Source: SD1

Twelvemile Creek
Watershed Characterization Report

Prepared for: Sanitation District No. 1 of Northern Kentucky

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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.

Twelvemile Creek is a 22-mile long perennial stream located in the East Study Basin (Figure 1). The 46.1-square mile watershed is predominantly rural, with forest and pasture/hay being the dominant land cover. This watershed is located primarily in Campbell County, but a small portion of the area extends into Pendleton County.

Twelvemile 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. The Brush Creek tributary to Twelvemile Creek has been assessed as impaired by the Kentucky Division of Water (KDOW, 2008). Water quality data collected have been collected in this watershed since 1993 and recent data indicate elevated bacteria levels. Violations of dissolved oxygen, temperature and pH have been historically observed at the USGS continuous monitoring station, but recent data from this location are still being reviewed and are not yet included in this assessment. Aquatic habitat in this watershed varies from not supporting to partially supporting a diverse and productive ecosystem. Biological data for Twelvemile and Brush Creek generally reveal conditions that range from poor to good.

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

[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.

The WAT! calculated a lower than average fecal coliform loading potential for this watershed under year-round conditions, with overland storm water runoff predicted to be the dominant bacteria source. This watershed had a slightly higher than average bacteria loading potential during base flow conditions. Septic systems are predicted to be the dominant source during base flow conditions.

The WAT! ranking is one of several factors that should be considered when prioritizing watersheds for improvement projects. Other factors include high public interest due to the new Eastern Regional Water Reclamation Facility (ERWRF) and completion of several restoration projects in the watershed, the presence of three surface water intakes downstream on the Ohio River, and the location of portions of this watershed in Source Water Assessment and Protection Zone 1.

Next steps for the Twelvemile Creek watershed may include additional habitat and biological assessments in the future to track improvements related to completed projects, such as the elimination of the Alexandria wastewater treatment plant. Coordination with the health department and permitting agencies may also help to address failing septic systems and permitted dischargers that are not meeting effluent limitations. Finally, site visits might help to assess riparian conditions and better identify sources within this watershed.

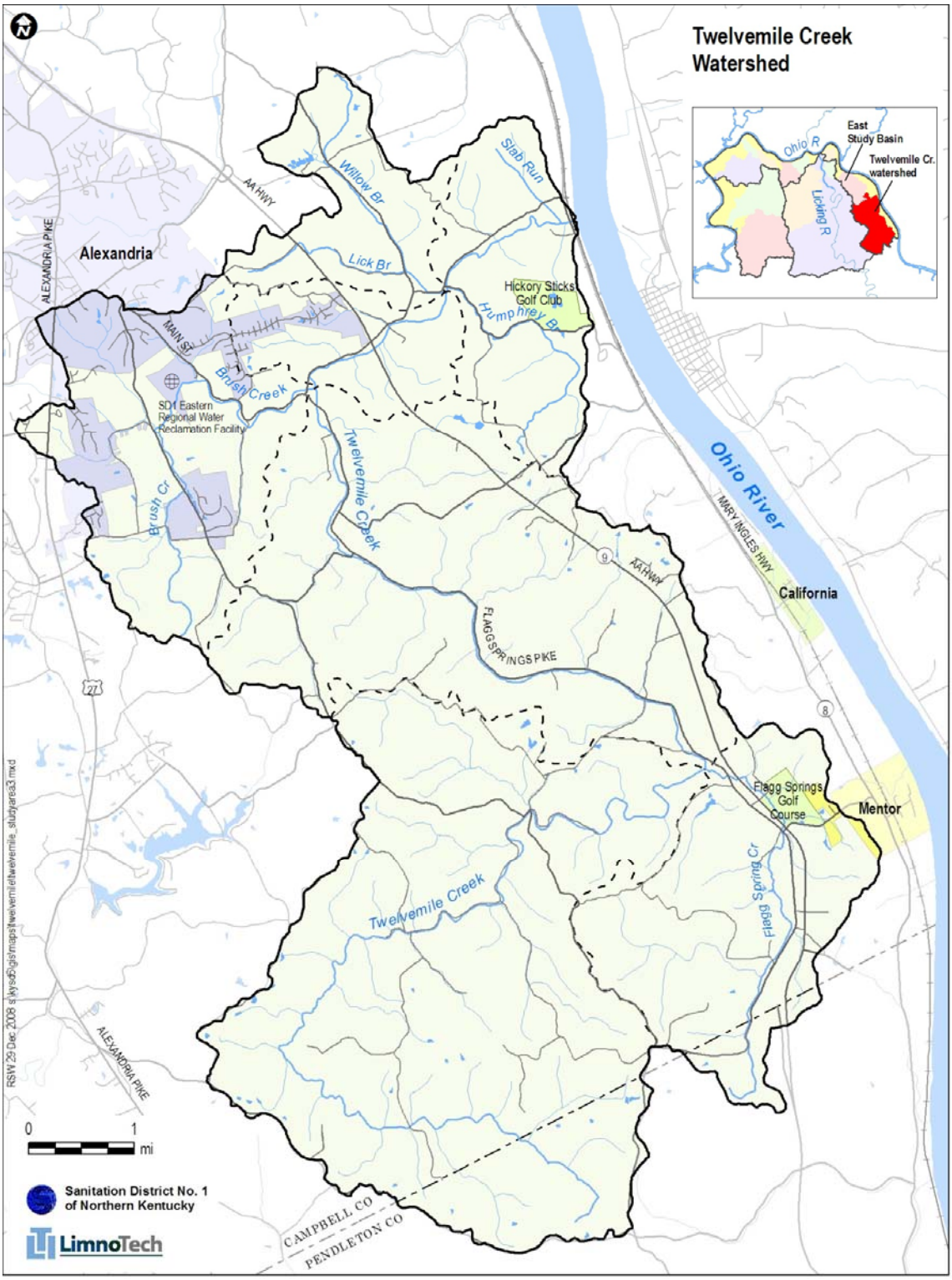

Figure 1. Twelvemile Creek Watershed

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2. WATERSHED FEATURES

Twelvemile Creek originates in Pendleton County and flows northward through Campbell County to the Ohio River. This 22-mile long creek has five major tributaries and drains a 46.1 square mile watershed.

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 Twelvemile Creek.

2.1.1 Hydrology

Twelvemile Creek is fed by five major tributaries: Flagg Spring Creek, Brush Creek, Lick Branch, Humphrey Branch and Slab Run. There are no natural lakes in the watershed, but several smaller impoundments have been created in the upper reaches of some tributaries.

An active USGS continuous monitoring station (03238745) is located on Twelvemile Creek at Highway 1997 near Alexandria, KY. The watershed draining to the station is 39 square miles, comprising approximately 85% of the Twelvemile Creek watershed. Daily discharge measurements are available at the station from January 2001 to the present[2]. The average flow at the station is 51 cfs (1/17/2001 - 9/30/2007), and 95% of flows are less than 223 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 2,450 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 low. Between January 2001 and September 2007 there were 32 days that flows were below 0.5 cfs, which all occurred in 2007.

Flooding occurs at the mouth of Twelvemile Creek (NRCS, 2007), and less frequently (once every 4 to 5 years) along Route 10/Flagg Springs Pike, between Stonehouse Road and California Crossroad (Boone, Campbell, Kenton Conservation Districts, 2007).

Floodplain maps indicate floodwaters are generally restricted to the low-lying areas adjacent to Twelvemile Creek, Willow Branch, Humphrey Branch, Brush Creek, and Flagg Spring Creek as well as some smaller tributaries. The widest floodplain areas are found near the Twelvemile Creek confluence with the Ohio River.

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

2.1.2 Geology

The Twelvemile Creek watershed is located in the Outer Bluegrass Physiographic[3] Region. This region is underlain primarily by Ordovician-age interbedded limestone and shale (Ray et. al., 1994). Although roughly one-third 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)[4].

The rolling upland areas in this watershed are underlain by the Grant Lake Limestone/Fairview formation, which produces broad stream valleys. The mainstem of this creek and the majority of the tributaries cut through the erodible shale found in the Kope formation. Near the mouth, Twelvemile Creek traverses unconsolidated alluvial deposits. Groundwater yield varies depending on geological formation. Groundwater is generally unavailable on the ridgetops, but wells in the valley bottoms may yield 100-500 gallons per day. This water may be hard and contain salt and hydrogen sulfide. Near the Ohio River, iron content may also be high (Carey and Stickney, 2005).

2.1.3 Topography

Much of the Twelvemile watershed is characterized by rolling hills and wide valleys. The highest elevations are found at the southwestern edge of the watershed near the Campbell/Pendleton County line (926 feet above mean sea level). The lowest elevation in the watershed (453.6 feet at normal Ohio River pool) occurs at the confluence of Twelvemile Creek and the Ohio River.

2.1.4 Soils

The nature of watershed soils influences the magnitude and timing of runoff, the potential for soil erosion, and chemical characteristics of the receiving waters. Most (96%) of the soils in the Twelvemile Creek watershed are classified as hydrologic soil group C (NRCS, 2006), meaning that they have slow infiltration rates when thoroughly wetted.

Approximately one-third of the soils in the watershed are ranked “highly erodible”, and the remaining two-thirds of the watershed soils 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 (discussed in Section 2.2).

[3] 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).

[4] 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.

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).

