



Source: SD1

Big Bone Creek Watershed Characterization Report

Prepared for: Sanitation District No. 1 of Northern Kentucky



January 2009

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1. WATERSHED SUMMARY

Watershed characterization reports are being developed for sixteen watersheds located in Northern Kentucky that lie within Sanitation District No. 1's (SD1's) service area. The purpose of the watershed characterization reports is to describe the physical and natural features, land cover, infrastructure, waterbody conditions, potential pollutant sources and other features in each watershed. This information will allow SD1 and other interested parties to develop an understanding of important features, pollutant sources and water quality in the watersheds. This information will also assist SD1 and others in goal-setting, prioritization of improvement projects, and assessment of the effectiveness of these projects. The watershed characterization reports meet the system characterization element for the receiving water that is required for a combined sewer overflow (CSO) Long-Term Control Plan (LTCP). Additionally, the Consent Decree requires that the Watershed Plans include elements of a LTCP.

The Big Bone Creek watershed is 82.6 square miles in size and is located primarily in Boone County (Figure 1), in the West Study Basin. This watershed is predominantly rural, with some developed areas located in the northeastern part of the watershed.

Big Bone Creek and its tributaries are designated for warm water aquatic habitat, primary contact recreation, secondary contact recreation and domestic water supply (at applicable points of withdrawal). Neither Big Bone Creek nor its tributaries appear on the 303(d) list of impaired waterbodies (KDOW, 2008). KDOW has proposed Little South Fork as a candidate for both exceptional water and outstanding state resource water designation (401 KAR 10reg:030) in the drafted amendments to the Kentucky Administrative Regulations anticipated in February 2009.

Water quality data have been collected in the Big Bone watershed since 1999. A comparison of recent water quality data to applicable water quality criteria revealed exceedences of the criteria for bacteria and dissolved oxygen. In addition, violations of dissolved oxygen, temperature and pH have been historically observed at the USGS continuous monitoring station on Mud Lick Creek, but more recent data are still being reviewed and are not yet included in this assessment.

The most recent habitat assessments reflect conditions that are partially to fully supporting of a diverse and productive ecosystem. Biological data are limited, but indicate good to excellent conditions.

Potential pollutant sources in this watershed include: one sanitary sewer overflow (SSO), KPDES-permitted dischargers, livestock, septic systems and overland storm water runoff. The potential for these sources to generate fecal coliform bacteria has been assessed using a Watershed Assessment Tool (WAT!)¹. The WAT! identifies the potential sources within a watershed and estimates their possible impact. It also allows SD1 to compare and rank the sixteen different Northern Kentucky watersheds.

The WAT! calculated a lower than average fecal coliform loading potential for year-round conditions for the Big Bone Creek watershed, with overland storm water runoff

¹ The WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

being the dominant source. The WAT! calculated an average loading potential for fecal coliform under base flow conditions. The dominant source during base flow conditions is predicted to be septic systems.

The WAT! ranking is one of several factors that should be considered when prioritizing watersheds for improvement projects. Other factors include moderate public interest due to past and ongoing improvement activities, the presence of two aquatic-dependent threatened or endangered species, the presence of one drinking water intake in this watershed and the presence of one creek as a candidate for exceptional water and OSRW designation.

Next steps for this watershed might include an assessment of dry weather bacteria sources upstream of Big Bone Creek RM 3.9 and assessment of riparian vegetation along Mud Lick Creek.

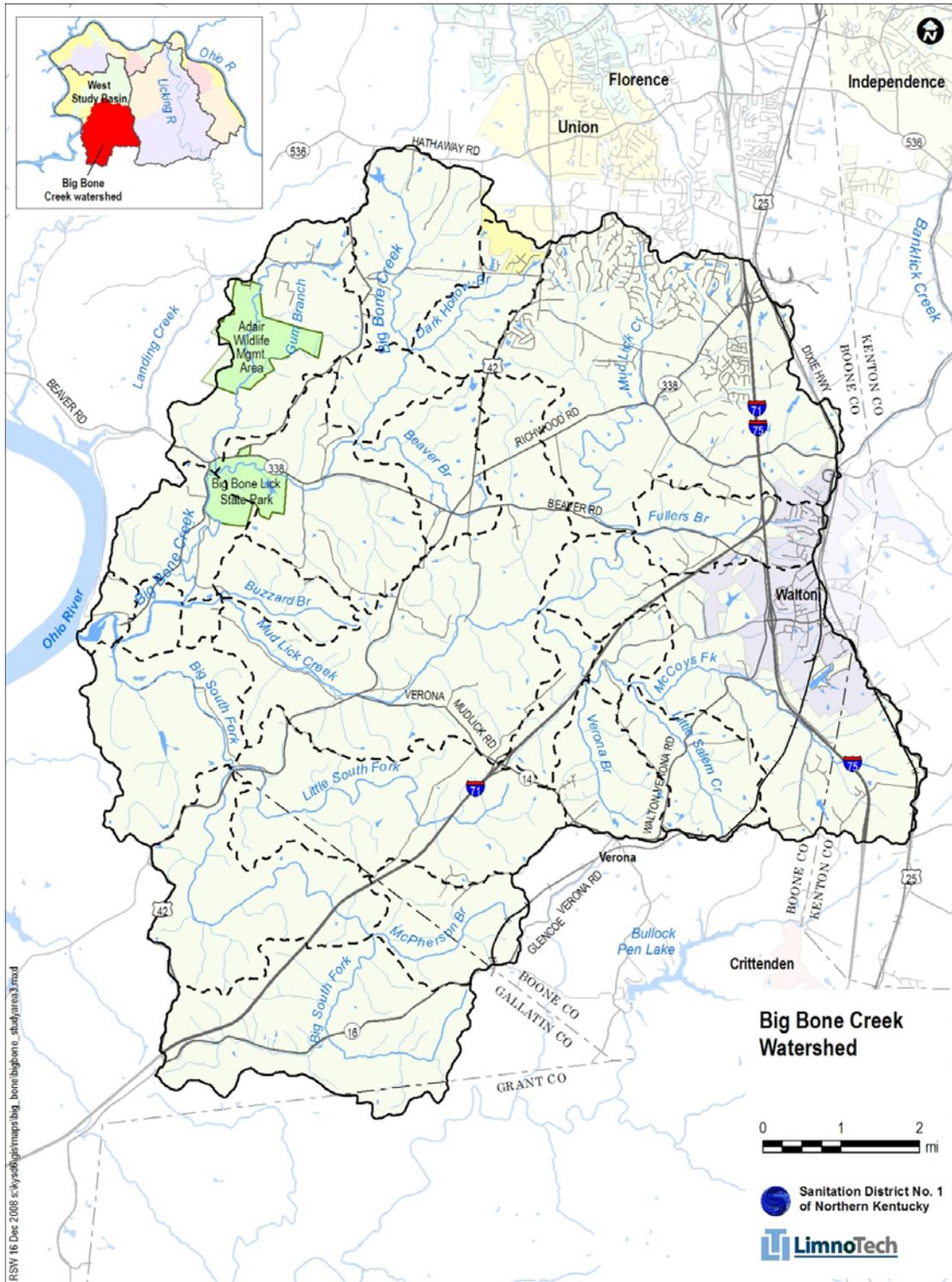


Figure 1. Big Bone Creek Watershed

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2. WATERSHED FEATURES

The Big Bone Creek watershed is 82.6 square miles in size and is located primarily in Boone County, with portions extending into Kenton, Gallatin and Grant Counties.

This 11.8-mile long creek originates southeast of Union and is joined by Mud Lick Creek and Big South Fork as it flows southwest to its confluence with the Ohio River. Big Bone Creek gets its name from large fossilized bones of animals, including mammoths and mastodons that were found in the marshes surrounding a warm salt spring, which attracted the animals to the area known as Big Bone Lick State Park.

2.1 PHYSICAL AND NATURAL FEATURES

The following sections describe key features of the watershed and creek, including hydrology, geology, topography, soils, climate, and habitat. These features are important because they affect land uses, and shape the chemical, biological, and hydrological characteristics of Big Bone Creek.

2.1.1 Hydrology

An active USGS continuous monitoring station (03277130) is located on Mud Lick Creek at the intersection of KY 14 and US Highway 42 near Beaverlick, KY within the Big Bone Creek watershed. The watershed draining to the station is 36 square miles², comprising approximately 44% of the Big Bone Creek watershed. Daily discharge measurements are available at the station from December 2000 to the present³. The average flow at the station is 53 cfs (12/1/2000 - 9/30/2007), and 95% of flows are less than 198 cfs. Base flows at this location have been measured at less than 2 cfs, with flows increasing by up to three orders of magnitude during a storm event. The maximum flow recorded at the USGS station is 2,510 cfs. The periods of high flow tend to be very brief and only last one to two days. In contrast, during extended periods of dry weather, flows at the station become intermittent. Between December 2000 and September 2007 there were 75 days with zero flow, which all occurred in 2002 and 2007.

The Boone County Comprehensive Plan notes that portions of the Mud Lick Creek watershed experiences frequent flooding (BCPC, 2005). The Big Bone Creek 100-year floodplain extends along the lower 9 miles of this creek, and is widest between RM 2.4 and 6.1 (approximately 3/8 mile wide). Floodplains also extend along most of the length of Mud Lick Creek, as well as the lower 3 miles of Big South Fork.

2.1.2 Geology

The Big Bone Creek watershed is located within the Outer Bluegrass Physiographic⁴ Region, which is underlain primarily by Ordovician-age interbedded limestone and shale

² This drainage area was calculated using a detailed watershed delineation developed for this project; the reported drainage area differs slightly from that reported by the USGS.

³ This analysis only uses approved data from USGS, and at the time of the analysis data was approved through 9/30/2007.

⁴ Physiographic regions are based on differences in geology, topography and hydrologic regime. The State of Kentucky is divided into five physiographic regions.

(Ray et al., 1994). Although roughly half of this watershed is underlain by bedrock with a moderate potential for karst development (Paylor and Currens, 2002), rocks in this region generally contain higher percentages of shale layers and do not develop extensive karst features (Ray et al., 1994)⁵.

The mainstem of this creek and the majority of the tributaries cut through the erodible shale found in the Kope formation. The rolling upland areas are underlain by the Grant Lake Limestone and Fairview formation, which produces broad stream valleys. Groundwater yield varies depending on geological formation. There is almost no groundwater available on the ridgetops, but wells in the valley bottoms can yield 100-500 gallons per day. This water is hard and may contain salt and hydrogen sulfide (Carey and Stickney, 2004).

2.1.3 Topography

The Big Bone Creek watershed has higher relief in the east, with upland areas dissected by headwater streams. The highest elevations in this watershed are along US 25, located along the eastern ridge of the watershed. The highest ground (964 feet above mean sea level) is at the intersection of Walton Nicholson Pike and U.S. 25. Closer to the Ohio River, the stream valleys widen significantly. The lowest elevation in the watershed (453.6 feet at normal Ohio River pool) is located at the confluence of Big Bone Creek with the Ohio River.

2.1.4 Soils

The nature of soils and topography in a watershed plays an important role in both the amount of runoff generated and the amount of soil erosion that can occur. Most (95%) of the soils in the Big Bone Creek watershed are classified as hydrologic soil group C (NRCS, 2006), meaning they have slow infiltration rates when thoroughly wetted.

