Final
Total Maximum Daily Load for *E. coli*
Five Stream Segments within the Hardwick Creek Watershed
Powell and Estill Counties, Kentucky
July, 2013

Hardwick Creek, Powell County, KDOW

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Kentucky
UNBRIDLED SPIRIT

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Kentucky Department for Environmental Protection
Division of Water

This report is approved for release

Sandra L. Gruzesky, P.E., Director
Division of Water

7/5/13
Date

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Glossary of Acronyms

AFO	Animal Feeding Operation
AWQA	Agriculture Water Quality Act
BMP	Best Management Practices
CAFO	Confined Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CPP	Continuing Planning Process
EPA	Environmental Protection Agency
GNIS	Geographic Names Information System
GPPs	Groundwater Protection Plans
HSG	Hydrology Soil Group
HUC	Hydrologic Unit Code
KAWQA	Kentucky Agriculture Water Quality Act
KDOW	Kentucky Division of Water
KGS	Kentucky Geological Survey
KPDES	Kentucky Pollution Discharge Elimination System
KRS	Kentucky Revised Statutes
KNDOP	Kentucky No Discharge Operating Permit
KWA	Kentucky Waterways Alliance
LA	Load Allocations
MAF	Mean Annual Flow
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NASS	National Agricultural Statistics Service
NLCD	National Landcover Database
NRCS	Natural Resources Conservation Service
OSTDS	On Site Sewage Treatment and Disposal System
PCR	Primary Contact Recreation
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RM	River Mile
SCR	Secondary Contact Recreation
SOP	Standard Operating Procedures
STPs	Sewage Treatment Plants
SWS	Sanitary Wastewater System
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WBID	Waterbody Identification Number

WLA	Waste Load Allocation
WQC	Water Quality Criteria
WWTP	Wastewater Treatment Plant

Total Maximum Daily Load Synopsis

State: Kentucky
Major River Basin: Kentucky
USGS HUC8 #: 05100204
Counties: Powell; Estill
Pollutant of Concern: *E. coli*

The Hardwick Creek watershed is primarily located in Powell County, with minor extensions into Estill County. The total watershed area is 27.3 square miles, with 23.4 square miles in Powell County and 3.9 square miles in Estill County. The Hardwick Creek watershed is close to Bert T Combs-Mountain PKWY, which traverses north of the watershed (Figure S.1).

During the primary contact recreation (PCR) season in 2006, Escherichia coli (*E. coli*) samples were collected at 6 sampling sites within the watershed. This document contains the monitoring results and describes Total Maximum Daily Load (TMDL) development for *E. coli* in the Hardwick Creek watershed as required under Section 303(d) of the Clean Water Act. Table S.1 indicates the *E. coli* impaired segments for which TMDLs are developed in this document.

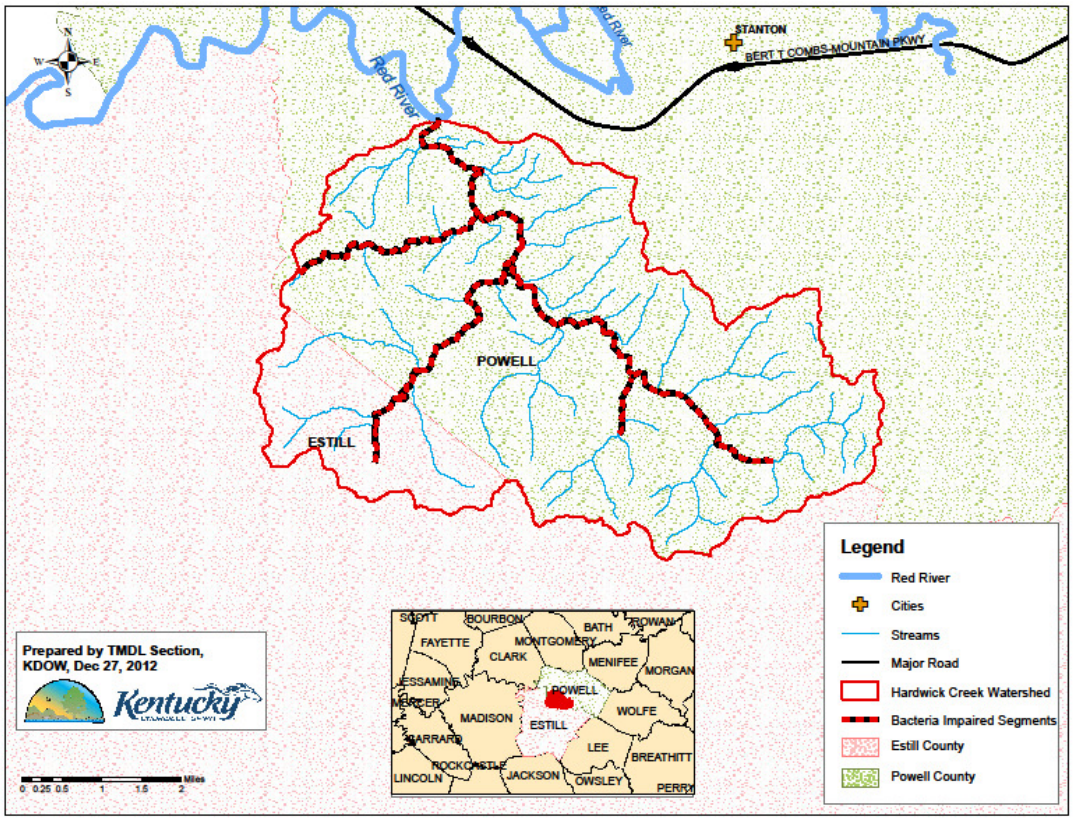

Figure S.1 Location of the Hardwick Creek Watershed

Table S.1 Impaired Waterbodies Addressed in this TMDL Document

Waterbody Name	Pollutant	County	Waterbody Identification Number (WBID)*	Suspected Sources	Impaired Use (Support Status)
Branham Branch 0.0 to 0.8	*E. coli*	Powell	KY510896_01	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (partial support)
Little Hardwick Creek 0.0 to 4.2	*E. coli*	Powell Estill	KY513488_01	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (nonsupport)
Frames Branch 0.0 to 2.95	*E. coli*	Powell	KY512238_01	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (nonsupport)
Hardwick Creek 3.25 to 8.6	*E. coli*	Powell	KY512561_02	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (nonsupport)
Hardwick Creek 0.0 to 3.25	*E. coli*	Powell	KY512561_01	On-site Treatment Systems (Septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (nonsupport)

* The Waterbody Identification Number (WBID) is a unique identifier assigned to all assessed waters in KY. It is based upon the USGS Geographic Names Information System (GNIS) (USGS, 1999) with a KY in front of the GNIS number and a _## where ## is a segment identification number.

Kentucky Water Quality Criteria (WQC) and the TMDL Endpoint (i.e. Water Quality Standard / TMDL Target):

E. coli is a bacteria indicator used to identify if the waterbody is polluted. Kentucky regulations have numbers for the safe amounts of *E. coli* in the water (401 KAR 10:031) for the Primary Contact Recreation (PCR) season (May – October only) and year round Secondary Contact Recreation (SCR) (Table S.2).

Table S.2 Kentucky's Bacteria Limits

	Summer PCR Limit (May 1 - Oct. 31)		SCR Limit (year round)	
Bacteria Indicator	Geometric Mean (colonies/100 ml)	Maximum (colonies/100 ml)	Geometric Mean (colonies/100 ml)	Maximum (colonies/100 ml)
E. coli	**130** (from 5 samples collected within 30 days)	**240** (number not to be exceeded in more than 20% of the samples)	No criterion (this does not mean that any number is safe; rather that KY regulations do not tell the safe limit)	No criterion (this does not mean that any number is safe; rather that KY regulations do not tell the safe limit)

TMDL Equation and Calculations:

A TMDL calculation is performed as follows:

$$TMDL = WLA + LA + MOS$$
(Equation 1)

The WLA usually has three components:

$$WLA = SWS\text{-}WLA + MS4\text{-}WLA + Future\ Growth\text{-}WLA$$
(Equation 2)

but there were no SWS or MS4 sources in this watershed so the WLA was only divided to the Future Growth-WLA.

Where:
TMDL: the WQC, expressed as a load. The WQC is defined in Section 6.0 as an instantaneous concentration of 240 colonies/100 ml for *E. coli*.
MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits and water quality.
TMDL Target: the TMDL minus the MOS.
WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from KPDES-permitted sources, such as SWSs and MS4s.

SWS-WLA: the WLA for KPDES-permitted sources, which have discharge limits for pathogen indicators (including wastewater treatment plants, package plants and home units).
Future Growth-WLA: the allowable loading for future KPDES-permitted sources, including new SWSs, expansion of existing SWSs, new storm water sources, and growth of existing storm water sources (such as MS4s). Also includes the allocation for the KPDES-permitted sources that existed but were not known at the time the TMDL was written.
Remainder: the TMDL minus the MOS and minus the SWS-WLA (also equal to Future Growth-WLA plus the MS4-WLA and the LA).
MS4-WLA: the WLA for KPDES-permitted municipal separate storm water sewer systems (including cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet, universities and military bases).
LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.
Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.
Critical Condition: the time period when the pollutant conditions are expected to be at their worst.
MAF: the Mean Annual Flow as defined by USGS.
Adjusted MAF: the MAF plus SWS-WLA design flows.
Critical Flow: the flow used to calculate the TMDL as a load (is equivalent to the Adjusted MAF for MAF TMDLs)
Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.
Percent Reduction: the loading reduction needed to bring the existing condition in line with the TMDL target.
Load: concentration * flow * conversion factor
Concentration: colonies per 100 milliliters (colonies/100ml)
Flow (i.e. stream discharge): cubic feet per second (cfs)
Conversion Factor: the value that converts the product of concentration and flow to load (in units of colonies per day); it is derived from the calculation of the following components: (28.31685L/f^3 * 86400seconds/day * 1000ml/L)/ (100ml) and is equal to 24,465,758.4.

<u>Calculation Procedure</u>:

1) The MOS, if an explicit value, is calculated and subtracted from the TMDL first, giving the TMDL Target;
2) Percent reductions are calculated to show the difference between Existing Conditions and the TMDL Target;
3) The Future Growth-WLA is calculated and subtracted from the Remainder;
4) Leaving the LA.

The TMDL for each *E. coli* impaired segment is shown in Tables S.3.

Table S.3 TMDLs for *E. coli* PCR Impaired Segments

Waterbody Name	TMDL (colonies/ day)	MOS (colonies/ day)	SWS-WLA (colonies/ day)	Future Growth-WLA (colonies/ day)	MS4-WLA (colonies / day)	LA (colonies/ day)	Percent Reduction (%)
Branham Branch 0.0 to 0.8	1.53E+10	1.53E+09	0	6.87E+07	0	1.37E+10	58.5
Little Hardwick Creek 0.0 to 4.2	5.05E+10	5.05E+09	0	2.27E+08	0	4.52E+10	98.8
Frames Branch 0.0 to 2.95	1.47E+10	1.47E+09	0	1.32E+08	0	1.31E+10	97.9
Hardwick Creek 3.25 to 8.6	1.06E+11	1.06E+10	0	4.78E+08	0	9.52E+10	98.1
Hardwick Creek 0.0 to 3.25	2.03E+11	2.03E+10	0	9.12E+08	0	1.81E+11	99.1

1.0 Introduction

Section 303(d) of the Clean Water Act (1972) requires states to identify waterbodies within their boundaries that have been assessed and are not currently meeting their designated uses (401 KAR 10:026 and 10:031) and that require the development of a Total Maximum Daily Load (TMDL). States must establish a priority ranking for such waters, taking into account their intended uses and the severity of the pollutant. Section 303(d) also requires that states provide a list of this information called the 303(d) list. This list is submitted to the Environmental Protection Agency (EPA) during even-numbered years and each submittal replaces the previous list. The 2010-303(d) information for Kentucky can be found in the *2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky Volume II. 303(d) List of Surface Waters* (Kentucky Division of Water [KDOW], 2011a) and can be obtained at: http://water.ky.gov. Following EPA approval, the final 2012-303(d) Report will be available at: http://water.ky.gov.

States are also required to develop TMDLs for the pollutants that cause each waterbody to fail to meet its designated uses. The TMDL process establishes the allowable amount (i.e. "load") of the pollutant the waterbody can naturally assimilate while continuing to meet the water quality criteria (WQC) for each designated use. The pollutant load must be established at a level necessary to implement the applicable WQC with seasonal variations and a Margin of Safety (MOS) that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. This load is then divided among different sources of the pollutant in a watershed. Information from EPA on TMDLs can be found at: http://www.epa.gov/owow/tmdl.

This document contains the monitoring results and describes TMDL development for *E. coli* in the Hardwick Creek watershed as required under Section 303(d) of the Clean Water Act. By providing bacteria allocations and reductions, this TMDL can provide an analytical foundation for identifying, planning, and implementing water quality-based controls to reduce bacteria pollution from identified sources. The ultimate goal is the restoration and maintenance of water quality in the waterbody so that designated uses are met.

2.0 Problem Definition

The Clean Water Act requires states to designate uses for surface waters within their jurisdiction. The designated uses assigned to waterbodies in Kentucky can be found in 401 KAR 10:026 and include PCR and SCR. 401 KAR 10:001 defines PCR or SCR waters as those "waters suitable for full body contact recreation during the recreation season of May 1 through October 31" or "waters suitable for partial body recreation, with minimal threat to public health due to water quality", respectively. 401 KAR 10:031 establishes standards that are "minimum requirements that apply to all surface waters in the Commonwealth of Kentucky in order to maintain and protect them for designated uses." The pathogen-related WQC in 401 KAR 10:031 are based upon those proposed by EPA (EPA, 1986).

The term pathogen refers to bacteria, viruses, or other biological agents (such as parasites) that can cause disease. Because it is currently resource intensive, difficult, and a potential health hazard to detect most pathogens in water, other organisms are used to indicate whether the presence of pathogens is likely in waters. Like EPA's proposed criteria, Kentucky uses Escherichia coli (*E. coli*) as indicator organism of pathogens. *E. coli* is found in the fecal waste of humans and warm-blooded animals (birds and mammals). The presence of these bacteria in a waterbody indicates that contamination from human or animal wastes has likely occurred and that pathogens may be present.

2.1 Watershed Description

The Hardwick Creek watershed is located in the Kentucky River Basin in eastern central Kentucky. The watershed is primarily located in Powell County, with minor extensions into Estill County.

2.2 303(d) Listing History

Hardwick Creek from river mile (RM) 0.0 to 3.2 was first listed as impaired for PCR (Nonsupport) from pathogens in the 2002-303(d) Report. The 2008-303(d) Report more correctly indentified the cause of impairment as fecal coliform as opposed to pathogens. This listing was carried forward on the 2010 and 2012 303(d) lists.

E. coli samples were collected at 6 sampling sites during PCR season in 2006.

3.0 Physical Setting

The Hardwick Creek watershed is located within the United States Geological Survey (USGS) 8-digit Hydrology Unit Code (HUC) of 05100204 in the Kentucky River Basin and is designated with an 11-digit HUC 05100204170. There are seven HUC 14 sub-watersheds within the Hardwick Creek watershed (Figure 3.1). Table 3.1 contains the HUC number, name and area in acres of the HUC 14 sub-watersheds.

Hardwick Creek arises in Powell County and flows north to the Red River, and then joins the Kentucky River. The stream length of Hardwick Creek is 10.3 miles, with an additional 58.1 miles of tributaries. The total watershed area is 27.3 square miles, with 23.4 square miles in Powell County and 3.9 square miles in Estill County. The Hardwick Creek watershed is close to Bert T Combs-Mountain PKWY, which traverses north of the watershed (Figure 3.1).

