SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM PROJECT FINAL REPORT

Grant # C9994861-01

**Development of Pathogen TMDLs for
Four 303(d) Listed Streams in the Kentucky River Basin**

Workplan# 01-07

Memorandum of Agreement # M-02153329

Project Period: May 2002-September 2006

Submitted By:

**Dr. Lindell Ormsbee
Dr. Chandramouli Viswanathan,
Dr. Jagadeesh Anmala,
Noppadon Kowsuvon,
Dr. Ramesh Teegavarapu**

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The Kentucky 2002 303(d) Report identified a 11.3 mile segment of Town Branch (from its confluence with South Elkhorn Creek), and a 4.1 mile segment of Wolf Run (from its confluence with South Elkhorn Creek) as not supporting the designated warm water use of primary contact recreation (swimming) due to pathogen impairment. The Report also identified a 17.6 mile segment of South Elkhorn Creek (from river mile 16.4 to 34.0) as only partially supporting primary contact recreation.

Subsequent data collection associated with the development of this total maximum daily load (TMDL) also revealed impairment on Lee's Branch and the lower reaches of South Elkhorn Creek. As a consequence, these segments were included in the development of the TMDL for the entire South Elkhorn watershed. Initial work on the TMDL for the South Elkhorn Creek watershed began in May 2002. A stream sampling system was developed for the South Elkhorn main stem and representative tributaries within the watershed. Sampling occurred between May 2002 and October 2002, including various sites on Cane Run, South Elkhorn Creek, Wolf Run, and Town Branch. Water quality samples were collected during rain and non-rain events in an effort to account for the potential impact of both point and nonpoint pathogen sources. The sampling data suggest that pathogen values in South Elkhorn Creek (and its tributaries) exceed the 30-day geometric mean limit set forth by Kentucky's Surface Water Standards (401 KAR 5:031) for primary contact recreation (i.e. a monthly geometric mean of 200 colonies per 100ml, or 200cfu/100ml) more than 90% of the time. Additional data obtained from the Georgetown Municipal Water Company and the Lexington Fayette Urban County Government similarly support that pathogen values in Cane Run and its tributaries exceed the 30-day geometric limit for primary contact recreation more than 90% of the time.

In order to assess the sources and associated pathogen loadings in the South Elkhorn Creek watershed, a HSPF computer model of the watershed was developed. The model was used to determine the total maximum daily load (TMDL) of pathogens in each catchment. These TMDLs were then separated into a wasteload allocation (the part of the TMDL associated with point sources) and a load allocation (the part of the TMDL associated with non-point sources). The non-point source loads were further sub-divided into distributed loads associated with the two main land uses in the watershed (agricultural and urban) and concentrated loads associated with failing septic systems, straight pipes, and in-stream loads associated with livestock. General wasteload and load reductions are required in order to achieve the TMDLs for each sub-watershed.

There are two wastewater treatment facilities and two package plants in the South Elkhorn watershed. In addition to these four permitted point sources, sampling and anecdotal evidence suggest the presence of additional unpermitted point sources discharging into Town Branch Creek. These may be associated with 1) two storm sewers that discharge into Town Branch (a major sanitary trunk main to the Town Branch wastewater treatment plant runs parallel to both storm sewers and raises the potential for cross connections between the two systems), and 2) the Lexington Stockyards. Additional data would suggest the probability of sanitary sewer overflows both in the South Elkhorn watershed and the Cane Run watershed. Eliminating loads associated with these additional potential point sources will be required in order to bring each watershed into compliance with current water quality standards for pathogens.

A preliminary draft of the fecal coliform TMDL for South Elkhorn Creek (including Town Branch and Wolf Run) was been submitted to the Kentucky Division of Water on February 20, 2008. Continued work on the Cane Run TMDL is in process.

Wasteloads (point source loads) in the South Elkhorn watershed were allocated to the wastewater treatment plants and the package plants in the watershed. General load reductions of between 25% and 50% are proposed for both agricultural and urban lands through better management of agricultural and urban wastes and litter. Concentrated load reductions were accomplished by assuming 100% elimination of straight pipes and the elimination of livestock access to streams. Additional concentrated load reductions were obtained through partial elimination (25% to 90%) of failing septic systems. Final nonpoint source loads in the South Elkhorn watershed were allocated between distributed loads (associated with the agricultural and urban land uses) and the remaining concentrated loads associated with failing septic systems.

This TMDL represents the first application of the HSPF water quality model in the state of Kentucky for the purposes of development fecal coliform TMDLs. As a consequence, the total modeling effort greatly exceeded the initial budget that was provided for the project.

Given the complexity of the pathogen sources in each of the watersheds, it was deemed reasonable if not necessary to employ a comprehensive computer modeling to assist in the development of the TMDLs. This study has demonstrated that use of such a sophisticated model can be extremely time consuming and costly. Where feasible, a simpler modeling approach should be considered such as the use of load duration curves.

INTRODUCTION & BACKGROUND

During the spring of 2001, representatives from the Kentucky Division of Water (KDOW) approached the Kentucky Water Resources Research Institute (KWRRI) at the University of Kentucky about developing fecal coliform TMDLs for South Elkhorn Creek, Town Branch, Wolf Run, and Cane Run all lying within central Kentucky (see Figures 1 and 2).

These discussions led to the formulation of a project proposal to address this need. The purpose of this project was to investigate the applicability of the Hydrologic Simulation Program – Fortran (HSPF, 1997) in the development of fecal coliform TMDLs for watersheds in Kentucky. The primary goal of the project was to provide information to the Kentucky Division of Water and community stakeholders in support of actions designed to bring four streams (i.e. South Elkhorn Creek, Town Branch, Wolf Run and Cane Run) into regulatory compliance. This goal was to be accomplished by satisfying the following project objectives:

1) Collect physiographic, demographic, and animal statistics for each watershed.
2) Characterize existing permitted and non-permitted non-point source loads within each watershed using the Bacterial Indicator Tool (EPA2001a).
3) Characterize historical point source loads by collecting flow and fecal coliform samples from previous Discharge Monitoring Reports (DMRs).
4) Collect flow and fecal coliform samples from each watershed.
5) Develop and calibrate HSPF models for each watershed.
6) Determine TMDLs (including appropriate MOS) for each watershed.
7) Determine load and wasteload allocations necessary to achieve the TMDLs.
8) Disaggregate the load and wasteload allocations among different sources.
9) Develop TMDL report for each watershed.

Following the submission of a proposal for the work, the KWRRI was notified on September 5, 2001 that the TMDL project would be funded. The KWRRI submitted a QA/QC plan for sampling on October 13, 2001 which was subsequently approved on January 23, 2002. The project was officially approved and funded on May 28, 2002 through memorandum of agreement Number M-02153329 with the KDOW Nonpoint Source Section through a grant from the U.S. Environmental Protection Agency as authorized by the Clean Water Act Amendments of 1987, §319(h) Nonpoint Source Implementation Grant #C9994861-01**.**

Work continued on the project through August 31, 2003, but due to several problems, neither the South Elkhorn nor the Cane Run TMDLs were completed by that date. These problems included the following:

1. The summer of 2002 was very dry. This, coupled with the karst nature of the upper part of the Cane Run watershed (the full extent of which was not known when the study was initiated), resulted in the stream remaining essentially dry the entire summer. As a consequence, additional data were needed to properly

characterize the pathogen loads in the watershed. The collected data were augmented with data from the Lexington Urban County Government and the Georgetown Water Company, which monitors discharge at Royal Springs, the primary source for water.

2. The application of HSPF to model the watersheds posed a greater challenge than originally anticipated, especially when the investigation discovered least half of the Cane Run watershed actually discharged into Royal Springs as a result of significant karst features. At the time of the analysis, no EPA protocols existed for the development of TMDLs within karst watersheds. As a result, additional research was needed to properly characterize and model the karst system.

3. The individual responsible for the TMDL modeling resigned unexpectedly at the beginning of the summer of 2003 which necessitated hiring and training a new modeler.

As a result of these issues, the KWRRI agreed to continue pursuing completion of the South Elkhorn TMDL but await additional funds for finalization of the Cane Run TMDL. This was consistent with the original understanding between KDOW and KWRRI relative to the limited amount of initial funding that was available.

A preliminary draft of the South Elkhorn TMDL (inclusive of Town Branch and Wolf Run) was submitted to the KDOW in the fall of 2005. Following comments by KDOW on November 9, 2005, the KWRRI made several revisions and then submitted a revised draft on September 7, 2006. A close out report for the original 319 grant was also submitted at that time. The final financial and administrative close out is provided in Appendix A.

Subsequent to these submittals, KDOW requested more changes to the South Elkhorn TMDL in light of additional data on sanitary sewer overflows and a desire to re-characterize the non point source loads as either municipal separate storm sewer system (MS4) loads or non MS4 loads. As a result, the KWRRI continued work on the TMDL and submitted another revision on February, 20, 2008. In the interim, the KWRRI also continued work on the Cane Run TMDL and in July 2008, received notification that additional funding would be provided to complete that work through a new 319 grant.

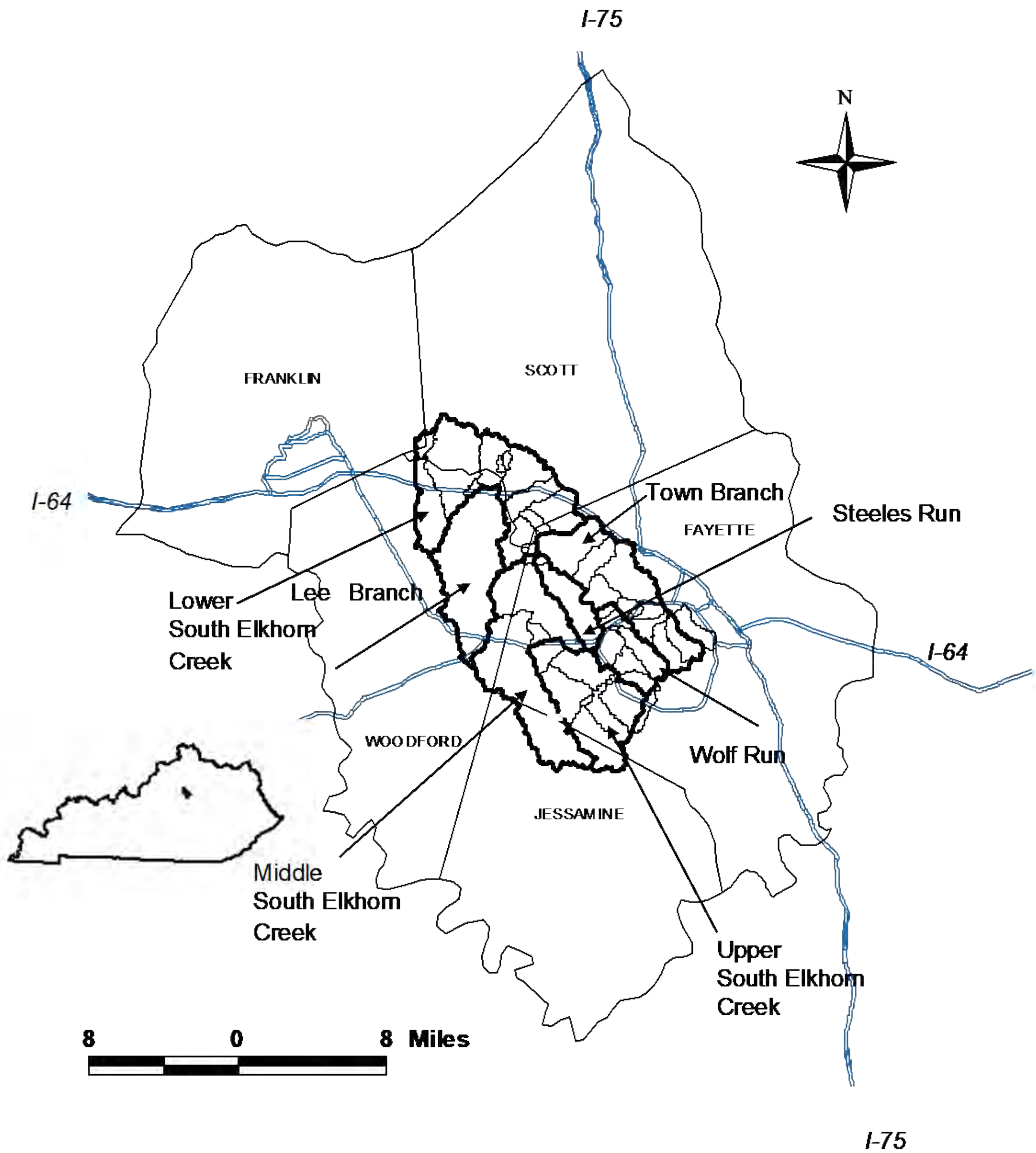

Figure 1. Location of the South Elkhorn (and associated tributaries) Watershed

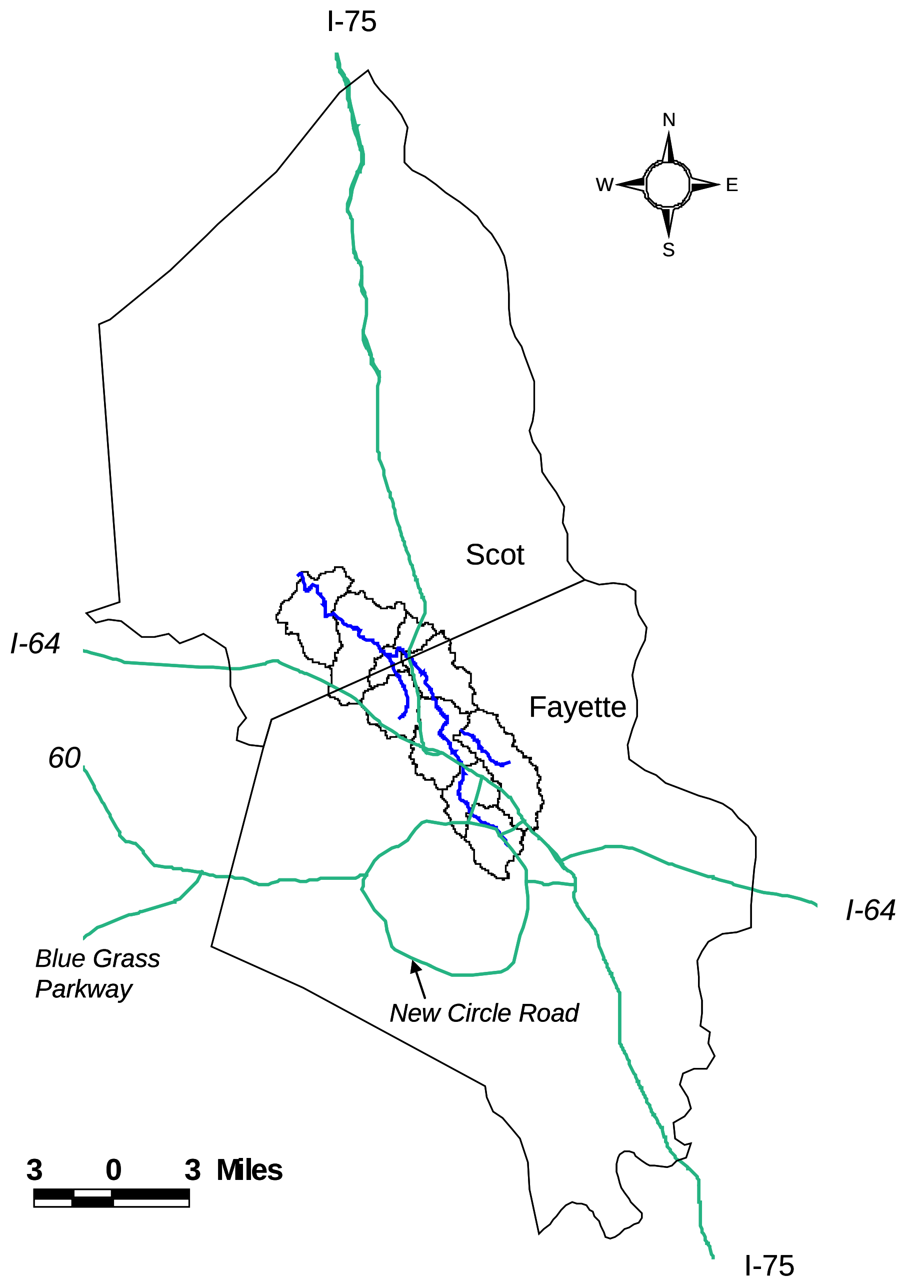

Figure 2. Location of Cane Run Watershed

MATERIALS AND METHODS

Impacted Stream Segments

The Kentucky 2004 303(d) Report identified, a 14.5 mile segment of Cane Run as not supporting the designated warm water use for primary contact recreation (swimming) due to pathogen impairment. It also identified a 11.3 mile segment of Town Branch (from its confluence with South Elkhorn Creek), and a 4.1 mile segment of Wolf Run (from its confluence with South Elkhorn Creek) as not supporting the designated use of primary contact recreation (swimming) due to pathogen impairment. Finally, the Report also identified a 17.6 mile segment of South Elkhorn Creek (from river mile 16.4 to 34.0) as only partially supporting primary contact recreation. Subsequent data collection associated with the development of this TMDL also revealed impairment on Lee's Branch and the lower reaches of South Elkhorn Creek. As a consequence, these segments were also included in the development of the TMDL for the entire South Elkhorn watershed.

Data Collection

Initial work on the TMDLs for the South Elkhorn Creek and the Cane Run watersheds began in May of 2002. A stream sampling system was developed for the Cane Run and South Elkhorn main stems and representative tributaries within the watershed. Sampling occurred between May 2002 and October 2002, including various sites on Cane Run, South Elkhorn Creek, Wolf Run, and Town Branch. A map of the sample locations in the South Elkhorn watershed is provided in Figure 3. A map of the sample locations in the Cane Run watershed is provided in Figure 4.

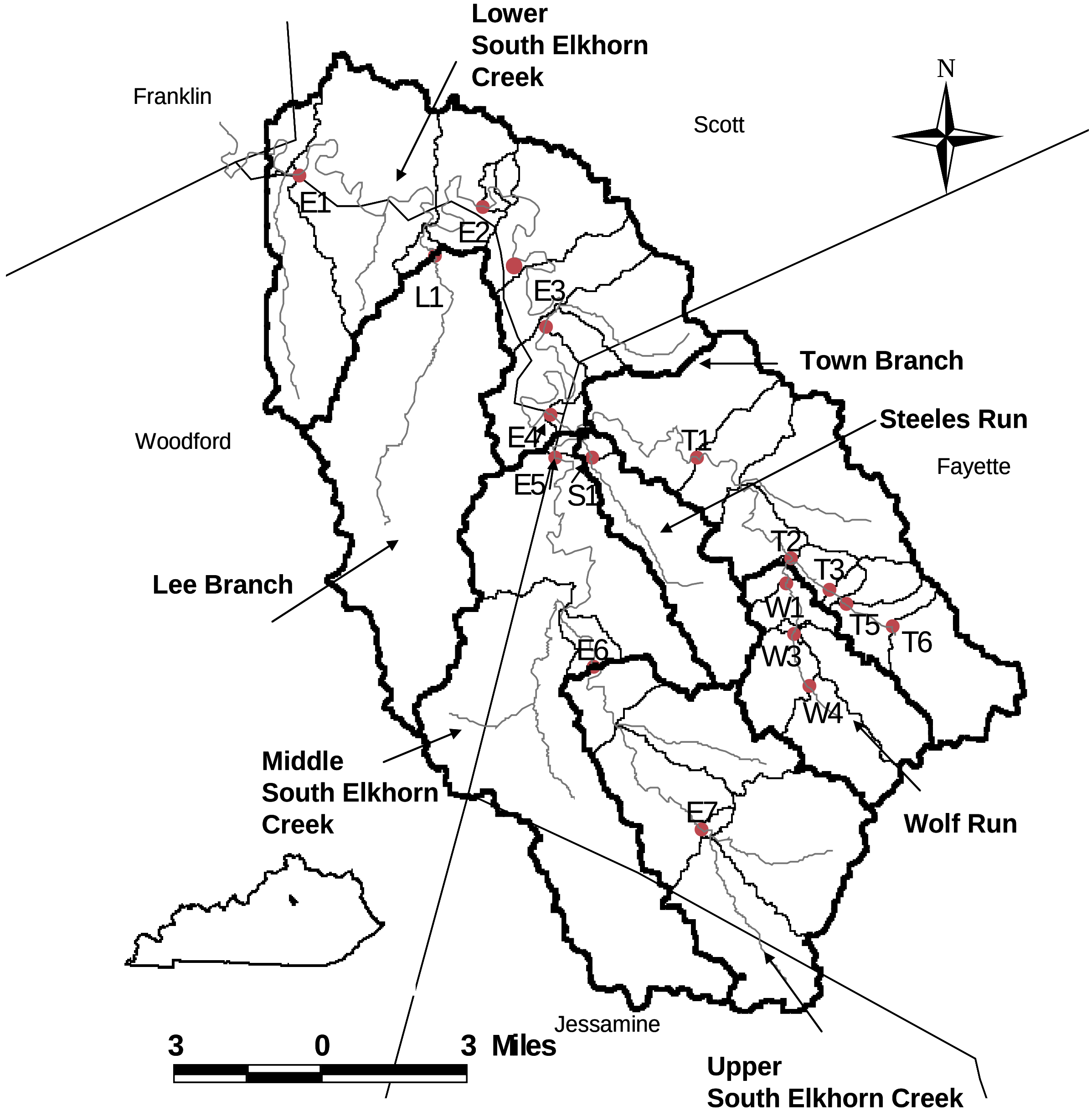

Figure 3. Map of Water Quality Monitoring Stations used in South Elkhorn TMDL

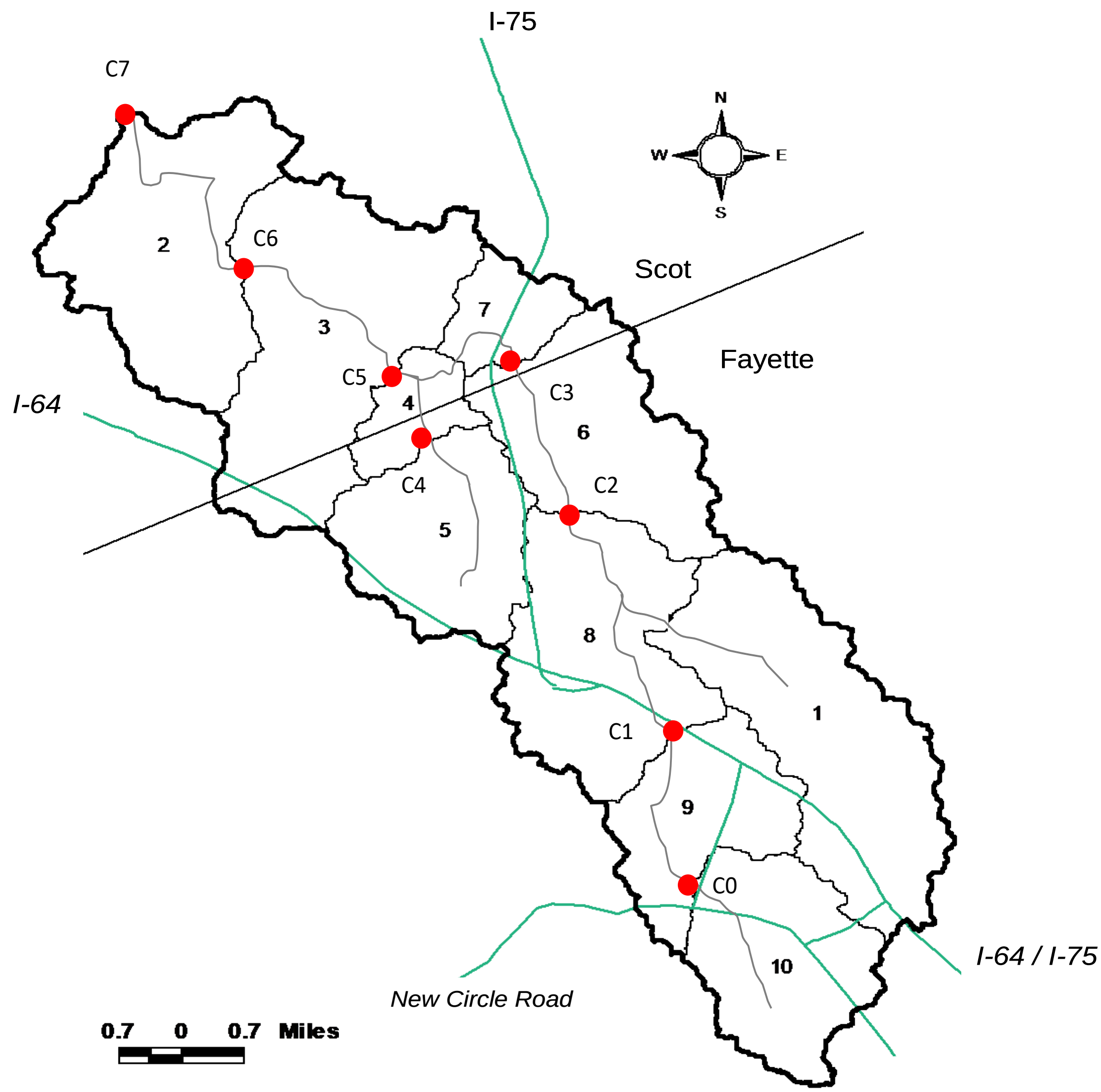

Figure 4. Map of Water Quality Monitoring Stations used in Cane Run TMDL

In an effort to account for the relative impact of point and nonpoint pathogen sources, water quality samples were collected during both rain and non-rain events. The associated QA/QC plan approved by the Kentucky Division of Water for this project is provided in Attachment B. Summaries of the data collected in the South Elkhorn watershed are provided in Appendix C. Summaries of the data collected in the Can Run watershed are provided in Appendix D.

Streamflow data for use in the modeling effort were obtained from existing USGS gaging stations within the watersheds. The locations of the stations used in the South Elkhorn TMDL are provided in Figure 5. The locations of the stations used in the Cane Run TMDL are shown in Figure 6.

Computer Modeling

EPA guidance (2001) allows TMDLs to be based on either steady state or dynamic water quality models. Steady state models provide predictions for only a single set of environmental conditions. For permitting purposes, steady-state models are applicable for a single "critical" environmental condition that represents an extremely low assimilative capacity. For discharges to riverine systems, critical environmental conditions typically correspond to low flows such as the 7Q10. The assumption behind steady state modeling is that permit limits that are protective of water quality during critical conditions will be protective for the large majority of environmental conditions. However, it is not appropriate to attempt to define a single critical stream flow for wet weather problems that is analogous to the critical (low flow) condition traditionally used with continuous point source discharges. Furthermore, when continuous simulation is used for point source discharges, the appropriate method of analysis is to examine the model-generated data (receiving water concentrations) in terms of frequency and duration rather than examining concentrations at a single critical flow.

Continuous simulation often generates daily or hourly values of stream flow and pollutant concentration data. With a well-calibrated model, the simulated stream flows and pollutant concentrations are representative of real-world conditions. Continuous simulation, as well as other dynamic modeling approaches, explicitly consider the variability in all model inputs and define effluent limits in compliance with the associated Water Quality Standard (WQS). This is achieved through selecting a critical period for which load allocations create the most stressful situation. Thus the critical period for TMDL development corresponds to the “worst case” scenario of environmental conditions in the waterbody for which the TMDL for the pollutant will continue to satisfy WQS (USEPA, 2001).

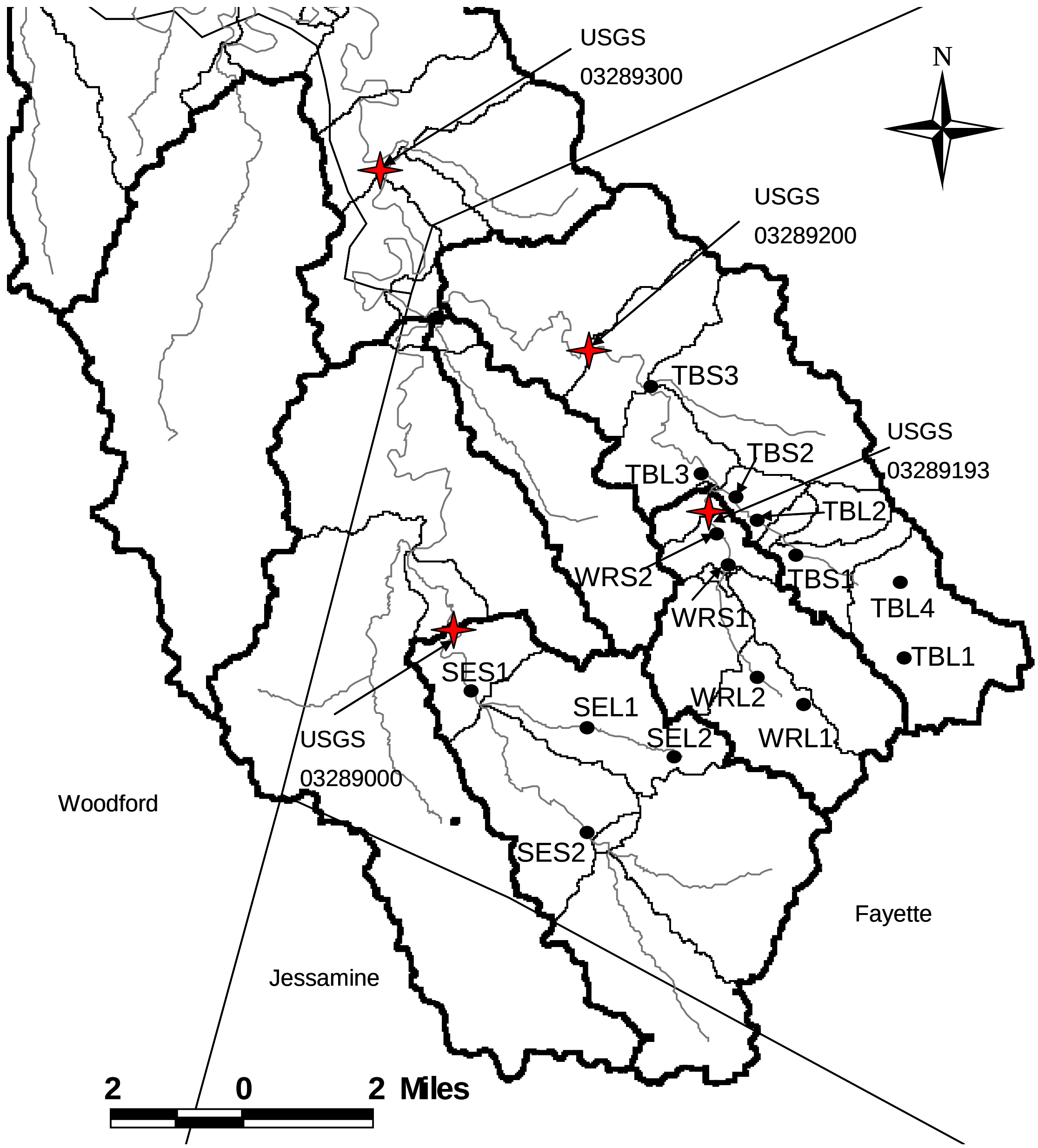

Figure 5. Map of USGS Streamflow Gaging Stations used in South Elkhorn TMDL

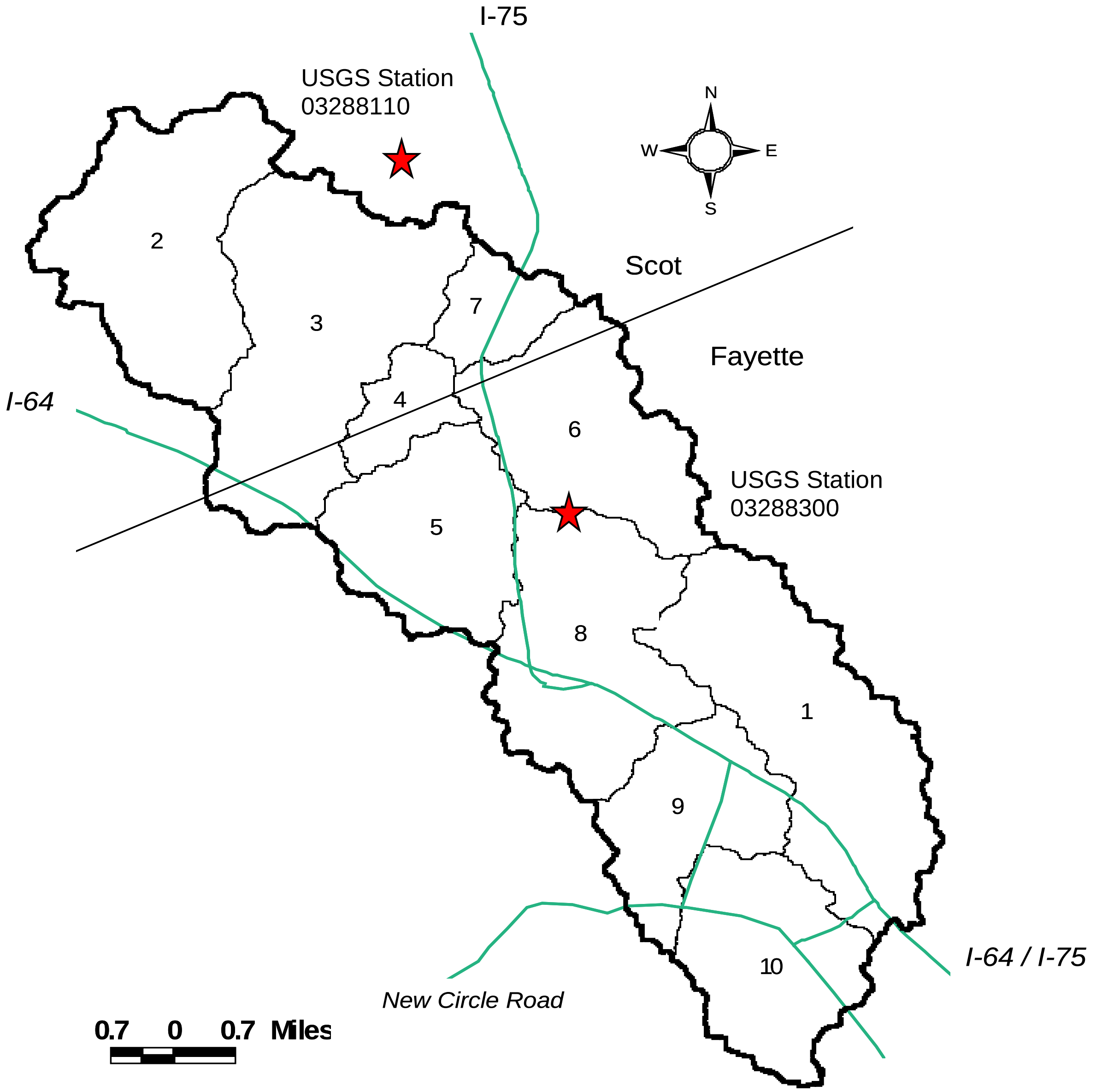

Figure 6. Map of USGS Streamflow Gaging Stations used in Cane Run TMDL

Model Selection

In order to model the origin and transport of pathogens through a stream system, some type of hydrologic model is needed. In the current study, the Non-Point Source Model (NPSM) along with the USEPA BASINS modeling environment were used. BASINS is a multipurpose environmental analysis software system for use by regional, state and local agencies in performing watershed and water quality-based studies. A geographic information system (GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landuse, monitoring stations, point source discharges, and stream descriptions. BASINS is useful in incorporating both point and nonpoint sources, while including instream transport and visualization. NPSM is a scaled-down windows version of the Hydrologic Simulation Program Fortran (HSPF, Bicknell et al, 1997). The NPSM model simulates nonpoint source runoff from selected watersheds as well as the transport and flow of the pollutants through stream reaches.

Model Setup

The South Elkhorn Creek TMDL model includes the 303(d)-listed section of the creek, as well as the evaluated drainage areas within the basin. All upstream contributors of bacteria are accounted for in the model. This watershed was divided into 45 catchments in an effort to isolate the major stream reaches in the South Elkhorn Creek watershed. This subdivision allowed the relative contribution of point and nonpoint sources to be addressed within each subwatershed.

All of the runoff in the upper part of the Cane Run watershed has the potential to be diverted out of the watershed via karst features (Figure 7). The most significant diversion is associated with the groundwater recharge area that discharges to Royal Spring in Georgetown, Kentucky. Based on observed flow data at the USGS gauging station at Berea Road (C2), it appears that all groundwater and stormwater flows upstream of the station are diverted except during periods of high rainfall, when part of the flows appear to bypass the karst features (most likely due to surcharging) and then continue to flow downstream of the station..

Modeling the karst aquifer conditions in the Cane Run watershed require several important data. Flow through each sinkhole and underground flow paths could provide exact modeling of the field situation. For Cane Run and Royal Springs, ground water flow paths through dye trace vector studies are available. However, the detailed flows through individual sinkholes are not observed routinely therefore not available for modeling. As a result, the daily discharges measured at two USGS gauging stations (USGS 03288200 at Canerun near Bonerail and USGS 03288110 at Royal Springs, Georgetown) are the only flow observations available for the Cane Run modeling.

In order to assess the sources and associated pathogen loadings in the Cane Run watershed, an HSPF computer model of the watershed was developed. The modeling is complicated because of the karst nature of the watershed. In particular a large part of the upper region of the watershed actually exits the watershed at approximately the location of the USGS gaging station and then flows under the ground where it then exits at Royal Spring in Georgetown. For the purposes of modeling and determining the associated TMDLs, the entire watershed was subdivided into two separate watersheds: upper Cane Run and lower Cane Run. Each watershed was then subdivided into several catchments: six catchments in upper Cane Run and seven catchments in lower Cane Run. Separate TMDLs and associated load allocations and reductions can then developed for each catchment and subwatershed.

Model Calibration Process

Before using the developed NPSM model for determination of the loading to the South Elkhorn Creek Watershed as well as the magnitude and distribution of the associated load reductions, the computer model was calibrated for hydrology and water quality. The general modeling process is illustrated below in Figure 8.

Hydrologic Calibration

The hydrologic calibration involved initial estimates and subsequent adjustment of the appropriate HSPF model parameters (such as infiltration index capacity (INFILT), lower zone evapotranspiration parameter (LZETP), lower zone soil moisture storage (LZSN), fraction of groundwater flow to deep recharge (DEEPFR) etc.) to reproduce the observed streamflows at the USGS stations (Table 1.2). Rainfall data for use in the model was developed using hourly rainfall data obtained from regional NOAA weather stations in Lexington, Kentucky. The hydrologic calibration was performed using observed streamflow values from 1997 to 2002.

Water Quality Calibration

Once the NPSM model was calibrated hydrologically, an attempt was made to calibrate the water quality parameters of the model (e.g. loading accumulation rates (ACCUM), decay rates (FSTDEC), and storage limit (SQOLIM) etc.) to match the observed instream fecal coliform concentrations from 2002. Additional adjustment of the point source load associated with select catchments were performed to match the observed fecal concentrations at sites. Plots of the observed and calibrated fecal concentrations for 2002 are provided in the Appendices of the associated TMDL reports sites.