Almost half of the soils in the watershed are ranked “highly erodible”, and 43% are ranked “fairly erodible” as indicated by an index for erodibility (NRCS, 2006). The erodibility of soils is important when soils are disturbed through activities such as land clearing for new development. Portions of this watershed are anticipated to undergo significant development in the future (Section 2.2).

2.1.5 Climate

The temperatures in this area are generally lowest in January and highest in July. Precipitation averages 41.2 inches annually, with the wettest months observed between March and July. Minimum precipitation is recorded in the fall and late winter as shown in Figure 2 (NCDC, 2008).

⁵ In areas with karst, an almost immediate connection between groundwater and surface water can exist, short-circuiting any attenuation of pollutant loads that might otherwise occur.

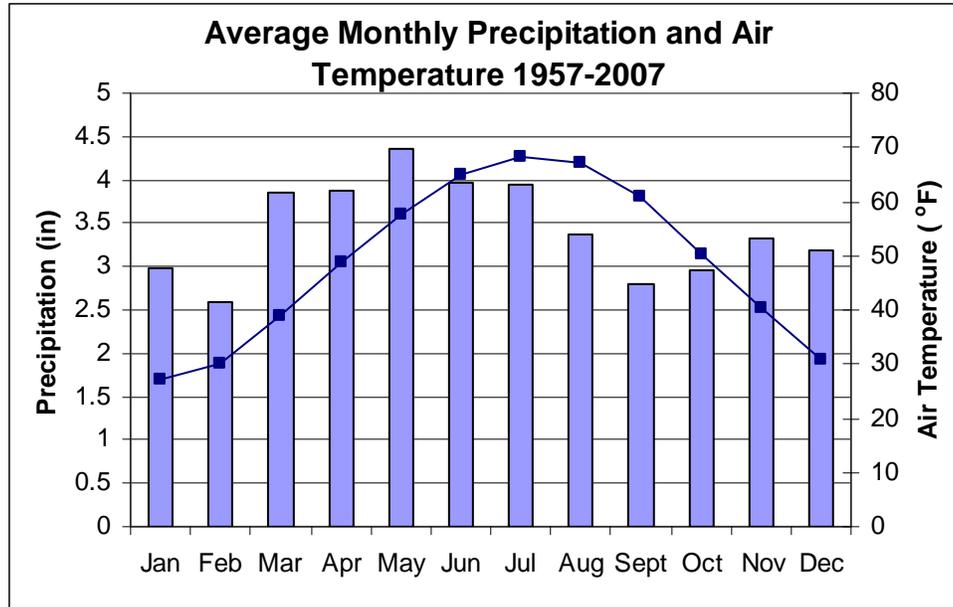


Figure 2. Average Monthly Precipitation and Air Temperature at the Cincinnati Northern Kentucky Airport (1957-2007)

2.1.6 Habitat

This watershed lies within the Outer Bluegrass ecoregion⁶, which is characterized by sinkholes, springs, entrenched rivers and intermittent and perennial streams (Woods et al., 2002). Wetlands are not common in this ecoregion and comprise less than 1% of this watershed. Streams are typically characterized as having relatively high levels of suspended sediment and nutrients. Glacial outwash exists in a few areas and tends to be highly erodible.

Pre-settlement conditions in this ecoregion consisted of open woodlands with barren openings, and vegetation was mostly oak-hickory, with some white oak, maple-oak-ash and American beech-sugar maple forests (Woods et al. 2002).

Today, natural habitats in the Big Bone Creek have been altered from their historical state (Section 2.2). The headwaters of Mud Lick Creek and Big Bone Creek are areas that are increasingly being developed as the population spreads to the southwest. Conversely, lower Mud Lick Creek and sections of Big Bone Creek within the Big Bone Lick State Park are undeveloped and relatively undisturbed.

A 512-acre natural area, Big Bone Lick State Park, is located near the confluence of Gum Branch and Big Bone Creek. Big Bone Creek within the park has some impacts from upstream land use, but the riparian zone is primarily intact and creek restoration projects are underway (Figure 3; see Section 2.5). Another large natural area in the watershed is the 631-acre Adair Wildlife Management Area (WMA), which lies along Gum Branch. This area is wooded with rolling hills.

⁶ Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources.

Aquatic habitats vary throughout the watershed. Erosion, eutrophication and aquatic habitat modification were visible during site visits in January 2007 (Figure 3). Instream habitat has been assessed⁷ at eight sites in the Big Bone Creek watershed and indicates variable habitat conditions (Table 1).



Figure 3. Big Bone Creek Within Big Bone Lick State Park

⁷ This assessment was conducted using EPA-established protocols and rated several components of physical habitat within the stream such as epifaunal substrate, embeddedness, sediment deposition, channel flow status, bank stability, and riparian vegetation zone width, among others.

Table 1. Aquatic Habitat and Biological Sampling

Stream	River Mile	Monitoring ^a							
		Habitat		Macroinvertebrates		Fish		Diatoms	
		Year	Ranking	Year	Ranking	Year	Result	Year	Result
Big Bone Creek	8.1	2004	Fully supporting	2004	Good				
Big Bone Creek	7.1			1995	Fair				
Big Bone Creek	5.5	2003	Not supporting			2003	Excellent		
Big Bone Creek	4.5	1999, 2004	Not supporting, Partially supporting			1999, 2004	Fair, Good		
McCoys Fork	1.7	1999	Fully supporting			1999	Good		
Mud Lick Creek	7.8	1999	Partially supporting			1999	Fair		
Mud Lick Creek	3	1999, 2004	Partially supporting			1999, 2002	Fair		
Little South Fork	4.3	2004	Supporting, but threatened	2004	Excellent				
Big South Fork	1.8	1999	Partially supporting					1999	Poor

^a When sampled more than once and rankings vary, both rankings are listed.

2.2 LAND COVER CHARACTERISTICS

Land cover and land use play an important role in the quantity and quality of runoff into receiving waters. Current and future land cover are described below.

2.2.1 Current Land Cover

The Kentucky Division of Geographic Information, Commonwealth Office of Technology provided a GIS dataset showing 2005 Kentucky land cover. This dataset was updated and improved to approximate 2007 land cover conditions (Figure 4) using a variety of other datasets that represent current impervious conditions (roads, parking lots, buildings), open space lands (including parks), and surface waters.

Development in the watershed is concentrated along roads and is primarily found in Union and Walton, the two incorporated communities located in the watershed. Other small communities in the watershed include Verona and Big Bone.

There are two large natural areas located in the Big Bone Creek watershed. These are the 512-acre Big Bone Lick State Park, and the 631-acre Adair Wildlife Management Area. Two campgrounds are also located in this watershed: Oak Creek, near McCoys Fork, and Big Bone Landing, near the mouth of Big Bone Creek.

Currently, 17% of the Big Bone Creek watershed is developed and 3% is covered with impervious surfaces. The dominant land cover in the watershed is forest, followed by pasture/hay. There is also one active landfill located in this watershed (Bavarian Trucking Landfill).

2.2.1.a Animal operations

There are no concentrated animal feeding operations (CAFOs) in this watershed (Kentucky Geographic Network, 2008). However, three animal feeding operation (AFO) permits were identified (Kentucky Geographic Network, 2008a). One of the AFOs is located in the Big South Fork watershed (24 beef cows) and one is in the McCoys Fork watershed (50 dairy cows). The permit for the third AFO was issued in 1993 in the Verona Branch watershed, but there are no animals currently listed on the permit. This can occur when people want to keep their permit, in case they want to have animals in the future (KDOW, 2007).

A tour of the watershed and a review of information obtained from the Conservation District in 2007 (Campbell, Kenton and Boone County Conservation District, 2007) confirmed that beef cattle and dairy cows are present in the Big Bone Creek and Mud Lick Creek watersheds. The agriculture within the watershed is primarily small, hobby farms with 50 to 100 head of cattle.

2.2.1.b Septic Systems

SD1 estimates that approximately 31% of all parcels in the Big Bone Creek watershed, within Boone County⁸ are potentially serviced by septic systems (Figure 13). Properties potentially serviced by septic systems are found in the highest densities in the eastern portion of the watershed, near the headwaters of an unnamed tributary to Mud Lick Creek, Fullers Branch and McCoys Fork.

The Northern Kentucky Health Department does not currently have available estimates for septic system failure rates in Kenton and Boone Counties. Anecdotal reports from Health Department inspectors suggest that 10% of the septic systems in these counties may be operating improperly due to incorrect installation, lack of maintenance or age of the system (NKHD, 2008).

In addition, one septic area was identified in the Mud Lick Creek subwatershed as having problems (septic “hot spot”). This is an area in an older subdivision that either has very small lots that have unrepairable failing systems, or has systems that have been repaired to the extent practicable on the site, but are not fully functional (NKHD, 2008a).

⁸ Information on properties potentially serviced by septic systems was not available for the portion of the watershed that lies in Gallatin County and Grant County.

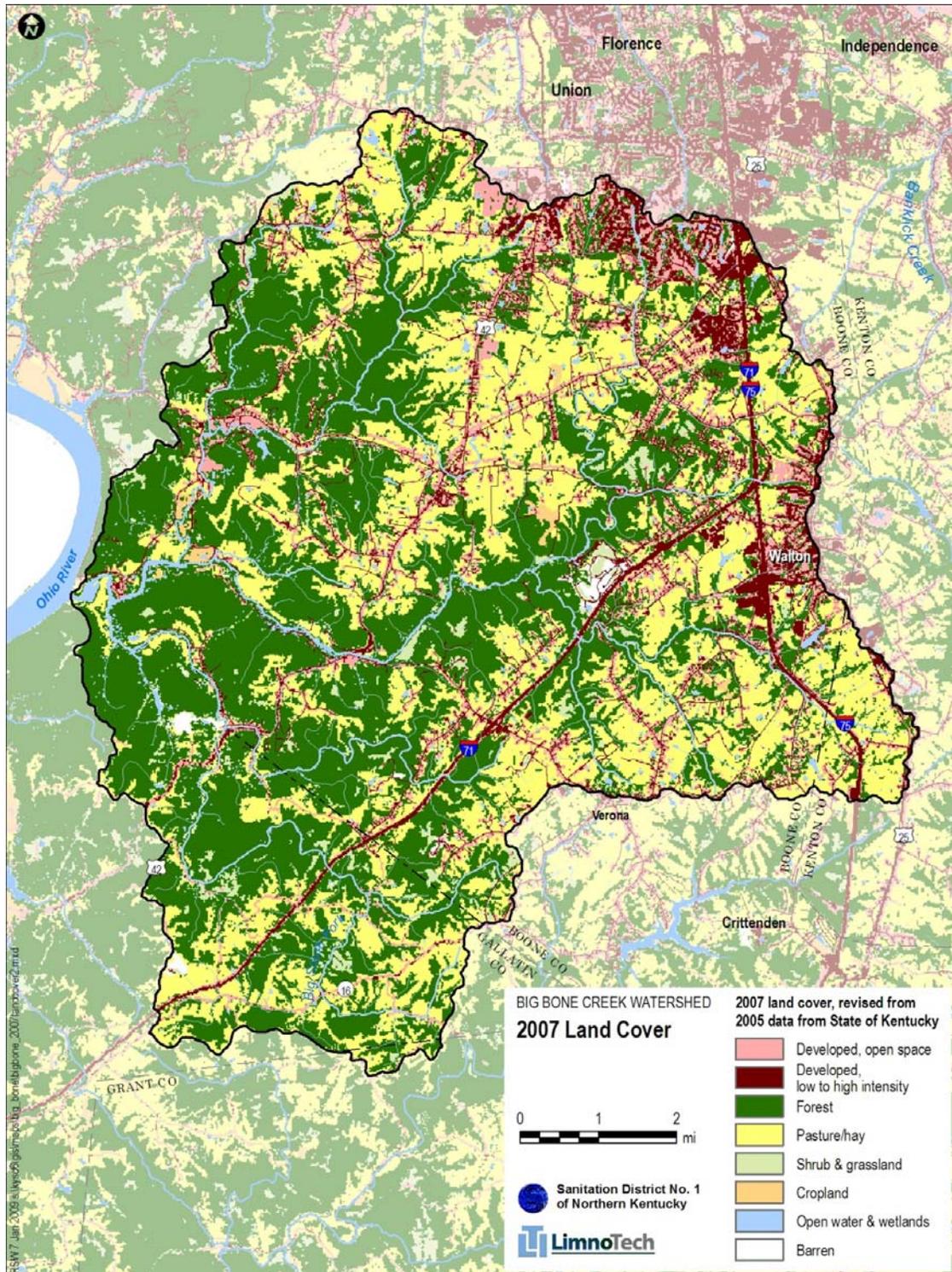


Figure 4. 2007 Land Cover

2.2.2 Future Conditions

Portions of the Big Bone Creek watershed are developing at a fairly rapid pace. Development is predicted to increase in the northeast corner of this watershed. Growth is expected in the I-71/I-75 corridor, especially near Walton, and in the area between Walton and Union. Development is also predicted to occur near Verona and its interchange on I-71.