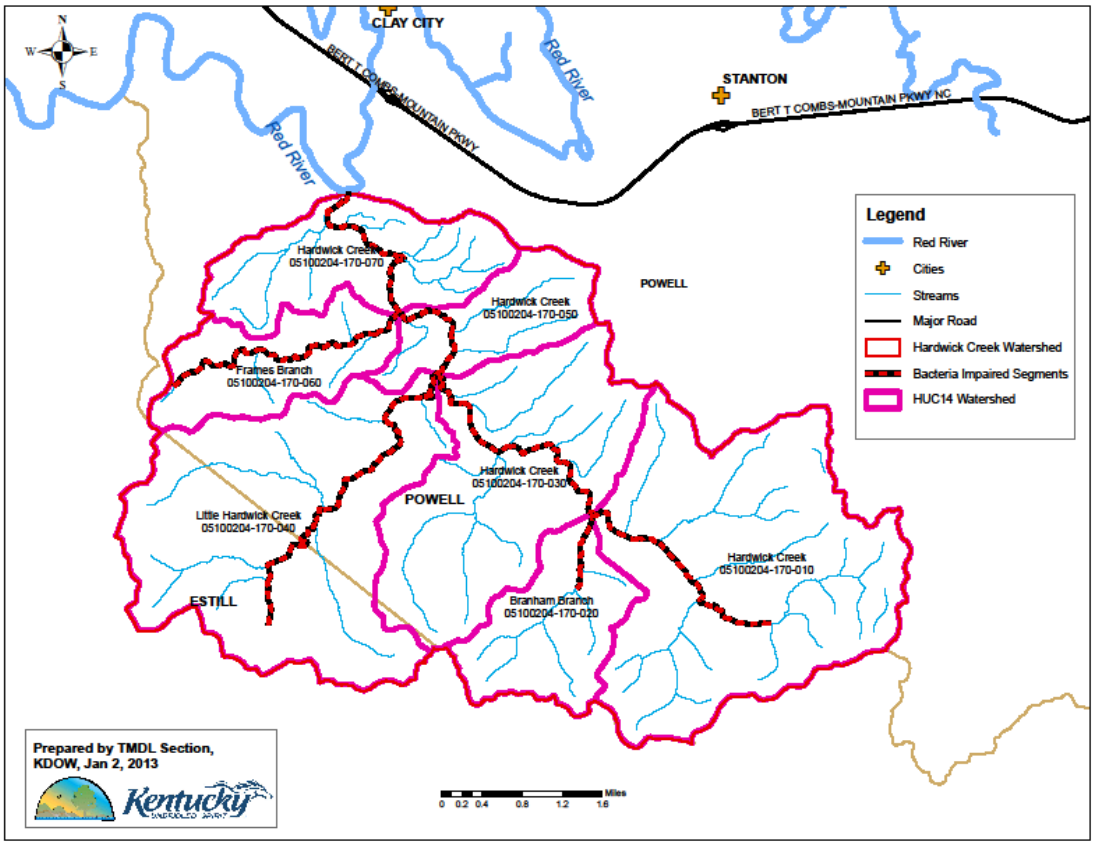

Figure 3.1 Location of HUC 14s in the Hardwick Creek Watershed

Table 3.1 HUC 14s in the Hardwick Creek Watershed

HUC_NUM	NAME	SQ_MILES	ACRES
05100204-170-070	Hardwick Creek	2.73	1724
05100204-170-050	Hardwick Creek	1.64	1042
05100204-170-060	Frames Branch	2.00	1276
05100204-170-030	Hardwick Creek	4.89	3121
05100204-170-040	Little Hardwick Creek	6.79	4337
05100204-170-010	Hardwick Creek	7.27	4628
05100204-170-020	Branham Branch	2.04	1304

3.1 Geology

The Hardwick Creek watershed is located in the Eastern Coal Field physiographic region. The majority of the watershed is in the Level III Ecoregion of the Western Allegheny Plateau and Level IV Ecoregion of the Knob-Lower Scioto Dissected Plateau, with the 22% of area in the Level III Ecoregion of the Interior Plateau and Level IV Ecoregion of Outer Bluegrass and 6% of area in the Level III Ecoregion of the Western Allegheny Plateau and Level IV Ecoregion of Northern Forested Plateau Escarpment (Figure 3.2). The Knob-Lower Scioto Dissected Plateau contains rounded hills and ridges, narrow valleys with high gradient stream, and a few wide, locally swampy, bottoms underlain by a mixture of Pennsylvanian-age through Silurian-age sediment rocks (Woods, et al. 2002).

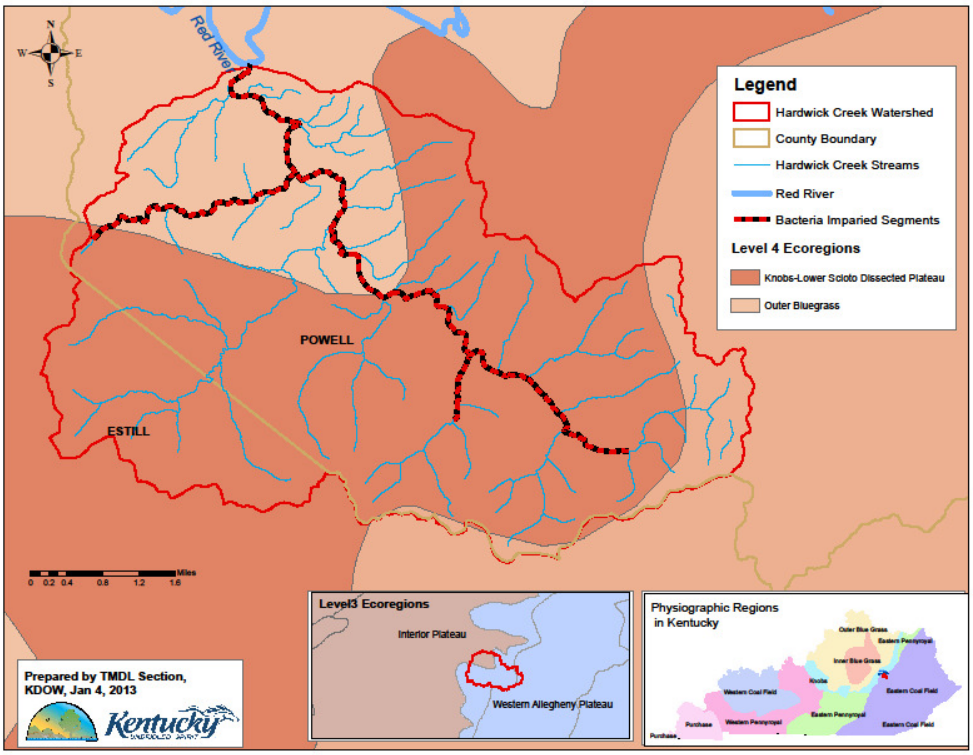

Figure 3.2 Level IV Ecoregions of the Hardwick Creek Watershed

The majority of the watershed is underlain with rocks by the Borden and the Pennington Formations from the Mississippian age which formed between 360 and 235 million years ago and consist of limestone with minor sandstone and shale. The northeast part of the watershed is underlain by the New Albany Formation from the Devonian to Mississippian ages between 410 and 235 million years ago and consist of black shale with minor dolostone and limestone. Alluvium also deposits along Hardwick Creek (Figure 3.3).

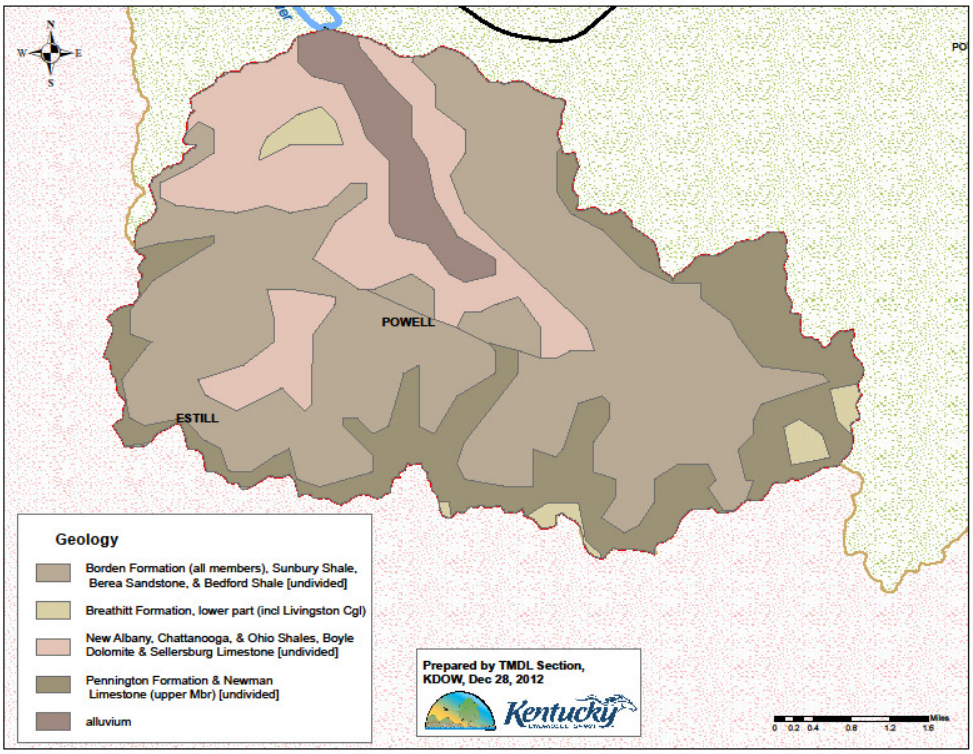

Figure 3.3 Geology of the Hardwick Creek Watershed

Karst features, such as geologic faults and sinkholes, are present in the Hardwick Creek watershed (Figure 3.4). Karst features are formed over centuries as rainwater dissolves limestone beneath the surface (Figure 3.5).

Official watershed boundaries may not be accurate in well-developed karst regions. Although groundwater drainage generally follows topographic basin boundaries, this is not always true. Subsurface drainage transfer between surface watersheds in a karst region does occur, which increases or decreases the actual boundaries of an affected stream basin. The KDOW and the Kentucky Geology Survey (KGS) maintain a Karst Atlas of groundwater tracing data and delineated basins (both as static PDF maps and ArcView shape files) that can be downloaded at http://kygeonet.ky.gov.

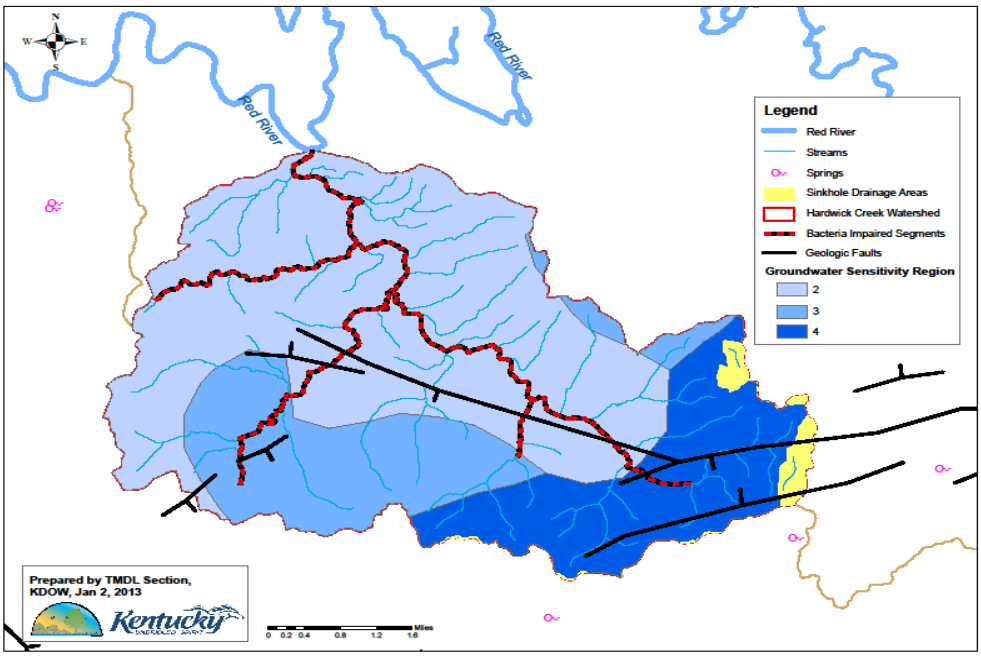

Figure 3.4 Sinkhole Drainage Areas and Groundwater Sensitivity Region within the Hardwick Creek Watershed; Springs near the Hardwick Creek Watershed; Geologic Faults within and near the Hardwick Creek Watershed

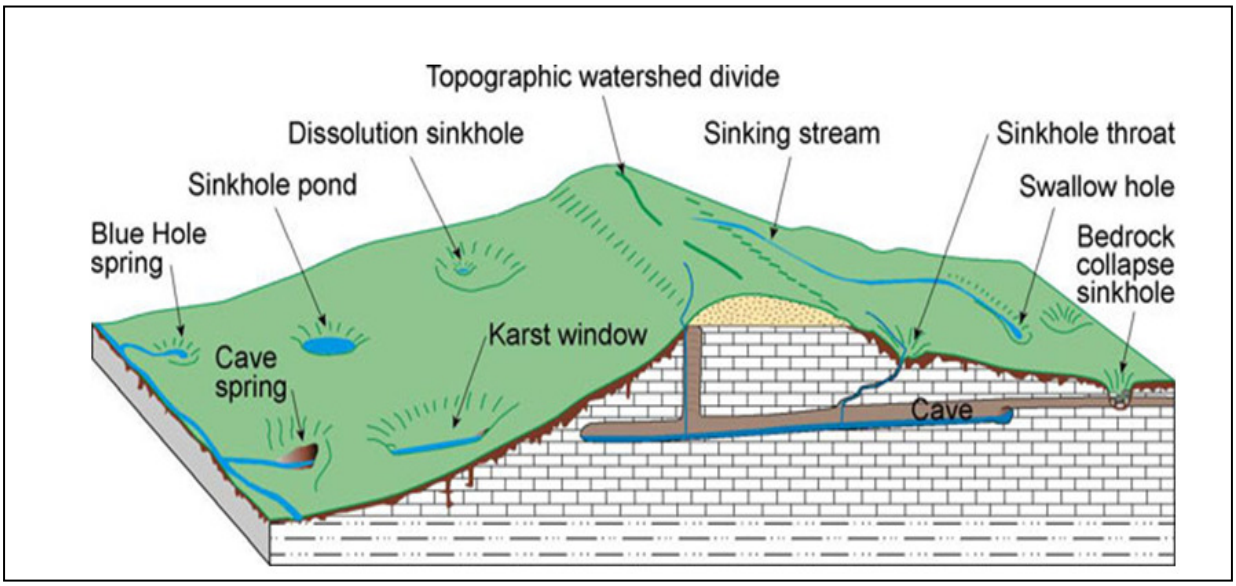

Figure 3.5 Conceptual Model of Typical Karst Terrain
accessed at: http://www.uky.edu/KGS/water/general/karst/karst_landscape.htm

Karst topography can create geological hazards such as sudden surface collapse (due to sinkholes), flooding (if a karst pathway becomes clogged with debris or overloaded due to improper surface flow routing), and soil erosion. Karst topography also creates a concern for groundwater and surface water contamination. Areas underlain by karst hydrology can have

rapid groundwater flow rates, with complex routes. Storm water and associated pollutants can quickly percolate through soils and sinkholes with little or no filtration or attenuation of the contaminants. Groundwater velocities within conduits are commonly measured in thousands of feet per day instead of the typical rate of inches or feet per year in non-karst systems – the maximum recorded conduit groundwater velocity in Kentucky exceeds 2600 feet per hour.

