: 482667 **Client Sample ID:** Peyton Creek **Sampled:** 04/12/2006 15:00

Sample Replicate # 1

Total Coliform **Method:** SM9223 **Prep. Method:** N/A

Analyzed by TWL on April 13, 2006 at 15:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Total Coliform	> 2,010	MPN	0	N/A	D
Ecoli	1,650	MPN	0	N/A	D

Chain of Custody: 45643
Project Name: Dix River TMDL-Hanging Fork
Project Number: 5167

Laboratory Sample #: 482667 **Client Sample ID:** Peyton Creek **Sampled:** 04/12/2006 15:00

Sample Replicate # 1

Specific Conductance (Field) **Method:** EPA120.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 15:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Specific Conductance (Field)	327.1	umhos/cm	N/A	N/A	

Dissolved Oxygen (Field) **Method:** EPA360.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 15:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Dissolved Oxygen (Field)	11.91	mg/L	N/A	N/A	

pH (Field) **Method:** EPA150.1/SW9045 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 15:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
pH (Field)	8.63	S.U.	N/A	N/A	

Temperature F (field) **Method:** EPA170.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 15:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Temperature (Field)	67.5	Fahrenheit	N/A	N/A	

Turbity (Field) **Method:** **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 15:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Turbidity	NA			N/A	

Inorganic Anions **Method:** EPA 300 **Prep. Method:** N/A

Analyzed by KTL on April 14, 2006 at 12:53.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Nitrite	< 0.150	MG/L	0.15	N/A	
Nitrogen, Nitrate	2.40	MG/L	0.11	N/A	

Carbon, Total Organic Sub **Method:** N/A **Prep. Method:** N/A

Analyzed by SUB LAB on at .

Carbon, Total Organic	1.90	mg/L	N/A	N/A	

Ammonia Nitrogen **Method:** EPA 350.1 **Prep. Method:** N/A

Analyzed by JEE on April 18, 2006 at 10:35.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Ammonia	< 0.100	mg/L	0.100	N/A	

Ortho-Phosphate Phosphorus **Method:** EPA 365.2 **Prep. Method:** N/A

Analyzed by JPM on April 14, 2006 at 09:57.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Ortho-Phosphate	0.069	mg/L as P	0.010	N/A	

Total Phosphorus **Method:** EPA 365.1 **Prep. Method:** EPA365.1

Analyzed by JPM on April 14, 2006 at 14:52. Prepped by JPM on April 14, 2006 at 10:50.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Total	0.080	mg/L as P	0.010	N/A	

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Chain of Custody: 45643
Project Name: Dix River TMDL-Hanging Fork
Project Number: 5167

Laboratory Sample #: 482667 **Client Sample ID:** Peyton Creek **Sampled:** 04/12/2006 15:00

Sample Replicate # 1

Total Kjeldahl Nitrogen **Method:** EPA 351.2 **Prep. Method:** EPA 351.2

Analyzed by JPM on April 18, 2006 at 16:17. Prepped by JPM on April 18, 2006 at 11:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Total Kjeldahl	0.552	mg/L	0.100	N/A	

Total Suspended Solids **Method:** EPA 160.2/160.4 **Prep. Method:** N/A

Analyzed by KTL on April 17, 2006 at 18:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Solids, Total Suspended	7.00	MG/L	5	N/A	

Laboratory Sample #: 482668 **Client Sample ID:** McKinney Branch **Sampled:** 04/12/2006 12:30

Sample Replicate # 1

Total Coliform **Method:** SM9223 **Prep. Method:** N/A

Analyzed by TWL on April 13, 2006 at 15:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Total Coliform	> 2,010	MPN	0	N/A	D
Ecoli	590	MPN	0	N/A	D

Specific Conductance (Field) **Method:** EPA120.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 12:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Specific Conductance (Field)	399.2	umhos/cm	N/A	N/A	

Dissolved Oxygen (Field) **Method:** EPA360.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 12:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Dissolved Oxygen (Field)	12.04	mg/L	N/A	N/A	

pH (Field) **Method:** EPA150.1/SW9045 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 12:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
pH (Field)	8.41	S.U.	N/A	N/A	

Temperature F (field) **Method:** EPA170.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 12:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Temperature (Field)	59.7	Fahrenheit	N/A	N/A	

Turbity (Field) **Method:** **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 12:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Turbidity	NA			N/A	

Inorganic Anions **Method:** EPA 300 **Prep. Method:** N/A

Analyzed by KTL on April 14, 2006 at 12:55.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Nitrite	< 0.150	MG/L	0.15	N/A	
Nitrogen, Nitrate	1.90	MG/L	0.11	N/A	

Results reported on a Wet Weight Basis

Issued: 4/26/2006

Laboratory Sample #: 482668 **Client Sample ID:** McKinney Branch **Sampled:** 04/12/2006 12:30

Sample Replicate # 1

Carbon, Total Organic Sub **Method:** N/A **Prep. Method:** N/A

Analyzed by SUB LAB on at .

