

**TOTAL MAXIMUM DAILY
LOAD (TMDL) DEVELOPMENT**

- PATHOGENS -

for

**FLEMING CREEK WATERSHED
(Fleming and Nicholas Counties, Kentucky)**

**Includes Allison Creek, Craintown Branch,
Doty Creek, Fleming Creek, Sleepy Run,
Town Branch, and Wilson Run
(Which are Included on the 1998 303(d) List)**

**Also Includes Cassidy Creek, Logan Run, Poplar Creek, and
Unnamed Tributary To Fleming Creek at River Mile 4.28**



**Natural Resources and
Environmental Protection Cabinet**

Kentucky Division of Water

April 2001

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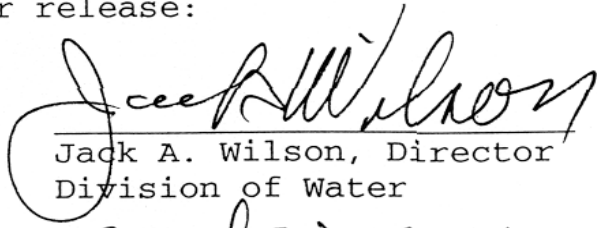
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**KENTUCKY DEPARTMENT FOR ENVIRONMENTAL PROTECTION
DIVISION OF WATER**

Frankfort, Kentucky

This report has been approved for release:



Jack A. Wilson, Director
Division of Water

April 30, 2001

Date

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DIVISION OF WATER**

Frankfort, Kentucky

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(FLEMING COUNTY, KENTUCKY)

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TMDL FACT SHEET

FLEMING CREEK WATERSHED

Project Name: Fleming Creek Watershed: Pathogens
Includes Allison Creek, Craintown Branch, Doty Creek, Fleming Creek, Sleepy Run, Town Branch, Wilson Run, Cassidy Creek, Logan Run, Poplar Creek, and the Unnamed Tributary (UT) at River Mile (RM) 4.28.

Location: Fleming County, Kentucky

Scope/Size:

Allison Creek	River Mile 0.0 to 4.7
Craintown Branch	River Mile 0.0 to 3.5
Doty Creek	River Mile 0.0 to 4.0
Fleming Creek	River Mile 0.0 to 39.2
Sleepy Run	River Mile 0.0 to 2.8
Town Branch	River Mile 0.0 to 4.0
Wilson Run	River Mile 0.0 to 5.1
Cassidy Creek	River Mile 0.0 to 3.9
Logan Run	River Mile 0.0 to 2.3
Poplar Creek	River Mile 0.0 to 3.1
UT at RM 4.28	River Mile 0.0 to 2.2

TMDL Issues: Point and Nonpoint Sources

Data Sources: KY Dept for Environmental Protection - Division of Water (DOW)

Control Measures: KY Pollutant Discharge Elimination System (KPDES) Regulations
KY No Discharge Operational Permit (KNDOP)
KY Non-point Source TMDL Implementation Plan
KY Watershed Management Framework
KY Agriculture Water Quality Act

Summary: The first 7 streams listed above were determined as not supporting the designated use of swimming and were therefore included on the 1994 and subsequent 303(d) lists for Total Maximum Daily Load (TMDL) development. A subsequent review of the data when this TMDL was developed indicated that 4 additional stream segments were also not supporting of the designated use of swimming because of pathogens contamination. The 11 stream segments are impacted by both point and nonpoint sources, but

mostly by nonpoint sources (polluted runoff from beef cattle and dairy operations). The greatest impact occurs during runoff events, but fecal coliform levels (which are used as an indicator of pathogens contamination) are high during base-flow conditions at several stream locations.

TMDL Development: Total maximum daily loads of fecal coliform (FC) in colonies per day were computed based on the allowable maximum FC value, of 400 colonies per 100 milliliters of sample in no more than 20 percent of samples during routine (monthly) sampling). For point source dischargers, the FC count shall not exceed 200 colonies/100 ml of sample (based on a geometric mean of 5 samples taken during a 30-day period) and shall not exceed 400 colonies per 100 milliliters of sample in 20 percent or more of all samples taken during the month. Although this level of data collection is generally not available, the dischargers are required to submit Discharge Monitoring Reports (DMRs) to the KDOW which includes a reporting of the monthly mean and the maximum FC determination of the effluent. The base-flow and runoff streamflow values correspond to a 90 percent and 10 percent daily streamflow exceedance value, respectively. This value is appropriate for this watershed, where 7Q10 streamflow for the main stem and tributaries is zero and where a 10 percent exceedance of the daily flow represents a normal runoff condition. The Waste Load Allocation (WLA) value is based on an FC count of 200 and the design flow of 1.0 cfs (0.66 mgd). Background loads for the base-flow and runoff conditions were based on a FC count of 10 and 50 colonies, respectively. Load Allocations (LAs) were determined by subtracting the WLA from the total load. The WLA incorporates background load, which can be delineated. The

Margin of Safety is based on a FC count of 25 colonies. The allowable FC loads are given in Tables 1 and 2.

Table 1. The Allowable Fecal Coliform Loads for the Base-flow Condition (xE8 colonies/day)

<u>Stream</u>	<u>WLA</u>	<u>LA</u>	<u>Background</u>	<u>Margin of Safety</u>
UT at RM 4.28	0	3.6	0.1	0.2
Poplar Creek	0	6.2	0.2	0.4
Doty Creek	0	22.3	0.6	1.5
Craintown Branch	0	5.3	0.2	0.4
Cassidy Creek	0	6.2	0.2	0.4
Allison Run	0	62.4	1.7	4.3
Wilson Run	0	11.0	1.0	1.0
Sleepy Run	0	5.3	0.2	0.4
Logan Run	0	5.3	0.2	0.4
Town Branch	48.8	8.6	0.6	0.6
Fleming Creek	0	124.9	3.4	8.5

Table 2. The Allowable Fecal Coliform Loads for the Runoff Condition (xE8 colonies/day)

<u>Stream</u>	<u>WLA</u>	<u>LA</u>	<u>Background</u>	<u>Margin of Safety</u>
UT at RM 4.28	0	468	72	36
Poplar Creek	0	953	146	73
Doty Creek	0	199	30	15
Craintown Branch	0	9,590	120	60
Cassidy Creek	0	951	146	73
Allison Run	0	2,145	330	165
Wilson Run	0	1,660	260	130
Sleepy Run	0	800	120	60
Logan Run	0	800	120	60
Town Branch	49	1,508	232	116
Fleming Creek	0	26,900	4,200	2,100

Implementation

Controls:

This will be a phased TMDL because of the presence of nonpoint sources of pollution on all of the stream reaches listed. A phased TMDL is necessary when the efficiency of remedial activities is unknown. Remedial activities will need to be implemented, and follow-up monitoring will need to be conducted. If water quality standards are still not being met upon review of the data from the

follow-up monitoring, the remedial activities will need to be modified. To assist in developing a remediation strategy, the Kentucky Watershed Management Framework (KWMF) will be utilized in conjunction with the Kentucky Agriculture Water Quality Plan (KAWQP) of 1996, which was developed by the Kentucky Agriculture Water Quality Authority (KAWQA, 1996). The KWMF is based on 5 watershed units, each on a 5-year cycle. Selected activities are planned during each year of the 5-year cycle. As part of the KWMF, a Licking River Basin Unit Team, with a Basin Coordinator, has been formed to carry out certain recommended activities. One of these activities is to develop a Local Watershed Task Force, which will then be asked to develop a Local Action Plan. The Local Action Plan will be the document that describes the remediation activities that are needed and how implementation will be achieved. The KAWQPs will be an integral part of the Action Plan. The Action Plan will be developed in the fourth year of the five-year cycle, and Implementation will occur in the fifth year of the cycle. This information is described in a document developed by the KDOW for addressing nonpoint TMDLs; Implementation Plan for Achieving Load Allocations for Nonpoint Source TMDLs. The Licking River Basin Unit is currently in the second year of the Watershed cycle. Stakeholder groups currently exist within the watershed and will be asked to participate in this process of developing an Action Plan.

Remedial actions to nonpoint sources of pollution will be taken based on the establishment of BMPs as described in the KAWQP of 1996 (KAWQA, 1996). Agricultural operations (including silviculture) of 10 acres or more must develop and implement a water quality plan (based on guidance from the KAWQP) for their agricultural operation by October 23, 2001. To assist landowners in developing their plan, the KAWQA developed

The Producer Workbook (KAWQA, 1997) is available along with many other planning tools through conservation districts and county extension offices. The tools were designed to provide a process for developing an individual water quality plan and also gives a list of contacts at various State and Federal agencies that can provide technical and financial assistance to develop and implement the plan.

The Fleming Creek Demonstration Project was initiated in 1992 by a group of local landowners concerned about the water quality of Fleming Creek and its tributaries. They formed the Fleming Creek Water Quality Committee, which was dedicated to assessing the needs and interests of all local citizens. Initially, this committee coordinated with local farmers and government agencies and represented the farmers. As the project evolved, the Community Farm Alliance (CFA) became the principal grassroots coordinating organization for those groups.

Tables 3 and 4 provide information on BMPs that have been installed in the watershed. The tables use data provided by the Division of Conservation (DOC, written commun., 1999). Also, an application was submitted by KDOW to the National Forum on Nonpoint Source Pollution (a private organization dedicated to finding solutions for nonpoint source pollution control) soliciting additional funds for animal waste management systems. Farm field days have been held at selected operations to encourage the use of and to demonstrate the benefit of BMPs to vicinity farmers. It is anticipated that the number of farmers that incorporate BMPs into their operations will increase.

Table 3. Applied Best Management Practices (BMPs) in the Fleming Creek Watershed, May 1, 1990 to May 31, 1994 (Peake, KDOW, written commun., 2000).

<u>Type of BMP</u>	<u>Funding Source</u>	<u>Unit</u>
Trough or Tank	FSA	124
Waste Management System	LTA, WSP	12
Diversion	LTA	800 feet
Fencing	LTA	1,200 feet
Waste Storage Pond	LTA	1
Heavy Use Area Protection	LTA	1 acre
Waste Utilization	LTA, WSP	107 acres
Filter Strip	WSP	2 acres

FSA = Food Security Act

LTA = Long Term Agreement

WSP = Water Quality Special Project

Table 4. Applied Best Management Practices (BMPs) in the Fleming Creek Watershed, June 1, 1994 to June 1, 1999 (Peake, KDOW, written commun., 2000).

<u>Type of BMP</u>	<u>Funding Source</u>	<u>Unit</u>
Waste Management System	CTA, FSA, LTA, WSP	16
Waste Storage Facility	CTA, FSA, LTA, WSP	13
Cover & Green Manure Crop	CTA	70 acres
Pond	CTA, FSA	8
Fencing	CTA, FSA	900 feet
Trough or Tank	CTA, FSA, WQP	190
Waste Utilization	CTA, FSA, WSP	239 acres
Filter Strip	FSA	4 acres
Use Exclusion	FSA	100 acres
Prescribed Grazing	FSA	30 acres
Heavy Use Area Protection	FSA, WSP	5 acres
Nutrient Management	FSA	40 acres
Sediment Basin	LTA	2
Waste Storage Pond	WSP	3

CTA = Conservation Technical Assistance

FSA = Food Security Act

LTA = Long Term Agreement

WSP = Water Quality Special Project

WQP = Water Quality Demonstration Project

More recently (1999), a work plan for the Fleming Creek CWAP has been submitted by the DOC to continue the work of identifying, evaluating, and implementing agricultural BMPs in the watershed (KDOW, 1999). The BMPs will permit sustained use of natural resources by meeting specific quality criteria. Follow-up monitoring will also be conducted as part of the project. Also, a proposal has been developed for an Agricultural Watershed Awareness Program (AWAP) by the DOC (Giesecke, written commun., 1999) to develop and foster educational programs to enhance the awareness of people living in the watershed to activities that promote the protection of water quality. Monitoring is proposed as part of the educational activities.

Animal feeding operations (AFOs) are permitted under 401 KAR 5:005 using a Kentucky No Discharge Operational Permit (KNDOP) for Agricultural Wastes Handling System. The Natural Resources Conservation Service (NRCS) works with the permittee to develop a Nutrient Management Plan for the handling of the wastes that are produced. KDOW Field Offices are currently involved in extensive surveillance activities to inventory both permitted and unpermitted AFOs. Regulations are currently being developed to define siting criteria for Concentrated Animal Feeding Operations (CAFOs) for beef and dairy operations and for the permittee to perform certain monitoring tasks. CAFOs would need a KPDES permit. A CAFO is generally defined as an animal feeding operation with more than 1000 animal units, with a beef cow being designated as 1.0 animal unit. The KPDES permit for beef and dairy operations would also require that a (more detailed) Comprehensive Nutrient Management Plan be developed which uses the most recent NRCS guidelines as a basis for waste management. The regulatory authority for remediating nonpoint sources of pollution from agricultural and silviculture operations in Kentucky is derived from:

(1) Kentucky Revised Statutes (KRS) 224; more specifically Title 401 of the Kentucky Administrative Regulations (KRA), Chapter 5, Section 31 (401 KAR 5:031); and (2) the Kentucky Agriculture Water Quality Act (The Act), which is KRS 224.71-100 to 224.71-140, and was the name given to Senate Bill 241 (passed by the Kentucky General Assembly in 1994). Remedial actions for nonpoint sources of pollution will be taken based on the establishment of BMPs as described in The Kentucky Agriculture Water Quality Plan (KAWQP) of 1996 (KAWQA, 1996). Governmental agricultural agencies have provided regular workshops and individual assistance to landowners required to develop plans. The Producer Workbook and KAWQP document provide information on potential sources of financial assistance to implement the BMPs described in the KAWQP. The Act provides procedures or protocols for corrective measures to resolve situations where it is documented that water pollution is occurring due to agricultural practices. The Act defines a ‘bad actor’ and provides actions that can be taken in this regard.

PATHOGENS TMDL DEVELOPMENT

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Unnamed Tributary at River Mile 4.28 of Fleming Creek**

INTRODUCTION

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop total maximum daily loads (TMDLs) for the water bodies that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relation between pollution sources and in-stream water quality conditions. States can then establish water-quality based controls to reduce pollution from both point and nonpoint sources and restore the quality of their water resources.