Karst pathways can serve as underground tributaries to surface water, and thus can serve as a transport pathway for pollutants to streams. Improper waste management activities (e.g. dumping into sinkholes, poorly installed or failing on site sewage treatment and disposal system[OSTDS]) or improper best management practices (e.g. lack of buffer strips around sinkholes in agricultural fields) can lead to direct contamination of water supplies. Karst also provides a challenge for nonpoint source pollution management as its pathways have long been regarded as "nature's sewer system" – sinkhole plains, sinking streams, and springs provide a direct connection between surface water and groundwater systems.

Several geologic faults occur in the Hardwick Creek watershed (Figure 3.4). The presence of faults in a watershed has the potential to influence groundwater/surface water flow. Typically, surface water flow will parallel a fracture zone for a distance before sinking off a non-soluble bedrock into a soluble limestone bedrock, near a fault. In the same way, groundwater flow may parallel a fracture zone for a distance before emerging as a spring near the contact (fault) between the soluble limestone and non-soluble bedrock.

The major area of the Hardwick Creek Watershed is rated as 2 in terms of the groundwater sensitivity (Figure 3.4). Because much of the watershed is underlain by carbonate rocks, this watershed has a moderate to high sensitivity rating for the potential of the groundwater to be contaminated by surface activities. Dye traces have not been conducted to date in the Hardwick Creek watershed. Dry traces would provide data to understand the connections between karst features and underground flow routes.

The soil in the Hardwick Creek watershed is diverse with more than 30 soil types representing this watershed (Figure 3.6). The dominant soil is Carpenter-Bledsoe-Berks complex which occupies 44% of watershed area. And the secondary prevalence are Jessietown-Muse-Rohan complex (11% of the watershed area) and Westbend silt loam (10% of the watershed area), which occupy the downstream area.

Soil erosion and water runoff can both move bacteria to a stream or to groundwater. The hydrologic soil groups (HSG) in the majority of the Hardwick Creek watershed are group B and C (Figure 3.7). The HSG is used to relay information about the runoff potential of a soil when thoroughly wet. HSGs B and C are rated as moderate and moderately high runoff potential, respectively (USDA-NRCS, 2009).

The USDA Natural Resources Conservation Service (NRCS) rates the performance of septic tank absorption fields. Soil ratings are based on soil properties, site features, and the observed performance of the soils - permeability, a high water table, depth to bedrock or to a cemented

pan, and flooding affect absorption of septic tank effluents. The soils in the Hardwick Creek watershed are rated as very limited for septic tank suitability as shown in Figure 3.8.

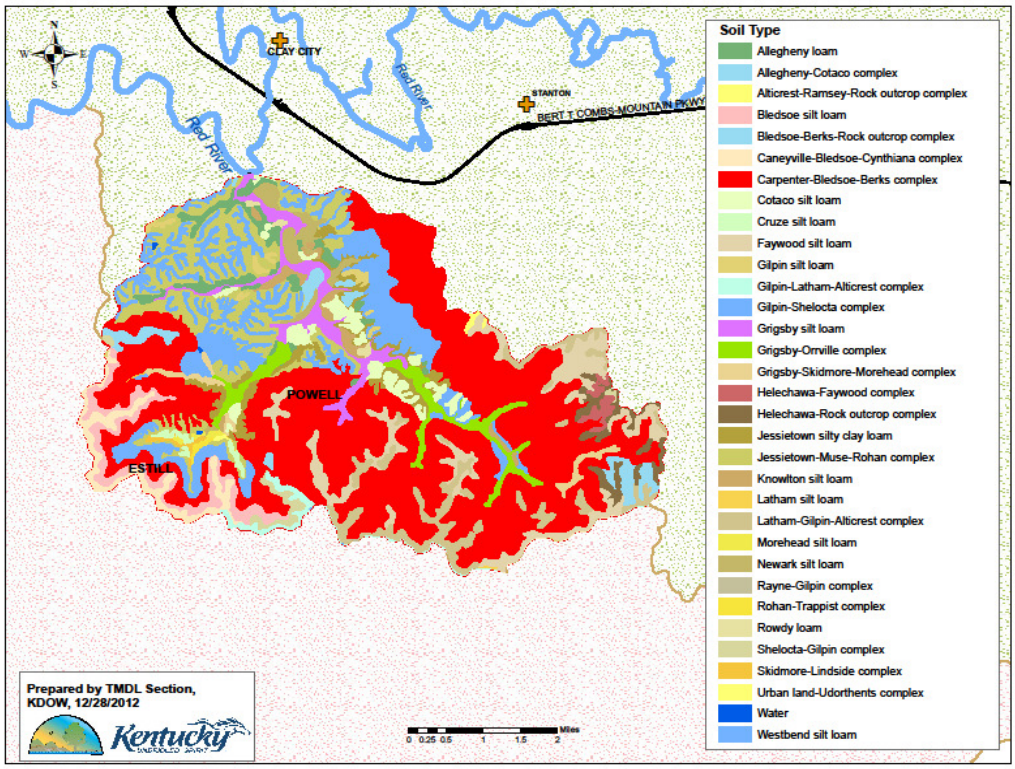

Figure 3.6 Soil type of the Hardwick Creek Watershed

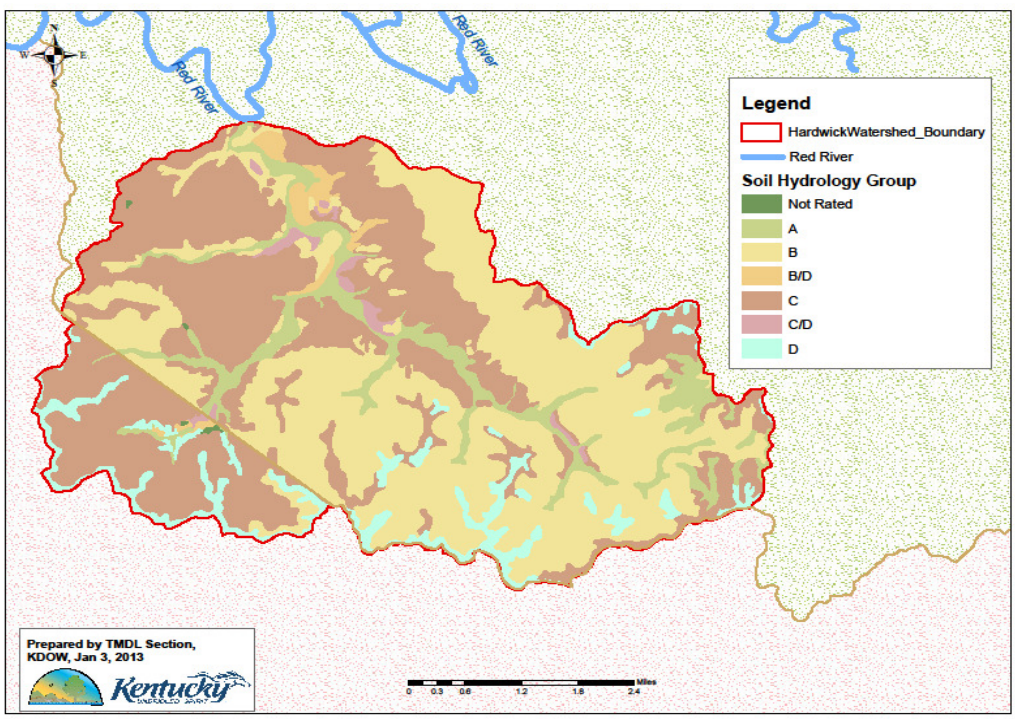

Figure 3.7 Soil Hydrology Group of the Hardwick Creek Watershed

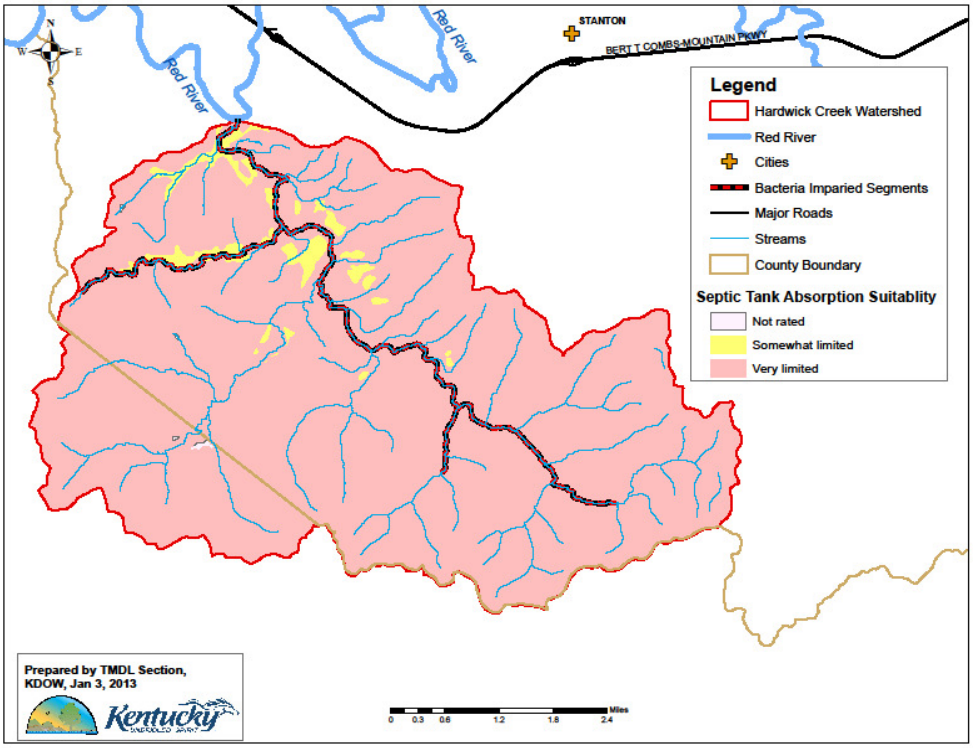

Figure 3.8 Soil Suitability for Septic Tanks of the Hardwick Creek Watershed

3.2 Hydrology

KDOW follows the Strahler (1952) method for stream order determination where small upstream segments with no tributaries are first order. When two first order streams merge, they form a second order stream segment; two second order segments merge to form a third order segment; and so on. In this method, a first order segment merging with a second order segment results in a continuation of the second order segment; order only increases when segments with the same order merge or if a tributary to a main segment has a larger order. First order streams tend to be small and carry little flow except during wet weather events while larger stream orders indicate larger systems with greater flow. At the outlet to the Red River, the Hardwick Creek is a third order stream.

There are no USGS flow gages or water withdrawals located within the Hardwick Creek watershed. There are 80 acres of identified wetland in the watershed (Figure 3.9).

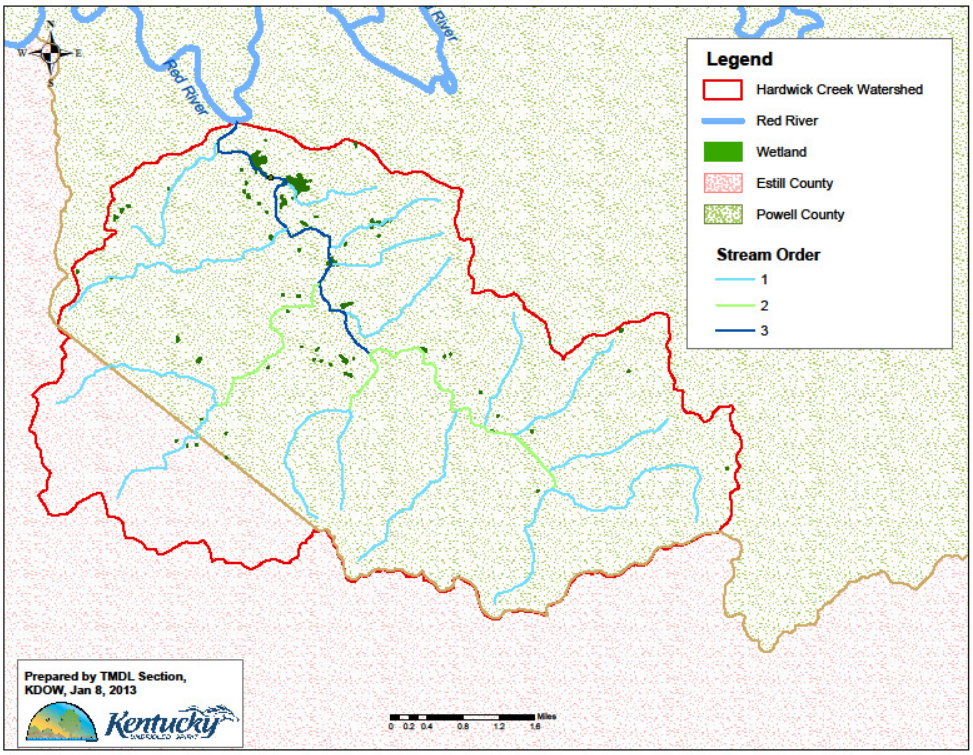

Figure 3.9 Stream Order and Wetland in the Hardwick Creek Watershed

3.3 Land Cover Distribution

The 2001 National Land Cover Dataset (USGS, 2003) was used to determine the land cover within the Hardwick Creek watershed. The 2001 National Land Cover Database (NLCD) Land Cover Class Definitions are in Appendix A. Table 3.2 lists the percent land cover by class within the watershed. To simplify the pollutant source analysis, some similar land cover categories were combined as following: all forested land (deciduous, evergreen and mixed) and shrubbery being aggregated and reported as one category - Forest; all residential land cover being aggregated and reported as one category- Developed; all wetland types being aggregated and reported as one category – Wetlands; and all agricultural land uses being aggregated into one category- Agriculture- but being presented individually.

The watershed consists primarily of forest land, and agricultural land of pasture/hay occupies 14% of the watershed area along the Hardwick Creek, Frames Branch and Little Hardwick Creek (Figure 3.10).

