CHAPTER III. MONITORING

A. *Existing Monitoring*

In order to evaluate the water quality within the Wolf Run Watershed, data was gathered from all available sources including scientific studies, government, and volunteer sources. Table 15 provides an overview of the available data that was gathered as a result of this collection effort.

TABLE 15 – WOLF RUN WATERSHED MONITORING DATA SUMMARY

Sampling Organization	Monitoring Type / Source	Stations Sampled	No. of Sampling Events	Years Sampled	Macroinvertebrates	Fish	Fecal Coliform / *E. coli*	Physicochemical	Nutrients	Total Suspended Solids	Metals	Pesticides / Herbicides	Volatiles / Semi-volatiles
LFUCG	MS4 Stormwater Permit Monitoring	2	68	1999-2011	X	X	X	X	X	X	X		
LFUCG	Golf Course Ponds and Streams	1	2	2010			X	X	X	X			
LFUCG, FOWR	McConnell Springs Stormwater BMP	5	9	2010				X	X	X	X		
UK KWRRI	South Elkhorn Pathogen TMDL	4	10	2002			X						
UK KWRRI	Town Branch Nutrient TMDL	1	2	2000					X				
UK KWRRI	Town Branch Nutrient Sampling	4	13	2009-2010				X	X	X			
UK ERTL	Fecal Source Tracking	24	1 to 10	2007-2008, 2010			X						
KRWW	Volunteer Sampling	7	Varies	1999-2011			X	X	X	X	X	X	
FOWR	Volunteer Conductivity Survey	303	1	2010				X					
KDOW	Groundwater / Spring Sampling	3	6 to 18	2004-2007			X		X	X	X	X	X

NOTE: Organizations abbreviated as follows: LFUCG=Lexington-Fayette Urban County Government, KRWW = Kentucky River Watershed Watch, UK KWRRI = University of Kentucky Water Resources Research Institute, UK = University of Kentucky, UK ERTL, University of Kentucky Environmental Research and Training Laboratory, KDOW= Kentucky Division of Water, FOWR = Friends of Wolf Run

Generators of water quality data for the watershed include LFUCG, Kentucky River Watershed Watch (KRWW), University of Kentucky Water Resources Research Institute (UK KWRRI), University of Kentucky Environmental Research and Training Laboratory (UK ERTL), KDOW, and Friends of Wolf Run. These studies were conducted at differing monitoring locations throughout the watershed over multiple years and for different parameters. Exhibits 23 and 24, pages III-2 and III-3, show the locations of the monitoring sites from which the water quality data was collected. In addition to the monitoring performed at designated sites, the LFUCG Division of Water Quality Compliance and Monitoring team conducted visual stream assessments by walking the streams.

Each of these data sources is described in further detail in the sections following. For studies that are planned or in-progress, the monitoring plan of the study is summarized.

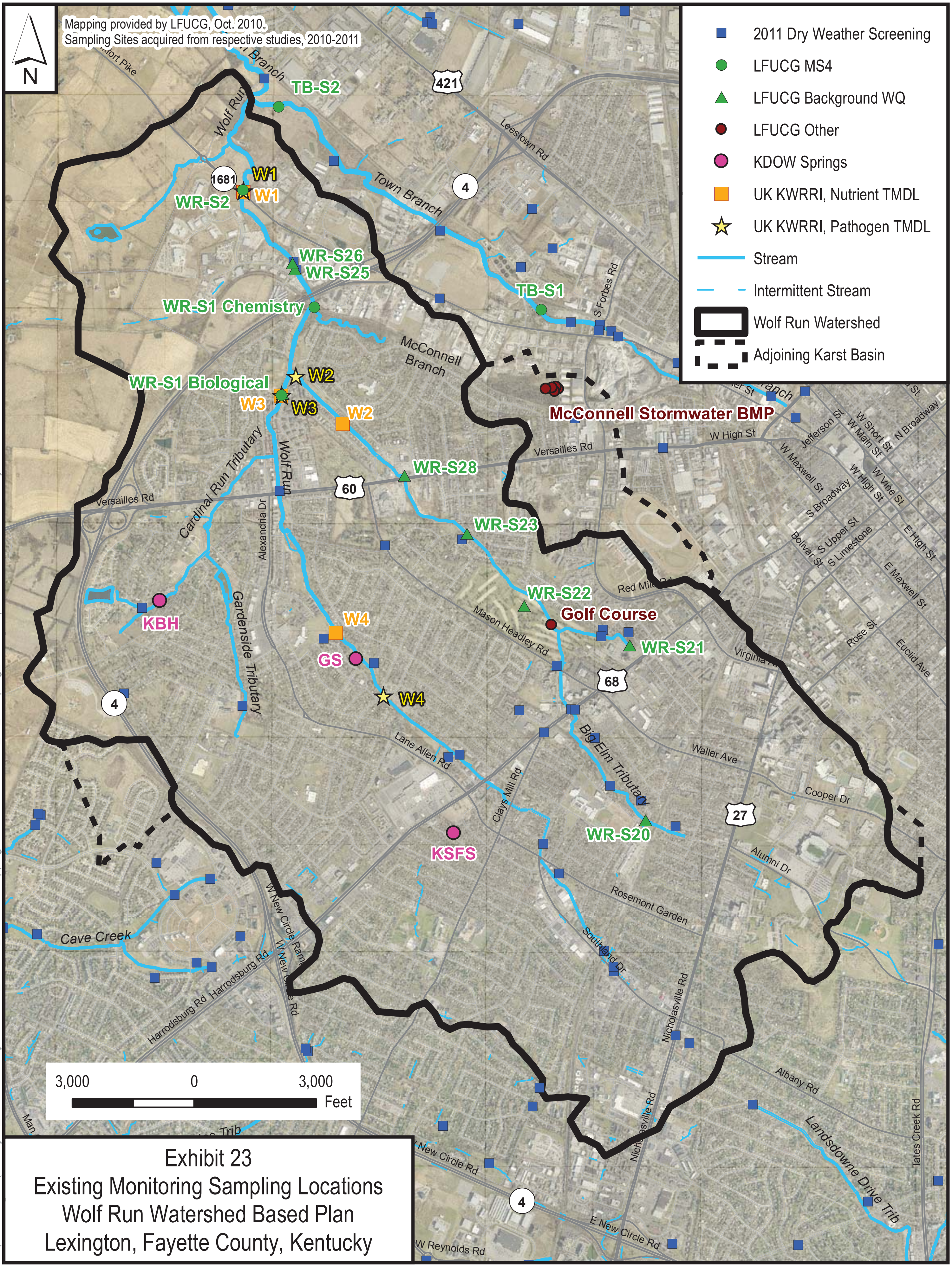

Exhibit 23
Existing Monitoring Sampling Locations
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_23_Sampling_Sites.mxd) 9/25/2012 -- 1:53:57 PM sje