PROBLEM DEFINITION

Fleming Creek and its tributaries (Figure 1) are classified for Warmwater Aquatic Habitat (WAH) and Primary and Secondary Contact Recreation uses by the Kentucky Division of Water (KDOW, 1984).

Several streams in the Fleming Creek watershed were determined as not supporting the designated use of swimming in the 1994 and subsequent 305(b) reports. Therefore the streams were listed on the 1994 and subsequent 303(d) lists for TMDL development (KDOW, 1998c). The 7 stream segments are impacted by pathogens, which is the result of both point and nonpoint sources, but the majority of the impacts are from

nonpoint sources (polluted runoff). The greatest impact occurs during runoff events, but levels of fecal coliform (FC), which is used as an indicator of the presence of pathogens, are also high during base-flow conditions (periods of no surface runoff) at several locations. Data collection conducted to characterize FC contamination in the streams in the watershed indicated that 4 other streams were not supporting the designated use of swimming because of high FC levels. They are Cassidy Creek, Logan Run, Poplar Creek, and the unnamed tributary (UT) at river mile (RM) 4.28 of Fleming Creek.

The predominant land use within the Fleming Creek watershed (61,670-acres) is agriculture (KDOW, 1996; KASS (Kentucky Agriculture Statistical Service), 1998). Fifty-nine percent (36,385 acres) of the watershed is managed for hayland and pasture, primarily to support dairy and beef cattle operations (KDOW, 1996; KASS, 1998). In 1991, there were approximately 85 animal feedlots located in the watershed, the largest of which are shown in Figure 2 (KDOW, 1996). Approximately 63 of these were dairy operations. More recent (March, 2000) information on ‘potential’ animal feeding operations (AFOs) in the watershed is shown in Figure 3 (Kentucky Pollutant Discharge Elimination System files, 2000). An AFO is an animal feeding operation where animals are confined for 45 or more days in a 12-month period. The term ‘potential’ is used because Figure 3 includes those AFOs that have a Kentucky No Discharge Operational Permit (KNDOP) and those agricultural operations inventoried by KDOW personnel that might meet the definition of an AFO, but that don’t currently have a KDNOP. As indicated by comparing Figures 2 and 3, there is a substantial reduction in the number of animal feeding operations from 1992 to 2000.

In 1991, there were approximately 48,500 head of cattle in Fleming County, with the majority of the animal waste pollution likely coming from dairy feedlots (KDOW, 1996). The total dairy cow population in this county exceeded 10,000 head, and the average herd size was 50 cows. For 1997-98, the total number of cows was approximately 46,000 and the number of dairy cows was approximately 6,400 (KASS, 1998). The high density of farm animals has resulted in water quality degradation.

In 1991, an estimated 1,700,000 ft³ of animal waste just from dairies could potentially have been washed into area streams annually (KDOW, 1996). That number would be approximately 1,100,000 ft³ for 1997-98 based solely on the reduced number of

animals. Moreover, roughly 65 percent of the livestock operations in the project area in 1991 were located within 100 feet of a stream (KDOW, 1996). In 1992, when the Fleming Creek Demonstration Project (to be described later in this report) was initiated, none of these operations utilized best management practices (BMPs), including animal waste management systems (KDA (Kentucky Department of Agriculture), 1991; USDA, 1992).

As of October 1998, the Flemingsburg Waste Water Treatment Plant (WWTP), which services the Flemingsburg area, was the only point source discharge facility within the Fleming Creek watershed that has a permit from KDOW to discharge FC. The Flemingsburg WWTP discharges to Town Branch. Although an inventory of septic systems and straight pipes in the Fleming Creek Watershed is not readily available (Watson, Fleming County Health Department, personal commun., 2000), the Fleming County Health Department (Watson, Fleming County Health Department, personal commun., 2000) and the KDOW Morehead Regional Office (Rice, KDOW, written commun., 2000) has not received any complaints related to failed septic systems or straight pipes in the watershed.

STUDY AREA DESCRIPTION

Location

The Fleming Creek watershed is contained almost entirely within Fleming County, in northeastern Kentucky (Figure 1). However, a short reach at the mouth flows into Nicholas County. Flemingsburg, the largest town within Fleming County, is situated in the northeastern portion of the watershed. This community lies approximately 23 miles northwest of Morehead, Kentucky.

Geology

The Fleming Creek drainage lies primarily within the Inner and Outer Bluegrass physiographic regions (Quarterman and Powell, 1978). Gently sloping ridgetops, steep to moderately steep hillsides, and limited bottom land characterize the landscape. Elevations within the watershed range from 580 feet above mean sea level (MSL) at the mouth to 800 feet above MSL in the headwaters.

The uppermost headwaters of Fleming Creek transect the Upper Devonian and Lower and Middle Silurian systems (Morris, 1965). However, the major portion of the

remaining watershed overlies Ordovician rock (Peck, 1969). Limestones dominate the Ordovician system. As is characteristic of some limestones, certain places along Fleming Creek are karstic (but are not generally well developed), and a limited number of sinkholes are present in these areas. (Morris, 1965; Peck, 1969).

Soils

Most of the soils on the ridgetops and hillsides within the study area are formed from residual limestones, siltstones and shales and overlie clayey subsoils (USDA, 1992). Soil types found in these areas include the Lowell, Beasley, Faywood and Shrouts. Some ridgetop soils here were formed with a silty mantle of loess over clay weathered from residual limestones, siltstones and shales. Associated soil types at such locations are the Sandview, Nicholason and Crider. In addition, soils on certain steep hillsides were weathered from interbedded limestones, siltstones and shales (Eden, Faywood and Cynthiana soil types). These steep hillside soils tend to be more shallow than other soils in the watershed.

Hydrology

The Fleming Creek drainage flows generally from east to west where it flows into the Licking River at river mile 106.9 in northeastern Nicholas County. Fleming Creek's mainstem is 39 miles long, draining an area of 61,670 acres (KDOW, 1984). The average gradient is 7.7 feet per mile. The estimated seven-day ten-year low flow ($7Q_{10}$) on the mainstem at river mile 12.2 near Hilltop, KY is $0.0 \text{ ft}^3/\text{s}$ (Ruhl and Martin, 1991). A wastewater treatment plant is located 13 miles upstream of this point. During extreme low-flow periods, the volume of water discharged by this facility is ultimately removed from Fleming Creek through agricultural withdrawal, evaporation, and by sinking into the groundwater.

Land Use

As stated previously, the predominant land use within the Fleming Creek watershed is agriculture. Fifty-nine percent (36,385 acres) of the watershed is managed for hayland and pasture, primarily to support dairy and beef cattle operations. Thirty-one percent

(19,118 acres) of the watershed area is used for cropland. Corn and tobacco are the principal row crops. Nine percent (5,500 acres) of the watershed is wooded, and 1 percent is urban (617 acres, 1%). Flemingsburg is the largest city in Fleming County, accounting for about 3,100 of the approximately 13,500 county residents.

In 1997-98, there were approximately 46,000 head of cattle in Fleming County. The total dairy cow population in Fleming County is approximately 6,400 head, with the average herd size being about 50 cows (KASS, 1998).

Fleming Creek and its tributaries are classified as Warmwater Aquatic Habitat and Primary (i.e. swimming) and Secondary Contact Recreation uses by KDOW (1984). Jones (1970) reported that Fleming Creek receives heavy fishing pressure, especially from the mouth to about 20 miles upstream.

Permitted Facilities

As of October 1998, there was one permitted facility within the Fleming Creek watershed permitted by KDOW for the discharge of FC (one point source discharger), which is the Flemingsburg WWTP. Other facilities of interest were a stockyard (not permitted) adjacent to Town Branch, and the Carpenter Landfill (permitted by the Division of Waste Management), which is next to Fleming Creek southeast of Flemingsburg. A Notice of Violation (NOV) was issued against the stockyard in December 1992. As a result, the owners of this facility removed large piles of manure and implemented a manure collection system. Also, there was local controversy over the Carpenter Landfill accepting out-of-state garbage and for exceeding permit boundaries. This site was closed in July 1992 (KDOW, 1996).

LAND USE TRACKING

The Kentucky Division of Conservation (DOC) tracks pertinent land use activities in the Fleming Creek watershed. The U.S. Natural Resource Conservation Service (NRCS) has also provided land-use information. As part of continuing studies within the Fleming Creek watershed, the watershed is divided into eight zones for compiling land-use data. This was done to investigate potential relations between land management activities (within certain sub-watersheds of particular interest) and water quality (through the monitoring

station data). The goal is to evaluate BMP effectiveness within the sub-watersheds. Dividing the project area into zones should assist in defining remaining problem areas within the Fleming Creek watershed where additional BMPs are needed. Specific types of land-use data being (or to be) compiled within each zone include:

- 1) location of AFOs;
- 2) feedlots within 100 feet of a stream;
- 3) number of animals-categorized as beef cattle or dairy cattle;
- 4) tons of animal waste produced per unit time;
- 5) location of BMPs installed as a result of USDA cost-share funding and those installed through other means;
- 6) agronomic activities-categorized by crop and acreage.

TARGET IDENTIFICATION

The criteria for listing stream segments in the 305(b) report as not meeting the designated use of swimming because of pathogens contamination follows. Partial support of the designated use of swimming occurs if the FC count exceeds 400 colonies per 100 milliliters (of sample) in 20-33 percent of the samples collected during routine (monthly) sampling. If the FC count exceeds 400 colonies per 100 milliliters (of sample) in more than 33 percent of the samples collected during routine (monthly) sampling, the stream is determined to be in nonsupport of the designated use of swimming (Title 401, Kentucky Administrative Regulations, Chapter 5:031).

The endpoint or target of the TMDL is to achieve a fecal coliform count (or the associated count in colonies per day based on the average daily flow rate, which constitutes a load) of 400 colonies or less per 100 milliliters of sample (KDOW, 1998a and 1998b). This designated use criteria applies where only periodic samples for FC are collected. For point source permitted to discharge FC (Flemingsburg WWTP), the FC count shall not exceed (1) 200 colonies/100 ml of sample based on a geometric mean of all samples taken during a 30-day period, and (2) shall not exceed 400 colonies per 100 milliliters of sample in 20 percent or more of all samples taken during the month. The dischargers are required to submit Discharge Monitoring Reports (DMRs) to the KDOW to assess compliance by the facility.

SOURCE ASSESSMENT

Water Quality Monitoring Program

The Nonpoint Source (NPS) Section of the KDOW has gathered bacteriological, physicochemical, and biological data designed to target the worst pollution problems (which are primarily from animal waste) within the Fleming Creek watershed and to establish general pre-BMP water quality conditions. Monitoring will continue after the installation of animal waste BMPs to document and demonstrate water quality changes resulting from BMP implementation. Specific responsibilities of the NPS Section include(d): (1) study plan development; (2) coordination of monitoring activities with other agencies; (3) implementation of water quality monitoring activities; and (4) documentation of water quality changes as a result of BMP installation. KDOW water quality monitoring efforts began in the spring of 1992 and continued through several seasons.

Twenty-eight stations (Table 1) were established throughout the project area for bacteriological sampling. Many of these stations were located on Fleming Creek immediately upstream and downstream of the major tributaries, and at the mouths of those tributaries. Other stations were established along Fleming Creek at three- to five-mile intervals. This station arrangement was used so that various portions of the watershed could be evaluated separately. Bacteriological/chemical data included both a low-flow (August 18, 1992) and high-flow (May 18, 1992) event. The FC counts from the two sampling runs are given in Table 2 and are shown in Figures 4 and 5. The data were taken from; Fleming Creek Demonstration Project, Pre-BMP Report (KDOW, 1996). A subsequent low-flow sampling survey was made on October 12, 1998 and a high-flow sampling survey was made on May 23, 1998. These latest 2 sampling surveys were made after installation of some BMPs in the watershed. The FC counts are given in Table 3 and in Figures 6 and 7.

The focus of this sampling was on FC counts within the Fleming Creek watershed. The initial purposes of this sampling were: (1) to document existing conditions within the watershed with respect to point and nonpoint pollution sources; and (2) to target portions of the watershed most impacted by animal waste. Information obtained from bacteriological surveys was made available to NRCS to assist with BMP placement. Streamflow was not measured at any site during any of the 4 bacteriological surveys. However, streamflow information was periodically determined when

Table 1. List of Bacteriological Sampling Locations in the Fleming Creek Watershed and Associated Drainage Areas. [mi², Square Miles; Cr, Creek; Hwy, Highway; UT, Unnamed Tributary; RM, River Mile; Rd, Road; WWTP, Waste Water Treatment Plant; ND, No Data]

<u>Site Location</u>	<u>River Mile</u> [*]	<u>Drainage Area (mi²)</u>
Fleming Cr at Hwy 132 bridge	1.3	95.2
UT at RM 4.28 (adjacent to Hammonds Rd)	0.3(4.28)	1.95
Fleming Cr adjacent to Yin Road	4.8	90.8
Fleming Cr adjacent to Pike Bluff Rd	8.75	85.6
Poplar Cr near the mouth	0.1(9.4)	3.94
Fleming Cr Downstream of Doty Cr	12.6	75.6
Doty Cr near the mouth	0.1(12.65)	2.72
Fleming Creek upstream of Doty Cr	12.7	72.8
Fleming Cr Downstream of Craintown Br	15.85	68.3
Craintown Br near the mouth	0.1(15.9)	3.31
Fleming Cr upstream of Craintown Br	15.9	65.0
Flat Run near the mouth	1.0(16.6)	2.55
Fleming Cr upstream of Flat Run	17.8	60.7
Fleming Cr Downstream of Cassidy Cr (at Hwy 11 bridge)	20.05	57.5
Cassidy Creek at Hwy 11 bridge	0.4(20.6)	3.90
Fleming Cr upstream of Cassidy Cr	20.65	53.0
Allison Cr Downstream of Smith's Dairy	0.8(22.1)	8.58
Fleming Cr upstream of Allison Cr	22.5	42.0
Fleming Cr Downstream of Town Br	25.9	38.4
Town Br (Flemingsburg WWTP effluent)	0.6(25.95)	5.85
Town Br near the mouth	0.1(25.95)	6.05
Fleming Cr upstream of Town Branch	26.0	32.3
Wilson Run near the mouth	0.2(27.9)	6.75
Fleming Cr upstream of Wilson Run (at Hwy 559 bridge)	28.2	21.3
Sleepy Run Downstream of Hwy 57 bridge	0.9(30.05)	3.31
Fleming Cr at Hwy 3301 bridge	31.0	15.9
Logan Run near the mouth	0.1(32.8)	3.18
Fleming Cr upstream of Logan Run	32.8	9.28

* For tributaries to Fleming Cr, the confluence with Fleming Cr is shown in parentheses.