In the Mud Lick Creek watershed, the I-75/Richwood Road (KY 338) interchange is planned for reconstruction and a right turn lane will be added to KY 338. Reconstruction is also planned for several stretches of Dixie Hwy (US 25) (Kentucky Transportation Cabinet, 2006), which traverses the eastern boundary of the watershed.

2.2.2.a Future land cover

Future land cover was developed by modifying 2007 land cover to reflect potential future conditions (roughly 2030) obtained from SD1 and the Northern Kentucky Area Planning Commission (NKAPC). It is predicted that development will primarily replace pasture and forest lands (Figure 5). Developed lands are predicted to increase from 17% to 30% and impervious surfaces in the watershed are predicted to increase from 3% to 6%.

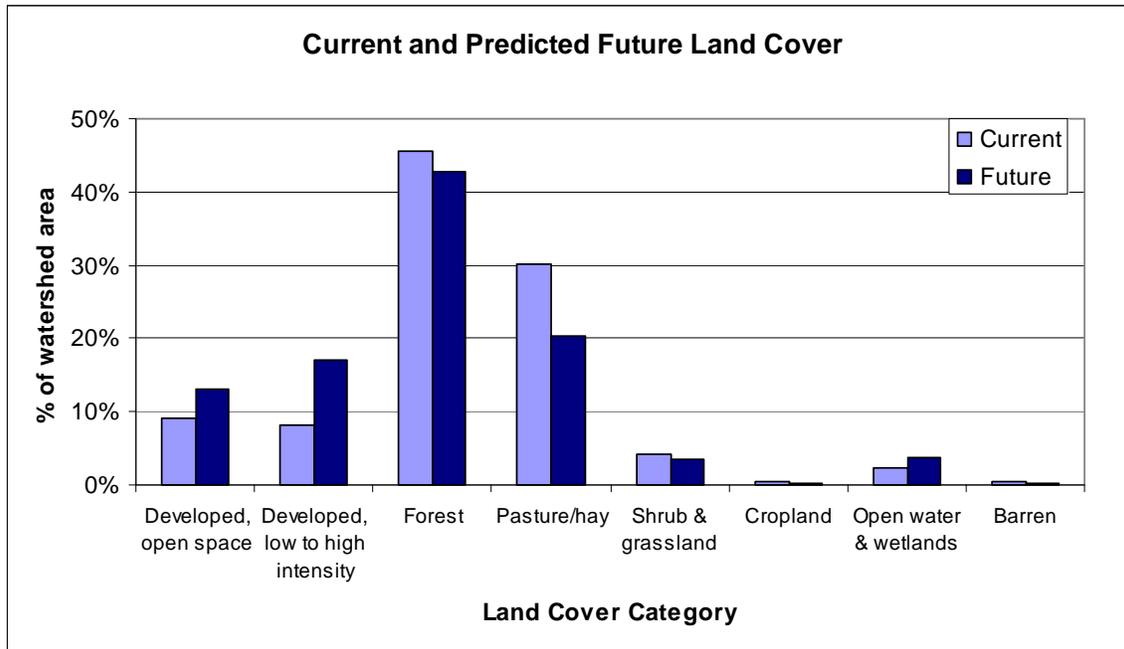


Figure 5. Current and Predicted Future Land Cover

2.3 INFRASTRUCTURE FEATURES

This section summarizes infrastructure features for the Big Bone Creek watershed⁹. Both the sanitary sewer and storm water infrastructure are located primarily in the northeastern

⁹ SD1 is undertaking a characterization and assessment of the sewer system, and overflows identified herein are subject to change. Information on the sanitary and storm water system in Section 2.3 was queried from SD1's geodatabase accessed on November 21, 2008.

part of the watershed, near the headwaters of Big Bone Creek and Mud Lick Creek (Figure 6).

Approximately 16% of the Big Bone Creek watershed is serviced by the 13.2 square mile separate sanitary sewer area. The City of Walton owns approximately 4.3 square miles of the separate sanitary sewer area in this watershed, but contracts with SD1 for operation and maintenance. The remainder is both owned and operated by SD1. In total, Big Bone Creek watershed contains approximately 50.3 miles of separate sanitary sewer lines.

Approximately 12% of this watershed lies within SD1's storm water service area. Within the service area, the storm water system is comprised of approximately 100.5 miles of streams and channels and approximately 23.9 miles of pipes.

There is no combined sewer system area in this watershed.

2.3.1 Point Sources and Infrastructure

The occurrence of KPDES-permitted discharges, sewer overflows and storm water discharges is discussed in this section.

2.3.1.a KPDES dischargers

There are 31 KPDES-permitted dischargers in the Big Bone Creek watershed. Twenty-three of these are sanitary wastewater, and the majority (15) of these are covered under general permits for residences. There are six KPDES-permitted discharges for storm water, four permitted discharges for storm water mixed with concrete mixer truck washout water, and a single permitted discharge for filter backwash water.

Based on a review of recent effluent monitoring data (January 2007 to June 2008), it was observed that 16 of the permitted discharges in the Big Bone Creek watershed have violated their permit limits for at least one of the following parameters: total ammonia, total suspended solids (TSS), fecal coliform, five-day carbonaceous biochemical oxygen demand (CBOD₅), *E. coli*, total chlorine, dissolved oxygen, oil and grease, total iron, and five-day biochemical oxygen demand (BOD₅). KDOW requires effluent monitoring for the residential general permits (monitoring is required twice a year); however data were not available for 11 of these facilities in this watershed. KDOW estimates that as a general group, residential dischargers fail at a rate that is believed to be higher than 10% (KDOW, 2007a).

Permitted dischargers are presented in Table 2.