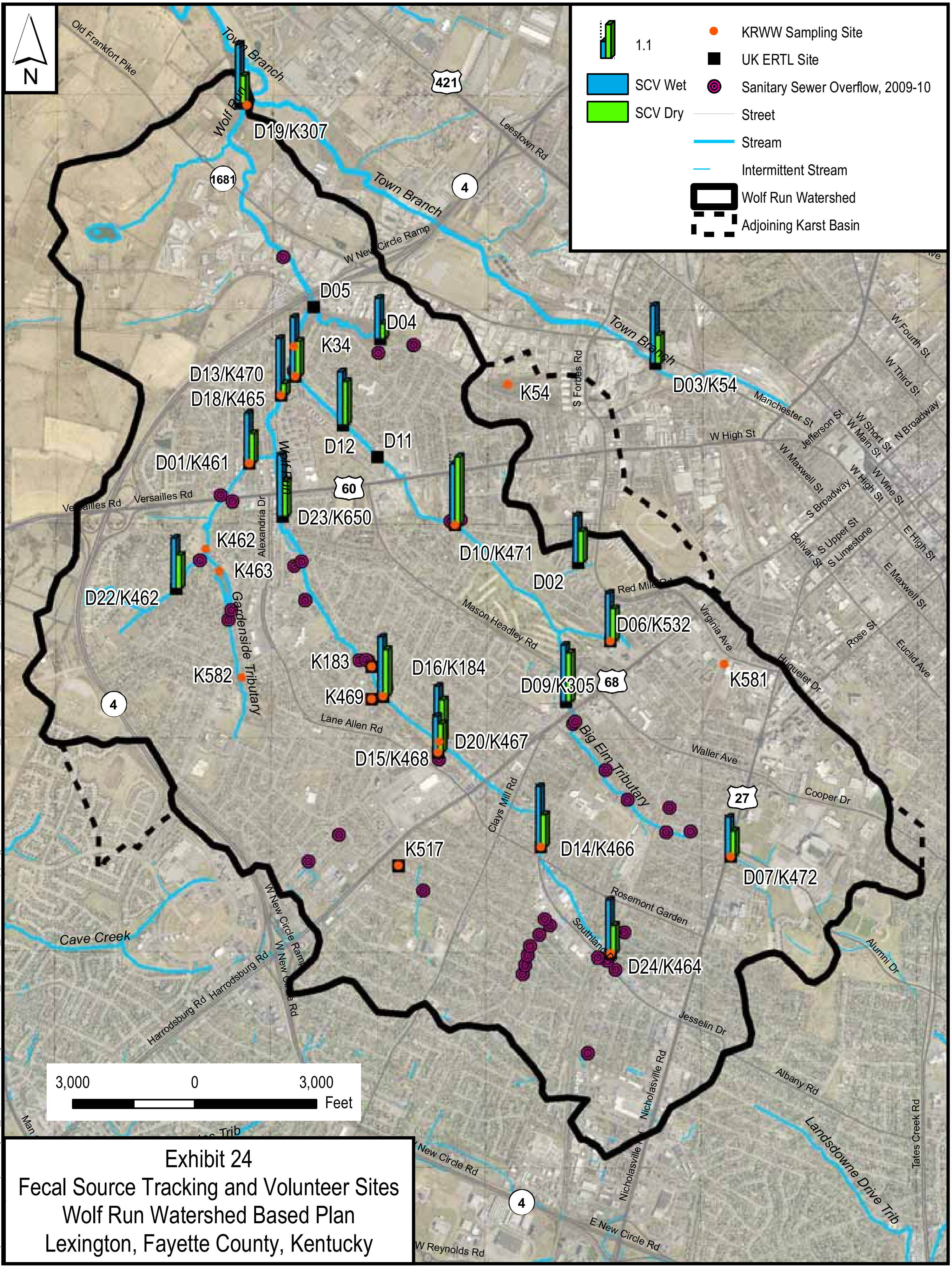

Exhibit 24
Fecal Source Tracking and Volunteer Sites
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

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1. *Lexington Fayette Urban County Government Monitoring*

The LFUCG conducts monitoring in conformance with its MS4 permit for each of the watersheds within the Urban Service Boundary. The monitoring program was initiated in the spring of 1996 with two stations (WR-S1 and WR-S2) located in the Wolf Run Watershed. Table 16 indicates the types of sampling conducted at these sites from 1999 to 2010. Wet weather chemical sampling was conducted as composite sampling during storm events sporadically in the years from 1999 to 2008. Prior to 1999, the parameters sampled for chemical parameters varied from year to year. However, solids (total dissolved and suspended), fecal coliform, oil and grease, cadmium, copper, lead, zinc, hardness, phenols, phosphorus (dissolved and total), nitrogen (ammonia, total kjeldahl, nitrate, nitrite), biochemical oxygen demand, chemical oxygen demand, specific conductance, dissolved oxygen, temperature, pH, and turbidity were routinely sampled over this period. Discharge and *E. coli* were added to this sampling list in the fall of 2008 when the chemical sampling frequency was increased to quarterly dry weather and wet weather sampling. WR-S1 was also dropped as a routine sampling site at this time.

TABLE 16 – SUMMARY OF MS4 PERMIT SAMPLING EVENTS

Sampling Type	Sampling Events / Year												
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
WR-S1													
Chemical Dry Weather		2	2	2	1	1	1	1	1				11
Chemical Wet Weather		1*						1*	2*				4
Habitat	Monitoring Protocols Changed 2003				1	1	1	1	1	1			6
Macroinvertebrate					2	2	2	1	1	1			9
Fish					1	1	1	1	1	1			6
WR-S2													
Chemical Dry Weather	1	2	2	2	1	1	1	1	1	1	4	4	21
Chemical Wet Weather		1*						1*	1*	1	4	4	12
Habitat	Monitoring Protocols Changed 2003				1		1	1	1	1	1	1	7
Macroinvertebrate					2	1	2	1	1	1	1	1	10
Fish					1	1	1	1	1	1	1	1	8

**Indicates composite sampling during storm events.*

Although biological sampling has occurred since 1996, the monitoring and analysis protocols were updated in 2003 such that data from this period onward is comparable. Current KDOW protocols have been utilized throughout the duration of the sampling. Sampling for habitat, macroinvertebrates, and fish have occurred at these sites with WR-S1 being dropped for monitoring in 2009.

The most recent results are summarized in the *Lexington-Fayette Urban County Government 2011 Monitoring Program Evaluation Report* (Remley 2012). Appendix G of the annual monitoring program evaluation report also contains a detailed analysis of the water quality in Wolf Run. Wolf Run Watershed monitoring data from 1999 through 2011 for the current monitoring site, WR-S2, and from 1999 to 2008 for the historic site, WR-S1, are summarized in Table 17, page III-5. These ratings were developed by comparison to LFUCG benchmarks. Of the parameters measured, the results demonstrated "good" water quality for most parameters at all sites, including water temperature, pH, dissolved oxygen, suspended solids, oil and grease, phenols, phosphorus, cadmium, copper, and lead. Several parameters exceeded benchmarks at both monitoring sites including dissolved solids/conductivity, nitrogen, and *E. coli*/fecal coliform. Zinc was found to be "poor" at WR-S1. Habitat and macroinvertebrate community rated "poor," and fish community "fair" at WR-S2, which was slightly worse than WR-S1.