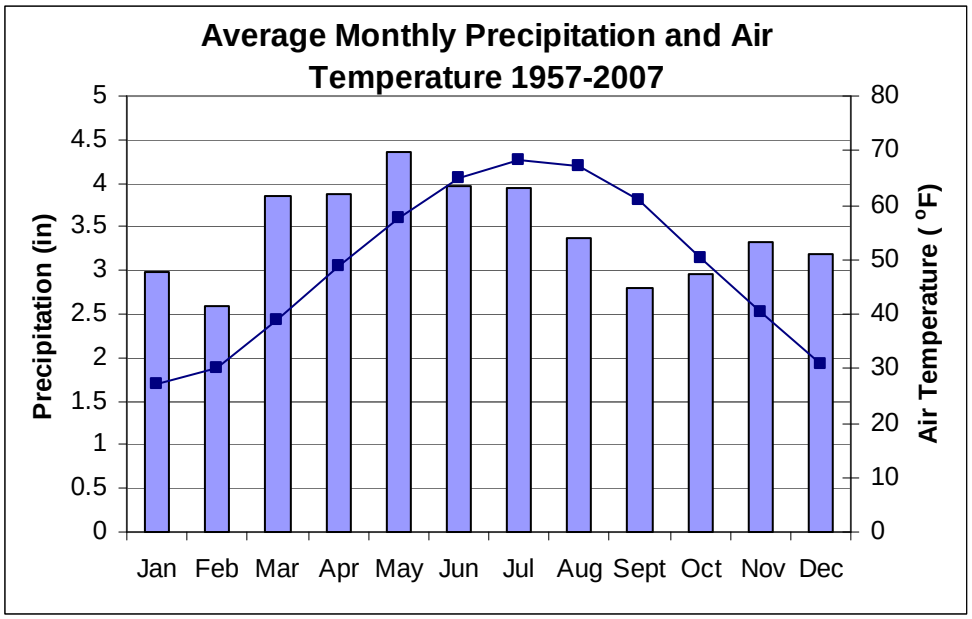

Figure 2. Average Monthly Precipitation and Air Temperature at the Cincinnati Northern Kentucky Airport (1957-2007)

2.1.6 Habitat

The northern part of this watershed lies within the Outer Bluegrass ecoregion[5], which is characterized as having sinkholes, springs, entrenched rivers and intermittent and perennial streams (Woods et al., 2002). Streams are characterized as having relatively high levels of suspended sediment and nutrients. Wetlands are uncommon in this ecoregion and comprise less than 1% of the area of this watershed. The wetlands near the mouth of this creek are reported to be in nice shape (NRCS, 2007).

The southern portion of this watershed lies within the Hills of the Bluegrass ecoregion, which has narrow ridges and hills leading down into narrow valleys. Streams have steep gradients and are generally lower in nutrients than those in the Outer Bluegrass ecoregion, but may suffer higher erosion rates (Woods et al., 2002).

Pre-settlement conditions in this watershed consisted mainly of open woodlands with barren openings, and vegetation was mostly oak-hickory, with some white oak, maple-

[5] Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources (Woods et al., 2002).

oak-ash and American beech-sugar maple forests (Woods et al., 2002). As described in Section 2.2.1, natural habitats have been altered from pre-settlement conditions.

Aquatic habitat varies throughout the watershed. In the upper watershed, Twelvemile Creek is wide and turbid, and shows little aquatic habitat variation (Figure 3). Farther downstream, some habitat heterogeneity is observed. Here, turbid waters flow through glide and pool habitats and the riparian zone is greater than 30 feet wide in some areas (Figure 4). Near the mouth, this creek is wide and it often receives Ohio River backwater flow. Reduced water clarity, possibly due to sedimentation and eutrophication, and a relatively wide riparian zone occur here (Figure 5). The size of the riparian zone[6] varies throughout the watershed, depending upon the proximity of the creek to Flagg Springs Pike (this road parallels Twelvemile Creek for much of its length) or the type of land the creek traverses (e.g., agricultural).

Figure 3. Twelvemile Creek at California Road (RM 9.3)

[6] Riparian zones are important to aquatic systems for several reasons: they provide wood for aquatic habitat recruitment potential, they support invertebrate food sources for fish and provide organic matter for instream invertebrates, they shade the water and allow cool temperatures to be maintained within the stream, and they filter sediment and toxics from entering the stream.

Figure 4. Twelvemile Creek at USGS Station 03238745 (RM 3.0).

Figure 5. Twelvemile Creek at Mary Ingles Highway (RM 0.2)

The Brush Creek tributary to Twelvemile Creek has limestone bedrock features (Figure 6) and intact riparian zones; however, aquatic habitats appear to be impacted by land use which has led to streambank erosion and a reduced riparian zone (Figure 7).

Figure 6. Brush Creek at Flagg Springs Pike (Brush Creek RM 0.3)

Figure 7. Upper Brush Creek at Persimmon Grove Pike

Habitat assessments have been conducted at nine sites within the watershed since 1999 (Table 1)[7]. Habitat in Twelvemile and Brush Creek was assessed at two sites in 1999 and was ranked "not supporting", indicating aquatic habitats cannot support a diverse and

[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.

productive ecosystem. In 2003 habitat ratings were compiled to score Twelvemile Creek at RM 11.3 as "partially supporting" and Brush Creek at RM 0.8 as "supporting but threatened".

Recent habitat assessments (2007) indicate habitat is partially supporting of a diverse and productive aquatic ecosystem in Twelvemile Creek, and is not supporting in Brush Creek.

Table 1. Aquatic Habitat and Biological Sampling

Stream	River Mile	Monitoring					
		Habitat		Macroinvertebrates		Fish	
		Year	Ranking	Year	Ranking	Year	Ranking
Brush Creek	0.3	2007	Not Supporting	2007[a] 2007[b]	Good, Poor	2007	Good
Brush Creek	0.8	1999, 2004	Not supporting, Supporting but threatened	---	n/a	1999, 2004	Excellent, Fair
Brush Creek	1.8	2007	Not Supporting	2007	Poor	---	n/a
Twelvemile Creek	1.9	2007	Partially supporting	2007	Poor	---	n/a
Twelvemile Creek	3.0	2007	Partially supporting	2007	Poor	2007	Fair
Twelvemile Creek	3.9	2007	Partially supporting	2007	Fair	2007	Fair
Twelvemile Creek	6.0	1999	Not supporting	1999	Fair	---	n/a
Twelvemile Creek	9.3	2007	Partially supporting	2007	Good	2007	Fair
Twelvemile Creek	11.3	2003	Partially supporting	---	n/a	2003	Excellent

[a]May 2007 sample. [b]September 2007 sample.

n/a- No data available

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 8) using a variety of other datasets that represent current impervious conditions (roads, parking lots, buildings), open space lands (including parks), and surface waters.

The Twelvemile Creek watershed is rural, comprised primarily of forest and agricultural land. During a recent site visit, it was observed that much of the forest is mixed with agricultural land uses. Developed lands, including portions of Alexandria and Mentor, are primarily located in the northern portion of the watershed. Roughly 19% of this watershed is developed and roughly 3% is impervious.

2.2.1.a Animal operations

There are no concentrated animal feeding operations (CAFOs) in this watershed. However, there are nine animal feeding operations (AFOs) which are beef farms with 8 to 150 animals (Kentucky Geographic Network, 2008, 2008a). There are also farms with beef cattle in the watershed, which are not AFOs (Campbell County Conservation District, 2007). It is estimated that there are over 3,000 cattle and approximately 1,700 horses in this watershed (Campbell County Agricultural Extension Office, 2008), and during a driving tour, cows were observed throughout the watershed, and also in the streams. According to the Conservation District, the farmers in this watershed are open to conservation and have applied Environmental Quality Incentives Program (EQIP) funding to implement controls to reduce animal waste. These controls include streambank protection, fencing and nutrient management controls, and creation of heavy use areas.

2.2.1.b Septic Systems

SD1 estimates that approximately 36% of all parcels in the Twelvemile Creek watershed[8] are serviced by septic systems. Properties potentially serviced by septic systems are found throughout the watershed, and most (98%) are mapped as being outside SD1's sanitary sewer service area. Many of the roads and associated development tend to follow river valleys, especially in the areas that are not serviced by separate sewer. As a result, septic systems are often found in close proximity to waterways.

Estimates of septic system failure rates are not available for Campbell County, however, anecdotal reports from Health Department inspectors suggest that 10% of the septic systems in Northern Kentucky may be operating improperly due to incorrect installation, lack of maintenance or age of the system. Furthermore, the Health Department has indicated that, based on slope, soil, and substrate characteristics, septic systems installed in Campbell County are prone to more frequent failures than those located in Boone or Kenton Counties (NKHD, 2008).

[8] At the time of this report, information on properties potentially served by septic was available for Campbell County but not for Pendleton County.