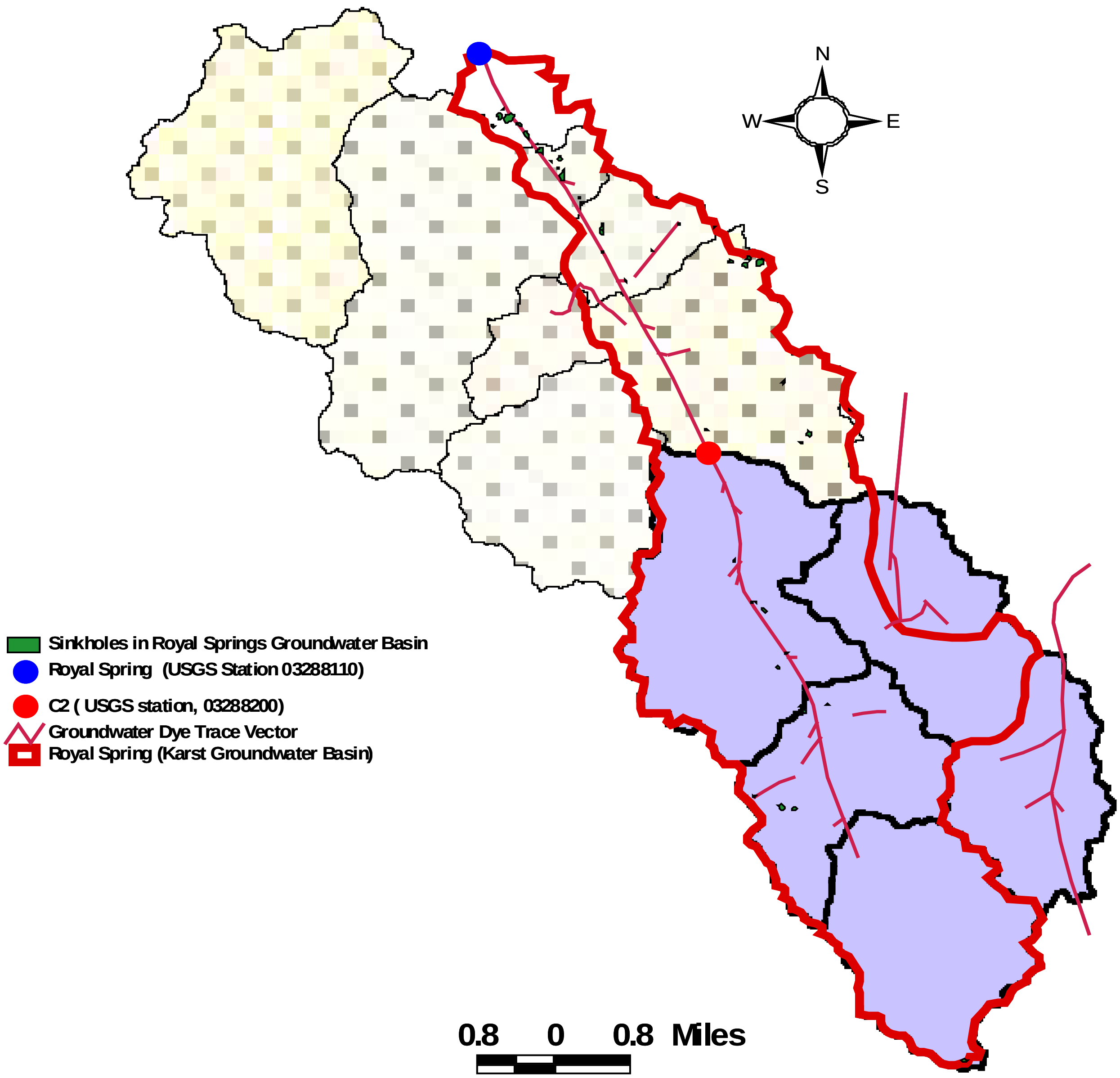

Figure 7. Map of Cane Run Watershed Showing Karst Features

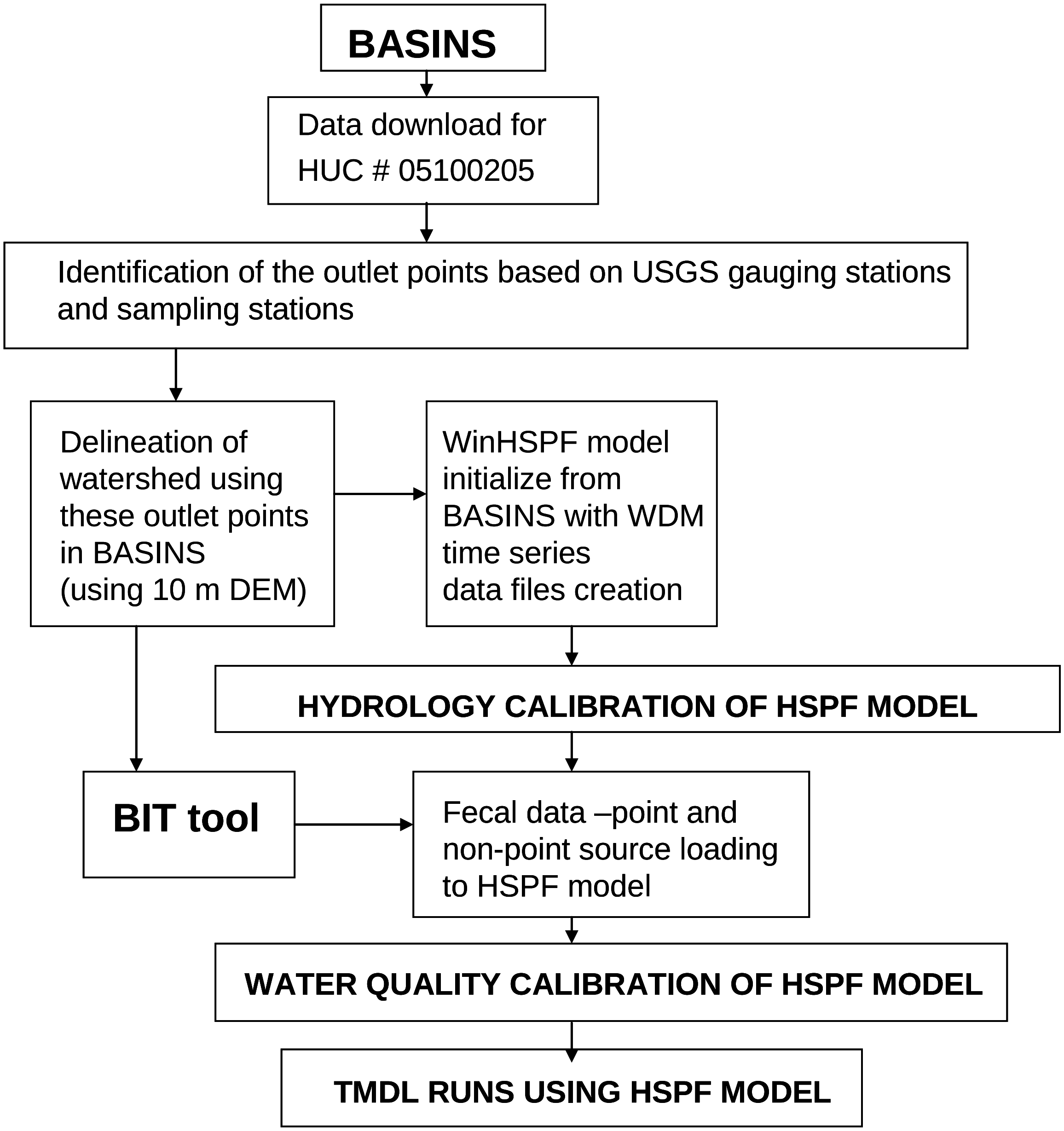

Figure 8. Map of General Modeling Process

Model Application

Once the model is calibrated, it can be used to determine the TMDL of the creek and the percent load reductions needed to bring the stream into regulatory compliance. The TMDL load reduction is accomplished by systematically reducing the associated loading functions or loading rates until both the 30-day geometric mean criterion and the 400 cfu/100 ml (for 80% or more of all data in a month) criterion are met. Plots of the existing conditions and post-TMDL reduction geometric mean model results for fecal coliform along with the daily post TMDL reduction results for the period from 1997 through 2002 are provided in the TMDL Report Appendices. Modeling of the load under existing conditions shows numerous violations of the geometric mean standard. Modeling of the load after TMDL reductions shows the streams are in the compliance with both water quality criteria.

RESULTS & DISCUSSION

Data collection and QA/QC

Fecal coliform were collected consistent with the QA/QC guidelines provided in Appendix B. Three dilutions of triplicates samples (i.e. 9 plates per sample) were performed to insure a very high level of precision of the reported results. In each case, the variance in the triplicates was within the acceptable tolerance (e.g. 90% confidence level). Analyses of collected blanks failed to identify any contamination problems with the sample collection or data analysis.

Data results

Data summaries from the monitoring results are provided in Appendices B and C. The data suggest that pathogen values in South Elkhorn Creek (and its tributaries) exceed the 30-day geometric limit set forth by Kentucky's Surface Water Standards (401 KAR 5:031) for primary contact recreation (i.e. a monthly geometric mean of 200 colonies per 100ml or 200cfu/100ml) more than 90% of the time.

In addition to the data collected by the KWRRI, data for Cane Run were also obtained from the Georgetown Municipal Water Company and from the Lexington Fayette Urban County Government. Collectively these data suggest that more than 90% of the time pathogen values in Cane Run (and its tributaries) exceed the 30-day geometric limit set forth by Kentucky's Surface Water Standards (401 KAR 5:031) for primary contact recreation.

Hydrologic Model Calibration

Plots of the observed and calibrated hydrographs, as well as scatter diagrams for each year of the simulation period were developed as part of the calibration effort. The predicted hydrographs matched the observed hydrographs fairly closely. In addition, the best-fit line through the scatter plots yielded a line with a fairly high correlation coefficient for most years, as well as a slope fairly close to one. The latter observation confirms that the resulting calibration is fairly free of any model parameter bias as a function of the magnitude of the flows.

Water Quality Calibration

Due to the high variability of instream fecal coliform concentration, model performance associated with the replication of individual daily fecal loads was evaluated using a log differential range of 0.5. An attempt was made to calibrate the model so that the daily difference between an observed and predicted fecal load was within a value of 0.5 of the differences of the logarithms of the actual values. This is consistent with 90% significance level when using a modified T-test (ie. when the sample size is less than 30) based on a lognormal probability distribution (Ormsbee, 2004). The results of these comparisons are shown in the TMDL Appendices. The predicted values tend to fall within these bounds for the majority of days and the majority of stations. In general, deviations outside the limits typically occur when the predicted value is above the upper limit, thus providing for a more conservative analysis. In addition to comparing the predicted and observed results for a given day, a comparison was also made between the observed values and the geometric mean of five days of predicted values centered on the date of the observed data point. This analysis was conducted to account for any variability of model performance as influenced by variations due to timing effects associated with hydrologic errors. The log difference of 0.5 criterion was satisfied for the vast majority of the time for all of the sites.

Model Results

In order to assess the sources and associated pathogen loadings in the South Elkhorn Creek watershed, an HSPF computer model of the watershed was developed. The model was then used to determine the total maximum daily load (TMDL) of pathogens in each catchment. These loads were then separated into a wasteload allocation (the part of the TMDL associated with point sources or permitted non-point sources, i.e. MS4 sources) and a load allocation (the part of the TMDL associated with non permitted non-point sources, i.e. on MS4 sources). The non-point source loads were further sub-divided into: 1) distributed loads associated with the two main land uses in the watershed (i.e. agricultural and urban, 2) concentrated loads associated with failing septic systems and straight pipes, and 3) in-stream loads associated with livestock. General load and wasteload reductions are required in order to achieve the TMDLs for each catchment and sub-watershed.

There are two wastewater treatment facilities and two package plants in the South Elkhorn watershed. In addition to these four permitted point sources, sampling and anecdotal evidence suggest the presence of point sources associated with; 1) two storm sewers (a major sanitary trunk main to the Town Branch wastewater treatment plant runs parallel to both storm sewers provides a possibility for cross connections), and 2) the Lexington Stockyards. The elimination of loads associated with these point sources will be required in order to bring the Town Branch into compliance with current water quality standards for pathogens.

Wasteloads (point source loads) in South Elkhorn watershed were allocated to permitted wastewater treatment plants and the package plants in the watershed. General load reductions of between 25% and 50% are proposed for both agricultural and urban lands through better management of agricultural and urban waste and litter. Concentrated load reductions were accomplished by assuming 100% elimination of straight pipes and the elimination of livestock access to streams. Additional concentrated load reductions were obtained through partial elimination (25% to 90%) of failing septic systems. Final nonpoint source loads in the South Elkhorn watershed were allocated between distributed loads (associated with the agricultural and urban land uses) and the remaining concentrated loads associated with failing septic systems. A draft of the proposed TMDL for South Elkhorn Creek (including Town Branch and Wolf Run) is provided in Appendix E. Additional revisions are continuing on the fecal coliform TMDL report for Cane Run.

Margin of Safety

The margin of safety (MOS) is an important part of the TMDL development process (Section 303(d)(1)(C) of the Clean Water Act). There are two basic methods for incorporating the MOS (USEPA, 1991a):

> (a) Implicitly incorporate the MOS using conservative model assumptions to develop allocations, or
> (b) Explicitly specify a portion of the total TMDL as the MOS using the remainder for allocations.

An implicit MOS was incorporated into the modeling effort by imposing a slightly positive bias in the model's water quality calibration. The results of the model calibration efforts show the model was calibrated so the predicted highest geometric mean values were generally higher than the observed values, thus giving an explicit MOS. Furthermore, using of a multi-year critical period results in a more conservative reduction strategy that provides for an overestimation of fecal loadings during at least 5 out of the 6 years. The reduction results provided in the TMDL Report Appendices illustrate the reductions called for result in instream fecal coliform values below the 200 cfu/100ml limit for most subwatersheds. In developing TMDLs and associated load allocations using a continuous simulation model Kentucky requires that the geometic mean criteria be met 90% of the time over the simulated total time series. In developing this TMDL, a much more stringent criteria was enforced (~100%), thus providing for an additional margin of safety. Finally, the discharge monitoring reports for all permitted point sources in the basin have consistently shown fecal coliform values below 100 cfu/100 ml. A use of an assumed discharge value of 200 cfu/100 ml (the permitted value) is likely to lead to conservative load reductions for the rest of the basin, thereby providing an additional MOS. The reductions must only be implemented until the WQS is achieved.

Discussion

As indicated previously, this was the first comprehensive application of HSPF for use in developing fecal coliform TMDLs in the Commonwealth of Kentucky. In addition, approximately half of the Cane Run watershed is diverted to another watershed due to significant karst features in the watershed. This additional complexity significantly complicated both the data collection effort and the associated modeling. As a consequence, the initial allocated budget for this project was woefully inadequate. Additional funding is needed to complete the project. Nonetheless, the KWRRI has continued to work on the project after the initial funding was depleted. The additional effort has allowed for the completion of preliminary draft reports for three of the four TMDLs while as initial model construction has been completed for the Cane Run TMDL. Finally completion of all TMDLs will await additional 319 funding.

CONCLUSIONS

The primary purpose of this project was to investigate the applicability of the Hydrologic Simulation Program – Fortran (HSPF, 1997) in the development of fecal coliform TMDLs for watersheds in Kentucky. The primary measure of success was to be the development of fecal coliform TMDLs for four 303(d) listed streams in the Kentucky River basin. Due to the complexity of the required modeling effort along with the added complexity of the karst features in Cane Run watershed, the specific goals of the project (i.e. the completion of EPA approved TMDLs for the four watersheds) were not achievable with the existing funding. As a consequence additionally funding has been sought and obtained to support the completion of all four of the TMDLs. In the interim, work has continued on all four TMDLs.

This project has demonstrated that HSPF can be successfully used to develop fecal coliform TMDLs for impaired watersheds in Kentucky. However, experience with this project has shown that HSPF should only be used for more complicated watershed applications, or those applications where the model could be used in the development of TMDLs for multiple pollutants (e.g. fecal coliforms, organic enrichment, nutrients, etc.). This study has demonstrated that use of such a sophisticated model can be extremely time consuming and costly, not only in the initial development of the model but also in subsequent applications that may be needed as part of the final TMDL review process. Where feasible, the simpler modeling approaches should be considered such as the use of load duration curves.

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http://www.epa.gov/waterscience/ftp/basins/systems/BASINS3/bit.htm.

APPENDIX A: FINANCIAL AND ADMINISTRATIVE CLOSEOUT

The project was initially tracked at the University of Kentucky through account number 4-65708. From 5/01/02-6/30/02, $8,974 was billed to the project in support of water quality monitoring. Because the state's fiscal year ended on June 30, 2002, a new internal University of Kentucky (UK) account (4-46603) was established to cover the activities of the project through June 30, 2003 with a total budget of $53,026.

A final invoice of $26,970.67 was submitted to the KDOW on November 26, 2003. This invoice was returned by the KDOW on January 15, 2004 with an explanation that a minimum of 5% of the total contract would be retained until such time as a final report was submitted. UK subsequently resubmitted an invoice for $23,811.12 reflecting both the 5% balance and the fact that the amount billed through the end of the contract period (i.e. August 31, 2003) was actually $51,945.70. Following several discussions over a two year period, this invoice was finally paid on December 5, 2005, leaving a residual balance of $3,158.90. The actual budget expenditures are summarized in the tables below.

FINANCIAL AND ADMINISTRATIVE CLOSE-OUT

OUTPUTS (MILESTONES) FOR SOUTH ELKHORN, TOWN BRANCH, AND WOLF RUN FECAL COLIFORM TMDLS

Milestone	Expected Begin Date	Expected End Date	Actual Begin Date	Actual End Date
1. Receive Cabinet approval on final drafts of all materials developed under this lead legal agreement and on existing materials used for outreach, education, or technical training under this legal agreement	Duration			
2. Collect data	5/2002	9/2002	5/2002	9/2002
3. Develop/calibrate computer models	5/2002	9/2002	9/2005	12/2002
4. Perform simulation analysis	10/2002	12/2002	7/2003	12/2003
5. Compute TMDLs	12/2002	1/2003	6/2004	12/2004
6. Compute loading reductions/allocations	1/2004	2/2004	6/2004	12/2004
7. Prepare and submit TMDL documents	2/2004	3/2004	1/2005	6/2005
8. Revise TMDL documents	3/2004	6/2004	11/2005	1/2006
9. Submit revised TMDL documents	6/2004	8/2004	1/2006	9/2006

ORIGINAL PROJECT BUDGET

Budget Summary:

Budget Categories	Project Activity Categories						
	BMP Imple-mentation	Project Management	Public Education	Monitoring	Technical Assistance	Other TMDL Development	Total
Personnel		$23,500		$13,000		$ 24,530	$61,030
Supplies				$9,720			$9,620.00
Equipment							
Travel				$435			$435
Contractual							
Operating Costs						$32,045	$32,045
Other							
TOTAL		$23,500		$23,155		$56,575	$103,230

Detailed Budget:

Budget Categories	Section 319(h)	Non-Federal Match	Total
Personnel	$37,530	$ 16,242.63	$50,476.63
Supplies	$9,720		$9,620.00
Equipment			
Travel	$435		$435.00
Contractual			
Operating Costs	$ 14,315	$17,730	$32,045
Other			
TOTAL	$62,000	$41,230	$103,230
	60%	40%	100%

ACTUAL EXPENSES

<u>Budget Summary</u>:

Budget Categories	Project Activity Categories						
	BMP Imple-mentation	Project Management	Public Education	Monitoring	Technical Assistance	Other	Total
Personnel		**$20,350.84**		**$11,257.92**		**$29,830.20**	**$61,438.96**
Supplies				**$4,604.25**			**$4,604.25**
Equipment							
Travel				**$732.16**			**$ 732.16**
Contractual							
Operating Costs						**$31,293.13**	**$31,293.13**
Other							
TOTAL		**$20,350.84**		**$16,594.33**		**$57,494.87**	**$98,068.50**

<u>Detailed Budget</u>:

Budget Categories	Section 319(h)	Non-Federal Match	Total
Personnel	**$43,302.96**	**$ 18,136.00**	**$61,438.96**
Supplies	**$ 4,604.25**		**$4,694.25**
Equipment			
Travel	**$ 732.16**		**$ 732.16**
Workshop			
Operating Costs	**$10,201.73**	**$ 21,091.40**	**$31,293.13**
Other			
TOTAL	**$58,841.10**	**$39,277.40**	**$98,068.50**
	60.0%	**40.0%**	**100.0%**

No equipment was purchased by UK as part of this contract. There were no special grant conditions for this contract.

APPENDIX B: QA/QC Plan for: Development of Pathogen TMDL's for four 303(d) Listed Streams in the Kentucky River Basin: South Elkhorn Creek in Scott County, Kentucky and Town Branch, Cane Run, and Wolf Run in Fayette County, Kentucky

By

Lindell Ormsbee, Kentucky Water Resources Research Institute

January 2, 2002

PROJECT ORGANIZATION AND RESPONSIBILITY

Project Manager: Dr. Lindell Ormsbee; Field Sampling Supervisor: Dr. Gail Brion, Department of Civil Engineering, University of Kentucky, Lexington, KY, 40506-0281, (859) 257-4467

WATERSHED INFORMATION

1. Waterbody: Cane Run:
   River Basin: Kentucky
   USGS 8-digit HUC#: 05100205
   Stream Order: Third
   County: Fayette
   USGS Quads: Centerville, Georgetown, Lexington East, and Lexington West
   Milepoints: 10.0 to 17.4

2. Waterbody: Wolf Run
   River Basin: Kentucky
   USGS 8-digit HUC#: 05100205
   Stream Order: Third
   County: Fayette
   USGS Quads: Lexington East and Lexington West
   Milepoints: 0.0-4.1

3. Waterbody: Town Branch:
   River Basin: Kentucky
   USGS 8-digit HUC#: 05100205
   Stream Order: Third
   County: Fayette
   USGS Quads: Georgetown, Lexington East, Lexington West, Midway, and Versailles
   Milepoints: 0.0 to 11.3

4. Waterbody: South Elkhorn
River Basin: Kentucky
USGS 8-digit HUC#: 05100205
Stream Order: Fourth
County: Scott
USGS Quads: Frankfort East, Georgetown, Keene, Lexington East, Lexington West, Midway, Nicholasville, Tyrone, and Versailles
Milepoints: 16.4-34.0

MONITORING OBJECTIVES

To collect Flow and Fecal coliform samples from selected sites in each watershed.

STUDY AREA DESCRIPTION

Cane Run

Cane Run runs through the northwestern section of Fayette County into the southern section of Scott County in central Kentucky. This report will examine its status preceding a thorough investigation and monitoring of the creek.

Location

The Cane Run watershed is contained mostly within Fayette and Scott Counties, in central Kentucky. Major highways or roads that traverse the watershed are I-75, I-64, and US-25. The Cane Run watershed includes parts of two cities, northern Lexington and southern Georgetown. The 7.5 minute quadrangle maps on which Cane Run can be found are Centerville, Georgetown, Lexington East, and Lexington West.

Hydrologic Information

Cane Run, a third order stream, originates in central Fayette County and flows north to discharge into the North Elkhorn Creek 44.3 km (27.5 miles) upstream of its confluence with the Elkhorn Creek. The Elkhorn Creek then carries the runoff from the county northwest to discharge into the Kentucky River. Cane Run contributes to the Kentucky River Watershed, HUC # 05100205.

The mainstem of Cane Run is approximately 28.0 km (17.4 miles) long and drains an area of 29,152 acres. The average gradient is 2.34 m/km (12.4 feet per mile). Elevations for Cane Run range from 297 m (975 ft) above mean sea level (msl) in the headwaters in Lexington to 232 m (760 ft) above msl at the confluence with the North Elkhorn Creek. Like most of the smaller watersheds, many of the tributary streams are intermittent.

Geologic Information

The Cane Run watershed is in the Inner Blue Grass physiographic region. The surface bedrock is of Ordovician age. Formations of the Ordovician age are mostly Lexington limestone with moderate amounts of shale and alluvium deposits. The relief of the Cane Run watershed ranges from nearly level to gently rolling and undulating hills (USDA 1978). Due to the area's karst topography sinkholes and caverns are common.

Landuse Information

The geology in the Cane Run watershed, with its phosphorus rich soils, is conducive to agricultural purposes. About three-quarters of the watershed is used for burley tobacco cultivation, thoroughbred and cattle farming. The bulk of the remaining area is urbanized and concentrated at the headwaters of Cane Run. The urban area ranges from residential to commercial and industrial tracts.

Soils Information

Cane Run watershed is dominated by nearly level to strongly sloping silt loam. The area is comprised mostly of the Maury and Lowell soils series. The Maury series are deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately rapid. The Lowell series are deep, well drained to moderately drained soils formed from weathered interbedded limestone and calcareous shale. Permeability for this series is moderately slow. (USDA 1978)

Wolf Run

Wolf Run runs through the western section of Fayette County in central Kentucky. This report will examine its status preceding a thorough investigation and monitoring of the creek.

Location

The Wolf Run watershed is contained completely within the city of Lexington, the county seat for Fayette County and lies in the western part of the county. Major highways or roads that traverse the watershed are US-27, US-60, US-68, and Junction 4, locally known as New Circle Road. The 7.5 minute quadrangle maps on which the Wolf Run watershed can be found are Lexington East and Lexington West.

Hydrologic Information

Wolf Run, a third order stream, originates in central Fayette County and flows northwest to discharge into the Town Branch 13.7 km (8.5 mile) upstream from its confluence with the South Elkhorn Creek. Wolf Run contributes to the Kentucky River Watershed, HUC # 05100205.

Wolf Run's mainstem is approximately 7.1 km (4.4 miles) long and drains an area of 26.35 sqkm (6,512 acres). The average gradient is 3.8 m/km (20 feet per mile). Elevations for Wolf Run range from 290 m (950 ft) above msl in the headwaters to 262 m (860 ft) above msl at the confluence with Town Branch. Like most of the smaller watersheds, many of the tributary streams are intermittent.

Geologic Information

The Wolf Run watershed is in the Inner Blue Grass physiographic region. The surface bedrock is of Ordovician age. Formations of the Ordovician age are mostly Lexington limestone with moderate amounts of shale and alluvium deposits. The relief of the Wolf Run watershed ranges from nearly level to gently rolling and undulating hills (USDA 1978). Due to the area's karst topography sinkholes and caverns are common.

Landuse Information

The majority of the Wolf Run watershed is developed and ranges from residential to commercial and industrial tracts. The region near the confluence with Town Branch does support some agricultural pastureland, primarily thoroughbred horse farms.

Soils Information

Wolf Run watershed is dominated by nearly level to strongly sloping silt loam. The area is comprised mostly of the Maury soil series. The Maury series are deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately rapid. (USDA 1978)

Town Branch

Town Branch runs through the western section of Fayette County in central Kentucky. This report will examine its status preceding a thorough investigation and monitoring of the creek.

Location

The Town Branch watershed is contained mostly within Fayette County, in central Kentucky. Major highways that traverse the watershed are US-421 and US-60. The Town Branch watershed houses two cities, Midway and Lexington being the most sizable.

The 7.5 minute quadrangle maps on which Town Branch can be found are Georgetown, Lexington East, Lexington West, Midway, and Versailles.

Hydrologic Information

Town Branch, a third order stream, originates as an underground stream in central Fayette County and flows northeast to discharge into the South Elkhorn Creek 54.7 km (34.0 miles) upstream of its confluence with the Elkhorn Creek. The Elkhorn Creek then carries the runoff from the county northwest to discharge into the Kentucky River. Town Branch contributes to the Kentucky River Watershed, HUC # 05100205. Town Branch is the discharge creek for Lexington's wastewater treatment plant. The creek's flow is primarily dominated by the plant's discharge.

The mainstem of Town Branch is approximately 18.2 km (11.3 miles) long and drains an area of 94.3 sq-km (23,302 acres). The average gradient is 2 m/km (11 feet per mile). Elevations for Town Branch range from 284 m (930 ft) above msl in the headwaters to 241 m (790 ft) above msl at the mouth. Like most of the smaller watersheds, many of the tributary streams are intermittent.

Geologic Information

The Town Branch watershed is in the Inner Blue Grass physiographic region. The surface bedrock is of Ordovician age. Formations of the Ordovician age are mostly Lexington limestone with moderate amounts of shale and alluvium deposits. The relief of the Town Branch watershed ranges from nearly level to gently rolling and undulating hills (USDA 1978). Due to the area's karst topography, sinkholes and caverns are common.

Landuse Information

The geology in the Town Branch watershed, with its phosphorus rich soils, is conducive to agricultural purposes. About half of the watershed is used for burley tobacco cultivation, thoroughbred and cattle farming. The bulk of the remaining area is urbanized and concentrated at the headwaters of Town Branch. The urban area ranges from residential to commercial and industrial tracts.

Soils Information

The Town Branch watershed is dominated by nearly level to strongly sloping silt loam and silty clay loam. The area is comprised mostly of the Maury, Lowell, and McAfee soils series. The Maury series are deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately rapid. The Lowell series are deep, well drained to moderately drained soils formed from weathered interbedded limestone and calcareous shale. Permeability for this series is moderately slow. The McAfee soil series are moderately deep to deep, well-drained soils formed from the weathered phosphatic limestone. Permeability for this series is moderate to moderately slow. (USDA 1978)

South Elkhorn Creek

South Elkhorn Creek drains much of Fayette, Scott, and Woodford Counties in central Kentucky. This report will examine its status preceding a thorough investigation and monitoring of the creek.

Location

The South Elkhorn watershed includes western parts of Fayette County, northern parts of Jessamine County, western parts of Franklin County, and straddles the Scott and Woodford Counties' border. The watershed encompasses several smaller watersheds, such as the already mentioned Town Branch and Wolf Run. Major highways that traverse the watershed are US-421, US-60, US-68, and I-64. The 7.5 minute quadrangle maps on which the South Elkhorn Creek watershed can be found are Frankfort East, Georgetown, Keene, Lexington East, Lexington West, Midway, Nicholasville, Tyrone, and Versailles.

Hydrologic Information

South Elkhorn Creek, a fourth order stream, originates in northwest Jessamine County and southwest Fayette County. The creek flows northwest to merge with the North Elkhorn Creek forming the Elkhorn Creek in Franklin County. South Elkhorn Creek contributes to the Kentucky River Watershed, HUC # 05100205.

South Elkhorn Creek’s mainstem is approximately 82.4 km (51.2 miles) long and drains an area of 464 sq-km (114,700 acres). The average gradient is 1.1 m/km (6 feet per mile) except for the lower 22 km (13.7 miles) which has an average gradient of 0.2 m/km (1 foot per mile). Elevations for South Elkhorn Creek range from 274 m (900 ft) above msl in the headwaters to 198 m (650 ft) above msl at the mouth.

Geologic Information

The South Elkhorn Creek watershed is in the Inner Blue Grass physiographic region. The surface bedrock is of Ordovician age. Formations of the Ordovician age are mostly Lexington and Cynthiana limestone with moderate amounts of shale, siltstone, and alluvium deposits. The relief of the South Elkhorn Creek watershed ranges from nearly level to gently rolling and undulating hills (USDA, 1978; USDA 1983). Due to the area's karst topography, sinkholes and caverns are common

Landuse Information

The geology in the South Elkhorn Creek watershed, with its phosphorus rich soils, is conducive to agricultural purposes. About three-quarters of the watershed is used for burley tobacco cultivation, thoroughbred and cattle farming. The bulk of the remaining area is urbanized and concentrated at the headwaters and confluence of South Elkhorn Creek. The urban area ranges from residential to commercial and industrial tracts.

Soils Information

The South Elkhorn Creek watershed is dominated by nearly level to strongly sloping silt loam and silty clay loam. The area is comprised mostly of the Maury, Lowell, and McAfee soils series. The Maury series are deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately rapid. The Lowell series are deep, well drained to moderately drained soils formed from weathered interbedded limestone and calcareous shale. Permeability for this series is moderately slow. The McAfee soil series are moderately deep to deep, well-drained soils formed from the weathered phosphatic limestone. Permeability for this series is moderate to moderately slow. (USDA 1978, USDA 1983)

MONITORING PROGRAM/TECHNICAL DESIGN

Sampling sites in both watersheds were selected to provide a basis for the development of loading models for the associated tributary basins. Exact locations of planned sites are provided in Tables 1–4 and in the attached site location maps.

At least 10 flow and fecal coliform samples will be collected at each of the proposed sites during the recreational months of May – October. Specific dates for sampling will be set to ensure that a variety of flow conditions (high, low, and moderate) are included in the sampling campaign.

Three students from the University of Kentucky will constitute the sampling team. Two students will perform each sampling trip. The third student is available to substitute in the event of sickness of one of the other team members. All three students will be trained in field procedures by the University of Kentucky faculty members participating in this project.

Stream flow field data will include both cross sectional area and velocity measurements at each sampling station. Current velocity will be measured using a Global model FP101 current meter. This meter will be calibrated against known flow velocities obtained using an Armfield model F1-10 hydraulics bench equipped with Armfield model F1-13 rectangular and v-notch weirs. Calibration of the current meter will be done prior to commencement, at mid-point, and at the termination of the sampling campaign.

Cross sectional areas will be surveyed during the first sampling run and plotted to scale using EXCEL. Thereafter, cross sectional areas for discharge computations for each collected sample will be determined by measuring the depth to the water surface as referenced to a fixed point on a bridge or a spike in a tree along the bank. Volumetric flow rate (discharge) will be computed from the measured velocity and cross sectional area for each sample location.

CHAIN OF CUSTODY PROCEDURES

All collected data and samples will be recorded in the field on a field data log and then transferred into an Excel Spreadsheet for subsequent storage and dissemination. The field data log will contain fields for the following information:

1. Monitoring Location
    a. County
    b. Monitoring location type
    c. Stream name
    d. Lat/Long (including method to acquire lat/long)
    e. Physical description of site
2. Unique Sample Identifier
    a. Person collecting the sample
    b. Date and time of sample
    c. Weather conditions

3. Sample Analysis Units
    a. Tapedown Reading
    b. Depth
    c. Velocity

5. Additional comments

QUALITY CONTROL PROCEDURES

The quality control/quality assurance plan proposed for this project includes (a) sampling, (b) personnel training, and (c) sampling oversight. These are detailed below.

Sampling

Quality assurance (QA) plans will be followed to insure that the methods used for data collection, analysis, and processing are valid and reliable. Elements of this QA plan are to use accepted microbiological and chemical quantitative analytical methods published in the *APHA Standard Methods for the Analysis of Water and Wastewater*. At minimum, environmental samples will be analyzed in duplicate for chemical analysis, and triplicate for bacterial and viral analysis. Personnel participating in the study will catalog all methods, results, dates, conditions, and data in lab books with permanent ink. Precision and accuracy estimates will be done periodically on all analytical methods. Standard practices of positive, negative, and spike controls will be practiced with each method before sampling begins and periodically thereafter. The data will be recorded in spreadsheet form and analyzed for distribution, mean, variance, and other statistical parameters by the SigmaStat program.

Sampling Procedure:

1.) Before field samples are analyzed, the methods selected for use will be analyzed for recovery efficiency at least 3 times before. Sterile water will be spiked with laboratory cultured organisms and the sample treated exactly as an environmental sample. Analysis of the variance in recovery as well as the precision of the method will be calculated from 7 identical samples for each microbial analyte.

2.) In the field, grab samples will be taken in sterile, polypropylene, containers pretreated with sodium thiosulfate to neutralize disinfectant residuals at mid stream depth and flow. In the event of high flows that preclude measurement at mid stream, a surface grab sample will be collected instead. Each sample will be labeled at the time of collection with the date, time, sample site, and sample technician name in permanent ink onto the sample bottles. After collection, all samples will be placed in a cooler on ice for transport to the lab. Upon receipt in the lab, samples will be logged in and analyzed within stated holding times. Sufficient dilutions will be performed to insure that greater than and less than values are not obtained.

3.) Samples will be processed within 6-12 hours from collection. The order of processing will be Fecal Coliforms (within 6 hours from sampling), Total Coliforms (within 12 hours), and Total Coliphage (within 12 hours). With each new batch of media, samples of sterile laboratory water will be analyzed as reagent blanks or negative controls. Positive controls will be run with an appropriate dilution of laboratory grown E. coli C-3000 or MS-2 bacteriophage as appropriate each time samples are brought into the lab. Periodically (every 4 weeks), an environmental sample will be spiked with lab grown microorganisms to determine matrix effects on microbial recovery for all sites sampled.

4.) Microbial data will be log10-transformed and the resulting geometric means reported for each sample site.

5.) Before using other statistical tests or data modeling, the underlying distribution of the data will be known. Tests will be done to determine if the data distribution has deviated from Poisson, or is normally distributed. Descriptive statistical analysis will be done by SigmaStat on log-transformed microbial concentrations to determine if the sample groups have equal variance, and generate mean, median, and standard deviations for all measured parameters.

Training

Students participating in the program will be trained by University of Kentucky faculty in all tasks to be performed during sampling prior to commencing the sampling. A faculty member will accompany the team on the first sampling round in order to verify correct field procedures. Instruction will include specifics of all techniques needed to measure (a) current velocity, (b) channel depth, and (c) proper method for collection of field samples. Students will participate in the initial survey of the cross sectional area of each sample site. Safety requirements for sampling will be discussed and demonstrated.

To ensure consistency in sampling, each sample site will be plotted on a U.S. Geological Survey 7 ½ minute topographic quad. These will be furnished to the student team. In addition, each sample station will be photographed during the initial sample session. Photos will be mounted in vinyl and furnished to the field crews. Finally, the field crews will be supplied with the survey field notes describing each site as obtained during the initial sample session.

Sampling Oversight

General sampling oversight will be provided by the University of Kentucky faculty members participating in this project. This oversight will include (a) issuing prior approval (or selecting) dates for each sampling session, (b) verifying proper operation of field equipment prior to each session, and (c) reviewing data following session completion and enter data into spreadsheet.