TABLE 17 – SUMMARY OF MS4 PERMIT WATER QUALITY MONITORING DATA

Parameter	WR-S1 Water Quality Status	WR-S2 Dry Weather	WR-S2 Wet Weather
Conductivity / Dissolved Solids	Poor	Poor	Poor
Water Temperature	Good	Good	Good
pH	Good	Good	Good
Dissolved Oxygen	Good	Good	Good
Suspended Solids	Good	Good	Good
Oil & Grease	Good	Good	Good
Phenols	Good	Good	Good
Phosphorus	Good	Good	Good
Nitrogen	Poor	Poor	Fair
E. coli / Fecal Coliform	Very Poor	Poor	Very Poor
Cadmium, Copper, Lead	Good	Good	Good
Zinc	Poor	Good	Good
Habitat	Fair	Poor	
Macroinvertebrate	Poor	Poor	
Fish	Good	Fair	

Dissolved solids/conductivity was "poor" at WR-S2 during both dry and wet weather conditions. Total nitrogen was "poor" at WR-S2 during dry conditions and "fair" during wet conditions. Nitrogen levels met benchmark criteria for only 36 percent of the dry weather samples and 69 percent of the wet weather samples. *E. coli* and fecal coliform levels were "poor" during dry events and "very poor" during wet events. Because both dry weather and wet weather samples regularly exceeded the regulatory limit, the source is not solely attributable to runoff related sources. However, the highest loads were primarily observed during wetter conditions, suggesting that the elevated fecal coliform was more associated with nonpoint source runoff events or sewer failures occurring during storm events.

The habitat at WR-S2 was the only site to have a "poor" rating in 2011. Reduced riparian zone vegetation protection and width and unstable banks contributed to the low habitat score for WR-S2. These conditions most likely contributed to the substrate embeddedness and sediment deposition observed at WR-S2, which further impaired the aquatic habitat. The macroinvertebrate community of WR-S2 has consistently rated "poor" throughout its sampling history from 2003 to 2011. High specific conductance levels and substrate embeddedness probably contributed to low taxa richness, EPT richness, and EPT abundance at WR-S2. Low values for these metrics contribute to the "poor" rating for WR-S2 throughout its sampling history from 2003 to 2011. The fish community rating at WR-S2 has been somewhat variable over its sampling history, ranging from "fair" to "excellent." Recently there has been a decline from an "excellent" rating in 2010 to "fair" in 2011. A decline in insectivore abundance and an increase in facultative headwater and tolerant species abundances were primarily responsible for this decline.

In addition to these monitoring stations, according to the MS4 permit, dry weather screening is to be performed at 125 locations per year throughout the permit area as wells as at all major outfalls and

90 percent of industrial outfalls every two years. In 2011, a total of 34 sites (shown in Exhibit 23, page III-2) were screened in the Wolf Run Watershed, with each site being screened twice. Fifteen of the screened sites had dry weather flow. Neither total copper nor total phenols were detected at any of the sites in 2010 or 2011. Of the 15 sites with dry weather flow, total dissolved solids exceeded 325 mg/L at all sites, total residual chlorine was detected at 10 sites, ammonia was detected at eight sites, and detergents did not exceed 0.25 mg/L at any site. These results indicate that the stormsewer system is contributing total dissolved solids as well as ammonia and nitrogen to the overall pollutant load.

In addition to the monitoring required for regulatory purposes, LFUCG has also conducted voluntary monitoring including background water quality sampling and BMP monitoring.

As shown in Exhibit 23, page III-2, nine samples were collected at five background water quality sites during two sampling events in 2011. The purpose of this sampling was to monitor portions of the Urban Services not captured by the MS4 permit sites, to increase geographic resolution in headwater areas, and to provide additional data for use in illicit discharge detection and elimination (IDDE) investigations. Although the samples were generally collected in dry weather conditions, no specific antecedent dry period was utilized to schedule monitoring. The data quality objectives for sensitivity, precision, and accuracy specified in the SWQMP were utilized in the sampling. The results, evaluated against the benchmarks detailed in this report, are shown in Table 18. This additional monitoring indicates that conductivity, *E. coli*, fecal coliform, nitrogen, and zinc are elevated at each of these locations.

TABLE 18 – 2011 LFUCG BACKGROUND WATER QUALITY MONITORING RESULTS IN WOLF RUN

Location	Cond (Field) uS/cm	DO (Field) mg/L	Temp °C	pH (Field) SU	TSS mg/L	*E. Coli* CFU/100mL	Fecal Coliform CFU/100mL	Zn mg/L	Phosphorus, Total mg/L	Ammonia mg/L	Nitrogen, Total mg/L
WR-S20	684	9.20	13.7	7.77	4	4080	2720	0.036	0.269	0.063	1.51
WR-S20	627	6.90	22.3	7.76	29	5040	4960	0.023	0.534	0.039	7.36
WR-S21	954	9.70	15.1	8.35	4	850	1580	0.055	0.232	0.054	1.32
WR-S21	1234	7.33	22.9	7.96	6	1340	1460	0.123	0.321	0.057	4.08
WR-S23	397	14.40	11.9	8.39	4	520	630	0.023	0.287	0.051	1.36
WR-S24	410	12.70	12.6	8.37	9	1340	1600	0.028	0.341	0.049	1.29
WR-S24	547	13.33	24.5	8.28	4	960	2560	0.013	0.313	0.032	5.63
WR-S25	470	9.70	13.5	8.07	6	1200	980	0.018	0.310	0.035	1.54
WR-S25	517	8.98	22.3	7.84	5	6890	5650	0.015	0.000	0.027	6.76

LFUCG also performed two rounds of sampling on the Picadome Golf Course in March and May 2010. Results showed high conductivity and total dissolved solids (greater than 1000 µS/cm, and 500 mg/L, respectively) as well as elevated bacterial levels (*E. coli* and fecal coliform above 700 and 1000 cfu/100mLs, respectively). Phosphorus (0.302 mg/L), ammonia (0,191 mg/L), and nitrate (16.7 mg/L) were high in March, and nitrate (8.27mg/L) was still elevated when sampled again in May. Low flow conditions were noted during both sampling events.