Carbon, Total Organic	2.00	mg/L	N/A	N/A	

Ammonia Nitrogen **Method:** EPA 350.1 **Prep. Method:** N/A

Analyzed by JEE on April 18, 2006 at 10:38.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Ammonia	< 0.100	mg/L	0.100	N/A	

Ortho-Phosphate Phosphorus **Method:** EPA 365.2 **Prep. Method:** N/A

Analyzed by JPM on April 14, 2006 at 09:58.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Ortho-Phosphate	0.068	mg/L as P	0.010	N/A	

Total Phosphorus **Method:** EPA 365.1 **Prep. Method:** EPA365.1

Analyzed by JPM on April 14, 2006 at 14:53. Prepped by JPM on April 14, 2006 at 10:50.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Total	0.076	mg/L as P	0.010	N/A	

Total Kjeldahl Nitrogen **Method:** EPA 351.2 **Prep. Method:** EPA 351.2

Analyzed by JPM on April 18, 2006 at 16:18. Prepped by JPM on April 18, 2006 at 11:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Total Kjeldahl	0.371	mg/L	0.100	N/A	

Total Suspended Solids **Method:** EPA 160.2/160.4 **Prep. Method:** N/A

Analyzed by KTL on April 17, 2006 at 18:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Solids, Total Suspended	< 5.00	MG/L	5	N/A	

Laboratory Sample #: 482669 **Client Sample ID:** Baughman Creek **Sampled:** 04/12/2006 10:00

Sample Replicate # 1

Total Coliform **Method:** SM9223 **Prep. Method:** N/A

Analyzed by TWL on April 13, 2006 at 15:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Total Coliform	> 2,010	MPN	0	N/A	D
Ecoli	340	MPN	0	N/A	D

Specific Conductance (Field) **Method:** EPA120.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 10:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Specific Conductance (Field)	275.9	umhos/cm	N/A	N/A	

Dissolved Oxygen (Field) **Method:** EPA360.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 10:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Dissolved Oxygen (Field)	11.28	mg/L	N/A	N/A	

pH (Field) **Method:** EPA150.1/SW9045 **Prep. Method:** N/A

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Chain of Custody: 45643
Project Name: Dix River TMDL-Hanging Fork
Project Number: 5167

Laboratory Sample #: 482669 **Client Sample ID:** Baughman Creek **Sampled:** 04/12/2006 10:00

Sample Replicate # 1

pH (Field) **Method:** EPA150.1/SW9045 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 10:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
pH (Field)	8.11	S.U.	N/A	N/A	

Temperature F (field) **Method:** EPA170.1 **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 10:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Temperature (Field)	54.6	Fahrenheit	N/A	N/A	

Turbity (Field) **Method:** **Prep. Method:** N/A

Analyzed by FIELD on April 12, 2006 at 10:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Turbidity	NA			N/A	

Inorganic Anions **Method:** EPA 300 **Prep. Method:** N/A

Analyzed by KTL on April 14, 2006 at 12:56.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Nitrite	< 0.150	MG/L	0.15	N/A	
Nitrogen, Nitrate	1.30	MG/L	0.11	N/A	

Carbon, Total Organic Sub **Method:** N/A **Prep. Method:** N/A

Analyzed by SUB LAB on at .