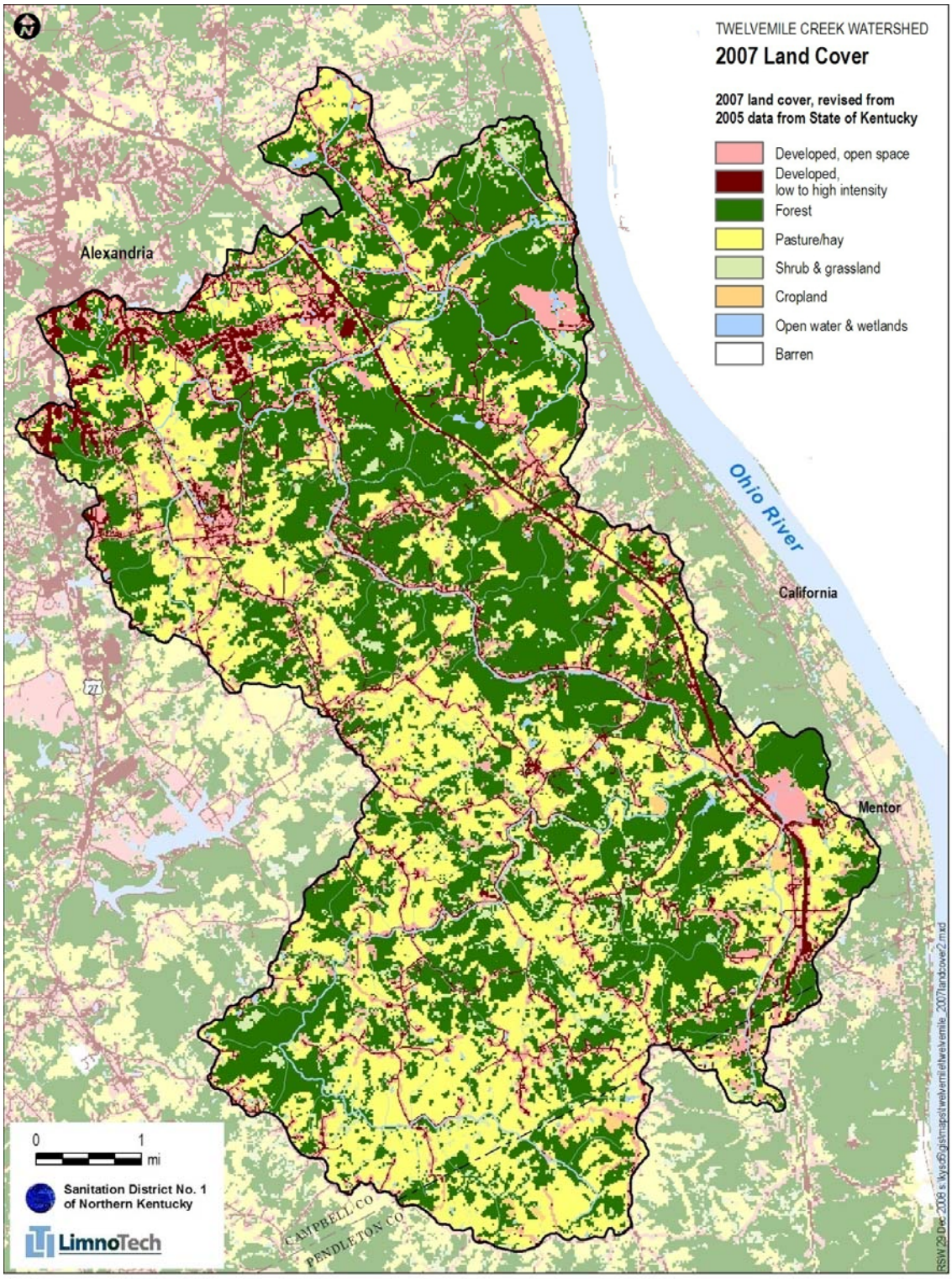

Figure 8. 2007 Land Cover

2.2.2 Future Conditions

Southern Campbell County has been under a construction moratorium due to a lack of sewage treatment capacity. The Eastern Regional Water Reclamation Facility recently went on-line and the construction moratorium was partially lifted as of May 2008. The realignment/ expansion of portions of US 27 (Alexandria Pike) is also expected to increase development in this area as this road runs north/south just to the west of the watershed (Figure 1). A proposed route connecting US 27 to the AA Highway (Kentucky Transportation Cabinet, 2006) would also contribute to development in this area.

Local interest in protecting farmland, if consistent with the results of a recent survey (AFT, 2005), might alter forecast future development patterns for this watershed. This survey found that, "65% of the farmland owners in Campbell County want their land to stay in agricultural production for the foreseeable future, about 20-30 years. About 32% would like to keep their land in agriculture even after they no longer own it, and 21% are willing to explore options for protecting their land for the future."

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 continue, with developed lands replacing forest and pasture/hay lands. Forest and pasture/hay are expected to remain the dominant land cover. Developed lands are predicted to increase from 19% to 25% and impervious surfaces in the watershed are predicted to increase from 3% to 4%.

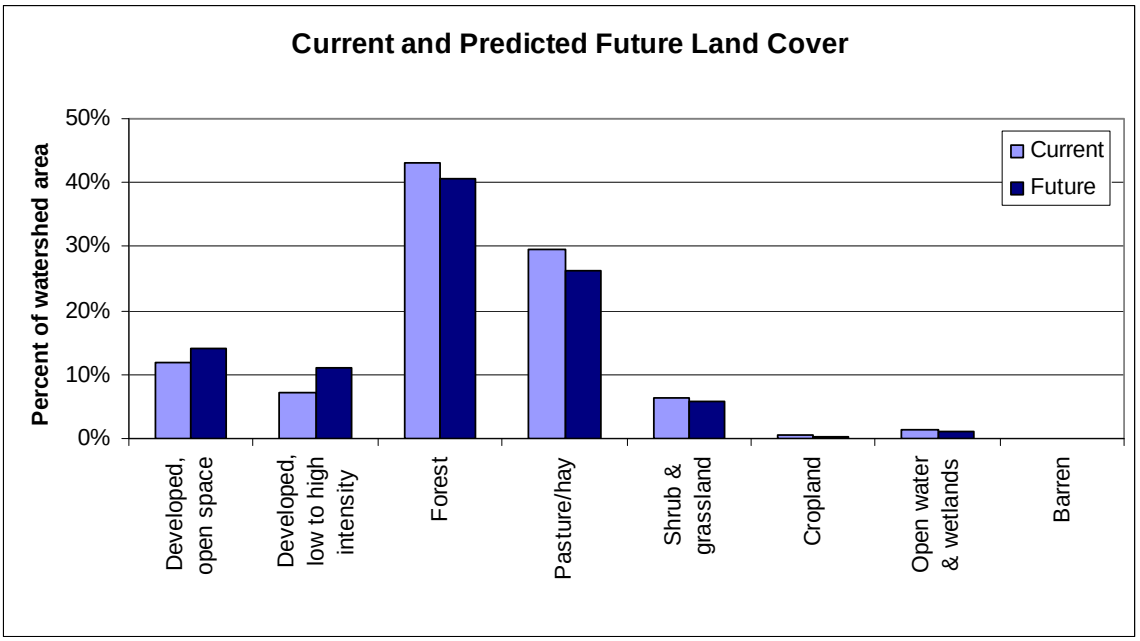

Figure 9. Current and Predicted Future Land Cover

2.3 INFRASTRUCTURE FEATURES

This section summarizes infrastructure features for the Twelvemile Creek watershed[9]. Approximately 7% of this watershed lies within SD1's sanitary sewer service area. This area contains approximately 22.1 miles of sanitary sewer lines.

Approximately 15% of this watershed lies within SD1's storm water service area. With in the service area, the storm water system is comprised of approximately 80.3 miles of streams and channels and approximately 10.9 miles of pipes. There is no combined sewer area in the Twelvemile Creek watershed.

The extent of the sanitary sewer and storm water service area in this watershed is shown in Figure 10.

[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.

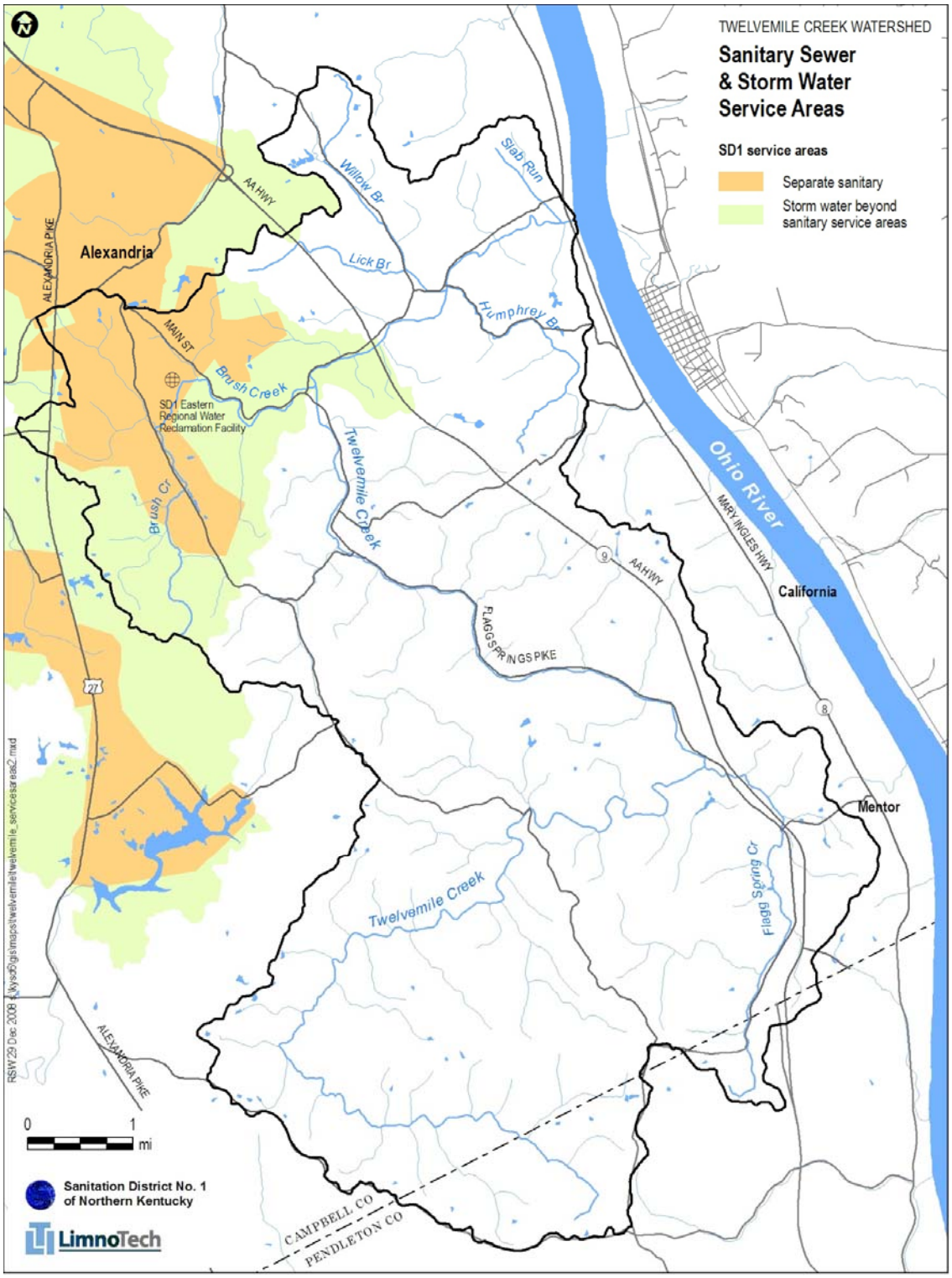

Figure 10. Sanitary Sewer and Storm Water Service Areas

2.3.1 Point Sources and Infrastructure

The occurrence of KPDES-permitted dischargers, sewer overflows and storm water discharges is described below.

2.3.1.a KPDES Dischargers

There are thirty-seven KPDES-permitted dischargers in the Twelvemile Creek watershed and the majority (28) are covered under general permits for residences. The remaining nine facilities are permitted for sanitary wastewater, with one facility's sanitary wastewater mixed with washwater and runoff.

SD1's Alexandria Wastewater Treatment Plant (WWTP) is no longer a permitted discharger in the Twelvemile Creek watershed and was replaced by the new Eastern Regional Water Reclamation Facility (ERWRF), which is also located in the watershed. The ERWRF was opened in September 2007.