The McConnell Springs Stormwater Quality Wetlands Pond Project was completed in 2009 using combinations of settling basins, nutrient separating baffle box structure, and polishing lagoon. Sampling was conducted by Friends of Wolf Run and McConnell Springs Nature Center staff trained students throughout 2010 and 2011 with emphasis on capturing runoff samples during storm events. Four sampling sites were initially identified (M1-M4), with an additional site (M5) added later in the year. Bimonthly samples were collected in 2010 and 2011. On-site measurements included: temperature, pH, ortho-phosphorus, dissolved oxygen, conductivity, total dissolved solids, and salinity. Additional analysis included: alkalinity, hardness, carbonaceous biological oxygen demand, total suspended solids, total ammonia, nitrate, nitrite, total phosphorus, orthophosphate, bacterial cultures (*E. coli* and other coliforms), and turbidity. Analyses of metal samples were conducted by the Kentucky Geological Survey (KGS) Laboratory. The sampling results indicate that the BMP is successful in providing reductions in total suspended solids, phosphorus, ammonia, nitrogen, and some metals as water passes through the system.

2. *University of Kentucky TMDL Monitoring*

a. *Pathogen*

Data was collected by UK KWRRI from the Wolf Run Watershed in support of a draft pathogen TMDL at four sampling sites during 10 sampling events in 2002 (Ormsbee *et al.* 2010). The data is summarized in Table 19. Of the three sites sampled, W2 on Vaughn's Branch showed the most consistently high fecal coliform counts, but all sites exceeded the instantaneous primary contact recreation limit (400 CFU/100mLs) consistently. The counts for the site on Vaughn's were much higher than would normally be associated with nonpoint sources. The draft TMDL hypothesized that these increased loadings were primarily due to sanitary sewer overflows (SSOs or leaking sewers) or potentially from runoff from the Red Mile racetrack. As shown in Exhibits 23 and 24 (pages III-2 and III-3) multiple SSOs are present upstream of this site as well as areas of high groundwater and rainfall sewer inflow/infiltration. The increased concentrations are most likely due to these sources.

TABLE 19 – FECAL COLIFORM RESULTS (2002) IN SUPPORT OF THE DRAFT PATHOGEN TMDL

Date	W1 (cfu/100ml)	W2 (cfu/100ml)	W3 (cfu/100ml)	W4 (cfu/100ml)
5/31/2002	204	796	946	889
6/17/2002	671	7,801	1,883	1,693
6/26/2002	540	10,173	342	2,527
6/29/2002	883	6,291	21,898	3,562
7/10/2002	3,407	54,480	29,595	8,322
7/16/2002	479	6,662	2,530	1,379
7/30/2002	1,690	27,914	2,935	74,665
8/29/2002	666	5,147	3,208	1,024
9/24/2002	997	2,904	1,235	2,842
10/2/2002	6,649	2,876	1,391	2,027
Instantaneous Limit	400	400	400	400
Median	777	6,477	2,207	2,277
Minimum	204	796	342	889
Maximum	6,649	54,480	29,595	74,665

b. *Nutrients*

The UK KWRRI has conducted two sampling efforts in support of a TMDL assessment of the Town Branch Watershed, of which Wolf Run is a tributary.

Two samples were collected from one site at the mouth of the Wolf Run Watershed on October 18 and 26, 2000 with total phosphorus results of 0.28 mg/L and 0.30 mg/L respectively (Ormsbee and Blandford 2002). However, because such data was insufficient for TMDL modeling purposes, an additional sampling effort was initiated in March 2009 by UK KWRRI. This effort is described in the report entitled "Town Branch and Wolf Run Data Collection Report" by Rob Doyle (2010). This involved sampling and monitoring 11 sites throughout Town Branch, four of which were located in the Wolf Run Watershed (three on Wolf Run and one on Vaughn's Branch). The samples were analyzed for multiple constituents including total nitrogen and total phosphorus. The data collection was performed monthly for a full year until March 2010. Data analysis was performed using load duration curves and historical flow data.

Town Branch and Wolf Run both show signs of eutrophication due to the growth of algae. Based on the initial analysis, phosphorus was believed to be the limiting nutrient controlling the algal growth (Ormsbee and Blandford 2002). Thus, monthly grab samples were analyzed for total nitrogen and multiple forms of phosphorus. The average concentrations of the nutrients sampled at the Wolf Run stations (W1 through W4) are shown in Table 20. The phosphorus results for Wolf Run are all near the draft TMDL target for phosphorus (0.3 mg/L) for all sites. There are some instances where the concentration is greater than 0.3 mg/L but these are typically during high flows. This suggests that elevated levels may be related to nonpoint sources or wet weather discharges. Nitrogen values were all above 2 mg/L indicating the levels are somewhat elevated compared to non-regulatory reference points.

TABLE 20 – AVERAGE NUTRIENT CONCENTRATIONS FOR 2009 NUTRIENT SAMPLING STUDY

Site Name	Orthophosphate (mg/L as P)	Total Recoverable Phosphorus (mg/L as P)	Total Nitrogen (mg/L as N)
W1	0.289	0.286	2.159
W2	0.329	0.320	2.138
W3	0.309	0.305	2.107
W4	N/A	0.277	N/A

3. University of Kentucky Microbial Source Tracking

In an effort to identify the sources of the high pathogen indicator concentration in the Wolf Run Watershed, UK ERTL has conducted three research projects utilizing microbial source tracking methods. The location of these sampling sites and results are shown in Exhibit 24, page III-3.

In 2007, Tricia Coakley and Dr. Gail Brion of the UK ERTL authored an initial study entitled "Fecal Source Tracking in the Wolf Run Watershed of Lexington, KY using molecular methods for *Bacteroides* bacteria" (Coakley and Brion 2007). Samples were collected at five sampling sites for analysis for *E.coli*, AC/TC ratio, and DNA primers of *Bacteroides* bacteria during five sampling events from July to mid-August of 2007. The AC/TC ratio is used as an indicator of the input freshness with low numbers indicating fresher inputs. The DNA primers of *Bacteroides* bacteria are linked with cattle and human specific source inputs.

No cattle specific inputs were detected in the watershed. AC/TC ratios were the lowest at McConnell Springs (K54), Wolf Run at Gardenside Park (K184), and Cardinal Run at Davenport (K461), indicating the freshest fecal inputs at those locations. Human specific markers were detected most frequently at McConnell Springs and Vaughn's Branch (K470. Wolf Run at Gardenside Park had the highest overall concentration of *E.coli*. Cardinal Run at Davenport showed no human specific markers. Although the number of sites was limited, the report indicated human source inputs were prevalent in the watershed and further analysis was warranted.

In 2009, a final report was published by Dr. Gail Brion, Dr. Alan Fryar, and Tricia Coakley of UK entitled "Identification of Human and Animal Fecal Sources in Central Kentucky Watersheds by qPCR of 16sDNA Markers from Host Specific Fecal Anaerobes" (Brion *et al.* 2009). This fecal source tracking study examined the results of samples collect at 34 sample locations in Central Kentucky, 19 of which were located in the Wolf Run Watershed. One sampling event was collected in 2008 for *E.coli*, AC/TC, and DNA primers indicating all *Bacteroides* (AllBac), human specific markers (HuBac), and bovine specific markers (BoBac). Of the 19 sites located in Wolf Run, seven were identified as "hot spots" of human fecal contamination (potentially from broken or leaking sewer lines) by human specific marker concentrations of greater than 20 percent of the corresponding general fecal marker concentrations. These sites included Preston's Spring and the downstream McConnell Branch (D04 and D05), multiple sites on Vaughn's Branch (K532/D06, D11, and K470/D13), and two sites on Wolf Run (K466/D14 and K468/D15).