DATA MANAGEMENT AND DATA REPORTING STANDARDS

All collected data will be recorded in the field on a field data log and then transferred into an Excel Spreadsheet for subsequent storage and dissemination. The Excel spreadsheet will be designed on the same format as the chain of custody form. For each sampling event, a separate row will be prepared which will include the following information:

1. Monitoring Location
    a. County
    b. Monitoring location type
    c. Stream name
    d. Lat/Long (including method to acquire lat/long)
    e. Physical description of site

2. Unique Sample Identifier
    a. Person collecting the sample
    b. Date and time of sample
    c. Weather conditions

3. Sample Analysis Units
    a. Tapedown Reading
    b. Depth
    c. Velocity
    d. Fecal Coliform
    e. Total Coliform
    f. Total Coliphage

4. Additional comments

Table 1. Proposed Sampling Locations for Town Branch

(T1)Yarnallton Road (SR 1977) at river mile 4.1
(T2) Viley Road at river mile 8.4
(T3) Laco Road or Bizzel Drive at river mile 9.5 (0.3 miles downstream of WWTP)
(T4)Town Branch WWTP at river mile 9.85
(T5) Jimmie Campbell Lane at river mile 10.2 (0.25 miles upstream of WWTP)
(T6) Rupp Arean Parking Lot at river mile 11.3

Table 2: Proposed Sampling Locations for Wolf Run

(W1) Old Frankfort Pike (SR 1681) at river mile 0.5
(W2) Vaughn's Branch
(W3) Cambridge Drive at river mile 1.6
(W4) Appomattox Drive at river mile 2.8

Table 3: Proposed Sampling Locations for Cane Run

(C0) Newton Pike
(C1) Interstate 64-75
(C2) Berea Rd at river mile 9.5
(C3) Leslie Road at river mile 6.9
(C4) Leslie Road (South Fork)
(C5) Coleman Lane Road
(C6) Highway 460
(C7) Highway 62

Table 4: Proposed Sampling Locations for South Elkhorn

(E1) SR 1685 at river mile 9.3
(E2) Midway Pike (SR 341) at river mile 19.6
(E2.1) Unamed Trib
(E2.2) Unamed Trib
(E2.3) Unamed Trib
(E2.4) Upstream of 64
(E3) Leestown Raod (US 241) at river mile 27.4
(E4) Paynes Depot Road (SR 1967) at river mile 33.0
(E5) Old Frankfort Pike (SR 1681) at river mile 34.9
(E6) Versailles Road (US 60) at river mile 42.2
(E7) Harrodsburg Road (US68) at river mile 48
(S1) Old Frankfort Pike (SR 1681) at Steeles Run at river mile 0.7
(L1)Leestown Road (US241) at Lee Branch at river mile 0.9

REFERENCES

1. USDA. 1978 Soil Survey for Fayette and Scott Counties.

2. USDA. 1983 Soil Survey for Jessamine and Woodford Counties.

APPENDIX C. Fecal Coliform Results for South Elkhorn Watershed

Table C.1 2002 Pathogen Results: South Elkhorn Creek Observations

Date	E1 (cfu/100ml)	E2 (cfu/100ml)	E3 (cfu/100ml)	E4 (cfu/100ml)	E5 (cfu/100ml)	E6 (cfu/100ml)	E7 (cfu/100ml)
6/5/2002	318	702	1,629	840	1,321	872	956
6/12/2002	647	1,024	725	1,519	284	2,489	13,565
6/25/2002	551	411	514	630	576	835	5,907
7/11/2002	233	318	200	87	232	854	336
7/18/2002	294	534	327	8,992	1,062	2,260	5,483
7/25/2002	474	787	468	1,720	527	677	618
7/31/2002	909	717	938	840	1,352	1,188	386
8/27/2002	203	1,781	387	492	441	1,709	1,994
9/6/2002	99	111	294	131	320	179	84
10/1/2002	453	119	595	300	489	297	480

Table C.2: 2002 Pathogen Results: Town Branch Observations

Date	T1 (cfu/100ml)	T2 (cfu/100ml)	T3 (cfu/100ml)	T5 (cfu/100ml)	T6 (cfu/100ml)
5/31/2002	167	432	223	531	950
6/17/2002	562	1,872	1,163	21,956	23,662
6/26/2002	750	939	1,869	55,615	9,352
6/29/2002	669	1,011	456	2,559	31,622
7/10/2002	287	6,445	10,970	54,288	26,304
7/16/2002	297	687	902	4,350	18,624
7/30/2002	16,619	3,417	1,774	7,026	56,994
8/29/2002	293	1,774	1,490	1,568	4,751
9/24/2002	14,518	20,628	8,653	2,601	2,601
10/2/2002	417	878	997	21,630	2,089

Table C.3 2002 Pathogen Results: Wolf Run Observations

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

APPENDIX D. Fecal Coliform Results for Cane Run Watershed

STA. ID	Date of observation	C0	C1	C2	C3	C4	C5	C6	C7
1	6/11/2002	9,215	2,289	DRY	334	832	387	1,497	4,697
2	6/14/2002	6,482	4,469	DRY	250	723	373	1,294	698
3	7/2/2002	7,058	DRY	DRY	391	3,972	840	4,176	1,930
4	7/9/2002	DRY	DRY	DRY	204	7,470	612	290	495
5	7/15/2002	DRY	DRY	DRY	1,055	34,605	704	5,385	552
6	7/22/2002	DRY	DRY	DRY	1,030	18,624	672	1,144	519
7	7/29/2002	DRY	DRY	DRY	5,239	441	425	572	2,116
8	9/9/2002	DRY	DRY	DRY	6,088	362	1,270	137	199
9	9/23/2002	7,361	DRY	DRY	986	414	221	789	201
10	9/30/2002	2,121	721	DRY	1,179	909	282	997	519

Note: Results Expressed in units of cfu/100 ml

APPENDIX E: Development of Pathogen TMDLs for three 303(d) Listed Streams in the Kentucky River Basin: South Elkhorn Creek in Scott County, Kentucky; and Town Branch, and Wolf Run in Fayette County, Kentucky

Kentucky Department for Environmental Protection

Division of Water

Frankfort, Kentucky

PRELIMINARY DRAFT

Development of Pathogen TMDLs for three 303(d) Listed Streams in the Kentucky River Basin: South Elkhorn Creek in Scott County, Kentucky; and Town Branch, and Wolf Run in Fayette County, Kentucky

Kentucky Department for Environmental Protection

Division of Water

Frankfort, Kentucky

This report has been approved for release

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Sandy Gruzesky, Acting Director

Division of Water

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Date

Development of Pathogen TMDLs for three 303(d) Listed Streams in the Kentucky River Basin: South Elkhorn Creek in Scott County, Kentucky; and Town Branch, Cane Run, and Wolf Run in Fayette County, Kentucky

Kentucky Department for Environmental Protection
Division of Water

Frankfort, Kentucky

List of Contributors

Dr. Lindell Ormsbee
Dr. Chandramouli Viswanathan, Research Scientist
Dr. Jagadeesh Anmala, Post-doc
Noppadon Kowsuvon, M.S. Student

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

State: Kentucky
Counties: Jessamine, Franklin, Scott, and Woodford
Major River Basin: Kentucky River Basin

Waterbody	River Mile	Listing Year	Use Impairment(s)	Pollutant
South Elkhorn Creek	16.4 – 34.0	2006	Non-Support Swimming	Pathogens
Town Branch Creek	0.0 – 10.3	2006	Non-Support Swimming	Pathogens
Wolf Run Creek	0.0 – 4.1	2006	Non-Support Swimming	Pathogens

Also, Lee Branch, RM 0.0 to 8.2, Steeles Run, RM 0.0 to 4.2, South Elkhorn Creek, RM 9.3 to 16.4, and South Elkhorn Creek, RM 34.0 to 49.8 were found to be impaired, and these segments receive allocations within this TMDL.

2. TMDL Endpoints (numerical/narrative target):

The goal of the TMDL process is to achieve a numeric pathogen loading within the assimilative capacity of the impaired creek under study that allows for primary recreation contact (swimming). The Kentucky Division of Water (KDOW) currently uses fecal coliform as an indicator of the likelihood of pathogen impairment. The water quality standard for fecal coliform is tied to a specific designated use of primary recreational contact which is enforced from May 1 through October 31. For this designated use, the water quality standard requires that:

Fecal coliform shall not exceed 200 colonies per 100 ml as a monthly geometric mean based on not less than 5 samples per month, nor exceed 400 colonies per 100 ml in 20 percent or more of the samples taken during the month.

Where the geometric mean (GM) of data series of n observations (i.e. y_1, y_2, y_3 …. y_n) can be defined as:

Thus the in-stream fecal coliform target for this TMDL is a 30-day geometric mean of 200 colony counts per 100 ml or a maximum of 400 colonies per 100 ml or more for less than 20% of the time.

During the non-recreational season, from November 1 to April 30, secondary contact recreation is protected by the regulations which state that:

Fecal coliform content shall not exceed 1000 colonies per 100 ml as a monthly geometric mean based on not less than five (5) samples per month; nor exceed 2000 colonies per 100 ml in twenty (20) percent or more of all samples taken during the month.

3. Pollutant Allocations:

Subwatershed	River Mile	TMDL (cfu/day)	Continuous Wasteload Allocation (cfu/day)	MS4 Wasteload Allocation (cfu/day)	Load Allocation (cfu/day)
Town Branch	0.0-10.3	3.53E+13	2.27E+11	8.52E+12	2.67E+13
Wolf Run	0.0-4.1	3.41E+12	-	2.05E+12	1.36E+12
Upper South Elkhorn Creek	34.0 -49.8	2.81E+13	-	4.84E+12	2.33E+13
Middle South Elkhorn Creek	16.0-34.0	9.77E+13	3.79E+08	-	9.77E+13
Lower South Elkhorn Creek	9-3-.16.4	1.22E+14	-	-	1.22E+14
Lee Branch	0.0 – 8.2	2.91E+13	2.93E+09	-	2.91E+13
Steeles Run	0.0 – 4.2	1.49E+13	-	2.48E+11	1.47E+13
Total		2.64E+14	3.31E+09	2.48E+11	2.64E+14

4. Designated Use(s): Primary Contact Recreation and Aquatic Life (Swimmable and Fishable)

5. Threatened and/or Endangered Species (yes or no): No

7. TMDL Proposal Date: July 2008

8. TMDL Impacted by Point and Nonpoint Sources: Point Sources: Municipal Point Sources, Sanitary Sewer Overflows, Non-point sources: Urban Runoff/Storm Sewers

9. Major KPDES Discharges to Surface Waters:

The following permitted facilities discharge to South Elkhorn Creek.

Facility	KPDES Permit Number	Receiving Waterbody	Design Discharge (mgd)	Wasteload Allocation (cfu/100ml)	Wasteload Allocation (cfu/day)
1.Town Branch Treatment Plant	0021491	Town Branch	30.000	200	2.27E+11
2. Midway Treatment Plant	0028410	Lee Branch	0.387	200	2.93E+09
3. Airport Food Mart	0083062	Middle South Elkhorn	0.010	200	7.57E+07
4.Dance Enterprises Inc	0102610	Middle South Elkhorn	0.040	200	3.03E+08

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List of ACRONYMS

ANN	Artificial Neural Network
BIT	Bacterial Indicator Tool
BMP	Best Management Practices
CAFO	Confined Animal Feeding Operation
DEP	Department for Environmental Protection
DMR	Discharge Monitoring Report
EMC	Estimated Mean Concentration
FC	Fecal coliform
FOWR	Friends of Wolf Run
GIS	Geospatial Information System
GM	Geometric Mean
GNIS	Geographic Names Information System
HRU	Hydrologic Response Unit
HSPF	Hydrologic Simulation Program Fortran
HUC	Hydrologic Unit Code
I/I	Infiltration and Inflow
KDOW	Kentucky Division of Water
KGS	Kentucky Geological Survey
KPDES	Kentucky Pollution Discharge Elimination System
KRWW	Kentucky River Watershed Watch
LA	Load Allocations
LFUCG	Lexington Fayette Urban County Government
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NGO	Non Governmental Organization
NRCS	Natural Resources Conservation Service
NPDES	National Pollution Discharge Elimination System
NPS	Non-Point Source
NPSM	Non Point Source Model
OWTS	On Site Wastewater Treatment System

PCR	Primary Contact Recreation
QAPP	Quality Assurance Project Plan
RM	River Mile
SSO	Sanitary Sewer Overflow
SSS	Sanitary Sewer System
TBT	Town Branch Trail
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WDM	Watershed Data Management
WLA	Waste Load Allocation
WQC	Water Quality Criteria
WQM	Water Quality Management
WQS	Water Quality Standard
WWTP	Waste Water Treatment Plant

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SOUTH ELKHORN TMDL EXECUTIVE SUMMARY

Project Name:	South Elkhorn Creek Fecal Coliform TMDL
Location:	Jessamine, Franklin, Scott, and Woodford Counties
Major Tributaries:	Wolf Run, Town Branch, South Elkhorn
303(d)-Listed Segments:	Wolf Run Creek, RM 0.0 to 4.1, Town Branch, RM 0.0 to 10.3 and RM 10.3 to 11.3, and South Elkhorn Creek, RM 16.4 to 34.0 Lee Branch, RM 0.0 to 8.2, Steeles Run, RM 0.0 to 4.2, South Elkhorn Creek, RM 9.3 to 16.4, and South Elkhorn Creek, RM 34.0 to 49.8 were also found to be impaired, and these segments receive allocations within this TMDL.
Scope/Size:	South Elkhorn Creek, watershed area 179.2 mi^2
Land Use Type:	Agricultural and urban
Type of Activity:	Fecal coliform from urban runoff/storm sewers and agricultural runoff, and wastewater treatment plant discharges
Pollutant(s):	Fecal coliform, an indicator for the presence of pathogenic organisms
TMDL Issues:	Point and nonpoint sources
Data Sources:	USGS streamflow monitoring, USGS rainfall data, UK Department of Civil Engineering data
Control Measures:	KPDES permits, Kentucky Agricultural Water Quality Act, Kentucky Watershed Framework Initiative

Summary: The Kentucky 2004 303(d) Report identifies a 11.3 mile segment of Town Branch (from its confluence with South Elkhorn Creek) and a 4.1 mile segment of Wolf Run (from its confluence with South Elkhorn Creek) as not supporting the designated use of Primary Contact Recreation (PCR, or swimming) due to pathogen impairment. The Report also identifies a 17.6 mile segment of South Elkhorn Creek (from river mile 16.4 to 34.0) as only partially supporting that designated use. Subsequent data collection during the development of this TMDL also revealed impairment on Lee's Branch from RM 0.0 to 8.2, on Steeles Run from RM 0.0 to 4.2, on South Elkhorn Creek from RM 9.3 to 16.4, and on South Elkhorn Creek from RM 34.0 to 49.8. As a consequence, these segments were included in the development of the TMDL for the entire South Elkhorn watershed.

TMDL Development: Initial work on the TMDL for the South Elkhorn Creek watershed began May 2002. A stream sampling system was developed for the South Elkhorn mainstem and representative tributaries within the watershed. Sampling occurred between May 2002 and October 2002, including various sites on South Elkhorn Creek, Wolf Run and Town Branch. In an effort to account for the potential impact of both point and nonpoint pathogen sources, water quality samples were collected during rain and non-rain events. The data suggest that more than 90% of the time, pathogen values in South Elkhorn Creek (and its tributaries) exceed the 30-day geometric limit set forth by Kentucky's Surface Water Standards (401 KAR 5:031) for the PCR use (i.e. the criterion is a monthly geometric mean of 200 colonies per 100 ml, which can also be stated as 200 colony forming units per 100 ml (cfu/100ml)).

South Elkhorn Creek's headwaters are in Fayette and Jessamine counties in central Kentucky, and it flows through Woodford and Scott counties to its confluence with Elkhorn Creek in Franklin County (see Figure S1). Figure S.2 shows all impaired segments in the watershed along with the major subwatersheds. The TMDLs for South Elkhorn Creek watershed and the associated subwatersheds are provided in Table S.1. The Wasteload Allocation (WLA) is the part of the TMDL allocated to point sources (both continuous and MS4 permitted stormwater sources) in the basin and the Load Allocation (LA) is the part of the TMDL allocated to nonpoint sources located outside of the Lexington MS4 permit area.

Table ES.1 Total Maximum Daily Loads (cfu/day) for Each South Elkhorn Creek Major Subwatershed

Subwatershed	TMDL (cfu/day)	Continuous Wasteload Allocation (cfu/day)	MS4 Wasteload Allocation (cfu/day)	Load Allocation (cfu/day)
Town Branch	3.53E+13	2.27E+11	8.52E+12	2.67E+13
Wolf Run	3.41E+12	-	2.05E+12	1.36E+12
Upper South Elkhorn Creek	2.81E+13	-	4.84E+12	2.33E+13
Middle South Elkhorn Creek	9.77E+13	3.79E+08	-	9.77E+13
Lower South Elkhorn Creek	1.22E+14	-	-	1.22E+14
Lee Branch	2.91E+13	2.93E+09	-	2.91E+13
Steeles Run	1.49E+13	-	2.48E+11	1.47E+13
Total	2.64E+14	3.31E+09	2.48E+11	2.64E+14

In order to assess the sources and associated pathogen loadings in the South Elkhorn Creek watershed, an HSPF computer model of the watershed was developed. In developing the computer model, the watershed was subdivided into 45 catchments (see Figure S.3). The computer model was used to determine the initial loading conditions in the watershed. Initial conditions include both the loading that is attributed to KPDES-permitted sources (point sources), called the Wasteload, and the loading attributed to all other sources (nonpoint sources), called the Load. Note Wasteload and Load are different than the Wasteload Allocation (WLA) and the Load Allocation (LA). The nonpoint source loads were further subdivided into distributed loads associated with the two main landuses in the watershed (i.e., agricultural and urban) and concentrated loads, which are those loads associated with straight pipes and livestock in streams. While straight pipes technically meet the definition of a point sources as defined by 401 KAR 5:002, EPA considers them to be a nonpoint source for load allocation purposes within a TMDL. An additional type of concentrated load is that from both failing and properly functioning Onsite Wastewater Treatment Systems (OWTS, e.g., septic systems). EPA (2002a) states that properly functioning OWTS can remove pathogens with an efficiency between 99% and 99.9%, after pathogen losses are accounted for in the soil column. Failing OWTS are assumed to have a removal efficiency of zero.

Once the initial conditions are determined, a Total Maximum Daily Load (TMDL) of pathogens is developed for each catchment. The TMDL target is the Water Quality Criteria (WQC) expressed as a load, minus a Margin Of Safety (MOS), which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the data or TMDL calculations. The allowable loading represented by the TMDL was then apportioned to a WLA and a LA for each catchment. The WLA is the portion of the allowable load attributed to KPDES-permitted point sources, and the LA is the portion of the allowable load attributed to all other sources. The difference between the allowable load and the initial conditions is the percent reduction required.

Wasteload Reductions

There are two permitted Wastewater Treatment Plants (WWTPs) in the South Elkhorn Creek watershed: the Town Branch Treatment Plant (KPDES Permit # 0021491) and the Midway Treatment Plant (KPDES Permit # 0028410). Both facilities have KPDES permit limits for fecal coliforms of 200 cfu/100ml. Discharge Monitoring Reports (DMRs) indicate that the geometric means for 2003 for both permits were less than 100 cfu/100 ml (KDOW, 2003). For the purpose of TMDL development, the effluent concentrations were assumed to be 200 cfu/100 ml, the current permitted value, thus providing an explicit Margin of Safety (MOS) in the TMDL calculations.

In addition to the two WWTPs, there are also two permitted package plants in the South Elkhorn Creek watershed: the Airport Food Mart (KPDES Permit # KY0083062) and Dance Enterprises Inc. (KPDES Permit # KY0102610). DMRs indicate the geometric means for 2003 for both permits were less than 100 cfu/100 ml (KDOW, 2003). However, for the purpose of TMDL development, the effluent concentrations were assumed to be 200 cfu/100 ml, thus providing an explicit MOS in the TMDL calculations.

In addition to the permitted continuous sources, a significant part of the watershed lies within the Lexington MS4 permit area (see Figure S.4). As a consequence, all of the associated nonpoint sources and loads within this area are quantified as part of the WLA. Conversely, those nonpoint sources outside of the MS4 area are quantified as part of the LA.

In order to achieve the TMDLs for each catchment and subwatershed within the MS4 area, wasteload reductions of between 25% and 50% are proposed for both agricultural and urban lands through better management of agricultural and urban litter. Concentrated wasteload reductions were accomplished by 100% elimination of failing OWTS, straight pipes and the elimination of livestock access to streams. In the case of the remaining (properly functioning) OWTS, some OWTS will eventually fail and will require maintenance or replacement as this occurs. However, loads from failed OWTS are illegal, and thus do not receive an allocation within a TMDL.

Within the MS4 area, both sampling and anecdotal evidence suggest the presence of a large storm sewer in Lexington which discharges into Town Branch just downstream of Manchester Street and upstream of the Town Branch wastewater treatment plant. Evidence also suggests the presence of a discharge from the main storm sewer that drains downtown Lexington and empties into Town Branch downstream of the Rupp Arena parking lot. A major sanitary trunk main to the Town Branch wastewater treatment plant currently runs parallel to both storm sewers, which raises the strong possibility of cross connections between the two systems and/or the possibility of sanitary sewer overflows. In addition, the Lexington Stockyards lies immediately downstream of both sites. The elimination of the loads associated with these potential point sources are required in order to bring Town Branch into compliance with the Water Quality Criterion (WQC) for pathogens.

Recent and historical data suggest the presence of a significant pathogen source in Vaughn Branch of Wolf Run. As in the case of Town Branch, a major sewer trunk main runs parallel to the creek. This sewer trunk serves the Cardinal Valley, Cardinal Hill, and Pine Meadow subdivisions of Lexington as well as the southern part of the University of Kentucky campus (including the UK Medical Complex). In addition, the watershed receives drainage from The Red Mile racecourse. Elimination of the loads associated with these potential point sources is required in order to bring Wolf Run into compliance with the WQC for pathogens.

In addition to these potential sources, at least 72 sanitary sewer overflows events associated with 22 different manholes were documented in 2003, all of which occurred within the MS4 area. The majority of these sources were associated with headwater streams within the watershed including the Town Branch subwatershed and the Upper South Elkhorn subwatershed (see Figure S.4). More recently, on December 13, 2007, 30 separate illicit discharges within the South Elkhorn watersheds (including Town Branch and Wolf Run) were documented to have occurred from a combination of sanitary sewer overflows, pump stations overflows, and cross connections with storm sewers (see Figure S.5). At least one of the overflows (the South Elkhorn Pump Station at Bowmans Mill Road) had a discharge in excess of 5 million gallons of sewage.

Since long term explicit loading data for these various sources were not available, the implicit loads associated with these sources were lumped under improperly functioning OWTS and straight pipes loads for the subwatersheds in which they occurred. The loads were then adjusted as part of the model calibration. In the case of Town Branch watershed (upstream of Rupp Arena) and Wolf Run watershed (Vaughn's Branch) the additional loads were handled through explicit calibrated point loads. These loads were subsequently eliminated as part of the final wasteload allocation.

Wasteload Allocations

The continuous WLA (i.e., point source loads) in the South Elkhorn Creek watershed was allocated to the two permitted wastewater treatment plants in the watershed (i.e., the Town Branch Treatment Plant and the Midway Treatment Plant) and the two permitted package plants in the watershed (i.e., the Airport Food Mart and Dance Enterprises Inc.) as shown in Table S.2.

Table ES.2 Wasteload Allocations for Each South Elkhorn Watershed

Facility	KPDES Permit Number	Catch-ment	Receiving Waterbody	Design Discharge (mgd)	Allocation (cfu/100ml)	Load (cfu/day)
1.Town Branch Treatment Plant	0021491	37	Town Branch	30.000	200	2.27E+11
2. Midway Treatment Plant	0028410	25	Lee Branch	0.387	200	2.93E+09
3. Airport Food Mart	0083062	44	Middle South Elkhorn	0.010	200	7.57E+07
4.Dance Enterprises Inc	0102610	17	Middle South Elkhorn	0.040	200	3.03E+08

In order to bring South Elkhorn Creek into regulatory compliance, all wasteloads associated with straight pipes and instream cattle and horses must be eliminated (see Table ES.3). The MS4 component of the WLA (i.e. permitted nonpoint sources) in the South Elkhorn Creek watershed was allocated between three general sources: agriculture, urban, and functional OWTS. Wasteloads from nonpoint sources such as urban areas and agricultural lands need to be reduced by 25% to 90% (see Table ES.4). The allocated load for properly functioning OWTS is shown in Table S.5. Removal efficiency for properly functioning OWTS was assumed to be 99.5% (EPA, 2002a). By using a conservative reduction strategy, the instream fecal coliform criterion (i.e., the target of a 30 day geometric mean less than 200 cfu/100 ml) was met for all 6 years in the critical period.

Load Reductions

In order to achieve the TMDLs for each catchment and subwatershed, load reductions of between 25% and 50% are proposed for both agricultural and urban lands through better management of agricultural and urban waste. Concentrated load reductions were accomplished by 100% elimination of failing OWTS, straight pipes and the elimination of livestock access to streams. In the case of the remaining (properly functioning) OWTS, some of these will eventually fail and will require maintenance or replacement as this occurs. However, loads from failed OWTS are illegal, and thus do not receive an allocation within a TMDL.

Load Allocations

Although the LA includes all non-KPDES permitted dischargers (i.e. outside of the MS4 area), and thus is normally thought of as including nonpoint sources, for the purposes of modeling, straight pipes, failing septic systems, and cattle in streams were treated as point sources. Likewise, wildlife, grazing cattle, manure applications, and urban runoff were treated as nonpoint sources.

In order to bring South Elkhorn Creek into regulatory compliance, all loads associated with straight pipes and instream cattle and horses must be eliminated. Failing septic system loads must be eliminated as shown in Table S.6. In addition, loads from nonpoint sources such as urban areas, cropland, and pasture land need to be reduced by 25% to 90% (see Table S.7). The allocated load for properly functioning OWTS is shown in Table S.8. Removal efficiency for properly functioning OWTS was assumed to be 99.5% (EPA, 2002a). By using a conservative reduction strategy, the instream fecal coliform criterion (i.e., the target of a 30 day geometric mean less than 200 cfu/100 ml) was met for all 6 years in the critical period.

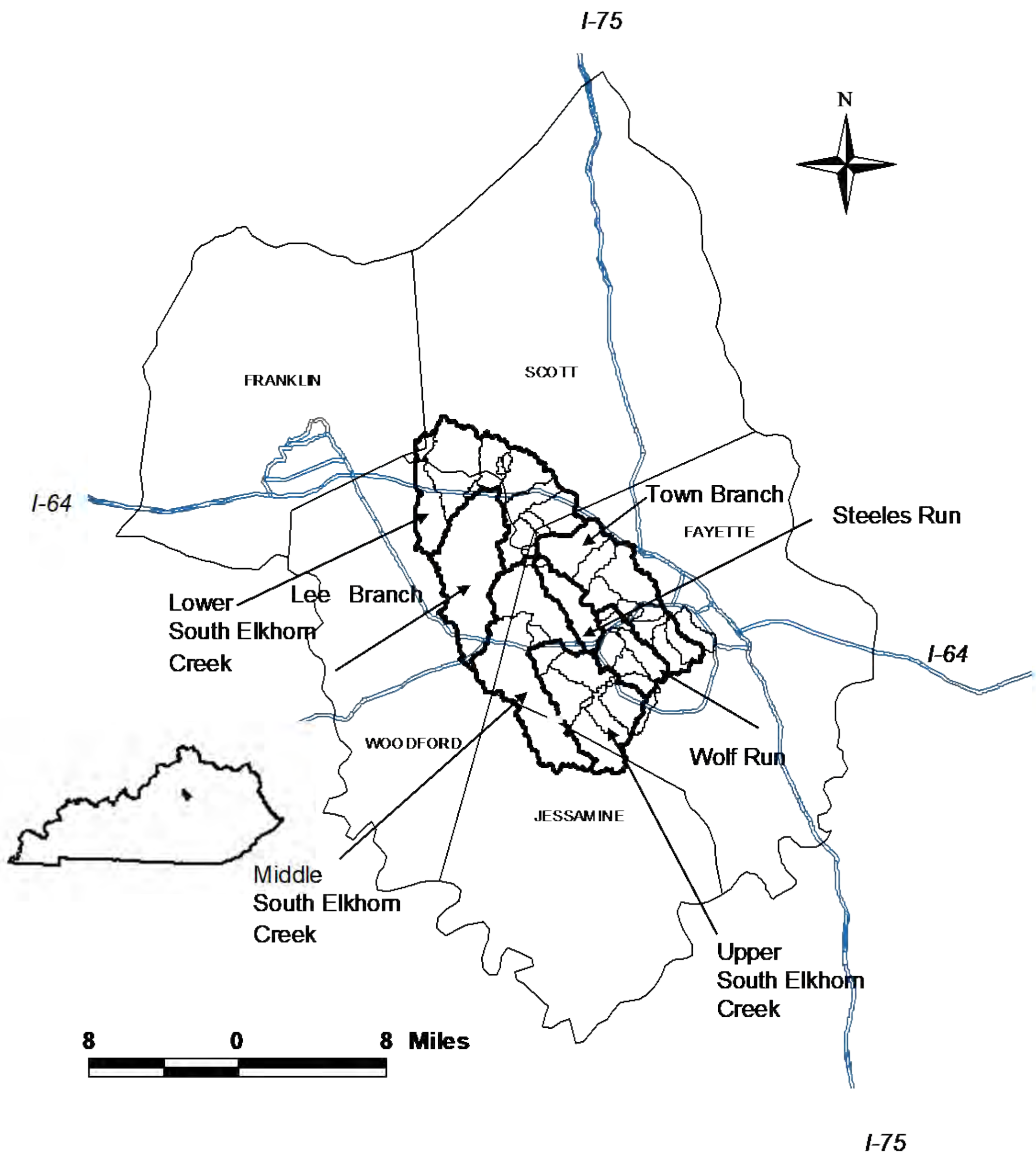

Figure ES.1 Location of South Elkhorn Creek Watershed

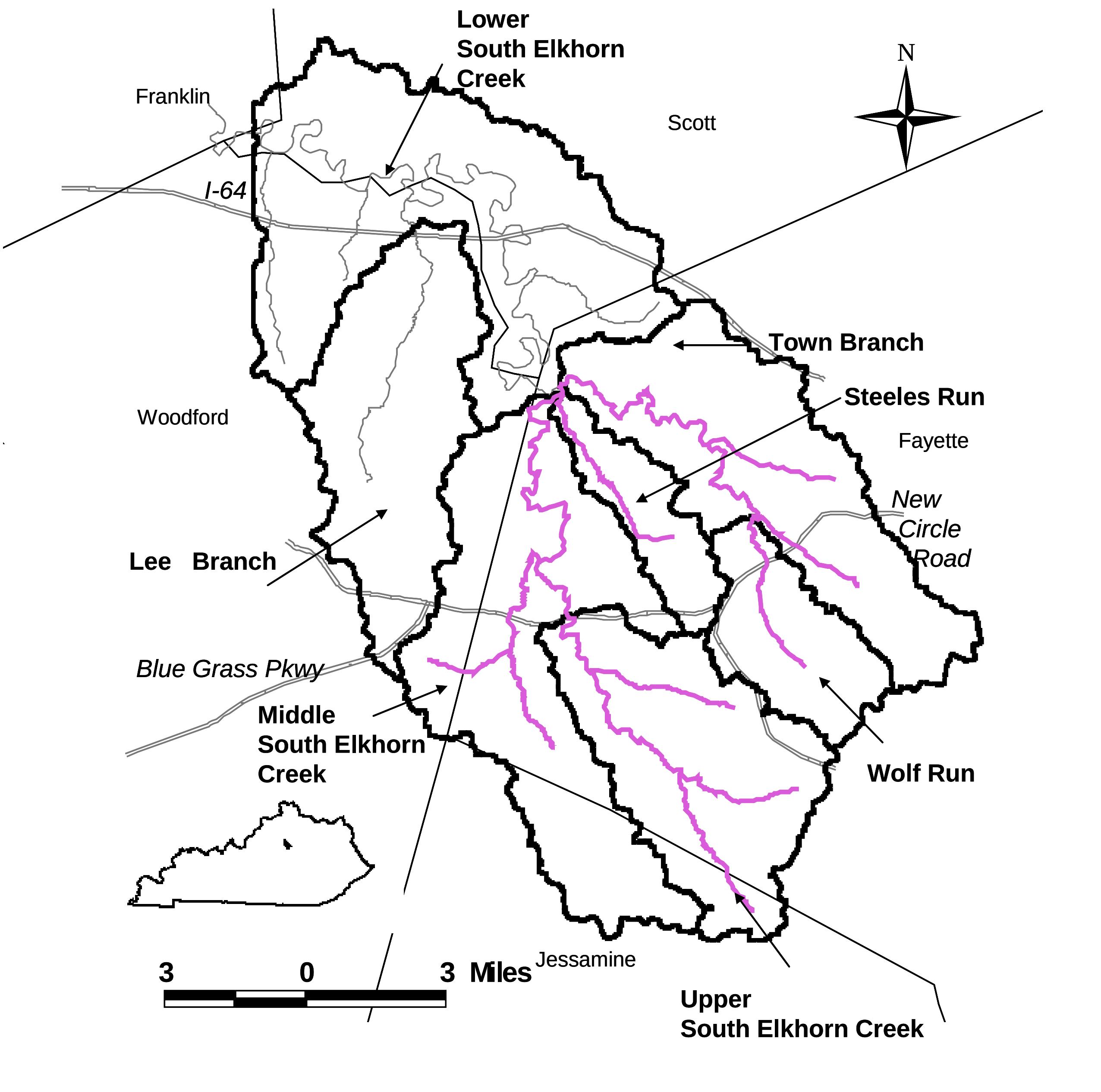

Figure ES.2 Map of South Elkhorn Creek Watershed and Subwatersheds Showing Impaired Stream Segments

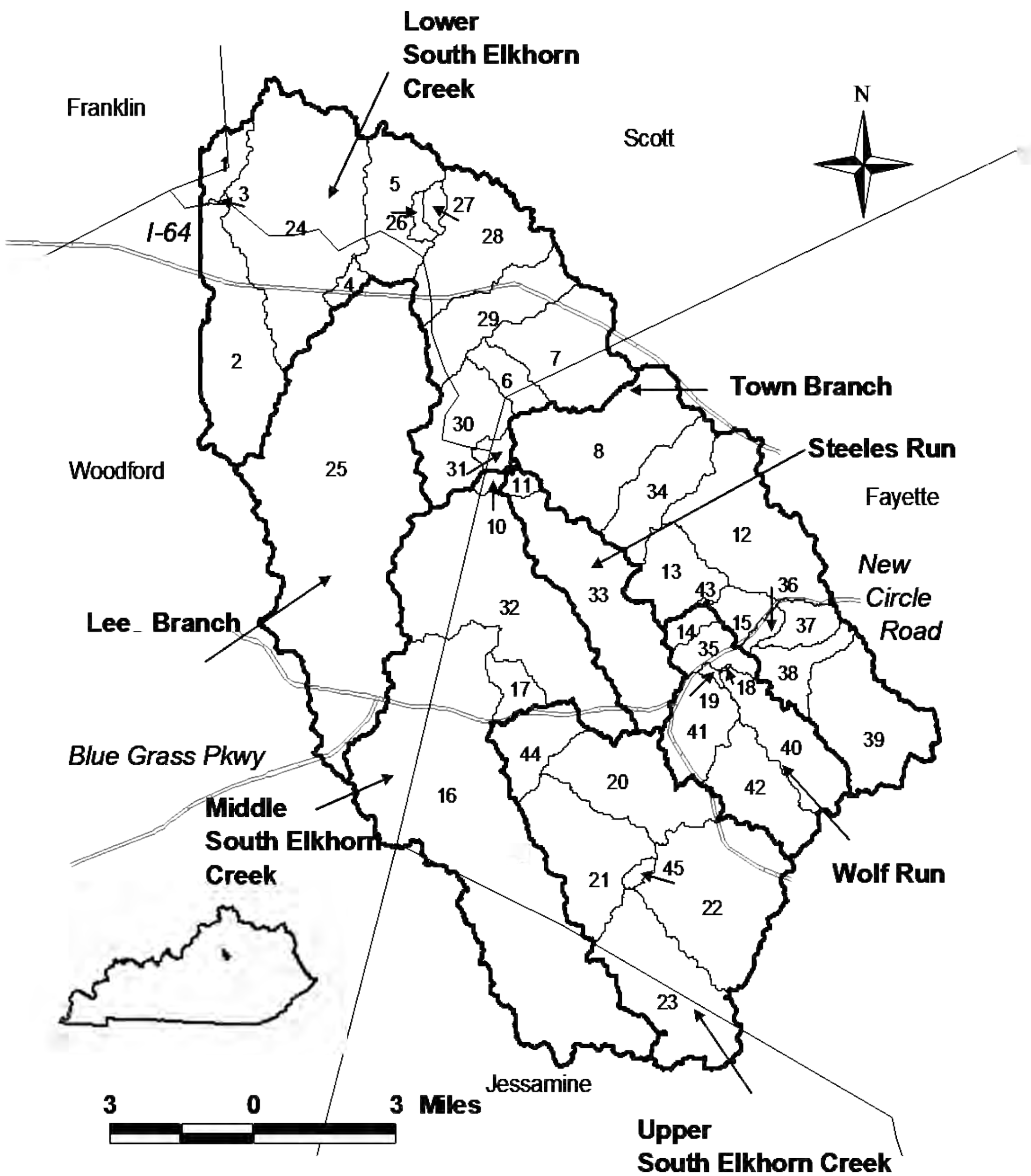

Figure ES.3 Map of Catchments of Elkhorn Creek Watershed

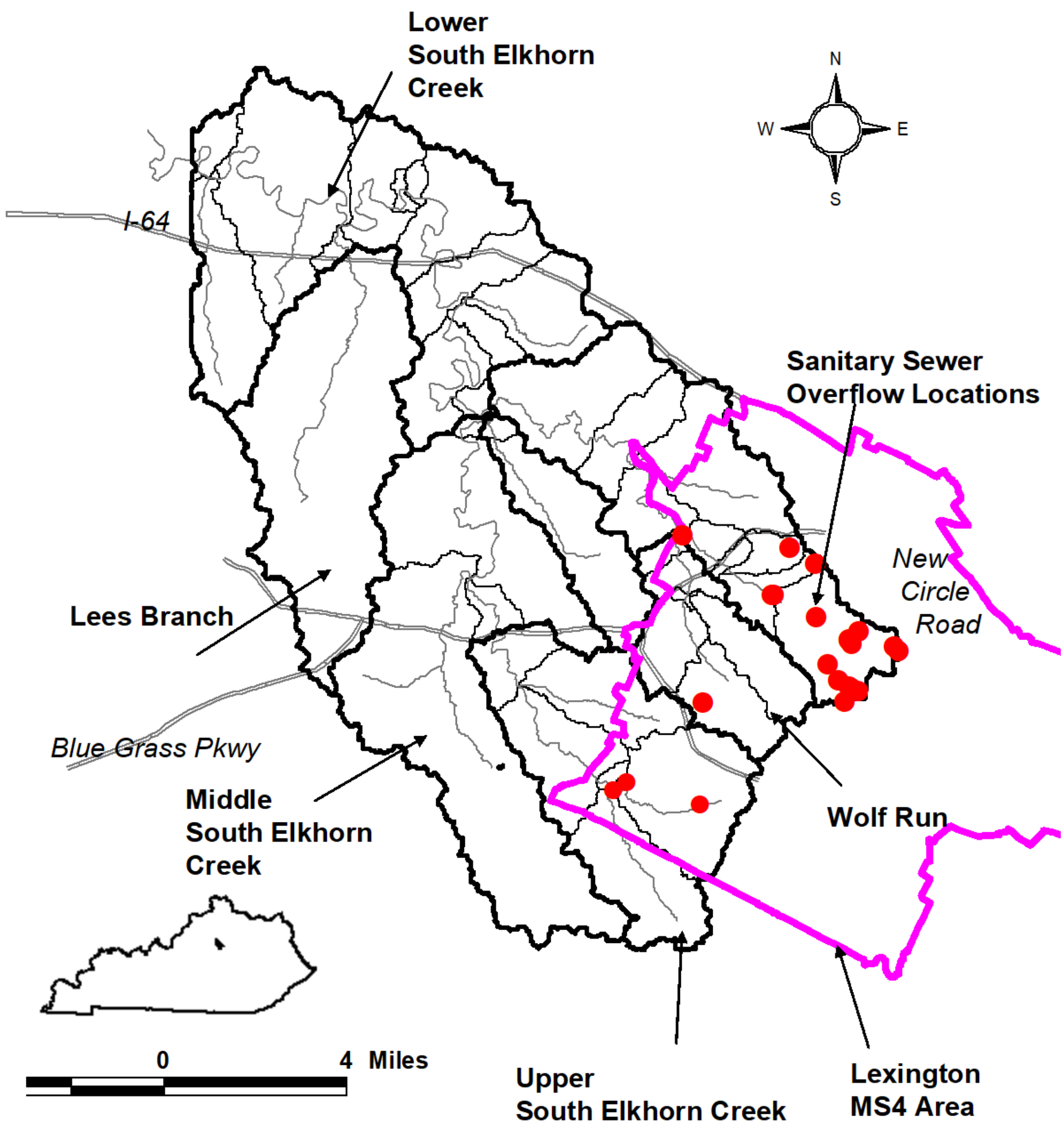

Figure ES.4. MS4 Area and Documented Sanitary Sewer Overflow Locations for 2003 (KYDOW, 2007)

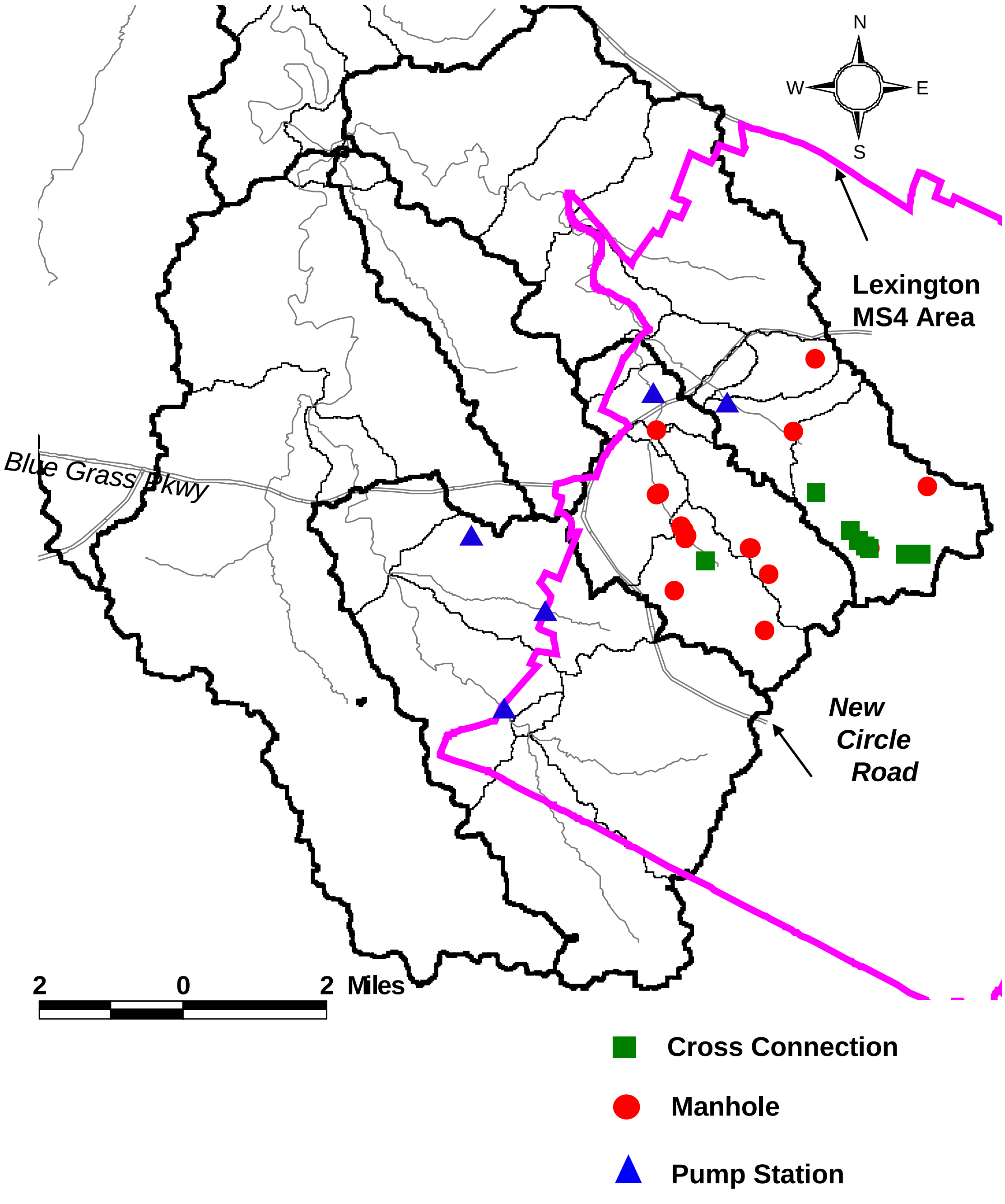

Figure ES.5. Locations of Overflowing Manholes, Pump Stations, and Cross Connections documented to have occurred during 2006 and 20077 (KDOW, 2008)