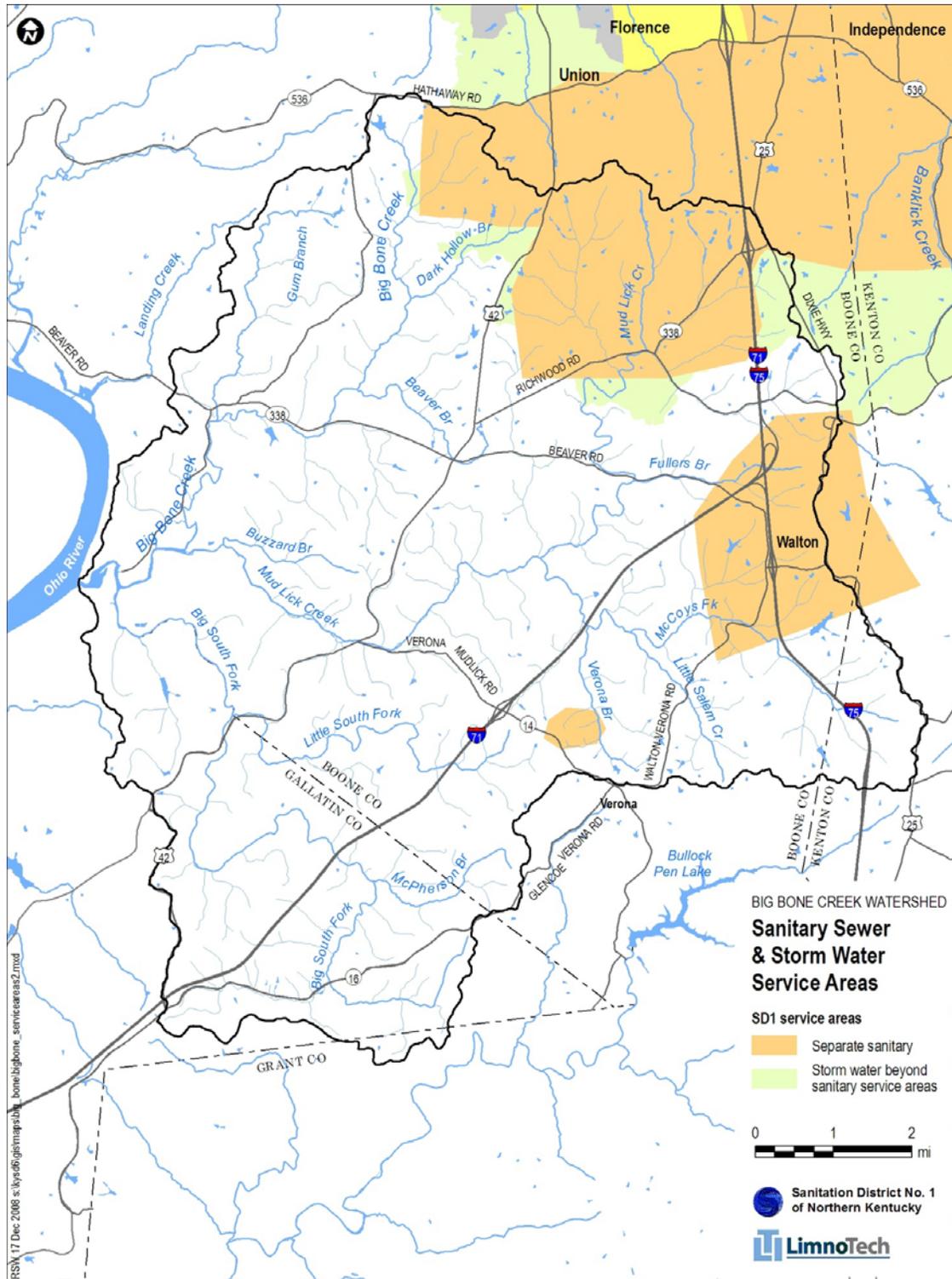


Figure 6. Sanitary Sewer and Storm Water Service Areas

Table 2. KPDES Permitted Dischargers

Receiving Water	KPDES ID	Facility Name	Outfall	Permit Type	Outfall Description	Currently Permitted? ^a	Permit Violations
Big Bone Creek	KY0020745	Big Bone Landing Marina	0012	Minor	Sanitary wastewater	Y	Total ammonia, TSS
Big Bone Creek	KYG400272	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Gum Branch	KYG400379	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Gum Branch	KYG400338	Residence	0011	Minor	Sanitary wastewater Type B	Y	Fecal coliform, total ammonia
Gum Branch	KYG400442	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Big Bone Creek	KY0024422	KY DOP Big Bone Lick St Pk	0012	Minor	Sanitary wastewater	Y	CBOD5, E. coli, fecal coliform, total chlorine, total ammonia, TSS
Big Bone Creek	KYG401103	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Big Bone Creek	KYG400485	Residence	0011	Minor	Sanitary wastewater Type B	Y	
Big Bone Creek	KYG400414	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Big Bone Creek	KYG402065	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Big Bone Creek	KYG400685	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Beaver Branch	KY0077101	Grandmas Restaurant	0011	Minor	Sanitary wastewater	Y	None
Big Bone Creek	KYG401887	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Big Bone Creek	KYG400511	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Buzzard Branch	KYG640138	KY DOP Big Bone Lick St Pk WTP	0011	Minor	Filter backwash water	Y	TSS
Mud Lick Creek	KY0075493	Beaverlick Baptist Church	0012	Minor	Sanitary wastewater	N ^b	CBOD5, DO, fecal coliform, total ammonia
McCoys Fork	KY0075612	Verona Chevron	0012	Minor	Sanitary wastewater	Y	E. coli, fecal coliform, total chlorine
Verona Branch	KY0077372	New Bethel Baptist Church	0012	Minor	Sanitary wastewater	Y	Dissolved oxygen, E. coli, fecal coliform, total chlorine, total ammonia, TSS
Verona Branch	KY0089699	US Bank	0011	Minor	Sanitary wastewater	Y	Dissolved oxygen, total chlorine, TSS
Verona Branch	KY0093025	Verona Commons Subd	0011	Minor	Sanitary wastewater	Y	None
McCoys Fork	KY0039756	Walton STP	0012	Minor	Municipal wastewater	Y	Total chlorine
McCoys Fork	KY0039756	Walton STP	001M	Minor	Metals monitoring yearly	Y	None
McCoys Fork	KY0078140	Ernst Concrete Walton Plant	001A	Minor	Mixer trk washout & storm water	Y	None
McCoys Fork	KY0078140	Ernst Concrete Walton Plant	002A	Minor	Mixer trk washout & storm water	Y	Oil and grease
McCoys Fork	KY0078140	Ernst Concrete Walton Plant	003A	Minor	Mixer trk washout & storm water	Y	None
McCoys Fork	KY0078140	Ernst Concrete Walton Plant	004A	Minor	Mixer trk washout & storm water	Y	TSS

Table 2. KPDES Permitted Dischargers - Continued

Receiving Water	KPDES ID	Facility Name	Outfall	Permit Type	Outfall Description	Currently Permitted? ^a	Permit Violations
McCoys Fork	KY0102091	Flying J Walton Truck Plaza	0011	Minor	Storm water runoff	Y	E. coli, fecal coliform, oil and grease, TSS
Mud Lick Creek	KY0072796	Vienna Woods Enterprises Inc	001A	Minor	Storm water runoff	Y	Total iron, TSS
Mud Lick Creek	KY0072796	Vienna Woods Enterprises Inc	001B	Minor	Storm water runoff	Y	None
Mud Lick Creek	KY0002801	Cincinnati South Travelcenter	0022	Minor	Storm water runoff	Y	TSS
Mud Lick Creek	KY0080772	Pilot Travel Centers LLC #321	001A	Minor	Storm water runoff	Y	Oil and grease, TSS
Mud Lick Creek	KY0089010	Pilot Travel Center #278	0021	Minor	Storm water runoff	Y	Oil and grease
Mud Lick Creek	KYG400263	Residence	0011	Minor	Sanitary wastewater Type B	Y	None
Mud Lick Creek	KYG400100	Residence	0011	Minor	Sanitary wastewater Type B	Y	BOD5, total ammonia
Mud Lick Creek	KYG400117	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Mud Lick Creek	KYG401170	Residence	0011	Minor	Sanitary wastewater Type B	Y	NA
Big South Fork	KYG840219	Sterling Materials Sierra One	0011	Minor	Precipitation	Y	NA

^a Discharge is permitted as of June 2008

^b Discharge permit inactivated 2/12/07 due to installation of on-site sewage disposal

NA – Monitoring data were not available

2.3.1.b Sewer overflows

There are no combined sewer overflows (CSOs) in the Big Bone Creek watershed. The Richwood pump station (2320PS3) has a constructed bypass and is located in the Mud Lick Creek subwatershed (Table 3). As described in section 2.3.3, the Richwood pump station bypass is planned for elimination.

Table 3. Sanitary Sewer Overflow Points

Manhole ID	Direct Discharge to Waterbody	Typical Year Spill Frequency (No.) ^a	Typical Year Volume (million gallons) ^a
2320PS3 (Richwood pump station)	Mud Lick Creek	0	0

^a The results presented were generated by models based on SD1's current understanding of the collection system infrastructure. These models are predictive tools and are based on numerous variables and assumptions on the characteristics of the collection system, and may differ from actual measured field conditions. These models are subject to change based on improved knowledge of the system, improvements to the system, and changes in land use and development. These results are subject to change and should therefore not be relied on or considered definitive.

2.3.1.c Storm water discharges

SD1's storm water service area is located near the Mud Lick Creek headwaters. Storm water pipe outlets are concentrated this area. In addition to storm water pipe outlets, there are approximately five suspected illicit activity (SIA) points. SIAs are locations where there was possible evidence of illicit activity during SD1's storm water mapping project (2001-2002). These locations are being further investigated to determine if they are recurring.

Much of this watershed is located outside of SD1's storm water service area, so outfalls and other illicit discharges may be located in these areas, but were not inventoried by SD1. Storm water outfalls covered by individual permits have been discussed previously.

2.3.2 Recently Completed Infrastructure Projects

There are two recently completed infrastructure projects in the Big Bone Creek watershed.

- Downs Subdivision Sewer Assessment Project. Completed in 2005 for \$586,274, this project extended sewer lines, giving 38 properties the opportunity to connect to sewer service in the Mud Lick Creek Watershed.
- Richwood Pump Station Improvements Project. Completed in 2006 for \$278,000, this project provided additional dry and wet weather pumping capacity at the pump station. It also eliminated odor complaints by installing a new oxygen-based odor control system to reduce hydrogen sulfide, and associated odors in the waste stream.

2.3.3 Ongoing or Planned Infrastructure Improvement Projects

There are several upcoming infrastructure improvement projects.

- Richwood Pump Station. SD1 will upgrade and install a new forcemain to convey flows to the new Union Sewer and Western Regional Water Reclamation Facility (WRWRF). This work is currently scheduled to be completed in 2013, depending on the schedule of the WRWRF.
- Pump Station Backup Power Program. SD1 is planning on installing backup power generators at two pump stations within the Big Bone Creek watershed: Lassing Green PS and Brushup Lane PS. These installations will eliminate any overflows that might occur at these locations as a result of power failure.

This work is summarized in Table 4.

Table 4. Planned Infrastructure Improvement Projects

Capital Improvement Project Title	Goals	Anticipated Start Date	Anticipated Completion Date	Project Total
Richwood Pump Station Upgrade and Forcemain	Convey flows to the new WRWRF and eliminate Richwood PS bypass	2011	2013	\$5,710,000
Pump Station Backup Power Program (Lassing Green and Brushup Lane PS)	Ensure that all pump stations have backup power or other appropriate measures for addressing power outages	2008	2015	\$254,000

2.4 SENSITIVE AREAS

The federal CSO Control Policy (USEPA, 1994) states EPA's expectation that a permittee's Long-Term Control Plan (LTCP) give the highest priority to controlling CSOs in sensitive areas. The CSO Control Policy indicates that sensitive areas include:

- Waters designated as Outstanding National Resource Waters (ONRW);
- Waters with threatened or endangered species and their habitat;
- Waters with primary contact recreation, such as bathing beaches;
- Public drinking water intakes and their designated protected areas;
- National Marine Sanctuaries (NMS) and
- Shellfish beds.

These six criteria were evaluated individually. None of the waterbodies in the Big Bone Creek watershed have been designated as ONRW (401 KAR 10:030) nor are there any NMS (NOAA, 2008). Additionally, there are no known commercial shellfish beds within the Big Bone Creek watershed nor is shellfish harvest for consumption by private individuals known to occur. Therefore these three criteria were determined not to be relevant to the identification of sensitive waters in the Big Bone Creek watershed. The remaining three criteria are discussed below.

2.4.1 Threatened & Endangered Species or Their Designated Critical Habitat

Threatened and endangered species, species of concern and their designated critical habitat within the Big Bone Creek watershed were identified by contacting the Kentucky State Nature Preserves Commission (KSNPC). KSNPC identified two species that are either threatened and/or endangered (running buffalo clover and nodding rattlesnake-root) and two species of concern (Table 5; KSNPC, 2007).

Running buffalo clover is a small herbaceous plant (Figure 7) that inhabits stream banks and upland areas, and erosion is noted as the biggest threat (KSNPC, 2006). Other factors contributing to population declines are loss of bison populations, non-native plants, and overall habitat loss (USFWS, 2003).



Figure 7. Running Buffalo Clover

Nodding rattlesnake-root is an herbaceous plant that inhabits various habitats, including riverine floodplains. Threats to this plant include timber removal, trail construction, introduced species and erosion (KSNPC, 2006).

The northern leopard frog is a state species of special concern that inhabits various habitats including slowly flowing areas in creeks and rivers, springs, the nearshore area of lakes, bogs, fens, herbaceous wetlands, riparian areas and grasslands (NatureServe, 2007). Threats to the northern leopard frog include habitat loss, commercial overexploitation and competition with introduced species (NatureServe, 2007).

Henslow's sparrow is a state species of special concern and a federal species of management concern which is neither aquatic nor dependent on aquatic habitats. This species inhabits grassland and savannah habitats and the greatest threat to the species is habitat loss (Reinking, 2002).

Table 5. Endangered Species, Threatened Species and Species of Concern

Taxonomic Group	Common name	Scientific name	Status ^a	Last Observed	Habitat(s)	Identified Threats
Vascular Plants	Running Buffalo Clover	<i>Trifolium stoloniferum</i>	Federal – Endangered State - Threatened	2006	Riparian areas, upland areas	Habitat loss, non-native species, bison decline ^b
	Nodding Rattlesnake-root	<i>Prenanthes crepidinea</i>	State - Threatened	1998	Various	Timber removal, trails, exotic species and increased erosion ^b
Amphibians	Northern Leopard Frog	<i>Rana pipiens</i>	State - Special Concern	1960	Ponds, wetlands, grasslands	Habitat loss, non-native species, commercial overexploitation ^c
Breeding Birds	Henslow's Sparrow	<i>Ammodramus henslowii</i>	Federal - SOMC State - Special Concern	1985	Grasslands, savannas	Habitat loss ^d

^a SOMC = Species of Management Concern, a federal designation.

^b KSNPC, 2006 and USFWS, 2003

^c NatureServe, 2007

^d Reinking, 2002

2.4.2 Primary Contact Recreation Waters

Kentucky does not have a tiered approach for primary contact recreation (PCR). This means that the State has designated that all PCR waters should be suitable for full body contact recreation during the recreation season of May 1 through October 31 (401 KAR 10:001E). However, the State water quality standards do not define full body contact recreation, so the bacteria criteria that have been developed are based on the presumption that people will ingest the water and could therefore become ill if the water was sufficiently contaminated with bacteria.