Table 3.2 Land Cover in the Hardwick Creek Watershed

Land Cover	SQ_MILES	ACRES	Percent (%)
Developed	0.96	684	3.92
Water	0.02	16	0.09
Barren	0.00	10	0.06
Forest	20.27	13236	75.85
Grassland	1.01	724	4.15
Agriculture	4.20	2729	15.64
Pasture/Hay	3.74	2423	13.89
Cultivated Crops	0.46	306	1.75
Wetlands	0.01	50	0.29

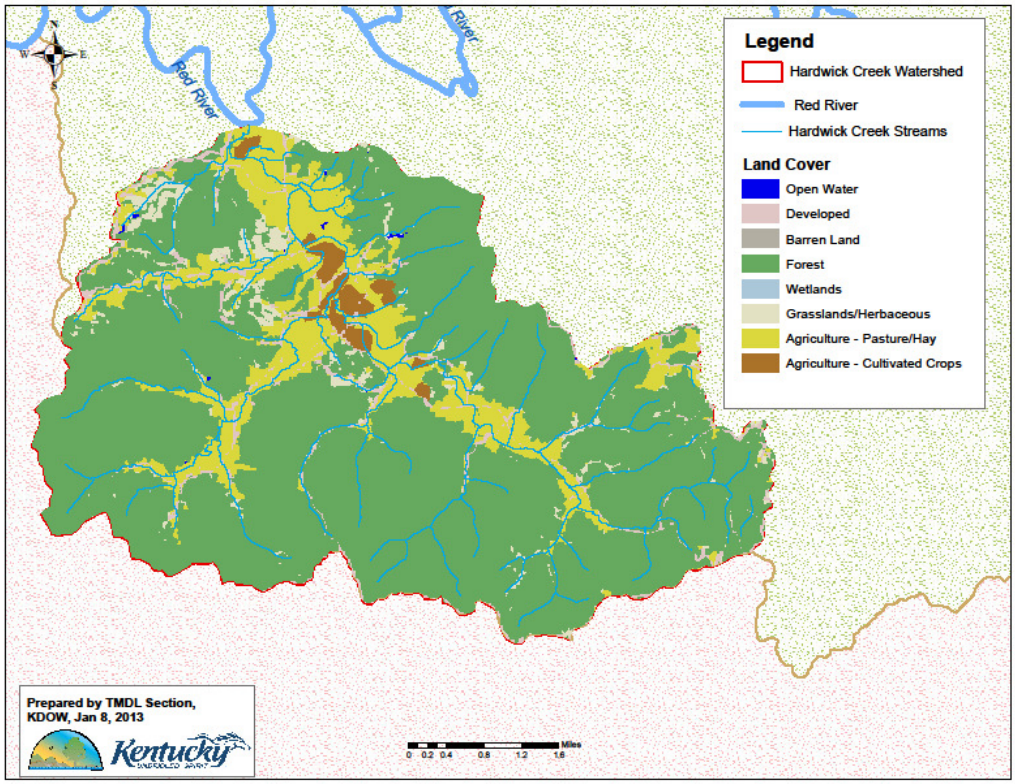

Figure 3.10 Land Cover of the Hardwick Creek Watershed

4.0 Monitoring

During the PCR season in 2006, *E. coli* samples were collected at 6 sampling sites within the watershed (Figure 4.1). The monitoring results in 2006 were used to define the impairments (Table 4.1) as well as to develop the *E. coli* TMDL document for the Hardwick Creek watershed. Sampling station locations are summarized in Table 4.2, and sampling data are summarized in Table 4.3.

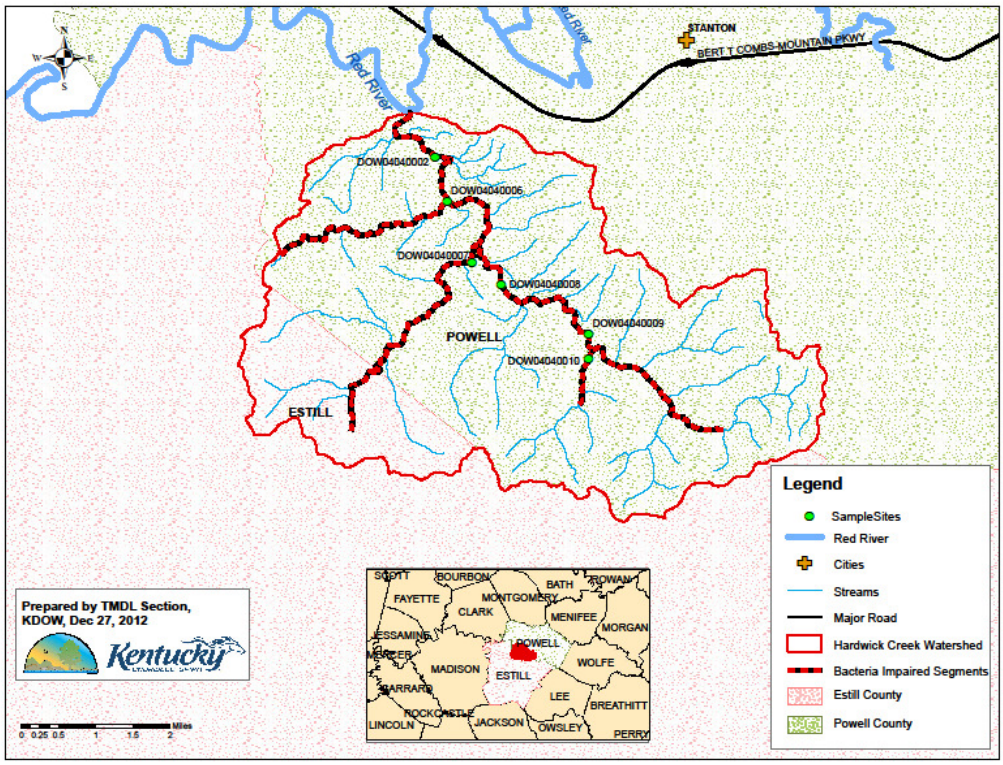

Figure 4.1 Sampling sites in the Hardwick Creek Watershed

Table 4.1 Impaired Waterbodies in the Hardwick Creek Watershed

Waterbody & Segment	County	Support Status	Impaired Use
Branham Branch 0.0 to 0.8	Powell	Partial support	PCR
Little Hardwick Creek 0.0 to 4.2	Powell; Estill	Nonsupport	PCR
Frames Branch 0.0 to 2.95	Powell	Nonsupport	PCR
Hardwick Creek 3.25 to 8.6	Powell	Nonsupport	PCR
Hardwick Creek 0.0 to 3.25	Powell	Nonsupport	PCR

Table 4.2 Sampling sites in the Hardwick Creek Watershed

Station Name	Latitude	Longitude	Stream Segment	RM
DOW04040002 (2006)	37.82361	-83.92056	Hardwick Creek 0.0 to 3.25	1.15
DOW04040010 (2006)	37.7837	-83.8839	Branham Branch 0.0 to 0.8	0.1
DOW04040007 (2006)	37.80319	-83.91210	Little Hardwick Creek 0.0 to 4.2	0.3
DOW04040006 (2006)	37.81500	-83.91790	Frames Branch 0.0 to 2.95	0.1
DOW04040008 (2006)	37.7985	-83.9050	Hardwick Creek 3.25 to 8.6	4.1
DOW04040009 (2006)	37.7886	-83.8838	Hardwick Creek 3.25 to 8.6	5.85

Table 4.3 TMDL Sample Site Data Summary

Station Name	Number of Observations	% Exceeding WQC (240 colonies/100 ml)	Minimum (colonies/ 100 ml)	Maximum (colonies/ 100 ml)	Average (colonies/ 100 ml)
DOW04040002	9	56	44	24200	2923
DOW04040010	8	25	9	520	128
DOW04040007	9	56	83	17330	2252
DOW04040006	8	63	107	10460	1683
DOW04040008	9	100	717	10500	2341
DOW04040009	9	78	10	11200	1890

During the PCR season in 2006, *E. coli* samples were collected at 6 sampling sites within the watershed. Validated *E. coli* data was used to perform stream assessment according to 305(b) listing requirements. Assessment results indicated that 4 additional stream segments within the watershed are bacterial impaired for the PCR use. Assessments from this monitoring were not included in the 2012 305(b) listing cycle. The proposed listings from these assessments are shown in Table 4.1.

Table 4.1 Proposed Listings in the Hardwick Creek Watershed

Waterbody & Segment	Impairment	County	WBID	Suspected Source(s)	Impaired Use (Support Status)[2]	Sites on Impaired Segment
Branham Branch 0.0 to 0.8 into Hardwick Creek[1]	*E. coli*[1]	Powell	KY510896_01	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR[3] (PS)	DOW04040010
Little Hardwick Creek 0.0 to 4.2 into Hardwick Creek[1]	*E. coli*[1]	Powell Estill	KY513488_01	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (NS)	DOW04040007
Frames Branch 0.0 to 2.95 into Hardwick Creek[1]	*E. coli*[1]	Powell	KY512238_01	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (NS)	DOW04040006
Hardwick Creek 3.25 to 8.6[1]	*E. coli*[1]	Powell	KY512561-02	On-site Treatment Systems (septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (NS)	DOW04040008 DOW04040009
Hardwick Creek 0.0 to 3.25 into Red River	*E. coli*[1]	Powell	KY512561_01	On-site Treatment Systems (Septic Systems and Similar Decentralized Systems) &Livestock (Grazing or Feeding Operations)	PCR (NS)	DOW04040002

Note: [1] Indicates a new listing not on the draft 2012 303(d) list.
[2]Support Status PS indicates that the segment is partially supporting and that a TMDL is required for the use; NS indicates that the segment is nonsupporting and that a TMDL is required for the use.
[3]PCR is the Primary Contact Recreation use.

5.0 Source Identification

For regulatory purposes, the sources of *E. coli* in a watershed can be placed into two categories: KPDES-permitted and non KPDES-permitted sources. A KPDES-permitted source requires a Kentucky Pollutant Discharge Elimination System (KPDES) discharge permit, a storm water permit, or a Municipal Separate Storm Sewer System (MS4) permit from the KDOW. KPDES discharge permits include wastewater treatment facilities that discharge directly to a stream, facilities discharging storm water, and some agricultural operations (e.g. Concentrated Animal Feeding Operations (CAFOs) with an individual discharge permit). KPDES is not the only permitting program that may affect water quality or quantity within a watershed; other permitting examples include water withdrawal permits, permits to build structures within a floodplain, permits to construct an on-site sewage treatment disposal system (OSTDS), and permits to land apply waste from sewage treatment plants. However, within the framework of the TMDL process a KPDES-permitted source is defined as one regulated under the KPDES program. Non KPDES-permitted sources include nonpoint sources of pollution. Nonpoint sources of pollution are often caused by runoff from precipitation over and/or through the ground and are correlated to land use.

5.1 KPDES-permitted Sources

Permitted sources include all sources regulated by the KPDES permitting program. In 401 KAR 10:001, KDOW adopted the definition of a point source per 33 U.S.C. 1362(14) as "any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or concentrated animal feeding operation or vessel or other floating craft, from which pollutants are or may be discharged." However, 401 KAR 10:001 exempts "agricultural storm water run-off or return flows from irrigated agriculture" from the definition of a point source. A Waste Load Allocation (WLA) is assigned to KPDES-permitted sources. There are no KPDES-permitted sources in this watershed.

5.1.1 Sanitary Wastewater Systems

Sanitary Wastewater Systems (SWSs) include all facilities with a design flow which are permitted to discharge *E. coli*. This includes Wastewater Treatment Plants (WWTPs), Sewage Treatment Plants (STPs), package plants and home units. There are no permitted SWSs within the Hardwick Creek watershed.

5.1.2 MS4 Sources

MS4s are defined in 401 KAR 5:002. EPA has categorized MS4s into three categories: small, medium, and large. The medium and large categories are regulated under the Phase I Storm Water program. Large systems, such as the cities of Lexington and Louisville, have populations

in excess of 250,000. Medium systems have populations in excess of 100,000 but less than 250,000; however, there are currently no medium-sized systems in Kentucky. Phase I systems have five-year permitting cycles and have annual reporting requirements. The small MS4 category includes all MS4s not covered under Phase I. Since this category covers a large number of systems, only a select group are regulated under the Phase II rule, either being automatically included based on population (i.e., having a total population over 10,000 or a population per square mile in excess of 1000) or on a case-by-case basis due to the potential to cause adverse impact on surface water. Water quality monitoring is not a requirement of Phase II MS4s, unless the waterbody has an approved TMDL and the MS4 causes or contributes to the impairment for which the TMDL was written. A WLA is assigned to all MS4 permit holders, including the KYTC, universities and military bases. There are no MS4 entities within the Hardwick Creek watershed.

5.1.3 Combined Animal Feeding Operations

Operations that are defined as a CAFO pursuant to 401 KAR 5:002 are required to obtain a KPDES permit. Once defined as a CAFO, the operation can be permitted under a KPDES General Permit or a KPDES Individual Permit depending upon the nature of the operation. Conditions of both types of permits include no discharge to surface waters; however, holders of a KPDES Individual Permit may discharge to surface waters during a 25-year (24-hour) or greater storm event.

There are no known regulated CAFOs in the Hardwick Creek watershed. However, there could be non-point source animal operations or small farm operations that do not require a KDOW permit.

5.2 Non KPDES-permitted Sources

Non KPDES-permitted sources include all sources not permitted by the KPDES permitting program and are often associated with land use. The loads to surface water from non-KPDES permitted sources are regulated by laws such as the Kentucky Agricultural Water Quality Act (AWQA, KRS 224.71-100 through 224.71-145, i.e., implementation of individual agriculture water quality plans and corrective measures), the federal Clean Water Act (i.e., the TMDL process) and 401 KAR 5:037 (Groundwater Protection Plans [GPPs]), among others. Unlike KPDES-permitted sources, non KPDES-permitted sources typically discharge pollutants to surface water in response to rain events. A Load Allocation (LA) is assigned to non KPDES-permitted sources.

5.2.1 Kentucky No Discharge Operating Permits

As stated in 401 KAR 5:005, facilities with agricultural waste handling systems or that dispose of their effluent by spray irrigation but do not discharge to surface waters are required to obtain a Kentucky No Discharge Operating Permit (KNDOP) from the KDOW prior to construction and operation. Animal Feeding Operations (AFOs) receive KNDOP permits. These operations

handle liquid waste in a storage component of the operation (e.g. lagoon, pit, or tank) and may land apply the waste via spray irrigation or injection to cropped acreages. Land application of the waste that results in runoff to a stream is prohibited. Facilities that handle animal waste as a liquid are required to submit a Short Form B, construction plans, and a Comprehensive Nutrient Management Plan to the KDOW. Also included in KNDOP requirements are golf courses that land apply treated wastewater via spray irrigation, typically from a holding pond - some industrial operations also spray-irrigate.

There is one KNDOP facility locating in the Hardwick Creek watershed (Figure 5.1), which is an industrial KNDOP associated with a wood mulch operation. The permit was not written for a domestic wastewater, therefore, the no-discharge KNDOP would not be an expected source of pathogens.

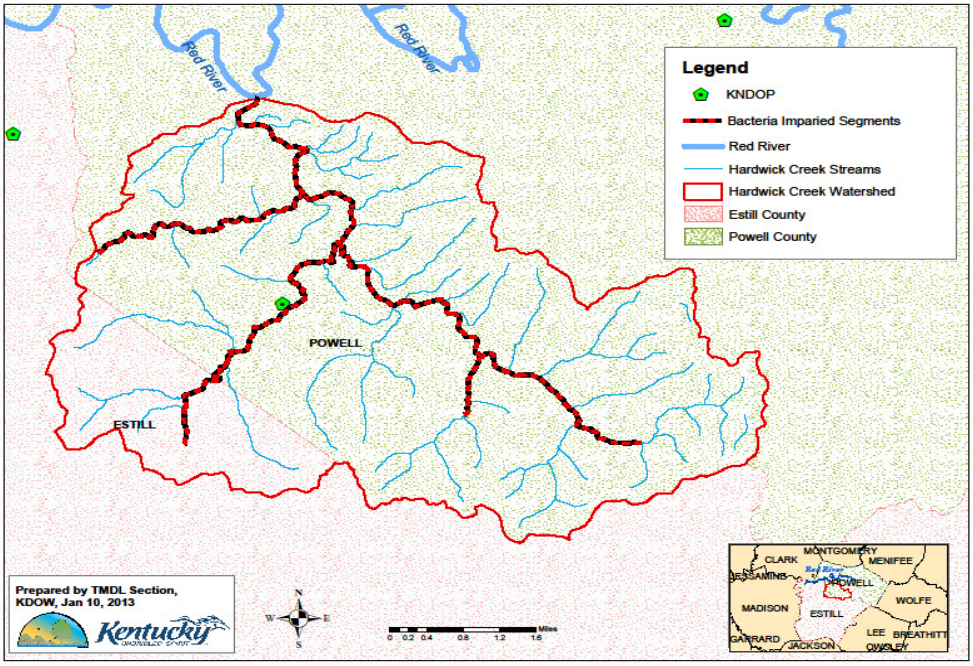

Figure 5.1 KNDOP in the Hardwick Creek Watershed

5.2.2 Agriculture

The Kentucky AWQA was passed by the 1994 General Assembly. The law focuses on the protection of surface water and groundwater resources from agricultural and silvicultural activities. The Act created the Kentucky Agriculture Water Quality Authority (KAWQA), a 15-member peer group comprising farmers and representatives from various agencies and organizations. The Act requires farms greater than 10 acres in size to adhere to the Best Management Practices (BMPs) specified in the Kentucky Agriculture Water Quality Plan. Specific BMPs have been designated for all operations.