A final study was conducted in 2010 by UK ERTL, which resulted in a final report, published on April 15, 2011 entitled "A Plan for Identifying Hot Spots and Affirming Remediation Impacts on Surface Water Quality: Phase I" (Brion *et al.* 2011). The volunteer group, Friends of Wolf Run, collected grab samples from 18 locations in the Wolf Run watershed during ten sampling events from April 6th to August 5th 2010. Grab samples from these sites, along with inlet domestic sewage and manhole overflows, were analyzed for indicators of fecal load (*E. coli*), fecal age (AC/TC ratio), and fecal source (two human host specific *Bacteroides* DNA markers, HuBac and qHF183) by UK ERTL. A sanitary category value (SCV) was developed by using a simple summation of three indicators (*E. coli*, AC/TC ratio, and the log-transformed ratio of HuBac to the maximum sewage HuBac signal), each assigned values 0 to 1 and summed such that raw sewage had a value of 3.0.

One site (D10) located on Vaughn's Branch at Tazwell Drive was found to have SCVs indistinguishable from sewage during dry conditions. A broken sewage pipe observed in the survey (which has since been repaired) confirmed this finding. D04 at Preston's Cave and D18 on Wolf Run at Roanoke Drive were the least human sewage impacted under dry weather conditions. Under wet conditions, the watershed quality declined. Nine sites (D23, D14, D10, D16, D13, D19, D03, D18, and D09) had SCV values statistically indistinguishable from sewage under rainy conditions. This indicates contributions from sanitary sewer overflows during precipitation. The report indicates Cardinal Run as the least sewage-impacted tributary under wet and dry conditions, Vaughn's Branch the most impacted during dry conditions and also heavily impacted under rain conditions, and Wolf Run impacted primarily with wet weather human sewage, although leaking sewers are suspected to also impact water quality during dry weather.

4. Kentucky Division of Water Groundwater Monitoring

Groundwater quality data for the Lexington West quadrangle (Miller 1967) from KDOW's consolidated groundwater database (KDOW 2010b) are compiled in an online data report summarizing 45 groundwater quality sites sampled between 1953 and 2008. Because the data is not regularly collected, it is of marginal value to the current analysis.

However, KDOW has conducted extensive groundwater monitoring data at three springs (shown in Exhibit 23, page III-2) within the Wolf Run Watershed: Gardenside Spring (GS), Kay-Springhurst Farm Spring

(KSFS), and Kenton Bluehole (KBH). GS and KSFS monitoring included full chemical and *E. coli* (March through July 2004, May through October 2006), while KBH was limited to full chemical (four seasons in 2004, winter and spring 2005). GS and KSFS showed some elevated levels (as compared with regulatory limits) of *E. coli*.

Conductivity, nitrate and phosphorus were high compared to reference values at all monitored springs, ranging from 413 to 682 µmho/c; 2.79 to 4.78 mg/L; and .246 to .318 mg/L, respectively. With the exception of a peak conductivity of 682 µmho/c, values were generally lower at KSFS than either GS or KBH. Values recorded at GS and KBH were similar for these three parameters.

5. Volunteer Monitoring Efforts

KRWW is a non-profit organization composed of the KWRRI, the Kentucky River Authority (KRA), and a network of volunteers. KWRRI and KRA selected six subwatersheds of the Kentucky River Basin to monitor for focused management efforts. The South Elkhorn watershed, one of the six priority basins, contains the Wolf Run Watershed. KRWW has eight monitoring sites located on Wolf Run from near its confluence with Town Branch to its headwaters.

The earliest monitoring at these sites began in 1999 at K034. Monitoring periods per site vary from four to eight years (with the exception of one year at K498). Collection at all sites is primarily limited to mid-summer (July) and early-fall (September). The range of data collected from year to year varies. Physicochemical and fecal data have been collected most regularly, while full chemical data collection varies from every other year at some sites to approximately every four years at others. Fecal coliform, *E. coli* and total phosphorus consistently exceed benchmarks at all sites. One notable factor in the results is the high concentrations of chloride measured in Wolf Run at several sites. Because chloride has a high ionic value, it can contribute to elevated conductivity and dissolved solid levels in the watershed. The most recent sampling conducted in the Wolf Run Watershed are summarized in "Summary of Kentucky River Watershed Watch 2011 Water Sampling Results" (KWRRI and KRA 2012).

In September 2010, the Friends of Wolf Run coordinated a survey of specific conductance in the Wolf Run Watershed. Twelve teams of volunteers were each equipped with Oaktan conductivity meters and sampled 16 kilometers of waterway in Wolf Run. Measurements were taken approximately every 30 meters on segments of 1,000 meters. Because this survey was conducted during a period of low flow, many stream segments were dry during the study, but this helped to identify karst inflow and outflow. The results of this survey are still in draft form.

B. Monitoring Needs and Plan

Subsequent to the review of the existing monitoring conducted in the Wolf Run Watershed, the additional monitoring necessary in order to have sufficient data to complete the watershed based plan were assessed. In order to address these gaps, a quality assurance project plan was developed by the project team and accepted by the KDOW (Evans 2012).

Six different monitoring activities were conducted under this project plan including:

1. Karst hydrograph characterization
2. Conductivity survey
3. Benthic macroinvertebrate collection

4. Watershed habitat assessment
5. Hydrogeomorphic assessment
6. Water quality monitoring

Each of these monitoring activities, conducted by Third Rock and the Friends of Wolf Run, are summarized in Table 21. Monitoring was planned to start in May 2011 and end in February 2012. Sites were selected by review of aerial mapping, previous sampling locations, and field review. Numerous factors including previously collected data, accessibility, land use, upstream disturbances and suspected sources, and projected cost were considered in determining the number of sampling sites and their locations. Summaries of the planned monitoring activities are included below. For details on the monitoring plan, see the Quality Assurance Project Plan (QAPP) (Evans 2012). The QAPP specified locations in which these sampling activities were to occur are shown in Exhibit 25, page III-12. A summary of the sampling site locations and the sampling dates are shown in Table 22 and Figure 3; both are located on page III-13.