Carbon, Total Organic	1.90	mg/L	N/A	N/A	

Ammonia Nitrogen **Method:** EPA 350.1 **Prep. Method:** N/A

Analyzed by JEE on April 18, 2006 at 10:43.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Ammonia	< 0.100	mg/L	0.100	N/A	

Ortho-Phosphate Phosphorus **Method:** EPA 365.2 **Prep. Method:** N/A

Analyzed by JPM on April 14, 2006 at 09:59.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Ortho-Phosphate	0.081	mg/L as P	0.010	N/A	

Total Phosphorus **Method:** EPA 365.1 **Prep. Method:** EPA365.1

Analyzed by JPM on April 14, 2006 at 14:54. Prepped by JPM on April 14, 2006 at 10:50.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Total	0.065	mg/L as P	0.010	N/A	

Total Kjeldahl Nitrogen **Method:** EPA 351.2 **Prep. Method:** EPA 351.2

Analyzed by JPM on April 18, 2006 at 16:19. Prepped by JPM on April 18, 2006 at 11:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Total Kjeldahl	0.530	mg/L	0.100	N/A	

Total Suspended Solids **Method:** EPA 160.2/160.4 **Prep. Method:** N/A

Analyzed by KTL on April 17, 2006 at 18:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Solids, Total Suspended	< 5.00	MG/L	5	N/A	

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Microbac

Chain of Custody: 45643
Project Name: Dix River TMDL-Hanging Fork
Project Number: 5167

Laboratory Sample #: 482670 **Client Sample ID:** West Hustonville **Sampled:** 04/12/2006 11:15
Sample Replicate # 1

Total Coliform **Method:** SM9223 **Prep. Method:** N/A
Analyzed by TWL on April 13, 2006 at 15:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Total Coliform	> 2,010	MPN	0	N/A	D
Ecoli	530	MPN	0	N/A	D

Specific Conductance (Field) **Method:** EPA120.1 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 11:15.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Specific Conductance (Field)	237.7	umhos/cm	N/A	N/A	

Dissolved Oxygen (Field) **Method:** EPA360.1 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 11:15.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Dissolved Oxygen (Field)	13.01	mg/L	N/A	N/A	

pH (Field) **Method:** EPA150.1/SW9045 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 11:15.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
pH (Field)	8.57	S.U.	N/A	N/A	

Temperature F (field) **Method:** EPA170.1 **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 11:15.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Temperature (Field)	55.7	Fahrenheit	N/A	N/A	

Turbity (Field) **Method:** **Prep. Method:** N/A
Analyzed by FIELD on April 12, 2006 at 11:15.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Turbidity	NA			N/A	

Inorganic Anions **Method:** EPA 300 **Prep. Method:** N/A
Analyzed by KTL on April 14, 2006 at 12:57.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Nitrite	< 0.150	MG/L	0.15	N/A	
Nitrogen, Nitrate	1.10	MG/L	0.11	N/A	

Carbon, Total Organic Sub **Method:** N/A **Prep. Method:** N/A
Analyzed by SUB LAB on at .

Carbon, Total Organic	1.80	mg/L	N/A	N/A	

Ammonia Nitrogen **Method:** EPA 350.1 **Prep. Method:** N/A
Analyzed by JEE on April 18, 2006 at 10:45.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Ammonia	< 0.100	mg/L	0.100	N/A	

Ortho-Phosphate Phosphorus **Method:** EPA 365.2 **Prep. Method:** N/A
Analyzed by JPM on April 14, 2006 at 10:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers

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Accredited Lab Data for Today's Environment

Microbac

Chain of Custody: 45643
Project Name: Dix River TMDL-Hanging Fork
Project Number: 5167

Laboratory Sample #: 482670 **Client Sample ID:** West Hustonville **Sampled:** 04/12/2006 11:15
Sample Replicate # 1

Ortho-Phosphate Phosphorus **Method:** EPA 365.2 **Prep. Method:** N/A
Analyzed by JPM on April 14, 2006 at 10:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Ortho-Phosphate	0.017	mg/L as P	0.010	N/A	

Total Phosphorus **Method:** EPA 365.1 **Prep. Method:** EPA365.1
Analyzed by JPM on April 14, 2006 at 14:55. Prepped by JPM on April 14, 2006 at 10:50.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Phosphorus, Total	0.019	mg/L as P	0.010	N/A	

Total Kjeldahl Nitrogen **Method:** EPA 351.2 **Prep. Method:** EPA 351.2
Analyzed by JPM on April 18, 2006 at 16:22. Prepped by JPM on April 18, 2006 at 11:30.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Nitrogen, Total Kjeldahl	0.403	mg/L	0.100	N/A	

Total Suspended Solids **Method:** EPA 160.2/160.4 **Prep. Method:** N/A
Analyzed by KTL on April 17, 2006 at 18:00.

Parameter	Result	Units	Reporting Limit	Client Limit	Qualifiers
Solids, Total Suspended	< 5.00	MG/L	5	N/A	

All samples were received intact and properly preserved unless otherwise noted.
The results reported relate only to the samples tested.
This report shall not be reproduced except in full, without written approval of this laboratory.

