Red River Gorge Watershed Plan and Restoration

Created by the Red River Watershed Team

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Chapter 1: Getting Started

1.1 Introduction

The Red River Gorge Restoration and Watershed Plan is part of a watershed planning project, and it addresses watershed-scale issues facing the Red River Watershed. This plan will focus primarily on *nonpoint source pollution,* but will also identify point sources and causes of pollution within the entire watershed. Nonpoint source pollution is pollution originating from diffuse areas (land surface or atmosphere) having no well-defined point of origin. Nonpoint source pollutants are generally carried off land and into waterways by rain or melting snow. Point sources are those with a specific point of origin, like a discharge pipe coming from a factory. This project focuses on identifying pollution sources in the watershed, quantifying pollution coming from each source, and making recommendations for Best Management Practices (BMPs) to improve and protect water quality in the Red River and four of its major tributaries. The creation of this watershed plan is made possible, in part, with a grant, titled "Red River Gorge Restoration and Watershed Plan," from the Kentucky Division of Water (KDOW) to the Daniel Boone National Forest.

Watershed planning is an interactive and iterative process that involves organizations, groups, and community members coming together to develop a tool (a watershed plan) to help improve water quality and meet other group goals. A watershed plan can be used to better understand a watershed, inform the public on local water resource issues, improve water quality by implementing recommended BMPs, and as a basis for applying for future funding.

1.2 The Watershed

The Red River flows for over 97 miles through eastern Kentucky, until it reaches the Kentucky River near Winchester. Over the years, the river formed the Red River Gorge. The Gorge is a beloved part of our state, known for its natural stone arches, caves, rock shelters, and cliffs overlooking magnificent stream valleys. The Red River is Kentucky's only Wild & Scenic River. Its headwaters are in the hills of the Cumberland Plateau in eastern Wolfe County.

This watershed plan focuses on four tributaries to the Red River: Swift Camp Creek in Wolfe County, Clifty Creek in Menifee and Wolfe Counties, Gladie Creek in Menifee County, and Indian Creek in Menifee and Powell Counties (see Figure 1.1). These tributary streams are headwaters streams to the Red River, and they each begin on private land surrounding the Gorge. The project study area includes the communities of Campton, Valeria, Pomeroyton, and Mariba. Frenchburg is just outside of the project area, to the north.

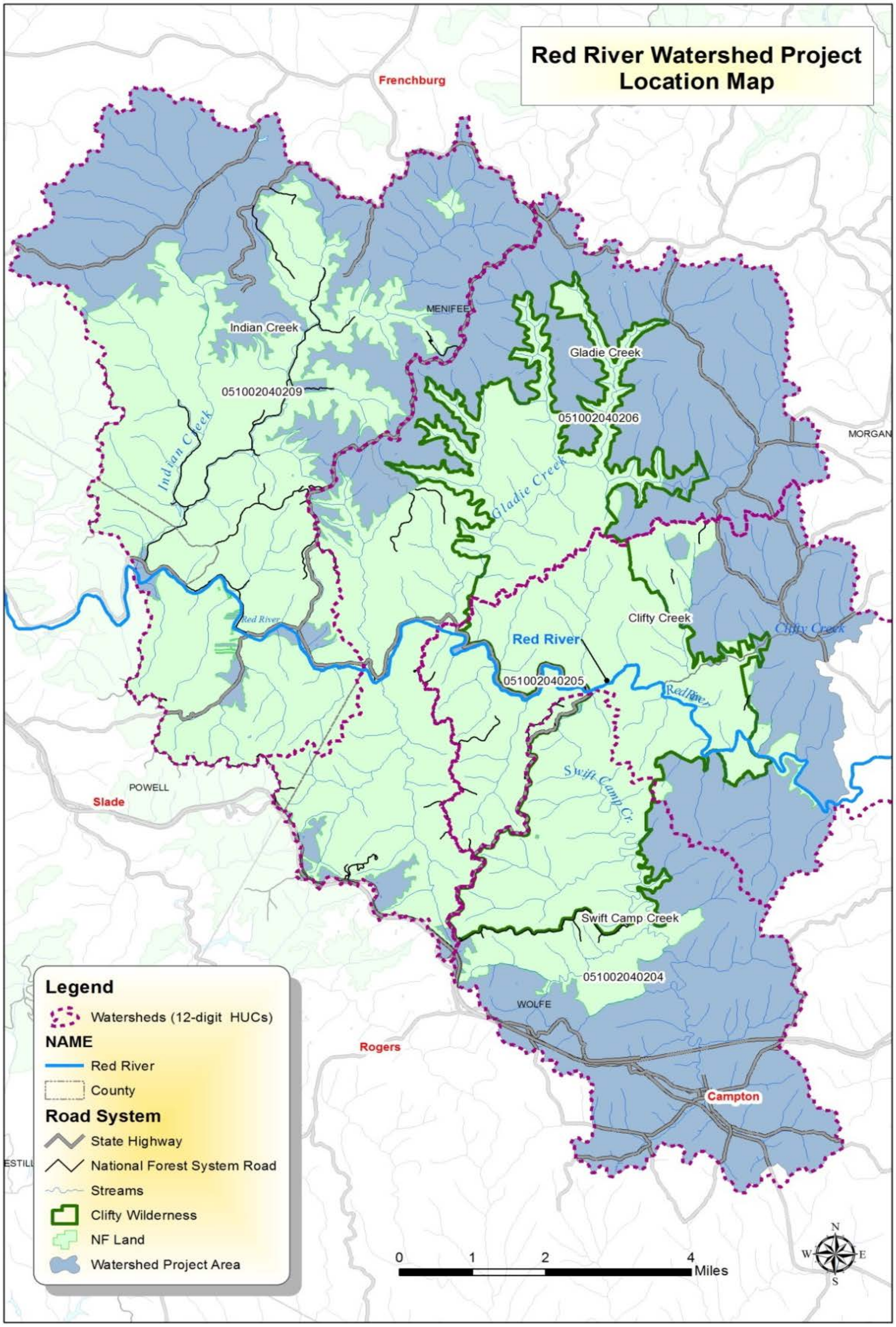

Figure 1.1: Map of the project area (USFS 2012).

What is a watershed plan, and why do Red River tributaries need one?
Watershed planning is a comprehensive, collaborative way to plan for the protection and improvement of the water quality in a given body of water. It makes sense to look at all the things affecting the Red River instead of just the water itself. Watershed planning involves gathering local stakeholders to share their knowledge, concerns, and ideas in developing the plan. It is a great way to take care of a stream with pollution issues, protect the streams in good condition, and outreach to communities about local water quality issues. The knowledge gathered from stakeholders, background research, water quality sampling data, and best management practices recommendations to combat pollution all go into the plan.
Swift Camp Creek, Clifty Creek, Indian Creek, and Gladie Creek were chosen for this project because they are all headwaters streams on private lands that flow into the Red River.

These headwaters streams are mostly in good condition (see Chapters 3 and 4) but are threatened by illegal dumps, loss of streamside vegetation, runoff from towns, agriculture, and mines. Bacteria in some creeks may exceed water quality standards. Swift Camp Creek and one of its unnamed tributaries are listed as impaired in the Kentucky 2010 Integrated Report to Congress (KDOW, 2010) for aquatic habitat. Suspected causes are sedimentation, loss of riparian habitat, septage disposal, and other unknown causes.

A portion of Indian Creek was also listed as impaired in 2010. Since that time, however, it has been determined through a thorough data review that the stream is not, in fact, impaired. A 'de-listing' process has been initiated by KDOW. The 2012 Integrated Report will address the delisting and is currently under review by the EPA. New information on this process will be added to this plan as available.

This plan will also serve as the foundation for seeking future funding to implement Best Management Practices (which can be both on-the-ground projects and educational outreach efforts). The plan can be used by local officials and leaders for planning purposes and to help protect water resources. The streams in good condition, and the streams with pollution issues, need a plan to help improve and protect water quality – a watershed plan.

1.3 A brief history of this project
The Daniel Boone National Forest (DBNF) began a process called the "Limits of Acceptable Change" in 2008 to address resource concerns on their land and to involve stakeholder groups in understanding and mitigating the issues.

Through this process, a watershed-based plan was created called *The Limits of Acceptable Change Watershed Plan*. It covers DBNF lands in the Red River Gorge. The plan showed that due to unregulated recreational use, some streams in the area are being severely degraded.

The headwaters of most of the tributaries to the Red River are located on privately owned land and have not yet been part of a comprehensive watershed based planning process.

Some of the streams draining into the Red River have been identified as impaired or threatened. Therefore, the *Red River Gorge Restoration and Watershed Plan* project is divided into two parts: the first part will finish the *Limits of Acceptable Change Watershed Plan* and its recommended Best Management Practices on the DBNF. The second part is the creation of local watershed teams and *this* watershed plan addressing the four tributaries Swift Camp Creek, Indian Creek, Clifty Creek, and Gladie Creek. These private headwaters streams have been studied through this watershed planning process, and solutions to identified issues have been proposed. Private landowners may choose to participate in any resulting programs to address water quality issues, or not. Likewise, city and county governments and other stakeholders may or may not choose to participate in proposed programs or initiatives.

1.4 Project Goals, Stakeholder Concerns, and Project Partners and Stakeholders

The following lists of project goals, stakeholder concerns, and project partners and stakeholders were compiled at public meetings in Campton and Frenchburg over the course of several meetings in 2011 and 2012.

<u>Watershed Team Member Goals for the project:</u>

-That the Red River be a world class river (and a draw for tourism)
- Get young people involved (and their parents)
- Build partnerships (between USFS and local citizens, organizations, govt., and businesses)
- Local action for clean water
- Education (specially discussed in context of soil degradation and eroding hillsides)
- Set framework to secure funding for Best Management Practices implementation locally
- Local ownership and action
- Trout fishing in Campton (Swift Camp Creek)
- Better coordination between all partners and agencies; streamline way to address issues
- To improving trail conditions from upper end to lower end
- To involve local horse breeding community

<u>Stakeholder Concerns:</u>

- Swimmable, fishable, usable
- Hanging out
- Recreational uses
- Headwaters
- Lessons learned and how to apply to entire watershed
- Eastern edge of Wilderness Area is adjacent to private land. Concerns about Wilderness areas and wilderness study areas (in lower watershed) and their water quality. Also issues of solitude, intrinsic value, and other services and amenities provided by wilderness.

- OHVs and horses in Wilderness
- Fish in Swift Camp Creek
- Trout throughout the watershed
- Trash (including tires)
- Clear, good waters
- Safe for kids
- Drinking water
- Physical stream issues, like bank erosion
- Economic aspect of recreation
- Red River used to flow year round
- Like to see river restored to past quality
- Educate public
- Less sediment in the water
-Scenic Beauty
- Project not comprehensive enough to address ecological function
- Buffers along the Red River tributaries
- Flooding, development, and land use
- Mussel species
- Horse damage to trails and river put-ins and safety (in regards to horses on local roads)

<u>Project Partners and Stakeholders:</u>

A number of people, agencies, and companies have been involved in the development of this Watershed Plan. These include but are not limited to the following list.

- Local citizens
- Conservation Board
- Agricultural extension agent
- User groups, including: fishers, climbers, hikers, horseback riders, OHV drivers, solitude seekers, water sports people, etc.
- Fish and Wildlife Service
- U.S. Forest Service
- Friend of Red River
- Land owners
- Farmers
- Water and waste water utilities
- Local elected officials
- Schools
- Faith Community
- Eastern KY PRIDE
- Business Owners
- Transportation Department
- Tourism entities
- Loggers

Watershed planning is an iterative process. As this plan develops, it will be possible to edit these lists and this chapter.

Technical Consultants: Rita Wright Consulting was the primary technical consultant on this project, collecting and analyzing water quality data. Third Rock Consulting, LLC, acted as a consultant for biological sampling on Swift Camp Creek.

Sponsoring organizations: Daniel Boone National Forest and Kentucky Division of Water

Subcontractor: Kentucky Waterways Alliance

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Chapter 2: Exploring Your Watershed

This chapter presents information on many facets of the Red River Watershed including water resources, natural features, regulatory factors, and human influences. Each of the creeks has distinctive attributes and water quality issues. This chapter covers existing information about them, and Chapters 3 and 4 cover new data collected for this project.

2.1 Water Resources

The Red River Watershed includes Menifee, Powell, and Wolfe counties in eastern Kentucky (see Figure 2.1). The river runs for over 97 miles and empties into the Kentucky River between Winchester and Irvine. Much of the Red River's course is through the Daniel Boone National Forest (DBNF), but many of the headwater streams begin on private land outside the DBNF.

The Red River has many tributary streams that make up its subwatersheds; this plan focuses on the private lands of four of these subwatersheds (see Table 2.1 and Figure 2.1). The study area does not capture the uppermost headwaters of the Red River, which lie east of Campton.

Table 2.1: Subwatersheds in the project area.

Watershed Name	County	HUC-12	Acres	Drainage Area (square miles)
Swift Camp Creek	Wolfe	051002040204	13,693	21.4
Clifty Creek	Menifee and Wolfe	051002040205	17,178	26.8
Gladie Creek	Menifee	051002040206	20,884	32.6
Indian Creek	Menifee and Powell	051002040209	37,002	57.8

The 12-digit codes in Table 2.1 are part of the Hydrologic Unit (HUC) system, a standardized watershed classification system developed by the US Geologic Survey (USGS). HUCs are watershed organized by size. The HUCs shown above have 12 digits to indicate the size of the watershed. Other watersheds comparable in size will also have a 12-digit number; it is like an address for the watershed. Bigger watersheds have smaller HUC numbers. Swift Camp Creek is a HUC-12. The entire Red River Watershed is a HUC-11. It is part of the larger Middle Kentucky River Basin, a HUC-8 of 1094 square miles. Examining the Red River in smaller subwatersheds makes planning quality more manageable (Figure 1.1). Figure 2.1 shows even smaller HUC-14 subwatersheds that will be used in later chapters to discuss the results of monitoring.

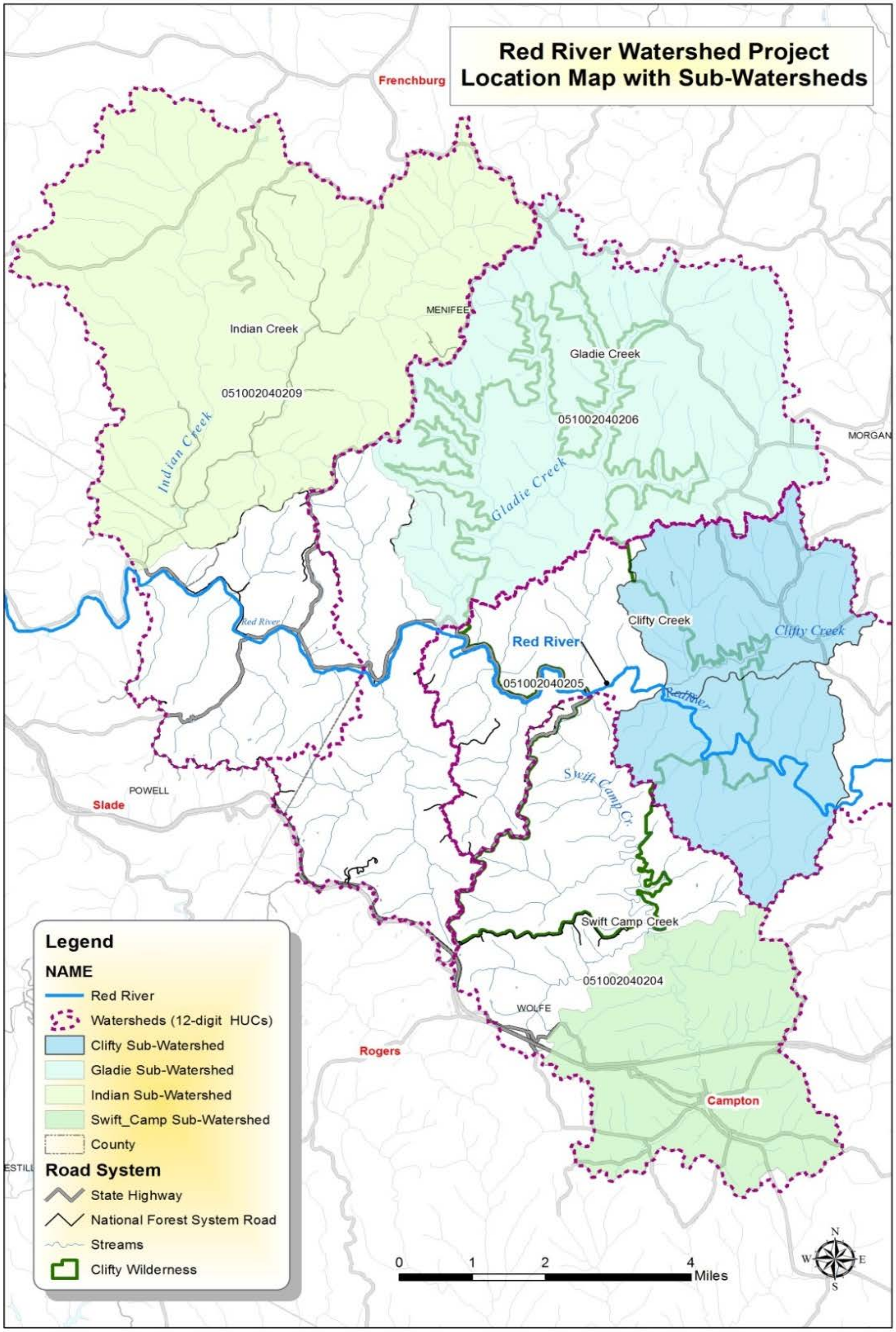


Figure 2.1: Project study area with subwatersheds (USFS 2013).

Surface Hydrology and Geomorphology

Hydrology is the study of water and its processes on the Earth's surface. Geomorphology is the study of landforms and the processes that shape them. It is important to consider the surface hydrology and the geomorphology of the project area because the physical condition of the stream banks and the land around them directly affects the water quality of the streams.

The project area is located in the Eastern Kentucky Coal Fields physiographic province in Kentucky. A closer look at the area reveals a landscape that is highly dissected by numerous streams and rivers. Landforms include rolling, winding, low-relief, low-elevation ridges and narrow valleys with steep, short slopes. Many of the streams are deeply entrenched and the side slopes average 30-40% slope, but may exceed 65% in the most entrenched valleys. Cliffs are common, well-developed, and prominent in the western part of the project area; however, cliffs are infrequent and poorly developed further east in the majority of the project area. Erosion, and to a much lesser extent bedrock block slides, are the primary geomorphological processes that have shaped these landscapes.

There are a moderate number of small to medium sized intermittent and perennial streams and rivers in the project area, including Indian Creek, Red River, and Swift Camp Creek. Narrow valleys historically limited agricultural development, so many of the streams were modified or moved to the bottom of the hill slope to provide more arable land. The larger streams and rivers are quite sinuous and have moderately broad, flat valleys with well-developed floodplains. Stream gradients are moderately high in the headwaters, and steep valley slopes promote rapid runoff and flash flooding. Large house-sized sandstone boulders are common in the Red River and Indian Creek. Pool substrate varies from sandstone gravels to shale bedrock.

Stream flow (also called discharge) measures the amount of water traveling through a stream in cubic feet per second (cfs). The USGS has gauging stations that record these data year-round on many streams throughout the country. There are no USGS gauging stations in the project study area. The closest station is near Hazel Green (#03282500), east of Campton, and there is another one on the Red River in Clay City (#03283500). Current stream conditions can be viewed for these two stations on a USGS website (http://waterdata.usgs.gov/ky/nwis/nwis).

Various stream flow levels are estimated for all streams in Kentucky based on historical data from nearby gaging stations and can be viewed at the Kentucky Watershed Viewer (http://gis.gapsky.org/watershed/). The information in Table 2.2 shows the estimated flow for streams in the project area during low flow, mid flow, and high flow conditions.

Table 2.2: Estimated flow for streams in the project area during low, mid, and high flow conditions.

Stream	Stream Flow in cubic feet per second (cfs)				
	Mean Annual Flow	**Low Flow (7Q10)***	**2-year flood**	**100-year flood**	**Watershed Size (sq. mi.)**
Red River (downstream)	380.0	1.1	9594	28788	297.0
Indian	36.0	0.0	1724	5538	28.1
Gladie	28.9	0.1	1464	4736	22.5
Swift Camp (downstream)	27.4	0.2	1413	4577	21.4
Swift Camp (upstream, below Campton Lake)	8.1	0.0	572	1920	6.2
Clifty	8.3	0.0	588	1974	6.4
Red River (upstream)	91.1	0.1	3376	10561	71.0

* 7Q10 is the lowest average flow that occurs for seven consecutive days that has a probability of occurring once every 10 years.

Figures 2.2 and 2.3 graphically show flood conditions (100-year event) and average discharge (mean annual flow).

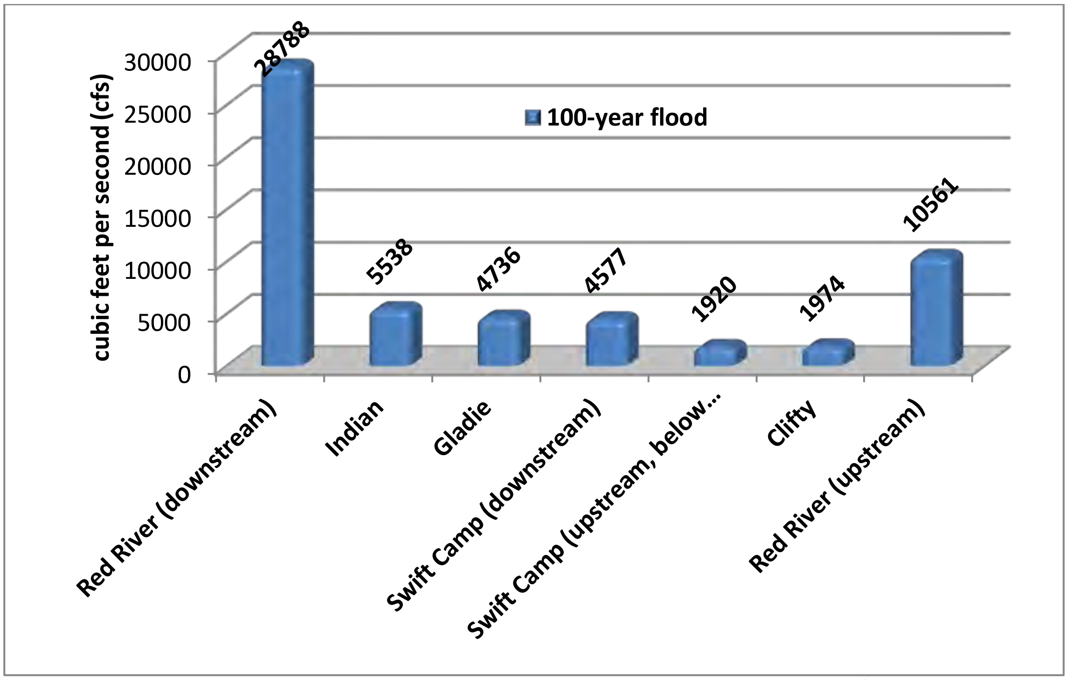


Figure 2.2: Flood conditions for a 100-year event for project area waterways.

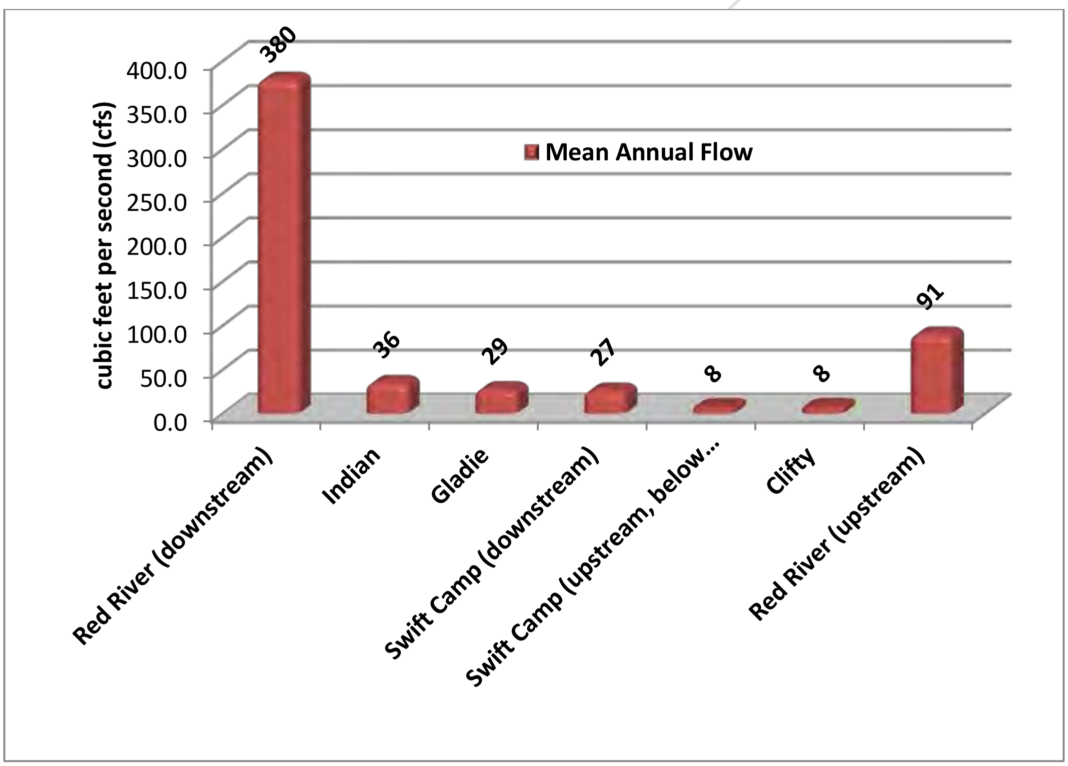


Figure 2.3: Average discharge (mean annual flow) for project area waterways.

Groundwater-Surface Water Interaction

Nearly all surface water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with groundwater. These interactions are important to consider because a stream can get water from, or lose water to, the groundwater system. This exchange of water can impact the water quality and quantity of waterways. Withdrawal of water from streams can deplete groundwater or conversely, withdrawal of groundwater can deplete water in streams, lakes, or wetlands. Similarly, pollution of surface water can degrade groundwater quality, and pollution of groundwater can degrade surface water. Effective watershed planning requires a clear understanding of linkages between groundwater and surface water (USGS 2012). Groundwater systems do not necessarily share the same watershed boundaries of surface waterways.

In many places in Kentucky, there are karst features. Karst topography is a landscape that is characterized by features such as sinkholes, sinking streams, caves, and springs. Karst topography is most often formed in limestone or dolomite. Water in karst areas is highly vulnerable to pollution, since the connection between surface water and groundwater is more direct than in most other aquifer types. The underlying rock in this project area is dominated by sandstone and shale, which do not weather as fast as limestone. However, there are narrow bands of limestone in the area, and they do exhibit karst features. There are sinkholes and caves in the Indian Creek subwatershed. The caves are generally small and not well developed. There are also a few caves in the Chimney Top Creek area. A few springs can be found in the area - one even supplies drinking water to the Gladie Visitor Center (Figure 2.4).

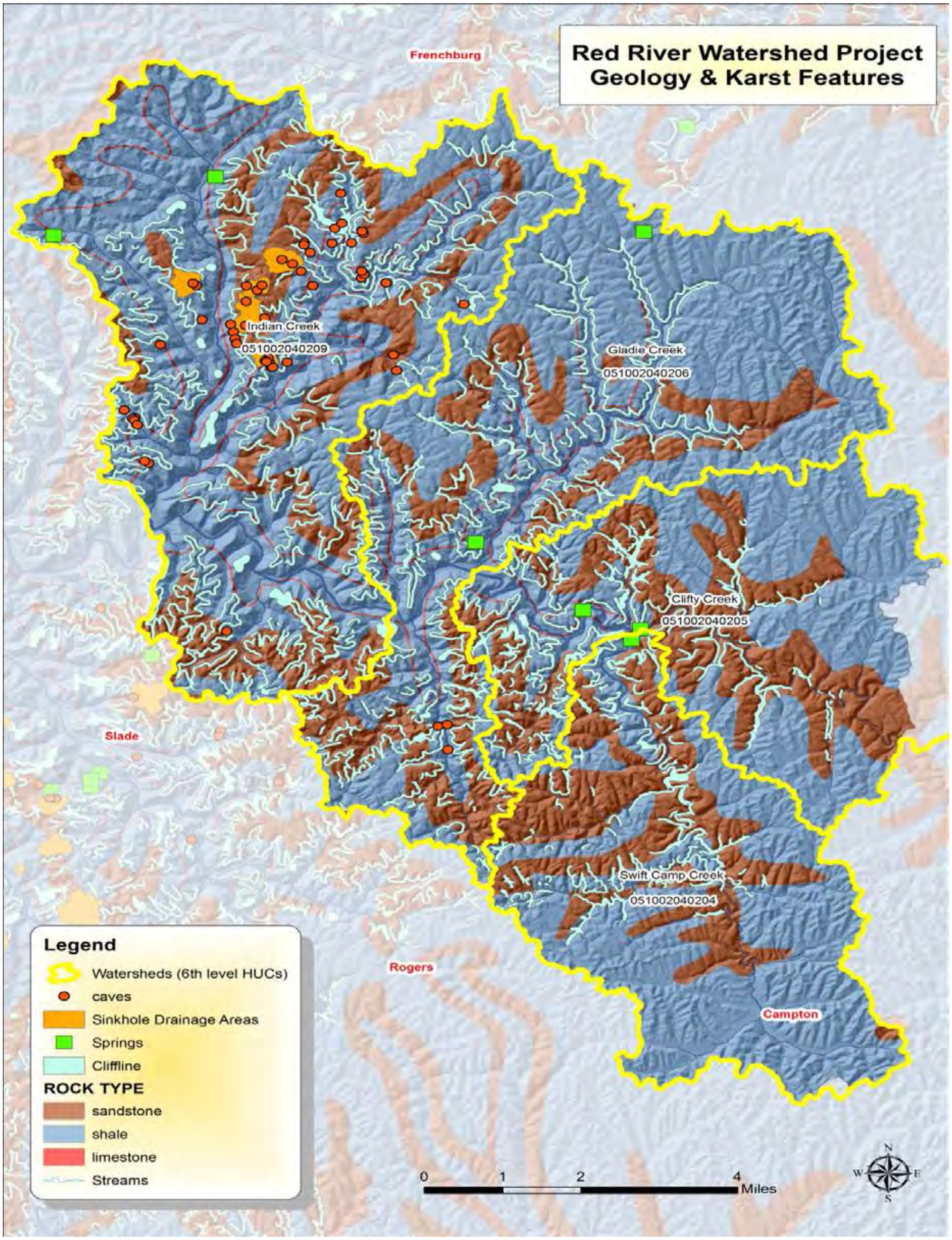


Figure 2.4: Geology and karst of the project area (USFS 2012).

Wetlands

There are many different types of wetlands, from ones that are always wet with soggy soil to others that only hold water seasonally. Wetlands are important ecologically because they absorb water when rivers overflow and thereby help to mitigate flooding, provide valuable habitat to plants and animals, and cleanse water by filtering out nutrients and other pollutants.

The National Wetlands Inventory, a national database of wetland data operated by the National Fish and Wildlife Service, shows that there are many fresh water ponds in the project study area, but not a significant number of wetland features.

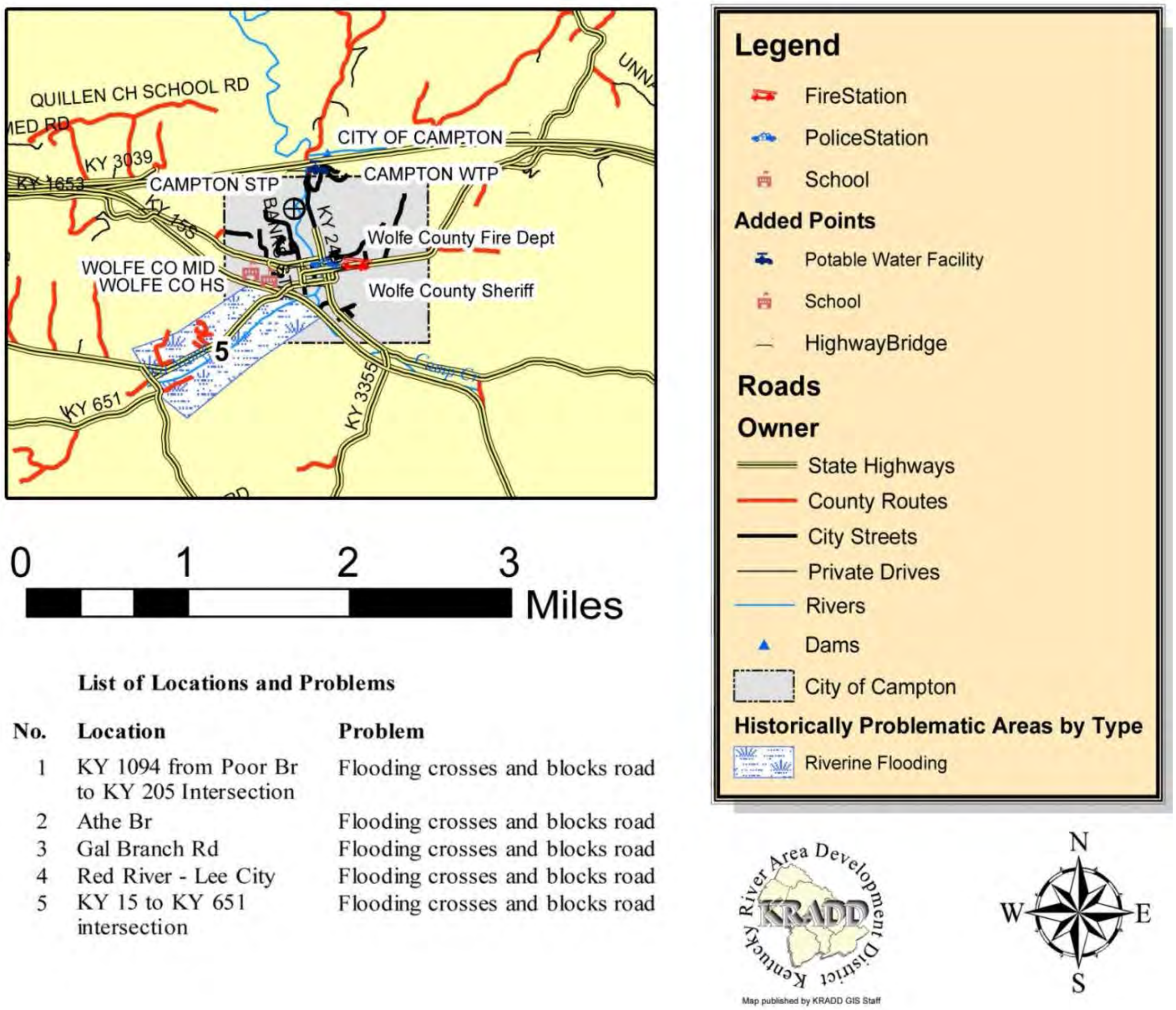
Flooding

Flooding is a natural phenomenon. The area immediately surrounding a waterway (the "floodplain") is prone to flooding. When portions of floodplains are preserved in a natural, vegetated state, they provide many benefits including reduction in number and severity of floods, help handling stormwater runoff, and minimizing impacts of nonpoint source water pollution. By allowing floodwater to spread out across the floodplain and slow down, the sediments settle out, improving water quality. The natural vegetation of the floodplain filters out impurities and uses excess nutrients.

Also affecting the rate and frequency of flooding is the amount of impervious surface in a community. An impervious surface is one that does not permit passage or infiltration of water, like concrete or rooftops. If a forest is converted into a shopping center, for example, all the rain that would have fallen on the trees and forest floor and either infiltrated into the soil or stayed on the site will now run off the roof and parking lot of the shopping center and into the stream. This can cause two problems. First, the runoff from a developed surface will pick up pollutants, such as oils and salts, and carry them to the stream. Second, impervious surfaces do not absorb water as does the porous forest floor, and as a result the runoff will enter the stream much faster. This swells the waterway downstream even more and carries pollutants from the land into the water. With more development and impervious surfaces, there is more and more run-off and flooding.

There is not a significant amount of urban development within the project area, but where it does exist, the size of the surrounding floodplains is a very important feature for mitigating floods when they occur (Figure 2.5). Most of the impervious surface within the project area is in the form of paved roads, parking lots, or buildings in Campton (Figure 2.6).

Any future development will have an impact on surrounding streams and water quality (see Figures 2.14 and 2.15).



List of Locations and Problems

No.	Location	Problem
1	KY 1094 from Poor Br to KY 205 Intersection	Flooding crosses and blocks road
2	Athe Br	Flooding crosses and blocks road
3	Gal Branch Rd	Flooding crosses and blocks road
4	Red River - Lee City	Flooding crosses and blocks road
5	KY 15 to KY 651 intersection	Flooding crosses and blocks road

Figure 2.5: Excerpted image from Wolfe County Flood Hazard Analysis (KY River Area Development District map).

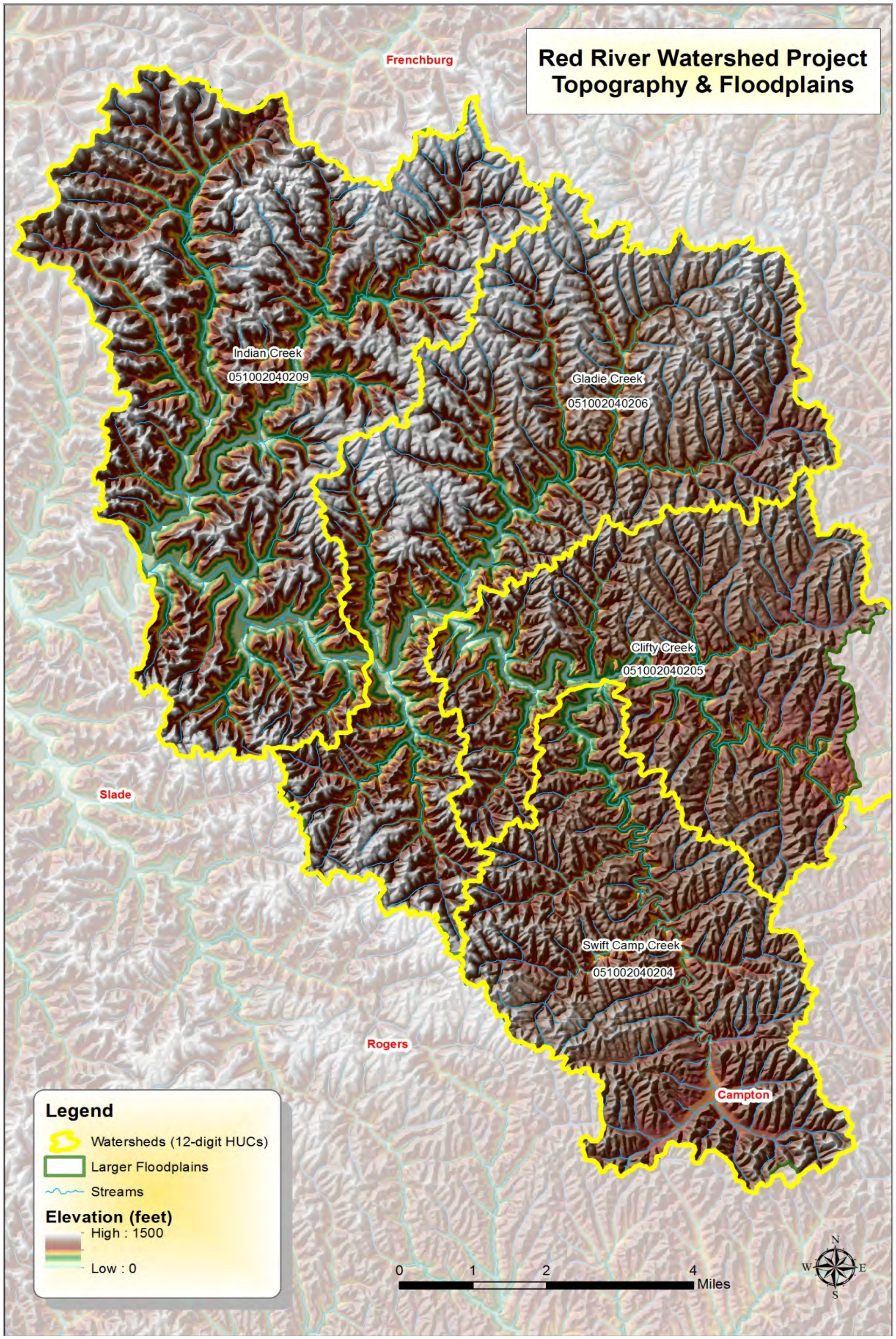


Figure 2.6: Topography and floodplains of project area (USFS 2012).

Regulatory Status of Waterways

Each of the four waterways being studied with this watershed plan has been assessed by the Kentucky Division of Water (KDOW). Swift Camp Creek is an impaired waterway and a direct tributary to the Red River. Improving the water quality of Swift Camp Creek may contribute to improving the water quality of the Red River. Gladie Creek, Indian Creek, and Clifty Creek are not impaired for their designated uses. Table 2.3 illustrates their assessment information.

<u>Designated Uses</u>

KDOW assigns designated uses to each waterway:

- warm water aquatic habitat
- cold water aquatic habitat
- primary contact recreation
- secondary contact recreation
- domestic water supply
- outstanding state resource water

For each use, certain chemical, biological, or descriptive ("narrative") criteria apply to protect the stream so that its uses are met. The criteria are used to determine whether a stream is "impaired." If a waterway does not meet water quality standards for its designated uses, then it is considered impaired. Impaired waterways are required to have a watershed-based plan or Total Maximum Daily Load (TMDL) study to address water quality issues.

<u>Impairment Status</u>

Impaired waterways are recorded in a report created by KDOW every two years, the *Integrated Report to Congress on the Condition of Water Resources in Kentucky*. It reports on the quality of water in the assessed streams, lakes, and reservoirs of all river basins of the state and includes the 303(d) list of impaired waterways. The list of impaired waters identifying a TMDL study is called the 303(d) list and can be found in Volume 2 of the Integrated Report. This is public information and may be accessed by contacting KDOW offices at (502) 564-3410 or online at http://water.ky.gov/waterquality/Pages/303dList.aspx

Each two year cycle focuses on a different river basin in Kentucky, but the Integrated Report includes information on all the impaired waterways in the state. Swift Camp Creek, an Unnamed Tributary to Swift Camp Creek, and the Red River are listed as impaired in the 303(d) List of the 2010 Integrated Report to Congress (see Figure 2.7).

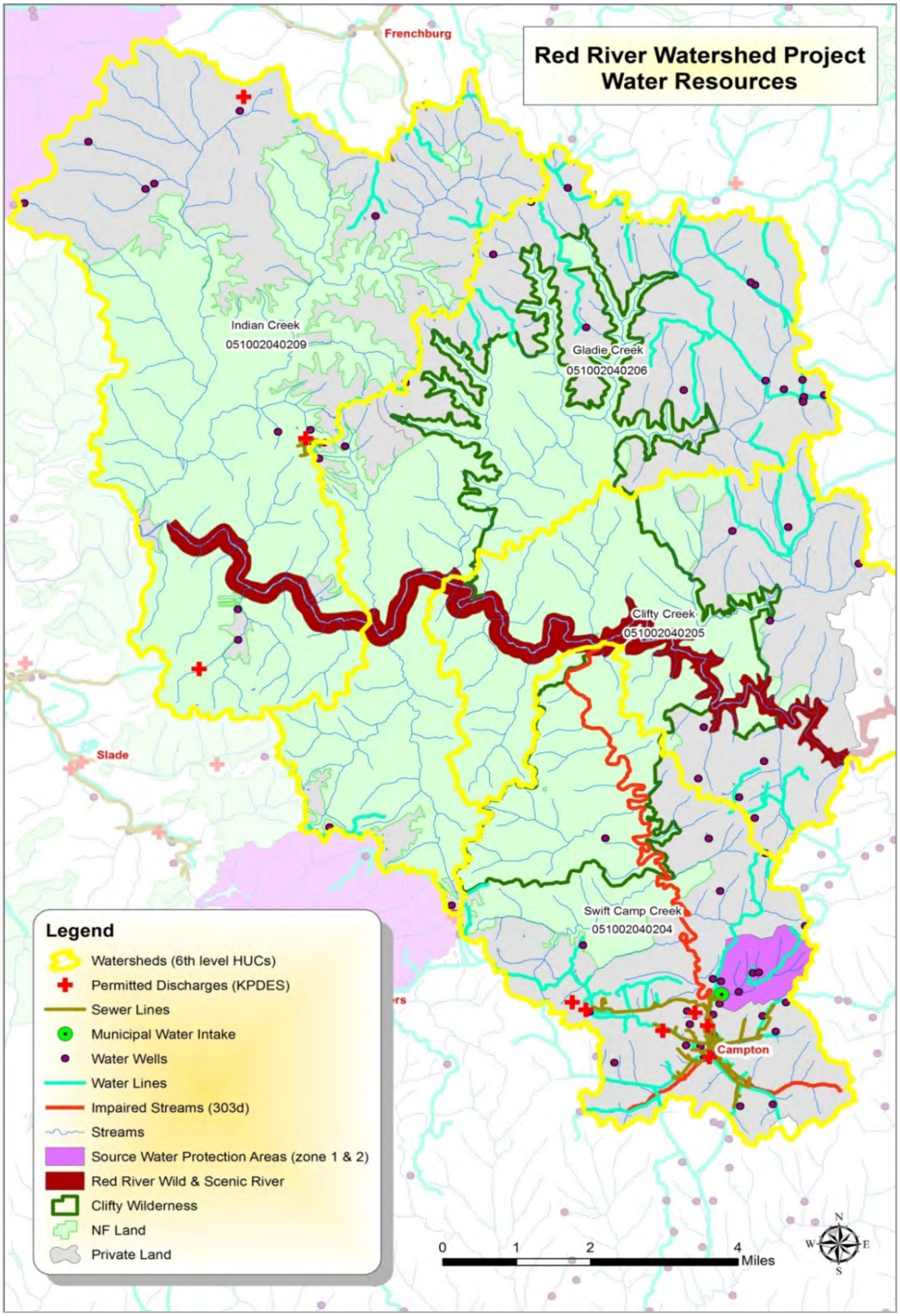


Figure 2.7: Regulatory Status of project waterways (KDOW 2012).

- Swift Camp Creek: impaired river miles 0.0 to 13.8.

Impaired Use(s): Cold Water Aquatic Habitat (Partial Support)
Pollutant(s): Unknown
Suspected Sources: Unknown
Other designated uses are Fish Consumption, Primary Contact Recreation, and Secondary Contact Recreation; these uses were not assessed. Date of assessment: 12/2/2009.

- Unnamed Tributary to Swift Camp Creek at RM 11.7: impaired river miles 0.0 to 1.5.

Impaired Use(s): Warm Water Aquatic Habitat (Non Support)
Pollutant(s): Sedimentation/Siltation.
Suspected Sources: Unknown
Other designated uses are Fish Consumption, Primary Contact Recreation, and Secondary Contact Recreation; these uses were not assessed. Date of assessment: 10/14/1999.

- Red River: impaired river miles 64.1 to 67.6

Impaired Use(s): Warm Water Aquatic Habitat (Partial Support)
Pollutant(s): Sedimentation/Siltation
Suspected Sources: Loss of Riparian Habitat; Managed Pasture Grazing

A section of Indian Creek was also listed as impaired in the 2010 Integrated Report, but it has since been determined that it does, in fact, meet all of its designated uses and is not impaired. This stream segment is being added to the "Just Cause" list where EPA will be petitioned for delisting in the 2012 305(b) cycle (personal communication, Bryan Marbert, 2/2011). This is how the impairment listing appeared in the Integrated Report:

- Indian Creek: impaired river miles 2.6 to 7.8.

Impaired Use(s): Cold Water Aquatic Habitat (Partial Support)
Pollutant(s): Sedimentation/Siltation; Total Dissolved Solids
Suspected Sources: Highway/Road/Bridge Runoff (Non-construction Related); Surface Mining

Table 2.3: Waterway assessment information (Integrated Report to Congress 2010).

Waterbody & Segment	WAH / CAH*	PCR *	SCR *	Fish Consump-tion*	DWS *	Assess Date	Designated Uses	Assess-ment Category *	Causes	Sources
Clifty Creek 0.0 to 2.0	2-FS	3	3	3	3	3.6.2001	WAH, FC, PCR, SCR	2		
Gladie Creek 0.5 to 7.25	2-FS	3	3	3	3	11.24.2009	CAH, FC, PCR, SCR	2		
Indian Creek 2.6 to 7.8	5-PS	3	3	3	3	10.4.2004	CAH, FC, PCR, SCR	5	Sedimentation/siltation and Total dissolved solids	Highway/road/bridge runoff (non-construction), Surface mining
Indian Creek 1.25 to 2.6	2-FS	3	3	3	3	11.25.2009	CAH, FC, PCR, SCR	2		
Swift Camp 0.0 to 13.8	5-PS	3	3	3	3	12.2.2009	CAH, FC, PCR, SCR	5	unknown	unknown
Red River 64.1 to 67.6	5-PS	3	3	3	3	10.1.2004	FC, PCR, SCR, WAH	5	Sedimentation / siltation	Loss of riparian habitat / managed grazing
UT to Swift Camp at RM 11.7; 0.0 to 1.5	5-NS	3	3	3	3	10.14.1999	FC, PCR, SCR, WAH	5	Sedimentation / siltation	Loss of riparian habitat / development / septic disposal

*Reporting categories assigned to surface waters during the assessment process:

Category 1 - Attaining all designated uses.
Category 2 - Attaining some designated uses; insufficient or no data available to determine if the remaining uses are attained.
Category 3 - Insufficient or no data and information are available to determine if any designated use is attained or impaired.
Category 4 - Impaired or threatened for one or more designated uses but does not require development of a TMDL:

A. TMDL has been completed
B. Pollution control requirements are reasonably expected to result in attainment of water quality standard in near future.
C. Impairment is not caused by a pollutant.

Category 5 - Impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL.

Special Use Waters

Kentucky identifies certain Special Use Waters, which receive greater protection than other waterways. Special Use designations are made because of some exceptional quality of the water that needs protection or maintenance of current water quality. There are occurrences of each of the Special Use Waters designations in the project area (see Figure 2.8 and Table 2.4):

- *Cold-water Aquatic Habitat* - are those surface waters and associated substrate that will support indigenous aquatic life or self-sustaining or reproducing trout populations on a year-round basis (401 KAR 10:031, Section 4).

- *Outstanding National Resource Water* - are waters that meet the requirements for an outstanding state resource water classification and are of national ecological or recreational significance (401 KAR 10:030, Section 1, Table 1).

- *Exceptional Waters* - refers to certain waterbodies whose quality exceeds that necessary to support propagation of fish, shellfish and wildlife and recreation in and on the water. Waters placed in this category are reference reach waters, Kentucky Wild Rivers, some outstanding state resource waters and waters with "excellent" fish or macroinvertebrate communities (401 KAR 10:030 Section 1).

- *Reference Reach Water* - are a representative subpopulation of the least-impacted streams within a bioregion. These streams serve as chemical, physical, and biological models from which to determine the degree of impairment (physical, chemical or biological) to similar stream systems in each representative bioregion. These are not necessarily pristine streams, but represent those least-disturbed conditions that are attainable in each bioregion.

- *Outstanding State Resource Water* - are those surface waters designated by the Energy and Environment Cabinet pursuant to 401 KAR 10:031, Section 8, and include unique waters of the Commonwealth, including those with federally threatened or endangered species.

- *State Wild River* - Portions of nine rivers of exceptional quality and aesthetic character are designated as Kentucky Wild Rivers. Each Wild River is a linear corridor encompassing all visible land on each side of the river up to a distance of 2,000 feet. Wild Rivers are designated by the General Assembly in recognition of their unspoiled character, outstanding water quality, and natural characteristics. In order to protect their features and quality, land-use changes are regulated by a permit system, and certain highly destructive land-use changes (for example, clear-cutting and strip mining) are prohibited within corridor boundaries.

- *Federal Wild River areas* - is a classification of the Wild and Scenic Rivers Act and refers to those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.

- *Federal Scenic River areas* - is a classification of the Wild and Scenic Rivers Act and means those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

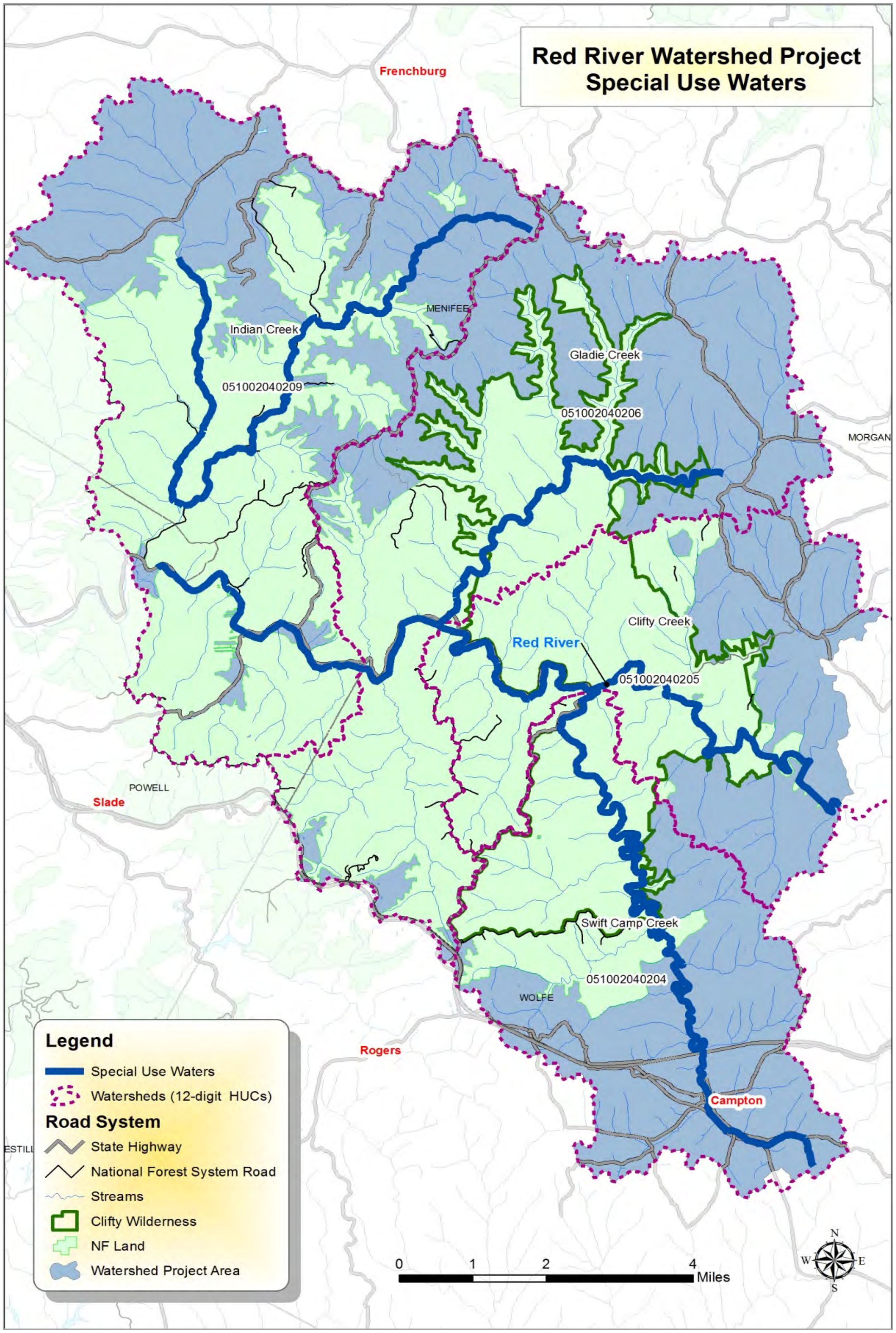


Figure 2.8: Map of Special Use Waters.

Table 2.4: Special Use Waters in the project area.

Waterway name	Counties	River miles	Cold Water Aquatic Habitat	Outstanding National Resource Water	Exceptional Water	Reference Reach Water	Outstanding State Resource Water	State Wild River	Federal Wild River	Federal Scenic River
East Fork Indian Creek	Menifee	0 to 9	Y		Y	Y	Y			
Indian Creek	Menifee	1.25 to 5.19	Y							
Gladie Creek	Menifee	0.5 to 7.25	Y		Y	Y	Y			
Red River	Menifee, Powell, and Wolfe	50.2 to 60.7		Y			Y			Y
Red River	Menifee, Powell, and Wolfe	60.7 to 70.4		Y			Y	Y	Y	
Swift Camp	Wolfe	0 to 13.9	Y							

Other Water Data

<u>Kentucky River Watershed Watch data</u>

Kentucky River Watershed Watch is a volunteer organization that samples water quality in streams all over the Kentucky River Basin, including the Red River Watershed. Typically, volunteers visit a site three times each year to collect water samples and make field observations. These samples are sent to a laboratory for analysis. There are seven sites that are near the project study area, but are actually on USFS land (see Figure 2.9). Data were collected in the study area from 1999 to 2010, but not on a consistent basis (see Table 2.5). No data were collected at these sites in 2011 or 2012. Not all data collected by Watershed Watch volunteers are collected with an approved quality assurance project plan, and therefore these data are not used in the data analysis for this project. However, these and other data collected without an approved quality project plan can be useful in comparison with project data to see if they indicate similar results. The Watershed Watch data are presented in Appendix A. For more information about the Kentucky River Watershed Watch or for more data, see their website: www.krww.org

Table 2.5: Kentucky River Watershed Watch sampling sites in project area (KRWW 2012).

Site ID #	Stream Name	Site Location	County	Years Sampled
745	Upper Red River	Big Branch canoe launch, at the mouth	Wolfe	1999, 2000, 2005, 2006, 2008, 2009
812	Swift Camp Cr	At Swift Camp Creek Camp	Wolfe	1999, 2000, 2001, 2002, 2003, 2010
900	Gladie Cr	Approx 300-500 yds upstream mouth	Menifee	2001, 2002, 2005, 2006
901	Red River	From Hwy 715 to Hwy 77	Wolfe	2001, 2002
902	Clifty Cr	Apprx 300-500 yds upstream mouth	Powell	2001, 2002
903	Swift Camp Cr	Between Castle Arch and Sky Bridge	Wolfe	2001
1082	Martins Fork	At Fletcher's ridge	Menifee	2005, 2006
1083	Powell's Branch	at Hwy 77	Menifee	2005, 2006
1086	Red River	At the John Swift Campground	Powell	2005, 2006, 2008

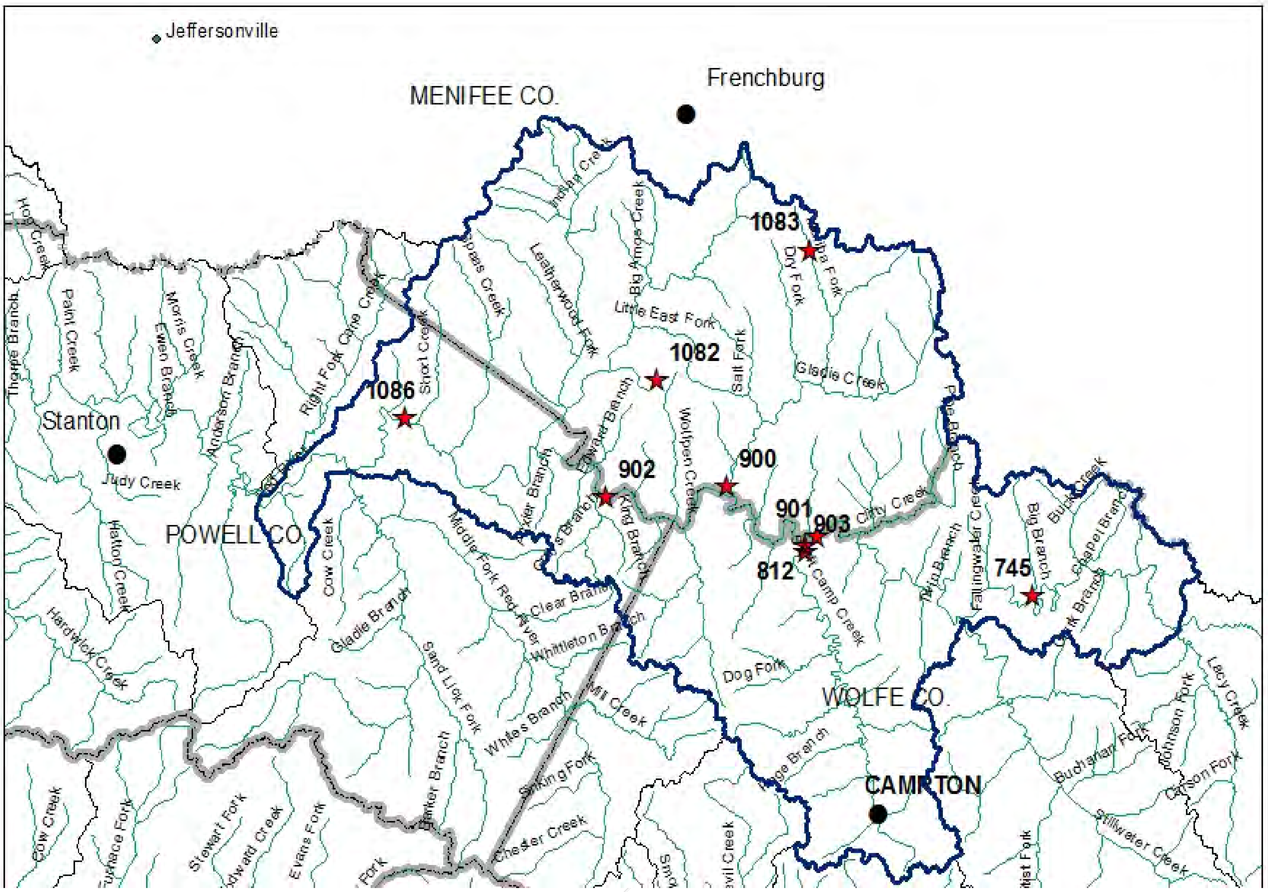


Figure 2.9: Kentucky River Watershed Watch Sampling Sites in the near project area (KRWW 2012).

<u>Kentucky Division of Water data</u>

There are seven sites in the project area, all in Swift Camp Creek, for which water quality data were collected by the TMDL section of KDOW from March 2003 to February 2004. Data were collected for these parameters: dissolved oxygen, pH, specific conductance, temperature, % saturation, and discharge. No bacteria (*E. coli*) data were collected for the TMDL study. These data provide a baseline for comparison with new data collected for this project. Table 2.6 displays collection information for these seven sites. Swift Camp Creek is the only waterway in the project area for which there are existing data. These data can be found in Appendix B.

Similar water quality data have been collected for sites in the vicinity of the project area, but are sites that lie on the Daniel Boone National Forest. Because these sites are outside the project area for this watershed plan, they are not discussed here. There are biological data collected throughout the project area by KDOW and the Daniel Boone National Forest. These data will be used in the data analysis in Chapter 4 along with new data.

Table 2.6: Existing water quality collection sites in the project area (KDOW 2012).

Station ID	Stream Name	Location	River Mile	Collection Dates
DOW 04043010	Swift Camp Creek	Unnamed tributary off State Road 15; TMDL #8	0.3	March 19, 2003
DOW 04043013	Swift Camp Creek	Below Hiram Branch, off unpaved road to oil well; below lake	10.35	April 2003 – Feb. 2004
DOW 04043014	Swift Camp Creek	Off Hwy 15 between Family Dollar and carwash	11.9	April 2003 – Feb. 2004
DOW 04043015	Swift Camp Creek UT	UT to Swift Camp Creek 0.5 miles above confluence of Swift Camp Creek; off KY 15	0.05	April 2003 – Feb. 2004
DOW 04043016	Swift Camp Creek UT	UT Swift Camp Creek; private drive off SR 651	1.6	April 2003 – Feb. 2004
DOW 04043017	Swift Camp Creek UT	UT to UT mile point 11.65; off Pete Center Drive	0.05	April 2003 – Feb. 2004
DOW 04043018	Swift Camp Creek	Campton Waste Water Treatment Plant Outfall*	11.17	April 2003 – Feb. 2004

*Note: Site DOW04043018 was sampled at the same location in 2003 and 2012. In 2008 the Waste Water Treatment Plant (WWTP) moved downstream making the 2012 sample site above the WWTP.

2.2 Natural Features

Geology

The geology of the project study area is sedimentary in nature; that is, it formed by the accumulation of sediment in thick horizontal layers, like a layer cake, over long periods of time. Sandstone, siltstone, shale, and limestone are the most common rock layers and types found in the area. Most of the exposed rock in the area was formed during the Mississippian and Pennsylvanian Periods, or roughly 360 to 299 million years ago. The project study area is located on the western escarpment of the Cumberland Plateau, a large, flat-topped tableland that is heavily dissected by numerous streams.

Prior to the formation of the southern Appalachian Mountains, this area was a shallow inland sea, much like the Gulf of Mexico today, and rich tree-fern forests covered the swampy ground. Over time, the accumulation of dead plants, animals, and sediments created the limestone, coal, sandstone, and siltstone layers we can and cannot see today on the landscape and underground. These layers are known as “strata,” and the entire profile is termed the “stratigraphic column.” The final uplift of the Appalachian Mountains, known as the Allegheny

Orogeny, occurred about 300 million years ago, and served to lift up the Cumberland Plateau out of the shallow sea. Shortly thereafter, the Pine Mountain overthrust occurred, which tilted the land of the Cumberland Plateau slightly downward to the NW from the high point of Pine Mountain. This began a period of intense erosion as the streams wore down through the less resistant rock strata and created the steep slopes, deep gorges, and hollows that make up the current landscape.

Within the project study area there are many opportunities to see and study the stratigraphic column of exposed bedrock. The layers can be described from the top down (see Table 2.7).

Table 2.7: Description of the stratigraphic column within the project study area (USFS 2012).

Name	Predominant Rock Type	Age
Corbin Sandstone of the Lee Formation	Sandstone	Middle Pennsylvanian
Grundy Formation	Shale and Coal	Lower to Middle Pennsylvanian
Newman Limestone	Limestone	Middle to Upper Mississippian
Renfro Member of the Borden Formation	Shale	Lower to Middle Mississippian
Nada Member of the Borden Formation	Shale	Lower Mississippian
Cowbell Member of the Borden Formation	Shale	Lower Mississippian
Nancy Member of the Borden Formation	Shale	Lower Mississippian

The Corbin Sandstone Member of the Lee Formation is a highly resistant sandstone, but the less resistant limestone and shale beneath erode faster. This is known as differential weathering. It is this phenomenon, driven by water and temperature, which has created the geologic features that are common to the area such as natural bridges, arches, windows, cliffs, and waterfalls.

Local Climate and Precipitation

The climate of the Red River Gorge area is temperate and moist. Winters are fairly short, and there are only a few days when temperatures are extremely low. Summers are long, but periods of excessive heat are short. Frequent changes of temperature occur in all seasons. Precipitation is fairly evenly distributed throughout the year (see Tables 2.8 and 2.9).

Precipitation has an impact on water quality and quantity. Sediment (soil) is the biggest water pollutant in Kentucky. When it rains, the water washes away soil and debris sitting on the surface into the stream. Oil and gasoline, fertilizer, pet waste, or agricultural by-products can get washed away by the rain into the stream and act as pollution. For these reasons, how much water runs off after a rain or snow melt is very important.

There are no weather stations located in the project study area. The closest is a University of Kentucky Climate data collection station south of the project area in Jackson, KY. Tables 2.8 and 2.9 below display the temperature and precipitation, respectively, at the Jackson Station for the years 2010-2011.

Table 2.8: Air temperature in Jackson, KY for 2010-2011 (UK Ag Weather Station)

Air Temperature in Jackson, KY (Breathitt County) 2010-2011						
		Average			Extreme	
	Month	Maximum	Minimum	Average	Maximum	Minimum
2010	Jan	36	24	30	56	6
	Feb	36	25	31	63	13
	March	56	39	48	74	25
	April	73	52	62	89	33
	May	76	59	67	86	38
	June	84	67	76	90	59
	July	85	68	77	91	57
	August	87	68	77	97	59
	September	81	60	71	92	50
	October	71	49	60	85	34
	November	59	40	49	73	27
	December	34	23	28	65	5
2011	Jan	38	25	31	58	3
	Feb	51	33	42	70	12
	March	57	39	48	80	29
	April	72	50	61	88	31
	May	73	55	64	90	34
	June	82	64	73	92	55
	July	86	69	78	92	63
	August	84	65	75	89	58
	September	75	58	66	96	46
	October	66	47	57	81	33
	November	61	44	53	73	26
	December	51	36	43	67	17

Table 2.9: Precipitation data from Jackson, KY weather station (UK Ag Weather Center 2012).

Precipitation data for Jackson, KY 2010-2011 (inches)			
	Month	Monthly Total	Cumulative Total
2010	Jan	4.26	4.26
	Feb	2.96	7.22
	March	2.38	9.6
	April	2.61	12.21
	May	7.92	20.13
	June	5.58	25.71
	July	2.63	28.34
	August	3.51	31.85
	September	2.05	33.9
	October	1.68	35.58
	November	5.5	41.08
	December	3.21	44.29
2011	Jan	2.7	2.7
	Feb	3.99	6.69
	March	4.73	11.42
	April	10.23	21.65
	May	6.66	28.31
	June	5.49	33.8
	July	6.02	39.82
	August	3.07	42.89
	September	3.2	46.09
	October	4.25	50.34
	November	5.48	55.82
	December	4.18	60

Soils

In general, soils are a combination of sand, silt, and clay-sized particles. The ratio of these three particles largely determines the characteristics of soil, such as productivity, strength, and erodibility. Most of the soils in the project study area may be classified as silt loams, which are thought to be the most productive soils for the growth of vegetation (personal communication with Dr. Claudia Cotton, USFS Soil Scientist, 2012). However, other factors, such as rock content, slope steepness, and aspect have a large influence on how soil is used. Additionally, soil can be classified based on where it originated. Residual soils are those that form in place directly over the parent material; they are often found on the tops of ridges in the project study area. Colluvial soils form elsewhere and are moved by gravity to another place on the landscape, such as a fan at the base of a mountain slope. Alluvial soils form elsewhere and are moved by water to another place on the landscape. Often, the soils in and around a stream are alluvial.

While soils provide many benefits, they can also be a problem for water quality. Sediment is the most common pollutant in our waters. Sedimentation occurs when sediment, which may include eroded soil, is deposited into a stream. Sediment pollution causes numerous problems in our waterways. Sediment carried in the water makes the water murky, making it difficult for aquatic animals to see their food sources. Sediment deposited on the stream bed fills in and buries habitat for aquatic creatures. Both of these processes disrupt the food chain, causing declines in fish populations and diversity. Additionally, suspended sediments increase costs for treating drinking water. Some sediments can also carry agricultural and urban pollutants into the streams, which compounds all the previously mentioned problems.

In the project study area, there are three general areas of soil types, seen in Figure 2.10. Most of the area is covered by silt loams, which form a complex that consists of the following soil series: Helechawa, Alticrest, Gilpin, and rock outcrops. These soils are a combination of residual and colluvial soils that are moderately deep to very deep, well drained to somewhat excessively well drained, and occur on many types of landscapes. The slopes are quite steep, ranging from 5% - 75%. Most of these soils weather from sandstone, or a combination of sandstone, siltstone, and shale parent materials. Hardwood forests grow well on these soils, but some may be in crops or pasture as well, depending on slope.

The eastern headwaters of the project study area are covered by silt loams, which form a complex of the Latham and Shelocta soil series. These soils are moderately deep to very deep, moderately well drained to well drained, and primarily occur on sideslopes. Slopes range from 2% to 90% and may be covered by oak/hickory forests or pasture and crops. These soils weather from shale, siltstone, and sandstone on uplands and may be residual and colluvial in origin.