TABLE 21 – SUMMARY OF PROJECT MONITORING ACTIVITIES AND SAMPLING DATES

Monitoring Activity	Collected by	No. of Sites	Monitoring Period / Dates
Karst hydrograph characterization	Third Rock	6	Loggers deployed from 6/13/2011 to 12/2/2011
Conductivity survey	Friends of Wolf Run	373	8 days from 9/17/2011 to 10/11/2011
Macroinvertebrate Collection	Third Rock	6	May 12, 17 and 18, 2011
Habitat Assessment	Third Rock and Friends of Wolf Run	33	16 days from 5/23/2011 to 10/10/2011
Hydrogeomorphic Assessment	Third Rock	9	Initial Survey – 5/23/2011 to 6/22/2011 Final Survey – 3/13/2012 to 5/17/2012
Water Quality Monitoring	Third Rock and Friends of Wolf Run	12	15 Days – 5/25/2011 to 2/17/2012

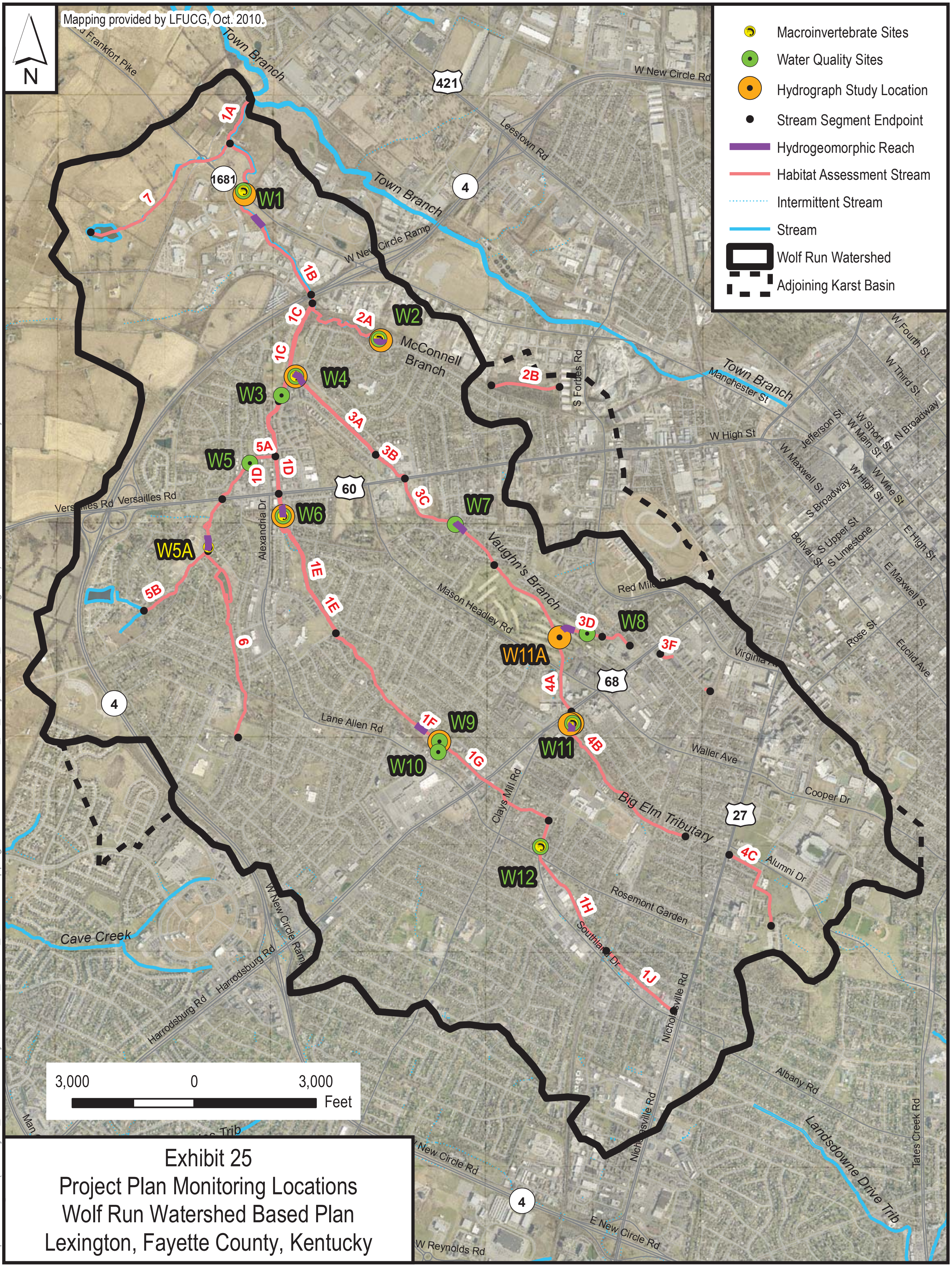


Exhibit 25
Project Plan Monitoring Locations
Wolf Run Watershed Based Plan
Lexington, Fayette County, Kentucky

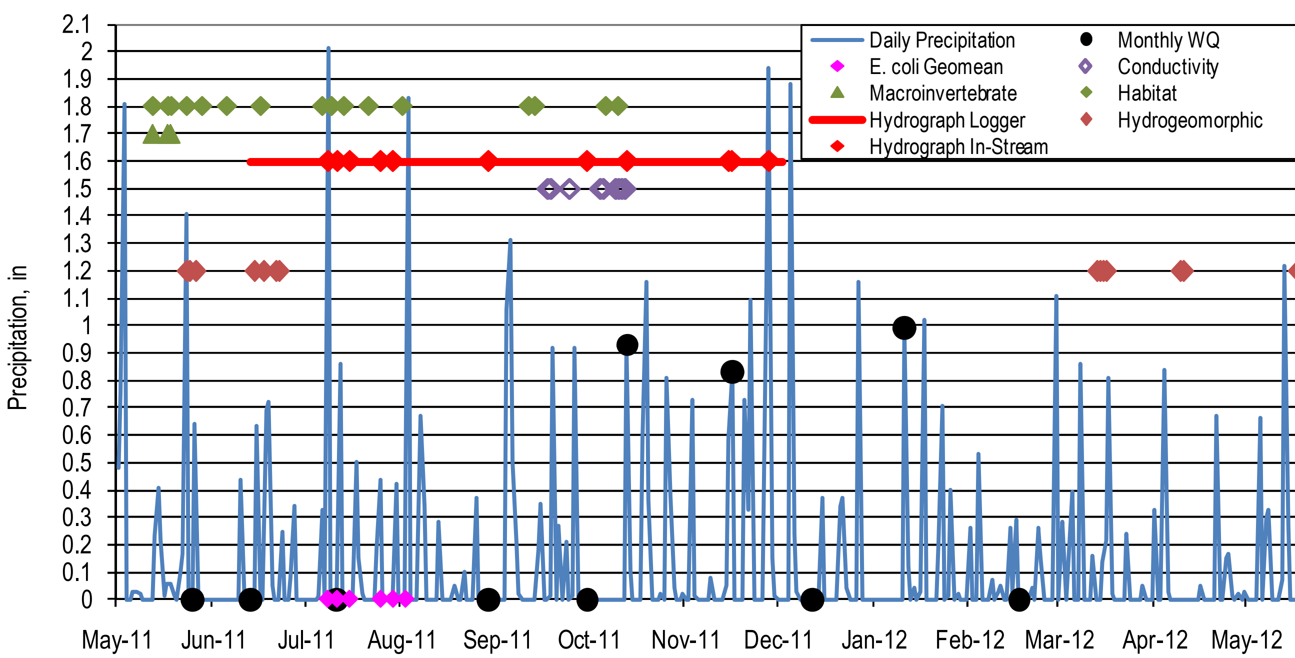
Map Document: (P:\Project_Files\Kentucky\KY10-030_LFUCG_WolfRun\Mapping\GIS\Exhibits\Exhibit_25_Project_Plan_Monitoring.mxd) 9/26/2012 -- 11:00:05 AM sje