The USDA National Agricultural Statistics Service (NASS) compiles Census of Agriculture data by County for virtually every facet of U.S. agriculture (USDA, 2007). Selected agricultural data from the latest Census of Agriculture reports for Powell and Estill Counties are listed in Table 5.1. These data are based on County-wide data with no assumptions made on a watershed level. The percentage of agricultural types of land cover is calculated in Table 3.1 (Section 3.3).

Table 5.1 Agricultural Statistics from the 2007 USDA Agricultural Census

	Powell County	Estill County
Farms (number/acres)	236/32,763	456/64,780
Total Cropland (acres)	13,255	22,546
Cattle and Calves Inventory (total number)	2,506	7,764
Beef Cows (total number)	1,711	(D)
Milk Cows (total number)	6	(D)
Horses and Ponies (total number)	-	-
Goats (total number)	-	-
Hogs and Pigs (total number)	10	1,949
Sheep and Lamb (total number)	(D)	2,436
Poultry Layers (total number)	139	459
Poultry Broilers (total number)	-	-
Corn for grain (acres)	1,204	915
Wheat for grain (acres)	0	(D)
Corn for Silage (acres)	0	29
Forage (acres)	4,731	11,677

(D) = data withheld to avoid disclosing data for individual farms
- = No data

5.2.3 Wildlife

Wildlife contributes bacteria to the Hardwick Creek watershed. Table 5.2 shows the estimates of deer density and population in Powell and Estill County, as provided by the Kentucky Department of Fish and Wildlife Resources (Kentucky Department of Fish and Wildlife Resources, 2006). Estimates on numbers of other types of animals are not available. Although wildlife contributes bacteria to surface water, such contributions represent natural background conditions, and do not receive a reduction as part of the TMDL.

Table 5.2 Number of Deer in Estill and Powell County

County	Deer Per Square Mile	Number of Deer
Estill	12	2,987
Powell	12	1,997

5.2.4 Human Waste

Human waste disposal is of particular concern in rural areas. Areas not served by sewers either employ an On Site Sewage Treatment and Disposal Systems (OSTDSs) or do not treat their sewage. OSTDS, including septic tank systems, are commonly used in areas where providing a centralized sewage collection and treatment system is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, septic systems are an effective means of disposing and treating domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, they can be a source of *E. coli* to both groundwater and surface water, see Section 5.3, Illegal Sources, for further discussion of failing OSTDSs.

Another type of non KPDES-permitted source that may exist in the watershed is straight-pipes, which are discrete conveyances that discharge sewage, gray water (i.e., water from household sinks, laundry, etc.), and stormwater to the surface waters of the Commonwealth without treatment.

Figure 5.2 shows the 2010 census blocks of population data in the Hardwick Creek watershed. Because there are no known sewer lines or wastewater treatment plants in the watershed, the entire population is estimated to be served by OSTDSs or to have no sewage treatment (i.e. use straight pipes). In the future when the economy improves, the Red River Authority may start exploring the feasibility of extending sewer service to people who live in Estill and Powell counties.

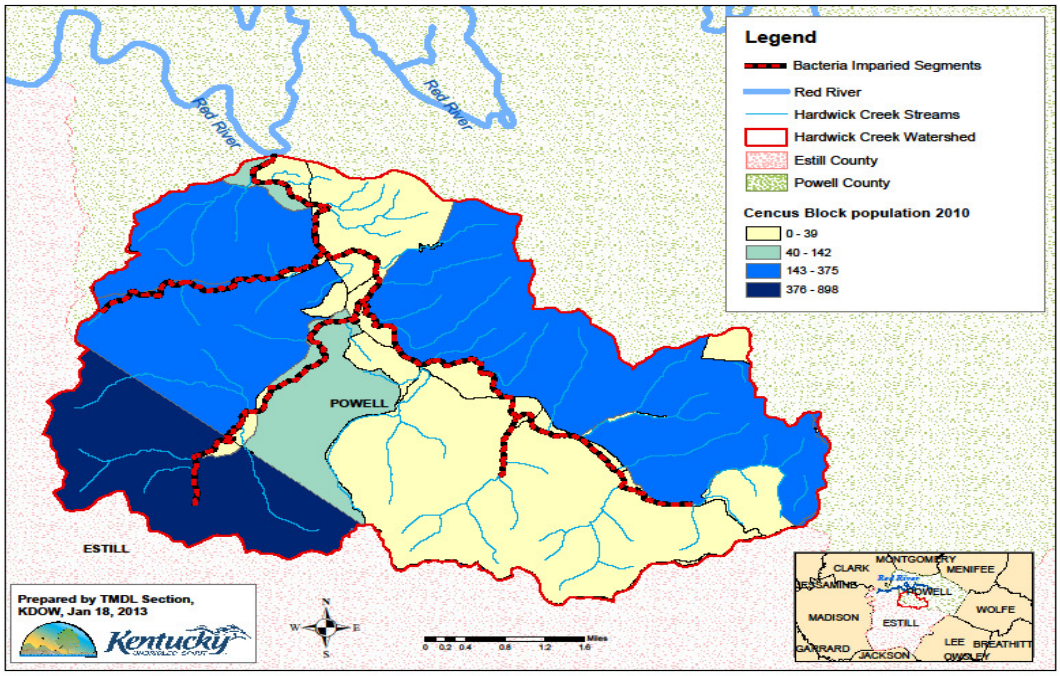

Figure 5.2 2010 Census Blocks of Population of the Hardwick Creek Watershed

5.2.5 Household Pets

Although household pets undoubtedly exist in this watershed, their contribution to the LA is deemed to be minimal compared to other sources. Pet waste may, however, be a larger contributor to bacteria runoff in areas where there is a higher density of households and less-permeable surfaces.

5.3 Illegal Sources

Both KPDES-permitted and non KPDES-permitted sources can discharge bacteria to surface water illegally. This includes sources that are illegal simply by their existence, such as straight-pipes and SSOs, which receive no allocation. There may also be legal sources that are operating illegally (e.g., outside of regulations, permit limits or conditions, etc.), such as a WWTP bypass or a failing OSTDSs, which receive no allocation above that of a properly functioning system (see Section 7.0 for TMDL allocations).

Another potential illegal source is livestock on farms that have no BMPs (as required under the AWQA) as well as farms where BMPs are present but are insufficient or failing in a manner that causes or contributes to surface water impairment; such farms receive no allocation above that of a farm with properly installed and functioning BMPs. Also included are KNDOPs, AFOs and CAFOs not in compliance with the appropriate regulations that cause or contribute to surface water impairment.

KDOW expects implementation of these TMDLs to begin with the elimination of illegal sources. This is intended to prevent legally operating sources from having to effect reductions in order to accommodate the pollutant loading of illegal sources. Note this Section of the TMDL is not intended to summarize the universe of potential illegal sources that may discharge pollutants into surface waters, nor does it attempt to summarize the universe of legal sources that may be operating illegally. Instead, it gives examples of illegal sources known to be present or that could be present in the watersheds (e.g., straight-pipes).

6.0 Water Quality Criterion

The WQC in 401 KAR 10:031 (Kentucky's Surface Water Standards) for the PCR use are based on *E. coli*. per 401 KAR 10:031:

"The following criteria shall apply to waters designated as primary contact recreation use during the primary contact recreation season of May 1 through October 31: Fecal coliform content or Escherichia coli *content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for* Escherichia coli*."*

There are insufficient *E. coli* measurements to calculate a 5-sample, 30-day geometric mean, so the instantaneous criterion of 240 colonies/100 ml was applied to calculate allowable loadings to bring the watershed into compliance with the PCR designated use. See Section 7.0 for TMDL loading calculations. When multiple sample sites were located within an impaired segment, the site with the greatest bacteria exceedance was used to establish the TMDL. TMDLs for the impaired stream segments within the Hardwick Creek watershed can be found in Section 8.2 of this document.

7.0 Total Maximum Daily Load

7.1 TMDL Equation and Definitions

A TMDL calculation is performed as follows:

$$TMDL = WLA + LA + MOS$$
(Equation 1)

The WLA usually has three components:

$$WLA = SWS\text{-}WLA + MS4\text{-}WLA + Future\ Growth\text{-}WLA$$
(Equation 2)

but there were no SWS or MS4 sources in this watershed so the WLA was only divided to the Future Growth-WLA.

Definitions:
TMDL: the WQC, expressed as a load. The WQC is defined in Section 6.0 as an instantaneous concentration of 240 colonies/100 ml for *E. coli*.
MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits and water quality.
TMDL Target: the TMDL minus the MOS.
WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from KPDES-permitted sources, such as SWSs and MS4s.
SWS-WLA: the WLA for KPDES-permitted sources, which have discharge limits for pathogen indicators (including wastewater treatment plants, package plants and home units).
Future Growth-WLA: the allowable loading for future KPDES-permitted sources, including new SWSs, expansion of existing SWSs, new storm water sources, and growth of existing storm water sources (such as MS4s). Also includes the allocation for the KPDES-permitted sources that existed but were not known at the time the TMDL was written.
Remainder: the TMDL minus the MOS and minus the SWS-WLA (also equal to Future Growth-WLA plus the MS4-WLA and the LA).
MS4-WLA: the WLA for KPDES-permitted municipal separate storm water sewer systems (including cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet, universities and military bases).
LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.
Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.

Critical Condition: the time period when the pollutant conditions are expected to be at their worst.
MAF: the Mean Annual Flow as defined by USGS.
Adjusted MAF: the MAF plus SWS-WLA design flows.
Critical Flow: the flow used to calculate the TMDL as a load (is equivalent to the Adjusted MAF for MAF TMDLs)
Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.
Percent Reduction: the loading reduction needed to bring the existing condition in line with the TMDL target.
Load: concentration * flow * conversion factor
Concentration: colonies per 100 milliliters (colonies/100ml)
Flow (i.e. stream discharge): cubic feet per second (cfs)
Conversion Factor: the value that converts the product of concentration and flow to load (in units of colonies per day); it is derived from the calculation of the following components: (28.31685L/f^3 * 86400seconds/day * 1000ml/L)/ (100ml) and is equal to 24,465,758.4.

Calculation Procedure:

1) The MOS, if an explicit value, is calculated and subtracted from the TMDL first, giving the TMDL Target and TMDL Remainder;
2) Percent reductions are calculated to show the difference between Existing Conditions and the TMDL Target;
3) The Future Growth-WLA is calculated and subtracted from the Remainder;
4) Leaving the LA.

7.2 Seasonality

Yearly factors such as temporal variations on source behavior and stream loading than can affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses. This TMDL addresses seasonality by only using samples collected within the PCR season (May 1 – October 31).

7.3 Critical Condition

The critical condition for nonpoint source bacteria loadings is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, bacteria builds up on the land surface, and are washed off by subsequent rainfall. Conversely, the critical condition for point source loading typically occurs during periods of low streamflow when dilution is minimized. There are no existing KPDES-permitted sources within the Hardwick Creek watershed. The critical condition for each bacteria-impaired segment is defined by the sample showing the highest exceedance.

7.4 Determine Mean Annual Flow

The Pathogen TMDL Standard Operating Procedure (SOP) (KDOW, 2011) was followed to determine flows and TMDLs for this document. The USGS publishes Mean Annual Flow (MAF) data on the internet via the "Hydrology of Kentucky" geographic data explorer (http://kygeonet.ky.gov/kyhydro/main.htm).

The MAF is calculated from multiple regression equations found in the USGS Report "Low-Flow Characteristics of Kentucky Streams" (Martin 2002). Mean Annual Flows were used to convert concentrations of *E. coli* into loads of *E. coli*. The MAF was determined at the downstream end of each impaired segment. When multiple sites were located on one impaired segment, the MAF for upstream sites was determined at the sample site location while it was determined at the end of the impaired segment for the downstream-most site.

7.5 Existing Load

Although not a part of the TMDL, existing loads were determined using the monitoring data. Existing loads provide a basis by which to determine the percent reduction that would have been required to meet the TMDL limits at the time of sample collection. For each sample site, the sample with the greatest concentration of *E. coli* was used as the existing concentration for the site. This provides a worst-case scenario for percent reduction calculations (i.e., the percent reduction is the greatest required to bring existing loads to the TMDL loading requirements). Existing loads were calculated as:

$$\text{Greatest Concentration (colonies/100ml)} \times \text{MAF (cfs)} \times \text{Conversion Factor } 24{,}465{,}758.4 = \text{Existing Load (colonies/day)}$$

7.6 TMDL

The TMDL is the allowable loading in a watershed. Loads are portioned from this load to the MOS, WLA, and LA.

TMDLs were calculated for each site using the *E. coli* criterion of 240 colonies/100 ml:

$$240 \text{ (colonies/100ml)} \times \text{MAF (cfs)} \times \text{Conversion Factor } 24{,}465{,}758.4 = \text{TMDL (colonies/day)}$$

7.7 Margin of Safety

There are two methods for incorporating a MOS in the TMDL analysis: implicitly include the MOS using conservative assumptions, or explicitly designate a (numerical) portion of the TMDL as the MOS and divide the remainder of the allowable load (i.e., the TMDL Target load) between the LA and WLA. For this TMDL, a 10% explicit MOS (i.e., 10% of the WQC, or 24

colonies/100ml, but expressed as a load where possible) was reserved to address uncertainties involving loading from non-SWS sources. SWS sources have an implicit MOS based on the fact that they seldom operate at their design flow. The explicit MOS load was calculated using the following equation:

24 (colonies/100ml)	×	MAF (cfs)	×	Conversion Factor 24,465,758.4	=	MOS (colonies/day)

7.8 TMDL Target

The Target Load is defined as the load at the WQC minus the explicit MOS load. It was calculated for each site by subtracting the explicit MOS from the Total TMDL:

Target Load = Total TMDL – MOS.

It can also be calculated as:

216 (colonies/100ml)	×	MAF (cfs)	×	Conversion Factor 24,465,758.4	=	TMDL Target (colonies/day)

7.9 Percent Reduction

A percent reduction is not part of the TMDL calculation, however, for informational purposes, a percent reduction was calculated for each site to show the percent reduction that would have been required at the time the samples were taken in order to meet the Target Load. The percent reduction was calculated as:

Percent Reduction (%) = [(Existing Load – Target Load) / Existing Load] * 100

7.10 WLA

The WLA is the portion of the TMDL allocated to KPDES-permitted sources within the watershed.

7.10.1 SWS WLA

The SWS WLA load was calculated using the following equation:

WQC (colonies/100ml)	×	MAF (cfs)	×	Conversion Factor 24,465,758.4	=	WLA (colonies/day)

The individual SWS WLAs for each facility that discharges above or to an impaired segment are summed to create a final SWS WLA for that segment. Since there are no existing KPDES-

permitted sources within the Hardwick Creek watershed, the value of the SWS-WLA load is zero.