Big Bone Creek and its tributaries are designated for PCR. It is not clear whether or not swimming activity occurs in the creeks, as public surveys regarding that information are unavailable. No public swimming beaches were identified in the watershed. Additional data will be gathered about uses of the creek.

2.4.3 Public Drinking Water Intakes or their Designated Protection Areas

There is one public drinking water intake from surface water located within the Big Bone Creek watershed, in Big Bone Lick State Park. A second intake is located on the Ohio River, far downstream of the Big Bone confluence with the Ohio River, near Louisville, Kentucky.

Source Water Assessment and Protection (SWAPP) zones are delineated to identify potential contaminants upstream of water intakes and are not used to support identification of sources potentially impacting the intakes. The entire watershed draining to Big Bone Lake lies within SWAPP Zone 1, due to the water intake for the State Park (Figure 8).

The Ohio River Valley Water Sanitation Commission (ORSANCO) has determined that the remainder of this watershed lies within SWAPP Zone 2, reflecting the fact that this watershed is more than 25 miles upstream of the Louisville intake.

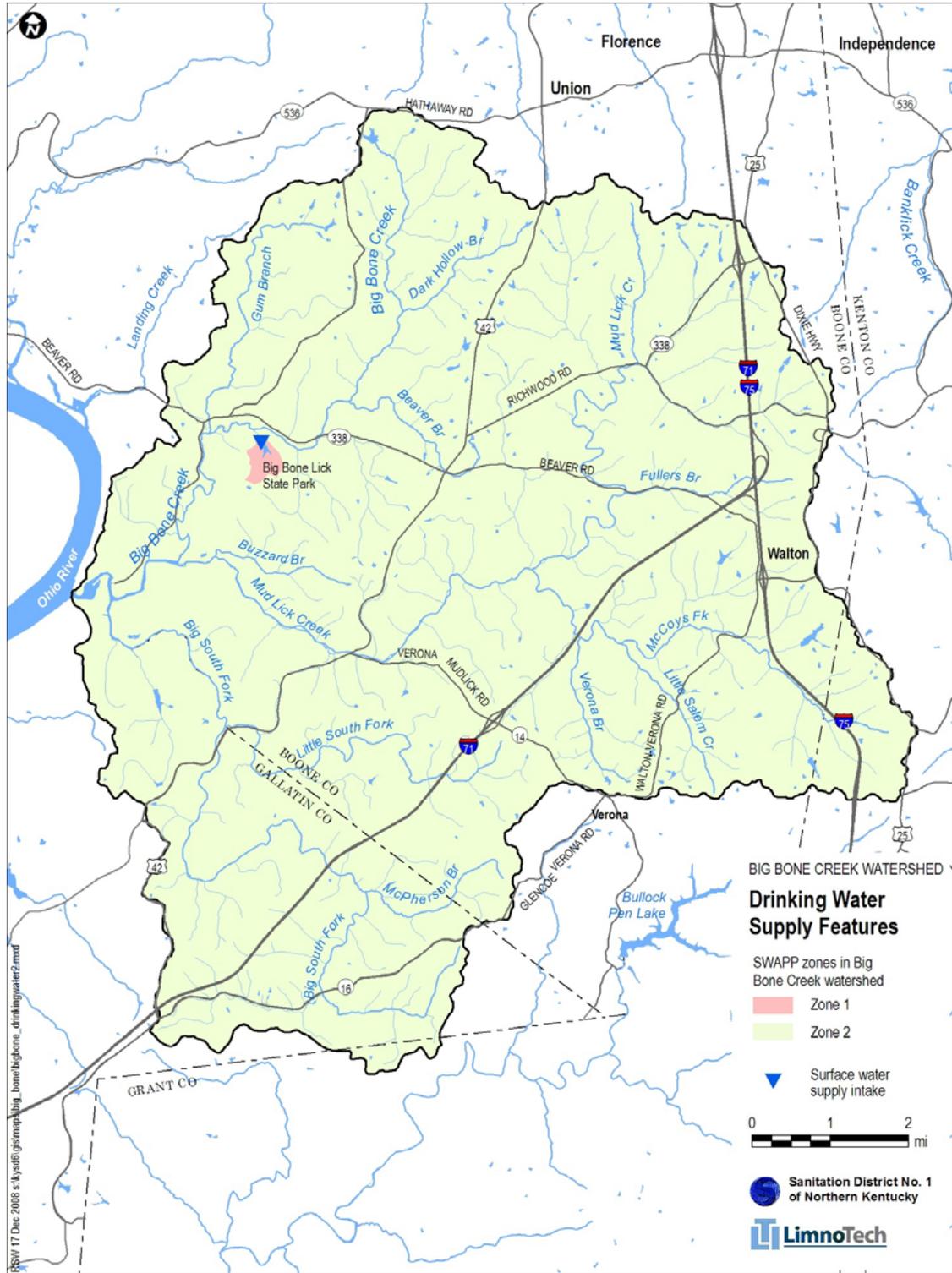


Figure 8. Drinking Water Supply Features

2.5 PUBLIC INTEREST/WATERSHED GROUP ACTIVITIES

Public interest in this watershed is considered to be moderate and is gauged by past monitoring and improvement projects conducted in this watershed. Several organizations have conducted monitoring in this watershed (Section 4.2).

The Northern Kentucky University (NKU) Center for Applied Ecology (CAE) has conducted restoration work at two locations within the Big Bone Creek watershed: Big Bone Lick State Park and Adair Wildlife Management Area.

The Big Bone Lick State Park Stream Corridor Restoration projects were implemented between 2003 and 2007. One project on a Big Bone Creek tributary included the stabilization of 200 feet of stream bank and 24 acres of native riparian vegetation restoration (Figure 9). In 2003, instream habitat was improved in Big Bone Lick State Park by removing a dam and adding rock riffles (Figure 10). This project was conducted to stop headcutting and incision within the creek. Another aspect of these projects was to move a small buffalo herd away from lowland/wetland areas in the park to reduce soil erosion and impacts to aquatic habitats. A 2.5-acre wildlife viewing area was also created.

More recent work (2006-2007) included stabilization of a 200-foot gully originating at the water treatment plant, stabilization of the 200-foot lake spillway channel, stabilization of 400 feet of incised stream, stabilization of 400 feet of an outside bend of Big Bone Creek, replacement of an undersized box culvert, and removal of concrete and asphalt debris from the floodplain. Riparian forest restoration and enhancement has also been completed and this work was partially funded by the Wildlife Habitat Incentive Program.



Figure 9. Stream Restoration of Big Bone Creek Tributary

Photos show before (left) and after (right)



Source: Northern Kentucky University Center for Applied Ecology

Figure 10. Instream Habitat Restoration Project on Big Bone Creek

Photos show before (left) and after (right).

CAE also completed projects in the Adair Wildlife Management Area focused on the tributaries and valley bottoms along Gum Branch. Activities included clean-up of 11 dump sites primarily located in stream channels, stream and wetland stabilizations and riparian reforestation. Planned future work includes creation of pools to improve aquatic habitat; restoration of sinuosity, floodplains, and riffle/pools; stabilization of stream bank and wetlands; removal of waste from the riparian zone; and reforestation of the riparian zone.

In addition to NKU CAE, the Boone County Conservancy is an organization dedicated to the creation of parks and protection of land with unique or significant recreational, natural, scenic, historical or cultural value. This group is working with professors at Thomas More College and Northern Kentucky University to identify unique or significant natural areas in Boone County and will work to protect areas through voluntary acquisition of land and interests in land, in partnership with the many constituencies in the community (<http://www.thebooneconservancy.org>).

Finally, the Boone County Greenways Plan is under development but was not available at the time of this report. This plan may contain additional information on proposed greenways in this watershed.

3. WATERBODY USES

This section describes designated and current uses for Big Bone Creek and its tributaries.

3.1 DESIGNATED USES

Big Bone Creek and its tributaries are designated for warm water aquatic habitat, primary contact recreation, secondary contact recreation and domestic water supply, applicable at existing points of public water supply withdrawal (401 KAR 10:026). These uses are defined below.

- **Warm water aquatic habitat** means any surface water and associated substrate capable of supporting indigenous warm water aquatic life.
- **Primary contact recreation** waters means those waters suitable for full body contact recreation during the recreation season of May 1 through October 31.
- **Secondary contact recreation** waters means those waters that are suitable for partial body contact recreation, with minimal threat to public health due to water quality.
- **Domestic water supply** means surface waters that with conventional domestic water supply treatment are suitable for human consumption through a public water system as defined in 401 KAR 8:010, culinary purposes, or for use in any food or beverage processing industry; and meet state and federal regulations under the Safe Drinking Water Act, as amended, 42 U.S.C. 300f - 300j.

Little South Fork has also been identified as a candidate for exceptional water and outstanding state resource water designation (401 KAR 10reg:030) in the drafted amendments to the Kentucky Administrative Regulations anticipated in February 2009. .

- **Exceptional waters** means a surface water categorized as exceptional by the cabinet pursuant to 401 KAR 10:030.
- **Outstanding state resource waters** means a surface water categorized by the cabinet as an outstanding national resource water pursuant to 401 KAR 10:031.

3.2 CURRENT USES

An assessment of available information found the following:

- Aquatic habitat assessments reflect highly variable ratings in Big Bone Creek, ranging from fully supporting at one location to not supporting in another. Habitat in Mud Lick Creek is rated partially supporting and in Little South Fork is rated supporting, but threatened.
- The most recent biological data suggest good to excellent conditions in Big Bone Creek and excellent conditions in Little South Fork. Slightly older data are available for Mud Lick Creek and suggest fair conditions.
- A statewide fish consumption advisory was issued on April 11, 2000 due to low levels of organic mercury found in fish taken from Kentucky waters (KDOW, 2007b).
- There are currently no swimming advisories for Big Bone Creek. However, the Kentucky Division of Water and the Division of Public Health Protection and Safety recommend against swimming or other full-body contact with surface waters

immediately following heavy rainfall events, especially in dense residential, urban and livestock production areas (KDOW, 2007c).

- Two fishing access sites are found in the watershed. One is on Big Bone Creek at Big Bone Landing marina and the other is in Big Bone State Park and is an access site for the lake (<http://kygeonet.ky.gov/kdfwr/viewer.htm>).
- Mud Lick Creek is identified by the Kentucky Department of Fish and Wildlife Resources as a smallmouth bass stream, based on fish populations (Ross, undated).
- There is one surface drinking water intake in the watershed, which is located in Big Bone Lick State Park.
- There are no active public water supply wells in the Big Bone Creek watershed (KDOW, 2008a; KDOW, 2007d).

4. WATERBODY CONDITIONS

This section describes monitoring programs and water quality and biological conditions in this watershed.

4.1 303(d) STATUS AND POLLUTANTS OF CONCERN

None of the waterbodies in this watershed appear on the 303(d) list of impaired waterbodies (KDOW, 2008).

4.2 MONITORING PROGRAMS

Water quality data have been collected in this watershed by Northern Kentucky University (NKU), Licking River Watershed Watch (LRWW), the Conservation District, KDOW, USGS and SD1. Data currently compiled by SD1 from known monitoring programs are presented in Table 6; however, only data which have been fully analyzed are discussed in section 4.3 Water Quality Data Analysis. Available data exists for the main stem of Big Bone Creek, as well as Little South Fork, McCoys Fork, Mud Lick Creek, and an unnamed tributary to Mud Lick Creek.

Data not included in this report will be reviewed and included in subsequent updates.