Table ES.3 Wasteload Reductions for Straight Pipes, Instream Horse and Cattle Contributions and Failing OWTS

Catch-ment	Livestock in Streams (counts/day)			Straight Pipes (counts/day)			Failing OWTS (counts / day)		
	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction
Town Branch Subwatershed									
8	2.70E+10	0	100	7.57E+09	0	100	3.27E+09	0	100
12	2.15E+10	0	100	7.57E+09	0	100	2.39E+09	0	100
13	9.49E+09	0	100	7.57E+09	0	100	1.16E+09	0	100
15	1.64E+09	0	100	6.81E+10	0	100	1.84E+08	0	100
34	1.17E+10	0	100	3.03E+10	0	100	1.36E+09	0	100
36	1.00E+09	0	100	0	0	100	7.16E+07	0	100
37	7.01E+08	0	100	4.54E+10	0	100	5.16E+07	0	100
38	1.51E+09	0	100	7.57E+09	0	100	6.36E+06	0	100
39	0.00E+00	0	100	0	0	100	0.00E+00	0	-
43	1.17E+08	0	100	0	0	100	1.43E+07	0	100
Wolf Run Subwatershed									
14	2.19E+09	0	100	0	0	100	2.74E+08	0	100
18	0.00E+00	0	100	0	0	100	0.00E+00	0	-
19	1.91E+04	0	100	0	0	100	0.00E+00	0	-
35	3.73E+09	0	100	6.06E+10	0	100	3.18E+08	0	100
40	0.00E+00	0	100	0	0	100	8.83E+07	0	100
41	2.15E+09	0	100	7.57E+09	0	100	1.07E+08	0	100
42	6.53E+07	0	100	0	0	100	0.00E+00	0	-
Upper South Elkhorn Creek Subwatershed									
20	1.14E+10	0	100	1.51E+10	0	100	1.86E+09	0	100
21	1.31E+10	0	100	7.57E+09	0	100	2.26E+09	0	100
22	7.11E+08	0	100	0	0	100	1.59E+09	0	100
23	2.74E+10	0	100	1.51E+10	0	100	2.76E+09	0	100
44	8.41E+09	0	100	7.57E+09	0	100	7.13E+08	0	100
45	2.07E+07	0	100	0	0	100	1.17E+08	0	100
Middle South Elkhorn Creek Subwatershed									
16	1.31E+11	0	100	2.27E+10	0	100	9.92E+09	0	100
17	3.95E+09	0	100	5.3E+10	0	100	2.77E+08	0	100
32	6.08E+10	0	100	7.57E+09	0	100	5.11E+09	0	100
Lower South Elkhorn Creek Subwatershed									
1	5.07E+09	0	100	0	0	100	5.56E+08	0	100
2	4.39E+10	0	100	1.51E+10	0	100	2.96E+09	0	100
3	2.33E+08	0	100	0	0	100	1.51E+09	0	100
4	3.12E+09	0	100	0	0	100	1.84E+08	0	100
5	2.28E+10	0	100	0	0	100	1.75E+09	0	100
6	6.70E+09	0	100	0	0	100	5.51E+08	0	100
7	2.52E+10	0	100	2.27E+10	0	100	2.11E+09	0	100
9	1.72E+08	0	100	0	0	100	1.19E+07	0	100
10	1.93E+09	0	100	0	0	100	1.18E+08	0	100
24	7.17E+10	0	100	3.79E+10	0	100	5.27E+09	0	100
26	2.01E+09	0	100	0	0	100	1.42E+08	0	100
27	2.32E+09	0	100	0	0	100	1.23E+08	0	100
28	3.09E+10	0	100	6.81E+10	0	100	2.15E+09	0	100
29	2.13E+10	0	100	3.03E+10	0	100	1.53E+09	0	100
30	2.39E+10	0	100	7.57E+09	0	100	1.67E+09	0	100
31	3.12E+09	0	100	0	0	100	2.33E+08	0	100
Lee Branch Subwatershed									
25	1.46E+11	0	100	3.79E+10	0	100	1.20E+10	0	100
Steeles Run Subwatershed									
11	1.72E+09	0	100	0	0	100	1.69E+08	0	100
33	2.68E+10	0	100	3.79E+10	0	100	3.04E+09	0	100
Total	7.79E+11			6.28E+11			7.00E+10	0	

Table ES.4 MS4 Wasteload Allocations (by Catchment) for the South Elkhorn Creek Watersheds

Sub-basin	Agricultural Land (counts/day)			Urban Land (counts/day)		
	Existing Load	Allocated Wasteload after deducting non MS4 load	Percent Reduction	Existing Load	Allocated Wasteload after deducting non MS4 load	Percent Reduction
Town branch Subwatershed						
8	1.76E+13	0.00E+00	25	6.47E+08	0.00E+00	25
12	1.37E+13	6.70E+12	25	6.40E+09	3.56E+09	25
13	5.89E+12	9.87E+11	25	8.71E+08	5.81E+06	25
15	8.84E+11	6.63E+11	25	1.61E+09	1.21E+09	25
34	8.65E+12	0.00E+00	25	1.91E+09	1.98E+08	25
36	5.01E+11	5.01E+10	90	1.84E+09	1.84E+08	90
37	3.43E+11	3.43E+10	90	7.51E+09	7.51E+08	90
38	6.76E+11	6.76E+10	90	9.21E+09	9.21E+08	90
39	0.00E+00	0.00E+00	-	3.92E+10	3.92E+09	90
43	5.41E+10	8.59E+09	25	0.00E+00	0.00E+00	-
Wolf Run Subwatershed						
14	1.79E+12	4.33E+11	25	0.00E+00	0.00E+00	-
18	0.00E+00	0.00E+00	-	1.67E+08	0.00E+00	50
19	0.00E+00	0.00E+00	-	1.11E+09	5.55E+08	50
35	2.65E+12	9.40E+11	50	2.08E+09	1.00E+09	50
40	3.07E+11	1.54E+11	50	2.21E+10	1.11E+10	50
41	1.10E+12	4.92E+11	50	1.84E+10	8.94E+09	50
42	0.00E+00	0.00E+00	-	2.78E+10	1.39E+10	50
Upper South Elkhorn Creek Subwatershed						
20	7.12E+12	1.56E+12	25	3.64E+09	1.62E+09	25
21	8.74E+12	1.31E+12	25	4.65E+08	0.00E+00	25
22	5.36E+11	3.89E+11	25	3.24E+10	2.43E+10	25
23	1.58E+13	1.54E+12	25	1.37E+09	2.21E+08	25
44	5.16E+12	0.00E+00	25	1.23E+09	0.00E+00	25
45	1.90E+10	1.42E+10	25	0.00E+00	0.00E+00	-
Middle South Elkhorn Creek Subwatershed						
16	8.58E+13	0.00E+00	25	1.21E+10	0.00E+00	25
17	2.46E+12	0.00E+00	25	3.19E+09	0.00E+00	25
32	4.20E+13	0.00E+00	25	2.46E+09	0.00E+00	25
Lower South Elkhorn Creek Subwatershed						
1	2.75E+12	0.00E+00	25	0.00E+00	0.00E+00	-
2	2.81E+13	0.00E+00	25	1.44E+07	0.00E+00	25
3	1.08E+11	0.00E+00	25	0.00E+00	0.00E+00	-
4	1.71E+12	0.00E+00	25	7.58E+06	0.00E+00	25
5	1.40E+13	0.00E+00	25	2.21E+08	0.00E+00	25
6	3.77E+12	0.00E+00	25	0.00E+00	0.00E+00	-
7	1.52E+13	0.00E+00	25	5.96E+08	0.00E+00	25
9	7.93E+10	0.00E+00	25	0.00E+00	0.00E+00	-
10	1.33E+12	0.00E+00	25	3.35E+08	0.00E+00	25
24	4.34E+13	0.00E+00	25	8.60E+08	0.00E+00	25
26	1.06E+12	0.00E+00	25	2.34E+08	0.00E+00	25
27	1.19E+12	0.00E+00	25	1.31E+09	0.00E+00	25
28	1.89E+13	0.00E+00	25	3.38E+09	0.00E+00	25
29	1.45E+13	0.00E+00	25	5.31E+08	0.00E+00	25
30	1.44E+13	0.00E+00	25	7.70E+08	0.00E+00	25
31	1.68E+12	0.00E+00	25	2.34E+08	0.00E+00	25
Lee Branch Subwatershed						
25	9.71E+13	0.00E+00	70	1.04E+10	0.00E+00	70
Steeles Run Subwatershed						
11	1.22E+12	0.00E+00	25	0.00E+00	0.00E+00	-
33	1.86E+13	0.00E+00	25	3.96E+09	0.00E+00	25
Total	5.01E+14	1.53E+13		2.21E+11	7.24E+10	

Table ES.5 MS4 Allocated Wasteload for Properly Functioning OWTS

Catchment	Allocated Load, counts/day
Town Branch Subwatershed	
8	0.00E+00
12	3.11E+08
13	5.18E+07
15	3.68E+07
34	0.00E+00
36	1.43E+07
37	1.03E+07
38	1.27E+06
39	0.00E+00
43	6.06E+05
Wolf Run Subwatershed	
14	1.77E+07
18	0.00E+00
19	0.00E+00
35	4.49E+07
40	1.77E+07
41	1.92E+07
42	0.00E+00
Upper South Elkhorn Creek Subwatershed	
20	1.09E+08
21	9.01E+07
22	3.08E+08
23	7.15E+07
44	0.00E+00
45	2.34E+07
Middle South Elkhorn Creek Subwatershed	
16	0.00E+00
17	0.00E+00
32	0.00E+00
Lower South Elkhorn Creek Subwatershed	
1	0.00E+00
2	0.00E+00
3	0.00E+00
4	0.00E+00
5	0.00E+00
6	0.00E+00
7	0.00E+00
9	0.00E+00
10	0.00E+00
24	0.00E+00
26	0.00E+00
27	0.00E+00
28	0.00E+00
29	0.00E+00
30	0.00E+00
31	0.00E+00
Lee Branch Subwatershed	
25	0.00E+00
Steeles Run Subwatershed	
11	0.00E+00
33	0.00E+00
Total	1.13E+09

Table ES.6 Load Reductions for Straight Pipes, Instream Horse and Cattle Contributions and Failing OWTS

Catch-ment	Livestock in Streams (counts/day)			Straight Pipes (counts/day)			Failing OWTS (counts / day)		
	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction
Town Branch Subwatershed									
8	2.70E+10	0	100	7.57E+09	0	100	3.27E+09	0	100
12	2.15E+10	0	100	7.57E+09	0	100	2.39E+09	0	100
13	9.49E+09	0	100	7.57E+09	0	100	1.16E+09	0	100
15	1.64E+09	0	100	6.81E+10	0	100	1.84E+08	0	100
34	1.17E+10	0	100	3.03E+10	0	100	1.36E+09	0	100
36	1.00E+09	0	100	0	0	100	7.16E+07	0	100
37	7.01E+08	0	100	4.54E+10	0	100	5.16E+07	0	100
38	1.51E+09	0	100	7.57E+09	0	100	6.36E+06	0	100
39	0.00E+00	0	100	0	0	100	0.00E+00	0	-
43	1.17E+08	0	100	0	0	100	1.43E+07	0	100
Wolf Run Subwatershed									
14	2.19E+09	0	100	0	0	100	2.74E+08	0	100
18	0.00E+00	0	100	0	0	100	0.00E+00	0	-
19	1.91E+04	0	100	0	0	100	0.00E+00	0	-
35	3.73E+09	0	100	6.06E+10	0	100	3.18E+08	0	100
40	0.00E+00	0	100	0	0	100	8.83E+07	0	100
41	2.15E+09	0	100	7.57E+09	0	100	1.07E+08	0	100
42	6.53E+07	0	100	0	0	100	0.00E+00	0	-
Upper South Elkhorn Creek Subwatershed									
20	1.14E+10	0	100	1.51E+10	0	100	1.86E+09	0	100
21	1.31E+10	0	100	7.57E+09	0	100	2.26E+09	0	100
22	7.11E+08	0	100	0	0	100	1.59E+09	0	100
23	2.74E+10	0	100	1.51E+10	0	100	2.76E+09	0	100
44	8.41E+09	0	100	7.57E+09	0	100	7.13E+08	0	100
45	2.07E+07	0	100	0	0	100	1.17E+08	0	100
Middle South Elkhorn Creek Subwatershed									
16	1.31E+11	0	100	2.27E+10	0	100	9.92E+09	0	100
17	3.95E+09	0	100	5.3E+10	0	100	2.77E+08	0	100
32	6.08E+10	0	100	7.57E+09	0	100	5.11E+09	0	100
Lower South Elkhorn Creek Subwatershed									
1	5.07E+09	0	100	0	0	100	5.56E+08	0	100
2	4.39E+10	0	100	1.51E+10	0	100	2.96E+09	0	100
3	2.33E+08	0	100	0	0	100	1.51E+09	0	100
4	3.12E+09	0	100	0	0	100	1.84E+08	0	100
5	2.28E+10	0	100	0	0	100	1.75E+09	0	100
6	6.70E+09	0	100	0	0	100	5.51E+08	0	100
7	2.52E+10	0	100	2.27E+10	0	100	2.11E+09	0	100
9	1.72E+08	0	100	0	0	100	1.19E+07	0	100
10	1.93E+09	0	100	0	0	100	1.18E+08	0	100
24	7.17E+10	0	100	3.79E+10	0	100	5.27E+09	0	100
26	2.01E+09	0	100	0	0	100	1.42E+08	0	100
27	2.32E+09	0	100	0	0	100	1.23E+08	0	100
28	3.09E+10	0	100	6.81E+10	0	100	2.15E+09	0	100
29	2.13E+10	0	100	3.03E+10	0	100	1.53E+09	0	100
30	2.39E+10	0	100	7.57E+09	0	100	1.67E+09	0	100
31	3.12E+09	0	100	0	0	100	2.33E+08	0	100
Lee Branch Subwatershed									
25	1.46E+11	0	100	3.79E+10	0	100	1.20E+10	0	100
Steeles Run Subwatershed									
11	1.72E+09	0	100	0	0	100	1.69E+08	0	100
33	2.68E+10	0	100	3.79E+10	0	100	3.04E+09	0	100
Total	7.79E+11			6.28E+11			7.00E+10	0	

Table ES.7 Load Reductions for Agricultural and Urban Lands

Sub-basin	Agricultural Land (counts/day)			Urban Land (counts/day)		
	Existing Load	**Allocated Load after deducting MS4 waste load**	**Percent Reduction**	**Existing Load**	**Allocated Load after deducting MS4 waste load**	**Percent Reduction**
Town branch Subwatershed						
8	1.76E+13	1.32E+13	25	6.47E+08	4.85E+08	25
12	1.37E+13	3.60E+12	25	6.40E+09	1.24E+09	25
13	5.89E+12	3.43E+12	25	8.71E+08	6.47E+08	25
15	8.84E+11	0.00E+00	25	1.61E+09	0.00E+00	25
34	8.65E+12	6.48E+12	25	1.91E+09	1.23E+09	25
36	5.01E+11	0.00E+00	90	1.84E+09	0.00E+00	90
37	3.43E+11	0.00E+00	90	7.51E+09	0.00E+00	90
38	6.76E+11	0.00E+00	90	9.21E+09	0.00E+00	90
39	0.00E+00	0.00E+00	-	3.92E+10	0.00E+00	90
43	5.41E+10	3.19E+10	25	0.00E+00	0.00E+00	-
Wolf Run Subwatershed						
14	1.79E+12	9.07E+11	25	0.00E+00	0.00E+00	-
18	0.00E+00	0.00E+00	-	1.67E+08	8.35E+07	50
19	0.00E+00	0.00E+00	-	1.11E+09	0.00E+00	50
35	2.65E+12	3.90E+11	50	2.08E+09	3.70E+07	50
40	3.07E+11	0.00E+00	50	2.21E+10	0.00E+00	50
41	1.10E+12	5.78E+10	50	1.84E+10	2.58E+08	50
42	0.00E+00	0.00E+00	-	2.78E+10	0.00E+00	50
Upper South Elkhorn Creek Subwatershed						
20	7.12E+12	3.78E+12	25	3.64E+09	1.11E+09	25
21	8.74E+12	5.24E+12	25	4.65E+08	3.49E+08	25
22	5.36E+11	1.31E+10	25	3.24E+10	0.00E+00	25
23	1.58E+13	1.04E+13	25	1.37E+09	8.09E+08	25
44	5.16E+12	3.87E+12	25	1.23E+09	9.23E+08	25
45	1.90E+10	0.00E+00	25	0.00E+00	0.00E+00	-
Middle South Elkhorn Creek Subwatershed						
16	8.58E+13	6.43E+13	25	1.21E+10	9.08E+09	25
17	2.46E+12	1.85E+12	25	3.19E+09	2.39E+09	25
32	4.20E+13	3.15E+13	25	2.46E+09	1.85E+09	25
Lower South Elkhorn Creek Subwatershed						
1	2.75E+12	2.06E+12	25	0.00E+00	0.00E+00	-
2	2.81E+13	2.11E+13	25	1.44E+07	1.08E+07	25
3	1.08E+11	8.13E+10	25	0.00E+00	0.00E+00	-
4	1.71E+12	1.28E+12	25	7.58E+06	5.69E+06	25
5	1.40E+13	1.05E+13	25	2.21E+08	1.66E+08	25
6	3.77E+12	2.83E+12	25	0.00E+00	0.00E+00	-
7	1.52E+13	1.14E+13	25	5.96E+08	4.47E+08	25
9	7.93E+10	5.95E+10	25	0.00E+00	0.00E+00	-
10	1.33E+12	9.98E+11	25	3.35E+08	2.51E+08	25
24	4.34E+13	3.26E+13	25	8.60E+08	6.45E+08	25
26	1.06E+12	7.98E+11	25	2.34E+08	1.76E+08	25
27	1.19E+12	8.95E+11	25	1.31E+09	9.83E+08	25
28	1.89E+13	1.41E+13	25	3.38E+09	2.54E+09	25
29	1.45E+13	1.09E+13	25	5.31E+08	3.98E+08	25
30	1.44E+13	1.08E+13	25	7.70E+08	5.78E+08	25
31	1.68E+12	1.26E+12	25	2.34E+08	1.76E+08	25
Lee Branch Subwatershed						
25	9.71E+13	2.91E+13	70	1.04E+10	3.12E+09	70
Steeles Run Subwatershed						
11	1.22E+12	9.16E+11	25	0.00E+00	0.00E+00	-
33	1.86E+13	1.38E+13	25	3.96E+09	2.81E+09	25
Total	5.01E+14	3.14E+14		2.21E+11	3.28E+10	

Table ES.8 Allocated Load for Properly Functioning OWTS

Catchment	Allocated Load, counts/day
Town Branch Subwatershed	
8	6.54E+08
12	4.78E+08
13	2.32E+08
15	3.68E+07
34	2.72E+08
36	1.43E+07
37	1.03E+07
38	1.27E+06
39	0.00E+00
43	2.86E+06
Wolf Run Subwatershed	
14	5.48E+07
18	0.00E+00
19	0.00E+00
35	6.36E+07
40	1.77E+07
41	2.14E+07
42	0.00E+00
Upper South Elkhorn Creek Subwatershed	
20	3.72E+08
21	4.52E+08
22	3.18E+08
23	5.52E+08
44	1.43E+08
45	2.34E+07
Middle South Elkhorn Creek Subwatershed	
16	1.98E+09
17	5.54E+07
32	1.02E+09
Lower South Elkhorn Creek Subwatershed	
1	1.11E+08
2	5.92E+08
3	3.02E+08
4	3.68E+07
5	3.50E+08
6	1.10E+08
7	4.22E+08
9	2.38E+06
10	2.36E+07
24	1.05E+09
26	2.84E+07
27	2.46E+07
28	4.30E+08
29	3.06E+08
30	3.34E+08
31	4.66E+07
Lee Branch Subwatershed	
25	2.40E+09
Steeles Run Subwatershed	
11	3.38E+07
33	6.08E+08
Total	1.40E+10

Implementation

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

The limited in-stream pathogen data used to develop the TMDL for South Elkhorn do not allow loads to be quantitatively allocated to the different sources within the watershed. Therefore, no specific recommendations for remediation are offered until additional watershed planning is conducted. Development of a watershed plan will provide an integrative approach for identifying and describing how, when, who and what actions should be taken in order to meet water quality standards. This TMDL will provide a foundation for developing a detailed watershed plan. In addition, several organizations already active in the watershed are listed below.

Thoroughbred RC&D Council

The Thoroughbred RC&D Council has been actively engaged in the development of a comprehensive program for managing equine waste through onsite compositing (Oldfield, 2002). To date the methodology has been implemented at over 10 farms in the Elkhorn Creek Watershed. The Thoroughbred RC&D recently purchased a compost windrow turner for lease by local horse farms. Significant matching funds are also available through USDA for the construction of lime based pads. Once composted, the resulting material can be used as on-site fertilizer or sold for other commercial landuse applications (e.g. mushroom farms).

NGOs

There are several NGOs operating in the South Elkhorn watershed that may help in implementing the TMDLs for South Elkhorn Creek, especially with regard to non-point source issues. These include Bluegrass PRIDE Inc., Kentucky River Watershed Watch Inc., Town Branch Trail Inc., and Friends of Wolf Run, Inc..

Bluegrass PRIDE

In addition to management activities associated with the local governments in each of the impacted counties, TMDL implementation in the region, especially associated with non-point source issues, may be facilitated by Bluegrass PRIDE. Bluegrass PRIDE was established in the Fall of 2001 to monitor the status of water quality in the Bluegrass region of Central Kentucky and provide funding and programs to help improve the quality of life of its citizens as well as the quality of the environment. More information about Bluegrass PRIDE can be found at: http://www.kentuckypride.com.

Kentucky River Watershed Watch

The Kentucky River Watershed Watch Inc. performs annual volunteer sampling throughout the Kentucky River Basin, including South Elkhorn Creek. This sampling and the associated data can also be used to help assess progress in meeting the designated use for the stream. Kentucky River Watershed Watch Inc. has also developed citizen's action plans for several subwatersheds in the Kentucky River Basin, including Elkhorn Creek. More information about Kentucky Watershed Watch can be found at: http://www.uky.edu/OtherOrgs/KRWW.

Town Branch Trail, Inc.

Town Branch Trail Inc. (TBT) was organized as a non-profit educational group in March 2001 to promote environmental preservation and development of a trail along Town Branch Creek from downtown Lexington to the McConnell Trace subdivision. For more information see: http://www.townbranch.org.

Friends of Wolf Run, Inc.

Friends of Wolf Run Inc. (FOWR) was organized as a Non-Profit educational group in Spring of 2005 to promote sound water resource management practices and conservation; promote an interest in, and a study of the streams, rivers, lakes and other water resources of the central Kentucky area; collect scientific information regarding water quality; and disseminate information regarding water resources and water quality. The group conducts focused water quality sampling in the Wolf Run watershed and is currently exploring ways to characterize and improve the water quality in the watershed. For more information see: http://kywater.net/WolfRun.

Modifications

In the future, KDOW may adjust the LA and/or WLA in this TMDL to account for new information or circumstances that develop or come to light during the implementation of the TMDL and a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment of the LA and WLA will only be made following an opportunity for public participation. New information generated during TMDL implementation may include, among other things, monitoring data, BMP effectiveness information and land use information. KDOW will propose adjustments only in the event that any adjusted LA or WLA will not result in a change to the TMDL Target load. The adjusted TMDL, including its WLAs and LAs, will be set at a level necessary to implement the applicable WQS. KDOW will notify EPA of any adjustments to this TMDL within 30 days of their adoption.

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require that States develop Total Maximum Daily Loads (TMDLs) for their water bodies that are not meeting designated uses under technology-based controls for pollution. The TMDL is a term used to describe the maximum amount of a pollutant a stream can assimilate without violating water quality standards. The units of load measurement are typically mass of pollutant per unit time (e.g., mg/hr, lbs/day). In the case of fecal coliforms, which are typically expressed in terms of number of organisms (colony forming units (cfu) or colonies) per unit volume (i.e. colonies/100 ml), the load is typically expressed in terms of colonies/day.

The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream water quality conditions. This method exists so that states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991). This report provides the pathogen TMDL for the South Elkhorn Creek watershed.

1.1 Location

The South Elkhorn Creek watershed is contained within parts of Fayette, Jessamine, Scott, and Woodford Counties, in central Kentucky as shown in Fig 1.1. The watershed receives drainage from the Town Branch subwatershed, the Wolf Run subwatershed, and the Steeles Run subwatershed, all of which drain highly urbanized areas of Lexington, Kentucky located within Fayette County. The watershed also contains the city of Midway which is located in the northeast corner of Woodford County in the Lee Branch subwatershed. Major highways that traverse the watershed include I-64 and I-75.

1.2 Hydrologic Information

South Elkhorn Creek, a fourth order stream, originates in northwest Jessamine County and southwest Fayette County. The creek flows northwest to merge with North Elkhorn Creek forming Elkhorn Creek in Franklin County. South Elkhorn Creek contributes to the Kentucky River Watershed, United States Geologic Survey (USGS) Hydrologic Unit Code (HUC) 05100205. The South Elkhorn Creek watershed encompasses several smaller subwatersheds, such as Town Branch, Wolf Run, Steeles Run, and Lee Branch (Figure 1.2). The main South Elkhorn Watershed can also be subdivided into three smaller subwatershed: upper South Elkhorn, middle South Elkhorn, and lower South Elkhorn (see Figure 1.2).

South Elkhorn Creek's mainstem is approximately 51.2 miles (82.4 km) long and drains an area of 179.2 mi^2 (464 square kilometers (km^2)). The average gradient is 6 feet/mile (1.1 m/km) except for the lower 13.7 miles (22 km), which have an average gradient of 1 foot/mile (0.2 m/km). Elevations for South Elkhorn Creek range from 900 ft (274 m) above mean sea level (msl) in the headwaters to 650 ft (198 m) above msl at the mouth (Figure 1.2).

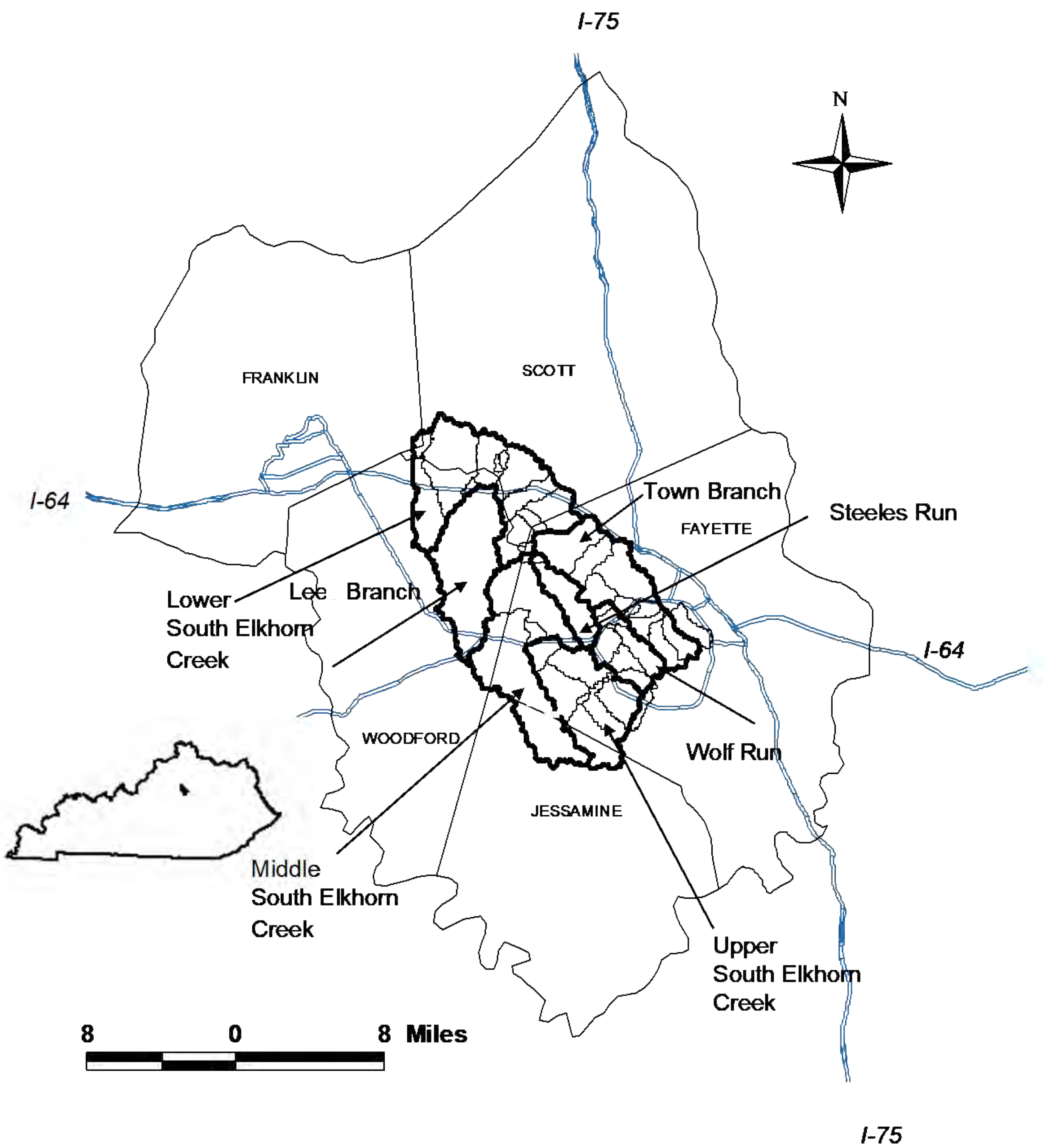

Figure 1.1 Location of South Elkhorn Creek Watershed

Town Branch, a third order stream, originates as an underground stream in central Fayette County and flows northeast to discharge into South Elkhorn Creek 34.0 miles (54.7 km) upstream of its confluence with North Elkhorn Creek. Town Branch serves as the receiving stream for discharge from Lexington's Town Branch wastewater treatment plant. During dry periods, the creek's flow is primarily dominated by the plant's discharge. The mainstem of Town Branch is approximately 11.3 miles (18.2 km) long and drains an area of 36.4 mi^2 (94.3 km^2). The average gradient is 11 feet/mile (2 m/km). Elevations for Town Branch range from 930 ft (284 m) above msl in the headwaters to 790 ft (241 m) above msl at the mouth.

Wolf Run, a third order stream, originates in central Fayette County and flows northwest to discharge into the Town Branch 8.5 miles (13.7 km) upstream from its confluence with South Elkhorn Creek. Wolf Run's mainstem is approximately 4.4 miles (7.1 km) long and drains an area of 10.2 mi^2 (26.4 km^2). The average gradient is 20 feet/mile (3.8 m/km). Elevations for Wolf Run range from 950 ft (290 m) above msl in the headwaters to 860 ft (262 m) above msl at its confluence with Town Branch.

Steeles Run, a third order stream, originates in central Fayette County and flows northwest to discharge into the South Elkhorn Creek 34.2 miles (55.0 km) upstream from its confluence with South Elkhorn Creek. Steeles Run's mainstem is approximately 6.2 miles (9.9 km) long and drains an area of 6.9 mi^2 (17.9 km^2). The average gradient is 22.6 feet/mile (4.3 m/km). Elevations for Steeles Run range from 950 ft (285 m) above msl in the headwaters to 806 ft (242 m) above msl at its confluence with South Elkhorn Creek.

Lee Branch, a third order stream, originates in central Fayette County and flows north to discharge into the South Elkhorn Creek 9.1 miles (14.6 km) upstream of its confluence with North Elkhorn Creek. Lee Branch mainstem is approximately 9.1 miles (14.7 km) long and drains an area of 23.14 mi^2 (59.92 km^2). The average gradient is 17.4 feet/mile (3.3 m/km). Elevations for Wolf Run range from 929 ft (279 m) above msl in the headwaters to 780 ft (234 m) above msl at the confluence with South Elkhorn Creek.

1.3 Catchment Delination

For the purposes of TMDL development, the South Elkhorn watershed has been split into 7 subwatersheds and 45 watershed catchments (see Figure 1.2). This division allows for analysis of pathogen contributions from both point and nonpoint sources within each catchment. The delineation of the watershed was accomplished using the United States Geological Survey's (USGS's) National Hydrography Dataset (USGS, 2003), which was burned into the natural topography based on a 10-meter digital elevation model (DEM) characterization of the watershed. Where necessary, the urban catchments were adjusted to insure they corresponded with human-made transportation boundaries (e.g. New Circle Road) and sewered catchment boundaries.

The South Elkhorn Creek watershed includes several karst features (e.g. sinkholes and springs). An examination of the available karst groundwater basin map from the Kentucky Geological Survey website (www.uky.edu/KGS/water/general/karst/karstgis.htm) shows the majority of groundwater basins within the South Elkhorn Creek watershed are coincident with or contained within their corresponding surface water catchments. In a few cases, runoff from within a delineated catchment exits the overall watershed boundary through a karst feature. To facilitate modeling of the stream system, all surface runoff is assumed to be consistent with surface catchment topology. Additional refinement of the resulting loading allocations may require a more in-depth karst analysis for those particular catchments.

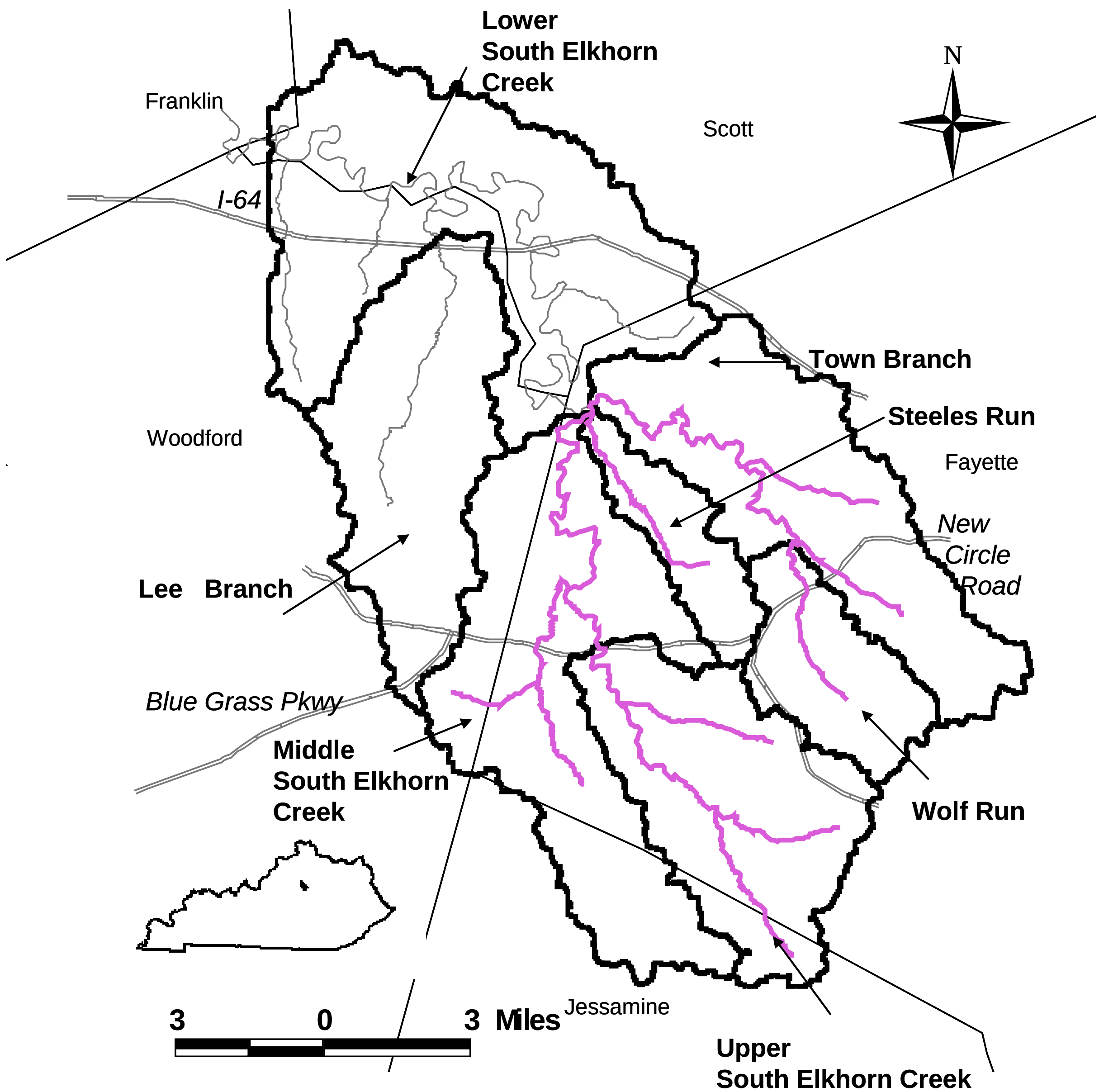

Figure 1.2 South Elkhorn Creek Subwatersheds

1.4 Geologic Information

The South Elkhorn Creek watershed is in the Inner Bluegrass physiographic region. The area is underlain with the Lexington Limestone formation of Ordovician age. The Lexington formation is a thinly bedded shaly limestone, phosphatic in content. The Tanglewood Limestone member of the Lexingon Limestone is exposed in the largest area of the basin and is likely contributing phosphorus to groundwater and surface water. Karst features such as sinkholes and springs dominate the geology. There are also moderate amounts of shale and alluvial deposits in the region (Soil Surveys of Fayette, Franklin, Jessamine, Scott, and Woodford Counties, USDA, 1968, 1977, 1983, 1985).

1.5 Landuse Information

The geology in the South Elkhorn watershed, with its phosphorus rich soils, is conducive to agriculture. The watershed consists of 81% agricultural area, and 19% urban area. The urban area ranges from residential to commercial and industrial tracts. A breakdown of the landuse distribution for each catchment is provided in Table 1.1. These values were derived using the BASINS 3.1 database (EPA, 2004).

1.6 Soils Information

The South Elkhorn Creek watershed is dominated by nearly level to strongly sloping silt loam and silty clay loam. The area is comprised mostly of the Maury, Lowell, and McAfee soils series. The Maury series are deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately rapid. The Lowell series are deep, well drained to moderately drained soils formed from weathered interbedded limestone and calcareous shale. Permeability for this series is moderately slow. The McAfee soil series are moderately deep to deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately low (Soil Surveys of Fayette, Franklin, Jessamine, Scott, and Woodford Counties, USDA, 1968, 1977, 1983, 1985).