Based on a review of recent effluent monitoring data (January 2007 to June 2008), it was observed that eighteen of the permitted dischargers in the Twelvemile Creek watershed have violated their permit limits for at least one of the following parameters: dissolved oxygen, total ammonia, fecal coliform, total suspended solids, biochemical oxygen demand (BOD), carbonaceous biochemical oxygen demand (CBOD), pH, and total chlorine. Although there are effluent monitoring requirements for the residential general permits (monitoring is required twice a year), data are not available for 15 of these facilities. KDOW estimates that residential dischargers, as a general group, fail at a rate that is believed to be higher than 10% (KDOW, 2007). Permitted dischargers are presented in Table 2.

Table 2. Permitted Dischargers

Receiving Water	KPDES ID	Facility Name	Permit Type	Outfall	Outfall Description	Currently Permitted? [a]	Permit Violations
Lick Branch	KYG400127	Residence	Minor	0011	Sanitary wastewater Type B	Y	pH, total ammonia, TSS
Lick Branch	KYG400288	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Willow Branch	KY0034223	Dietz Lake	Minor	0011	Sanitary wastewater	Y	Dissolved oxygen, fecal coliform, total ammonia
Willow Branch	KYG400344	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Brush Creek	KY0023485	SD #1 Alexandria	Minor	0011	Sanitary wastewater	N	Dissolved oxygen, total chlorine
				001M	Metals / yearly	N	
Brush Creek	KY0088803	First Assembly Of God Church	Minor	0011	Sanitary wastewater	Y	Dissolved oxygen
Brush Creek	KY0091928	Perkins Acres	Minor	0011	Sanitary wastewater	Y	Total chlorine
Brush Creek	KY0098191	Campbell Co Bd Of Ed Transport	Minor	0011	Washwater, Sanitary and Runoff	Y	Total ammonia
				0012	Washwater, Sanitary and Runoff	Y	None
Brush Creek	KY0102245	Alexandria Dairy Mart #3208	Minor	0011	Sanitary wastewater	Y	Dissolved oxygen
Brush Creek	KY0105031	Eastern Regional STP	Major	0011	Municipal discharge	Y	$CBOD_5$
				001P	Pretreatment annual	Y	None
				001X	Biomonitoring/metals monthly	Y	None
				001Y	Biomonitoring/metals quarterly	Y	NA
Brush Creek	KYG401076	Residence	Minor	0011	Sanitary wastewater Type B	Y	Fecal coliform
Brush Creek	KYG400401	Residence	Minor	0011	Sanitary wastewater Type B	Y	BOD_5, fecal coliform, total ammonia, TSS
Brush Creek	KYG400099	Residence	Minor	0011	Sanitary wastewater Type B	Y	None
Flagg Spring Creek	KY0101745	Flagg Springs Golf Course	Minor	0011	Sanitary wastewater	Y	Dissolved oxygen, fecal coliform
Flagg Spring Creek	KYG400490	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA

Table 2. Permitted Dischargers - Continued

Receiving Water	KPDES ID	Facility Name	Permit Type	Outfall	Outfall Description	Currently Permitted? [a]	Permit Violations
Flagg Spring Creek	KYG400523	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Flagg Spring Creek	KYG400325	Residence	Minor	0011	Sanitary wastewater Type B	Y	None
Flagg Spring Creek	KYG401924	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Flagg Spring Creek	KYG400405	Residence	Minor	0011	Sanitary wastewater Type B	Y	Total ammonia, TSS
Flagg Spring Creek	KYG400271	Residence	Minor	0011	Sanitary wastewater Type B	Y	Total ammonia, TSS
Twelvemile Creek	KY0102521	Hickorysticks Golf Club	Minor	0011	Sanitary wastewater	Y	Fecal coliform, total ammonia
Twelvemile Creek	KYG401855	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG400304	Residence	Minor	0011	Sanitary wastewater Type B	Y	Fecal coliform
Twelvemile Creek	KYG400429	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG400171	Residence	Minor	0011	Sanitary wastewater Type B	Y	Fecal coliform
Twelvemile Creek	KYG400863	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG400859	Residence	Minor	0011	Sanitary wastewater Type B	Y	None
Twelvemile Creek	KYG400708	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG400453	Residence	Minor	0011	Sanitary wastewater Type B	Y	None
Twelvemile Creek	KYG400283	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG401231	Residence	Minor	0011	Sanitary wastewater Type B	Y	TSS
Twelvemile Creek	KYG400280	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG400629	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KY0101010	Sts Peter & Paul Elem School	Minor	0011	Sanitary wastewater	Y	Dissolved oxygen, total ammonia, TSS
Twelvemile Creek	KYG401538	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG400535	Residence	Minor	0011	Sanitary wastewater Type B	Y	Fecal coliform
Twelvemile Creek	KYG401033	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA
Twelvemile Creek	KYG400364	Residence	Minor	0011	Sanitary wastewater Type B	Y	NA

[a] Discharge is permitted as of June 2008

NA = no data available

2.3.1.b Sewer overflows

There are no combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs) in this watershed.

2.3.1.c Storm water discharges

SD1's storm water service area extends into the northern portion of this watershed. Storm water pipe outlets are concentrated in the northwestern portion of the watershed.

In addition to the storm water outfalls, there are approximately three suspected illicit activity (SIA) points located in the City of Alexandria. SIAs are locations where there was possible evidence of illicit discharges 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. One facility with an individual permit covering runoff is discussed in Section 2.3.1.a.

2.3.2 Recently Completed Infrastructure Projects

SD1 recently completed several construction projects. These are:

- Eastern Regional Water Reclamation Facility (ERWRF). The new ERWRF will receive and treat flows that were previously served by the Alexandria WWTP. As a result, the Alexandria WWTP was taken off-line and an SSO located at the Alexandria WWTP was eliminated. The new treatment plant is being sized initially to treat 4 MGD with a 1.5 million gallon equalization basin to accommodate wet weather flows. Future upgrades can be implemented to achieve an ultimate treatment capacity of up to 8 MGD. The ERWRF began operation in September 2007.
- Eastern Regional Conveyance System. New gravity sewers were built to convey peak flows to the ERWRF.

2.3.3 Ongoing or Planned Infrastructure Improvement Projects

Infrastructure project information is presented in Table 3. Construction of additional sanitary sewers is planned to convey additional flows to the new ERWRF. Completion of the new gravity sewers from the Alex-Licking pump station, which is under construction in the Licking River watershed, and the new gravity sewers from the Riley Road pump station, will convey peak flows to the new ERWRF.

Table 3. Ongoing Infrastructure Improvement Project

Capital Improvement Project Title	Goals	Anticipated Start Date	Anticipated Completion Date	Project Total
Alex-Licking Gravity Sewer Improvements	Convey flow from the new Alex-Licking PS to the ERWRF	Current	2009	$4.35 million
Eastern Regional Conveyance System	Convey new pump station flow to ERWRF.	Already started	2009	$6,100,000[a]

[a]This work will occur in both the Fourmile and Twelvemile Creek watersheds, however, it is not possible to separate out the cost by watershed, and so the total project cost is presented.

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;
- 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; and
- Shellfish beds.

These six criteria were evaluated individually for this watershed. None of the waterbodies have been designated as Outstanding National Resource Waters (401 KAR 10:030), there are no threatened or endangered species within the watershed (KSNPC, 2007), and there are no National Marine Sanctuaries (NOAA, 2008). Additionally, there are no known commercial shellfish beds within the Twelvemile Creek watershed, nor is shellfish harvest for consumption by private individuals known to occur. The remaining two criteria were evaluated and are discussed below.

2.4.1 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.

Twelvemile 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.

2.4.2 Public drinking water intakes or their designated protection areas

There are no public drinking water intakes from surface water or public groundwater wells within this watershed. There are three public drinking water intakes located in the Ohio River, approximately 11.5 miles downstream from this watershed. These intakes are operated by the Northern Kentucky Water District and Greater Cincinnati Water Works.

Source Water Assessment and Protection (SWAPP) Zones for the Ohio River intakes are determined by the Ohio River Valley Water Sanitation Commission (ORSANCO). SWAPP zones are not used in a regulatory sense, but are delineated to identify potential contaminants upstream of water intakes and are used to support identification of sources potentially impacting the intakes. Due to the location of the three intakes, ORSANCO has determined that portions of this watershed are located within SWAPP Zone 1, the zone of critical concern, which extends twenty-five miles upstream of the water intakes.

Drinking water supply features are shown in Figure 11.