4.2.1 Future Sampling

SD1 plans to continue monitoring in Big Bone Creek during base flow conditions with at least one survey per year. The five sampling locations are: Big Bone Creek RM 3.9, Mud Lick Creek RM 3.0 and 12.0, Big South Fork RM 1.8, and McCoys Fork RM 1.7. Typical analyses will include bacteria, nutrients, solids, oxygen-demanding constituents and physical parameters.

SD1 is planning to collect wet weather data at the five baseline locations in the Big Bone Creek watershed in 2010. Attempts will be made to collect data during three events of varying characteristics (total rainfall, maximum intensity). Samples may be analyzed for bacteria, nutrients, solids, oxygen-demanding constituents and physical parameters. Within each event, samples will be collected near hour 0, 2, 4, 6, 12, 24, 36 and 48 hours of the start of the storm, though these intervals are dependent on the storm characteristics and may be changed if necessary.

Biological monitoring is also planned for this watershed in 2010 at five locations. This will include habitat surveys along with fish and macroinvertebrate population assessments. Additionally, surveys to assess the degree of stream hydromodification are currently underway.

The USGS will continue to operate the stage gage and measure flow and water quality (physical parameters) at RM 3.0 (station 03277130). This station is operated and funded via a cooperative agreement between USGS and SD1.

Table 6. Summary of Water Quality Monitoring Data

Entity	Dates	Parameters Sampled	Sampling Locations ^b	Number of Samples
NKU	2003	Fecal coliform, alkalinity, boron, chloride, hardness, DO, conductivity, temperature, silicon, sulfate, TSS, nutrients, metals	Big Bone Cr. RM 5.7; McCoys Fork RM 1.7, 4.2; Mud Lick Cr. RM 3.0, 5.0; Unnamed Trib. RM 0.1	1 sample (9/6/2003)
NKU	2001	Fecal coliform, E. coli, DO, pH	Big Bone Cr. RM 1.0, 5.3, 6.9	1 sample (8/25/2001)
NKU	2003	Fecal coliform	Big Bone Cr. RM 5.7; McCoys Fork RM 1.7, 4.2; Mud Lick Cr. RM 3.0, 5.0, 8.4	1 sample (7/10/2003)
NKU	2002	Atrazine, DO, pH	Big Bone Cr. RM 6.9	1 sample (5/18/2002)
LRWW	2003	Fecal coliform	Big Bone Cr. RM 5.7; McCoys Fork RM 1.7, 4.2; Mud Lick Cr. RM 3.0, 8.4	1 sample (5/14/2003)
LRWW	2003	Fecal coliform	McCoys Fork RM 0.1; Unnamed Trib. RM 0.1	1 sample (7/10/2003)
LRWW	2003	Fecal coliform	Mud Lick Cr. RM 8.4	1 sample (9/5/2003)
Conservation District	2003	DO, pH, conductivity, nutrients	Big Bone Cr. RM 5.7	1 sample (7/12/2003)
Conservation District	2003	Triazine	Big Bone Cr. RM 5.7	1 sample (5/17/2003)
Conservation District	2004	Fecal coliform, E. coli, DO, pH, conductivity, temperature	Big Bone Cr. RM 5.7	2 samples (May, July)
LRWW, Conservation District	2004	Fecal coliform	McCoys Fork RM 0.1, 1.7; Mud Lick Cr. RM 3.0, 5.0, 8.4; Unnamed Trib. RM 1.8 of McCoys Fork RM 3.3; Unnamed Trib. RM 0.1 of Mud Lick Cr. RM 6.0	1 sample (5/22/2004)
LRWW, Conservation District	2004	Fecal coliform	McCoys Fork RM 0.1; Mud Lick Cr. RM 3.0, 5.0; Unnamed Trib. RM 1.8 of McCoys Fork RM 3.3; Unnamed Trib. RM 0.1 of Mud Lick Cr. RM 6.0	1 sample (July)
LRWW, Conservation District	2004	Fecal coliform, E. coli	McCoys Fork RM 0.1; Mud Lick Cr. RM 5.0, 8.4; Unnamed Trib. RM 0.1 of Mud Lick Cr. RM 6.0	1 sample (Sept)
Conservation District	2004	Fecal coliform, E. coli, alkalinity, chloride, DO, pH, conductivity, temperature, sulfate, TSS, nutrients	Big Bone Cr. RM 5.7; McCoys Fork RM 1.7; Mud Lick Cr. RM 3.0; Unnamed Trib. RM 1.8 of McCoys Fork RM 3.3	1 sample (Sept)

Table 6. Summary of Water Quality Monitoring Data - Continued

Entity	Dates	Parameters Sampled	Sampling Locations	Number of Samples
Conservation District	2005	Fecal coliform, E. coli, DO, pH, conductivity, temperature	Big Bone Cr. RM 5.7; Mud Lick Cr. RM 3.0	2 samples (May, July)
Conservation District	2005	Fecal coliform, E. coli, alkalinity, chloride, DO, pH, conductivity, temperature, sulfate, nutrients	Big Bone Cr. RM 5.7; Mud Lick Cr. RM 3.0; Unnamed Trib. RM 1.8 of McCoys Fork RM 3.3	1 sample (9/10//2005)
Conservation District	2006	Fecal coliform, E. coli, DO, pH, conductivity, temperature	Big Bone Cr. RM 5.7; Mud Lick Cr. RM 3.0; Unnamed Trib. RM 1.8 of McCoys Fork RM 3.3	1 sample (5/13/2006)
Conservation District	2006	Fecal coliform, E. coli, DO, pH, conductivity, temperature	Big Bone Cr. RM 5.7; McCoys Fork RM 1.7; Mud Lick Cr. RM 3.0; Unnamed Trib. RM 1.8 of McCoys Fork RM 3.3	1 sample (7/15/2006)
Conservation District	2006	Fecal coliform, E. coli, alkalinity, chloride, DO, pH, conductivity, temperature, sulfate, nutrients	McCoys Fork RM 1.7; Mud Lick Cr. RM 3.0; Unnamed Trib. RM 1.8 of McCoys Fork RM 3.3	1 sample (9/9/2006)
SD1	2006	Fecal coliform, E. coli, DO, pH, conductivity, turbidity, temperature	Big Bone Cr. RM 3.9; Mud Lick Cr. RM 3.0, 12.0	2 samples from baseline survey (9/27/2006 & 10/16/2006)
SD1	2007	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, TSS, temperature, turbidity, nutrients	Big Bone Cr. RM 3.9; Mud Lick Cr. RM 3.0, 12.0; McCoys Fork RM 1.7; Big South Fork RM 1.8	1 sample (7/31/2007)
SD1	2008 ^a	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, TSS, temperature, turbidity, nutrients	Big Bone Cr. RM 3.9; Mud Lick Cr. RM 3.0, 12.0; McCoys Fork RM 1.7; Big South Fork RM 1.8	1 sample (10/21/2008)
KDOW	2004	Alkalinity, chloride, hardness, DO, pH, conductivity, temperature, sulfate, TSS, TOC, nutrients	Little South Fork RM 4.3	1 sample (4/29/2004)
KDOW	1999, 2004	DO, pH, conductivity, temperature	Big Bone Cr. RM 4.5	2 samples (8/6/1999 & 7/29/2004)
KDOW	1999, 2002	DO, pH, conductivity, temperature	Mud Lick Cr. RM 3.0	2 samples (8/6/1999 & 8/8/2002)
KDOW	1999	DO, pH, conductivity, temperature	McCoys Fork RM 1.7; Mud Lick Cr. RM 7.8	1 sample (8/12/1999)
KDOW	2003	DO, pH, conductivity, temperature	Big Bone Cr. RM 5.5	1 sample (8/20/2003)
USGS	2000-present ^a	Gage height, discharge, precipitation, DO, DO % sat, pH, conductivity, turbidity, temperature	Mud Lick Cr. RM 3.0 (station number 03277130)	15-minute intervals

^aData not analyzed in Section 4.3, including USGS data collected after WY 2005

^b RM = River mile

4.3 WATER QUALITY DATA ANALYSIS

Historical water quality data (1999-2005) have been analyzed to identify past water quality problems in this watershed. Historical exceedances of bacteria, sulfate, dissolved oxygen, pH and temperature have been observed. The dissolved oxygen, temperature, and pH violations were only observed at the USGS continuous monitoring station.

Recent data (2006-present) have been analyzed in more detail because these data better reflect the effect of existing sources on instream water quality. This analysis has revealed dissolved oxygen violations and exceedances of the bacteria criteria. The recent data analysis does not include the continuous USGS measurements or recent data collected by the Conservation District. These data are still being reviewed and will be included in the next update of this report.

4.3.1 Historical Data

Both discrete measurements and the continuous water quality data were analyzed to identify historical water quality problems. The 15-minute data collected at the station through water year 2005 have been previously analyzed and documented in a report by Cumberland Environmental Group (2007). This report is used as the basis for the continuous data analysis. Locations with historical water quality issues are presented in Tables 7 and 8. Measurements at locations or parameters not shown met water quality criteria.

Table 7. Historical Bacteria Exceedances

Stream	River Mile	Parameters exceeding criteria			
		Fecal coliform		<i>E. coli</i>	
		# samples	% of samples exceeding criteria ^a	# samples	% of samples exceeding criteria ^a
Big Bone Creek	5.3	---	n/a	1	100%
Big Bone Creek	5.7	9	78%	5	80%
Mud Lick Creek	3.0	9	44%	5	50%
Mud Lick Creek	5.0	5	40%	2	50%
Mud Lick Creek	8.4	5	20%	---	n/a
Unnamed tributary entering Mud Lick Creek at RM 6.0	0.1	5	100%	2	100%
McCoys Fork	0.1	4	50%	2	50%
McCoys Fork	1.7	5	80%	---	n/a
McCoys Fork	3.3	6	67%	2	50%

^a There are no instances where 5 samples were collected from a single location within a 30-day period. Therefore the comparison to the geometric mean portion of the fecal coliform and *E. coli* criteria, which requires a minimum of 5 samples taken during a 30-day period, is not possible. Comparisons were, however, made to the part of the criteria that reads, "Content shall not exceed 400 colonies/100 ml in 20 percent or more of all samples taken during a 30-day period for fecal coliform or 240 colonies/100ml for *E. coli*." Even this comparison is conservative as the criterion is meant to be applied to a dataset of 5 or more samples collected over a 30-day period.

Table 8. Historical Sulfate Violations

Stream	River Mile	Parameters violating criteria	
		Sulfate	
		# samples	% of samples in violation ^a
Mud Lick Creek	5.0	1	100%

^a The sulfate criterion is 250 mg/l.

The dissolved oxygen, temperature and pH violations discussed below have only been observed historically at the USGS station on Mud Lick Creek.

Violations of the 4 mg/l dissolved oxygen criterion were reported in every water year (2001-2005) and most of these violations occurred between May and September. The lowest dissolved oxygen concentrations generally occurred on days where a very low or zero flow was recorded at the station. The primary production cycle has been identified as primarily responsible for the dissolved oxygen violations (CEG, 2007).

Between water year 2001 and 2005, Mud Lick Creek had the most temperature violations of the eight continuously monitored locations in Northern Kentucky (CEG, 2007). Violations of the temperature criteria were reported in every water year (2001-2005) and all were observed during low flow conditions. All temperature violations occurred between June and September (CEG, 2007).

pH was observed to change more than 1 su in a 24 hour period in every water year (2001-2005). pH outside of the 6-9 su pH range was only observed in WY 2002. Most of these violations occurred in late June during a period of extremely low flow. The apparent cause of pH violations is algal growth and photosynthesis (CEG, 2007).