1.7 Watershed History

The South Elkhorn Creek watershed contains many natural and cultural landmarks. The streams in the watershed are home to diverse wildlife and vegetation that are unique to the Bluegrass and are excellent for fishing. The streams have supported the agricultural industry in the area through irrigation and livestock watering. Recreationally, the streams provide scenic canoeing and swimming.

The watershed is steeped in historical significance. Lexington can trace its humble beginnings to a settlement near Town Branch. Old gristmills, limestone fences, and other features listed on the National Register of Historic Sites dot the landscape of the South Elkhorn creek system. South Elkhorn Creek, which receives flows from Town Branch, has even drawn the favored observations of writer Walt Whitman (1999).

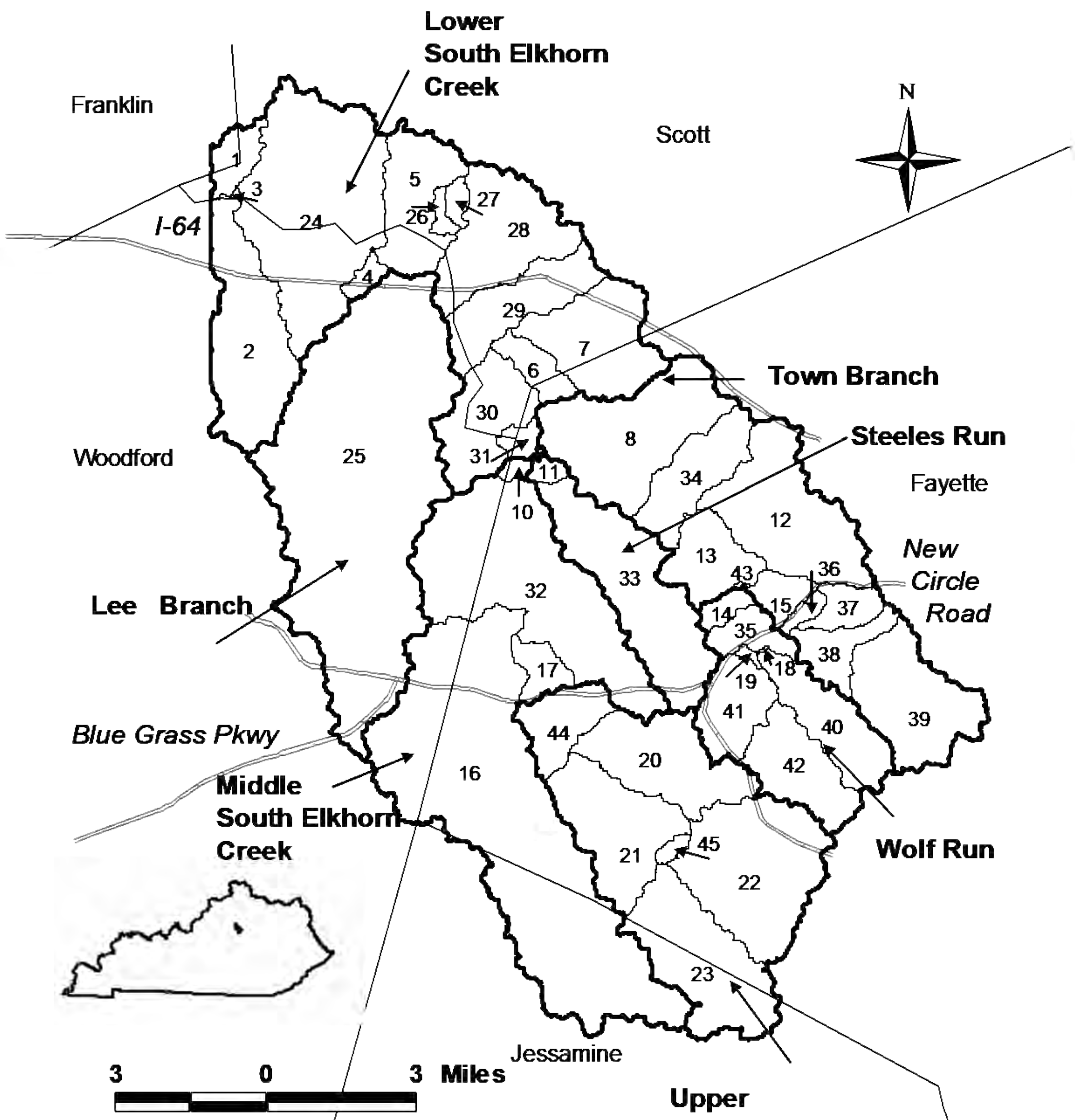

Figure 1.3 South Elkhorn Catchments

Table 1.1 Land Use in Acres in the South Elkhorn Creek Watershed

Catchment	Urban Land		Agricultural Land		Total Area (Acres)
	Area (Acres)	%	Area (Acres)	%	
1	0	0.00	699	100.00	699
2	72	1.90	3720	98.10	3792
3	0	0.00	19	100.00	19
4	38	14.13	231	85.87	269
5	14	0.63	2195	99.37	2209
6	0	0.00	693	100.00	693
7	124	4.46	2657	95.54	2781
8	40	0.96	4108	99.04	4148
9	0	0.00	15	100.00	15
10	20	11.90	148	88.10	168
11	0	0.00	212	100.00	212
12	828	21.59	3007	78.41	3835
13	52	3.44	1458	96.56	1510
14	0	0.00	345	100.00	345
15	330	58.72	232	41.28	562
16	884	6.61	12480	93.39	13364
17	272	43.87	348	56.13	620
18	10	100.00	0	0.00	10
19	68	100.00	0	0.00	68
20	526	18.32	2345	81.68	2871
21	42	1.46	2843	98.54	2885
22	2371	54.18	2005	45.82	4376
23	99	2.77	3476	97.23	3575
24	180	2.65	6624	97.35	6804
25	1007	6.80	13801	93.20	14808
26	14	7.29	178	92.71	192
27	78	33.48	155	66.52	233
28	330	10.89	2700	89.11	3030
29	140	6.78	1924	93.22	2064
30	46	2.14	2104	97.86	2150
31	14	4.56	293	95.44	307
32	440	6.40	6431	93.60	6871
33	391	9.29	3817	90.71	4208
34	148	7.95	1713	92.05	1861
35	322	44.60	400	55.40	722
36	128	58.72	90	41.28	218
37	603	90.27	65	9.73	668
38	981	99.19	8	0.81	989
39	3084	100.00	0	0.00	3084
40	1866	94.39	111	5.61	1977
41	1370	91.03	135	8.97	1505
42	2000	100.00	0	0.00	2000
43	0	0.00	18	100.00	18
44	444	33.11	897	66.89	1341
45	0	0.00	147	100.00	147
Total	19376	18.59	84847	81.41	104223

1.8 Monitoring History

The South Elkhorn creek has been the focus of sampling and monitoring since the late 1960's. There are four USGS stations in the watershed (see Figure 1.4 and Table 1.2). The Lexington Fayette Urban County Government (LFUCG) also maintains an instream gaging station approximately 0.1 mile upstream of the effluent discharge point of the Town Branch Wastewater Treatment Plant (WWTP). LFUGC has been performing pathogen sampling in Town Branch in support of its Kentucky Pollutant Discharge Elimination System (KPDES) Stormwater Permit since 1993. The sampling network includes 16 monitoring stations that are located within the South Elkhorn watershed (see Figure 1.4 and Table 1.3).

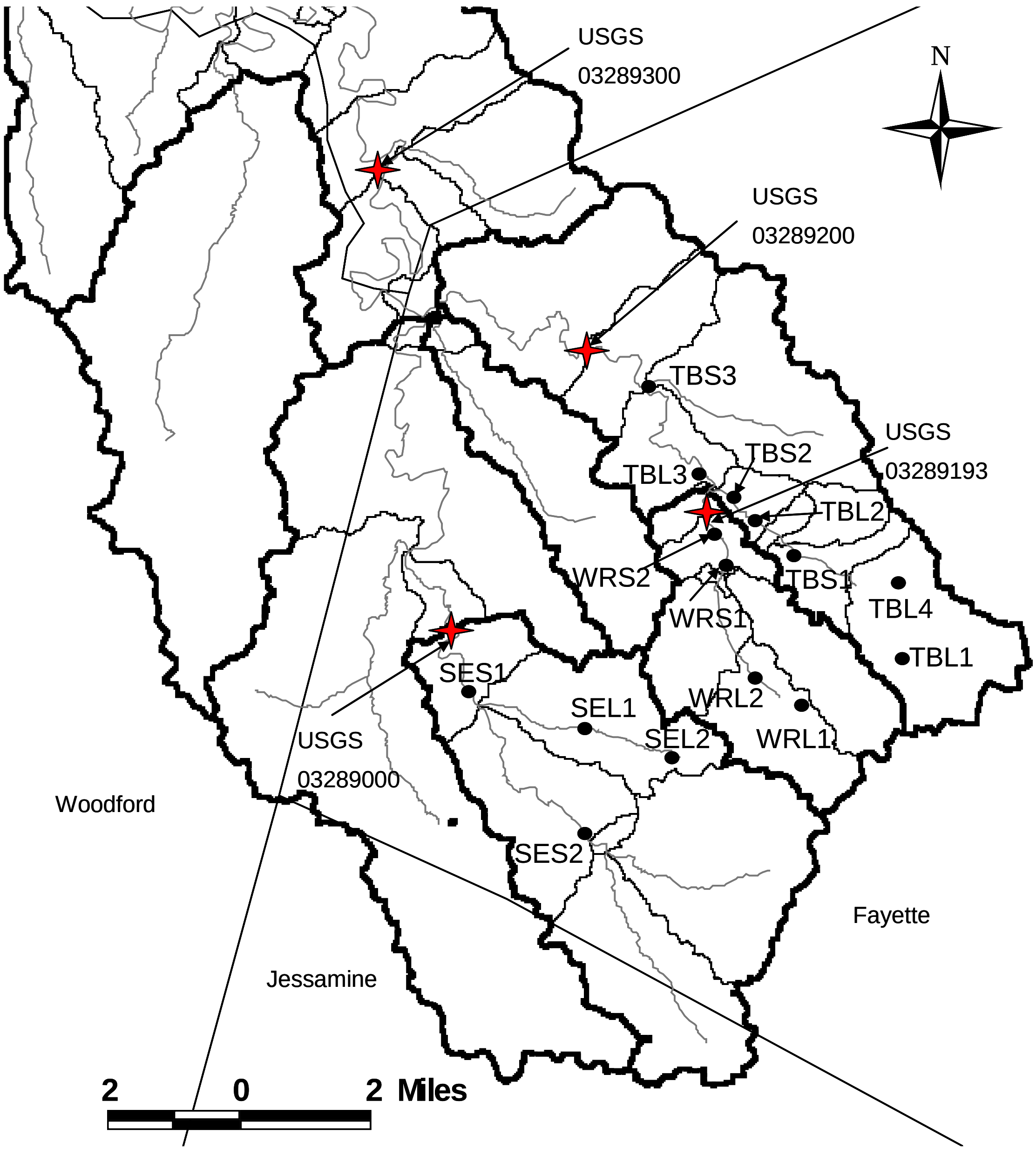

Figure 1.4 LFUCG Stream Gaging/Monitoring Sites

Table 1.2 USGS Streamflow Gaging Stations

Station ID	Station Description	Duration
03289000	South Elkhorn at Fort Springs	1950 - present
03289193	Wolf Run at Old Frankfort Pike	1997 - present
03289200	Town Branch at Yarnallton Road	1997 - present
03289300	South Elkhorn Near Midway	1984 - present

Table 1.3 LFUGC Water Quality Monitoring Stations

Station ID	Station Description	Sampling Dates	Fecal Geometric Mean Cfu/100 ml
TBL1	Mt Vernon	Jun-92 to Dec 97	12,659
TBL2	Leestown Road	Jun-92 to May-98	8,235
TBL3	Viley Road	Jun-92 to Sep-96	4,707
TBL4	Bank One	Nov-97 to Jan-98	5,515
TBS1	TB Above WWTP	Jan-93 to Nov-03	11,427
TBS2	TB Above Wolf Run	May-96 to Nov-03	1,790
TBS3	TB Near Bracktown	May-98 to Nov-03	412
WRL1	Southland Dr	Jun-00 to Jun-01	445,063
WRL2	Cardinal Rd - Composite Sample 1-3	Jul-00 to Jun-01	130,699
WRS1	WR Village Drive	Jun-00 to Nov-03	3,330
WRS2	WR Old Frankfort Pike	May-96 to Nov-03	2,536
SEL1	Harrods Hill-Sample	Nov-99 to Dec-99	570,188
SEL2	Harrods Hill-Sample	Dec-99 to Jan-00	5,511
SES1	SE Parkers Mill Road	May-98 to Nov-03	206
SES2	SE Harrodsburg Road	Jan-00 to Jun-01	160

TB is an abbreviation for Town Branch
WR is an abbreviation for Wolf Run
SE is an abbreviation for South Elkhorn

2.0 PROBLEM DEFINITION

The Kentucky Division of Water's (KDOW's) 2002 and 2004 303(d) list of waters for Kentucky indicates that the South Elkhorn Creek watershed does not support the Primary Contact Recreation (PCR) use due to pathogen. The streams include South Elkhorn Creek (river mile (RM) 16.4 to 34.0), Town Branch (RM 0.0 to 10.3, and RM 10.3 to 11.3), and Wolf Run (RM 0.0 to 4.1). The impaired segments are illustrated in Figure 2.1. Subsequent data collection during the development of this TMDL also revealed impairment on Lee's Branch from RM 0.0 to 8.2, on Steeles Run from RM 0.0 to 4.2, on South Elkhorn Creek from RM 9.3 to 16.4, and on South Elkhorn Creek from RM 34.0 to 49.8. As a consequence, these segments were also included in the development of the TMDL for the entire South Elkhorn watershed

2.1 Target Identification

The goal of this TMDL process is to achieve a numeric pathogen loading within the assimilative capacity of the impaired creek under study that allows for the sustainability of the PCR use. KDOW currently uses fecal coliform as an indicator of the likelihood of pathogen impairment. The Water Quality Standard (WQS) for fecal coliform is in effect during the recreation season from May 1st through October 31st. For this designated use, the Water Quality Criterion states:

Fecal coliform shall not exceed 200 colonies per 100 ml as a monthly geometric mean based on not less than 5 samples per month, nor exceed 400 colonies per 100 ml in 20 percent or more of the samples taken during the month.

Where the geometric mean (GM) of data series of n observations (i.e. y_1, y_2, y_3 …. y_n) can be defined as:

$$GM = \sqrt[n]{y_1.y_2.y_3...y_n} \qquad (1)$$

Thus the instream fecal coliform target for this TMDL is a 30-day geometric mean of 200 colony counts per 100 ml and cannot exceed 400 colonies per 100 ml more than 20% of the time.

2.2 Water Quality Assessment

As demonstrated by Table 1.3, significant fecal coliform contamination exists across the basin. In an attempt to collect more data for the development of this TMDL, instream samples were collected on a weekly basis from May through October 2002 to determine the location and magnitude of potential pathogen sources. A map of the sampled sites is provided in Figure 2.1. A description of the sites is provided in Table 2.1. The pathogen results obtained are shown in Appendix A. Histograms of the resultant geometric means for fecal coliforms measured in Town Branch, Wolf Run, Steeles Run, Lee Branch, and South Elkhorn Creek are shown in Figures 2.3–2.10.

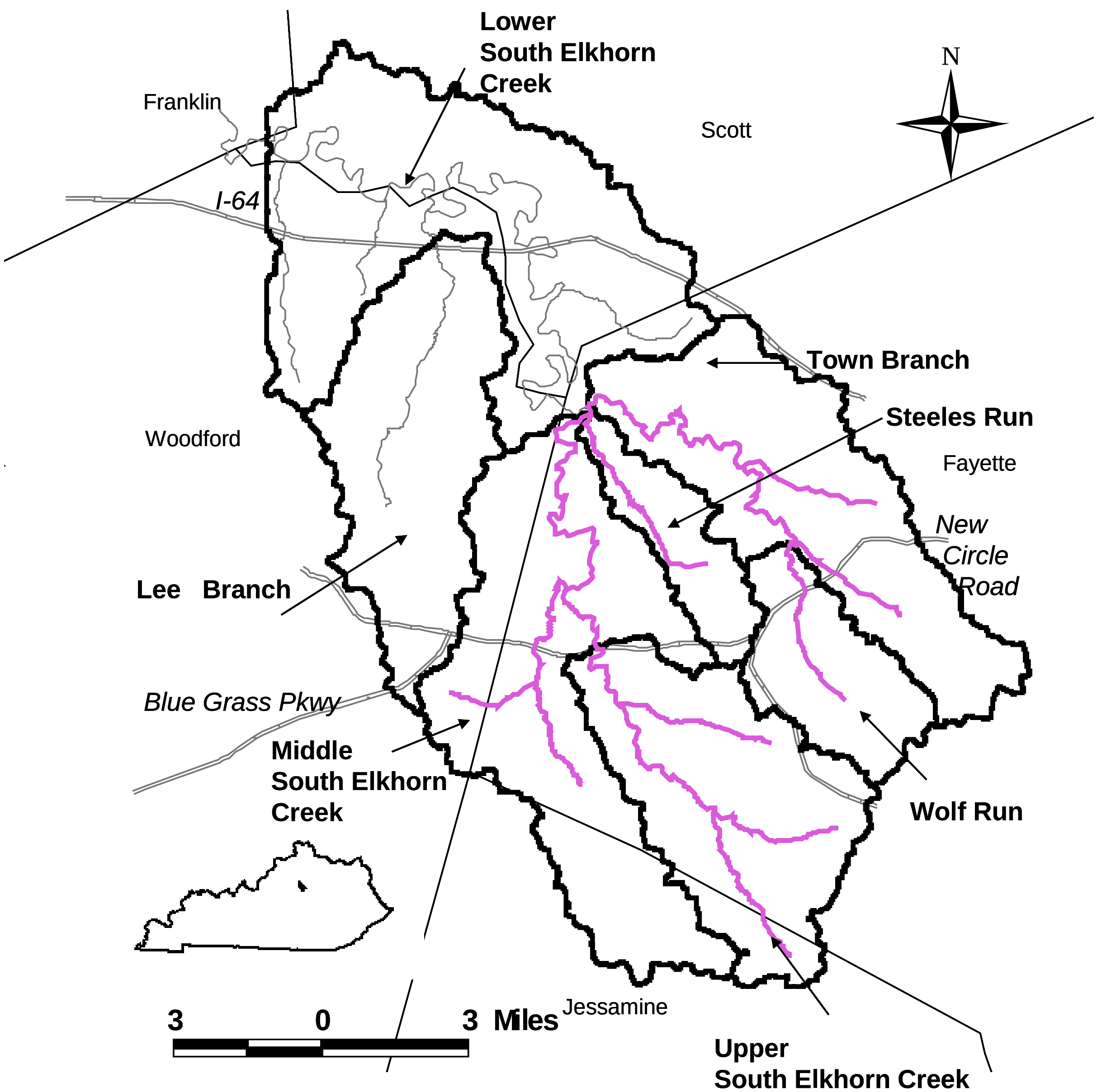

Figure 2.1 South Elkhorn Creek Subwatersheds and 303(d) Impaired Stream Segments

All the streams (South Elkhorn Creek, Town Branch, Wolf Run, Steeles Run, and Lee Branch) failed to meet the designated use criteria for PCR on the basis of the geometric means greater than 200 cfu/ml. In an attempt to differentiate the likely source(s) of the pathogen loads to Town Branch Creek north of the Town Branch WWTP, the samples results were divided between wet and dry days. Based on a statistical analysis of historical rainfall and runoff data for the project area, wet days were characterized as days in which the sum of the current and previous two day rainfall totals were in excess of 0.3 inches. These results are shown in Figure 2.7 to 2.10. The pathogen loads during wet events are significantly higher than dry events, especially for sites T5 and T6. Much of this load can be attributed to sanitary sewer overflow (SSO) discharges into Town Branch Creek from the storm sewer exiting the Rupp Arena Parking lot and from the storm sewer that enters Town Branch Creek at Manchester Street. The Lexington Stockyards are also located immediately upstream of site T5. In addition to Town Branch, the results for Wolf Run were also analyzed for both wet and dry days. These results are shown in Figures 2.9 and 2.10. As can be seen from the figures, the results are higher for wet days. In addition, site W2 exhibits the highest values for the watershed. It should be noted that site W2 is downstream of the University of Kentucky, The Red Mile race track and several subdivisions (e.g. Cardinal Hill, Cardinal Valley, and Pine Meadows). This load may either be due to leaking sanitary sewers in the watershed or runoff from The Red Mile race track, however the frequency and magnitude of the load appear to indicate the load is associated with some type of point source.

Table 2.1 UK-KWRRI Water Quality Monitoring Stations

Station ID	Creek	Stream Mile	Description
T6	Town Branch	11.3	Rupp Arena Parking Lot
T5	Town Branch	10.2	Jimmie Campbell Lane
T3	Town Branch	9.5	Laco Road
T2	Town Branch	8.4	Viley Road
T1	Town Branch	4.1	Yarnallton Road (SR 1977)
W4	Vaughn’s Branch	0.1	Cambridge Drive
W3	Wolf Run	3.0	Gardenside Park
W2	Wolf Run	1.6	Cambridge Drive
W1	Wolf Run	0.5	Old Frankfort Pike (SR 1681)
L1	Lee Branch	0.9	Leestown Road (US 241)
S1	Steeles Run	0.5	Old Frankfort Pike (SR 1681)
E7	South Elkhorn	48.0	Harrodsburg Road (US 68)
E6	South Elkhorn	42.2	Versailles Road (US 60)
E5	South Elkhorn	34.9	Old Frankfort Pike (SR 1681)
E4	South Elkhorn	33.0	Paynes Depot Road (SR 1967)
E3	South Elkhorn	27.4	Leestown Road (US 241)
E2	South Elkhorn	19.6	Midway Pike (SR 341)
E1	South Elkhorn	9.3	Old Frankfort Pike (SR 1685)

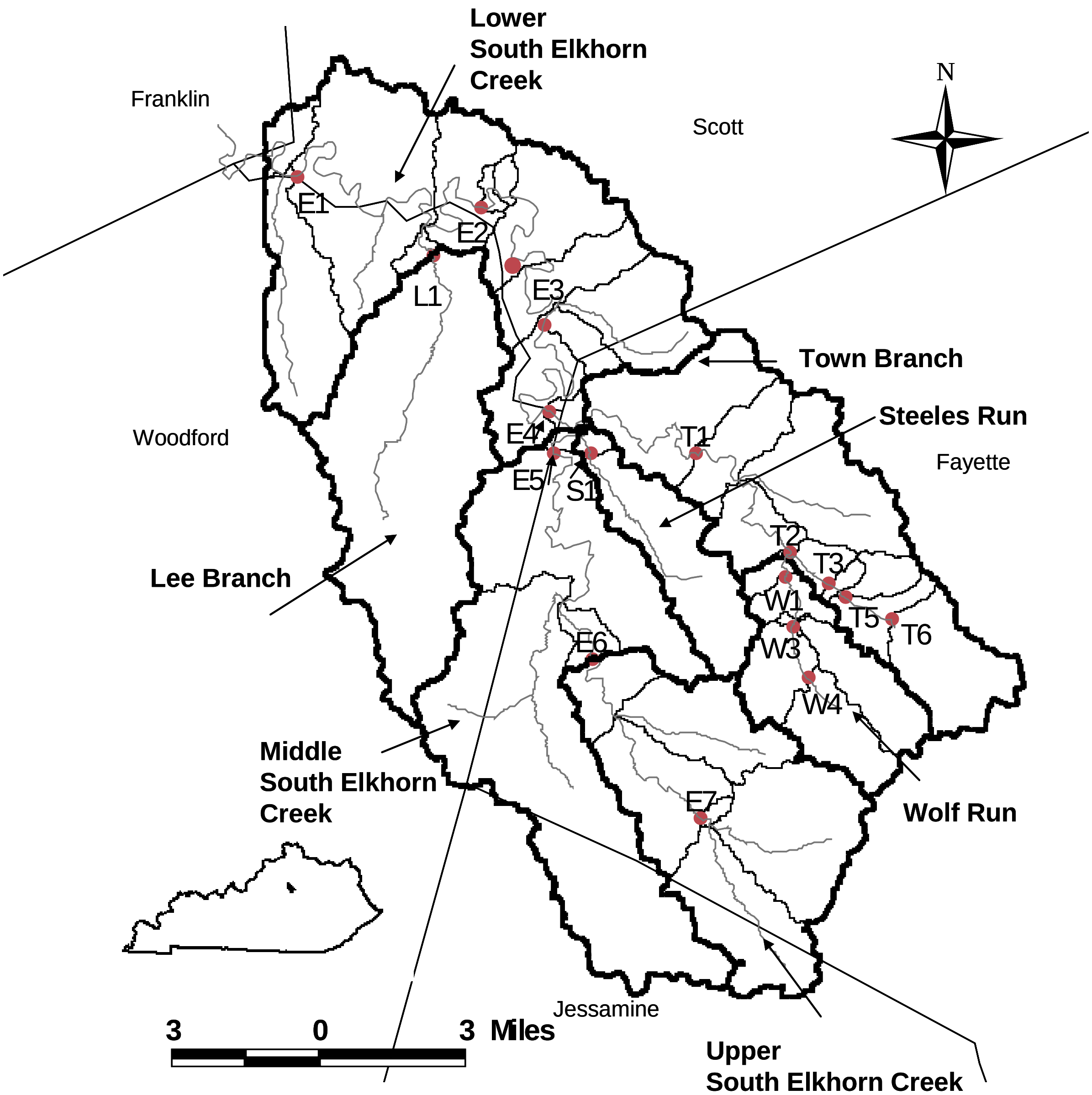

Figure 2.2 South Elkhorn Watershed Sampling Sites

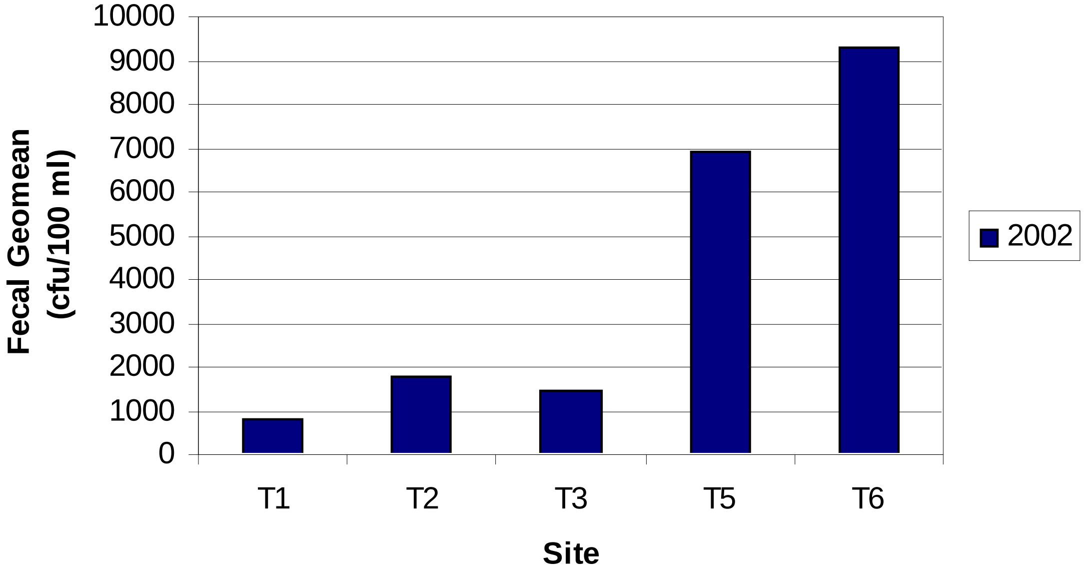

Figure 2.3 Fecal Coliform Geometric Means for Days Sampled in 2002, Town Branch

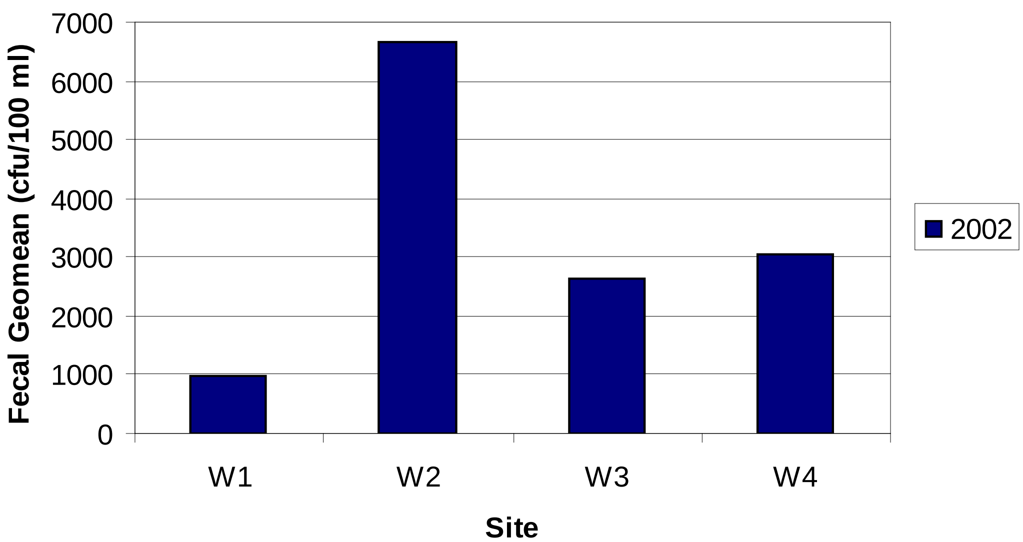

Figure 2.4 Fecal Coliform Geometric Means for Days Sampled in 2002, Wolf Run

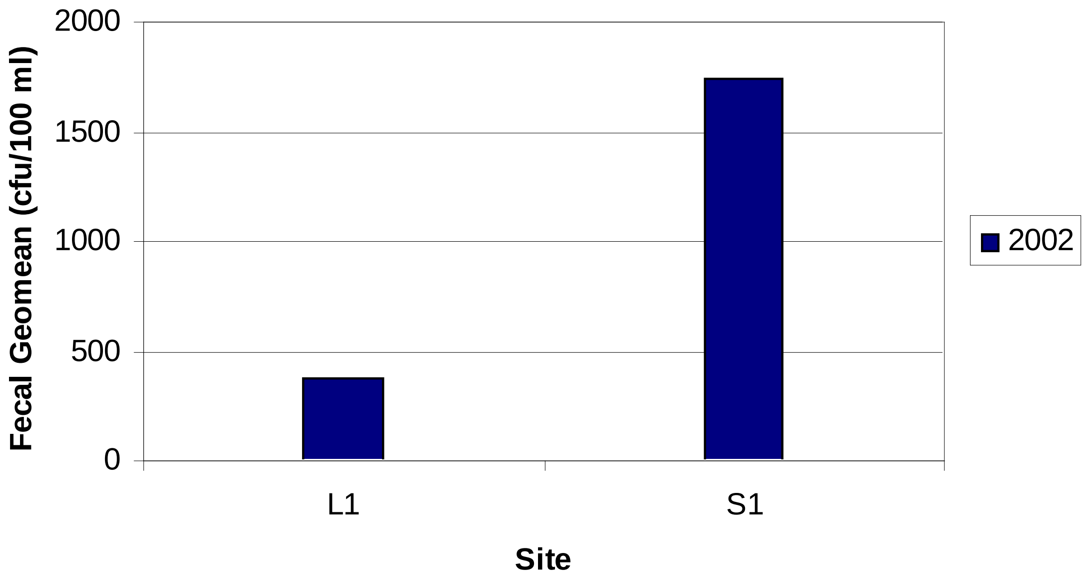

Figure 2.5 Fecal Coliform Geometric Means for Days Sampled in 2002, Steeles Run and Lee Branch

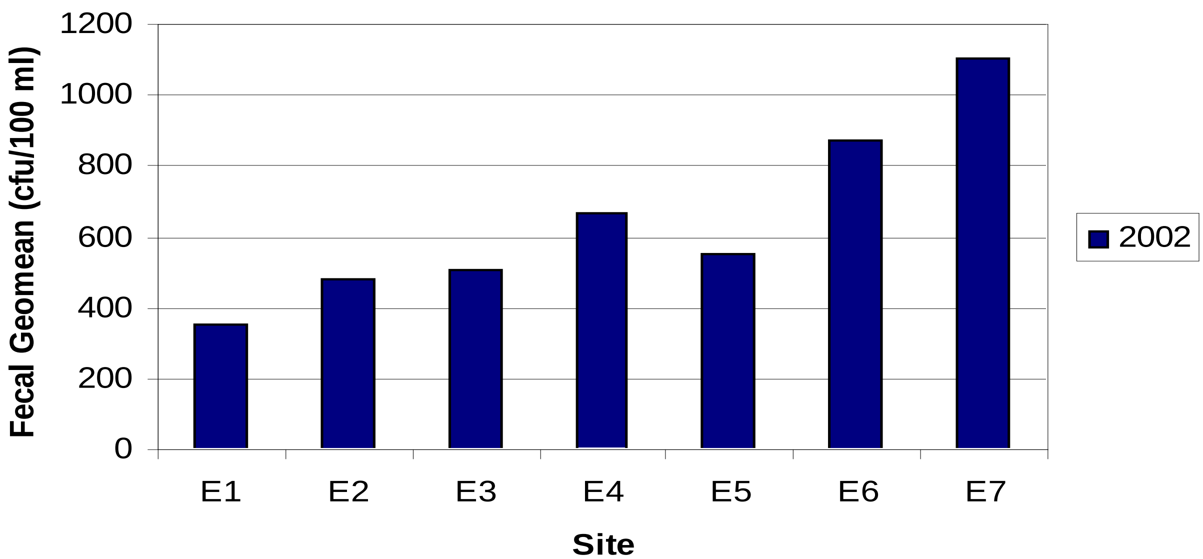

Figure 2.6 Fecal Coliform Geometric Means for Days Sampled in 2002, South Elkhorn Creek

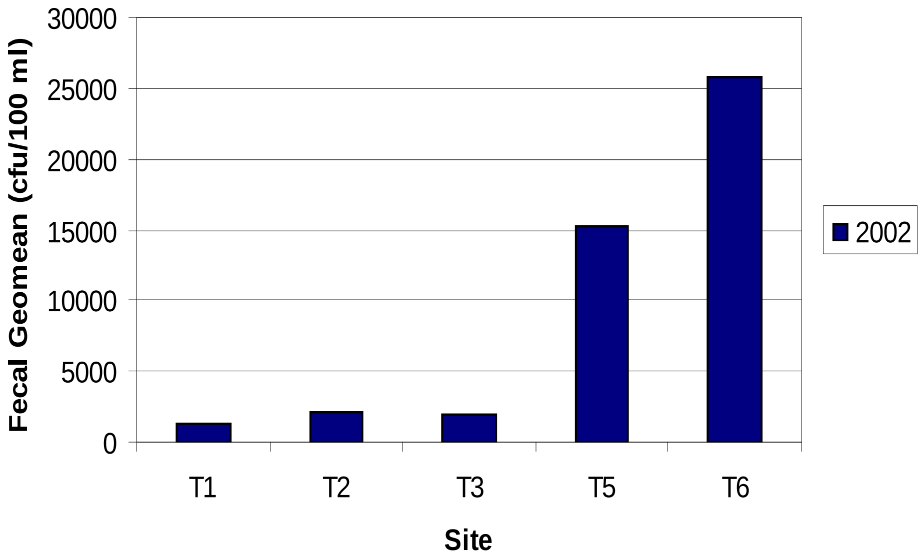

Figure 2.7 Fecal Coliform Geometric Means for Wet Days Sampled in 2002, Town Branch

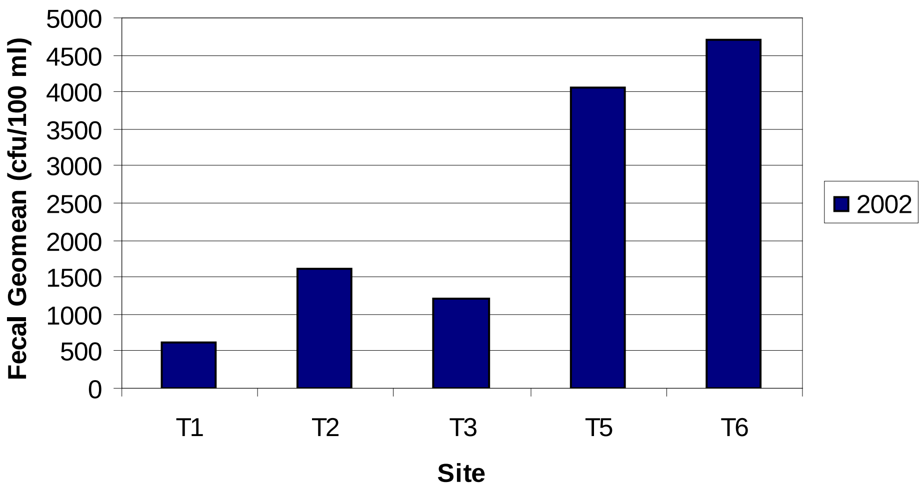

Figure 2.8 Fecal Coliform Geometric Means for Dry Days Sampled in 2002, Town Branch

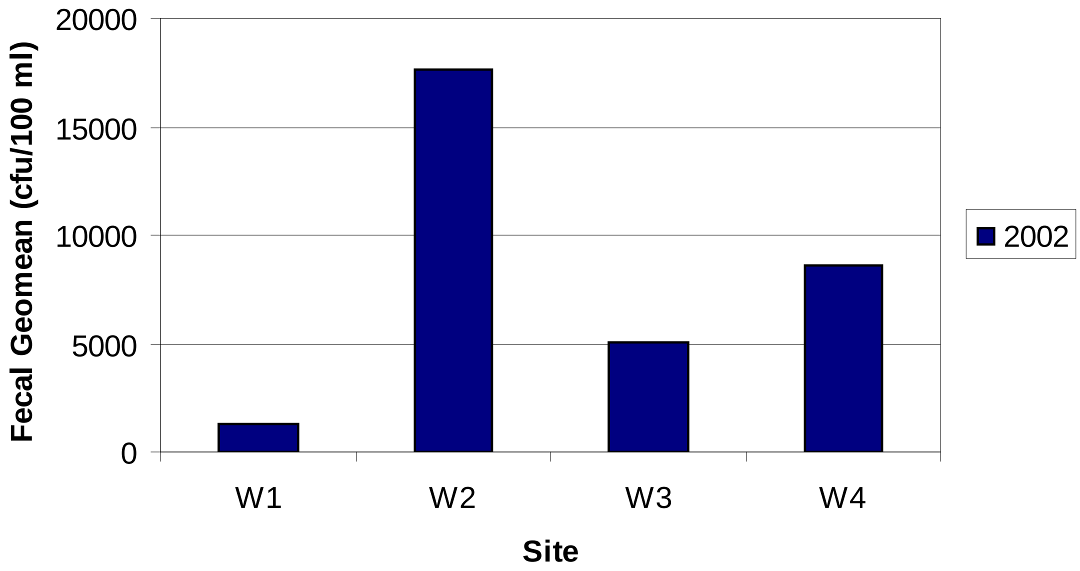

Figure 2.9 Fecal Coliform Geometric Means for Wet Days Sampled in 2002, Wolf Run

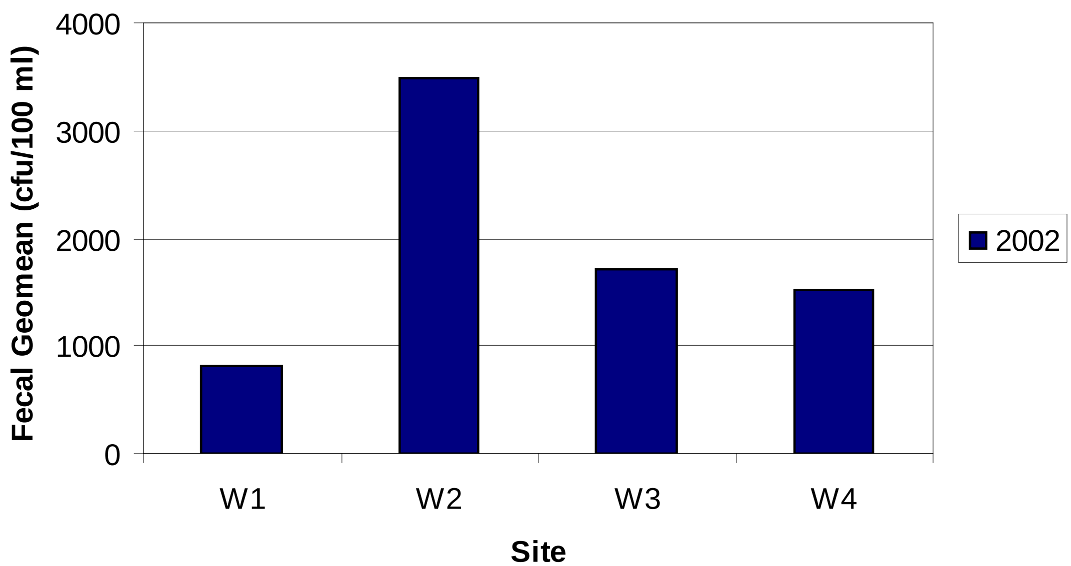

Figure 2.10 Fecal Coliform Geometric Means for Dry Days Sampled in 2002, Wolf Run

3.0 SOURCE ASSESSMENT

Observed instream fecal coliforms in South Elkhorn Creek are attributable to both point and nonpoint sources. Nonpoint sources can be further characterized as permitted MS4 sources and nonpermitted sources. Assessments of each of the two major categories (i.e. point and nonpoint sources) are provided in the following sections.