Table 2. Fecal Coliform Counts from the Bacteriological Sampling Surveys of May 18, 1992 and August 18, 1992 in the Fleming Creek Watershed (KDOW, 1996). [Cr, Creek; Hwy, Highway; UT, Unnamed Tributary; RM, River Mile; Rd, Road; WWTP, Waste Water Treatment Plant; ND, No Data; >, Greater Than]

<u>Site Location</u>	<u>Fecal Coliform Counts*</u>	
	<u>(colonies/100 milliliters)</u>	
	<u>August 18,1992</u>	<u>May 18,1992</u>
	<u>(Base-flow Sample)</u>	<u>(Runoff Sample)</u>
Fleming Cr at Hwy 132 bridge	20/30	400
UT at RM 4.28 (adjacent to Hammonds Rd)	100	9,200
Fleming Cr adjacent to Yin Road	60	560
Fleming Cr adjacent to Pike Bluff Rd	100	4,600
Poplar Cr near the mouth	260	9,200
Fleming Cr Downstream of Doty Cr	60	750
Doty Cr near the mouth	80	5,000
Fleming Creek upstream of Doty Cr	140	740/650
Fleming Cr Downstream of Craintown Br	120	250
Craintown Br near the mouth	90	520
Fleming Cr upstream of Craintown Br	30/60	460
Flat Run near the mouth	10	500
Fleming Cr upstream of Flat Run	130	500
Fleming Cr Downstream of Cassidy Cr	210	210
(at Hwy 11 bridge)		
Cassidy Creek at Hwy 11 bridge	10	2,400/1,800
Fleming Cr upstream of Cassidy Cr	270	500
Allison Cr Downstream of Smith's Dairy	>16,000	>16,000
Fleming Cr upstream of Allison Cr	250	420
Fleming Cr Downstream of Town Br	1,000	15,000
Town Br (Flemingsburg WWTP effluent)	3,600	ND
Town Br near the mouth	6,800	>16,000
Fleming Cr upstream of Town Branch	1,100	500
Wilson Run near the mouth	720	5,600
Fleming Cr upstream of Wilson Run	490/430	1,400
(at Hwy 559 bridge)		
Sleepy Run Downstream of Hwy 57 bridge	500	16,000
Fleming Cr at Hwy 3301 bridge	200	12,000
Logan Run near the mouth	100	3,200
<u>Fleming Cr upstream of Logan Run</u>	<u>530</u>	<u>>16,000</u>

* Two values are given when a duplicate sample was collected.

Table 3. Fecal Coliform Counts from the Bacteriological Sampling Surveys of May 23, 1998 and October 12, 1998 in the Fleming Creek Watershed (Peake, written commun., 1999). [Cr, Creek; Hwy, Highway; UT, Unnamed Tributary; RM, River Mile; Rd, Road; >, Greater Than; WWTP, Waste Water Treatment Plant; ND, No Data]

<u>Site Location</u>	<u>Fecal Coliform Counts*</u>	
	<u>(colonies/100 milliliters)</u>	
	<u>October 12,1998</u> <u>(Base-flow Sample)</u>	<u>May 23,1998</u> <u>(Runoff Sample)</u>
Fleming Cr at Hwy 132 bridge	50/70	>16,000(100,000)
UT at RM 4.28 (adjacent to Hammonds Rd)	10	>11,000
Fleming Cr adjacent to Yin Road	10	>16,000(60,000)
Fleming Cr adjacent to Pike Bluff Rd	10	>16,000(90,000)
Poplar Cr near the mouth	80	>16,000(18,000)
Fleming Cr Downstream of Doty Cr	60	>16,000(100,000)
Doty Cr near the mouth	ND	ND
Fleming Creek upstream of Doty Cr	220	>16,000(80,000)
Fleming Cr Downstream of Craintown Br	ND	ND
Craintown Br near the mouth	130	>16,000(50,000)
Fleming Cr upstream of Craintown Br	10	>16,000(60,000)
Flat Run near the mouth	ND	ND
Fleming Cr upstream of Flat Run	60	>16,000(60,000)
Fleming Cr Downstream of Cassidy Cr (at Hwy 11 bridge)	10	>16,000(20,000/60,000)
Cassidy Creek at Hwy 11 bridge	ND	>16,000(30,000)
Fleming Cr upstream of Cassidy Cr	ND	ND
Allison Cr Downstream of Smith's Dairy	ND	>16,000(60,000)
Fleming Cr upstream of Allison Cr	60	>16,000(80,000)
Fleming Cr Downstream of Town Br	450	>16,000(80,000)
Town Br (Flemingsburg WWTP effluent)	ND	>16,000(20,000)
Town Br near the mouth	600	>16,000(60,000)
Fleming Cr upstream of Town Branch	270	>16,000(100,000)
Wilson Run near the mouth	6000	>16,000(100,000)
Fleming Cr upstream of Wilson Run (at Hwy 559)	150	>16,000(20,000)
Sleepy Run Downstream of Hwy 57 bridge	120	>16,000(18,000)
Fleming Cr at Hwy 3301 bridge	200	>16,000(80,000)
Logan Run near the mouth	70	>16,000(100,000)
Fleming Cr upstream of Logan Run	30	>16,000(100,000)

* Two values are given when a duplicate sample was collected. The value in parentheses is an estimate of the actual FC count.

physicochemical monitoring was done at five sites in the watershed. These five sites are Logan Run, Allison Creek, Craintown Branch, Fleming Creek at Highway 3301 (Flemingsburg-Beechburg Road), and Fleming Creek at Highway 170. These streamflow determinations, in conjunction with daily streamflow records at a number of nearby continuous-record streamflow gaging stations (USGS, 1993; USGS written commun., 1999), were used to determine a mean value of streamflow for each site where a FC sample was collected.

Quality Assurance/Quality Control

Sampling locations, water quality parameters, and project objectives are provided in the project study plan (KDOW, 1993a), which is available upon request through the KDOW NPS Section. Sample collection and handling procedures given in the Ecological Support Section's Quality Assurance/Quality Control Guidelines and Methods Manuals (KDOW 1986a, 1986b, and 1993b) were used. Analysis for FC bacteria was accomplished using the membrane filter technique. The American Public Health Association (APHA, 1992), and U.S. EPA-approved field and laboratory methods and procedures were used when appropriate, including adherence to holding times and proper sample preservation. Duplicates or splits were collected and analyzed for at least ten percent of the water samples. Chain-of-custody procedures were followed for all samples. A log was maintained for all water and biological samples. All pertinent field equipment was calibrated according to manufacturer's recommendations prior to use.

Base-flow Fecal Coliform Surveys

The August 18, 1992 and October 12, 1998 FC sampling surveys (Figure 4 and 6, respectively) were made when base-flow conditions existed, and the results from the surveys are indicative of low base-flow conditions. Many streams in the watershed have no flow in the middle or late summer, so the samples were collected during a period of sustained base flow. For these two FC surveys, the flow conditions are considered to be steady state. The FC counts were determined as the number of colonies per 100 milliliters of sample.

For the August 18, 1992 survey (Table 2, Figure 4), the FC counts were greater than 400 colonies at most Fleming Creek sites upstream from Cassidy Creek, and on selected

tributaries upstream of Cassidy Creek (Sleepy Run, Wilson Run, Town Branch, and Allison Creek). The FC counts on Fleming Creek at the sites immediately upstream and downstream of Town Branch were 1,100 and 1,000 colonies, respectively. The sample collected in the drain (which flows into Town Branch) immediately below the outfall of the Flemingsburg WWTP yielded 3,600 colonies. The FC count near the mouth of Town Branch was 6,800 colonies. On Fleming Creek downstream from this location (and just above Allison Creek) the FC count had decreased to 250 colonies. Allison Creek had the highest FC count of any location during the survey, greater than 16,000 colonies. However, the FC count on Fleming Creek downstream from Allison Creek (just upstream of the confluence with Cassidy Creek) had decreased to 270 colonies, only slightly higher than the count above Allison Creek. From this data, it appears that the FC count on Fleming Creek decreases fairly rapidly only a short distance downstream from the tributaries that are contributing high FC concentrations. Downstream of Cassidy Creek, the FC count did not exceed 260 colonies at any sampling location. For this survey, the high FC counts upstream of Cassidy Creek on the main stem of Fleming Creek and on the tributaries sampled are most likely due to access to the creek by livestock and/or leakage from manure holding ponds and the WWTP.

For the October 12, 1998 FC sampling survey (Table 3, Figure 6), the FC counts were greater than 400 colonies at Wilson Run, Town Branch, and Fleming Creek just downstream from Town Branch. No data were available for the Flemingsburg WWTP, Allison Creek, Fleming Creek just downstream from Allison Creek, Cassidy Creek, Flat Creek, Fleming Creek just downstream from Craitown Branch, or Doty Creek. Wilson Run had the highest FC count (6,000 colonies) of any location during the survey. However, as noted, no sample was collected on Allison Creek (which had the highest FC value for the August 18, 1992 sampling survey) because the sampling site was inaccessible, and no sample was collected on Fleming Creek just below Allison Creek. Town Branch at the mouth had a FC count of 600 colonies, and Fleming Creek below Town Branch was 450 colonies. These values represent a significant reduction from the August 18, 1992 sampling survey, probably due to the WWTP achieving better results and the apparent lack of AFOs in the watershed (Figure 3). This is not to say that there are no agricultural operations (such as free ranging cattle) in the watershed, just that there are no identified AFOs.

Downstream of Cassidy Creek, the FC count did not exceed 220 colonies at any sampling location for the October 12, 1998 sampling survey. The high FC count on Wilson Run is most likely due to access to the creek by livestock and/or leakage from manure holding ponds. The elevated FC count on Town Branch is most likely due to access to the creek by livestock, leakage from manure holding ponds, and the Flemingsburg WWTP. According to the Fleming County Health Dept. (Watson, personal commun., 2000) and KDOW personnel (Rice, written commun., 2000), there have been no complaints related to failing septic systems or to straight pipes in the Fleming Creek Watershed. A review of topographic maps and subsequent field inspections on October 12, 2000 indicated that few homes are located along the main stem of the UT at RM 31.7, Wilson Run, or Allison Creek. During this survey, cows having access to the creek were observed near the mouth of Wilson Run and Town Branch. Work has been done to limit access of cows to Allison Creek near the mouth of Allison Creek. The FC count for Fleming Creek just upstream from Sleepy Run was elevated compared to the results of samples taken above that location (Figure 6). This indicates that FC contamination was being contributed from a source above this location, but below Logan Run because Logan Run and Fleming Creek above Logan Run had FC counts of 70 and 30, respectively. The apparent source of the FC during the base-flow is from the UT at RM 31.7. Based on mass balance analysis (using streamflow estimates provided later in this report), the FC count for the UT at RM 31.7 would be 1,500 colonies. There are several AFOs on this UT and no indication of AFOs on the main stem in the reach from Logan Run to Sleepy Run (Figure 3). Access to the creek by livestock and/or leakage from manure holding ponds are the most probable sources. The base-flow sampling surveys indicate that access to the creeks by cattle and/or leakage from manure holding ponds, and the Flemingsburg WWTP (Town Branch and Fleming Creek immediately downstream from Town Branch only), are most likely the main factors contributing to elevated FC values in:

- Fleming Creek below the UT at RM 31.7;
- Wilson Run (and Fleming Creek below Wilson Run);
- Town Branch (and Fleming Creek below Town Branch); and
- Allison Creek (and Fleming Creek below Allison Creek).

Allison Creek had the highest value for either sampling survey, but was not sampled during the 1998 survey because of access limitations. This subwatershed contains a high concentration of AFOs (Figure 3).

Runoff Fecal Coliform Surveys

The May 18, 1992 and May 23, 1998 FC sampling surveys (Figure 5 and 7) were made during runoff conditions and are, therefore, indicative of nonpoint source pollution. For analysis purposes, the flow during these events is considered to be quasi-steady state and estimates of the flow values for the sites were based on mean daily flows from nearby streamflow gaging stations, streamflow measurements made at selected sites in the watershed during runoff periods, and drainage area ratios. The estimated streamflow values are presented later in the report. The FC counts were determined as the number of colonies per 100 milliliters of sample.

The May 18, 1992 FC sampling survey (Figure 5) was made during a runoff period (0.75 inches of rain) and, therefore, provides information on nonpoint source pollution (polluted runoff). Only samples from three locations had FC counts of 400-colonies/100 ml or less. These three locations are on the main stem of Fleming Creek in the lower half of the watershed. In addition, all main stem samples from just above Allison Creek to the confluence with the Licking River were equal to or less than 750 colonies except at the location immediately below Poplar Creek, which was 4,600. Flat Run and Craitown Branch had a FC count of 500 and 520 colonies, respectively. Field personnel indicated that the flow in these streams appeared to have less flow, relatively speaking, than other streams in the basin, which indicates that there was less runoff. Also, as indicated later in the report, there are a number of BMPs located in the Craitown Branch watershed. Cassidy Creek averaged 2,100 colonies. All other sampled tributaries had FC counts greater than or equal to 5,000 colonies. Logan Run, Sleepy Run, Town Branch, and Allison Creek all had counts greater than or equal to 16,000 colonies. The FC count just upstream from Sleepy Run was 12,000, which is high when compared to the results of samples taken above that location (Figure 5), particularly for the distance involved. The FC count on Logan Run was greater than 16,000, but the actual value could not be defined. Still, the value of 12,000 colonies at a distance of 1.05 miles below Logan Run is high. As with the October 12, 1998 sampling

survey, this indicates that FC contamination was being contributed from a source above this location, but below Logan Run. The apparent source is the UT at RM 31.7. As mentioned previously, there are several AFOs on this UT (Figure 3) which are potential sources of FC contamination. Figure 3 indicates that there are no AFOs along the main stem of Fleming Creek in this reach (from Logan Run to Sleepy Run). Based on mass balance analysis (using streamflow estimates provided later in this report), the FC count for the UT at RM 31.7 was approximately 32,500. This value would be a maximum because it is based on a FC count of 16,000 for Logan Run. The FC analysis indicated that the count was >16,000, but no estimate of the actual value was made. For example, a FC count of 30,000 (about double) for Logan Run would result in a FC count for the UT at RM 31.7 of about 19,700.