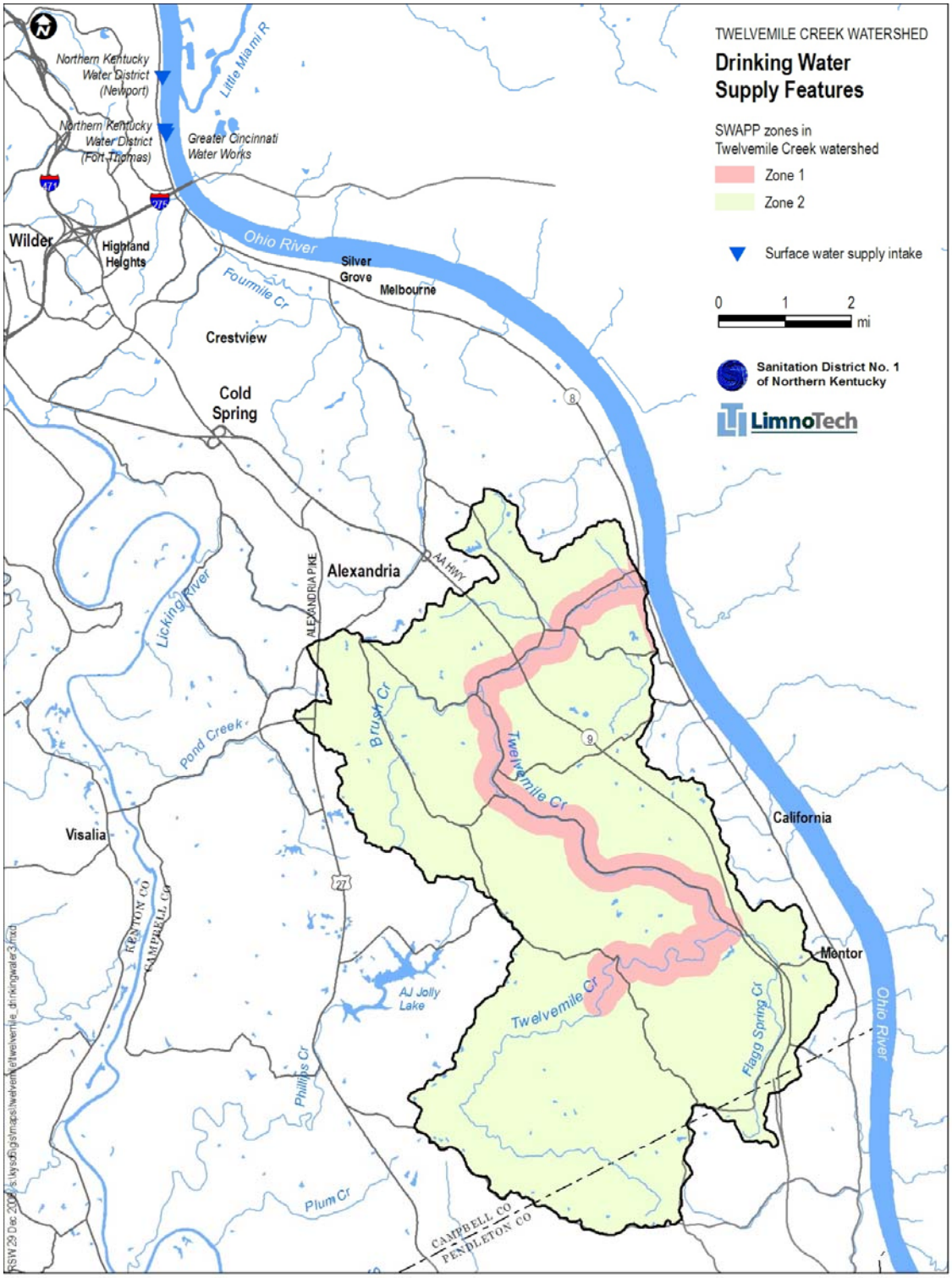

Figure 11. Drinking Water Supply Features

2.5 PUBLIC INTEREST/WATERSHED GROUP ACTIVITIES

Public interest in this watershed is high, due to the recent activation of the Eastern Regional Water Reclamation Facility, which has drawn attention to sources upstream of the three Ohio River water intakes.

Another indicator of interest in this watershed is expressed through sampling conducted by numerous organizations (Section 4.2). Previous watershed improvement projects also indicate interest in this watershed, which the USDA designated as a priority area in 2001. Major threats to this watershed were identified as urbanization, erosion and lack of riparian buffers (Landscapes, 2001), and a range of BMPs were identified to address these issues. BMPs identified included: conservation buffers, timber management within the streamside management zone, controlling grazing, improved vegetative cover and education/outreach programs. The relocation of cattle and feeding areas away from streams was identified as a critical need. Farmers in this watershed have worked with the Campbell County Conservation District over the past five years to implement projects aimed at controlling animal waste. These included: streambank protection, fencing and nutrient management, and creation of heavy use areas. Funding was provided through EQIP.

One conservation-oriented organization is active in Campbell County, but its involvement in this watershed has not been confirmed. This is the Campbell County Conservancy which is working to conserve green space and preserve land that has unique or significant natural, historical or scenic value in order to enhance the quality of life for current and future generations (http://www.campbellcounty.ky.gov/boards/conservancy.htm).

3. WATERBODY USES

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

3.1 DESIGNATED USES

Twelvemile 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 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.

3.2 CURRENT USES

An assessment of available information found the following:

- Recent habitat assessments indicate habitat is ranked “partially supporting” in Twelvemile Creek and “not supporting” in Brush Creek. Recent biological data indicate variable conditions that are generally better upstream of RM 3.9.
- 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, 2007a).
- No swimming advisories have been issued for Twelvemile Creek. However, the KDOW 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, 2007b).
- No fishing access sites were found in the watershed (http://kygeonet.ky.gov/kdfwr/viewer.htm).
- There are no active surface drinking water intakes the watershed.
- There are no active public water supply groundwater wells in this watershed (KDOW, 2008a; KDOW, 2007c).

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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

Brush Creek appears on Kentucky's 2008 303(d) list of impaired waters (Table 4; KDOW, 2008). This listing is based on fecal coliform data collected by the Kentucky Division of Water in 1999 (KDOW, 2005).

TMDL development has not yet been initiated (KDOW 2008). The suspected source is identified as municipal point source discharges (KDOW, 2008). This was more specifically identified as sewage bypass and discharge of sewage sludge from the Alexandria WWTP in a previous 303(d) listing (KDOW, 2005). As described previously, the Alexandria WWTP was recently replaced by the Eastern Regional Water Reclamation Facility and an SSO at the Alexandria WWTP was eliminated (Section 2.3.2).

Table 4. 303(d) Listing

Waterbody Segment	Designated Use (Use support)	Pollutant	Suspected Sources
Brush Creek (RM 0.0 – 1.6)	Primary Contact Recreation (Not supporting)	Fecal coliform	Municipal point source discharges

4.2 MONITORING PROGRAMS

Water quality data have been collected in this watershed by KDOW, the Ohio River Valley Water Sanitation Commission (ORSANCO), Northern Kentucky University (NKU), Licking River Watershed Watch (LRWW), USGS and SD1. Data currently compiled by SD1 from known monitoring programs are presented in Table 5; however, only data which have been fully analyzed are discussed in Section 4.3 Water Quality Data Analysis. Water quality data exist for Brush Creek, Lick Branch and the main stem of Twelvemile Creek.

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

Table 5. Summary of Water Quality Monitoring Data

Entity	Dates	Parameters Sampled	Sampling Locations[b]	Number of Samples
KDOW	1993	Fecal coliform	Twelvemile Cr. RM 1.7, 3.0, 3.9; Brush Cr. RM 0.1	1 sample (6/9/1993)
KDOW	1999, 2004	DO, pH, conductivity, turbidity, temperature	Brush Cr. RM 0.8	2 samples (8/30/1999 & 8/11/2004); No turbidity data in 2004
KDOW	2003	DO, pH, conductivity, temperature	Twelvemile Cr. RM 11.3	1 sample (9/11/2003)
ORSANCO	2007	E. coli	Twelvemile Cr. RM 1.9	2 samples (8/30/2007 & 10/2/2007)
NKU	1998	"2,4-D, Dichlorophenoxyacetic acid", Alachlor, Atrazine, Chlorpyrifos-methyl, Metolachlor	Twelvemile Cr. RM 3.9	1 sample (5/17/1998)
NKU	1998	Fecal coliform, DO, pH	Twelvemile Cr. RM 3.9	1 sample (7/14/1998)
NKU	2001	Fecal coliform, Fecal strep	Twelvemile Cr. RM 3.9, 11.3	1 sample (7/14/2001)
NKU	2001	Fecal coliform, E. coli, DO, pH, temperature	Twelvemile Cr. RM 1.3; Lick Br. RM 0.2	1 sample (8/25/2001)
NKU	2001	Atrazine, Metolachlor	Twelvemile Cr. RM 3.9, 11.3	1 sample (6/2/2001)
NKU	2002	DO, temperature, pH, Atrazine	Twelvemile Cr. RM 11.3	1 sample (5/18/2002)
NKU	2003	Fecal coliform, DO, pH, temperature	Twelvemile Cr. RM 3.9, 11.3	1 sample (5/17/2003)
NKU	2003	Fecal coliform, alkalinity, boron, bromide, chloride, DO, hardness, pH, conductivity, silicon, sulfur, sulfate, TSS, temperature, nutrients, metals	Twelvemile Cr. RM 3.9, 11.3	1 sample (Sept) No boron, sulfur, silicon, or metals for RM 11.3
NKU	2003	Fecal coliform	Twelvemile Cr. RM 3.9, 11.3	1 sample (7/10/2003)
LRWW	2002	Fecal coliform	Twelvemile Cr. RM 3.9, 11.3	1 sample (7/12/2002)
LRWW	2004	Fecal coliform, E. coli	Twelvemile Cr. RM 3.9, 11.3	3 samples (May, July, Sept) No E. coli for May
SD1	2006	Fecal coliform, E. coli, CBOD5, TSS, DO, pH, conductivity, turbidity, temperature, nutrients	Twelvemile Cr. RM 0.2, 1.9, 3.0, 3.9, 9.3; Brush Cr. RM 0.3, 1.8	1 sample for Dry weather event (10/25/2006)
SD1	2006	Fecal coliform, E. coli, CBOD5, TSS, DO, pH, conductivity, temperature, nutrients	Twelvemile Cr. RM 0.2, 1.9, 3.0, 3.9, 9.3; Brush Cr. RM 0.3, 1.8	8 samples for 1st wet weather event (9/27-30/2006); 12 samples for 2nd wet weather event (10/26-30/2006)
SD1	2007	Fecal coliform, E. coli, CBOD5, TSS, DO, pH, conductivity, turbidity, temperature, nutrients	Twelvemile Cr. RM 1.9, 3.0, 3.9, 9.3; Brush Cr. RM 0.3, 1.8	1 sample for Baseline Survey (5/1/2007)
SD1	2008[a]	Fecal coliform, E. coli, CBOD5, TSS, DO, pH, conductivity, turbidity, temperature, nutrients	Twelvemile Cr. RM 1.9, 3.0, 3.9, 9.3; Brush Cr. RM 0.3, 1.8	1 sample for Baseline Survey (10/13/2008)
USGS[a]	2000-present	Gage height, discharge, precipitation, DO, DO % sat, pH, conductivity, turbidity, temperature	USGS Station No. 03238745;Twelvemile Cr. RM 3.0	15-minute intervals

[a]Data not analyzed in Section 4.3, including USGS data collected after WY 2005

[b] RM = River mile

4.2.1 Future Sampling

SD1 plans to continue monitoring Twelvemile Creek during base flow conditions with at least one survey per year. The six sampling locations are Twelvemile Creek RM 1.9, 3.0, 3.9, 9.3 and Brush Creek RM 0.3 and 1.8. Typical analyses will include bacteria, nutrients, solids, oxygen-demanding constituents and physical parameters. Additionally, surveys to assess the degree of stream hydromodification are currently underway by SD1.