7.10.2 Remainder

The Remainder is not part of the TMDL; however, it is used in the TMDL calculations. It is calculated as the Target Load minus the sum of all individual SWS-WLAs. The Remainder value is the same as TMDL Target load since the value of the SWS-WLA load is zero for this watershed.

7.10.3 Future Growth-WLA

Because the WLA must include all KPDES-permitted sources, often a TMDL will anticipate future growth of these sources (i.e., an increase in the number of WLA sources or in the loading per discharger) in order to avoid having to re-open the TMDL and change the WLA when new sources begin discharging. Future growth is represented by a portion of the Remainder that is set aside (i.e., is not part of the LA nor is it part of the WLA for current/known sources). It can also include existing storm water sources that are later discovered to discharge the pollutant of concern, even though this fact was not known at the time the TMDL was written. The amount reserved for future growth is determined using Table 7.1, which assumes that growth occurs more rapidly in developed areas (which is determined by the sum of Developed Open Space, Developed Low Intensity, Developed Medium Intensity and Developed High Intensity areas as defined by the USGS NLCD) than in rural areas:

The Future Growth WLA is calculated using the following formula:

$$\text{Remainder} \times \text{Future Growth WLA percentage} = \text{Future Growth WLA}$$

Table 7.1 Future Growth

Percent Developed Area in the Subwatershed	Future Growth WLA Percentage
≥25%	5%
≥20% – <25%	4%
≥15% – <20%	3%
≥10% – <15%	2%
≥5% – <10%	1%
<5%	0.5%

7.11 LA

The LA is where non KPDES-permitted sources (i.e., nonpoint sources, or those sources not permitted by KPDES) receive their allocation within the TMDL. Non KPDES-permitted sources include properly functioning OSTDS (i.e. septic systems), wildlife, household pets and facilities (e.g., farms, landfarms for municipal STP sludge) with properly functioning BMPs. The LA is calculated using the following equation:

$$\text{Remainder} - \text{Future Growth WLA} = \text{LA}$$

The available sampling data were insufficient to apportion the existing loading among the various LA sources; therefore, it is attributed to all LA sources.

8.0 TMDL Calculations

8.1 Data Validation

The sampling data was validated as follows:

1. Quality Analysis/Quality Control samples (e.g., duplicates) were not considered during TMDL analysis.
2. Only samples collected from a flowing stream were considered in analysis.
3. Some samples were reported using either the *less than* (denoted using the "<") symbol or the *greater than* (denoted using the ">") symbol, indicating the true concentration was unknown but was either below or above the reported value, respectively. For these samples, the reported value was used verbatim. For *greater than* values, the exact value of the exceedance is unknown and likely higher than the number reported, however the sample still provides insight into the status of the waterbody at the time the sample was taken.

8.2 Individual Stream Segment Analysis

Data collection and analysis from various sources (including Federal, State and local government and public entities) was carried out for each individually listed stream segment and its associated drainage area. Most of the data collected for the development of this document can be accessed and downloaded from the KYGEONET (http://kygeonet.ky.gov). In this section, descriptions of each impaired subwatershed are presented along with tables of land cover, general subwatershed information and TMDL allocations. The land cover table for each segment includes the percentage used to calculate the Future Growth WLA. The Waterbody Identification Number (WBID) is included in the table of general information about the impaired segment. This number is a unique identifier assigned to all assessed waters in KY. It is based upon the USGS Geographic Names Information System (GNIS) (USGS, 1999) with a KY in front of the GNIS number and a _## where ## is a segment identification number.

8.2.1 Branham Branch RM 0.0 to 0.8

Branham Branch is a first order stream. Table 8.1 displays the Branham Branch RM 0.0 to 0.8 information, including sample site location, catchment area and MAF. This subwatershed consists primarily of forest land (96.7%), agricultural land of pasture/hay (1.2%) and developed area (1.7%). (Figure 8.1 and Table 8.2). Sampling data is presented in Table 8.3 and TMDL allocations in Table 8.4.

The sample station (DOW04010010) is located at RM 0.1 of the Branham Branch. The watershed areas above the station and the impaired segment have a difference of 1.3%. However, since this station is very close to the end of the impaired segment, the MAFs are identical. Also

there are no MS4 areas in this subwatershed, so the separate maps, land cover tables and TMDL calculations are not needed for this station.

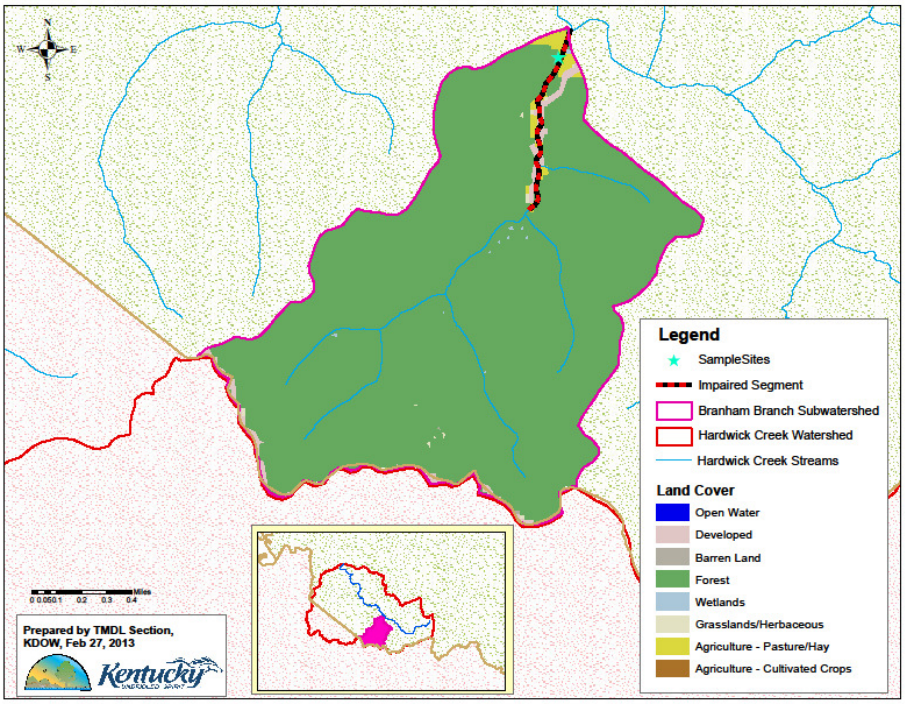

Figure 8.1 Land Cover and TMDL Site Location in the Branham Branch 0.0 to 0.8 Subwatershed

Table 8.1 Branham Branch RM 0.0 to 0.8 Segment Information

WBID	Stream	Lat	Segment	MAF	Square Miles	County
KY510896_01	Branham Branch	37.7837	Branham Branch RM 0.0 - 0.8	2.6	2.04	Powell
Station ID	River Mile	Long	Stream Order	RM for MAF calculation	Acres	
DOW04040010	0.1	-83.8839	1	0	1304	

Table 8.2 Land Cover in the Branham Branch RM 0.0 to 0.8 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.03	21.6	1.66	0.5
Barren	0.00	0.4	0.03	
Forest	1.96	1257.7	96.70	
Grassland	0.00	3.1	0.24	
Ag-Pasture/Hay	0.03	15.9	1.22	
Wetlands	0.00	2.0	0.15	

Table 8.3 Branham Branch RM 0.0 to 0.8 Data

Collection Date	*E. coli* (cfu/100ml)	Discharge (cfs)	Instantaneous Load (colonies/day)
5/15/2006	22	0.26	1.40E+08
6/22/2006	9	0.003	6.61E+05
7/11/2006	276	0.077	5.20E+08
8/23/2006	70	0.058	9.93E+07
9/12/2006	25	0.002	1.22E+06
9/19/2006	520	1.23	1.56E+10
9/19/2006 (QA Sample)	770	1.33	
9/27/2006	63	0.851	1.31E+09
10/10/2006	41	0.228	2.29E+08
Highest Concentration	520		

Table 8.4 TMDL Calculations for the Branham Branch RM 0.0 to 0.8

TMDL Table	Load
Existing Load	3.31E+10
Total TMDL	1.53E+10
MOS	1.53E+09
Target Load	1.37E+10
% Reduction	58.5
Remainder	1.37E+10
Future Growth WLA	6.87E+07
LA	1.37E+10

8.2.2 Little Hardwick Creek RM 0.0 to 4.2

Little Hardwick Creek is a second order stream. Table 8.5 displays the Little Hardwick Creek RM 0.0 to 4.2 information, including sample site location, catchment area and MAF. This subwatershed consists primarily of forest land (80%), agricultural land (14%) and developed area (2.9%) (Figure 8.2 and Table 8.6). Sampling data is presented in Table 8.7 and TMDL allocations in Table 8.8.

The sample station (DOW04010007) is located at RM 0.3 of the Little Hardwick Creek. Since this station is very close to the end of the impaired segment, the MAFs are identical. Also, the watershed areas above the station and the impaired segment have a difference less than 1% and no MS4 existed in the watershed, so the separate maps, land cover tables and TMDL calculations are not needed for this station.

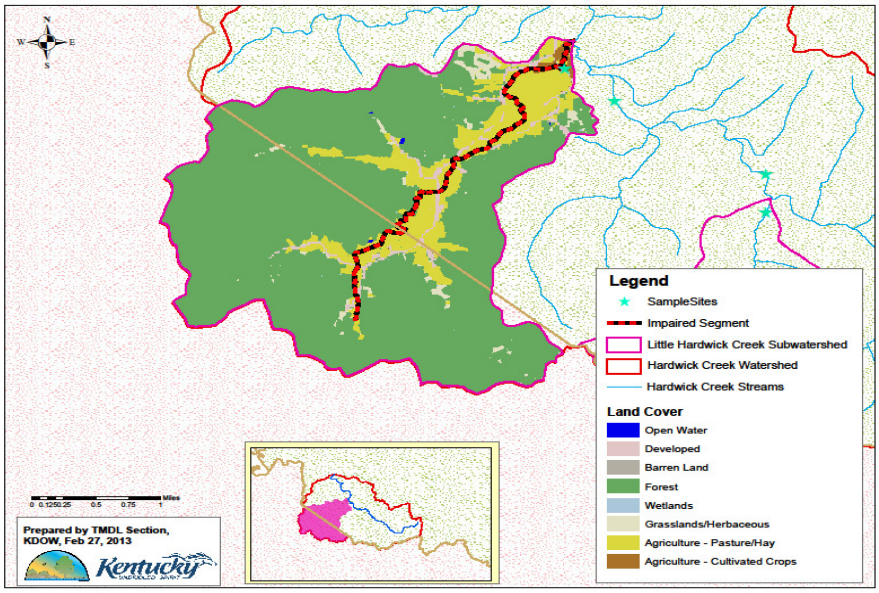

Figure 8.2 Land Cover and TMDL Site Location in the Little Hardwick Creek RM 0.0 to 4.2 Subwatershed

Table 8.5 Little Hardwick Creek RM 0.0 to 4.2 Segment Information

WBID	Stream	Lat	Segment	MAF	Square Miles	County
KY513488_01	Little Hardwick Creek	37.80319	Little Hardwick Creek 0.0 to 4.2	8.6	6.79	Powell, Estill
Station ID	River Mile	Long	Stream Order	RM for MAF calculation	Acres	
DOW04040007	0.3	-83.9121	2	0	4340	

Table 8.6 Land Cover in the Little Hardwick Creek RM 0.0 to 4.2 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.172	126.8	2.93	0.5
Water	0.005	2.9	0.07	
Barren	0.001	1.0	0.02	
Forest	5.360	3485.4	80.45	
Grassland	0.129	99.4	2.30	
Ag	0.945	609.6	14.07	
Pasture/Hay	0.910	584.6	13.49	
Cultivated Crops	0.035	25.0	0.58	
Wetlands	0.001	7.0	0.16	

Table 8.7 Little Hardwick Creek RM 0.0 to 4.2 Data

Collection Date	E. Coli (cfu/100ml)	Discharge (cfs)	Instantaneous Load (colonies/day)
5/15/2006	250	0.686	4.20E+09
6/22/2006	196	0.131	6.28E+08
7/11/2006	649	0.073	1.16E+09
8/10/2006	172	0.001	4.21E+06
8/10/2006 (QA Sample)	101	n/a	
8/23/2006	308	0.202	1.52E+09
9/12/2006	83	0.045	9.14E+07
9/19/2006	17330	5.26	2.23E+12
9/27/2006	1046	3.063	7.84E+10
10/10/2006	231	0.985	5.57E+09
Highest Concentration	17330		

Table 8.8 TMDL Calculations for the Little Hardwick Creek RM 0.0 to 4.2

TMDL Table	Load
Existing Load	3.65E+12
Total TMDL	5.05E+10
MOS	5.05E+09
Target Load	4.54E+10
% Reduction	98.8
Remainder	4.54E+10
Future Growth WLA	2.27E+08
LA	4.52E+10

8.2.3 Frames Branch RM 0.0 to 2.95

Frames Branch is a first order stream. Table 8.9 displays the Frames Branch RM 0.0 to 2.95 information, including sample site location, catchment area and MAF. This subwatershed consists primarily of forest land (62%), agricultural land of pasture/hay (19.2%) and developed area (7.3%) (Figure 8.3 and Table 8.10). Sampling data is presented in Table 8.11 and TMDL allocations in Table 8.12.

The sample station (DOW04010006) is located at RM 0.1 of the Frames Branch. Since this station is very close to the end of the impaired segment, the MAFs are identical. Also, the watershed areas above the station and the impaired segment have a difference less than 1% and no MS4 existed in the watershed, so the separate maps, land cover tables and TMDL calculations are not needed.