The May 23, 1998 sampling survey (Figure 7) was made during a runoff period and, therefore, provides information on nonpoint source pollution (polluted runoff). This storm event was of greater magnitude and was more widespread than the May 18, 1992 survey storm event. As a result, the FC counts are higher than what was determined for the May 18, 1992 survey. All of the FC values were reported as being greater than 16,000 except for the value at the UT at RM 4.28, which was 11,000. Estimates of the actual values for the samples with FC greater than 16,000 were made, and these values are shown in Table 3 and Figure 7. The only distinct pattern was that all values on the main stem remained very high, particularly in the lower part of the watershed. An anomaly was the high value at the most downstream Fleming Creek site (100,000 colonies) even though the contribution from the UT at RM 4.2 was 11,000 and the value for Fleming Creek upstream of the UT at RM 4.28 was 60,000 colonies. Of interest is that the values for the UT at RM 4.28 and Poplar Creek are 11,000 and 18,000 respectively. These are the lowest values for the survey. Figure 3 indicates that there are no AFOs in either of these watersheds. This is also the case for Town Branch, yet the value of FC is very high (60,000) at the mouth. This is not to say that there are no free ranging cattle in the watershed, just that there are no identified, confined animal feeding operations. Also, because the value for Logan Run and the most upstream Fleming Creek site were both 100,000 colonies and the FC count for the Fleming Creek site above Sleepy Run was 80,000 colonies, it is difficult to make an estimate of the contribution from the UT at RM 31.7, except to say that it is probably very high (probably greater than 50,000 colonies).

The runoff sampling surveys (in particular the May 23, 1998 survey) indicate that there is a significant contribution of FC contamination from nonpoint sources and from the Flemingsburg WWTP (Town Branch). The values were very high at all sites sampled during the May 23, 1998 sampling survey and at many sites sampled during the May 18, 1992 sampling survey. The FC contamination during runoff events can be mostly attributed to the beef and dairy operations in the watershed, of which there are a substantial number (Figure 3). The sources may include grazing activities (and lack of buffer strips along the stream channels), AFOs in close proximity to the stream, land application of manure, and manure holding ponds, and the Flemingsburg WWTP.

LINKING WATER QUALITY TARGETS AND SOURCES

Streamflow Estimates

Streamflow estimates for the five sampling sites in the watershed (which had some streamflow information) for the May 18, 1992 and August 18, 1992 sampling surveys are shown in Table 4. These five sites are Logan Run, Allison Creek, Craintown Branch, Fleming Creek at Highway 3301, and Fleming Creek at Highway 170. The flow estimates for these five sampling sites for the May 23, 1998 and October 12, 1998 sampling surveys are shown in Table 5. The flow estimates are based on mean daily flow values from nearby continuous-record streamflow gaging stations (referred to hereafter as gaging stations). The mean daily flows from the nearby gaging stations are also shown in Tables 4 and 5.

May 18, 1992 Sampling Survey

For the May 18, 1992 runoff sample, the target was to estimate flow at Fleming Creek at Hwy 170, and use that value to estimate flows at the other four sites. This was done using drainage area ratios and flow information from the sampling surveys on the other dates that are shown in Table 4. The flow at Fleming Creek at Hwy 170 was estimated based primarily on the flow data from the gaging station at North Fork Licking River at Mt. Olivet. The reasoning for this decision follows. For the May 18, 1992 sampling survey, the rainfall was not widespread and occurred predominantly in the area around Flemingsburg (0.75 inches of rainfall in the previous 24 hours was reported in the

1996 KDOW report) and north of Flemingsburg (including Mt. Olivet). This is evident by the higher streamflow value at the Mt. Olivet gaging station than at the other three gaging stations shown in Table 4. The gaging station at Mt. Olivet is approximately 20 miles northwest of Flemingsburg (Flemingsburg is centrally located in the Fleming Creek watershed). Much lower streamflow values were reported at the two gaging stations near Morehead, Kentucky and also at the gaging station near Carlisle, Kentucky. Morehead is located approximately 25 miles southeast of Flemingsburg and the North Fork of Triplett Creek extends to an area northeast of Morehead. Carlisle is located approximately 25 miles to the southwest of Flemingsburg. Also, at these three gaging stations, the streamflow for May 18, 1992 was approximately 20% less than the flow on May 17, 1992. This indicates that there was no significant runoff in these watersheds located to the south of the Flemingsburg watershed.

The May 8 and 12, 1992 determinations of streamflow at Fleming Creek at Hwy 170 were compared to the mean daily flow at the North Fork Licking River at Mt. Olivet gaging station for the purpose of estimating flow at the Hwy 170 site for the May 18, 1992 sampling survey. At Mt. Olivet the increase in daily flow from May 8 to May 12, 1992 was 190%, and the increase from May 8 to May 18 was 130%. For Fleming Creek at Hwy 170 the flow from May 8 to May 12, 1992 was 350%. Multiply the 350% by the ratio of the Mt. Olivet flows (1.3/1.9) to obtain the multiplier needed to estimate the May 18, 1992 flow from the May 8, 1992 flow determination. The result is 41 cubic feet per second (cfs) at Fleming Creek at the Hwy 170 site for May 18, 1992.

From this value, flows were estimated at the other four sites using a combination of drainage area ratios, and observations of concurrent flow determinations made on the other dates (Table 4). Streamflows were estimated at all of the remaining sites sampled using drainage area ratios and flow accounting. During this process, it was determined that the flow estimate at the Hwy 170 site needed to be increased slightly to account for the tributary inflows. Therefore the flow estimate at the Hwy 170 bridge was increased from 41 to 49 cfs. This scenario assumes a quasi-steady state condition existing throughout the watershed.

May 23, 1998 Sampling Survey

For the May 23, 1998 runoff sample, a ratio of the streamflows at the gaging stations for January 5, 1993 and May 23, 1998 was used estimate flow at the five sampling sites (including the Hwy 170 site) shown in Table 5. No streamflow measurements were made during a high flow condition in 1997 or 1998 and the values for the January 5, 1993 event at the gaging stations was similar to the flows on May 23, 1998. The Flemingsburg WWTP discharge was assumed to be 1.0 cfs, which is the permitted design flow. Flows were estimated at all of the remaining sampling sites using a combination of drainage area ratios and flow accounting.

Flow duration analysis using data from 1992-98 for the gaging stations at North Fork Licking River at Mt. Olivet and Hinkston Creek near Carlisle was performed. The mean daily flow for May 23, 1998 averaged out to be approximately 10 percent, which means that, over time, 10 percent of the mean daily flows occurring for streams in the area are greater than the values defined for May 23, 1998. This is a reasonable value to use for this analysis to determine loads, and no further adjustments were made to the flow values that were used to compute daily loads for the streams in the Fleming Creek watershed. The resulting streamflow values and associated FC counts for all of the sampling sites in the watershed are shown in Figure 8.

August 18, 1992 Sampling Survey

Steady-state flow conditions were assumed to be present during the August 18, 1992 survey. Again, the gaging station information and data were used to make an estimate at the Fleming Creek at Hwy 170 location. The August 18, 1992 flows were divided by the respective drainage area to define a multiplier. The multipliers are:

Triplett Creek at Morehead	0.031
North Fork Triplett Creek near Morehead	0.055
North Fork Licking River near Mt. Olivet	0.084
Hinkston Creek near Carlisle	0.090

The values indicate a rather large spread in cubic feet per second per square mile (cfsm). The low and high values were omitted and the other two values were averaged, resulting in a value of 0.70 as the multiplier. The flow estimate at the Hwy 170 bridge is 5.4 cfs using

0.70 multiplied by 77.2 square miles (Table 4). The Flemingsburg WWTP discharge was assumed to be 1.0 cfs, which is the design flow. Streamflow at the other four locations was estimated based on a combination of drainage area ratios, and observations of concurrent flow determinations made on the other dates. Flows were estimated at all of the remaining sites sampled using a combination of drainage ratios and flow accounting.

October 12, 1998 Sampling Survey

To estimate the flow for this survey, the ratio between flows for October 12, 1998 at the gaging stations and the respective drainage areas was determined. This average value was 0.21, which was then used as a multiplier. The August 18, 1992 flow estimates at the five sampling sites shown in Table 4 were multiplied by 0.21 to provide an estimate of the flow for October 12, 1998. The October 12, 1998 sampling survey was made several days after a small rainfall event, which provided for a fairly stable base-flow condition. This timing of the sample was necessary because the streams in the watershed have no flow during the late summer and early fall. This is evident from the Table 5 streamflow data. In fact, the 7Q₂ and 7Q₁₀ streamflow at the Highway 170 site on Fleming Creek are both 0.0 cfs (Ruhl and Martin, 1991). The 7Q₂ and 7Q₁₀ streamflows are the 50 and 10 percent chance, respectively, that there will be a nonexceedance of that streamflow value at some time during any year. Because of this, streamflows for the five sites did not correlate well with the gaging station flows. Therefore, the correlation with the August 18, 1992 flows was made. The streamflow values at the five sites for the August 18, 1992 sample (shown in Table 4) were multiplied by 0.21. These values are shown in Table 5. The flow value at Fleming Creek at Highway 170 was increased from 1.1 to 1.3 cfs based on flow estimates for the tributaries and flow accounting. The resulting streamflow values and associated FC counts are shown in Figure 9.

Flow duration analysis using data from 1992-98 for the gaging stations at North Fork Licking River at Mt. Olivet and Hinkston Creek near Carlisle was performed to make an estimate of the frequency of occurrence for the October 12, 1998 sampling survey. The mean daily flow for October 12, 1998 for the two gaging stations averaged out to be approximately 90 percent, which means that, over time, 90 percent of the mean daily flows

occurring for streams in the area are greater than the values defined for October 12, 1998. This is a reasonable value to use for a base-flow analysis to define loads. Therefore, no further adjustments were made to the flow values that were used to compute daily loads for the streams in the Fleming Creek watershed.

LOAD ESTIMATES

Load estimates were made by multiplying the FC count for each observation by the streamflow estimate. Figures 8 and 9 show the FC count and associated streamflow value for each site. The loads for the tributaries are presented first, followed by the loads for the main stem Fleming Creek sites. The load computation is:

$$\#cfs \times (1mgd/1.55cfs) \times (3.785l/1gal) \times (1000ml/1l) \times \#colonies/100ml = \#colonies/day.$$

Reducing and rearranging the terms yields a fecal coliform load equation of;

$$\#colonies/day = (24.42 E6)(\#cfs)(\#colonies \text{ in a } 100 \text{ milliliter sample})$$

The May 23, 1998 and October 12, 1998 sample values (if available) were used for determining the loads for the runoff and base-flow conditions, respectively, for all stream locations (Figures 8 and 9). It is the most recent data. If a value was not available, the data from the May 18, 1992 or August 18, 1992 sampling survey may have been used to determine the load. Also, streamflow values for the October 12, 1998 sampling survey were lower than for the May 18, 1992 survey, providing for a better assessment of FC contamination under low base-flow conditions.

The TMDL equation is:

$$TMDL = WLA + LA + MOS$$

where;

TMDL = Total Maximum Daily Load

WLA = Waste Load Allocation (point sources)

LA = Load Allocations (nonpoint sources) and includes Background

MOS = Margin of Safety (either Explicit or Implicit)

Point Sources

There are no point sources of FC contamination except for the Flemingsburg WWTP, which discharges to a drain that flows to Town Branch. The WWTP is permitted to meet a limit of ≤ 200 colonies/100ml.

Nonpoint Sources

The target for the nonpoint sources is 400 colonies/100 ml. This value will be computed as the total load minus the background and minus any point sources. The information is provided for each tributary to Fleming Creek, progressing from the most downstream site to the most upstream site, with the exception of Town Branch, which is presented after the other tributaries. This is followed by the Fleming Creek analysis.

Background

The background FC count was estimated to be 10 colonies per 100 ml during base-flow conditions and 50 colonies per 100 ml during runoff conditions. These values are based on a review of the data from selected sampling locations during the four sampling surveys. During the low base-flow surveys of August 18, 1992 and October 12, 1998, the following observations were made:

Cassidy Creek	= 10 colonies/100 ml
Flat Run	= 10 colonies/100 ml
Fleming Cr (at 2 sites)	= 10 colonies/100 ml

As a result, a background value of 10 colonies/100 ml was selected. For the runoff survey of May 18, 1992, no true control site was sampled. However, the following observations were made:

Fleming Creek below Cassidy Creek	= 210 colonies/100 ml
Fleming Creek below Craintown Br	= 250 colonies/100 ml

Assuming that 20-25 percent of these values can be attributed to natural conditions, use 50 colonies/100 ml as the background FC value for the runoff conditions.

Margin of Safety

An explicit margin of safety of 25 colonies/100 ml is assigned to FC values for this TMDL for both the base-flow and runoff conditions for the nonpoint sources. For

the point sources, a margin of safety is implied, because the point sources are permitted to maintain an average FC count of 200 colonies/100 ml.