3.1 Assessment of Point Sources

There are four active KPDES dischargers in the South Elkhorn watershed that are permitted for fecal coliforms. These include 1) the Town Branch Sewage Treatment Plant (KYPDES# KY0021491, 2) the Midway Sewage Treatment Plant, (KYPDES# KY0028410, 3) the Airport Food Mart (KYPDES# KY0083062, 4) and Dance Enterprises Inc. (KYPDES# KY0102610). Estimates of effluent loads were derived using the discharge permit limits, historical discharge monitoring reports (KYDOW, 2003) and information on treatment type (see Table 3.1). A map showing the relative locations of these facilities is provided in Figure 3.1. A map of the locations of the major sanitary sewer trunk mains and pressure mains located within the South Elkhorn watershed that serve the Town Branch wastewater treatment plant is shown in Figure 3.2.

Table 3.1 Inventory of Point Source Discharges

Facility	KPDES Permit	Receiving Waterbody	Design Discharge (mgd)	Permit Limit (cfu/100ml)	2003 Historical Geomean (cfu/100ml)
1.Town Branch Treatment Plant	0021491	Town Branch	30.000	200	18
2. Midway Treatment Plant	0028410	Lee Branch	0.387	200	43
3. Airport Food Mart	0083062	Middle South Elkhorn	0.010	200	83
4.Dance Enterprises Inc	0102610	Middle South Elkhorn	0.040	200	31

In addition to these four permitted point sources, sampling and anecdotal evidence indicates there is an unpermitted point source associated with the large storm sewer which discharges into Town Branch just downstream of Manchester Street and upstream of the Town Branch wastewater treatment plant. Another unpermitted point source discharge from the main storm sewer that drains downtown Lexington and empties into Town Branch just downstream of the Rupp Arena parking lot is also indicated (see Figure 3.3). A major sanitary trunk main to the Town Branch wastewater treatment plant currently runs parallel to both storm sewers, which raises the likelihood of cross connections between the two systems. In addition, the Lexington Stockyards lies immediately downstream of both sites. Because the Lexington Stockyards does not constitute an animal feeding operation, it is not required to have a Confined Animal Feeding Operation (CAFO) permit. As a result, all three potential sources are regulated under Lexington's MS4 stormwater permit.

Recent and historical data suggest the presence of a significant pathogen source in Vaughn Branch of Wolf Run (upstream of site W2). As in the case of Town Branch, a major sewer trunk main runs parallel to the creek. This trunk sewer services Cardinal Valley, Cardinal Hill, and Pine Meadow subdivisions as well as the southern part of the University of Kentucky campus (including the UK medical complex). In addition, the watershed also receives drainage from The Red Mile race track, which is currently regulated under the Lexington MS4 stormwater permit.

In addition to these potential sources, at least 72 sanitary sewer overflows events associated with 22 different manholes were documented in 2003, all of which occurred within the MS4 area. The majority of these sources were associated with headwater streams within the watershed including the Town Branch subwatershed and the Upper South Elkhorn subwatershed (see Figure 3.4). More recently, on December 13, 2007, 30 separate illicit discharges within the South Elkhorn watersheds (including Town Branch and Wolf Run) were documented to have occurred from a combination of sanitary sewer overflows, pump stations overflows, and cross connections with storm sewers (see Figure 3.5 and Table 3.2). At least one of the overflows (the South Elkhorn Pump Station at Bowmans Mill Road) had a discharge in excess of 5 million gallons of sewage.

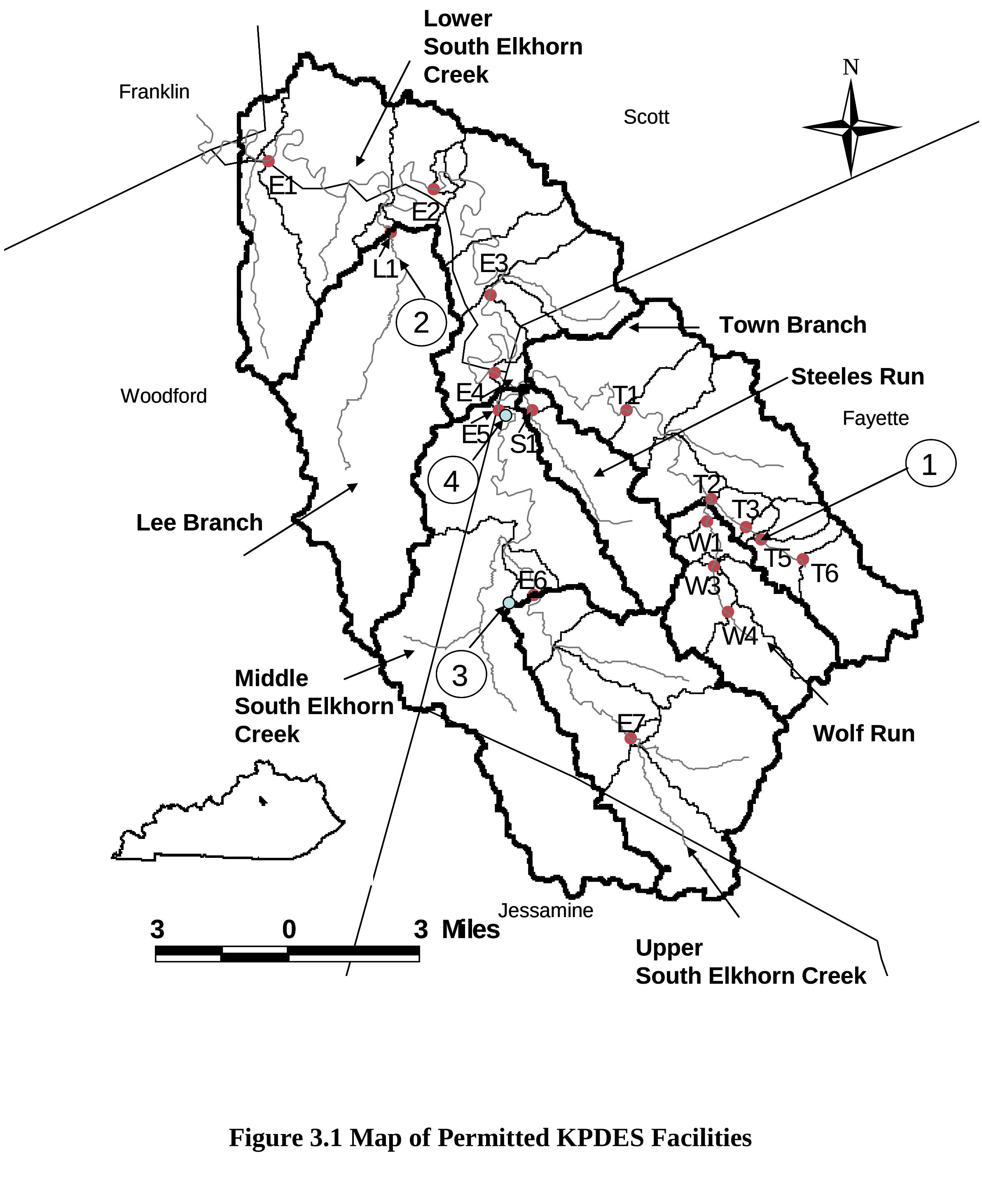

Figure 3.1 Map of Permitted KPDES Facilities

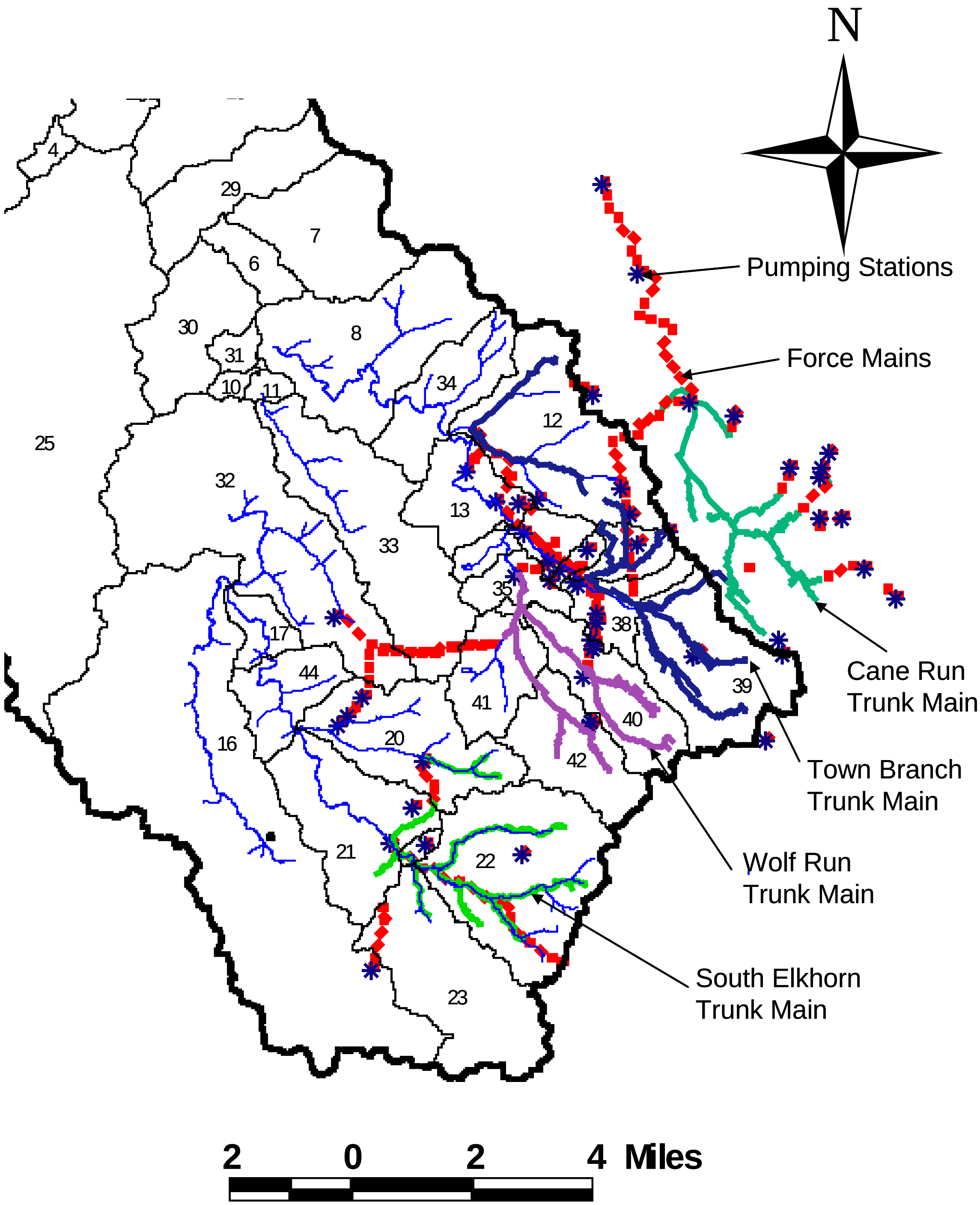

Figure 3.2 Location of Major Sanitary Sewer Trunk Mains and Force Mains

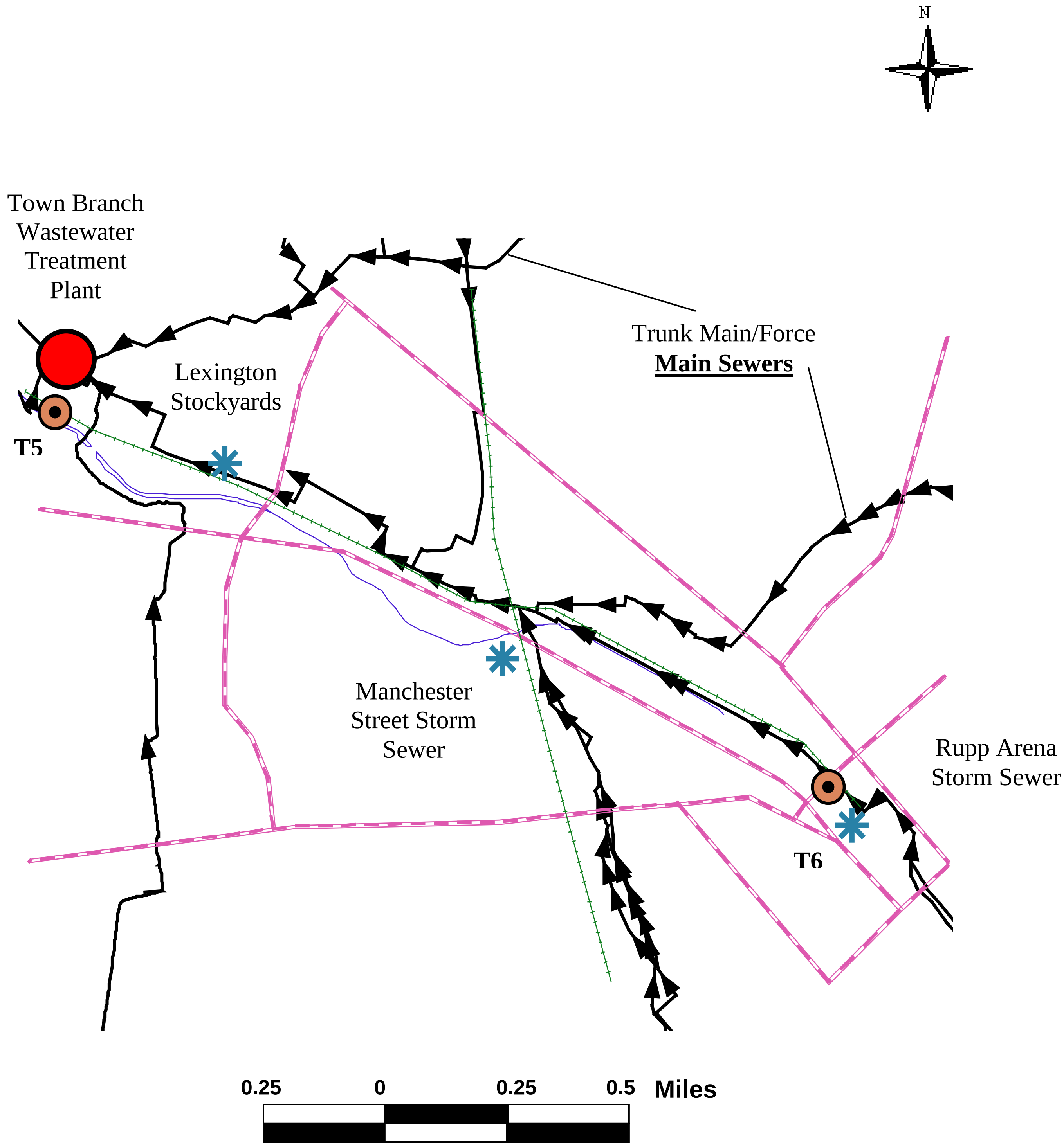

Figure 3.3 Possible Point Sources on Town Branch Creek

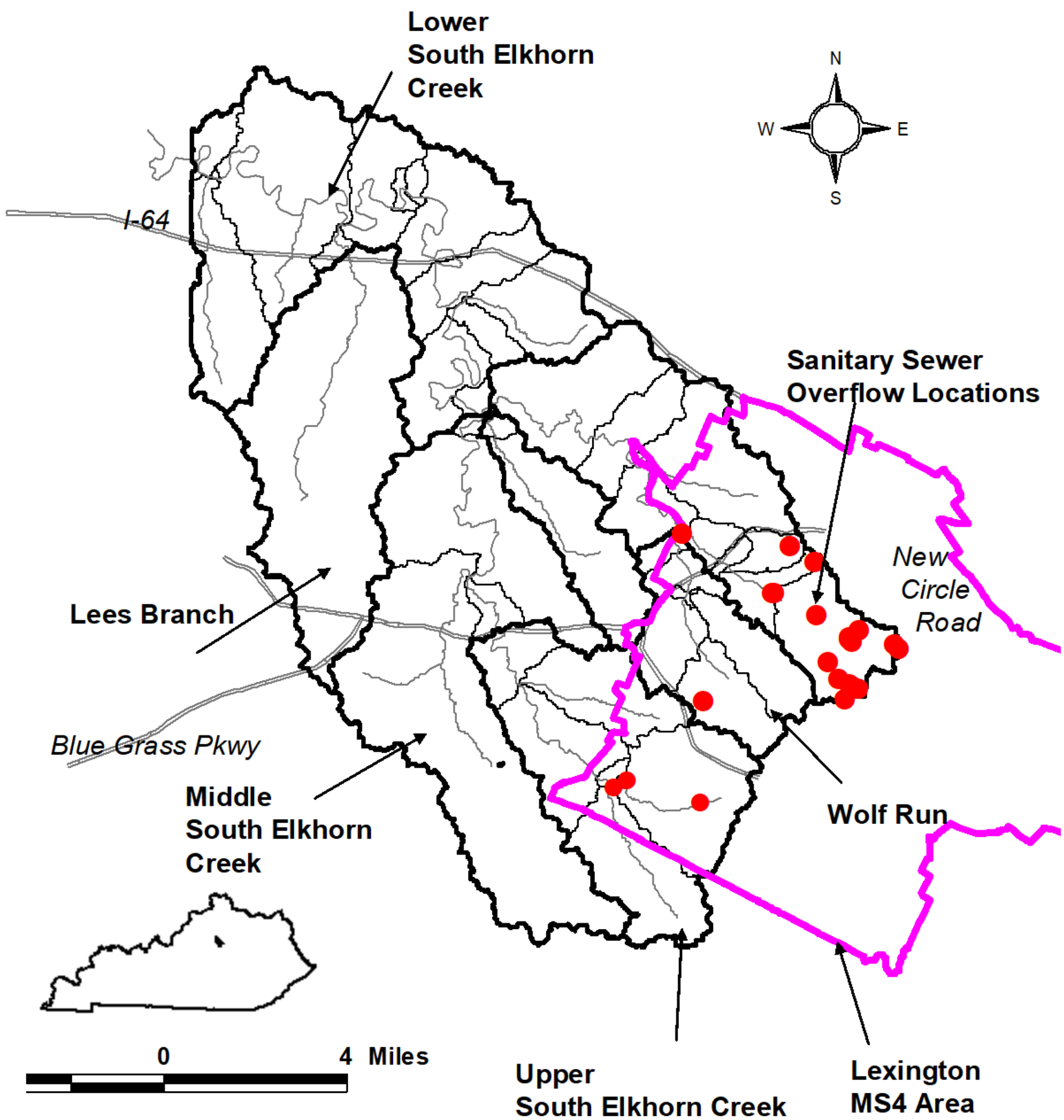

Figure 3.4 Map of Documented Sanitary Sewer Overflows in 2003 (KYDOW, 2007)

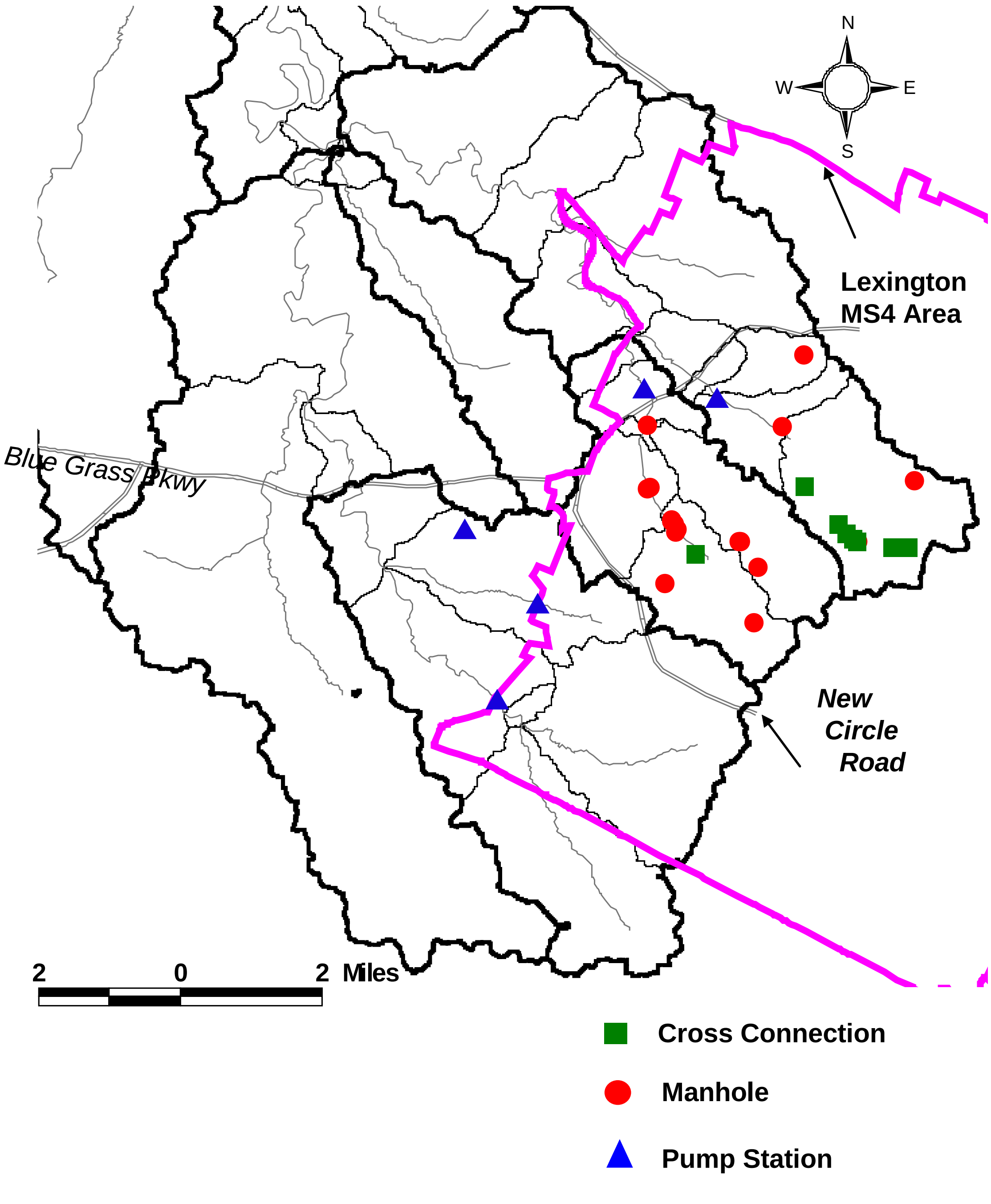

Figure 3.5 Locations of Overflowing Manholes, Pump Stations, and Cross Connections documented to have occurred during 2006 and 2007 (LFUCG, 2008)

Table 3.2 Locations of Overflowing Manholes, Pump Stations, and Cross Connections documented to have occurred during 2006 and 2007 (LFUCG, 2008)

OVERFLOW SOURCE	ESTIMATED RELEASE (MG)	LOCATION
SOUTH ELKHORN WATERSHED		
Pump Station	5,708,600	South Elkhorn, Bowmans Mill Rd.
Pump Station		Mint Lane, Man O War Bld. @ Dunbar H.S.
Pump Station		Bluegrass Field, Bluegrass Airport
TOWN BRANCH WATERSHED		
Cross Connection		410 Rose Lane
Cross Connection		457 Woodland
Cross Connection		146 McDowell Rd.
Cross Connection		1004 Slashes Rd.
Cross Connection		441 Park Ave.
Cross Connection		443 Oldham Ave.
Cross Connection		648 S. Broadway
Manhole		Bamberger Rd.
Manhole		Manchester Ave
Manhole		Nelson Ave.
Manhole		Park Ave.
Pump Station		Town Branch, Old Frankfort Pike
WOLF RUN WATERSHED		
Cross Connection		782 Allendale Dr.
Manhole		Southland Dr.
Manhole	162,000	Bob-O-Link Dr
Manhole	24,000	Bob-O-Link Dr.
Manhole	24,000	Bob O Link Dr.
Manhole		Gettysburg & Yorktown
Manhole		Yorktown & Normandy
Manhole		Holly Springs / Beacon Hill
Manhole		Gardenside Park
Manhole		Gardenside Park
Manhole	97,500	Maywick View.
Manhole	48,000	Maywick View
Manhole		Deauville Dr.
Manhole		Poppy Rd.
Pump Station		Wolf Run, Enterprise Dr.

3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria for South Elkhorn Creek, including:

Failing and properly functioning Onsite Wastewater Treatments Systems OSWTS (i.e., septic systems)
Straight pipes
Wildlife (deer, waterfowl, etc.)
Grazing animals (horses and cows)
Instream loads (horses and cows)
Urban development (including domestic animals)
Keeneland and The Red Mile race tracks
Lexington Stockyards

3.2.1 Onsite Wastewater Treatment Systems

OWTSs include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines, and lack of maintenance may cause septic systems to release wastewater with a high level of fecal coliforms into surface water and groundwater. EPA (2002a) states that properly functioning OWTS can remove pathogens with an efficiency between 99% and 99.9%, after pathogen losses are accounted for in the soil column. Failing OWTS are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, there are failing septic systems in the South Elkhorn Creek watershed. For modeling purposes, the total estimated number of failing septic systems was aggregated and treated as a single source for each subwatershed. The estimated number of failing septic systems per catchment is provided in Table 3.3. These estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, it was assumed that 2.5% of the septic systems were failing (EPA, 2001). Fractional numbers of failing OWTSs were used to calculate loads when generated by the above procedure. However, in Table 3.3, the fractions of failing OWTSs were rounded to the nearest integer.

3.2.2 Straight Pipes

Straight pipes include those "wastewater systems" in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes discharge into South Elkhorn Creek, although the exact number and location are unknown. While straight pipes technically meet the definition of a point sources as defined by 401 KAR 5:002, EPA considers them to be a nonpoint source for load allocation purposes within a TMDL. For modeling purposes, the total estimated number of straight pipes were aggregated and treated as a single source for each subwatershed. The estimated number of straight pipes per catchment is provided in Table 3.3. These estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes.

3.2.3 Wildlife

The South Elkhorn Creek watershed contains deer, raccoons, and other wildlife. In addition, migratory geese and ducks also exist in the watershed. Countywide estimates of the number of the number of deer were obtained from the Kentucky Department of Fish and Wildlife (2005) and distributed to each catchment based on the number of animals in each county and the total number of acres of agricultural land in the catchment. Unfortunately, the Kentucky Department of Fish and Wildlife does not maintain similar data for other wildlife. As a result, estimates of raccoons, beaver, ducks, and geese were obtained using the actual number of deer and the default ratio of the number of these animals to the number of deer as specified in the EPA BIT (EPA, 2001). An estimate of the number of each type of animal per catchment is provided in Table 3.4.

3.2.4 Livestock

Countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). An estimate of the total number livestock in each catchment is provided in Table 3.5.

The manure on pastureland deposited by livestock (grazing cattle, horses, etc.) is washed off and delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. All grazing livestock are assumed to be pastured for grazing throughout the day within a watershed area. Grazing livestock deposit manure directly onto pastureland, which is carried to the nearby stream by runoff. For the purposes of modeling, the fraction of the total daily fecal load from livestock is aggregated and treated as a daily fecal load for each watershed, which then experiences build-up during dry periods and subsequent runoff during wet periods.

When not grazing, animals may be confined to stalls or other confined spaces. In such instances, any generated manure or muck is typically collected into piles (which may or may not be effectively managed) or deposited in remote parts of a farm, sometimes in sinkholes. In some instances the associated manure may be used on-site as fertilizer. In recent years, a few horse farms in the South Elkhorn Creek watershed have begun composting their horse muck prior to application as fertilizer (Oldfield, 2002). For the purposes of modeling, all manure and muck associated with confined spaces are assumed to be evenly distributed over the pastureland. This provides a conservative loading estimate for each catchment.

3.2.5 Cattle and Horse Fecal Contributions (Directly Deposited Instream)

Instream fecal sources include direct deposition of manure from livestock. The land slopes, geographic terrain, and topography of South Elkhorn Creek watershed are such that the cattle and horses can access the intermittent streams that run through the pastureland within a watershed area. For the purposes of modeling it is assumed that the grazing cattle and horses spend 2% of their time standing in the stream (EPA, 2002b). For modeling purposes, the total estimated number of stream deposits were aggregated and treated as a single source for each stream reach modeled in the analysis.

3.2.6 Urban Development (Including Domestic Animals)

Approximately 19% of the total watershed landuse is urban. Urban fecal loading consists primarily of fecal loadings from domestic animals. The total number of acres of urban land per catchment was provided in Table 1.1.

3.2.7 Racetracks

There are two commercial horse racetracks located within the South Elkhorn Creek watershed: Keeneland Racecourse (located in catchment 21) and The Red Mile (located in catchment 40). Estimates of the number of horses housed at both racetracks during the year were obtained by published information and by communication with personnel associated with both racetracks. These estimates are provided in Table 3.6. Muck associated with the racetracks is typically collected in stockpiles that may be held for subsequent transport and disposal. Recently, Keeneland Racecourse made a significant financial investment in their horse muck handling system by installing a biofermenation facility. Unfortunately, the technology has not proved to be viable, and they have now fallen back to use of a contracting service to manage and dispose of their wastes. Currently, both Keeneland Racecourse and The Red Mile employ Creech Services to dispose of their collected horse muck (http://www.creechhay.com/muck.html).

3.2.8 Lexington Stockyards

The Lexington Stockyards are located at 375 Lisle Industrial Avenue in Lexington Kentucky and border Town Branch Creek (see Figure 3.3). The stockyards have been located at this address for over 50 years. Currently, the Lexington Stockyards are the fourth largest (by volume of sales) in the United States. During the peak months of the year (September through November), the stockyards may average 8,000 cattle a week. Normally the livestock are delivered to the stockyards in the morning, sold, and then transported away in the afternoon. Due to the fact that the stockyard is not a slaughterhouse or a feeding operation, but more of a bovine transition center, the stockyard is not considered a CAFO and thus is not required to obtain a discharge permit. Nonetheless, some animal muck is still generated at the site. The current practice is to collect the muck and place it in a stockpile on the banks of Town Branch Creek where it is then picked up by a local contractor for subsequent transport and disposition. The water quality impacts of the associated on-site management system are currently not documented. For the last several years, the Lexington Stockyards has been seeking to move the stockyards from its current location.

Table 3.3 Estimated Number of Failing OWTS and Straight Pipes in Each Catchment

Catchment	Failing Septic System	Straight Pipes
1	2	0
2	12	2
3	0	0
4	1	0
5	7	0
6	2	0
7	8	3
8	13	1
9	0	0
10	0	0
11	1	0
12	10	1
13	5	1
14	1	0
15	1	9
16	40	3
17	1	7
18	0	0
19	0	0
20	7	2
21	9	1
22	6	0
23	11	2
24	21	5
25	44	5
26	1	0
27	0	0
28	9	9
29	6	4
30	7	1
31	1	0
32	20	1
33	12	5
34	5	4
35	1	8
36	1	0
37	1	6
38	1	1
39	0	0
40	1	0
41	1	1
42	0	0
43	1	0
44	3	1
45	0	0
Total	273	83

Table 3.4 Estimated Number of Wildlife in Each Catchment

Catchment	Area (ac)	Ducks	Geese	Deer	Beaver	Raccoons
1	699	69	34	34	7	14
2	3792	206	103	103	21	41
3	19	2	1	1	0	0
4	269	13	6	6	1	3
5	2209	167	83	83	17	33
6	693	45	23	23	5	9
7	2781	174	87	87	17	35
8	4148	58	29	29	6	12
9	15	0	0	0	0	0
10	168	2	1	1	0	0
11	212	3	1	1	0	1
12	3835	42	21	21	4	8
13	1510	21	10	10	2	4
14	345	5	2	2	0	1
15	562	3	2	2	0	1
16	13364	376	188	188	38	75
17	620	5	2	2	0	1
18	10	0	0	0	0	0
19	68	0	0	0	0	0
20	2871	33	16	16	3	7
21	2885	40	20	20	4	8
22	4376	28	14	14	3	6
23	3575	168	84	84	17	34
24	6804	457	229	229	46	91
25	14808	761	380	380	76	152
26	192	15	7	7	1	3
27	233	13	6	6	1	3
28	3030	216	108	108	22	43
29	2064	154	77	77	15	31
30	2150	145	73	73	15	29
31	307	5	3	3	1	1
32	6871	143	72	72	14	29
33	4208	54	27	27	5	11
34	1861	24	12	12	2	5
35	722	6	3	3	1	1
36	218	1	1	1	0	0
37	668	1	0	0	0	0
38	989	0	0	0	0	0
39	3084	0	0	0	0	0
40	1977	2	1	1	0	0
41	1505	2	1	1	0	0
42	2000	0	0	0	0	0
43	18	0	0	0	0	0
44	1323	13	6	6	1	3
45	147	2	1	1	0	0
Total	104205	3474	1737	1737	347	695

Table 3.5 Estimated Number of Livestock in Each Catchment

Catchment	Cattle	Horses	Goats	Chickens
1	87	0	1	2
2	752	225	4	16
3	4	0	0	0
4	54	0	0	1
5	391	142	4	9
6	115	0	1	3
7	432	142	5	13
8	463	355	2	29
9	3	0	0	0
10	33	75	0	1
11	30	71	0	1
12	369	213	1	24
13	163	71	1	11
14	38	142	0	2
15	28	0	0	2
16	2253	1744	77	79
17	68	71	0	4
18	0	0	0	0
19	0	0	0	0
20	195	71	1	13
21	225	213	4	13
22	12	0	1	0
23	469	0	34	16
24	1229	75	10	28
25	2507	1350	13	53
26	34	0	0	1
27	40	0	0	1
28	531	150	5	12
29	366	501	3	8
30	410	0	3	9
31	54	0	1	1
32	1042	876	5	40
33	459	639	2	30
34	200	426	1	13
35	64	142	0	8
36	17	0	0	0
37	12	0	0	0
38	26	0	0	0
39	0	0	0	0
40	0	0	0	0
41	37	0	0	2
42	1	0	0	0
43	2	0	0	0
44	144	71	1	10
45	0	0	0	0
Total	13359	7765	180	455

Table 3.6 Average Monthly Number of Horses at Keeneland and The Red Mile (2004)

Month	Keeneland	The Red Mile
Jan	300	50
Feb	300	50
Mar	300	50
Apr	1500	50
May	300	50
Jun	300	50
Jul	300	50
Aug	300	450
Sep	1700	450
Oct	800	50
Nov	1700	50
Dec	300	50

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

TMDL is a term used to describe the maximum amount of a pollutant a stream can assimilate without violating water quality standards. The units of a load measurement are typically mass of pollutant per unit time (i.e. mg/hr, lbs/day). In the case of fecal coliforms, the load is typically expressed in terms of colonies/day. TMDLs are comprised of the sum of individual Wasteload Allocations (WLAs) for KPDES-permitted point sources, and Load Allocations (LAs) for all other sources (including nonpoint sources and natural background). The sum of these components may not result in an exceedance of Water Quality Standard (WQS) for that watershed. In addition, the TMDL must include a Margin of Safety (MOS), which is either implicit or explicit, that accounts for the uncertainty in the relation between pollutant loads and the water quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \Sigma\,(\text{WLAs}) + \Sigma\,(\text{LAs}) + \text{MOS} \qquad (4.1)$$

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development to allow for the evaluation of management options to achieve desired source load reductions. The link can be established though a range of techniques, from qualitative assumptions to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

4.1 Modeling Framework Selection

EPA guidance (2001) allows TMDLs to be based on either steady state or dynamic water quality models. Steady state models provide predictions for only a single set of environmental conditions. For permitting purposes, steady-state models are applicable for a single "critical" environmental condition that represents an extremely low assimilative capacity. For discharges to riverine systems, critical environmental conditions typically correspond to low flows such as the 7Q10. The assumption behind steady state modeling is that permit limits that are protective of water quality during critical conditions will be protective for the large majority of environmental conditions. However, it is not appropriate to attempt to define a single critical stream flow for wet weather problems that is analogous to the critical (low flow) condition traditionally used with continuous point source discharges. Furthermore, even when continuous simulation is used for point source discharges, the appropriate method of analysis is to examine the model-generated data (receiving water concentrations) in terms of frequency and duration rather than examining concentrations at a single critical flow.

Continuous simulation often generates daily or hourly values of stream flow and pollutant concentrations. With a well-calibrated model, the simulated stream flows and pollutant concentrations are representative of real-world conditions. Continuous simulation, as well as other dynamic modeling approaches, explicitly considers the variability in all model inputs and defines effluent limits in compliance with the associated WQS. This is achieved through selecting a critical period for which load allocations create the most stressful situation. Thus the critical period for TMDL development corresponds to the “worst case” scenario of environmental conditions in the waterbody for which the TMDL for the pollutant will continue to satisfy WQS (USEPA, 2001).

4.2 Critical Period

Because fecal coliforms may be attributable to both point and nonpoint sources, the critical condition used for the modeling and evaluation of stream response was represented by a multi-year period. Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet weather and high surface runoff, while the critical conditions for waters impaired by point sources generally occur during periods of dry weather and low surface runoff. In order to select a critical period for analysis, historical flows from the South Elkhorn station at Midway (USGS gaging station ID 03289300) were analyzed for the twenty-year period from 1983 to 2003. The mean six month average flow (during the primary recreational period) for each year is shown in Figure 4.1 along with the associated 25%, and 75% flow values for all years in the dataset.

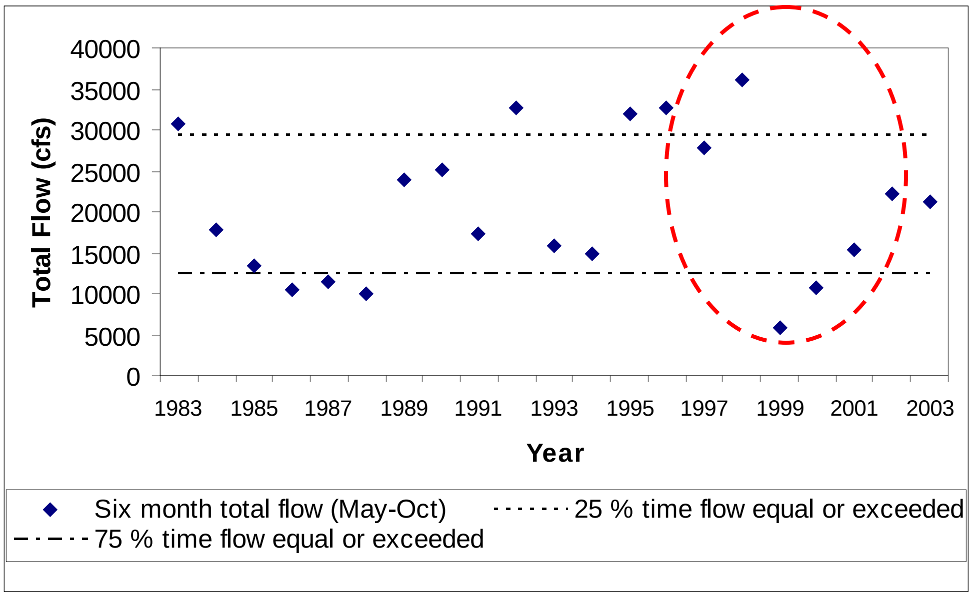

Figure 4.1 Critical Period Assessment Using South Elkhorn Creek Flow Data Observed at Midway

Instead of using the entire 21-year series, a shorter time series from 1997 to 2002 was used for developing the TMDL for South Elkhorn Creek due to the 1997 installation of stream gaging stations on Town Branch (at Yarnallton) and Wolf Run (at Old Frankfort Pike). Examination of Figure 4.1 and Table 4.1 reveals that this 6-year time series captures the same basic range of flows as the 20-year series as well as the extremes of the 20-year series and thus should be sufficient for capturing a range of conditions associated with both wet and dry weather.