Sandy loams are common in Indian creek, and may be described by the complex that includes the following soil series: Rigley, Brookside, and Steinsburg. These soils are mostly colluvial in nature but can have some residual influences as well. They are moderately deep to very deep, moderately well drained to well drained, and occur mainly on upland slopes. Slopes range from 0% to 70% and are primarily covered in oak forests, but may be in pasture or crops as well on gentle slopes in the bottoms. The parent material of these soils may be sandstone, siltstone, and conglomerate, or a combination of these.

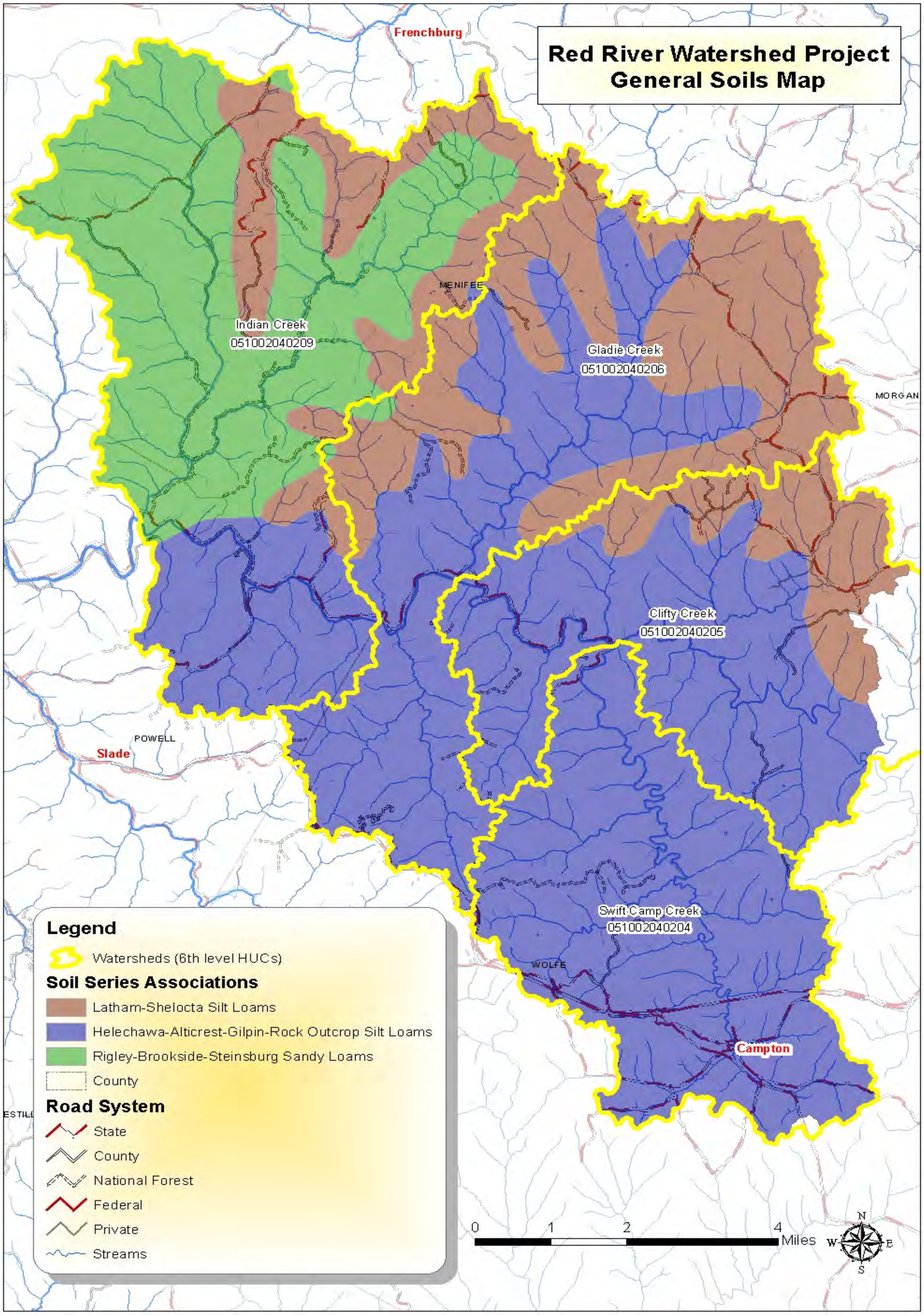


Figure 2.10: Soils of the project area (USFS 2012).

Ecoregion

Ecoregions are those areas that represent general similarity in ecological systems and in the type, quality, and quantity of environmental resources. They are typically broad-scale subdivisions based on terrain, rock type, and geologic structure and history. The Ecoregions of Kentucky project has described the state with a map (Figure 2.11) as well as descriptions of all the ecoregions (with a paper copy of the map, the descriptions of ecoregions appear on the back of the map). The map and more information about it can be found here: www.epa.gov/wed/pages/ecoregions/ky_eco.htm. The Ecoregions of Kentucky project includes other information about each region such as climate, geology, soils, and land cover.

According to the EPA's Ecoregion map of Kentucky, the Red River Watershed occurs in the Northern Forested Plateau Escarpment, referred to as section "70g" (Woods et al 2002). When looking at the map, section 70g is the narrow lime green linear section (see Figure 2.11). The following description is from the Ecoregions of Kentucky Map:

> Physiography - Unglaciated. Very rugged, highly dissected hills, narrow ridges, coves, and along rivers, cliffs. Narrow valleys and ravines are common. Karst is not extensive but does occur. Streams are typically cool, clear, and have moderate to high gradients and cobble, boulder, or bedrock bottoms.
>
> Natural Vegetation – Mixed mesophytic forest; American chestnut was a former dominant on drier sites. On slopes: mixed oak and oak-pine forest variously dominated by white oak, chestnut oak, scarlet oak, black oak, hickory, Virginia pine, shortleaf pine, yellow-poplar, white pine, red maple, and eastern red cedar. On footslopes, terraces, well-drained bottoms, and in coves: yellow-poplar, black walnut, white oak, white pine, northern red oak, sugar maple, rhododendron, and eastern hemlock. On deep, poorly-drained bottoms: forests dominated by pin oak, sweetgum, sycamore, red maple, and river birch.
>
> Landuse – Mostly forest; also some pastureland and, on bottomlands and some ridge tops, cropland. Logging, recreational opportunities, livestock farming, and oil production. Some corn, hay, and small patches of tobacco are grown. Past land use and topographic variation have contributed to today's highly variable forest composition.

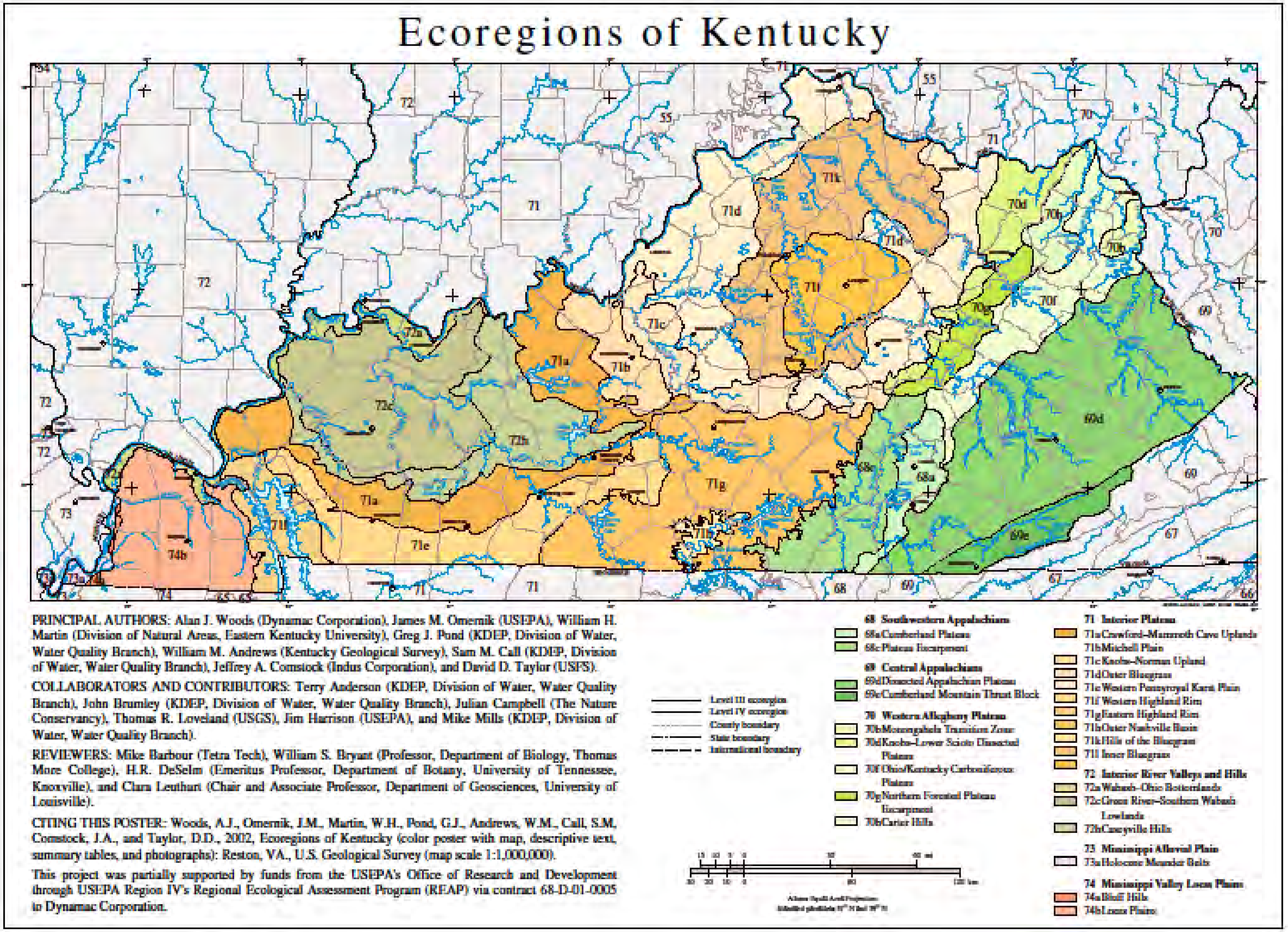


Figure 2.11: Ecoregions of Kentucky Map (Woods, A.J., Omernik, J.M., Martin, W.H., Pond, G.J., Andrews, W.M., Call, S.M, Comstock, J.A., and Taylor, D.D., 2002, Ecoregions of Kentucky).

Riparian/Streamside Vegetation
Streamside vegetation is known as "riparian" vegetation. Trees, grasses, and shrubs along a stream bank are beneficial to the health of the stream in many ways. A riparian area can slow down the water running over land (rain or snow melt or human use like lawn watering) before it enters the creek. This allows the water to drop the sediment it carries and thus keep that sediment out of the stream. Similarly, a healthy riparian area can keep other pollutants out of the stream by serving as a physical buffer. Another important way a riparian area can help is by providing shade. Shade along a creek makes the water temperature lower and generally better habitat for aquatic organisms. Also, plant roots stabilize the stream banks and reduce erosion, which is a major cause of stream sedimentation.

In general, the entire project area is highly forested. This contributes to the high water quality in many places throughout the watershed. Along the streams and rivers throughout the project area, one will likely find sycamore, eastern hemlock, red maple, yellow buckeye, witch hazel, rhododendron, river birch, sweet birch, black willow, and Kentucky cane, among others. See page 43 for a list of invasive plant species observed creek side.

Swift Camp Creek, however, does not have adequate riparian cover through much of its course through Campton. Figure 2.12 shows Swift Camp Creek as it runs through Campton. There are spots in town where there are trees along the stream. But in many other places, there is little vegetation other than lawn grass. See page 58 for results from the Swift Camp Creek walks of July 2012.

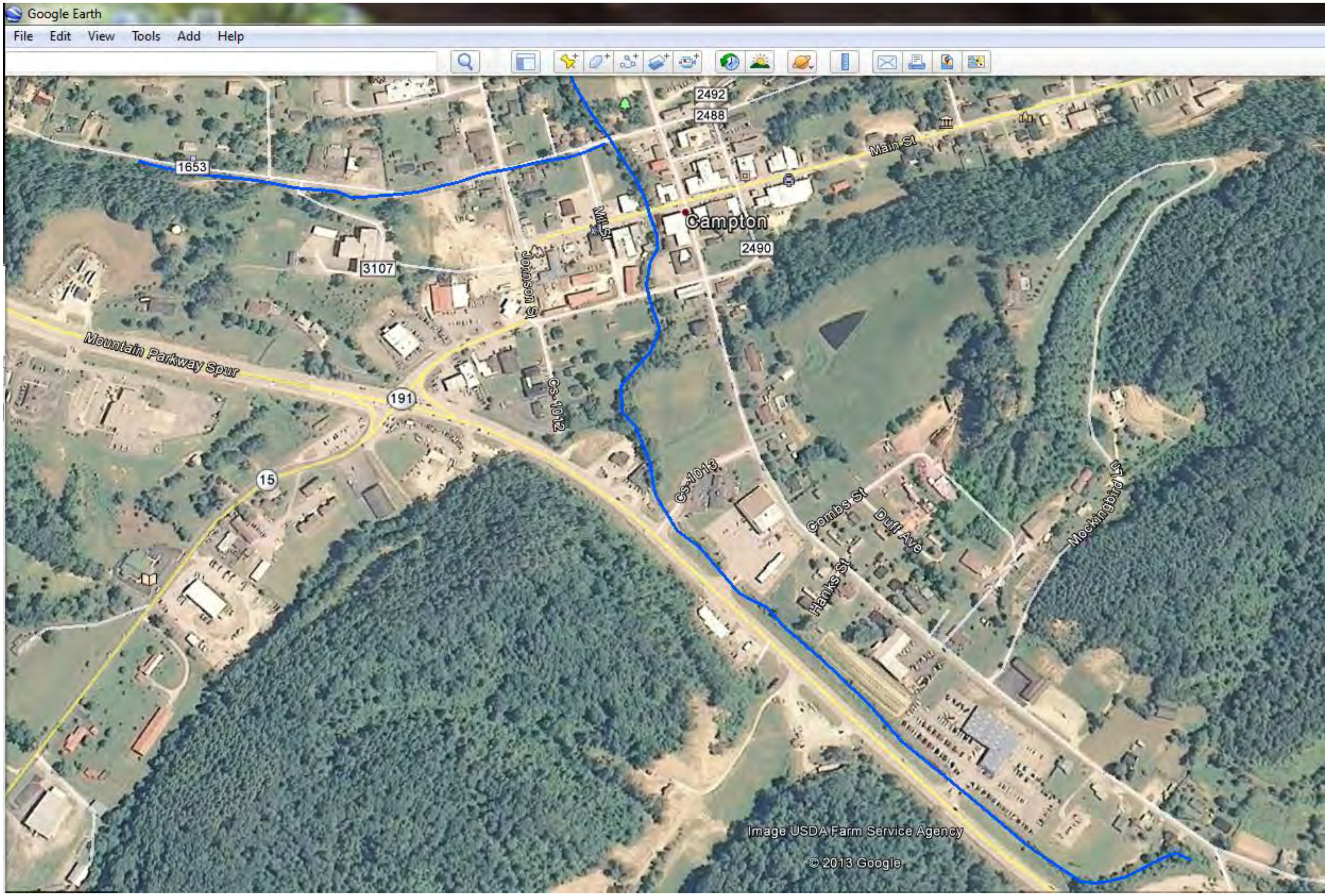


Figure 2.12: Aerial photo of Campton and Swift Camp Creek (Google Earth Image 2014).

Rare and Exotic/Invasive Plants and Animals

The Kentucky State Nature Preserves Commission works throughout the state on cataloguing threatened and endangered plants and animals. Table 2.10 below displays these species that correspond to the Red River Watershed project area. This report was created for the watershed project area by the Kentucky State Nature Preserves Commission and is specific to the watershed, not the counties at large.

A list of exotic and invasive plants in the area created during a Watershed Team Creek Walk on Swift Camp Creek in July 2012 include:

- Japanese Knot Weed (*Polygonum cuspidatum*)
- English Ivy (*Hedera helix*)
- Bush Honeysuckle (*Lonicera maackii*)
- Vine Honeysuckle (*Lonicera japonica*)
- Autumn Olive (*Elaeagnus umbellate*)
- Winter Creeper (*Euonymus fortunei*)
- Chinese Yam (*Dioscorea oppositifolia*)
- Smartweed (*Polygonum pensylvanicum)*
- Japanese Barberry (*Berberis thunbergii*)
- Canary Grass (*Phalaris arundinacea*)

Table 2.10 List of Endangered, Threatened, and Special Concern Species in the Red River Watershed Project Area (KSNPC 2012).

Report of Endangered, Threatened, and Special Concern Plants, Animals, and Natural Communities for the project area (including a 200 ft buffer)

Kentucky State Nature Preserves Commission

Taxonomic Group	Scientific name	Common name	Statuses	Ranks	# of Occurrences E	H	F	X	U
Vascular Plants	*Circaea alpina*	Small Enchanter's Nightshade	S /	G5 / S3	2	0	0	0	0
Vascular Plants	*Cypripedium parviflorum*	Small Yellow Lady's-slipper	T /	G5 / S2	1	0	0	0	0
Vascular Plants	*Solidago albopilosa*	White-haired Goldenrod	T / LT	G2 / S2	0	0	2	0	0
Vascular Plants	*Stenanthium gramineum*	Eastern Featherbells	T /	G4G5 / S2S3	1	0	0	0	0
Vascular Plants	*Taxus canadensis*	Canadian Yew	T /	G5 / S2S3	0	0	1	0	0
Freshwater Mussels	*Alasmidonta marginata*	Elktoe	T / SOMC STWG	G4 / S2	1	0	0	0	0
Mammals	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat	S / SOMC STWG	G3G4 / S3	3	0	0	0	0
Mammals	*Corynorhinus townsendii virginianus*	Virginia Big-eared Bat	E / LE STWG	G4T2 / S1	6	0	0	0	1
Mammals	*Myotis leibii*	Eastern Small-footed Myotis	T / SOMC STWG	G3 / S2	1	0	0	0	0
Mammals	*Myotis sodalis*	Indiana Bat	E / LE STWG	G2 / S1S2	3	0	0	0	0
Mammals	*Ursus americanus*	American Black Bear	S / STWG	G5 / S2	1	0	0	0	0
Communities	*Appalachian mesophytic forest*		N /	GNR / S4S5	1	0	0	0	0
Communities	*Hemlock-mixed forest*		N /	GNR / S4S5	2	0	0	0	0
					22	**0**	**3**	**0**	**1**

State Status: E = endangered; T = threatened; S = special concern; H = historic; X = extirpated; N = none; Federal status: LE = listed endangered; LT = listed threatened; C = candidate for federal listing; Other status: SOMC = federal species of management concern; STWG = State Wildlife Grant species of greatest conservation need; F = "Failed to find" This indicates that the species was not observed at the most recent visit but the habitat appears to be intact, and it is believed the species is likely to still use the area. Further searching is needed; U = "Unrankable" The data collected about the occurrence were insufficient to assign a rank. Often this is resolved when we receive additional information from the observer or if the occurrence is re-visited to obtain more detailed information; E = "Extant" The species or community is known to occur here; H = "Historic" The species or community is known to have occurred in the past, but it has not been documented in many years (usually 20+ years); X = "Extirpated" There is documented destruction of the habitat or environment of the occurrence, or persuasive evidence of its eradication based on extensive survey efforts.

2.3 Human Influences and Impacts

Humans greatly impact our environment, and everything we do on the land affects the water. The following section discusses some the local impacts of water use in the project study area and the regulations in place to monitor these impacts.

Water Use

In Kentucky, the water withdrawal program, administered by KDOW, regulates all withdrawals of water greater than 10,000 gallons per day from any surface, spring, or groundwater source with the exception of water required for domestic purposes, agricultural withdrawals including irrigation, steam-powered electrical generated plants regulated by the Kentucky Public Service Commission, or injection underground as part of operation for the production of oil and gas.

According to the Water Quantity Section of KDOW, there is one ground water and one surface water withdrawal permit in the project study area. Both are held by the Campton Water Treatment Plant. There are no permitted withdrawals south of Frenchburg in the project area, although there may be water withdrawals that do not require regulation, such as water used for irrigation.

According to KDOW Drinking Water section's "Drinking Water Watch" database, Wolfe County, including Campton, gets most of its drinking water from its Campton Lake, next to the Bert T. Combs Mountain Parkway. It has a new water well next to the new water treatment plant that can also supply its needs. The city is in the process of developing several new wells for possible backup. Campton can buy water from Beattyville, Frenchburg, or Morgan County, if necessary. Frenchburg buys its water from a water treatment plant developed by Cave Run Water Commission (personal communication with Jack Stickney of KY Rural Water Association, 2012).

Source Water Protection Plans, Wellhead Protection Program, Groundwater Protection Plans

Source Water Protection Plans are required under the Safe Drinking Water Act to assess the quantity of water used in a public water system and to formulate protection plans for the source waters used by these systems. In Campton, there is a Source Water Protection Plan area around Campton Lake, which provides drinking water for the town (see Figure 2.7). There are no other municipalities in the project area with a Source Water Protection plan (KDOW 2012).

Wellhead Protection Plans are used to assist communities that rely on groundwater as their public water source. According to the Wellhead Protection Program of KDOW, there are no Wellhead Protection Plans in the project study area. However, there is one under development for the City of Campton with the assistance of the KY Rural Water Association and KDOW (personal communication with Jack Stickney of the KY Rural Water Association, 2012).

Groundwater Protection Plans (GPPs) are required for any facility or entity engaged in activities that have the potential to pollute groundwater. These activities include anything that could leach into the ground, including septic systems and pesticide storage. The law requires that these facilities have a GPP, but does not monitor this requirement. GPPs are required to be recertified every three years and must be updated if activities are changed.

According to the Groundwater Branch of KDOW, there are at least two GPPs in the Swift Camp Creek Watershed:

- Wolfe County Maintenance Garage has an active GPP on file.
- Campton Waste Water Treatment Plant has an active GPP on file.

It is not known if there are other facilities in the project area that need a GPP. Because the GPP regulations are self-guided, it can be difficult to know if all facilities are in compliance.

Permitted Discharges

Point source pollution is pollution that has a known source, or discharge point, usually a pipe. Examples of point sources could include municipal and industrial facilities and wastewater plants that discharge directly into a stream. The point of discharge is called an outfall.

In Kentucky, point sources are required to have a permit through the Kentucky Pollutant Discharge Elimination System. These permits allow specified levels of substances into waterways – permitted discharges. According to the EPA's ECHO website www.epa-echo.gov/echo/, there are five entities that have permits in the project area (see Table 2.11).

Discharge permits and data are public information and available through online sources like ECHO, the facility itself, or a Freedom of Information Act request to KDOW. Most facilities are required to file a monthly or quarterly report that details the contents of what was discharged from their facilities, called a Discharge Monitoring Report. The facility's permit specifically states the limits of the pollutant(s) allowable. The Discharge Monitoring Report will show any discharge permit violations made at a facility, such as an effluent (discharge) exceedance. A facility outfall pipe often discharges directly to a waterway. For example, the Campton Sewage Treatment Plant discharges directly into Swift Camp Creek in Campton.

For the most part, this watershed plan is concerned with nonpoint sources of pollution. However, it is necessary to understand all sources of pollution in a watershed to isolate nonpoint sources from point sources of pollution and to calculate accurate pollutant loads (see Chapter 4).

Table 2.11: Permitted Discharges in the project area (ECHO 2012).

Facility Name	Sub watershed	Permit Number	Expiration Date	Permit/Facility Description	# Effluent Exceedances (3 yrs)
Campton Sewage Treatment Plant	Swift Camp Creek	KY0104728	6/30/2012	Sewerage Systems	47 (*E. coli*, BOD, TP, DO, N, TSS)
Bert T. Combs Mountain Parkway	Swift Camp Creek	KY0108413	8/31/2015	Stormwater/Bridge tunnel, elevated hwy construction	0 No limit data
Bringer Private Residence	Swift Camp Creek	KYG402027	12/31/2012	Sewage Package Plant/Operator of dwellings other than apartment buildings	0 No records returned
Frenchburg Job Corps Center	Indian Creek	KY0022047	2/28/2013	Sewage Package Plant/Land, mineral, wildlife, and forest conservation	33 (*E. coli*, BOD, DO, N, chlorine, pH)
Walker Company Rock Quarry	Indian Creek	KYG840063	6/30/2012	Rock Quarry/Crushed and broken limestone	1 (solids, settleable)

If CWA permit is past expiration date, this normally means the permitting authority has not yet issued a new permit. Then, the expired permit is usually administratively extended and kept in effect until new permit is issued.

Other watershed plans or projects in the area

KDOW awarded $780,000 Section 319(h) grant funds in 2009 to the DBNF to develop and implement a watershed plan for the Red River Gorge Geologic Area. It was a follow-up to the *Limits of Acceptable Change* project by conducted by the Daniel Boone from 2004 to 2008. It is connected to this project in that the best management practices recommended by the *Limits of Acceptable Change* process are now being implemented.

The East Fork of Indian Creek is home to a stream restoration project that is part of KY Department of Fish and Wildlife Resource's *Fees In Lieu Of* program with DBNF as project sponsor.

A brief project description from the Environmental Assessment:

> The United States Department of Agriculture, Forest Service (Forest Service) proposes a project that would restore portions of the East Fork Indian Creek in Menifee County, Kentucky on National Forest System land to improve habitat for fish and wildlife and to restore the stream channel to a properly functioning condition. The restoration involves removing two concrete culvert stream crossings that are acting like dams, two-concrete plank crossings that are affecting fish passage, and 3-sections of historically channeled stream. The project is a partnership effort involving the Kentucky Department of Fish and Wildlife Resources (KDFWR) and the Forest Service (excerpt from *East Fork Indian Creek Stream Restoration Environmental Assessment*, 2010).

Sewer and Septic

In rural areas, it is common to have septic tank systems instead of sewer lines and sewage treatment plants. Septic tanks and other types of onsite wastewater treatments (like lagoons or wetlands) are acceptable ways to treat sewage if maintained properly. The Kentucky Onsite Wastewater Association recommends pumping out septic tanks every three to five years, depending on the number of people living in the home.

The Swift Camp Creek Watershed has both areas serviced by sewer lines and unsewered areas (areas with septic tank systems). The sewer lines in the project area are limited to the town of Campton. Figure 2.13 illustrates these areas as well as the areas of proposed sewer line expansion. In places with old or outdated sewer and water line systems, the pipes themselves can be a source of water pollution. The pipes can leak out sewage and/or allow rain water into the sewage pipes. These types of problems are not uncommon and often referred to as "inflow and infiltration" or "i and i" issues.

Other parts of the project area do not have sewer lines. It is assumed, and it is the law, that homes and businesses in those areas have some type of onsite wastewater treatment (a septic tank, a small package treatment system, or lagoon system, for example). As noted in Table 2.10, the Frenchburg Job Corps Center and the Bringer Residence hold discharge permits. These permits are for onsite package treatment plants for the facilities.

The project area may have businesses or private residences with failing or absent wastewater systems. Wolfe County officials estimate that there are approximately 35 failing septic systems or direct discharges in the Swift Camp Creek area (personal communication with Wolfe County Health Department, 2012). The City of Campton has proposed an extension of existing sewer lines (see Figure 2.13).

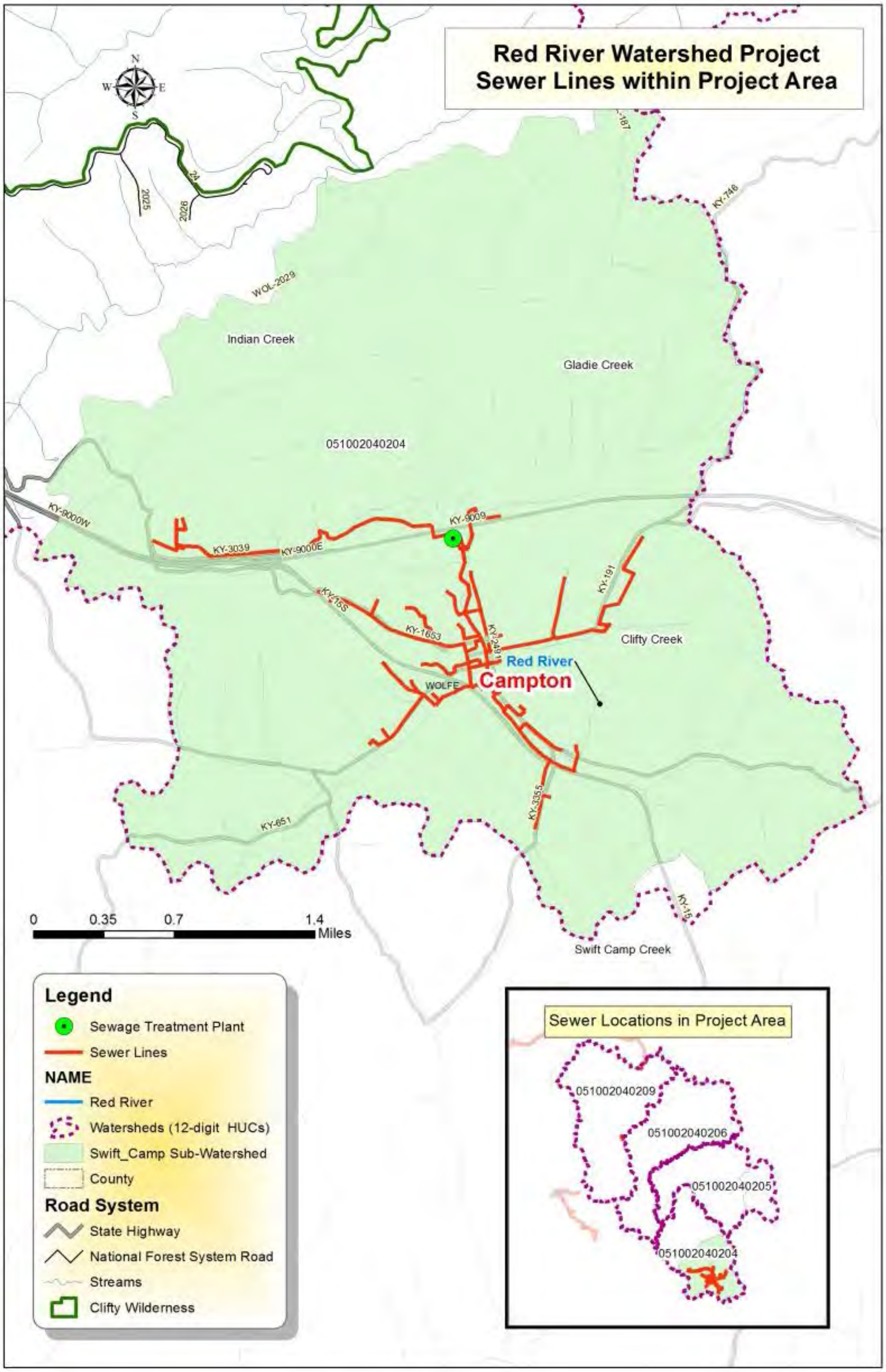


Figure 2.13: Existing and proposed sewer lines in Campton (KY Infrastructure Authority 2012).

Land Use

Examining land use in a watershed can help illustrate the types of activities on the land that may be impacting water quality. Most of this project area is highly forested, which is typically good for instream water quality (Figure 2.14). Table 2.12 shows the acreage and percentages of different types of general land use in the entire project area.

Table 2.12: Red River Watershed Land Use (USFS 2005).

Land Use	Acres	Percent
Water	26	0.04
Developed	5751	8.00
Barren	224	0.31
Forest	57640	80.18
Shrub	30	0.04
Grassland/Herbaceous	3252	4.52
Pasture/Hay	4949	6.88
Cultivated Crops	19	0.03
Total	**71891**	

The watershed is mainly forested with residential development concentrated in the town of Campton and along the roads which run along the streams (Figure 2.14). Table 2.12 shows the distribution of land use and land cover types in the watershed in 2005. Overall, the watershed contains approximately 8% impervious surfaces.

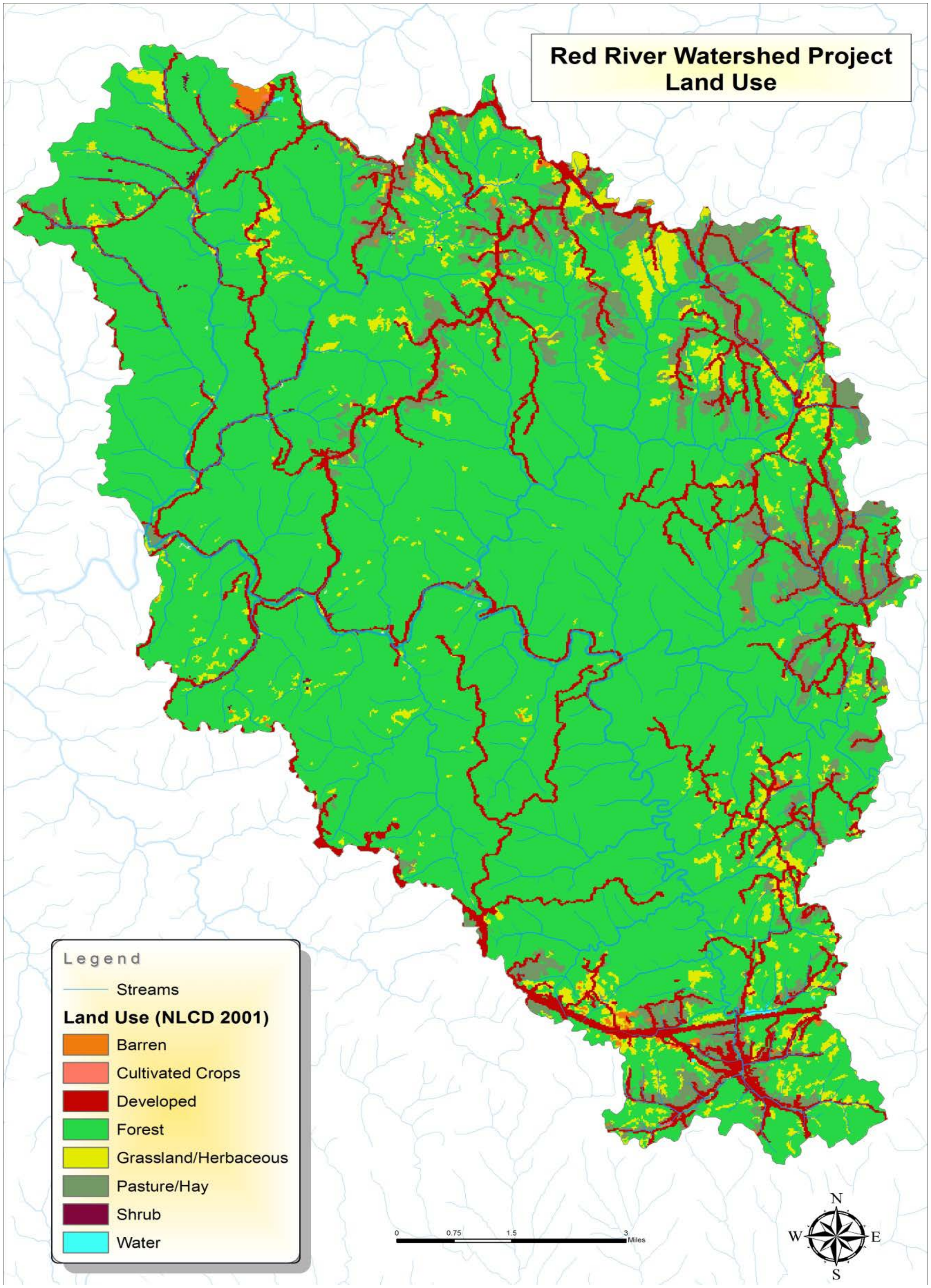


Figure 2.14: Land use in the project area (USFS 2012).

The majority of developed land use in the project area is concentrated in Campton (Table 2.13 and Figure 2.15). As the table and figure illustrate, most of the land in the Campton area is forested. In the center of the town, however, there is almost no forest or vegetative cover. There is some land in agricultural uses such as hay and cultivated crops.

Table 2.13: Land use in the Swift Camp Creek Watershed (USFS 2012).

Land Use	Acres	Percent
Water	20	0.29
Developed	1090	16.02
Barren	69	1.01
Forest	4238	62.3
Shrub	0	0
Grassland/Herbaceous	683	10.04
Pasture/Hay	699	10.27
Cultivated Crops	4	0.06
Total	**6803**	

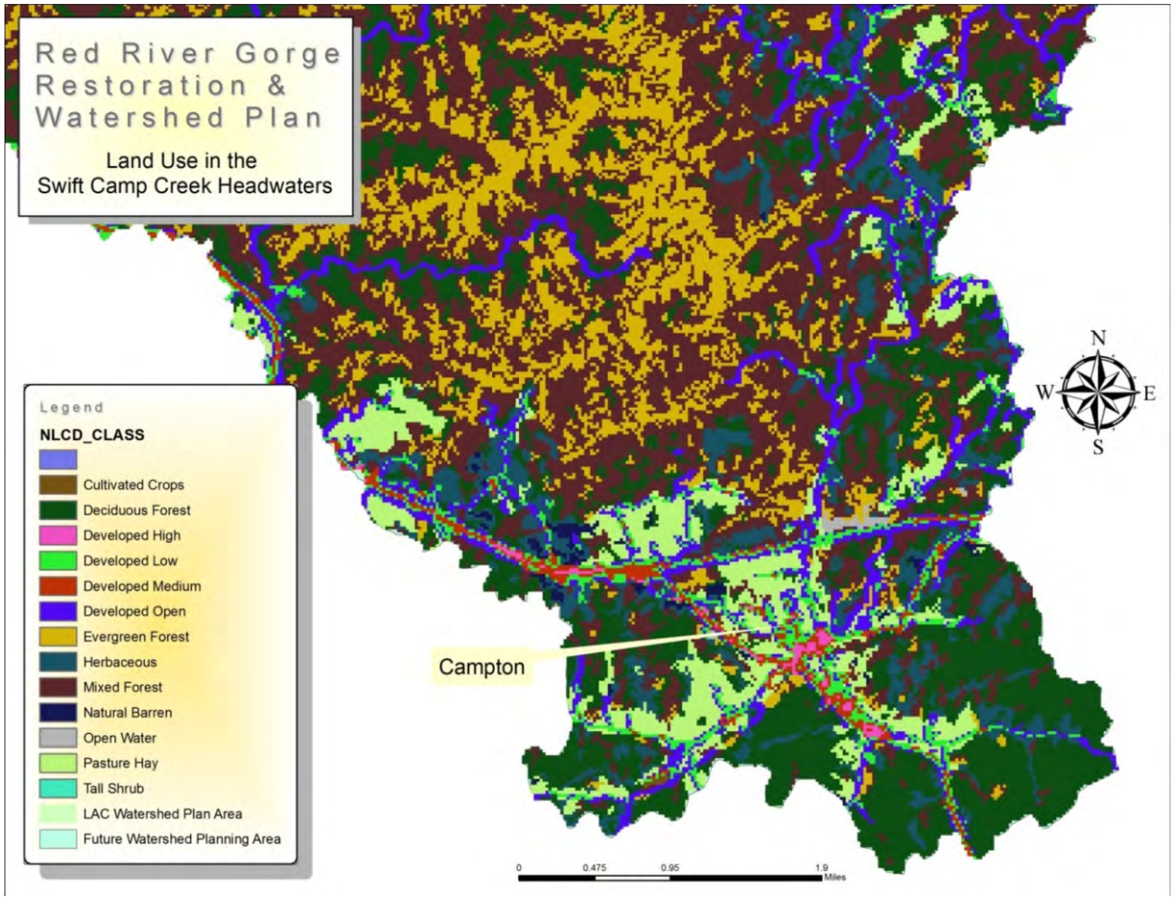


Figure 2.15: Land use in the Swift Camp Creek Watershed (USFS 2012).

Other Water Disturbances

401 and 404 Permits

Any person, firm, or agency (including federal, state, and local government agencies) planning to work in jurisdictional waters of the United States, or dump or place dredged or fill material in waters of the United States should contact the U.S. Army Corps of Engineers (USACE) office in your area and the KDOW, Water Quality Certification Section to obtain a permit. The 401 Water Quality Certification Program of the KDOW is the Commonwealth's review and authorization of selected federal license and permits.

Examples of federal licenses and permits subject to 401 certification include Clean Water Act 404 permits for discharge of dredged or fill material issued by the USACE, Federal Energy Regulatory Commission (FERC) hydropower licenses, and Rivers and Harbors Act 9 and 10 permits for activities that have a potential discharge in navigable waters issued by the USACE. A 401 certification from the Commonwealth of Kentucky also affirms that the discharge will not violate Kentucky's water quality standards (KDOW website: water.ky.gov/permitting/Pages/KYWaterQualityCertProg.aspx).

Examples of activities that may require a certification from KDOW, Water Quality Certification Section include:

- Placement of dredged or fill materials into waters of the state and/or wetlands
- Structural fill such as culverts and bridge supports
- Road and utility crossings
- Dredging, excavation, channel widening, or straightening
- Flooding, excavating, draining and/or filling a wetland
- Bank sloping; stabilization
- Stream channel relocation
- Water diversions
- Divert, obstruct or change the natural flow or bed of any waters of the state (e.g. debris removal, bank stabilization or installing a culvert)
- Construct a barrier across a stream, channel, or watercourse that will create a reservoir: dams, weirs, dikes, levees or other similar structures (Kentucky Division of Water website water.ky.gov/permitting/Pages/KYWaterQualityCertProg.aspx).

A Freedom of Information Act request to the Louisville District Army Corps of Engineer for any 404 permits in the counties of Menifee, Powell, and Wolfe for the time period of January 1, 2007 to December 31, 2011 resulted in two permits within the project study area (see Table 2.14). There were many more permits issued within these counties that fell outside of watershed project area.

Table 2.14: Record of 404 permits issued in project study area from 2007-2012 (US Army Corps of Engineer via FOIA request by KWA 2012).

Project Name	DA Number	Start Date	End Date	Action Type
Mountain Parkway Widening	LRL-2008-00203-jct	April 22, 2008	August 21, 2008	SP
City of Campton Water Treatment Plant Project	LRL-2009-00096	Sept. 17, 2009	Sept. 25, 2009	NWP

Land Disturbances

There is a limestone quarry in the watershed project area, in the Indian Creek subwatershed. The facility has a KDPES discharge permit (#KYG840063). Also, there are several gas wells and a few oil wells scattered around the entire project area (see Figure 2.16).

The Kentucky Geological Survey created maps for each county in Kentucky to help identify areas of concern or areas in need of protection when planning for development. Figure 2.16 shows the Wolfe County map, zoomed in on the Campton area and the Swift Camp Creek subwatershed. It illustrates the Source Water Protection Area surrounding Campton Lake as well as several oil wells and public and domestic water wells and enhanced recovery wells.

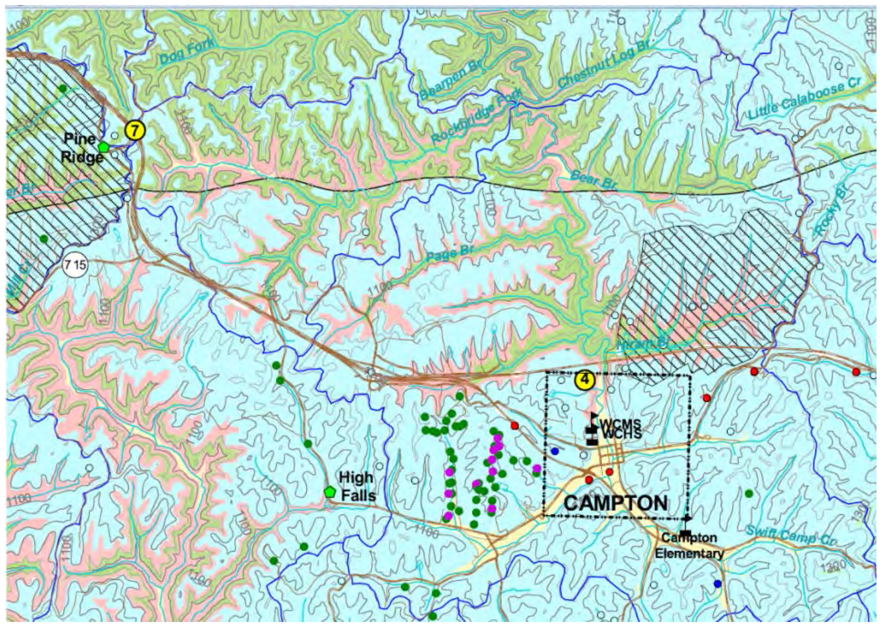


Figure 2.16: Kentucky Geological Society Land Use Planning Map for Wolfe County (cropped) (KGS 2005).

Hazardous Material
Information about sites that store or contain hazardous materials and/or waste is available through a number of programs administered by the KY Division of Waste Management. According to a phone call placed to the KY Division of Waste Management in July 2012, there are no known hazardous materials contained or being stored in the project area (personal communication with an employee of the KY Division of Waste Management, 2012).

2.4 Demographics

The project area falls within three counties, Wolfe, Menifee, and Powell, but does not include the entirety of these counties. The County Seat of Wolfe County, Campton, is the only concentrated population center in the project area. There are other small townships and private homes and businesses throughout the project area. The population of Campton in 2010 was 441 people. This represents a 4% increase from the population of 2000. The median age of town residents in 2010 was 40.4 years old; and median household income in 2009 was $14,498 (www.city-data.com).

The town of Campton was first settled in the late 1810s. Most historians regard Nim Wills as the founder of Campton. Wills established the new town on the waters of Swift Camp Creek at the site of believed to have been first used by John Swift and his party of silver prospectors 100 years prior (and for whom the creek was named). At first, the town was known as Camp Town after the camp site. The town was named county seat of the new Wolfe County in 1860 and was formally incorporated ten years later (http://www.rootsweb.ancestry.com/~kywolfe/ 2012).

A nearby community that is just north of the project area is Frenchburg in Menifee County. The 2009 population was 535 people; median age of town residents in 2009 was 36.2; the median household income in 2009 was $17,274 (www.city-data.com). There is also the Frenchburg Job Corps Center, which lies in the project area on USFS land. This is a population of approximately 100 people. Students ages 16 to 24 come from all over the U.S. for no cost vocational training.

2.5 Team Observations

Swift Camp Creek Walks

On July 11, 2012, watershed team members participated in a Swift Camp Creek Walk. The team used the Natural Resources Conservation Service's Visual Stream Survey forms to make observations on the section of Swift Camp Creek starting at the city park on Washington Street down to State Transportation Garage on KY Highway 15. The forms can be found in Appendix C. A general synopsis of the experience and information gathered is presented here, along with a sample of photographs (see Figures 2.17-2.20).

The sections of the creek encountered, in general, revealed degraded habitat and lack of robust riparian buffers. The group encountered several pipes and other water and wastewater structures in the creek. There were several areas of healthy riparian buffer with a diversity of native plants (Figure 2.17). While some fish and macroinvertebrates were observed, the group thought that the populations did not appear to be very diverse. The physical stream bank varied from intact with vegetated riparian to more developed, degraded conditions (Figure 2.18). There also were several eroding, entrenched sections (Figure 2.19).

On July 18, 2012, watershed team members participated in a second Swift Camp Creek Walk. The group started north of the Mountain Parkway and continued to the Forest Service boundary near Rock Bridge Fork. This section of Swift Camp Creek was more rural with well-defined riparian areas. The major impacts observed were solid waste (Figures 2.20 and 2.21) and bank erosion (Figure 2.22). The concentration of trash decreased downstream. There were several scenic sections along the way (Figures 2.23).

Figure 2.17: Buttonbush observed along Swift Camp Creek (photo by Rita Wehner 2012).

Figure 2.18: Watershed team member observing built structures in creek (photo by Jon Walker 2012).

Figure 2.19: Stretch of Swift Camp Creek with eroded and incised banks (photo by Jon Walker 2012).


Figures 2.20-2.21: Trash and tires observed in upper section of Swift Camp Creek (photos by Jon Walker 2012).

Figure 2.22: Bank erosion on upper Swift Camp Creek (photo by Jon Walker 2012).

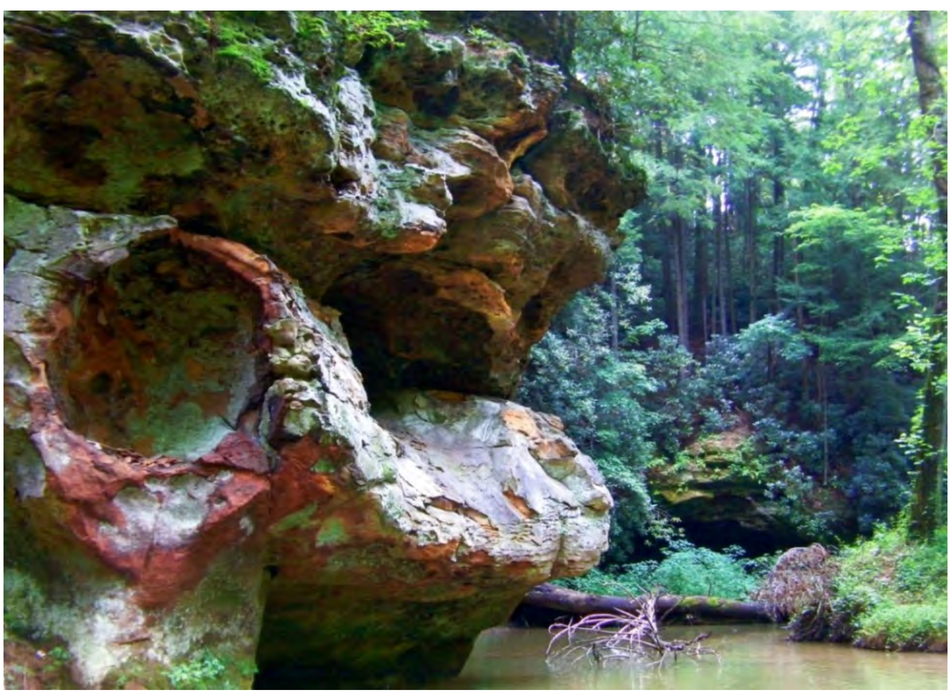


Figure 2.23: Scenic view of Swift Camp Creek, north of Campton (photo by Claudia Cotton 2012).

2.6 Interim Conclusions

The project area represents some to the most beautiful land and best surface water quality in the state of Kentucky not the place for opinions. The four waterways of this project merit water quality management efforts for their own intrinsic value and because they are tributaries to the Red River. Education about Kentucky surface waters and water quality is needed. Is this paragraph needed at all?

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Chapter 3: Learning More - Monitoring to Secure New Data

3.1 Introduction

There are two main goals of watershed planning: protect good water quality and improve poor water quality. *The Red River Gorge Restoration and Watershed Plan Project* is working toward both of these goals. The work presented in Chapter 2 created an inventory of available information about the project area and its subwatersheds. Now additional data and in-depth analysis are needed to identify current pollutant sources and guide implementation projects to places where they will have the most benefit.

3.2 Existing Data

Existing data about the watershed were presented in Chapter 2. This is valuable information, providing a background on the conditions of the four focus streams of the project. Swift Camp Creek and an unnamed tributary are impaired waterways.

The existing data include water quality data collected for the Total Maximum Daily Load study on Swift Camp Creek by the Kentucky Division of Water (KDOW) in 2003-2004 (see Appendix B). There are no Kentucky River Watershed Watch sites within the project area. The existing data from KDOW and Daniel Boone National Forest are used in the analysis with the new data as described in Chapter 4.

3.3 New Data

The purpose of collecting new data is to create a better understanding of the current conditions in each stream. Data were collected specifically for this project at twelve sites for one year I don't think this is correct. Not all mapped sites had data collection for one year, from July 2011 to June 2012. Sites were selected based on their proximity to pertinent land use features, tributary confluences, and available access in order to better isolate sources of pollution and areas for protection (see Figure 3.1 and Tables 3.1 and 3.2).

Additional data collection was conducted when? in Campton in an effort to isolate sources of bacteria called microbial source tracking. These data may provide more insight into the sources and thus, potential solutions to bacteria issues in Swift Camp Creek and the Red River. These data should be discussed in this plan.

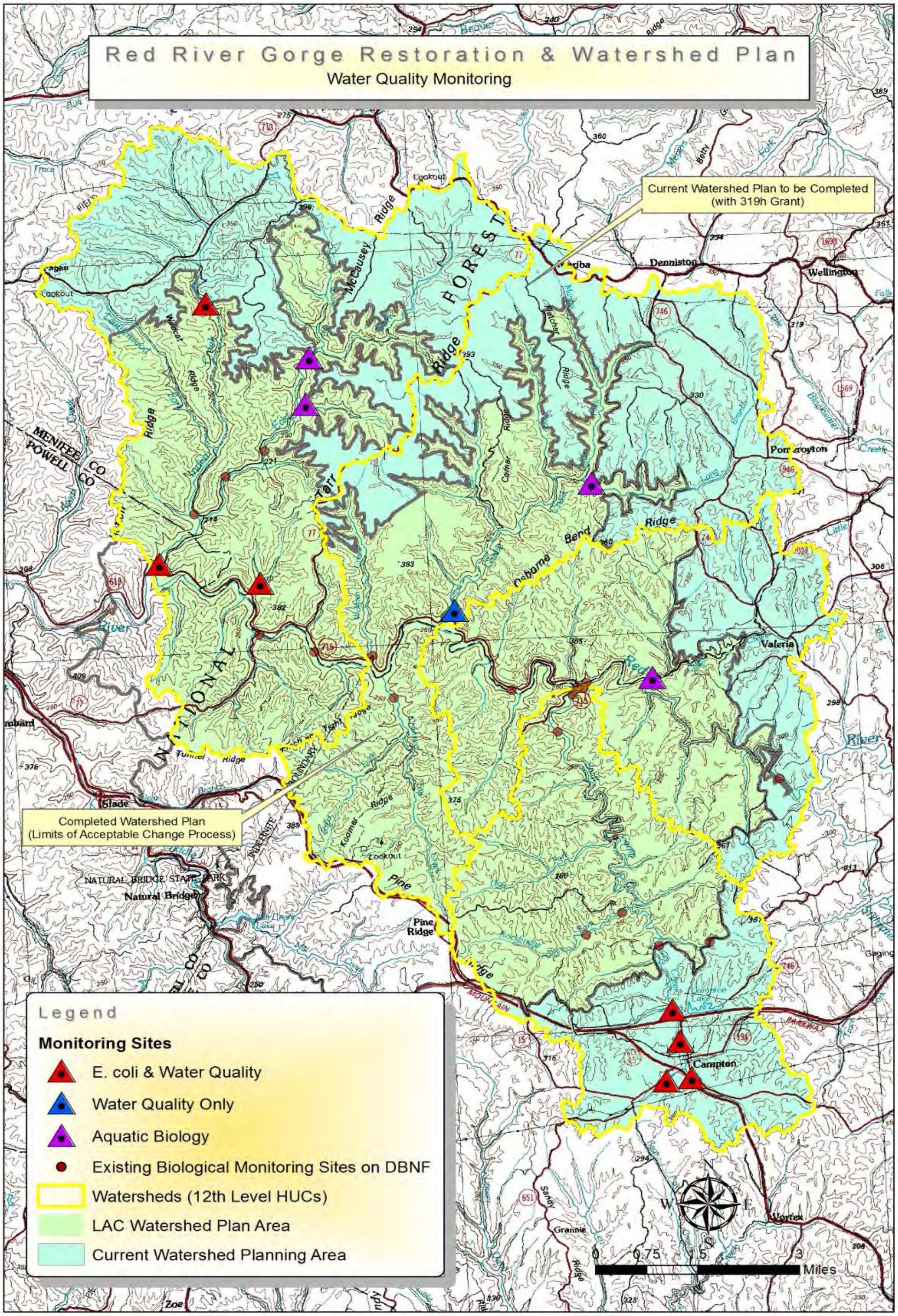


Figure 3.1: Water quality monitoring sites in the project area (USFS 2012).

The new data for this project were collected by three entities: Rita Wright Consulting, the Daniel Boone National Forest, and Third Rock Consulting. Sampling was conducted according to guidelines in the *Watershed Planning Guidebook for Kentucky Communities*, first edition (see Table 3.2) and the Quality Assurance Project Plan (see Appendix D). In order to better understand the implications of these data, they must be examined within the context of the relevant watershed area.

General information about water quality, what each parameter means and how it is collected, can be found in the *Watershed Planning Guidebook for Kentucky Communities*. The "Watershed Basics" section reviews watershed planning, regulatory issues, and the science behind water quality testing. It can be viewed online: www.kwalliance.org.

Water quality and bacteria

The water quality and bacteria sampling was conducted by Rita Wright Consulting from July 2011 until June 2012. Sampling was done over the course of one year, collected monthly, to capture different conditions and environmental situations such as during wet weather and dry weather conditions. Wet weather samples are intended to capture information about runoff pollution; wet weather is defined as "a seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions" (*Watershed Planning Guidebook for Kentucky Communities*). Samples were taken after rain events that did increase instream flow, but failed to create run-off conditions. Thus, none of the samples reported in Chapter 4 are considered wet weather samples, however samples collected under higher flow conditions are addressed in Chapter 4. Bacteria (*E. coli*) samples were processed at the Morehead State University Lab, and the rest of the samples were processed by Fouser Lab in Versailles, Kentucky. Field data such as water temperature, flow, and pH were measured onsite at each visit with an Orion Field Meter.

For bacterial (*E. coli*) testing, 7 sites were each sampled 16 times - once a month for 1 year plus 5 times in 30 days in May 2012. Eight sites were sampled for water quality parameters 12 times (once a month for one year).

Biology

Biological sampling in the Swift Camp Creek subwatershed was conducted by Third Rock Consulting in the summer of 2011 to establish the biological and habitat conditions. The survey was conducted at four sites near Campton. DBNF personnel conducted biological sampling at sites in the Indian, Creek, Gladie Creek, and Clifty Creek subwatersheds (see Table 3.1) in the summer of 2011. All of these data are used in the biological analysis in Chapter 4.

Table 3.1: Sampling sites and parameters for data collection for the Red River Gorge Restoration and Watershed Plan project.

Sampling Sites and Parameters

Swift Camp Creek sites

These four sites were sampled for water quality parameters, bacteria, and biology:

•DOW04043010 – Unnamed Tributary off State Road 15
•DOW04043014 – Off KY 15; Between Family Dollar and the Car Wash
•DOW04043018 – Campton WWTP (sample taken upstream of outfall*)
•DOW04043013 – Below Hiram Branch, lake, and WWTP; off unpaved road to oil well **

Indian Creek sites

These two sites were sampled for water quality parameters and bacteria:

•DOW04042017 –Off Bear Branch Road, on what was once a Forest Service Jeep Trail
•DBF04015 – At the mouth of Indian Creek at the road 613 Bridge

These three sites were sampled for biology only:

•DBF0404022 - New Site on Edwards Branch, above 613 Road
•DBF04042024 – East Fork Indian Creek, downstream from Hall Sink Branch
•DBF04042021 – Little East Fork, just upstream of East Fork Indian Creek

Gladie Creek sites

This site was sampled for biology only:

•DBF04042025 – Gladie Creek (upstream), downstream of Browns Branch

This site was sampled for water quality parameters only:

•DOW04042011 – Gladie Creek (downstream), 0.25 miles upstream of HWY 746 Bridge.

Clifty Creek site

The site was sampled for biology only:

•DBF0404023 **-** New Site downstream of Osborne Branch.

*Note: Site DOW04043018 was sampled at the same location in 2003 and 2012. In 2008 the Waste Water Treatment Plant (WWTP) moved downstream making the 2012 sample site above the WWTP).

**Note: Since the Lake flows intermittently, DOW04043013 serves as the 2012 “below WWTP” monitoring site.

Table 3.2: Watershed Plan Monitoring Guidelines

Group	Parameter	Monthly	5X/30days May or June	1X/year May or June	Every Time	Standard Operating Pro.
Bacteria	*E. coli* (*Escherichia coli*)	x	x			DOWSOP03017
Chemistry	NO3/ NO2 (Nitrate/Nitrite)	x				DOWSOP03015
	NH3-N (Ammonia – Nitrogen)	x				DOWSOP03015
	TKN (Total Kjeldahl Nitrogen)	x				DOWSOP03015
	TP (Total Phosphorous)	x				DOWSOP03015
	OP (Orthophosphate)	x				DOWSOP03015
	BOD5* (Biochemical Oxygen Demand)	x				DOWSOP03015
Sediment	TSS (Total Suspended Solids)	x				DOWSOP03015
Flow	Stream Discharge				x	DOWSOP03019
Field Data	Turbidity (actual or estimated)				x	DOWSOP03014/ DOWSOP0315
	pH				x	DOWSOP03014
	DO (Dissolved Oxygen)				x	DOWSOP03014
	Conductivity				x	DOWSOP03014
	% Saturation (Percentage of DO)				x	DOWSOP03014
	Temperature				x	DOWSOP03014
Habitat	Habitat Assessment			x		DOW SOPs
Biology	Biological Assessment			x		DOW SOPs

*BOD5: the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter.

The Watershed Planning Guidebook for Kentucky Communities, first edition (2010), page 83.

The State of Kentucky has criteria for certain water quality parameters, either numeric or narrative. Numeric and narrative water quality criteria include the parameters listed in Table 3.3. Narrative water quality criteria include provisions that surface waters shall not be aesthetically or otherwise degraded by substances that:

- Settle to form objectionable deposits;
- Float as debris, scum, oil, or other matter to form a nuisance;
- Produce objectionable color, odor, taste, or turbidity;
- Injure, are chronically or acutely toxic to or produce adverse physiological or behavioral responses in humans, animals, or fish and other aquatic life;
- Produce undesirable aquatic life or result in the dominance of nuisance species; or
- Cause fish flesh tainting.

Table 3.3: Numeric & Narrative Criteria: Warm Water Aquatic Habitat, Primary/Secondary Contact Recreation. This should also include CAH

Parameter	Values
Dissolved Oxygen	5.0 mg/L Daily Average; 4.0 mg/L Instantaneous
pH	6.0 – 9.0 Standard Units
Temperature	89°F Instantaneous; 84°F 30-Day Summer Average (31.7° and 28.9° C, respectively)
Total Dissolved Solids	No adverse effects on indigenous aquatic community
Total Suspended Solids	No adverse effects on indigenous aquatic community
Settleable Solids	No adverse effects on indigenous aquatic community
Ammonia	< 0.05 mg/L after mixing
Fecal Coliform (Primary Contact Recreation)	200 CFU / 100 mL geometric mean for 5 samples over 30 days, 5/1 – 10/31. 20% of samples must not exceed 400 CFUs.
Escherichia Coli (Primary Contact Recreation)	130 CFU / 100 mL geometric mean for 5 samples over 30 days, 5/1 – 10/31. 20% of samples must not exceed 240 CFUs.
Fecal Coliform (Secondary Contact Recreation)	1000 CFU / 100 mL geometric mean for 5 samples over 30 days, year-round 20% of samples must not exceed 2000 CFUs.

Source: Kentucky Water Quality Standards (401 KAR 10:031).

Table 3.3 covers Warmwater Aquatic Habitat. Swift Camp Creek is designated for Coldwater Aquatic Habitat. There are different standards for temperature and dissolved oxygen for Coldwater Aquatic Habitat:

(2) Cold water aquatic habitat. The following parameters and criteria are for the protection of productive cold water aquatic communities and streams that support trout populations, whether self-sustaining or reproducing, on a year-round basis. The criteria adopted for the protection of warm water aquatic life also apply to the protection of cold water habitats with the following additions:

(a) Dissolved oxygen.

1. A minimum concentration of six and zero-tenths (6.0) mg/L as a twenty-four (24) hour average and five and zero-tenths (5.0) mg/L as an instantaneous minimum shall be maintained.

2. In lakes and reservoirs that support trout, the concentration of dissolved oxygen in waters below the epilimnion shall be kept consistent with natural water quality; and

(b) Temperature. Water temperature shall not be increased through human activities above the natural seasonal temperatures (401 KAR 10:031).

Benchmarks

Phosphorus, nitrogen, and conductivity are important parameters to consider in overall stream health, but there are no numeric Kentucky water quality standards for them. In lieu of state standards, KDOW created benchmarks based on data collected on Reference Reach Streams (Table 3.4). Reference Reach streams are streams within specific bioregions that represent the least impacted conditions. Water quality data for these streams can be used to set target levels, or benchmarks. See Appendix E for more information about benchmarks.

Table 3.4: Parameter benchmarks for the Red River Gorge Restoration and Watershed Plan Project.

Parameter	Benchmark Value
Nutrients:	
Total Phosphorus	0.020 mg/L
Total Kjeldahl Nitrogen	0.500 mg/L
Nitrate-Nitrite	0.200 mg/L
Total Nitrogen	0.600 mg/L
Non-Nutrients:	
Ammonia-N	<0.050 mg/L
Unionized Ammonia	0.0002 – 0.0007 mg/L
Sulfate	20.0 mg/L
Specific Conductance	218 (µS/cm)
Alkalinity	72.2 (mg/L as $CaCO_3$)
Total Suspended Solids*	6.0 mg/L
Turbidity*	5.9 NTU

*For TSS and Turbidity, these reference benchmarks are only to compare normal April-October flow conditions and not high flow events or winter samples. Benchmarks provided by KDOW 2012.

Chapter 4: Analyzing Results

Chapter Four will help you:

- Understand what the data and information collected tell you about the watershed
- Target subwatershed areas for implementation

Water quality, bacteriological, biological, and habitat monitoring were conducted in four subwatersheds within the Red River Watershed. This chapter presents results and analysis of data for the Swift Camp Creek subwatershed, the Indian Creek subwatershed, the Gladie Creek subwatershed, and the Clifty Creek subwatershed.

For more background information on these subwatershed areas, see Chapter 2. Chapter 5 presents Best Management Practices that could potentially alleviate the water quality, habitat, and biology issues discussed in this chapter, and Chapter 6 presents those practices that have been chosen by the watershed team to be the best fit for the issues and local communities.

4.1 Overall Data Summary

Water Quality

Eight sites were sampled monthly for one year for water quality parameters for a total of 12 sampling events. Seven sites were sampled monthly for one year for *E. coli* as well as for 5 days within a 30 day time period. Eight sites were sampled for macroinvertebrates at a one-time event. Sample locations are shown in Figure 4.1. Sample identifiers are shown in Table 4.1 including site letters to help the reader better identify sites on chapter maps. Monitoring was conducted between July 2011 and June 2012. Parameters collected on-site were flow, dissolved oxygen, pH, conductivity, and temperature. Parameters analyzed in the laboratory were Total Phosphorus, Nitrate, Nitrite, Orthophosphorus, Total Kjeldahl Nitrogen, Total Suspended Solids, and *E. coli.* Total Nitrogen was calculated from summing Nitrate, Nitrite, and Total Kjeldahl Nitrogen. Pollutant loadings were calculated for Total Phosphorus, Total Nitrogen, Total Suspended Solids, and *E. coli*, as directed by the *Watershed Planning Guidebook for Kentucky Communities* (Kentucky Waterways Alliance and the Kentucky Division of Water 2010).

Table 4.1: Site Letters and Kentucky Division of Water Site Numbers.

Site Letter	Site ID	Site Name	Site Description
A	DOW04043018	Swift Camp Creek at WWTP	Above the outfall of the WWTP *
B	DOW04043010	Swift Camp Creek at Unnamed Tributary	Along an un-named tributary south of KY 15
C	DOW04043018	Swift Camp Creek at KY SR 15	Along State Road 15
D	DOW04043013	Swift Camp Creek at Hirams Br	Below Hirams Branch
E	DOW04042017	Indian Creek at Bear Branch Rd	At end of Bear Branch Rd
F	DBF04015	Indian Creek at Mouth	Near mouth of Red River
G	DBF00042024	East Fork Indian Creek	Along East Fork Little Indian Rd
H	DBF04042021	Little East Fork	At mouth, confluence with East Fork Indian Creek
I	DBF04042025	Gladie Creek	At mouth, confluence with Laurel Fork
J	DBF0404023	Clifty Creek	At mouth, confluence with Red River
K	DBF0404022	Edwards Branch	At mouth, confluence with Red River
L	DOW04042011	Gladie Creek Downstream	At mouth, confluence with Red River

*Note: Site DOW04043018 was sampled at the same location in 2003 and 2012. In 2008, the Waste Water Treatment Plant (WWTP) moved downstream making the 2012 sample site above the WWTP.

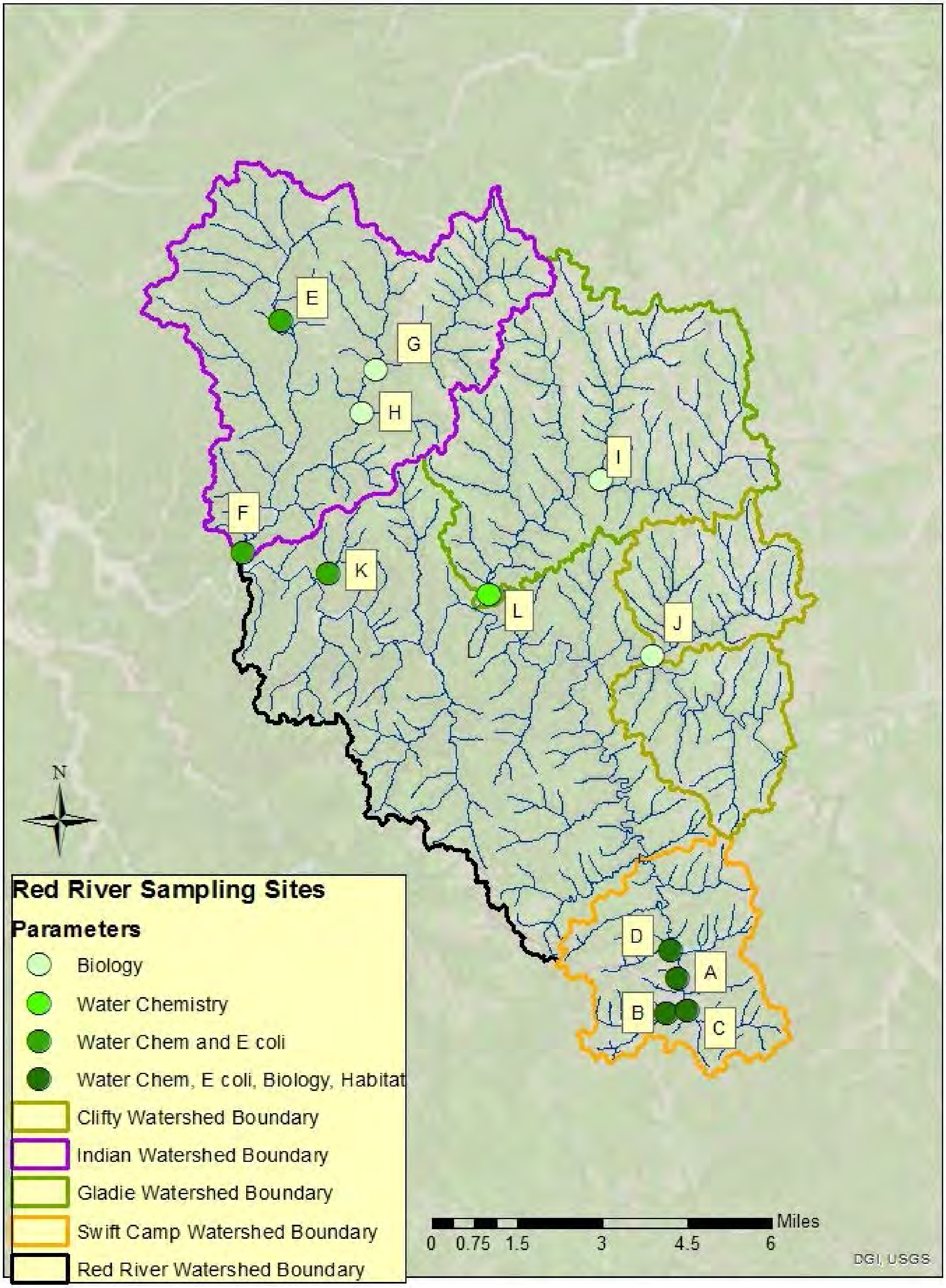


Figure 4.1: Red River Project Monitoring Locations.