TABLE 22 – DESCRIPTION OF PROJECT MONITORING LOCATIONS

Site Name	Stream	Location	Latitude	Longitude	Upstream Area (Acres)	Upstream Sites
W01	Wolf Run	Old Frankfort Pike	38.067303	-84.554182	6614* **	All
W02	McConnell Branch	Preston's Cave	38.057333	-84.542169	418*	-
W03	Wolf Run	Valley Park	38.053742	-84.550782	3532**	W05, W06, W09, W10, W12
W04	Vaughn's Branch	Valley Park	38.054904	-84.549624	1966	W07, W08, W11, W11A***
W05	Cardinal Run	Devonport Dr	38.048594	-84.553867	1033**	-
W05A	Cardinal Run	Parkers Mill Rd	38.043212	-84.557131	810**	W05
W06	Wolf Run	Wolf Run Park	38.045274	-84.550661	2234	W09, W10, W12
W07	Vaughn's Branch	Pine Meadow Park	38.044927	-84.536148	1630	W08, W11, W11A***
W08	Vaughn's Branch	Picadome Golf Course	38.037453	-84.525057	575	-
W09	Wolf Run	Faircrest Drive	38.029954	-84.537091	1024	W12
W10	Springs Branch	Faircrest Drive	38.029855	-84.537196	428	-
W11	Big Elm Tributary	Harrodsburg Road	38.031245	-84.526027	581	-
W11A	Big Elm Tributary	Picadome Golf Course	38.037494	-84.527095	678	W11
W12	Wolf Run	Lafayette Parkway	38.022932	-84.528581	749	-

* Includes 402 acres of misbehaved karst in the Town Branch watershed that flow to McConnell Springs.
** Includes 121 acres of misbehaved karst in the South Elkhorn watershed that flow to the Kenton Blue Hole.
*** The Big Elm Tributary only flows into Vaughn's Branch under conditions of excessive rainfall when the Picadome sinkhole is overwhelmed.

FIGURE 3 – PROJECT SAMPLING EVENT SUMMARY



1. *Karst Hydrograph Characterization*

The Wolf Run Watershed has a karst influence which should be considered during the loading calculations and can influence the decision making process in development of the action plan. Based on dye traces, a substantial fraction of both the Vaughn's Branch and main stem of Wolf Run sub-watersheds are captured by the Preston's (McConnell) Spring basin. During base flow and dryer conditions most of the surface water in the karst-influenced fractions of these subwatersheds are directed to Preston's Spring. During high flow conditions the surface component of the discharge becomes greater as the karst system conduit limits are approached. In order to determine the influence of the karst system, storm event gauging of Preston's Spring was to be conducted to determine the discharge and the nature of the hydrograph.

Simultaneous gaging of the three affected tributaries and a major sinkhole were planned to be conducted during base flow conditions and during a wet weather event. Temporary water level gages (pressure transducers with data loggers) were installed at each of the five gaging stations. Surface flow was measured at each of these locations to evaluate the flow into and out of the karst system.

Flow measurements was to be conducted according to KDOW's *Measuring Stream Discharge Standard Operating Procedure* (KDOW 2010c). The base flow event was to be a single flow measurement at each of six gaging stations as shown on Exhibit 25, page III-12. It was anticipated that the base flow period would occur in late August to October 2011. The wet weather event was to target a storm event that is expected to have uniform rainfall across the watershed with expected accumulation of over one inch. The gaging was to be performed by two teams of surveyors circulating to each of the five gaging points a minimum of every 30 minutes during the storm event. Monitoring was to continue until past the hydrograph peak.

2. *Conductivity Survey*

Specific conductance was recently listed as a cause of impairment in the Wolf Run Watershed. Although specific conductance or conductivity has been analyzed during several studies and the Friends of Wolf Run conducted a broad study of conductivity levels in the watershed, a study under base flow conditions was necessary to aid in identifying inputs and problem areas.

During medium to low-flow conditions (0.5 to 5 cfs at the USGS gage), a survey was planned to use *in situ* field temperature and specific conductance measurements to identify locations of "jumps" in the specific conductance levels as possible locations of pollution. Using GPS data loggers, field meters, data sheets, and photographs, all streams and tributaries (approximately 13.5 miles) were to be measured at approximately 100-foot intervals (approximately 700 locations). Volunteer samplers were trained to perform the survey. The survey was targeted for completion within a one-week period, but in the event of a precipitation event was to be delayed until conditions returned to the initial survey conditions.

3. *Benthic Macroinvertebrate Collection*

Macroinvertebrate samples had been collected at two sites in the watershed, both located near the mouth of Wolf Run. The nutrient/eutrophication biological indicators impairment of Wolf Run was based on the macroinvertebrate data collected at these sites. However, the health of the macroinvertebrate community in the headwaters of the watershed had not been assessed.

To address this need, macroinvertebrate samples were to be collected at six sites within the Wolf Run Watershed. The six sites are located on Vaughn's Branch, Big Elm Tributary, Cardinal Run, McConnell Branch, and two sites on Wolf Run (one upstream of Harrodsburg Road, one upstream of Versailles Road).

These sites are identified on Exhibit 25, page III-12. A seventh site is also identified at Old Frankfort Pike and Wolf Run, which is be sampled annually under LFUCG's MS4 permit.

The macroinvertebrate community at each site was to be sampled using the recommended methods developed by KDOW (2009b, 2009c), which involve the collection of a riffle and multihabitat sample at each location. The riffle sample consisted of four 0.25 meters^2 (m^2) samples collected from two separate riffles at each station using a 0.25 m^2 grid and a kicknet (600µm mesh). Riffle collections at each station were composited to form one semi-quantitative sample. The qualitative, multihabitat sample includes, where habitat is available, samples from leaf packs; sticks/wood; bedrock/slabrock; undercut banks/submerged roots; aquatic macrophyte beds; soft sediment; hand-picking of rocks from riffles, runs, and pools; *aufwuchs* material off rocks, sticks, leaves, and filamentous algae; and visual searches of large woody debris. All samples collected with the dip net and the rock and wood samples were processed through a wash bucket and composited to form one sample for each station. Samples will be preserved and returned to the laboratory for processing and identification. All organisms were identified to the lowest possible taxonomic level and recorded on laboratory data sheets using methods described by KDOW (2009b).