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

4.3 WATER QUALITY DATA ANALYSIS

Historical water quality data (1993-2005) have been analyzed to identify past water quality problems in this watershed. Historical exceedances of bacteria, as well as dissolved oxygen, temperature and pH violations were identified. The dissolved oxygen, temperature, and pH violations were only observed at the USGS station.

Recent data (2006-present) have been analyzed in more detail to describe current stream conditions, because these data better reflect the effect of existing sources on instream water quality. Recent bacteria exceedances have been observed. It should be noted that the data collected at the USGS station are not included in this assessment of recent data. These data are being reviewed 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.

Historical data reveal bacteria exceeding applicable water quality criteria at multiple sampling locations (Table 6). Historical violations of the dissolved oxygen, water temperature and pH criteria were identified through a review of continuous data at the USGS station (WY 2001- WY 2005) (CEG, 2007). Violations were not observed at the other locations with available data. Measurements for locations or parameters not shown met the respective water quality criteria.

Table 6. Historical Water Quality Exceedances

Stream	River Mile	Parameters exceeding criteria			
		Fecal coliform bacteria		*E. coli* bacteria	
		# samples	% of samples exceeding criteria[a]	# samples	% of samples exceeding criteria[a]
Brush Creek	0.1	1	100%	0	
Twelvemile Creek	1.7	1	100%	0	
Twelvemile Creek	3.0	1	100%	0	
Twelvemile Creek	3.9	10	100%	2	50%
Twelvemile Creek	11.3	8	50%	2	0

[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 was meant to be applied to a dataset of five samples collected over a 30-day period.

Dissolved oxygen (DO) less than 4 mg/l was observed at the USGS station in all five water years analyzed (WY 2001-2005), and all violations occurred between April and September.

Fifteen-minute dissolved oxygen measurements were analyzed for periods when violations were noted. Significant diurnal variations (i.e., DO ranging from less than 2 mg/l to greater than 18 mg/l) were observed, and algal growth (Figure 12) is believed to contribute to the dissolved oxygen fluctuations at this site.

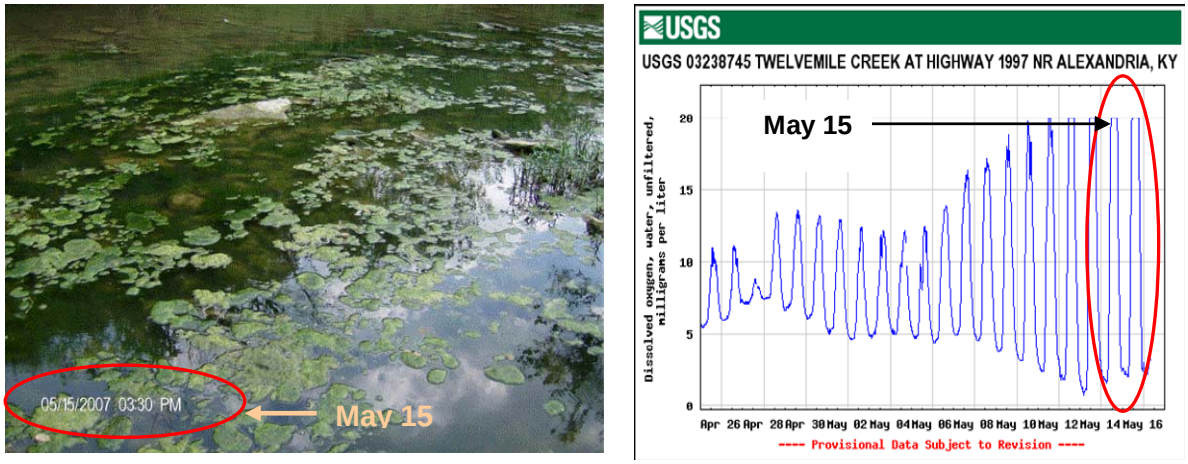

Figure 12. Twelvemile Creek algal growth (May 15, 2007) and dissolved oxygen during the same period

Temperature violations were observed in WY 2002, 2004 and 2005. In this rural watershed, a loss of riparian vegetation in the upstream watershed may be a more important factor than impervious cover affecting instream temperature (CEG, 2007).

pH violations have been observed in all years analyzed (WY 2001-2005). pH measurements greater than 9 su have been observed and pH fluctuations of more than 1 su over a 24 period have also been observed. pH fluctuations are the most frequent cause of pH criteria violation observed in this creek and are thought to be caused by algae.

4.3.2 Recent Data

Recent water quality data were available for five locations along the mainstem of Twelvemile Creek (RM 0.2, 1.9, 3.0, 3.9 and 9.3) and two locations on Brush Creek (RM 0.3 and 1.8). Numerous exceedances of the bacteria criteria have been observed at all stations sampled (Table 7). Measurements for parameters not shown met water quality criteria. Recent data collected at the USGS station are being reviewed and will be included in the next update of this report.

Table 7. Recent (2006-2007) Bacteria Exceedances

Stream	River Mile	Parameters exceeding criteria			
		Fecal coliform bacteria		*E. coli* bacteria	
		# samples	% of samples exceeding criteria[a]	# samples	% of samples exceeding criteria[a]
Brush Creek	0.3	22	77%	22	82%
Brush Creek	1.8	22	86%	22	91%
Twelvemile Creek	0.2	21	86%	21	81%
Twelvemile Creek	1.9	22	82%	24	79%
Twelvemile Creek	3.0	22	77%	22	82%
Twelvemile Creek	3.9	22	68%	22	73%
Twelvemile Creek	9.3	22	82%	22	82%

[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 was meant to be applied to a dataset of five samples collected over a 30-day period.

4.3.2.a Bacteria

Fecal coliform and *E. coli* data were available for both base flow and storm conditions. As shown in Figure 13, base flow fecal coliform concentrations exceeded the applicable criterion in Brush Creek in two of the four base flow samples. Storm flow samples exceeded the criterion throughout Twelvemile and Brush Creeks. The maximum base flow fecal coliform concentration, 960 cfu/100 ml, was observed at Brush Creek RM 0.3 on May 1, 2007. The highest storm flow concentration, 11,771 cfu/100 ml, was observed at Twelvemile Creek RM 0.2 during the October 26-30, 2006 sampling event.

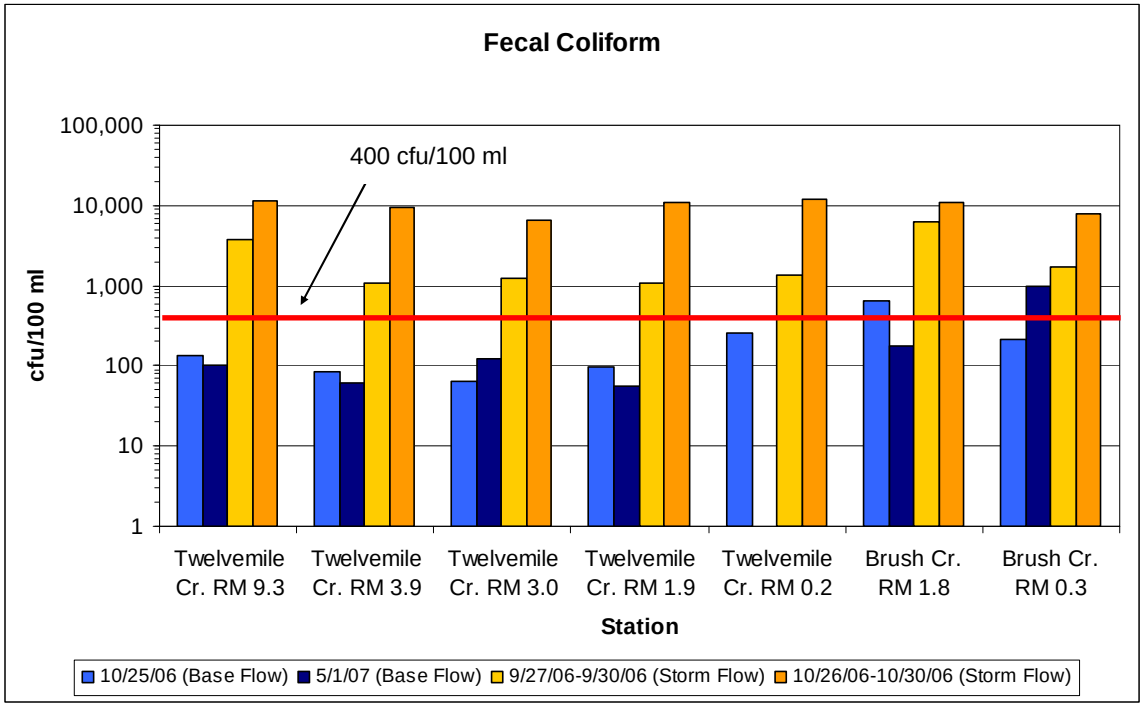

Figure 13. 2006-07 Base Flow and Average Storm Flow Fecal Coliform Concentrations Compared to 400 cfu/100 ml Criterion

Figure 14 shows a similar pattern for *E. coli*. Base flow *E. coli* concentrations exceeded the applicable criterion Brush Creek in three of the four base flow samples. Storm flow samples exceeded the criterion throughout Twelvemile and Brush Creeks. The maximum base flow *E. coli* concentration, 2,747 cfu/100 ml, was observed at Brush Creek RM 0.3 on May 1, 2007. The highest storm flow concentration, 10,381 cfu/100 ml, was observed at Twelvemile Creek RM 0.2 during the October 26-30, 2006 sampling event.