4.2 Water quality parameters overview

This section serves as a reminder of categories of waters in Kentucky and how one may assess the quality and health of those waters. These topics are also covered in Chapters 2 and 3.

Designated Uses

A designated use is a category of waters that is indicated for a specific purpose. Kentucky has six identified designated uses for waters across the Commonwealth:

1. Warm water aquatic habitat
2. Cold water aquatic habitat
3. Primary Contact Recreation
4. Secondary Contact Recreation
5. Outstanding State Resource Waters
6. Domestic Water Supply

And while Fish Consumption is not a designated use, it is recognized as an important human health indicator (per 401 KAR 10:031 Section 2) and has criteria to measure levels of pollutants.

A water is classified as "not meeting its designated use" when the stream conditions exceed either numeric or narrative water quality standards under Kentucky laws. This can occur when the natural environment is altered due to elevated pollutant loads or a level of pollution. An example of a pollutant is nitrogen, ammonia, or bacteria. An example of pollution is aquatic habitat alteration, or a disturbed, 'unnatural' flow pattern.

There are waters within the project area that are designated as cold water aquatic habitat (CAH) and outstanding state resource waters (OSRWs) (401 KAR 10:026). Both designations are intended to provide a certain level of protection from potentially harmful pollutant discharges.

CAH is defined as productive cold water aquatic communities and streams that support trout populations, whether self-sustaining or reproducing, year-round. There are minimum and maximum values that will support this designated use, and exceeding these values will cause the use to not be met, and may be included on the list of impaired waters (the 303(d) list).

OSRWs are defined as unique waters of the Commonwealth, which include circumstances like:

- Presence of threatened or endangered species
- Waters designated as Federal Wild and Scenic
- Waters included in a state nature preserve
- Other water as defined in 401 KAR 10:031

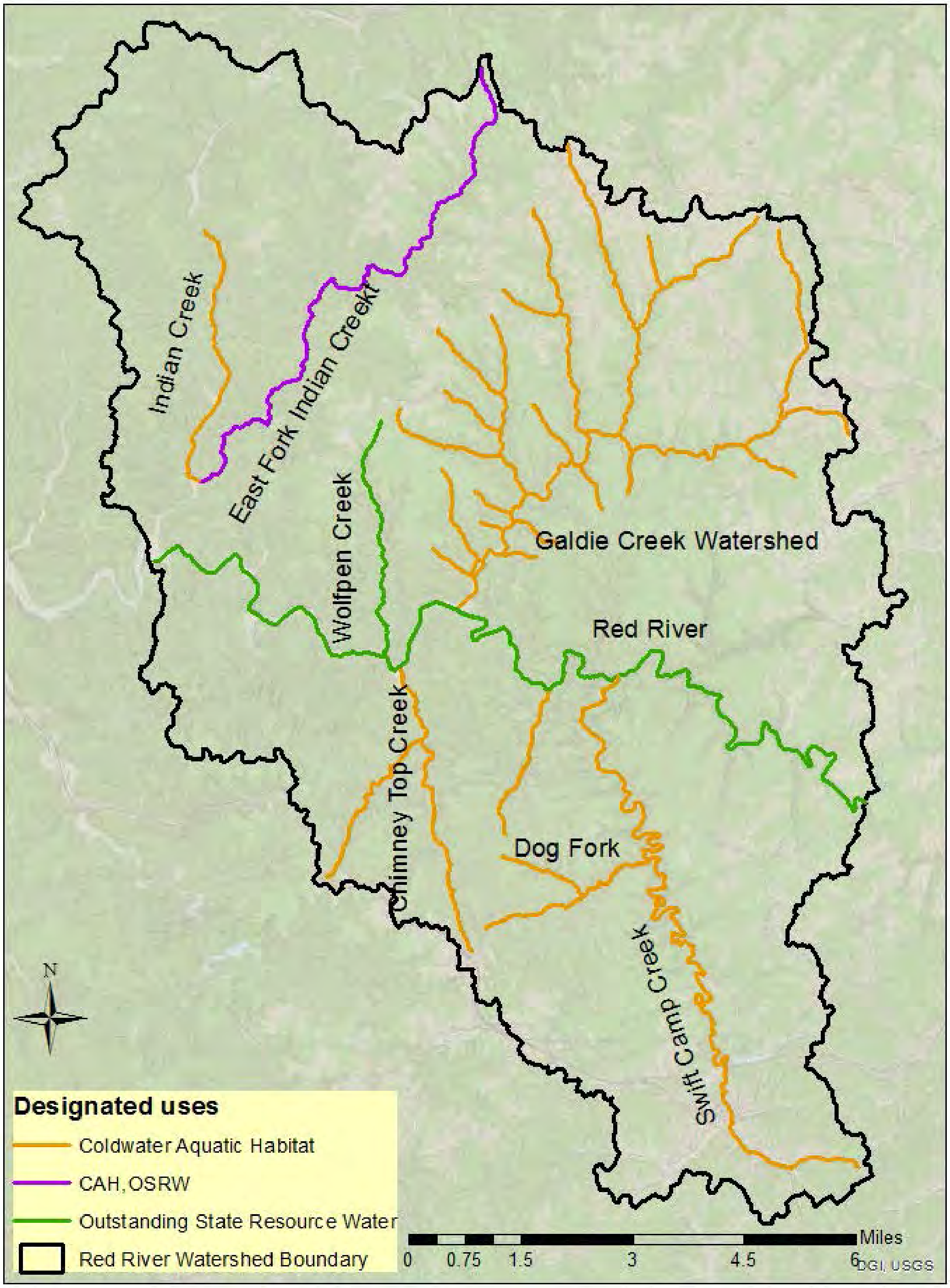


Figure 4.2 Designated Use Waters

Benchmarks and Water Quality Standards

To understand water quality information, the data that were collected can be compared with a benchmark value or the water quality standards under Kentucky law (401 KAR 10:031) (Table 4.2). Proposed benchmarks are not regulatory and are not recommended as future standards for regulations or as absolute targets. Rather, they are proposed as reasonable measures with which to compare the water quality of streams within an area for the purpose of determining protection or restoration measures. Benchmark values can be used as indicators of desired conditions when evaluating stream water quality and when evaluating which Best Management Practices to implement. On the other hand, water quality standards are regulatory and consist of both numeric and narrative standards (Table 4.3).

Table 4.2: Project Benchmarks for water quality, nutrient and non-nutrient.

Parameter	Benchmark Value
Nutrients:	
Total Phosphorus*	0.020 mg/L
Total Kjeldahl Nitrogen	0.500 mg/L
Nitrate-Nitrite	0.200 mg/L
Total Nitrogen	0.600 mg/L
Non-Nutrients:	
Ammonia-N	<0.050 mg/L
Unionized Ammonia	0.0002 – 0.0007 mg/L
Sulfate	20.0 mg/L
Specific Conductance	218 (µS/cm)
Alkalinity	72.2 (mg/L as $CaCO_3$)
Total Suspended Solids**	6.0 mg/L
Turbidity**	5.9 NTU

*Based on lab reporting limit. The benchmark for TP was calculated to be 0.020 mg/L; however samples were run with a reporting limit of 0.033 mg/L. Therefore, the lab reporting limit served as the value for analysis purposes.

**For TSS and turbidity, these reference benchmarks are only to compare normal April-Oct. flow conditions and not high flow events or winter samples. Benchmarks provided by KDOW 2012.

Table 4.3: Kentucky Water Quality Standards.

Parameter	Numerical Water Quality Standard
Dissolved Oxygen (DO)	*Warm water habitat* > 5.0 mg/L as 24 hr average; or > 4.0 mg/L instantaneous *Cold water habitat* – > 6.0 mg/L as 24 hr average or 5.0 mg/L instantaneous
pH	Between 6.0 – 9.0 Standard Units, not to fluctuate 1.0 over 24 hr period
Temperature	Warm and Cold water habitat - not to exceed 31.7 °C (89 °F) instantaneous measurement, or 28.9 °C (84 °F) 30-day summer average (Table 4.2)
E. coli	130 cfu/ 100 mL as a 30 day geometric mean of 5 or more samples (May 1 – Oct 31) Not more than 20% of samples to exceed 240 cfu/100 mL as an instantaneous measurement

Pollutant Loadings

Pollutant loading is the amount of a pollutant that passes a specific point of a stream in a specific amount of time. It is determined using sampled chemical and bacterial parameters and stream flow data collected at the same time. Loads are generally expressed by a mass unit (of a pollutant) and a period of time, resulting in pounds per day, for example. Pollutant loads are important in watershed planning because they allow a more balanced comparison of subwatersheds. Large loads may have significant impacts on the larger watershed as a whole, while smaller loads may have site-specific impacts on aquatic use, habitat, and water quality.

4.3 Data Summaries – All Subwatersheds

Dissolved Oxygen

Most aquatic organisms obtain the oxygen they need to survive from oxygen dissolved in water. Oxygen enters water from the atmosphere and/or from groundwater. In streams with rapid currents or riffles, more oxygen is usually present compared with stagnant (still) water. Cold water can hold more dissolved oxygen (DO) than warm water. In winter and early spring, when the water temperature is low, DO concentrations are higher. During warmer months, the DO concentration falls. Loss of DO will occur if too many bacteria or other biological processes in the water consume oxygen as organic matter decays. Eutrophication is a process that occurs when a body of water receives an overabundance of dissolved nutrients such as phosphates and nitrates. Excess nutrients can cause excessive algal growth, and then as the algae die, DO is depleted. This is especially a problem in a stagnant body of water such as a lake with a large amount of decomposing material and warm temperatures. In the summer, lakes around the country may report fish kills due to eutrophication. The amount of DO will vary during the day with temperature changes. DO is measured in the stream at the time that other samples are collected. It is measured in the unit milligrams per liter of water (mg/L). The Kentucky surface water standard for DO is 4 mg/L, which is the acute level, and 5 mg/L, which is the chronic level. This means that the minimum for an instantaneous measurement should be 4.0 mg/L, and the daily average for DO should be at least 5.0 mg/L.

<u>Results</u>
The streams in the Red River Watershed have moderately steep gradients, which helps increase the oxygen levels in the water. All the DO levels that were measured met the state water quality standards for cold water and warm water aquatic habitats (6.0 mg/L average minimum and 5.0 mg/L instantaneous minimum, and 5.0 mg/L average and 4.0 mg/L instantaneous minimum, respectively). Dissolved oxygen was not indicated as a cause of impairment for aquatic habitats.

pH
The pH of a sample of water is a measure of the concentration of hydrogen ions. The actual term "pH" refers to the way hydrogen ions are calculated. Measuring pH is important because it indicates whether the water is acidic or basic. The scale for measuring pH ranges from 0 to 14. A water sample with a pH of 7 is considered neutral. If the pH is below 7, then the water is acidic. If the pH is above 7, it is basic. (For reference, vinegar is acidic, with a pH around 3; bleach is basic, with a pH around 12.5) The largest variety of animals living in water prefers a pH range of 6.5-8.0. pH outside this range reduces the diversity in the stream because it stresses most organisms and can reduce reproduction. Also, solutions that are too acidic or too basic change the solubility (amount that can be dissolved in the water) of materials in the watershed. For example, rocks with heavy metals may leach metals into acidic water because of the increased solubility. In other words, metals are more toxic and mobile in waters with a lower pH. The pH of a stream will vary, but it will depend on such factors as the local geology

and the pH of rainfall. As rocks dissolve, hydrogen ions are released into the water. In the last several decades, rainfall has become more acidic as a result of particulates released into the atmosphere. The acid rain lowers the pH of a receiving water body. Another form of pollution that will change the pH of water is runoff from a mining operation. The runoff may be highly acidic and could kill fish any living in the system.

The test for pH is usually performed in the stream at the time that other samples are collected. The Kentucky surface water standard for pH is in the range between 6.0 and 9.0.

Results
The pH levels in these watersheds vary from 7.34 to 8.84 and are all within state water quality standards. The lower pH levels are near neutral; however, the higher pH levels are approaching the upper threshold of 9.0 for aquatic life use and primary contact recreation. The highest levels are at the upper Indian Creek site. This site is just below a limestone quarry that could be increasing pH above natural conditions.

Temperature
The plants and animals that live in a stream are dependent on certain temperature ranges for their optimal health. Variations above or below that range affect the life processes of these organisms. The best temperatures for fish depend on the species - some survive best in colder water, whereas others prefer warmer water. Most of the animals living in Kentucky's streams, lakes, or wetlands are sensitive to temperature and will move in the stream, to the extent possible, to find areas with their optimal temperature. If temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die. In addition to having direct impacts on life processes, warmer water cannot hold as much DO. Low oxygen levels cause many negative impacts to organisms living in the stream (see DO above).

Temperature will vary depending on the weather and seasonal changes. Daily variation also may occur, especially in the surface layers, which are warmed during the day and cooled at night. Elevated temperatures can occur if the trees and other vegetation that normally provide shade for the stream are removed. Water body temperatures may increase if the water receives industrial discharges, urban stormwater, or groundwater inflows (depending on time of year), and will also increase in impoundments (a body of water confined by a barrier, such as a dam).

Stream temperature is measured along with other site parameters whenever samples are collected. In Kentucky, streams designated as Warm water Aquatic Habitat (WAH) should not exceed 31.7°C (89°F). In a stream designated as a Cold water Aquatic Habitat (CAH) temperature shall not be increased through human activities above the natural seasonal temperatures.

Results

In upper Swift Camp Creek, the monitored temperatures got as high as 28.8°C in August. Temperatures maxed out at 23°C in Gladie Creek and 24.9°C at the mouth of Indian Creek. Based on these results indication is available that there are some anthropogenic increases in temperature in a few of the CAH streams. The cause for the temperature increases is most likely the removal of riparian vegetation as a result of urbanization or pasture development (see temperature discussion in following sections).

However, water temperature did not exceed the water quality standards at any of the sites, including the overall maximum high temperature of 31.7 °C, or the monthly instantaneous maximum (Table 4.4). Depending on the seasonal or daily timing of the higher water temperatures, temperature may still be a factor in the impairments of aquatic habitats.

The downstream Red River Gorge sections of these streams are tree lined and shaded, but it is different in the headwaters. There is localized urban and agricultural development on these privately managed tracts of land where riparian vegetation has been removed. Like many CAH streams in Kentucky, temperatures in these streams are naturally too warm for trout to reproduce (13°C and colder is required) and in many cases too warm for them to hold over from one year to the next (21°C is the maximum temperature withstood).

Table 4.4: Monthly instantaneous maximum temperatures under Kentucky water quality standards

Month/Date	Instantaneous Maximum °C	Month/Date	Instantaneous Maximum °C
Jan 1-31	10	June 16-30	31
Feb 1-29	10	July 1-31	32
Mar 1-15	13	Aug 1-31	32
Mar 16-31	15	Sep 1-15	31
Apr 1-15	18	Sep 16-30	30
Apr 16-30	21	Oct 1-15	28
May 1-15	23	Oct 16-31	25
May 16-31	27	Nov 1-30	22
June 1-15	29	Dec 1-31	14

Conductivity

Conductivity is a measure of water's ability to conduct an electric current and is an indicator of the presence of dissolved ions in the water. Pure water has a very low conductivity. Conductivity is affected by temperature; the warmer the water, the higher the conductivity. Conductivity is reported as conductivity at 25 °C. Discharges of some chemicals to streams can change the conductivity. The discharge from a failing sewage system would raise the conductivity because sewage contains chlorides, phosphates, and nitrates. Oil that enters the stream, such as automotive oils carried in runoff or oils from a leaking storage tank, would lower the conductivity.

Conductivity in streams and rivers is affected by the geology of the area through which the water flows. Streams that run through granite bedrock will have lower conductivity, and those that flow through limestone, shale, and clay soils will have higher conductivity values.

Conductivity levels above benchmark could indicate that the water isn't suitable for the life cycle conditions necessary for aquatic animals.

<u>Results</u>

For this project a 218 µS/cm benchmark was set by KDOW. This benchmark is exceeded at several locations in both Swift Camp Creek and Indian Creek. Figure 4.3 is a map illustrating the average conductivity concentrations over the twelve month period for the project area.

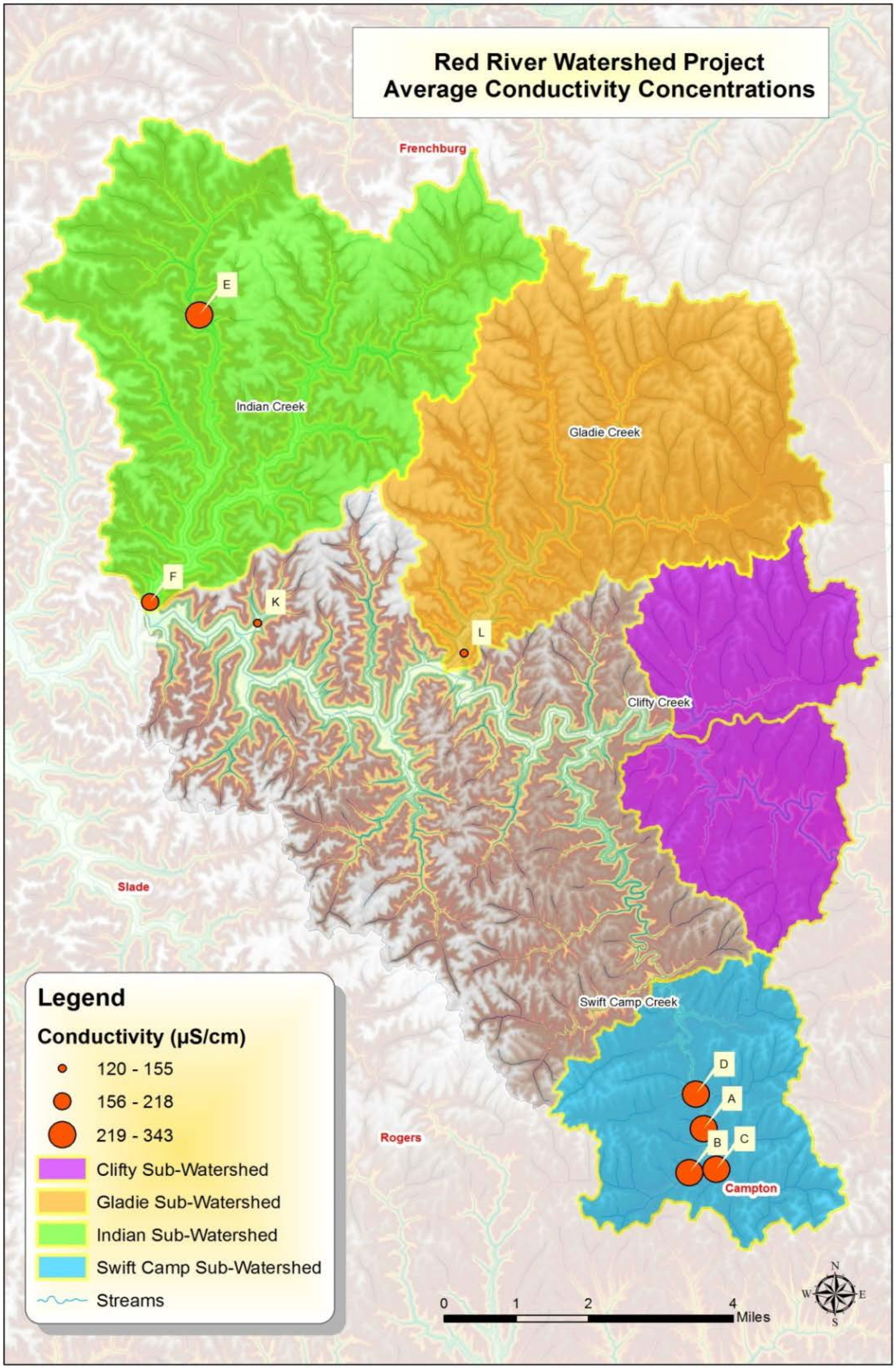


Figure 4.3: Average Conductivity Concentrations.

Total Suspended Solids and Turbidity

Total suspended solids (TSS) and turbidity are each used to measure the amount of solid material suspended in the water. However, the TSS test measures an actual weight of material per volume of water, while turbidity measures the amount of light scattered from a water sample (more suspended particles cause greater scattering of light). In a water body with a large amount of suspended material or high turbidity, the water will likely appear muddy or cloudy. The water in a stream or lake with little suspended material is clear; it is easy to see objects at greater depths. Less light is able to reach plants at deeper depths in the stream or lake when there is a higher concentration of suspended material in a water body. Suspended materials are also likely to be carrying other pollutants such as metals and bacteria.

The amount of TSS and turbidity are influenced by how much runoff enters the water. Heavy rains and fast-moving water cause erosion and carry soil and other materials into the water. After a heavy rain, a stream near a cleared patch of land may look muddy. Streams with banks cleared of vegetation are especially at risk of increased TSS and turbidity. Stormwater drains also deliver suspended material to a stream.

TSS concentrations are measured in milligrams of suspended solids per liter of water (mg/L). Turbidity is reported as nephelometric turbidity units (NTU). TSS and turbidity values will vary greatly between different water bodies and different seasons. This project only compares April through October flow conditions, due to data from the reference sites only being collected during a stable low-flow environment. If low-flow events demonstrate a minimal effect, but there are identified issues with sediment, then measuring high flow concentrations may give a better overall picture of these parameters.

Results

The data indicate that TSS and turbidity increase and decrease proportionally. TSS and turbidity are difficult to evaluate since they are often very flow dependent. TSS and turbidity do not have numeric water quality standards. Project benchmarks were set as 6.0 mg/L and 5.9 NTU, respectively. Some samples were collected during or after rain events that created higher flow conditions, but there was not enough rain to create runoff conditions. Thus, by definition, these were not “wet weather” events.

The highest TSS can be found in the unnamed tributary to Swift Camp Creek (Figure 4.4). This site has the greatest amount of urbanization in the project area and stream banks are eroding in many locations. There are other sites in Swift Camp Creek where TSS and turbidity are elevated, but a load reduction is only necessary in the Swift Camp Creek Unnamed Tributary. Figure 4.4 displays the average concentration of TSS in the project area. Biological results also state that causes for poor scores are due to sedimentation, siltation, and dissolved solids.

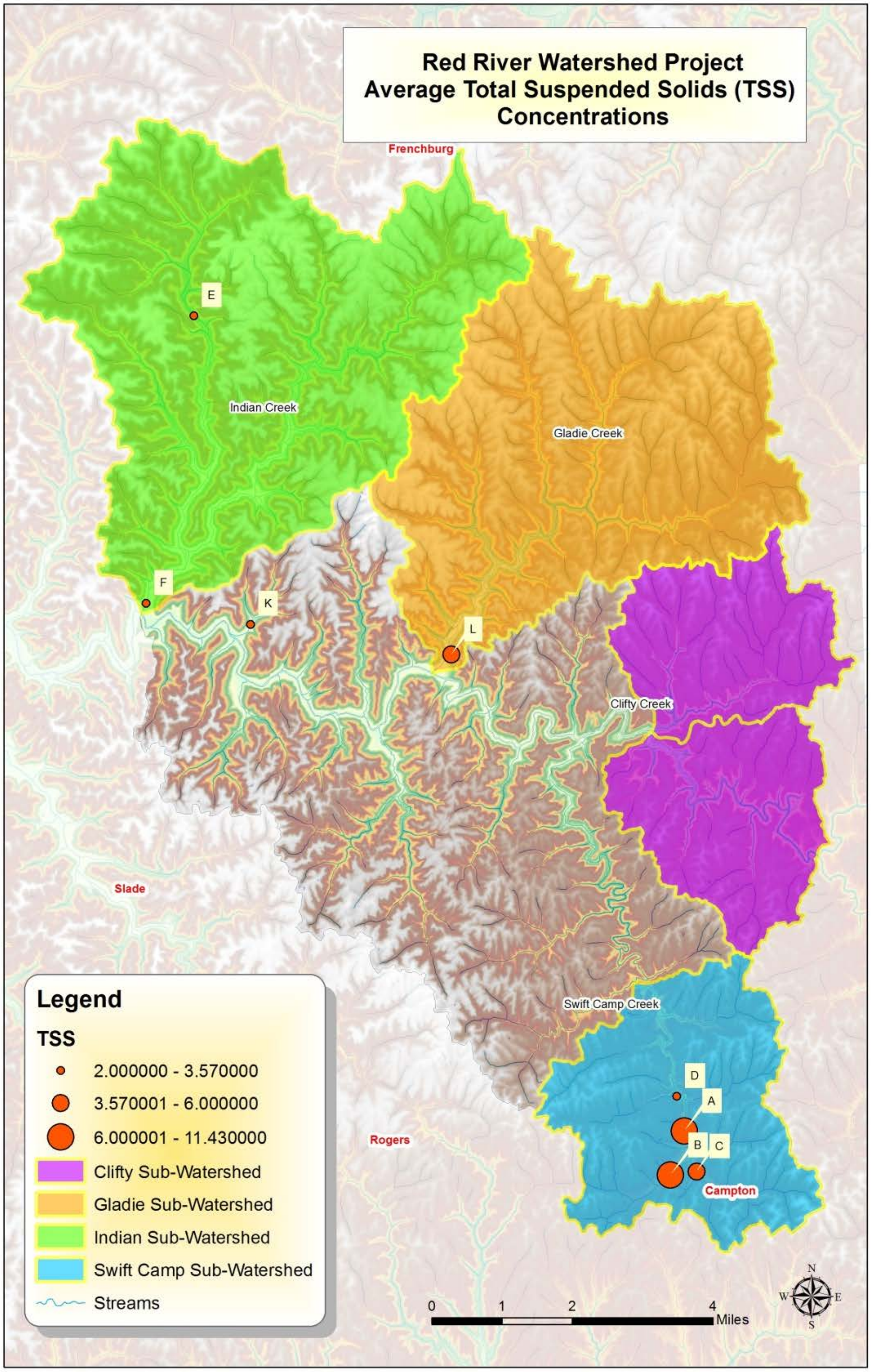


Figure 4.4: Average Total Suspended Solids Concentrations.

Nutrients - Nitrogen and Phosphorus

Two primary nutrients are nitrogen (N) and phosphorus (P). These two elements are essential for plant growth and are found in fertilizers applied to farms and lawns and gardens. They occur naturally in waterways.

Nutrients are ingredients in soil, water, and organisms that are essential for life, yet excess nutrients are not healthy for streams. Nutrients in groundwater are also potentially harmful. Excess nitrogen in drinking water is dangerous to humans, especially small children and infants. The amount of nutrients in the watershed will vary depending on several factors. In summer, nutrients levels may increase due to fertilization of farm crops, lawns, and gardens. Not all of the fertilizing nutrients will be used by the land or plants and excess nutrients are washed away during a rainstorm. Decomposition of organic matter also releases nutrients, and streams may experience greater nutrient loading during winter as dead leaves and other debris decay.

Excess nutrients are usually the result of pollution from land use activities. Nutrient sources include stormwater runoff, waste products from farm animals and domestic pets, failing septic systems, and discharges from industrial and municipal wastewater treatment plants.

Phosphorus (P) and Nitrogen (N) are measured in several forms. Formations of the various phosphorus and nitrogen compounds are governed by factors such as pH, temperature, oxygen concentration, and biological activity. The forms that are of primary concern are those that are used by plants and other organisms. It is important to know the amount that is available for growth.

Phosphorus (P) will bond with oxygen (O) to form Phosphate (PO_4). Phosphorus can be measured as the following:

- Total phosphorus (TP)
- Orthophosphate (OP). Orthophosphate represents the fraction of TP that is soluble in water and available to organisms for growth.

Nitrogen will bond with oxygen (O) to form nitrate (NO_3) or nitrite (NO_2). It will also bond with hydrogen to form ammonia (NH_4). Nitrogen can be measured as the following:

- Total Nitrogen (TN). TN refers to the total amount of nitrogen in a sample.
- Total Kjeldahl Nitrogen (TKN). TKN represents the fraction of TN that is unavailable for growth or bound up in organic form; it also includes NH_4.
- Nitrate-nitrogen (NO_3)
- Nitrite-nitrogen (NO_2)

Results for Nitrogen

For this project, nitrate-nitrite and total nitrogen were evaluated. The average total nitrogen levels were below the 0.600 mg/L benchmark at all sites except Swift Camp Creek below Hirams Branch. In spite of exceedances, no load reductions are required, but BMPs could still be considered to address this issue. However, average nitrate-nitrate levels often exceeded the benchmark. The nitrate-nitrite portion of total nitrogen is the inorganic component that is available for plant uptake, and thus, it may increase risk of algae blooms. It may also be an indicator of human or animal waste. The levels are not extremely high, but the load in several streams needs to be reduced by up to 50 percent, especially in the headwaters of Swift Camp Creek where urbanization and failing infrastructure are most likely causing this increase.

The headwaters of Indian Creek also have elevated nitrate-nitrite levels, although it appears to be less of a threat downstream (Figure 4.5). The source may be development near the stream above the Indian Creek/Bear Branch site. There are small pastures, homes, businesses, and septic systems in this valley. A 49 percent load reduction was calculated for this site.

Results for Phosphorus

Phosphorus samples were analyzed for orthophosphorus (OP) and total phosphorus (TP), although only TP is discussed here. The project benchmark for TP was set at 0.020 mg/L. However, during lab analysis, the reporting limit was set at 0.033 mg/L. As it is unknown what the actual concentration was for TP when reported to be less than the reporting limit, these data cannot be considered as exceeding the benchmark. Conversely, these results are also not necessarily indicative of TP being below the level thought to negatively affect aquatic life.

Since any concentrations in the range of 0.020 – 0.032 mg/L is considered to negatively impact aquatic life, and presence in that range is unknown, consideration should be made for TP throughout the sampling period when deciding priorities for BMPs. Considering this, a conservative approach was taken when determining whether TP is an issue. Load reduction requirements were calculated using 0.033 mg/L as the default value for samples with reported results of <0.033 mg/L, and therefore actual reduction requirements may be less.

Figure 4.6 shows that the highest TP concentrations can be found in the headwaters sites of Swift Camp Creek and range between 0.133 and 0.241 mg/L. As a result, the greatest load reductions are needed at these sites. TP loads in Indian Creek may also need to be reduced. Similar to elevated nitrogen levels, higher than expected TP loads are probably a result of urbanization, failing sewage collection lines, septic systems, and pastures near streams.

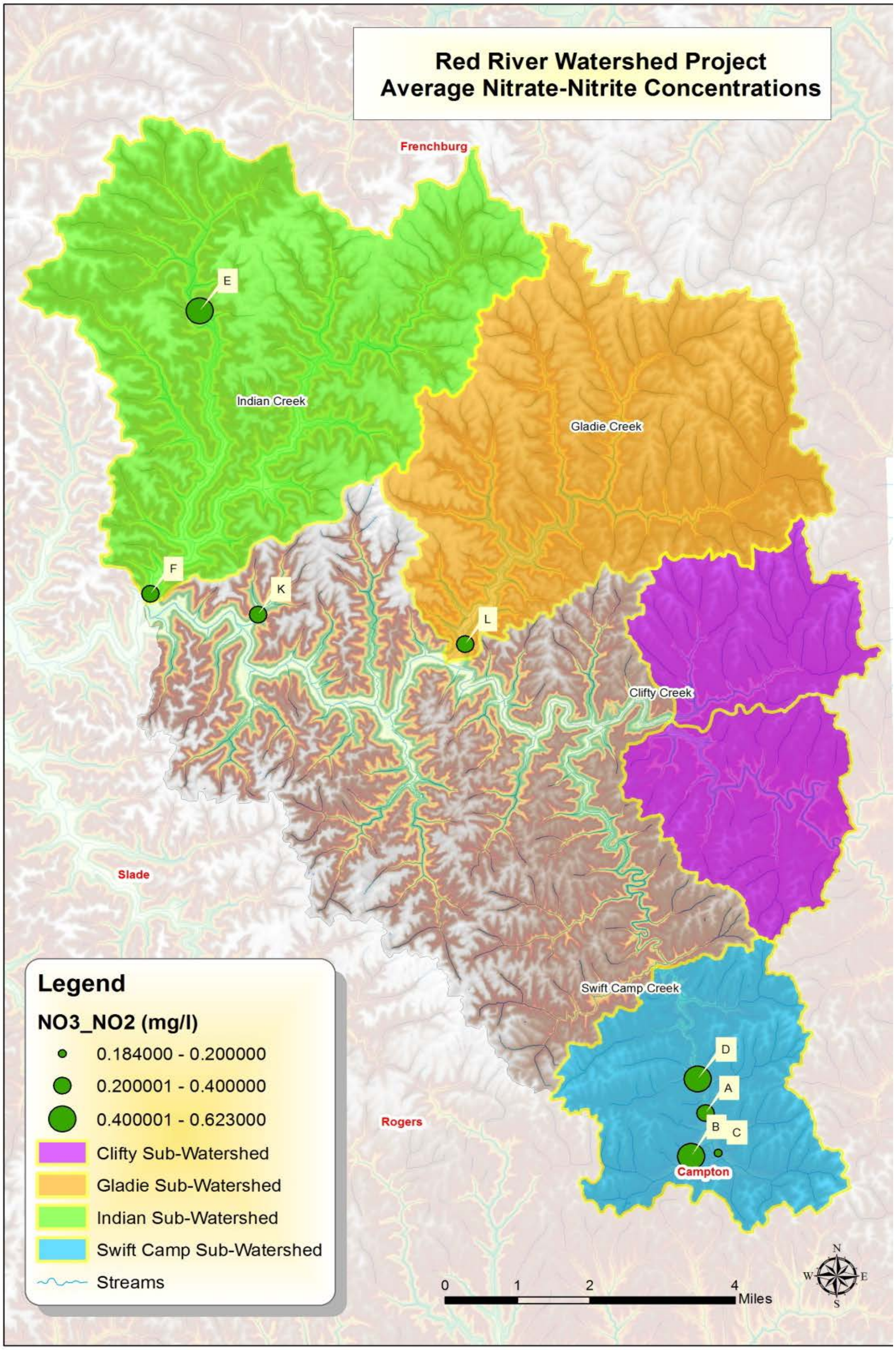


Figure 4.5: Average Nitrate-Nitrite Concentrations.

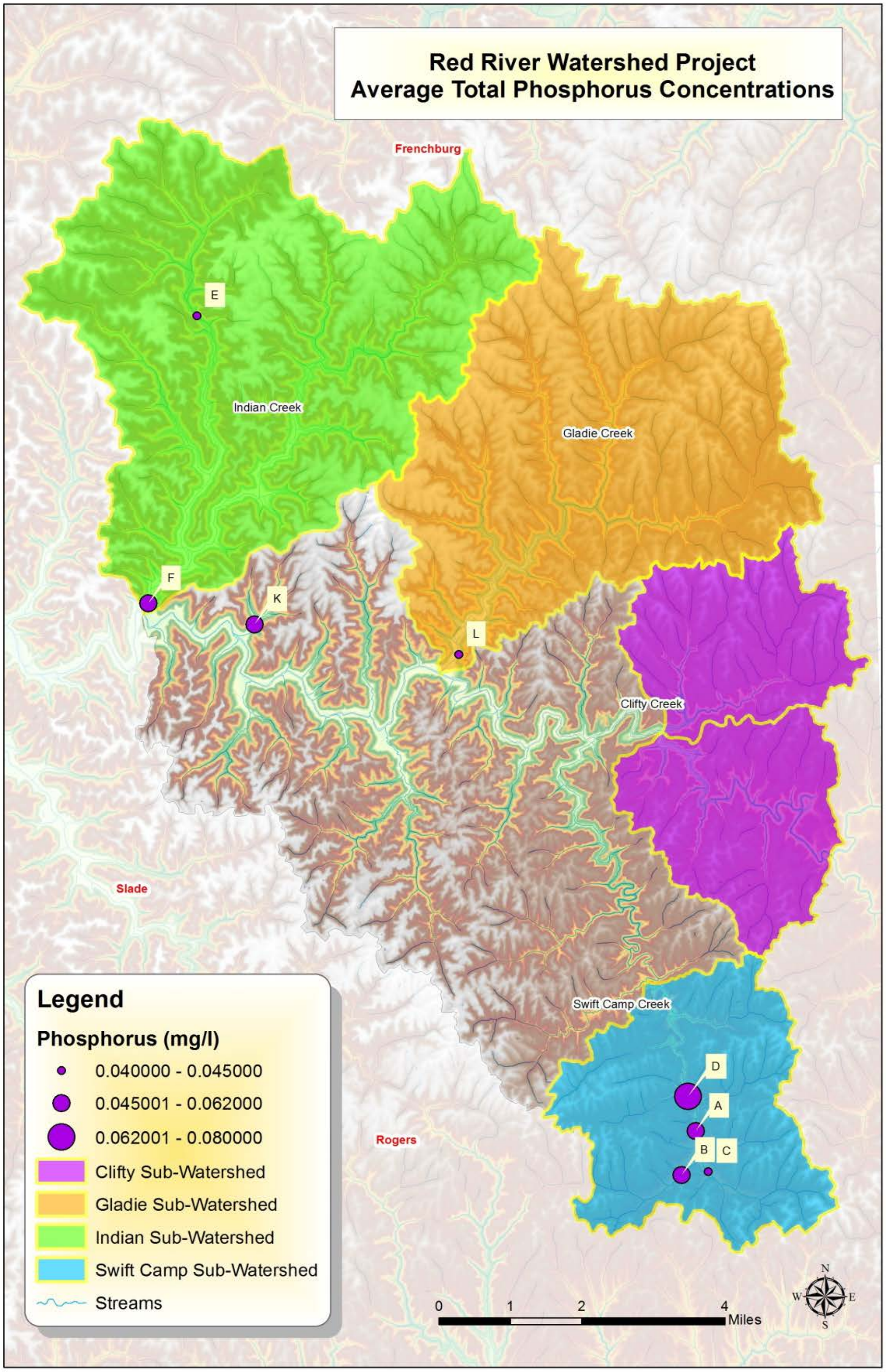


Figure 4.6: Average Total Phosphorus Concentrations.

Bacteria

Bacteria are organisms that are microscopic, not able to be seen with the naked eye. They are found everywhere, on our skin, inside our bodies, in soil, in water, on plants, etc. Most bacteria are harmless to humans, and some of them are actually very helpful to humans.

There is a grouping of 16 different bacteria that have similar properties called total coliform bacteria. They are found in soils, plants, and in the intestines and waste of warm-blooded and cold-blooded animals. Coliform bacteria aid in the digestion of food. Of these 16 total coliform, 6 are found only in fecal waste of humans and other warm-blooded animals. These six are called fecal coliform. One member of the group is called *Escherichia coli*, abbreviated as *E. coli*. *E. coli* has many forms, and one of these is a strain that can cause dangerous illness in humans.

Samples of water are analyzed in a lab for the presence of fecal coliform and/or *E. coli*. The two main reasons the presence of these bacteria is used to indicate if water is safe for use are:

1. These bacteria are fairly easy to detect in a lab test
2. These bacteria serve as an indicator of the possible presence of harmful strains of fecal bacteria. If any of these bacteria are present, then other pathogens may also be present. I don't like these reasons, but I am unsure if we need to add something else, or just delete them.

Water samples are put in containers with a food source that allows the bacteria to reproduce, and placed in an incubator to encourage the bacteria to reproduce in large clusters called *colonies* that can be seen with the naked eye. These colonies are then counted, and the number of colonies is reported by the lab as colony forming units (cfu).

Elevated bacteria counts and pH too low or too high for human safety are two of the conditions that may lead to an impairment listing for contact stream use: primary contact recreation (full immersion, such as swimming), and/or secondary contact recreation (partial immersion, such as wading or fishing).

<u>Results</u>

E. coli sampling was conducted at seven sites once a month from July 2011 to June 2012. In addition, an intensive survey was done during the month of May 2012: sites were sampled on 5 days in a 30-day period in order to calculate the geometric mean for *E. coli*. All results for *E. coli* in Swift Camp Creek exceeded the instantaneous and geometric mean for water quality standards, except for two instantaneous values at Swift Camp Creek at KY 15. Indian Creek subwatershed did not have exceedances of the geometric mean. Gladie Creek was not sampled for bacteria.

Stream reaches for this project were not previously assessed for primary or secondary contact recreation. Data from this monitoring effort suggest that sampled streams could be listed as impaired for primary contact recreation in the future. Figure 4.7 shows the average *E. coli* concentrations for the project area.

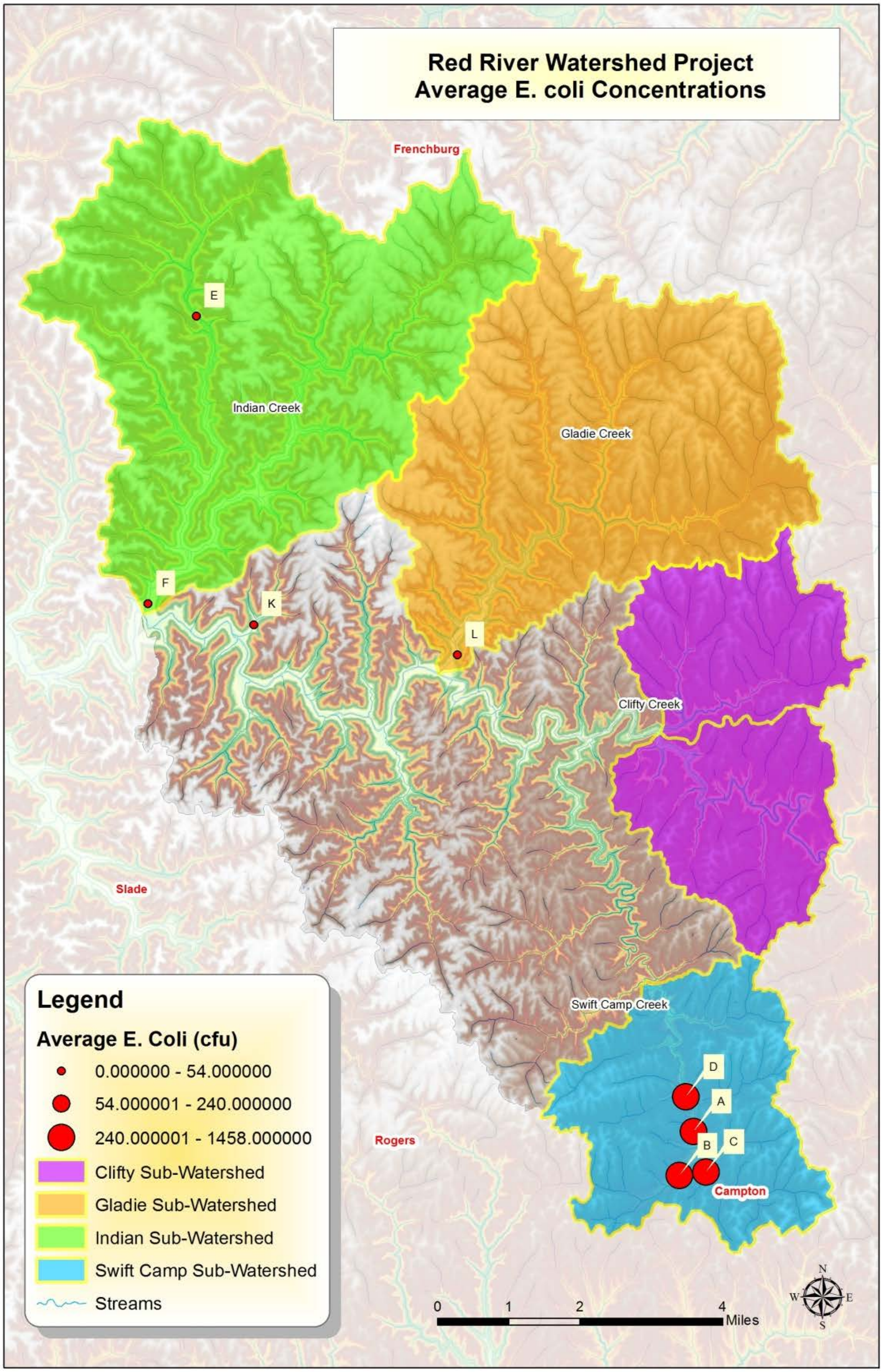


Figure 4.7: Average E. coli concentrations.

Biology

Since water in a stream is constantly moving downstream, a sample of water collected from a stream will only give information for that moment in time. There could have been a huge storm the week before that washed a lot of dirt into the water that had already settled out by the time the sample was collected. Or, the next day after the sample was collected a property owner could dump containers of pesticides in a ditch that flows to the stream. These pollution events would not be detected in the sample collected. However, there is a sample that can be collected that shows the effects of pollution from the watershed that enters the stream over time - a sample of the stream invertebrates (animals without spines) and their habitats.

Using biological surveys to determine watershed health is called a biological assessment. When the stream animals are used in this way, they are called biological indicators. Since different organisms can tolerate different conditions and levels of pollution in the water, they can be used to indicate the quality of the water. Biological indicators that can be observed for assessment purposes are macroinvertebrates (organisms that are visible to the naked eye and that do not have backbones), such as insects, crayfish, worms, snails, leeches, and mussels.

<u>Results</u>

Macroinvertebrate data were collected at eleven sites check this number throughout the Red River Watershed. Results from macroinvertebrate sampling are discussed in the subwatershed sections.

An Unnamed Tributary to Swift Camp Creek, Swift Camp Creek itself, and Indian Creek have been designated as impaired for CAH and/or WAH. Data collected from this project may indicate that these uses are still impaired.

The Swift Camp Creek and Indian Creek Watersheds results are discussed in the following sections. Gladie Creek and Clifty Creek results are discussed in separate sections. Because Gladie and Clifty Creeks only have one water quality and/or biological sample, detailed analyses and recommendations are not possible for these watersheds.

Flow

Good watershed planning requires sampling at all sites during wet and dry weather events. However, there was no rainfall on sampling days during the project or any events that were under a falling hydrograph (indicating rainfall in preceding days) (University of Kentucky Agriculture Weather Center for Jackson, Kentucky (www.agwx.ca.uky.edu). Flow was measured in-stream at all water chemistry and *E. coli* sites, and discussion of low and high flows will be noted as an instantaneous measure, and compared with 'normal' flows where those data were available.

Results

Flow was measured at every water chemistry and *E. coli* site. Water flow typically increases from the headwaters to the mouth of the stream due to the increasing input of water from tributaries along the main stem. This situation often results in the "dilution effect" of water quality parameters. For example, if in-stream TP concentrations are high in the headwaters, but low at the mouth, the pollution is likely being diluted by the addition of flows from tributaries over the length of the stream. Or, if in-stream TP concentrations are high in the headwaters, and also high at the mouth, then it would warrant investigation for TP contribution in streams below the headwaters as well. For this project, flow data displayed anomalies in flow volume from headwaters to mouth. In some of the samples, flow decreased in the downstream direction. Potential causes for this situation are discussed in the following subwatershed section.

These variables are why pollutant loads (which include flow) are a good way to conceptualize the amount of pollution in a waterway. Figures at the end of this chapter illustrate parameters that have pollutant loads calculated along with the associated flow.

Flows in the subwatersheds of this project were evaluated for consistency with the above concept and also checked for seasonal conditions resulting in differing flow measurements.

4.4 Results of Swift Camp Creek Subwatershed

The four sites that were monitored for water quality and biology were:

- Unnamed Tributary to Swift Camp Creek
- Swift Camp Creek below Hiram Branch
- Swift Camp Creek off State Road (SR) KY15
- Swift Camp Creek above the Campton Wastewater Treatment Plant (WWTP)

These four sites will be discussed in terms of the water quality, biological, and bacteriological results from this project (Figure 4.8).

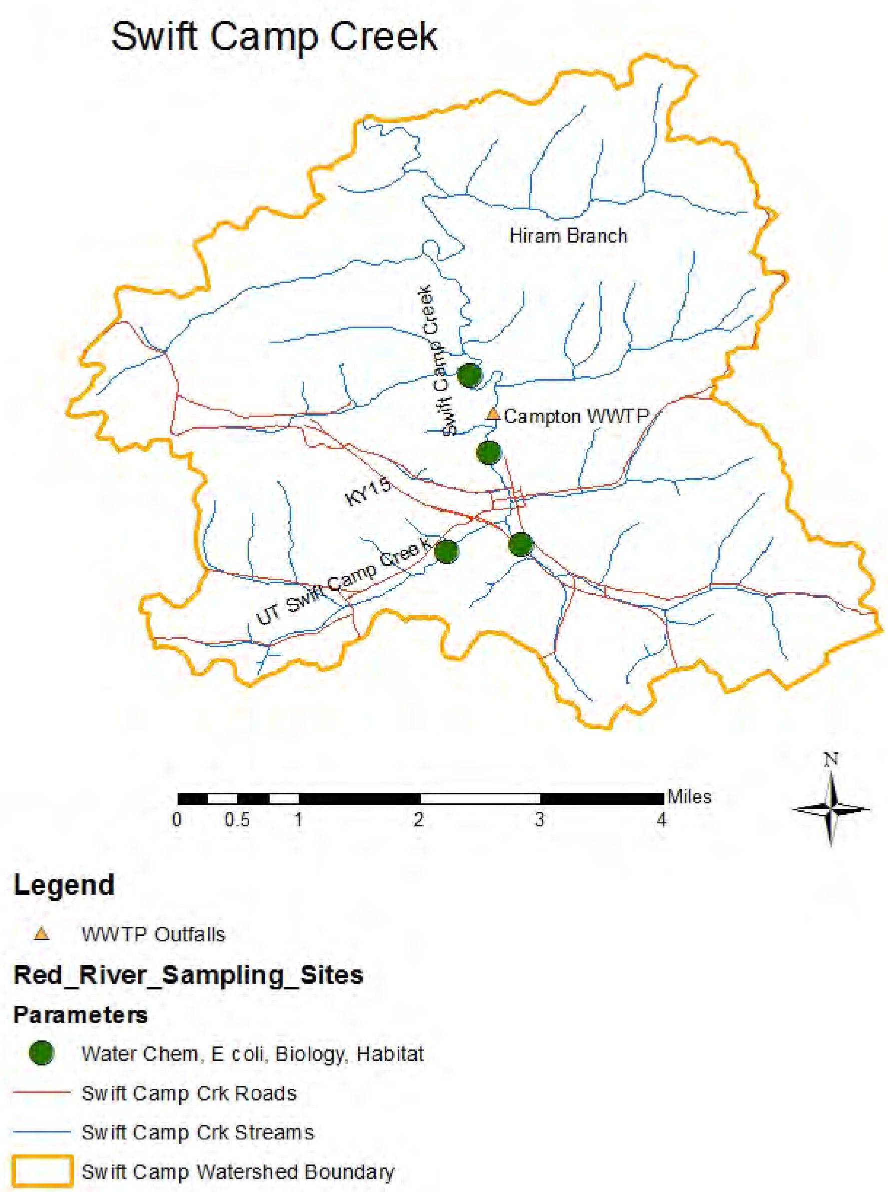


Figure 4.8: Swift Camp Creek Subwatershed and Monitoring Locations.

Bacteria

All samples analyzed for *E. coli* exceeded the instantaneous primary recreation water quality standard of 240 cfu/100 mL except for two dates from Swift Camp Creek off KY15 (90 cfu/100 mL and 220 cfu/100 mL) (Figure 4.9). The KY15 site is the most downstream location, and may have experienced a dilution during September and October, which had higher flows than previous months. The spike in August 2011 at the Unnamed Tributary may have been caused by an instantaneous discharge of pollution such as from a straight pipe, as remaining values match more closely the rest of the sites along Swift Camp Creek.

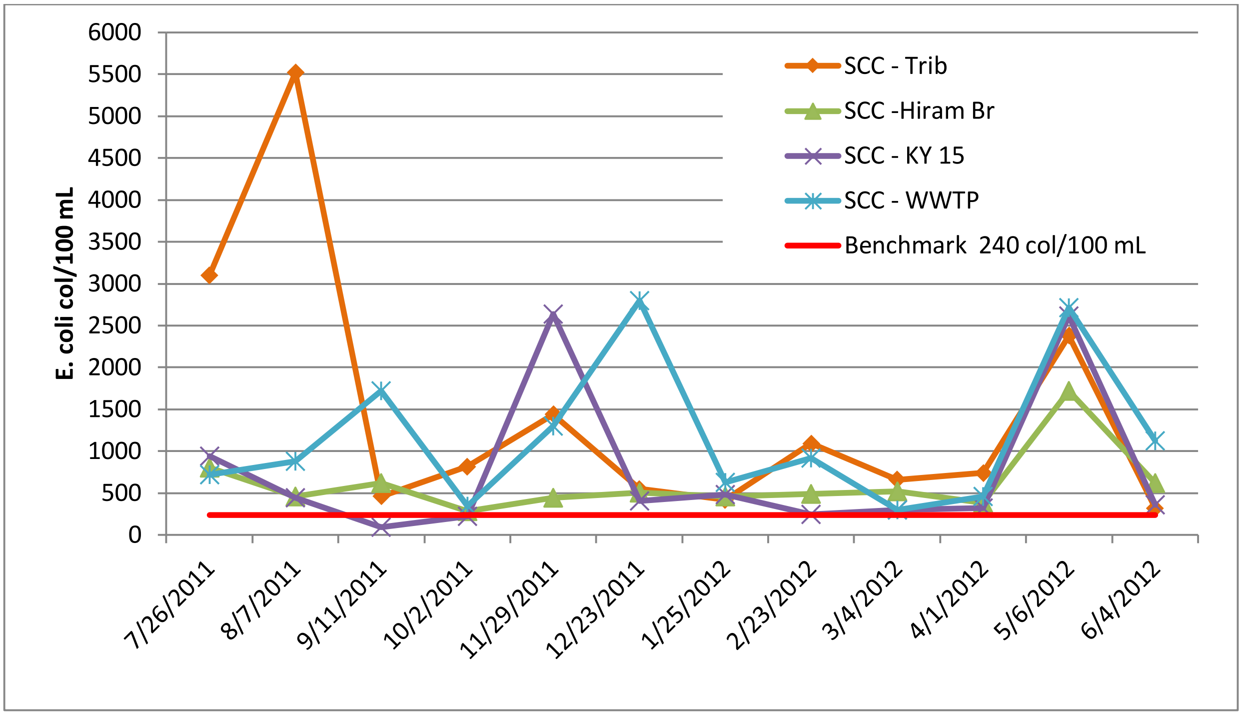


Figure 4.9: *E. coli* concentrations by site in Swift Camp Creek.

E. coli exceeded the water quality standard geometric mean of 130 cfu/100 mL during the month of May 2012, except one sample at the site upstream of the wastewater treatment plant on May 20 (86 cfu/100 mL). It is not known why this might have occurred. The geometric mean concentrations are shown in Table 4.4.

Table 4.4: The geometric mean concentrations (cfu/100 mL) at Swift Camp Creek sites.

	Swift Camp Creek Unnamed Tributary	Swift Camp Creek Below Hirams Branch	Swift Camp Creek Off KY 15	Swift Camp Creek Above Campton WWTP
5/2/2012	1680	880	16320	31060
5/6/2012	2380	1720	2612	2710
5/13/2012	3800	1800	6200	10100
5/20/2012	960	1620	680	86
5/27/2012	600	800	400	2220
Geomean	1543	1287	2351	2767

The percent reduction needed for each site is shown in Table 4.5 below. All sites require over a 50% load reduction.

Table 4.5: *E. coli* Load Reductions in Swift Camp Creek.

Site	Average Annual Load lbs/year	Target Load lbs/year	% Reduction Needed
Swift Camp Unnamed Tributary	1.34E+13	2.79E+12	79
Swift Camp Below Hirams Branch	2.70E+13	1.03E+13	62
Swift Camp Off KY 15	1.12E+13	4.53E+12	60
Swift Camp Campton WWTP	4.29E+13	8.87E+12	79

Other ways of looking at *E. coli* data from this project include:

1. Annual average of 12 samples, collected monthly
2. Six month average during the primary contact recreation season (May – October)
3. Geometric mean of five days collected in a 30-day period
4. Annual average including the five samples in 30 days

All methods of examining data exceeded the primary contact water quality standard of 240 cfu/100 mL (Figure 4.10).

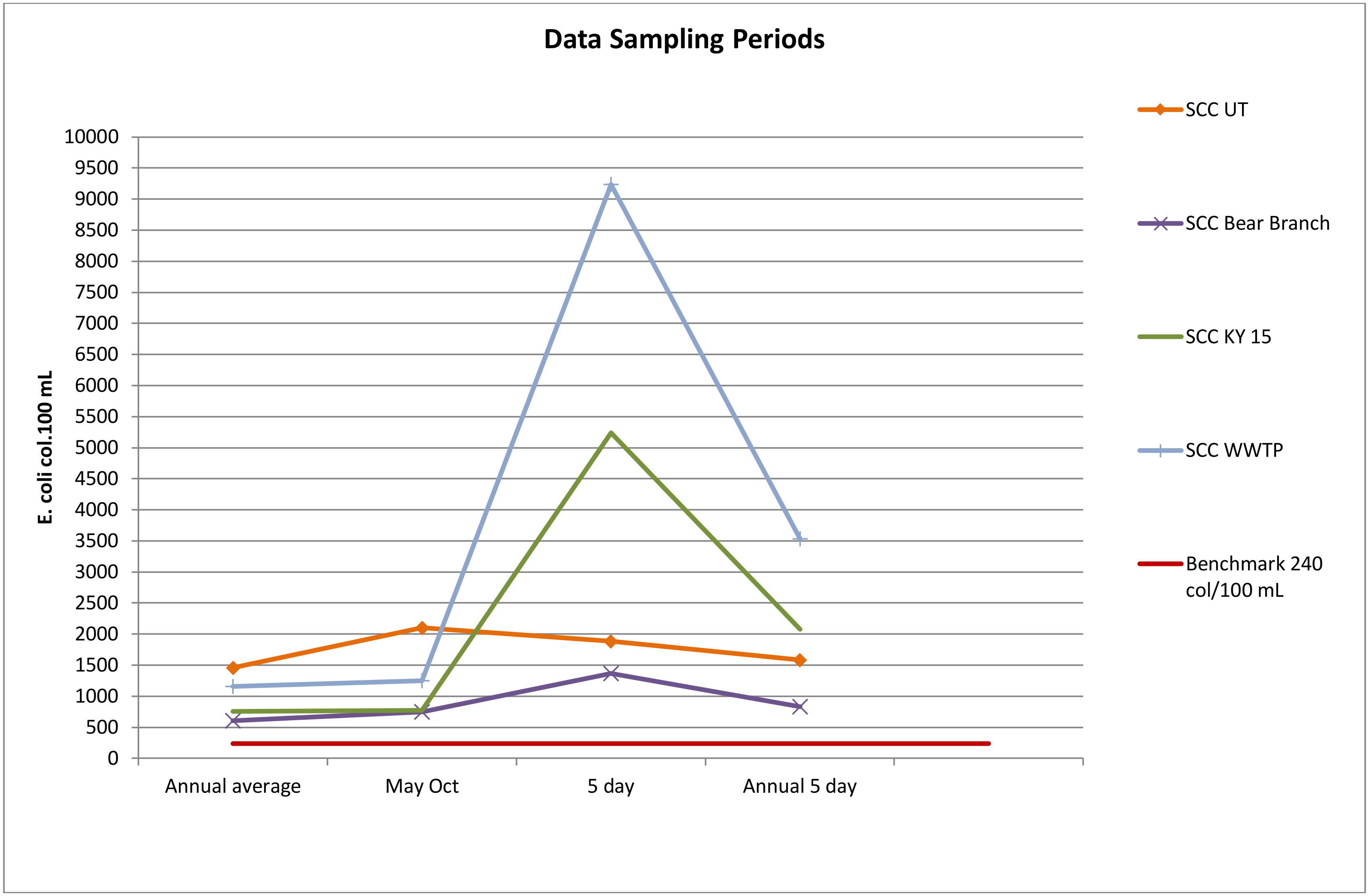


Figure 4.10: ***E. coli*** **Concentrations by Timing of Sampling in Swift Camp Creek.**

Human uses (e.g., wastewater treatment plant discharges, straight pipe discharges, and failing septic systems) are most likely the cause of the elevated bacteria loads in Swift Camp Creek. Due to its accessibility, this creek has a potential for high recreational use in the summer months and high use during the autumn and winter during river cleanups. Local residents also report that use is high during the summer and autumn months.

Flow

Bacteria concentrations plotted against flow measurements indicate that higher flows correspond to lower *E. coli* levels, with several exceptions (May 2012) (Nov 2011) for all Swift Camp Creek sites. Spikes in *E. coli* not seemingly related to flow could indicate unlawful discharges (like illegal dumping) or single incidents with septic systems or leaking pipes.

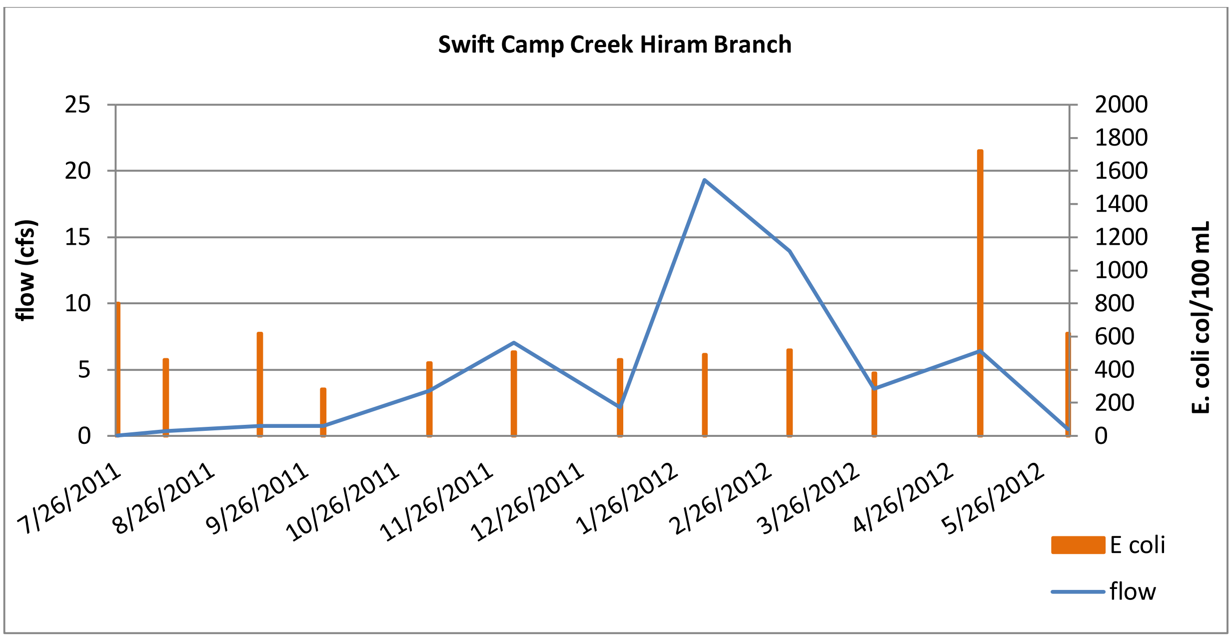


Figure 4.11: Comparison of flow to bacteria levels at Swift Camp Creek Hirams Branch

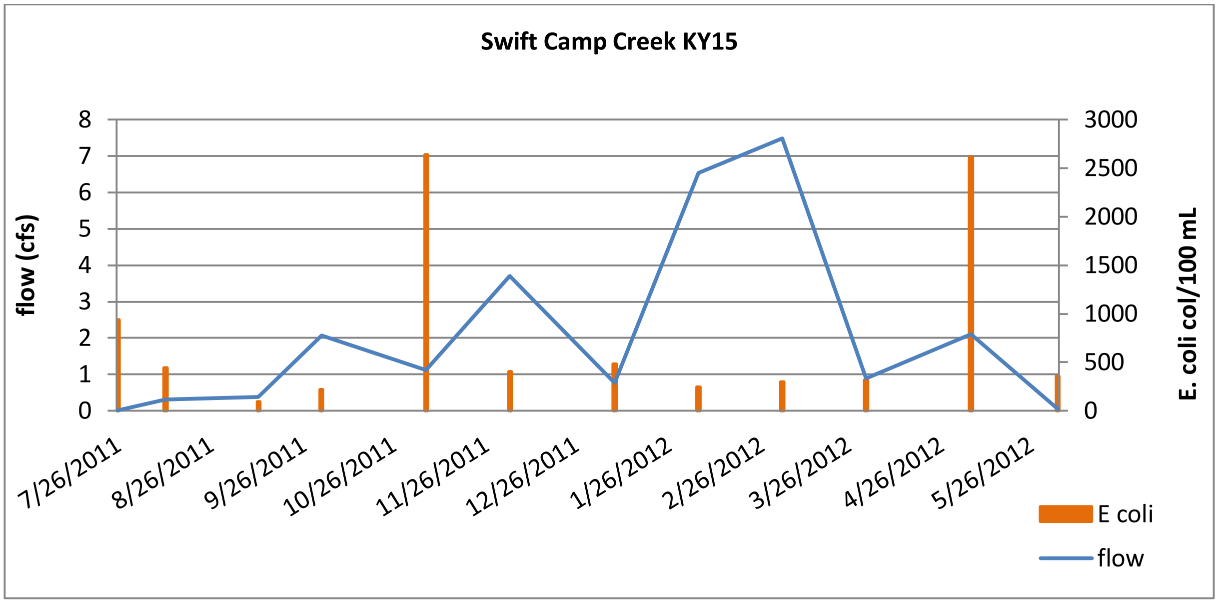


Figure 4.12: Comparison of flow to bacteria levels at Swift Camp Creek Off KY15.

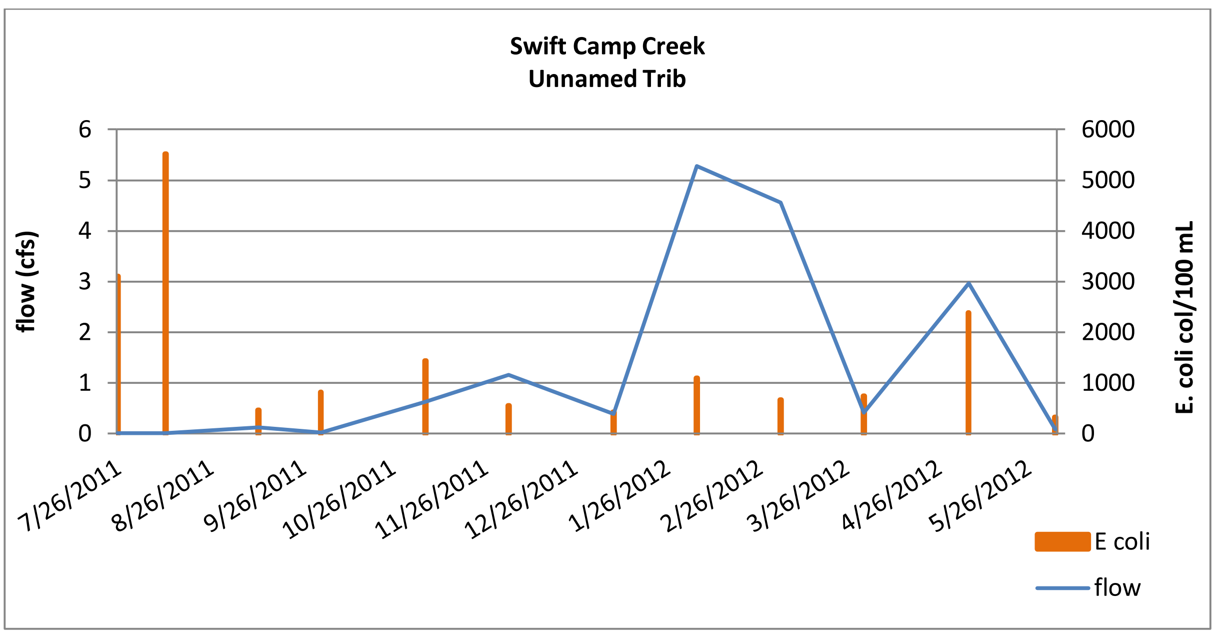
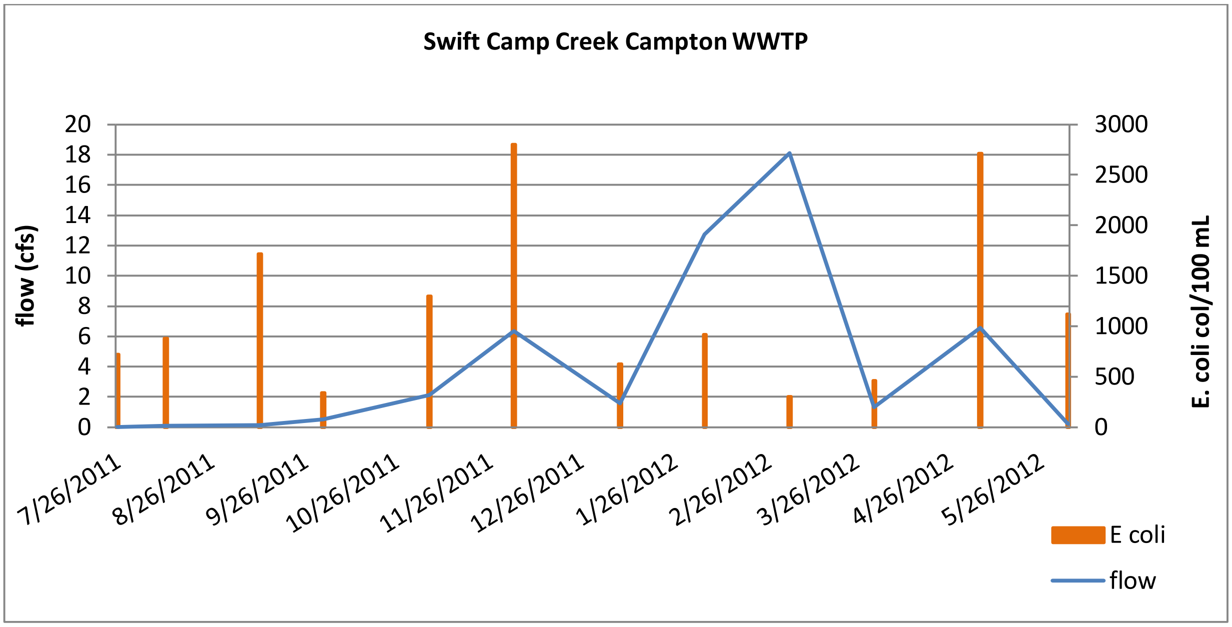


Figure 4.13: Comparison of flow to bacteria levels at Swift Camp Creek Unnamed Tributary.



Figures 4.14: Comparison of flow to bacteria levels at Swift Camp Creek Campton WWTP.

Conductivity

Conductivity exceeded the benchmark of 218 µS/cm at all four sites for the four sampling events from July - October 2011 and again in June 2012. For the period from November 2011 – June 2012, all conductivity values were below the benchmark except for Swift Camp Creek below Hirams Branch in January and April 2012 (Figure 4.15). Flow and conductivity data indicate that during lower flows the conductivity is higher, and conversely, higher flows are related to lower conductivity (Figures 4.16 – 4.19). The higher flows in summer months may decrease conductivity primarily by dilution, and water chemistry is also affected by factors that differ from stream to stream, such as type of substrate, channel depth and sinuosity, and riparian buffers. Figure 4.15 displays the conductivity values across the project area.

The headwaters of Swift Camp Creek near the town of Campton had some of the highest conductivity levels and exceeded the benchmark approximately half of the year, usually during the warmer summer months. The higher conductivity levels are probably a result of contributions from urbanization, infrastructure issues, failing septic systems, and possible chemicals delivered from road and surface runoff.