4.3.2 Recent Data

Recent (2006-2007) water quality data were available for the mainstem of Big Bone Creek (RM 3.9), McCoys Fork (RM 1.7), Big South Fork (RM 1.8) and Mud Lick Creek (RM 3.0 and 12.0). These measurements are only available for base flow conditions, with wet weather monitoring planned for 2010. Additionally, recent data collected at the USGS station on Mud Lick Creek are still being reviewed and will be included in the next update of this report.

Bacteria exceeded water quality criteria at two locations, and dissolved oxygen was less than the criteria at one location. There were 11 samples each for fecal coliform, *E. coli*, and dissolved oxygen. Measurements for parameters and at locations not shown met water quality criteria.

4.3.2.a Bacteria

Four of the five locations had no fecal coliform criteria exceedances and three had no *E. coli* criteria exceedances (Table 9). Elevated levels of *E. coli* have been observed in Big Bone Creek and Mud Lick Creek; elevated levels of fecal coliform have also been observed in Big Bone Creek.

As shown in Figure 11, two fecal coliform samples from Big Bone Creek exceeded the applicable criterion. The maximum fecal coliform concentration, 860 cfu/100 ml, was observed on July 31, 2007 at RM 3.9.

Table 9. Recent Bacteria Exceedances

Stream	River Mile	Parameters exceeding criteria			
		Fecal coliform		<i>E. coli</i>	
		# samples	% of samples exceeding criteria ^a	# samples	% of samples exceeding criteria ^a
Big Bone Creek	3.9	3	67%	3	67%
Mud Lick Creek	12.0	3	0%	3	33%

^a There are no instances where 5 samples were collected from a single location within a 30-day period. Therefore the comparison to the geometric mean portion of the fecal coliform and *E. coli* criteria, which requires a minimum of 5 samples taken during a 30-day period, is not possible. Comparisons were, however, made to the part of the criteria that reads, "Content shall not exceed 400 colonies/100 ml in 20 percent or more of all samples taken during a 30-day period for fecal coliform or 240 colonies/100ml for *E. coli*." Even this comparison is conservative as the criterion is meant to be applied to a dataset of 5 or more samples collected over a 30-day period.

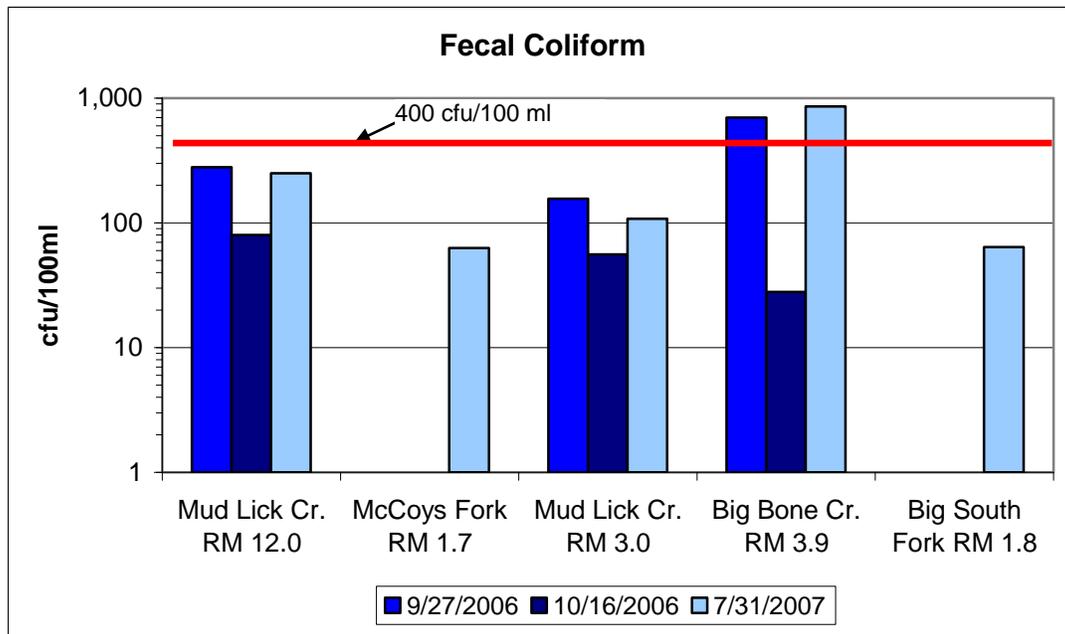


Figure 11. 2006-2007 Base Flow Sampling Results for Fecal Coliform Compared to 400 cfu/ 100 ml Criterion

As shown in Figure 12, two *E. coli* samples from Big Bone Creek exceeded the applicable criterion, as did one sample from Mud Lick Creek. The maximum *E. coli* concentration, 600 cfu/100 ml, was observed on July 31, 2007 at RM 3.9.

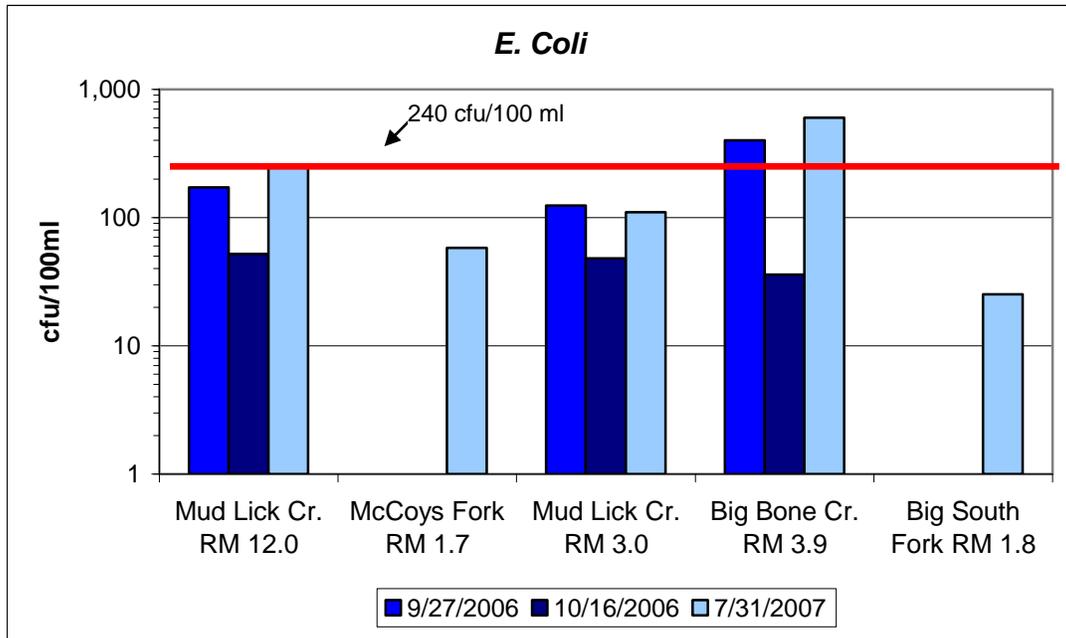


Figure 12. 2006-2007 Base Flow Sampling Results for *E. Coli* Compared to 240 cfu/100 ml Criterion

4.3.2.b Dissolved oxygen

Dissolved oxygen only violated criteria at one of the five sampled locations (Table 10). One of three dissolved oxygen measurements at Big Bone Creek RM 3.9 violated the applicable criterion. A concentration of 3 mg/l was observed on July 31, 2007. All of these measurements were taken during base flow conditions.

Table 10. Recent Dissolved Oxygen Violations

Stream	River Mile	Parameters violating criteria	
		Dissolved oxygen	
		# measurements	% of measurements in violation ^a
Big Bone Creek	3.9	3	33%

^a The dissolved oxygen criterion is 4 mg/l.

4.4 BIOLOGICAL CONDITIONS

Biological conditions in the study area have been assessed at several sites in the Big Bone Creek watershed. The data from these studies reveal variable conditions (Table 1).

Macroinvertebrate communities are susceptible to water quality and habitat degradation, and data from these communities are used as a tool to detect changes in habitat and water quality and assessing stream health (KDOW 2008b). KDOW sampled macroinvertebrates at two sites within the watershed. All MBI scores¹⁰ were “fair” or better and a site on Little South Fork ranked as “excellent” (Table 1).

Benthic algae are useful biological indicators of water quality because they are sensitive to changes in water quality and are the primary producers within aquatic ecosystems. Diatoms are benthic algae that are useful indicators of biological integrity because at least a few can be found under almost any condition and they are identifiable to species (KDOW, 2008b). In 1999, Big South Fork received a poor rating based on diatom measurements.

The most recent fish data reflect good to excellent fish communities, according to the KIBI scores¹¹ calculated at two locations (Table 1).

4.5 STREAM METABOLISM

Stream metabolism can be used as a measure of ecosystem health because it responds to the complex interactions between instream conditions (physical, biological and chemical) and watershed conditions. It can be assessed by looking at the ratio of primary production (P), which is influenced by instream conditions (light and nutrient inputs), to respiration (R), which is influenced by watershed conditions (other nutrient and detritus inputs). This ratio can be calculated using continuous instream dissolved oxygen measurements, because dissolved oxygen responds to both instream and watershed inputs. Smaller ratios (e.g., P:R less than 1) suggest that stream system health is more strongly affected by watershed inputs than by instream and near stream processes.

Stream metabolism has been analyzed at the eight USGS continuous monitoring stations which deploy multi-parameter sondes. These stations are located in watersheds that have varying levels of watershed impacts; however, none are located in an unimpacted or reference watershed. For the 2000-2005 period, all eight sites have ratios that indicate the health of these streams is more strongly affected by watershed inputs than instream and near stream inputs.

For the period 2000 to 2005, Mud Lick Creek (RM 3.0) had the third lowest P/R ratio among all monitored sites, suggesting that stream metabolism at this site is more

¹⁰ The macroinvertebrate data collected by KDOW were used to calculate the Kentucky macroinvertebrate biotic index (MBI). The MBI compiles attributes of the macroinvertebrate community such as taxa richness, pollution tolerant species and pollution intolerant species. Additional metrics are added depending on the stream size and/or ecoregion.

¹¹ The data from the fish surveys were used to calculate the Kentucky Index of Biotic Integrity (KIBI), a multimetric index using fish as an indicator of stream health. The KIBI compiles attributes of the fish community such as taxa richness and abundance, pollution tolerance/ intolerance, feeding and reproductive needs, and presence or absence of native species in order to provide a numerical value and corresponding narrative classification for streams.

dominated by organic consumption processes than the other monitored sites. Further, fluctuations in average annual metabolism measures for the Mud Lick Creek site are second greatest among other monitoring sites for the 2000-2005 period. Continued evaluation of stream metabolism at the Mud Lick Creek station will help to understand the natural variability of metabolism and the potential of changes within this watershed impacting the production/respiration balance at this site.

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5. SOURCE ANALYSIS

This section summarizes potential pollutant sources in the Big Bone Creek watershed and its subwatersheds in order to provide information related to observed impairments. Conclusions are based on the watershed characterization and available water quality data.

5.1 WATERSHED SOURCE ANALYSIS

Potential sources of bacteria and oxygen-demanding constituents were identified within the Big Bone Creek watershed, based on the watershed characterization information provided. Recent water quality issues were observed during base flow conditions; however, all potential sources currently identified are summarized in Table 11 and their location is shown in Figure 13. As shown in this table, there are no CSOs in this watershed.