Unnamed Tributary to Fleming Creek (confluence at RM 4.28 of Fleming Creek)

For the Base-flow Condition (October 12, 1998)

Observed is
 (24.42 E6)(0.04 cfs)(10 colonies/100ml) = 0.09 E8 colonies/day
 Background is
 (24.42 E6)(0.04 cfs)(10 colonies/100 ml) = 0.09 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(0.04 cfs)(25 colonies/100 ml) = 0.24 E8 colonies/day
 WQ Standard is
 (24.42 E6)(0.04 cfs)(400 colonies/100 ml) = 3.9 E8 colonies/day
 No point sources of fecal coliform

COMPUTATIONS

Observed = 0.1 E8 colonies/day	Target (TMDL) = 3.9 E8 colonies/day
0 point sources	0 point sources
0.1 E8 background	0.1 E8 background
0 E8 nonpoint source	0.2 E8 margin of safety
	3.6 E8 for nonpoint source

Water quality standards are currently being met for the Base-flow Condition.

For the Runoff Condition (May 23, 1998)

Observed is
 (24.42 E6)(5.9 cfs)(11,000 colonies/100ml) = 15,850 E8 colonies/day
 Background is
 (24.42 E6)(5.9 cfs)(50 colonies/100 ml) = 72 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(5.9 cfs)(25 colonies/100 ml) = 36 E8 colonies/day
 WQ Standard is
 (24.42 E6)(5.9 cfs)(400 colonies/100ml) = 576 E8 colonies/day
 No point sources of fecal coliform

COMPUTATIONS

Observed = 15,850 E8 colonies/day	Target (TMDL) = 576 E8 colonies/day
0 E8 point sources	0 point sources
72 E8 background	72 E8 background
15,778 E8 nonpoint source	36 E8 margin of safety
	468 E8 for nonpoint source

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There are no delineated AFOs in the watershed (Figure 3), but runoff from pastures at livestock operations, land application of animal wastes, and preexisting manure holding ponds are potential sources of FC. The

reduction in nonpoint source load (not including background) that is needed to meet WQ standards is:

$$15,778 \text{ E8} - 468 \text{ E8} = 15,310 \text{ E8 colonies/day}$$

Poplar Creek

For the Base-flow Condition (October 12, 1998)

Observed is
 $(24.42 \text{ E6})(0.07 \text{ cfs})(80 \text{ colonies/100ml}) = 1.4 \text{ E8 colonies/day}$
 Background is
 $(24.42 \text{ E6})(0.07 \text{ cfs})(10 \text{ colonies/100 ml}) = 0.2 \text{ E8 colonies/day}$
 Margin of Safety is
 $(24.42 \text{ E6})(0.07 \text{ cfs})(25 \text{ colonies/100 ml}) = 0.4 \text{ E8 colonies/day}$
 WQ Standard is
 $(24.42 \text{ E6})(0.07 \text{ cfs})(400 \text{ colonies/100 ml}) = 6.8 \text{ E8 colonies/day}$
 No point sources of fecal coliform

COMPUTATIONS

Observed = 1.4 E8 colonies/day	Target (TMDL) = 6.8 E8 colonies/day
0 point sources	0 point sources
0.2 E8 background	0.2 E8 background
1.2 E8 nonpoint source	0.4 E8 margin of safety
	6.2 E8 for nonpoint source

Water quality standards are currently being met for the Base-flow Condition.

For the Runoff Condition (May 23, 1998)

Observed is
 $(24.42 \text{ E6})(12 \text{ cfs})(18,000 \text{ colonies/100ml}) = 52,747 \text{ E8 colonies/day}$
 Background is
 $(24.42 \text{ E6})(12 \text{ cfs})(50 \text{ colonies/100 ml}) = 146 \text{ E8 colonies/day}$
 Margin of Safety is
 $(24.42 \text{ E6})(12 \text{ cfs})(25 \text{ colonies/100 ml}) = 73 \text{ E8 colonies/day}$
 WQ Standard is
 $(24.42 \text{ E6})(12 \text{ cfs})(400 \text{ colonies/100ml}) = 1,172 \text{ E8 colonies/day}$
 No point sources of fecal coliform

COMPUTATIONS

Observed = 52,747 E8 colonies/day	Target (TMDL) = 1,172 E8 colonies/day
0 E8 point sources	0 point sources
146 E8 background	146 E8 background
56,601 E8 nonpoint source	73 E8 margin of safety
	953 E8 for nonpoint source

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There are no delineated AFOs in the watershed (Figure 3), but runoff from pastures at livestock operations, land application of animal wastes, and preexisting manure holding ponds are potential sources of FC. The

reduction in nonpoint source load (not including background) that is needed to meet WQ standards is:

$$56,601 \text{ E8} - 953 \text{ E8} = 55,648 \text{ E8 colonies/day}$$

Doty Creek

For the Base-flow Condition (Using data from the August 18, 1992 sampling survey)

Observed is	
(24.42 E6)(0.25 cfs)(80 colonies/100 ml)	= 4.9 E8 colonies/day
Background is	
(24.42 E6)(0.25 cfs)(10 colonies/100 ml)	= 0.6 E8 colonies/day
Margin of Safety is	
(24.42 E6)(0.25 cfs)(25 colonies/100 ml)	= 1.5 E8 colonies/day
WQ Standard is	
(24.42 E6)(0.25 cfs)(400 colonies/100 ml)	= 24.4 E8 colonies/day
No point sources of fecal coliform	

Observed = 4.9 E8 colonies/day	Target (TMDL) = 24.4 E8 colonies/day
0.0 point sources	0.0 point sources
0.6 E8 background	0.6 E8 background
4.3 E8 nonpoint source	1.5 E8 margin of safety
	22.3 E8 for nonpoint source

Water quality standards are currently being met for the Base-flow Condition.

For the Runoff Condition (Using data from the May 18, 1992 sampling survey)

Observed is	
(24.42 E6)(2.5 cfs)(5000 colonies/100 ml)	= 3,053 E8 colonies/day
Background is	
(24.42 E6)(2.5 cfs)(50 colonies/100 ml)	= 30 E8 colonies/day
Margin of Safety is	
(24.42 E6)(2.5 cfs)(25 colonies/100 ml)	= 15 E8 colonies/day
WQ Standard is	
(24.42 E6)(25 cfs)(400 colonies/100 ml)	= 244 E8 colonies/day
No point sources of fecal coliform	

Observed = 3,053 E8 colonies/day	Target (TMDL) = 244 E8 colonies/day
0 point sources	0 point sources
30 E8 background	30 E8 background
3,023 E8 nonpoint source	15 E8 margin of safety
	199 E8 for nonpoint source

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There is an AFO in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is:
 $3,023 \text{ E8} - 199 \text{ E8} = 2,824 \text{ E8 colonies/day}$

Craintown Branch

For the Base-flow Condition (October 12, 1998)

Observed is
 (24.42 E6)(0.06 cfs)(130 colonies/100ml) = 1.9 E8 colonies/day
 Background is
 (24.42 E6)(0.06 cfs)(10 colonies/100 ml) = 0.2 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(0.06 cfs)(25 colonies/100 ml) = 0.4 E8 colonies/day
 WQ Standard is
 (24.42 E6)(0.06 cfs)(400 colonies/100 ml) = 5.9 E8 colonies/day
 No point sources of fecal coliform

Observed = 1.9 E8 colonies/day	Target (TMDL) = 5.9 E8 colonies/day
0 point sources	0 point sources
0.2 E8 background	0.2 E8 background
1.7 E8 nonpoint source	0.4 E8 margin of safety for nonpoint source
	5.3 E8

Water quality standards are currently being met for the Base-flow Condition

For the Runoff Condition (May 23, 1998)

Observed is
 (24.42 E6)(10.0 cfs)(50,000 colonies/100ml) = 122,100 E8 colonies/day
 Background is
 (24.42 E6)(10.0 cfs)(50 colonies/100 ml) = 120 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(10.0 cfs)(25 colonies/100 ml) = 60 E8 colonies/day
 WQ Standard is
 (24.42 E6)(10.0 cfs)(400 colonies/100ml) = 9,770 E8 colonies/day
 No point sources of fecal coliform

Observed = 121,100 E8 colonies/day	Target (TMDL) = 9,770 E8 colonies/day
0 E8 point sources	0 point sources
120 E8 background	120 E8 background
120,980 E8 nonpoint source	60 E8 margin of safety for nonpoint source
	9,590 E8

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There is an AFO in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is:
 120,980 E8 – 9,590 E8 = 111,390 E8 colonies/day

Cassidy Creek

For the Base-flow Condition (October 12, 1998)

Observed is
 (24.42 E6)(0.07 cfs)(10 colonies/100ml) = 0.2 E8 colonies/day
 Background is
 (24.42 E6)(0.07 cfs)(10 colonies/100 ml) = 0.2 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(0.07 cfs)(25 colonies/100 ml) = 0.4 E8 colonies/day
 WQ Standard is
 (24.42 E6)(0.07 cfs)(400 colonies/100 ml) = 6.8 E8 colonies/day
 No point sources of fecal coliform

Observed = 0.2 E8 colonies/day	Target (TMDL) = 6.8 E8 colonies/day
0 point sources	0 point sources
0.2 E8 background	0.2 E8 background
0 E8 nonpoint source	0.4 E8 margin of safety for nonpoint source
	6.2 E8

Water quality standards are currently being met for the Base-flow Condition.

For the Runoff Condition (May 23, 1998)

Observed is
 (24.42 E6)(12 cfs)(30,000 colonies/100ml) = 87,910 E8 colonies/day
 Background is
 (24.42 E6)(12 cfs)(50 colonies/100 ml) = 146 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(12 cfs)(25 colonies/100 ml) = 73 E8 colonies/day
 WQ Standard is
 (24.42 E6)(12 cfs)(400 colonies/100ml) = 1,170 E8 colonies/day
 No point sources of fecal coliform

Observed = 87,910 E8 colonies/day	Target (TMDL) = 1,170 E8 colonies/day
0 E8 point sources	0 point sources
146 E8 background	146 E8 background
87,764 E8 nonpoint source	73 E8 margin of safety for nonpoint source
	951 E8

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There is an AFO in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is:

$$87,764 \text{ E8} - 951 \text{ E8} = 86,813 \text{ E8 colonies/day}$$

Allison Creek

For the Base-flow Condition (August 18, 1992)

Observed is
 (24.42 E6)(0.7 cfs)(use 16,000 colonies/100ml) = 2,735 E8 colonies/day
 Background is
 (24.42 E6)(0.7 cfs)(10 colonies/100 ml) = 1.7 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(0.7 cfs)(25 colonies/100 ml) = 4.3 E8 colonies/day
 WQ Standard is
 (24.42 E6)(0.7 cfs)(400 colonies/100 ml) = 68.4 E8 colonies/day
 No point sources of fecal coliform

Observed = 2,735 E8 colonies/day	Target (TMDL) = 68.4 E8 colonies/day
0 point sources	0 point sources
2 E8 background	1.7 E8 background
2,733 E8 nonpoint source	4.3 E8 margin of safety
	62.4 E8 for nonpoint source

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Base-flow Condition. There are a number of AFOs in the watershed (Figure 3) and the source of the contamination is most likely cattle accessing the stream and/or leakage from manure holding ponds. The reduction in nonpoint source that is needed to meet WQ standards is:

$$2,733 \text{ E8} - 62 \text{ E8} = 2,671 \text{ E8 colonies/day}$$

For the Runoff Condition (May 23, 1998)

Observed is
 (24.42 E6)(27 cfs)(use 60,000 colonies/100ml) = 395,605 E8 colonies/day
 Background is
 (24.42 E6)(27 cfs)(50 colonies/100 ml) = 330 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(27 cfs)(25 colonies/100 ml) = 165 E8 colonies/day
 WQ Standard is
 (24.42 E6)(27 cfs)(400 colonies/100ml) = 2,640 E8 colonies/day
 No point sources of fecal coliform

Observed = 395,605 E8 colonies/day	Target (TMDL) = 2,640 E8 colonies/day
0 E8 point sources	0 point sources
330 E8 background	330 E8 background
395,275 E8 nonpoint source	165 E8 margin of safety
	2,145 E8 for nonpoint source

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There are several AFOs in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is:

$$395,275 \text{ E8} - 2,145 \text{ E8} = 393,130 \text{ E8 colonies/day}$$

Wilson Run

For the Base-flow Condition (October 12, 1998)

Observed is
(24.42 E6)(0.13 cfs)(6,000 colonies/100ml) = 190 E8 colonies/day
Background is
(24.42 E6)(0.13 cfs)(10 colonies/100 ml) = 1 E8 colonies/day
Margin of Safety is
(24.42 E6)(0.13 cfs)(25 colonies/100 ml) = 1 E8 colonies/day
WQ Standard is
(24.42 E6)(0.13 cfs)(400 colonies/100 ml) = 13 E8 colonies/day
No point sources of fecal coliform

Observed = 190 E8 colonies/day	Target (TMDL) = 13 E8 colonies/day
0 point sources	0 point sources
1 E8 background	1 E8 background
189 E8 nonpoint source	1 E8 margin of safety for nonpoint source
	11 E8

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Base-flow Condition. There are several AFOs in the watershed (Figure 3) and the source of the contamination is most likely cattle accessing the stream and/or leakage from manure holding ponds. The reduction in nonpoint source that is needed to meet WQ standards is:

$$189 \text{ E8} - 11 \text{ E8} = 178 \text{ E8 colonies/day}$$

For the Runoff Condition (May 23, 1998)

Observed is
(24.42 E6)(21 cfs)(100,000 colonies/100ml) = 512,280 E8 colonies/day
Background is
(24.42 E6)(21 cfs)(50 colonies/100 ml) = 260 E8 colonies/day
Margin of Safety is
(24.42 E6)(21 cfs)(25 colonies/100 ml) = 130 E8 colonies/day
WQ Standard is
(24.42 E6)(21 cfs)(400 colonies/100ml) = 2,050 E8 colonies/day
No point sources of fecal coliform

Observed = 512,280 E8 colonies/day	Target (TMDL) = 2,050 E8 colonies/day
0 E8 point sources	0 point sources
260 E8 background	260 E8 background
512,020 E8 nonpoint source	130 E8 margin of safety for nonpoint source
	1,660 E8

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There are several AFOs in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is:

$$512,020 \text{ E8} - 1,660 \text{ E8} = 510,360 \text{ E8 colonies/day}$$

Sleepy Run

For the Base-flow Condition (October 12, 1998)

Observed is
 (24.42 E6)(0.06 cfs)(120 colonies/100ml) = 1.8 E8 colonies/day
 Background is
 (24.42 E6)(0.06 cfs)(10 colonies/100 ml) = 0.2 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(0.06 cfs)(25 colonies/100 ml) = 0.4 E8 colonies/day
 WQ Standard is
 (24.42 E6)(0.06 cfs)(400 colonies/100 ml) = 5.9 E8 colonies/day
 No point sources of fecal coliform

Observed = 1.8 E8 colonies/day	Target (TMDL) = 5.9 E8 colonies/day
0 point sources	0 point sources
0.2 E8 background	0.2 E8 background
1.6 E8 nonpoint source	0.4 E8 margin of safety for nonpoint source
	5.3 E8

Water quality standards are currently being met for the Base-flow Condition.