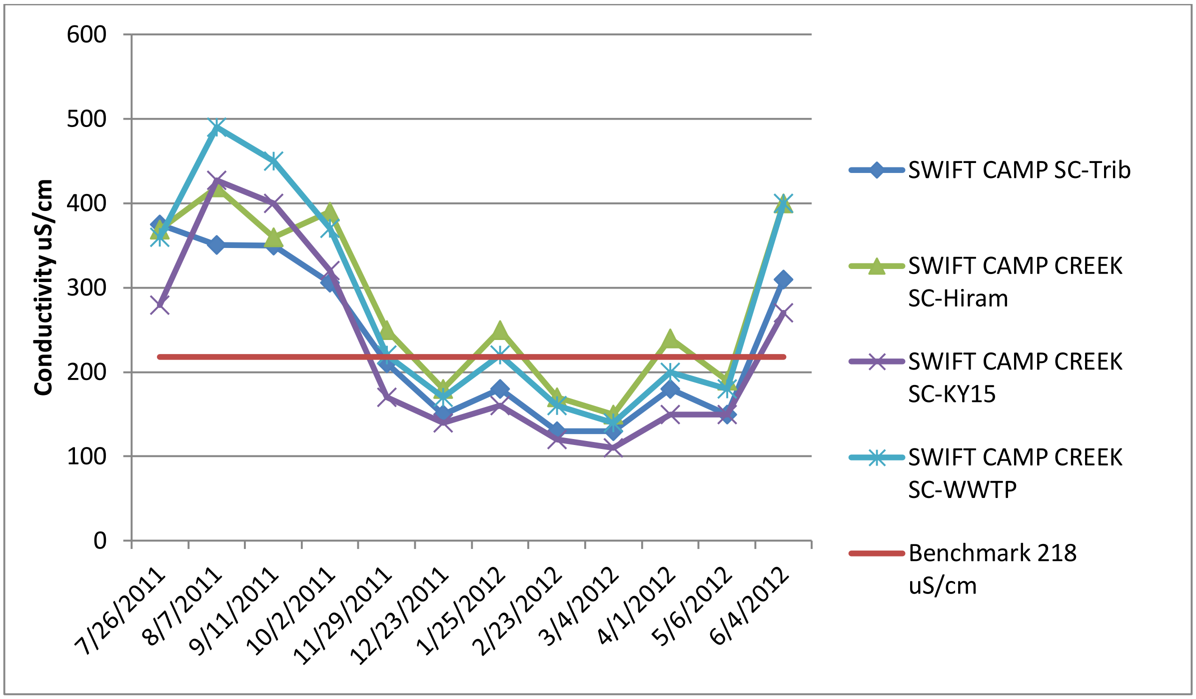


Figure 4.15: Conductivity Concentrations at all Swift Camp Creek sites.

Flow and conductivity plotted over the sample dates show a lower conductivity concentration for higher flows, across all sites.

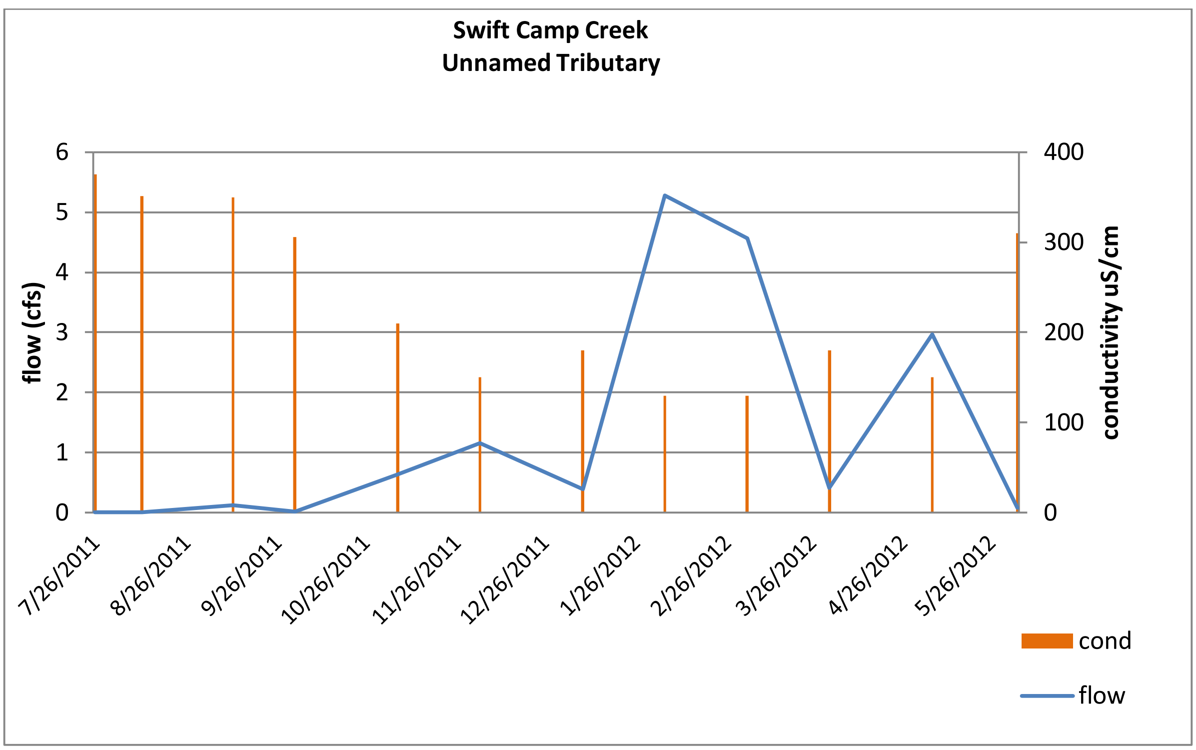


Figure 4.16: Conductivity and flow at Swift Camp Creek Unnamed Tributary.

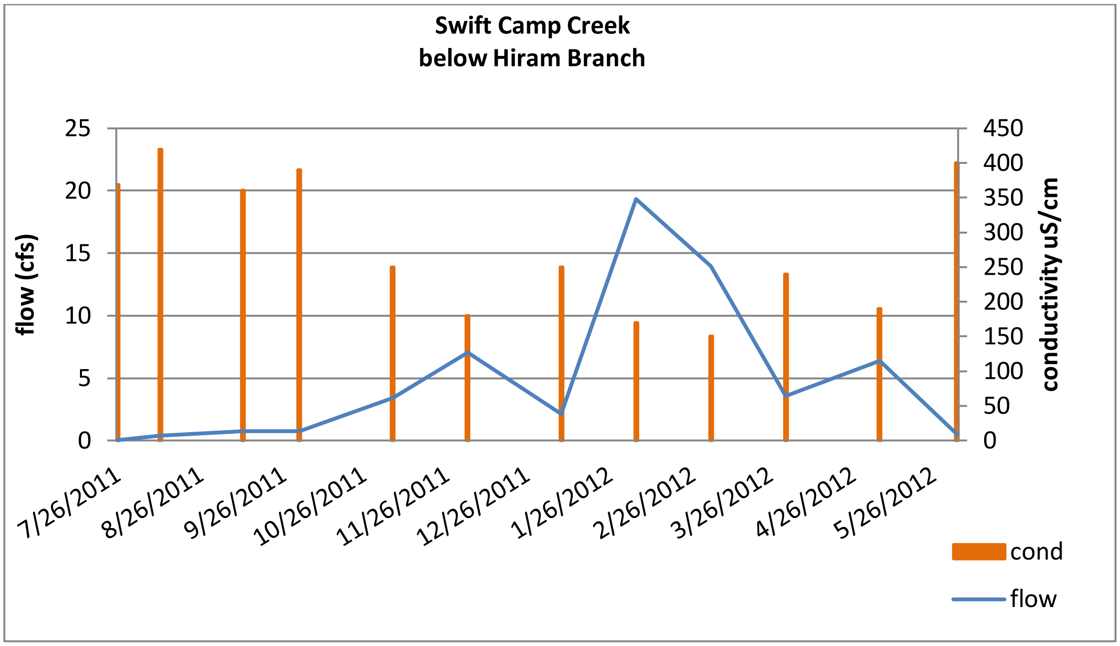


Figure 4.17: Conductivity and Flow at Swift Camp Creek Below Hirams Branch.

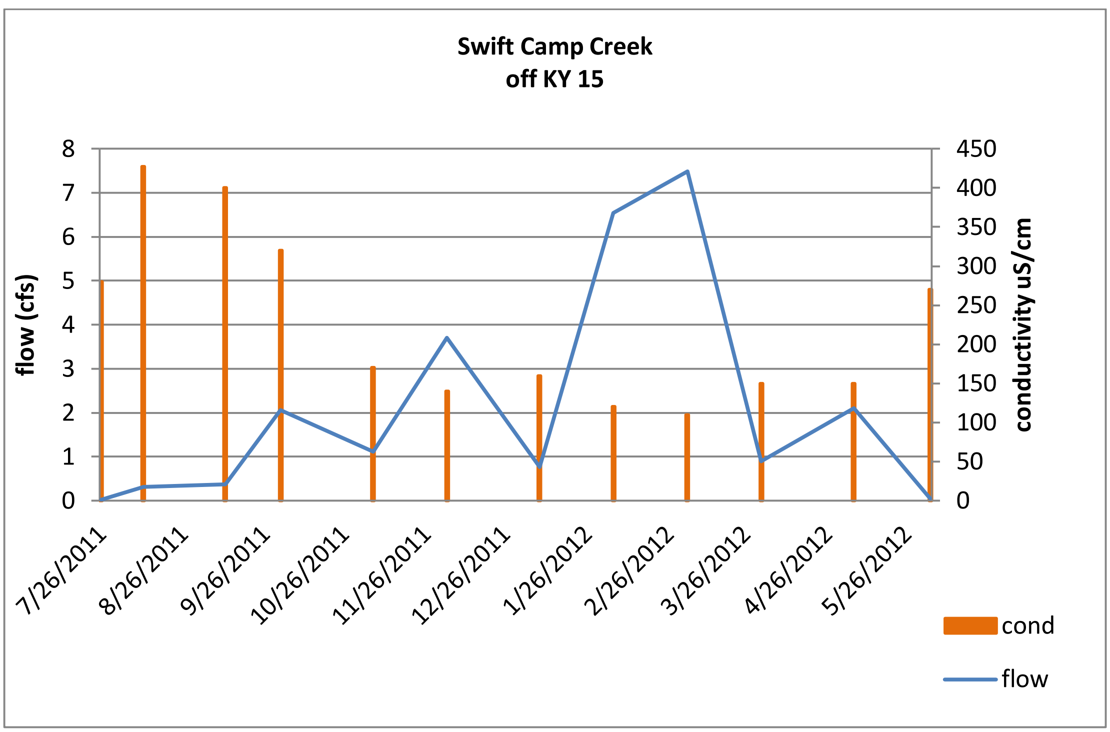
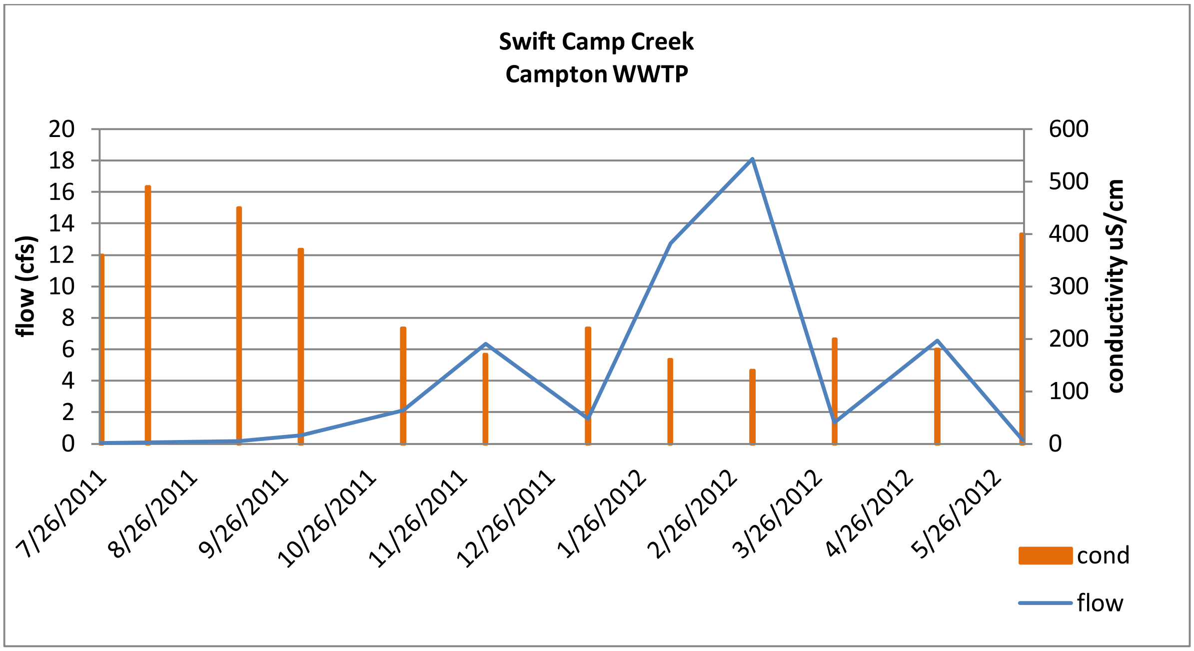


Figure 4.18: Conductivity and Flow at Swift Camp Creek Off KY 15.



Figures 4.19: Conductivity and Flow at Swift Camp Campton WWTP.

Temperature

Water temperature did not exceed the maximum of 31.7 °C at any of the sites during the collection period (Figure 4.20).

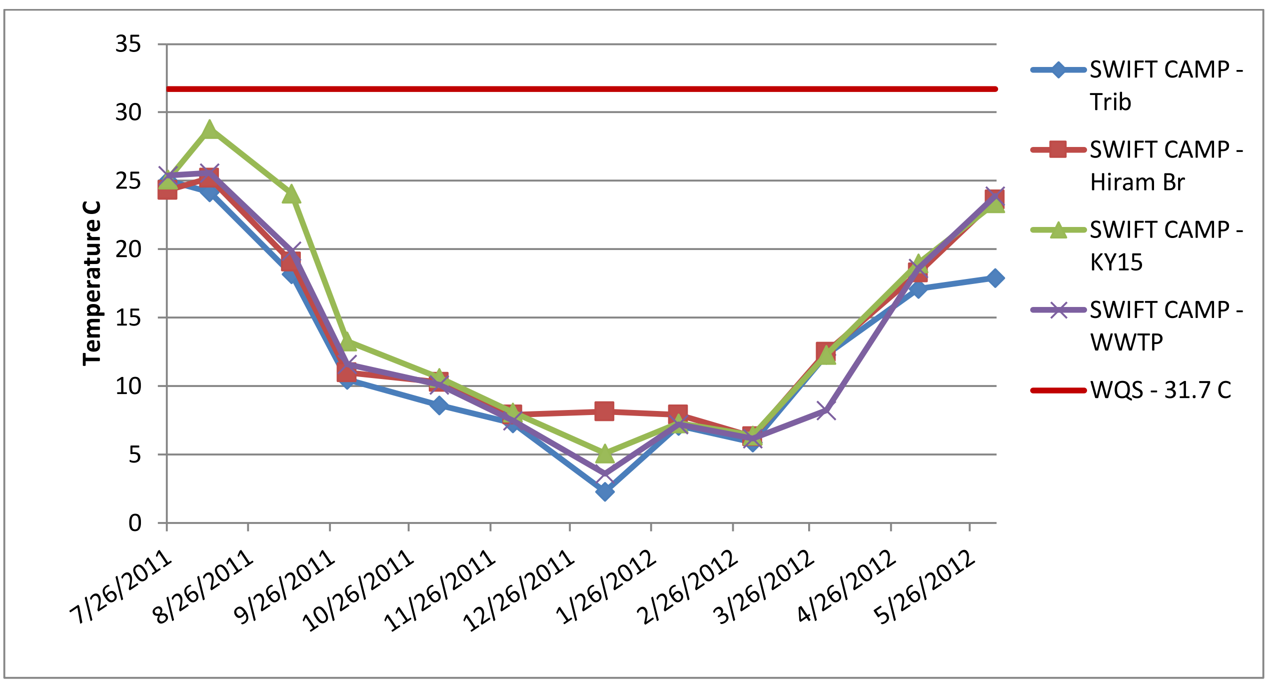


Figure 4.20: Temperature Data at all Swift Camp Creek sites.

Dissolved Oxygen

For warm water aquatic habitat, DO did not fall below the water quality standard of 5.0 mg/L as an average over a twenty-four hour period (Figure 4.21) or below 4.0 mg/L as an instantaneous minimum during the sample period. Likewise, for cold water aquatic habitat, DO did not fall below water quality standard of the twenty-four hour average of 6.0 mg/L or the instantaneous minimum of 5.0 mg/L.

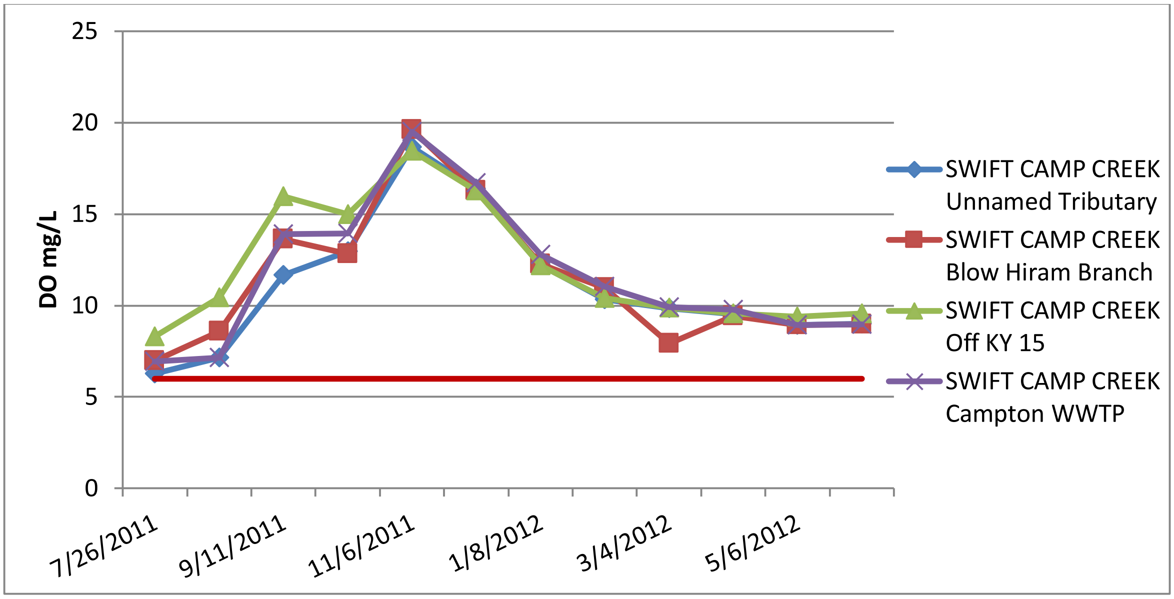


Figure 4.21: Dissolved Oxygen Concentrations at all Swift Camp Creek sites.

pH

pH did not exceed the minimum or maximum limits of the water quality standard, of 6.0 or 9.0, during the collection period (Figure 4.22).

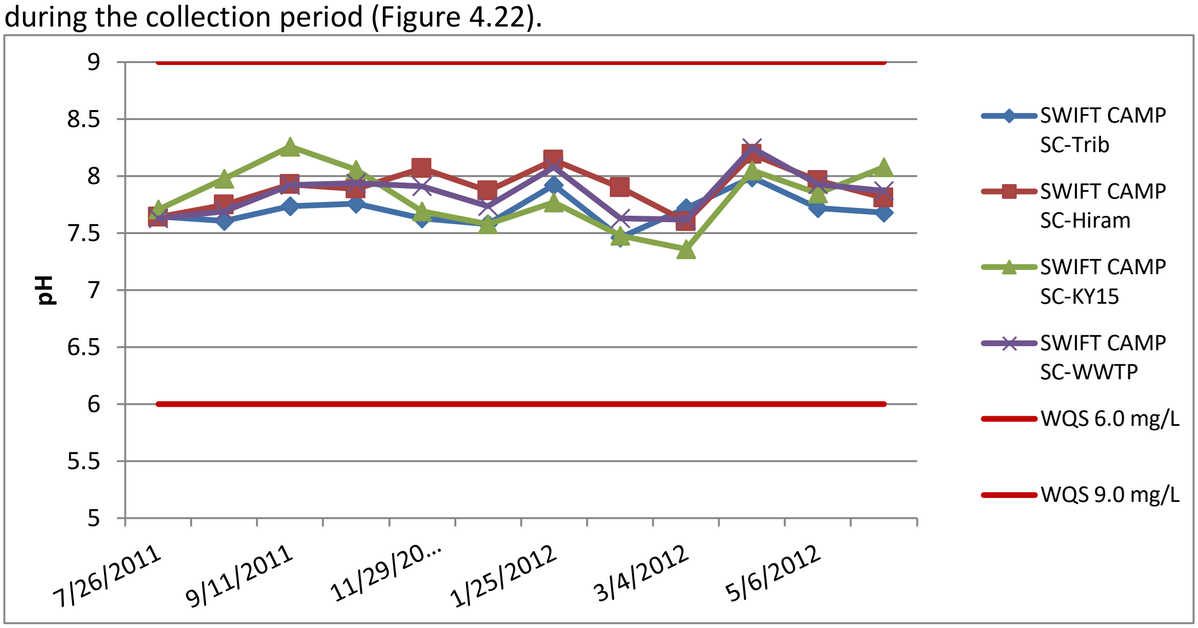


Figure 4.22: pH Concentrations at all Swift Camp Creek sites.

Nutrients

<u>Total Nitrogen</u>

The total nitrogen benchmark of 0.6 mg/L was exceeded at Hirams Branch from July – October and again in January. The unnamed Tributary to Swift Camp Creek also exceeded the benchmark in July and August, and again in November and December (Figure 4.23). The calculated percent reductions needed to meet water quality benchmarks are outlined below (Table 4.6) for total nitrogen and total phosphorus.

Total nitrogen data do not show reductions needed at any site, although the samples for Hirams Branch show nitrogen benchmark exceedances from July – October, and then another exceedance in January. There is little development documented in the area of this sampling point; there could have been some sort of flush of nutrients from septic or agricultural practices, although the latter is unlikely in January. This site may bear further investigation as a priority location for BMP implementation.

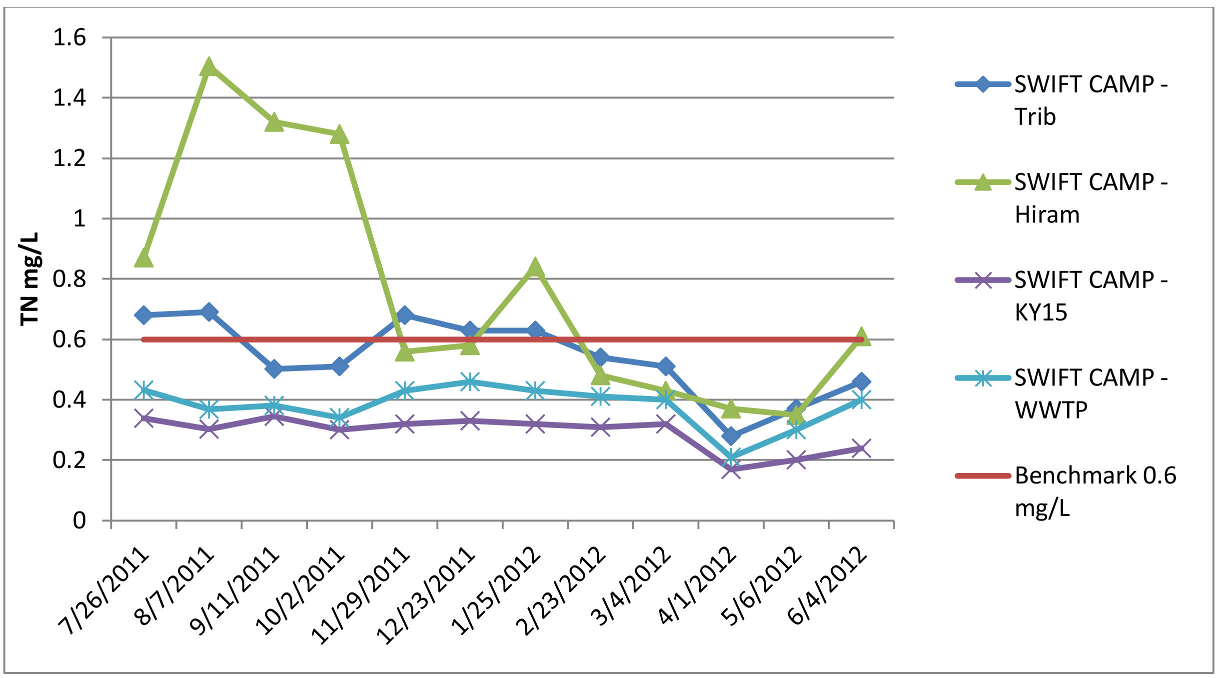


Figure 4.23: Total Nitrogen Concentrations at all Swift Camp Creek sites.

Table 4.6: Total Nitrogen Reductions

Site	Average Annual Load lbs/year	Target Load lbs/year	% Reduction Needed
Swift Camp Unnamed Tributary	1297	1538	No reduction needed*
Swift Camp Below Hirams Branch	4744	5734	No reduction needed**
Swift Camp Off KY 15	1259	2501	No reduction needed
Swift Camp Campton WWTP	3213	4899	No reduction needed

*although exceedences occurred during four months of the collection year
**although exceedences occurred during five months of the collection year

Flow and total nitrogen plotted for the study period show higher flows in winter and spring and lower nitrogen results in that time. February showed a peak in nitrogen, except for Swift Camp Creek Below Hirams Branch (Figures 4.24 – 4.27).

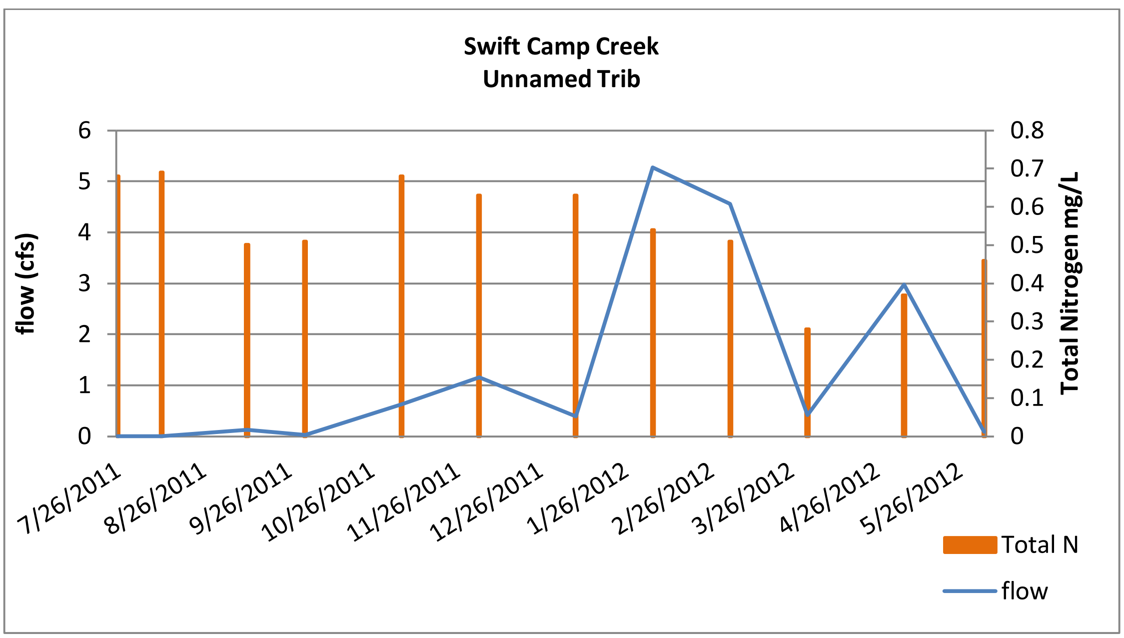


Figure 4.24: Flow and total nitrogen for Swift Camp Creek Unnamed Tributary

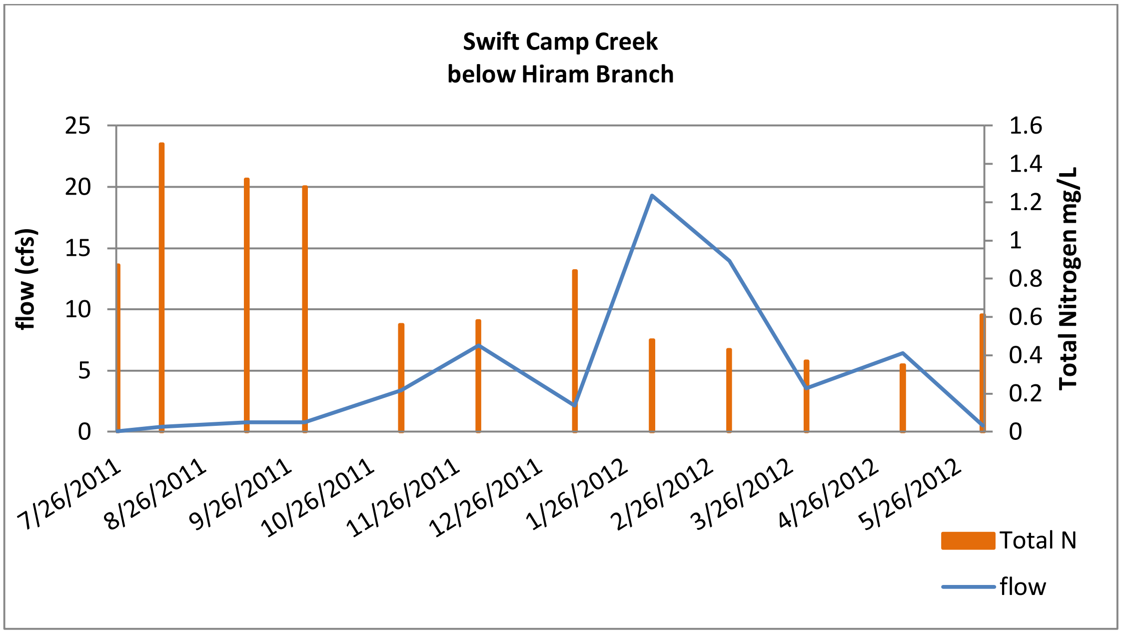


Figure 4.25: Flow and total nitrogen for Swift Camp Creek Below Hirams Branch

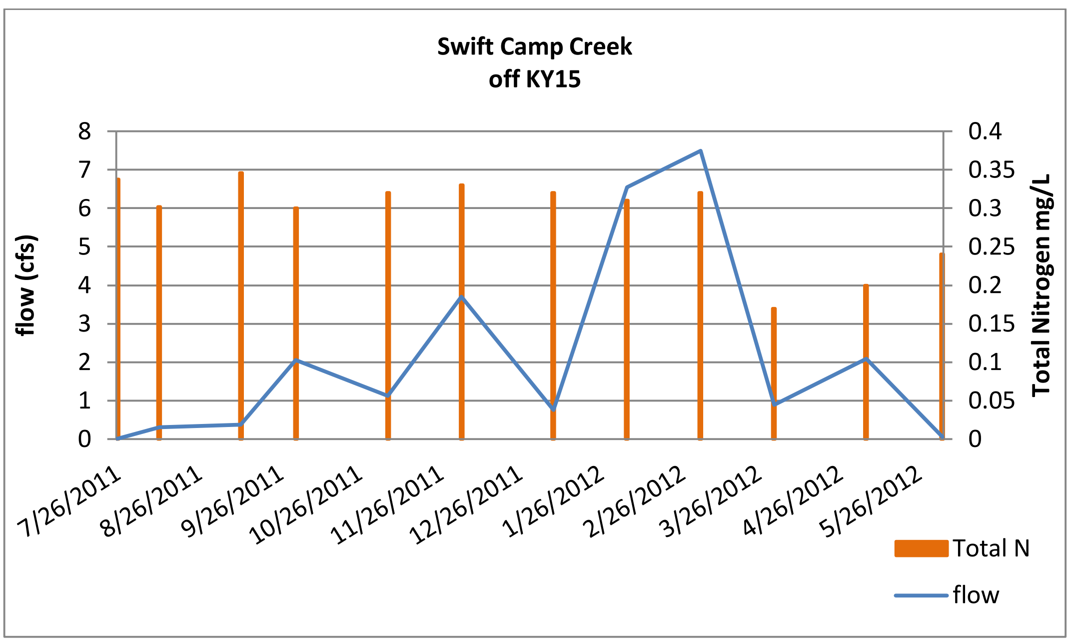
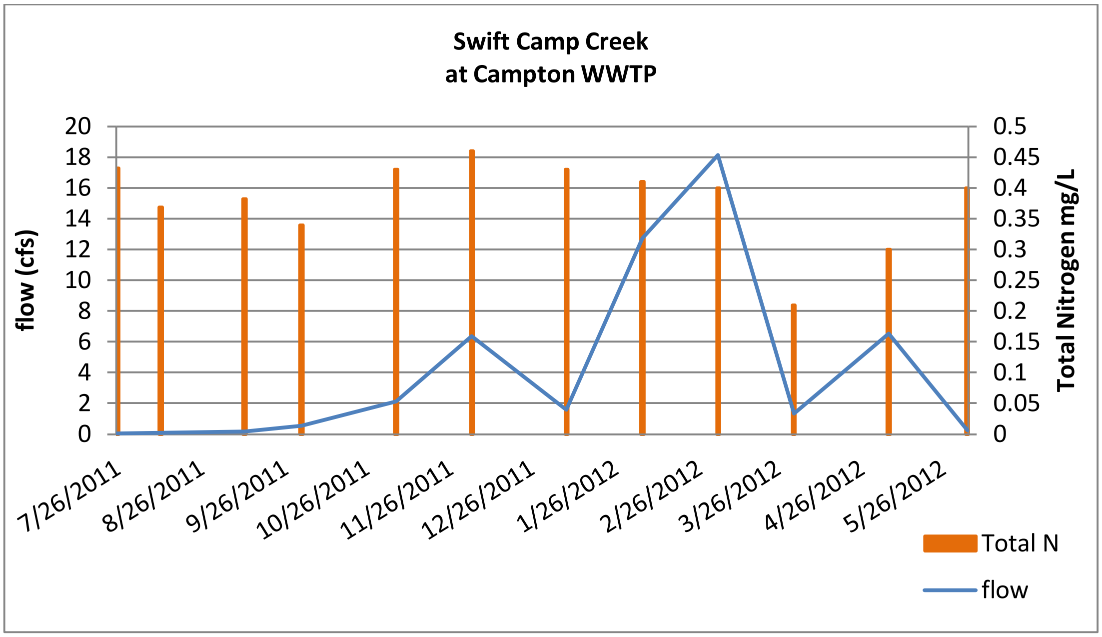


Figure 4.26: Flow and total nitrogen for Swift Camp Creek Off KY 15.



Figures 4.27: Flow and total nitrogen for Swift Camp Creek Campton WWTP.

Total Phosphorus

The benchmark for TP was originally set at 0.02 mg/L for indication of conditions not supporting aquatic life use. However, the lab reporting limit was set at 0.033 mg/L, therefore this discussion will be in reference to the lab's reporting limit. All Swift Camp Creek sites exceeded the reporting limit for TP from January through May 2012, and Hirams Branch exceeded the reporting limit throughout the sampling period. Since the reporting limit was above the benchmark, and TP was detected during several sampling events, consideration should be made for phosphorus throughout the entire sampling period when deciding priorities for BMPs for Swift Camp Creek.

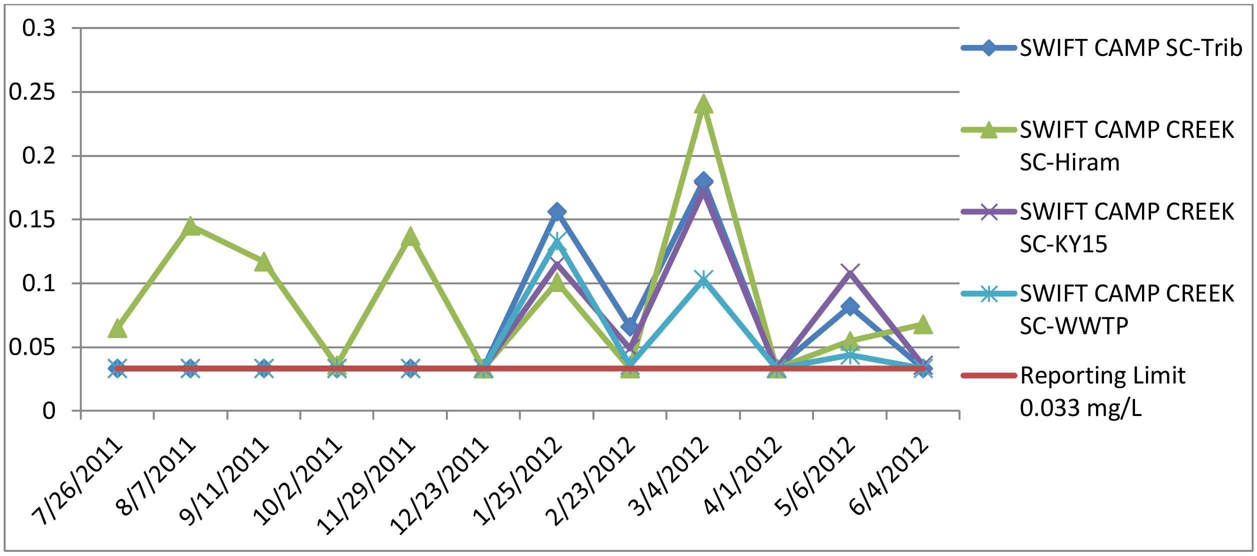


Figure 4.28: Total Phosphorus Concentrations in Swift Camp Creek.

Table 4.7: Total Phosphorus Reductions in Swift Camp Creek.

Site	Average Annual Load lbs/year	Target Load lbs/year	% Reduction Needed
Swift Camp Creek Unnamed Tributary	255	51	80
Swift Camp Creek Below Hirams Branch	917	191	79
Swift Camp Creek Off KY 15	362	83	77
Swift Camp Creek Campton WWTP	521	163	69

The highest levels of TP were detected in the winter and spring. Flows are higher during those times, but these do not necessarily correlate strongly as there are phosphorus spikes during decreased flow as well. Phosphorus and flows did seem to affect water quality as reductions are needed at all sites. March showed a spiked in phosphorus level at each of the four sites, but there was no obvious reason observed in the watershed (Figures 4.29 – 4.32).

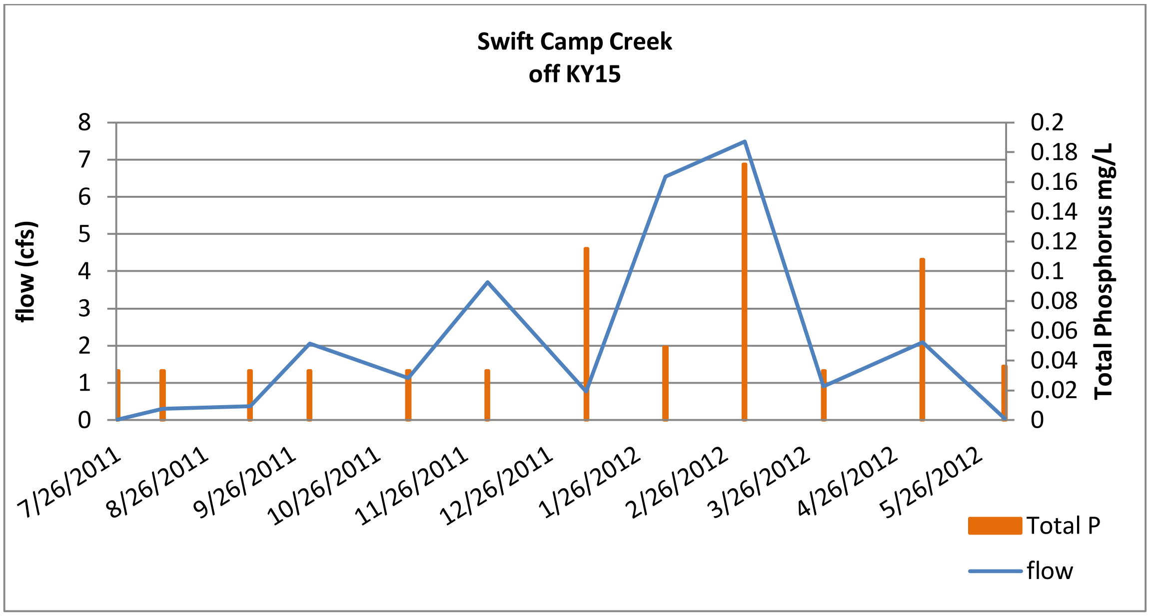


Figure 4.29: Total Phosphorus and flow at Swift Camp Creek Off KY 15.

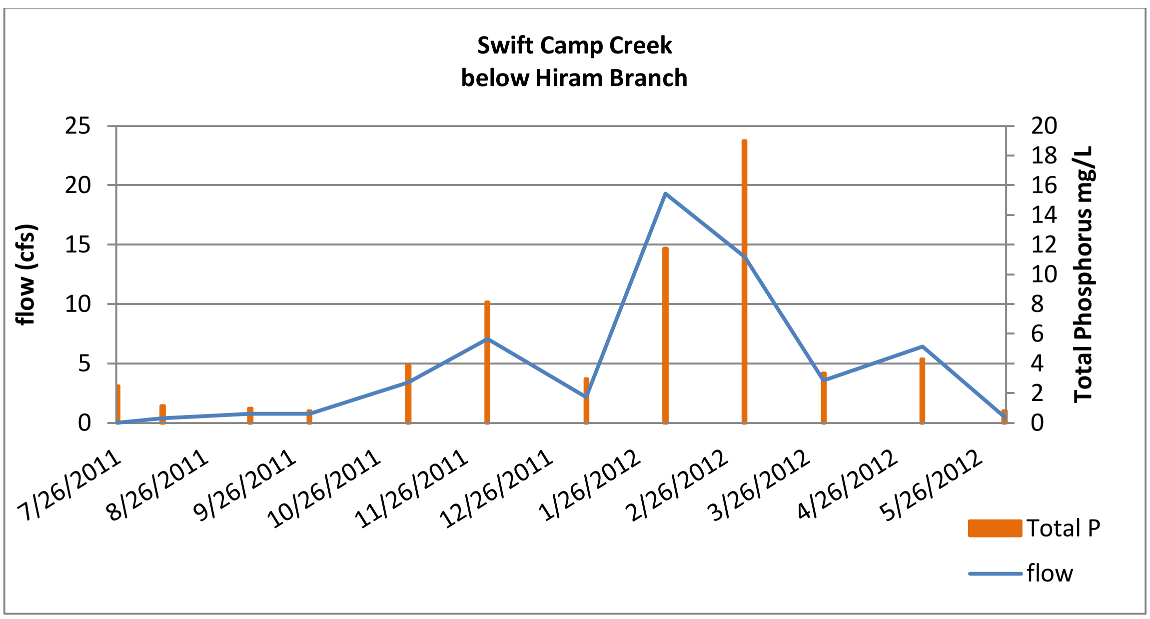


Figure 4.30: Total Phosphorus and flow at Swift Camp Creek Below Hirams Branch.

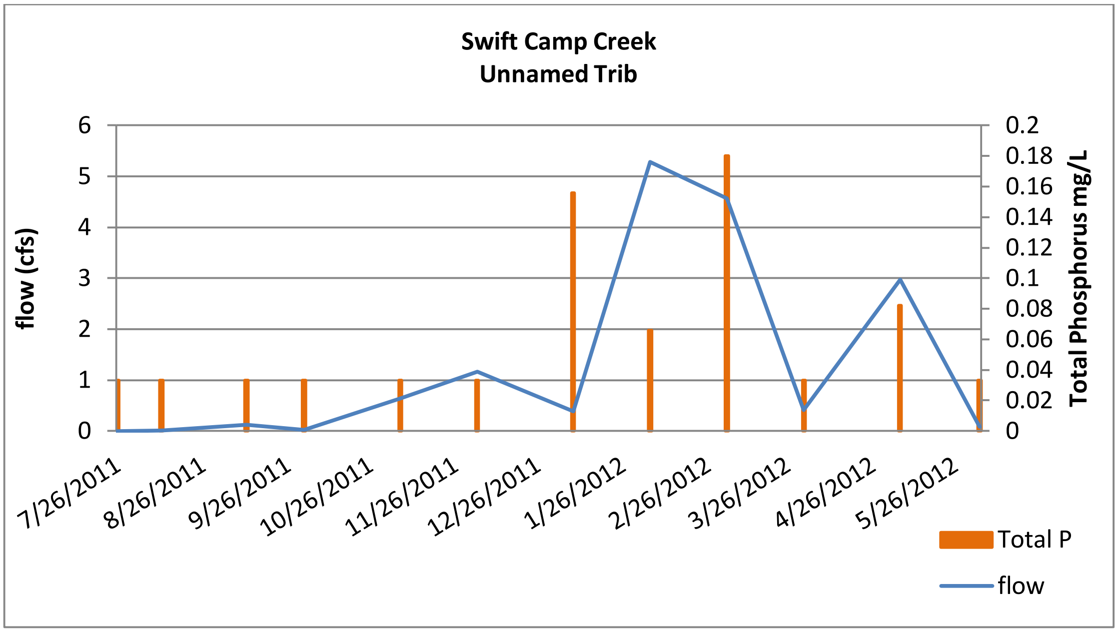
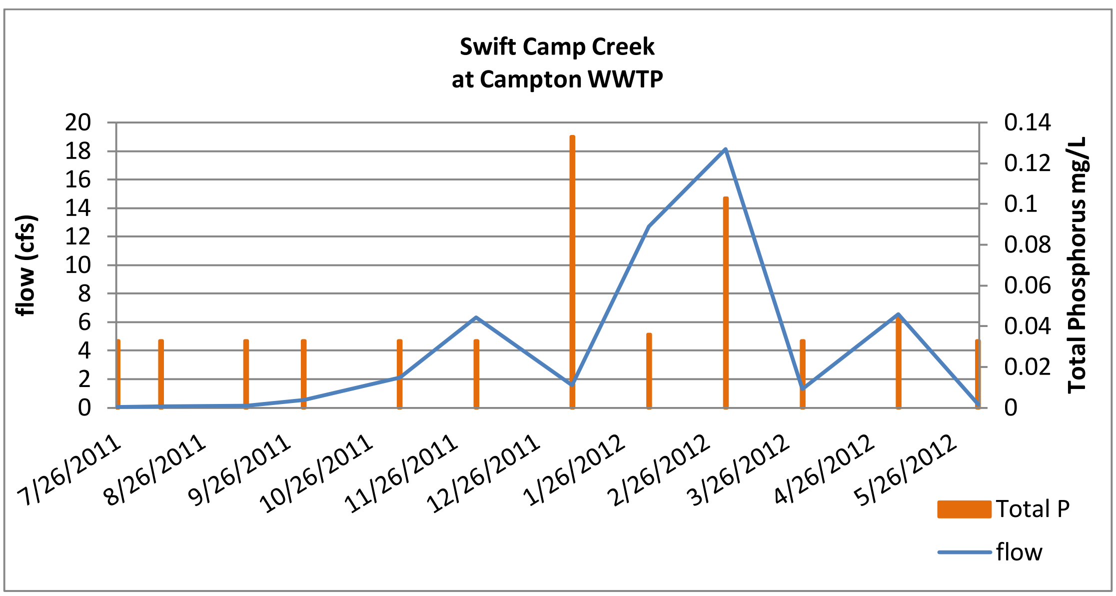


Figure 4.31: Total Phosphorus and flow at Swift Camp Creek Unnamed Tributary.



Figures 4.32: Total Phosphorus Concentrations and Flow at Swift Camp Creek Campton WWTP.

Total Suspended Solids

The TSS benchmark was set at 6.0 mg/L. TSS exceeded the benchmark at Swift Camp Creek Unnamed Tributary July – September 2011, February and March 2012, and May 2012 (Figure 4.33). Similarly, Swift Camp Creek Hirams Branch and Swift Camp Creek WWTP exceeded the benchmark during the early months of 2012 and May. TSS are affected by many factors upstream and in-stream, often coming from unidentified and/or unquantifiable sources, and may be hard to identify a source to target with BMPs.

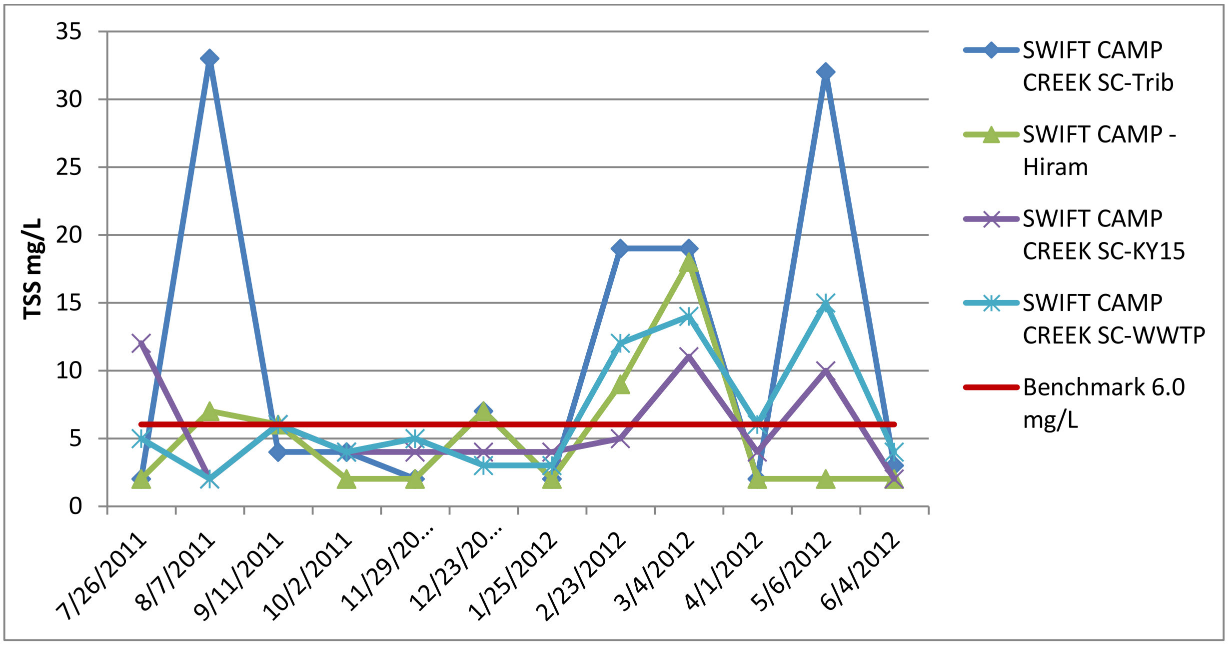


Figure 4.33: TSS Concentrations in Swift Camp Creek.

If this watershed plan or future analyses do identify sources of TSS, then the stream segments on Swift Camp Creek Unnamed Tributary, Swift Camp Creek Below Hirams Branch, and Swift Camp Creek Campton WWTP should be considered for BMP implementation.

Table 4.8: Total Suspended Solid Load Reductions in Swift Camp Creek.

Site	Average Annual Load lbs/year*	Target Load lbs/year	% Reduction Needed
Swift Camp Creek Unnamed Tributary	15,848	3,557	76
Swift Camp Creek Below Hirams Branch	4,871	12,189	None needed
Swift Camp Creek Off KY 15	5,898	5,714	3
Swift Camp Creek Campton WWTP	18,054	12,924	28

* Average loads calculated from April – October only

TSS concentrations and flow didn't appear to follow a pattern at any sites, except possibly a note to be taken at the WWTP during a higher flow in February/March. TSS benchmarks are only applicable April – October during low flow conditions (Figures 4.34 – 4.37).

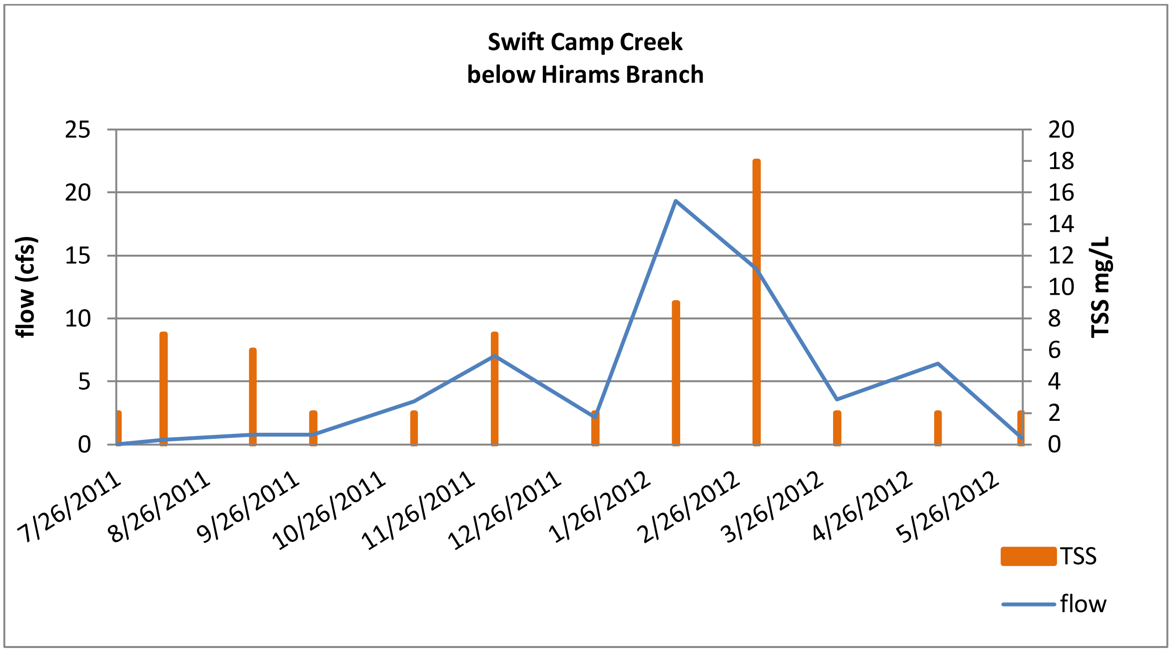


Figure 4.34: TSS and flow at Swift Camp Creek Below Hirams Branch.

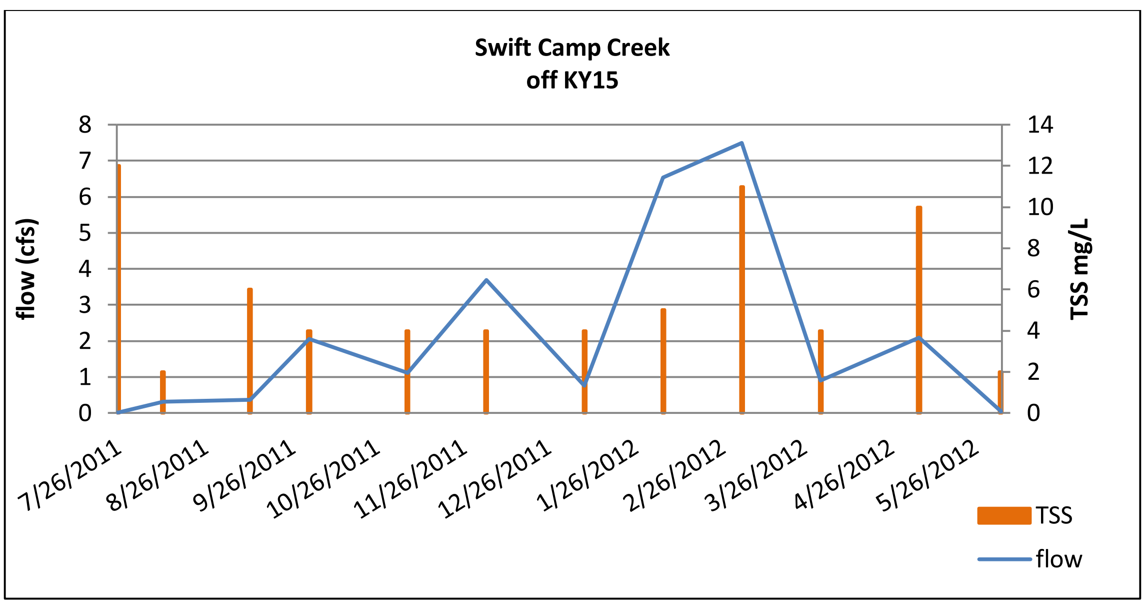


Figure 4.35: TSS and flow at Swift Camp Creek Off KY 15.

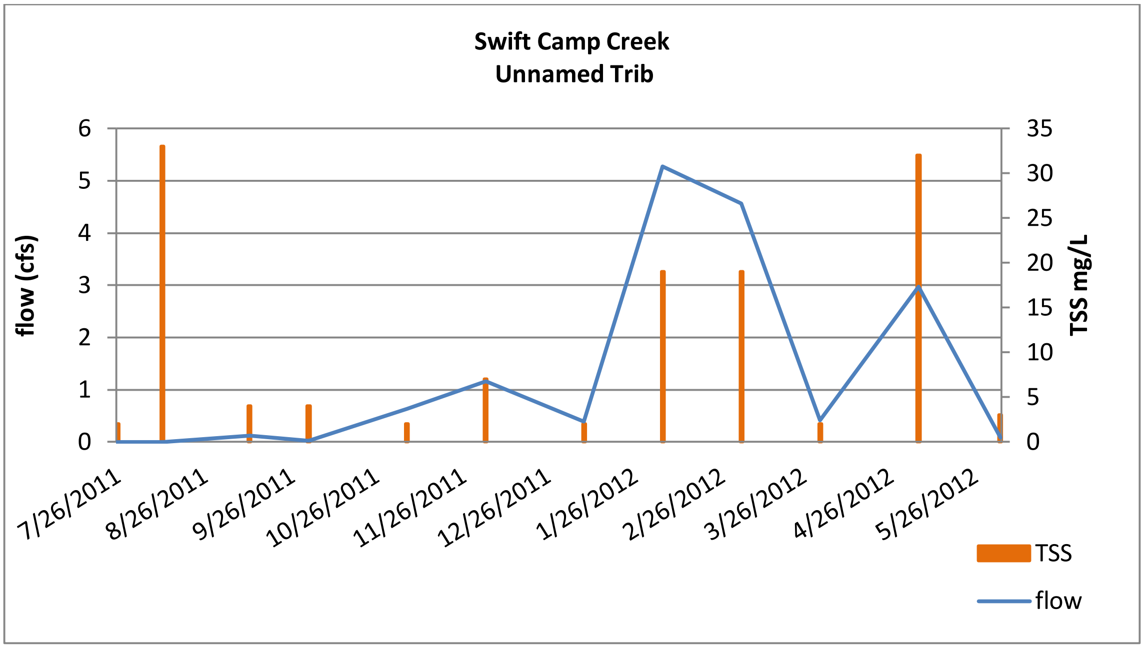
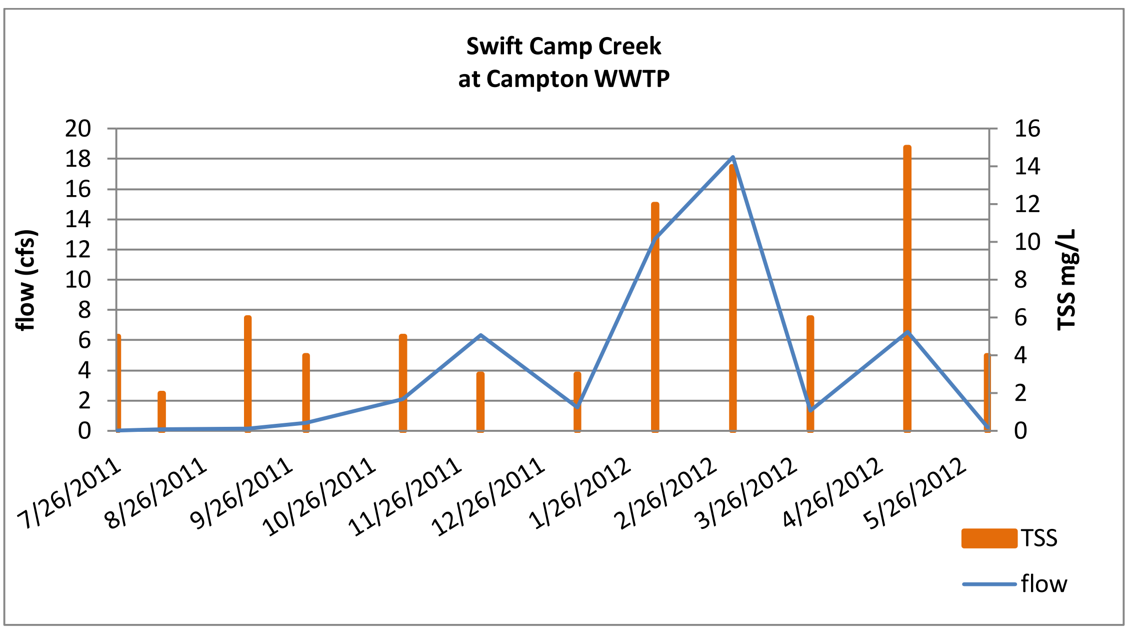


Figure 4.36: TSS and flow at Swift Camp Creek Unnamed Tributary.



Figures 4.37: TSS Concentrations and Flow at Campton WWTP.

Biological Data

Aquatic Habitat

Habitat scores for the Swift Camp Creek Watershed were fair to poor (Table 4.9). The individual habitat parameters that scored in the low to mid-range are sediment deposition, channel alteration, velocity/depth regime, narrow to no riparian buffers, and embeddedness.

Macroinvertebrate Sampling

Sampling locations in Swift Camp Creek for macroinvertebrates scored from fair to very poor (Table 4.9), likely related in part to the habitat conditions (see above paragraph) that are important for healthy aquatic communities. Fair to very poor scores indicate a non-use attainment for the designated uses of cold water or warm water aquatic habitat.

Table 4.9: Macroinvertebrate and Habitat Scores Results in Swift Camp Creek.

Site	MBI Rating	Habitat Rating
Swift Camp Creek Unnamed Tributary	Poor	Fair
Swift Camp Creek Hirams Branch	Fair	Fair
Swift Camp Creek Off KY15	Poor	Poor
Swift Camp Creek Campton WWTP	Very Poor	Fair

Flow

Swift Camp Creek showed some anomalous data for flow. On a few dates, some flow measurements showed a decrease in flow in the direction of the mouth of the stream, as opposed to increasing due to the input of flow from tributaries, as is more typical. Suggested explanations for this include the natural geology and soils – the upstream sites sit on alluvium, which could indicate that flow would go sub-surface at lower flows than would a stream with a bedrock bottom. Also, the Mountain Parkway bisects the sampling area, which could affect flow due to impervious surface drainage and ditch conveyances. Additionally, the wastewater treatment plant has an effect on stream volume, as plant operations often make up the majority of flow in the stream, depending on whether plant valves are open or closed.

Pollutant Yields

Calculation of a pollutant yield allows for a normalization of annual loads in relation to a geographic size area. This allows for a comparison of sites. Annual pollutant yields were calculated by dividing the annual load by the area (in acres) upstream of each site. Annual target pollutant loads were calculated by dividing the target load by the area in acres upstream of each site. Results are shown in Table 4.10.

Table 4.10: Annual and Target Yields for Swift Camp Creek by Parameter.

Parameter	Unit	Annual Yield [Target Yield]			
		Swift Camp Creek Unnamed Tributary	Swift Camp Creek Hirams Branch	Swift Camp Creek Off KY15	Swift Camp Creek Campton WWTP
Upstream Area	Acres	1.40	6.25	2.21	4.92
E. coli	CFU/100mL	9.57E+12 [2.79E+12]	4.32E+12 [1.64E+12]	5.1E+12 [2.05E+12]	8.75E+12 [1.80E+12]
TN	mg/L	926 [1,098]	759 [917]	569 [1,131]	653 [995]
TP	mg/L	182 [36]	146 [30]	163 [37]	105 [33]
TSS	mg/L	34,425 [10,992]	13,527 [6,290]	12,870 [11,319]	18,362 [9,958]

4.5 Results of Indian Creek Subwatershed

Three sites were monitored in and adjacent to the Indian Creek Watershed: Indian Creek at Bear Branch Road, the mouth of Indian Creek, and Edwards Branch, a tributary to the Red River, above where Indian Creek flows into the Red River (Figure 4.38). There were two sites on East Fork Indian Creek collected for biology, but no water chemistry was measured.

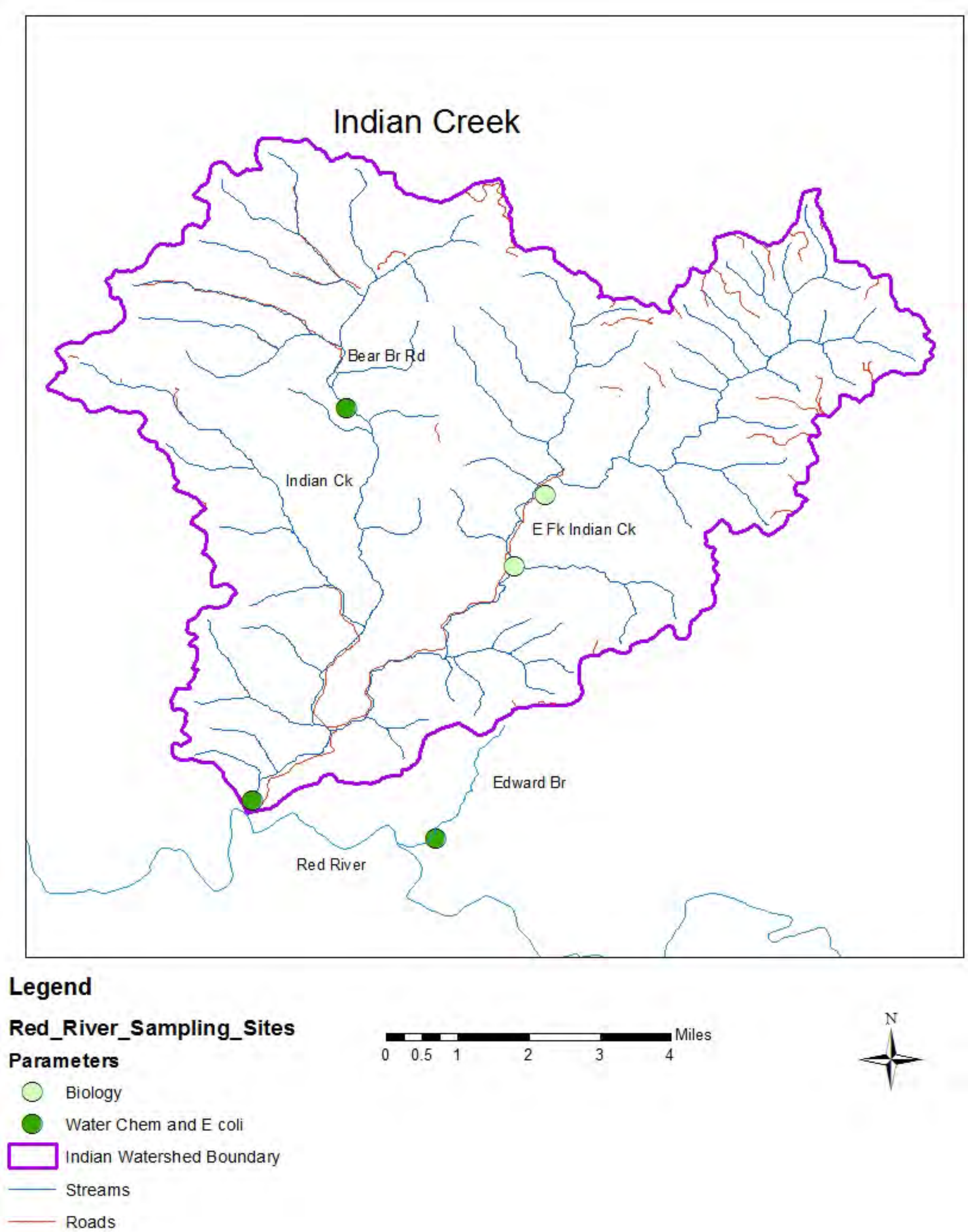


Figure 4.38: Indian Creek Boundary and Monitoring Locations.

Bacteria

Bacteria sampling results indicate that all sites in the Indian Creek Subwatershed had values lower than the water quality standard for *E. coli* (Figure 4.39). However, the geometric mean at Bear Branch did exceed the standard of 130 cfu/100 mL (Table 4.11) for 3 of the 5 events. The highest value of 1220 cfu/100 mL may be skewing the geomean, and could be explained by a one-time event of an influx of bacteria through direct dumping of waste, discharge from a straight pipe, or other source. Further investigation could be done along Bear Branch to identify sources of *E. coli* and install appropriate BMPs. Target loads compared with annual loads indicate no reductions are needed for this subwatershed (Table 4.12).

Table 4.11: Geometric Mean Calculations of *E. coli* (cfu/100 mL).

Date	Indian Creek		
	Bear Branch Road	Mouth	Edwards Branch
5/2/2012	349	82	8
5/6/2012	130	41	50
5/13/2012	165	56	130
5/20/2012	1,220	20	4
5/27/2012	126	24	0
Geomean	**258**	**39**	**21**

Table 4.12: *E. coli* Load Reductions.

Site	Average Annual Load lbs/year	Target Load lbs/year	% Reduction Needed
Indian Creek Bear Branch*	1.69E+12	1.06E+13	No reduction needed
Indian Creek Mouth	4.9E+12	4.41E+13	No reduction needed
Indian Creek Edwards Branch	2.28E+11	2.82E+12	No reduction needed

*The geometric mean did show exceedances in the water quality standard at Bear Branch, but overall load reductions were not required according to the annual averages.

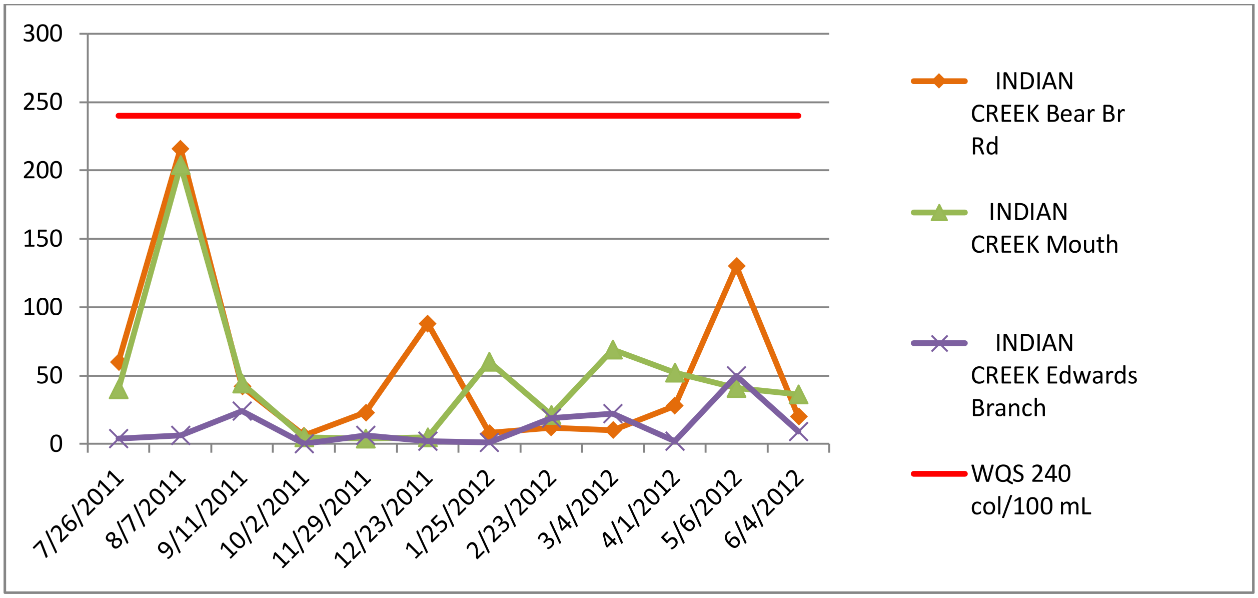


Figure 4.39: *E. coli* Concentrations in Indian Creek.