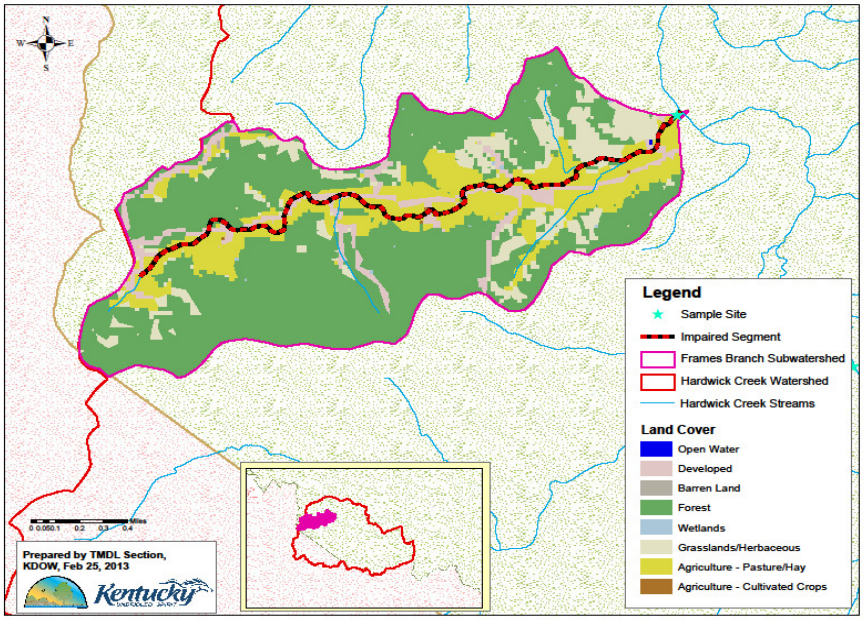

Figure 8.3 Land Cover and TMDL Site Location in the Frames Branch 0.0 to 2.95 Subwatershed

Table 8.9 Frames Branch RM 0.0 to 2.95 Segment Information

WBID	Stream	Lat	Segment	MAF	Square Miles	County
KY512238_01	Frames Branch	37.815	Frames Branch 0.0 - 2.95	2.5	1.99	Powell
Station ID	River Mile	Long	Stream Order	RM for MAF calculation	Acres	
DOW04040006	0.1	-83.9179	1	0	1276	

Table 8.10 Land Cover in the Frames Branch RM 0.0 to 2.95 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.13	93.1	7.31	1
Water	0.00	0.2	0.02	
Barren	0.00	0.4	0.03	
Forest	1.16	785.7	61.68	
Grassland	0.21	146.9	11.53	
Ag	0.37	244.5	19.20	
Pasture/Hay	0.37	243.4	19.11	
Cultivated Crops	0.00	1.1	0.09	
Wetlands	0.00	2.9	0.22	

Table 8.11 Frames Branch RM 0.0 to 2.95 Data

Collection Date	E. Coli (cfu/100ml)	Discharge (cfs)	Instantaneous Load (colonies/day)
5/15/2006	410	0.293	2.94E+09
6/22/2006	107	0.005	1.31E+07
6/22/2006 (QA Sample)	172		
7/11/2006	1046	0.014	3.58E+08
7/11/2006 (QA Sample)	1300	0.027	
8/23/2006	156.5	0.05	1.91E+08
9/12/2006	238	0.005	2.91E+07
9/19/2006	10460	1.47	3.76E+11
9/27/2006	336	1.376	1.13E+10
10/10/2006	717	0.593	1.04E+10
Highest Concentration	10460		

Table 8.12 TMDL Calculations for the Frames Branch RM 0.0 to 2.95

TMDL Table	Load
Existing Load	6.40E+11
Total TMDL	1.47E+10
MOS	1.47E+09
Target Load	1.32E+10
% Reduction	97.9
Remainder	1.32E+10
Future Growth WLA	1.32E+08
LA	1.31E+10

8.2.4 Hardwick Creek RM 3.25 to 8.6

Hardwick Creek RM 3.25 to 8.6 is a third order stream segment. There are two sample sites within this impaired segment. The highest exceedance from the two stations was used to generate the Existing Condition concentration for the segment. The MAF from the bottom of the impaired segment is applied to determine the Critical Flow. Table 8.13 displays the Hardwick Creek RM 3.25 to 8.6 subwatershed information, including sample sites locations, catchment area and MAF. This subwatershed consists primarily of forest land (82%) and agriculture land occupies 12% of the watershed area mainly along Hardwick Creek (Figure 8.4 and Table 8.14). Sampling data is presented in Table 8.15 and TMDL allocations in Table 8.16.

One of the sample stations (DOW04010009) is located at RM 5.85 of Hardwick Creek and the other (DOW04010008) is located at RM 4.10 of Hardwick Creek. Separate maps, land cover tables and TMDL calculations for those two stations are listed at Appendix B.

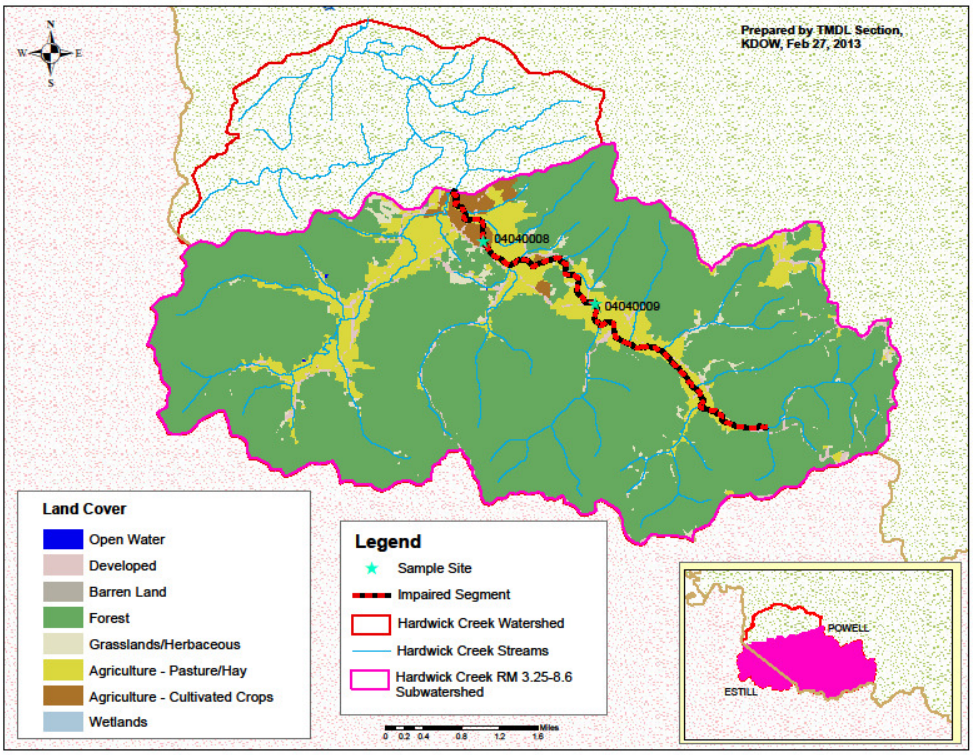

Figure 8.4 Land Cover and TMDL Site Location in the Hardwick Creek RM 3.25 to 8.6 Subwatershed

Table 8.13 Hardwick Creek RM 3.25 to 8.6 Segment Information

WBID	Stream	Square Miles	MAF	County
KY512561_02	Hardwick Creek	20.9	18.1	Powell, Estill
Segment	Stream Order	Acres	RM for MAF calculation	
Hardwick Creek 3.25 - 8.6	3	13391	3.3	
Sample Site#	Station ID	River Mile	Lat	Long
1	DOW04040008	4.10	37.7985	-83.9050
2	DOW04040009	5.85	37.7886	-83.8838

Table 8.14 Land Cover in the Hardwick Creel RM 3.25 to 8.6 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.63	448.2	3.35	0.5
Water	0.01	3.5	0.03	
Barren	0.00	6.6	0.05	
Forest	16.80	10899.8	81.53	
Grassland	0.54	395.4	2.96	
Ag	2.45	1590.3	11.90	
Pasture/Hay	2.19	1417.8	10.61	
Cultivated Crops	0.26	172.5	1.29	
Wetlands	0.00	25.6	0.19	

Table 8.15 Hardwick Creel RM 3.25 to 8.6 Data

Collection Date	E. Coli (cfu/100ml)	Discharge (cfs)	Instantaneous Load (colonies/day)
Sample Site 1			
5/15/2006	1200	2.52	7.40E+10
6/22/2006	1120	0.305	8.36E+09
7/11/2006	921	0.532	1.20E+10
8/10/2006	>2400	1.782	1.05E+11
8/23/2006	933	1.934	4.41E+10
9/12/2006	2610	0.164	1.05E+10
9/19/2006	10500	15.3	3.93E+12
9/19/2006 (QA Sample)	8160		
9/27/2006	717	11.199	1.96E+11
10/10/2006	727	3.021	5.37E+10
Sample Site 2			
5/15/2006	480	1.14	1.34E+10
6/22/2006	10	0.16	3.91E+07
7/11/2006	579	0.467	6.62E+09
8/10/2006	2400	1.049	6.16E+10
8/23/2006	816	1.436	2.87E+10
9/12/2006	201	0.221	1.09E+09
9/19/2006	11200	7.95	2.18E+12
9/27/2006	563	6.275	8.64E+10
9/27/2006 (QA Sample)	473	6.742	
10/10/2006	767	1.99	3.73E+10
10/10/2006 (QA Sample)	605		
Highest Concentration	11200		

Table 8.16 TMDL Calculations for Hardwick Creel RM 3.25 to 8.6

TMDL Table	Load
Existing Load	4.96E+12
Total TMDL	1.06E+11
MOS	1.06E+10
Target Load	9.57E+10
% Reduction	98.1
Remainder	9.57E+10
Future Growth WLA	4.78E+08
LA	9.52E+10

8.2.5 Hardwick Creek RM 0.0 to 3.25

The Hardwick Creek RM 0.0 to 3.25 is a third order stream. Table 8.17 displays the Hardwick Creek RM 0.0 to 3.25 subwatershed information, including sample site location, catchment area and MAF. This subwatershed consists primarily of forest land (82%), and agriculture land occupies 12% of the watershed area mainly along Hardwick Creek (Figure 8.5 and Table 8.18). Sampling data is presented in Table 8.19 and TMDL allocations in Table 8.20.

The sample station (DOW04010002) is located at RM 1.15 of Hardwick Creek. Separate maps, land cover tables and TMDL calculations for this station are listed at Appendix B.

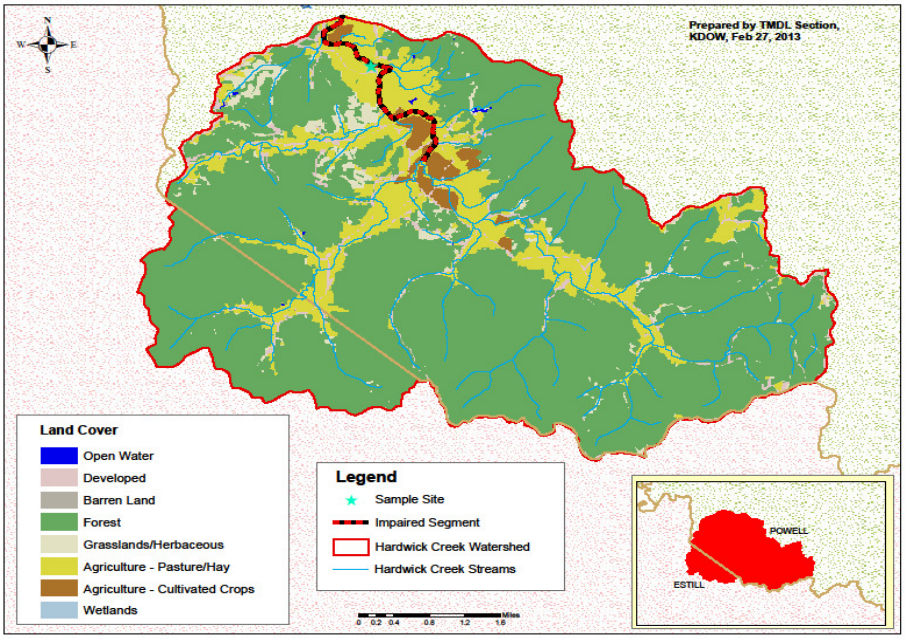

Figure 8.5 Land Cover and TMDL Site Location in the Hardwick Creek RM 0.0 to 3.25 Subwatershed

Table 8.17 Hardwick Creek RM 0.0 to 3.25 Segment Information

WBID	Stream	Lat	Segment	MAF	Square Miles	County
KY512561_01	Hardwick Creek	37.8236	Hardwick Creek 0.0 - 3.25	34.5	27.33	Powell, Estill
Station ID	River Mile	Long	Stream Order	RM for MAF calculation	Acres	
DOW04040002	1.15	-83.9206	3	0	17492	

Table 8.18 Land Cover in the Hardwick Creek RM 0.0 to 3.25 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.96	684	3.92	0.5
Water	0.02	16	0.09	
Barren	0.00	10	0.06	
Forest	20.27	13236	75.85	
Grassland	1.01	724	4.15	
Agriculture	4.20	2729	15.64	
Pasture/Hay	3.74	2423	13.89	
Cultivated Crops	0.46	306	1.75	
Wetlands	0.01	50	0.29	

Table 8.19 Hardwick Creek RM 0.0 to 3.25 Data

Collection Date	E. Coli (cfu/100ml)	Discharge (cfs)	Instantaneous Load (billion colonies/day)
5/15/2006	310	1.905	1.44E+10
6/22/2006	104	0.129	3.28E+08
7/11/2006	147	0.614	2.21E+09
8/10/2006	344	2.365	1.99E+10
8/23/2006	325.5	2.132	1.70E+10
9/12/2006	44	0.239	2.57E+08
9/19/2006	24200	28.7	1.70E+13
9/27/2006	754	17.796	3.28E+11
10/10/2006	85	4.978	1.04E+10
Highest Concentration	24200		

Table 8.20 TMDL Calculations for the Hardwick Creek RM 0.0 to 3.25

TMDL Table	Load
Existing Load	2.04E+13
Total TMDL	2.03E+11
MOS	2.03E+10
Target Load	1.82E+11
% Reduction	99.1
Remainder	1.82E+11
Future Growth WLA	9.12E+08
LA	1.81E+11

9.0 Implementation Options

Section 303(e) of the Clean Water Act and 40 CFR Part 130, Section 130.5, require states to have a continuing planning process (CPP) composed of several parts specified in the Act and the regulation. The CPP provides an outline of agency programs and the available authority to address water issues. Under the CPP umbrella, the Watershed Management Branch of KDOW will provide technical support and leadership with developing and implementing watershed plans to address water quality and quantity problems and threats. Developing watershed plans enables more effective targeting of limited restoration funds and resources, thus improving environmental benefit, protection and recovery.

Watershed plans provide an integrative approach for identifying and describing how, when, who and what actions should be taken in order to meet water quality standards. At this time, a comprehensive watershed restoration plan for the Hardwick Creek watershed has not been developed. This TMDL provides bacteria allocations and reduction goals that may assist with developing a detailed watershed plan to guide watershed restoration efforts.

A watershed plan for the Hardwick Creek watershed should address nonpoint sources of pollution in the watershed and should build on existing efforts as well as evaluate new approaches. Because of the specific landscape and location of the impairments in the Hardwick Creek watershed, a watershed plan should incorporate all available restoration and protection mechanisms. A comprehensive watershed plan should consider both voluntary and regulatory approaches to meet water quality standards. When such a plan is developed, pollutant trading may be a viable management strategy to consider for meeting the TMDL load reduction goals.

9.1 Kentucky Watershed Management Framework

A Watershed Management Framework approach to Water Quality Management was adopted by the KDOW in 1998. The plan divides Kentucky's major drainage basins into five groups of basins which are cycled through a five year staggered process which involves monitoring, assessment, prioritization, plan development, and plan implementation. As part of the process, a basin coordinator is assigned to each river basin to work with the citizens of the basin to develop a local Watershed Management Team associated with each priority watershed. For more information about the river basins see: http://water.ky.gov/watershed/Pages/Basins.aspx.

9.2 Non-Governmental Organizations

There are several Non-Governmental Organizations (NGO) operating in the Hardwick Creek watershed that may help to implement the TMDL, particularly with regard to nonpoint source issues. These organizations include the Kentucky River Watershed Watch and Kentucky Waterways Alliance.

9.2.1 Kentucky River Watershed Watch

The Kentucky River Watershed Watch (KRWW) is a citizen's water monitoring effort that relies on volunteers to provide administration, training, and volunteer and equipment coordination. The volunteers measure basic parameters of stream health to determine whether streams meet important "uses" under the Clean Water Act including aquatic life, human recreation, and drinking water.

Several water quality parameters have been monitored by KRWW. Volunteers collect physical measurements, such as temperature, pH, dissolved oxygen, and conductivity. Stream monitoring also includes macroinvertebrate and habitat assessments. Annually, water samples are tested for bacteria (*E. coli*), and some sites are also tested for nutrients, and metals. Data from annual monitoring is routinely used to help identify problems in the watershed, and assist with prioritizing streams for restoration and protection activities. One site on Hardwick Creek has been sampled by KRWW in the past, but is no longer being monitored.