Table 11. Summary of Potential Sources

	Big Bone Creek	Mud Lick Creek	Big South Fork
<i>Recent observed impairment=></i>	<i>Bacteria, Dissolved oxygen</i>	<i>Bacteria^{c,d}</i>	
SSO-Pump Station ^a		1	
KPDES sanitary outfalls ^b	14	9	
KPDES storm water/other outfalls		11	1
Active Landfill		1	
Livestock	Cattle	1 AFO (cattle) Other cattle	1 AFO (cattle)
Septic Systems	Many	Many 1 "septic hot spot"	Information limited
Urban storm water runoff	Urban and rural	Urban and rural	Rural
Streambank erosion	Observed		
Watershed improvements	Stream and wetland restoration completed in Big Bone Lick State Park and Adair Wildlife Mgmt Area. Additional restoration work planned on Gum Branch.	Richwood pump station capacity improved in 2006, and bypass is planned for elimination by 2013. Back up power planned for two other pump stations.	

^a SD1 is undertaking a characterization and assessment of the sanitary sewers, and sources are subject to change.

^b Excludes permitted CSOs

^c Flooding has also been reported

^d DO, pH and temperature violations have historically been observed at the USGS station, but recent data are not yet available .

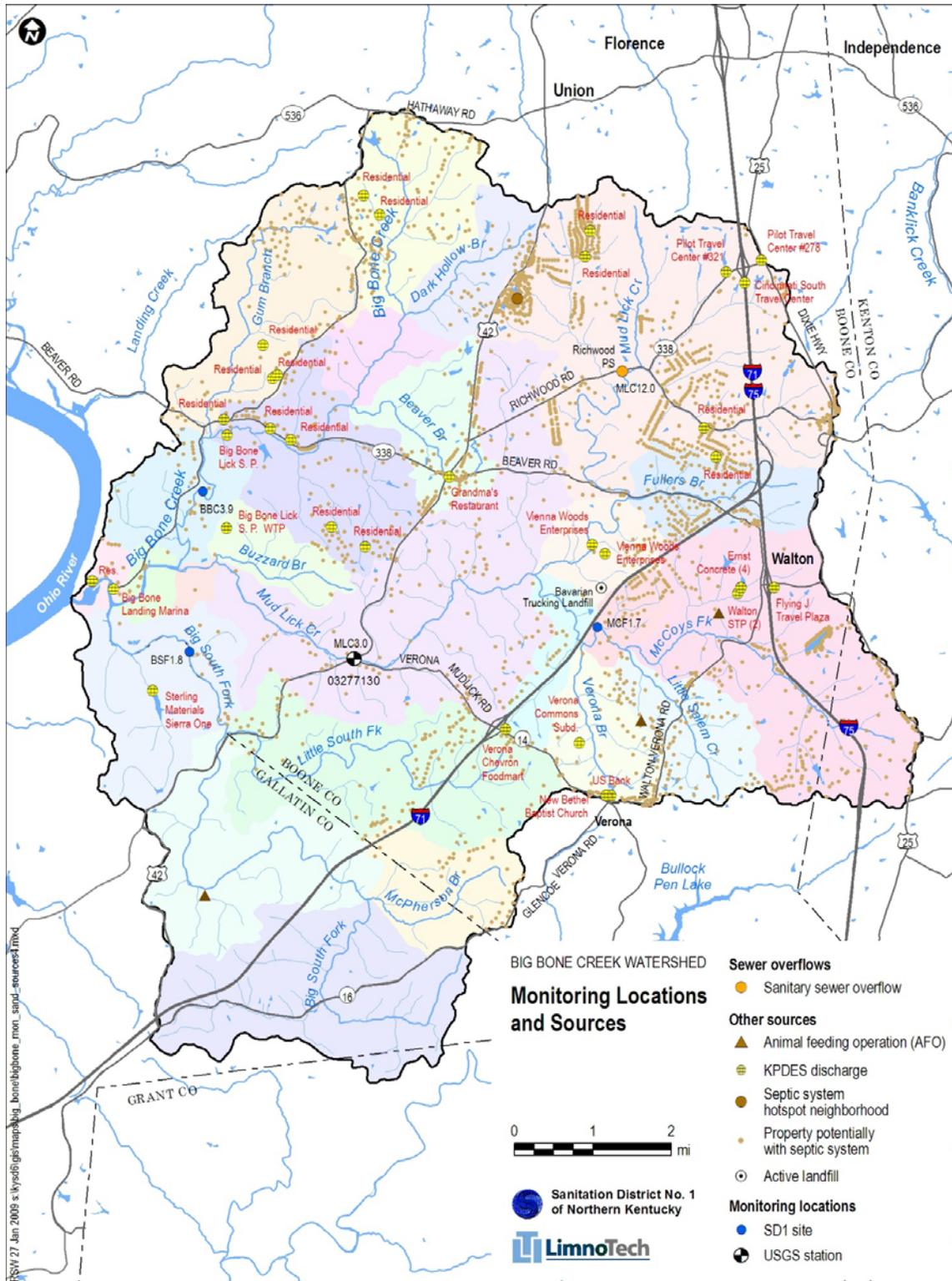


Figure 13. Monitoring Locations and Sources

6. RANKING

6.1 RESULTS

The WAT! is a tool that assesses the potential for point and nonpoint sources to generate fecal coliform, total solids and total phosphorus pollutant loads. WAT! was developed for these three pollutants because data to support modeling were readily available and they are representative indicators of potential water quality conditions. Calibration of the WAT! tool for total solids and total phosphorus is planned, and results should be available in future reports. Results for fecal coliform are discussed below.

This analysis was conducted for each of the sixteen watersheds located within SD1's study area. In addition to assessing pollutant loading potential by source, the WAT! also assesses pollutant loading potential by watershed, which allows for ranking and comparisons among the sixteen watersheds.

WAT! results¹² indicate that the Big Bone Creek watershed has a lower than average ranking for bacteria. In addition to watershed rank, other factors such as special designations, and the presence of aquatic-dependent threatened and endangered (T&E) species may affect watershed prioritization. These and other ranking considerations are summarized in Table 12.

Table 12. Watershed Ranking Considerations

CSOs (#)	SSOs (#)	SWAPP Zone	Aquatic-dependent T&E Species (#)	Special Designations	Public interest	WAT Rank, year-round conditions ^a
						Bacteria
0	1 Pump Station	Zone 1 (Big Bone Lick State Park intake), Zone 2 (Louisville intake)	2 ^b	Little South Fork is a candidate for exceptional water and OSRW designation	Moderate	12 of 16

^a The WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

^b In addition, there is one aquatic-dependent species of special concern and one terrestrial species of special concern which is also a federal species of management concern

6.2 SCREENING TO DETERMINE IF ADDITIONAL DATA ARE NEEDED

Big Bone Creek has been sampled since 1999. Additionally, the USGS continuous monitoring station on Mud Lick Creek provides a good record of flow, DO, temperature, pH and a few other parameters.

¹² WAT is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

6.2.1 Data Gap Analysis

Sufficient water quality data exist or are planned for collection to characterize current conditions in this watershed. Recent biological and habitat data are very limited for this large watershed; however, the assessments planned for 2010 will help address this data gap.

Sources contributing to elevated levels of the base flow bacteria at RM 3.9 on Big Bone Creek are not known and further investigation is recommended. Historical temperature measurements at the USGS station show that Mud Lick Creek is the warmest of the eight monitored streams in the study area. An investigation of riparian vegetation along Mud Lick Creek upstream of RM 3.0 would also be useful to assess if lack of shade from riparian vegetation is a contributing factor to the temperature violations in Mud Lick Creek.

Wet weather event-based sampling is scheduled for 2010. This monitoring will better characterize the contribution of wet weather sources and overall watershed health.

6.3 SOURCE PRIORITIZATION

The sources identified through the process of watershed characterization have been quantified using the WAT!. WAT! has been applied for a five-year period (1992-1996 climatological conditions), to quantify fecal coliform contributions by source. Together the characterization and WAT! results help inform source prioritization for improvement or elimination.

6.3.1 WAT! Results

The relative fecal coliform load generated by source is shown in Figure 14. These WAT! results incorporate predicted sewer overflow volumes from infrastructure model simulations for 1992-1996 climatological conditions¹³. CSOs were not a factor in the WAT! results, as none occur in the watershed. The one SSO in this watershed is not predicted to overflow under the modeled climate conditions.

Under year-round conditions, the largest source of fecal coliform bacteria is overland storm water runoff. Septic systems are not a significant contributor to the total annual bacteria load; however, during base flow conditions they are estimated to contribute the majority of the fecal coliform load.

¹³ The results presented were generated by models based on SD1's current understanding of the collection system infrastructure. These models are predictive tools and are based on numerous variables and assumptions on the characteristics of the collection system, and may differ from actual measured field conditions. These models are subject to change based on improved knowledge of the system, improvements to the system, and changes in land use and development. These results are subject to change and should therefore not be relied on or considered definitive.

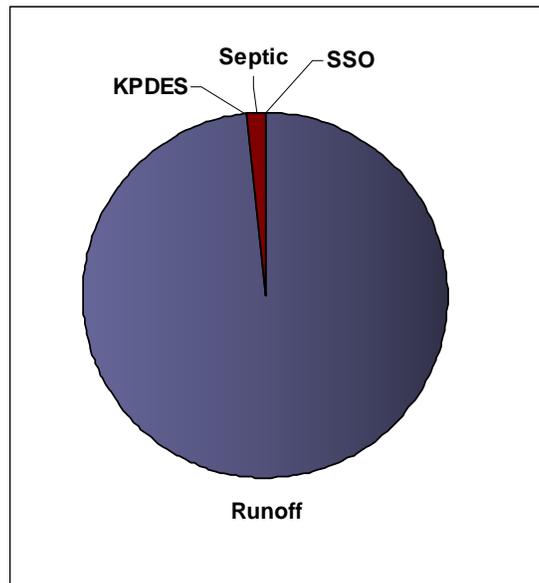


Figure 14. Initial Year-Round WAT! Results for Fecal Coliform

WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

WAT! results should be considered preliminary as ongoing work may affect the WAT! source analysis and rankings. Work is currently ongoing to refine the bacteria contribution from septic systems.

6.4 WATSHED RANKING

The WAT! produced a ranking, by watershed for sixteen watersheds, based on their potential to generate fecal coliform loads over a 1-year period. The water quality impact score (analogous to load) for each of the sixteen watersheds was used as a ranking metric. Additional detail on the ranking is available in the WAT! documentation.

The WAT! produces rankings of the watersheds for both base flow and year-round conditions. By separating base flow conditions, the impacts of dry weather sources on stream conditions can be differentiated from the combined impact of dry and wet weather sources. The ranking of the Big Bone Creek watershed during year-round and base flow conditions is provided in Table 13.

Table 13. WAT! Watershed Rankings

	Rank for Year-Round Conditions ^{a,b}	Rank for Base flow Conditions ^{a,b}
Fecal coliform	12	8

^a Rank ranges from 1 to 16. A rank of 1 indicates a high water quality impact score, which is analogous to load. The lowest rank possible is 16.

^b WAT is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

The WAT! analysis for both total solids and total phosphorus will be presented in future reports upon completion of the WAT! calibration. Future wet weather monitoring programs will further populate and refine WAT! results and rankings, aiding in characterization of potential sources.

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