A2LA
ACCREDITED
Lab#: 100343

Submitted by: Heather J Weidner

Client Manager: Heather Weidner
Please contact Heather Weidner with any questions.

Specific tests covered by the A2LA accreditation meet the requirements of the A2LA accreditation standard. Please refer to http://www.envirodatagroup.com/EDG_A2LA_Accredited_Analytes.pdf on our website for a list of our current A2LA accreditations.

Data Qualifiers

Qualifier	Description
A	E. coli present.
A'	E. coli absent.
B	Analyte detected in associated MB.
C	Sample result confirmed.
D	Results reported from dilution.
E	Analyte concentration exceeds calibration range.
F	Unable to analyze due to sample matrix interference.
H	Sample was received or analyzed past the established holding time.
J	Estimated concentration.
K	Sample contained lighter hydrocarbon fractions.
L	Sample contained heavier hydrocarbon fractions.
M	MS and/or MSD recovery outside acceptance limits.
N	Presumptive evidence of analyte present.
O	Sample hydrocarbon pattern does not match calibration standard pattern.
P	Percent difference between primary and secondary column concentrations exceeds acceptance limit.
Q	LCS outside acceptance limits.
R	Data unusable.
S	Surrogate outside acceptance limits on initial and reanalysis.
S'	Surrogates diluted below detection.
T	Sample received improperly preserved.
U	Analyte not detected.
W	Raised quantitation or reporting limit due to limited sample volume.
Y	Replicate/Duplicate precision outside acceptance limits.
Z'	Calibration criteria exceeded but for this situation acceptable by method.
Z	Calibration criteria exceeded.
M'	Result from Method of Standard Additions (MSA).
Q'	LCS/LCD analyzed due to insufficient sample for MS/MSD.

The uncertainty of analytical results can be calculated using the following equation:

$$n = t*s/1.414$$

where

t=12.706 (Students t value for 95% confidence interval of two replicates)
s= standard deviation of sample and duplicate data
1.414 is square root of the number of replicates (two)

Abbreviations

Laboratory Control Sample	(LCS)
Laboratory Control Duplicate	(LCD)
Matrix Spike	(MS)
Matrix Spike Duplicate	(MSD)
Method Blank	(MB)

APPENDIX J

FIGURE 10:
CHLOROPHYLL a DATASHEET

CHLOROPHYLL-a DATA SHEET
DIX RIVER PROJECT

SAMPLE ID	*COLLECTOR*	*WATERSHED*	*DATE/TIME COLLECTED*	*DATE/TIME FILTERED*	*VOLUME FILTERED*	*TOTAL # FILTER PADS*	*AREA COLLECTED*

Filtering Technician Signature: ___________________________

Form updated 5/10/06 mlw

THIRD ROCK
CONSULTANTS

APPENDIX K

TABLE 1:
RESULTS SUMMARY FOR DIX RIVER WATERSHED PROJECT

Table 1: Sample / Results Summary for Dix River Watershed

Parameters	Analyte Name	Clarks Run Select	Clarks Run Non-Select	Hanging Fork Select	Hanging Fork Non-Select	Dix River Select	Dix River Non-Select	TOTAL
Sites	Number of Sites	4	4	6	8	1	8	31
Parameters	Analyte Name	Number of samples*						
Total P	Phosphorus, Total	48	48	60	96	12	96	360
Ortho-P	Phosphorus, Ortho	48	48	60	96	12	96	360
NO2	Nitrite as N	48	48	60	96	12	96	360
NO3	Nitrate as N	48	48	60	96	12	96	360
TKN	Total Kjeldahl Nitrogen	48	48	60	96	12	96	360
NH3-N	Ammonia as N	48	48	60	96	12	96	360
TOC	Organic Carbon, Total	48	48	60	96	12	96	360
TSS	Solids, Total Suspended	48	48	60	96	12	96	360
TC/EColi	Total Coliform / E. coli	48	48	60	96	12	96	360
DO	Dissolved Oxygen	48	48	60	96	12	96	360
Temp	Temperature	48	48	60	96	12	96	360
Cond	Conductivity	48	48	60	96	12	96	360
Flow	Flow	48	48	60	96	12	96	360
pH	pH	48	48	60	96	12	96	360
Turbidity	Turbidity	39	-	42	-	12	-	93
CBOD5	Biochemicial Oxygen Demand, 5-Day Carbonaceous	48	48	60	-	12	-	168
CBOD15	Biochemicial Oxygen Demand, 15-Day Carbonaceous	48	-	-	-	-	-	48
Chlorides	Chloride	16	-	20	-	4	-	40
Chloro a	Chlorophyll a	48	-	60	-	12	-	120
Alkalinity	Alkalinity	48	-	60	-	12	-	120
Periphyton	Periphyon	8	-	12	-	2	-	22
24hr. Diurnal DO	24hr. Diurnal Dissolved Oxygen	2 total from 2 sites						2