Flow

A general pattern was observed for sampling site flows and bacteria concentrations: during low flows, there were higher concentrations of bacteria and during higher flows, there were lower concentrations of bacteria (Figures 4.40 – 4.42). This relationship could indicate that some of the *E. coli* bacteria are coming from such sources as leaking septic tanks or sewer lines.

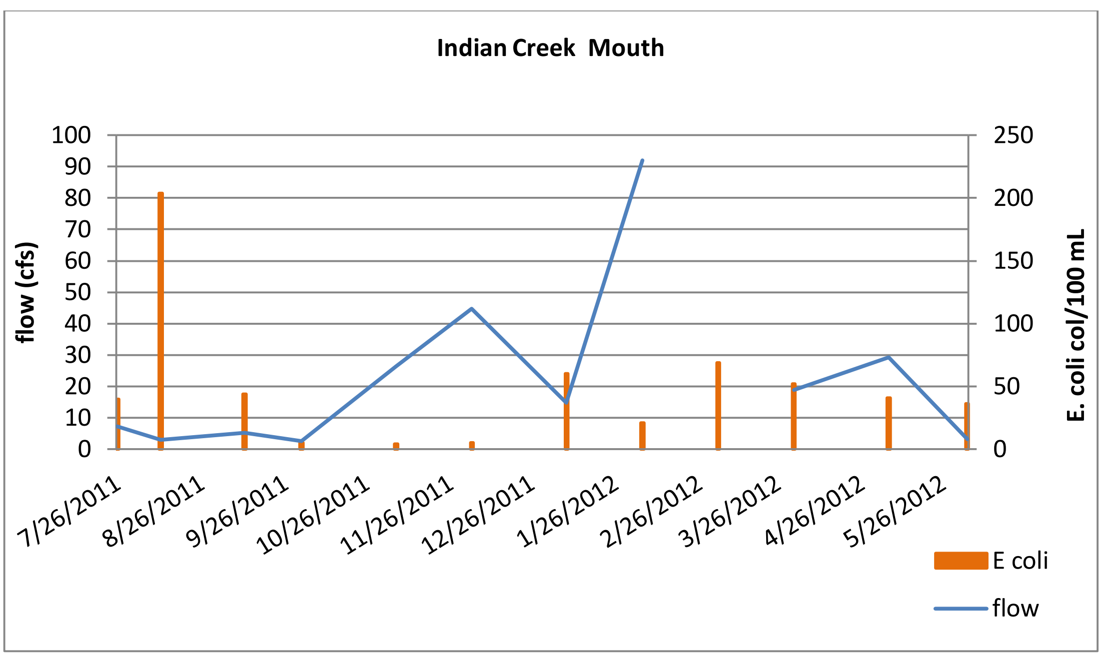


Figure 4.40: *E. coli* Concentrations and Flow at Indian Creek Mouth.

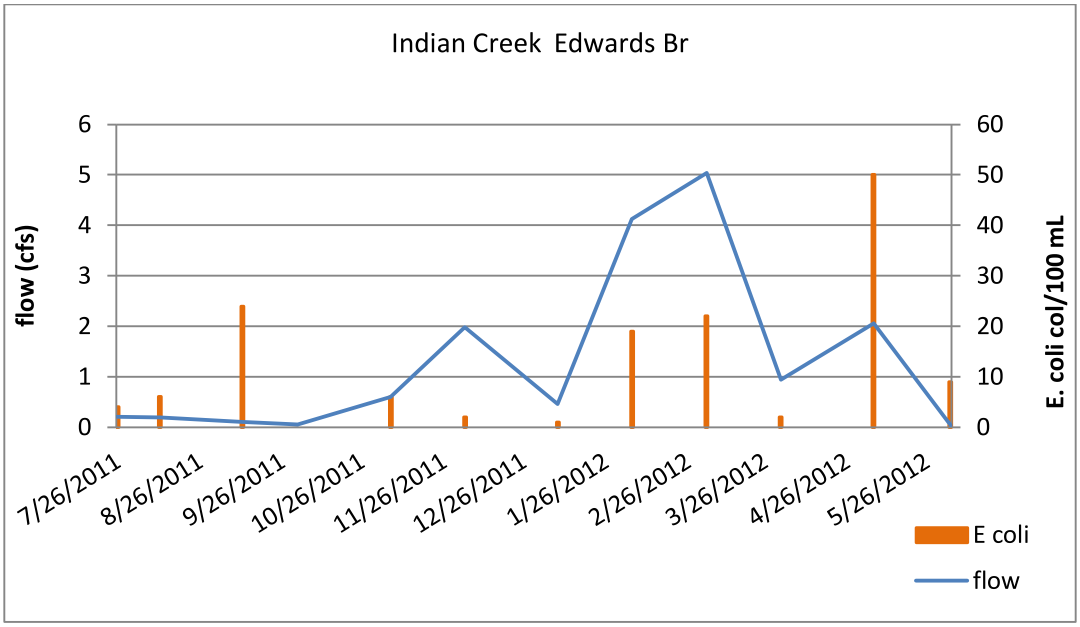


Figure 4.41: ***E. coli*** **Concentrations and Flow at Edwards Branch.**

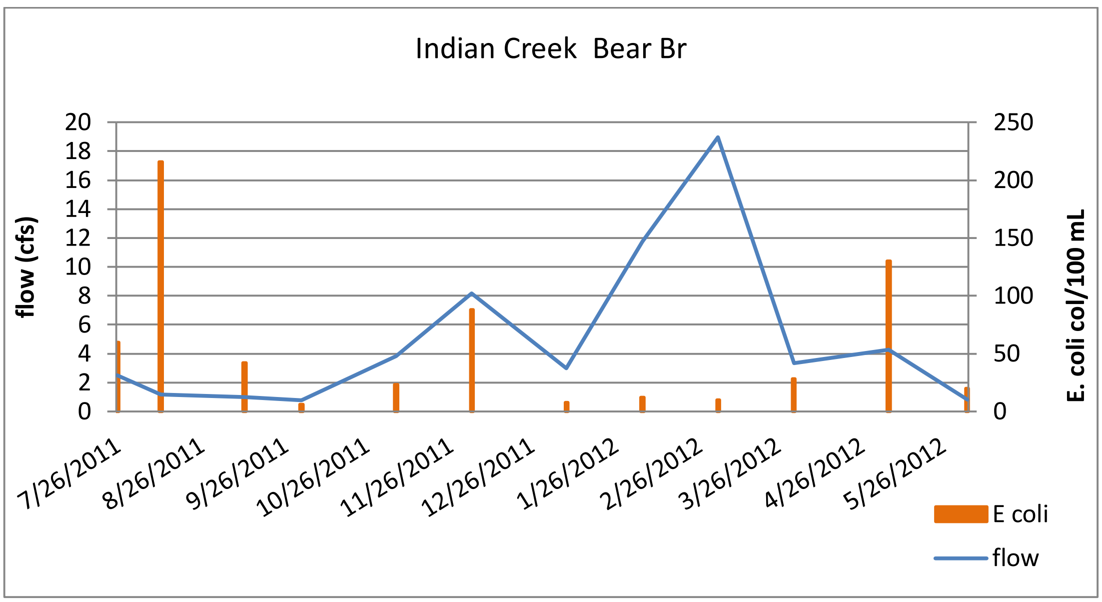


Figure 4.42: ***E. coli*** **Concentrations and Flow at Indian Creek Bear Branch.**

Conductivity

Conductivity exceeded the benchmark of 218 µS/cm in late summer (July – October 2011) for the mouth of Indian Creek and exceeded the benchmark at all times at Indian Creek at Bear Branch Rd (Figure 4.43). Lower flows and higher conductivities were seen in the summer months (Figures 4.44 – 4.46). Flow and conductivity concentration patterns were similar for all sites. This could be indicative of natural fluctuations as the stream moves downstream, changes in geology, or there could have been an input of pollution that affected conductivity.

The highest average conductivity levels were in the headwaters at Bear Branch, and all 12 monthly samples exceeded the benchmark. Conductivity values decreased downstream at the mouth of Indian Creek with dilution but still remained a concern. The higher than expected conductivities may be a result of water flowing through limestone and shale geology. The highest concentration of sinkholes, caves, and other features of limestone geology can be found in this subwatershed. The upstream limestone quarry could also be affecting conductivity. In addition, there is a pollutant discharge permit for stormwater upstream of this site, approximately 1.4 miles. There is a possibility that the concentrated input of stormwater runoff could be causing higher conductivities.

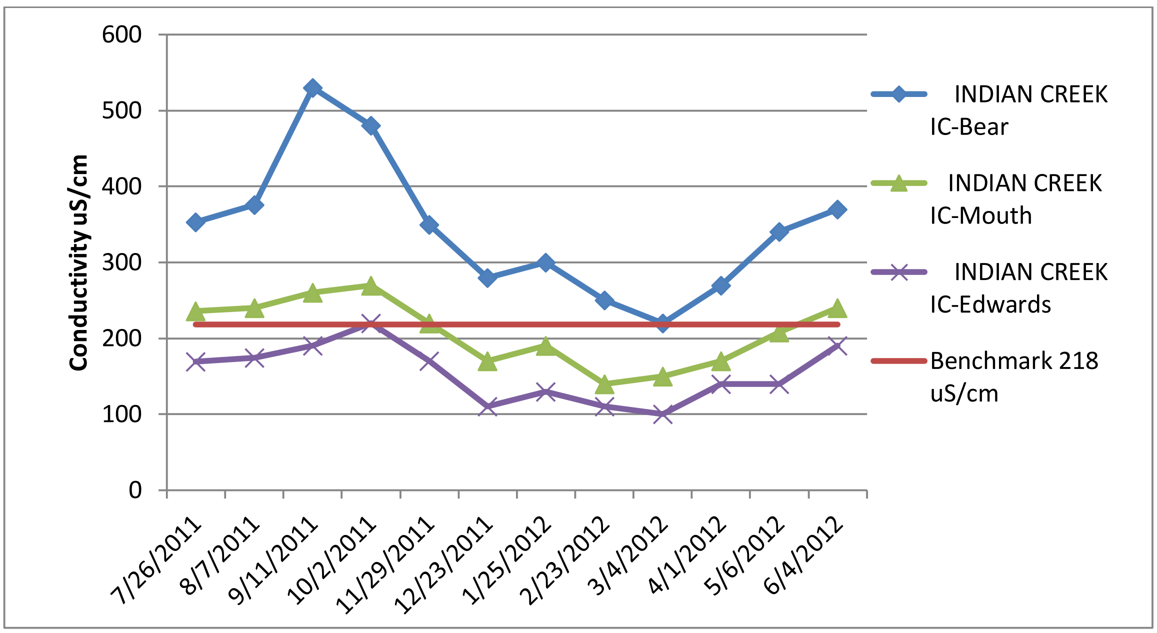


Figure 4.43: Conductivity Concentrations in Indian Creek.

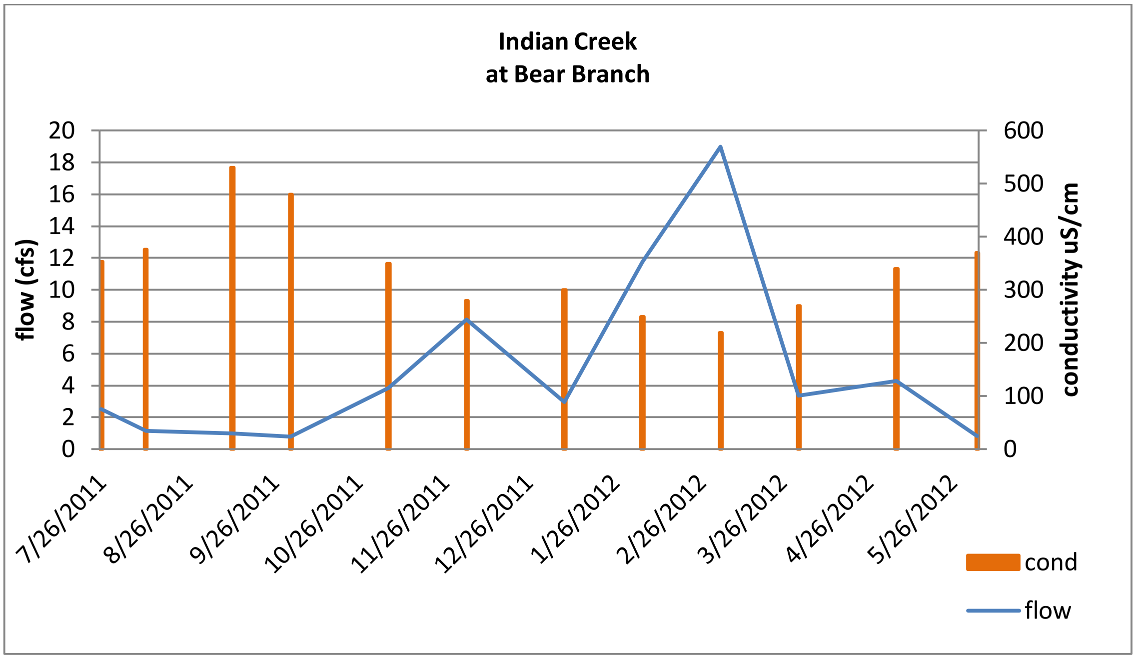


Figure 4.44: Conductivity Concentrations and Flow at Indian Creek Bear Branch.

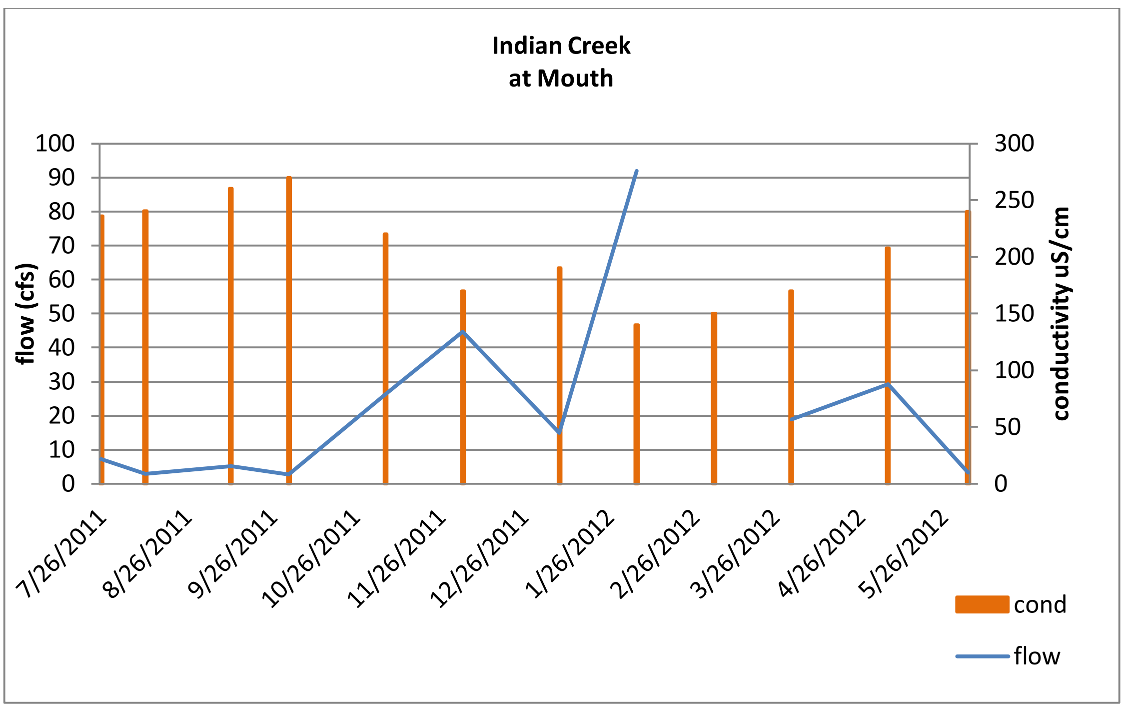


Figure 4.45: Conductivity Concentrations and Flow at Indian Creek at Mouth.

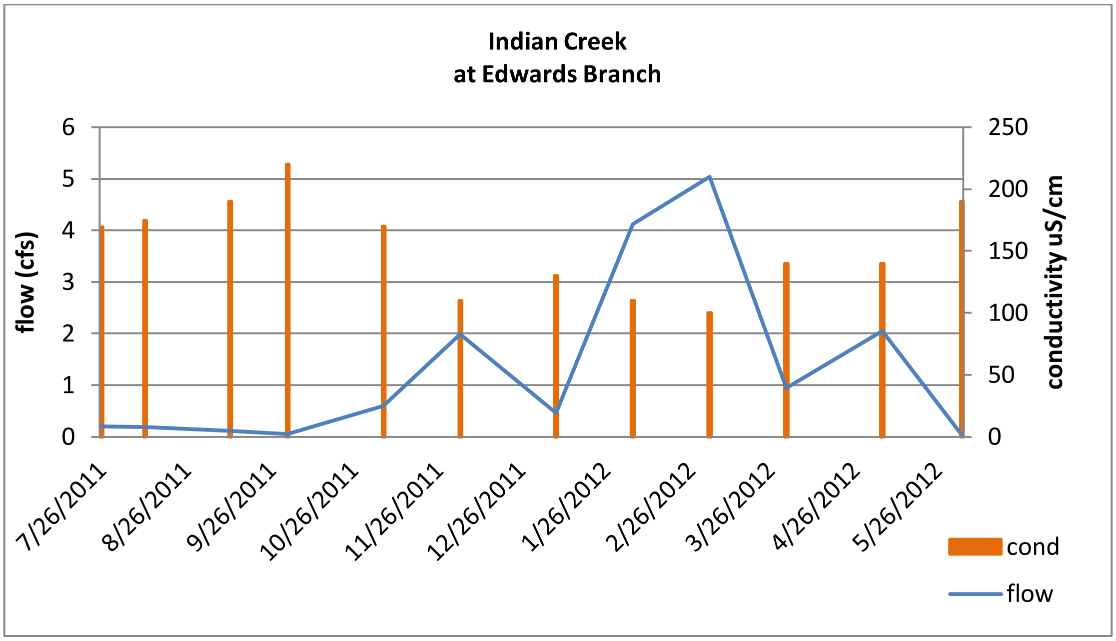


Figure 4.46: Conductivity Concentrations and Flow at Edwards Branch.

Temperature

None of the data for temperature exceeded the instantaneous maximum of 31.7 °C during the study period (Figure 4.47).

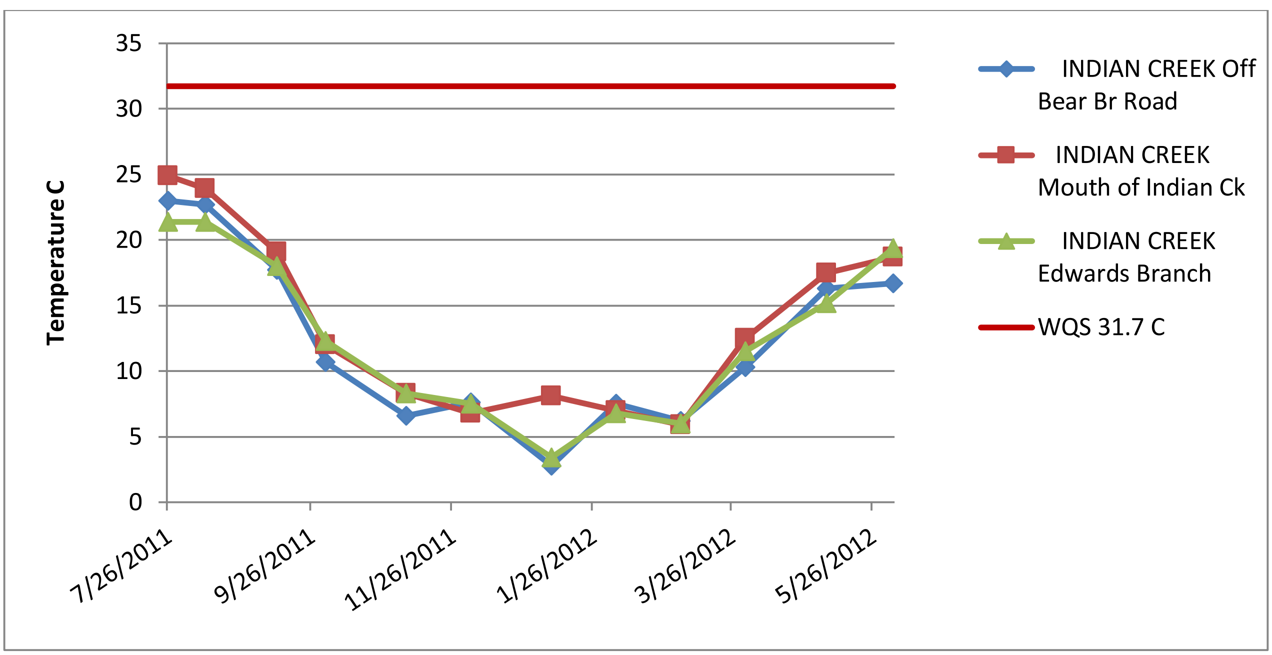


Figure 4.47: Temperature Data for all Indian Creek sites.

Dissolved Oxygen

DO did not measure below the instantaneous minimum of 6.0 mg/L °C for any month (Figure 4.48).

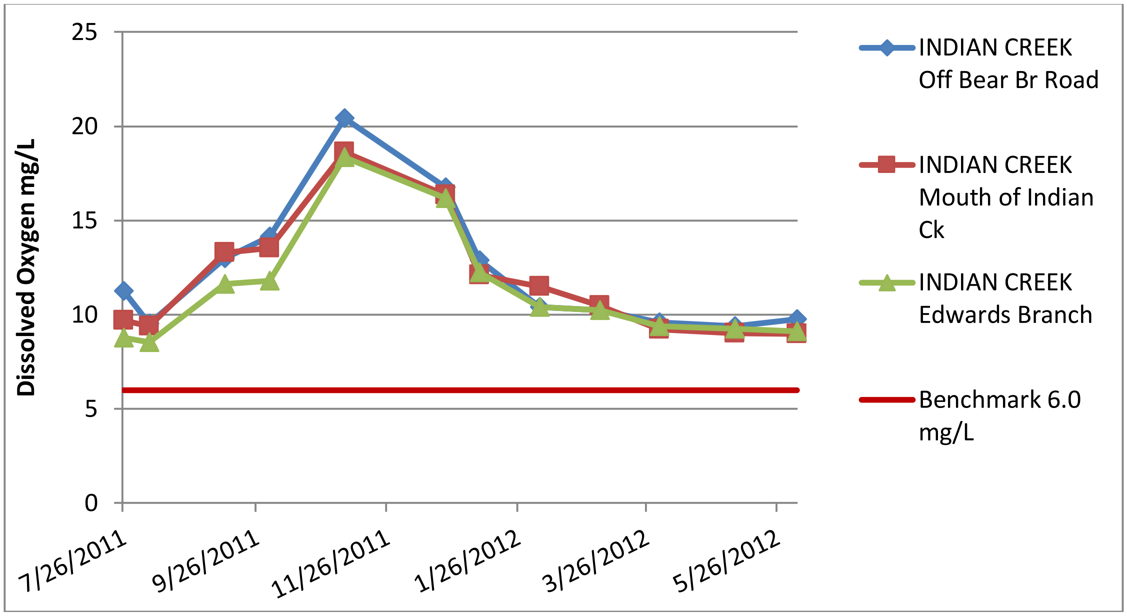


Figure 4.48: Dissolved Oxygen Concentrations at all Indian Creek sites.

pH

All instantaneous pH measurements were within the water quality standards range of 6.0 to 9.0 during the sampling period (Figure 4.49).

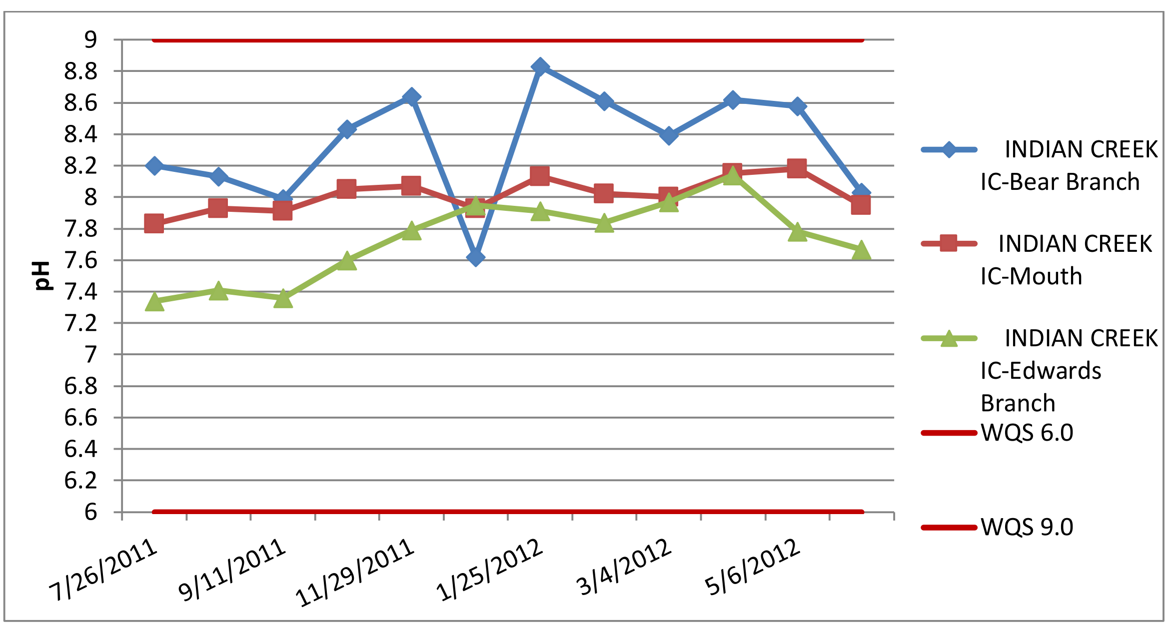


Figure 4.49: pH Concentrations in Indian Creek.

Nutrients

Total Nitrogen

Indian Creek at Bear Branch exceeded the TN benchmark (0.6 mg/L) from July through November of 2011, and again in January 2012 (Figure 4.50). Other sites did not exceed the benchmark. Bear Branch load calculations did not indicate a necessary reduction (Table 4.13), although the spikes in nitrogen at the site during the late summer months could indicate the need for agricultural BMPs for farming operations.

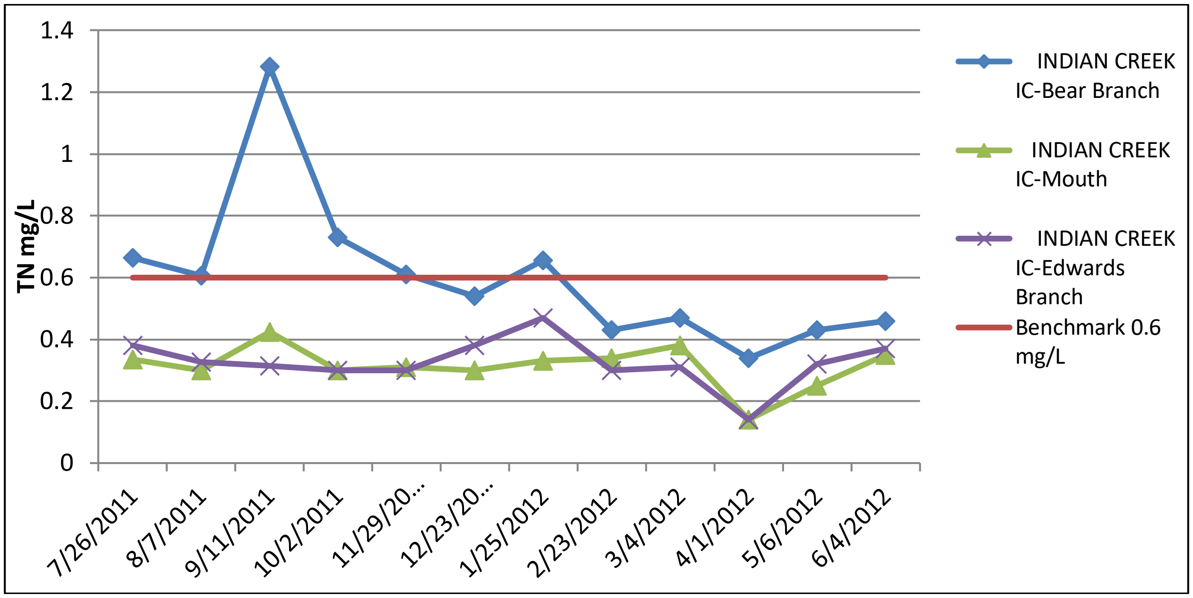


Figure 4.50: Total Nitrogen Concentrations in Indian Creek.

Table 4.13: Total Nitrogen Loads Reductions in Indian Creek.

Site	Average Annual Load lbs/year	Target Load lbs/year	% Reduction Needed
Indian Creek Off Bear Branch Rd	4,956	5,862	No reduction needed*
Indian Creek Mouth	12,332	24,353	No reduction needed
Indian Creek Edwards Branch	810	1,554	No reduction needed

*noted late summer elevated levels

Flow and TN concentrations did not show the pattern of low flows correlating to high concentration (Figures 4.51 – 4.53). TN remained at a fairly steady concentration, regardless of flow.

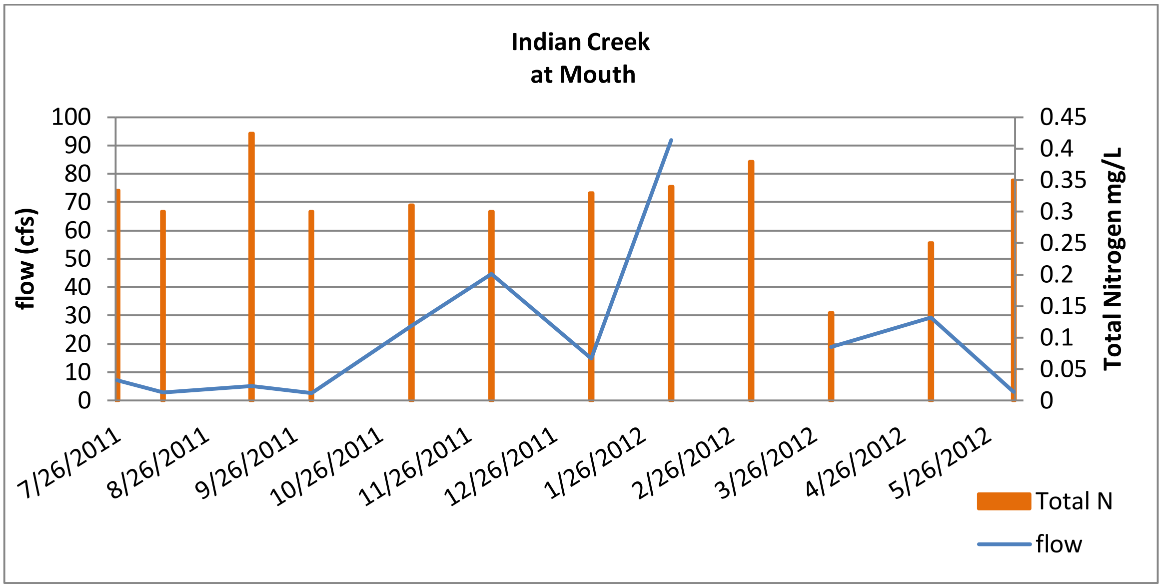


Figure 4.51: Total Nitrogen at the Mouth of Indian Creek.

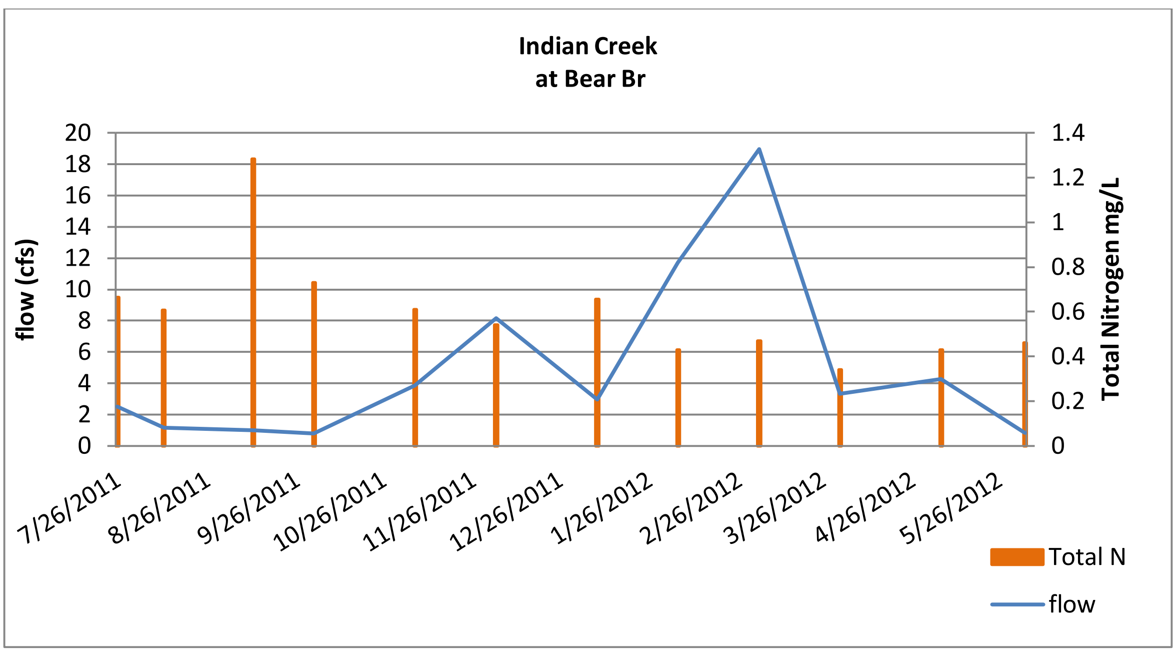


Figure 4.52: Total Nitrogen at Indian Creek at Bear Branch.

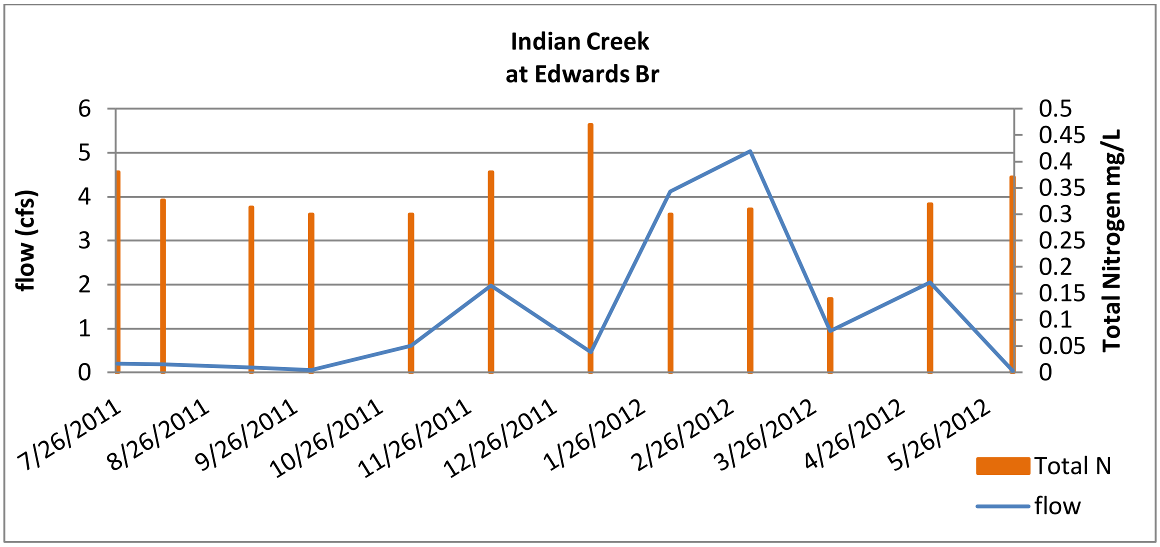


Figure 4.53: Total Nitrogen and Flow at Indian Creek at Edwards Branch.

<u>Total Phosphorus</u>

The benchmark for TP was calculated to be 0.02 mg/L; however, the lab set the reporting limit for this parameter above the benchmark at 0.33 mg/L. Therefore, this discussion is in reference to the lab's reporting limit. Actual reduction requirements may be less since samples were analyzed at a reporting limit greater than the benchmark. All sites spiked during Jan. 2012 and then varied from month to month. Indian Creek at the Mouth had the highest value (Figure 4.54). Load reductions are necessary for all sites (Table 4.14). Similar to elevated nitrogen levels, higher than expected TP loads may be a result of urbanization, failing sewage collection lines, septic systems and pasture runoff near streams.

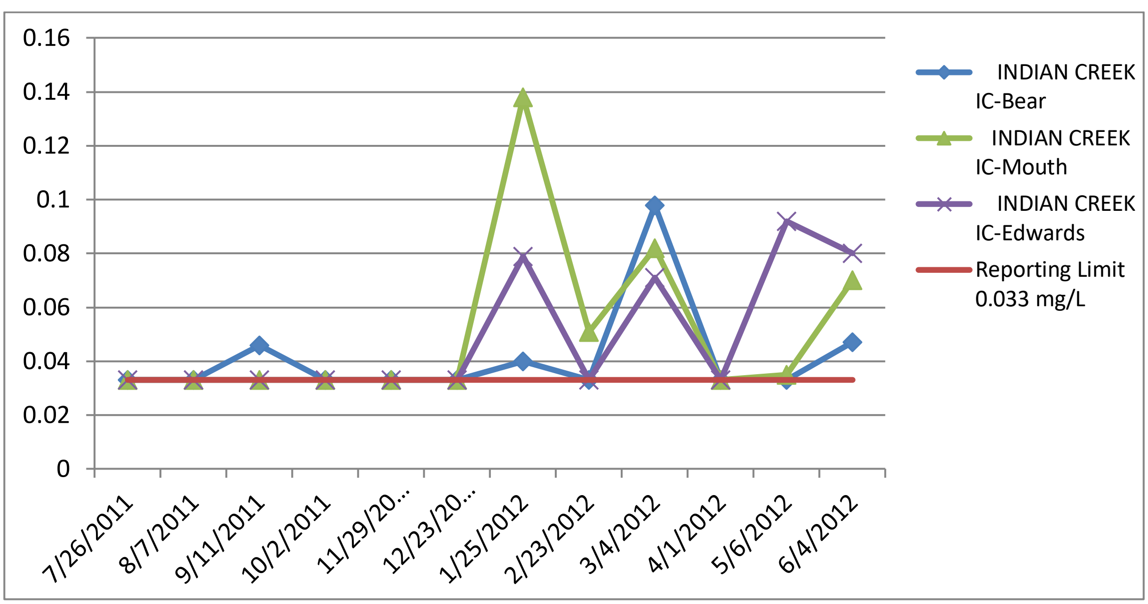


Figure 4.54: Total Phosphorus Concentrations at all Indian Creek sites.

Table 4.14: Total Phosphorus Load Reductions in Indian Creek.

Site	Average Annual Load lbs/year	Target Load lbs/year	% Reduction Needed
Indian Creek Off Bear Branch Road	530	195	63
Indian Creek Mouth	1896	811	57
Indian Creek Edwards Branch	140	51	64

Flow

There were no distinct patters of total phosphorus and flow (Figure 4.55 – 4.57). Indian Creek at the Mouth and Edwards Branch showed a spike in January. The same unknown factors could be causing both conditions.

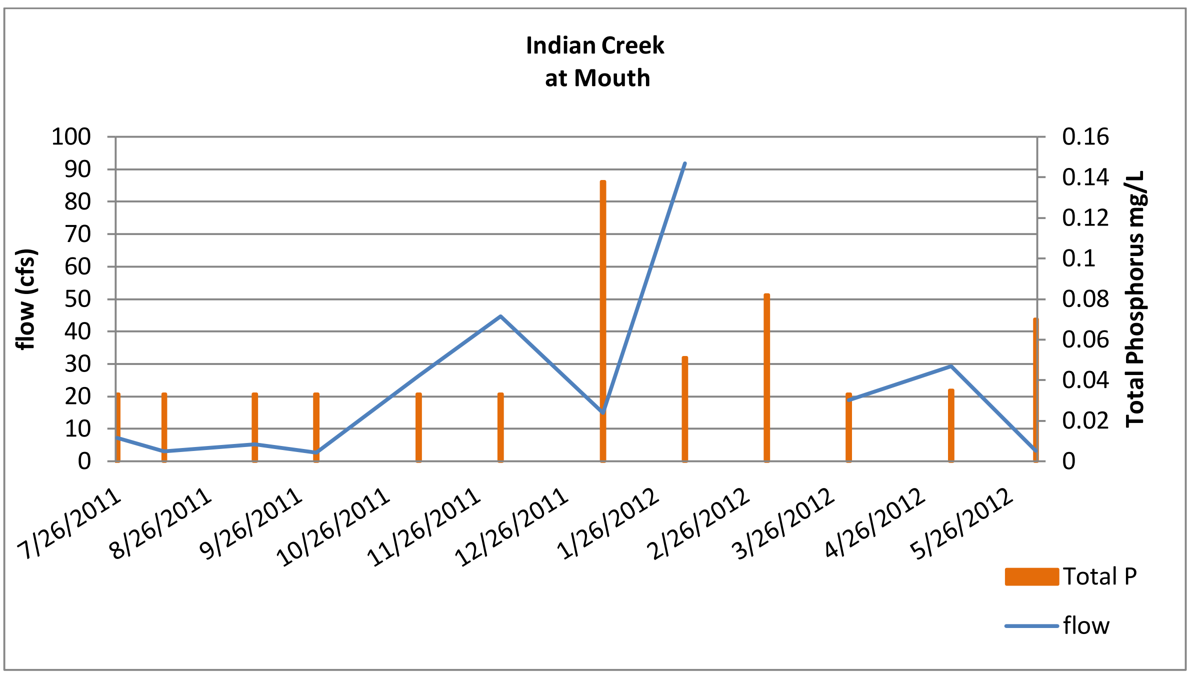


Figure 4.55: Total Phosphorus and Flow at Indian Creek at Mouth.

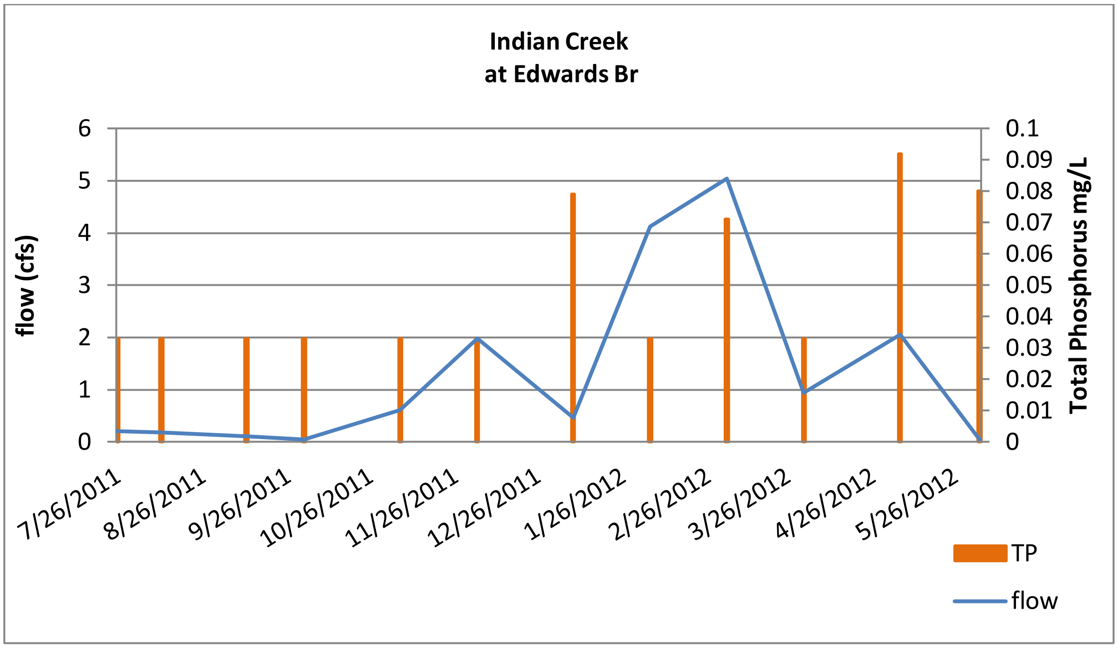


Figure 4.56: Total Phosphorus and Flow at Indian Creek at Edwards Branch.

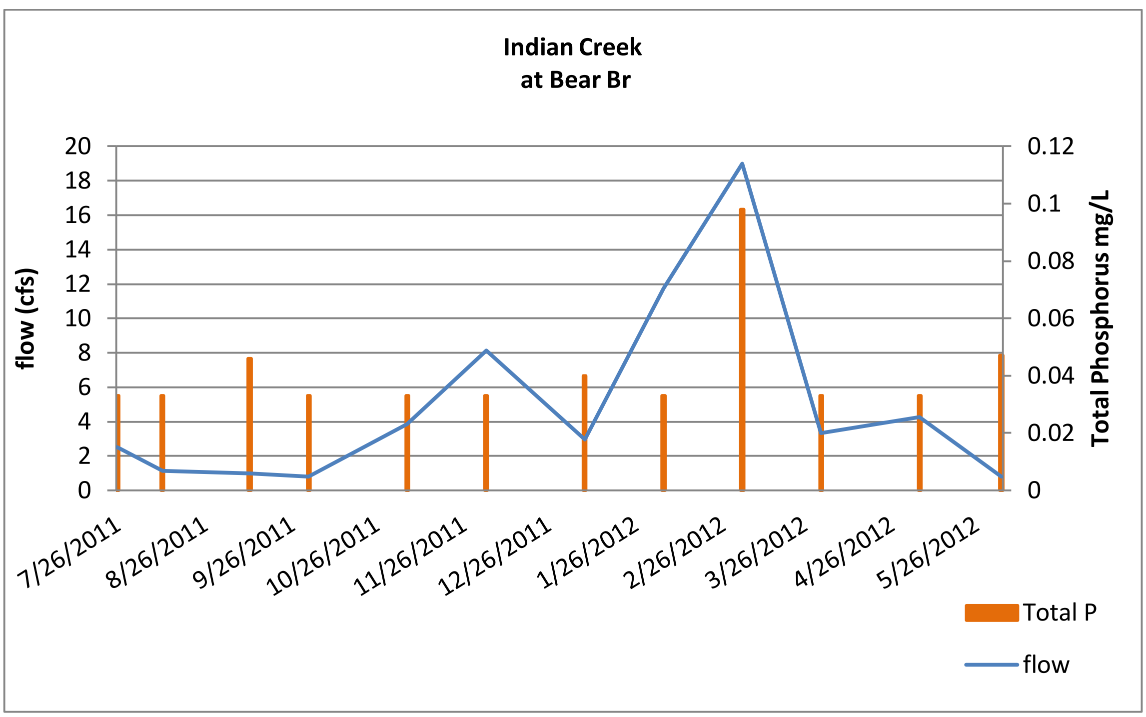


Figure 4.57: Total Phosphorus and Flow at Bear Branch.

Total Suspended Solids
Only one sample at one site exceeded the benchmark of 6.0 mg/L: Edwards Branch in May 2012 (Figure 4.58). Load reductions were not required for TSS (Table 4.15).

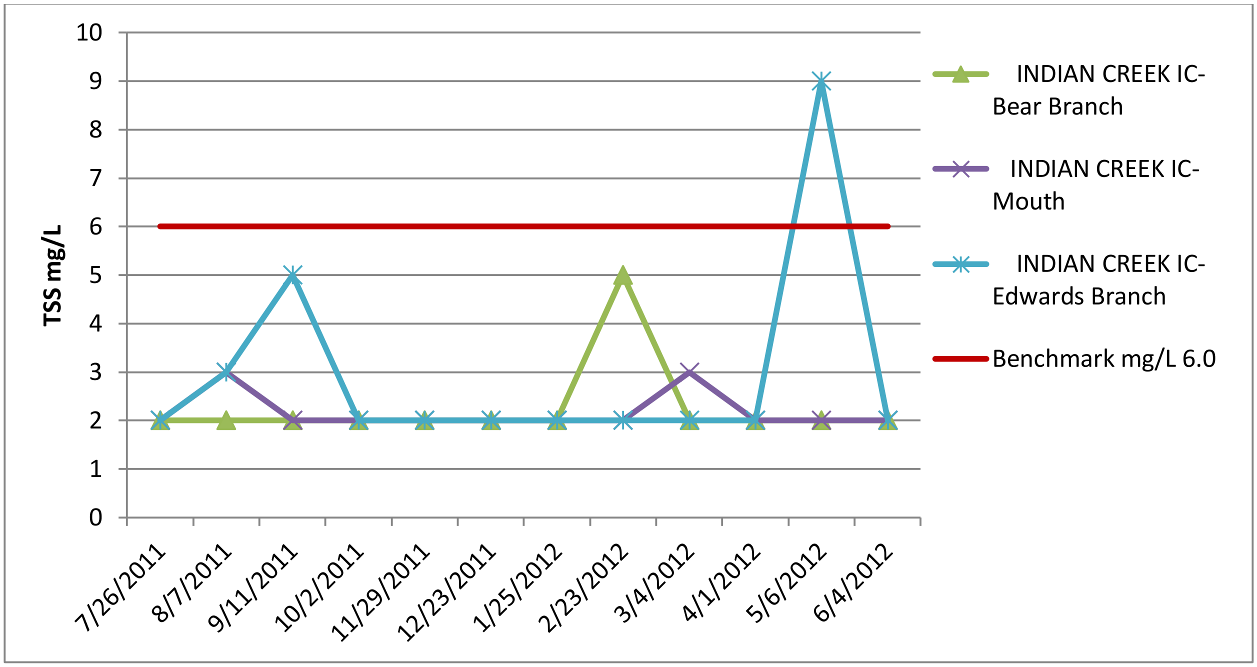


Figure 4.58: TSS Concentrations in Indian Creek.

Table 4.15: TSS Load Calculations in Indian Creek.

Site	Average Annual Load lbs/year*	Target Load lbs/year	% Reduction Needed
Indian Creek Off Bear Branch Rd	4,550	13,650	No reduction needed
Indian Creek Mouth	22,807	68,423	No reduction needed
Indian Creek Edwards Branch	3,590	3,536	No reduction needed

*TSS loads calculated from April - October

Flow

Indian Creek TSS concentrations did not follow flow patterns or seasonality changes. There was a spike in TSS at Indian Creek at Edwards Branch in May 2012, but the mainstem sites were not affected (Figures 4.59 – 4.61).

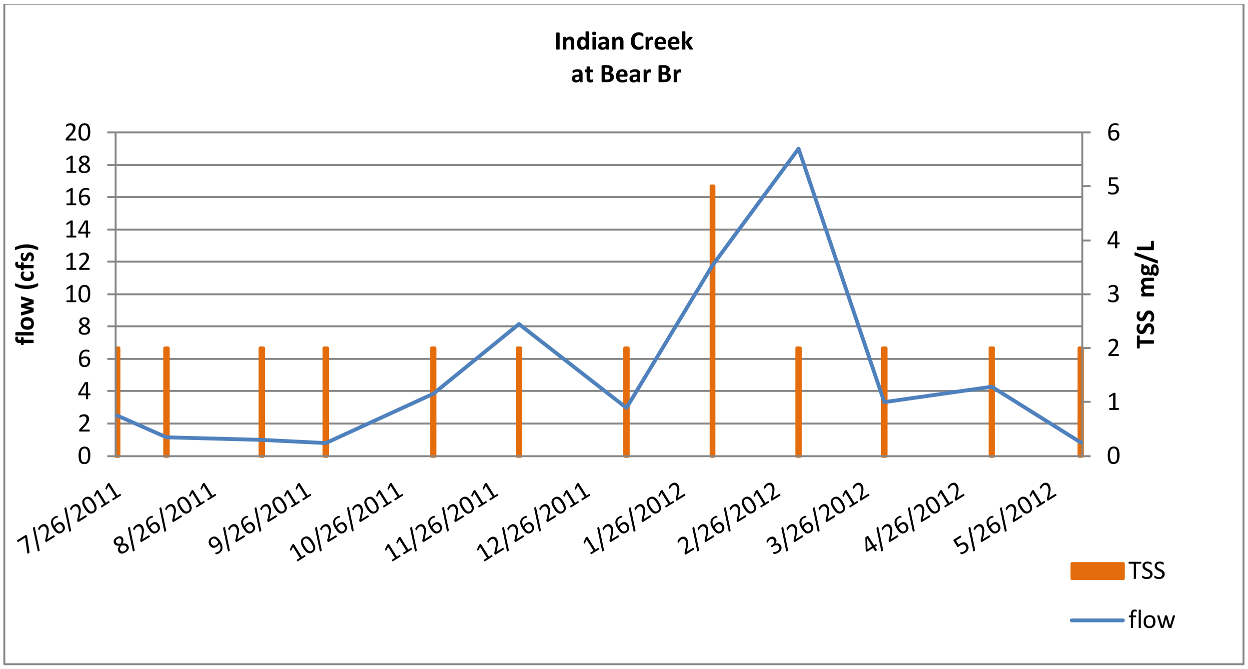


Figure 4.59: TSS and flow at Indian Creek at Bear Branch site.

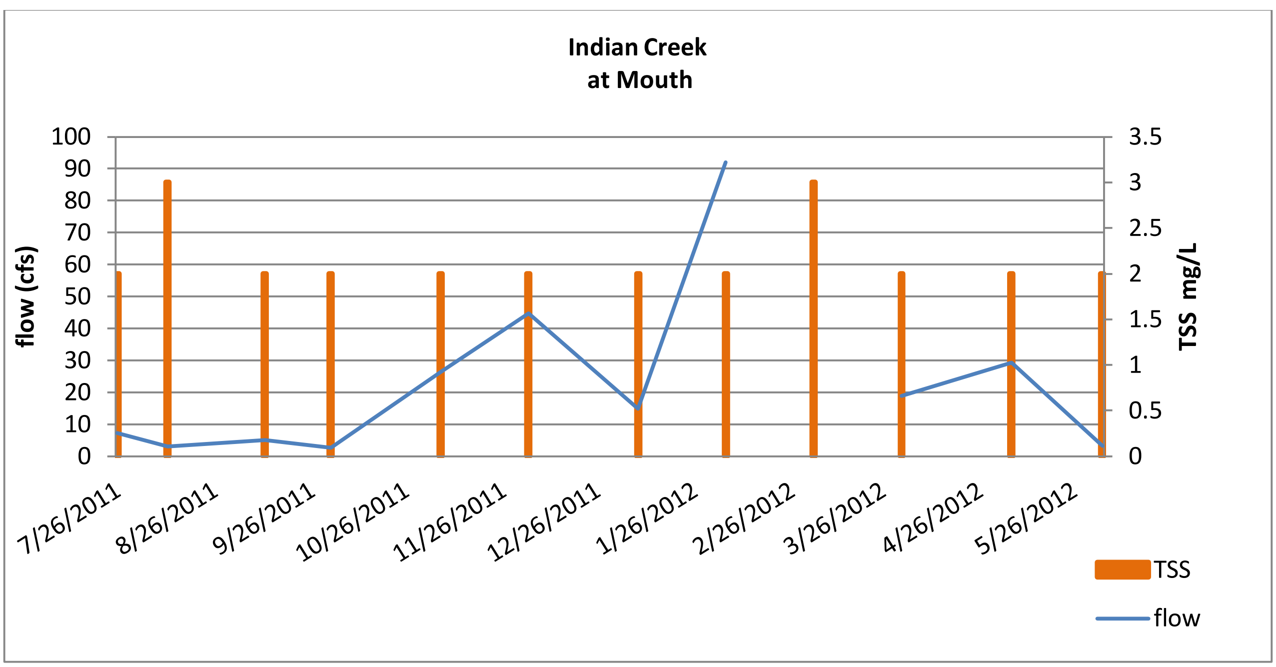
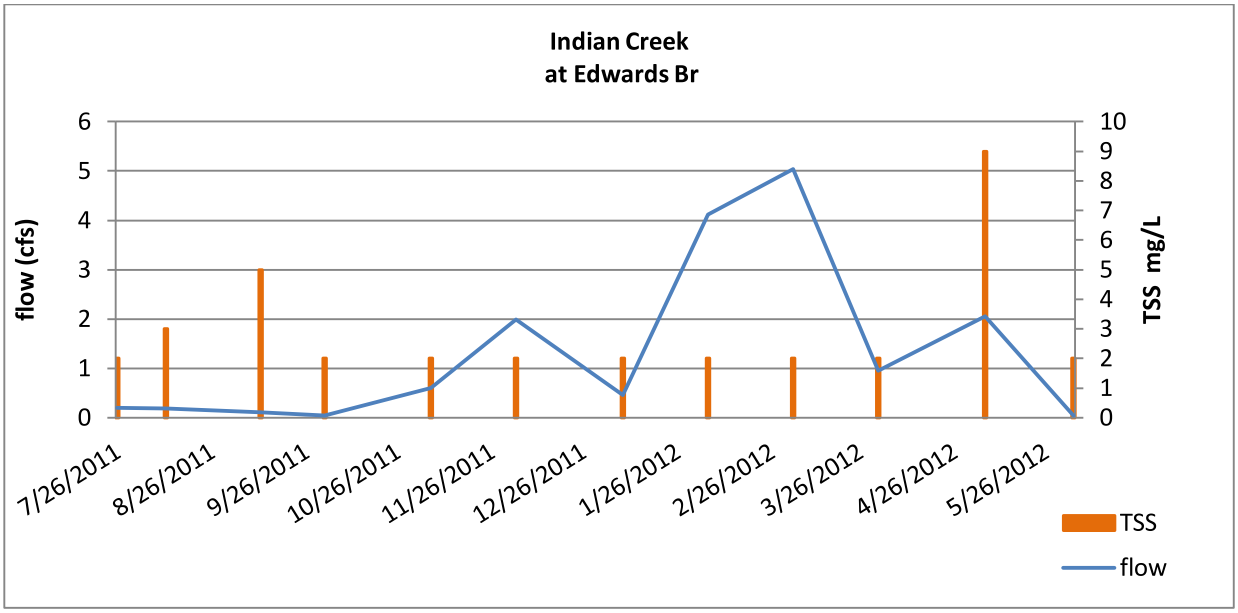


Figure 4.60: TSS and flow at Indian Creek at the Mouth.



Figures 4.61: Total Suspended Solids and flow at Indian Creek at Edwards Branch.

Biological Data

Sites on and tributaries to Indian Creek were fair to good for macroinvertebrates; habitat was not reported (Table 4.16). Indian Creek scored a Fair for macroinvertebrates, and does not meet its designated use of cold water aquatic habitat.

Table 4.16: Indian Creek Sites Biological Scores in Indian Creek.

Site	MBI Rating	Habitat Rating
Little East Fork	Good	Not Reported
East Fork Indian Creek	Good	Not Reported
Indian Creek	Fair	Not Reported

4.6 Results of Gladie Creek Subwatershed

Water chemistry samples were taken near the mouth of Gladie Creek, and a biology sample was collected on Gladie Creek near Laurel Fork (Figure 4.62).

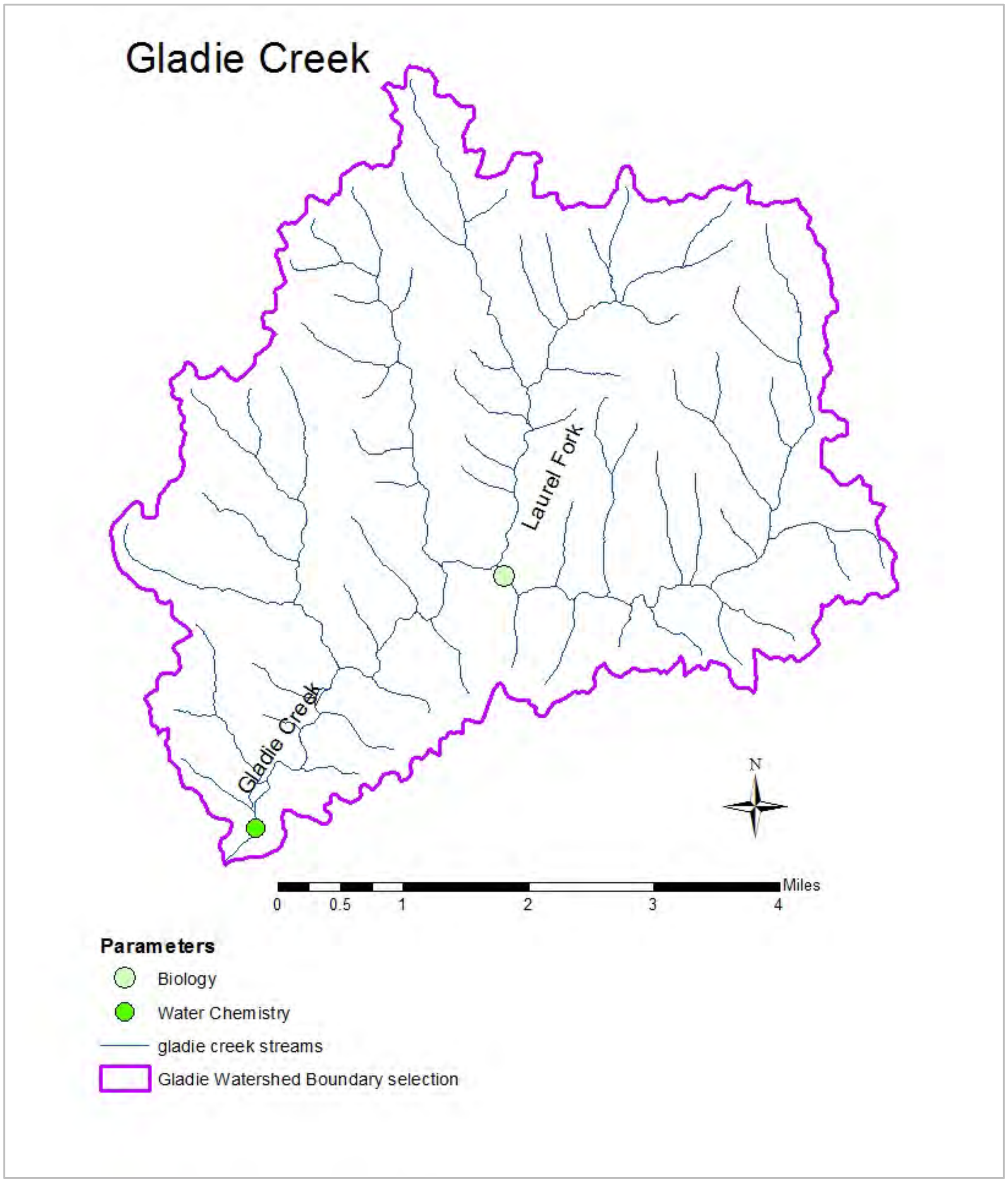


Figure 4.62: Gladie Creek Sampling Locations.

Bacteria

There were no bacteria data collected for Gladie Creek.

Conductivity
Conductivity concentrations were all below the benchmark of 218 uS/cm (Figure 4.63).

pH
All pH results were within the water quality standard range of 6.0 – 9.0 pH units (Figure 4.64).

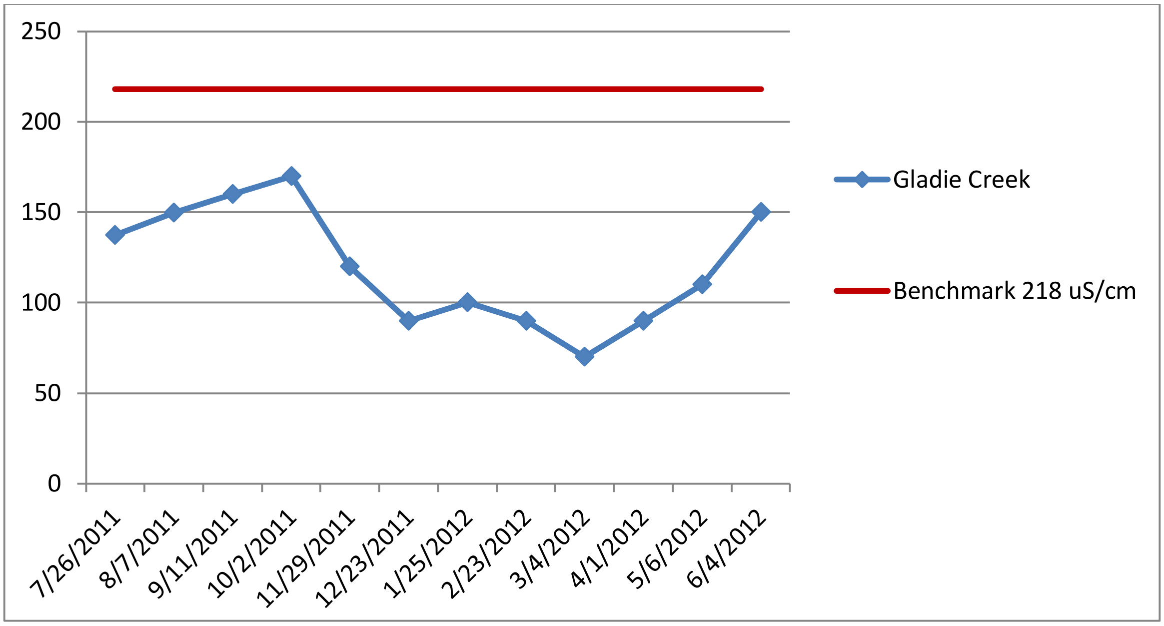


Figure 4.63: Conductivity Concentrations in Gladie Creek.

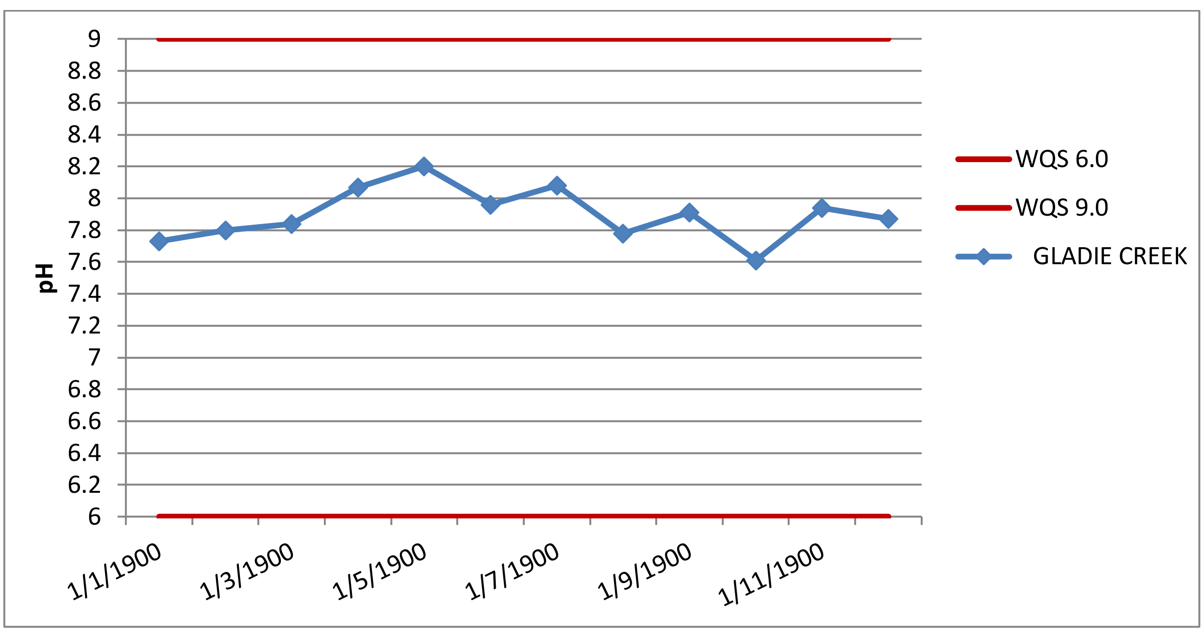


Figure 4.64: pH Concentrations in Gladie Creek.

Temperature

All temperatures were below the water quality standard maximum value of 31.7 °C (Figure 4.65) set for sustaining aquatic life.

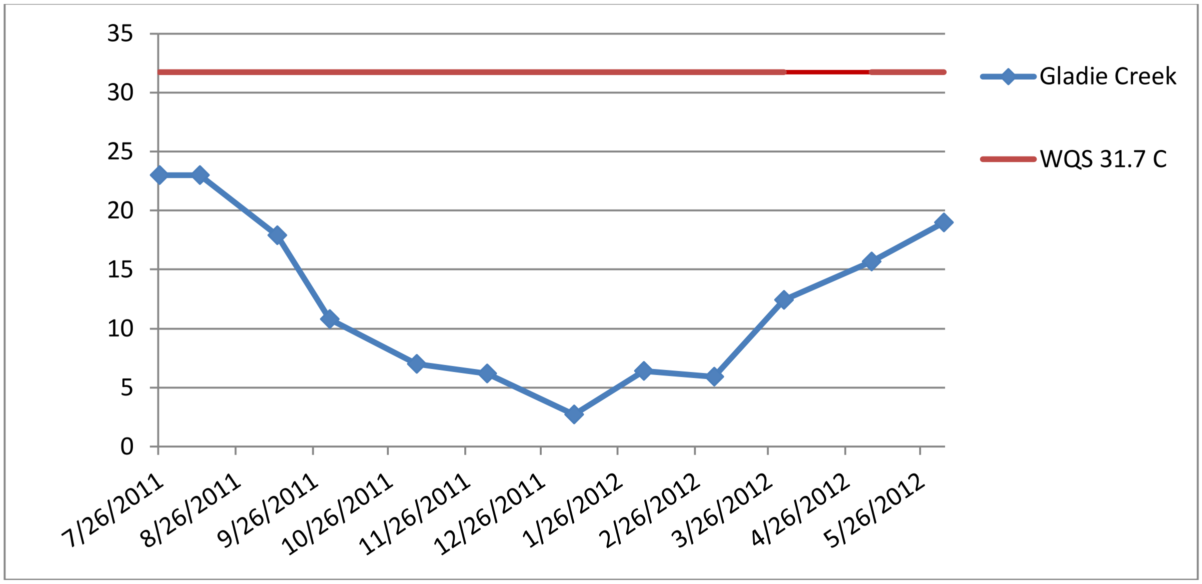


Figure 4.65: Temperature Data at Gladie Creek.

Dissolved Oxygen

All DO concentrations were above the instantaneous minimum of 4.0 mg/L (Figure 4.66).

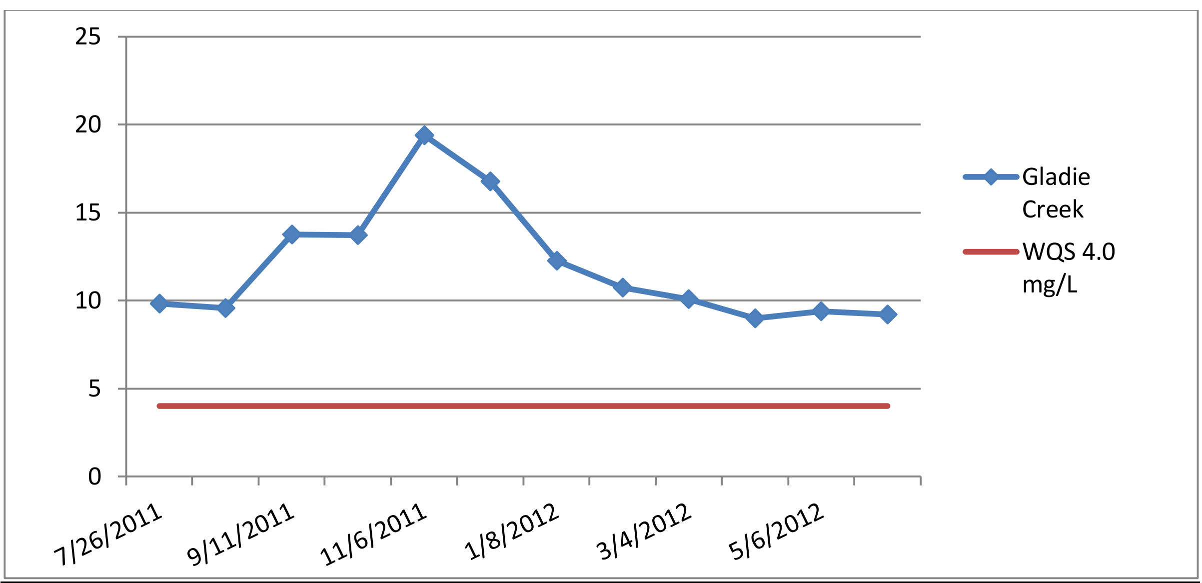


Figure 4.66: Dissolved Oxygen Concentrations at Gladie Creek.