9.2.2 Kentucky Waterways Alliance

The formation of Kentucky Waterways Alliance (KWA) was the result of a series of meetings sponsored by the Kentucky Environmental Quality Commission. The KWA has a mission to protect and restore Kentucky's waterways and their watersheds through alliances for watershed stewardship. This includes strengthening community and governmental stewardship for the restoration and preservation of Kentucky's water resources. The Alliance promotes networking, communication and mutual support among groups, government agencies, and businesses working on waterway issues. For more information about KWA see: http://www.kwalliance.org.

10.0 Public Participation

This TMDL was published for a 30-day public comment period ending June 24, 2013. A public notice was distributed electronically through the 'Press Release' mailing list maintained by the Governor's Office of media outlets across the Commonwealth and advertisements were purchased in local newspapers (Estill County Tribune in Irvine, KY and Citizen Voice & Times in Irvine, KY). Additionally, the public notice was distributed electronically through the 'Nonpoint Source Pollution Control' mailing list. One public comment was received on this TMDL document.

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Appendix A. Land Cover Definitions

Table A.1 National Land-Cover Database Class Descriptions (taken from Homer et. al., 2004)

11. **Open Water** - All areas of open water, generally with less than 25% cover of vegetation or soil.

21. **Developed, Open Space** - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes

22. **Developed, Low Intensity** - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

23. **Developed, Medium Intensity** - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

24**. Developed, High Intensity** - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

31. **Barren Land (Rock/Sand/Clay)** - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

41. **Deciduous Forest** - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

42. **Evergreen Forest** - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. **Mixed Forest** - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

52. **Shrub/Scrub** - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.

71. **Grassland/Herbaceous** - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. **Pasture/Hay** - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

82. **Cultivated Crops** - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. **Woody Wetlands** - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

95. **Emergent Herbaceous Wetlands** - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Appendix B. Sample Stations TMDL Calculations

DOW04010009

This sample station is located at RM 5.85 of Hardwick Creek (Figure B.1). Table B.1 displays sample site location, catchment area and MAF. Table B.2 shows the land cover in this subwatershed. Sampling data is presented in Table B.3 and TMDL allocations in Table B.4.

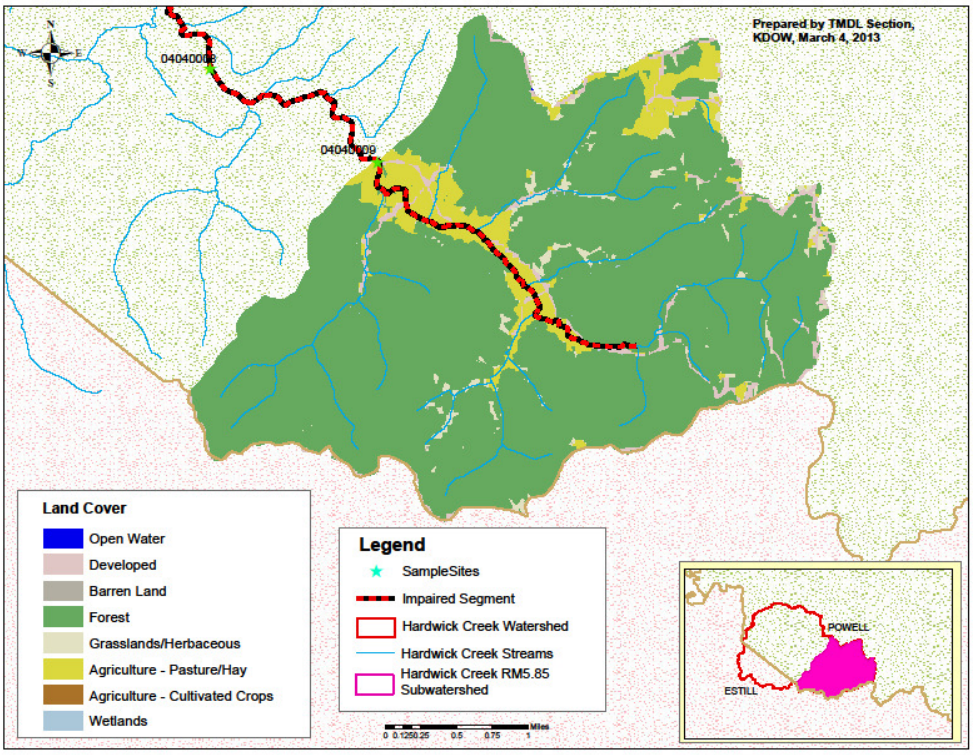

Figure B.1 Land Cover and TMDL Site Location of DOW04040009 Subwatershed

Table B.1 DOW04040009 Site Location and Subwatershed Information

WBID	Stream	Lat	Segment	MAF	Square Miles	County
KY512561_02	Hardwick Creek	37.7886	Hardwick Creek 3.25 - 8.6	12.1	9.361	Powell
Station ID	River Mile	Long	Stream Order	RM for MAF calculation	Acres	
DOW04040009	5.85	-83.8838	2	5.85	5991	

Table B.2 Land Cover in the DOW04040009 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.31	208.0	3.48	0.5
Water	0.000	0.140	0.002	
Barren	0.00	5.4	0.09	
Forest	7.87	5089.1	85.11	
Grassland	0.27	196.8	3.29	
Ag- Pasture/Hay	0.72	468.8	7.84	
Wetlands	0.00	11.2	0.19	

Table B.3 DOW04040009 Data

Collection Date	E. Coli (cfu/100ml)	Discharge (cfs)	Instantaneous Load (colonies/day)
5/15/2006	480	1.14	1.34E+10
6/22/2006	10	0.16	3.91E+07
7/11/2006	579	0.467	6.62E+09
8/10/2006	2400	1.049	6.16E+10
8/23/2006	816	1.436	2.87E+10
9/12/2006	201	0.221	1.09E+09
9/19/2006	11200	7.95	2.18E+12
9/27/2006	563	6.275	8.64E+10
9/27/2006 (QA Sample)	473	6.742	
10/10/2006	767	1.99	3.73E+10
10/10/2006 (QA Sample)	605		
Highest Concentration	11200		

Table B.4 TMDL Calculations for DOW04040009

TMDL Table	Load
Existing Load	3.32E+12
Total TMDL	7.10E+10
MOS	7.10E+09
Target Load	6.39E+10
% Reduction	98.1
remainder	6.39E+10
Future Growth WLA	3.20E+08
LA	6.36E+10

DOW04010008

This sample station is located at RM 4.10 of Hardwick Creek (Figure B.2). Table B.5 displays sample site location, catchment area and MAF. Table B.6 shows the land cover in this subwatershed. Sampling data is presented in Table B.7 and TMDL allocations in Table B.8.

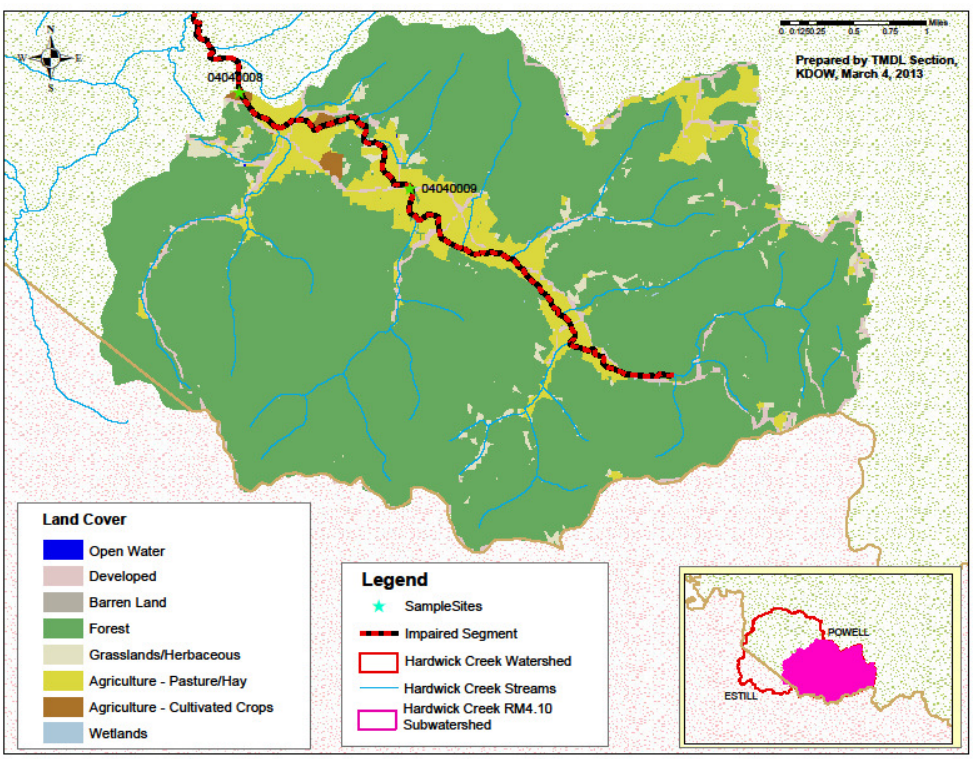

Figure B.2 Land Cover and TMDL Site Location of DOW04040008 Subwatershed

Table B.5 DOW04040008 Site Location and Subwatershed Information

WBID	Stream	Lat	Segment	MAF	Square Miles	County
KY512561_02	Hardwick Creek	37.7985	Hardwick Creek 3.25 - 8.6	16.9	13.149	Powell, Estill
Station ID	River Mile	Long	Stream Order	RM for MAF calculation	Acres	
DOW04040008	4.10	-83.9050	3	4.10	8415	

Table B.6 Land Cover in the DOW04040008 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.44	302.2	3.60	0.5
Water	0.00	0.6	0.007	
Barren	0.00	5.6	0.07	
Forest	10.91	7061.6	84.05	
Grassland	0.39	281.7	3.35	
Ag	1.12	732.25	8.72	
Pasture/Hay	1.08	703.1	8.37	
Cultivated Crops	0.04	29.1	0.35	
Wetlands	0.00	18.2	0.22	

Table B.7 DOW04040008 Data

Collection Date	E. Coli (cfu/100ml)	Discharge (cfs)	Instantaneous Load (colonies/day)
5/15/2006	1200	2.52	7.40E+10
6/22/2006	1120	0.305	8.36E+09
7/11/2006	921	0.532	1.20E+10
8/10/2006	>2400	1.782	1.05E+11
8/23/2006	933	1.934	4.41E+10
9/12/2006	2610	0.164	1.05E+10
9/19/2006	10500	15.3	3.93E+12
9/19/2006 (QA Sample)	8160		
9/27/2006	717	11.199	1.96E+11
10/10/2006	727	3.021	5.37E+10
Highest Concentration	10500		

Table B.8 TMDL Calculations for DOW04040008

TMDL Table	Load
Existing Load	4.34E+12
Total TMDL	9.92E+10
MOS	9.92E+09
Target Load	8.93E+10
% Reduction	97.9
remainder	8.93E+10
Future Growth WLA	4.47E+08
LA	8.89E+10

DOW04010002

This sample station is located at RM 1.15 of Hardwick Creek (Figure B.3). Table B.9 displays sample site location, catchment area and MAF. Table B.10 shows the land cover in this subwatershed. Sampling data is presented in Table B.11 and TMDL allocations in Table B.12.

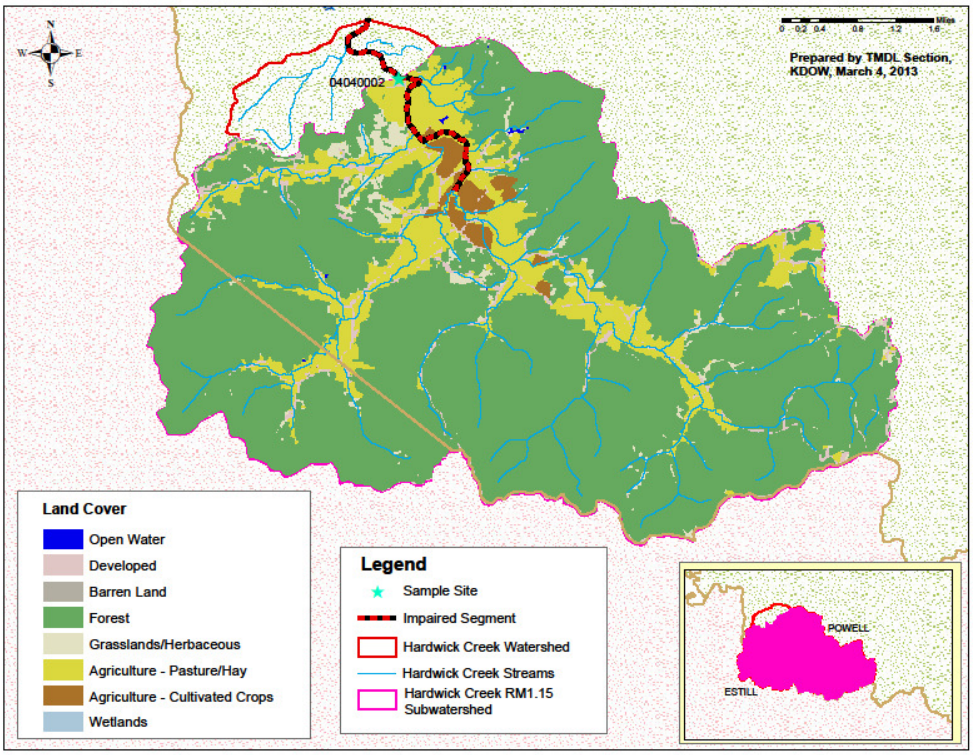

Figure B.3 Land Cover and TMDL Site Location of DOW04040002 Subwatershed

Table B.9 DOW04040002 Site Location and Subwatershed Information

WBID	Stream	Lat	Segment	MAF	Square Miles	County
KY512561_01	Hardwick Creek	37.8236	Hardwick Creek 0.0 - 3.25	32.4	25.73	Powell, Estill
Station ID	River Mile	Long	Stream Order	RM for MAF calculation	Acres	
DOW04040002	1.15	-83.9206	3	1.1	16466	

Table B.10 Land Cover in the DOW04040002 Subwatershed

Land Cover	SQ_MILES	ACRES	Percent (%)	Future Growth WLA %
Developed	0.85	604	3.69	0.5
Water	0.02	13	0.08	
Barren	0.00	8	0.05	
Forest	19.42	12667	77.32	
Grassland	0.82	598	3.65	
Agriculture	3.78	2453.48	14.98	
Pasture/Hay	3.36	2180	13.30	
Cultivated Crops	0.41	274	1.67	
Wetlands	0.01	39	0.24	

Table B.11 DOW04040002 Data

Collection Date	E. Coli (cfu/100ml)	Discharge (cfs)	Instantaneous Load (colonies/day)
5/15/2006	310	1.905	1.44E+10
6/22/2006	104	0.129	3.28E+08
7/11/2006	147	0.614	2.21E+09
8/10/2006	344	2.365	1.99E+10
8/23/2006	325.5	2.132	1.70E+10
9/12/2006	44	0.239	2.57E+08
9/19/2006	24200	28.7	1.70E+13
9/27/2006	754	17.796	3.28E+11
10/10/2006	85	4.978	1.04E+10
Highest Concentration	24200		

Table B.12 TMDL Calculations for DOW04040002

TMDL Table	Load
Existing Load	1.92E+13
Total TMDL	1.90E+11
MOS	1.90E+10
Target Load	1.71E+11
% Reduction	99.1
remainder	1.71E+11
Future Growth WLA	8.56E+08
LA	1.70E+11