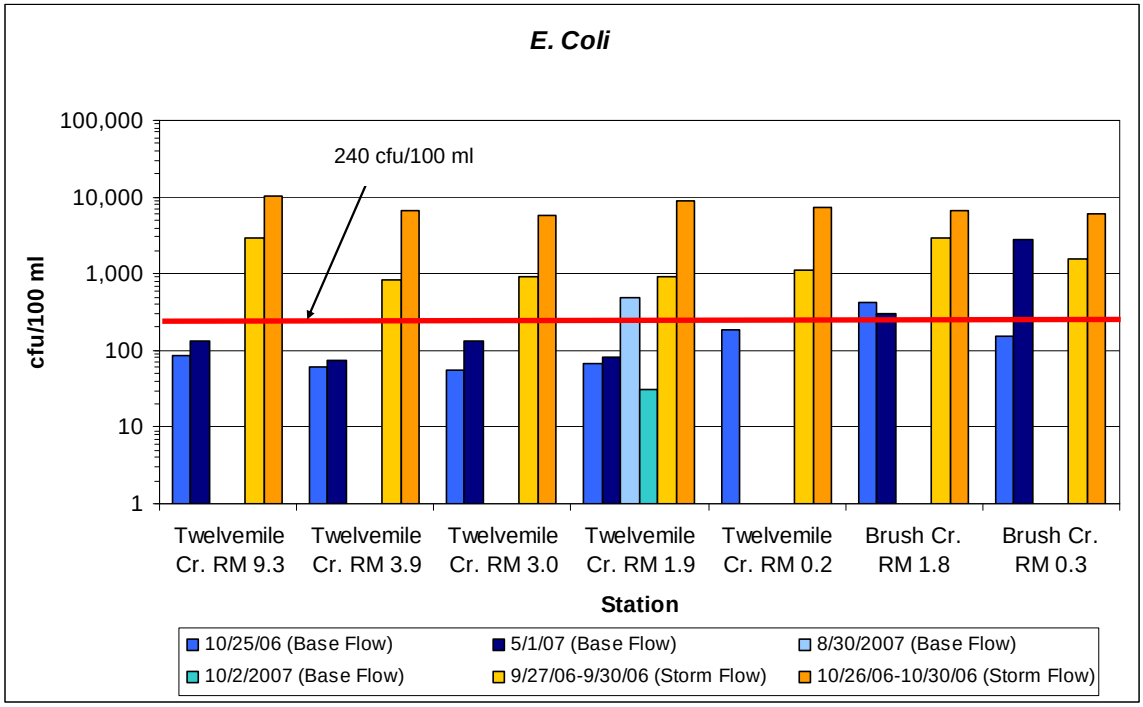

Figure 14. 2006-07 Base Flow and Average Storm Flow *E. coli* Concentrations Compared to 240 cfu/100 ml Criterion

4.4 BIOLOGICAL CONDITIONS

Biological conditions in the watershed have been assessed in Twelvemile Creek and Brush Creek and the data generally reveal conditions that are fair or better.

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 aquatic macroinvertebrates in one site in Twelvemile Creek off of State Route 10 in 1999 (RM 6.0). The MBI score[10] calculated for this site indicated that the stream was in fair condition.

In 2007, SD1 sampled macroinvertebrates at 6 additional sites within the watershed (Table 1). Within Brush Creek, the RM 0.3 site was sampled in May and resampled in September. Evaluation of the site data resulted in a "good" ranking in May and a "poor" ranking in September, suggesting annual variation in macroinvertebrate assemblages. An additional site in Brush Creek (RM 1.8) was sampled in May as well and ranked as "poor".

[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.

Four Twelvemile Creek locations were sampled for macroinvertebrates in 2007 (Table 1). The rankings generally improved in an upstream direction ranging from "poor" quality at RM 1.9 and RM 3.0 to "good" at RM 9.3 (Table 1).

Fish were sampled from Twelvemile Creek in 2003 off of Schababele Road (RM 11.3) and on Brush Creek in 1999 and 2004 downstream of the Barris Road crossing (Brush Creek RM 0.8). The calculated KIBI scores[11] indicated "excellent" conditions in Twelvemile Creek in 2003 and "fair" conditions in Brush Creek in 2004. Brush Creek was previously (1999) found to have "excellent" conditions for fish communities, suggesting that conditions may be changing for fish at this site. In 2007, fish sampling within the watershed found rankings ranging from "fair" to "good" at the four sites sampled (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 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, Twelvemile Creek (RM 3.0) has the second highest P/R ratio among all monitored sites, suggesting that stream metabolism at this site, on average is relatively well balanced and less dominated by organic consumption processes than the other monitored sites. Further, fluctuations in average annual metabolism measures for the Twelvemile Creek site appear to vary similar to the averages observed at other monitoring sites for the 2000-2005 period. Continued evaluation of stream metabolism at the Twelvemile Creek site 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.

[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.

5. SOURCE ANALYSIS

This section discusses potential pollutant sources in the Twelvemile Creek watershed to provide information related to recent observed impairments. Conclusions are based on the watershed characterization and available water quality data.

5.1 WATERSHED SOURCE ANALYSIS

The sources identified through the process of watershed characterization have been introduced previously and are summarized in Table 8 and mapped in Figure 15. There are no CSOs or SSO in this watershed.

Table 8. Summary of Potential Sources

	Twelvemile Cr Headwaters–RM 3.9	Brush Creek	Twelvemile Cr RM 3.9 – mouth
Recent observed impairment =>	Bacteria	Bacteria[c]	Bacteria[a]
Septic systems	Many	Many	Many
KPDES –sanitary outfalls[b]	22	9	7
KPDES – other outfalls[d]		2	
Storm water runoff	Rural	Urban and rural	Urban and rural
Livestock	9 AFOs; Numerous cattle		Cattle
Watershed improvements	*Past work with farmers to control animal waste*	*Alexandria WWTP and an SSO at the Alexandria WWTP were eliminated in 2007*	

[a] DO, pH and temperature violations have historically been observed at the USGS continuous monitoring station, but recent data have not been reviewed.

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

[c] Municipal point source discharges are identified as the suspected source related to the impaired primary contact recreation use in Brush Creek (KDOW, 2008).

[d] Two outfalls are for both sanitary wastewater and runoff.

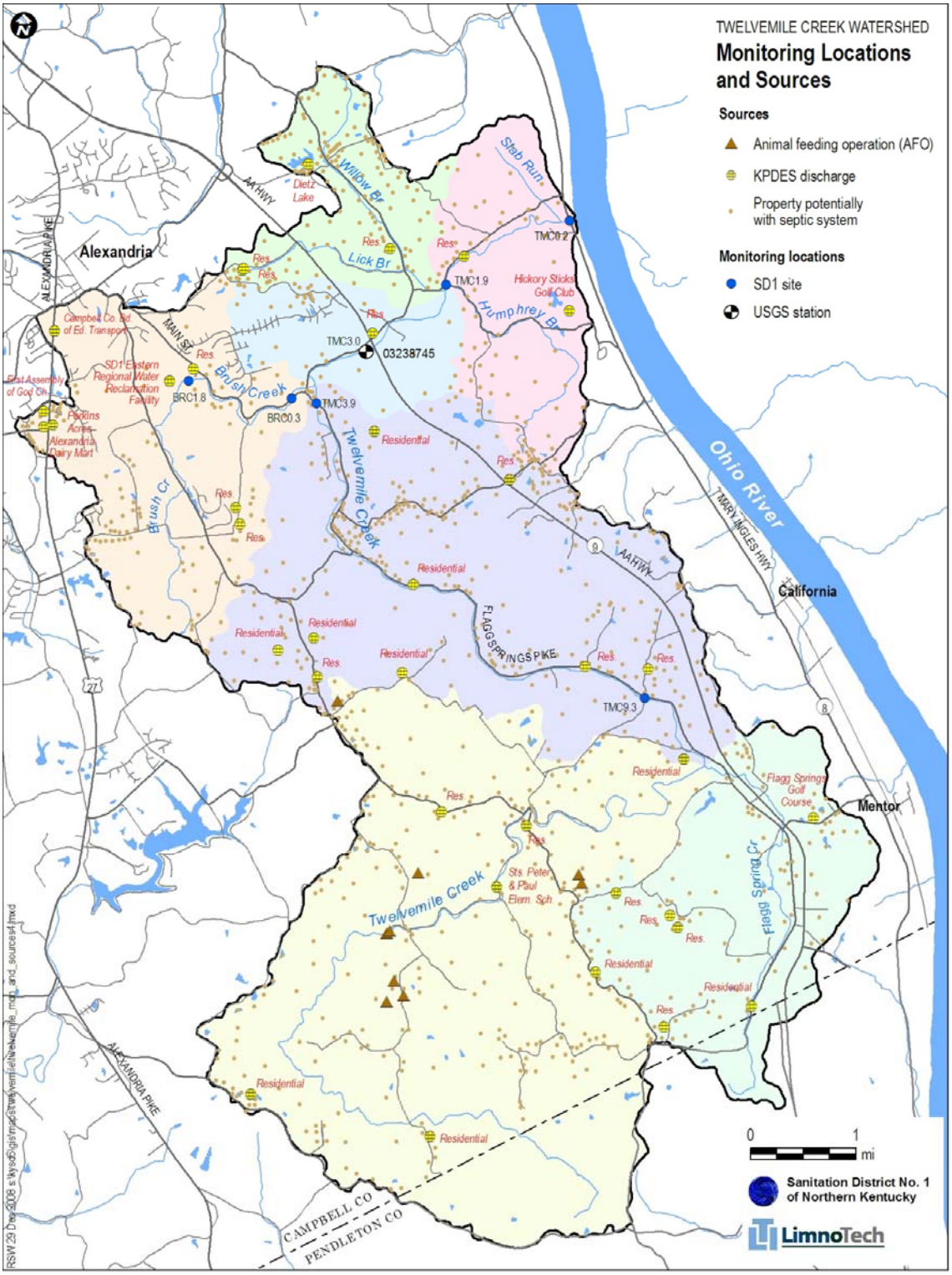

Figure 15. Monitoring Locations and Sources

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! results[12] indicate that under year-round conditions, the Twelvemile Creek watershed has a lower than average rank (analogous to load) for fecal coliform, relative to the sixteen identified watersheds in SD1's jurisdictional area.

In addition to WAT! results, other factors such as presence of public drinking water features, presence of aquatic-dependent threatened and endangered (T&E) species, special designations, and public interest may affect watershed prioritization. These and other ranking considerations are summarized in Table 9.