Habitat assessments were performed by Third Rock personnel at each of these sites according to the procedures outlined in *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (Barbour *et al.* 1999).

4. Watershed Habitat Assessments

In addition to the habitat assessments conducted at the macroinvertebrate sites, habitat assessments were performed by trained volunteers throughout the watershed on parcel-sized or 100-meter stream reaches. Using the visual-based habitat assessment procedures in Barbour *et al.* 1999, volunteers surveyed as many segments as time permitted within 24 selected stream segments into which the watershed has been subdivided. At least one assessment was to be performed in each segment

5. Hydrogeomorphic Assessment

No assessments for the hydrogeomorphic condition of the watershed were identified in the existing data. To address this need, nine hydrogeomorphic monitoring sites, as shown in Exhibit 25, page III-12, were designated to measure channel changes in representative reaches. Assessments at these sites were to include cross-section and longitudinal profile surveys and streambed substrate evaluation to determine the extent of the effects of hydromodification. The relative potential for improvement was also to be qualitatively assessed based on the lack of obvious physical constraints in a reach, position in the landscape, or position in the watershed.

The baseline cross-section, profile, and bed substrate were to be compared to a subsequent survey to determine the degree and type of changes in physical structure and stream function that has occurred. The hydrogeomorphic assessments were to supplement biological, physicochemical, and habitat data in determining the overall health of the stream reach and stream-use designation. The sampling was to quantify physical stream changes that occurred over time, help identify potential BMPs/implementation solutions, and prioritize reaches for implementation of those solutions.

6. Water Quality Monitoring

Although sampling data is available at multiple sites throughout the watershed, most of the available data was limited spatially or temporally. According to KDOW's "Watershed Planning Guidebook for Kentucky

Communities" (2010d), monitoring data needs to meet the sampling protocol for new data in order to satisfy the requirements of KY 319-funded plans. This includes monthly sampling for one year during dry and wet conditions for discharge, total suspended solids, total phosphorus ortho-phosphorus, ammonia, total kjeldahl nitrogen, nitrate+nitrite, total dissolved soilds, turbidity, dissolved oxygen, specific conductance, temperature, and pH.

Water quality monitoring was conducted during 10 monthly sampling events at 12 sampling stations in the watershed, shown in Exhibit 25, page III-12, during dry and wet conditions. The sampling date within each month was to be flexible such that at least two of the events were considered "wet weather" and two of the events were considered "dry weather." Sampling parameters included discharge, *E. coli*, fecal coliform, total suspended solids, total phosphorus, ortho-phosphorus, ammonia, total kjeldahl nitrogen, nitrate, nitrite, total dissolved solids, carbonaceous biochemical oxygen demand, turbidity, dissolved oxygen, specific conductance, temperature, and pH. The LFUCG Town Branch laboratory analyzed samples for *E. coli*, fecal coliform, total suspended solids, ammonia, nitrite, total dissolved solids, alkalinity, and hardness. KGS analyzed samples for total phosphorus, ortho-phosphorus, total kjeldahl nitrogen, and nitrate. Friends of Wolf Run volunteer samplers performed field measurements of turbidity, dissolved oxygen, specific conductance, temperature, and pH. Third Rock staff accompanied the volunteers and conducted discharge monitoring and field filtered ortho-phosphorus samples. Additionally, two wet weather sampling events were to be collected on the hydrographic rise by Third Rock staff.

In addition to the monthly sampling, volunteers were collect an additional four events within a 30-day period during the Primary Contact Recreation period (May 1 to October 31) for *E. coli* and fecal coliform to evaluate the geometric mean for the primary contact period. A Third Rock staff member was to accompany the volunteers during each event to conduct discharge monitoring. Only flow, *E. coli* and fecal coliform were collected during these events. The LFUCG Town Branch laboratory analyzed the samples.

C. Monitoring Implementation Overview

Technical reports detailing the results of each of the monitoring activities are provided in the following reports:

- Karst Hydrograph Characterization Report (Appendix B)
- Conductivity Survey (Appendix C)
- Habitat and Macroinvertebrate Assessment Report (Appendix D)
- Hydrogeomorphic Assessment Report (Appendix E)
- Watershed Monitoring Report (Appendix F)

The monitoring plan was primarily executed as planned. However, some changes were made to account for irregular circumstances that arose during the project.

The monitoring effort was conducted during the wettest year on record for Fayette County. Because of this, antecedent dry conditions were difficult to achieve during the study. Only 14 percent of days within the entire monitoring period had an antecedent dry period of seven days, which was originally specified in the QAPP per KDOW's recommendation. With these specifications, sampling could only be conducted four days a month, making coordination difficult, particularly for wet weather conditions that can occur in evenings or on weekends. A three-day (72-hour) antecedent dry period was used to define wet and dry weather events due to these conditions.

Some water quality results had to be rejected due to the precision or accuracy of the results or the conditions under which they were collected, but sufficient data was collected to fulfill the project goals. Unusable data was qualified for screening use only or rejected from loading calculation and analysis. The LFUCG Town Branch Laboratory utilized this project to improve its quality control testing and reporting criteria, so some of the initial sampling events were deficient in the quality control testing. However, the data quality improved with the project and the laboratory has improved and expanded its capabilities as a result.

This project was unique in that the sampling efforts were coordinated between consultant staff and volunteer samplers. It is believed that the collaboration between the volunteers and consultants enhanced the experience of the volunteers and provided additional insight into their understanding of stream water quality and sampling methodology. The volunteers were competent in their responsibilities and quality control issues were identified and addressed early in the project so as to not be an obstacle in analysis. As a result of the collaborative experience, the need for improved field equipment was identified and now is available for future volunteer efforts. However, the scheduling of sampling activities with volunteers and consultants proved challenging due to conflicts in time availability. In future monitoring efforts, use of trained staff or volunteer monitoring with periodic quality control checks may improve efficiency and mobilization.

For the karst hydrograph characterization, loggers recorded data from June 13 until December 2, 2011. Because the caps were cemented in place to prevent theft, loggers could not be downloaded until after the wet event was monitored, which was delayed due to the infrequency of such a heavy rain event. One wet event was captured, but only two or three measurements were recorded at each site due to the time required to make each measurement. Although fewer measurements were made during a single wet weather event than expected, more events were measured than initially planned due to the long installation period. In total, flow was measured during 11 monitoring events conducted during the period of data logger recording. The cross-sectional areas, longitudinal profiles, and pebble counts measured at the karst sites were also utilized to predict flows and improve the stage-discharge curves generated for each site.

The conductivity survey was conducted at 373 sites on eight days from September 17, 2011 to October 11, 2011. A rain event delayed the surveys from being collected within one week of initiation, but all sites were collected under medium to low flows meeting the objective for the study. Each stream segment was surveyed within a single day, such that changes along a reach could be assessed. Some reaches could not be sampled because they were either dry or could not be accessed.