Table 4.1 Critical Period Assessment: Comparing Periods 1983 to 1997 and 1998 to 2002

Probability of exceedances	1983 – 1996	1997 – 2002
75%	28.6	16.7
50%	78.6	66.7
25%	42.9	50.0

4.3 Model Selection

In order to model the origin and transport of pathogens through a stream system, some type of hydrologic model is needed. In the current study, the Non-Point Source Model (NPSM) along with the USEPA BASINS modeling environment were used. BASINS is a multipurpose environmental analysis software system for use by regional, state and local agencies in performing watershed and water quality-based studies. A geographic information system (GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landuse, monitoring stations, point source discharges, and stream descriptions. BASINS is useful in incorporating both point and nonpoint sources, while including instream transport and visualization. NPSM is a scaled-down windows versions of the Hydrologic Simulation Program Fortran (HSPF, Bicknell et al, 1997). The NPSM model simulates nonpoint source runoff from selected watersheds as well as the transport and flow of the pollutants through stream reaches.

4.4 Model Setup

The South Elkhorn Creek TMDL model includes the 303(d)-listed section of the creek, as well as the evaluated drainage areas within the basin. All upstream contributors of bacteria are accounted for in the model. This watershed was divided into 45 catchments in an effort to isolate the major stream reaches in the South Elkhorn Creek watershed. This subdivision allowed the relative contribution of point and nonpoint sources to be addressed within each subwatershed.

4.5 Point Source Representation

4.5.1 KPDES-Permitted Sources

Point sources were represented in the model using a total discharge and an associated fecal coliform concentration. For the purposes of modeling point source impacts into South Elkhorn Creek, two different potential sources were considered: permitted facilities and sanitary sewer overflows. For the purposes of modeling the permitted facilities shown in Table 3.1, a conservative fecal coliform effluent concentration of 200 cfu/100 ml was assumed. This is equal to the current permit limit but significantly higher than historically observed values, thus providing an explicit margin of safety associated with the load or nonpoint allocations.

4.5.2 Catchment 39

A significant portion of the pathogen loading to Town Branch Creek appears to originate somewhere between the Rupp Arena Parking lot and the Town Branch Wastewater treatment plant. Potential sources include leaking sewers along the creek, cross connections with the Manchester Street and Rupp Arena stormwater sewers or possibly the Lexington Stockyards. In the model, the aggregate load from all potential sources was treated as a point source associated with catchment 39 (downtown Lexington). The daily point load for this basin was estimated during the model calibration process by adjusting the load until the predicted instream fecal coliform concentration replicated the daily loading observed at sites T5 and T6.

An artificial neural network (ANN) computer model was developed for estimating the point source load at Reach 39. The ANN model was calibrated using the available fecal observations to estimate the point source load from the storm sewers during high rainfall days. Previous five-day rainfall values were used as input data to obtain a fecal load value. A threshold value of antecedent rainfall magnitude of 0.25 inches was decided based on the available observations above which significant fecal load increases were noticed. The point load contribution to the creek at Reach 39 was implemented in the model only on those days satisfying the above criterion. The monthly average loads are presented in Table 4.2.

Table 4.2 Assumed Monthly Point Source Load for Catchment 39

Month	Fecal Loading Counts/day
Jan	7.61E+13
Feb	7.38E+13
Mar	1.63E+14
Apr	8.80E+13
May	1.06E+14
Jun	9.22E+13
Jul	7.86E+13
Aug	2.44E+13
Sep	3.91E+13
Oct	4.03E+13
Nov	3.41E+13
Dec	6.81E+13
Annual Average	7.36E+13

4.5.3 Catchment 40

As with Catchment 39 (in Town Branch), it appears that Catchment 40 (in Vaughn's Branch of Wolf Run) contains a pathogen source that is much higher than would normally be associated with nonpoint sources. In the model, the additional observed load was treated as a point source. The daily point load for this basin was estimated during the model calibration process by adjusting the load until it replicates the daily loading observed at site W2.

Similar to Catchment 39, an artificial neural network (ANN) computer model was developed for estimating the point source load for Catchment 40. The ANN model was calibrated using the available fecal observations to estimate the point source load from the storm sewers during high rainfall days. Previous five-day rainfall values were used as input data to obtain the fecal load value. A threshold value of antecedent rainfall magnitude of 0.25 inches was decided based on the available observations above which significant fecal load increases were noticed. The point load contribution to the creek from Catchment 40 was implemented in the model only on those days satisfying the above criterion. The monthly average loads are presented in Table 4.3.

Table 4.3 Assumed Monthly Point Source Load for Catchment 40

Month	Fecal Loading Counts/day
Jan	3.99E+12
Feb	3.85E+12
Mar	8.40E+12
Apr	5.71E+12
May	5.99E+12
Jun	5.91E+12
Jul	5.04E+12
Aug	2.06E+12
Sep	2.54E+12
Oct	2.34E+12
Nov	1.87E+12
Dec	3.57E+12
Annual Average	4.27E+12

4.6 Nonpoint Source Representation

Several different types of non-point sources of fecal coliforms were considered in the model. These included failing OWTSs, straight pipes, instream loads from livestock, loads from grazing livestock, land application of manure from dairy cattle, wildlife, urban development, and racetracks. The specific loadings for each watershed were determined using the EPA's Bacterial Indicator Tool - BIT (EPA, 2001), which is a spreadsheet used to estimate point and nonpoint loads as a function of both physical and demographic data associated with each catchment. Separate unit loading factors were determined for the major nonpoint source categories which were then aggregated into a total unit load per watershed.

4.6.1 Straight Pipes and Failing OWTS

For the purposes of modeling, the assumed daily discharge from an individual straight pipe was 200 gallons and the assumed fecal concentration was 10^6 cfu/100 ml. The assumed daily discharge from an individual failing OWTS or septic system was 70 gallons (Horsely & Whitten, 1996, EPA, 2001b) and the assumed fecal coliform concentration was 10^4 cfu/100 ml (Horsely & Whitten, 1996).

For modeling purposes, the total estimated number of failing OWTSs and straight pipes were aggregated and treated as a single source for each subwatershed modeled in the analysis. For the purposes of this study, it was assumed that 2.5% of the OWTSs were failing (EPA, 2001a) and that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. The resulting catchment loads for straight pipes and OWTSs is shown in Table 4.4.

4.6.2 Instream Loads from Horses and Cattle

The number of cattle and horses in each catchment were estimated using annual Kentucky agricultural statistics as well as communication with local officials. For the purposes of modeling, cattle were assumed to be in the streams 2% of the day (EPA 2002b). When cattle are standing in a stream, their fecal coliform production is estimated as flow in cubic feet per second and a concentration in cfu per hour. The fecal coliform concentration is calculated using the number of cows in the stream and a bacteria production rate of 3.75E+09 cfu/animal/day (Metcalf and Eddy, 1991). Although horses are not known to readily stand in streams as cattle do, the conservative assumption was made that horses also spend 2% of their time in streams. Similarly for horses, a bacteria production rate of 4.18E+08 (NCSU, 1994) cfu/animal/day is used.

Table 4.4 Initially Assumed Nonpoint Source Loads from Straight Pipes, Cattle in Streams and Failing OWTS by Catchment

Catchment	Livestock in Streams (counts per day)	Straight Pipes (counts/day)	Failing OWTS (counts/day)	Total Load (counts/day)
1	5.07E+09	0	5.56E+08	5.63E+09
2	4.39E+10	1.51E+10	2.96E+09	6.20E+10
3	2.33E+08	0	15108869	2.48E+08
4	3.12E+09	0	1.84E+08	3.31E+09
5	2.28E+10	0	1.75E+09	2.45E+10
6	6.70E+09	0	5.51E+08	7.25E+09
7	2.52E+10	2.27E+10	2.11E+09	5.00E+10
8	2.70E+10	7.57E+09	3.27E+09	3.78E+10
9	1.72E+08	0	11927255	1.84E+08
10	1.93E+09	0	1.18E+08	2.05E+09
11	1.72E+09	0	1.69E+08	1.89E+09
12	2.15E+10	7.57E+09	2.39E+09	3.15E+10
13	9.49E+09	7.57E+09	1.16E+09	1.82E+10
14	2.19E+09	0	2.74E+08	2.46E+09
15	1.64E+09	6.81E+10	1.84E+08	7.00E+10
16	1.31E+11	2.27E+10	9.92E+09	1.64E+11
17	3.95E+09	5.3E+10	2.77E+08	5.72E+10
18	0.00E+00	0	0	0.00E+00
19	1.91E+04	0	0	1.91E+04
20	1.14E+10	1.51E+10	1.86E+09	2.84E+10
21	1.31E+10	7.57E+09	2.26E+09	2.29E+10
22	7.11E+08	0	1.59E+09	2.31E+09
23	2.74E+10	1.51E+10	2.76E+09	4.53E+10
24	7.17E+10	3.79E+10	5.27E+09	1.15E+11
25	1.46E+11	3.79E+10	1.1E+10	1.95E+11
26	2.01E+09	0	1.42E+08	2.15E+09
27	2.32E+09	0	1.23E+08	2.44E+09
28	3.09E+10	6.81E+10	2.15E+09	1.01E+11
29	2.13E+10	3.03E+10	1.53E+09	5.31E+10
30	2.39E+10	7.57E+09	1.67E+09	3.32E+10
31	3.12E+09	0	2.33E+08	3.35E+09
32	6.08E+10	7.57E+09	5.11E+09	7.35E+10
33	2.68E+10	3.79E+10	3.04E+09	6.77E+10
34	1.17E+10	3.03E+10	1.36E+09	4.33E+10
35	3.73E+09	6.06E+10	3.18E+08	6.46E+10
36	1.00E+09	0	71568328	1.07E+09
37	7.01E+08	4.54E+10	51688237	4.62E+10
38	1.51E+09	7.57E+09	6361629	9.09E+09
39	0.00E+00	0	0	0.00E+00
40	0.00E+00	0	88267604	8.83E+07
41	2.15E+09	7.57E+09	1.07E+08	9.83E+09
42	6.53E+07	0	0	6.53E+07
43	1.17E+08	0	14313666	1.31E+08
44	8.41E+09	7.57E+09	7.13E+08	1.67E+10
45	2.07E+07	0	1.17E+08	1.38E+08
Total	7.79E+11	6.28E+11	6.75E+10	1.47E+12

4.6.3 Grazing Livestock

The model assumes that the manure produced by grazing livestock is evenly spread on pastureland throughout the year. The livestock count per county is based upon the 2002 Census of Agriculture data (Kentucky Agricultural Statistics, 2002). The county livestock count is used to estimate the number of livestock on a subwatershed scale. This is calculated by multiplying the county livestock figures by the area of the county within the subwatershed boundaries. This assumes livestock are uniformly distributed throughout the county.

The associated fecal loadings for different kinds of livestock (i.e. cattle, horses, etc.) were obtained using the EPA BIT (EPA, 2001a). For example, the fecal coliform loading due to manure produced by grazing cattle was estimated by multiplying the number of grazing cattle by a fecal coliform production of 3.75E+09 cfu/day/animal (EPA, 2001a). Likewise, the fecal coliform loading due to manure produced by grazing horses was estimated by multiplying the number of grazing horses by a fecal coliform production of 4.18E+09 cfu/day/animal (EPA, 2001a).

4.6.4 Land Application of Manure

There are no permitted CAFOs in the South Elkhorn watershed. Nonetheless, there are small confined feeding operations. Application of waste produced by animals such as cattle, horses and poultry during confinement is applied as manure in agricultural lands. The annual production of manure is calculated from animal statistics. Percentage of manure applied during December to February is less than for the remainder of the year. The application of manure for different animals are handled using EPA BIT tool (EPA, 2001a). Once calculated, these loads were added to the loads associated with grazing livestock to arrive at a total livestock load. These aggregate loads are shown in Table 4.5.

4.6.5 Wildlife

The estimated number of deer, by county, were obtained from the Kentucky Department of Fish and Wildlife and distributed to each catchment based on the total number of acres of forest and pastureland in the catchment. Estimates of additional wildlife and fecal loadings, were obtained using published ratios from the EPA's BIT (EPA, 2001a). Fecal load from ducks, geese, deer, beaver and raccoons were estimated as 3.80E+07, 3.83E+08, 3.91E+06, 3.91E+05 and 3.91E+05 respectively. The total wildlife load per catchment is provided in Table 4.5.

4.6.6 Urban Land (Domestic Pets)

The South Elkhorn Creek watershed includes 19% urban landuse. In the model, fecal coliforms are assumed to build up during dry periods and then wash off during wet periods. Fecal coliform buildup rates for urban areas were determined using EPA's BIT (EPA, 2001a). For fecal modeling, the urban buildup area is classified into four groups namely 1) commercial and services, 2) mixed urban or build-up, 3) residential and 4) transportation-communication-utilities. For each group, fecal accumulation rates of 6.21E+06, 1.13E+07, 1.67E+07, 2.00E+05 cfu/acre/day (Horner, 1992) were adopted. The resulting loads for each catchment are shown in Table 4.5.

Table 4.5 Daily Nonpoint Loads by Subbasin

Catchment	Wildlife Total Load (counts/day)	Livestock Loads (counts/day)	Urban Land Builtup Area Load (counts/day)	Total (counts/day)
1	1.60E+10	2.73E+12	0.00E+00	2.75E+12
2	4.76E+10	2.81E+13	1.44E+07	2.81E+13
3	3.64E+08	1.08E+11	0.00E+00	1.08E+11
4	2.96E+09	1.71E+12	7.58E+06	1.71E+12
5	3.86E+10	1.40E+13	2.21E+08	1.40E+13
6	1.05E+10	3.76E+12	0.00E+00	3.77E+12
7	4.04E+10	1.52E+13	5.96E+08	1.52E+13
8	1.34E+10	1.76E+13	6.47E+08	1.76E+13
9	4.88E+07	7.93E+10	0.00E+00	7.93E+10
10	4.82E+08	1.33E+12	3.35E+08	1.33E+12
11	6.90E+08	1.22E+12	0.00E+00	1.22E+12
12	9.79E+09	1.37E+13	6.40E+09	1.37E+13
13	4.75E+09	5.89E+12	8.71E+08	5.90E+12
14	1.12E+09	1.79E+12	0.00E+00	1.79E+12
15	7.55E+08	8.83E+11	1.61E+09	8.85E+11
16	8.69E+10	8.57E+13	1.21E+10	8.58E+13
17	1.13E+09	2.46E+12	3.19E+09	2.46E+12
18	0.00E+00	0.00E+00	1.67E+08	1.67E+08
19	0.00E+00	0.00E+00	1.11E+09	1.11E+09
20	7.63E+09	7.11E+12	3.64E+09	7.12E+12
21	9.25E+09	8.73E+12	4.65E+08	8.74E+12
22	6.53E+09	5.29E+11	3.24E+10	5.68E+11
23	3.90E+10	1.58E+13	1.37E+09	1.58E+13
24	1.06E+11	4.33E+13	8.60E+08	4.34E+13
25	1.76E+11	9.69E+13	1.04E+10	9.71E+13
26	3.41E+09	1.06E+12	2.34E+08	1.06E+12
27	2.97E+09	1.19E+12	1.31E+09	1.19E+12
28	5.00E+10	1.88E+13	3.38E+09	1.89E+13
29	3.57E+10	1.45E+13	5.31E+08	1.45E+13
30	3.36E+10	1.44E+13	7.70E+08	1.44E+13
31	1.23E+09	1.68E+12	2.34E+08	1.68E+12
32	3.32E+10	4.20E+13	2.46E+09	4.20E+13
33	1.24E+10	1.86E+13	3.96E+09	1.86E+13
34	5.58E+09	8.64E+12	1.91E+09	8.65E+12
35	1.30E+09	2.65E+12	2.08E+09	2.65E+12
36	2.93E+08	5.01E+11	1.84E+09	5.03E+11
37	2.12E+08	3.43E+11	7.51E+09	3.51E+11
38	2.60E+07	6.76E+11	9.21E+09	6.85E+11
39	0.00E+00	0.00E+00	3.92E+10	3.92E+10
40	3.61E+08	3.07E+11	2.21E+10	3.29E+11
41	4.39E+08	1.10E+12	1.84E+10	1.12E+12
42	0.00E+00	0.00E+00	2.78E+10	2.78E+10
43	5.86E+07	5.40E+10	0.00E+00	5.41E+10
44	2.92E+09	5.16E+12	1.23E+09	5.16E+12
45	4.78E+08	1.85E+10	0.00E+00	1.90E+10
Total	8.04E+11	5.00E+14	2.21E+11	5.01E+14

4.6.7 Racetracks

Monthly loads associated with both racetracks were calculated using EPA's BIT (EPA, 2001a) based on the estimated number of horses at each track as provided in Table 3.5. The resulting loads are shown in Table 4.6. Although Creech Services is currently being employed to manage onsite muck, to be conservative, the loads in Table 4.6 were assumed to be applied to each of the corresponding watersheds.

Table 4.6 Daily Nonpoint Source Loads for Keeneland and The Red Mile

Month	Keeneland Load (counts/day)	The Red Mile Load (counts/day)
Jan	1.53E+10	2.55E+09
Feb	1.53E+10	2.55E+09
Mar	1.53E+10	2.55E+09
Apr	7.66E+10	2.55E+09
May	1.53E+10	2.55E+09
Jun	1.53E+10	2.55E+09
Jul	1.53E+10	2.55E+09
Aug	1.53E+10	2.30E+10
Sep	8.69E+10	2.30E+10
Oct	4.09E+10	2.55E+09
Nov	8.69E+10	2.55E+09
Dec	1.53E+10	2.55E+09

4.6.8 Lexington Stockyards

Due to the fact that the stockyards are not considered a CAFO, there is no discharge permit associated with its operation. As a result, no specific discharge or loading was assumed. However, as noted previously, a significant pathogen load has been observed downstream of the stockyards as well as from two identified point sources associated with the Manchester Street storm sewer and discharge from the storm sewer which exits the Rupp Arena Parking lot. There is also a possibility that sewers running parallel to Town Branch may be leaking into the Creek (possibly through groundwater). The composite loads from all of these potential sources have been modeled as a point source as discussed previously in Section 4.5.2.

4.7 Model Calibration Process

Before using the developed NPSM model for determination of the loading to the South Elkhorn Creek Watershed as well as the magnitude and distribution of the associated load reductions, the computer model was calibrated for hydrology and water quality. The general modeling process is illustrated below in Figure 4.2.

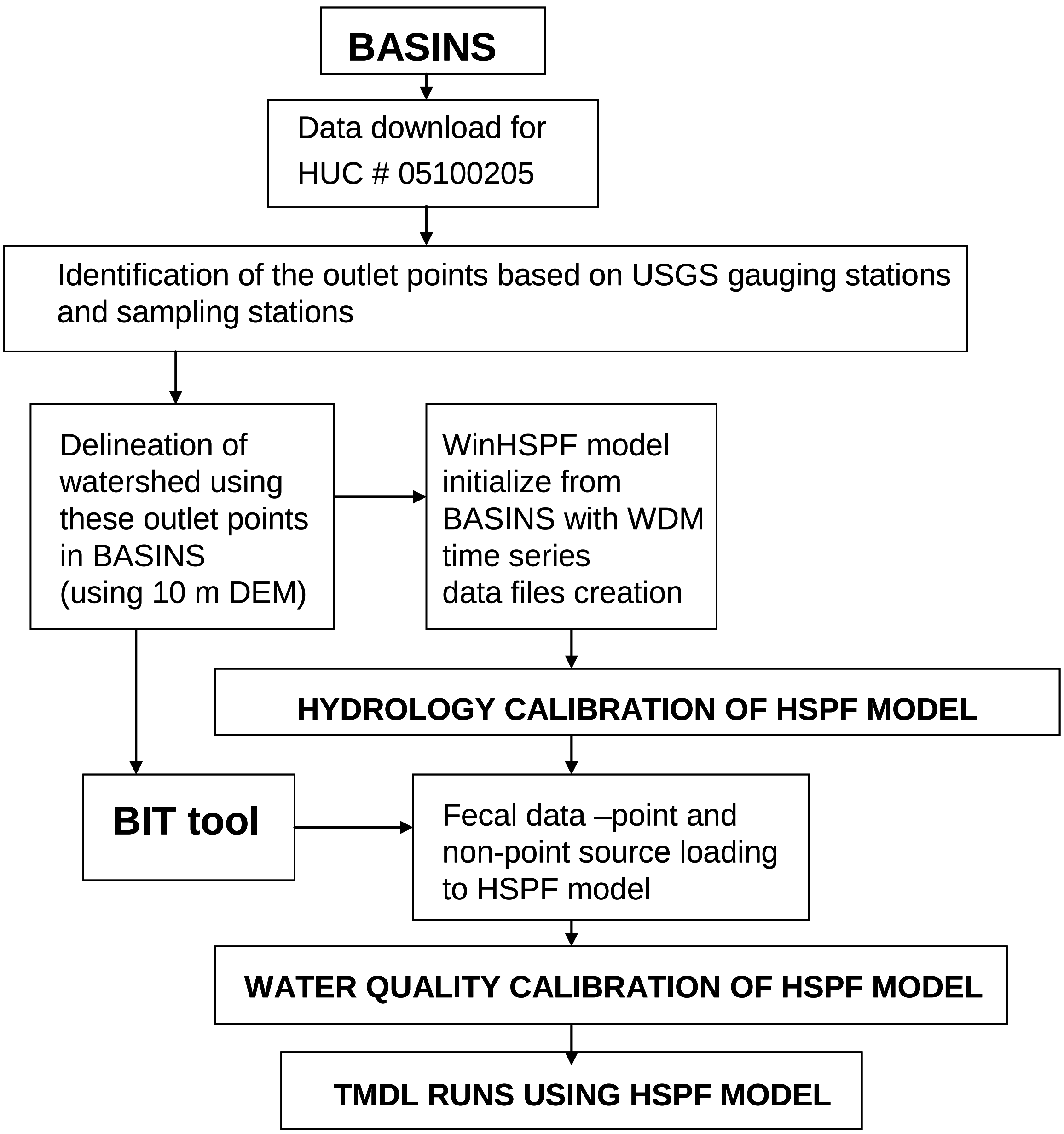

Figure 4.2 Overall Modeling Process

4.7.1 Hydrologic Calibration

The hydrologic calibration involved initial estimates and subsequent adjustment of the appropriate model parameters (such as infiltration index capacity (INFILT), lower zone evapotranspiration parameter (LZETP), lower zone soil moisture storage (LZSN), fraction of groundwater flow to deep recharge (DEEPFR) etc.) to reproduce the observed streamflows at the USGS stations (Table 1.2). Rainfall data for use in the model was developed using hourly rainfall data obtained from regional NOAA weather stations in Lexington. The hydrologic calibration was performed using observed streamflow values from 1997 to 2002.

Plots of the observed and calibrated hydrographs, as well as scatter diagrams for each year of the simulation period, are shown in Appendix B. The predicted hydrographs matched the observed hydrographs fairly closely. In addition, the best-fit line through the scatter plots yielded a line with a fairly high correlation coefficient for most years, as well as a slope fairly close to one. The latter observation confirms that the resulting calibration is fairly free of any model parameter bias as a function of the magnitude of the flows.

Based on the available land use patterns four different landuse types, namely urban area, crop land (agriculture land and pasture land), forestland and barren land were used for the watershed modeling. Hydrology calibration of the HSPF model was done using year 2002 data. Four USGS gauging station flow records (Table 1.2) were used for this purpose. Based on field data, recommended values for USZN, LSZN, infiltration rate, deep groundwater losses, evapotranspiration parameters etc. were identified and used in the initial model. Observed flow hydrographs and simulated flow hydrographs were compared on each simulation and the essential parameters were tuned in different trials. The best-tuned model was used for fecal modeling. Comparisons between the observed and predicted values for the four USGS gaging stations identified in Table 1.2 are provided in Figures 4.3 through 4.14. Summary comparisons are provided for each station using a plot of the residual series, the flow duration curves, and a visualization of the deviation of the annual volumes. In general, the residual plots reveal the absence of model bias for each of the modeled gaging stations, except for the station at Yarnallton Road which shows a slight positive bias. The simulated and observed flow duration curves for each station also reveal fairly consistent results. The annual volume deviation plots illustrated the deviation of the predicted from the observed values for each station and also reveal the absence of any persistent model bias. The mean annual volumetric deviation was 18% for Yarnallton Road in 1998, and was less that 10% for all other stations and years.

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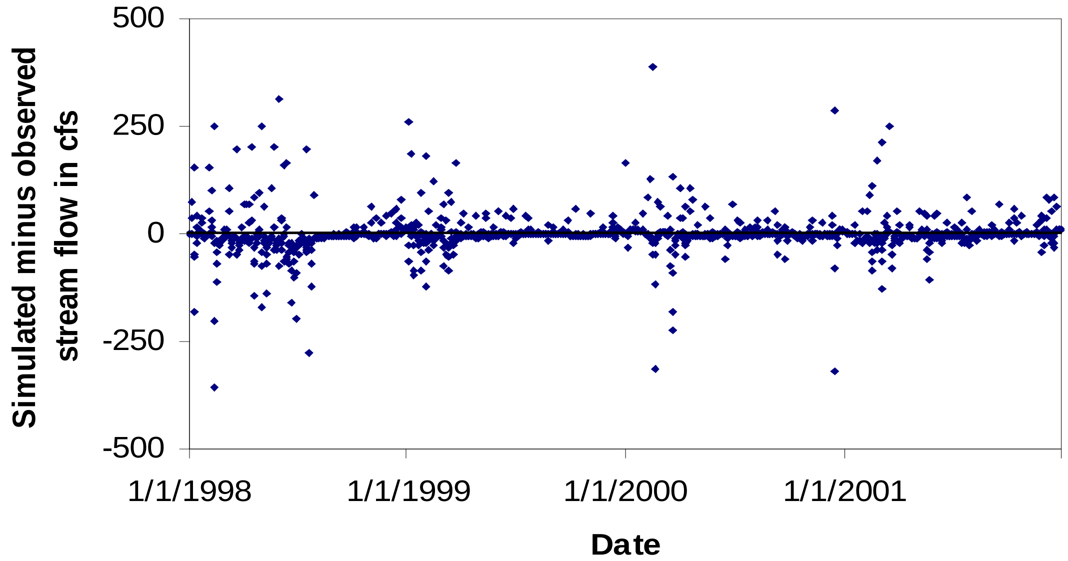

Figure 4.3 Residual Series for South Elkhorn Creek at Fort Springs

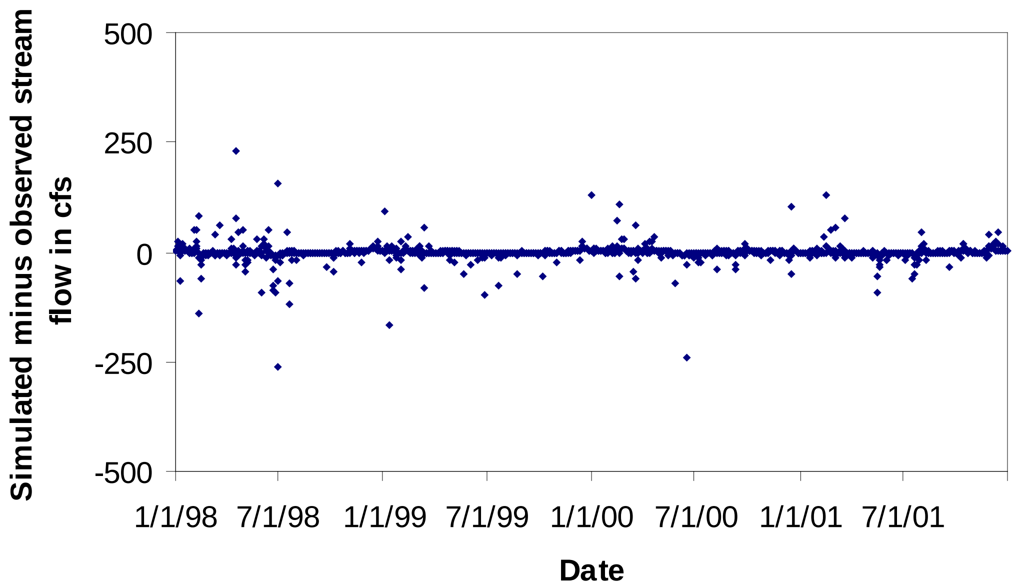

Figure 4.4 Residual Series for Wolf Run Creek

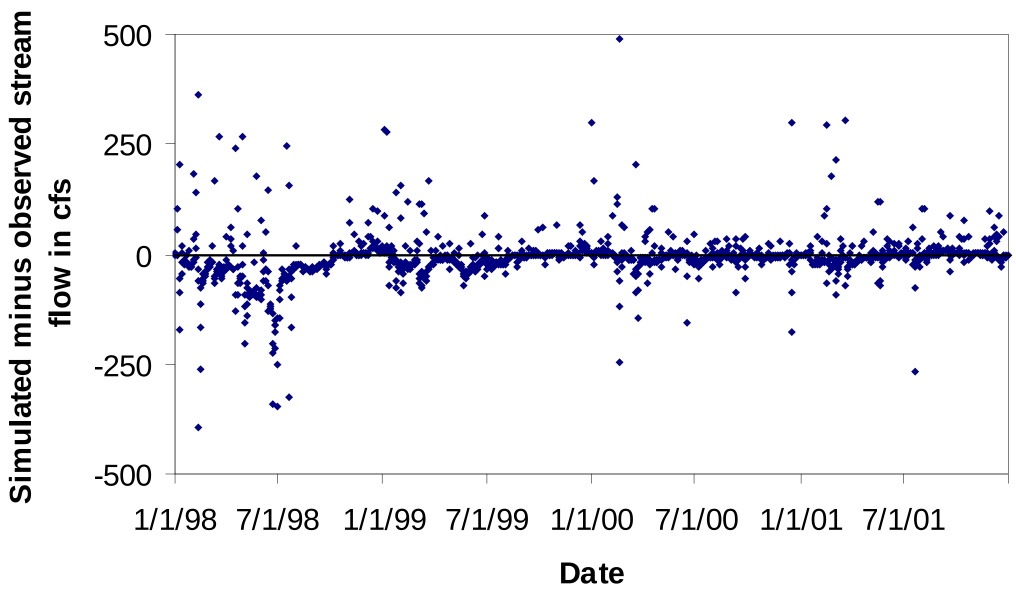

Figure 4.5 Residual Series for Town Branch at Yarnallton Road

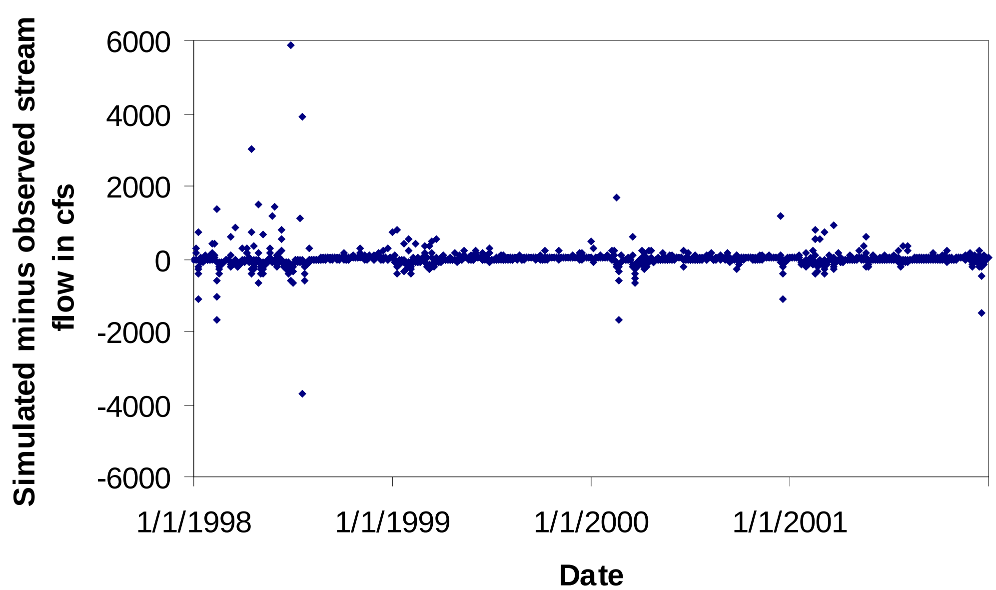

Figure 4.6 Residual Series for South Elkhorn Creek at Midway

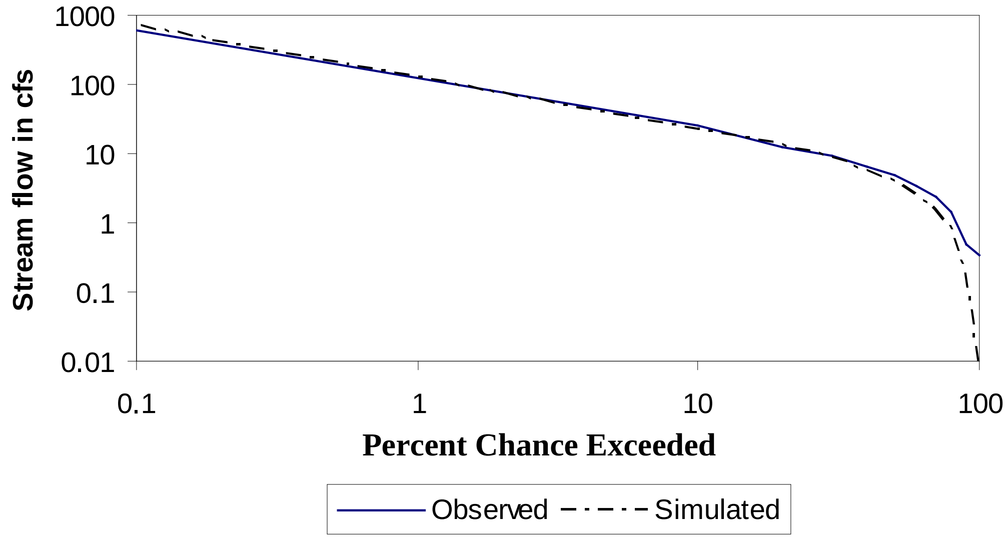

Figure 4.7 Flow Duration Curves for South Elkhorn Creek at Fort Springs

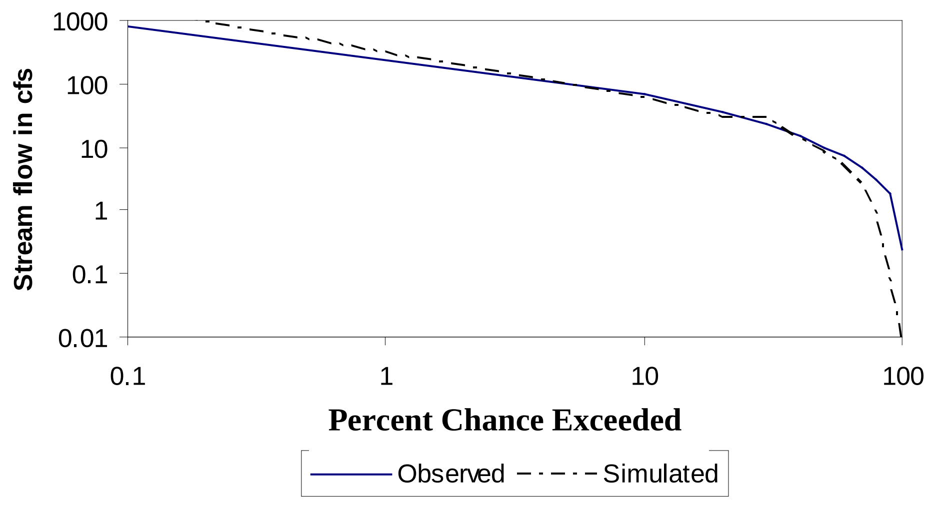

Figure 4.8 Flow Duration Curves for Wolf Run Creek

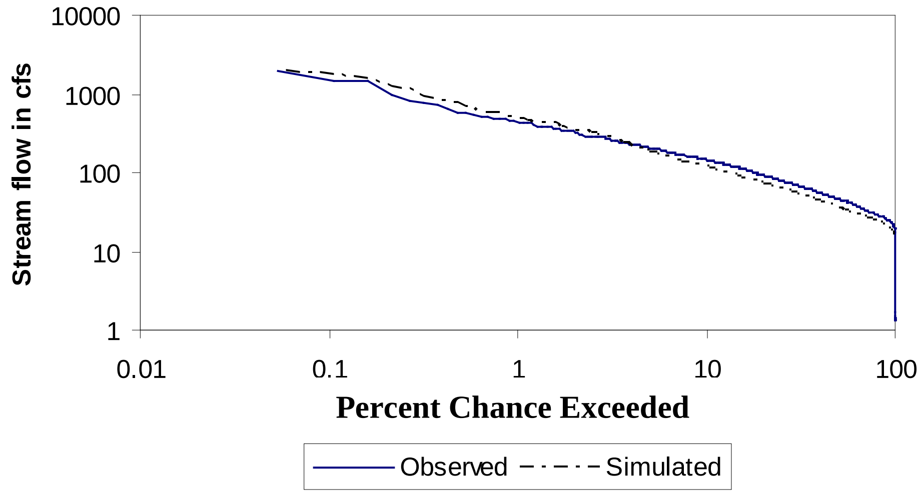

Figure 4.9 Flow Duration Curves for Town Branch at Yarnallton Road

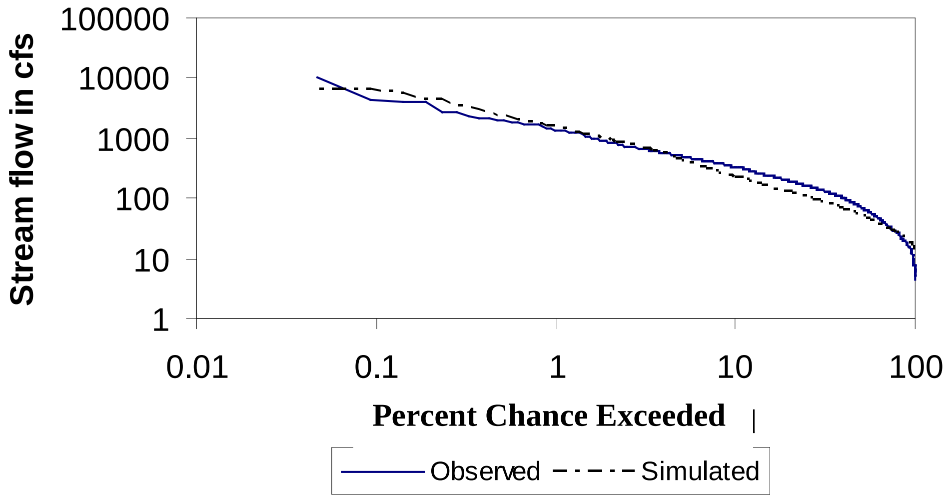

Figure 4.10 Flow Duration Curves for South Elkhorn Creek at Midway

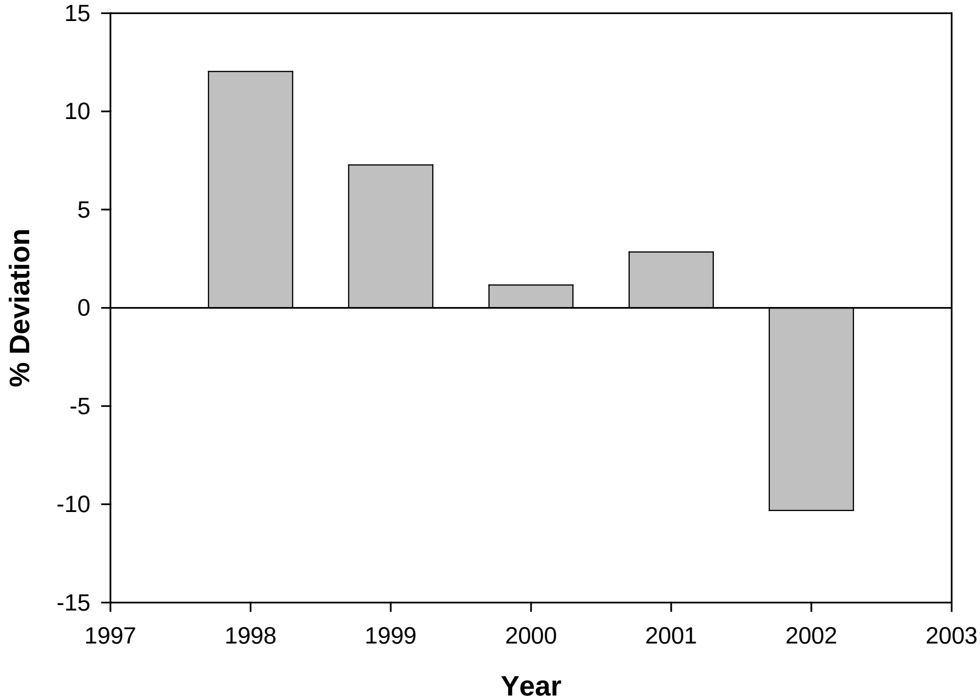

Figure 4.11 Annual Hydrograph Volume Deviations for South Elkhorn Creek at Fort Springs