For the Runoff Condition (May 23, 1998)

Observed is
 (24.42 E6)(10 cfs)(18,000 colonies/100ml) = 43,960 E8 colonies/day
 Background is
 (24.42 E6)(10 cfs)(50 colonies/100 ml) = 120 E8 colonies/day
 Margin of Safety is
 (24.42 E6)(10 cfs)(25 colonies/100 ml) = 60 E8 colonies/day
 WQ Standard is
 (24.42 E6)(10 cfs)(400 colonies/100ml) = 980 E8 colonies/day
 No point sources of fecal coliform

Observed = 43,960 E8 colonies/day	Target (TMDL) = 980 E8 colonies/day
0 E8 point sources	0 point sources
120 E8 background	120 E8 background
43,840 E8 nonpoint source	60 E8 margin of safety for nonpoint source
	800 E8

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There are several AFOs in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is:
 43,840 E8 – 800 E8 = 43,040 E8 colonies/day

Logan Run

For the Base-flow Condition (August 23, 1998)

Observed is
(24.42 E6)(0.06 cfs)(70 colonies/100ml) = 1.0 E8 colonies/day
Background is
(24.42 E6)(0.06 cfs)(10 colonies/100 ml) = 0.2 E8 colonies/day
Margin of Safety is
(24.42 E6)(0.06 cfs)(25 colonies/100 ml) = 0.4 E8 colonies/day
WQ Standard is
(24.42 E6)(0.06 cfs)(400 colonies/100 ml) = 5.9 E8 colonies/day
No point sources of fecal coliform

Observed = 1.0 E8 colonies/day	Target (TMDL) = 5.9 E8 colonies/day
0 point sources	0 point sources
0.2 E8 background	0.2 E8 background
0.8 E8 nonpoint source	0.4 E8 margin of safety 5.3 E8 for nonpoint source

Water quality standards are currently being met for the Base-flow Condition.

For the Runoff Condition (May 23, 1998)

Observed is
(24.42 E6)(10 cfs)(100,000 colonies/100ml) = 244,200 E8 colonies/day
Background is
(24.42 E6)(10 cfs)(50 colonies/100 ml) = 120 E8 colonies/day
Margin of Safety is
(24.42 E6)(10 cfs)(25 colonies/100 ml) = 60 E8 colonies/day
WQ Standard is
(24.42 E6)(10 cfs)(400 colonies/100ml) = 980 E8 colonies/day
No point sources of fecal coliform

Observed = 244,200 E8 colonies/day	Target (TMDL) = 980 E8 colonies/day
0 E8 point sources	0 point sources
120 E8 background	120 E8 background
244,080 E8 nonpoint source	60 E8 margin of safety 800 E8 for nonpoint source

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There are several AFOs in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is:
 $244,080 \text{ E8} - 800 \text{ E8} = 243,280 \text{ E8 colonies/day}$

Town Branch

For the Base-flow Condition (October 12, 1998, at the mouth of Town Branch)

Observed is

$$(24.42 \text{ E6})(1.1 \text{ cfs})(600 \text{ colonies}/100\text{ml}) = 161.2 \text{ E8 colonies}/\text{day}$$

Point Source Contribution (WWTP);

FC assumed to be 450, therefore 350 at RM 0.0

$$(24.42 \text{ E6})(1.0 \text{ cfs})(\text{ND, but assumed } 350) = \text{ND, but use } 85.6 \text{ E8 colonies}/\text{day}$$

Background is

$$(24.42 \text{ E6})(0.1 \text{ cfs})(25 \text{ colonies}/100 \text{ ml}) = 0.6 \text{ E8 colonies}/\text{day}$$

Margin of Safety is

$$(24.42 \text{ E6})(0.1 \text{ cfs})(25 \text{ colonies}/100 \text{ ml}) = 0.6 \text{ E8 colonies}/\text{day}$$

WQ Standard (nonpoint sources) is

$$(24.42 \text{ E6})(0.10 \text{ cfs})(400 \text{ colonies}/100 \text{ ml}) = 9.8 \text{ E8 colonies}/\text{day}$$

WQ Standard (point sources) is

$$(24.42 \text{ E6})(1.0 \text{ cfs})(200 \text{ colonies}/100 \text{ ml}) = 48.8 \text{ E8 colonies}/\text{day}$$

Observed = 161.2 E8 colonies/day	Target (TMDL) = 48.8 + 9.8 = 58.6 E8 colonies/day
85.6 E8 point sources	48.8 E8 point sources
0.6 E8 background	0.6 E8 background
	0.6 E8 margin of safety
75.6 E8 nonpoint source	8.6 E8 for nonpoint source

The water quality standards are not being met for the Base-flow Condition. The source of the contamination is most likely cattle accessing the stream and/or leakage from manure holding ponds, and the Flemingsburg WWTP. There are no delineated AFOs in the watershed (Figure 3), but that is not to say that there are not free ranging cattle that may be accessing the creek or preexisting manure-holding ponds in the watershed. DMR data should be reviewed on a continuing basis to confirm compliance by the Flemingsburg WWTP. There are few, if any septic systems or straight pipes in the Flemingsburg area. From the above analysis, the reduction in point sources that is needed is $85.6 \text{ E8} - 48.8 \text{ E8} = 36.8 \text{ E8}$. The reduction in nonpoint source that is needed is: $75.6 \text{ E8} - 8.6 \text{ E8} = 67 \text{ E8 colonies}/\text{day}$

For the Runoff Condition (May 23 1998, at the mouth of Town Branch)

Observed is

$$(24.42 \text{ E6})(20 \text{ cfs})(60,000 \text{ colonies}/100\text{ml}) = 293,040 \text{ E8 colonies}/\text{day}$$

Point Source Contribution (WWTP) is

$$(24.42 \text{ E6})(1.0\text{cfs})(20,000 \text{ colonies}/100 \text{ ml}) = 4,880 \text{ E8 colonies}/\text{day}$$

Background is

$$(24.42 \text{ E6})(19 \text{ cfs})(50 \text{ colonies}/100 \text{ ml}) = 232 \text{ E8 colonies}/\text{day}$$

Margin of Safety is

$$(24.42 \text{ E6})(19 \text{ cfs})(25 \text{ colonies}/100 \text{ ml}) = 116 \text{ E8 colonies}/\text{day}$$

WQ Standard (nonpoint sources) is

$$(24.42 \text{ E6})(19 \text{ cfs})(400 \text{ colonies}/100\text{ml}) = 1,856 \text{ E8 colonies}/\text{day}$$

WQ Standard (point sources) is

$$(24.42 \text{ E6})(1.0 \text{ cfs})(200 \text{ colonies}/100\text{ml}) = 49 \text{ E8 colonies}/\text{day}$$

Observed = 293,040 E8 colonies/day	Target (TMDL) = 1,856 + 49 = 1,905 E8 colonies/day
4,880 E8 point sources	49 E8 point sources
232 E8 background	232 E8 background
	116 E8 margin of safety
287,928 E8 nonpoint source	1,508 E8 for nonpoint source

The water quality standards are currently not being met for the Runoff Condition. The observed point source is greater than the target for the point source value. The observed nonpoint source value is greater than the target value for nonpoint source. The source of the FC contamination is the Flemingsburg WWTP (point source) and polluted runoff (nonpoint source). DMR data should be reviewed on a continuing basis to confirm compliance by the Flemingsburg WWTP. There are few, if any septic systems or straight pipes in the Flemingsburg area. There are no delineated AFOs in the watershed (Figure 3), but runoff from pastures at other livestock operations, land application of animal wastes, and preexisting manure holding ponds are potential sources of FC. From the above analysis, the reduction in point source that is needed to meet WQ standards is:

$$4,880 \text{ E8} - 49 \text{ E8} = 4,831 \text{ E8 colonies/day.}$$

The reduction in nonpoint source load (not including background) that is needed to meet WQ standards is:

$$287,928 \text{ E8} - 1,508 \text{ E8} = 285,692 \text{ E8 colonies/day.}$$

For the October 12, 1998 base-flow sampling survey, a FC sample was not collected from the Flemingsburg WWTP outfall. However, DMR (Discharge Monitoring Record) data from October 1998 indicated that the FC count was a maximum of 450 during the month and averaged 70 colonies. As a conservative approach, the value of 450 colonies was used as the point discharge value for the Flemingsburg WWTP discharge for the October 12, 1998 sampling survey. Assuming 1.0 cfs from the WWTP and a flow of 1.1 cfs at the mouth of Town Branch, a die-off and mass balance analysis was done to make an estimate of FC from the Flemingsburg WWTP that could be attributable to the FC count at the mouth of Town Branch. For the die-off analysis, a velocity of 0.15 ft/sec (2.5 miles/day) was assumed. A die-off rate of 1.0 day⁻¹ was used (Greenfield, EPA, Region 4, personal commun., 1987) and the distance from the mouth of Town Branch to the location of the WWTP is approximately 0.6 miles. Using this information, the FC count is 350 colonies.

$$C = C_o \exp(-kx/\text{vel})$$

$$C = 450 \exp(-1.0(0.6)/2.5)$$

$$C = 350 \text{ colonies}$$

The value of 350 colonies is used in the TMDL computation for the base-flow condition for Town Branch. Using this same analysis, a value of 760 colonies is computed at a location

just downstream of the WWTP. Using the 760 colonies and assuming 450 colonies as a conservative estimate of the WWTP discharge, a colony count for Town Branch above the WWTP was estimated to be 3,900 (from mass balance).

$$C_{\text{mix}} = \frac{(C_1)(Q_1) + (C_2)(Q_2)}{Q_1 + Q_2}$$

$$760 = \frac{(C_1)(0.1) + (450)(1.0)}{0.1 + 1.0}$$

$$C_1 = 3,900 \text{ colonies}$$

The analysis indicates that FC counts on Town Branch upstream of the WWTP discharge could be quite high. This would be the result of nonpoint sources. Additional information needs to be collected in the Town Branch watershed to more accurately define conditions during base flow. Additional monitoring is planned as part of programs that are being proposed in the watershed. Discussions with the KDOW Regional Field Office in Morehead, KY (Rice, KDOW, personal commun., 2000) and a review of the DMR data, indicate that the Flemingsburg WWTP has had a good record of compliance in 1999. This is with the exception of one high value (>400 colonies) in January and one in July. However, the average for FC counts for these 2 months was below the permit value of 200 colonies. There are no delineated AFOs in the watershed (Figure 3), but free ranging cattle may still be accessing the stream. There are few, if any, septic systems in the Town Branch watershed and the KDOW Morehead Regional Office has not received any complaints related to failed septic systems in the watershed (Rice, KDOW, written commun., 2000). No straight pipes are known to exist in the Flemingsburg area. (Rice, KDOW, written commun., 2000).

For the May 23, 1998 runoff sample, the observed FC count at the mouth of Town Branch was 60,000 colonies and the FC count from the WWTP was 20,000 colonies. Because the stream velocity that would be present during a runoff event would be fairly high, no adjustment was made to the 20,000 FC count as was done for the base-flow condition. These high values indicate both a significant point and nonpoint source contribution of FC to Town Branch. The Flemingsburg WTTP violation was the result of a mechanical problem. On May 28, 1998 an inspection of the WWTP was made by KDOW Morehead Regional Office personnel. On May 23, 1998 (when the sampling survey was

being conducted), a pump for a surge tank, which was installed in 1994 for control of Biochemical Oxygen Demand (BOD) and Inflow and Infiltration (I & I), did not engage because of a faulty starter. The surge tank then overflowed and the overflow went to chlorination contact, where increased chlorination occurred (as designed). However, chlorination did not occur in sufficient amounts to produce good disinfection of the stormwater. The faulty starter has been replaced. Since May 1998, the plant has been operating properly and there have been only minor I & I problems (Rice, KDOW, written commun., 2000).

As previously stated, there are few, if any, septic systems in the Town Branch watershed and the KDOW Morehead Regional Office has not received any complaints related to failed septic systems in the watershed (Rice, KDOW, written commun., 2000). No straight pipes are known to exist in the Flemingsburg area. Also, the Flemingsburg stockyard has: (1) removed the manure pile that was on the site; (2) seeded the area between the stockyard and Town Branch; and (3) the cattle holding areas are currently under roof, limiting the chance for runoff of FC (Rice, KDOW, written commun., 2000).

Fleming Creek (main stem)

For the tributaries described above, a FC sample was collected at or near the mouth. For the main stem of Fleming Creek, samples were collected above and below selected tributaries and at intervening locations along the main stem (Figures 4 - 7) during the base-flow and runoff sampling surveys. With this additional information, a fairly good picture emerged with respect to where FC contamination was occurring along the main stem during both base-flow and runoff conditions.

For the Base-flow Condition

Steady-state conditions were assumed to exist during the base-flow sampling surveys of August 18, 1992 and October 12, 1998. The focus will be on the October 12, 1998 sampling survey because that is the most recent data. If data were not collected during that sampling survey for a particular site of interest, then the August 18, 1992 data may have been used. The FC counts and the estimated streamflow values for the selected tributaries and for selected main stem Fleming Creek sites for the October 12, 1998

sampling survey are shown in Figure 9. As stated previously, the streamflows are based on the information previously provided in Table 5 and on: (1) a combination of drainage area ratios; and (2) flow increases along the main stem of Fleming Creek. For the October 12, 1998 survey, there were no FC violations (greater than 400 colonies per 100 milliliters of sample) on the main stem of Fleming Creek or at the mouth of any sampled tributaries downstream of the confluence with Cassidy Creek. A value greater than 400 colonies was observed at the mouth of Wilson Run, at the mouth of Town Branch, and on Fleming Creek just downstream of the confluence of Town Branch. It is assumed that Allison Creek would still have a large value of FC, even though no sample was collected at the site. It also follows that an exceedance could be expected on the main stem of Fleming Creek below Wilson Run and below Allison Creek. Mass balance analysis was performed and confirmed this assumption for the values shown in Figure 9. The value of FC on Fleming Creek just downstream of Wilson Run and Allison Creek are approximately 1,500 and 1,700 colonies, respectively.