TSS

The TSS benchmark of 6.0 mg/L was exceeded twice on Gladie Creek - in February and May 2012, although only the May result is considered in the discussion (Figure 4.67). If TSS concentrations are consistently high in May during critical periods in the life cycle of macroinvertebrates, it could affect aquatic habitat and populations and therefore affect whether Gladie Creek maintains its designated use of cold water aquatic habitat. However, a load reduction is not indicated from the calculations.

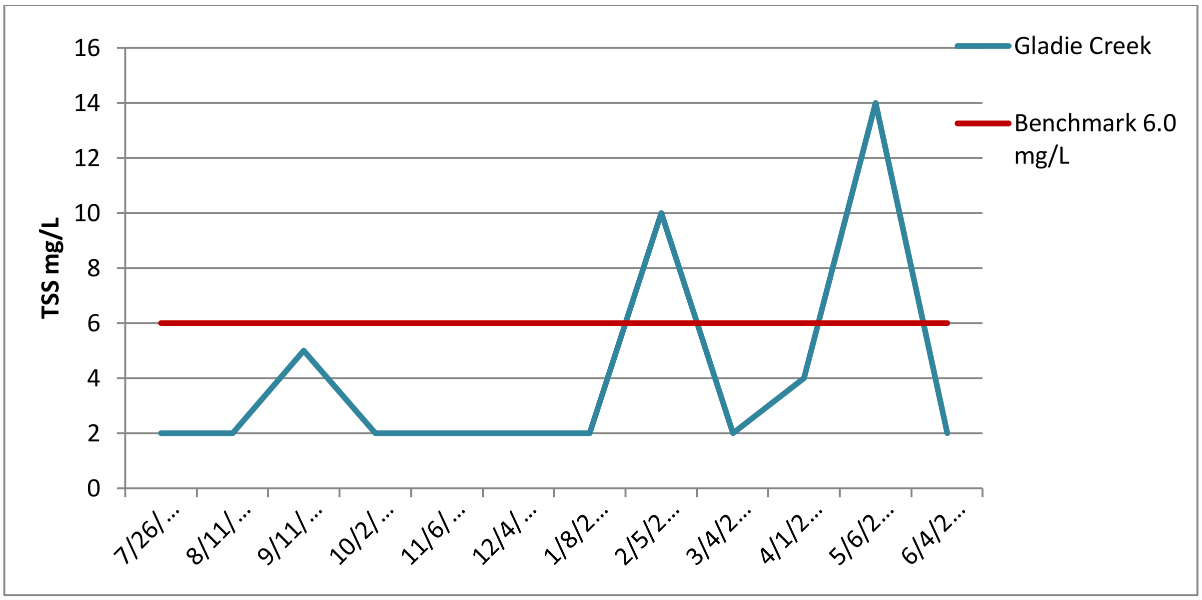


Figure 4.67: TSS Concentrations at Gladie Creek.

Flow

Gladie Creek did not exhibit a pattern of high TSS concentrations during low flow (Figure 4.68).

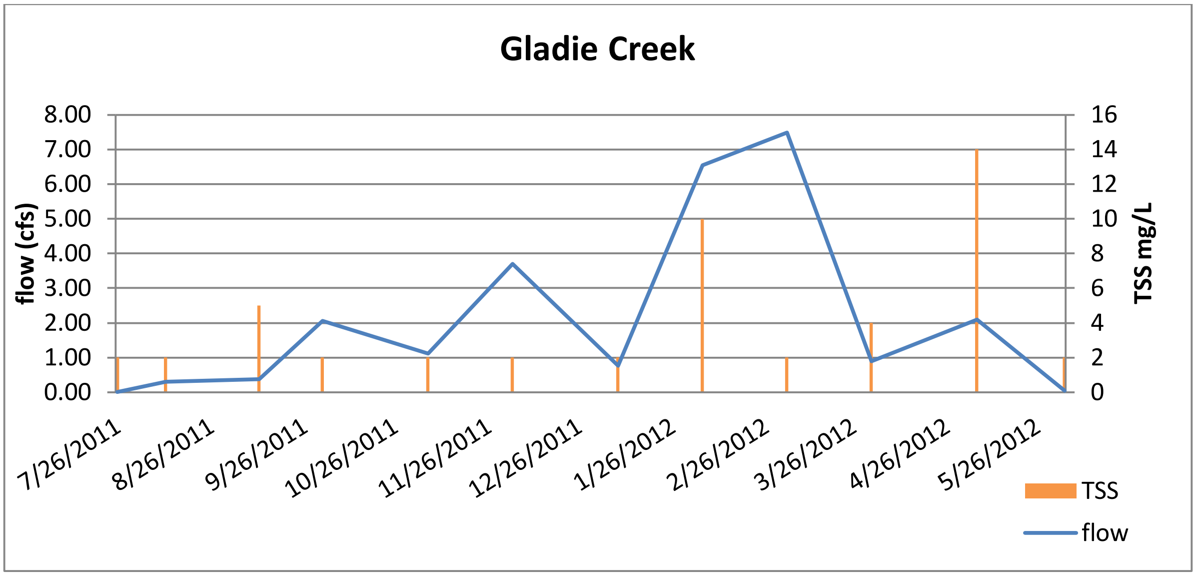


Figure 4.68: TSS and Flow in Gladie Creek.

Nutrients

<u>Nitrogen</u>

The TN benchmark of 0.6 mg/L was not exceeded at any time for Gladie Creek (Figure 4.69).

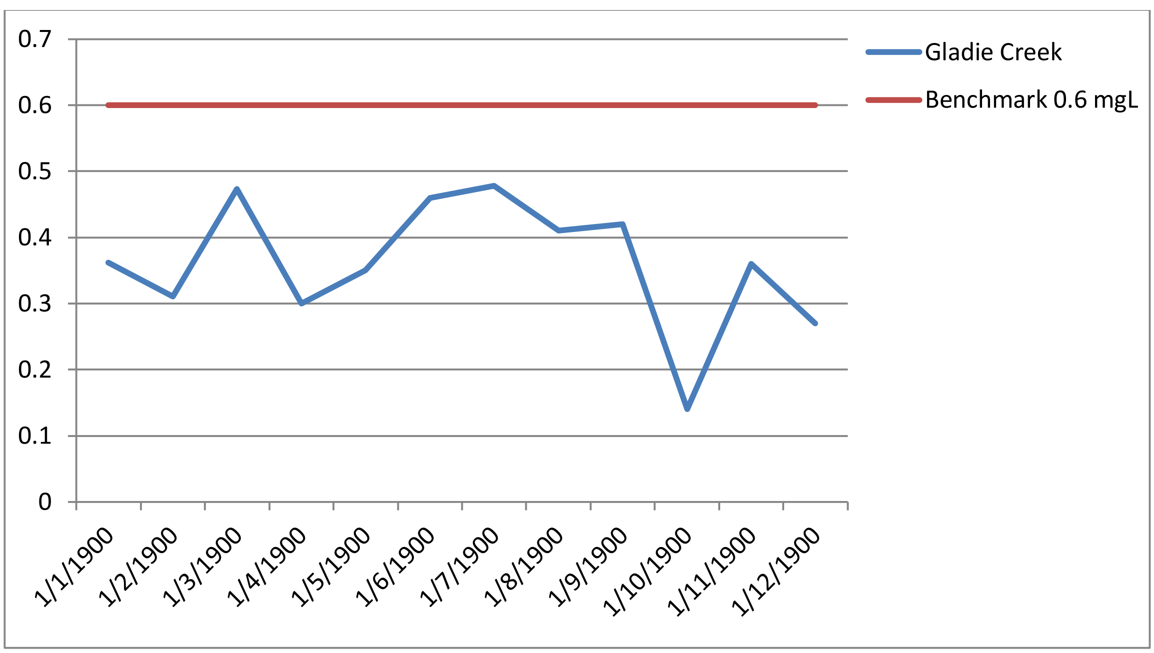


Figure 4.69: Total Nitrogen Concentration at Gladie Creek.

Phosphorus

The benchmark for total phosphorus was set at 0.02 mg/L. However, the lab set 0.033 mg/L as their reporting limit. Therefore, total phosphorus is discussed in relation to the reporting limit. The total phosphorus reporting limit was exceeded at Gladie Creek three times, and the remaining days were below the reporting limit (Figure 4.70). This indicates that there is an environmental or more likely human-caused source for higher phosphorus, and this site could benefit from site-specific BMPs targeting nutrients/phosphorus. The average total phosphorus exceeded the reporting limit three times (Table 4.16a), and a 66% load reduction is necessary at Gladie Creek (Table 4.17). Actual reduction requirements may be less, since samples were analyzed at a reporting limit greater than the benchmark.

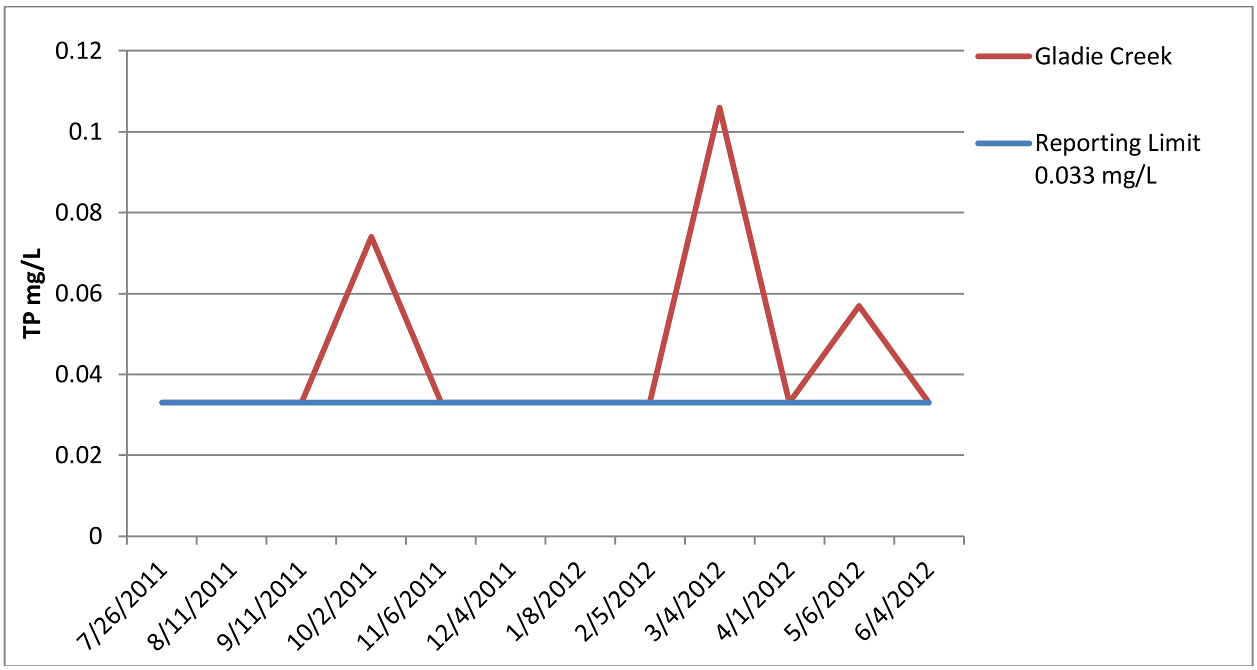


Figure 4.70: Total Phosphorus Concentration at Gladie Creek.

Table 4.16a: Phosphorus Concentration Results in Gladie Creek.

Monitoring Site	Total Phosphorus Range	Number of monthly samples exceeding reporting limit (0.033 mg/L)	Average Total Phosphorus
Gladie Creek Downstream	<0.033 – 0.106	3	0.045

Table 4.17: Phosphorus Load Reductions in Gladie Creek.

Monitoring Site	Average Phosphorus Loads (lbs/year)	Target Phosphorus Load (lbs/year)	Needed Reduction
Gladie Creek - Downstream	2,953	997	66 %

Flow

Concentration of TP did not indicate a pattern based on low or high flows (Figure 4.71).

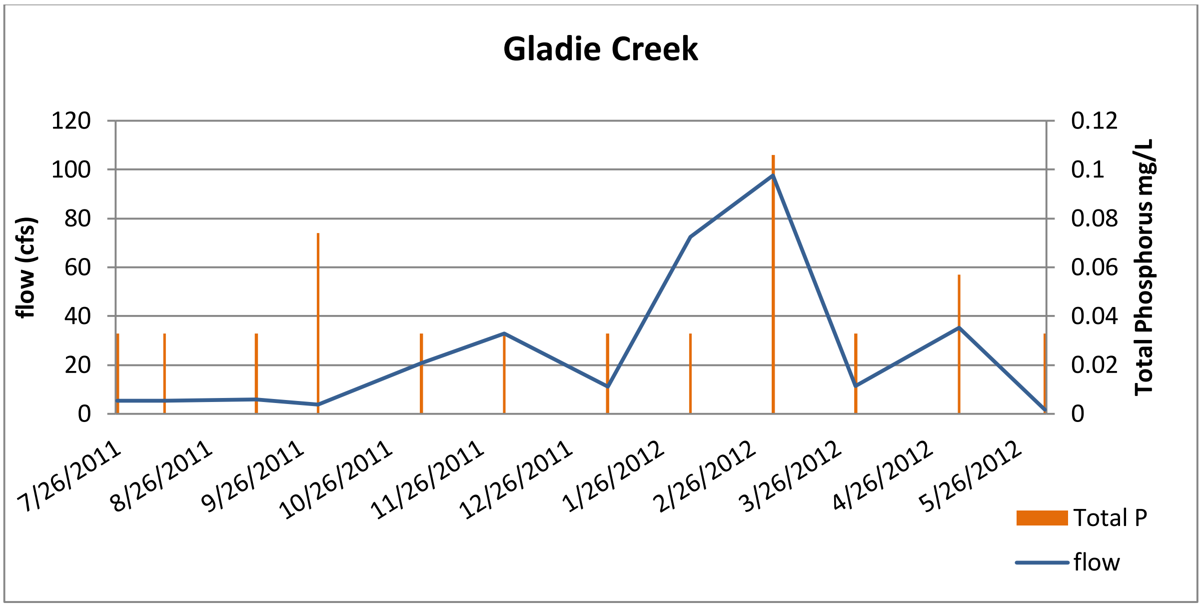


Figure 4.71: Total Phosphorus and Flow at Gladie Creek.

Biology

The macroinvertebrate score for Gladie Creek was rated “Good” which means the stream meets its designated use for coldwater aquatic habitat (when last sampled in 2011). This condition should be maintained and preserved, through re-sampling prior to and after any project implementation in the area should be conducted to determine if the use is still being met.

4.6 Results of Clifty Creek Subwatershed
There was one site sampled for biology at the mouth of Clifty Creek (Figure 4.72).

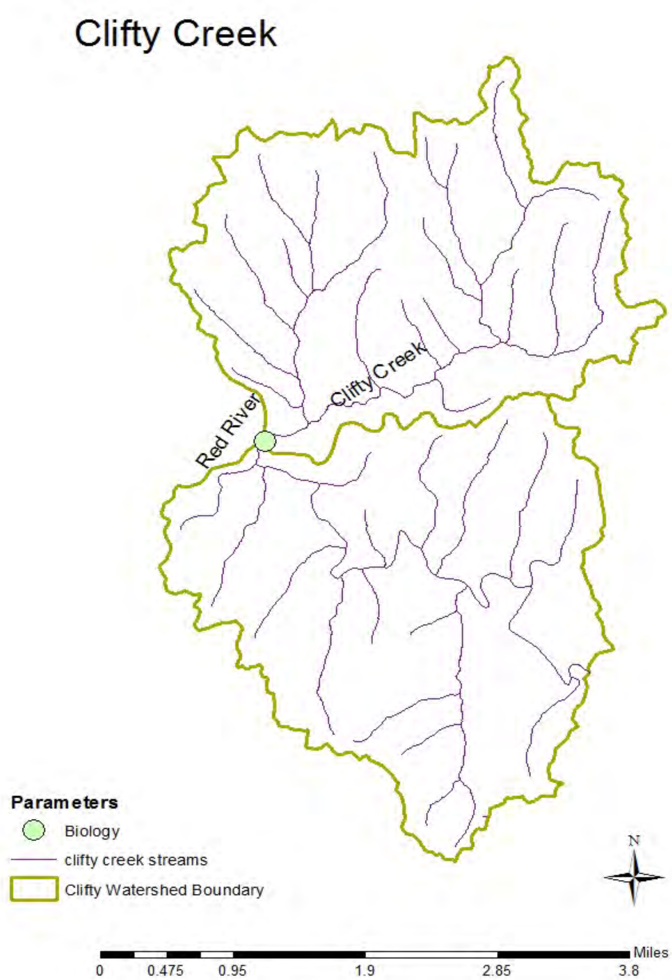


Figure 4.72: Clifty Creek Sampling Location

Bacteria and Water Chemistry
There were no bacteria or water chemistry data collected in the Clifty Creek Watershed.

Biology
There was a biological sample taken on Clifty Creek near the mouth of the Red River in 2011. The score was Fair, indicating the designated use is not being met. Additional monitoring should be conducted for biology and water chemistry to determine current conditions.

4.7 Discussion on Swift Camp Creek, Indian Creek, and Gladie Creek

Comparison of conductivity concentration data

Conductivity averages showed Edwards Branch of Indian Creek and Gladie Creek did not exceed the benchmark of 218 µS/cm; all other site averages exceeded the benchmark (Table 4.18). All site exceedances were in the summer and fall months (exception at Indian Creek at Bear Branch where the benchmark was exceeded during all sampling months) (Figure 4.73). During lower flows, conductivity was highest, indicating that reducing the cause or source(s) of increased conductivity from June through November may reduce the overall conductivity concentrations. However, low flow is not likely to be the only cause of higher conductivities.

Table 4.18: Conductivity Averages

Monitoring Site	Conductivity range (µS/cm)	Number of monthly samples exceeding State benchmark (218 µS/cm)	Average Conductivity (µS/cm)
Swift Camp Creek Unnamed Tributary	130 - 375	5	235
Swift Camp Creek Below Hirams	150 - 419	7	273
Swift Camp Creek Off KY 15	110 - 427	6	231
Swift Camp Creek Campton WWTP	140 - 490	7	280
Gladie Creek Hwy 746	70 - 170	0	120
Indian Creek Bear Branch	250 - 530	12	343
Indian Creek Mouth	140 - 270	6	207
Indian Creek Edwards Branch	100 - 220	1	154

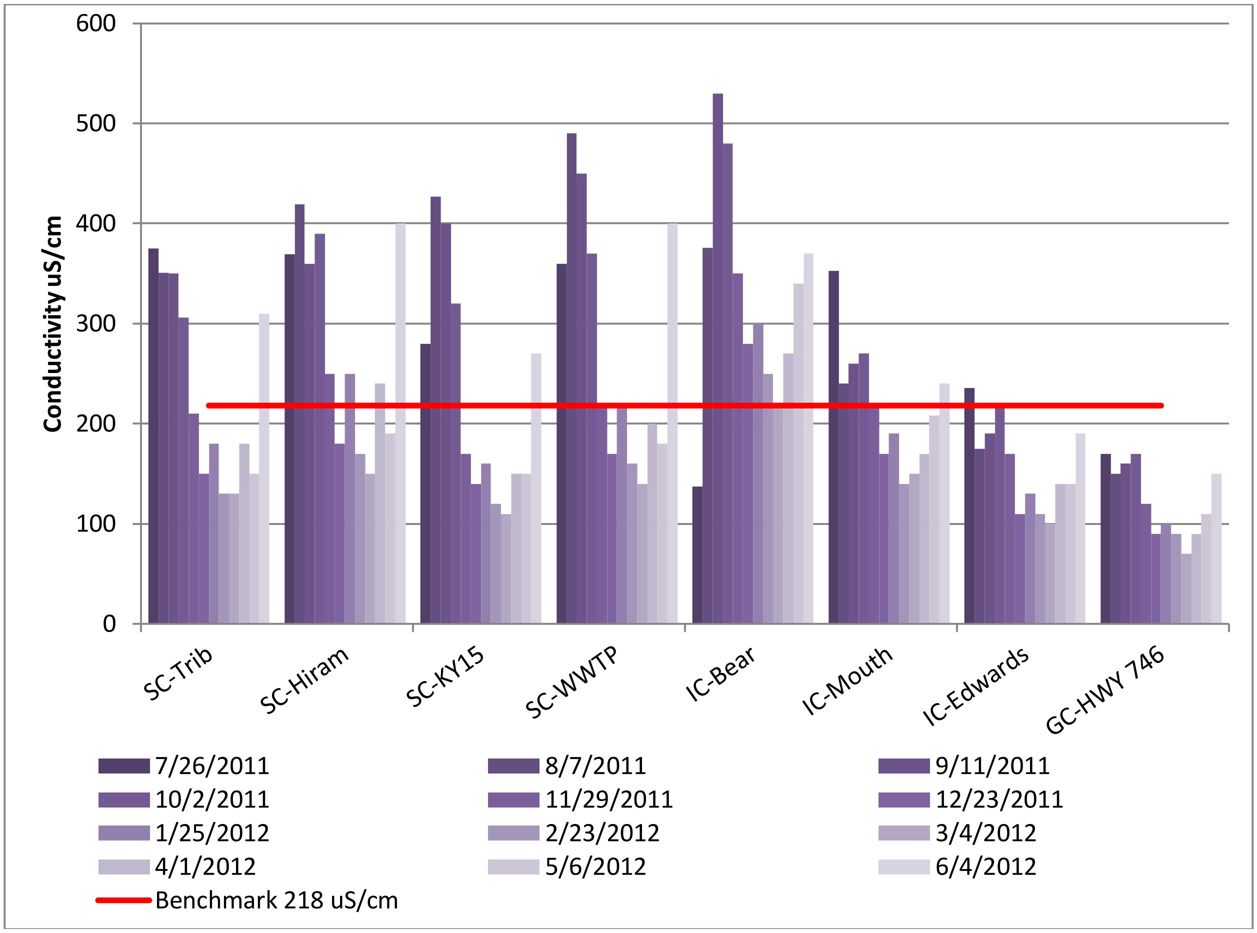


Figure 4.73: Conductivity Concentrations Comparison.

The headwaters of Swift Camp Creek near the town of Campton had some of the highest conductivity levels and exceeded the benchmark approximately half of the year, primarily during the warmer months. The higher conductivity levels are probably a result of urbanization, infrastructure issues, failing septic systems, and chemicals from runoff.

The other subwatershed that is a concern is Indian Creek. The highest conductivity levels were in the headwaters at Bear Branch, although Indian Creek at the mouth also exceeded the benchmark during the summer months. Impacts decreased downstream with dilution but still remained a concern. The higher than expected conductivities may be a result of limestone geology. The highest concentration of sinkholes, caves, and other limestone features can be found in this subwatershed. In addition, the upstream limestone quarry may be contributing to the elevated conductivity levels.

Gladie Creek data did not show conductivity exceedances during the sampling period.

Comparison of Total Phosphorus concentration data

There were no distinct patterns in TP concentration data across the sites, across the seasons. Swift Camp at Hirams Branch had the most exceedances of the total phosphorus reporting limit. Remaining sites showed exceedances in the early part of the year during winter and early spring (Figure 4.74).

The highest phosphorus concentrations can be found in the headwaters of Swift Camp Creek. As a result, the greatest load reductions are needed at these sites. Phosphorus loads in Indian Creek may need to be reduced. Higher phosphorus loads are probably a result of urbanization, failing sewage collection lines, septic systems, and pasture run-off adjacent to streams.

Gladie Creek also exceeded TP benchmarks three times, although not in consecutive months.

Table 4.19: Total Phosphorus Averages.

Monitoring Site	Total Phosphorus range (mg/L)	Number of monthly samples exceeding reporting limit (0.033 mg/L)	Average Total Phosphorus (mg/L)
Swift Camp Creek Unnamed Tributary	<0.033 – 0.156	4	0.062
Swift Camp Creek Hirams Branch	<0.033 – 0.241	9	0.080
Swift Camp Creek Off KY 15	<0.033 – 0.172	5	0.040
Swift Camp Creek Campton WWTP	<0.033 – 0.133	4	0.048
Gladie Creek Hwy 746	<0.033 – 0.106	3	0.045
Indian Creek Bear Branch	<0.033 – 0.098	4	0.041
Indian Creek Mouth	<0.033 – 0.082	5	0.051
Indian Creek Edwards Branch	<0.033 – 0.092	4	0.049

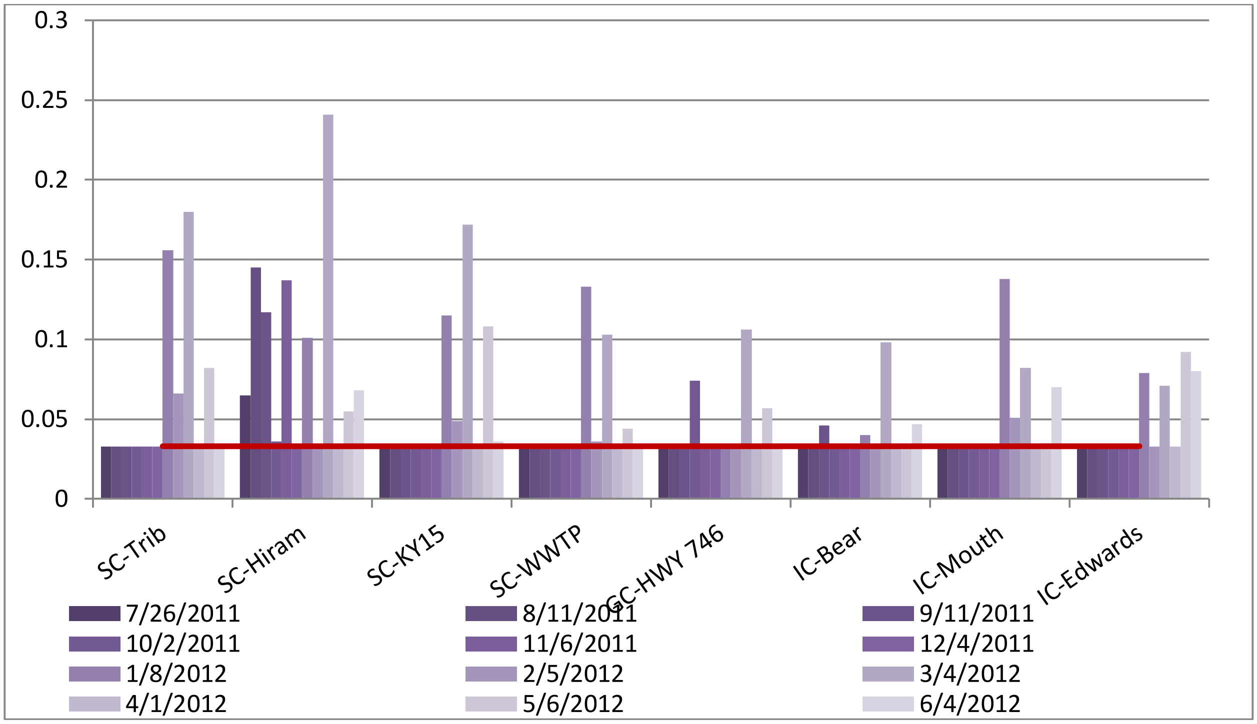


Figure 4.74: Total Phosphorus Concentration Comparisons.

Comparison of Total Nitrogen Concentration Data

Swift Camp at Hirams Branch had summer and January exceedances for total nitrogen – above 0.6 mg/L, and Indian Creek at Bear Branch had a similar pattern. Other sites were mainly below the benchmark throughout the sampling year.

For this watershed plan, nitrate – nitrite as N and total nitrogen were evaluated. At all the sites except Swift Camp Creek below Hirams Branch, the average total nitrogen levels were below the 0.6 mg/L benchmark, and there were no load reductions needed. The nitrate – nitrite portion of total nitrogen is the inorganic component that is available for plant uptake. Since it is available for plant uptake, it may increase the risk of algae blooms. It may also be an indicator of human or animal waste. This is particularly true in the headwaters of Swift Camp Creek where urbanization and failing infrastructure are most likely causing this increase.

The headwater sample from Indian Creek also has elevated total nitrogen levels, although it appears to be less of an occurrence downstream (Figure 4.75). The source may be the development near the stream above the Indian Creek/Bear Branch site. There are small pastures, homes, businesses, and septic systems in this valley.

Table 4.20: Total Nitrogen Averages.

Monitoring Site	Total Nitrogen Range (mg/L)	Number of monthly Total Nitrogen samples exceeding benchmark (0.6 mg/L)	Average Total Nitrogen (mg/L)
Swift Camp Creek Unnamed Tributary	0.28 – 0.69	5	0.541
Swift Camp Creek Hirams	0.26 – 1.504	6	0.759
Swift Camp Creek Off KY 15	0.017 – 0.346	0	0.291
Swift Camp Creek Campton WWTP	0.21 – 0.46	0	0.380
Gladie Creek	0.14 – 0.478	0	0.361
Indian Creek Bear Branch	0.34 – 1.283	6	0.601
Indian Creek Mouth	0.14 – 0.424	0	0.313
Indian Creek Edwards Branch	0.14 – 0.47	0	0.326

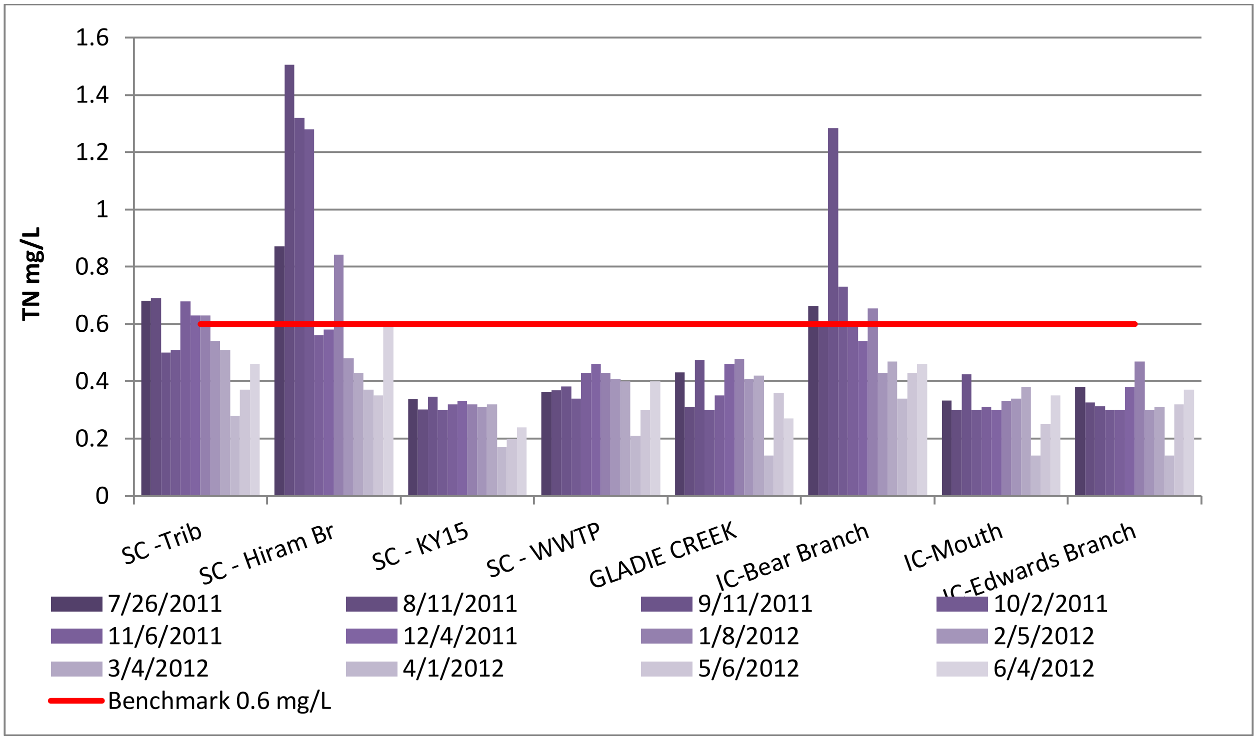


Figure 4.75: Total Nitrogen Concentration Comparison.

Comparison of TSS Data

Sites on Swift Camp Creek and its tributary had higher TSS values than sites on Indian Creek. The month of April showed values exceeding the 6.0 mg/L benchmark for TSS on Swift Camp and Edwards Branch (Figure 4.76). The Campton Wastewater Treament plant may be a cause of TSS exceedances in the Swift Camp Creek subwatershed. The facility was fined in 2009 and was out of compliance with their permit for settleable solids in 2011, which has continued into 2013.

It appears that TSS and turbidity increase and decrease proportionally. In addition, both TSS and turbidity are difficult to evaluate since they are often very flow dependent. Sediment moves more readily and in greater mass and volume in streams during high flow events, and the sampling protocol for this project did not include storm sampling. With that said, the highest TSS level was found in the Unnamed Tributary to Swift Camp Creek. This site has the greatest amount of urbanization in the project area, and stream banks are eroding in many locations. There are other sites in Swift Camp Creek where TSS and turbidity are elevated, but a load reduction is only necessary in the Unnamed Tributary. Even though erosion is occurring in the other subwatersheds in this project area, it does not appear (based on non-storm sampling) that it has reached critical levels.

Table 4.21: TSS Averages.

Monitoring Site	Total Suspended Solids range mg/L	Number of monthly samples exceeding 6.0 mg/L	Average Total Suspended Solids (mg/L)
Swift Camp Creek Unnamed Tributary	2 - 33	2	11.43
Swift Camp Creek Hirams	<2 - 7	1	2.14
Swift Camp Creek Off KY 15	<2 - 12	2	5.14
Swift Camp Creek Campton WWTP	2 -15	3	6.00
Gladie Creek HWY 746	2 – 14	1	4.43
Indian Creek Bear Branch	2 - 2	0	2.00
Indian Creek Mouth	2 - 3	0	2.14
Indian Creek Edwards Branch	2 - 9	1	3.57

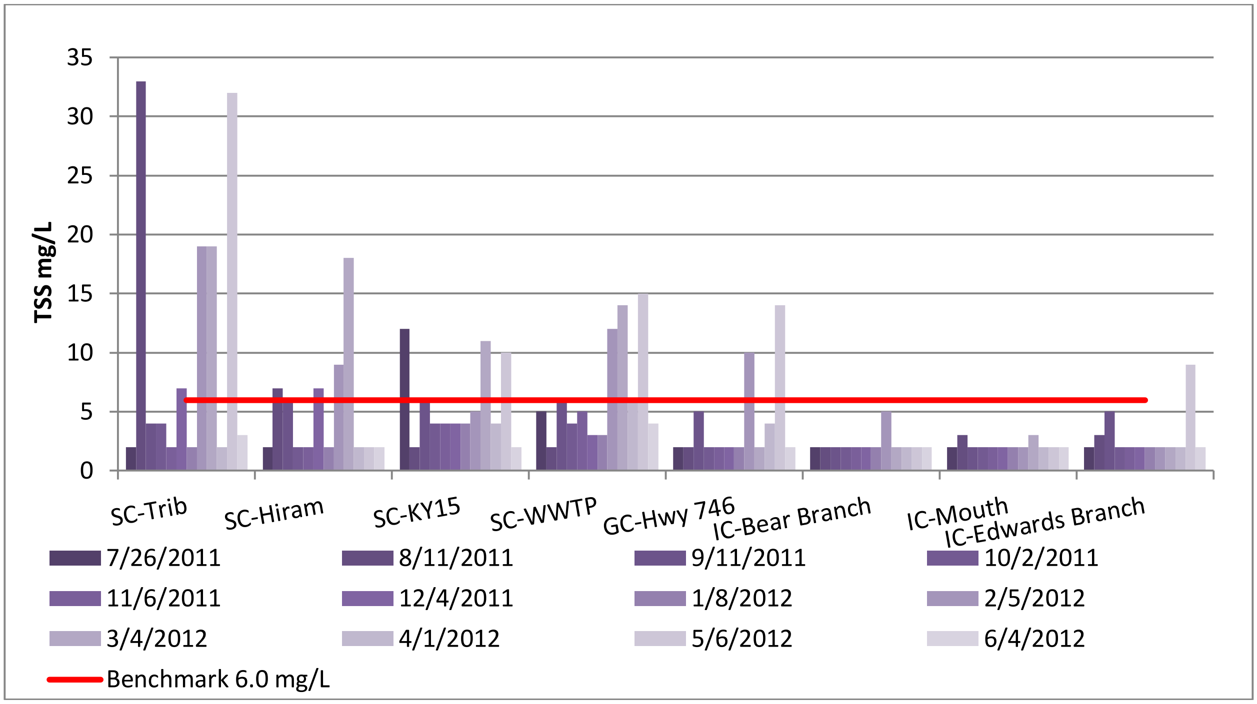


Figure 4.76: TSS Concentration Comparison.

Bacteria Discussion

No more than 20 percent of the *E. coli* samples can exceed 240 cfu/100 mL in a given sampling event. Swift Camp Creek sites exceeded the 240 cfu/100 mL at all sites during all sampling periods with the exception of Swift Camp Creek at KY 15 for the Sept. and Oct. 2011 sampling events. Indian Creek's three sites did not exceed the water quality standard. The average *E. coli* at the Swift Camp sites ranged from 90 cfu to 5,520 cfu (Table 4.22). The highest concentrations were found in the Unnamed Tributary to Swift Camp Creek near Campton, with the maximum value reaching as high as 5,520 cfu. The sample site below the outfall from the waste water treatment plant also had a relatively high average, but the maximum level was considerably lower - at 2800 cfu - than that in the Unnamed Tributary.

To address the *E. coli* issues, annual loading values were calculated based on average concentration and stream flow. These values showed that in the Swift Camp Creek subwatershed, loads need to be reduced by 60 to 79 percent. This is from both point and non-point sources. The sources most likely include failing infrastructure (sewer lines), septic systems, and discharge from the waste water treatment plant. There were no *E. coli* load reductions necessary in the remainder of the project area.

In July 2012, the local watershed group walked several of the streams near Campton. Many possible causes of elevated *E. coli* were observed. It appeared that the sanitary sewer collection lines were old and some locations were corroding near stream channels. There was indication of sewer lines being overwhelmed by storm runoff and, in some cases, land management practices could be contributing to the *E. coli* and nutrient problems. There is a need to extend sewer lines to homes near the Unnamed Tributary to Swift Camp Creek where septic problems have been reported. Unfortunately, limited funding may be an issue with the extension (personal communications with the Campton Mayor).

There are water quality issues with wastewater treatment facilities in the watershed. The Campton Wastewater Treatment Plant has had numerous violations through the years, and it has exceeded permit limitations for several parameters including *E. coli* during the monitoring period for this project. The USFS Frenchburg Job Corp Center on Edwards Branch of Indian Creek also has had permit violations for their sewage package plant over the last three years. However, based on the *E. coli* concentration levels, it appears that any problems are diluted in the downstream reaches of the stream.

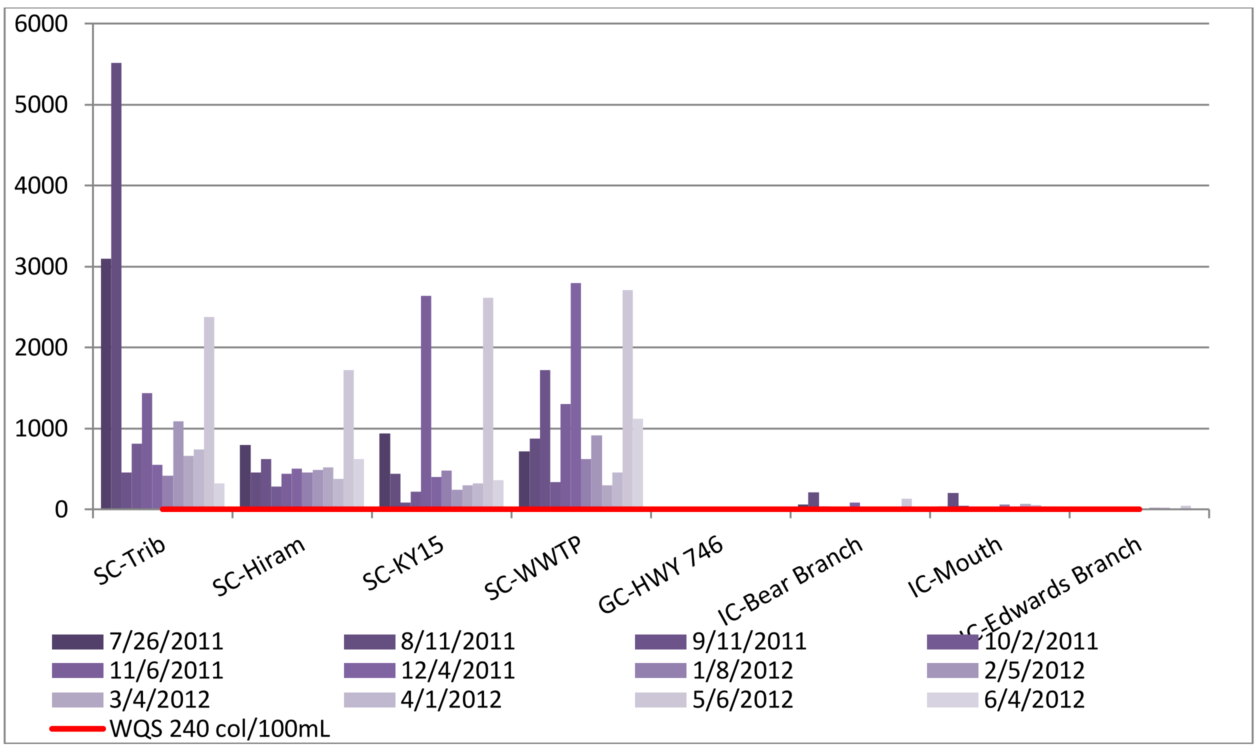


Figure 4.77: *E. coli* Concentration Comparison.

Table 4.22: E. coli Data Averages.

Monitoring Site	*E. coli* range (240 col/100 mL)	Number of monthly samples exceeding State standard (240 col/100 mL)	Average *E. coli* (240 col/100 mL)
Swift Camp Creek Unnamed Tributary	420 – 5,520	12	1,458
Swift Camp Creek Hirams	284 – 1,720	12	609
Swift Camp Creek Off KY 15	90 – 2,640	10	754
Swift Camp Creek WWTP	300 – 2,800	12	1,158
Gladie Creek HWY 746	no data	no data	no data
Indian Creek Bear Branch	6 – 216	0	54
Indian Creek Mouth	4 – 204	0	48
Indian Creek Edwards Branch	0 – 50	0	12

Biological Discussion
The Macroinvertebrate Biological Integrity (MBI) ratings are significantly lower in Swift Camp Creek than in the other sites in the project area (Table 4.23). The lower ratings in Swift Camp Creek are the result of a combination of lower numbers of insects present, less diversity (fewer types of insects), and more pollution-tolerant species. These results seem to mirror the water quality findings.

Of the sites in the other subwatersheds, the main stem of Indian Creek had the lowest MBI scores. The ratings in Indian Creek are in the upper end of the “Fair” category

The MBI scores for the Swift Camp and Indian Creek Watersheds could indicate that the stream segments should be assessed as not meeting their designated uses for aquatic life support.

Gladie Creek received a Good score for macroinvertebrates, which indicates that when the site was sampled, the designated use was being met.

Clifty Creek had a rating of Fair, indicating a failure to meet the designated use.

Table 4.23: MBI Ratings.

Stream Name	Site ID	MBI Score	Rating
Swift Camp Creek Unnamed Tributary	DOW04043010	24.3	Poor
Swift Camp Creek Below Hirams	DOW04043013	51.5	Fair
Swift Camp Creek Off KY 15	DOW04043014	39.0	Poor
Swift Camp Creek Campton WWTP	DOW04043018	23.3	Very Poor
Indian Creek Bear Branch	DOW04042017	68.7	Fair
Indian Creek Mouth	DBF04015	69.8	Fair
Indian Creek Edwards Branch	DBF04042022	85.2	Good
Clifty Creek	DBF04042023	73.8	Fair
Gladie Creek	DBF04042025	77.0	Good
Little East Fork	DBF04042021	81.5	Good
East Fork Indian Creek	DBF0404024	76.5	Good

4.8 Prioritization of Subwatersheds

The following sections summarize the issues and threats within the subwatershed areas, identify feasibility factors for implementing in those areas, and provide an overview of the priority implementation measures. This information will be built upon with more detailed implementation strategies in the following chapters.

Swift Camp Creek – 21.4 Square Miles

As discussed in the previous sections of this chapter, the Swift Camp Creek is the most impacted of the four subwatersheds. In many cases, the four sites within the subwatershed have the highest number of samples exceeding the standard or benchmark for *E.coli*, conductivity, TN, TP and TSS. The fair to very poor MBI and habitat scores for the sites indicate that the segments currently listed as not supporting Aquatic Life are still impaired. Swift Camp Creek needs load reductions for *E. coli*, TP and TSS. Figure 4.78 displays pollutant load reductions needed for each calculated parameter.

As shown in the aerial imagery of Figure 4.78, most of the developed land is along the mainstem and tributaries in the southern portion of the watershed and the Bert T. Combs Mountain Parkway. The sewer and waterlines are concentrated in this area as well, indicating that most residential and commercial development is located in these areas. Based on the areas with public water lines but without sewer lines, it's likely a number of residents are using septic systems or an alternative form of wastewater treatment. The Northwest portion of the subwatershed is part of the DBNF.

There are identified impairments in the subwatershed that need improvement, but protection of the healthy waters is a priority as well. The entire length of Swift Camp Creek is a Special Use Water and designated as Cold Water Aquatic Habitat. This subwatershed also contains Campton Lake, which is the drinking water source for the area. It's important that threats within the Source Water Protection Area are addressed through targeted implementation.

<u>Feasibility Discussion</u>

There is public interest in Swift Camp Creek. Throughout the development of this plan, events and meetings were held with representation from the local residents, local governments, and the U.S. Forest Service with an interest in cleaning up the creek. The watershed team in Campton is an active group who may be interested in future monitoring and/or plan implementation. The city of Campton has provided information on planned sewer extension lines within and expanding outside the city limits, although funding is a possible obstacle. There may be opportunities to work with KDOW to acquire funding.

Options for acquiring funding to address the point source issues are outlined in Appendix E

<u>Summary</u>

All four sites within the subwatershed need load reductions for *E.coli* and TP. The three upper sites (A, B and C) need load reductions for TSS as well. It's possible that the elevated *E.coli* and TP loads are due to failing sewer infrastructure and unmaintained or failing septic systems. The concentrated development along the stream and resulting hydromodification of the stream channels could be contributing to the elevated TP and TSS loads.

Swift Camp Creek should be targeted for prioritization for addressing *E.coli* and TP through the following:

- Identify and eliminate straight pipes by connecting to existing or new sewer lines, or installing alternative wastewater systems.
- Identify and secure funding to address failing sewer infrastructure.
- Work with local Health Department to inspect and offer assistance to homeowners with failing septic systems. This work should be targeted to the areas upstream of sites B and C where sewer doesn't exist.
- Identify and encourage maintenance of septic systems through education.
- Identify and secure funding for agricultural BMPs.

Swift Camp Creek should be targeted for prioritization for addressing TSS, TP and habitat issues through the following:

- Target BMPs to developed sites to improve surface water runoff through infiltration. In areas with failing sewer lines, the lines should be repaired prior to installing BMPs that aid in infiltration. Otherwise the increased infiltration could overload the failing lines and result in additional problems.

- Identify areas for future stream restoration/stabilization and secure funding for the work.
- Improve degraded riparian areas through re-vegetation and educating the public about the benefits of protecting riparian areas.
- Identify and secure funding for agricultural BMPs.
- Educate local decision makers and public about the issues associated with stormwater runoff and associated hydromodification, and the BMPs to address the impacts.

As noted above, protection is a priority in this watershed as well. Protection efforts should be targeted throughout the watershed through the following:

- Educate the public about the importance of the natural areas in the watershed.

- Work with the local decision makers and the drinking water utility to protect the Hiram Branch subwatershed, which is the Source Water Protection Area for Campton Lake.
- Continue efforts within the DBNF area to minimize recreational impacts.

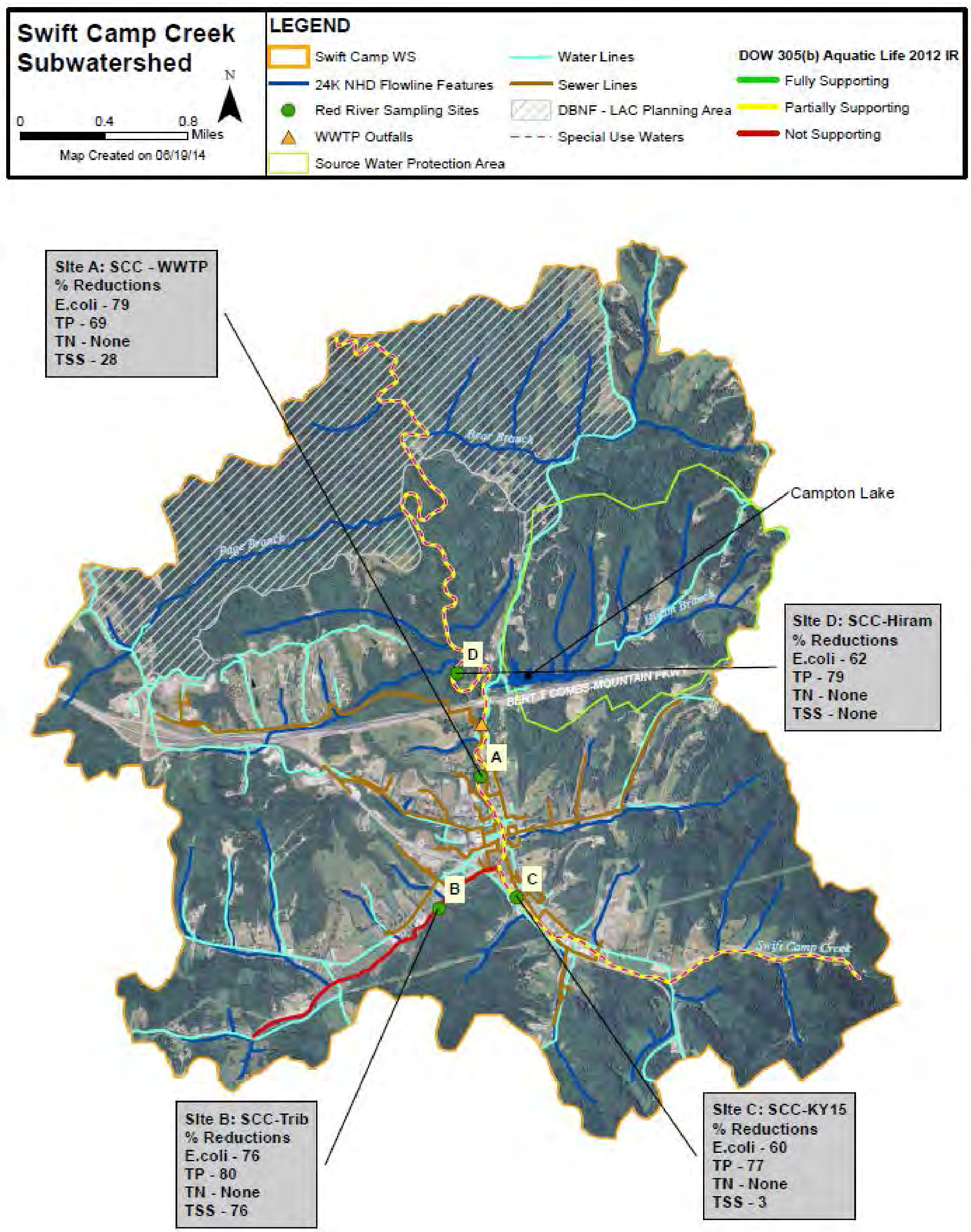


Figure 4.78: Swift Camp Creek Pollutant Load Reductions Needed.

Indian Creek – 57.8 Square Miles

Although there are impacts and some potential threats within Indian Creek, overall the water quality issues are not extensive. Figure 4.79 displays pollutant load reductions needed for each parameter. None of the three sites (E, F and K) require load reductions for *E.coli*, TN or TSS. However, there were elevated TN levels during late summer at the Bear Branch site. Sites G and H were only monitored for biology. They had MBI scores of good. Habitat was not assessed.

All three sites require load reductions for TP. The Indian Creek Quarry is located upstream from the Indian Creek sampling sites and may be a cause of higher phosphorus as well as the elevated conductivity levels at sites E and F. Mining has ceased to occur under the permitting authority of KDOW. However, runoff from storms or other high flow events could be continuing to deliver materials from the site to the streams, causing elevated levels of these parameters. The WWTP outfall upstream of Site K on Edwards Branch may contribute to the higher loads at that site. Although, as noted earlier, the TP load reductions may be an overestimation of the actual load reductions needed.

As shown in Figure 4.79, most of the subwatershed is within the DBNF area, and the majority of the headwater area is heavily forested. There are water lines and small farms in portions of the headwaters. A large section of Indian Creek, East Fork Indian Creek, and the section of the Red River that receives these streams are Special Use Waters (Table 2.4). BMPs focusing on protection of these resources should be a priority in this watershed.

<u>Feasibility Discussion</u>

There is not currently an active watershed team in the Indian Creek area. Additional outreach from the current watershed team in Swift Camp Creek could expand into the Indian Creek Watershed. The Forest Service may also provide outreach at visitor centers to encourage attention in this watershed. A stream restoration in East Fork Indian Creek was started in April 2015 and may increase public interest in this portion of the Watershed Planning area.

Summary

Pollution issues in the Indian Creek subwatershed include elevated TN levels during late summer at the Bear Branch site (E), elevated conductivity levels at Sites E and F, and TP loads that need reductions at all three sites, E, F and K.

As noted above, protection is a priority in this subwatershed as well. Protection efforts should be targeted throughout the subwatershed through the following:

- Educate the public about the importance of the natural areas in the watershed.
- Reach out to the landowners in the headwaters to ensure they are properly maintaining septic systems.
- Work with the local decision makers to protect the areas outside of DBNF.

- Continue efforts within the DBNF area to minimize recreational impacts.

Indian Creek should be targeted for prioritization for addressing TP issues through the following:

- Visual assessments of possible contributors (Quarry) and targeted implementation to address the impacts.
- Identifying and securing funding for agricultural BMPs in the headwaters.

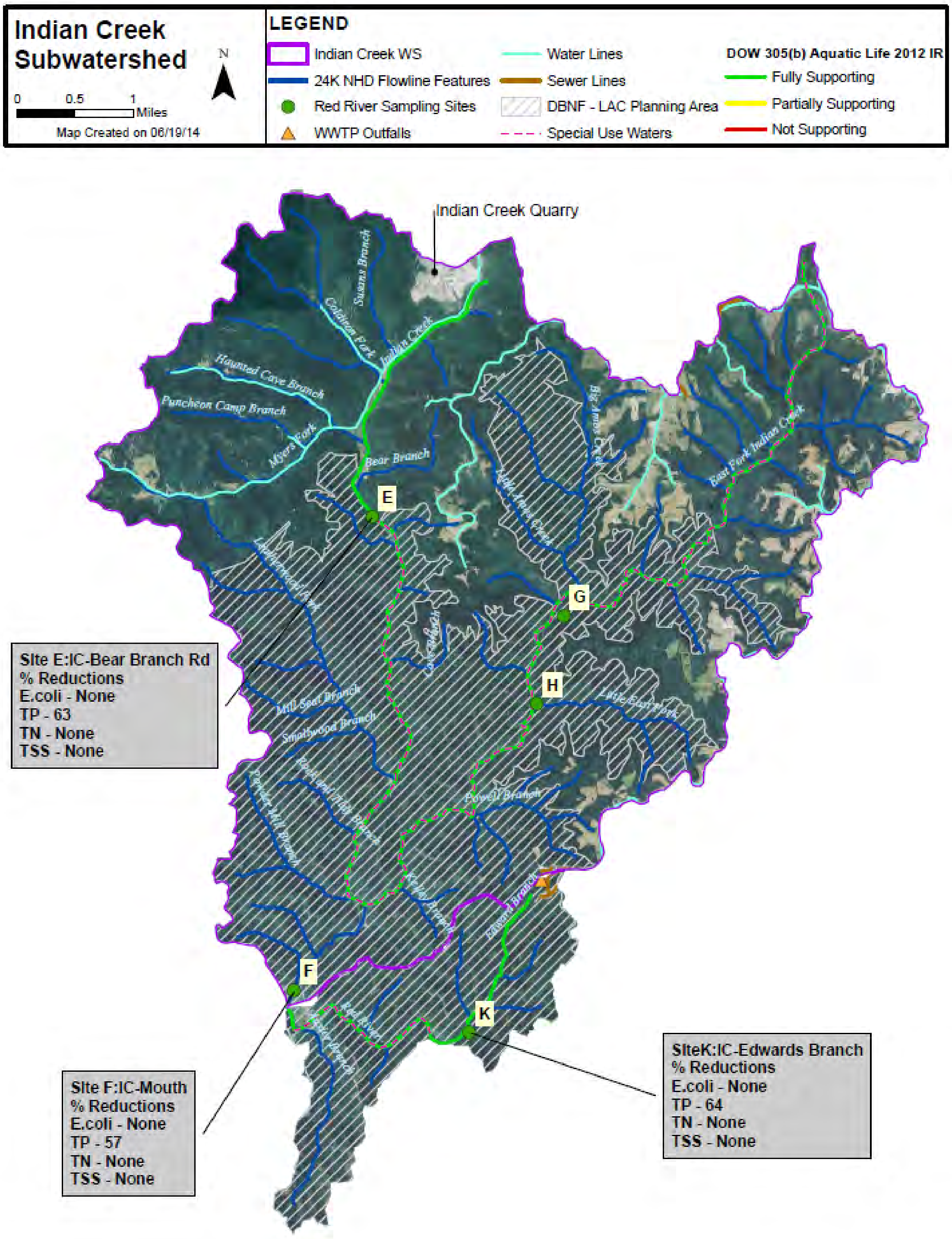


Figure 4.79: Indian Creek Pollutant Load Reductions Needed.

Gladie Creek – 32.6 Square Miles

Load reductions are not required for TN and TSS. *E. coli* was not collected, so load reductions are not known for that parameter. TP was calculated as requiring a load reduction. The Gladie Creek sub-watershed is mostly forested; however areas within the headwaters outside of the Daniel Boone National Forest are less forested and include residential and farming areas.

There are multiple Special Use Water designations in Gladie Creek. All of Gladie Creek is listed as Cold Water Aquatic Habitat, and a segment of it is listed as an Exceptional, Reference Reach, and Outstanding State Resource Water (Figure 4.80). The MBI biological score near Laurel Fork (Site I) was good when sampled in 2011.

<u>Feasibility Discussion</u>

Currently, there is not an active watershed team in the area. As the project moves into implementation, education and outreach efforts may help build local support and interest in this area. USFS will support protection efforts and minimize future threats on the large portion of DBNF land in the subwatershed.

Summary:

Protection is a priority in this watershed, along with further investigation to target BMPs to address the TP issues. Additional monitoring to determine potential *E.coli* impairments would be beneficial as well.

Protection efforts should be targeted throughout the subwatershed through the following:

- Educate the public about the importance of the natural areas in the watershed.
- Reach out to the landowners in the headwaters to ensure they are properly maintaining septic systems.
- Work with the local decision makers to protect the areas outside of DBNF.
- Continue efforts within the DBNF area to minimize recreational impacts.

Indian Creek should be targeted for prioritization for addressing TP issues through:

- Visual assessments of possible contributors.
- Identifying and securing funding for agricultural BMPs in the headwaters.

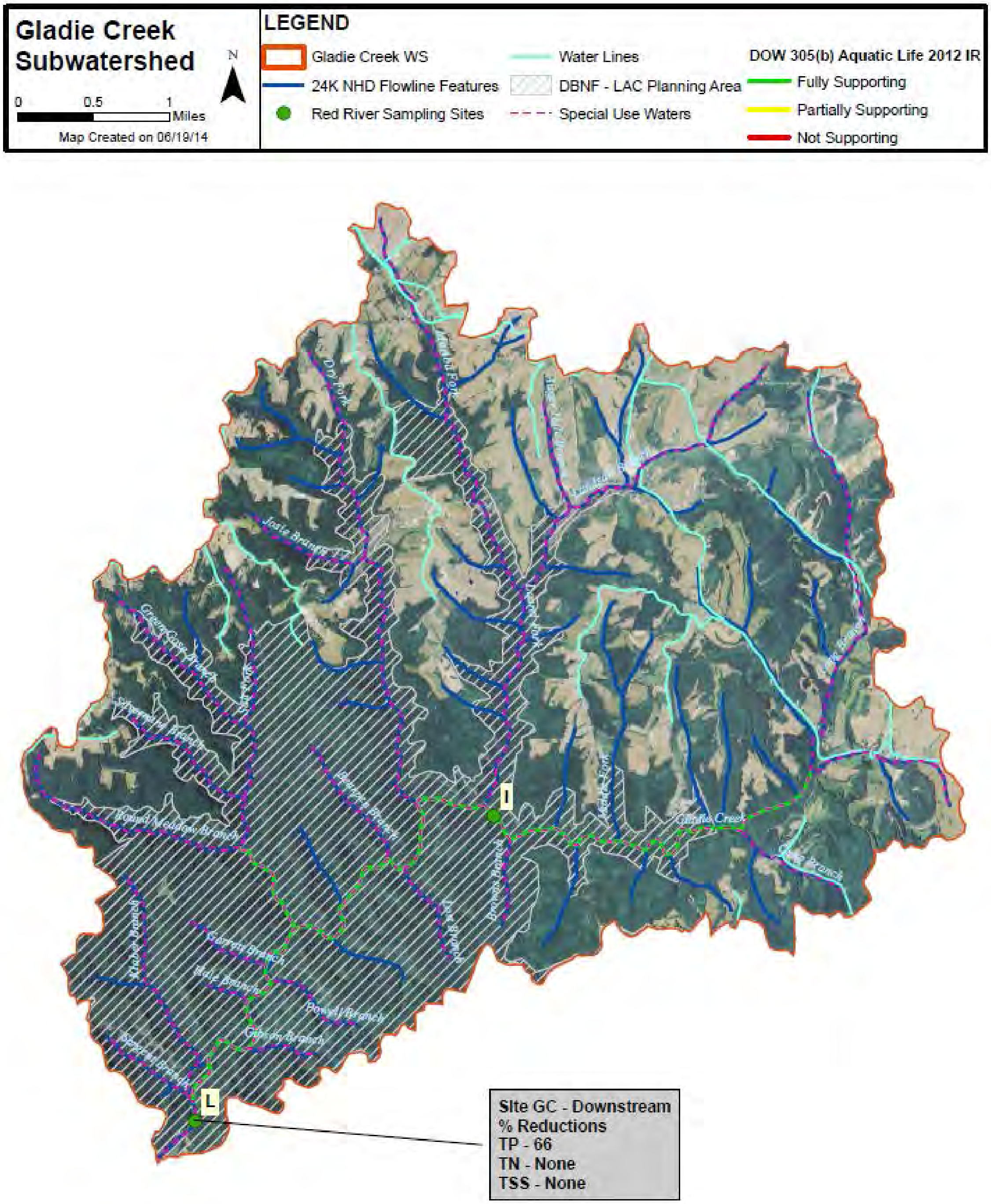


Figure 4.80: Gladie Creek Load Reductions Needed.

Clifty Creek and Red River Headwaters – 13.5 Square Miles

The Clifty Creek and the headwaters of the Red River subwatersheds are combined for this discussion. These adjacent watersheds are treated as one unit for summarizing water quality issues and prioritizing implementation.

Water chemistry and bacteria data were not collected in these areas, so no pollutant loads can be calculated. A biology sample was collected at the mouth of Clifty Creek in 2011. The sample scored Fair, indicating that there may be activities impacting the segment that is currently listed as fully supporting aquatic life. The upper portions of both subwatersheds are outside of the DBNF and contain small farms and residential areas (Figure 4.81).

There are multiple Special Use Water designations in the Red River headwaters. It's listed as an Outstanding National Resource Water, Outstanding State Resource Water, and both a Federal and State Wild River. Therefore, protection efforts are important and should be a focus of implementation in this area.

Feasibility Discussion

The capacity in these subwatersheds is similar to Gladie Creek. Involvement of local residents may increase though education and outreach efforts. USFS will support protection efforts and minimize future threats on the large portion of DBNF land in the subwatershed.

Summary

Protection is a priority in this subwatershed, along with further investigation to target BMPs to address potential threats. Additional bacteria and water chemistry monitoring will assist with targeting BMPs and gauging the success of implementation.

Protection efforts should be targeted throughout the subwatershed through the following:

- Educate the public about the importance of the natural areas in the watershed.
- Reach out to the landowners in the headwaters to ensure they are properly maintaining septic systems.
- Work with the local decision makers to protect the areas outside of DBNF.
- Continue efforts within the DBNF area to minimize recreational impacts.
- Complete visual assessments of possible contributors.
- Identify and secure funding for agricultural BMPs in the headwaters.

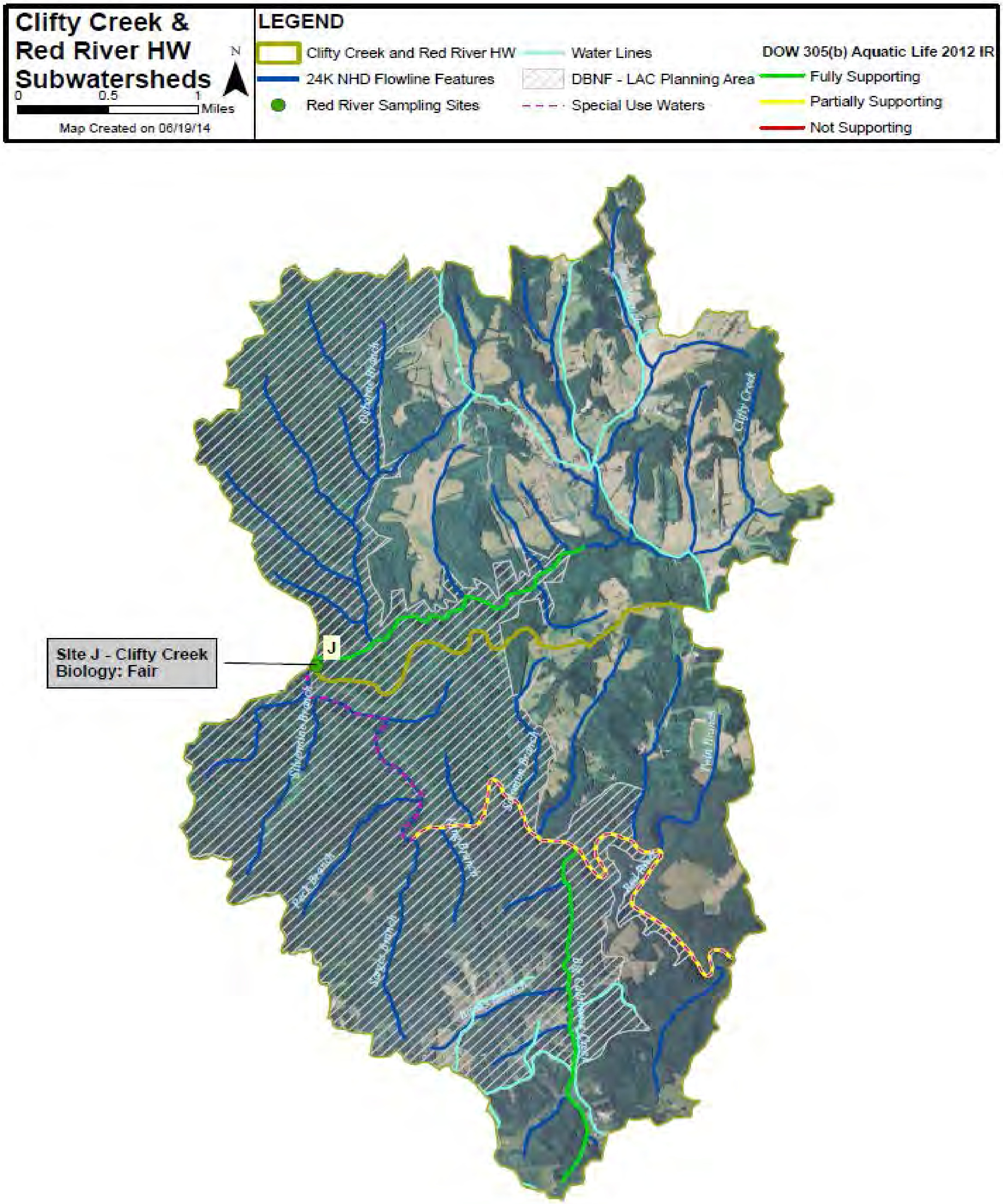


Figure 4.81: Clifty Creek and Red River Headwaters.

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Chapter 5: Find Solutions - Exploring BMP Options

5.1 Introduction

In watershed planning, a best management practice, or BMP, is traditionally defined as something built on the ground with documentable results in reducing nonpoint source pollution (pollution from diffuse sources). The phrase is also used to refer to non-structural practices designed to improve water quality. Targeted BMP implementation is vital to successful watershed management.

BMPS may be:

- Structural – these BMPs require construction, installation, and maintenance. They're usually BMPs that one can see such as stream buffers, rain gardens, and silt fences.
- Nonstructural – these BMPs involve changes in activities or behavior in people. Examples include education or events like watershed meetings and creek cleanups.

Figure 5.1: Examples of structural best management practices.

BMPs can greatly improve water quality. See Figure 5.1. Curb cuts in roads (top left) capture stormwater to decrease runoff pollution. Trees help prevent erosion and reduce in-stream water temperatures (top right). Riparian (vegetative) buffers near waterways (bottom right) improve habitat and catch pollutants before they enter the water. Silt fences (bottom left) reduce erosion and keep sediment out of waterways.

There are many types of BMPs to address all sorts of issues. Because everything we do on the land affects the water, most types of land use have associated best management practices. BMPs can address agricultural issues such as erosion and manure management, residential issues such as failing septic systems and stormwater runoff, construction issues such as erosion, and many others. In watershed planning, there should be a direct link between a specific, identified watershed issue and the proposed BMP that will help alleviate that issue.

Education is considered a BMP also. Education is a critical part of bringing about changes in behavior that are necessary to reduce our negative impact on water quality issues, and is recommended for many aspects of this project. It's more practical and economical to protect good water quality than to improve poor water quality.

5. 2 Best Management Practices

With the source identification and prioritization from Chapter 4, knowledge gathered from community members, and background information presented in Chapter 2, we can select BMPs to recommend for future implementation in the Red River Watershed. Table 5.1 is a recap of which subwatershed areas need BMPs for specific issues.

Table 5.1: BMPs needed in each project subwatershed.