Table 9. Watershed Ranking Considerations

CSOs (#)	SSOs (#)	SWAPP Zone	Aquatic-dependent T&E Species[a] (#)	Special designation	Public interest	WAT! Rank, Year-Round Conditions[b]
						Bacteria
0	0	Zone 1 and 2. 3 intakes located in the Ohio River, downstream of this watershed.	0	None	High	11 of 16

[a] There are no aquatic-dependent or terrestrial species that are threatened, endangered (T&E) or of special concern in this watershed.

[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.

6.2 SCREENING TO DETERMINE IF ADDITIONAL DATA ARE NEEDED

The existing data are sufficient for characterizing current water quality conditions, and the sampling planned for this watershed, in conjunction with the ongoing operation of the USGS continuous monitoring station at RM 3.0 will be sufficient for tracking water quality improvements that results from the startup of the ERWRF.

[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

There are several sources which may be contributing to bacteria, dissolved oxygen and pH violations in this watershed, including livestock, septic systems and KPDES-permitted discharges that are not meeting permit limits. A site visit to investigate these sources is recommended, as is coordination with the health department to identify failing septic systems. Coordination with the permitting agency is recommended to address permitted facilities that are not meeting effluent limits.

An investigation of the riparian zone along this stream would also be useful in identifying whether lack of riparian shade contributes to the warmer temperatures in this creek.

Future habitat and biological sampling in Brush Creek and Twelvemile Creek would be useful to assess whether improvements are occurring in response to source reductions resulting from the ERWRF, and other watershed improvements.

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 16. These WAT! results incorporate predicted sewer overflow volumes from infrastructure model simulations for 1992-1996 climatological conditions[13]. Neither CSOs nor SSOs were a factor in the WAT! results, as none occur in the watershed.

Under year-round conditions, the largest source of fecal coliform bacteria is 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.

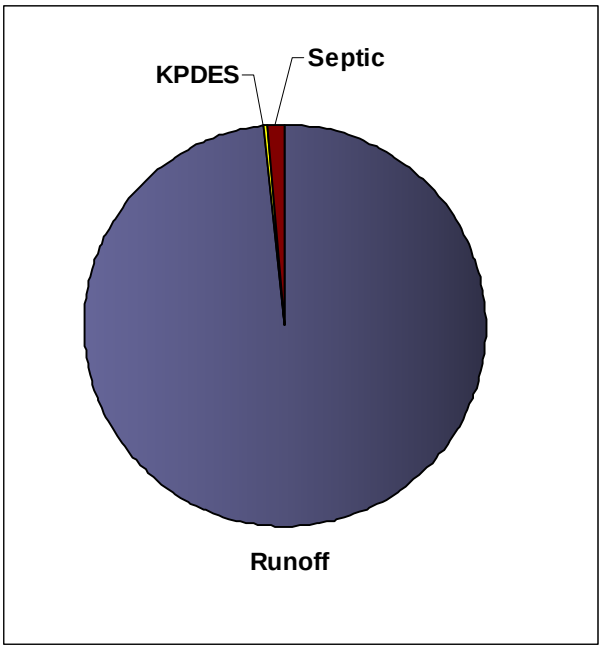

Figure 16. Initial Year-Round WAT! Results for Fecal Coliform
WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

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 WATERSHED RANK

The WAT! produced a ranking, by watershed for the 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 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 Twelvemile Creek watershed during year-round and base flow conditions is provided in Table 10.

Table 10. WAT! Watershed Rankings

	Rank for Year-Round Conditions[a,b]	Rank for Base flow Conditions[a,b]
Fecal coliform	11	6

[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 monitoring programs will further populate and refine WAT! results and rankings, aiding in characterization of potential sources.

7. REFERENCES

American Farmland Trust (AFT), 2005. A Profile of Agriculture and Cost of Community Services Study. Campbell County Kentucky. Commissioned by Campbell County Conservation District.

Boone, Campbell and Kenton County Conservation Districts, 2007. Personal communication May 15, 2007.

Campbell County & Municipal Planning & Zoning Commission. Undated. 2000 Comprehensive Plan: 2000-2020 Update, Including Unincorporated Campbell County and the Cities of Crestview, Melbourne, Silver Grove and Southgate. Prepared by The Northern Kentucky Area Planning Commission

Campbell County Conservation District, 2007. Agricultural Water Quality Self Certifications - Tracking Sheet.

Campbell County Agricultural Extension Office, 2008. Personal communication, September 5, 2008.

Carey, D. I. and Stickney, J. F., 2005. Groundwater Resources of Campbell County, Kentucky. Kentucky Geological Survey County Report 19, Series XII, ISSN 0075-5567.

Cumberland Environmental Group (CEG), 2007. Continuous Monitoring Network Synthesis Report Water Years 2001-2005. Prepared for Sanitation District No. 1 of Northern Kentucky. December 6, 2007.

Grace, M. and S. Imberger, 2006. Stream Metabolism: Performing & Interpreting Measurements. New South Wales Department of Environmental Conservation Stream metabolism workshop. May 2004, Sydney Australia. Workshop developed technical manual. Accessed at http://www.sci.monash.edu.au/wsc/docs/tech-manual-v3.pdf

Kentucky Administrative Regulations (KAR). 2008. Title 401 Natural Resources and Environmental Protection Cabinet Department for Environmental Protection. Chapter 10. Regulation 001E. Statement of Emergency Regulation. Definitions for 401 KAR Chapter 10.

Kentucky Administrative Regulations (KAR). 2008. Title 401 Natural Resources and Environmental Protection Cabinet Department for Environmental Protection. Chapter 10. Regulation 026. Designation of Uses of Surface Waters. Administrative Register of Kentucky.

Kentucky Administrative Regulations (KAR). 2008. Title 401 Natural Resources and Environmental Protection Cabinet Department for Environmental Protection. Chapter 10. Regulation 030. Antidegradation Policy Implementation Methodology.

Kentucky Commonwealth Office of Technology, 2005. 2005 Kentucky Land Cover. Obtained in November, 2007.

Kentucky Division of Water (KDOW), 2005. 2004 303(d) List of Waters for Kentucky. September 2005.

Kentucky Division of Water (KDOW), 2007. Personal communication April 9, 2007. Florence Regional Office.

Kentucky Division of Water (KDOW), 2007a. Fish Consumption Advisories in Kentucky. www.water.ky.gov/sw/advisories/fish.htm Last modified 7/25/2007. Accessed 2/24/2008.

Kentucky Division of Water (KDOW). 2007b. Swimming Advisories in Kentucky. URL: http://www.water.ky.gov/sw/advisories/swim.htm. Last modified 11/8/07.

Kentucky Division of Water (KDOW), 2007c. Personal communication on status of domestic and public water wells. December 2007.

Kentucky Division of Water (KDOW), Kentucky Environmental and Public Protection Cabinet. 2008. 2008 Integrated Report to Congress on the Condition of Water Resources in Kentucky. Volume II. 303(d) List of Surface Waters. Final. May, 2008.

Kentucky Division of Water (KDOW), 2008a. Kentucky Drinking Water Watch Database Version 1.2. Accessed March 2008.

Kentucky Division of Water (KDOW), Natural Resources and Environmental Protection Cabinet. 2008b. Standard Methods for Assessing Biological Integrity of Surface Waters in Kentucky. February.

Kentucky Geographic Network, 2008. April 9, 2008. http://kygeonet.ky.gov/geographicexplorer/explorer.jsf

Kentucky Geographic Network, 2008a. August 11, 2008. http://kygeonet.ky.gov/geographicexplorer/explorer.jsf

Kentucky Geological Survey. 2006. Generalized Geologic Map for Land-Use Planning: Campbell County, Kentucky. KGS Map and Chart 128, Series XII.

Kentucky State Nature Preserves Commission (KSNPC). 2007. Natural Heritage Program Database Review. Data Request 07-097. February 14.

Kentucky Transportation Cabinet (KTC). 2006. Six Year Highway Plan. FY 2006 – 2012. May 25, 2006. http://transportation.ky.gov/progmgmt/06syp.html

Landscapes, 2001. Volume XIV, No. 3. December 2001.

McTammany, M.E., E.F. Benefeld and J.R. Webster. 2007. Recovery of stream ecosystem metabolism from historical agriculture. Journal of the North American Benthological Society 26(3):532-545.

National Climatic Data Center (NCDC), NOAA Satellite and Information Service. 2008. Data obtained for Cincinnati Northern KY Airport, Covington/Cincinnati, KY, United States. WBAN 93814.

National Oceanic and Atmospheric Administration (NOAA). 2008. National Marine Sanctuaries. http://sanctuaries.noaa.gov/welcome.html. Revised February 7, 2008. Accessed February 11, 2008.

Natural Resources Conservation Service (NRCS), 2006. SSURGO/GIS format. [online] http://datagateway.nrcs.usda.gov/.

Natural Resources Conservation Service (NRCS), 2007. Personal communication Ed Thomas.

Northern Kentucky Health Department (NKHD), 2008. Personal communication, 2008.

Northern Kentucky Water District. 2003. Source Water Assessment and Protection Plan, Susceptibility Analysis and Protection Recommendations for Campbell County.

Odum, E.P. 1956. Primary production in flowing waters. Limnology and Oceanography. 1:102-117.

Paylor, R.L. and J.C. Currens. *Karst Occurrence in Kentucky*. University of Kentucky, Kentucky Geological Survey. 2002. http://kgsweb.uky.edu/olops/pub/kgs/mc33_12.pdf. Accessed on May 21, 2007.

Ray, J.A., Webb, J.S., O'Dell, P.W. (Kentucky Department of Environmental Protection, Division of Water, Groundwater Branch), 1994. Groundwater Sensitivity Regions of Kentucky.

United States Environmental Protection Agency (USEPA). April 19, 1994. Combined Sewer Overflow (CSO) Policy. *Fed. Regist*. Vol. 59 pg. 18688.

Woods, A.J., J.M. Omernik, W.H. Martin, G.J. Pond, W.M. Andrews, S.M. Call, J.A. Comstock, and D.D. Taylor. 2002. Ecoregions of Kentucky. Color poster with map, descriptive text, summary tables, and photographs, U.S. Geological Survey (map scale 1:1,000,000), Reston, Virginia.