Using this information, the greatest load on Fleming Creek would occur just downstream of the confluence with Allison Creek. The FC load computation for

Fleming Creek downstream from the confluence with Allison Creek (river mile 22.1)

For the Base-flow Condition (October 12, 1998)

Estimated value based on mass balance is
 $(24.42 \text{ E}6)(1.4 \text{ cfs})(1,700 \text{ colonies}/100\text{ml}) = 581 \text{ E}8 \text{ colonies}/\text{day}$
 Background is
 $(24.42 \text{ E}6)(1.4 \text{ cfs})(10 \text{ colonies}/100 \text{ ml}) = 3.4 \text{ E}8 \text{ colonies}/\text{day}$
 Margin of Safety is
 $(24.42 \text{ E}6)(1.4 \text{ cfs})(25 \text{ colonies}/100 \text{ ml}) = 8.5 \text{ E}8 \text{ colonies}/\text{day}$
 WQ Standard is
 $(24.42 \text{ E}6)(1.4 \text{ cfs})(400 \text{ colonies}/100 \text{ ml}) = 136.8 \text{ E}8 \text{ colonies}/\text{day}$
 The WWTP would not contribute to FC contamination at this location because of die-off.

Estimated = 581 E8 colonies/day	Target (TMDL) = 136.8 E8 colonies/day
0 point sources	0 point sources
3.4 E8 background	3.4 E8 background
577.6 E8 nonpoint source	8.5 E8 margin of safety
	124.9 E8 for nonpoint source

The observed nonpoint source value is greater than the target value for nonpoint source. Therefore, the water quality standards are currently not being met for the Base-flow Condition.

The load exceeds the water quality standard because of the influence of FC contamination from Allison Creek. This indicates that cattle are accessing the stream and/or leakage from manure holding ponds (Allison Creek). The reduction in nonpoint source that is needed to meet WQ standards is $577.6 \text{ E8} - 124.9 \text{ E8} = 452.7 \text{ E8}$ colonies/day.

The same conditions exist for Fleming Creek below Wilson Run and Town Branch as for Fleming Creek below Allison Creek. For base-flow conditions, if the contamination from these two streams is reduced to meet water quality standards, then water quality standards will be met at all locations along Fleming Creek. As stated previously, remediation may include fixing leaking manure holding ponds and/or limiting access by livestock to Wilson Run, Town Branch, and Allison Creek. Limiting access of cows to the stream has been done in a portion of Allison Creek. Review of DMRs from the Flemingsburg WWTP is also needed to ensure compliance by the facility. Assuming a fecal coliform count of 16,000 at the mouth of Allison Creek, and performing a die-off analysis, a fecal coliform count of 400 would have been achieved approximately 1.5 miles downstream from Allison Creek (which is just upstream from Cassidy Creek). From this location to the mouth of Fleming Creek, there are no further exceedances of the 400 colony count criteria. The FC load computation at the mouth of Fleming Creek is

Fleming Creek near the mouth (river mile 1.3)

For the Base-flow Condition (October 12, 1998)

Observed is

$$(24.42 \text{ E6})(1.4 \text{ cfs})(60 \text{ colonies}/100\text{ml}) = 20.5 \text{ E8 colonies}/\text{day}$$

Background is

$$(24.42 \text{ E6})(1.4 \text{ cfs})(10 \text{ colonies}/100 \text{ ml}) = 3.4 \text{ E8 colonies}/\text{day}$$

Margin of Safety is

$$(24.42 \text{ E6})(1.4 \text{ cfs})(25 \text{ colonies}/100 \text{ ml}) = 8.5 \text{ E8 colonies}/\text{day}$$

WQ Standard is

$$(24.42 \text{ E6})(1.4 \text{ cfs})(400 \text{ colonies}/100 \text{ ml}) = 136.8 \text{ E8 colonies}/\text{day}$$

The WWTP would not contribute to FC contamination at this location because of die-off.

Observed = 20.5 E8 colonies/day	Target (TMDL) = 136.8 E8 colonies/day
0 point sources	0 point sources
3.4 E8 background	3.4 E8 background
17.1 E8 nonpoint source	8.5 E8 margin of safety
	124.9 E8 for nonpoint source

Therefore, water quality standards are currently being met for the Base-flow Condition at the mouth of Fleming Creek. The target values at this site are identical to those for the site below Allison Creek (RM 22.1).

For the Runoff Condition

The flow condition for the runoff samples of May 18, 1992 are assumed to be 'near' steady state. It does not appear that there was a significant amount of runoff during the event, so the streamflow hydrograph would not have increased by a large amount. The flow at North Fork Licking River at Mt. Olivet (Table 3) for May 18, 1992 was 203 cfs, which is less than 1.0 cfs. The rainfall gages in the Fleming Creek watershed the previous 24 hours recorded 0.75 inches. Streamflow at gaging stations located south of the Fleming Creek watershed showed little response to the rainfall event, indicating that the rainfall was not widespread in the area.

The flow condition for the runoff samples of May 23, 1998 are assumed to also be 'near' steady state. Rainfall was fairly significant at 1.7 inches (Rice, KDOW, written commun., 2000), but it was postulated that the samples at most of the locations were collected near the time of the peak of the hydrograph or slightly after the peak had occurred (McMurray, personal commun., 2000). As mentioned previously, the daily flow resulting from this event had a flow duration of approximately 10 percent.

As with the base-flow analysis, the focus will be on the May 23, 1998 sampling survey because this is the most recent data. Also, the rainfall was greater, resulting in a more complete wash-off of the material that had been deposited on the land surface. If data were not collected at a particular site during the May 23, 1998, an estimate was not made. For the May 23, 1998 survey, FC counts of greater than 400 colonies were observed at all of the tributary sampling locations and at all of the Fleming Creek main stem sampling locations. All FC counts were very high, and were reported as >16,000 except at one location where a FC count of 11,000 was determined. For the samples having counts of >16,000, an estimate was made of the actual value (Table 3).

The FC counts and the estimated streamflow values for the selected tributaries and on the main stem of Fleming Creek for the May 23, 1998 sampling survey are shown in Figure 8. The streamflows are based on the information previously provided in Table 5 and on (1) a combination of drainage area ratios and (2) flow increases along the main stem of Fleming Creek. The highest FC load occurred at the most downstream site:

Fleming Creek near the mouth (river mile 1.3)

For the Runoff Condition (May 23, 1998)

Observed is	
(24.42 E6)(340 cfs)(100,000 colonies/100ml)	= 8,303,800 E8 colonies/day
Background is	
(24.42 E6)(340 cfs)(50 colonies/100 ml)	= 4,200 E8 colonies/day
Margin of Safety is	
(24.42 E6)(340 cfs)(25 colonies/100 ml)	= 2,100 E8 colonies/day
WQ Standard is	
(24.42 E6)(340 cfs)(400 colonies/100 ml)	= 33,200 E8 colonies/day
No point sources of fecal coliform	

Observed = 8,303,800 E8 cols/day	Target (TMDL) = 33,200 E8 cols/day
0 E8 point sources	0 E8 point sources
4,200 E8 background	4,200 E8 background
8,299,600 E8 nonpoint source	2,100 E8 margin of safety for nonpoint source
	26,900 E8

The observed nonpoint source is greater than the Target for nonpoint source. Therefore, standards are currently not being met for the Runoff Condition. The source of the FC contamination is polluted runoff. There are several AFOs in the watershed (Figure 3) and runoff from pastures at other livestock operations, land application of animal wastes, and manure storage ponds are all potential sources of FC. The reduction in nonpoint source (not including background) that is needed to meet WQ standards is: 8,299,600 E8 – 26,900 E8 = 8,272,700 E8 colonies/day

LOAD ALLOCATION

Base-flow Condition

From the base-flow survey of October 12, 1998, the exceedance of the 400-colony count occurred on Wilson Run, Town Branch, and on the main stem of Fleming Creek immediately downstream from Town Branch (Figures 6 and 9). Because of the elevated colony count on the main stem of Fleming Creek immediately above Sleepy Run, it is apparent that the colony count on the UT at RM 31.7 is also high. Based on current information, there are a number of AFOs in this watershed, and there are no AFOs along the main stem of Fleming Creek between Logan Run and Sleepy Run (Figure 3). Even though no sample was collected on Allison Creek on October 12, 1998, it is assumed that Allison Creek would still have high FC values during base-flow conditions. Also, stretches of Fleming Creek below Wilson Run and Allison Creek would also have high

FC counts because of the contribution from these tributaries. Therefore, the general statement can be made that the FC count is exceeded on the main stem of Fleming Creek from the confluence with Cassidy Creek (RM 20.6 to the confluence with Wilson Run at RM 27.9). For Fleming Creek just upstream of Cassidy Creek to the mouth of Fleming Creek, there were no further exceedances of the 400 FC count criteria. Figure 10 shows the stream segments impacted by FC contamination during base flow. The allowable FC loads for the base-flow condition are shown in Table 6.

Table 6. The Allowable Fecal Coliform Loads for the Base-flow Condition (xE8 colonies/day)

<u>Stream</u>	<u>WLA</u>	<u>LA</u>	<u>Background</u>	<u>Margin of Safety</u>
UT at RM 4.28	0	3.6	0.1	0.2
Poplar Creek	0	6.2	0.2	0.4
Doty Creek	0	22.3	0.6	1.5
Craintown Branch	0	5.3	0.2	0.4
Cassidy Creek	0	6.2	0.2	0.4
Allison Run	0	62.4	1.7	4.3
Wilson Run	0	11.0	1.0	1.0
Sleepy Run	0	5.3	0.2	0.4
Logan Run	0	5.3	0.2	0.4
Town Branch	48.8	8.6	0.6	0.6
Fleming Creek	0	125	3.0	9.0

The flow condition for the October 12, 1998 sampling survey corresponds to a flow duration of approximately 90 percent. The survey was made several days after a small runoff event had occurred, but base-flow conditions existed (no direct runoff) during the sampling survey. This was done because during late summer and early fall most of the streams have no flow (with the exception of the lower section of Town Branch below the Flemingsburg WWTP).

Although the allowable loadings will be higher for the runoff condition because of the increased streamflow value, this situation underscores the inherent problem with computing a load for a constituent such as FC, which is independent of flow conditions. The BMPs for remediating FC contamination during base-flow conditions include limiting access to the stream by livestock and preventing leakage from waste holding ponds. A different approach will be required to remediate FC contamination from runoff events.

Runoff Condition

From the runoff survey of May 23, 1998, the exceedance of the 400 colony count occurred at all tributary sites and all main stem Fleming Creek sites by a significant amount (Figure 8). A sample was not collected on Doty Creek, Flat Run, or several main stem Fleming Creek locations where a sample had been collected during one of the other sampling surveys. All samples taken during the May 23, 1998 sampling survey had counts exceeding 16,000 colonies except for the UT at RM 4.28 (11,000 colonies). An estimate of the actual FC count was made and these values were used to compute the 'loads' given previously in this report. No distinct pattern emerges from the data, except that FC counts on the main stem of Fleming Creek decrease if there is no significant tributary inflow between sampling sites or if the tributary count is low. This occurs below Sleepy Run – the fecal count upstream of Sleepy Run is 80,000, but reduces to 20,000 below Sleepy Run because of the combination of die-off on the main stem and because the contribution from Sleepy Run is 18,000 colonies. This also occurs on the main stem of Fleming Creek between Poplar Creek and the UT at RM 4.28 where there is no significant inflow and the colony count decreases from 90,000 to 60,000. However, anomalies occur in this data set. Most notable is that the coliform count on Fleming Creek near the mouth is 100,000 whereas the FC count on the UT at RM 4.28 is 11,000 and the count on Fleming Creek above the UT is 60,000.

The runoff sampling survey of May 23, 1998 indicates that there is significant contribution of FC from nonpoint sources and from the Flemingsburg WWTP (Town Branch). The nonpoint source contributions are from agricultural practices associated with the dairy and beef cattle operations. There are numerous AFOs in the Fleming Creek watershed (Figure 3). To remediate FC contamination during runoff conditions, it is recommended to install waste management systems for those operations that currently do not have them. Also, other BMPs at these agricultural operations should be implemented throughout the watershed. These are discussed in the next section, Implementation Plan. The only point source in the Fleming Creek watershed (1998) is the Flemingsburg WWTP on Town Branch, which contributed to the high FC count on Town Branch and probably on Fleming Creek immediately downstream from Town

Branch on May 23, 1998. In 1994 a surge tank was installed at the WWTP to capture I & I and to reduce BOD. On May 23, 1998 (when the sampling survey was being conducted), a pump for a surge tank, which was installed in 1994 for control of BOD as well as I & I, did not engage because of a faulty starter. Because the pump did not engage, the surge tank overflowed and the overflow went to chlorination contact, where increased chlorination occurred (as designed). However, chlorination did not occur in sufficient amounts to produce good disinfection of the stormwater. The faulty starter has been replaced. This occurrence created the high FC count (20,000 colonies) observed from the plant outfall. An inspection of the WWTP on May 28, 1998 documented this occurrence. Since that time the plant has operated properly and the KDOW field inspector is confident that the plant operators have addressed this particular problem. Since May 1998 there have only been minor problems associated with I and I at the WWTP. Discussions with the KDOW Regional Field Office personnel in Morehead, KY (Rice, KDOW, personal commun., 2000) and a review of the DMR data, indicate that the Flemingsburg WWTP has had a good record of compliance in 1999. This is with the exception of one high value (>400 colonies) in January and one in July. However, the average for FC counts for these 2 months was below the permit value of 200 colonies. As shown in Figure 8, the FC count at the mouth of Town Branch was 60,000, indicating significant contribution from nonpoint sources in that particular watershed. Discussions with KDOW Field Office Personnel have indicated that they are not aware of any septic systems in the watershed (which is adjacent to the City of Flemingsburg) and that they have not had any complaints of failing septic systems in the area (Rice, KDOW, written commun., 2000). No straight pipes are known to exist in Flemingsburg, and the Flemingsburg stockyard has: (1) removed the manure pile that was on the site; (2) seeded the area between the stockyard and Town Branch; and (3) the cattle holding areas are currently under roof, limiting the chance for runoff of FC (Rice, KDOW, written commun., 2000).