	Sampled for water chemistry	Sampled habitat and biology	*E. coli*	Total Suspended Solids	Total Phosphorus	Conductivity	Protection
Swift Camp Creek	Yes = 4 sites	Yes = 4 sites	All sites need reduction	Yes = 3 sites	All sites need reduction	All sites need reduction	All sites need protection
Indian Creek	Yes = 3 sites	Yes = 3 sites	No	No	All sites need reduction	Yes = 2 sites need reduction	All sites need protection
Gladie Creek	Yes = 1 site	Yes = 1 site	No	No	Site needs reduction	No	Site need protection
Clifty Creek	No	Yes = 1 site	n/a	n/a	n/a	n/a	Site needs protection

All of the following BMPs have the potential to address specific pollutant issues in the subwatersheds studied in this plan. The BMPs are grouped by which water quality issue/pollution source they may help mitigate. In Chapter 6, feasibility factors like economics, stakeholder cooperation, regulatory matters, political will, and other watershed management activities occurring are considered to help select the recommended BMPs for the watershed.

Education and Planning BMPs

Educating people about water quality, how the activities on the land affect water quality, and how behavior changes can reduce our impact may be the most effective type of BMP because the collective daily actions of watershed residents that have large impacts on water quality and habitat.

Education on watershed issues and nonpoint source pollution – Educating people about water quality and how the activities on the land affect water quality, and providing them with specific behavior changes arms people with the tools to be able to change the direction of our impacts on water quality and stream health.

Conservation easements - A conservation easement is a voluntary agreement that allows a landowner to limit the type or amount of development on their property while retaining private ownership of it. An easement can be used to help establish healthy riparian areas, shield land from development, or protect parcels of land to maintain or improve watershed health.

Creek Cleanups – Getting together as a community to pick up trash from waterways and the adjacent roads and hillsides can help drive home the message that what we do on the land affects the water. It also helps remove solid waste from waterways.

Groundwater Protection Plans – A groundwater protection plan (GPP) identifies all activities at a site that have the potential to release contamination onto the soil, which can then pollute groundwater, and defines BMPs used to protect groundwater. A GPP identifies actions to protect groundwater for all current and future uses, and when it is implemented properly it prevents groundwater pollution.

Wellhead and Source Water Protection Plan - The 1986 amendments to the Safe Drinking Water Act required states to develop a wellhead protection program (WHPP) to protect groundwater that is used as a public water source. This regulation requires that counties develop water supply plans that assess the quantity of water used by public water systems and create protection plans for source waters used by those systems. The WHPP is designed to assist communities relying on groundwater as their drinking water source to develop groundwater protection plans.

Planning and zoning – Review and update local ordinances to reduce our impact on water quality. Some issues to review include protecting riparian buffers near public and commercial properties, management of storm water, rules for future development regarding impervious surfaces and reduction of soil leaving the site, and others.

Wastewater BMPs

Septic system improvements may help reduce the amount of *E. coli* and Total Phosphorus in the waterways. BMPs dealing with sewer lines are not eligible for nonpoint source pollution funding, but the watershed team could pursue alternate funding for these types of initiatives.

Education about septic issues – This BMP could be implemented in a variety of ways and tailored to different audiences. Educational materials about proper septic system maintenance could be mailed to households outside of sewer line service area, used in public service announcements, discussed at community meetings and events, and otherwise distributed.

Financial assistance for septic system pump outs – Financial assistance could be provided to help homeowners have their septic systems inspected and pumped.

Financial assistance for septic system repair or replacement – Financial assistance could be provided to help homeowners repair or replace their septic system. This BMP may reduce bacteria, total phosphorus, and conductivity issues originating from failing septic systems.

Financial assistance for sewer line repairs and/or extension – Addressing inflow and infiltration issues in Campton could help mitigate bacteria, total phosphorus, and conductivity issues originating from failing or absent sewer lines in Swift Camp Creek. Additionally, a sewer line extension may alleviate bacteria issues originating from failing or absent septic systems. (Appendix E)

Riparian buffer establishment – Riparian areas are those areas directly adjacent to waterways. Establishing a buffer of trees, shrubs and grasses around a waterway, also known as a filter strip, can help improve the health of the water in many ways. There are many ways a riparian buffer can help protect waterways: they catch and filter out pollutants that would otherwise flow into the water during or after a rain event; they hold back soils that would enter into streams during and after rains; they stabilize creek banks with plant roots; and they provide shade for the water and its inhabitants, reducing the fluctuation in stream temperature. Riparian buffers can be effective on farms, suburban yards, and in towns. Riparian buffers can be used to help reduce *E. coli*, total phosphorus, and conductivity issues by filtering the water that flows from various sources in the project areas.

Sewer line updating – In Campton, inflow and infiltration issues with the existing sewer and drinking water lines has been documented. Fixing or updating these lines may provide a significant reduction in *E. coli*, Total Phosphorus, and Conductivity issues.

Sewer line extension – Septic systems, when installed and maintained properly, are acceptable for human waste disposal. When a community cannot maintain systems properly, however, bacteria can be a public health and environmental issue. An extension of the sewer line from Campton to the rest of the watershed would greatly reduce the number of failing septic systems or straight pipes.

Stormwater BMPs
When it rains and when ice and snow melt, the water soaks into the soil. Once the soil is saturated it can no longer take in water, and the water begins to flow on the surface. In areas with greater amounts of impervious surfaces, such as roads, parking lots and buildings, runoff occurs more readily. This can be a significant problem in developed areas like Campton because as the water runs off and into the nearest waterway, it carries with it contaminants from roads and parking lots; sediment from construction sites, yards, and farms; lawn chemicals from yards and golf courses; trash from streets and parking lots; and many other types of pollution found on the ground. Excess water and sediments delivered to streams contribute to erosion of the stream banks and channel. There is also an issue with more water being delivered to the wastewater treatment plant than the plant can handle. When this happens, wastewater can be discharged directly to Swift Camp Creek.

Education about stormwater impacts – Educational materials about the impacts of stormwater can be effective at getting the word out on the value of capturing stormwater at homes and businesses. Education could focus both on capturing stormwater runoff and on reducing substances like lawn fertilizer or oil drips in the driveway that get washed into waterways.

Green infrastructure design
Incorporating green infrastructure design into new city planning or retrofitting it into existing structures can help reduce the amount of runoff by giving water more area to soak in. There are numerous design options from easy fixes like rain barrels and rain gardens to more complicated projects like green roofs and pervious pavement.

Silt Fences – installing a temporary fence to keep disturbed soil at construction or other land disturbance sites from running off site helps keep soil out of nearby waterways.

Riparian buffer establishment – See above.

Conductivity
As discussed in Chapter 4, sources that affect conductivity in these subwatersheds likely include geology, failing septic systems and sewer line infrastructure, runoff from agricultural operations, and road runoff. This can be a significant problem in developed areas like Campton because as the water runs off and into the nearest waterway, it carries with it contaminants. The solotions will be similar to those listed for wastewater and stormwater.

Silt Fences – See above.

Financial assistance for septic system repair or replacement - See above.

Financial assistance for sewer line repairs and/or extension – See above.

Riparian buffers – See above.

Sewer line extension – See above.

Sewer line updating – See above.

Agricultural BMPs

Agriculture in the watershed is not extensive. However, for those existing operations, there are BMPs that can reduce soil erosion from row crop and livestock farming practices and reduce *E. coli* and Total Phosphorus from livestock farming practices. Local conservation districts can provide expert advice and information about programs that promote responsible agriculture practices. They may also be a source of state cost-share funding. To qualify for state cost-share funding, landowners must first complete or update an existing Agricultural Water Quality Plan.

Agricultural Water Quality Plans - The Kentucky General Assembly passed the Kentucky Agriculture Water Quality Act in 1994. The goal of the act is to protect surface and groundwater resources from pollution as a result of agriculture and silviculture (forestry) activities.

The Agriculture Water Quality Act requires all landowners with 10 or more acres that are being used for agriculture or silviculture operations to develop and implement a water quality plan based upon guidance from the Kentucky Agriculture Water Quality Plan. It is the responsibility of each landowner to develop and implement a water quality plan for their individual operations, and to make revisions when needed.

The Kentucky Agriculture Water Quality Plan is a compilation of BMPs from six different areas: silviculture, pesticides and fertilizers, farmstead, crops, livestock, and streams and other waters. Each BMP includes definitions and descriptions, regulatory requirements, Agriculture Water Quality Authority requirements, design information, practice maintenance, technical assistance, cost-share assistance, recommendations and references.

Habitat BMPs

The habitat issues covered in Chapter 4 indicate that all areas covered in the plan would benefit from habitat improvement BMPs.

Stream restoration - Restoring a section of a stream so that it allows high flows to flow out into a floodplain or other retention area can greatly reduce flooding impacts. It can also restore habitat functions. Both of these changes can improve overall water quality in a watershed.

Wetlands – Restoring or creating a wetland can be a huge boon for water quality and habitat improvement. It entails establishing wetland hydrology, vegetation, and wildlife habitat functions on soils capable of supporting those functions. As mentioned in stream restoration, a wetland can hold stormwater and reduce flood impacts in a stream. A wetland can be established as an educational project.

Trail improvements – Improving trails to limit the amount and severity of erosion may help to improve water quality. Trail improvements may include installing water bars or rolling grade dips to slow down water flow and soil movement, rerouting trails away from low lying and frequently flooded spots, temporarily or permanently closing trails to allow vegetation to regrow, and educating the trail users about these changes.

Riparian buffer establishment – See above.

Conservation easements – See above.

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Note that point sources of pollution such as sewer line leakages, or permitted discharges such as from wastewater treatment plants, or a rock quarry are not eligible for 319 nonpoint source grant funding, but can still be addressed by the watershed team via alternate funding or volunteer work. KDOW Nonpoint Source Section grants can only fund work addressing nonpoint source pollution.

5.3 Individual Subwatershed Planning

Swift Camp Creek

Swift Camp Creek and an unnamed tributary to Swift Camp Creek are impaired waterways. Swift Camp Creek needs improvement in many water quality parameters and habitat (see Table 5.2). Load reductions are needed for total phosphorus, total suspended solids, and *E. coli.* Conductivity levels were above benchmark levels at all four sites. Additionally, Macroinvertebrate Biological Integrity (MBI) ratings are significantly lower in the headwaters of Swift Camp Creek than in the other sites in the project area.

Table 5.2: Water quality issues in Swift Camp Creek subwatershed and possible BMPs to address them.

Water Quality Issue	Suspected Source(s)	Best Management Practice
E. coli	Failing septic systems	Education about septic issues
		Septic pumpout and/or repair and replacement program
Total Suspended Solids	Stormwater runoff	Education on stormwater pollution in the watershed
	Urbanization	Riparian buffer establishment and/or conservation easements
Nitrate-Nitrite	Failing septic systems	Education about septic issues
		Septic repair and replacement program
	Urbanization	Riparian buffer establishment and/or conservation easements
Total Phosphorus	Failing septic systems	Education about septic issues
		Septic repair and replacement program
	Urbanization	Riparian buffer establishment and/or conservation easements
Conductivity	Failing septic systems	Education about septic issues Septic repair and replacement program
	Urbanization	Riparian buffer establishment and/or conservation easements
Microinvertebrate Biological Integrity	Failing septic systems	Education about septic issues Septic repair and replacement program
	Urbanization	Riparian buffer establishment and/or conservation easements

Indian Creek
Total phosphorus and conductivity are issues for Indian Creek. This may be due to development near the headwaters including homes and businesses, and failing septic systems in the area. Both of these elevated parameters could be contributed to natural limestone geology and/or the limestone quarry located near the headwaters (see Table 5.3). Indian Creek had the lowest MBI score of 68.7/69.8 = Fair, other than Swift Camp Creek.

Table 5.3: Water quality issues in the Indian Creek subwatershed and possible BMPs to address them.

Water Quality Issue	Suspected Source(s)	Best Management Practice
Nitrate-Nitrite	Failing septic systems	Education about septic issues
		Septic repair and replacement program
	Urbanization	Riparian buffer establishment and conservation easements
Total Phosphorus	Failing septic systems	Education about septic issues
		Septic repair and replacement program
	Urbanization	Riparian buffer establishment and conservation easements
Conductivity	Failing septic systems	Education about septic issues Septic repair and replacement program
	Urbanization	Riparian buffer establishment and conservation easements
Macroinvertebrate Bioassessment Integrity	Urbanization	Riparian buffer establishment and/or conservation easements

Gladie Creek
Gladie Creek appears to be in relatively good condition. This is evident by the “excellent” MBI score. BMPs may not be necessary in the headwaters of this stream. Although, continuing the erosion work related to recreation lower in the subwatershed may be a good idea.

Clifty Creek
Clifty Creek had the lowest prioritization score of the four subwatersheds studied. This means that overall it has the best water quality. However, there was only one site in the Clifty Creek subwatershed, and it was only sampled for biology – no water quality parameters were collected at this site.

Chapter 6: Strategy for Success

6.1 Introduction

Best Management Practices (BMPs) were presented in Chapter 5 to address the specific pollution and biological issues outlined in Chapter 4. This chapter plans out the BMPs selected by the Red River Watershed Team as feasible for their communities. Other BMPs discussed in Chapter 5 may become possibilities in the future.

In this chapter, you will:

- see which BMPs were selected by the watershed team
- learn about the estimated pollutant load reductions expected from these BMPs in the specific subwatershed where they are assigned
- BMP priorities for each subwatershed

This chapter is first organized by subwatershed area and related water quality issues and BMPs. Then, in Table 6.5, the BMPs are organized by objective. The expected pollutant load reductions and more specific Action Items are then presented in subsequent tables.

6.2 Feasibility

There are multiple solutions to many of the pollution issues discussed in this watershed plan. However, not all of them are feasible at this time. Factors to consider in feasibility are cost, available funding, cost-benefit analysis, existing priority status, areas of local concern, political will, other local projects such as sewer line extensions, stakeholder cooperation, and regulatory matters. These factors have been considered by the watershed team, and the following tables, broken down by subwatershed, display the BMPs that are considered feasible at this time.

In the following BMP planning, some projects are already slated for implementation while others will need to be explored by the watershed team and Watershed Coordinator. Other factors, such as future sewer line extension in Campton, should also be considered. Which are implemented will depend on the watershed community and other local factors.

A note on pollutant load reductions

Many of the BMPs discussed in this chapter may have greater impacts than the pollutant load tables indicate. It is not possible to calculate the pollutant loads for a community education campaign, for example, but such a BMP may have an enormous impact.

Similarly, other BMPs may have more far reaching impacts on pollutant loads than illustrated in the planning tables. Repairing or replacing a septic system, for example, can have many benefits for water quality, not just removing *E. coli*. A new septic system may also reduce total suspended solids, total phosphorus, conductivity, and nitrogen. Although there are issues with conductivity and nitrogen in some parts of the project area, the BMP planning does not specifically address these pollutants. Many of the other prescribed BMPs will likely reduce conductivity and nitrogen levels, but actual reductions are difficult to calculate.

6.3 Subwatersheds and recommended BMPs

Swift Camp Creek

Swift Camp Creek and Unnamed Tributary (UT) to Swift Camp Creek are both impaired waters. As discussed in Chapter 4, Swift Camp Creek needs improvement in many water quality parameters, habitat, and biology (see Table 6.1). Pollutant load reductions are needed for *E. coli*, total suspended solids, and total phosphorus. Conductivity issues were reported for all Swift Camp Creek sites.

Because water quality and habitat protection are vital to each of the four subwatershed areas, it has been included as a BMP for all areas.

Table 6.1: Water quality issues in Swift Camp Creek subwatershed and selected BMPs to address them.

Water Quality Issue	Suspected Source(s)	Best Management Practice
E. coli	Failing septic systems	Education about wastewater issues
		Septic system repair and replacement program
Total Suspended Solids	Stormwater runoff	Education on stormwater pollution in the watershed
	Urbanization	Riparian buffer establishment or improvement
Total Phosphorus	Septic systems	Education about septic systems and phosphates
		Septic system repair and replacement program
Watershed Protection	Urbanization	Riparian buffer establishment or improvement
	Recreation	Trail & campsite erosion work

Gladie Creek
Gladie Creek appears to be in relatively good condition. This is evident by the "excellent" MBI score. Total phosphorus is an issue at the downstream site. BMPs to address total phosphorus and continuing the erosion work related to dispersed recreation lower in the subwatershed may be beneficial for the area. No conductivity issues were reported.

Table 6.2: Water quality issues in the Gladie Creek subwatershed and selected BMPs to address them.

Water Quality Issue	Suspected Source(s)	Best Management Practice
Total Phosphorus	Wastewater systems	Education about wastewater and phosphates
	Urbanization	Riparian buffer establishment or improvement
Watershed Protection	Urbanization	Riparian buffer establishment or improvement
	Recreation	Trail & campsite erosion work

Septic system BMPs are not being recommended for Gladie Creek at this time. Education on wastewater, in general, is being advised to reduce the amount of phosphates from detergents or soaps entering the waterways.

Indian Creek
Total phosphorus and conductivity are issues for Indian Creek. This may be due to development near the headwaters including homes and businesses, and failing septic systems in the area. These elevated parameters can be partly attributed to the limestone geology and/or the limestone quarry located near the headwaters (see Table 5.2).

Indian Creek had the lowest MBI score outside of the Swift Camp Creek subwatershed. It was determined to be "fair." This may be due to development activities in the headwaters area.

Table 6.3: Water quality issues in the Indian Creek subwatershed and selected BMPs to address them.

Water Quality Issue	Suspected Source(s)	Best Management Practice
Total Phosphorus	Wastewater systems	Education about septic issues
	Urbanization	Riparian buffer establishment or improvement
Watershed Protection	Urbanization	Riparian buffer establishment or improvement
	Recreation	Trail & campsite erosion work

Clifty Creek

Clifty Creek had the lowest prioritization score of the four subwatersheds studied. However, there was only one site in the Clifty Creek subwatershed, and it was only sampled for biology – no water quality parameters were collected at this site. Practices to help protect the water quality and habitat are recommended.

Table 6.4: Water quality issues in the Clifty Creek subwatershed and selected BMPs to address them.

Water Quality Issue	Suspected Source(s)	Best Management Practice
Watershed Protection	Urbanization	Riparian buffer establishment or improvement
	Recreation	Trail & campsite erosion work

Table 6.5: BMPs organized by objective.

Objective	BMP	Action Items
#1: Reduce bacteria loads from failing residential septic systems	Community education about onsite wastewater issues and responsibilities	1. Work with local agencies and organizations on public awareness measures. 2. Create or update outreach materials
	Financial incentives for septic system repair and replacement.	3. Work with local health departments to identify areas of need. 4. Create BMP implementation plan and application including educational materials.
#2: Reduce sediment loads	Trail and recreation site improvements	1. Install water bars and rolling grade dips to reduce water damage.
		2. Close or rehabilitate eroded trails and recreation sites.
	Create or improve riparian buffers	3. Plant native vegetation along streams. 4. Reach out to community and user groups about the importance of riparian areas.
#3: Reduce total phosphorus loads	Community education about onsite wastewater issues and responsibilities	1. Work with local agencies and organizations on public awareness measures. 2. Create or update outreach materials
	Financial incentives for septic system repair and replacement.	3. Work with local health departments to identify areas of need. 4. Create BMP implementation plan and application including educational materials.
	Community awareness campaign on phosphates in detergents and soaps and water quality impacts	5. Work with local agencies and organizations on public awareness measures
	Create or improve riparian buffers	6. Plant native vegetation along streams. 7. Reach out to community and user groups about the importance of riparian areas.
#4: Protect and improve water quality and habitat	Create or improve riparian area buffers	1. Create or adapt outreach materials on benefits of good water quality and healthy riparian areas. 2. Collaborate with local agencies or organizations on public outreach on tree planting and no mow zones. 3. Conduct planning and zoning review to facilitate the wider use and acceptance of protected areas and riparian buffers.
#5: Community Education and Outreach	Creek cleanups	1. Work with local agencies and organizations on awareness of garbage issues and host cleanups.

6.4 Action Item Planning

Objective #1: Reduce E. coli pollutant loads from failing residential septic systems

<u>Primary Target Area: Swift Camp Creek</u>

Septic system repair or replacement will be implemented on a case-by-case basis. Before any work is done, many factors will be considered, such as surrounding land uses, soils, proximity to creek, and site location within the subwatershed. The project watershed coordinator will conduct a site visit.

For septic system education and septic system repair and replacement BMPs, there is an additional table (Table 6.6) depicting the pollutant load reductions expected at each of the four Swift Camp Creek sites. Before any BMP work begins, it will be important to determine the future plans of the town of Campton in regards to sewer line extensions. If a household is scheduled for connection to the main line, then proper closure of the septic tank would need to be considered. Other subwatersheds of the project do not have significant *E. coli* pollutant loading, thus septic system BMPs are not recommended at this time for those areas.

The load calculations presented here (Table 6.6) are based on literature values and best estimates of current conditions in the subwatershed. Repairing or replacing septic systems will likely have the added benefit of reducing total suspended solids, total phosphorus, conductivity, and total nitrogen loads even though those loads are not calculated in this plan.

Septic systems and E. coli loading

There are no sewer lines in parts of the Swift Camp Creek Watershed, so all human sources of bacteria are assumed to be due to failing septic systems or straight pipes. A conservative estimate of daily wastewater flow for a single home with 2.5 occupants is 150 gallons per day (US EPA “Onsite Wastewater Treatment Systems Manual”). An estimate of fecal coliform in raw wastewater reaching the stream (Mayer et al., 1999) is 10,000,000 colony-forming units (cfu) per 100 milliliters (mL). Removing a straight pipe or failing system that flows into surface water by replacing it with a working system will remove 56,781,176,700 fecal coliform colonies per day per home. This equates to 13,056,831,582,165 *E. coli* cfu/year for each septic system remediated. The pollutant load reductions provided in Table 6.6 are rough estimates, as many variables affect the rates including household habits, distance from stream, soil type and depth, groundwater interaction, and *E. coli* concentration.

The exact number of septic systems or how many of those are failing in the watershed is not known. Also, the exact percentage of human source bacteria (versus animal) is not known, so estimated load reduction are based on the entire *E. coli* load being of human origin. There are sewer lines in part of Campton, but not all of Campton is on sewer. According to a study published by the Kentucky River Area Development District (2000) and data gathered from the KY Gazetteer:

- 7,502 people live in Wolfe County
- 8% of them are on sewer lines (about 600 people)
- 2,700 County residents use onsite wastewater systems, most of which are septic systems
- Population of Campton is 441
- Wolfe County is made up of 142,188 acres total
- Campton is 704 acres

There are 13,693 acres in the watershed, which means that there are 12,989 acres in the watershed excluding Campton. The Wolfe County population excluding Campton is 7,062. There are 141,484 acres in Wolfe County excluding Campton, therefore, there are 0.05 people per acre (this assumes an even population distribution outside of Campton).

Approximately 649 people live in the watershed outside of Campton. The total number of people that live in the watershed equals 1,090 (649 plus 441 people in Campton) = 1090. If there are 600 people on sewer lines, that leaves 490 people in the watershed not on sewer. If 37% of the county uses onsite septic systems (Appendix F), then 181.3 people in the watershed use onsite systems. That leaves 308.7 people in the watershed area not using onsite septic systems or sewer. With an estimated 2.5 people per household, there are 124 homes without sewer or onsite septic systems. This number is an estimate. The exact number is unknown.

Tables 6.6 and 6.7 present the pollutant loads and pollutant load reductions needed to meet water quality standards (discussed in Chapter 4) and the recommended septic system BMPs per subwatershed site.

Table 6.6: Estimated *E. coli* Load Reductions for septic system BMPs for Swift Camp Creek.

BMP	Indicator	Subwatershed - Site	*E. coli* load*	Load Reduction Needed*	# of septic systems recommended	Estimated Load Reduction Expected**
Education on residential septic system function and maintenance.	n/a	All of Swift Camp Creek	n/a	n/a	n/a	Not measureable
Financial incentive program for septic system tank repair or replacement	Bacteria Count	Unnamed Trib	13.4	10.6	1	13 trillion/97.0%
		Below Hirams	27.0	16.7	2	26 trillion/96.2%
		Off KY 15	11.2	6.6	1	13 trillion/116.0%
		Above WWTP	42.9	34.0	4	52 trillion/121.2%

*units of trillion *E. coli* cfu/100 mL/yr
**based on 13 trillion *E. coli* cfu/100 mL/yr reduction for each corrected failing septic system. Literature values from U.S. EPA, National Environmental Services Center, and AWWA Research Foundation.

Table 6.7: Action Item details for septic system BMPs for Swift Camp Creek subwatersheds.

BMP	Site/subwatershed	Responsible Party	Technical assistance	Cost	Funding Mechanism
Education on residential septic system function and maintenance.	Unnamed Trib Below Hirams Off KY 15 Above WWTP	Project Watershed Coordinator and Watershed Team	Eastern KY PRIDE, Health Department of Wolfe County, KOWA, and KDOW	Fees for facility rental, printed materials, and other supplies.	319 grant
Financial incentive program for septic system tank repair or replacement	Unnamed Trib Below Hirams Off KY 15 Above WWTP	Homeowner	Eastern KY PRIDE, Health Department of Wolfe County, KOWA, and KDOW	$2,000 to $7,000 per septic system	319 grant Matching funds from homeowners

Objective #2: Reduce total suspended solids loads through improvements to trails and recreation sites and create or improve riparian buffers.

Primary Target Area: Swift Camp Creek, Gladie Creek, Indian Creek, and Clifty Creek

In all of the watershed study areas, there are some total suspended solid issues, though only Swift Camp Creek required pollutant load reductions. A portion of the total suspended solids in these areas comes from the erosion of sediment from hiking trails, campsites, and other recreational features. Because all of these areas are adjacent to the Red River Gorge Geological Area in the Daniel Boone National Forest and are host to millions of hiking and camping guests each year, these recreational sources of sediment should be directly addressed.

Table 6.8: Estimated reductions in total suspended solids

	Swift Camp	Gladie	Clifty	Indian
# of campsites	25	25	10	20
Campsite erosion (tons/year)	12.5	12.5	5	10
Trail miles	1.8	1.8	0.75	1.5
Trail erosion (tons/year)	23	23	10	19
Total erosion (tons/year)	**35.5**	**35.5**	**15**	**29**

Based on the Water Erosion Prediction Project (WEPP) model (Elliott, et al., 2000).

Objective #3: Reduce Total Phosphorus pollutant loads

Target Areas: Swift Camp Creek, Indian Creek, and Gladie Creek

Swift Camp Creek, Indian Creek, and Gladie Creek all had issues with total phosphorus during the water quality sampling period. As noted in Chapter 4, total phosphorus can be attributed to a variety of sources, but one common source is wastewater.

Properly functioning septic systems will remove a percentage of total phosphorous, but are not typically thought to be cost effective treatments as BMPs (Toor et al., 2011). The septic system BMPs planned for Swift Camp Creek will undoubtedly help with total phosphorus issues in that subwatershed. In the other areas where septic system BMPs are not planned, however, another source of total phosphorus can be targeted.

Reducing the amount of total phosphorus going into wastewater systems (failing or functional septic system or sewer system) has been shown to reduce total phosphorus pollutant loads reaching surface and ground waters. According the EPA, eliminating phosphates from detergent can reduce phosphorus loads to septic systems by 40 to 50 percent (USEPA, 1980). As of October 1993, 17 states had enacted phosphate detergent restrictions or bans – not including Kentucky (Soap and Detergent Association, 1993). Phosphate restrictions are most effective when used as part of a BMP system that involves other source reduction practices such as elimination of garbage disposals and use of low-volume plumbing fixtures, as well as mitigation BMPs such as upgrading and regular maintenance in areas served by septic systems (Osmond et al., 1995). Low-phosphate or phosphate-free detergents and/or soaps may be difficult to procure in rural locations. Community awareness and education on the matter may go a long way to treat the issue in a cost-efficient manner.

Objective #4: Protect and improve water quality and habitat

<u>Location: Swift Camp Creek, Gladie Creek, Indian Creek, and Clifty Creek</u>

Protecting habitat in all four subwatersheds may be one of the best ways to improve overall water quality. Creating or improving riparian buffers is the BMP selected by community stakeholders to address habitat protection for the project area. Riparian buffers have many benefits for a creek. In some parts of the project area, there is an existing riparian buffer. Where there are existing buffers, a wider or denser swath of vegetation may be developed. In those places without a buffer, native grasses, trees, and/or shrubs may be planted. In places where a wide riparian buffer is not practical or desirable, a "no-mow" zone may also have a positive impact. Education about why a buffer is important will be critical to the long term success of the buffer.

Specifically, riparian buffers have been shown to slow down flow as water enters the stream, allowing some sediment to settle out, can reduce erosion of surface soils at the top of stream banks, and can also provide some filtration of pollutants contained in runoff (see Chapter 5 for more information). Additionally, the shade provided by developed riparian areas reduces stream temperature fluctuations.

Objective #5: Community Education and Outreach

<u>Location: Swift Camp Creek, Gladie Creek, Indian Creek, and Clifty Creek</u>

As seen above education and outreach (E&O)is part of all the objectives. The Watershed Coordinator will continually evaluate the E&O process and opportunities. E&O will be geared toward promoting implementation measures identified in this plan and may include creek clean-ups, septic system workshops, and recreation user education. The success of these BMPs will be evaluated based on how they were implemented and the effectiveness of the BMP in meeting the desired conditions.

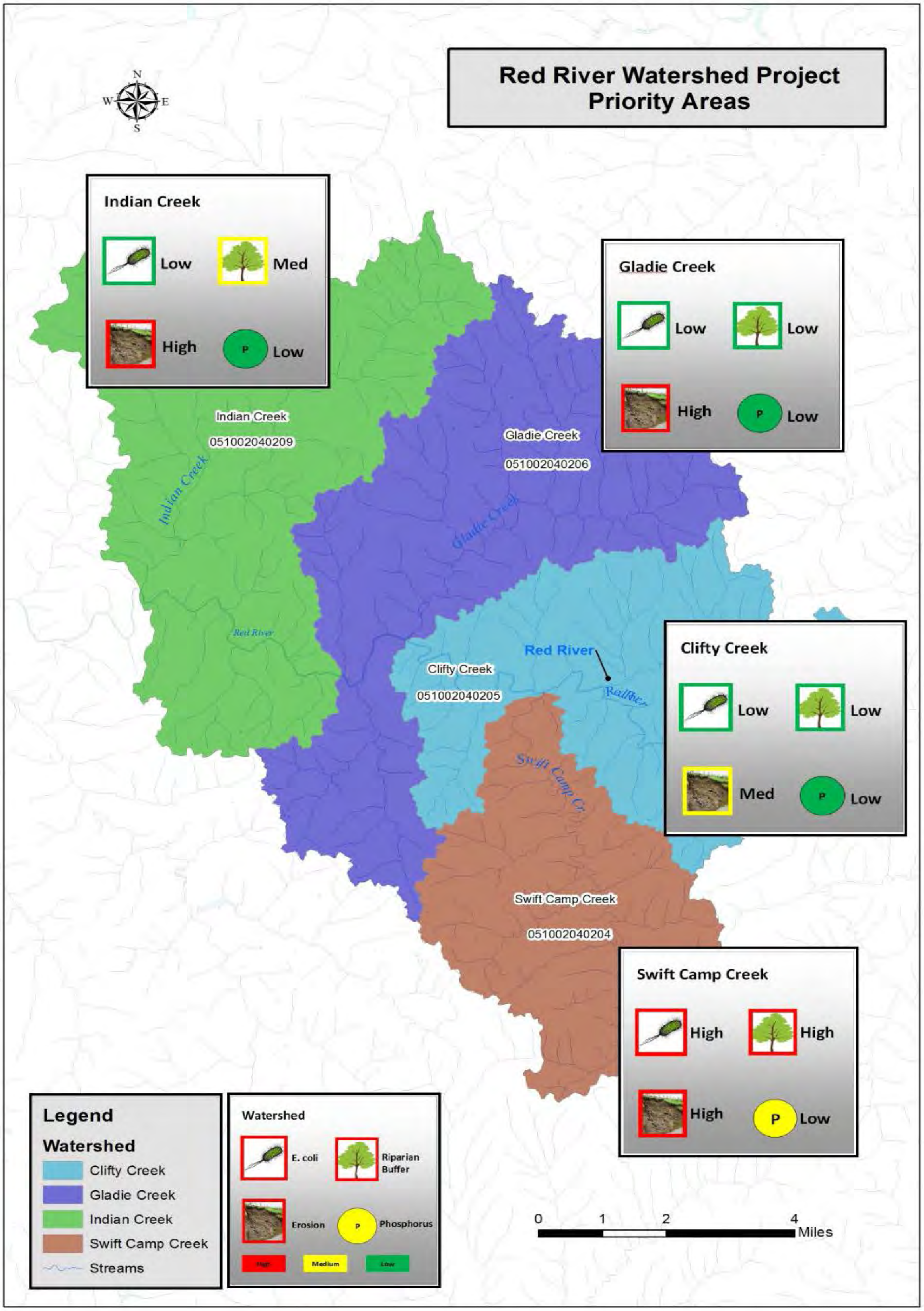

Figure 6.1 Priorities by subwatershed.

Table 6.9: BMP and Action Item Planning Table.

Target Pollutant	BMP	Subwatershed	Specific sites	Cost**	Estimated Load Reduction*	Action Items	Responsible Parties	Technical Assistance	Funding Sources
E. coli	Wastewater Education	Swift Camp Creek	All 4 sites	n/a	Not measureable	Work with agencies and organizations on public awareness measures. Create or update outreach materials	Watershed Coordinator and USFS	Wolfe County Health Depart. and PRIDE	319 grant (secured)
E. coli	Septic System Repair or Replacement	Swift Camp Creek	All 4 sites	Repair cost depends on issue; $2500-7000 per new system.	See Table 6.4	Work with local health department to identify areas of need. Create BMP plan and application including educational materials.	Watershed Coordinator and USFS	Wolfe County Health Depart. and PRIDE	319 grant (secured) and participant match
Total Suspended Solids	Create or improve riparian buffers	Swift Camp Creek	Unnamed Tributary 50 foot buffer for 500 feet	90 lbs/yr/dollar 10 per linear foot of stream	50% removal of sediment and nutrients	Plant native trees, shrubs, and/or grasses along streams. Reach out to community and user groups about importance of riparian	Watershed Coordinator and USFS	USFS	319 grant (secured)
Total Suspended Solids	Trail and recreation site improvements	All subwatersheds	Lower watershed sections on USFS	$870/ton	115 tons	Install water bars and rolling grade dips and close or rehab eroded trails and recreation sites	USFS	USFS	319 grant (secured)
Total Phosphorus	Septic System Repair or Replacement	Swift Camp Creek	All 4 sites	Repair cost depends on issue; $2500-7000 per new system.	30-40% reduction per systems	Work with local health department to identify areas of need. Create BMP plan and application including educational materials.	Watershed Coordinator and USFS	Wolfe County Health Depart. and PRIDE	319 grant (secured) and participant match
Total Phosphorus	Education on phosphate sources and impacts	Swift Camp Creek, Indian Creek, Gladie Creek	All sites	$1000 per year	Up to 50%	Work with local agencies and organizations on public awareness measures.	Watershed Coordinator and USFS	Wolfe County Health Depart. and PRIDE	319 grant (secured)

Table 6.9: BMP and Action Item Planning Table (continued).

Target Pollutant or Protection Object	BMP	Subwatershed	Specific sites	Cost**	Estimated Load Reduction	Action Items	Responsible Parties	Technical Assistance	Funding Sources
Total Phosphorus	Create or improve riparian buffers	Swift Camp Creek	Unnamed Tributary 50 foot buffer for 500 feet	90 lbs/yr/dollar 10 per linear foot of stream	50% removal of sediment and nutrients	Plant native trees, shrubs, and/or grasses along streams. Reach out to community and user groups about riparian areas importance	Watershed Coordinator and USFS	USFS	319 grant (secured)
Habitat Protection	Create or improve riparian buffers	All subwatersheds	All sites	90 lbs/yr/dollar 10 per linear foot of stream	50% removal of sediment and nutrients	Plant native trees, shrubs, and/or grasses along streams. Reach out to community and user groups about riparian areas importance	Watershed Coordinator and USFS and Watershed Team	USFS	319 grant (secured)
Community Education and Outreach	Creek cleanups	All subwatersheds	All sites	$300 per cleanup	Not measurable	Work with local agencies and organizations on community awareness of garbage issues Host cleanups	Watershed Coordinator and USFS and Watershed Team	USFS and PRIDE	319 grant (secured) and community partners

*Based on literature values. See Appendix F.

**Based on past experience and local knowledge.

6.5 Draft Milestone Schedule

This schedule was adapted from the 2014 Kentucky Division of Water 319(h) grant application and will need to be updated if it is awarded.

22. Milestone Schedule		
Milestone	Date	
	Expected Begin	Expected Completion
Submit all draft materials to NPS Program staff for review and approval.	January 2016	January 2019
Submit advanced written notice to NPS Program staff for all educational public meetings, field days, workshops, etc..	January 2016	January 2019
Develop and submit a BMP Implementation Plan for NPS program staff approval.	January 2016	March 2016
Meet with KDOW staff to discuss WBP monitoring strategy as part of the QAPP update process.	February 2016	February 2016
Revise and submit a QAPP for KDOW approval.	February 2016	May 2016
Collect *E. coli* samples in Swift Camp Creek per QAPP.	May 2018	July 2018
Submit all reports required by QAPP.	July 2018	September 2018
Hire a local Watershed Coordinator.	January 2016	March 2015
Continue to support local watershed planning team.	January 2016	January 2019
Conduct two watershed team meetings per year.	January 2016	January 2019

Submit an Annual Report if requested by KDOW.	September 2016	September 2018
Installation of Red River Gorge BMPs, obliterate user created trails and campsites. Conduct clean-up efforts. • 25% of BMPs completed • 50% of BMPs completed • 75% of BMPs completed • 100% of BMPs completed	March 2016	September 2018
Repair and/or installation of failing septic systems in cooperation with PRIDE. • 25% completed • 50% completed • 75% completed • 100% completed	March 2016	September 2018
Enforce Red River Gorge trail and campsite closures.	January 2016	January 2019
Coordinate with the volunteer Red River Trail Crew.	January 2016	January 2019
Coordinate Student Conservation Association volunteers & seasonal employees.	March 2016	September 2018
Work with PRIDE on an environmental education program in local grade schools.	January 2016	January 2019
Conduct community activities such a clean-up days.	August 2016	August 2018
Conduct annual “Leave No Trace” educational demonstrations.	August 2016	August 2018
Submit Final Report	September 2018	January 2019

Chapter 7: Making It Happen

Organization

The implementation of this watershed plan will be a collaborative effort. There are many community partners that are currently involved that need to stay involved, and there are other entities that need to be re-invited to the project. Successful implementation depends on local buy in and participation.

The plan should be presented to all public officials in the watershed area. Accounts of the process of writing the plan and many components of the plan should be presented at public meetings and to interest groups. It will also be available online.

The cooperation and collaboration of these groups is critical to meeting the goals of the plan. Each group should be accountable for its assigned action items for each BMP through the implementation of the plan. Evaluating progress throughout the process is an important element as well. An adaptive management approach may be taken to make sure implementation stays on track and is meeting its goals.

Because of the number of involved parties, studies conducted, and recommendations made within the plan, it is recommended to employ a local watershed coordinator. The Watershed Coordinator would be a link between responsible parties, funding agencies, watershed residents, and technical resources. The watershed coordinator would also monitor the progress of plan-related projects or activities and provide updates on progress made.

Fundraising

The Daniel Boone National Forest has secured a Kentucky Division of Water 319 grant to implement the watershed plan. This grant will cover the cost of a part-time local watershed coordinator to help oversee implementation. The grant will also cover a selected number of the recommended Best Management Practices (BMPs). Additional funding is needed to put more BMPs on the ground and ensure the long term success of them.

Monitoring success

Success of implementation activities will be determined through two separate but related activities: tracking the implementation and outcome of activities and BMPs listed in the plan, and monitoring water quality in Swift Camp Creek after implementation measures have begun.

The first set of monitoring tasks, tracking activity measures, would consist of documenting the planning, execution, and outcome of the various work items listed in the watershed management plan, e.g., environmental education programs, community clean-up days, installing recreation BMPs, and repairing septic systems. These actions are absolutely critical for building awareness of water quality issues in the Red River Watershed, increasing understanding of the technical aspects of recommended management practices, building support for BMP implementation, and providing overall support for water quality improvement.

The second set of monitoring tasks would involve documenting changes in water quality in the watershed. It will be up to the KDOW, the Watershed Coordinator, and the Daniel Boone National Forest project staff to craft a post-implementation monitoring plan for the subwatersheds where BMPs are implemented. At a minimum, this will involve monitoring *E. coli* in Swift Camp Creek. The success monitoring plan will address the impairments identified in Chapters 2- 4. The monitoring plan will be designed to monitor for parameters targeted by BMPs for each area/site. Sampling will begin soon after BMPs have been implemented for a sufficient time period. The Watershed Coordinator will document progress of implementation activities (such as with an excel spreadsheet) to keep track of what was done, where, when, by whom, costs, observations, etc. (e.g. if it's installing exclusion fencing, some info you would want to track would be how many miles of creek are protected? How many cattle have been fenced out? Is it on a trib or main stem?) Through the process of continuous evaluation, it will be determined if activities are addressing enough BMPs and in the right places to make a difference in the identified issues. If activities are proving less effective than anticipated, activities will be re-considered and modified.

Evaluating and updating your plan

Watershed planning is an iterative process. The first draft of this watershed plan was started in 2012 and completed 2015. It is expected that some of the information in the plan will need updating. Stakeholders and project partners will likely change, data will be added, land uses may change, local priorities may shift, and restoration efforts and BMPs may improve water quality and habitat conditions. The Watershed Coordinator and the Watershed Team may update the plan near the conclusion of the next Kentucky Division of Water 319 grant.

Conclusions

As part of the process of creating this watershed plan, public meetings were held in Wolfe and Menifee Counties, numerous road-side and creek-side cleanups were held, various other educational events have taken place, and recreation BMPs were installed. It is the sincere hope of the project partners involved that these important efforts will continue as the community works toward a cleaner, safer watershed.

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Appendix A: Kentucky River Watershed Watch data for Red River sites

New Site ID#	Sample ID #	Stream Name	Site Location	County	11 Digit HUC ID	Latitude (dec. deg.)	Longitude (dec. deg.)
745	K06	Upper Red Rv	Big Branch canoe launch, at the mouth	Wolfe	5100204120	37.80204	-83.4842
812	K74	Swift Camp Cr	At Swift Camp Creek Camp	Wolfe	5100204120	37.81748	-83.57722
900	K169	Gladie Cr	Apprx 300-500 yds upstream mouth	Menifee	5100204120	37.835878	-83.609371
901	K170	Red Rv	From Hwy 715 to Hwy 77	Wolfe	5100204120	37.850000	-83.720000
902	K171	Clifty Cr	Apprx 300-500 yds upstream mouth	Powell	5100204120	37.830000	-83.540000
903	K172	Swift Camp Cr	Between Castle Arch and Sky Bridge	Wolfe	5100204120	37.815558	-83.577052
1082	K413	Martins Fork	At Fletcher's ridge	Menifee	5100204120	37.8687	-83.6375
1083	K414	Powell's Branch	at Hwy 77	Menifee	5100204120	37.9087	-83.5751
1086	K417	Red River	At the John Swift Campground	Powell	5100204120	37.8204	-83.5734

Site 745, K006 – Upper Red River, Big Branch Canoe Launch at mouth

krww_id	sample_date	analyte_group	analyte	results	units
K006	18-Sep-99	Metals	Aluminum	0.19	mg/L
K006	18-Sep-99	Metals	Antimony	0	mg/L
K006	18-Sep-99	Metals	Barium	0.03	mg/L
K006	18-Sep-99	Metals	Beryllium	0.001	mg/L
K006	18-Sep-99	Metals	Boron	0.09	mg/L
K006	18-Sep-99	Metals	Calcium	17.28	mg/L
K006	18-Sep-99	Metals	Chromium	0.04	mg/L
K006	18-Sep-99	Metals	Cobalt	0.005	mg/L
K006	18-Sep-99	Metals	Copper	0	mg/L
K006	18-Sep-99	Metals	Iron	0.15	mg/L
K006	18-Sep-99	Metals	Lead	0	mg/L
K006	18-Sep-99	Metals	Lithium	0	mg/L
K006	18-Sep-99	Metals	Magnesium	9.56	mg/L

K006	18-Sep-99	Metals	Manganese	0.15	mg/L
K006	18-Sep-99	Metals	Potassium	3.41	mg/L
K006	18-Sep-99	Metals	Selenium	0	mg/L
K006	18-Sep-99	Metals	Silicon	0.8	mg/L
K006	18-Sep-99	Metals	Sodium	4.36	mg/L
K006	18-Sep-99	Metals	Strontium	0.06	mg/L
K006	18-Sep-99	Metals	Sulfur	12.45	mg/L
K006	18-Sep-99	Metals	Thallium	0	mg/L
K006	18-Sep-99	Metals	Vanadium	0	mg/L
K006	18-Sep-99	Metals	Zinc	0.009	mg/L
K006	18-Sep-99	Nutrients	Ammonia(NH3)	0	mg/L
K006	10-Sep-00	Nutrients	Ammonia(NH3)	0	mg/L
K006	18-Sep-99	Nutrients	Ammonia(NH3-N)	0	mg/L
K006	10-Sep-00	Nutrients	Ammonia(NH3-N)	0	mg/L
K006	18-Sep-99	Nutrients	Nitrate(NO3)	0.2	mg/L
K006	10-Sep-00	Nutrients	Nitrate(NO3)	0.9	mg/L
K006	18-Sep-99	Nutrients	Nitrate(NO3-N)	0.04	mg/L
K006	10-Sep-00	Nutrients	Nitrate(NO3-N)	0.2	mg/L
K006	18-Sep-99	Nutrients	Total Nitrogen	0	mg/L
K006	10-Sep-00	Nutrients	Total Nitrogen	0	mg/L
K006	18-Sep-99	Nutrients	Total Nitrogen	0.04	mg/L
K006	10-Sep-00	Nutrients	Total Nitrogen	0.2	mg/L
K006	18-Sep-99	Nutrients	Total Nitrogen	0	mg/L
K006	10-Sep-00	Nutrients	Total Nitrogen	0	mg/L
K006	18-Sep-99	Nutrients	Total Nitrogen	0.043	mg/L
K006	10-Sep-00	Nutrients	Total Nitrogen	0.009	mg/L
K006	18-Sep-99	Nutrients	Total Nitrogen	0.014	mg/L
K006	10-Sep-00	Nutrients	Total Nitrogen	0.003	mg/L
K006	18-Sep-99	Nutrients	Total Phosphorus	0.07	mg/L
K006	10-Sep-00	Nutrients	Total Phosphorus	0	mg/L
K006	18-Sep-99	Nutrients	Sulfate	71.3	mg/L
K006	10-Sep-00	Nutrients	Sulfate	49.5	mg/L
K006	07-May-99	Pesticides Herbicides	2,4-D	0	ug/L
K006	07-May-99	Pesticides Herbicides	Chlorpyrifos	0	ug/L
K006	07-May-99	Pesticides Herbicides	Triazines	0	ug/L
K006	16-Jul-99	Physical Chemical	Dissolved Oxygen	6.25	mg/L
K006	16-Jul-99	Physical Chemical	pH	7.4	
K006	18-Sep-99	Physical Chemical	Alkalinity	35	mg/L CaCO3
K006	10-Sep-00	Physical Chemical	Alkalinity	57	mg/L
K006	18-Sep-99	Physical Chemical	Chlorides	5.6	mg/L
K006	10-Sep-00	Physical Chemical	Chlorides	7.4	mg/L
K006	18-Sep-99	Physical Chemical	Conductivity	227	(uS/cm)
K006	10-Sep-00	Physical Chemical	Conductivity	237	(uS/cm)
K006	18-Sep-99	Physical Chemical	Total Suspended Solids	4	mg/L
K006	10-Sep-00	Physical Chemical	Total Suspended Solids	0	mg/L
K006	18-Sep-99	Physical Chemical	Total Hardness	90	mg/L
K006	10-Sep-00	Physical Chemical	Total Hardness	104	mg/L
K006	18-Sep-99	Physical Chemical	Total Organic Carbon	3.9	mg/L

K006	10-Sep-00	Physical Chemical	Total Organic Carbon	2.8	mg/L
K006	16-Sep-06	Physical Chemical	Flow Conditions	2	
K006	09-Jul-05	Physical Chemical	Flow Conditions	2	
K006	29-Jul-06	Physical Chemical	Flow Conditions	2	
K006	30-Jul-05	Physical Chemical	Flow Conditions	2	
K006	17-Sep-05	Physical Chemical	Dissolved Oxygen	5	mg/L
K006	09-Jul-05	Physical Chemical	Dissolved Oxygen	6	mg/L
K006	29-Jul-06	Physical Chemical	Dissolved Oxygen	6	mg/L
K006	16-Sep-06	Physical Chemical	Dissolved Oxygen	6.8	mg/L
K006	17-Sep-05	Physical Chemical	pH	7	
K006	16-Sep-06	Physical Chemical	pH	7.5	
K006	09-Jul-05	Physical Chemical	pH	7.5	
K006	29-Jul-06	Physical Chemical	pH	7.5	
K006	16-Sep-06	Physical Chemical	Total Suspended Solids	8	mg/L
K006	17-Sep-05	Physical Chemical	Chlorides	11.5	mg/L
K006	17-Sep-05	Physical Chemical	Conductivity	11.5	(uS/cm)
K006	16-Sep-06	Physical Chemical	Chlorides	12.3	mg/L
K006	17-Sep-05	Physical Chemical	Total Suspended Solids	16	mg/L
K006	16-Sep-06	Physical Chemical	Water Temperature	18	°C
K006	17-Sep-05	Physical Chemical	Water Temperature	20	°C
K006	09-Jul-05	Physical Chemical	Water Temperature	20	°C
K006	29-Jul-06	Physical Chemical	Water Temperature	24	°C
K006	16-Sep-06	Physical Chemical	Alkalinity	61	mg/L CaCO3
K006	17-Sep-05	Physical Chemical	Alkalinity	61	mg/L CaCO3
K006	16-Sep-06	Physical Chemical	Conductivity	271	(uS/cm)
K006	29-Jul-06	Physical Chemical	Conductivity	444	(uS/cm)
K006	16-Jul-99	Synoptic Fecal	Fecal Coliform count	10	cfu/100 mL
K006	29-Jul-00	Synoptic Fecal	Fecal Coliform count	270	cfu/100 mL
K006	16-Jul-99	Synoptic Fecal	Fecal Strep Count	340	cfu/100 mL
K006	29-Jul-00	Synoptic Fecal	Fecal Strep Count	600	cfu/100 mL
K006	16-Jul-99	Synoptic Fecal	Fecal/Strep Ratio	0.029	
K006	29-Jul-00	Synoptic Fecal	Fecal/Strep Ratio	0.45	
K006	29-Jul-06	Follow Up Fecal	AC/TC Ratio	51.51515	
K006	29-Jul-06	Follow Up Fecal	Atypical Coliform Count	17000	cfu/100 mL
K006	29-Jul-06	Follow Up Fecal	E coli Count	31	cfu/100 mL
K006	29-Jul-06	Follow Up Fecal	Total Coliform Count	330	cfu/100 mL
K006	14-Sep-08	Physical Chemical	Alkalinity	87	mg/L CaCO3
K006	14-Sep-08	Physical Chemical	Chloride	13.2	mg/L
K006	14-Sep-08	Physical Chemical	Conductivity	281	(uS/cm)
K006	14-Sep-08	Physical Chemical	Total Suspended Solids	15	mg/L
K006	14-Sep-08	Nutrients	Nitrate (No3-N)	0.02	mg/L

K006	14-Sep-08	Nutrients	Total Nitrogen	0.15	mg/L
K006	14-Sep-08	Nutrients	Total Recoverable Phosphorus	0.06	mg/L
K006	14-Sep-08	Nutrients	Sulfate	43.8	mg/L
K006	14-Sep-08	Metals	Barium	0.03	mg/L
K006	14-Sep-08	Metals	Beryllium	0.001	mg/L
K006	14-Sep-08	Metals	Chromium	0.024	mg/L
K006	14-Sep-08	Metals	Copper	0.005	mg/L
K006	14-Sep-08	Metals	Iron	0.25	mg/L
K006	14-Sep-08	Metals	Manganese	0.62	mg/L
K006	14-Sep-08	Metals	Nickel	0.002	mg/L
K006	14-Sep-08	Metals	Zinc	0.002	mg/L
K006	12-Jul-08	Synoptic Fecal	E coli	199	cfu/100 mL
K006	14-Sep-08	Physical Chemical	Dissolved Oxygen	3.5	mg/L
K006	14-Sep-08	Physical Chemical	pH	7	
K006	14-Sep-08	Physical Chemical	Flow Conditions	1	
K006	14-Sep-08	Physical Chemical	Chlorides	13.2	mg/L
K006	14-Sep-08	Nutrients	Nitrate(NO3)	0.1	mg/L
K006	14-Sep-08	Metals	Aluminum	0.13	mg/L
K006	14-Sep-08	Metals	Antimony	0.012	mg/L
K006	14-Sep-08	Metals	Arsenic	0.014	mg/L
K006	14-Sep-08	Metals	Boron	0.03	mg/L
K006	14-Sep-08	Metals	Cadmium	0.001	mg/L
K006	14-Sep-08	Metals	Cobalt	0.001	mg/L
K006	14-Sep-08	Metals	Gold	0.034	mg/L
K006	14-Sep-08	Metals	Lithium	0.008	mg/L
K006	14-Sep-08	Metals	Phosphorus	0.03	mg/L
K006	14-Sep-08	Metals	Selenium	0.011	mg/L
K006	14-Sep-08	Metals	Sodium	8.12	mg/L
K006	14-Sep-08	Metals	Thallium	0.041	mg/L
K006	14-Sep-08	Metals	Vanadium	0.008	mg/L
K006	14-Sep-08	Metals	Calcium	27	mg/L
K006	14-Sep-08	Metals	Lead	0.01	mg/L
K006	14-Sep-08	Metals	Magnesium	12.6	mg/L
K006	14-Sep-08	Metals	Potassium	4.41	mg/L
K006	14-Sep-08	Metals	Silicon	1.04	mg/L
K006	14-Sep-08	Metals	Silver	0.003	mg/L
K006	14-Sep-08	Metals	Strontium	0.08	mg/L
K006	14-Sep-08	Metals	Sulfur	14.8	mg/L
K006	14-Sep-08	Metals	Tin	0.012	mg/L

Site 812, K074-Swift Camp Creek, at Swift Camp Creek Camp

krww_id	sample_date	sample_year	analyte_group	analyte	results	units
K074	19-Sep-99	1999	Metals	Aluminum	0.21	mg/L
K074	19-Sep-99	1999	Metals	Antimony	0	mg/L
K074	19-Sep-99	1999	Metals	Barium	0.02	mg/L

K074	19-Sep-99	1999	Metals	Beryllium	0	mg/L
K074	19-Sep-99	1999	Metals	Boron	0.13	mg/L
K074	19-Sep-99	1999	Metals	Calcium	12.24	mg/L
K074	19-Sep-99	1999	Metals	Chromium	0.02	mg/L
K074	19-Sep-99	1999	Metals	Cobalt	0.002	mg/L
K074	19-Sep-99	1999	Metals	Copper	0	mg/L
K074	19-Sep-99	1999	Metals	Iron	0.16	mg/L
K074	19-Sep-99	1999	Metals	Lead	0	mg/L
K074	19-Sep-99	1999	Metals	Lithium	0	mg/L
K074	19-Sep-99	1999	Metals	Magnesium	3.51	mg/L
K074	19-Sep-99	1999	Metals	Manganese	0.01	mg/L
K074	19-Sep-99	1999	Metals	Potassium	2.82	mg/L
K074	19-Sep-99	1999	Metals	Selenium	0	mg/L
K074	19-Sep-99	1999	Metals	Silicon	1.17	mg/L
K074	19-Sep-99	1999	Metals	Sodium	9.43	mg/L
K074	19-Sep-99	1999	Metals	Strontium	0.4	mg/L
K074	19-Sep-99	1999	Metals	Sulfur	2.66	mg/L
K074	19-Sep-99	1999	Metals	Thallium	0	mg/L
K074	19-Sep-99	1999	Metals	Vanadium	0	mg/L
K074	19-Sep-99	1999	Metals	Zinc	0	mg/L
K074	10-Sep-00	2000	Nutrients	Ammonia(NH3)	0	mg/L
K074	19-Sep-99	1999	Nutrients	Ammonia(NH3)	0	mg/L
K074	10-Sep-00	2000	Nutrients	Ammonia(NH3-N)	0	mg/L
K074	19-Sep-99	1999	Nutrients	Ammonia(NH3-N)	0	mg/L
K074	23-Sep-01	2001	Nutrients	Ammonia(NH3-N)	0	mg/L
K074	10-Sep-00	2000	Nutrients	Nitrate(NO3)	0.3	mg/L
K074	19-Sep-99	1999	Nutrients	Nitrate(NO3)	0.1	mg/L
K074	19-Sep-02	2002	Nutrients	Nitrate(NO3-N)	0.02	mg/L
K074	10-Sep-00	2000	Nutrients	Nitrate(NO3-N)	0.07	mg/L
K074	19-Sep-99	1999	Nutrients	Nitrate(NO3-N)	0.02	mg/L
K074	23-Sep-01	2001	Nutrients	Nitrate(NO3-N)	0.02	mg/L
K074	10-Sep-00	2000	Nutrients	Total Nitrogen	0	mg/L
K074	19-Sep-99	1999	Nutrients	Total Nitrogen	0	mg/L
K074	19-Sep-02	2002	Nutrients	Total Nitrogen	0	mg/L
K074	10-Sep-00	2000	Nutrients	Total Nitrogen	0.07	mg/L
K074	19-Sep-99	1999	Nutrients	Total Nitrogen	0.02	mg/L
K074	23-Sep-01	2001	Nutrients	Total Nitrogen	0.02	mg/L
K074	10-Sep-00	2000	Nutrients	Total Nitrogen	0	mg/L
K074	19-Sep-99	1999	Nutrients	Total Nitrogen	0	mg/L
K074	23-Sep-01	2001	Nutrients	Total Nitrogen	0	mg/L
K074	10-Sep-00	2000	Nutrients	Total Nitrogen	0.021	mg/L
K074	19-Sep-99	1999	Nutrients	Total Nitrogen	0.014	mg/L
K074	10-Sep-00	2000	Nutrients	Total Nitrogen	0.007	mg/L
K074	19-Sep-99	1999	Nutrients	Total Nitrogen	0.005	mg/L
K074	10-Sep-00	2000	Nutrients	Total Phosphorus	0	mg/L
K074	19-Sep-99	1999	Nutrients	Total Phosphorus	0	mg/L
K074	23-Sep-01	2001	Nutrients	Total Phosphorus	0.04	mg/L
K074	19-Sep-02	2002	Nutrients	Sulfate	10.2	mg/L

K074	10-Sep-00	2000	Nutrients	Sulfate	11	mg/L
K074	19-Sep-99	1999	Nutrients	Sulfate	10.8	mg/L
K074	23-Sep-01	2001	Nutrients	Sulfate	9.7	mg/L
K074	07-May-99	1999	Pesticides Herbicides	2,4-D	0	ug/L
K074	07-May-99	1999	Pesticides Herbicides	Chlorpyrifos	0	ug/L
K074	07-May-99	1999	Pesticides Herbicides	Triazines	0	ug/L
K074	07-May-99	1999	Physical Chemical	Dissolved Oxygen	8.1	mg/L
K074	19-Sep-99	1999	Physical Chemical	Dissolved Oxygen	9.6	mg/L
K074	07-May-99	1999	Physical Chemical	pH	7.6	
K074	16-Jul-99	1999	Physical Chemical	pH	7.5	
K074	19-Sep-99	1999	Physical Chemical	pH	7.5	
K074	19-Sep-02	2002	Physical Chemical	pH	7.2	
K074	19-Sep-99	1999	Physical Chemical	Alkalinity	47	mg/L CaCO3
K074	10-Sep-00	2000	Physical Chemical	Alkalinity	42	mg/L CaCO3
K074	23-Sep-01	2001	Physical Chemical	Alkalinity	53	mg/L CaCO3
K074	19-Sep-02	2002	Physical Chemical	Alkalinity	44	mg/L CaCO3
K074	19-Sep-99	1999	Physical Chemical	Chlorides	19.5	mg/L
K074	10-Sep-00	2000	Physical Chemical	Chlorides	10.4	mg/L
K074	23-Sep-01	2001	Physical Chemical	Chlorides	8.7	mg/L
K074	19-Sep-02	2002	Physical Chemical	Chlorides	11.5	mg/L
K074	19-Sep-99	1999	Physical Chemical	Conductivity	173	(uS/cm)
K074	10-Sep-00	2000	Physical Chemical	Conductivity	137	(uS/cm)
K074	23-Sep-01	2001	Physical Chemical	Conductivity	156	(uS/cm)
K074	19-Sep-02	2002	Physical Chemical	Conductivity	145	(uS/cm)
K074	19-Sep-99	1999	Physical Chemical	Total Suspended Solids	0	mg/L
K074	10-Sep-00	2000	Physical Chemical	Total Suspended Solids	0	mg/L
K074	23-Sep-01	2001	Physical Chemical	Total Suspended Solids	0	mg/L
K074	19-Sep-02	2002	Physical Chemical	Total Suspended Solids	0	mg/L

K074	19-Sep-99	1999	Physical Chemical	Total Hardness	73	mg/L
K074	10-Sep-00	2000	Physical Chemical	Total Hardness	54	mg/L
K074	23-Sep-01	2001	Physical Chemical	Total Hardness	76	mg/L
K074	19-Sep-02	2002	Physical Chemical	Total Hardness	54	mg/L
K074	19-Sep-99	1999	Physical Chemical	Total Organic Carbon	2	mg/L
K074	10-Sep-00	2000	Physical Chemical	Total Organic Carbon	2.2	mg/L
K074	23-Sep-01	2001	Physical Chemical	Total Organic Carbon	3.49	mg/L
K074	14-Jul-03	2003	Synoptic Fecal	Fecal Coliform count	60	cfu/100 mL
K074	16-Jul-99	1999	Synoptic Fecal	Fecal Coliform count	10	cfu/100 mL
K074	29-Jul-00	2000	Synoptic Fecal	Fecal Coliform count	250	cfu/100 mL
K074	16-Jul-99	1999	Synoptic Fecal	Fecal Strep Count	300	cfu/100 mL
K074	29-Jul-00	2000	Synoptic Fecal	Fecal Strep Count	1100	cfu/100 mL
K074	16-Jul-99	1999	Synoptic Fecal	Fecal/Strep Ratio	0.033	
K074	29-Jul-00	2000	Synoptic Fecal	Fecal/Strep Ratio	0.227	

Site 900, Sample ID K169 - Gladie Creek, 300-500 yards upstream of mouth

krww_id	sample_date	sample_year	analyte_group	analyte	results	units
K169	23-Sep-01	2001	Metals	Aluminum	0.3	mg/L
K169	23-Sep-01	2001	Metals	Antimony	0	mg/L
K169	23-Sep-01	2001	Metals	Arsenic	0	mg/L
K169	23-Sep-01	2001	Metals	Barium	0.03	mg/L
K169	23-Sep-01	2001	Metals	Beryllium	0	mg/L
K169	23-Sep-01	2001	Metals	Boron	0.07	mg/L
K169	23-Sep-01	2001	Metals	Cadmium	0	mg/L
K169	23-Sep-01	2001	Metals	Calcium	21.2	mg/L
K169	23-Sep-01	2001	Metals	Chromium	0	mg/L
K169	23-Sep-01	2001	Metals	Cobalt	0.009	mg/L
K169	23-Sep-01	2001	Metals	Copper	0	mg/L
K169	23-Sep-01	2001	Metals	Gold	0	mg/L
K169	23-Sep-01	2001	Metals	Iron	0.1	mg/L
K169	23-Sep-01	2001	Metals	Lead	0	mg/L
K169	23-Sep-01	2001	Metals	Magnesium	2.17	mg/L
K169	23-Sep-01	2001	Metals	Manganese	0.02	mg/L
K169	23-Sep-01	2001	Metals	Nickel	0	mg/L
K169	23-Sep-01	2001	Metals	Potassium	1.84	mg/L
K169	23-Sep-01	2001	Metals	Selenium	0	mg/L
K169	23-Sep-01	2001	Metals	Silicon	2.13	mg/L
K169	23-Sep-01	2001	Metals	Silver	0	mg/L

K169	23-Sep-01	2001	Metals	Sodium	2.79	mg/L
K169	23-Sep-01	2001	Metals	Strontium	0.07	mg/L
K169	23-Sep-01	2001	Metals	Sulfur	2.39	mg/L
K169	23-Sep-01	2001	Metals	Thallium	0	mg/L
K169	23-Sep-01	2001	Metals	Tin	0	mg/L
K169	23-Sep-01	2001	Metals	Vanadium	0	mg/L
K169	23-Sep-01	2001	Metals	Zinc	0	mg/L
K169	23-Sep-01	2001	Nutrients	Ammonia(NH3-N)	0	mg/L
K169	23-Sep-01	2001	Nutrients	Nitrate(NO3-N)	0.04	mg/L
K169	23-Sep-01	2001	Nutrients	Total Nitrogen	0.04	mg/L
K169	23-Sep-01	2001	Nutrients	Total Nitrogen	0	mg/L
K169	23-Sep-01	2001	Nutrients	Sulfate	5.4	mg/L
K169	26-May-02	2001	Pesticides Herbicides	Alachlor	0	ug/L
K169	26-May-02	2001	Pesticides Herbicides	Metolachlor	0	ug/L
K169	26-May-02	2001	Pesticides Herbicides	2,4-D	0	ug/L
K169	26-May-02	2001	Pesticides Herbicides	Chlorpyrifos	0	ug/L
K169	26-May-02	2001	Pesticides Herbicides	Triazines	0	ug/L
K169	23-Sep-01	2001	Physical Chemical	Dissolved Oxygen	7.4	mg/L
K169	23-Sep-01	2001	Physical Chemical	pH	7.2	
K169	23-Sep-01	2001	Physical Chemical	Alkalinity	92	mg/L CaCO3
K169	23-Sep-01	2001	Physical Chemical	Chlorides	4.2	mg/L
K169	23-Sep-01	2001	Physical Chemical	Conductivity	167	(uS/cm)
K169	23-Sep-01	2001	Physical Chemical	Total Suspended Solids	0	mg/L
K169	23-Sep-01	2001	Physical Chemical	Total Hardness	120	mg/L
K169	23-Sep-01	2001	Physical Chemical	Total Organic Carbon	1.06	mg/L
K169	17-Sep-05	2005	Physical Chemical	Total Suspended Solids	1.5	mg/L
K169	15-Sep-06	2006	Physical Chemical	Total Suspended Solids	1.5	mg/L
K169	11-Jul-05	2005	Physical Chemical	Flow Conditions	2	
K169	29-Jul-06	2006	Physical Chemical	Flow Conditions	2	
K169	15-Sep-06	2006	Physical Chemical	Flow Conditions	3	
K169	07-Jul-06	2006	Physical Chemical	Flow Conditions	4	
K169	15-Sep-06	2006	Physical Chemical	Chlorides	4.7	mg/L

K169	17-Sep-05	2005	Physical Chemical	Chlorides	5.6	mg/L
K169	15-Sep-06	2006	Physical Chemical	pH	7.2	
K169	15-Sep-06	2006	Physical Chemical	Water Temperature	19	°C
K169	17-Sep-05	2005	Physical Chemical	Alkalinity	74	mg/L CaCO3
K169	15-Sep-06	2006	Physical Chemical	Alkalinity	76	mg/L CaCO3
K169	17-Sep-05	2005	Physical Chemical	Conductivity	173	(uS/cm)
K169	15-Sep-06	2006	Physical Chemical	Conductivity	176	(uS/cm)
K169	07-Jul-06	2006	Physical Chemical	Conductivity	360	(uS/cm)
K169	29-Jul-06	2006	Physical Chemical	Conductivity	362	(uS/cm)
K169	13-Jul-02	2002	Synoptic Fecal	Fecal Coliform count	270	cfu/100 mL
K169	17-Jul-01	2001	Synoptic Fecal	Fecal Coliform count	130	cfu/100 mL
K169	29-Jul-06	2006	Follow Up Fecal	AC/TC Ratio	79.16667	
K169	29-Jul-06	2006	Follow Up Fecal	Atypical Coliform Count	19000	cfu/100 mL
K169	29-Jul-06	2006	Follow Up Fecal	E coli Count	148	cfu/100 mL
K169	29-Jul-06	2006	Follow Up Fecal	Total Coliform Count	240	cfu/100 mL
K169	11-Jul-05	2005	Synoptic Fecal	Fecal Coliform count	13	cfu/100 mL
K169	07-Jul-06	2006	Synoptic Fecal	E coli Count	393	cfu/100 mL

Site 901, K170 - Red River, From Hwy 715 to Hwy 77

krww_id	sample_date	sample_year	analyte_group	analyte	results	units
K170	23-Sep-01	2001	Metals	Aluminum	0.28	mg/L
K170	23-Sep-01	2001	Metals	Antimony	0	mg/L
K170	23-Sep-01	2001	Metals	Arsenic	0	mg/L
K170	23-Sep-01	2001	Metals	Barium	0.03	mg/L
K170	23-Sep-01	2001	Metals	Beryllium	0	mg/L
K170	23-Sep-01	2001	Metals	Boron	0.08	mg/L
K170	23-Sep-01	2001	Metals	Cadmium	0	mg/L
K170	23-Sep-01	2001	Metals	Calcium	20.1	mg/L
K170	23-Sep-01	2001	Metals	Chromium	0	mg/L
K170	23-Sep-01	2001	Metals	Cobalt	0	mg/L
K170	23-Sep-01	2001	Metals	Copper	0	mg/L
K170	23-Sep-01	2001	Metals	Gold	0	mg/L
K170	23-Sep-01	2001	Metals	Iron	0.17	mg/L
K170	23-Sep-01	2001	Metals	Lead	0	mg/L
K170	23-Sep-01	2001	Metals	Lithium	0.07	mg/L

K170	23-Sep-01	2001	Metals	Magnesium	6.9	mg/L
K170	23-Sep-01	2001	Metals	Manganese	0.024	mg/L
K170	23-Sep-01	2001	Metals	Nickel	0	mg/L
K170	23-Sep-01	2001	Metals	Potassium	2.41	mg/L
K170	23-Sep-01	2001	Metals	Selenium	0	mg/L
K170	23-Sep-01	2001	Metals	Silicon	1.45	mg/L
K170	23-Sep-01	2001	Metals	Silver	0	mg/L
K170	23-Sep-01	2001	Metals	Sodium	4.48	mg/L
K170	23-Sep-01	2001	Metals	Strontium	0.09	mg/L
K170	23-Sep-01	2001	Metals	Sulfur	14.6	mg/L
K170	23-Sep-01	2001	Metals	Thallium	0	mg/L
K170	23-Sep-01	2001	Metals	Tin	0	mg/L
K170	23-Sep-01	2001	Metals	Vanadium	0	mg/L
K170	23-Sep-01	2001	Metals	Zinc	0	mg/L
K170	23-Sep-01	2001	Nutrients	Ammonia(NH3-N)	0	mg/L
K170	23-Sep-01	2001	Nutrients	Nitrate(NO3-N)	0.04	mg/L
K170	23-Sep-01	2001	Nutrients	Total Nitrogen	0.04	mg/L
K170	23-Sep-01	2001	Nutrients	Total Nitrogen	0	mg/L
K170	23-Sep-01	2001	Nutrients	Total Phosphorus	0.02	mg/L
K170	23-Sep-01	2001	Nutrients	Sulfate	44.2	mg/L
K170	23-Sep-01	2001	Physical Chemical	Dissolved Oxygen	9	mg/L
K170	23-Sep-01	2001	Physical Chemical	pH	7.2	
K170	13-Jul-02	2002	Physical Chemical	pH	7.4	
K170	23-Sep-01	2001	Physical Chemical	Alkalinity	69	mg/L CaCO3
K170	23-Sep-01	2001	Physical Chemical	Chlorides	5.5	mg/L
K170	23-Sep-01	2001	Physical Chemical	Conductivity	222	(uS/cm)
K170	23-Sep-01	2001	Physical Chemical	Total Suspended Solids	0	mg/L
K170	23-Sep-01	2001	Physical Chemical	Total Hardness	132	mg/L
K170	23-Sep-01	2001	Physical Chemical	Total Organic Carbon	2.22	mg/L
K170	13-Jul-02	2002	Synoptic Fecal	Fecal Coliform count	190	cfu/100 mL
K170	17-Jul-01	2001	Synoptic Fecal	Fecal Coliform count	120	cfu/100 mL