***NOTE: Number of samples indicates the expected total number of samples collected at the specified sites over the entire sampling period.**

APPENDIX L

TABLE 2:
METHODS, ANALYTES, AND REPORTING LIMITS FOR THE DIX RIVER WATERSHED

Table 2: Methods, Analytes, and Data Quality Indicators for the Dix River Watershed

Parameters	Analyte Name	Units	Reporting Limit	Precision Criteria (%RPD)	Accuracy Criteria MS (% Uncertainty)	Accuracy Criteria LCS (% Uncertainty)
CBOD15	Biochemicial Oxygen Demand, 15-Day Carbonaceous	mg/L	2	20	N/A	15
CBOD5	Biochemicial Oxygen Demand, 5-Day Carbonaceous	mg/L	2	20	N/A	15
TSS	Solids, Total Suspended	mg/L	3	20	N/A	20
Total P	Phosphorus, Total	mg/L as P	0.4	20	10	10
Ortho-P	Phosphorus, Ortho	mg/L as P	0.14	20	10	10
NO2	Nitrite as N	mg/L as N	0.1	20	20	10
NO3	Nitrate as N	mg/L as N	0.1	20	20	10
NH3-N	Ammonia as N	mg/L as N	0.1	20	10	10
Chlorides	Chloride	mg/L	1	20	20	10
TKN	Total Kjeldahl Nitrogen	mg/L	0.1	20	10	10
TOC	Organic Carbon, Total	mg/L	0.7	20	10	10
Alkalinity	Alkalinity	mg/L CaCO3	7	20	20	20
Turbidity	Turbidity	NTU	0.01	N/A	10	10
pH	pH	S.U.	0-14	N/A	N/A	5
DO	Dissolved Oxygen	mg/L	1	N/A	N/A	10
Temp	Temperature	°F	40	N/A	N/A	5
Cond	Conductivity	umhos/cm	1	N/A	N/A	10
Flow	Flow	ft3/sec	0.33 for small, 0.20 for large	N/A	N/A	N/A
TC/EColi	Total Coliform / E. coli	MPN	0	20	N/A	N/A
Chloro a	Chlorophyll a	ug/L	N/A	20	N/A	10
Periphyton	Periphyon	NA	NA	NA	N/A	NA
24hr. Dinural DO	24hr. Dinural Dissolved Oxygen	mg/L	1	N/A	N/A	15

Definitions:

RPD = Relative Percent Difference

LCS = Laboratory Control Sample

MS= Matrix Spike

APPENDIX M

TABLE 3:
SUMMARY OF PROJECT SAMPLING AND ANALYTICAL REQUIREMENTS

Table 3: Summary of Project Sampling and Analytical Requirements

Parameters	Analyte Name	Method	Minimum Sample Volume	Containers	Preservation	Maximum Hold Time
CBOD15	Biochemicial Oxygen Demand, 15-Day Carbonaceous	EPA 405.1 MOD or SM5210B MOD	1 L	Plastic	Cool 4°C	48 hrs
CBOD5	Biochemicial Oxygen Demand, 5-Day Carbonaceous	EPA 405.1 MOD or SM5210B MOD	1 L	Plastic	Cool 4°C	48 hrs
TSS	Solids, Total Suspended	EPA 160.2	1 L	Plastic	Cool 4°C	7 days
Total P	Phosphorus, Total	EPA 365.1 or 365.4	50mL	Plastic	Cool 4°C, H_2SO_4 to pH <2	28 days
Ortho-P	Phosphorus, Ortho	EPA 300.0 or 365.2	250mL	Plastic	Cool 4°C	48 hrs
NO2	Nitrite as N	EPA 300.0	50ml	Plastic	Cool 4°C	48 hrs*
NO3	Nitrate as N	EPA 300.0	50mL	Plastic	Cool 4°C	48 hrs*
NH3-N	Ammonia as N	EPA 350.1	500mL	Plastic	Cool 4°C, H_2SO_4 to pH <2	28 days
Chloride	Chloride	EPA 300.0	25mL	Plastic	Cool 4°C	28 days
TKN	Total Kjeldahl Nitrogen	EPA 351.2	50mL	Plastic	Cool 4°C, H_2SO_4 to pH <2	28 days
TOC	Organic Carbon, Total	EPA 415.1	25mL	Amber Glass	Cool 4°C, H_2SO_4 to pH <2	28 days
Alkalinity	Alkalinity	EPA 310.1 or 310.2	100mL	Plastic	Cool 4°C	14 days
Turbidity	Turbidity	EPA 180.1	Sufficient volume to submerge probe	Direct source measurement	NA	On-Site [1]
pH	pH	EPA 150.1			NA	Immediately/On-Site
DO	Dissolved Oxygen	EPA 360.1			NA	Immediately/On-Site
Temp	Temperature	EPA 170.1			NA	Immediately/On-Site
Cond	Conductivity	EPA 120.1			NA	On-Site [1]
Flow	Flow	USGS Modified	NA	NA	NA	NA
TC/EColi	Total Coliform / E. coli	SM 9223	100mL	Glass/Plastic, Sterile	Cool <10°C, $Na_2S_2O_3$ (No Cl_2)	24 hrs
Chloro a	Chlorophyll a	SM 10200H**	Varies	Amber Glass	***	****
Periphyton	Periphyton	Douglas, 1958	Varies	Amber Glass	See Note[2]	NA
24hr. Dinural DO	24hr. Dinural Dissolved Oxygen	EPA 360.1	Sufficient volume to submerge probe	Direct source measurement	NA	Immediately/On-Site

* Optional preservation of 250 mL with H2SO4 (1+1) to a pH <2 results in a holdtime of 28 days for Nitrate-Nitrite.

** Trichromatic

*** Cool, 4°C, Protect From Light - Wrap Amber Glass Bottle in Aluminum Foil

**** Concentrate sample as soon as possible after collection. *Filter* samples from waters w/ pH =/> 7.0 can be placed in air tight bag and stored frozen for 3 weeks; *filter* samples from waters w/ pH <7.0 should be processed as soon as possible to prevent chlorophyll degradation.

[1] Samples can be collected for laboratory analysis: Turbidity - 100mls, plastic, cool 4°C, 48hr hold; Conductivity - 100mls, plastic, cool 4°C, 24hr hold if sample is unfiltered/28 day hold if sample is filtered through 0.45um membrane filter.

[2] Lugol's iodine solution, 0.3mL per 100mL of sample

APPENDIX N

TABLE 4:
DIX RIVER WATERSHED ASSESSMENT AND MANAGEMENT REPORTS

Table 4: Dix River Watershed Assessment and Management Reports

Assessment Type	Frequency	Purpose	Internal or External	Parties Responsible for Performing		Method of Reporting
				Performing Assessments	Responding to Assessments	
KDOW Audit	As requested	Ensure conformance to project objectives	External	KDOW	Parties of concern	Corrective Action Response
Laboratory Demonstration of Capability	Prior to initial analysis	Ensure analyst is capable of performing the method to specifications.	Internal	Laboratory QA Director	Laboratory Analysts	Internal Lab documentation
Laboratory Performance Evaluation	Annually, at minimum	Independent assessment of the accuracy of its analyses	External	Laboratory QA Director	Laboratory Analysts	Internal Lab documentation
Laboratory Internal Audits	Annually, at minimum	Ensure conformance to methods, regulations, and procedures.	Internal	Laboratory QA Director	Laboratory Analysts	Internal Lab documentation
Laboratory External Audits	usually biannually	Ensure conformance to methods, regulations, and procedures.	External	Regulatory Body	Laboratory QA Director	Internal Lab documentation
Project Status Meeting	Weekly	Evaluate the status on project related objectives and concerns	Internal	QA Manager	Project Administrator	Status Meeting Minutes
Field Systems Audit	Quarterly, at minimum	Assess sampling technicians adherence to proper documentation and protocols.	Internal	Field Logistics Coordinator	Sampling Technicians	Email Correspondance
Analytical Results Review	Monthly	Assess progress and results of analytical findings of each station.	External	KDOW	Project Administrator	Analytical Monthly Summary