The flow condition for the runoff samples of May 23, 1998 are assumed to also be 'near' steady state. Rainfall was fairly significant at 1.7 inches (Rice, KDOW, written commun., 2000), but it was postulated that the samples at most of the locations were collected near the time of the peak of the hydrograph or slightly after the peak had occurred (McMurray, personal commun., 2000). As mentioned previously, the daily flow

resulting from this event had a flow duration of approximately 10 percent. The allowable loads for the runoff condition are given in Table 7.

Table 7. The Allowable Fecal Coliform Loads for the Runoff Condition (xE8 colonies/day)

<u>Stream</u>	<u>WLA</u>	<u>LA</u>	<u>Background</u>	<u>Margin of Safety</u>
UT at RM 4.28	0	468	72	36
Poplar Creek	0	953	146	73
Doty Creek	0	199	30	15
Craintown Branch	0	9,590	120	60
Cassidy Creek	0	951	146	73
Allison Run	0	2,145	330	165
Wilson Run	0	1,660	260	130
Sleepy Run	0	800	120	60
Logan Run	0	800	120	60
Town Branch	49	1,508	232	116
Fleming Creek	0	26,900	4,200	2,100

REGULATORY AUTHORITY

Animal feeding operations (AFOs) are permitted under 401 KAR 5:005 using a Kentucky No Discharge Operational Permit (KNDOP) for Agricultural Wastes Handling System. The Natural Resources Conservation Service (NRCS) works with the permittee to develop a Nutrient Management Plan for the handling of the wastes that are produced. KDOW Field Offices are currently involved in extensive surveillance activities to inventory both permitted and unpermitted AFOs. Regulations are currently being developed to define siting criteria for Concentrated Animal Feeding Operations (CAFOs) for beef and dairy operations and for the permittee to perform certain monitoring tasks. CAFOs would need a KPDES permit. A CAFO is generally defined as an animal feeding operation with more than 1000 animal units, with a beef cow being designated as 1.0 animal unit. The KPDES permit for beef and dairy operations would also require that a (more detailed) Comprehensive Nutrient Management Plan be developed which uses the most recent NRCS guidelines as a basis for waste management.

The regulatory authority for remediating nonpoint sources of pollution from agricultural and silviculture operations in Kentucky is: (1) KRS (Kentucky Revised Statutes) 224; more specifically Title 401 of the KAR (Kentucky Administrative Regulations),

Chapter 5, Section 31 (401 KAR 5:031); and (2) the Kentucky Agriculture Water Quality Act (The Act), which is KRS 224.71-100 to 224.71-140, and is the name given to Senate Bill 241 (passed by the Kentucky General Assembly in 1994). Remedial actions to nonpoint sources of pollution will be taken based on the establishment of BMPs as described in The Kentucky Agriculture Water Quality Plan (KAWQP) of 1996 (KAWQA, 1996). Agricultural operations (including silviculture) of 10 acres or more must develop and implement a water quality plan (based on guidance from the KAWQP) for their agricultural operation by October 23, 2001. To assist landowners in developing an individual water-quality plan, The Kentucky Agriculture Water Quality Authority (KAWQA) has developed The Producer Workbook (KAWQA, 1997) which is available along with many other planning tools through conservation districts and county extension offices. These tools were designed to provide a process for developing an individual water-quality plan and also gives a list of various State and Federal agencies that can provide technical and financial assistance to develop and implement the plan. The Producer Workbook and KAWQP document provide information on potential sources of financial assistance to implement the BMPs described in the KAWQP. The Act provides a method for resolving situations where it is documented that water pollution is occurring due to agricultural practices and defines a 'bad actor' and provides actions that can be taken in this regard.

IMPLEMENTATION PLAN

This will be a phased TMDL because of the presence of nonpoint sources of pollution on all of the stream reaches listed. A phased TMDL is necessary when the efficiency of remedial activities is unknown. Remedial activities will need to be implemented, and follow-up monitoring will need to be conducted. If water quality standards are still not being met upon review of the data from the follow-up monitoring, the remedial activities will need to be modified. If water quality standards are being met based upon a review of the data from the follow-up monitoring, then the stream segment(s) can be removed (delisted) from the 303(d) list of impaired waters.

To assist in developing a remediation strategy, the Kentucky Watershed Management Framework (KWMF) will be utilized in conjunction with the KAWQPs. As part of the KWMF, a Licking River Basin Unit Team, with a Basin Coordinator, has been

formed to carry out certain recommended activities. One of these activities is to develop a Local Watershed Task Force, which will then be asked to develop a Local Action Plan. For streams impacted by nonpoint source pollution, it is recommended that the Local Action Plan be developed by a Local Watershed Task Force. The Local Action Plan will be the document that describes the remediation activities that are needed and how implementation will be achieved. The KAWQPs will be an integral part of the Action Plan. The Action Plan will be developed in the fourth year of the 5-year watershed cycle, and Implementation will occur in the fifth year of the cycle. This information is described in a document developed by the KDOW for addressing nonpoint TMDLs; Implementation Plan for Achieving Load Allocations for Nonpoint Source TMDLs. The Licking River Basin Unit is currently entering into the second year of the Watershed cycle. Stakeholder groups currently exist within the watershed and will be asked to participate in this process of developing an Action Plan.

The base-flow sampling survey results indicate that FC contamination is occurring as a result of direct input of manure to:

Unnamed Tributary (UT) at River Mile (RM) 31.7,
Wilson Run,
Allison Creek, and
Town Branch (which also receives effluent from the Flemingsburg WWTP).

Fleming Creek immediately below the confluence with these streams is impacted by these four streams. No direct evidence exists that the Fleming Creek reach is being directly impacted. However, a conservative approach is to also list this section of stream reach until such time as the tributary streams are shown not to be contributing to FC contamination to Fleming Creek during base-flow conditions. Figure 10 shows these stream segments. Therefore, one or more of the following BMPs and remedial activities (or others as deemed necessary) are recommended to remediate FC contamination during base-flow conditions:

Limit access of livestock to the impacted stream segments (and use alternative water systems),
Limit access points to the impacted streams, and
Inspect waste holding ponds and repair waste holding ponds that are leaking.

An inspection of septic systems in these watersheds may also be appropriate. Because of the topography (moderate to steep hill slopes) of the Fleming Creek watershed, cattle often have limited space to lay down, and areas along streams are often the only areas available (Jackson, DOW, personal commun., 2000). Therefore, limiting access to the stream and streambank by livestock may present a challenge. Stakeholder groups will be an important part of developing Action Plans as part of the KWMF and Clean Water Action Plan (CWAP) to implement BMPs in the watershed. Also, additional FC information is needed in the Town Branch watershed, particularly on stream segments upstream of the Flemingsburg WWTP.

The runoff sampling survey results indicate that the source of the FC contamination during runoff events is the agricultural practices related to beef and dairy operations. There are numerous AFOs in the Fleming Creek watershed (Figure 3). To remediate FC contamination during runoff conditions, it is recommended that waste management systems be installed for those operations that currently do not have them. Also, other BMPs at these agricultural operations should be implemented throughout the watershed. BMPs to control FC contamination to the stream reach during runoff events may include, but are not limited to:

- Planned Grazing Systems
- Proper Grazing Use
- Riparian Area Protection
- Waste Management Systems
- Waste Storage Structures (Including Holding Tanks or Stack Pads) or Ponds
- Waste Treatment Lagoons
- Sediment or Solids Separation Basins
- Feeding and Heavy Use Area Management
- Milking Canter Wastewater Treatment

These BMPs are discussed as part of the KAWQPs that are to be developed and implemented by October 2001 for agricultural operations of 10 acres or more (KAWQA, 1996).

REASONABLE ASSURANCE

Because the effectiveness of BMPs to remediate FC contamination in surface waters is uncertain, follow-up monitoring will need to be conducted through programs

such as CWAP , AWAP, and the KWMF (KDOW, 1997). Monitoring in the Licking Unit will be conducted in 2004-05 as part of the KWMF, but it is anticipated that monitoring will be conducted before that time as part of the CWAP or AWAP programs.

REMEDIATION ACTIVITIES

The Fleming Creek Demonstration Project was initiated in 1992 by a group of local landowners concerned about the water quality of Fleming Creek and its tributaries. They formed the Fleming Creek Water Quality Committee, which was dedicated to assessing the needs and interests of all local citizens. Initially, this committee coordinated with local farmers and government agencies and represented the farmers. As the project evolved, the Community Farm Alliance (CFA) became the principal grassroots coordinating organization for those groups.

In response to the pollution problem and the local interest in remediation of the problem, the U.S. Department of Agriculture requested and received funding for animal waste management systems for the watershed. In 1992 the USDA allocated \$200,000 through the Agricultural Conservation Program (ACP) for the purpose of providing cost-share monies for the installation of animal waste management systems. The USDA awarded another \$17,500 to the project for the installation of a constructed wetland. During FFY 1994, farmers within the Fleming Creek watershed received \$152,000 in USDA Water Quality Incentive Program (WQIP) funds for the implementation of nonstructural agricultural BMPs. The WQIP funding was used for items such as limiting access to the stream by livestock and for manure management, as well as for agronomic activities. Figure 11 shows the location of selected BMPs installed in the watershed. Figure 11 was constructed using information provided by the DOC (Sundys, DOC, written commun., 1998). More recent information is provided in Table 8 and 9. Table 8 provides information on BMPs that were installed in the watershed from May 1990 to May 1994. Table 9 provides information on BMPs that were installed from June 1994 to May 1999. The tables use data provided by the DOC (DOC, written commun., 1999). Also, an application was submitted by KDOW to the National Forum on Nonpoint Source Pollution (a private organization dedicated to finding solutions for nonpoint source pollution control) soliciting additional funds for animal waste management systems. There may also be BMPs

Table 8. Applied Best Management Practices (BMPs) in the Fleming Creek Watershed, May 1, 1990 to May 31, 1994 (Peake, KDOW, written commun., 2000).

<u>Type of BMP</u>	<u>Funding Source</u>	<u>Unit</u>
Trough or Tank	FSA	124
Waste Management System	LTA, WSP	16
Diversion	LTA	800 feet
Fencing	LTA	1,200 feet
Waste Storage Pond	LTA	1
Heavy Use Area Protection	LTA	1 acre
Waste Utilization	LTA, WSP	107 acres
<u>Filter Strip</u>	<u>WSP</u>	<u>2 acres</u>

FSA = Food Security Act

LTA = Long Term Agreement

WSP = Water Quality Special Project

that were installed in the watershed by individuals outside of these programs that may not be indicated here.

Farm field days have been held at selected operations to encourage the use of and to demonstrate the benefit of BMPs to vicinity farmers. It is anticipated that the number of farmers that incorporate BMPs into their operations will increase. In addition, CFA has initiated an educational project, funded in part through U.S. EPA Section 319(h) monies, to promote conservation of water resources throughout the Fleming Creek watershed. Not only are school students being taught about conservation, they will act as an outreach tool to help enlighten the local farm community.

The KDOW, Nonpoint Source Section, received federal Section 319(h) Nonpoint Source Implementation Grant funds during FFY 1991, 1992, and 1993 for the purpose of documenting and demonstrating the effectiveness of the BMPs in improving water quality in the Fleming Creek watershed. Based upon the high number of livestock operations, the main pollutants of concern are nutrients and FC bacteria. The pre-BMP bacteriological monitoring was conducted in 1992 and post-BMP monitoring was conducted in 1998. The results of that monitoring are provided in this report and are the basis for developing

Table 9. Applied Best Management Practices (BMPs) in the Fleming Creek Watershed, June 1, 1994 to June 1, 1999 (Peake, KDOW, written commun., 2000).

<u>Type of BMP</u>	<u>Funding Source</u>	<u>Unit</u>
Waste Management System	CTA, FSA, LTA, WSP	16
Waste Storage Facility	CTA, FSA, LTA, WSP	13
Cover and Green Manure Crop	CTA	70 acres
Pond	CTA, FSA	8
Fencing	CTA, FSA	900 feet
Trough or Tank	CTA, FSA, WQP	190
Waste Utilization	CTA, FSA, WSP	239 acres
Filter Strip	FSA	4 acres
Use Exclusion	FSA	100 acres
Prescribed Grazing	FSA	30 acres
Heavy Use Area Protection	FSA, WSP	5 acres
Nutrient Management	FSA	40 acres
Sediment Basin	LTA	2
Waste Storage Pond	WSP	3

CTA = Conservation Technical Assistance
 FSA = Food Security Act
 LTA = Long Term Agreement
 WSP = Water Quality Special Project
 WQP = Water Quality Demonstration Project

this TMDL. Some progress has been made in that during base-flow conditions, FC counts were less on the section of Fleming Creek upstream of Logan Run, on Sleepy Run, and on Town Branch. However, the information in Table 8 and 9 indicate that only a modest amount of BMPs have been installed in the watershed to remediate FC contamination. Additional programs are needed for installing BMPs and to conduct follow-up monitoring.

More recently (1999), a work plan for the Fleming Creek CWAP has been submitted by the DOC to continue the work of identifying, evaluating, and implementing agricultural BMPs in the watershed (KDOW, 1999). The BMPs will permit sustained use of natural resources by meeting specific quality criteria. Follow-up monitoring will also be conducted as part of the project. Also, a proposal has been developed for the Agricultural Watershed Awareness Program (AWAP) by the DOC (Giesecke, written

commun., 1999) to develop and foster educational programs to enhance the awareness of people living in the watershed to activities that promote the protection of water quality. Monitoring is proposed as part of the educational activities.

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