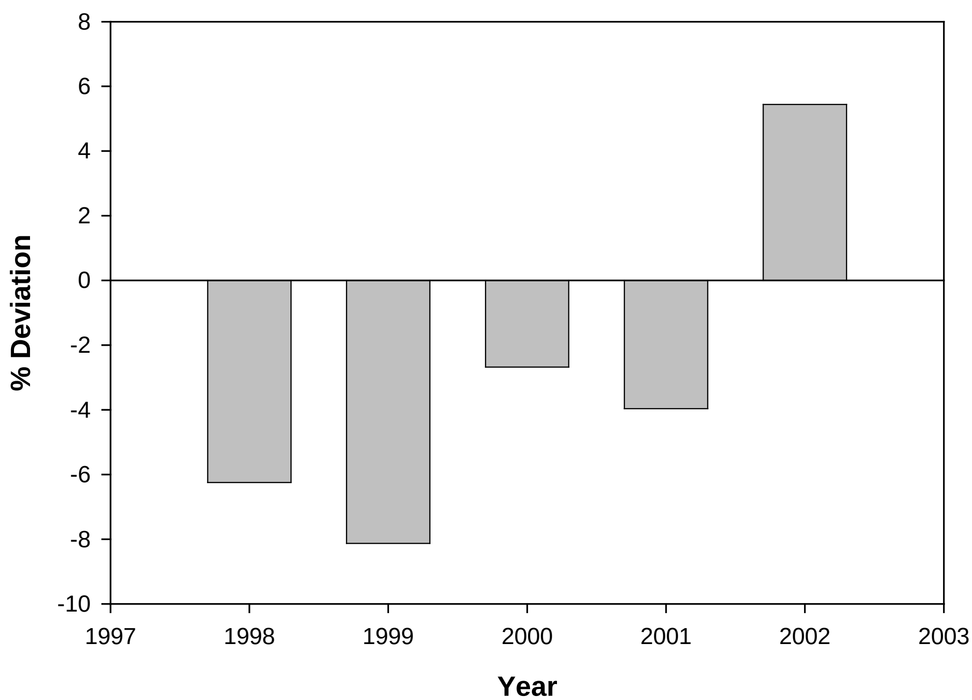

Figure 4.12 Annual Hydrograph Volume Deviations for Wolf Run Creek

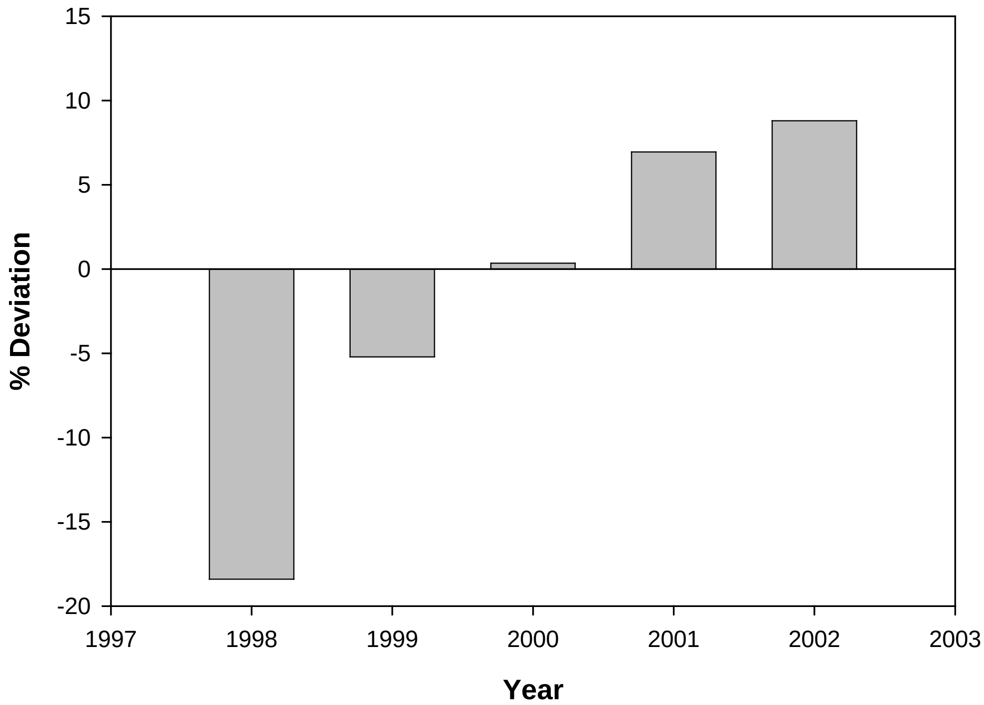

Figure 4.13 Annual Hydrograph Volume Deviations for Town Branch at Yarnallton Road

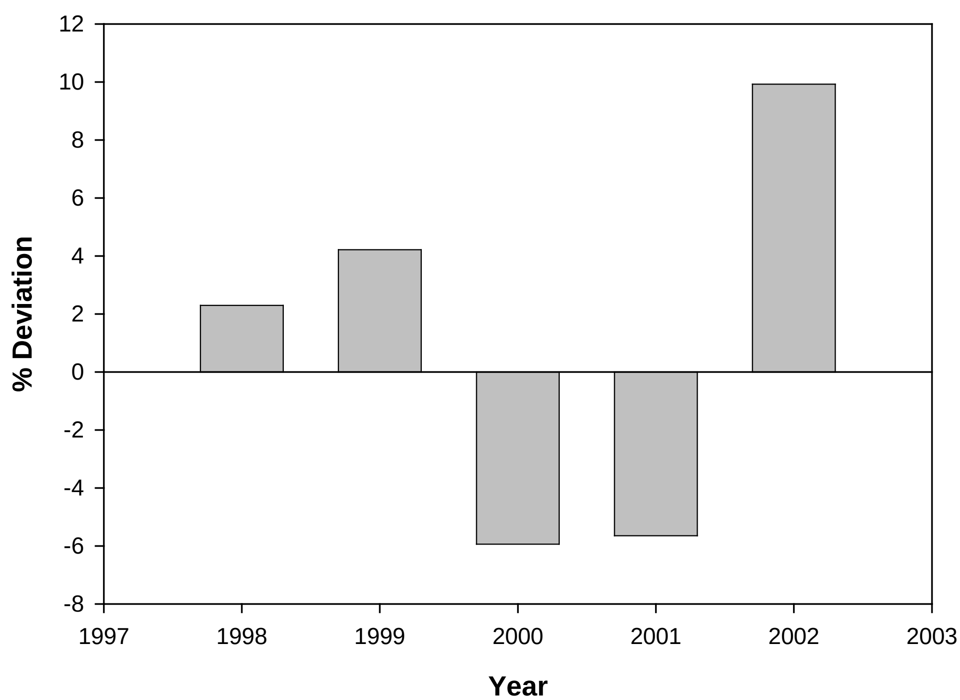

Figure 4.14 Annual Hydrograph Volume Deviations for South Elkhorn Creek at Midway

4.7.2 Water Quality Calibration

Once the NPSM model was calibrated hydrologically, an attempt was made to calibrate the water quality parameters of the model (e.g. loading accumulation rates (ACCUM), decay rates (FSTDEC), and storage limit (SQOLIM) etc.) to match the observed instream fecal coliform concentrations from 2002. Additional adjustment of the point source load associated with catchment 39 and catchment 40 were performed to match the observed fecal concentrations at sites T6, T5 and W2, respectively. Plots of the observed and calibrated fecal concentrations for 2002 are shown in Appendix C. Due to the high variability of instream fecal coliform concentration, model performance associated with the replication of individual daily fecal loads was evaluated using a log differential range of 0.5. An attempt was made to calibrate the model so that the daily difference between an observed and predicted fecal load was within a value of 0.5 of the differences of the logarithms of the actual values. This has been found to be consistent with 90% significance level when using a modified T-test (ie. when the sample size is less than 30) based on a lognormal probability distribution (Ormsbee, 2004). The results of these comparisons are shown in Appendix C. The predicted values tend to fall within these bounds for the majority of days and the majority of stations. In general, deviations outside the limits typically occur when the predicted value is above the upper limit, thus providing for a more conservative analysis. In addition to comparing the predicted and observed results for a given day, a comparison was also made between the observed values and the geometric mean of five days of predicted values centered on the date of the observed data point. This analysis was conducted to account for any variability of model performance as influenced by variations due to timing effects associated with hydrologic errors. The log difference of 0.5 criterion was satisfied for the vast majority of the time for all of the sites.

4.8 Model Application

Once the model is calibrated, it can be used to determine the TMDL of the creek and the percent load reductions needed to bring the stream into regulatory compliance. The TMDL load reduction is accomplished by systematically reducing the associated loading functions or loading rates until both the 30-day geometric mean criterion and the 400 cfu/100 ml (for 80% or more of all data in a month) criterion are met. Plots of the existing conditions and post-TMDL reduction geometric mean model results for fecal coliform for the period from 1997 through 2002 are shown in Appendix D. Plots of the daily post-TMDL reduction fecal coliform results for the period from 1997 through 2002 are shown in Appendix E. Modeling of the load under existing conditions shows numerous violations of the geometric mean standard. Modleing of the load after TMDL reductions shows the streams are in the compliance with both water quality criteria. The specific allocations strategy required to meet this condition are discussed Section 5.

4.9 Margin of Safety

The margin of safety (MOS) is an important part of the TMDL development process (Section 303(d)(1)(C) of the Clean Water Act). There are two basic methods for incorporating the MOS (USEPA, 1991a):

(a) Implicitly incorporate the MOS using conservative model assumptions to develop allocations, or
(b) Explicitly specify a portion of the total TMDL as the MOS using the remainder for allocations.

An implicit MOS was incorporated into the modeling effort by imposing a slightly positive bias in the model's water quality calibration. The figures in Appendix C as well as the associated tables show the model was calibrated so the predicted highest geometric mean values were generally higher than the observed values, thus giving an explicit MOS. Furthermore, using of a multi-year critical period results in a more conservative reduction strategy that provides for an overestimation of fecal loadings during at least 5 out of the 6 years. The reduction results in Appendix D illustrate the reductions called for result in instream fecal coliform values below the 200 cfu/100ml limit for most subwatersheds. In developing TMDLs and associated load allocations using a continuous simulation model Kentucky requires that the geometic mean criteria be met 90% of the time over the simulated total time series. In developing this TMDL, a much more stringent criteria was enforced (~100%), thus providing for an additional margin of safety. Finally, the discharge monitoring reports for all permitted point sources in the basin have consistently shown fecal coliform values below 100 cfu/100 ml. A use of an assumed discharge value of 200 cfu/100 ml (the permitted value) is likely to lead to conservative load reductions for the rest of the basin, thereby providing an additional MOS. Note that reductions must only be implemented until the WQS is achieved.

5.0 TMDL, LOAD ALLOCATION, AND LOAD REDUCTIONS

5.1 TMDL

Once the HSPF model for South Elkhorn was developed and calibrated, the associated point and nonpoint loads for each catchment were reduced until the instream WQC were satisfied. The resulting TMDL for each catchment is shown in Table 5.1.

Table 5.1 Total Maximum Daily Loads (cfu/day) for Each Impaired Segment

Subwatershed	River Mile	TMDL (cfu/day)	Continuous Wasteload Allocation (cfu/day)	MS4 Wasteload Allocation (cfu/day)	Load Allocation (cfu/day)
Town Branch	0.0-10.3	3.53E+13	2.27E+11	8.52E+12	2.67E+13
Wolf Run	0.0-4.1	3.41E+12	-	2.05E+12	1.36E+12
Upper South Elkhorn Creek	34.0 - 49.8	2.81E+13	-	4.84E+12	2.33E+13
Middle South Elkhorn Creek	16.0-34.0	9.77E+13	3.79E+08	-	9.77E+13
Lower South Elkhorn Creek	9-3-.16.4	1.22E+14	-	-	1.22E+14
Lee Branch	0.0 – 8.2	2.91E+13	2.93E+09	-	2.91E+13
Steeles Run	0.0 – 4.2	1.49E+13	-	2.48E+11	1.47E+13
Total		2.64E+14	3.31E+09	2.48E+11	2.64E+14

5.2 Allocations

Once the TMDL for the watershed has been determined, the associated load must be allocated between the WLA and the LA. The difference between the initial conditions load and the TMDL allocations provides the amount of load reduction required. Note the TMDL and load reductions only apply during the May through October recreational season.

5.2.1 Wasteload Allocations

The WLA provides allocation for KPDES-permited sources in the watershed. There are four permitted point sources in the South Elkhorn Creek watershed. For the purposes of modeling, these facilities were assumed to operate at their permitted discharge limits. As a result, the WLA for these facilities are summarized in Table 5.2.

Table 5.2 Wasteload Allocations for Permitted Facilities in the South Elkhorn Creek Watershed

Facility	KPDES Permit	Catch-ment	Receiving Waterbody	Design Discharge (mgd)	Allocated Wasteload FC (cfu/100ml)	Load/Day (cfu)
1.Town Branch Treatment Plant	0021491	37	Town Branch	30.000	200	2.27E+11
2. Midway Treatment Plant	0028410	25	Lee Branch	0.387	200	2.93E+09
3. Airport Food Mart	0083062	44	Middle South Elkhorn	0.010	200	7.57E+07
4.Dance Enterprises Inc	0102610	17	Middle South Elkhorn	0.040	200	3.03E+08

In addition to these four permitted point discharges, it was observed that two storm sewers in Catchment 39 were contributing a significant fecal load to Town Branch. The fecal load associated with each outfall should be completely eliminated, resulting in an estimated average load reduction of 7.36E+13 cfu/day. Finally, a significant fecal load was also observed in Catchment 40 which contributes to the observed load in Wolf Run. This load may either be due to leaking sanitary sewers in the watershed or runoff from the Red Mile race track. However, the frequency and magnitude of the load indicates it is associated with a point source. In order for the TMDL to be satisfied, this additional load will need to be eliminated which results in an estimated total load reduction of 4.27 E+12 cfu/day. Implementation of this allocation will require an investigation to identify the source of the existing loads and additional steps to eliminate the source.

In order to bring South Elkhorn Creek into regulatory compliance, all wasteloads associated with straight pipes and instream cattle and horses must be eliminated (see Figure 5.3). The MS4 component of the WLA (i.e. permitted nonpoint sources) in the South Elkhorn Creek watershed was allocated between three general sources: agriculture, urban, and functional OWTS. Wasteloads from nonpoint sources such as urban areas and agricultural lands need to be reduced by 25% to 90% (see Table 5.4). The allocated load for properly functioning OWTS is shown in Table 5.5. Removal efficiency for properly functioning OWTS was assumed to be 99.5% (EPA, 2002a). By using a conservative reduction strategy, the instream fecal coliform criterion (i.e., the target of a 30 day geometric mean less than 200 cfu/100 ml) was met for all 6 years in the critical period.

Table 5.3 Wasteload Reductions for Straight Pipes, Instream Horse and Cattle Contributions and Failing OWTS

Catch-ment	Livestock in Streams (counts/day)			Straight Pipes (counts/day)			Failing OWTS (counts / day)		
	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction
Town Branch Subwatershed									
8	2.70E+10	0	100	7.57E+09	0	100	3.27E+09	0	100
12	2.15E+10	0	100	7.57E+09	0	100	2.39E+09	0	100
13	9.49E+09	0	100	7.57E+09	0	100	1.16E+09	0	100
15	1.64E+09	0	100	6.81E+10	0	100	1.84E+08	0	100
34	1.17E+10	0	100	3.03E+10	0	100	1.36E+09	0	100
36	1.00E+09	0	100	0	0	100	7.16E+07	0	100
37	7.01E+08	0	100	4.54E+10	0	100	5.16E+07	0	100
38	1.51E+09	0	100	7.57E+09	0	100	6.36E+06	0	100
39	0.00E+00	0	100	0	0	100	0.00E+00	0	-
43	1.17E+08	0	100	0	0	100	1.43E+07	0	100
Wolf Run Subwatershed									
14	2.19E+09	0	100	0	0	100	2.74E+08	0	100
18	0.00E+00	0	100	0	0	100	0.00E+00	0	-
19	1.91E+04	0	100	0	0	100	0.00E+00	0	-
35	3.73E+09	0	100	6.06E+10	0	100	3.18E+08	0	100
40	0.00E+00	0	100	0	0	100	8.83E+07	0	100
41	2.15E+09	0	100	7.57E+09	0	100	1.07E+08	0	100
42	6.53E+07	0	100	0	0	100	0.00E+00	0	-
Upper South Elkhorn Creek Subwatershed									
20	1.14E+10	0	100	1.51E+10	0	100	1.86E+09	0	100
21	1.31E+10	0	100	7.57E+09	0	100	2.26E+09	0	100
22	7.11E+08	0	100	0	0	100	1.59E+09	0	100
23	2.74E+10	0	100	1.51E+10	0	100	2.76E+09	0	100
44	8.41E+09	0	100	7.57E+09	0	100	7.13E+08	0	100
45	2.07E+07	0	100	0	0	100	1.17E+08	0	100
Middle South Elkhorn Creek Subwatershed									
16	1.31E+11	0	100	2.27E+10	0	100	9.92E+09	0	100
17	3.95E+09	0	100	5.3E+10	0	100	2.77E+08	0	100
32	6.08E+10	0	100	7.57E+09	0	100	5.11E+09	0	100
Lower South Elkhorn Creek Subwatershed									
1	5.07E+09	0	100	0	0	100	5.56E+08	0	100
2	4.39E+10	0	100	1.51E+10	0	100	2.96E+09	0	100
3	2.33E+08	0	100	0	0	100	1.51E+09	0	100
4	3.12E+09	0	100	0	0	100	1.84E+08	0	100
5	2.28E+10	0	100	0	0	100	1.75E+09	0	100
6	6.70E+09	0	100	0	0	100	5.51E+08	0	100
7	2.52E+10	0	100	2.27E+10	0	100	2.11E+09	0	100
9	1.72E+08	0	100	0	0	100	1.19E+07	0	100
10	1.93E+09	0	100	0	0	100	1.18E+08	0	100
24	7.17E+10	0	100	3.79E+10	0	100	5.27E+09	0	100
26	2.01E+09	0	100	0	0	100	1.42E+08	0	100
27	2.32E+09	0	100	0	0	100	1.23E+08	0	100
28	3.09E+10	0	100	6.81E+10	0	100	2.15E+09	0	100
29	2.13E+10	0	100	3.03E+10	0	100	1.53E+09	0	100
30	2.39E+10	0	100	7.57E+09	0	100	1.67E+09	0	100
31	3.12E+09	0	100	0	0	100	2.33E+08	0	100
Lee Branch Subwatershed									
25	1.46E+11	0	100	3.79E+10	0	100	1.20E+10	0	100
Steeles Run Subwatershed									
11	1.72E+09	0	100	0	0	100	1.69E+08	0	100
33	2.68E+10	0	100	3.79E+10	0	100	3.04E+09	0	100
Total	7.79E+11			6.28E+11			7.00E+10	0	

Table 5.4 MS4 Wasteload Allocations (by Catchment) for the South Elkhorn Creek Watersheds

Sub-basin	Agricultural Land (counts/day)			Urban Land (counts/day)		
	Existing Load	Allocated Wasteload after deducting non MS4 load	Percent Reduction	Existing Load	Allocated Wasteload after deducting non MS4 load	Percent Reduction
Town branch Subwatershed						
8	1.76E+13	0.00E+00	25	6.47E+08	0.00E+00	25
12	1.37E+13	6.70E+12	25	6.40E+09	3.56E+09	25
13	5.89E+12	9.87E+11	25	8.71E+08	5.81E+06	25
15	8.84E+11	6.63E+11	25	1.61E+09	1.21E+09	25
34	8.65E+12	0.00E+00	25	1.91E+09	1.98E+08	25
36	5.01E+11	5.01E+10	90	1.84E+09	1.84E+08	90
37	3.43E+11	3.43E+10	90	7.51E+09	7.51E+08	90
38	6.76E+11	6.76E+10	90	9.21E+09	9.21E+08	90
39	0.00E+00	0.00E+00	-	3.92E+10	3.92E+09	90
43	5.41E+10	8.59E+09	25	0.00E+00	0.00E+00	-
Wolf Run Subwatershed						
14	1.79E+12	4.33E+11	25	0.00E+00	0.00E+00	-
18	0.00E+00	0.00E+00	-	1.67E+08	0.00E+00	50
19	0.00E+00	0.00E+00	-	1.11E+09	5.55E+08	50
35	2.65E+12	9.40E+11	50	2.08E+09	1.00E+09	50
40	3.07E+11	1.54E+11	50	2.21E+10	1.11E+10	50
41	1.10E+12	4.92E+11	50	1.84E+10	8.94E+09	50
42	0.00E+00	0.00E+00	-	2.78E+10	1.39E+10	50
Upper South Elkhorn Creek Subwatershed						
20	7.12E+12	1.56E+12	25	3.64E+09	1.62E+09	25
21	8.74E+12	1.31E+12	25	4.65E+08	0.00E+00	25
22	5.36E+11	3.89E+11	25	3.24E+10	2.43E+10	25
23	1.58E+13	1.54E+12	25	1.37E+09	2.21E+08	25
44	5.16E+12	0.00E+00	25	1.23E+09	0.00E+00	25
45	1.90E+10	1.42E+10	25	0.00E+00	0.00E+00	-
Middle South Elkhorn Creek Subwatershed						
16	8.58E+13	0.00E+00	25	1.21E+10	0.00E+00	25
17	2.46E+12	0.00E+00	25	3.19E+09	0.00E+00	25
32	4.20E+13	0.00E+00	25	2.46E+09	0.00E+00	25
Lower South Elkhorn Creek Subwatershed						
1	2.75E+12	0.00E+00	25	0.00E+00	0.00E+00	-
2	2.81E+13	0.00E+00	25	1.44E+07	0.00E+00	25
3	1.08E+11	0.00E+00	25	0.00E+00	0.00E+00	-
4	1.71E+12	0.00E+00	25	7.58E+06	0.00E+00	25
5	1.40E+13	0.00E+00	25	2.21E+08	0.00E+00	25
6	3.77E+12	0.00E+00	25	0.00E+00	0.00E+00	-
7	1.52E+13	0.00E+00	25	5.96E+08	0.00E+00	25
9	7.93E+10	0.00E+00	25	0.00E+00	0.00E+00	-
10	1.33E+12	0.00E+00	25	3.35E+08	0.00E+00	25
24	4.34E+13	0.00E+00	25	8.60E+08	0.00E+00	25
26	1.06E+12	0.00E+00	25	2.34E+08	0.00E+00	25
27	1.19E+12	0.00E+00	25	1.31E+09	0.00E+00	25
28	1.89E+13	0.00E+00	25	3.38E+09	0.00E+00	25
29	1.45E+13	0.00E+00	25	5.31E+08	0.00E+00	25
30	1.44E+13	0.00E+00	25	7.70E+08	0.00E+00	25
31	1.68E+12	0.00E+00	25	2.34E+08	0.00E+00	25
Lee Branch Subwatershed						
25	9.71E+13	0.00E+00	70	1.04E+10	0.00E+00	70
Steeles Run Subwatershed						
11	1.22E+12	0.00E+00	25	0.00E+00	0.00E+00	-
33	1.86E+13	0.00E+00	25	3.96E+09	0.00E+00	25
Total	5.01E+14	1.53E+13		2.21E+11	7.24E+10	

Table 5.5 MS4 Allocated Wasteload for Properly Functioning OWTS

Catchment	Allocated Load, counts/day
Town Branch Subwatershed	
8	0.00E+00
12	3.11E+08
13	5.18E+07
15	3.68E+07
34	0.00E+00
36	1.43E+07
37	1.03E+07
38	1.27E+06
39	0.00E+00
43	6.06E+05
Wolf Run Subwatershed	
14	1.77E+07
18	0.00E+00
19	0.00E+00
35	4.49E+07
40	1.77E+07
41	1.92E+07
42	0.00E+00
Upper South Elkhorn Creek Subwatershed	
20	1.09E+08
21	9.01E+07
22	3.08E+08
23	7.15E+07
44	0.00E+00
45	2.34E+07
Middle South Elkhorn Creek Subwatershed	
16	0.00E+00
17	0.00E+00
32	0.00E+00
Lower South Elkhorn Creek Subwatershed	
1	0.00E+00
2	0.00E+00
3	0.00E+00
4	0.00E+00
5	0.00E+00
6	0.00E+00
7	0.00E+00
9	0.00E+00
10	0.00E+00
24	0.00E+00
26	0.00E+00
27	0.00E+00
28	0.00E+00
29	0.00E+00
30	0.00E+00
31	0.00E+00
Lee Branch Subwatershed	
25	0.00E+00
Steeles Run Subwatershed	
11	0.00E+00
33	0.00E+00
Total	1.13E+09

5.2.2 Load Allocations

Although the LA includes all non-KPDES permitted dischargers (i.e. outside of the MS4 area), and is normally thought of as including nonpoint sources, for the purposes of modeling, straight pipes, failing septic systems, and cattle in streams were treated as point sources. Likewise, wildlife, grazing cattle, manure applications, and urban runoff were treated as nonpoint sources.

In order to bring South Elkhorn Creek into regulatory compliance, all loads associated with straight pipes and instream cattle and horses must be eliminated. Failing septic system loads must be eliminated as shown in Table 5.6. In addition, loads from nonpoint sources such as urban areas, cropland, and pasture land need to be reduced by 25% to 90% (see Table 5.7). The allocated load for properly functioning OWTS is shown in Table 5.8. Removal efficiency for properly functioning OWTS was assumed to be 99.5% (EPA, 2002a).

Table 5.6 Load Reductions for Straight Pipes, Instream Horse and Cattle Contributions and Failing OWTS

Catch-ment	Livestock in Streams (counts/day)			Straight Pipes (counts/day)			Failing OWTS (counts / day)		
	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction	Existing Load	Allocated Load	Percent Reduction
Town Branch Subwatershed									
8	2.70E+10	0	100	7.57E+09	0	100	3.27E+09	0	100
12	2.15E+10	0	100	7.57E+09	0	100	2.39E+09	0	100
13	9.49E+09	0	100	7.57E+09	0	100	1.16E+09	0	100
15	1.64E+09	0	100	6.81E+10	0	100	1.84E+08	0	100
34	1.17E+10	0	100	3.03E+10	0	100	1.36E+09	0	100
36	1.00E+09	0	100	0	0	100	7.16E+07	0	100
37	7.01E+08	0	100	4.54E+10	0	100	5.16E+07	0	100
38	1.51E+09	0	100	7.57E+09	0	100	6.36E+06	0	100
39	0.00E+00	0	100	0	0	100	0.00E+00	0	-
43	1.17E+08	0	100	0	0	100	1.43E+07	0	100
Wolf Run Subwatershed									
14	2.19E+09	0	100	0	0	100	2.74E+08	0	100
18	0.00E+00	0	100	0	0	100	0.00E+00	0	-
19	1.91E+04	0	100	0	0	100	0.00E+00	0	-
35	3.73E+09	0	100	6.06E+10	0	100	3.18E+08	0	100
40	0.00E+00	0	100	0	0	100	8.83E+07	0	100
41	2.15E+09	0	100	7.57E+09	0	100	1.07E+08	0	100
42	6.53E+07	0	100	0	0	100	0.00E+00	0	-
Upper South Elkhorn Creek Subwatershed									
20	1.14E+10	0	100	1.51E+10	0	100	1.86E+09	0	100
21	1.31E+10	0	100	7.57E+09	0	100	2.26E+09	0	100
22	7.11E+08	0	100	0	0	100	1.59E+09	0	100
23	2.74E+10	0	100	1.51E+10	0	100	2.76E+09	0	100
44	8.41E+09	0	100	7.57E+09	0	100	7.13E+08	0	100
45	2.07E+07	0	100	0	0	100	1.17E+08	0	100
Middle South Elkhorn Creek Subwatershed									
16	1.31E+11	0	100	2.27E+10	0	100	9.92E+09	0	100
17	3.95E+09	0	100	5.3E+10	0	100	2.77E+08	0	100
32	6.08E+10	0	100	7.57E+09	0	100	5.11E+09	0	100
Lower South Elkhorn Creek Subwatershed									
1	5.07E+09	0	100	0	0	100	5.56E+08	0	100
2	4.39E+10	0	100	1.51E+10	0	100	2.96E+09	0	100
3	2.33E+08	0	100	0	0	100	1.51E+09	0	100
4	3.12E+09	0	100	0	0	100	1.84E+08	0	100
5	2.28E+10	0	100	0	0	100	1.75E+09	0	100
6	6.70E+09	0	100	0	0	100	5.51E+08	0	100
7	2.52E+10	0	100	2.27E+10	0	100	2.11E+09	0	100
9	1.72E+08	0	100	0	0	100	1.19E+07	0	100
10	1.93E+09	0	100	0	0	100	1.18E+08	0	100
24	7.17E+10	0	100	3.79E+10	0	100	5.27E+09	0	100
26	2.01E+09	0	100	0	0	100	1.42E+08	0	100
27	2.32E+09	0	100	0	0	100	1.23E+08	0	100
28	3.09E+10	0	100	6.81E+10	0	100	2.15E+09	0	100
29	2.13E+10	0	100	3.03E+10	0	100	1.53E+09	0	100
30	2.39E+10	0	100	7.57E+09	0	100	1.67E+09	0	100
31	3.12E+09	0	100	0	0	100	2.33E+08	0	100
Lee Branch Subwatershed									
25	1.46E+11	0	100	3.79E+10	0	100	1.20E+10	0	100
Steeles Run Subwatershed									
11	1.72E+09	0	100	0	0	100	1.69E+08	0	100
33	2.68E+10	0	100	3.79E+10	0	100	3.04E+09	0	100
Total	7.79E+11			6.28E+11			7.00E+10	0	

Table 5.7 Load Reductions for Agricultural and Urban Lands

Sub-basin	Agricultural Land (counts/day)			Urban Land (counts/day)		
	Existing Load	Allocated Load after deducting MS4 waste load	Percent Reduction	Existing Load	Allocated Load after deducting MS4 waste load	Percent Reduction
Town branch Subwatershed						
8	1.76E+13	1.32E+13	25	6.47E+08	4.85E+08	25
12	1.37E+13	3.60E+12	25	6.40E+09	1.24E+09	25
13	5.89E+12	3.43E+12	25	8.71E+08	6.47E+08	25
15	8.84E+11	0.00E+00	25	1.61E+09	0.00E+00	25
34	8.65E+12	6.48E+12	25	1.91E+09	1.23E+09	25
36	5.01E+11	0.00E+00	90	1.84E+09	0.00E+00	90
37	3.43E+11	0.00E+00	90	7.51E+09	0.00E+00	90
38	6.76E+11	0.00E+00	90	9.21E+09	0.00E+00	90
39	0.00E+00	0.00E+00	-	3.92E+10	0.00E+00	90
43	5.41E+10	3.19E+10	25	0.00E+00	0.00E+00	-
Wolf Run Subwatershed						
14	1.79E+12	9.07E+11	25	0.00E+00	0.00E+00	-
18	0.00E+00	0.00E+00	-	1.67E+08	8.35E+07	50
19	0.00E+00	0.00E+00	-	1.11E+09	0.00E+00	50
35	2.65E+12	3.90E+11	50	2.08E+09	3.70E+07	50
40	3.07E+11	0.00E+00	50	2.21E+10	0.00E+00	50
41	1.10E+12	5.78E+10	50	1.84E+10	2.58E+08	50
42	0.00E+00	0.00E+00	-	2.78E+10	0.00E+00	50
Upper South Elkhorn Creek Subwatershed						
20	7.12E+12	3.78E+12	25	3.64E+09	1.11E+09	25
21	8.74E+12	5.24E+12	25	4.65E+08	3.49E+08	25
22	5.36E+11	1.31E+10	25	3.24E+10	0.00E+00	25
23	1.58E+13	1.04E+13	25	1.37E+09	8.09E+08	25
44	5.16E+12	3.87E+12	25	1.23E+09	9.23E+08	25
45	1.90E+10	0.00E+00	25	0.00E+00	0.00E+00	-
Middle South Elkhorn Creek Subwatershed						
16	8.58E+13	6.43E+13	25	1.21E+10	9.08E+09	25
17	2.46E+12	1.85E+12	25	3.19E+09	2.39E+09	25
32	4.20E+13	3.15E+13	25	2.46E+09	1.85E+09	25
Lower South Elkhorn Creek Subwatershed						
1	2.75E+12	2.06E+12	25	0.00E+00	0.00E+00	-
2	2.81E+13	2.11E+13	25	1.44E+07	1.08E+07	25
3	1.08E+11	8.13E+10	25	0.00E+00	0.00E+00	-
4	1.71E+12	1.28E+12	25	7.58E+06	5.69E+06	25
5	1.40E+13	1.05E+13	25	2.21E+08	1.66E+08	25
6	3.77E+12	2.83E+12	25	0.00E+00	0.00E+00	-
7	1.52E+13	1.14E+13	25	5.96E+08	4.47E+08	25
9	7.93E+10	5.95E+10	25	0.00E+00	0.00E+00	-
10	1.33E+12	9.98E+11	25	3.35E+08	2.51E+08	25
24	4.34E+13	3.26E+13	25	8.60E+08	6.45E+08	25
26	1.06E+12	7.98E+11	25	2.34E+08	1.76E+08	25
27	1.19E+12	8.95E+11	25	1.31E+09	9.83E+08	25
28	1.89E+13	1.41E+13	25	3.38E+09	2.54E+09	25
29	1.45E+13	1.09E+13	25	5.31E+08	3.98E+08	25
30	1.44E+13	1.08E+13	25	7.70E+08	5.78E+08	25
31	1.68E+12	1.26E+12	25	2.34E+08	1.76E+08	25
Lee Branch Subwatershed						
25	9.71E+13	2.91E+13	70	1.04E+10	3.12E+09	70
Steeles Run Subwatershed						
11	1.22E+12	9.16E+11	25	0.00E+00	0.00E+00	-
33	1.86E+13	1.38E+13	25	3.96E+09	2.81E+09	25
Total	5.01E+14	3.14E+14		2.21E+11	3.28E+10	

Table 5.8 Allocated Load for Properly Functioning OWTS

Catchment	Allocated Load, counts/day
Town Branch Subwatershed	
8	6.54E+08
12	4.78E+08
13	2.32E+08
15	3.68E+07
34	2.72E+08
36	1.43E+07
37	1.03E+07
38	1.27E+06
39	0.00E+00
43	2.86E+06
Wolf Run Subwatershed	
14	5.48E+07
18	0.00E+00
19	0.00E+00
35	6.36E+07
40	1.77E+07
41	2.14E+07
42	0.00E+00
Upper South Elkhorn Creek Subwatershed	
20	3.72E+08
21	4.52E+08
22	3.18E+08
23	5.52E+08
44	1.43E+08
45	2.34E+07
Middle South Elkhorn Creek Subwatershed	
16	1.98E+09
17	5.54E+07
32	1.02E+09
Lower South Elkhorn Creek Subwatershed	
1	1.11E+08
2	5.92E+08
3	3.02E+08
4	3.68E+07
5	3.50E+08
6	1.10E+08
7	4.22E+08
9	2.38E+06
10	2.36E+07
24	1.05E+09
26	2.84E+07
27	2.46E+07
28	4.30E+08
29	3.06E+08
30	3.34E+08
31	4.66E+07
Lee Branch Subwatershed	
25	2.40E+09
Steeles Run Subwatershed	
11	3.38E+07
33	6.08E+08
Total	1.40E+10

6.0 IMPLEMENTATION

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

The limited in-stream pathogen data used to develop the TMDL for South Elkhorn do not allow loads to be quantitatively allocated to the different sources within the watershed. Therefore, no specific recommendations for remediation are offered until additional watershed planning is conducted. Development of a watershed plan will provide an integrative approach for identifying and describing how, when, who and what actions should be taken in order to meet water quality standards. This TMDL will provide a foundation for developing a detailed watershed plan. In addition, several organizations are already active in the watershed are listed below.

6.1 Thoroughbred RC&D Council

The Thoroughbred RC&D Council has been actively engaged in the development of a comprehensive program for managing equine waste through onsite compositing (Oldfield, 2002). To date the methodology has been implemented at over 10 farms in the Elkhorn Creek Watershed. The Thoroughbred RC&D recently purchased a compost windrow turner for lease by local horse farms. Significant matching funds are also available through USDA for the construction of lime based pads. Once composted, the resulting material can be used as on-site fertilizer or sold for other commercial landuse applications (e.g. mushroom farms).

6.2 NGOs

There are several NGOs operating in the South Elkhorn watershed that may help in implementing the TMDLs for South Elkhorn Creek, especially with regard to non-point source issues. These include Bluegrass PRIDE Inc., Kentucky River Watershed Watch Inc., Town Branch Trail Inc., and Friends of Wolf Run.

6.2.1 Bluegrass PRIDE

In addition to management activities associated with the local governments in each of the impacted counties, it is expected that TMDL implementation in the region, especially associated with non-point source issues, may be facilitated by Bluegrass PRIDE. Bluegrass PRIDE was established in the Fall of 2001 to monitor the status of water quality in the Bluegrass region of Central Kentucky and provide funding and programs to help improve the quality of life of its citizens as well as the quality of the environment. More information about Bluegrass PRIDE can be found at: http://www.kentuckypride.com/.

6.2.2 Kentucky River Watershed Watch

The Kentucky River Watershed Watch Inc. performs annual volunteer sampling throughout the Kentucky River Basin, including South Elkhorn Creek. This sampling and the associated data can also be used to help assess progress in meeting the designated use for the stream. Kentucky River Watershed Watch Inc. has also developed citizen's action plans for several subwatersheds in the Kentucky River Basin, including Elkhorn Creek. More information about Kentucky Watershed Watch can be found at: http://www.uky.edu/OtherOrgs/KRWW/.

6.2.3 Town Branch Trail, Inc.

Town Branch Trail Inc. (TBT) was organized as a non-profit educational group in March 2001 to promote environmental preservation and development of a trail along Town Branch Creek from downtown Lexington to the McConnell Trace subdivision. For more information see: http://www.townbranch.org.

6.2.4 Friends of Wolf Run, Inc.

Friends of Wolf Run Inc. (FOWR) was organized as a Non-Profit educational group in Spring of 2005 to promote sound water resource management practices and conservation; promote an interest in, and a study of the streams, rivers, lakes and other water resources of the central Kentucky area; collect scientific information regarding water quality; and disseminate information regarding water resources and water quality. The group conducts focused water quality sampling in the Wolf Run watershed and is currently exploring ways to characterize and improve the water quality in the watershed. For more information see: http://kywater.net/WolfRun/.

6.3 Modifications

In the future, KDOW may adjust the LA and/or WLA in this TMDL to account for new information or circumstances that develop or come to light during the implementation of the TMDL and a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment of the LA and WLA will only be made following an opportunity for public participation. New information generated during TMDL implementation may include, among other things, monitoring data, BMP effectiveness information and land use information. KDOW will propose adjustments only in the event that any adjusted LA or WLA will not result in a change to the TMDL Target load. The adjusted TMDL, including its WLAs and LAs, will be set at a level necessary to implement the applicable WQS. KDOW will notify EPA of any adjustments to this TMDL within 30 days of their adoption.

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