Site 902, K171 - Clifty Creek, Apprx 300-500 yds upstream mouth

krww_id	sample_date	sample_year	analyte_group	analyte	results	units
K171	23-Sep-01	2001	Metals	Aluminum	0.34	mg/L
K171	23-Sep-01	2001	Metals	Antimony	0	mg/L
K171	23-Sep-01	2001	Metals	Arsenic	0	mg/L
K171	23-Sep-01	2001	Metals	Barium	0.03	mg/L
K171	23-Sep-01	2001	Metals	Beryllium	0	mg/L
K171	23-Sep-01	2001	Metals	Boron	0.1	mg/L
K171	23-Sep-01	2001	Metals	Cadmium	0	mg/L
K171	23-Sep-01	2001	Metals	Calcium	17.8	mg/L
K171	23-Sep-01	2001	Metals	Chromium	0	mg/L
K171	23-Sep-01	2001	Metals	Cobalt	0	mg/L

K171	23-Sep-01	2001	Metals	Copper	0	mg/L
K171	23-Sep-01	2001	Metals	Gold	0	mg/L
K171	23-Sep-01	2001	Metals	Iron	0.28	mg/L
K171	23-Sep-01	2001	Metals	Lead	0	mg/L
K171	23-Sep-01	2001	Metals	Magnesium	4.73	mg/L
K171	23-Sep-01	2001	Metals	Manganese	0.049	mg/L
K171	23-Sep-01	2001	Metals	Nickel	0	mg/L
K171	23-Sep-01	2001	Metals	Potassium	2.09	mg/L
K171	23-Sep-01	2001	Metals	Selenium	0	mg/L
K171	23-Sep-01	2001	Metals	Silicon	1.68	mg/L
K171	23-Sep-01	2001	Metals	Silver	0	mg/L
K171	23-Sep-01	2001	Metals	Sodium	4.25	mg/L
K171	23-Sep-01	2001	Metals	Strontium	0.06	mg/L
K171	23-Sep-01	2001	Metals	Sulfur	9.46	mg/L
K171	23-Sep-01	2001	Metals	Thallium	0	mg/L
K171	23-Sep-01	2001	Metals	Tin	0	mg/L
K171	23-Sep-01	2001	Metals	Vanadium	0	mg/L
K171	23-Sep-01	2001	Metals	Zinc	0	mg/L
K171	23-Sep-01	2001	Nutrients	Ammonia(NH3-N)	0	mg/L
K171	23-Sep-01	2001	Nutrients	Nitrate(NO3-N)	0.02	mg/L
K171	23-Sep-01	2001	Nutrients	Total Nitrogen	0.02	mg/L
K171	23-Sep-01	2001	Nutrients	Total Nitrogen	0	mg/L
K171	23-Sep-01	2001	Nutrients	Total Phosphorus	0.02	mg/L
K171	23-Sep-01	2001	Nutrients	Sulfate	26	mg/L
K171	23-Sep-01	2001	Physical Chemical	Dissolved Oxygen	7.4	mg/L
K171	23-Sep-01	2001	Physical Chemical	pH	7.1	
K171	23-Sep-01	2001	Physical Chemical	Alkalinity	71	mg/L CaCO3
K171	23-Sep-01	2001	Physical Chemical	Chlorides	6.1	mg/L
K171	23-Sep-01	2001	Physical Chemical	Conductivity	189	(uS/cm)
K171	23-Sep-01	2001	Physical Chemical	Total Suspended Solids	0	mg/L
K171	23-Sep-01	2001	Physical Chemical	Total Hardness	92	mg/L
K171	23-Sep-01	2001	Physical Chemical	Total Organic Carbon	2.17	mg/L
K171	13-Jul-02	2002	Synoptic Fecal	Fecal Coliform count	1900	cfu/100 mL
K171	17-Jul-01	2001	Synoptic Fecal	Fecal Coliform count	230	cfu/100 mL

Site 1082, K413 - Martin's Fork at Fletcher's Ridge

krww_id	sample_date	sample_year	analyte_group	analyte	results	units
K413	17-Sep-05	2005	Metals	Beryllium	0.0005	mg/L
K413	17-Sep-05	2005	Metals	Zinc	0.0015	mg/L
K413	17-Sep-05	2005	Metals	Cobalt	0.002	mg/L
K413	17-Sep-05	2005	Metals	Nickel	0.0025	mg/L
K413	17-Sep-05	2005	Metals	Cadmium	0.004	mg/L
K413	17-Sep-05	2005	Metals	Copper	0.0045	mg/L
K413	17-Sep-05	2005	Metals	Lithium	0.005	mg/L

K413	17-Sep-05	2005	Metals	Chromium	0.0075	mg/L
K413	17-Sep-05	2005	Metals	Phosphorus	0.0075	mg/L
K413	17-Sep-05	2005	Metals	Selenium	0.008	mg/L
K413	17-Sep-05	2005	Metals	Silver	0.0085	mg/L
K413	17-Sep-05	2005	Metals	Vanadium	0.0095	mg/L
K413	17-Sep-05	2005	Metals	Lead	0.01	mg/L
K413	17-Sep-05	2005	Metals	Manganese	0.01	mg/L
K413	17-Sep-05	2005	Metals	Arsenic	0.0105	mg/L
K413	17-Sep-05	2005	Metals	Gold	0.011	mg/L
K413	17-Sep-05	2005	Metals	Strontium	0.0195	mg/L
K413	17-Sep-05	2005	Metals	Boron	0.02	mg/L
K413	17-Sep-05	2005	Metals	Antimony	0.025	mg/L
K413	17-Sep-05	2005	Metals	Thallium	0.0255	mg/L
K413	17-Sep-05	2005	Metals	Barium	0.03	mg/L
K413	30-May-05	2005	Pesticides Herbicides	Triazines	0.03	ug/L
K413	30-May-05	2005	Pesticides Herbicides	Metolachlor	0.04	ug/L
K413	17-Sep-05	2005	Metals	Tin	0.069	mg/L
K413	17-Sep-05	2005	Metals	Aluminum	0.13	mg/L
K413	17-Sep-05	2005	Metals	Iron	0.16	mg/L
K413	17-Sep-05	2005	Metals	Sulfur	1.16	mg/L
K413	15-Sep-06	2006	Physical Chemical	Chlorides	1.2	mg/L
K413	17-Sep-05	2005	Metals	Potassium	1.38	mg/L
K413	15-Sep-06	2006	Physical Chemical	Total Suspended Solids	1.5	mg/L
K413	11-Jul-05	2005	Physical Chemical	Flow Conditions	2	
K413	17-Sep-05	2005	Metals	Magnesium	2.65	mg/L
K413	15-Sep-06	2006	Physical Chemical	Flow Conditions	3	
K413	30-May-05	2005	Physical Chemical	Flow Conditions	3	
K413	17-Sep-05	2005	Metals	Sodium	3.22	mg/L
K413	17-Sep-05	2005	Physical Chemical	Chlorides	3.8	mg/L
K413	17-Sep-05	2005	Metals	Silicon	3.83	mg/L
K413	17-Sep-05	2005	Physical Chemical	Total Suspended Solids	6	mg/L
K413	15-Sep-06	2006	Physical Chemical	pH	6.8	mg/L
K413	17-Sep-05	2005	Metals	Calcium	11.2	mg/L
K413	15-Sep-06	2006	Physical Chemical	Water Temperature	20	°C
K413	15-Sep-06	2006	Physical Chemical	Alkalinity	27	mg/L CaCO3
K413	17-Sep-05	2005	Physical Chemical	Alkalinity	31	mg/L CaCO3
K413	15-Sep-06	2006	Physical Chemical	Conductivity	65	(uS/cm)

K413	17-Sep-05	2005	Physical Chemical	Conductivity	88	(uS/cm)
K413	11-Jul-05	2005	Synoptic Fecal	Fecal Coliform count	7	cfu/100 mL

Site 1083, K414 - Powell's Branch at Highway 77

krww_id	sample_date	sample_year	analyte_group	analyte	results	units
K414	17-Sep-05	2005	Metals	Beryllium	0.0005	mg/L
K414	17-Sep-05	2005	Metals	Zinc	0.0015	mg/L
K414	17-Sep-05	2005	Metals	Cobalt	0.002	mg/L
K414	17-Sep-05	2005	Metals	Nickel	0.0025	mg/L
K414	17-Sep-05	2005	Metals	Cadmium	0.004	mg/L
K414	17-Sep-05	2005	Metals	Lithium	0.004	mg/L
K414	17-Sep-05	2005	Metals	Copper	0.0045	mg/L
K414	17-Sep-05	2005	Metals	Chromium	0.0075	mg/L
K414	17-Sep-05	2005	Metals	Phosphorus	0.0075	mg/L
K414	17-Sep-05	2005	Metals	Selenium	0.008	mg/L
K414	17-Sep-05	2005	Metals	Silver	0.0085	mg/L
K414	17-Sep-05	2005	Metals	Vanadium	0.0095	mg/L
K414	17-Sep-05	2005	Metals	Boron	0.01	mg/L
K414	17-Sep-05	2005	Metals	Lead	0.01	mg/L
K414	17-Sep-05	2005	Metals	Arsenic	0.0105	mg/L
K414	17-Sep-05	2005	Metals	Gold	0.011	mg/L
K414	17-Sep-05	2005	Metals	Antimony	0.025	mg/L
K414	17-Sep-05	2005	Metals	Thallium	0.0255	mg/L
K414	30-May-05	2005	Pesticides Herbicides	Triazines	0.03	mg/L
K414	17-Sep-05	2005	Metals	Barium	0.04	mg/L
K414	17-Sep-05	2005	Metals	Manganese	0.04	mg/L
K414	30-May-05	2005	Pesticides Herbicides	Metolachlor	0.04	mg/L
K414	17-Sep-05	2005	Metals	Strontium	0.05	mg/L
K414	17-Sep-05	2005	Metals	Tin	0.069	mg/L
K414	17-Sep-05	2005	Metals	Aluminum	0.1	mg/L
K414	17-Sep-05	2005	Metals	Iron	0.14	mg/L
K414	17-Sep-05	2005	Physical Chemical	Total Suspended Solids	1.5	mg/L
K414	17-Sep-05	2005	Metals	Potassium	1.82	mg/L
K414	11-Jul-05	2005	Physical Chemical	Flow Conditions	2	
K414	17-Sep-05	2005	Metals	Silicon	2.23	mg/L
K414	17-Sep-05	2005	Metals	Sulfur	2.29	mg/L
K414	30-May-05	2005	Physical Chemical	Flow Conditions	3	
K414	17-Sep-05	2005	Metals	Sodium	3.56	mg/L
K414	17-Sep-05	2005	Physical Chemical	Chlorides	3.8	mg/L
K414	17-Sep-05	2005	Metals	Magnesium	4.35	mg/L
K414	17-Sep-05	2005	Metals	Calcium	28.3	mg/L
K414	17-Sep-05	2005	Physical Chemical	Alkalinity	32	mg/L CaCO3
K414	17-Sep-05	2005	Physical Chemical	Conductivity	88	(uS/cm)

K414	11-Jul-05	2005	Synoptic Fecal	Fecal Coliform count	125	cfu/100 mL
K414	15-Sep-06	2006	Physical Chemical	Flow Conditions	0	
K414	29-Jul-06	2006	Physical Chemical	Flow Conditions	0.5	
K414	07-Jul-06	2006	Physical Chemical	Flow Conditions	1	
K414	15-Sep-06	2006	Physical Chemical	pH	7.4	
K414	15-Sep-06	2006	Physical Chemical	Water Temperature	22	°C
K414	15-Sep-06	2006	Physical Chemical	Alkalinity	25	mg/L CaCO3
K414	15-Sep-06	2006	Physical Chemical	Chlorides	59.8	mg/L
K414	15-Sep-06	2006	Physical Chemical	Total Suspended Solids	248	mg/L
K414	15-Sep-06	2006	Physical Chemical	Conductivity	295	(uS/cm)
K414	07-Jul-06	2006	Physical Chemical	Conductivity	636	(uS/cm)
K414	29-Jul-06	2006	Physical Chemical	Conductivity	729	(uS/cm)
K414	29-Jul-06	2006	Follow Up Fecal	AC/TC Ratio	11.47059	
K414	29-Jul-06	2006	Follow Up Fecal	Atypical Coliform Count	117000	cfu/100 mL
K414	29-Jul-06	2006	Follow Up Fecal	E coli Count	7270	cfu/100 mL
K414	29-Jul-06	2006	Follow Up Fecal	Total Coliform Count	10200	cfu/100 mL
K414	07-Jul-06	2006	Synoptic Fecal	E coli Count	419	cfu/100 mL

Site 1086, K417 - Red River at the John Swift Campground

krww_id	sample_date	sample_year	analyte_group	analyte	results	units
K417	17-Sep-05	2005	Metals	Beryllium	0.0005	mg/L
K417	17-Sep-05	2005	Metals	Zinc	0.0015	mg/L
K417	17-Sep-05	2005	Metals	Cobalt	0.002	mg/L
K417	17-Sep-05	2005	Metals	Nickel	0.0025	mg/L
K417	17-Sep-05	2005	Metals	Cadmium	0.004	mg/L
K417	17-Sep-05	2005	Metals	Copper	0.0045	mg/L
K417	17-Sep-05	2005	Metals	Lithium	0.006	mg/L
K417	17-Sep-05	2005	Metals	Chromium	0.0075	mg/L
K417	17-Sep-05	2005	Metals	Phosphorus	0.0075	mg/L
K417	17-Sep-05	2005	Metals	Selenium	0.008	mg/L
K417	17-Sep-05	2005	Metals	Silver	0.0085	mg/L
K417	17-Sep-05	2005	Metals	Vanadium	0.0095	mg/L
K417	17-Sep-05	2005	Metals	Boron	0.01	mg/L
K417	17-Sep-05	2005	Metals	Lead	0.01	mg/L
K417	17-Sep-05	2005	Metals	Arsenic	0.0105	mg/L
K417	17-Sep-05	2005	Metals	Gold	0.011	mg/L
K417	17-Sep-05	2005	Metals	Antimony	0.025	mg/L
K417	17-Sep-05	2005	Metals	Thallium	0.0255	mg/L

K417	17-Sep-05	2005	Metals	Barium	0.04	mg/L
K417	17-Sep-05	2005	Metals	Strontium	0.05	mg/L
K417	17-Sep-05	2005	Metals	Tin	0.069	mg/L
K417	17-Sep-05	2005	Metals	Manganese	0.13	mg/L
K417	17-Sep-05	2005	Metals	Aluminum	0.19	mg/L
K417	17-Sep-05	2005	Metals	Iron	0.37	mg/L
K417	17-Sep-05	2005	Physical Chemical	Total Suspended Solids	1.5	mg/L
K417	17-Sep-05	2005	Metals	Silicon	1.88	mg/L
K417	09-Jul-05	2005	Physical Chemical	Flow Conditions	2	
K417	30-Jul-05	2005	Physical Chemical	Flow Conditions	2	
K417	17-Sep-05	2005	Metals	Potassium	2.49	mg/L
K417	17-Sep-05	2005	Metals	Sodium	5.75	mg/L
K417	17-Sep-05	2005	Physical Chemical	Dissolved Oxygen	6.3	mg/L
K417	09-Jul-05	2005	Physical Chemical	Dissolved Oxygen	6.4	mg/L
K417	17-Sep-05	2005	Metals	Magnesium	6.44	mg/L
K417	09-Jul-05	2005	Physical Chemical	pH	7	
K417	17-Sep-05	2005	Physical Chemical	pH	7	
K417	17-Sep-05	2005	Physical Chemical	Chlorides	8.1	mg/L
K417	17-Sep-05	2005	Metals	Sulfur	8.7	mg/L
K417	09-Jul-05	2005	Physical Chemical	Water Temperature	22	°C
K417	17-Sep-05	2005	Metals	Calcium	22.6	mg/L
K417	17-Sep-05	2005	Physical Chemical	Water Temperature	23	°C
K417	17-Sep-05	2005	Physical Chemical	Alkalinity	50	(mg/L as CaCO3)
K417	17-Sep-05	2005	Physical Chemical	Conductivity	184	(uS/cm)
K417	30-Jul-05	2005	Follow Up Fecal	Fecal Coliform Count	8	cfu/100 mL
K417	30-Jul-05	2005	Follow Up Fecal	AC/TC Ratio	11	
K417	30-Jul-05	2005	Follow Up Fecal	Atypical Coliform Count	2200	cfu/100 mL
K417	30-Jul-05	2005	Follow Up Fecal	E coli Count	67	cfu/100 mL
K417	30-Jul-05	2005	Follow Up Fecal	Total Coliform Count	200	cfu/100 mL
K417	09-Jul-05	2005	Synoptic Fecal	Fecal Coliform count	0	cfu/100 mL
K417	17-May-06	2006	Pesticides Herbicides	Metolachlor	0.03	ug/L
K417	17-May-06	2006	Pesticides Herbicides	Triazines	0.04	ug/L
K417	17-May-06	2006	Physical Chemical	Dissolved Oxygen	9.2	mg/L
K417	17-May-06	2006	Physical Chemical	pH	7	

K417	17-May-06	2006	Physical Chemical	Flow Conditions	3	
K417	17-May-06	2006	Physical Chemical	Water Temperature	15	°C
K417	29-Jul-06	2006	Physical Chemical	Flow Conditions	2	
K417	16-Sep-06	2006	Physical Chemical	Flow Conditions	2	
K417	16-Sep-06	2006	Physical Chemical	Total Suspended Solids	3	mg/L
K417	29-Jul-06	2006	Physical Chemical	Dissolved Oxygen	6	mg/L
K417	16-Sep-06	2006	Physical Chemical	Dissolved Oxygen	7	mg/L
K417	29-Jul-06	2006	Physical Chemical	pH	7	
K417	16-Sep-06	2006	Physical Chemical	pH	7.5	
K417	16-Sep-06	2006	Physical Chemical	Chlorides	9.5	mg/L
K417	16-Sep-06	2006	Physical Chemical	Water Temperature	20	°C
K417	29-Jul-06	2006	Physical Chemical	Water Temperature	25	°C
K417	16-Sep-06	2006	Physical Chemical	Alkalinity	59	(mg/L as CaCO3)
K417	16-Sep-06	2006	Physical Chemical	Conductivity	201	(uS/cm)
K417	29-Jul-06	2006	Physical Chemical	Conductivity	415	(uS/cm)
K417	29-Jul-06	2006	Follow Up Fecal	AC/TC Ratio	21	
K417	29-Jul-06	2006	Follow Up Fecal	Atypical Coliform Count	21000	cfu/100 mL
K417	29-Jul-06	2006	Follow Up Fecal	E coli Count	146	cfu/100 mL
K417	29-Jul-06	2006	Follow Up Fecal	Total Coliform Count	1000	cfu/100 mL
K417	14-Sep-08	2008	Physical Chemical	Alkalinity	83	(mg/L as CaCO3)
K417	14-Sep-08	2008	Physical Chemical	Chloride	9.1	mg/L
K417	14-Sep-08	2008	Physical Chemical	Conductivity	176	(uS/cm)
K417	14-Sep-08	2008	Physical Chemical	Total Suspended Solids	3	mg/L
K417	14-Sep-08	2008	Nutrients	Nitrate (No3-N)	0.02	mg/L
K417	14-Sep-08	2008	Nutrients	Total Nitrogen	0.32	mg/L
K417	14-Sep-08	2008	Nutrients	Total Recoverable Phosphorus	0.13	mg/L
K417	14-Sep-08	2008	Nutrients	Sulfate	12.4	mg/L
K417	14-Sep-08	2008	Metals	Barium	0.03	mg/L
K417	14-Sep-08	2008	Metals	Beryllium	0.001	mg/L
K417	14-Sep-08	2008	Metals	Chromium	0.024	mg/L
K417	14-Sep-08	2008	Metals	Copper	0.005	mg/L
K417	14-Sep-08	2008	Metals	Iron	0.33	mg/L

K417	14-Sep-08	2008	Metals	Manganese	0.1	mg/L
K417	14-Sep-08	2008	Metals	Nickel	0.002	mg/L
K417	14-Sep-08	2008	Metals	Zinc	0.004	mg/L
K417	12-Jul-08	2008	Synoptic Fecal	E coli	10	cfu/100 mL
K417	14-Sep-08	2008	Physical Chemical	Dissolved Oxygen	6	mg/L
K417	14-Sep-08	2008	Physical Chemical	pH	7	
K417	14-Sep-08	2008	Physical Chemical	Flow Conditions	1	
K417	14-Sep-08	2008	Physical Chemical	Chlorides	9.1	mg/L
K417	14-Sep-08	2008	Nutrients	Nitrate(NO3)	0.1	mg/L
K417	14-Sep-08	2008	Metals	Aluminum	0.1	mg/L
K417	14-Sep-08	2008	Metals	Antimony	0.012	mg/L
K417	14-Sep-08	2008	Metals	Arsenic	0.014	mg/L
K417	14-Sep-08	2008	Metals	Boron	0.07	mg/L
K417	14-Sep-08	2008	Metals	Cadmium	0.001	mg/L
K417	14-Sep-08	2008	Metals	Cobalt	0.001	mg/L
K417	14-Sep-08	2008	Metals	Lead	0.01	mg/L
K417	14-Sep-08	2008	Metals	Lithium	0.006	mg/L
K417	14-Sep-08	2008	Metals	Phosphorus	0.02	mg/L
K417	14-Sep-08	2008	Metals	Selenium	0.011	mg/L
K417	14-Sep-08	2008	Metals	Silver	0.003	mg/L
K417	14-Sep-08	2008	Metals	Thallium	0.041	mg/L
K417	14-Sep-08	2008	Metals	Vanadium	0.008	mg/L
K417	14-Sep-08	2008	Metals	Calcium	19.7	mg/L
K417	14-Sep-08	2008	Metals	Gold	0.034	mg/L
K417	14-Sep-08	2008	Metals	Magnesium	5.79	mg/L
K417	14-Sep-08	2008	Metals	Potassium	2.31	mg/L
K417	14-Sep-08	2008	Metals	Silicon	1.78	mg/L
K417	14-Sep-08	2008	Metals	Sodium	5.71	mg/L
K417	14-Sep-08	2008	Metals	Strontium	0.05	mg/L
K417	14-Sep-08	2008	Metals	Sulfur	4.77	mg/L
K417	14-Sep-08	2008	Metals	Tin	0.012	mg/L

Appendix B – KY Division of Water TMDL data for Swift Camp Creek

Site	Collection Date	***Alkalinity mg/L	Ammonia-Nitrogen mg/L	Chloride mg/L	***Hard-ness mg/L	Nitrate mg/L	Organic Carbon mg/L	*Ortho-phosphorus mg/L	Phosphorus, Total mg/L	Sulfate mg/L	Total Kjeldhal Nitrogen mg/L	Total Suspended Solids mg/L	Dissolved Oxygen mg/L	pH	Temp. C	Specific Conduc-tance	Flow
DOW04043011	04/30/2003	19.7	<0.05	7.22	61	Below RL			0.009	8.46	0.111	1	10.25	7.62	16.45	94.1	10.9
Swift Camp Cr. at RM 0.2	05/28/2003	24.5	<0.05	7.48	38.0	0.165	1.63		0.025	9.05	0.088	2.	10	6.55	14.17	97.3	13.72
Site #1	06/25/2003		<0.05	7.96		0.063	1.63		0.015	6.69		3.	10.12	7.13	20.05	94.4	7.56
	07/02/2003												9.3	7.5	20.7	109.7	
	07/31/2003	43.2	Below RL	11.4	59	0.0974	2.93		0.024	7.55	0.231	7	8.39	7.2	21.97	145.8	4.01
	08/26/2003	52.4	Below RL	14.0	66.0	0.302	2.93		0.009	7.08	Below RL	1	8.57	7.32	22.58	180.1	2.28
	09/25/2003	51.3	0.131	18.9	84.0	0.504	3.56		0.015	13.9	0.329	2.00	10.06	7.35	16.19	196.6	3.2
	10/30/2003	42.5	Below RL	14.7	64.0	0.241	3.50	Below RL	0.0937	12.6	0.233	Below RL	10.66	7.65	10.46	173.1	6.27
	11/06/2003	36.3	Below RL	10.1	50.0	0.267	1.87	0.033	0.0224	8.88	0.361	Below RL	10.54	7.07	8.13	144	8.51
	12/22/2003	19.8	Below RL	29.3	43.0	0.233	0.989	Below RL	0.0209	9.44	Below RL	Below RL	17.24	6.85	1.36	169.2	29.76
	01/27/2004	18.4	Below RL	73.8	52.0	0.227	1.14	0.068	0.0152	12.4	Below RL	2.00	13.84	6.84	1.05	313.5	34.176
	02/25/2004	19.5	Below RL	9.29	45.0	0.109	1.07	Below RL	0.0176	11.3	0.139	Below RL	15.8	6.93	4.71	92.3	9.806

Site	Collection Date	***Alkalinity mg/L	Ammonia-Nitrogen mg/L	Chloride mg/L	***Hardness mg/L	Nitrate mg/L	Organic Carbon mg/L	*Ortho-phosphorus mg/L	Phosphorus, Total mg/L	Sulfate mg/L	Total Kjeldhal Nitrogen mg/L	Total Suspended Solids mg/L	Dissolved Oxygen mg/L	Ph	Temperature	Specific Conductance	Flow
DOW04043013	04/30/2003		0.324	23.2		0.266	1.99		0.054	24.3		3	9.62	7.23	18.23	246.6	2.4
Swift Camp Cr. at bridge	05/28/2003		0.111	27.9		0.405	2.15		0.069	21.3		4.	9.07	7	17.8	251	2.47
at RM 10.7, below lake	06/25/2003		<0.05	26.7		0.299	2.26		0.186	23.8		4.	8.01	6.91	19.65	252.1	1.57
Site #3	07/31/2003		0.975	45.9		0.510	4.55		0.243	28.8		16.5	5.17	6.86	21.42	402.6	0.49
	08/26/2003		5.43	43.4		0.192	6.11		0.451	22.1		5.5	4.02	6.79	20.62	457.8	0.39
	09/25/2003		1.89	41.2		0.894	3.76		0.719	34.4		5.00	6.1	6.89	16.95	419	0.56
	10/30/2003		1.38	35.5		0.692	3.24		0.111	27.1		2.00	9.72	7.48	12.14	371.4	0.96
	11/06/2003		0.0948	23.2		0.533	2.14		0.0268	22.3		3.00	9.46	7.34	9.84	284	1.87
	12/22/2003		0.0617	20.3		0.415	1.28		0.0343	14.9		2.50	14.56	6.81	4.43	192.1	9.427
	01/27/2004		0.068	91.0		0.435	1.75		0.0746	26.4		29.0	12.7	6.82	3.61	444.1	9.6567
	02/25/2004		1.06	30.4		0.324	2.08		0.207	32.2		3.50	14.17	6.91	6.05	274.9	1.49

Site	Collection Date	***Alkalinity mg/L	Ammonia-Nitrogen mg/L	Chloride mg/L	***Hardness mg/L	Nitrate mg/L	Organic Carbon mg/L	*Ortho-phosphorus mg/L	Phosphorus, Total mg/L	Sulfate mg/L	Total Kjeldhal Nitrogen mg/L	Total Suspended Solids mg/L	Dissolved Oxygen mg/L	Ph	Temperature	Specific Conductance	Flow

DOW040430 14	03/19/2003												9.7	8	15.1	205	
Swift Camp Cr. off	04/30/2003		<0.05	11.3		0.088	1.87		0.014	12.9		2	10.55	7.44	18.82	146.7	0.66
KY15	05/28/2003		<0.05	13.9		0.129	3.78		0.030	13.9		5.	9.5	7.09	19.75	166.4	0.54
Site #4	06/25/2003		<0.05	13.4		0.161	1.45		0.016	13.0		3.	9.29	7.02	18.49	164.5	0.36
	07/31/2003		Below RL	36.4		0.0737	2.82		0.026	17.3		4.5	6.72	7.19	22.7	387.1	0.05
	08/26/2003		Below RL	32.3		0.059	3.45		0.065	12.4		41.5	6.01	6.98	21.49	394.7	0.12
	09/25/2003		Below RL	35.2		0.071	3.01		0.031	16.5		5.50	8.66	7.14	17.03	370.2	0.08
	10/30/2003		Below RL	24.2		0.072	1.86		0.0442	14.8		1.00	11.33	7.85	11.62	269.6	0.25
	11/06/2003		Below RL	16.0		0.292	1.35		0.0202	12.6		2.50	10.07	7.43	8.8	204	0.46
	12/22/2003		Below RL	12.8		0.261	0.924		0.0207	9.66		1.00	13.72	6.68	4.55	130.9	2.827
	01/27/2004		Below RL	54.4		0.296	1.55		0.0614	15.3		62.5	12.48	6.71	3.71	276.4	3.1149
	02/25/2004		Below RL	17.0		0.196	1.20		0.019	17.6		12.0	12.84	7.08	5.45	166.1	0.5282
Site	**Collection Date**	*****Alkalinity mg/L**	**Ammonia-Nitrogen mg/L**	**Chloride mg/L**	*****Hardness mg/L**	**Nitrate mg/L**	**Organic Carbon mg/L**	***Ortho-phosphorus mg/L**	**Phosphorus, Total mg/L**	**Sulfate mg/L**	**Total Kjeldhal Nitrogen mg/L**	**Total Suspended Solids mg/L**	**Dissolved Oxygen mg/L**	**Ph**	**Temperature**	**Specific Conductance**	**Flow**
DOW040430 15	03/19/2003												11.6	8.7	13.9	318	
Swift Camp Cr. UT	04/30/2003	6.30E+01	0.059	24.6	78	0.363	1.88		0.018	15.2	0.281	5	9.05	7.06	16.02	237	0.7
at Hazard Spur	05/28/2003	78.5	<0.05	26.5	97.0	0.434	1.92		0.030	18.1	0.214	4.	9.06	7	15.89	262.5	0.55
Site #6	06/25/2003		<0.05	27.0		0.422	2.12		0.029	15.1		4.	8.74	7.05	18.35	256.4	0.28
	07/31/2003	149	Below RL	88.3	186	0.284	3.90		0.028	15.1	0.295	16.5	6.85	7.22	22.06	600.5	0.24
	08/26/2003	146	Below RL	70.4	176	0.266	3.77		0.028	13.2	Below RL	17.5	7.37	7.19	20.71	573.9	0.02
	09/25/2003	124	Below RL	44.7	150	0.411	3.06		0.031	18.4	0.342	2.50	8.45	7.27	16.1	427	0.12
	10/30/2003	108	Below RL	34.2	133	0.322	2.50	Below RL	0.0202	19.1	0.250	1.00	9.39	7.73	8.58	354.7	0.39
	11/10/2003	71.6	Below RL	21.2	101	0.682	1.73	0.011	0.0202	14.4	0.094	2.50	9.5	7.37	7.36	266	0.56
	12/22/2003	39.8	Below RL	40.3	75.0	0.647	1.16	Below RL	0.0264	15.3	Below RL	3.00	13.38	6.72	3.78	270.3	2.343
	01/27/2004	46.2	0.0797	107	103	0.512	1.58	0.022	0.032	27.0	0.165	7.00	12.5	6.74	3.25	508.1	3.1726
	02/25/2004	54.7	Below RL	32.7	86.0	0.439	1.45	Below RL	0.0173	23.4	0.202	1.50	13.9	7.13	3.01	261.2	0.46
Site	**Collection Date**	*****Alkalinity mg/L**	**Ammonia-Nitrogen mg/L**	**Chloride mg/L**	*****Hardness mg/L**	**Nitrate mg/L**	**Organic Carbon mg/L**	***Ortho-phosphorus mg/L**	**Phosphorus, Total mg/L**	**Sulfate mg/L**	**Total Kjeldhal Nitrogen mg/L**	**Total Suspended Solids mg/L**	**Dissolved Oxygen mg/L**	**Ph**	**Temperature**	**Specific Conductance**	**Flow**
DOW040430 16	03/19/2003												10.4	8	14.7	208	
Swift Camp Cr UT	04/30/2003		<0.05	9.5		0.673	1.11		0.012	10.8		4	9.75	6.98	15.14	145.8	0.09
at prive dr. off SR651	05/28/2003		<0.05	9.64		0.769	1.33		0.024	11.6		4.	9.41	6.74	15.48	160.5	0.04
Site #9	06/25/2003		0.071	7.87		0.850	1.55		0.020	9.77		5.	8.95	6.71	16.72	135.7	0.08

	07/31/2003		0.396	33.3		0.143	4.17		0.084	6.97		5.5	7.53	7.16	20.83	343.7	0.01
	08/26/2003		0.343	29.6		0.159	4.10		0.040	6.35		12.0	6.86	7.1	19.04	332.9	0.007
	09/25/2003		0.097	24.4		0.250	3.03		0.031	11.7		13.0	9.26	7.24	14.92	303.1	0.04
	10/30/2003		0.145	21.7		0.290	2.24		0.0244	11.8		9.00	10.1	7.62	8.08	265.2	0.08
	11/10/2003		0.121	17.5		0.299	1.88		0.0202	11.5		5.50	9.31	6.57	8.01	180	0.11
	12/22/2003		Below RL	9.91		0.299	1.00		0.0236	9.39		3.50	15.64	5.04	4.46	113.2	0.7306
	01/27/2004		Below RL	33.8		0.343	1.54		0.0575	12.8		16.5	12.2	6.57	3.34	253	0.674
	02/25/2004		Below RL	17.2		0.160	1.43		0.0192	15.9		2.50	13.94	6.75	2.58	160.7	0.0741
Site	**Collection Date**	*****Alkalinity mg/L**	**Ammonia-Nitrogen mg/L**	**Chloride mg/L**	*****Hardness mg/L**	**Nitrate mg/L**	**Organic Carbon mg/L**	***Ortho-phosphorus mg/L**	**Phosphorus, Total mg/L**	**Sulfate mg/L**	**Total Kjeldhal Nitrogen mg/L**	**Total Suspended Solids mg/L**	**Dissolved Oxygen mg/L**	**Ph**	**Temperature**	**Specific Conductance**	**Flow**
DOW04043017	03/19/2003												11.4	7.8	11.8	227	
Swift Camp Cr UT of UT	04/30/2003		<0.05	12.8		0.088	1.63		0.032			10	9.99	7.08	15.84	178.1	0.22
off of Pete Center Drive	05/28/2003		<0.05	16.2		0.136	1.89		0.038	12.0		6.	8.61	6.78	17.93	202	0.23
Site #10	06/25/2003		<0.05	7.85		0.132	2.25		0.029	9.94		6.	8.71	6.79	17.67	205.2	0.09
	07/31/2003		Below RL	25.7		0.566	2.95		0.038	14.1		0.038	4.74	7	21.69	404.9	0.01
	08/26/2003		Below RL	21.2		0.689	2.57		0.015	9.37		0.015	4.75	6.89	20.36	422.2	0.012
	09/25/2003		Below RL	23.5		0.971	2.58		0.068	12.0		0.068	7.16	7.02	15.68	347.9	0.03
	10/30/2003		Below RL	16.2		0.801	1.62		0.0202	11.1		0.0202	10.13	7.64	9.66	285.2	0.08
	11/10/2003		Below RL	10.2		1.40	1.40		0.0202	9.31		0.0202	9.12	7.41	8.16	249	0.17
	12/22/2003		Below RL	8.31		1.08	0.902		0.0193	9.61		0.0193	12.87	6.53	4.44	141.7	0.7931
	01/27/2004		0.0657	44.7		0.878	1.42		0.0577	13.2		0.0577	12.5	6.75	3.61	224.2	1.0562
	02/25/2004		Below RL	12.6		0.857	0.989		0.0131	13.6		0.0131	15.16	7.12	3.83	182.6	0.13
Site	**Collection Date**	*****Alkalinity mg/L**	**Ammonia-Nitrogen mg/L**	**Chloride mg/L**	*****Hardness mg/L**	**Nitrate mg/L**	**Organic Carbon mg/L**	***Ortho-phosphorus mg/L**	**Phosphorus, Total mg/L**	**Sulfate mg/L**	**Total Kjeldhal Nitrogen mg/L**	**Total Suspended Solids mg/L**	**Dissolved Oxygen mg/L**	**Ph**	**Temperature**	**Specific Conductance**	**Flow**
DOW04043018	04/30/2003	87.0	6.7	53.4	104	0.047	6.45		1.13	40.8	9.96	21	8.29	6.55	16.12	455	121700
Swift Camp Creek	05/28/2003	72.4	2.99	55.8	106.	0.063	8.18		1.64	43.7	7.93	60.	8.4	6.2	17.5	396	167000
at Campton WWTP outfall	06/25/2003		0.138	53.8		0.045	6.09		0.818	45.6		5.	8.36	6.28	20.38	343.7	98000
Site #11	07/31/2003	67.5	5.55	69.4	108	0.027	18.0		5.11	50.5	9.48	28	8.56	6.45	23.32	489.5	92000
	08/26/2003	109	13.6	67.5	97.0	0.023	20.7		3.01	18.8	24.6	48.0	7.69	6.56	23.19	527.1	84800
	09/25/2003	100	10.4	72.3	109	0.027	7.74		2.44	43.5	14.5	26.5	7.93	6.67	20.43	525.2	104900
	10/30/2003	84.3	8.48	61.3	114	0.042	7.41	0.288	0.457	43.1	10.5	8.50	8.96	7.22	15.69	486.1	113900

	11/10/2003	58.5	0.639	50.2	112	1.21	6.19	0.193	0.503	42.8	2.25	10.0	8.05	6.75	14.01	384	126000
	12/22/2003	74.8	1.17	58.4	129	1.21	4.81		0.323	29.7	2.55	12.0	11.31	6.38	8.41	433.5	243000
	01/27/2004	71.5	1.44	98.4	135	1.23	5.07		1.34	40.0	3.93	25.5	10.42	6.22	6.58	546	241000
	02/25/2004	81.9	10.4	63.0	101	0.031	11.1	1.38	1.90	61.8	11.4	14.0	10.93	6.31	7.76	497.2	120000

Site	Collection Date	***Alkalinity mg/L	Ammonia-Nitrogen mg/L	Chloride mg/L	***Hardness mg/L	Nitrate mg/L	Organic Carbon mg/L	*Ortho-phosphorus mg/L	Phosphorus, Total mg/L	Sulfate mg/L	Total Kjeldhal Nitrogen mg/L	Total Suspended Solids mg/L	Dissolved Oxygen mg/L	Ph	Temperature	Specific Conductance	Flow
DOW04043019	03/21/2003												10.7	7.4	10	145	
Rockbridge Fork	04/30/2003		<0.05	7.54		0.04	1.68		Below RL	7.04		Below RL	10.08	7	15.95	68.6	1.7
off Rockbridge trail	05/28/2003		<0.05	7.11		0.128	1.58		0.023	7.85		3	10	6.38	12.78	71.5	1.9
Site #12	06/25/2003		<0.05	7.74		0.115	1.78		0.010	5.82		2.	9.8	6.77	17.31	61.4	1.18
	07/31/2003		Below RL	0.39		0.105	4.90		0.053	3.89		51	8.95	6.81	19.7	61.3	1.09
	08/26/2003		Below RL	5.16		0.063	3.52		0.014	2.93		1	9.13	6.9	20.05	78.9	0.25
	09/25/2003		Below RL	12.6		0.065	3.02		Below RL	5.65		1.00	9.63	6.94	14.94	103.1	0.38
	10/30/2003		Below RL	11.3		0.008	2.81		0.0202	6.09		2.00	11.33	7.57	8.92	109.4	0.72
	11/10/2003		Below RL	1.34		0.168	1.80		0.0202	5.78		Below RL	9.84	7.49	7.07	109	1.31
	12/22/2003		Below RL	36.4		0.295	1.07		0.0172	7.41		Below RL	15.65	6.86	1.98	176.1	3.999
	01/27/2004		Below RL	44.6		0.286	1.29		0.0126	10.7		1.50	13.34	6.57	2.02	194.2	5.669
	02/25/2004		Below RL	8.15		0.144	1.08		0.0131	9.45		Below RL	14.04	7.04	3.86	67	1.4713
***Ortho-p's started in October**																	
*****Alkalinity and Hardness only assessed at TKN/Ortho-P sites**																	

Appendix C – Swift Camp Creek Walk forms

Stream Visual Assessment Protocol

Owners name: Campton   Evaluator's name: Cotton   Date: 7/11

Stream name: Swift Camp   Waterbody ID number: ______

Reach location: 1st - just off park b/f bridge to just past 1st trib by concrete brick wall

Ecoregion: ______   Drainage area: ______   Gradient: ______

Applicable reference site: ______

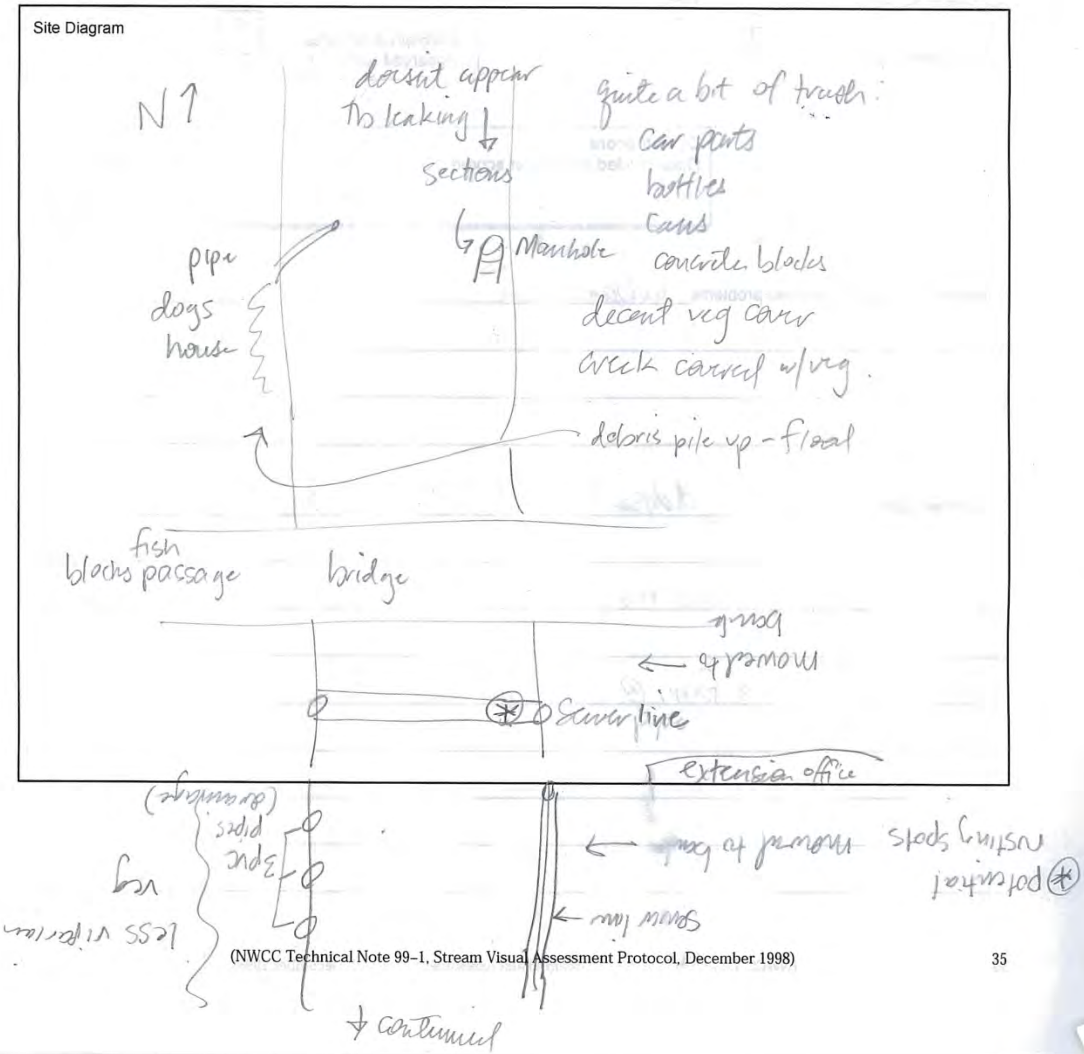
Land use within drainage (%): row crop ______ hayland ______ grazing/pasture ______ forest ______ residential ______

confined animal feeding operations ______ Cons. Reserve ______ industrial ______ Other: commercial 100%

Weather conditions-today: sunny & hot   Past 2-5 days: ______

Active channel width: ~21'   Dominant substrate: boulder ______ gravel ✓ sand ✓ silt ✓ mud ______

Site Diagram



(NWCC Technical Note 99-1, Stream Visual Assessment Protocol, December 1998) 35

Assessment Scores

Channel condition	3	Pools	5
Hydrologic alteration	4	Invertebrate habitat	6
Riparian zone	7	***Score only if applicable***	
Bank stability	5	Canopy cover	8
Water appearance	6	Manure presence	/
Nutrient enrichment	6	Salinity	/
Barriers to fish movement	1 bridge	Riffle embeddedness	5
Instream fish cover	5	Marcroinvertebrates Observed (optional)	2

Overall score (Total divided by number scored) ________	<6.0	**Poor**
	6.1-7.4	**Fair**
	7.5-8.9	**Good**
	>9.0	**Excellent**

Suspected causes of observed problems urbanization

Recommendations Crayfish, dobson fly (emerald green), kingfisher

DOW: Only saw mayfly larvae

One person does a form @ ea. site

Stream Visual Assessment Protocol

Owners name ______________________ Evaluator's name ______________________ Date ____________

Stream name ______________________ Waterbody ID number ______________________

Reach location ____

____

Ecoregion ______________ Drainage area ______________ Gradient ______________

Applicable reference site ____

Land use within drainage (%): row crop _____ hayland _____ grazing/pasture _____ forest _____ residential _____

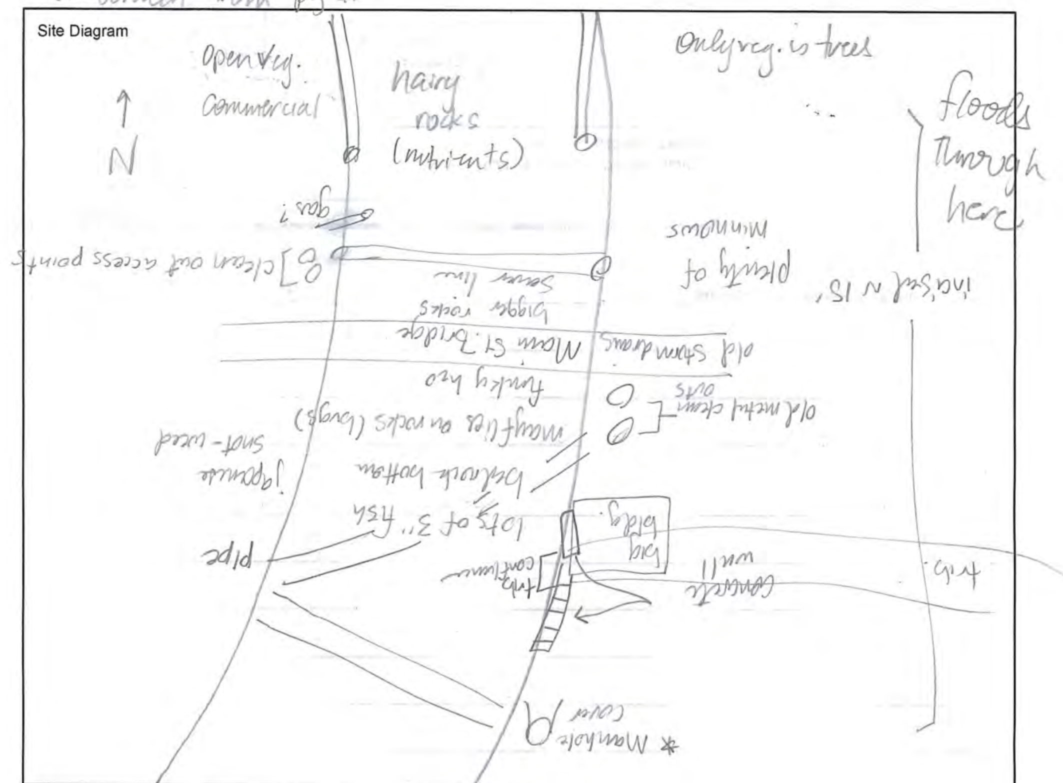
confined animal feeding operations _____ Cons. Reserve _______ industrial _______ Other: _____________

Weather conditions-today ______________________ Past 2-5 days ______________________

Active channel width ______________ Dominant substrate: boulder _____ gravel _____ sand _____ silt _____ mud _____

continued from pg 1

Site Diagram



*Dow guy said he saw this manhole flowing raw sewage into creek (grass laid down) after a small rain

Combined sewer overflo

(NWCC Technical Note 99-1, Stream Visual Assessment Protocol, December 1998) 35

Jack
(606) 975-2255
Jon 859 771
2513

Stream Visual Assessment Protocol

Owners name Campton Evaluator's name Chad Date 7-11

Stream name Swift Camp Waterbody ID number

Reach location 1st trib to confluence

Ecoregion Drainage area Gradient

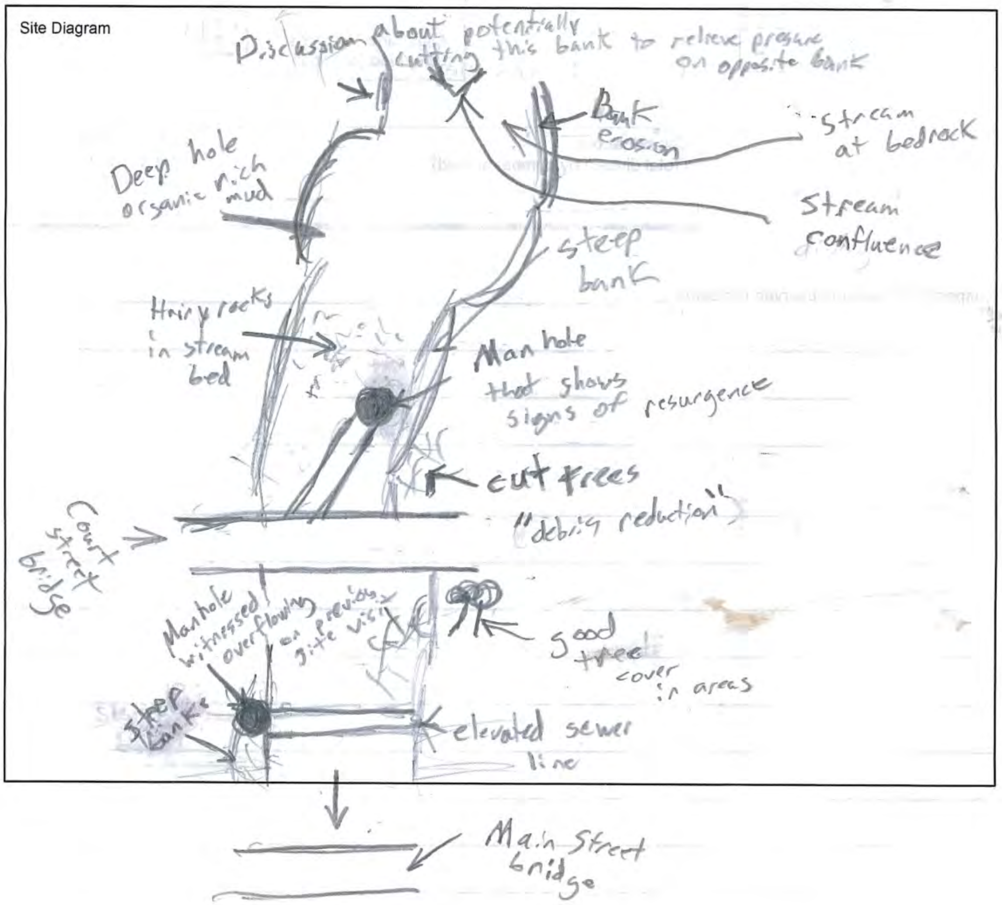
Applicable reference site

Land use within drainage (%): row crop hayland 5 grazing/pasture forest residential 10

confined animal feeding operations Cons. Reserve industrial 85 Other:

Weather conditions-today Sunny hot Past 2-5 days

Active channel width 14' Dominant substrate: boulder gravel sand ✓ silt ✓ mud



(NWCC Technical Note 99-1, Stream Visual Assessment Protocol, December 1998) 35

Assessment Scores

Channel condition	5
Hydrologic alteration	5
Riparian zone	6
Bank stability	7 ← one in certain areas
Water appearance	6
Nutrient enrichment	6
Barriers to fish movement	5
Instream fish cover	4
Pools	5
Invertebrate habitat	6

Score only if applicable

Canopy cover	8
Manure presence	/
Salinity	/
Riffle embeddedness	5
Marcroinvertebrates Observed (optional)	2

Overall score (Total divided by number scored) ______	<6.0	**Poor**
	6.1-7.4	**Fair**
	7.5-8.9	**Good**
	>9.0	**Excellent**

Suspected causes of observed problems ______________________________

____

____

____

Recommendations ______________________________

____

____

____

____

____

____

____

____

Stream Visual Assessment Protocol

Owners name Campton Evaluator's name Chad Date 7-11

Stream name Swift Camp Waterbody ID number ______

Reach location Confluence to State Garage

Ecoregion ______ Drainage area ______ Gradient ______

Applicable reference site ______

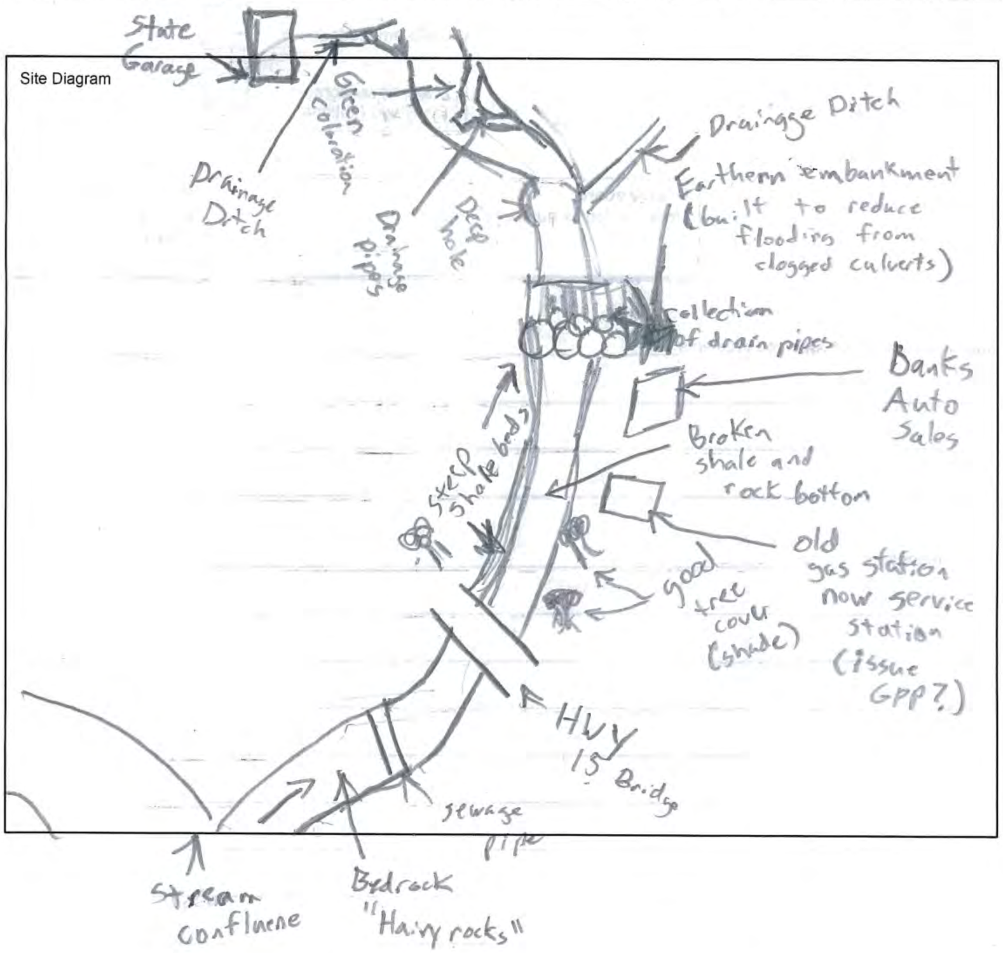
Land use within drainage (%): row crop ______ hayland ______ grazing/pasture ______ forest 20 residential 40

confined animal feeding operations ______ Cons. Reserve ______ industrial 40 Other: ______

Weather conditions-today Sunny Hot Past 2-5 days ______

Active channel width 11' Dominant substrate: boulder ______ gravel ______ sand ______ silt ______ mud ______

Site Diagram



(NWCC Technical Note 99-1, Stream Visual Assessment Protocol, December 1998) 35

Appendix D – KY Division of Water project benchmarks

Red River Watershed Plan
Benchmark Recommendations for Nutrient Parameters
Kentucky Division of Water
5/8/2012

Nutrient benchmarks given here represent the best information available to the Kentucky Division of Water (KDOW) at this time. They are estimates of typical in-stream concentrations below which it is unlikely that nutrients are a cause of observed impairments. As such, they are useful in identifying sub-basins with potential nutrient issues when setting priorities for further monitoring or for development of load reduction strategies. In making these recommendations we have considered regional and watershed-specific nutrient expectations, regional-scale patterns in biological effects, and specific indicators of nutrient enrichment observed in the watershed. These benchmarks may be more stringent than targets to be used ultimately as management endpoints; watershed-specific characteristics, practical considerations, and insight gained from early phase monitoring might suggest alternate values for that purpose. The Watershed Group may wish to discuss with KDOW alternative benchmarks and/or targets based on more detailed local information or consultation with experts familiar with the watershed. A summary of candidate benchmarks is given here along with a final set of recommendations to provide more assistance in interpreting nutrient data throughout project phases.

Ecoregional Reference Reach candidate benchmarks:

The watersheds for this project lie within the Ohio-Kentucky Carboniferous Plateau (70f) and the Northern Forested Plateau Escarpment (70g) sub-ecoregions of the Allegheny Plateau (Ecoregion 70). Reference Reaches in these ecoregions are typically low in nutrients. Since Reference Reach nutrient concentrations differ somewhat within the Allegheny Plateau, only those specific sub-ecoregions are summarized here for selecting candidate benchmarks.

Reference Reach nutrient sample summary for sub-ecoregions 70f, 70g and combined:

	Ecoregion	Number Samples	MIN	MAX	MED	**75th percentile**	90th percentile
TP(mg/L)	70f	24	<0.010	0.041	<0.020	<0.020	0.024
	70g	26	<0.010	0.035	<0.010	<0.020	0.024
	70fg	50	<0.010	0.041	<0.010	<0.020	0.025
NN(mg/L)	70f	33	<0.010	0.587	0.061	0.118	0.167
	70g	30	<0.020	0.416	0.137	0.247	0.348
	70fg	63	<0.010	0.587	0.102	0.177	0.324
TKN(mg/L)	70f	33	<0.200	0.579	<0.200	<0.200	<0.500
	70g	30	<0.200	0.581	<0.200	<0.200	<0.500
	70fg	63	<0.200	0.581	<0.200	<0.200	<0.500
TN(mg/L)	70f	33	<0.210	0.587-0.849	0.102-0.302	0.210-0.520	0.339-0.613
	70g	30	0.010-0.220	0.928	0.185-0.385	0.258-0.528	0.379-0.627
	70fg	63	<0.210	0.928	0.120-0.320	0.246-0.520	0.363-0.617

* the calculated values for Total N are given as interval ranges that incorporate KY DEP's detection and quantitation limits for Nitrate-Nitrite-N and TKN (0.010/0.020 and 0.200/0.500, respectively)

Watershed reference candidate benchmarks:

If there are segments within the project watershed(s) or within closely comparable watersheds where uses are fully supported, then nutrient data from those streams can be summarized as a "watershed reference." These need not be Reference Reaches designated by KDOW, as long as they have been assessed as being fully supporting of the most sensitive use, in this case aquatic life, and have substantial nutrient data available. Although there are several streams within the project watersheds that have high biological integrity or are Reference Reaches, there are a limited number of nutrient samples from those streams. Blackwater Creek is a Reference Reach in 70f, that coincides with an Ambient Water Quality Monitoring Network watershed rotating station, LRW008. Two years of monthly data are available for this station, summarized below:

	Number Samples	MED	**75th percentile**	90th percentile
TP(mg/L)	23	<0.020	**0.022**	0.026
NN(mg/L)	21	0.372	**0.469**	0.536
TKN(mg/L)	23	<0.200	**<0.500**	<0.500
TN(mg/L)	21	0.414-0.629	**0.527-0.736**	0.608-0.898

Effects-based candidate benchmarks:

The entire watershed falls within the Mountains Bioregion and is not near a boundary. The benchmarks from a KDOW draft bioregional nutrient benchmarks report for the Mountains Bioregion are TP 0.025 mg/L, TN 0.650 mg/L. Those benchmarks were based largely on nutrient conditions observed in Reference Reaches and streams with Good-Excellent quality macroinvertebrate communities in the Mountains Bioregion, which encompasses Ecoregions 68, 69 and 70. Those benchmarks also were informed by literature guidelines that suggest that concentrations near below these levels represent oligotrophic conditions.

Final benchmark recommendations:

Because of the large number of OSRWs in the project area, benchmarks were selected from candidates conservatively so that even low level risks of nutrient effects on aquatic life can be identified.

Total P	0.020
TKN	0.500
Nitrate-Nitrite-N	0.200
Total N	0.600

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Consult water quality standards for parameters that have a numeric standard (e.g., pH, dissolved oxygen). Note that the watershed contains segments designated as Outstanding State Resource Water (OSRW) and Cold Water Aquatic Habitat, which have a lower or additional water quality standards relative to Warm Water Aquatic Habitat designated segments.

In general, for non-nutrient parameters that **do not** have numeric standards, use the 75th percentile of ecoregional Reference Reach data from Ecoregion 70, Western Allegheny Plateau, for data screening and prioritization (see table below). This conservative upper range provides the best estimate of regional expectations based on reference conditions, with the following qualifications/exceptions:

> For TSS and Turbidity, use these reference benchmarks only to compare normal April-October flow conditions and not high flow events or winter samples. The reference stream data came exclusively from biology sampling visits which are conducted only during stable flow conditions during these months. New monitoring data collected for the watershed plan project may identify streams where suspended sediment issues are minimal; if so, then high flow sample events from those streams could be used to derive a high flow screening benchmark.
>
> For Unionized Ammonia, use the WQS of 0.05mg/L as the main benchmark for screening. However, there may be cases where there is a concern for chronic effects to sensitive mussels at lower concentrations of unionized ammonia, especially at higher temperature and pH. If Ammonia-N at a site is routinely higher than 0.1 mg/L, then consult with the KDOW Nonpoint Source Section Technical Advisor (TA) to review the data for that site for potential chronic ammonia issues.

Benchmarks for data screening and prioritization may be lower than those to be used ultimately as targets for reduction in the watershed plan, since reference conditions may be well below reductions necessary to restore uses. Targets for reduction should take into consideration the extent and magnitude of problems as well as achievability. Consult the TA for assistance during goal-setting phases.

Ecoregional Reference summary

	Ecoregion	Number samples	MIN	MAX	MED	**75th Percentile**	90th Percentile
Ammonia-N (mg/L)	70	88	<0.025	0.173	<0.050	**<0.050**	<0.050
Unionized Ammonia (mg/L)	70	15	<0.0001	0.0005-0.0011	0.0001-0.0003	**0.0002-0.0007**	0.0004-0.0010
Sulfate (mg/L)	70	74	5.0	85.5	12.4	**20.0**	25.4

	Ecoregion	Number samples	MIN	MAX	MED	**75th Percentile**	90th Percentile
Specific Conductance (µS/cm)	70	81	44	322	170	**218**	252
Alkalinity (mg/L as $CaCO_3$)	70	47	10.1	176.0	49.5	**72.2**	84.2
TSS (mg/L)	70	70	<2.0	68.0	3.0	**6.0**	8.4
Turbidity (NTU)	70	29	0.61	37.8	3.8	**5.9**	10.2

Appendix E – Sewer Line & Waste Water Treatment Funding Options

Carigan, Deven (EEC)

From: Carigan, Deven (EEC)
Sent: Tuesday, January 14, 2014 3:42 PM
To: Walker, Jon -FS
Cc: Shireman, Brooke (EEC)
Subject: Campton WWTP options

Hi, Jon. Here are the funding options available to WWTPs.

1. **SRF** (State Revolving Fund, for investments in water infrastructure). This is a loan, currently the city would qualify for at 0.75% interest rate based on MHI (median household income). The term is for 20 years, but can go up to 30 years.

You have said that the mayor said that the system can't get this loan because they cannot repay it. Anshu says that Campton has 2 loans already, 1 for wastewater and 1 for drinking water. The clean water SRF requires 10% of the funds to give in the form of principle forgiveness. The city might be able to get some principle forgiveness so the system might want to look into. They must be at or below the MHI of $33,261, and Campton's MHI is somewhere around $19k.
http://www.gwadd.org/Sept_24_2012_WMC/2%20CWSRF%20Fact%20Sheet.pdf this link is from Fall 2012, so there might be updates.

2**. ARC** (Appalachian Regional Commission). They can give out a max of $500k. We would have to work with them. Someone from Campton would have to set a meeting and involve several entities interested in improving the watershed, the drinking water situation, or the wastewater situation. The goal would be to try to get as much grant money as possible to improve the lines at the WWTP. The plant itself seems to be fine, the lines are where the issues are.

3. **CBDG** (Community Block Development Grant). Implemented by DLG (Department for Local Government). Campton would qualify because it's a low income area, but these grants are pretty hard to get as the money is getting low.

The 1st option is implemented by KIA (KY Infrastructure Authority), and ARC & CBDG grants are implemented by groups that their office at KIA's offices.

4.**Rural Development**, implemented by USDA. This is a 70/30 – 70% of the money is a loan, and interest rates vary, and 30% of the money is a grant. I don't have info on the max amount.

First steps:
Any of this work will need to come from the mayor, and you will need to go through the ADD (Area Development District). Wolfe Co is in the Kentucky River ADD (KRADD). http://www.kradd.org/ Anshu Singh, with the DOW's Water Infrastructure Branch, said the contact in this ADD would be Jennifer McIntosh, and Anshu would also be glad to help with questions in these processes.

Campton will need to have an estimate of the money needed to perform the upgrade work necessary. Anshu suspected it would be in the area of $500k, going on the thought that the system didn't have more than 6-7 miles of line. She said installing liners should be an option in some parts, while replacement would be necessary in others, depending on the condition of the lines.

Some selling points that could be helpful to Campton receiving some grant money are that the drinking water system derives its water from both a reservoir and a well, and the well has been designated as a GUDI well, which is Groundwater Under the Direct Influence of surface water. The argument there is that any improvement made to surface water in this area will reduce contaminants that must be removed before the water is suitable for drinking. Having fewer contaminants to address helps keep the water facility equipment in good shape, requiring less maintenance. That seems like a good argument since

Campton water has a high tech membrane system for its drinking water. I would also imagine the citizens would greatly appreciate a mayor who was instrumental in the watershed having fewer fecal bacteria in their recreational and drinking water. Additionally, if we are doing nonpoint source work in the watershed, and that is coupled with point source improvement, there is possibility for delisting the impaired stream. All of these outcomes would be very desirable in this major recreational water.

Additional info:
*I found out a bit more about the SSES (Sanitary Sewer Evaluation Study). This is a study that the WWTP would do or have done, where they would do a smoke test and/or run a camera through the lines to identify leaks and other weaknesses in the lines. Campton would use the information to assess the system, to be able to determine if the lines need to be replaced or if they can be rehabilitated using a liner. It is not necessary that they already have the SSES to apply for money; the project should be SSES followed by rehabilitation or replacement of the lines.

*Below are links for information regarding Kentucky Operator Certification requirements and trainings can be found here http://dca.ky.gov/certification/Pages/CertifiedOperator.aspx . This could be useful for the operators of both the drinking water and the wastewater treatment facilities. I have also included some links provided by Chad VonGruenigen, who recently came (back) to us from DCA (Division of Compliance Assistance).

Deven Carigan, Technical Advisor
Nonpoint Source and Basin Team Section
Watershed Management Branch
KY Division of Water
502-564-3410 x4950
fax: 502-564-9899
From: Von Gruenigen, Chad (EEC)
Sent: Friday, January 10, 2014 12:22 PM
To: Carigan, Deven (EEC)
Cc: Shireman, Brooke (EEC)
Subject: Operator Training Info

Hello,
Below is a link to Kentucky's Operator Certification Program 2014 Training Schedule.
http://dca.ky.gov/certification/Training%20Schedule/currenttrainsched.pdf

List of alternative training providers
http://dca.ky.gov/certification/Documents/AlternativeTrainingProvidersRev070113.pdf

You may also look up operator training information at the link below.
http://dep.gateway.ky.gov/eSearch/Search_License.aspx
These are two common associations that offer training: KWWOA training events unfortunately the agendas may not have been approved as of yet.
http://www.kwwoa.org/training-registration

KRWA training events unfortunately the agendas may not have been approved as of yet.
http://www.krwa.org/training/

Thank you,
Chad Von Gruenigen
Basin Coordinator
KY Division of Water
200 Fair Oaks Lane, 4th Floor
Frankfort, Ky
(502) 564-3410 ext. 4941
chad.vongruenigen@ky.gov

Appendix F – Pollutant Load Reduction Calculations & Assumptions

The following documents how pollutant loads were calculated and some of the assumptions that were made. The numbers are specific to Swift Camp Creek.

Site	Average Annual Load lbs/year	Target Load lbs/year	% Reduction Needed Actual number of reduction needed
Swift Camp Unnamed Tributary	1.34E+13	2.79E+12	79% 10,610,000,000,000
Swift Camp Below Hirams Branch	2.70E+13	1.03E+13	62% 16,700,000,000,000
Swift Camp Off KY 15	1.12E+13	4.53E+12	60% 6,670,000,000,000
Swift Camp Campton WWTP	4.29E+13	8.87E+12	79% 34,030,000,000,000

Facts from KRADD and KY Gazeteer:

7503 people in county

8% of people in county are on sewer lines

2700 people in county treat wastewater onsite

All of the sewer lines are in Swift Camp Creek Watershed.

The County is 142,188 acres

Campton is 704 acres

Watershed area total is 13,693 acres

So, my extrapolation:

There are 7,503 people living in county. 8% of them are on sewer lines, so about 600 people. 2700 county residents use onsite systems, so 36% of County residents use onsite systems.

All of sewer lines are in watershed, so all 600 sewer hookups in watershed.

Campton is 1.1 square miles or 704 acres. There are 13,693 acres in watershed total. Subtract and you have 12,989 acres in the watershed excluding Campton. 7062 people live in county outside of Campton. There are 142,188 acres in Wolfe County total. So there are 141,484 acres in Wolfe County excluding Campton, therefore, there are 0.05 people per acre (this does assume an even population distribution outside of Campton, which is ok).

So 649 people live in watershed outside of Campton. 649 plus 441 people in Campton = 1090 people in watershed.

600 people on sewer lines. That leaves 490 people in the watershed not on sewer. If 37% of county uses onsite, then 181.3 people in watershed use onsite. That leaves 308.7 people not using onsite or sewer. With an estimated 2.5 people per households, there are 124 homes without sewer or onsite.

Also, as reported in Chapter 2, local health department experts estimated 35 failing septic systems in watershed.